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Gasoline Engine Tune-Up
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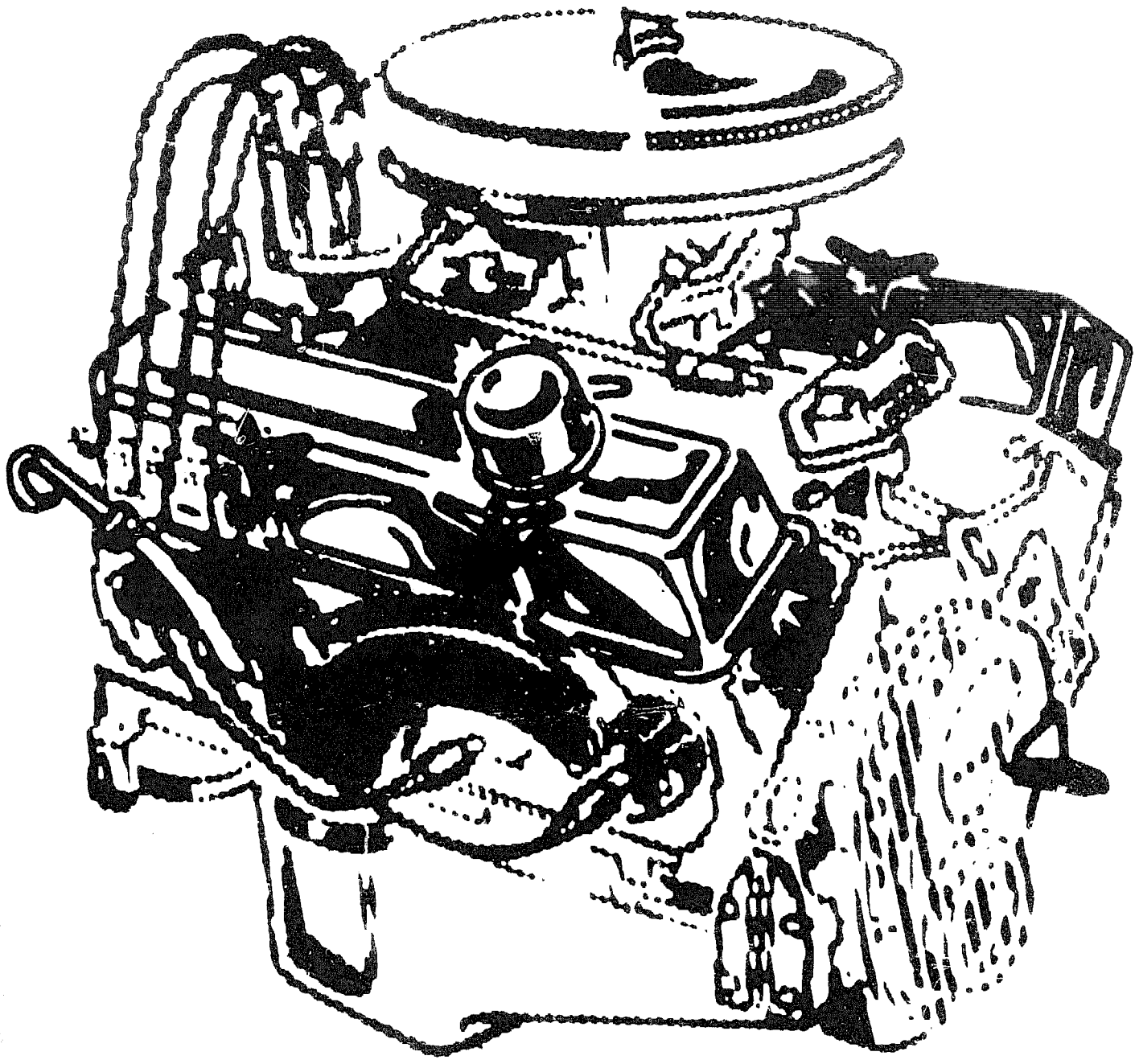
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THE THREE-PART GASOLINE ENGINE TUNEUP



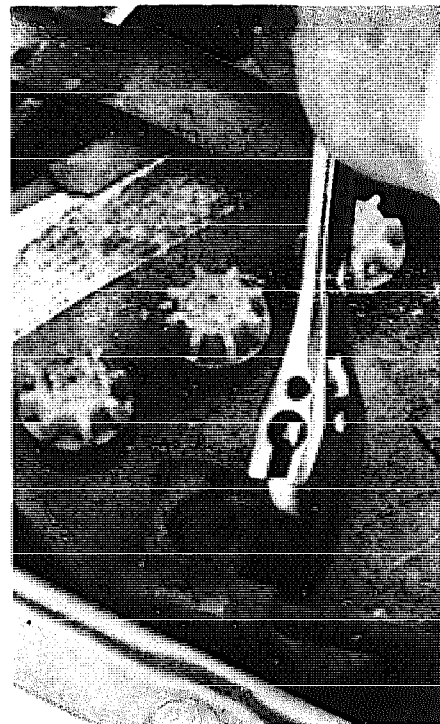
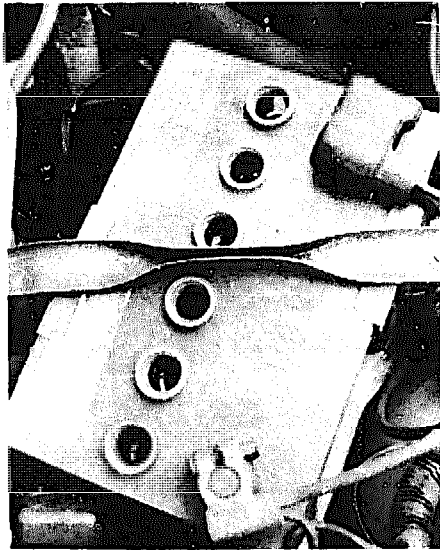
The Backyard Mechanic

(right)

When your auto record book tells you it's been 15,000 miles or one year since your car's last tuneup, it's time to grab a good workshop manual and bring your engine up to specifications.

(below)

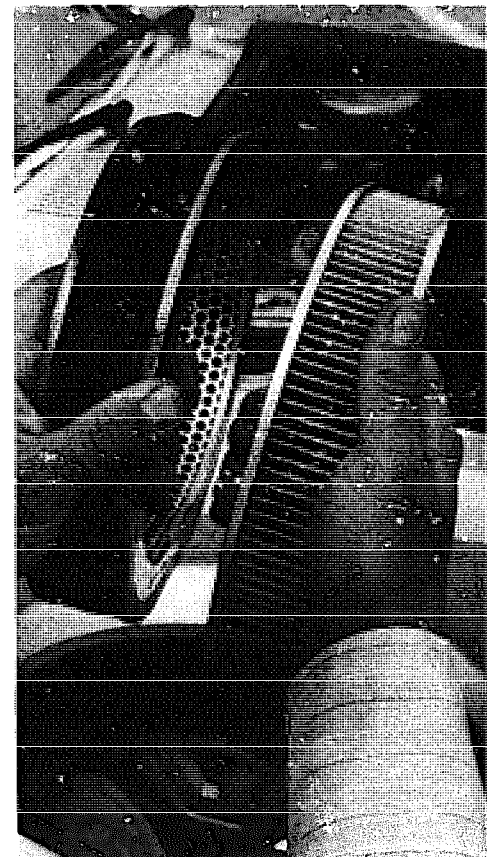
Wear eye protection when checking the fluid level in the battery cells.



Always disconnect the ground (negative, on most cars) first and reconnect it last.



The air cleaner should be checked every year and replaced every other tuneup no matter how good it looks.



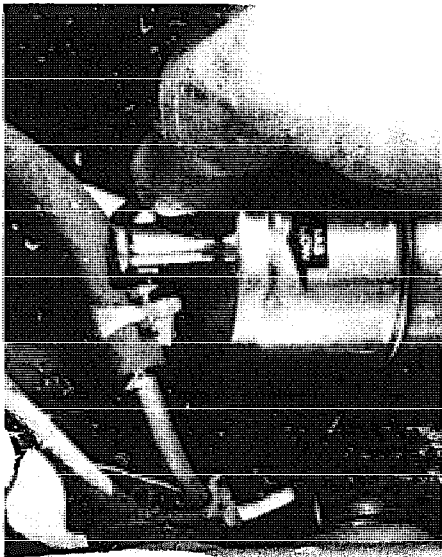
You can see how the dirty air cleaner on the left would restrict air flow.

THE THREE-PART 1 Gasoline 2 ENGINE 3 Tuneup

Introduction

Tuning your vehicle is one of the best preventive maintenance steps you can take. Besides avoiding costly breakdowns, tuneups prevent wasteful consumption of fuel as well as your dollars.

Studies have found that 42 out of every 100 vehicles show signs of improper engine maintenance and are wasting fuel. Yet the average tuneup improves fuel economy 11.7 percent. And, in some cases, 50 percent improvements have resulted from such maintenance. In addition, an average tuneup will pay for itself in 7000 miles — 2500 miles if you do the work yourself.



Make sure the gas flow arrow is pointing in the right direction when replacing the fuel filter.

Instead of waiting for a noticeable drop in your mileage — rough idling, hesitation, dieseling, hard starting, stalling, surging, pingin' g, misfire or lack of power — you should tune your car annually or every 15,000 miles if you drive more than that each year.

While there are no magic tricks or gadgets that are going to double your car's miles per gallon, it is going to operate at its best when tuned properly to the manufacturer's specifications. Thus the best way to maximize your car's mileage and performance is to give it a thorough tuneup.

Because the key to a proper tuneup is setting the vehicle to the manufacturer's specifications, you'll need a good workshop manual for your specific vehicle. In addition to providing all the correct specifications, such manuals furnish information and procedures for routine maintenance and servicing as well as diagnostic and repair procedures to follow when trouble occurs. As procedures do vary from vehicle to vehicle, you'll only be able to use the Backyard Mechanic as a general guide.

Be sure to read the tuneup section of the manual from start to finish before tackling the job. You'll not only get a good idea about what's involved, as well as what parts and tools will be required, but you also may find very helpful hints buried in the fine print. Sometimes there's even a hint about step 11 written in step 37.

Furthermore, after reading the tuneup section you may decide the work is beyond your skills and have a professional do the job for you. You'll still be ahead of the game because you'll have a better understanding of what has to be done and how.

After reviewing the manual, the first step in a tuneup is a quick inspection of the basic components that affect reliability and performance.

First, after removing any jewelry, pop the battery filler caps off and check the fluid level. Don't look directly into the cells without wearing some sort of eye protection. If the fluid level is below the fill line or doesn't cover the tops of the plates in all the cells, bring it up with distilled water. Tap water is okay in emergencies only.

Of course you can't check the fluid level in a maintenance-free battery, but there are some checks that can be performed, so read your owner's manual to find out what they are.

Next make sure the battery case and terminals are clean. When removing the battery cables, be sure to disconnect the ground cable first (the cable that runs to the frame or engine — usually negative). When reconnecting the cables, do the ground last.

Terminal and connection corrosion (white fluffy deposits that are brittle to the touch) should be cleaned off with steel wool, a wire brush or a special cleaning tool until the metal is bright. A dirty battery case can be washed with a baking soda and water solution and rinsed with clean water. Be careful not to get any of the soda solution in the cells.

Trace the positive cable to make sure all electrical connections are tight, especially at the starter. The cables should be replaced every four years or 50,000 miles as part of a preventive maintenance program.

Put grease or petroleum jelly around the base of the terminals — not on the terminals — before reconnecting the cables. After reconnecting the cables, also coat the top of the cleaned battery terminals. The coat-

continued

continued



The PCV valve is usually located in the rocker arm or valve cover.



The PCV filter is found in the air cleaner housing and should be replaced when the PCV valve is.



If you hear any rattling when tapping the fuel evaporation system canister, replace it.

Gasoline ENGINE 23 Tuneup

ing helps prevent corrosion.

A dirty air filter restricts the air flow to the carburetor and causes the engine to burn more fuel than necessary. So, a clean air filter is essential for the best performance and mpg.

The air filter is usually located in a housing on top of the engine. In most cases, removing a single wingnut will allow you to lift the top plate off the housing and pull the paper element filter out. If there are any vacuum hoses attached to the top plate, be sure to mark them in some way (such as with matching tape numbers) so that you can reattach them properly. Be very careful not to drop anything down the carburetor.

Check the filter by holding it up to bright sunlight or to a light bulb. If you can't see light coming through all the way around the filter, it should be replaced. If the filter is more than two years old or has been in service more than 30,000 miles, replace it anyway. Before putting an old filter back

into the housing, wipe it clean with a rag. And regardless of whether you're using the old filter or a new one, wipe the housing clean too. Be sure the filter seats properly in the bottom of the housing before replacing the lid.

A plugged fuel filter can stall your engine completely without warning. Since there's no way to check the filter, it should be replaced at every tuneup.

There are two basic types of fuel filters—the type used on most General Motors products installs inside the carb. Most other vehicles use an in-line filter that clamps in the fuel line between the fuel pump and the carburetor.

The G/M-type filter can be replaced by very carefully removing the fuel line at the carburetor while holding a rag under the line connection to catch leaking gasoline. When you remove the line note how the filter and spring insert in the filter hous-

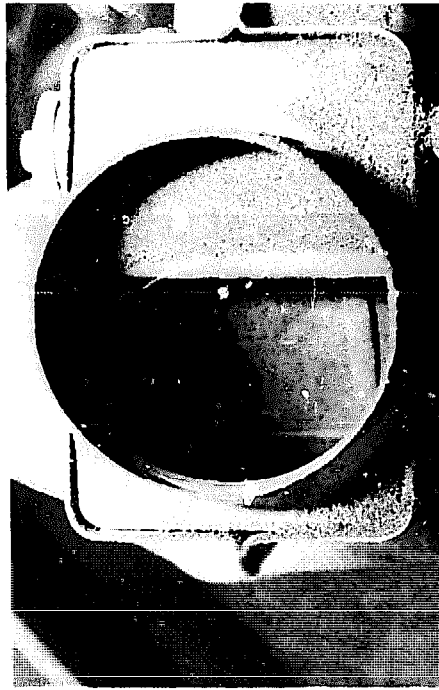
ing so you can install the new filter correctly.

The in-line filter either clamps into the fuel line or, on most Ford products, it screws into the carburetor with the fuel line clamped to the other end. When removing this type of fuel filter, also be sure to have a rag under the connections to catch leaking gasoline. Be sure to clamp the new filter into place exactly as the old filter came out, and be certain that any arrows on the filter point toward the carburetor.

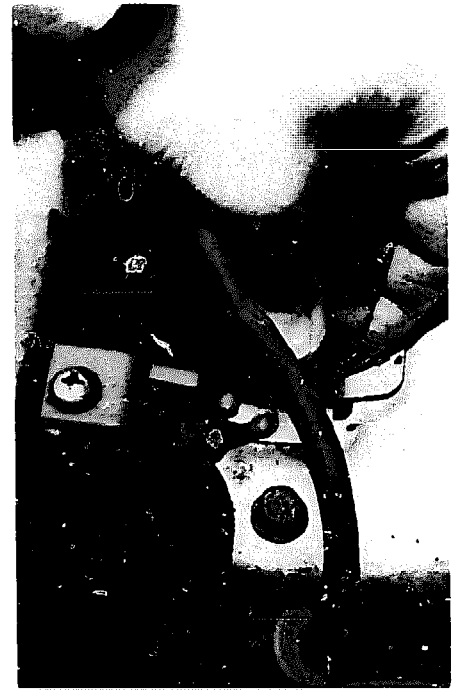
Emissions systems have to be properly maintained to keep emissions down and performance up. During a tuneup, your main concerns should be the Positive Crankcase Ventilation (PCV) system, Exhaust Gas Recirculation (EGR) valve, fuel evaporation system canister, manifold heat control valve and thermostatic air control system. Your car may have all or only some of these systems, or, if it is a pre-1968 model (other than



Although the EGR valve is often hard to locate on the intake manifold, it must be checked at every tuneup.



Another hard-to-see item is the flapper in the air cleaner snorkel. This one is closed, as it should be when the engine is cold.



Plug wires are removed by grabbing the boot (and only the boot), twisting until it "pops" and then pulling them off the spark plug.

California vehicles), it may have none.

The PCV valve is usually pushed into one of the rocker arm or valve covers on the engine with a hose connecting it to either the carburetor or intake manifold. The simplest way to check its operation is to put a sheet of paper over the oil filler neck with the engine running. If the paper is pulled in by the suction, the system is operating.

Another way to check PCV valve operation is to remove the valve from its rubber grommet seat and press your finger over its open end. Engine speed should drop at least 40 rpm if the valve is functioning properly.

Regardless of how good the valve acts, replace it every three years or 40,000 miles.

Also check the rubber grommet in the cover for damage. If it is faulty, replace it with a new one. Also replace it when installing a new PCV valve. When reinstalling the PCV

valve make sure that it is properly seated and/or clamped in its hose, the end pushed securely into its rocker cover seat.

On nearly all cars there is also a PCV filter located inside the air cleaner housing. It should be inspected and replaced when the PCV valve is.

The EGR valve is normally located on the intake manifold, near the carburetor. With the engine warmed up and running at slow idle, disconnect the hose leading to the EGR and attach a hand vacuum pump to the valve. Pump the tool until it reads at least four inches of mercury. The engine should either start running rough and missing or stop. If it doesn't, the EGR valve needs servicing or, in most cases, replacing.

The complicated looking fuel evaporation system is really one of the simplest and most trouble-free portions of the emissions network. You can usually tell if it isn't working

right because there'll be a strong odor of gasoline present.

At tuneup time you'll want to check the hoses for cracks and secure connections, and test the purge valve(s). As these tests vary from vehicle to vehicle, consult your car's workshop manual for details.

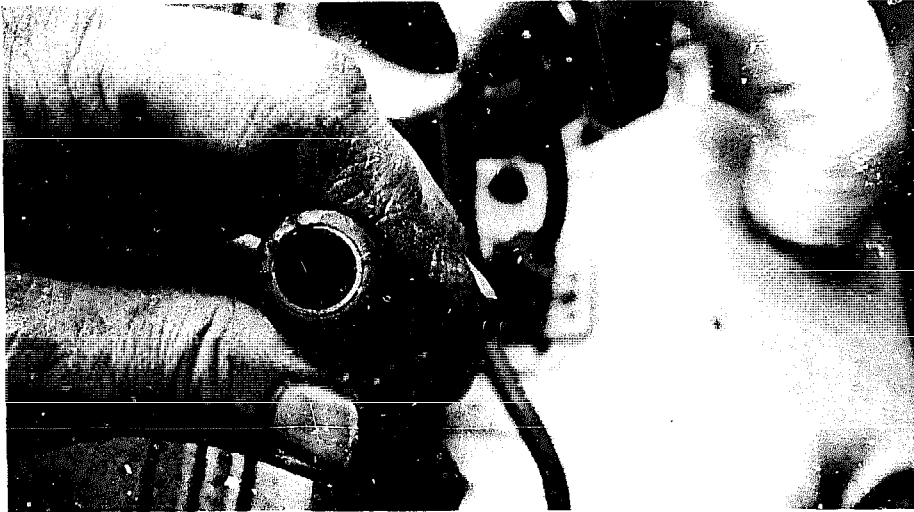
Basically you are going to disconnect and plug the purge valve's vacuum source and make sure that air doesn't pass through the valve. Then reconnect (and unplug) the vacuum line and ensure that air does go through the valve when the engine is running between 1,500 and 2,000.

The fuel evaporation system canister should be inspected for charcoal leakage and loose internal parts. Tap the charcoal canister and if you hear any rattling noise, replace it.

Most American-built cars have canisters with replaceable filters in the base. While one manufacturer suggests replacing the filter every 15,000 miles and the canister every

continued

continued



Inspect inside the rubber plug wire boot for corrosion.

2 Gasoline ENGINE 3 Tuneup

30,000, another says the filter should last 30,000, and the other says no service is needed. Replacing the filter every other tuneup should be adequate.

Older model cars will have a manifold heat control valve located on the exhaust pipe or crossover near the exhaust manifold. When the engine is cold — and turned off — see if you can move the valve. If you can, give both ends of the valve's shaft a shot of manifold heat control valve solvent. If it's stuck, try tapping it lightly with a plastic mallet to free it up. Once it is free moving, be sure to lubricate it.

Most cars built since 1971 and many older than that have thermostatic air control systems instead of a manifold heat control valve (a few still use both). Vehicles with thermostatically-controlled air cleaners will have a hot air tube or pipe running from the exhaust manifold to the air cleaner intake. Inside the long snorkel air cleaner intake, about where the hot air tube or pipe connects to it, is a vacuum flapper door.

The best way to test this system is with both the engine and outside air cold. Start the engine and keep your

eye on the flapper door: It should close over the snorkel. As the engine warms up to operating temperature, the flapper should open to allow cooler air into the air cleaner. This could take a minute, or 10 to 15 minutes.

If the valve doesn't open by the time the engine has reached 100 to 120 degrees Fahrenheit some repairs are required.

All the emissions system and vacuum hoses should also be inspected

for cracking, loose clamps and leaking. Trace the full length of each hose — removing the air cleaner if necessary — squeezing it to check for cracks and look for swelling, discoloration and leaks.

If there are a lot of miles on the vehicle and one or more of the hoses are suspect, it's a good idea to replace them all. Measure the length and inside diameter of each hose, obtaining and cutting each replacement to size. Replace each hose one at a time to avoid the possibility of confusion.

Spark plug wires are probably among the most neglected tuneup items next to the spark plugs, and air and fuel filters. As a result they can and do cause plenty of problems.

Inspect the wires one at a time to avoid mixing up their order. Begin by disconnecting the wire from the spark plug. A special removal tool can be very helpful for this since it prevents damage to the wire. Without the tool you must grab the wire's rubber boot, twist slightly until it "pops" and then pull the wire free. Be sure that you are pulling on the boot, not the wire.

Inspect inside the boot for a white crusty powder which is a sign of corrosion. Don't mistake the white conductive grease currently being used for corrosion. While it may be possible to clean the corrosion from the boot, it would be better to replace the wire.

Push the boot and wire back onto the spark plug. It should fit tightly. If it doesn't, pull it back off and use a



Inspect each wire for burns, cracks and other damage while wiping it clean.

pair of pliers to carefully crimp the metal connector inside the boot until the fit is snug.

Now use a clean rag and remove all the dirt and grease from the full length of the wire. As you're doing this, check for burns, cracks or other damage. Bend the wire in several places to ensure that the conductive core inside has not hardened. But remember the core is brittle and will not tolerate rough handling.

Disconnect the wire at the distributor (again, pulling and twisting the rubber boot only). Check this end for corrosion and a tight fit also. Now check the remaining spark plug wires in the same way, making sure they are all securely fastened to the spark plug and distributor, as well as clean and in good condition.



Check all vacuum lines for cracks and other signs of leaks. This one will have to be replaced.

A visual check of the wires can also be made in a darkened garage. Make sure the garage is well ventilated before starting the engine and looking at each plug wire. If there is a break or fault in the wire, you will see a small spark or arcing at the bad area.

You can also run a continuity test on each wire with a voltmeter and a 12-volt battery. Connect the wire being tested in series with the voltmeter. If the voltage ranges from 7.8 to 12.4 volts, the wire is good. If the voltage is less than 7.8 volts, replace the wire.

Keep in mind that if one wire is bad, the others will probably fail soon, too. Regardless of how good they seem, you should replace the wires every other tuneup.

The best way to install new wires is to buy a replacement kit designed specially for your car's engine. These kits come with wires pre-cut to the proper length and with the rubber boots already installed. The only trick is to replace one wire at a time so that you keep the proper firing order.

continued



Safety First

Set the parking brake and chock the wheels. Put manual transmission in neutral, automatic in park.

Operate the engine in well-ventilated areas only.

Keep hands, hair, loose clothing and test leads well away from moving engine parts.

Don't touch hot exhaust manifolds, radiators, spark plugs and coil terminals.

Never look into a carburetor while the engine is being cranked or is running.

Don't smoke, use open flame (torch) or allow sparks to occur near the carburetor,

fuel line, fuel filter, fuel pump, spilled gasoline, cleaning solvents, other flammables or a charging battery.

Be very cautious using anything electrical within 18 inches of the floor.

Gasoline is NOT a cleaning solvent.

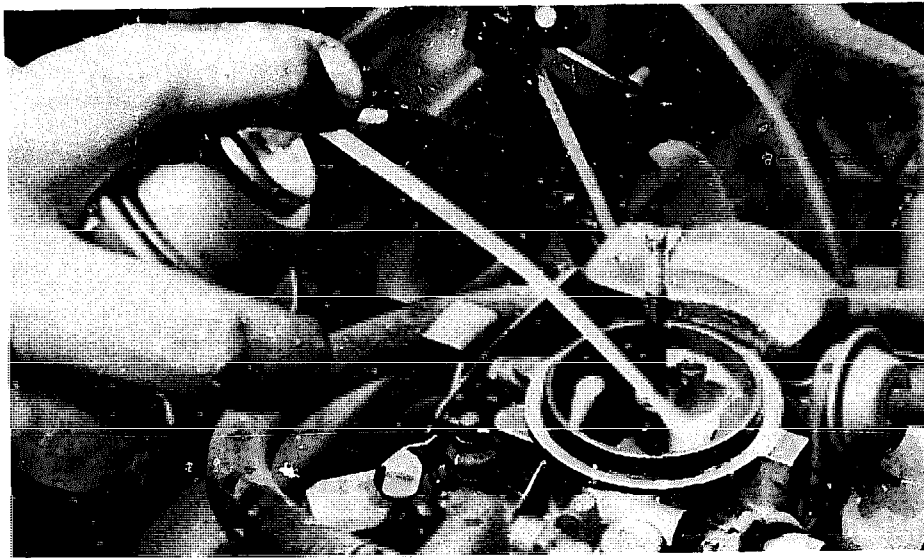
Keep a fire extinguisher rated for gasoline and electrical fires handy.

Use the proper tool of the proper size and fit for every job.

Wear safety goggles when drilling, grinding, or using a chisel.

Uniform of the day — Wearing coveralls to protect your clothing and yourself from dirt and grease is a very good idea. Now, tie up your long hair and remove any rings, watches, bracelets and other jewelry you're wearing. If that ring is so sentimental that you won't (or can't) take it off, cover it with duct tape. You might want to wrap those loose legs with tape to keep them out of harm's way, too.

continued




Clean the inside of the carburetor according to the instructions of the carburetor combustion chamber cleaner can.

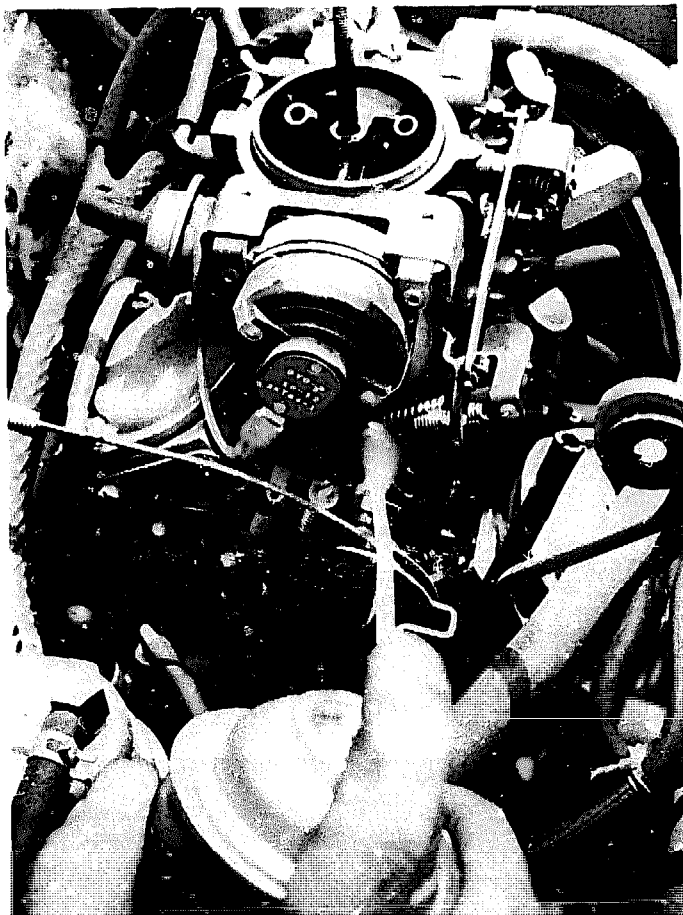
At every tuneup, if not more frequently, a can of carburetor combustion chamber cleaner should be sprayed down the carb's throat according to the can's instructions. The outside of the carburetor — especially the choke plate and linkages — should also be sprayed clean with carburetor cleaner or choke solvent.

Move the throttle linkage back and forth once or twice. If gasoline doesn't shoot into the carburetor, check the fuel system for a malfunction before continuing the tuneup.

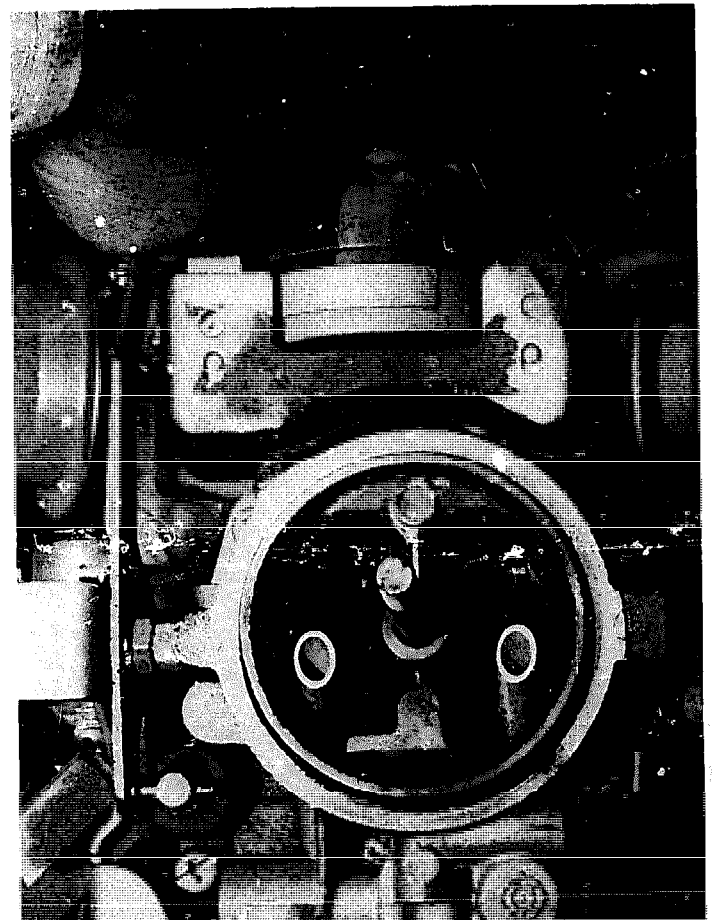
With the engine cold, start it and make sure that the choke closes and then fully opens as the engine warms up. If it doesn't, check its operation following your workshop manual.

After checking other basics such as drive belts, radiator hoses, coolant level, etc., you'll be ready to get into the actual tuneup in next month's **DRIVER**. 

2 Gasoline ENGINE 3 Tuneup

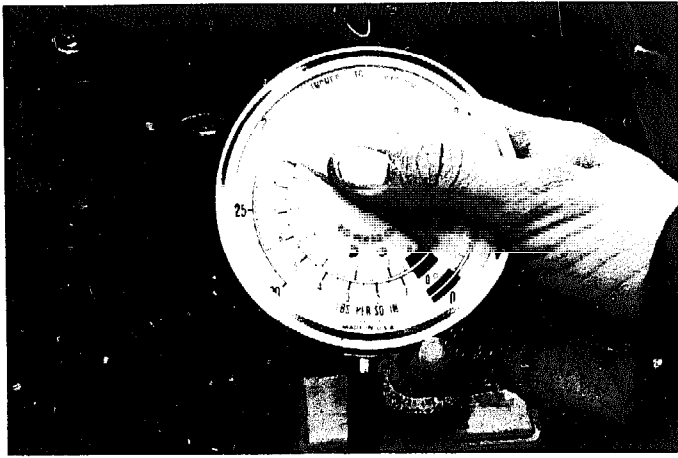


The outside of the carburetor must also be cleaned and the linkage lubricated.



Raw fuel should shoot into the carburetor when the throttle is moved back and forth.

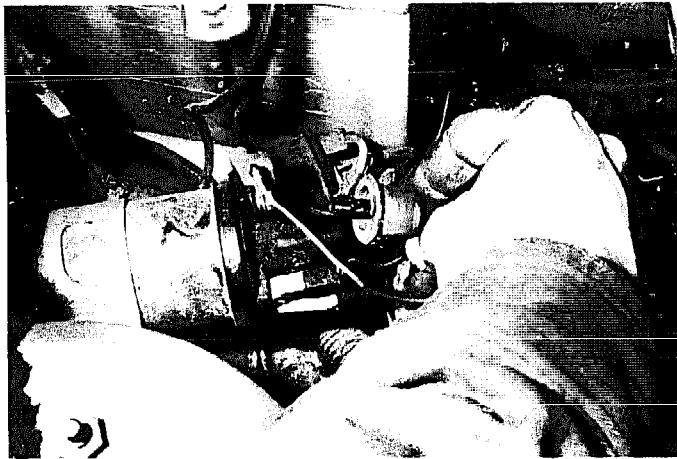
THE BACKYARD MECHANIC



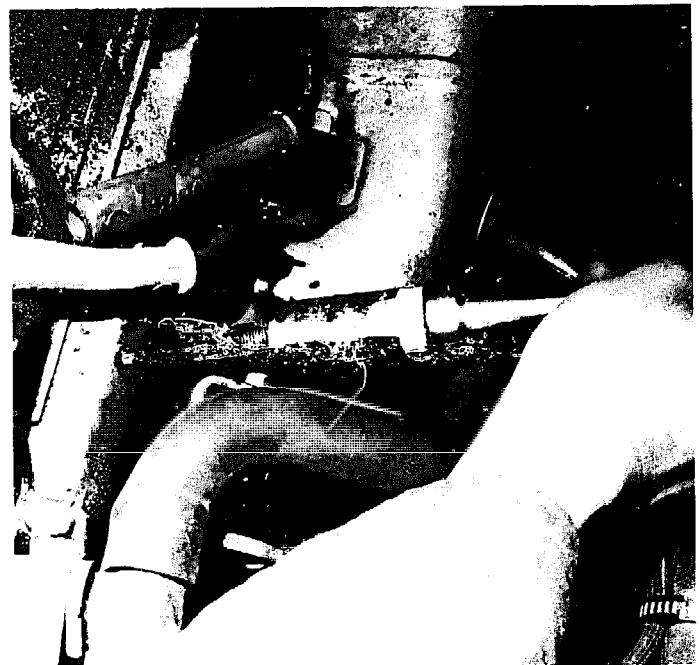
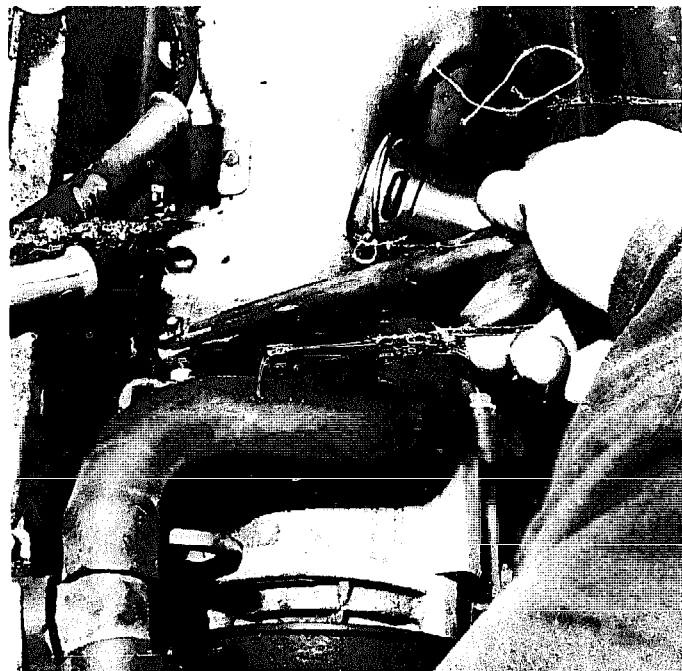
A vacuum gauge gives an instant engine analysis. A healthy engine pulls a steady 17 to 22 inches of vacuum



If you don't have compressed air for blowing dirt out of the spark plug ports, use a straw and your lungs.



Anytime you are going to crank the engine but you don't want it to start, the coil high-tension cable must be removed from the coil or distributor and grounded.



(left and above)
A spark plug wrench makes spark plug removal easier. However, if you don't have one you can put a section of garden hose over the insulator for easier removal once you've loosened the plug.

THE THREE-PART 2 | Gasoline 3 | ENGINE Tuneup

Testing

Your car is going to operate at its best when tuned properly to the manufacturer's specifications. Therefore, the best way to maximize your car's mileage and performance is to give it a thorough tuneup annually or every 15,000 miles if you drive more than that each year.

The average tuneup improves fuel economy 11.7 percent and will pay for itself in 7000 miles — 2500 if you do the work yourself. So instead of waiting for a noticeable drop in your mileage, rough idling, hesitation, dieseling, hard starting, stalling, surging, ping, misfire or lack of power, you should tune your car regularly as a preventive maintenance step.

In the first part (June 1983) of this three-part series the Backyard Mechanic inspected the battery, replaced the air and fuel filters, checked the emissions control systems, cleaned and examined the spark plug wires, and cleaned the carburetor. Also discussed in the first part of the series was the importance of having a good workshop manual for your specific vehicle as well as reading the entire tuneup section before tackling the job.

In this month's installment you are going to check the engine's internal condition before beginning the actual tuneup. After all, tuning a malfunctioning engine is a waste of time and money and will do nothing to improve mileage, performance or emissions. The internal engine checks are done by testing vacuum and compression.

A \$10 vacuum gauge can help you diagnose more than 30 different engine problems from sticking valves to poor rings, including bad carburetor adjustments and a leaky head gasket. Since specific engine problems affect manifold vacuum in certain ways, the gauge can be used to accurately diagnose the condition of an engine by

measuring the amount and condition of vacuum.

To provide this measure and condition report, the vacuum gauge must be hooked up correctly. You can't just pull any vacuum line and attach the instrument. Accurate, reliable readings can be obtained only from primary manifold vacuum sources.

On older vehicles with vacuum-operated windshield wipers, remove the wiper system vacuum hose at the intake manifold and attach the gauge hose. Many vehicles have a threaded plug in the intake manifold that can be removed and a special fitting installed to attach the gauge to. If there isn't a manifold source to attach the gauge hose to, put a T-fitting in the vacuum line to the power brake unit or vacuum assist on disk brake-equipped cars.

For best results, always attach the gauge as close to the vacuum source as possible.

To check the engine's vacuum, warm the engine up to operating temperature. At idle a healthy engine will give a steady, constant reading of 17 to 22 units (inches of Mercury), although some newer four- and six-cylinder models deliver acceptable performance as low as 15 points. Also, a slight flicker of the needle can be expected with high-performance engines. There is a drop of one inch for each 1,000 feet above sea level.

The engine that gives a steady vacuum reading at idle, with the needle dropping toward zero and jumping back past 20 when the throttle is opened and closed quickly, is in good condition. Anything else can spell trouble.

For example, if the reading is fairly steady but two inches lower than normal there can be several problems. One might be that the engine isn't fully warmed up. Another could be that the engine oil is too heavy.

Other problems that cause this lower than normal steady reading include late valve timing, late ignition timing or intake manifold leaks.

If the steady reading is three to four inches lower than normal, open and close the throttle rapidly. If the needle sinks and then soars the piston rings are leaking.

Steady readings that are extremely low can be caused by a cracked or warped intake manifold, or a very bad carburetor to manifold gasket. Such readings can be as much as 15 units low.

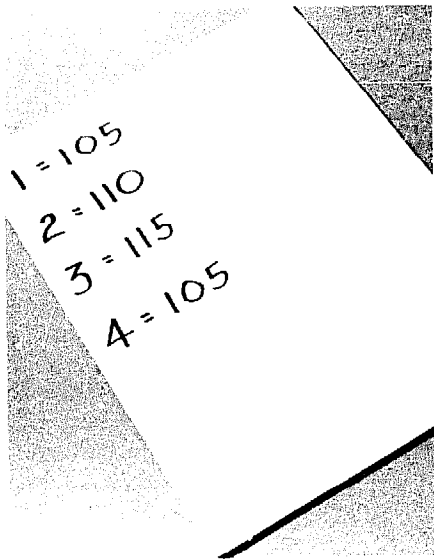
If the needle alternately drops four to five points and then returns to normal you've got a sticking valve(s). Should the point alternately fall more than five units before returning to normal you're facing a burned valve(s).

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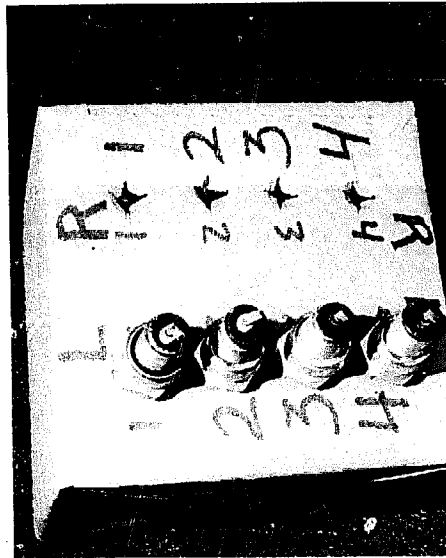


A remote starter switch helps make quick work of doing compression checks.

continued



Record the highest compression reading from each cylinder and then compare them to be sure that they are within the specifications.



A box with holes punched into it makes an excellent spark plug holder. Although this box was made for eight-cylinder engines, it works equally well for four-cylinder models and can be used for sixes both straight and vee-design.



Examine the plugs at the firing end to learn how each cylinder has been performing during the past year or 15,000 miles.

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A needle that fluctuates with a rhythm is telling you that there's a problem with only one cylinder. The problem could be a fouled spark plug, burned valve seat, blown head gasket, cracked distributor cap, distributor cap tracking or any number of things that affect only one cylinder.

A wavering, irregular needle tells you that the problem is affecting more than one cylinder. Again, there are a number of things that can cause this condition. They include: a poorly adjusted carburetor, a high float level, a distributor shaft or bushing, distributor advance control mechanism trouble, excessive spark timing advance or retard, unsynchronized dual ignition points, too wide a spark plug gap, or poorly seating intake valves.

To help you pinpoint what a needle that sweeps or wanders erratically through several inches of vacuum is trying to tell you, up the engine speed to about 2000 rpm.

If the pointer steadies, check the

ignition system, timing and carburetor mixture adjustment at idle — all things you'll be doing in part three of this basic tuneup next month. However, you don't want to overlook the possibility of the problem coming from worn valve guide stems.

Should the sweeps become even larger at 2000 rpm the problem may be weak or broken valve springs. However, if the sweeps are shorter but more rapid, the problem could be either sticky valves or an induction system leak.

A needle that vibrates excessively at all engine speeds is pointing toward a leaking head gasket.

If at a steady 2000 rpm the needle drops slowly toward zero there is an exhaust system restriction.

Should there be no wide sweeps in the amount of vacuum when you suddenly open and close the throttle, you could have an intake leak (gaskets, valve seats, etc.)

Any time you suspect an external leak is causing a problem, squirt

some oil where you think the leak might be. Then check the vacuum reading again. If the oil temporarily seals the leak, the readings will improve.

For the compression test you must first remove all the spark plug wires one at a time. Be careful to label each so that it can be returned to its proper cylinder. One way to label the cables is with numbered tapes. Another labeling method is to mark numbers on clip-type clothespins and attach them to each wire.

If you don't have a spark plug cable remover, grip the boot — and only the boot — by hand being careful not to burn yourself on nearby manifolds. Then twist the boot back and forth until it "pops" signaling that it's lost its grip on the plug. Then pull the boot off the spark plug. Never pull on the cables.

Before removing the spark plugs, clean any dirt particles out of the ports. If you don't have compressed air to do this with, blow the dirt out



A spark plug's gap is correct if there is a slight drag on the proper size wire of the gauge.



To adjust the gap, use the notched adjuster on the gauge body to bend the curved side electrode slightly.

test circuit is usually built into the ignition system and may be damaged if the engine is cranked with the ignition off.

With the compression gauge in the number one cylinder spark plug hole, crank the engine over for at least four compression strokes (this could take as long as 20 seconds). The compression should build up quickly.

After recording the highest reading obtained, repeat the procedure on the remaining cylinders. Now compare the results with the specifications in your workshop manual. The readings should be relatively close and your manual will tell you how much variance is allowed. The variance will either be stated as a percentage or in actual pounds per square inch (psi). The range is usually between 10 and 30 percent.

For example, the manual may say that the compression pressure should be 140 psi with a maximum variation of 20 psi. That means that if the highest reading you get is 140, the lowest shouldn't be less than 120. Likewise, the manual may call for a 150 psi with a 25 percent variance. In this case if the highest reading was 150 psi, the lowest acceptable reading for any of the other cylinders would be 112.5 psi.

If the difference between the lowest and highest readings is greater than that allowed, then you'll have to assume that the valves, rings, pistons and/or cylinders are damaged. Consequently, there's no sense in doing the tuneup until the internal problem has been cleared up.

If the two low-reading cylinders are side-by-side, there's a good chance that the head gasket is blown. A quick check of the cylinders will probably show that they have water and/or oil in them. There may also be water in the crankcase oil and/or oil and air bubbles in the radiator.

Low compression on the first stroke that builds on the following strokes but doesn't reach specifications indicates worn piston rings. However, a low reading on the first stroke that doesn't build up during the following strokes points to valves that are leaking or a blown head gasket.

continued

with a straw. Be sure to wear some kind of eye protection while doing this.

Now you can remove the spark plugs, but be careful to keep them in order. A cardboard box with holes punched into it numbered according to engine position makes an excellent holder for the plugs.

Now remove the coil high-tension cable from the distributor and ground it to the engine block. Also block the throttle and choke wide open.

If you're going to be using a remote starter switch on a General Motors vehicle having a High Energy Ignition (HEI) you've got different disconnections to make. On V-6 and V-8 HEIs, disconnect the primary wire from the "Bat" terminal on the distributor cap. In-line six-cylinder and four-cylinder HEIs require removal of the high tension coil wire from the coil secondary terminal. Then connect a jumper wire between the coil secondary terminal and a good ground on the engine. On those GM

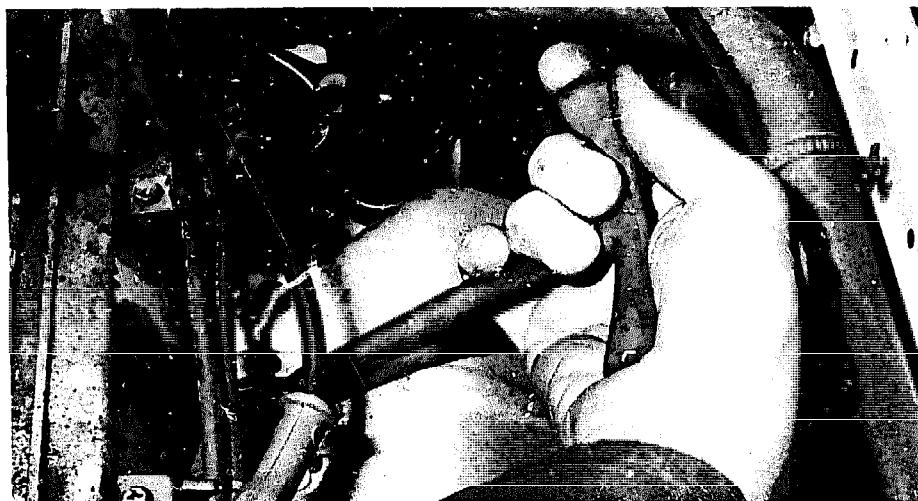
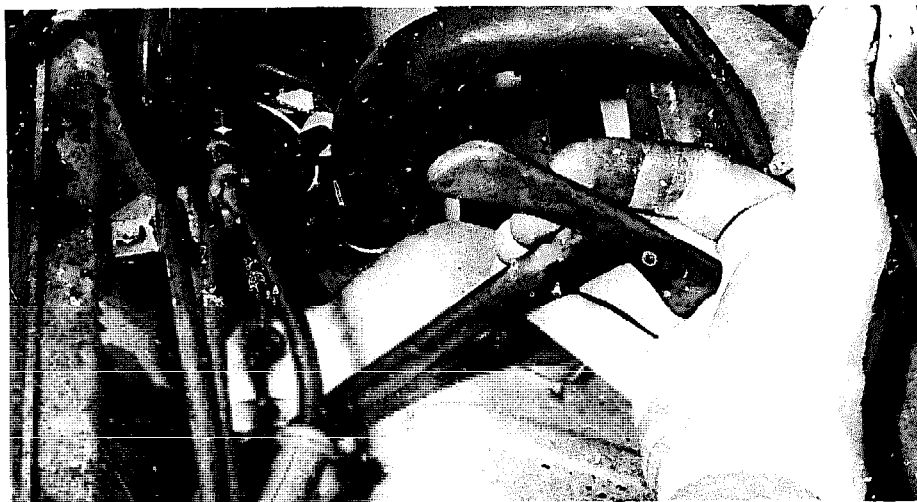
HEIs with an engine electrical diagnostic connector, run a jumper wire from the #6 space on the electronic diagnostic connector to an engine ground.

The remote starter switch is a good idea because it allows you to crank the engine without the assistance of a friend behind the wheel. However, you must be careful to disconnect the correct leads and make doubly sure the transmission is in "park" or "neutral" with the emergency brake set and the wheels chocked.

Normally, the remote starter switch is connected to the solenoid or starter relay with one lead on the battery side and the other on the terminal usually marked "S." However, on GM vehicles with the engine electrical diagnostic connector, the leads must be adapted to terminals #1 and #8.

Also, turn the ignition switch on before using the remote control starter switch. If the vehicle is equipped with a "HOT" indicator, the lamp

continued



Once the spark plug is installed finger tight, a quarter-turn of the wrench will properly tighten it if it has a gasket. If the plug is designed to work without a gasket, 1/16th of a turn will be right.

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To figure out if it's the rings or valves for sure, pour a teaspoon of engine oil into the affected cylinder(s). A squirt can work great for this. Then repeat the compression test. If the compression increases 10 psi or more after the oil is added, the piston rings are definitely worn. If there's no significant increase, the leakage is at the valves or head gasket.

Should the compression pressure

be considerably higher than specified, the combustion chamber is probably coated with carbon (has the car been pinging or dieseling?). The cylinder head(s) should be removed and the carbon deposits scraped off.

If the compression varies greatly between cylinders or is way down, you should take the car to a reputable automotive repair shop for a "leak-down" test to pinpoint exactly where the leakage is and what can be done to repair it.

Now let's check those spark plugs that you carefully kept in order. They'll also tell you a lot about how each cylinder has been performing.

Plugs that have a crumbly chocolate-brown or grey-brown deposit lightly coating the core nose indicate normal engine operation.

However, spark plugs with a dry, black, sooty deposit are being carbon fouled. The engine is running too rich. Check the carburetor mixture settings, float level and choke operation. You should have already taken care of one of the major causes of carbon fouling by replacing the dirty air filter.

If a plug is black, wet and oily, it is either burning too cold or oil is leaking into the combustion chamber and fouling it. Oil fouling is common in older engines with worn piston rings.

On the other hand, if the electrodes appear glazed and the core nose looks to be white with very few deposits, the cylinder is burning too hot. The plug could be too hot, the ignition timing wrong, your fuel octane too low or the fuel mixture too lean.

Pre-ignition and overheating can actually melt the plugs' electrodes. However, if the core has been damaged you should suspect pre-ignition or the wrong gap-setting techniques. Check the ignition timing, cooling system, fuel octane rating and fuel mixture.

While normal burning plugs and those that have been oil or carbon fouled can be cleaned and reused, it is really better to install new spark plugs at tune-up time. It is important that you buy the correct spark plugs for your engine. For this information check the tune-up decal in your engine compartment or your workshop manual.

At the same time it is important to keep in mind what the old plugs told you about the engine's running condition. If the old plugs were oil-fouled you'll have to purchase hotter spark plugs. If they were burning too hot, then you'll have to get colder ones. This is one of those times when the counter personnel at an auto parts store can be helpful.

If you want to reuse old plugs you must first open the gap an additional .010 to .015-inch with a gap tool. (The gap grows about .001-inch every 1000

miles.) Then spray the firing end with a solvent to dilute oily deposits. Now clean the electrodes and insulator with a blast from an air gun. The results should be a dry firing end.

Using a high-pressure abrasive-compound cleaner, rotate the plug to provide a thorough cleaning. After several rotations, examine the firing end and repeat the process until all the contaminants are removed. Now air blast the shell bore with high pressure to remove every trace of abrasive compound. If any of this compound gets inside an engine it will rapidly wear on the rings, pistons and cylinder walls.

Once cleaned, the plug electrodes must be filed and reshaped. Be sure to clean the filings from firing end when done. Also clean the threads with a wire brush, but don't touch the insulator with the wires. A metallic coating on the insulator may cause a short circuit in the plug.

It's also a good idea to wipe the upper insulator and terminal with solvent to remove greasy fingerprints or films which may cause flash-over inside the boot.

Any spark plug, new or used, should be gapped before being reinstalled in the engine. Yes, the factory pregaps new plugs but they should still be double-checked before installation. The gap information is also on the decal inside your engine compartment. If not, it is in your workshop manual.

The gap is checked by inserting the proper thickness wire or a spark plug gauge between the electrodes at the firing end of the plug. If there is a slight drag on the gauge, the gap is correct. If the gap isn't right, use the notched adjuster on the gauge body to bend the curved side electrode slightly until the proper gap is obtained.

Put a small amount of anti-seize compound or molybdenum-type thread lubricant on the first few spark plug threads before installing them finger tight. The plugs should screw easily into the engine. If they don't, change the angle slightly because you are probably cross-threading them.

It is best to use a torque wrench to tighten the spark plugs to the specifications listed in your workshop manual. However, if you don't have a torque wrench you can use a spark plug wrench. If the spark plugs don't have gaskets, only turn them an additional 1/16 of a turn beyond finger

tight. Plugs that do have gaskets are given a quarter turn with the plug wrench.

Here's another reason for installing new plugs at tune-up time: gaskets shouldn't be reused. And it's next to impossible to find new gaskets for spark plugs without buying new plugs.

You'll also want to check the ignition system before doing the fine tuning. The conventional ignition system (one that has breaker points in the distributor as opposed to an electronic ignition system) is relatively easy to check. However, to best judge the performance of an electronic ignition system you should follow the instructions in your vehicle's workshop manual.

There are two ways to check a conventional system. The first, best and safest way is with a voltmeter. The other method is the good, old-fashioned jumping blue spark style.

For the voltmeter test you first remove the coil high-tension cable from the distributor and ground it to the engine block. Then you connect the voltmeter's positive lead to the coil terminal marked BAT or +, and the negative lead to a good ground.

Crank the engine. The voltmeter should register 9.5 volts or more. A reading of less than 9.5 indicates a primary ignition circuit problem.

To do the old-fashioned test without a voltmeter you'll need a screwdriver with an insulated handle. First you disconnect one of the spark plug

wires. Remember, if you don't have a spark plug cable remover, only twist and pull on the boot. Now push the screwdriver head into the connector inside the boot.

Holding the screwdriver by the insulated handle, place the shank about half an inch away from a clean engine ground. A bright blue spark should jump the gap between the screwdriver shank and the ground when the engine is cranked. (See why you're holding onto an insulated screwdriver. That would have been a dandy shock!) A weak yellow or orange spark points to problems in the primary ignition circuit.

The primary ignition circuit includes the battery, ignition switch, ammeter (or warning light), coil primary winding, breaker points, condenser, ballast resistor and low-voltage wiring. If you're doing the blue spark test, a weak spark could also mean you have rotor damage, distributor cap problems or the particular spark plug wire you're using is bad.

Although electronic ignition systems can be checked with the blue-spark method, it is really best to follow the test steps outlined in your vehicle's workshop manual.

OK, now that you know that the engine is sound enough to be tuned, all you have to do is get the fuel and ignition systems working together. That's what the Backyard Mechanic will help you do in the final installment of this series next month. ☺

Safety First

Set the parking brake and chock the wheels. Put manual transmission in neutral, automatic in park.

Operate the engine in a well-ventilated area only.

Keep hands, hair, loose clothing and test leads well away from moving engine parts.

Don't touch hot exhaust manifolds, radiators, spark plugs and coil terminals.

Never look into a carburetor while the engine is being cranked or is running.

Don't smoke, use open flame (torch) or allow sparks to occur near the carburetor, fuel line, fuel filter, fuel pump, spilled gaso-

line, cleaning solvents, other flammables or a charging battery.

Be very cautious using anything electrical within 18 inches of the floor.

Gasoline is NOT a cleaning solvent.

Keep a fire extinguisher rated for gasoline and electrical fires handy.

Use the proper tool of the proper size and fit for every job.

Wear safety goggles when drilling, grinding or using a chisel.

Don't wear rings, watches, bracelets, jewelry, neckties or loose clothing.

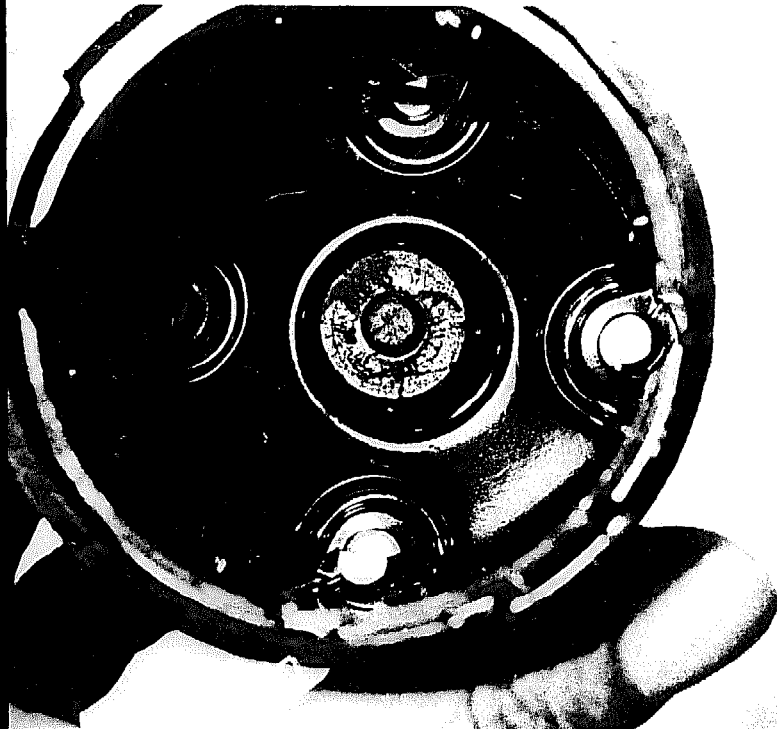
The Backyard Mechanic



The cylinder head bolts must be torqued to the proper specifications in the proper order. Check your workshop manual for this information.



With the locknut loosened, turn the adjusting screw until there is a slight drag on the feeler gauge when adjusting the valves.



The center tower contact in this distributor cap is in poor condition and the cap should be replaced.



This rotor matches the distributor cap with a bad center contact and will have to be replaced.

THE THREE-PART 1 Gasoline 2 ENGINE 3 Tuneup

Fine Tuning

While there are no magic tricks or gadgets that are going to double your car's fuel mileage, it is going to operate at its best when tuned carefully and accurately. The average tuneup improves fuel economy 11.7 percent and will pay for itself in 7000 miles — 2500 miles if you do the work yourself.

Therefore, the best way to maximize your car's mileage and performance is to give it a thorough tuneup annually or every 15,000 miles if you drive more than that each year. So instead of waiting for a noticeable drop in your mileage, rough idling, hesitation, dieseling, hard starting, stalling, surging, pinging, misfire or lack of power, you should tune

your car regularly as a preventive maintenance step.

In the first part (June 1983) of this three-part series the Backyard Mechanic showed you how to inspect the battery, replace the air and fuel filters, check the emissions control systems, clean and examine the spark plug wires, and clean the carburetor. Also discussed in that first part of the series was the importance of having a good workshop manual for your specific vehicle and reading the entire tuneup section before tackling the job.

You were shown how to check the engine's internal fitness by performing vacuum and compression tests in the second part of this series (July 1983). You also learned how to read spark plugs and how to do a basic ignition system check in that middle article.

The final step of the tuneup is to get the fuel and ignition systems working together. So in this month's installment you'll adjust the valves, set the distributor, adjust the carburetor and set the timing.

Now not all cars require a valve adjustment. The hydraulic lifters in big V-8s are basically self-adjusting. However, today's smaller engines need the precise intake and exhaust timing that comes from a "solid" connection between the cam and valves to develop their power and economy. You'll also find this "solid" connection in performance engines of all sizes.

You don't actually adjust the valves; you adjust the clearance in the system. While there are many types of systems, the basic clearances are between the valve stem and rocker arm, and at the other end of the rocker arm, between it and either the lifter or cam.

The clearance specifications are usually on a decal inside the engine compartment. However, this is another area

where a good workshop manual for your specific vehicle is extremely important in getting the job done right. Not only will the manual provide the exact specifications required, but it will also give detailed instructions on how to do the job correctly.

The specifications will be given as either "cold" or "hot." Adjustments for the cold specifications are always made with the engine off. However, hot specifications may have to be done with the engine running.

For the hot specifications you want to warm the engine up to operating temperature and then remove the valve cover(s). On many engines you may have to remove the air cleaner and other engine associated hardware to get to the cover. Be sure to label these items so that they can be properly reinstalled.

With the valve cover removed, torque the cylinder head to specifications. It is very important to follow the sequence for tightening these cylinder head bolts shown in the workshop manual.

Engines with self-locking hex-head screws for valve adjusting can be set while running. However, some engines may squirt oil on you or the outside of the engine when running without valve covers. If this is the case, you'll either have to rig a shield or make the adjustments with the engine off.

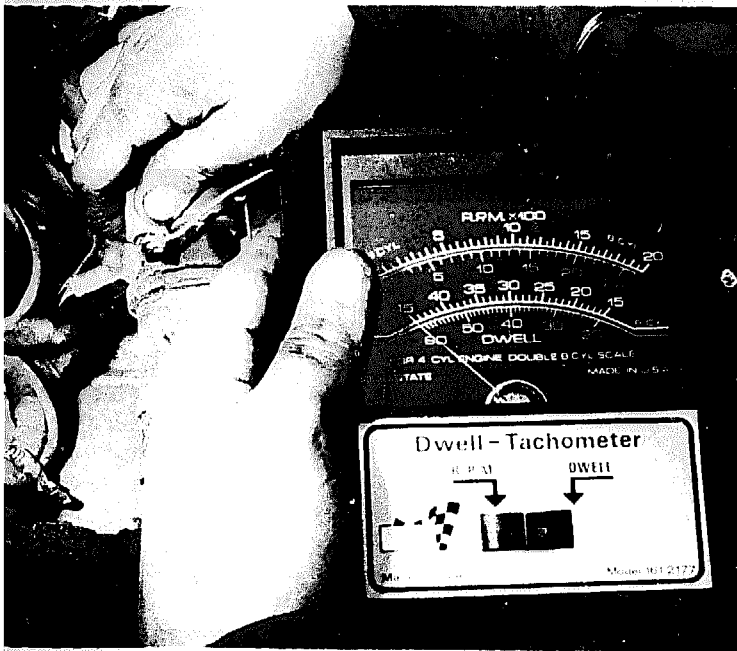
With the engine running at an idle, slip the right size feeler gauge between the rocker and valve stem. If it won't fit, back off the screw until it does. The adjustment is correct when there is a moderate drag on the gauge. The drag is only for the instant that the valve is closed. The rest of the time the gauge will be locked in place.

Since intake and exhaust valve clearances are different, you must know which is which. Check the manual carefully for

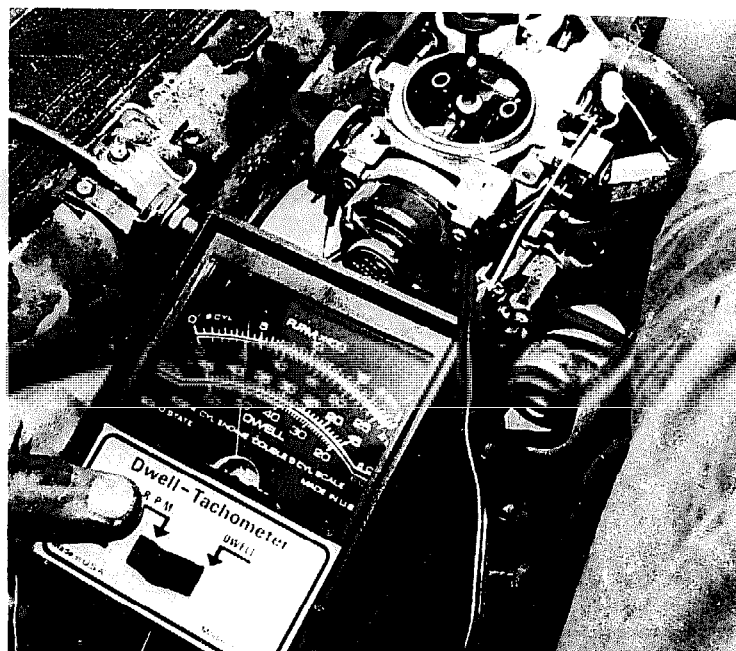


We're holding this set of contact points open so that you can see where the gap (just above the index finger) will have to be adjusted when the set is back inside the distributor.

continued



After you've reassembled a conventional ignition you'll have to check the point dwell angle.



About all you can do with today's carburetors is adjust the idle speed to specifications.

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this information.

Engines with slotted screw and locknut adjustments will have to be set with the engine off.

The idea is to check the clearance with the cam at its lowest point and the valves seated closed. With overhead cam engines this is relatively easy because you can see when the rocker arm is on the cam's bottom (lowest) point. However, when you're working with lifters and therefore can't see the cam you'll want to locate top dead center (TDC) for each cylinder. At that point both intake and exhaust valves will be closed.

To locate TDC, remove the spark plugs. Don't forget to only twist and pull on the boots when removing the cables and to label them so that they can be returned to the proper cylinders. Be sure to clean the ports before actually pulling the plugs.

Now put your thumb over the number one cylinder spark plug port and turn the engine until you feel a push of air. Be sure you're turning the engine in the correct direction (check the manual), usually clockwise. There are several ways to turn the engine. You can try to move it by hand with the fan belt and crankshaft pulley, but be very careful not to get your fingers caught between the two. You can also bump the engine over slowly with the starter via a remote starter switch. Or you can use a suitable wrench on the crankshaft pulley nut for turning (but this may require the help of a friend under the vehicle — which is properly supported on jack stands with the wheels blocked, of course).

After the rush of air, continue to rotate the engine until the timing mark comes to TDC (a couple degrees to one side or the other isn't going to hurt). The number

one piston is now at TDC.

Insert the proper size feeler gauge between the valve stem and rocker arm. If the clearance is right, there will be a slight drag on the gauge blade when you remove it.

If the gap isn't right, loosen the locknut and turn the screw until you get the right gap. Then, holding the screw in place with a screwdriver, tighten the locknut and recheck the clearance.

Should you be working on a straight four-cylinder engine, finding TDC for the next cylinder is easy. After one complete rotation the next cylinder in the firing order (listed in the manual) will be at TDC. Otherwise you have a couple of slightly different courses for locating TDC for the rest of the cylinders.

You can remove the distributor cap and rotate the engine slowly. When the rotor comes to the next terminal location, track



The third timing light lead has to be connected to the number one spark plug cable.

the wire attached to that tower to the cylinder that is TDC. Or you can attach a test light to the breaker point terminal of the coil and ground. When the ignition switch is on the light will be on. Slowly rotate the engine by hand. The light will go out. When it comes back on, stop turning the engine. The next cylinder in the firing order is at TDC.

There are numerous other systems used by various manufacturers to adjust the valves, so it is important that you read your manual before tackling the job. In some cases, the adjustments require the use of shims and should be left to professional mechanics.

After all the valves have been adjusted, it wouldn't be a bad idea to go back and recheck them all. Then with a new gasket in place, reinstall the valve cover. Also replace the spark plugs and refit whatever else you removed.

Let's move on to the distributor. Whether your car has a conventional or electronic ignition system, first remove the distributor cap without disconnecting the spark plug cables. The cap is usually held in place by two spring clips. Wipe the distributor cap clean inside and out. Then look for cracks, burns, carbon tracking, terminal erosion, and damaged towers.

If the cap is bad, replace it. To do this identify one tower in relation to the keyway that locates the cap on the distributor. Then transfer one wire at a time from the old cap to its corresponding tower on the new one.

With good distributor caps all you have to do is clean any corrosion from the metal contact surfaces inside with a wire brush.

Next remove the rotor and wipe it clean. Now check it for cracks, chips,

burns and erosion. If the connection to the center terminal is a spring, check it for tension. If there is a felt wick in the center of the distributor shaft put two drops of SAE 10W engine oil on it.

There are no more tuneup procedures for the distributors on electronic ignition engines. However, if you have a conventional ignition there are breaker points to be serviced.

Loosen the screws and remove the old contact point set and condenser being careful not to drop the screws into the distributor. Just for your own sake, stuff a cloth into all the openings where the screws might fall. Be sure to note the position of all wires and terminals as you disconnect them.

If the points are badly pitted or burned they'll have to be replaced. You get one pass over them with a fine distributor-point file to bring them up to par or out they go. Also, if the rubbing block or pivot are loose, or the spring is weak, toss them out.

When replacing the points, replace the condenser.

Now wipe the cam lobes clean and lubricate with special grease included in the point tuneup kit. Should the cam have a wick, don't add the lubricant. Just turn the wick one-half turn. Replace a dried out wick with a new one.

Hold the condenser firmly in position while tightening the mounting screw. Then attach the condenser wire and primary coil wire to the new point set terminal. Carefully position the wire terminals exactly as they were before and set the nut finger-tight. Make sure any extrusions in the mounting plate fit properly in the point set.

When you're certain that the point set is positioned properly, hold it firmly while tightening the mounting screws. Then tighten the wire terminal nut.

Now connect a dwellmeter according to instructions. On cars other than those General Motors models that have an externally adjustable point dwell, remove the high-tension wire from the ignition coil and ground it. Then crank the engine until you get the rubbing block to rest at the highest point on a distributor cam lobe.

continued



After cleaning the timing marks and pointer, carefully aim the timing light to read the ignition timing.

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Using a feeler gauge, adjust the point opening to the specifications in your workshop manual. Resecure the high-tension wire into the coil tower, and install the rotor and distributor cap. Now crank the engine and check the dwell angle against the manual's specifications.

If the dwell has to be increased, the point gap will have to be decreased. Of course, to decrease the dwell angle, increase the gap.

For those GM models with the external adjustment, install the rotor and cap. Then start the engine and run at an idle. Check the dwell angle. If it needs adjustment, raise the shutter window of the distributor cap and insert the wrench furnished with the tuneup kit into the head of the adjusting screw. Then turn it until you get the desired reading on the dwellmeter. Don't forget to close the window tightly when you're done.

With today's strict pollution standards have come complicated carburetors that

require expensive test equipment such as an infrared exhaust analyzer, combustion analyzer and artificial enrichment with propane in order to adjust the fuel mixture. As a result you must find a shop with such equipment in order to get an accurate adjustment.

With pre-1975 cars, the job is easier. With the engine warmed up, you connect a tachometer and follow the steps outlined in your manual. Some cars have to have the transmission in neutral while others must be in drive. Some have the idle set with the lights or air conditioning on, others with everything off. Generally, however, you'll have to remove the air cleaner in order to get at the adjusting screw.

Check the idle speed on the tachometer. If it isn't right, turn the slow-idle-speed screw or idle-stop solenoid until it is as specified.

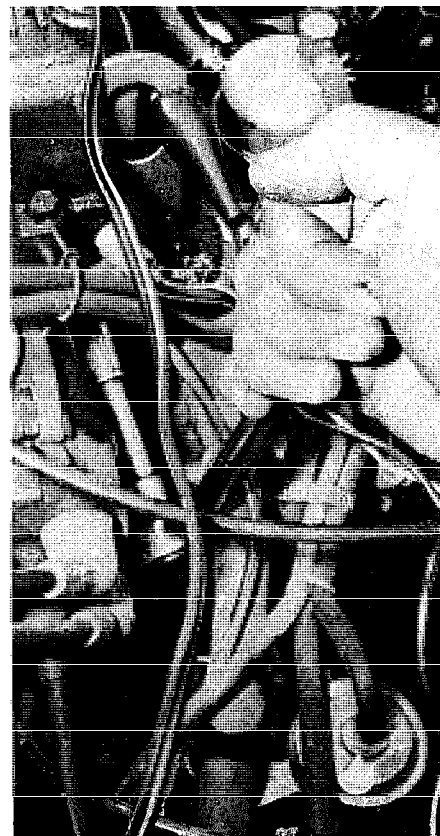
After setting the idle you're ready to make the final and most important adjust-

ment — the ignition timing. After hooking the timing light properly to its power source (either AC or the battery — read the light's instructions), the third light lead is connected with the number one cylinder spark plug wire (again, according to the light's instructions). Check your workshop manual for the location of the number one cylinder — it varies from engine to engine.

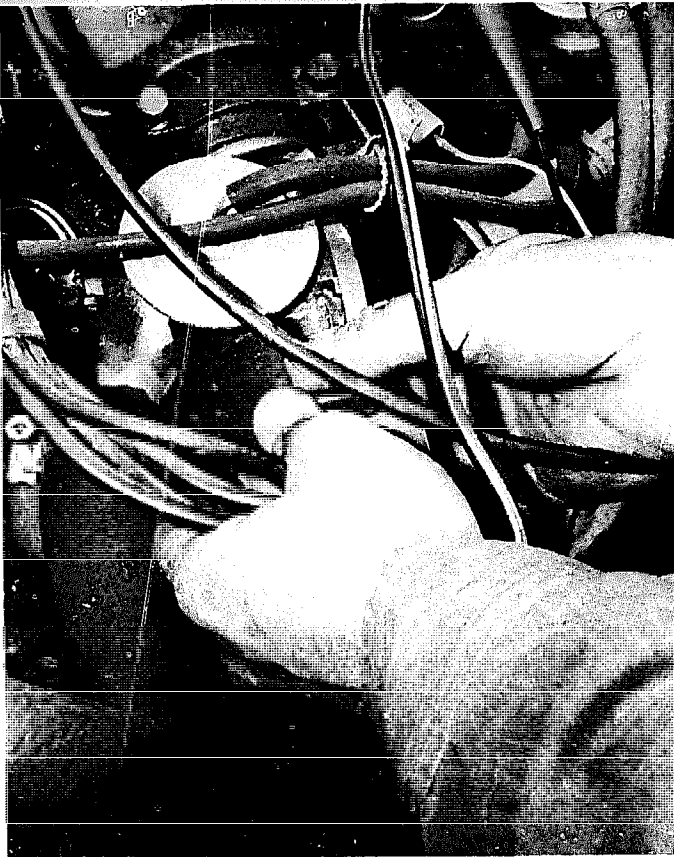
Now locate the timing marks. They also vary greatly from engine to engine. And again, the manual will help you find them.

After locating the timing marks, clean them and then very carefully outline the pointer and the specified timing mark with chalk, paint or nail polish to make them stand out. On most cars the timing is set with the vacuum advance line to the distributor disconnected and plugged. A golf tee or pencil stub make good plugs.

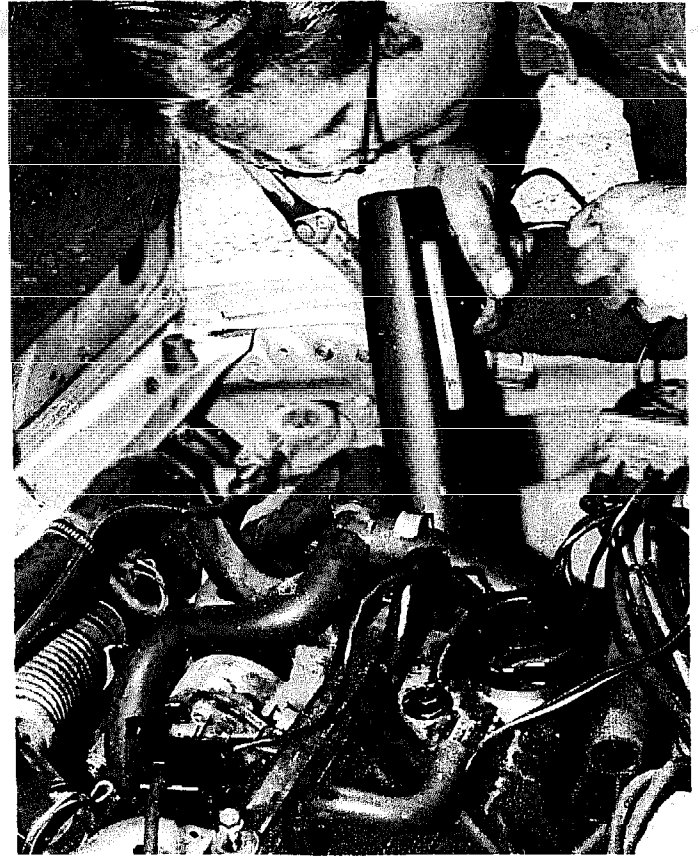
With the engine warm and idling at the



If the timing isn't correct, loosen the distributor hold-down bolts . . .




... and turn the distributor until the specified timing is obtained.



After re-tightening the distributor hold-down, double-check the timing.

correct speed, carefully aim the light at the timing marks. The timing light will flash each time the number one cylinder fires and make the timing marks appear to stand still.

If the specified timing mark doesn't appear to be stationary in relation to the pointer, you'll have to adjust the timing by rotating the distributor. To do this you loosen the distributor hold-down bolts and turn the distributor until the timing marks line up correctly. Be sure to tighten the distributor hold-down and recheck the setting.

OK, go back and quickly doublecheck everything you've done again. Once you're sure that you've done everything right and not left anything unhooked or loose tools lying around, you're finished. You might want to take your handiwork for a test drive. Other than that, you should be set for economical motoring for the next year or 15,000 miles — whichever comes first. 

Safety First

Set the parking brake and chock the wheels. Put manual transmission in neutral, automatic in park.

Operate the engine in well-ventilated areas only.

Keep hands, hair, loose clothing and test leads well away from moving engine parts.

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Never look into a carburetor while the engine is being cranked or is running.

Don't smoke, use open flame (torch) or allow sparks to occur near the carburetor, fuel line, fuel filter, fuel pump, spilled

gasoline, cleaning solvents, other flammables or a charging battery.

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Gasoline is NOT a cleaning solvent.

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