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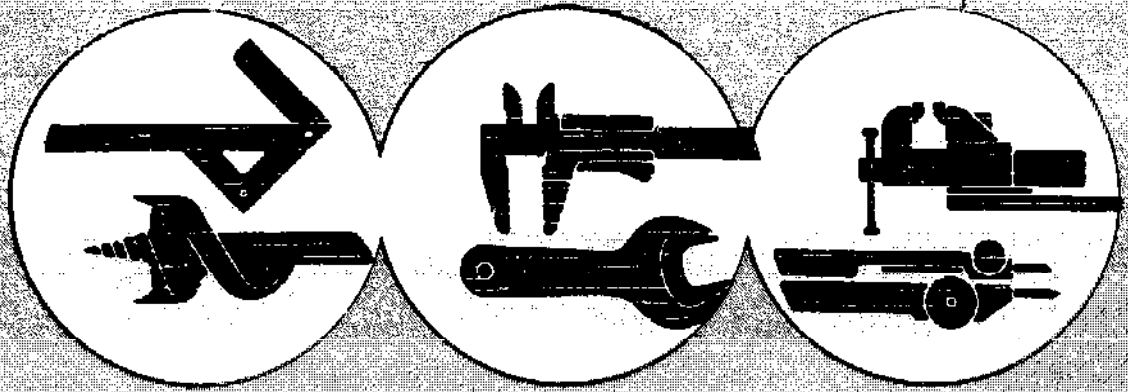
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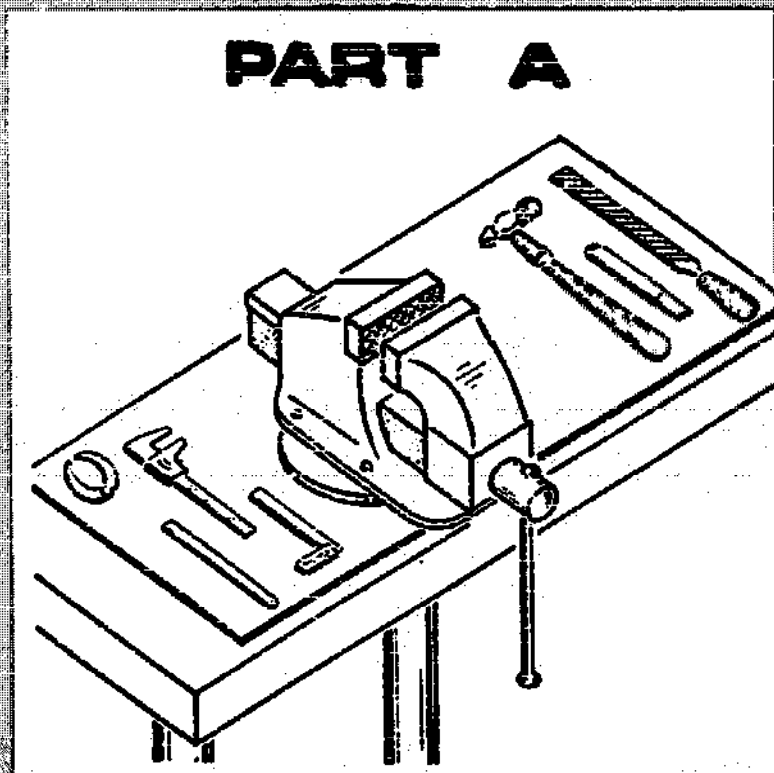
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# TECHNOLOGY METAL 1

## FUNDAMENTAL SKILLS



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# **TECHNOLOGY METAL 1**

## **PART A**

### **FUNDAMENTAL SKILLS**

**EDITOR-IN-CHIEF**  
**ING. H.N.C. STAM.**

**INTEMS b.v.**

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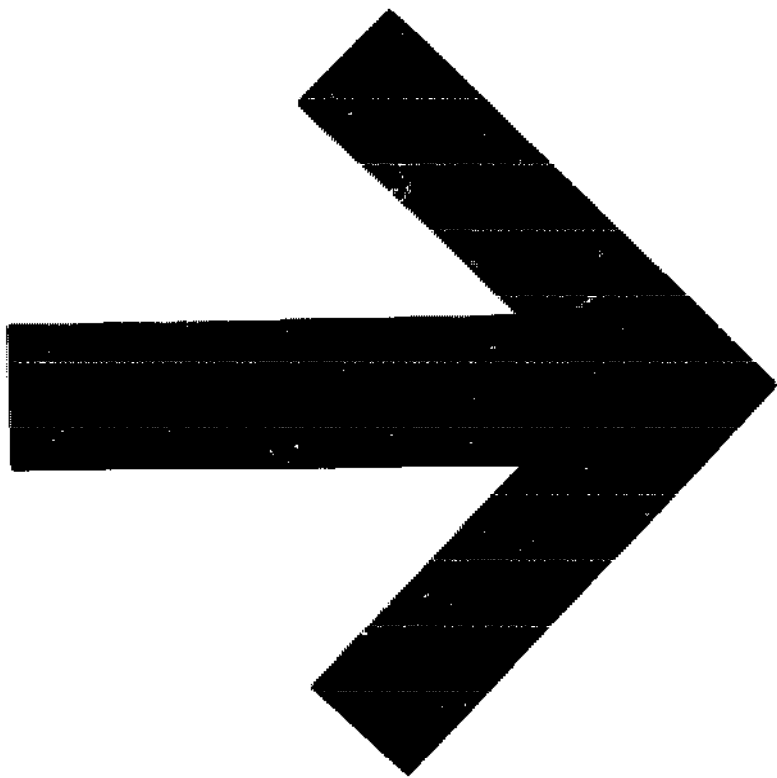
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# TECHNOLOGY METAL 1

## PART A: FUNDAMENTAL SKILLS

<u>Code</u>	<u>Title</u>	<u>Pages</u>
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1012	Marking out 1	16
1013	Holding the work (clamping)	8
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1015	Filing	16
1016	Drilling	16
1017	Sawing	12
1018	Chipping, chiselling and grinding	12
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## SERIES TECHNOLOGY METAL

### TECHNOLOGY METAL I

- Part A: Fundamental skills
- Part B: Workshop processes
- Part C: Mechanisms, transmissions and fittings
- Part D: Introduction to machine-tools
- Part E: The workshop, organisation and maintenance

### TECHNOLOGY METAL II

- Part A: Hand and power tools for fitting
- Part B: Limits and tolerances
- Part C: Sheet-metal work
- Part D: Machine tools
- Part E: Soldering and welding
- Part F: Forging
- Part G: Pipe fitting and installation
- Part H: Ferro materials

### TECHNOLOGY METAL III

- Part A: Turning
- Part B: Milling
- Part C: Shaping
- Part D: Non-ferro materials

### OTHER VOLUMES OF INTEMS PICTORIAL SYSTEM

- Workshop exercises metal
- Operation sheets metal
- Automobile mechanics
- Electricity
- Technology wood
- Workshop exercises wood
- Safety
- Technical drawing, blue-print reading and free-hand sketching
- Workshop mathematics
- Applied science and mathematics
- Teaching outlines

## INTEMS PICTORIAL SYSTEM

## MEASURING 1

## UNIT OF LENGTH

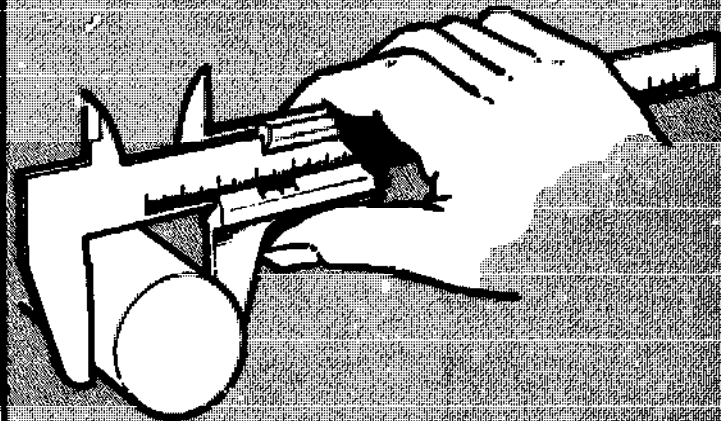
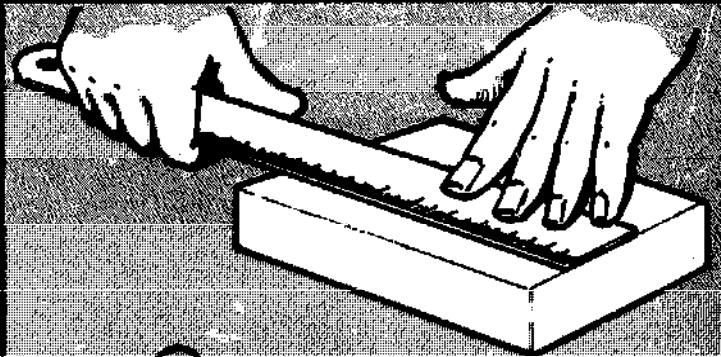
To indicate the dimensions of any work, units of length are used. One such unit is the metre (m).

The metre is divided into 100 equal parts. One hundredth part of a metre is called a centimetre (cm). So a hundred centimetres make one metre.

Again a centimetre is divided into ten equal parts called millimetres (mm). 10 millimetres make 1 centimetre, 100 centimetres make 1 metre.

A rule is usually 30 cm long, with divisions in centimetres and millimetres. Sometimes the first part has divisions of half millimetres.

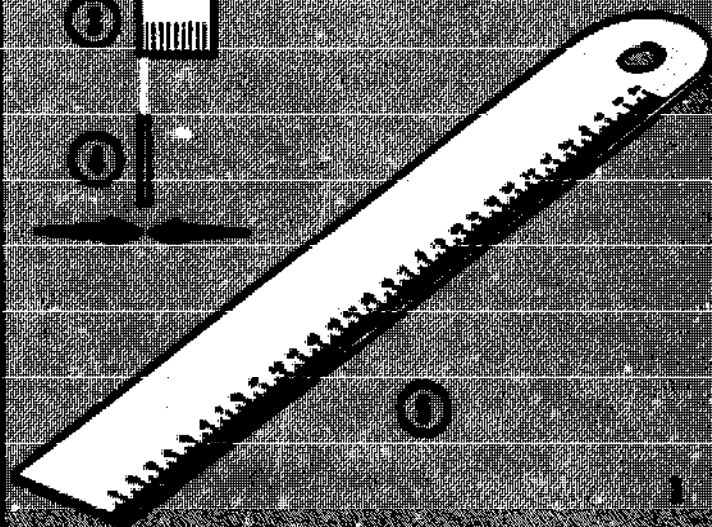
1  
Measuring



2  
One centimetre  
3  
Ten millimetres  
4  
One millimetre



5  
Measuring rule





## TRY SQUARE

- 1 Try square
- 2 Blade
- 3 Stock

The try square is used for testing the squareness of two surfaces. "Square" means at right angles.

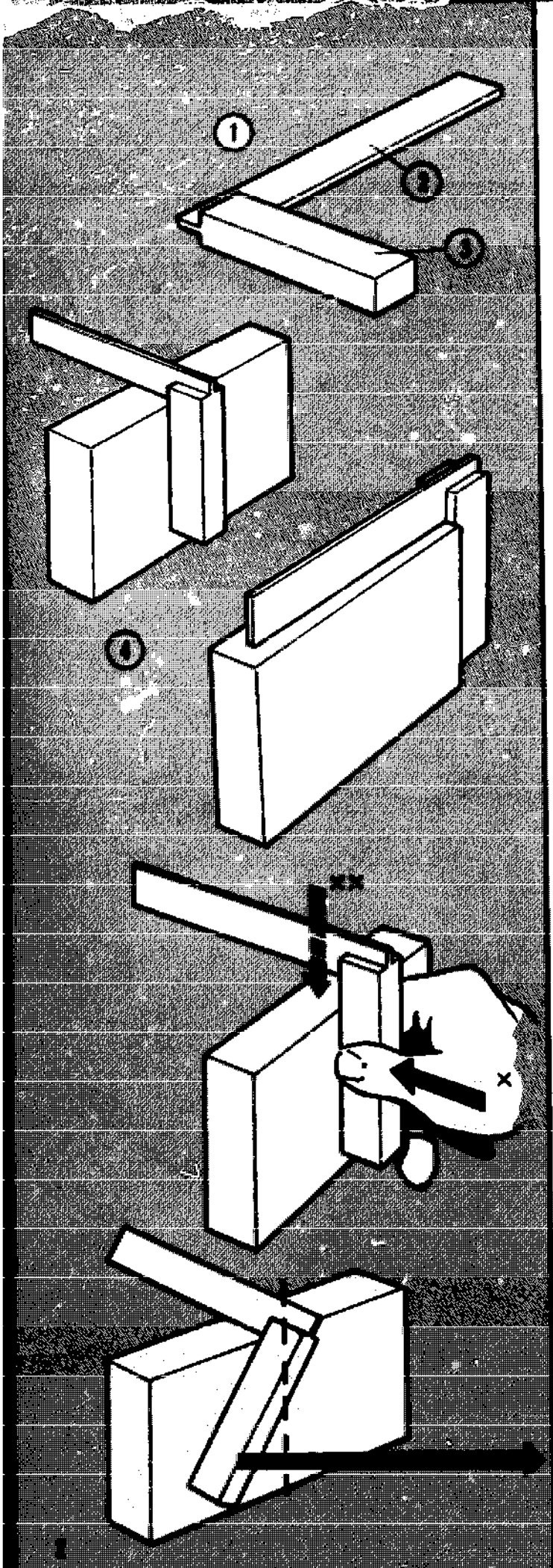
- 4 Testing a workpiece

- X first press  
XX then lower

For testing, first press the stock to the work, then lower the try square until its blade makes contact.

Always keep the try square at right angles to the surface to be tested.

WRONG



## BEVEL

A bevel is used to test whether the angles between two surfaces are the same everywhere.

There are bevels with an adjustable blade which can be used for all angles.

Another type of bevel is the fixed one, which can be used for one angle only.

The bevel shown in fig. 2 is used for angles of 135 and 45 degrees.

The bevel of fig. 3 is meant for angles of 120 and 60 degrees.

An angle is measured by degrees.

The angles shown here are:

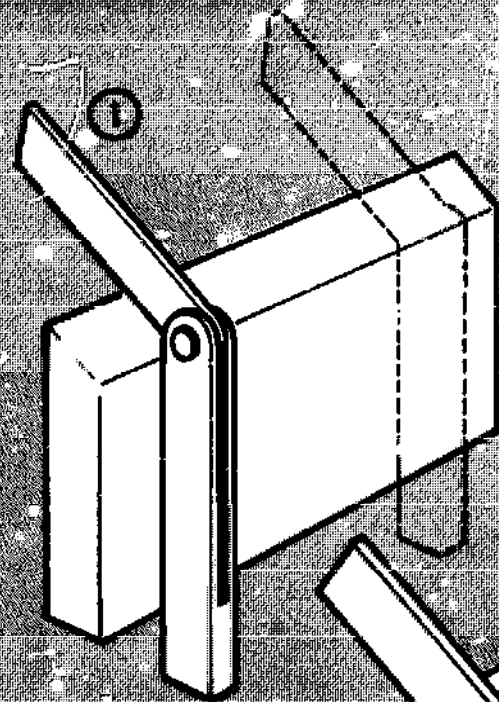
30 degrees ( $30^{\circ}$ )

60 degrees ( $60^{\circ}$ )

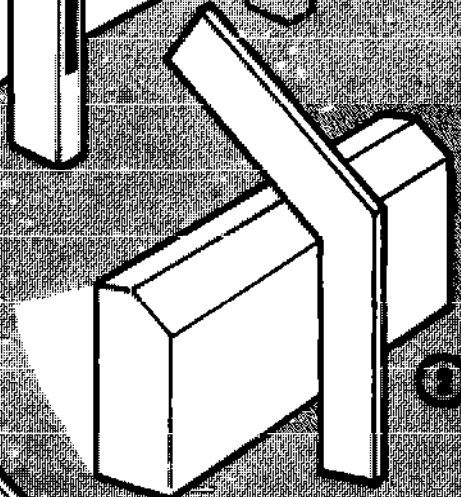
135 degrees ( $135^{\circ}$ )

A right angle is  $90^{\circ}$ .

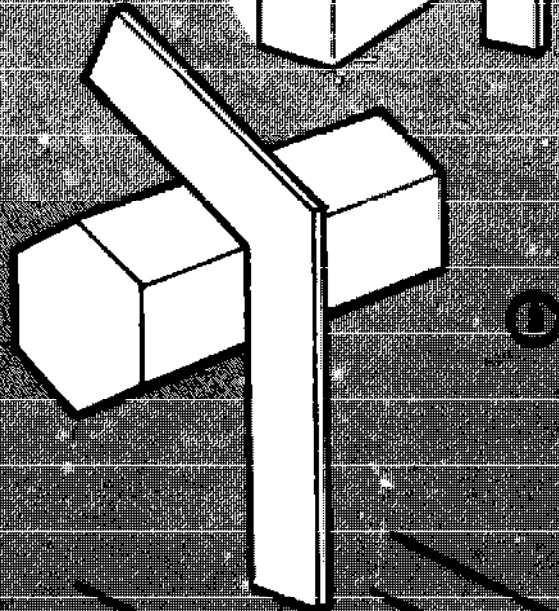
1  
Adjustable  
bevel



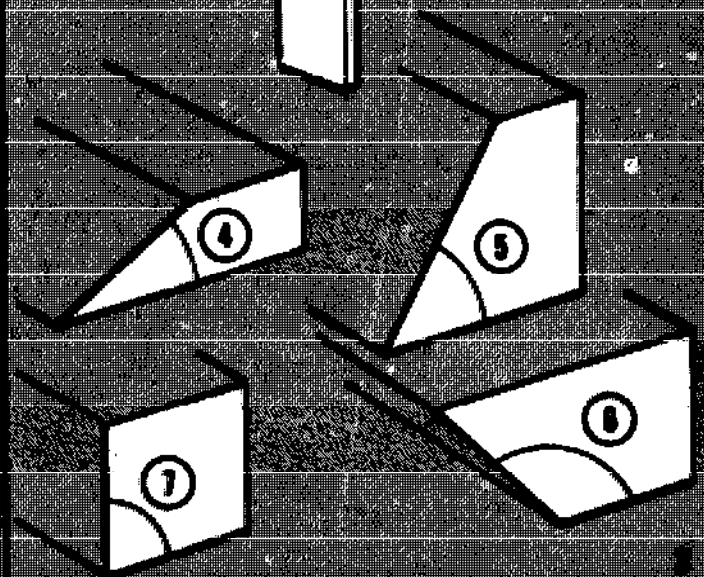
2  
Bevel with  
fixed angle



3  
Fixed bevel

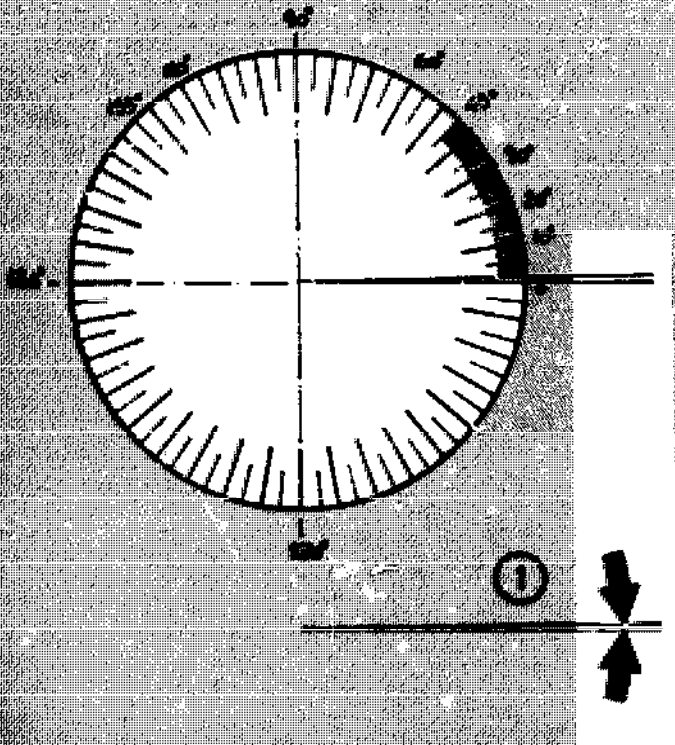


4  $30^{\circ}$   
5  $60^{\circ}$   
6  $135^{\circ}$   
7  $90^{\circ}$

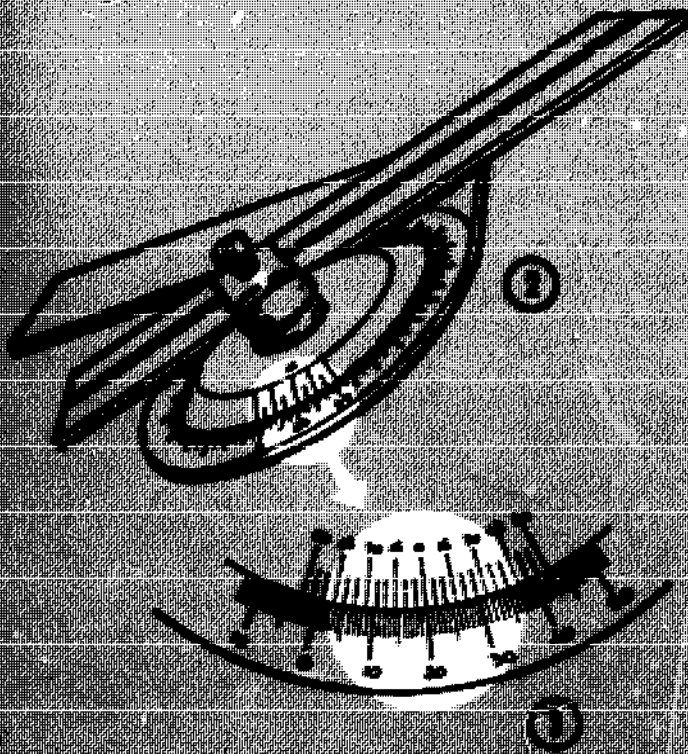


## BEVEL PROTRACTORS

A circle can be divided into 360 equal angles. Each angle is called one degree. So a circle is 360 degrees ( $360^{\circ}$ ).

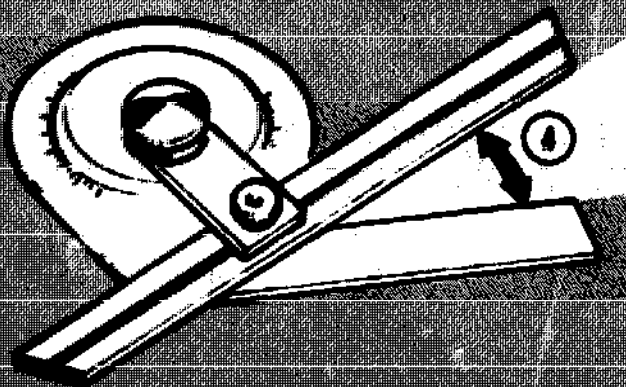


1  
One degree  
( $1^{\circ}$ )



2  
Bevel  
protractor

A bevel protractor is an instrument for measuring angles. If the zero-line on one of the scales is set opposite a number on the other scale this indicates the number of degrees of the angle between the blades.



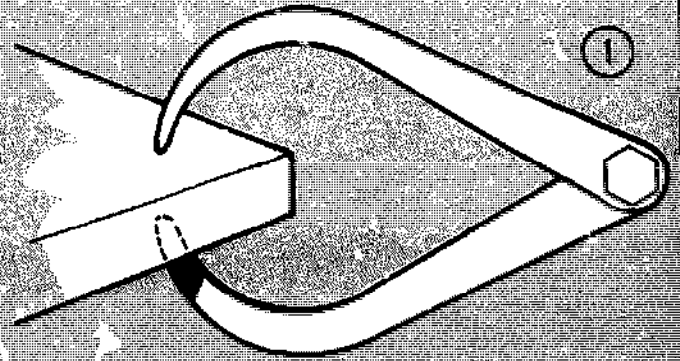
3  
Bevel  
protractor  
set to  $20^{\circ}$

4  
Angle  
between  
the two  
blades

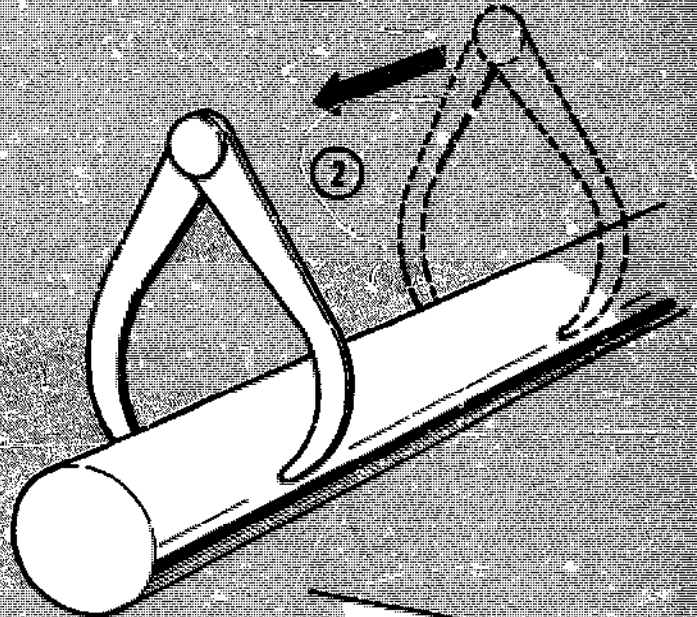
## CALLIPERS

Outside callipers are used for checking whether the thickness of a workpiece is the same everywhere.

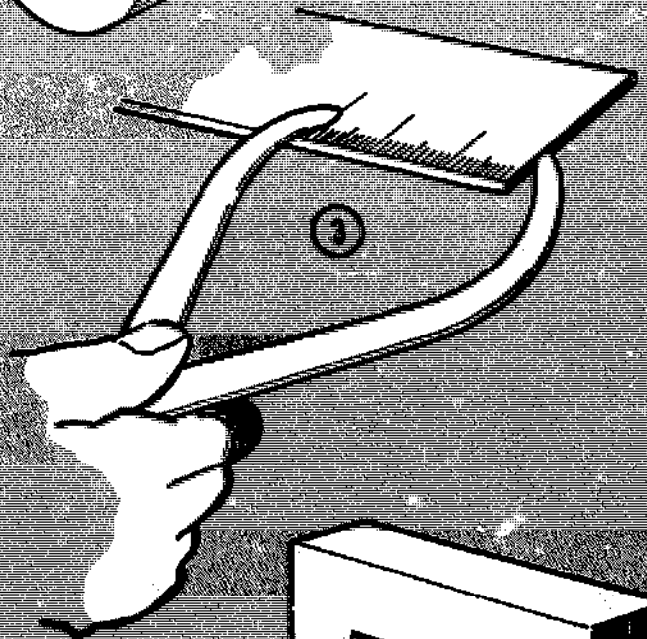
1  
Outside  
callipers



2  
Checking the  
diameter  
of a rod



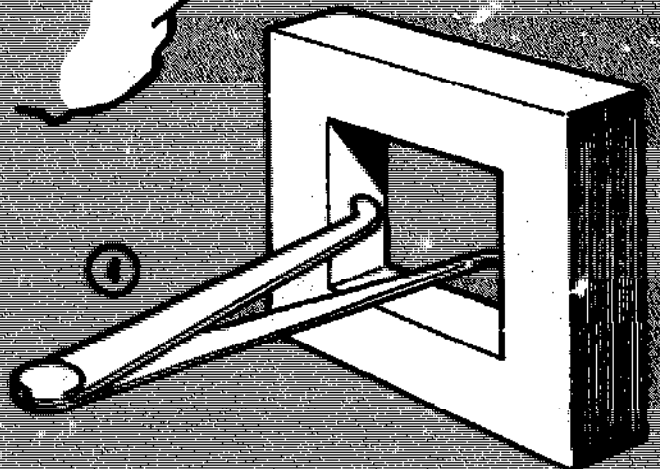
3  
Setting to  
required  
measurement



Outside callipers are also used for setting off and checking dimensions.

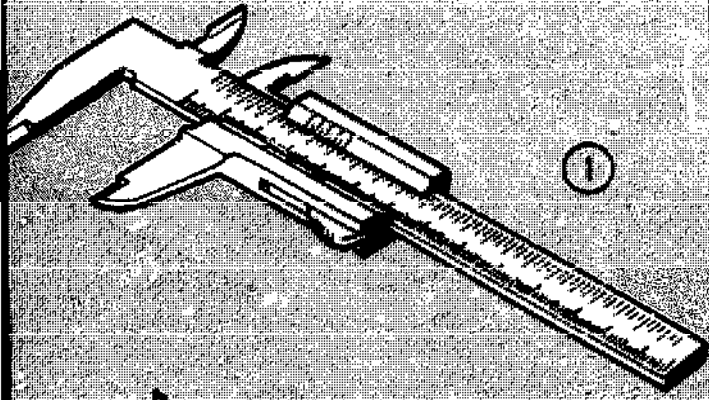
The calliper legs should move smoothly but not too easily. Callipers are held between thumb and forefinger.

4  
Inside  
callipers



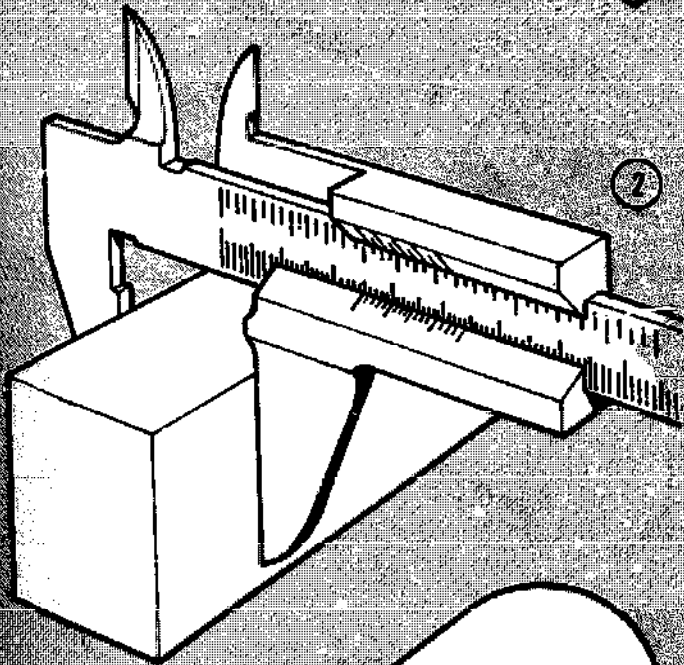
For inside dimensions, inside callipers are used.

## VERNIER CALLIPERS



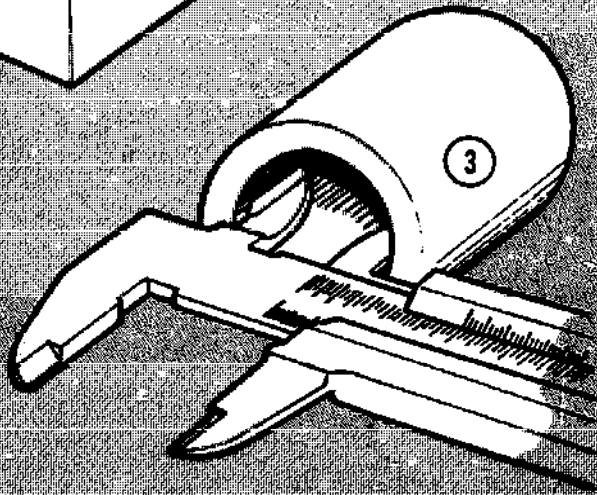
1  
Vernier  
callipers

Vernier callipers are used for more accurate measuring than can be achieved with a measuring rule.

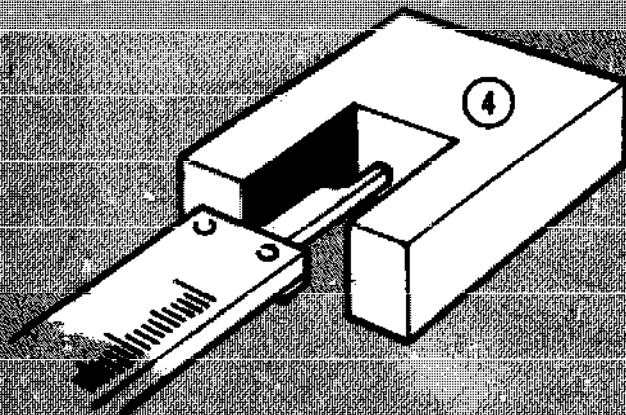


2  
Measuring  
outside  
dimensions

Inside and outside dimensions as well as depths can be measured with vernier callipers.



3  
Measuring  
inside  
dimensions



4  
Measuring  
depths

Ensure that the recess in the depth gauge is in the corner.

Rules and vernier callipers may be graduated either in millimetres or in inches, or they may carry both graduations. One inch (1 in or 1") equals 25.4 mm.

The movable part of the vernier callipers is called the sliding head.

On the sliding head there is also a division called the vernier scale. With both metric and inch scales the degree of accuracy at which the reading can be taken, varies. The most common graduations are given below.

Measuring to within 0.1 mm.

Measuring to within 1/128 in.

Measuring to within 0.05 mm.

Measuring to within 0.001 in.

In this position the two outer lines of the vernier scale coincide with the zero line and another one of the fixed scale. In this case the ninth line.

1 Millimetres

2 Inches

3 Sliding head

4 Vernier scale

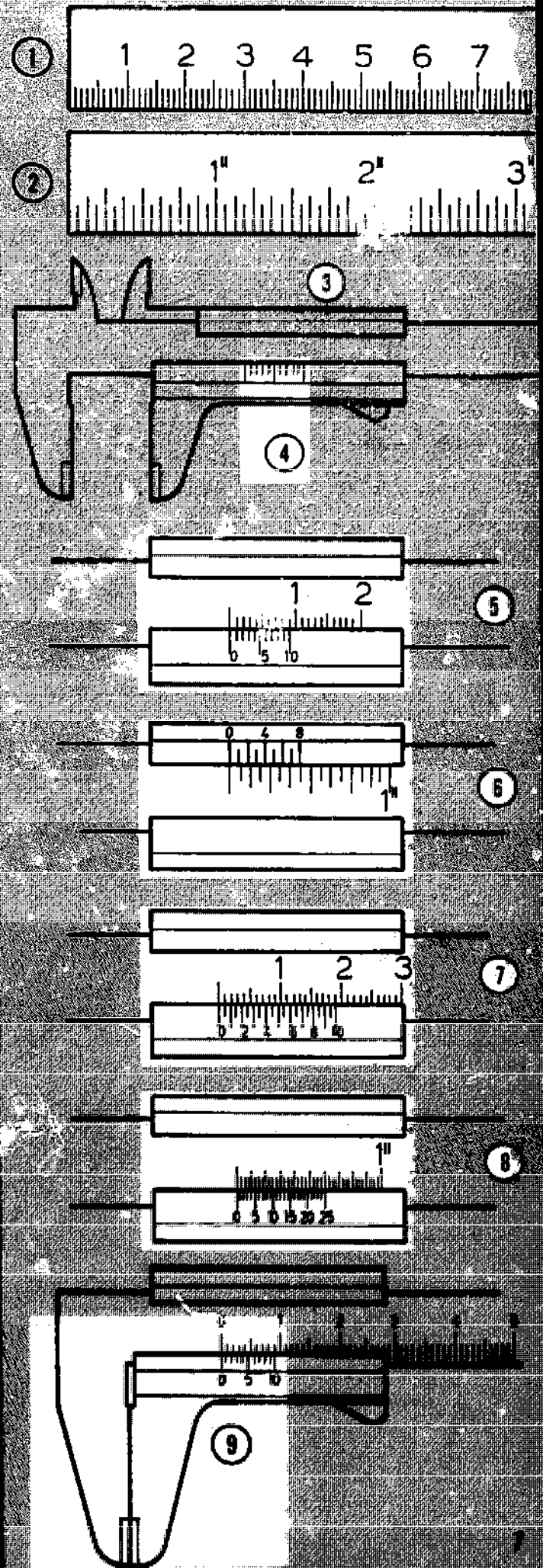
5 Accurate within 0.1 mm

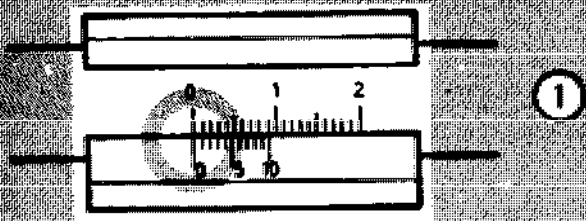
6 Accurate within 1/128 in

7 Accurate within 0.05 mm

8 Accurate within 0.001 in

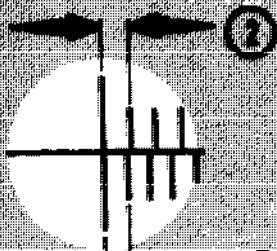
9 Closed position





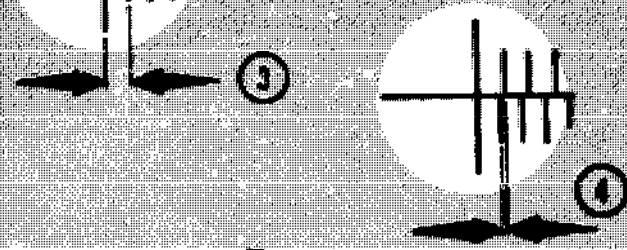
1  
Accurate  
within  
0.1 mm

Measuring with vernier  
callipers to within 0.1 mm.



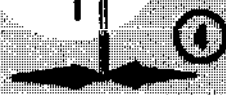
2  
On bar scale  
1 mm

The bar of the vernier  
callipers is marked off in  
millimetres.



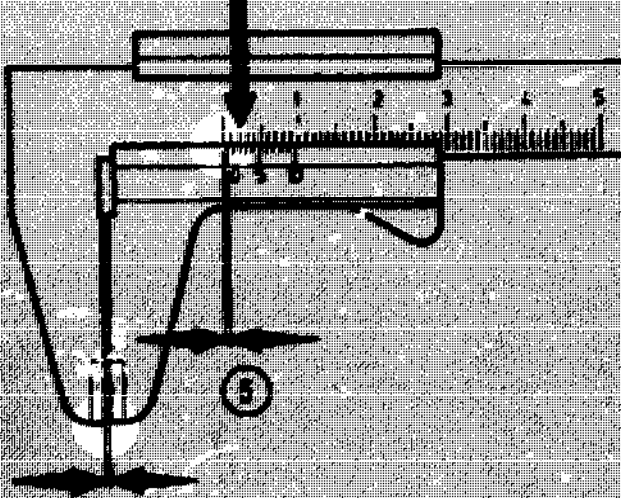
3  
On vernier  
scale  
0.9 mm

The vernier scale is divided  
into ten equal parts.  
Each division is equal to  
 $9/10$  mm.



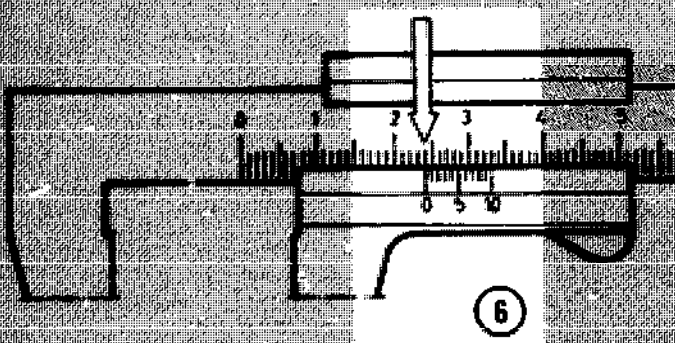
4  
Difference  
0.1 mm

Consequently the difference  
between one division on the  
bar scale and one division  
on the vernier scale is  
 $1/10$  mm.



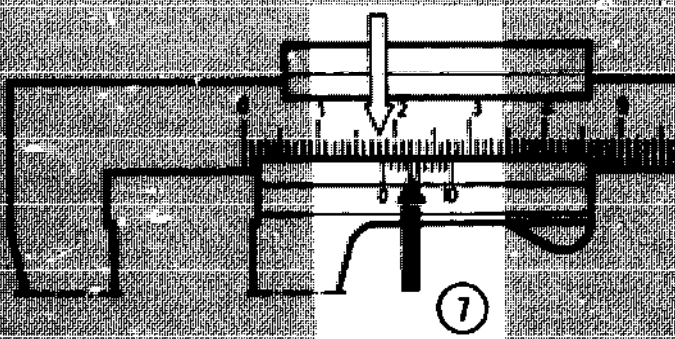
5  
Space  
between  
jaws  
0.2 mm

When the 2 on the vernier  
scale is opposite the 2 mm  
mark on the bar scale - as  
shown here - the space  
between the jaws is  $2/10$  mm.



6  
Space  
between  
jaws  
24 mm

In this figure the zero on  
the vernier scale is oppo-  
site the 24 mm mark on the  
bar scale (see white arrow).  
So the space between the  
jaws is 24 mm.



7  
Space  
between  
jaws  
18.4 mm

Here the zero on the vernier  
scale is past the 18 mm mark  
on the bar scale (white  
arrow) while the 4 on the  
vernier scale coincides with  
a line on the bar (black  
arrow). The reading is  
18.4 mm, so the distance  
between the jaws is also  
18.4 mm.

Measuring with vernier callipers to within  $1/128$  in.

The vernier scale has a total length of  $7/16$  in, and is divided into 8 parts. Each division is then  $7/128$  in.

The bar scale is marked off in  $1/16$  in.  
 $1/16$  in is equal to  $8/128$  in.

Difference between one division on the bar scale and one division on the vernier scale is  $1/128$  in.

When 1 on the vernier scale coincides with first line next to the zero line on the bar scale, the space between the jaws is  $1/128$  in.

Here the zero of the vernier scale coincides with the 13th line on the bar scale. So the reading is  $13/16$  in.

In fig. 7 the vernier zero is past 1 in and again past  $3/16$  in (white arrow). Furthermore the fourth line of the vernier scale coincides with a line on the bar scale (black arrow). This means  $4/128$  in or  $1/32$  in. So the reading taken is  $1$  in +  $3/16$  in +  $1/32$  in =  $1 \frac{7}{32}$  in. This equals 30.95 mm (see table on page 16).

1  
 Accurate within  $1/128$  in

2  
 On vernier scale  $7/128$  in

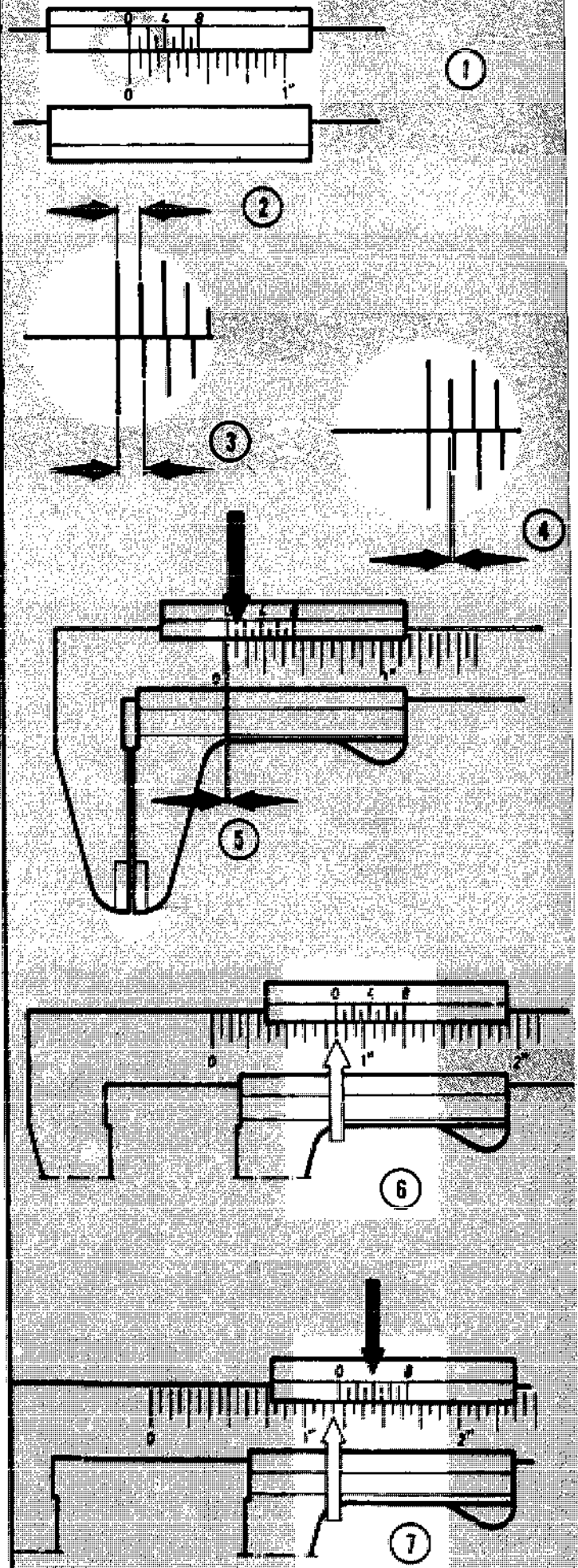
3  
 On bar scale  $8/128$  in

4  
 Difference  $1/128$  in

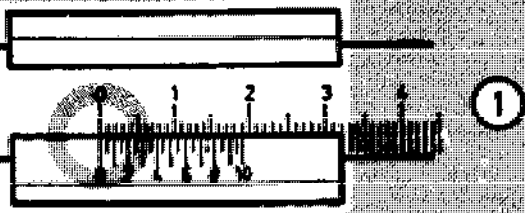
5  
 Space between jaws  $1/128$  in

6  
 Space between jaws  $13/16$  in

7  
 Space between jaws  $1 \frac{7}{32}$  in

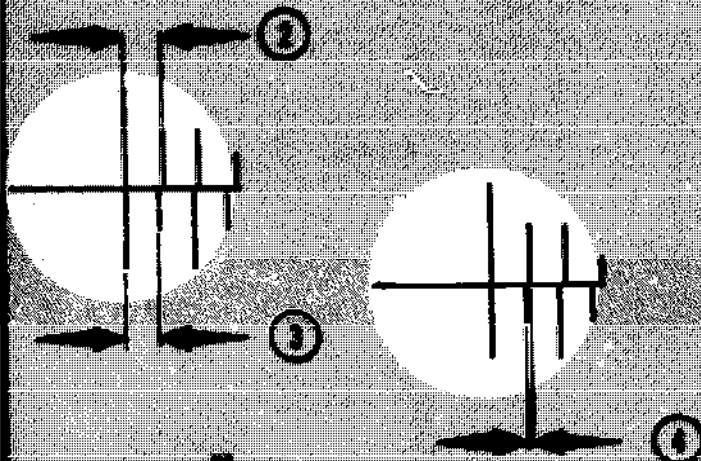






1  
Accurate  
within  
0.05 mm

Measuring with vernier  
callipers to within 0.05 mm.



2  
On bar scale  
1 mm

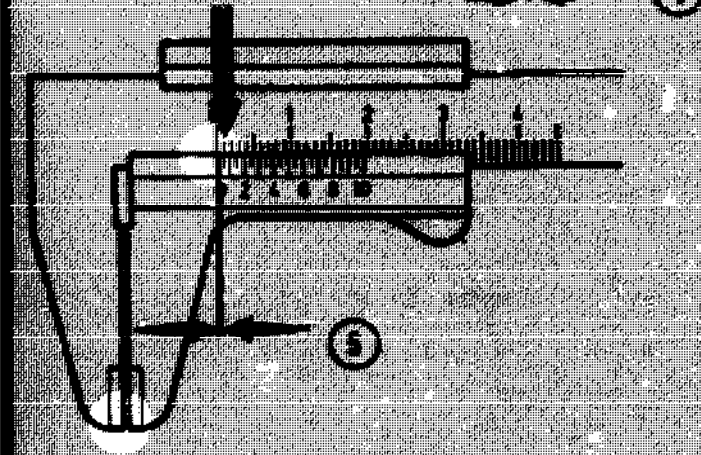
Each division on the bar  
scale is 1 mm.

3  
On vernier  
scale  
0.95 mm

The vernier scale is 19 mm  
long and divided into 20  
equal parts. Each division  
is  $19/20$  mm, which is equal  
to 0.95 mm.

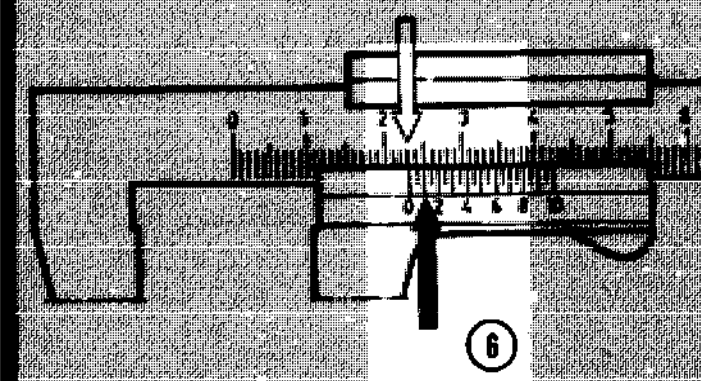
4  
Difference  
0.05 mm

The difference between one  
division on the bar scale  
and one division on the  
vernier scale is  $1/20$  mm or  
0.05 mm.



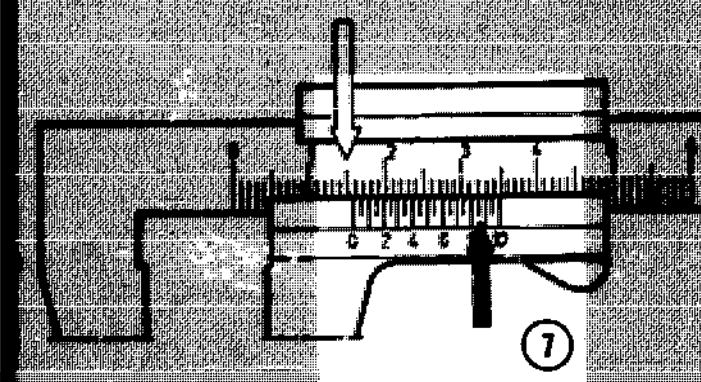
5  
Space  
between  
jaws  
0.05 mm

When the first line on the  
vernier scale coincides  
with the 1 mm mark on the  
bar, the space between the  
jaws is 0.05 mm.



6  
Space  
between  
jaws  
23.10 mm

Here the zero of the vernier  
scale is past 23 mm (white  
arrow) and the second line  
(black arrow) coincides  
with a line on the bar.  
This means  $2 \times 0.05$  mm =  
0.1 mm, so the reading is  
23.1 mm. The numbers at the  
lines indicate tenths of one  
millimetre.



7  
Space  
between  
jaws  
15.85 mm

Here the zero of the vernier  
scale is past 15 mm (white  
arrow). The black arrow  
shows that the distance  
past 15 mm is 0.85 mm.  
So the reading is 15.85 mm.

Measuring with vernier callipers to within 0.001 in.

Each inch on the bar scale is divided into ten equal parts. Each part of 1/10 in is subdivided into four small parts. In all, therefore, there are  $10 \times 4 = 40$  divisions each equalling 0.025 in.

The vernier scale has a length equal to 24 bar scale divisions but it is divided into 25 equal parts so that each vernier division equals  $24/25 \times 0.025$  in = 0.024 in.

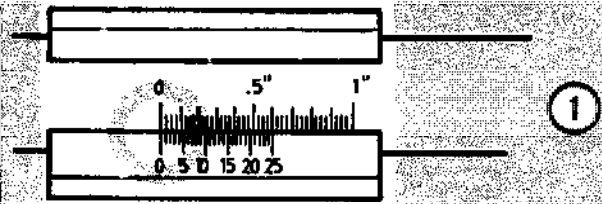
The difference is:  
 $0.025 - 0.024 = 0.001$  in.

When the 1 on the vernier scale coincides with the 1 mark on the bar the space between jaws is 0.001 in.

In fig. 6 the vernier zero coincides with the first line past 0.700 in, so the reading is  $0.700 + 0.025 = 0.725$  in.

In fig. 7 the vernier zero is past the first line after 1.4 in. So  $1.4$  in +  $0.025$  in =  $1.425$  in (see white arrow), and the 16th line of the vernier scale coincides with a line on the bar (black arrow). Hence 0.016 in should be added to the first value read, and the result is  $1.425 + 0.016 = 1.441$  in.

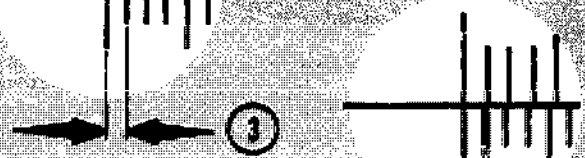
1  
 Accurate within 0.001 in



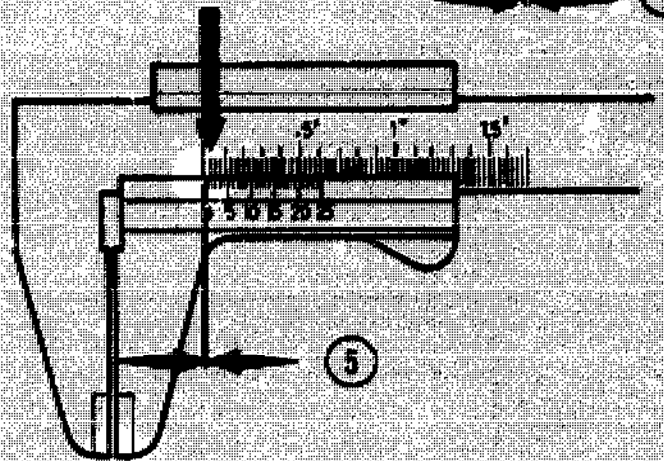
2  
 On bar scale 0.025 in



3  
 On vernier scale 0.024 in

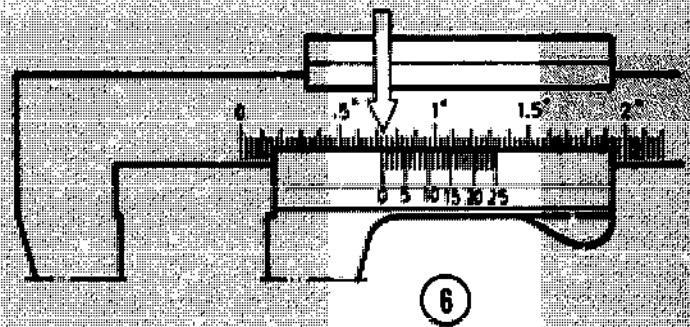


4  
 Difference 0.001 in

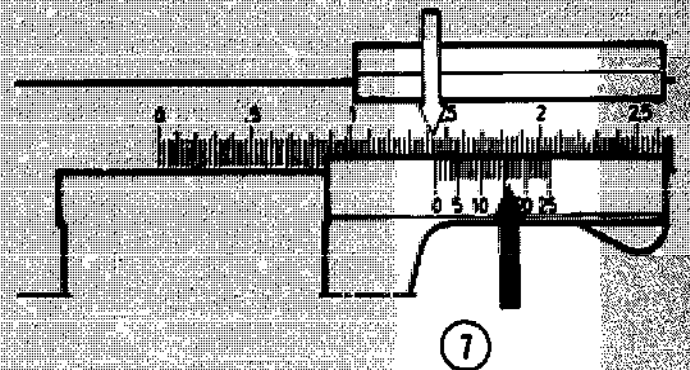


5  
 Space between jaws 0.001 in

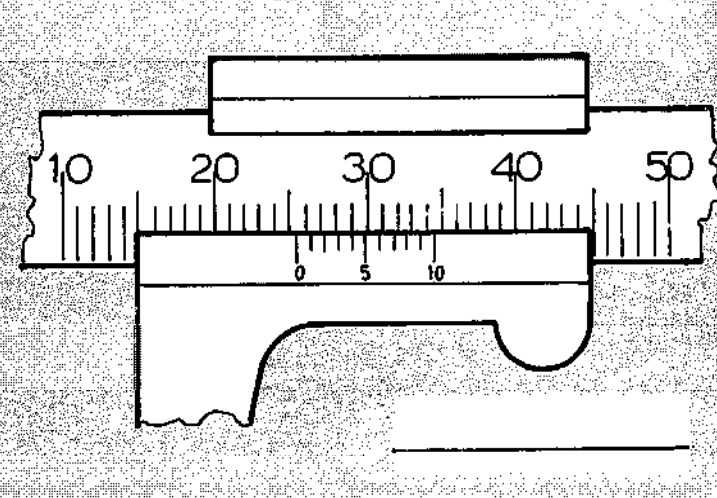
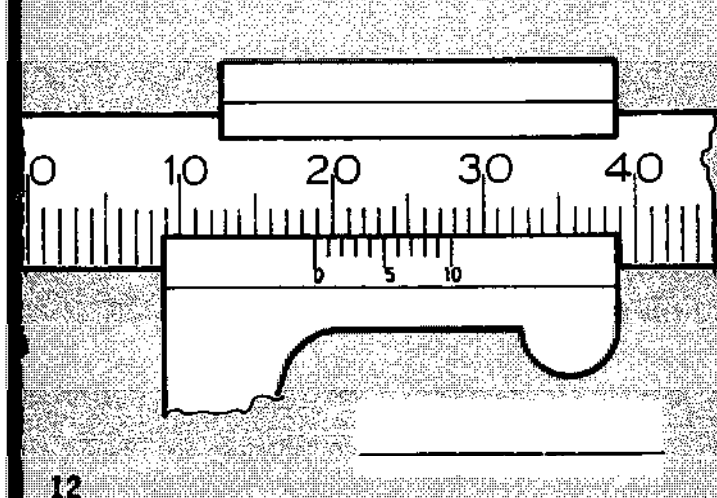
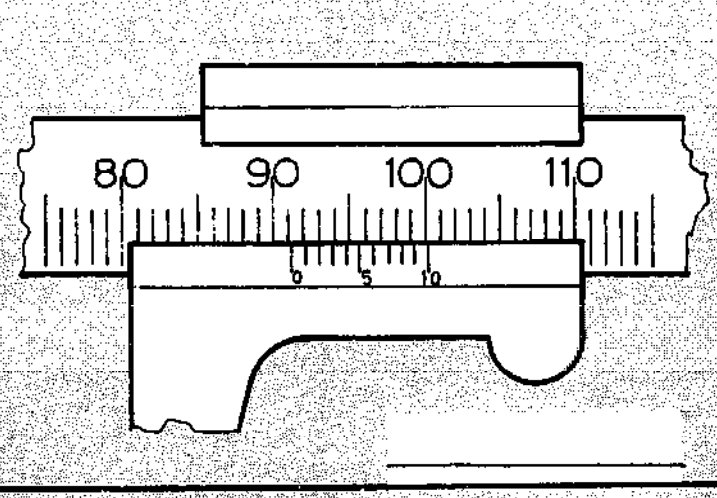
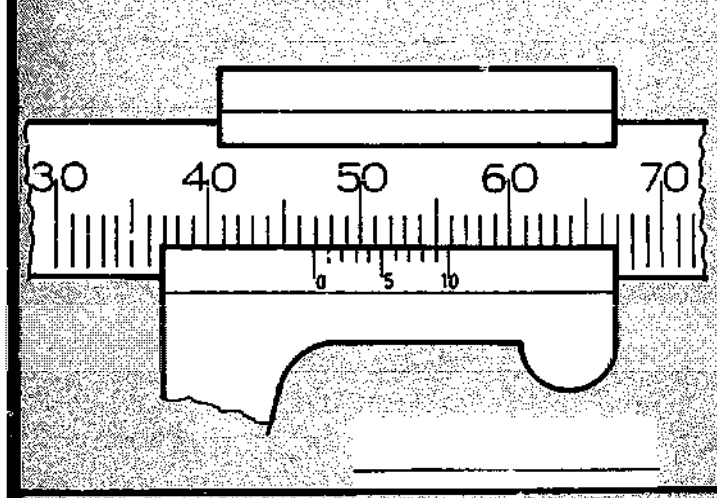
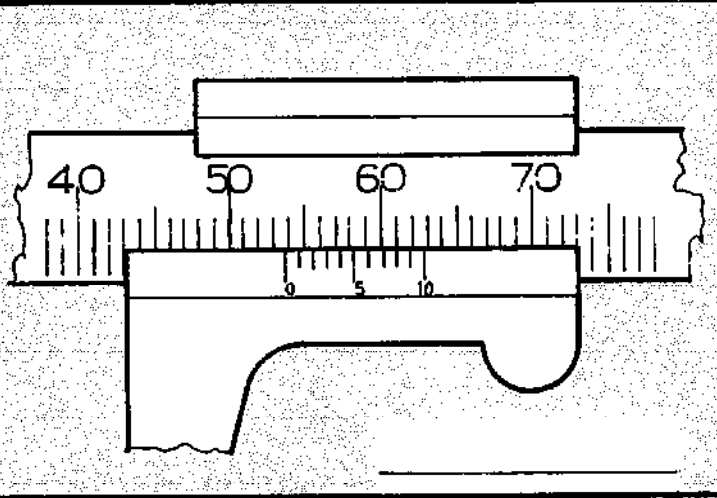
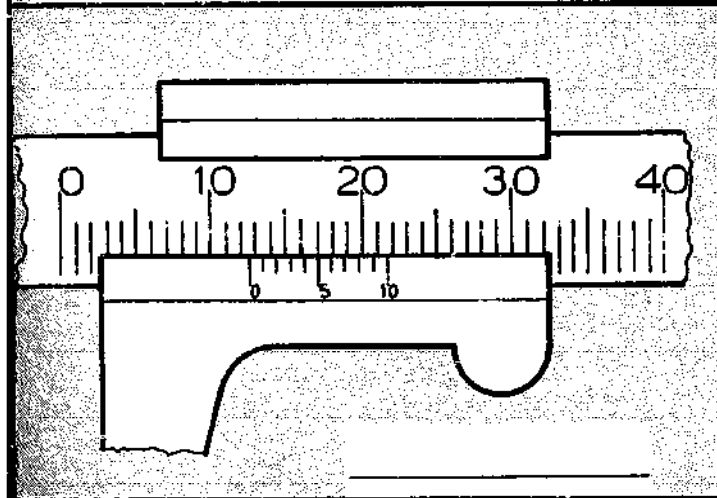
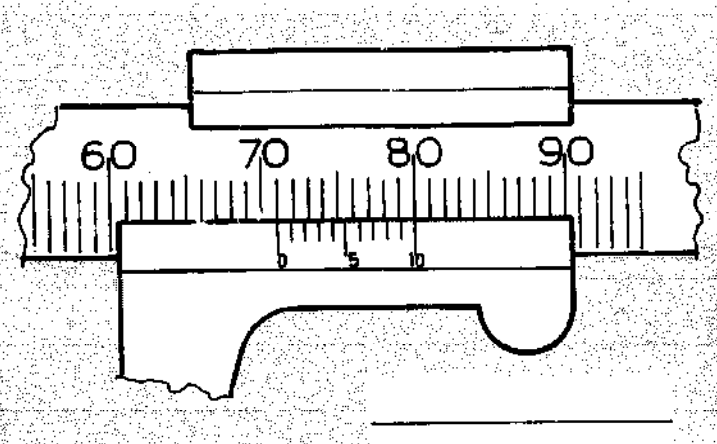
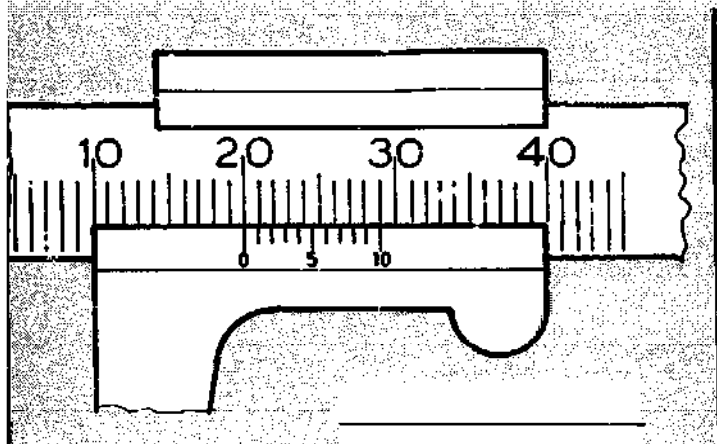
6  
 Space between jaws 0.725 in



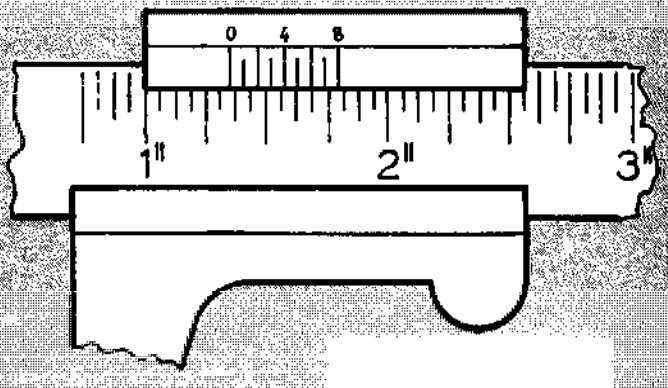
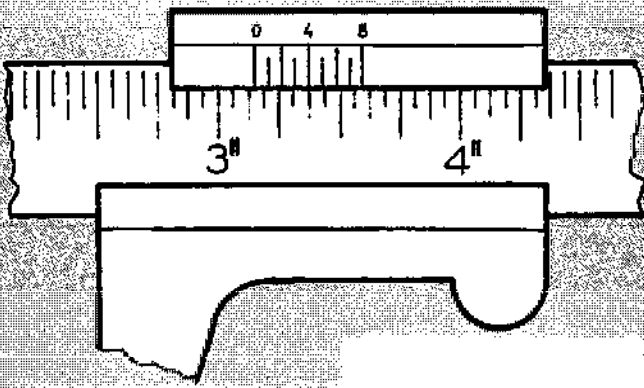
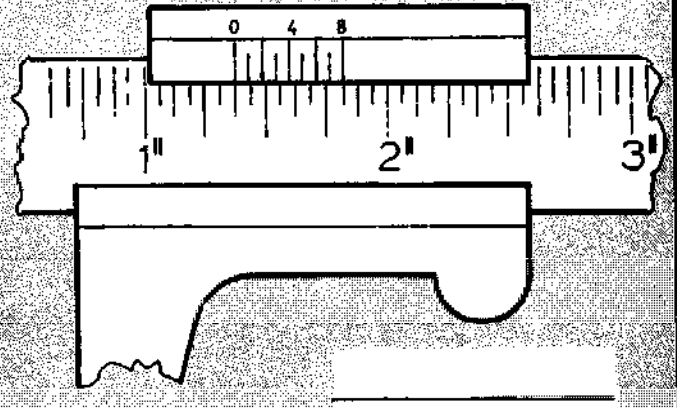
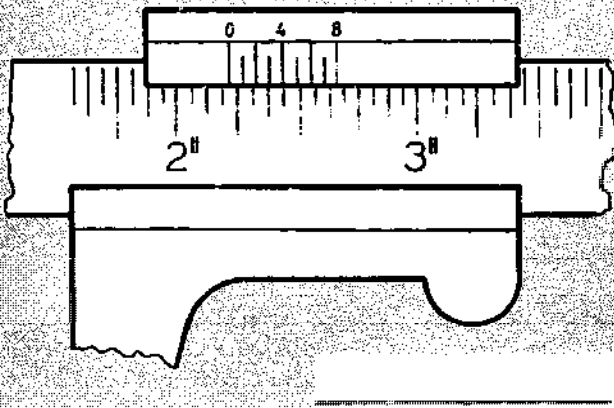
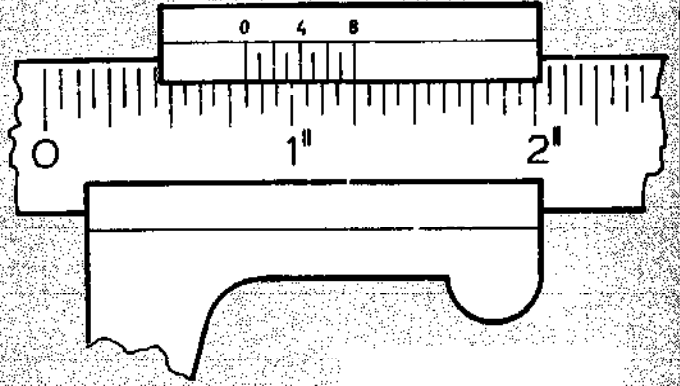
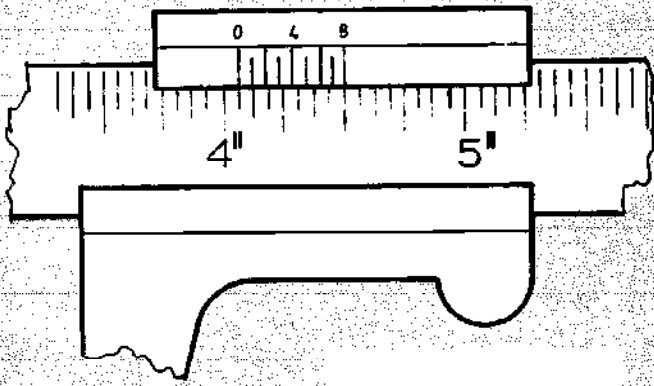
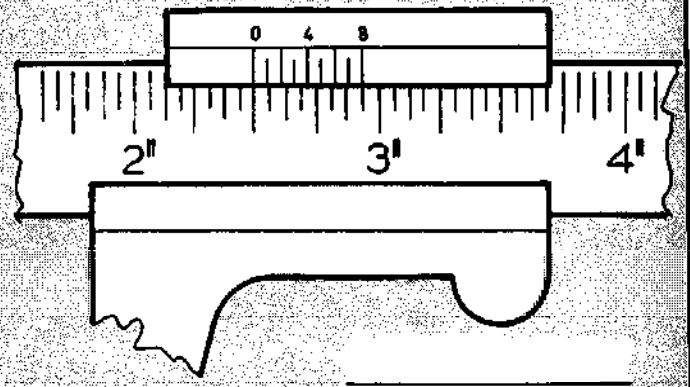
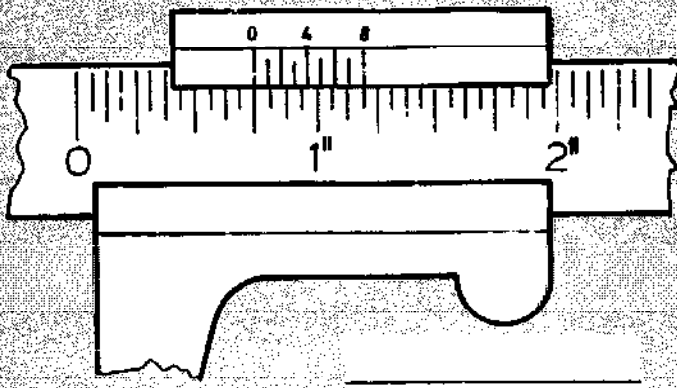
7  
 Space between jaws 1.441 in



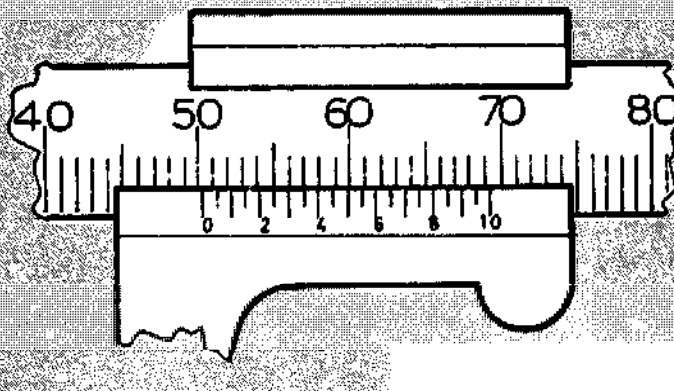
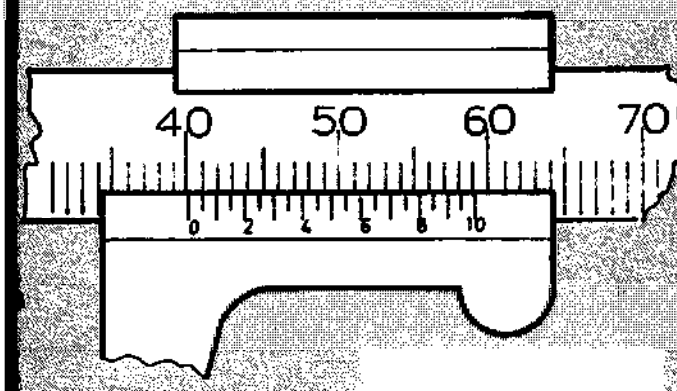
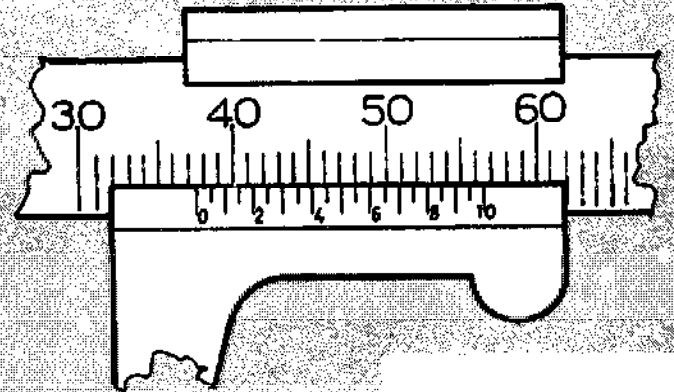
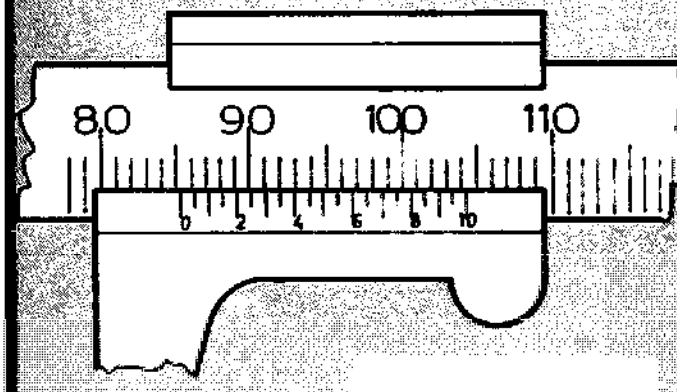
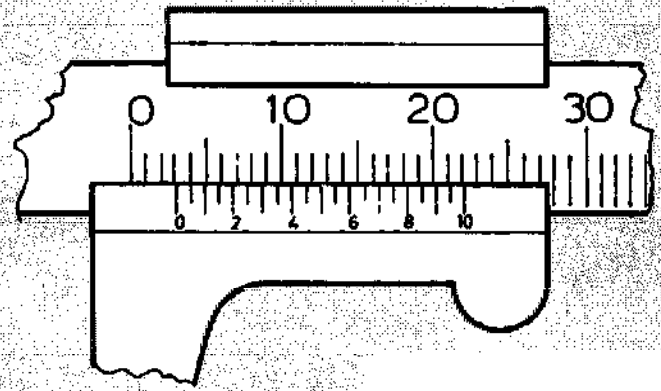
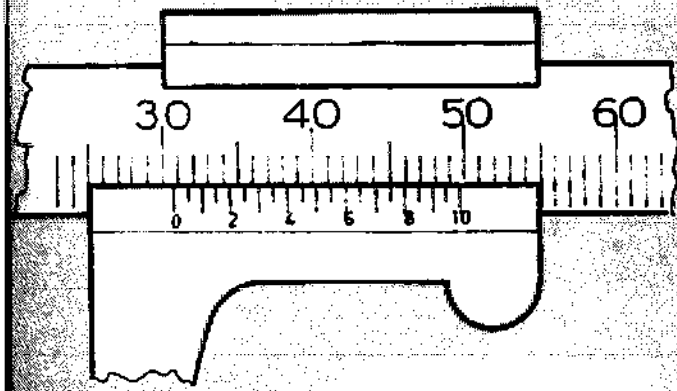
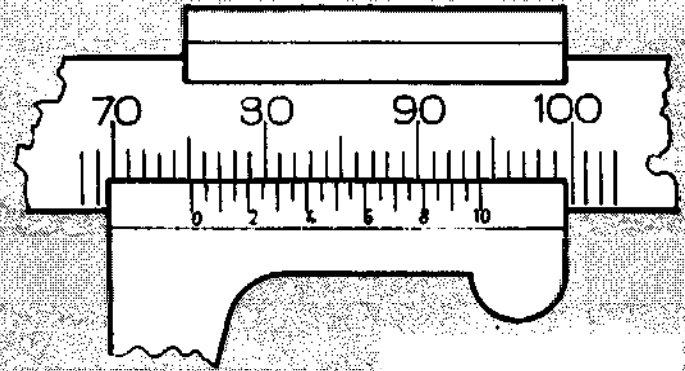
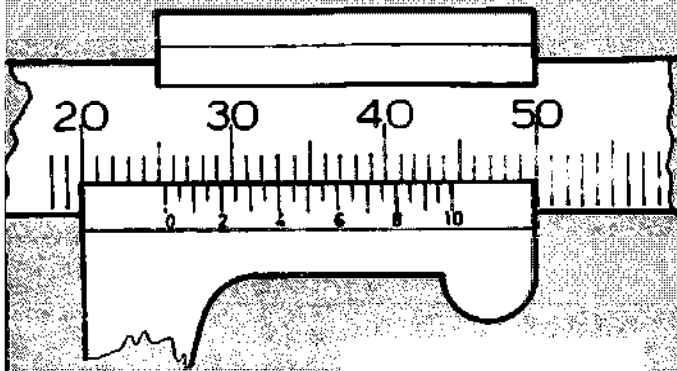
SOME READING EXERCISES WITH METRIC SCALES ACCURATE TO WITHIN 0.1 mm.



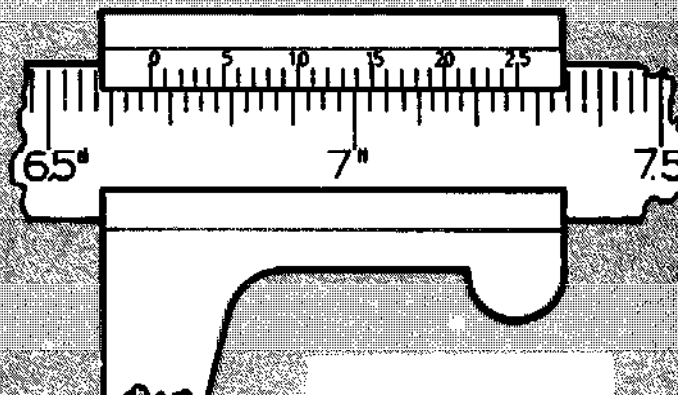
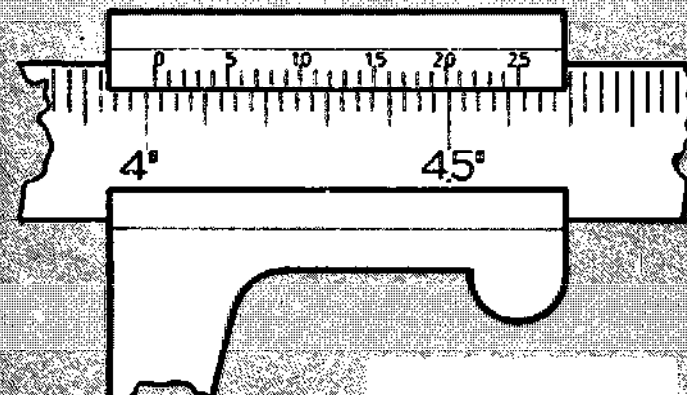
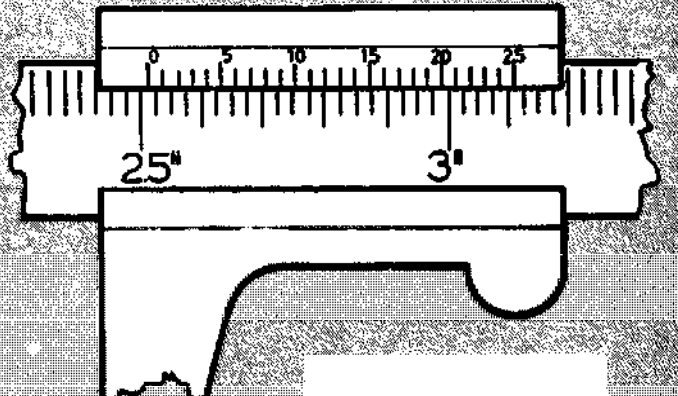
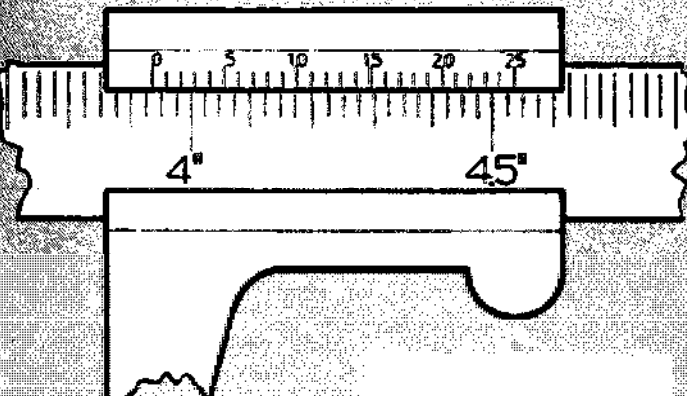
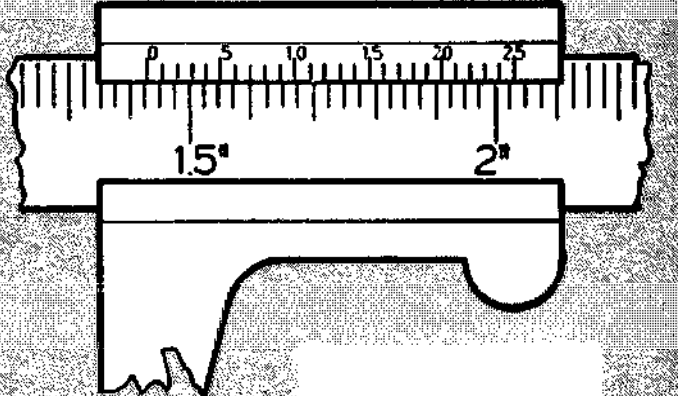
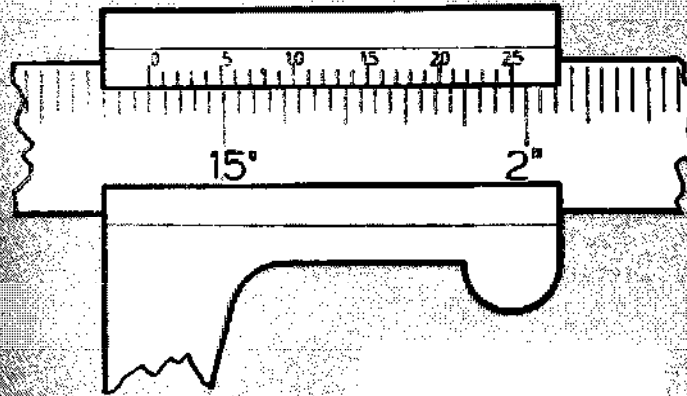
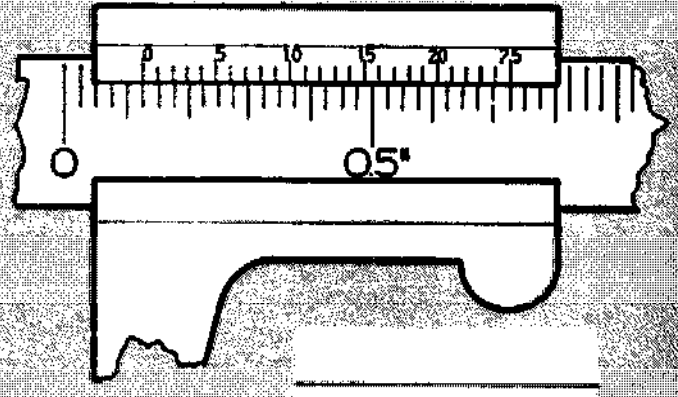
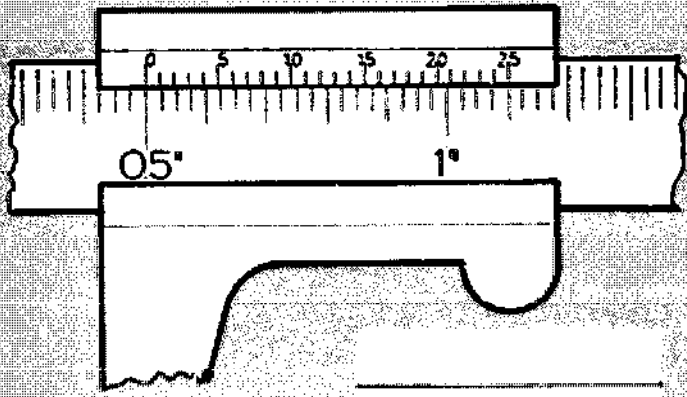
SOME EXERCISES WITH INCH SCALES ACCURATE TO WITHIN 1/128 inch.



SOME EXERCISES WITH METRIC SCALES ACCURATE TO WITHIN 0.05 mm.



SOME EXERCISES WITH INCH SCALES ACCURATE TO WITHIN 0.001 inch.





## INTEMS PICTORIAL SYSTEM

## MARKING OUT 1

Marking out means marking on the material all the lines and points we need to produce work from it.

Suppose the item shown here has to be made.

First we require a dimensioned drawing, that is a drawing showing the exact shape with all dimensions indicated.

Next we take a piece of material and accurately copy onto it the shape of the work from the drawing.

The last preliminary step is to cut out the piece of material (the blank) with the work marked out on it, leaving it slightly larger than its greatest length and width.

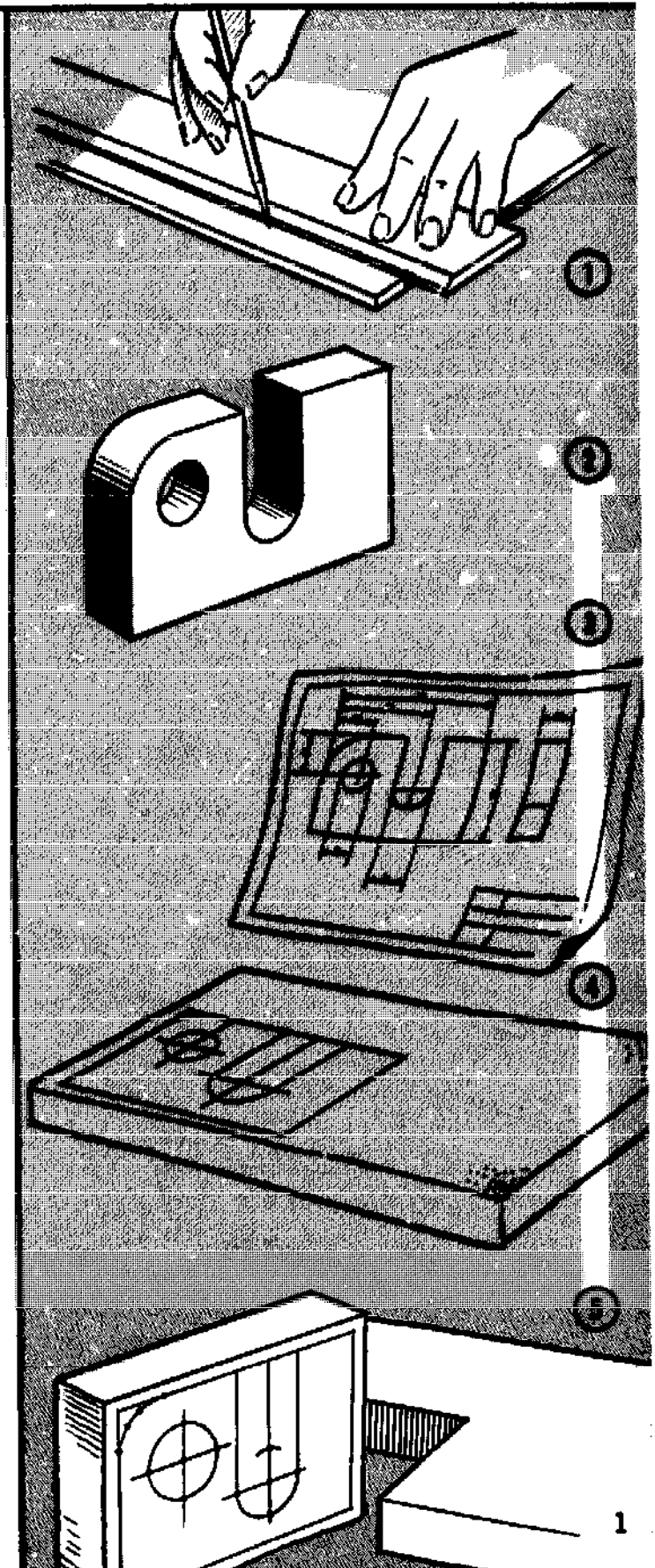
1  
Marking out

2  
Workpiece

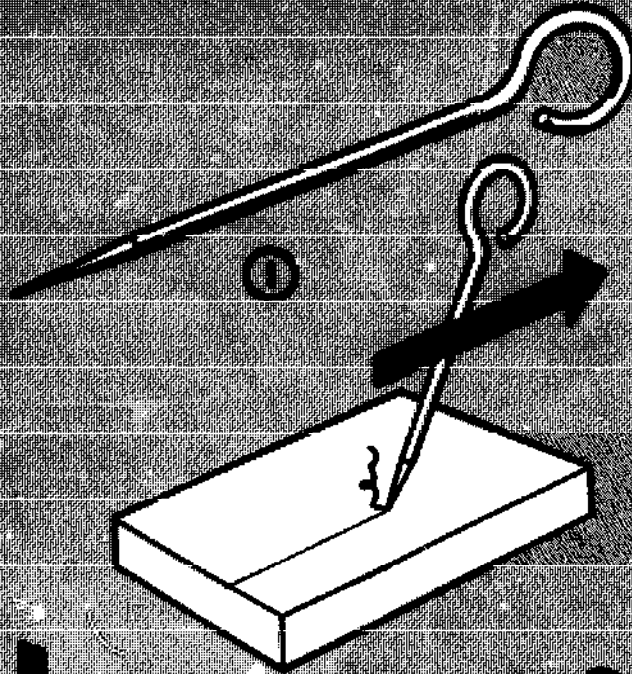
3  
Drawing

4  
Material

5  
Result

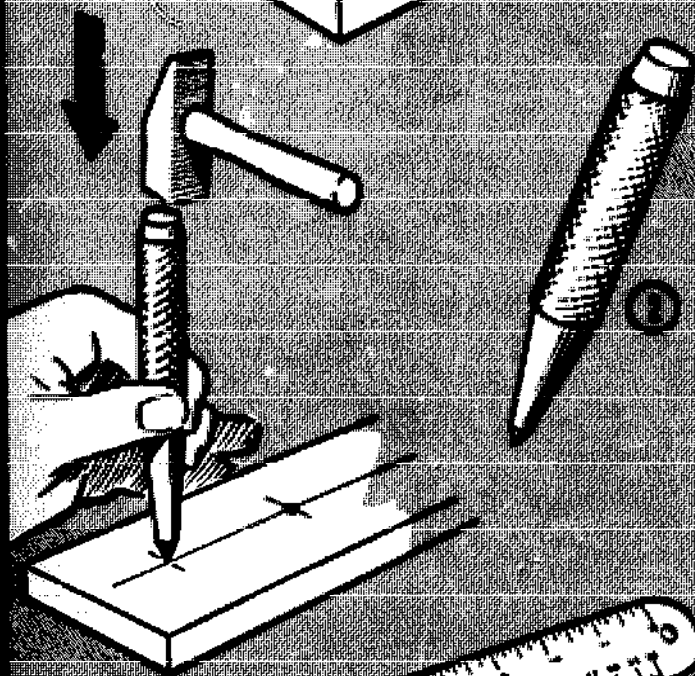






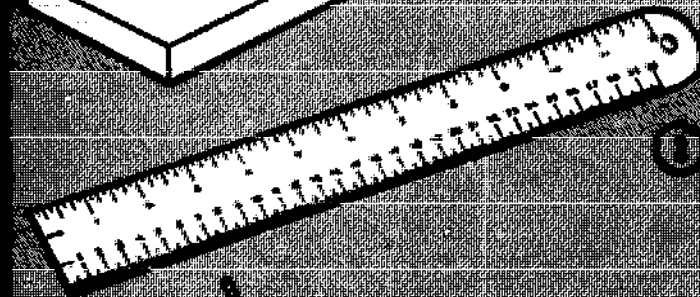
1  
Scriber

Lines that need not or must not be removed are scratched on the material with the sharp point of a scriber.



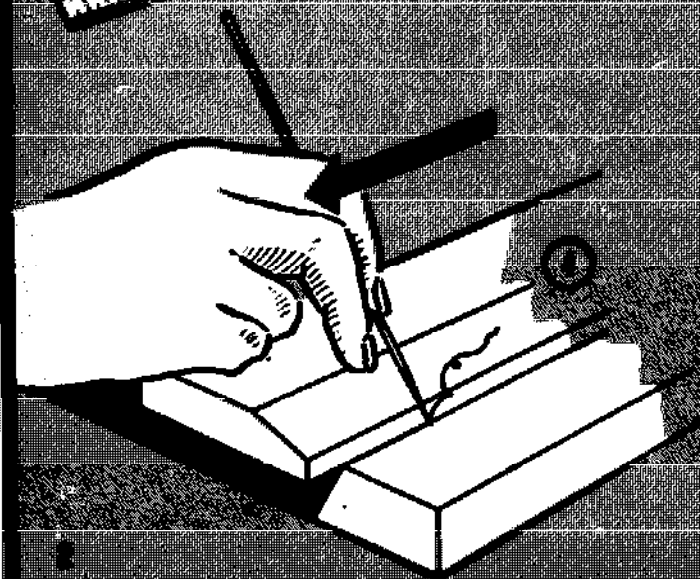
2  
Centre punch

A centre punch is used for marking hole centres. (Without this the drill would twist away). The centre punch is also used for marking dots along a line before filing or cutting (dot punching). In this way lines are made more visible. Punched dots should be lighter than punched centres and a special dot punch is often used for it.



3  
Steel rule

A steel rule is used for measuring and marking off lengths.

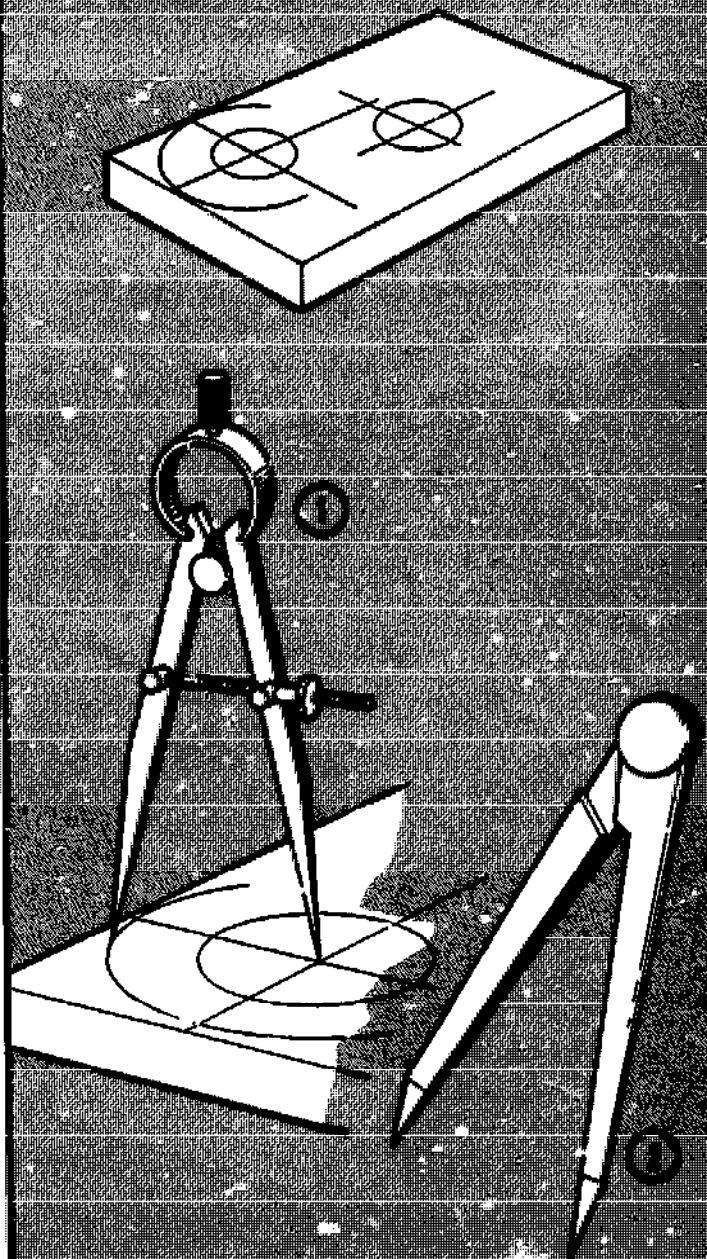


4  
Straight-edge

Straight, sharp lines are scribed along a steel straight-edge.

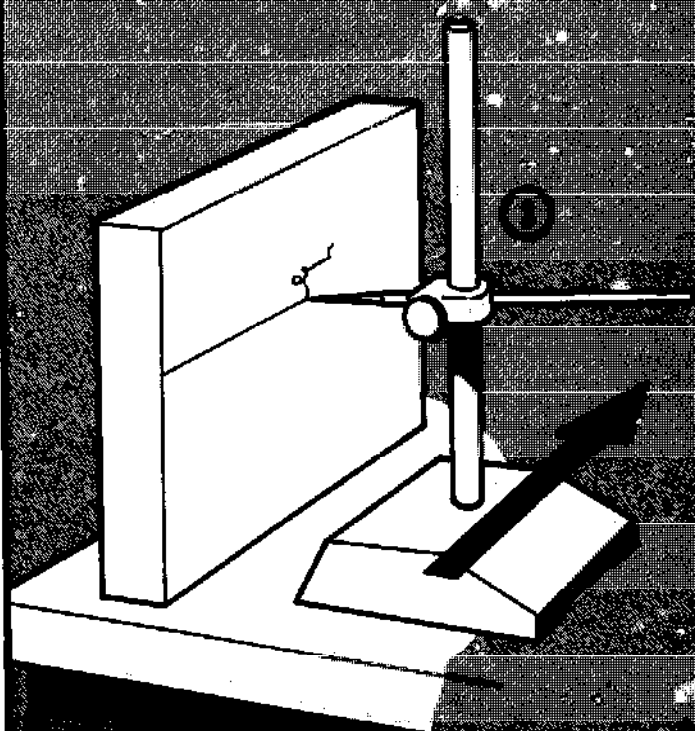
Dividers are used for scribing circles and arcs, and for transferring and stepping off distances.

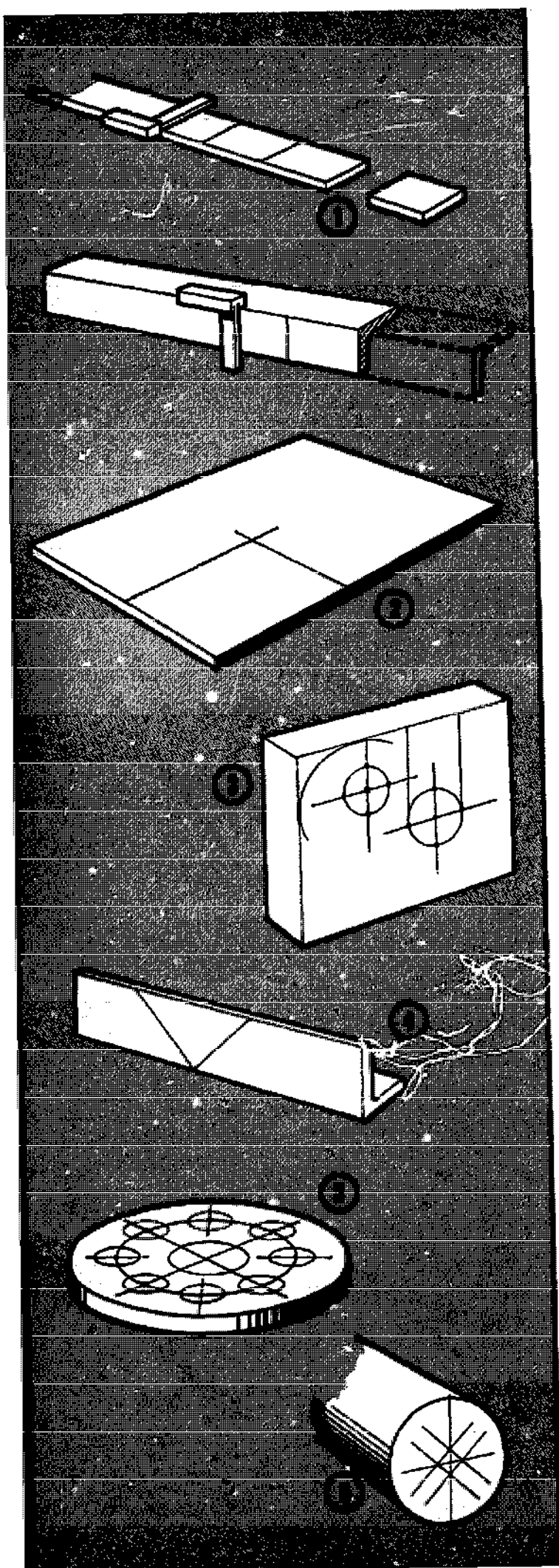
1 and 2  
Dividers



For scribing straight lines the scribing block may also be used. It is moved along a flat surface very accurately finished, called a surface plate. The scribing block is also called a surface gauge, especially when both the pillar and the scriber are adjustable to various angles.

3  
The use of a  
scribing block





Marking out is used for the following purposes:

1. Cutting off bars.

2. Cutting out from sheets and plates.

3. Blanks for initial or further operations.

4. Cutting bevelled angles.

5. Pitch circles for holes that have to be drilled.

6. Centre finding.

**Methods of making lines visible on materials.**

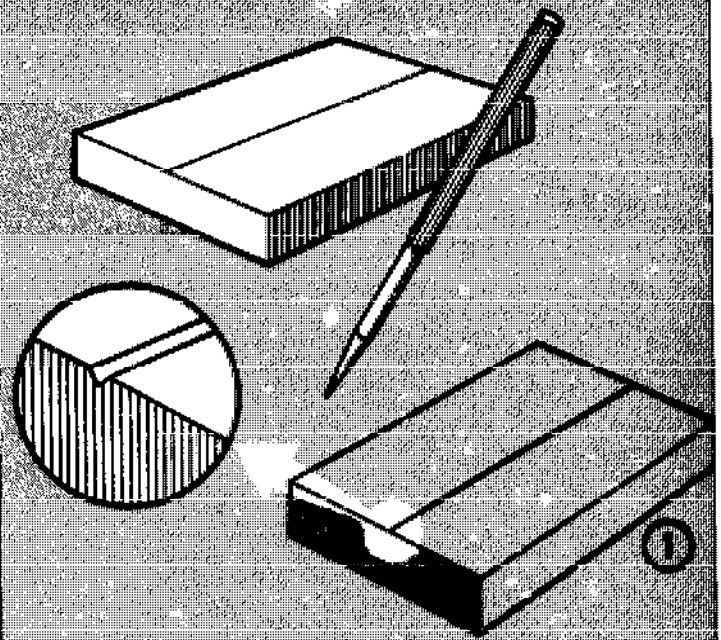
Lines may be scratched into materials by means of a hard scriber.

With a soft scriber or a pencil it is possible to draw lines on the material. Such lines do not stand out so sharply.

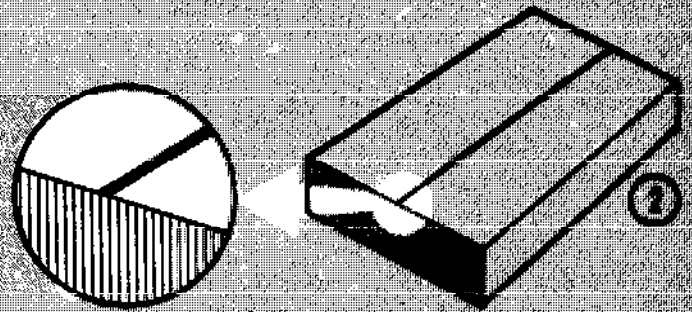
A further possibility is to coat the material with chalk or varnish before scribing.

Hold the scriber at an angle in order to get into the corner when scribing along a straight-edge. In this way a sharp line is obtained.

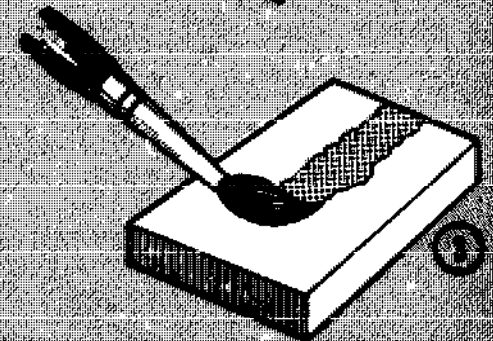
**1**  
Scratching



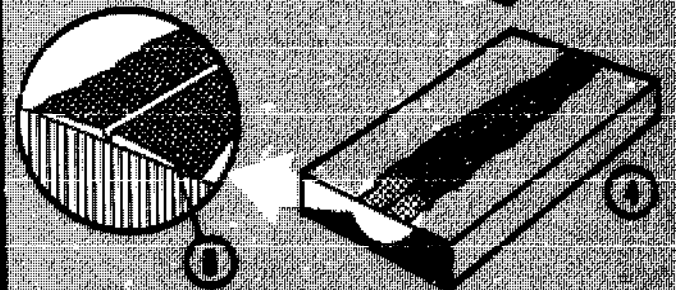
**2**  
Drawing



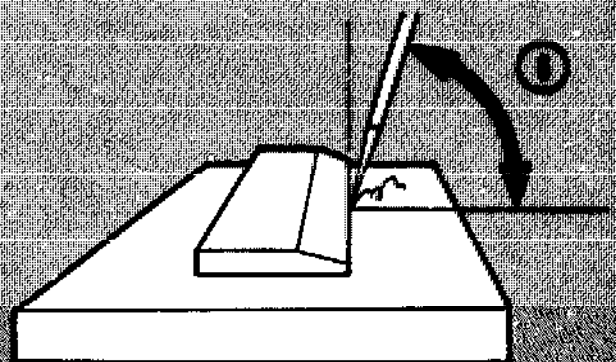
**3**  
Coating

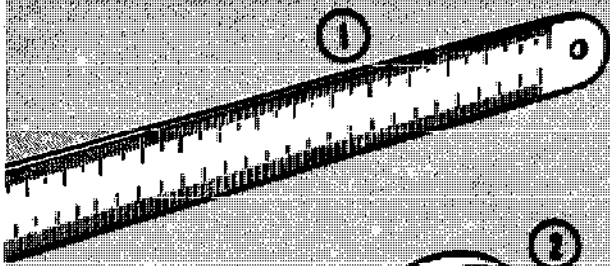


**4 and 5**  
Line in coating



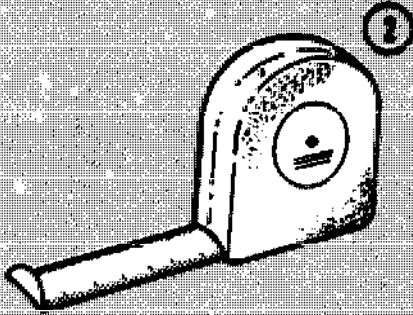
**6**  
Scribing along a straight-edge



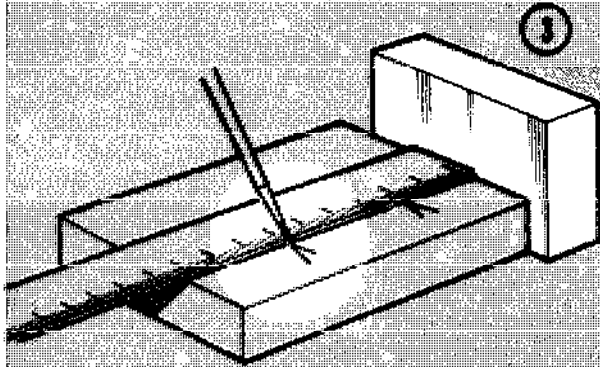


1  
Rule

For setting out lengths, a rule or a metal measuring tape is used.

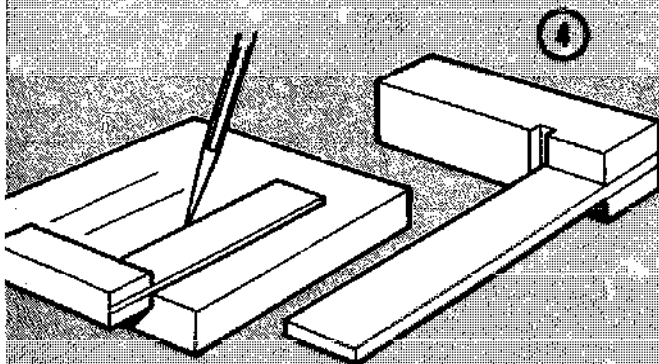


2  
Measuring  
tape



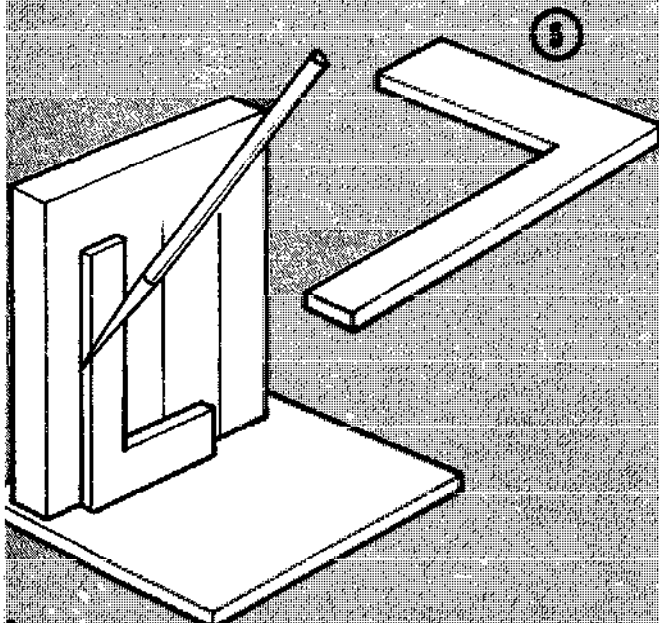
3  
Stop block

Whenever possible use a stop block with a rule. Put V-mark exactly at division required.



4  
Try square

For squaring and for lines at right angles, a try square or flat L-square is used.



5  
Flat  
L-square

There are various types of dividers. They are used for transferring distances and scribing circles and arcs.

If a measured length must be transferred the dividers are set with aid of a rule.

Points should always be well sharpened.

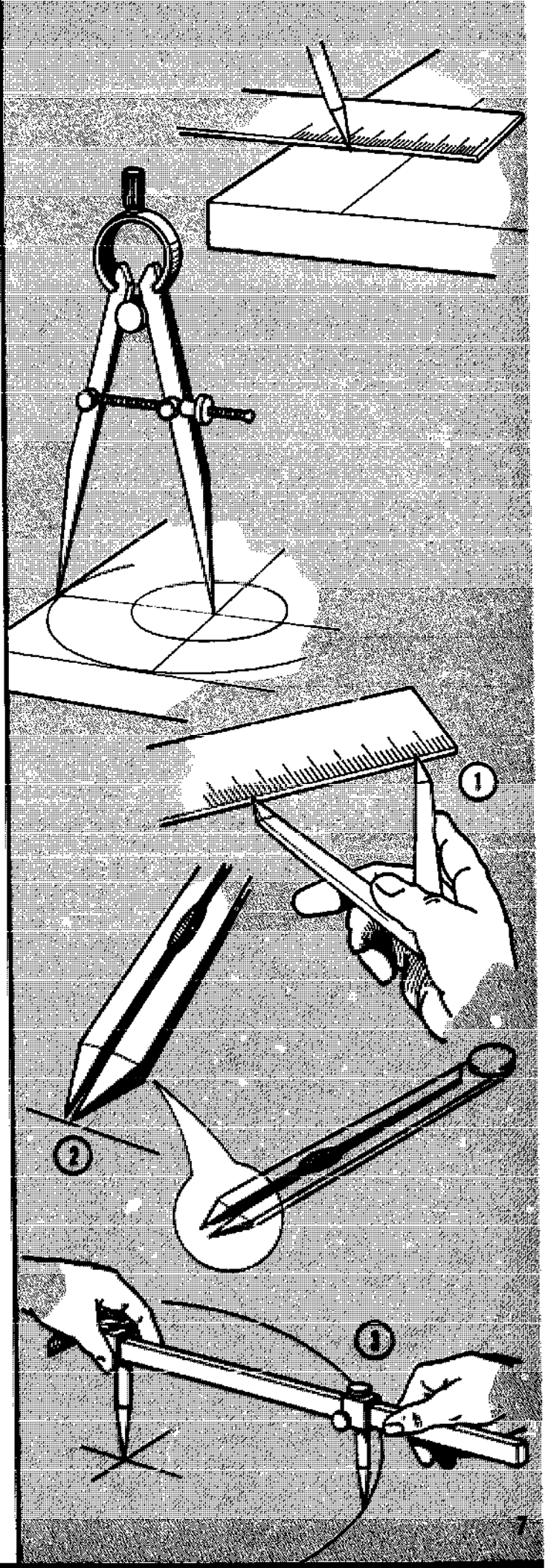
The legs of dividers must be of equal length.

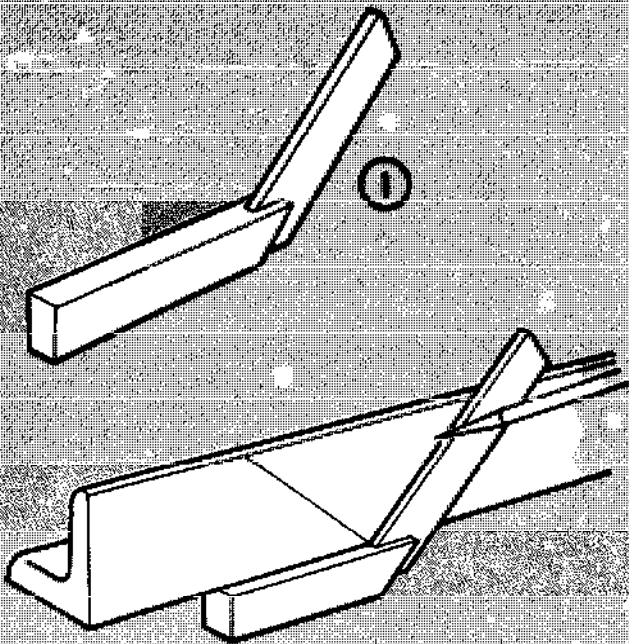
For large circles beam compasses (also called trammels) are used.

1  
Using  
dividers  
with a  
rule

2  
Lengths of  
legs

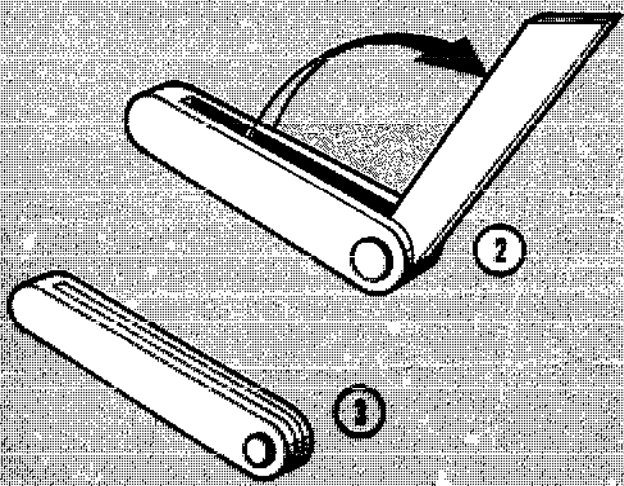
3  
Beam  
compasses  
(trammels)





1  
Bevel

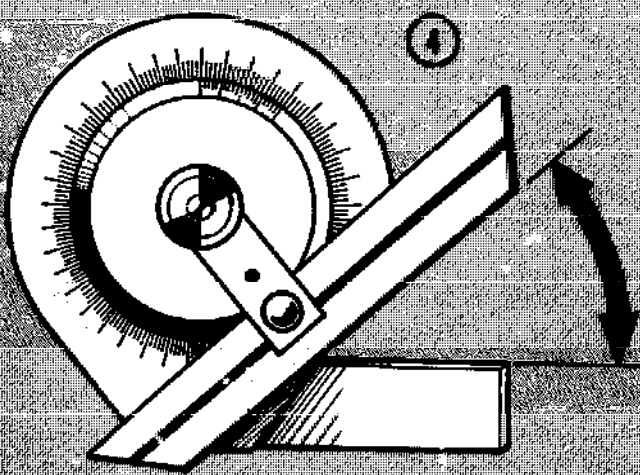
For marking angles a bevel (also called a mitre square) is used. Fixed bevels may have angles of 60, 30 or 45 degrees.



2  
Sliding  
bevel

Sliding bevels may be set to any angle.

3  
Sliding  
bevel  
(closed)



4  
Bevel  
protractor

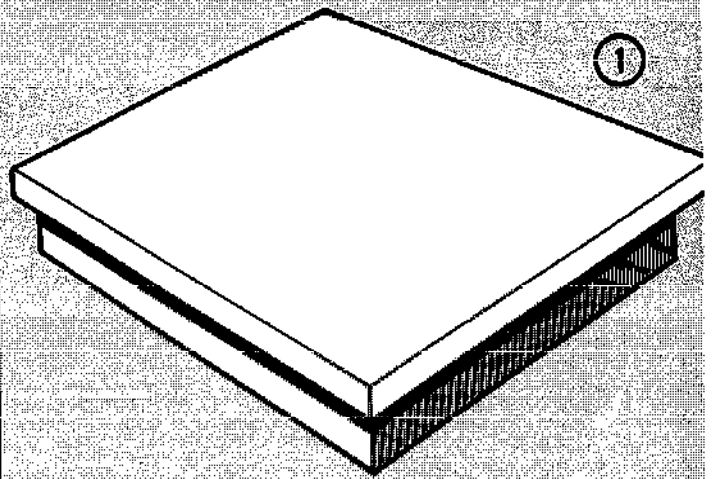
The same applies to the bevel protractor. It has a graduated or vernier scale by which any angle may be accurately set.

For marking out, a surface plate is often used. This is a plate with a flat surface of great accuracy that is used for testing the flatness of other surfaces and - together with other instruments - for measuring, testing and marking out purposes.

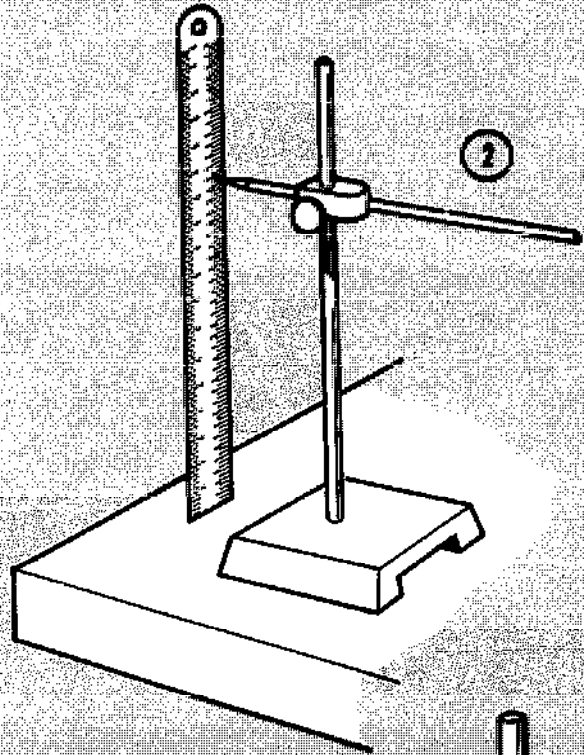
One of the instruments used together with a surface plate is the scribing block. The height of the scribe in the block may be set with the aid of a rule.

If a vertical scale is attached to the pillar of the scribing block, the latter is called a height gauge.

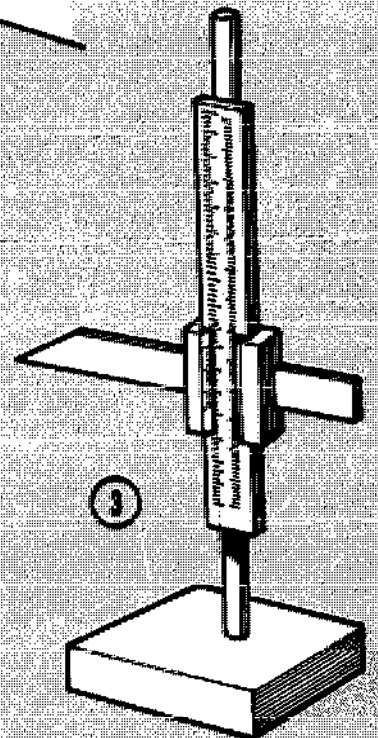
1  
Surface plate



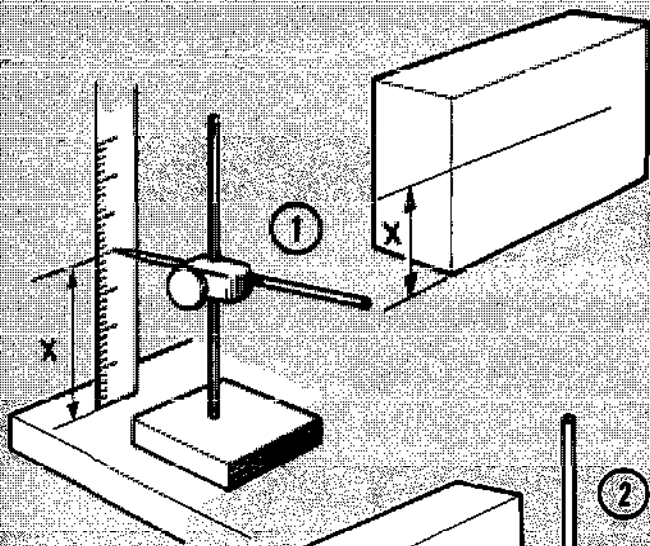
2  
Scribing block



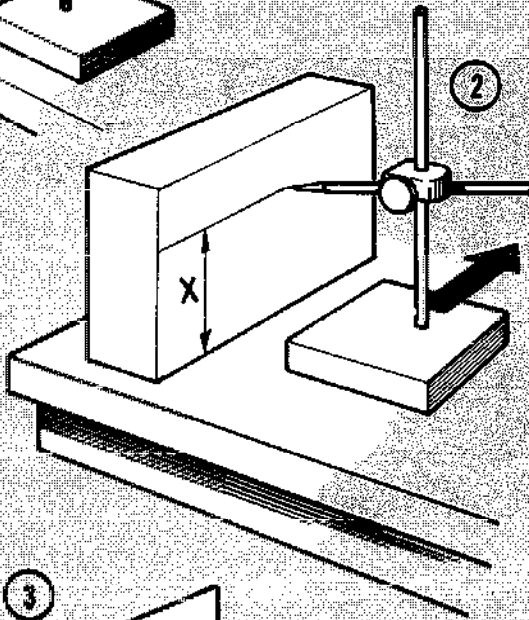
3  
Height gauge



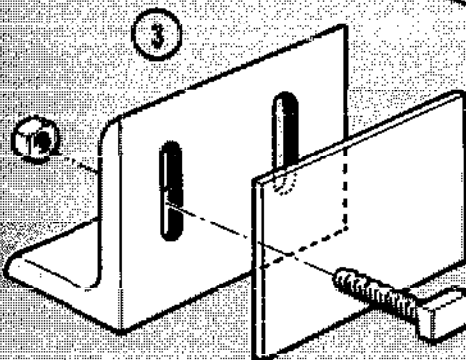




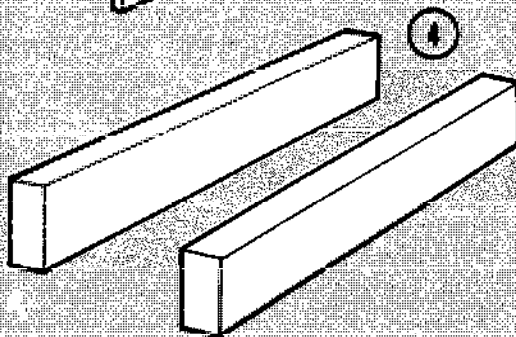
1  
Setting the  
scribing  
block



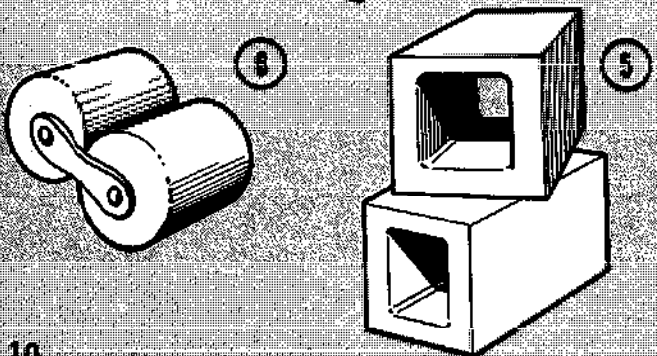
2  
Scribing



3  
Angle plate



4  
Parallels



5  
Box angles

6  
Roller  
blocks

For marking-out operations the scribing block is used in the following way. Suppose a line is to be marked at a height of 4 cm on the face of a metal block.

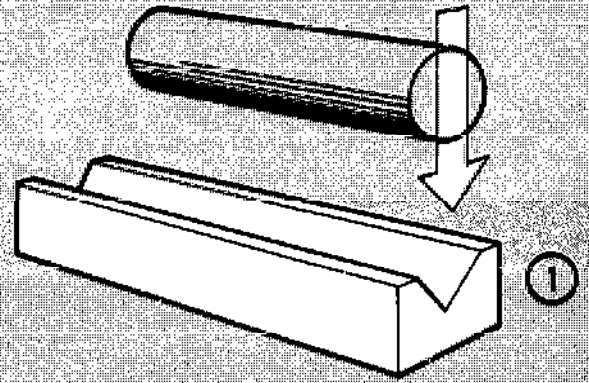
1. With the aid of a rule or the scale, the point of the scribe is set to a height of 4 cm above the surface plate. The point should be as near the pillar as possible.
2. The work is then placed on the surface plate with the point of the scribe touching its face. The scribing block is moved across the surface plate, scribing a line on the work.

If the shape of the work will not allow a steady base it may be placed against or clamped to an angle plate.

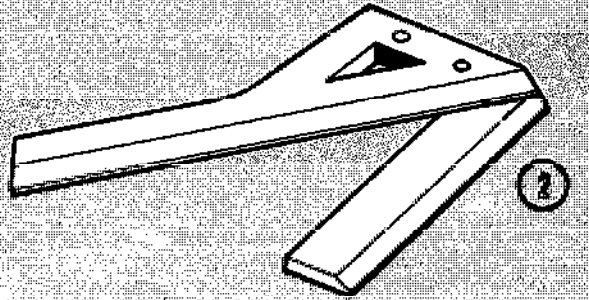
Other accessories used with a surface plate to support or position the work include parallels, box angles and roller blocks.

For supporting circular bars etc. V-blocks are used, e.g. in combination with a centre finder to determine the centre of the bar.

1  
V-block

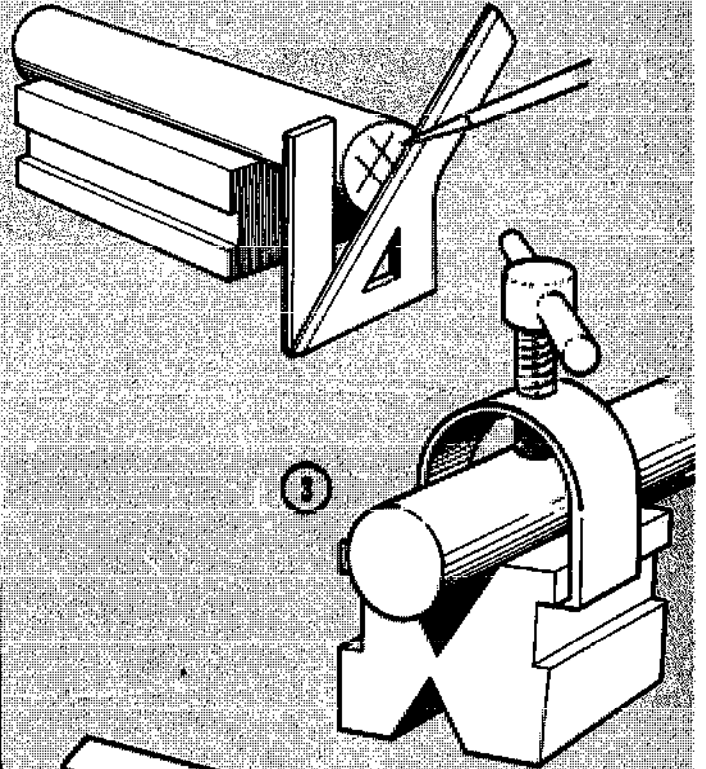


2  
Centre  
finder



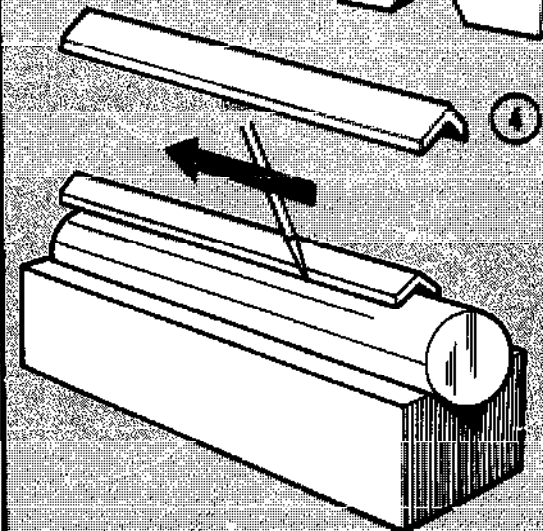
If necessary the bar can be clamped.

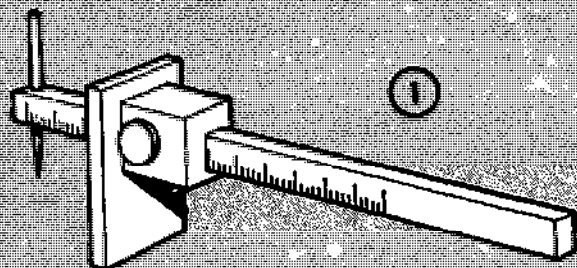
3  
Combination  
V-block and  
clamp



For scribing longitudinal lines on circular bars an angle bar is often used.

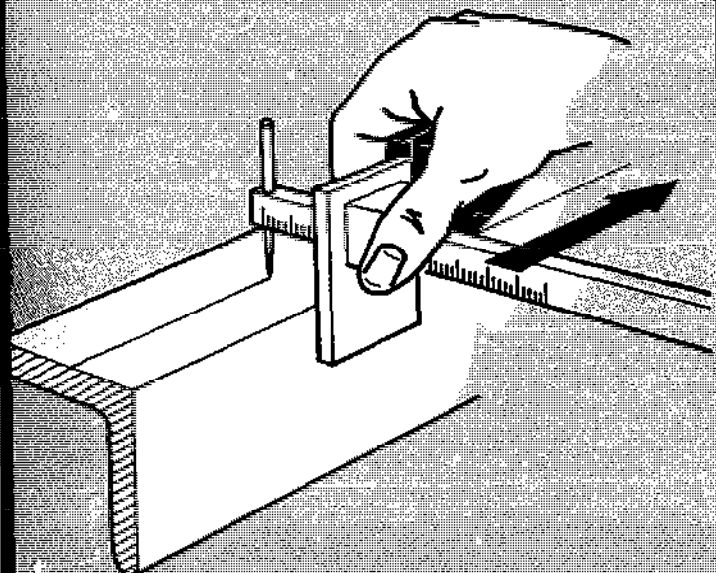
4  
Angle bar



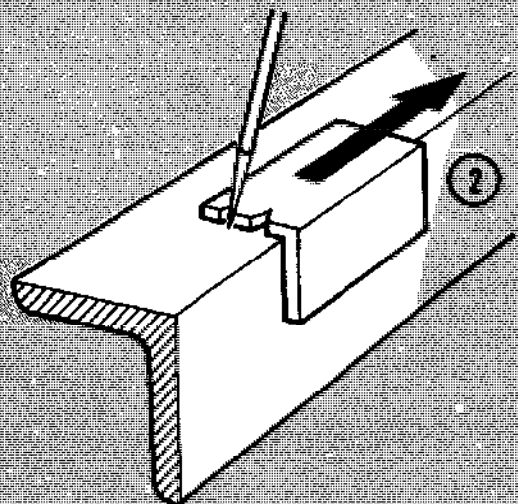


1  
Scribing  
tool

This scribing tool has a graduated bar with a scribe that slides through the guide block and may be fixed at any distance.



By moving the tool along a channel or angle bar we can scribe a required line.



2  
Auxiliary  
piece

The same purpose is served by making a small notch in a piece of angle steel, the scribe being inserted in the notch.

Centring of holes is very important. It is done with a centre punch.

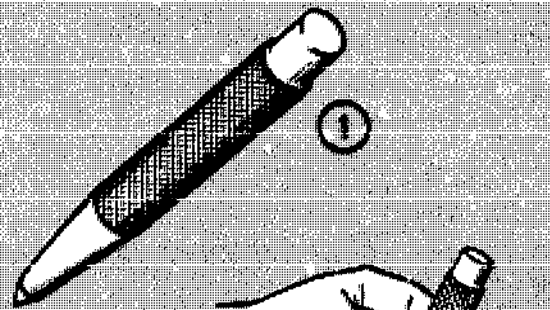
For locating the centre the punch is held at an angle. When the punch is struck with a hammer it is held upright.

A blow with the hammer on the centre punch produces an indentation in the material.

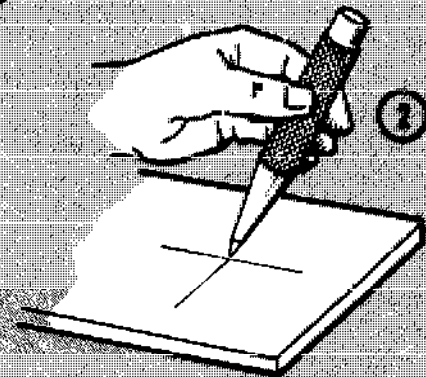
Marking dots are punched in the same way but are lighter than hole centres. A dot punch is often used for this. The diameter of a hole centre should be larger than the core of the drill.

The angle at the point of the centre punch should be  $55^{\circ}$ . It should be resharpened when required.

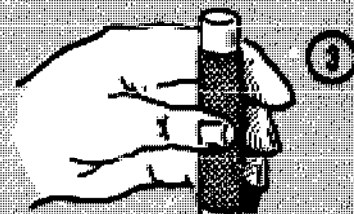
1  
Centre punch



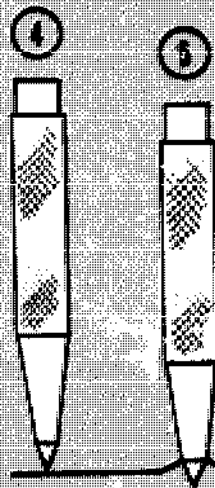
2  
At angle for locating



3  
Upright when being struck



4  
Before the blow

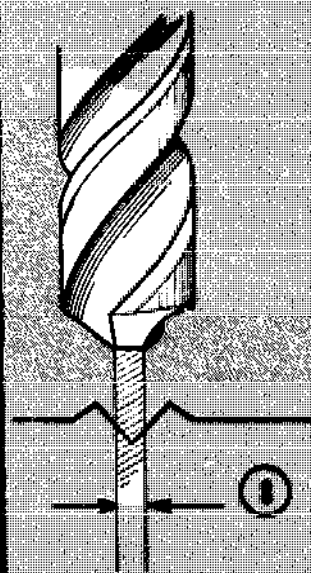


5  
After the blow

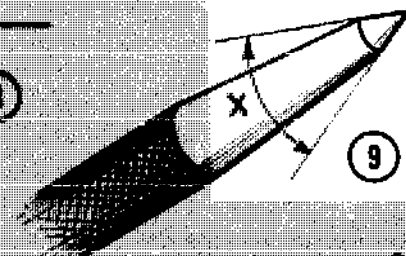
6  
Marking dot  
7  
Hole centre

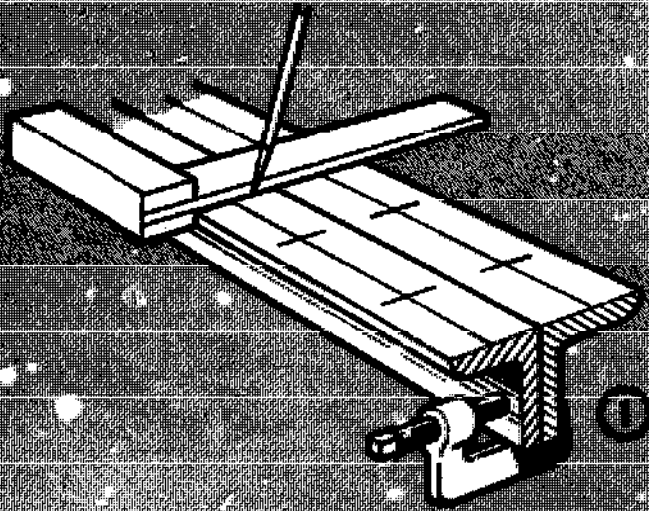


8  
Drill core



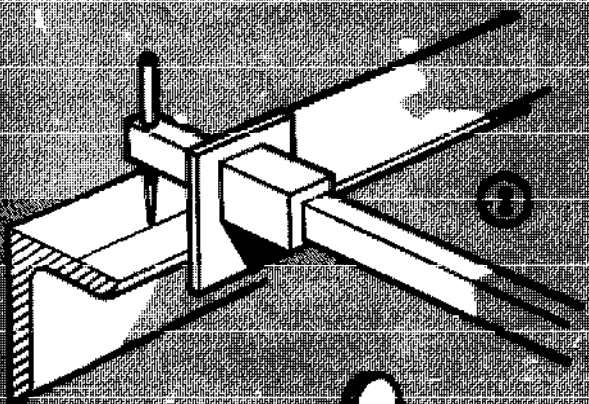
9  
Point of centre punch





**1**  
Clamping

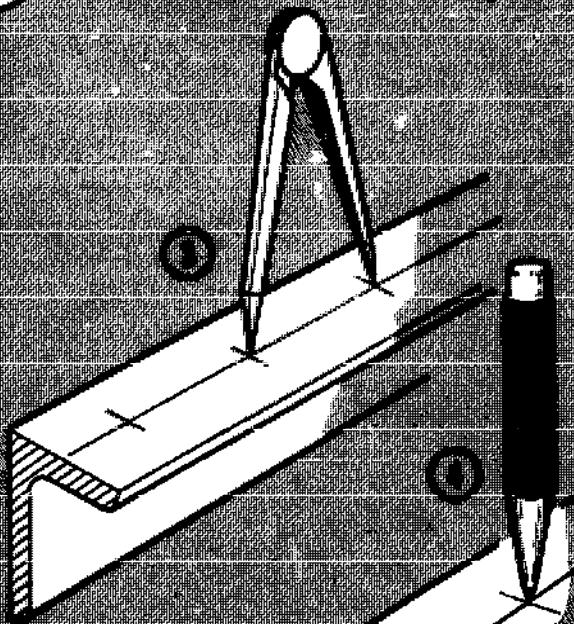
Two equal angle bars on which the same lines are to be scribed may be clamped together.



**2**  
Scribing

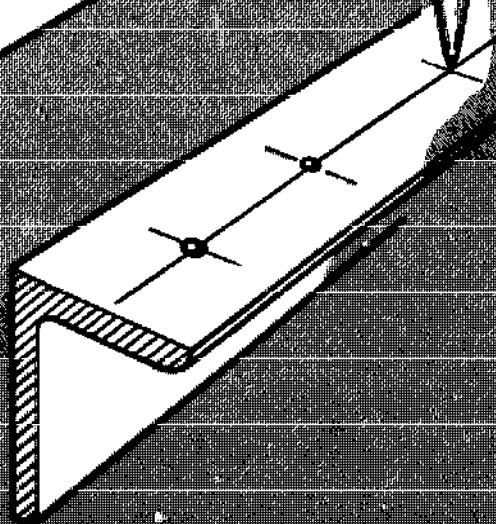
Holes to be drilled in an angle bar are marked in the following way.

a. Datum line is scribed.



**3**  
Pitch

b. Equal distances (the pitch) are stepped off with dividers.



**4**  
Centre  
punching

c. Centres are punched.

## MAINTENANCE

Never use a tool for any other purpose than that for which it is meant.

Always clean measuring and marking instruments after use. The surface plate is cleaned with paraffin, then rubbed with acid-free oil on a soft cloth.

Keep the surface plate under a wooden cover lined on the inside with felt strips.

Resharpen centre punches and scribes regularly and to the correct angles. The scribe of a height gauge should be ground on the angle side only.

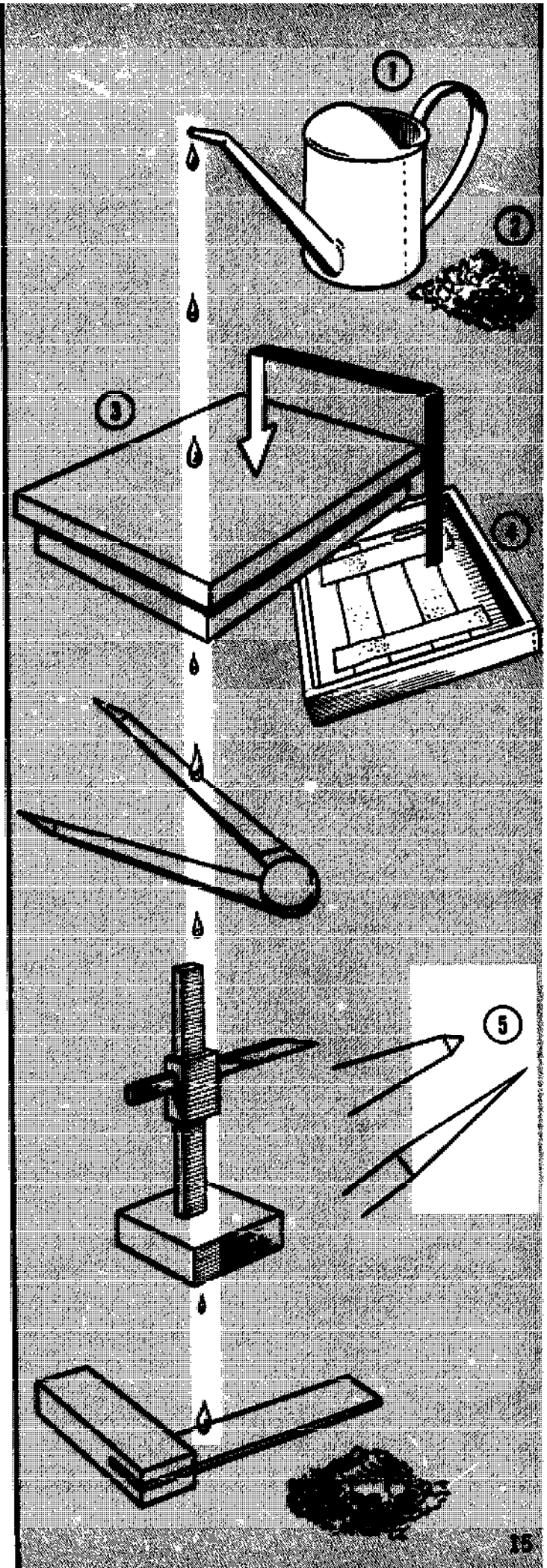
1  
Oil can

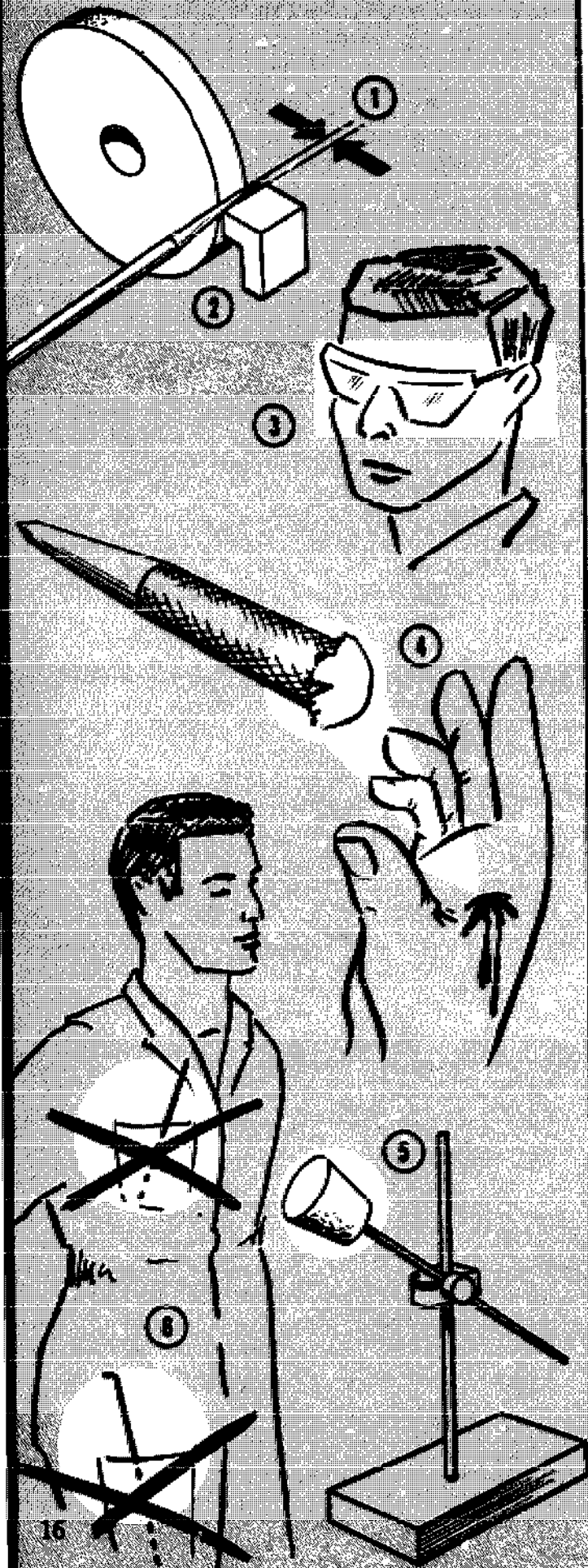
2  
Cotton waste

3  
Surface  
plate

4  
Cover

5  
Points





1  
Clearance

Be careful when resharpening scribes.

2  
Hand rest

Keep the clearance between hand rest and grinding wheel as small as possible.

3  
Goggles

When grinding always use goggles.

4  
Burred end

Burred centre punches may cause injuries.

5  
Cork

Protect point of scribe with cork.

6  
Unsafe

Don't carry sharp scribes in pockets.

INTEMS PICTORIAL SYSTEM

CLAMPING

By clamping is meant holding a work in such a way that it cannot move during an operation.

The method of clamping varies according to the nature of the operation required.

For operation by hand the most commonly used clamping device is the vice.

On the vice, shown here, we see a solid jaw and a movable jaw.

By means of a spindle and handle the movable jaw may be moved.

The work is clamped between these two jaws. The distance between the jaws is called the holding width.

The jaws remain parallel, hence the name: parallel vice.

On the jaws are tiny teeth. They might damage the work and therefore vice clamps are often used to protect finished surfaces. Usually we make the vice clamps ourselves, and we can adapt them to the workpiece.

Vice clamps are made from a soft material such as lead, copper or mild steel.

1 Clamping

2 Vice clamps

3 Jaw pieces

4 Holding width

5 Width of jaw

6 Anvil

7 Movable jaw

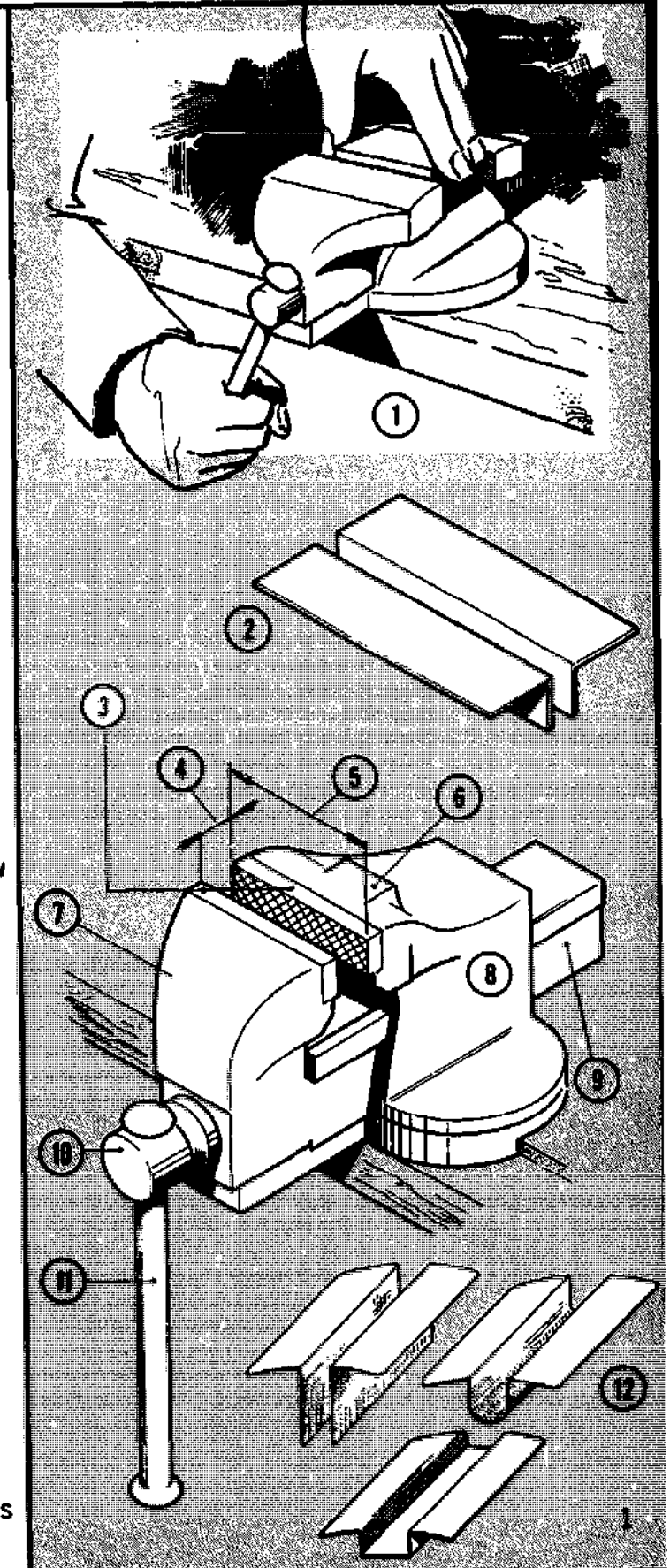
8 Solid jaw

9 Guide piece

10 Spindle

11 Handle

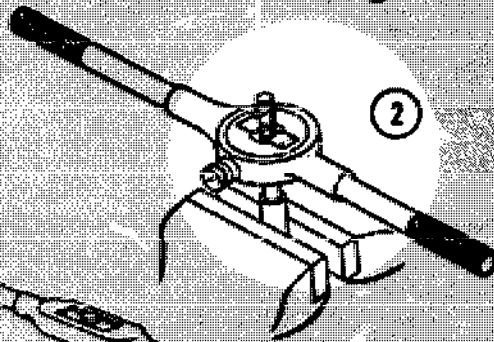
12 Various types of vice clamps



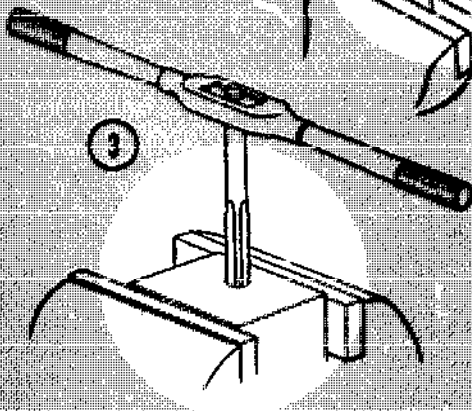




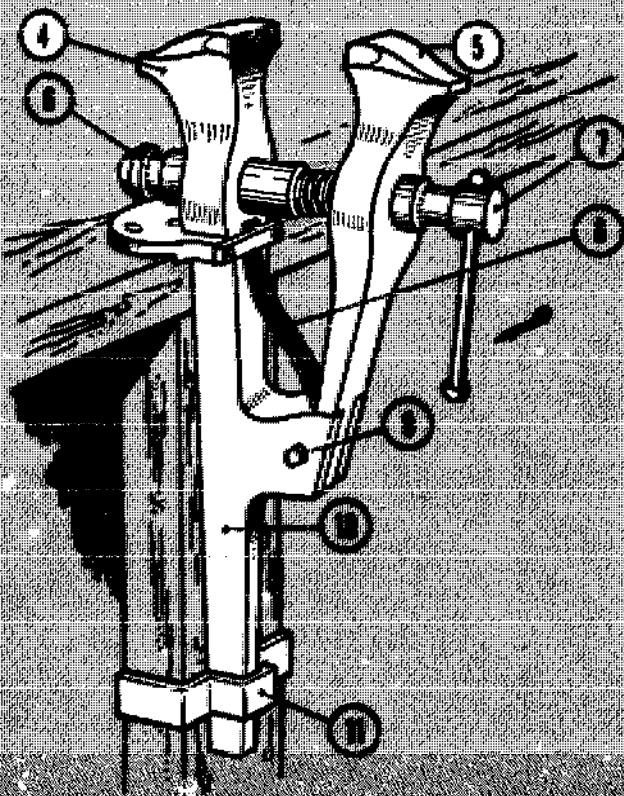
1  
Filing



2  
Thread cutting



3  
Thread tapping



4 Solid jaw  
5 Movable jaw  
6 Threaded bush  
7 Spindle  
8 Spring  
9 Pivot

10  
Leg

11  
Clamp

The vice is an instrument which is used in many ways. On this page a number of uses of the vice are shown - filing, thread cutting and thread tapping.

Another type of vice is the leg vice. Here the movable jaw turns around a pivot.

As a result the jaws are not always parallel and the work is not clamped as efficiently as in a parallel vice, so there is a greater risk of damage.

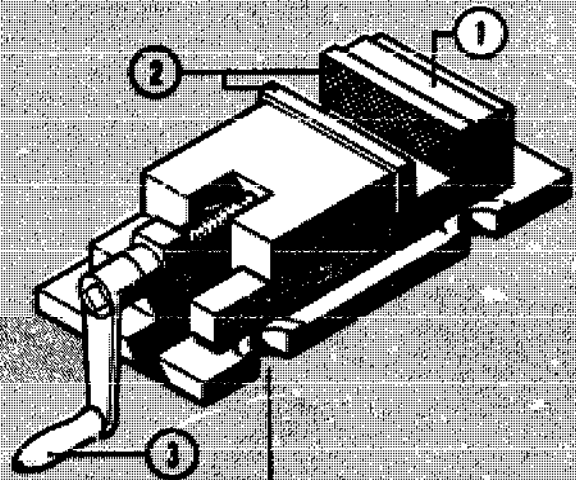
This type of vice is still used for rough work, e.g. in the forge.

Another clamping device is the machine vice. Its main use is holding the work during drilling in a drilling machine.

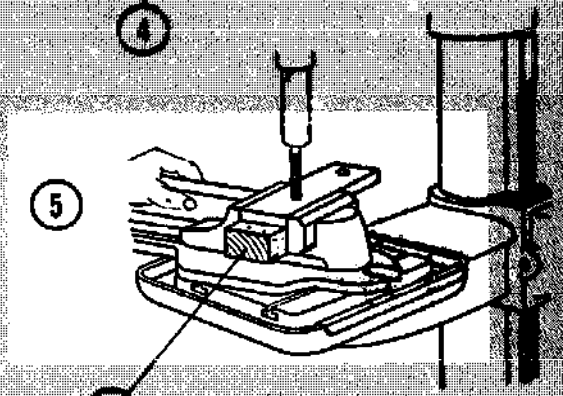
For light drilling the vice can be held in its place by hand but in most cases it is better to bolt it to the driller table by means of two bolts. For through holes the work should always be clamped in such a way that it is impossible to drill into the vice. This can be done, for instance, by using a wooden packing under the work.

Differences in machine vices are mainly found in the shape of the jaws. Some of them are shown here.

1 Machine vice  
2 Jaws

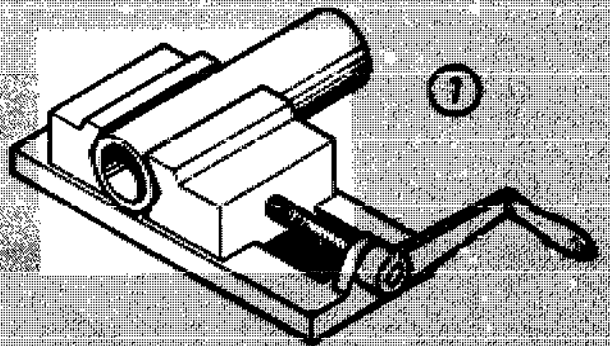


3 Handle  
4 Recess for fixing to the driller table

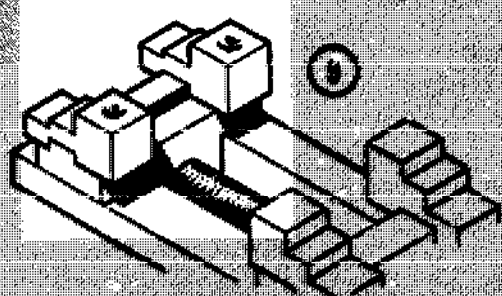
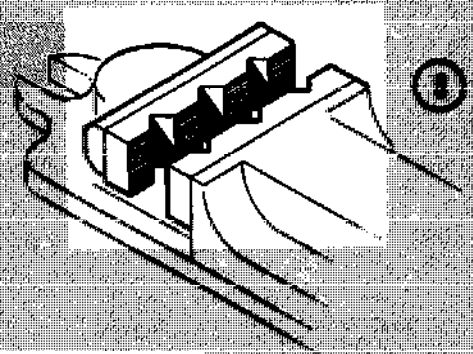


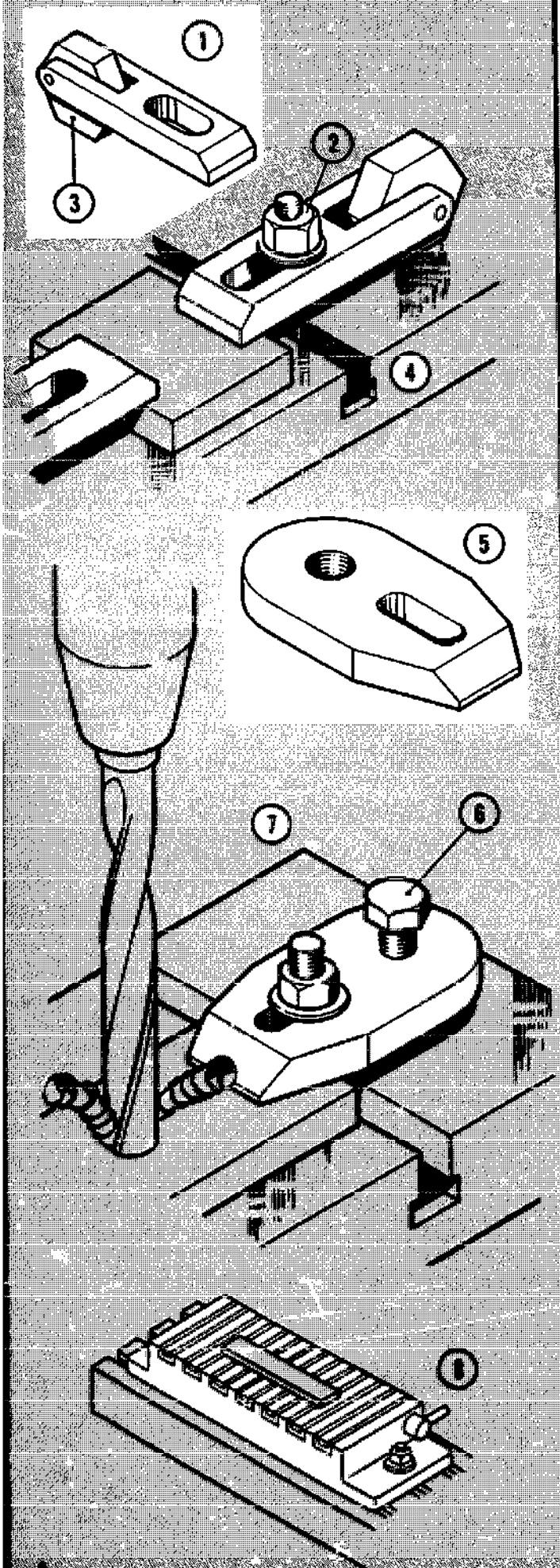
5 Machine vice on drilling machine

6 Wooden packing block



7, 8, 9 Various types of machine vices





1  
Clamp (dog)

2  
Bolt

3  
Hexagon

4  
Clamping by  
means of  
clamps or  
dogs

5  
Clamp or  
dog

6  
Adjusting  
screw

7  
Work clamped  
by means of  
dog

8  
Magnetic  
vice

The work may also be clamped with various types of clamps, or dogs. Some of them, and the ways in which they are used, are shown here.

Material of various thicknesses can be clamped by means of the hexagon at the rear. The adjusting screw is used for the same purpose (see fig. 6).

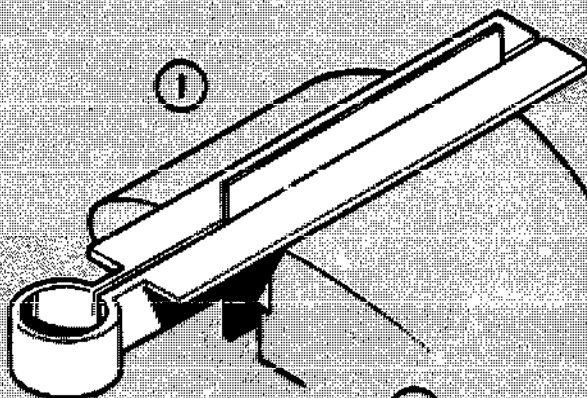
There are also magnetic vices.

For operations on thin sheet metal special folding bars may be used, or alternatively two pieces of angle section may be taken between which the work is clamped in a vice. If necessary a hand vice or G-cramp is also employed.

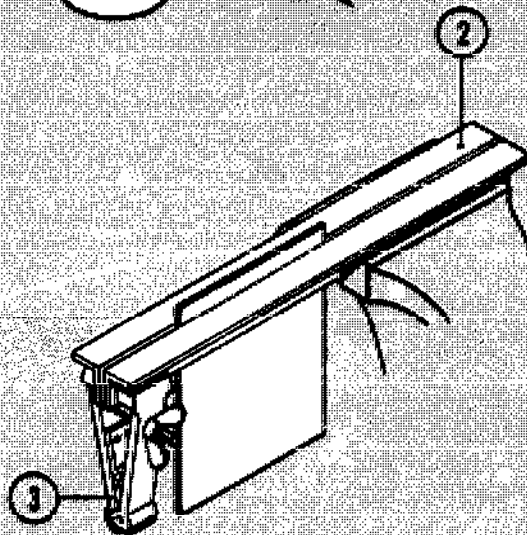
Folding bars are used for bending, chiselling, filing or other operations on sheet metal.

For filing, clamp the work as low as possible.

1  
Folding bars

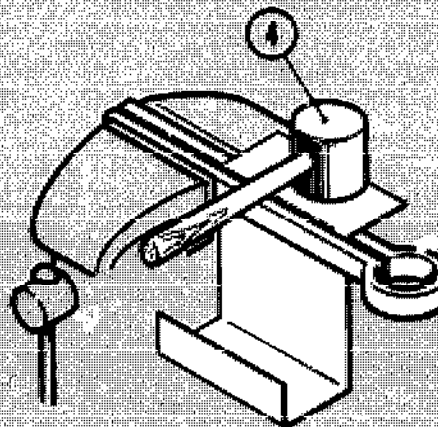


2  
Angle sections

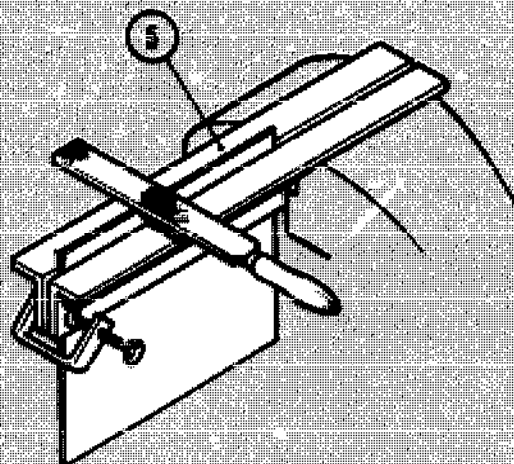


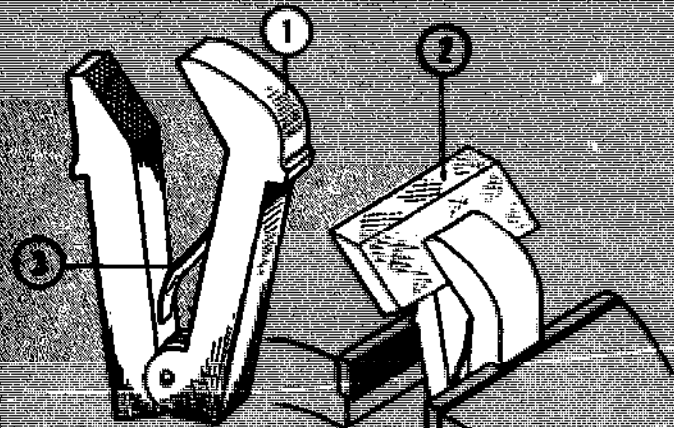
3  
Hand vice

4  
Rubber mallet



5  
Angle sections





1  
Angle vice  
2  
Bevelled  
edge

For special purposes there exist various types of clamping devices. A number of them, together with their uses are shown here.

3  
Spring

4  
Filing a  
bevelled  
edge

For filing a bevelled edge an angle clamp may be used.

5  
Clamping at  
angle

The work may also be clamped at an angle in the vice. If an angle clamp is used it is held in the vice.

6  
Hand vice

A hand vice is used for holding together a number of things, for instance when they have to be drilled. The hand vice is tightened by means of the wing nut.

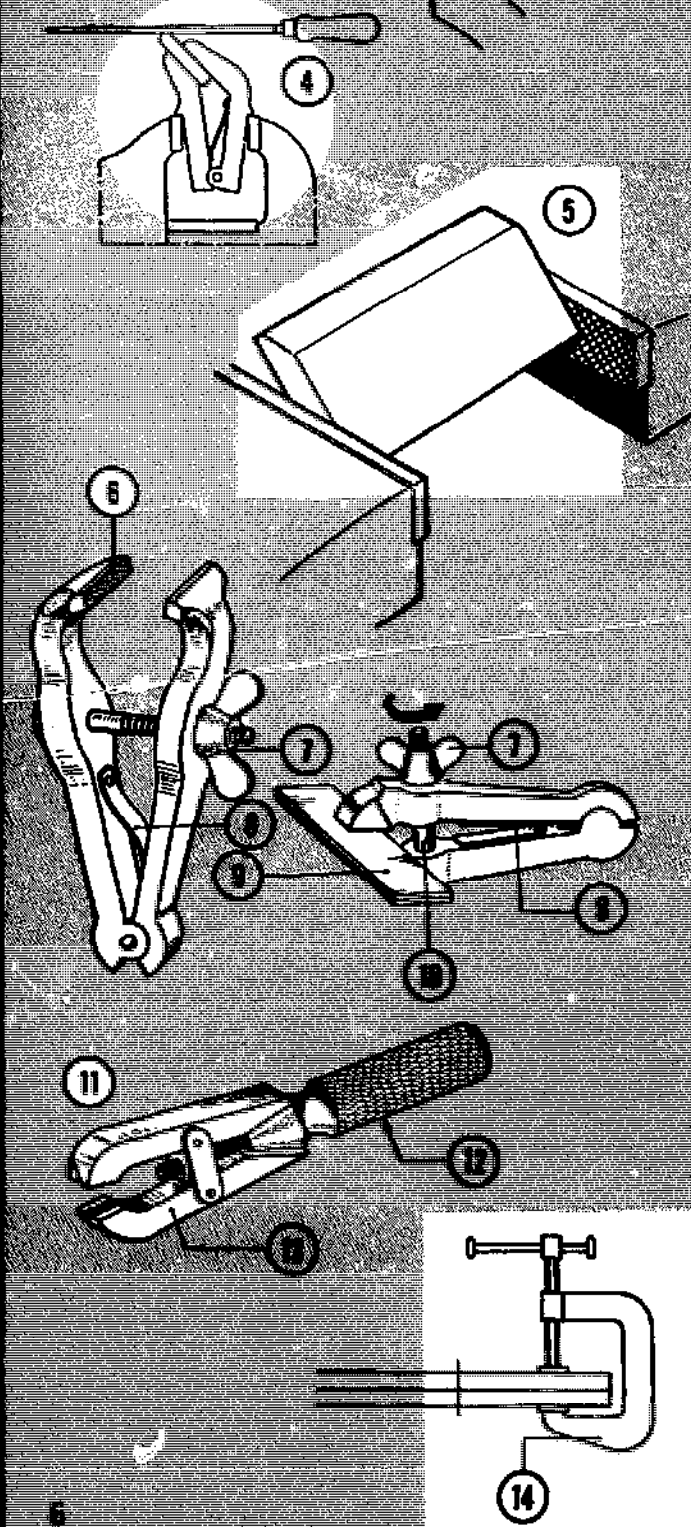
7  
Wing nut

8  
Spring  
9  
Workpiece  
10  
Stud

11  
Pin vice  
12  
Knurled  
handle  
13  
Jaws

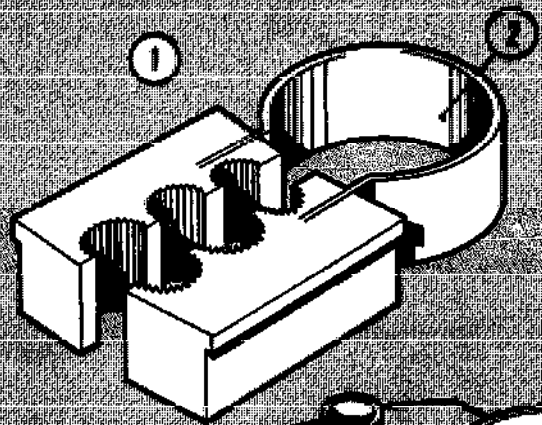
The pin vice. By turning the knurled handle the jaws are opened or closed.

14  
G-cramp

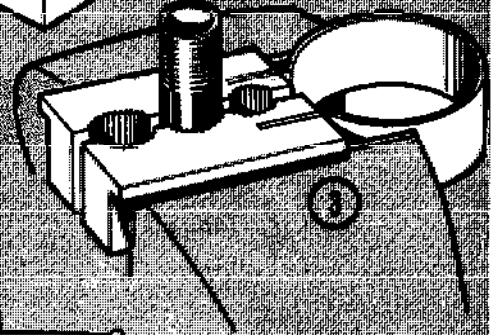


Pipes may easily be distorted if they are clamped in the vice.  
Therefore they may be held in a pipe clamp.

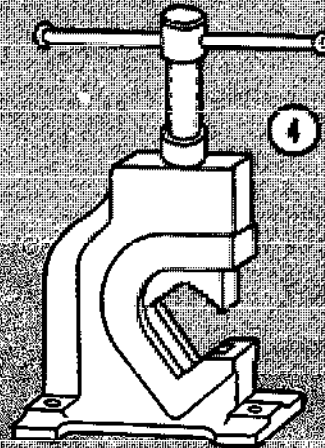
- 1 Pipe clamp
- 2 Spring



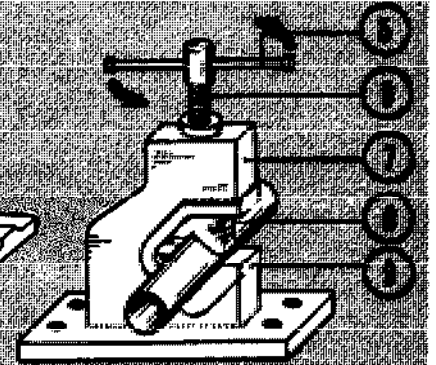
- 3 Pipe clamp in vice



- 4 Yoke vice



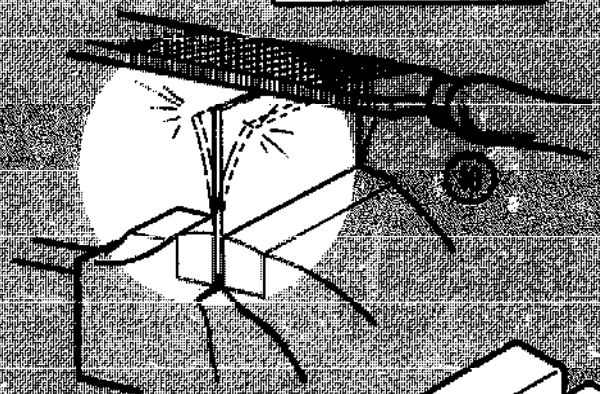
- 5 Handle
- 6 Threaded spindle
- 7 Yoke
- 8 Movable jaw
- 9 Solid jaw



**A few instructions:**

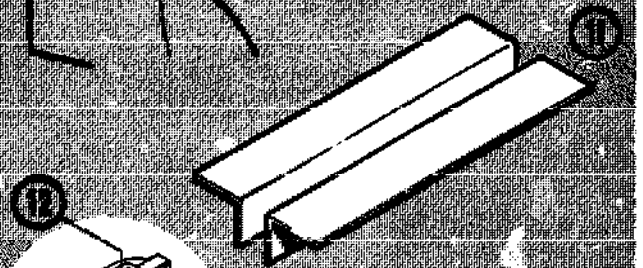
— Clamp the work as low as possible. It makes working less noisy and saw or file will live longer as teeth will not break so easily.

- 10 Work too high in vice



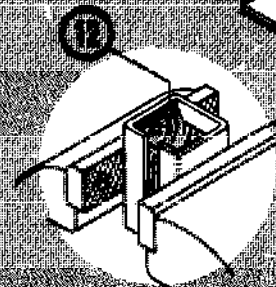
— If necessary use vice clamps to prevent finished parts from being damaged. Before clamping remove any filings from jaws or clamps.

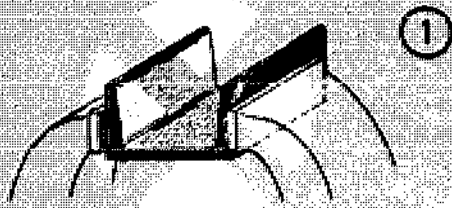
- 11 Vice clamps



— Avoid distortion of the work by using packings.

- 12 Wooden packing

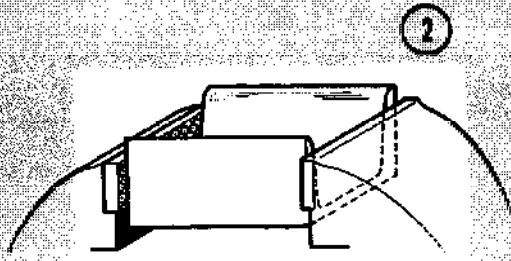




1  
Wrong

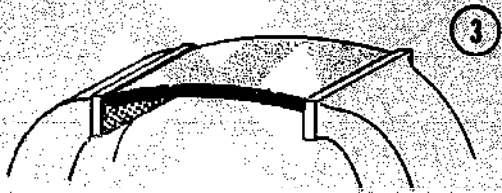
Examples of correct and incorrect clamping.

In fig. 1 the channel section will bend when the vice is tightened.



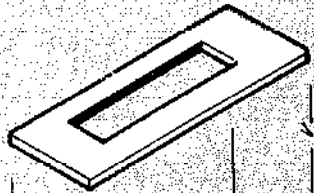
2  
Correct

In fig. 2 no distortion will occur.



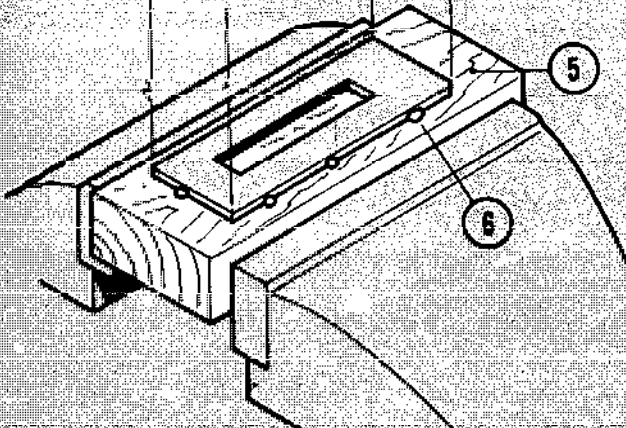
3  
Wrong

If a long, thin workpiece is clamped lengthwise it may collapse.

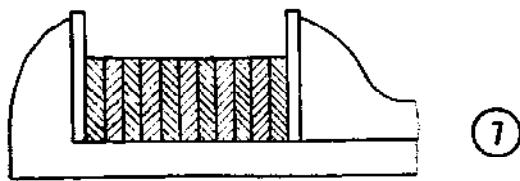


4  
Correct

Therefore it should be either clamped crosswise or else supported by a piece of wood to which it is fastened by means of panel pins.

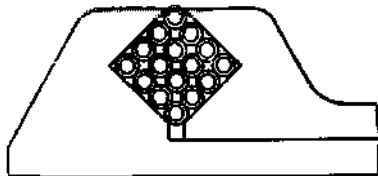


5  
Piece of wood  
6  
Panel pins



7  
Clamping together

If a number of pieces of the same length are to be cut off they may be clamped together in a machine vice.



8

## INTEMS PICTORIAL SYSTEM

## HAND TOOLS

By hand tools are meant hammers, spanners, pliers, wrenches, screwdrivers, drifts and punches.

In this lesson some types of each and their uses are discussed.

1  
Hammer

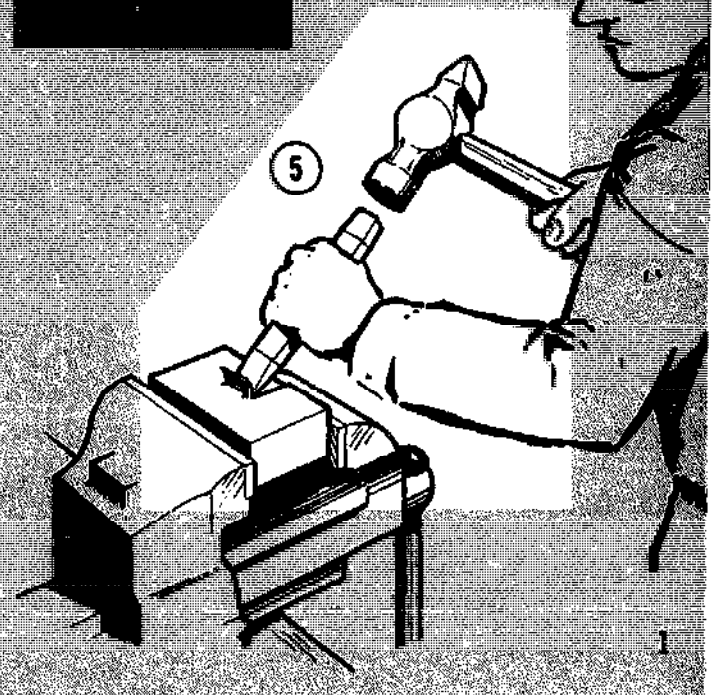
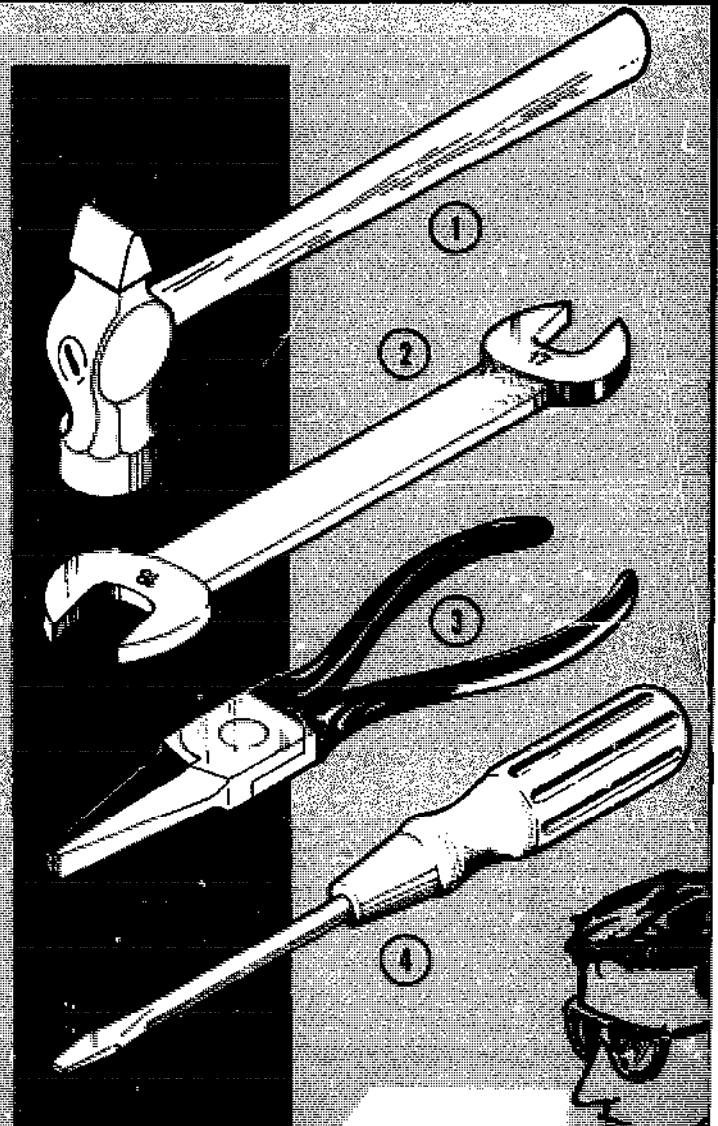
2  
Spanner

3  
Pliers

4  
Screwdriver

5  
Use of  
hammer

A hammer can be used for many purposes. The man in fig. 5 is busy chiselling.





## HAMMERS

1  
Head

The two parts of a hammer are the head and the handle.

2  
Handle

The parts of the head are called the face, the cheek, the pein.

3  
Pein

For general fitting work the cross pein hammer, shown in fig. 1 is used.

4  
Cheek

5  
Face

6  
Ball pein

There are also ball pein hammers.

For light work a light hammer is used, for heavy work a heavy hammer.

7  
Hammer

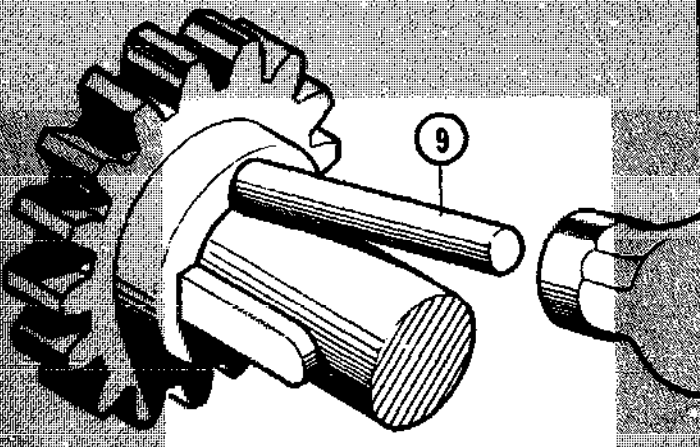
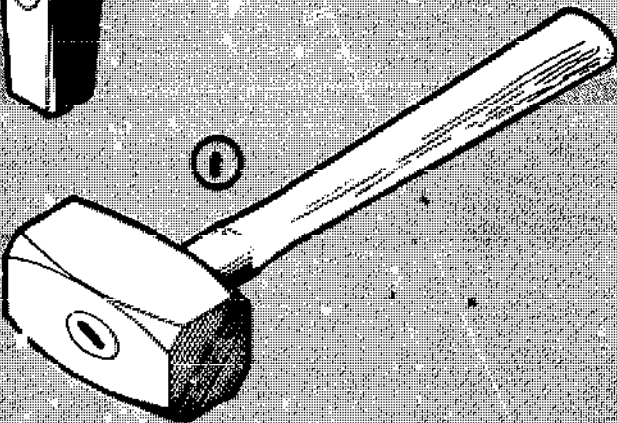
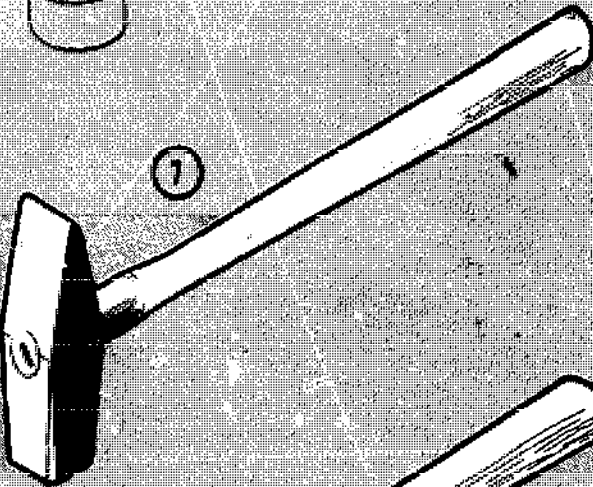
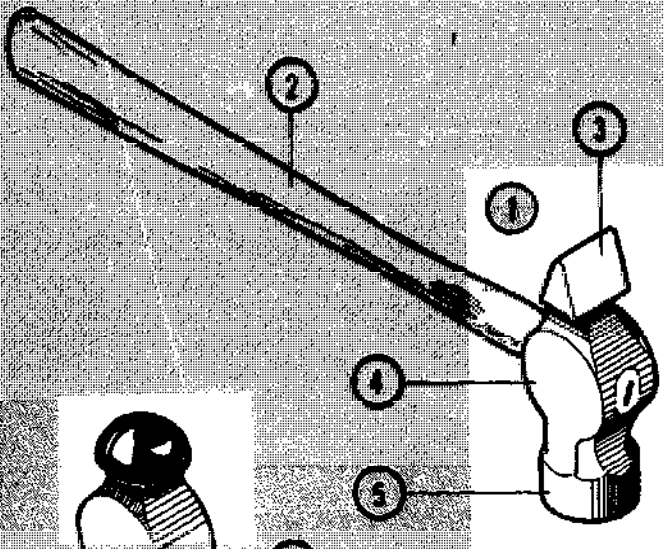
In fig. 7 a different type of hammer is shown. Where is the face, where the pein here? (Mark face X, mark pein XX). This hammer is often used for riveting.

8  
Copper  
hammer

The copper hammer shown in fig. 8 is used for assembling and disassembling machine parts which must not be damaged.

9  
Copper peg

Instead of a copper hammer, a piece of wood or a copper peg may be used. The copper peg is used as a tool. In this case the hammer need not be a copper one.



## MALLETS

Other hammers used for working on machinery are:  
the wooden mallet  
the rawhide mallet  
the plastic mallet  
the copper mallet

The heads of plastic mallets are often interchangeable.

For sheet metal work a rubber mallet is used.

1  
Wooden  
mallet

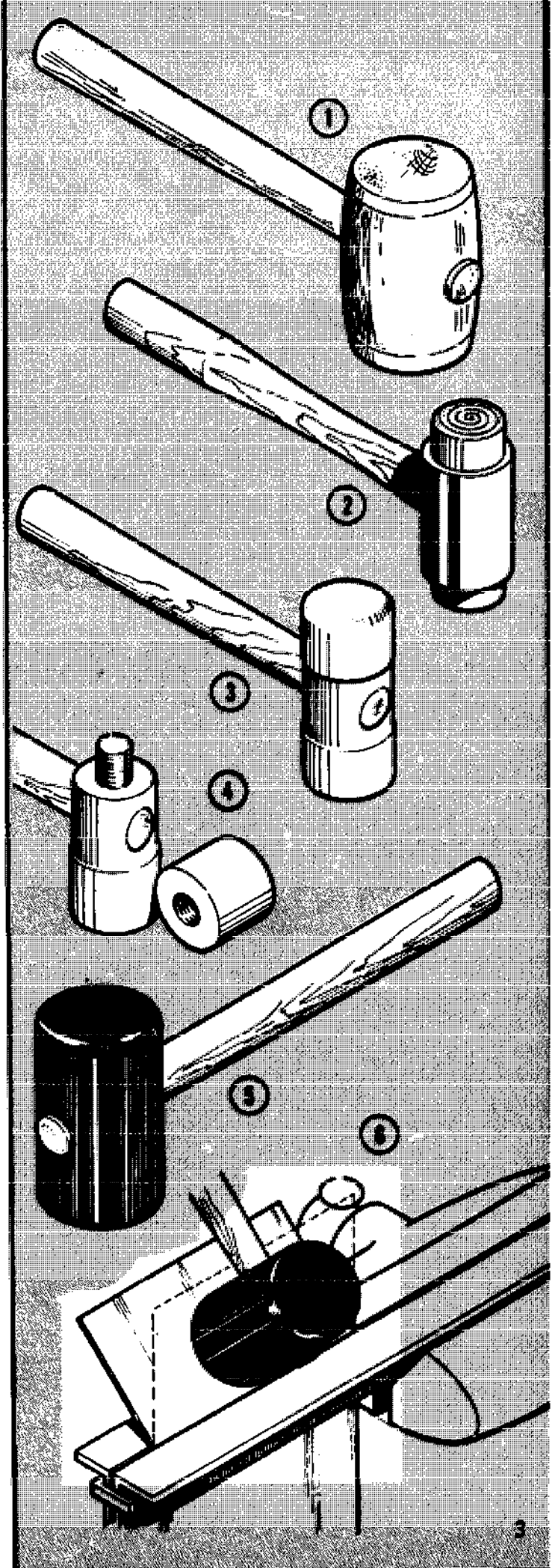
2  
Rawhide  
mallet

3  
Plastic  
mallet

4  
Inter-  
changeable  
head

5  
Rubber  
mallet

6  
Sheet  
metal work



1  
Handle

2  
Head

3  
Wedge

4  
Position  
of wedge

5  
Holding a  
hammer

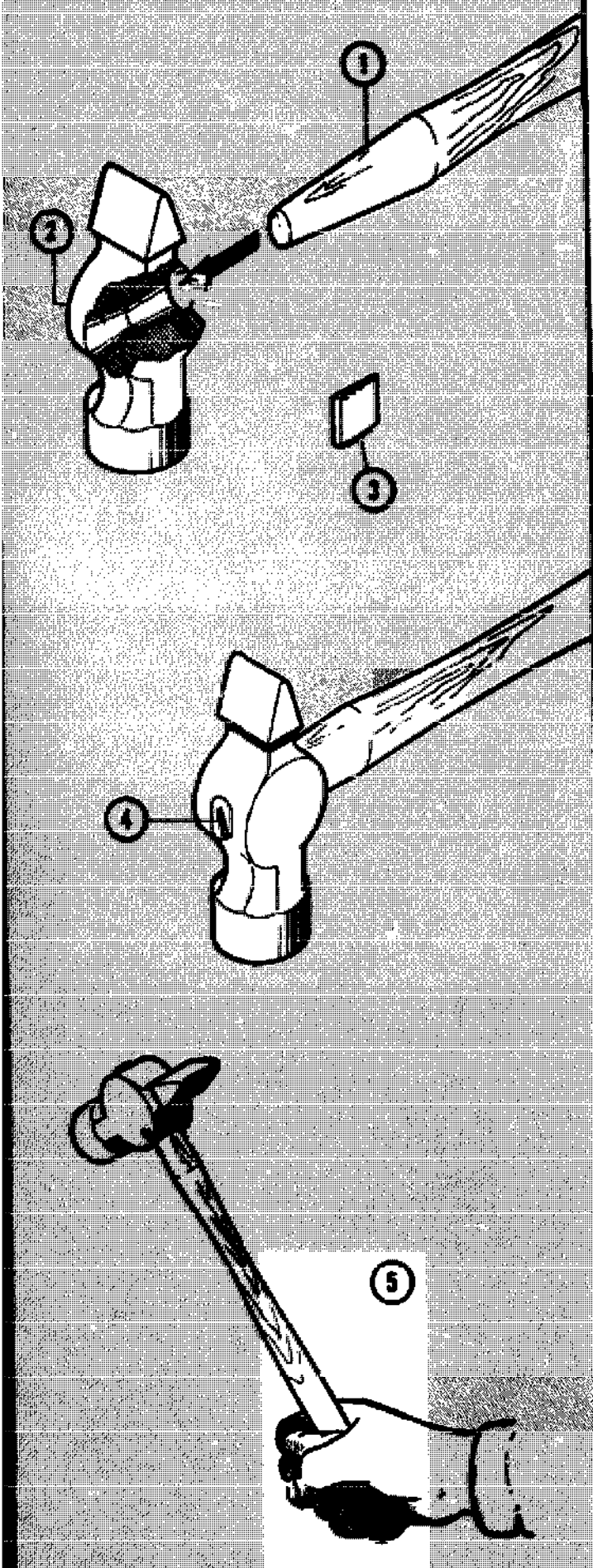
The handle should fit tightly in the eye of the hammer head. The eye is narrower in the middle.

By driving a wedge into the upper end of the handle, the shaft is made to expand and thus secures the head tightly.

Note the position of the wedge.

The hammer is always held by the end of the handle, which acts more or less as a spring and enables heavier blows to be given.

If the thumb is placed on the top of the shaft, the striking movement is more accurate. This is especially so for forgework where directional blows are important.



## SPANNERS

Spanners are used for tightening and loosening bolts and nuts.

1  
Bolt and  
nut

2  
Tightening  
a nut

A DOUBLE ENDED SPANNER is shown here.

3  
Jaw

4  
Centre bar

For each size of nut or screw head a fitting spanner should be used.

5  
Nut gap

The width of the nut gap is indicated on the jaw either in millimetres or in inches.

6  
Nut gap  
size in  
mm.

The bar is at an angle of  $15^{\circ}$  to the jaw so that a turning angle of  $30^{\circ}$  is sufficient if space is limited. The spanner can then be used in two ways.

7  
Nut gap  
size in  
inches

8  
Position  
for  
tighteni  
in two  
ways

# SPANNERS

Spanners are used for tightening and loosening bolts and nuts.

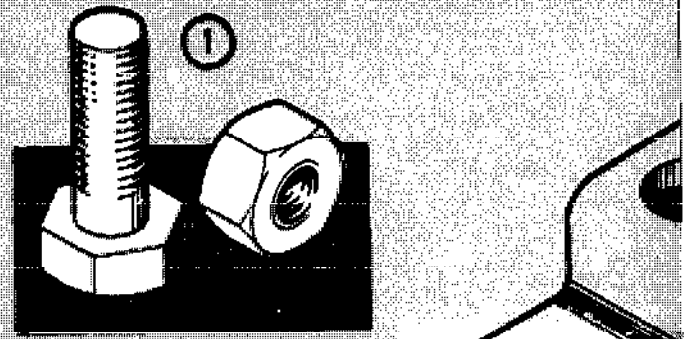
A DOUBLE ENDED SPANNER is shown here.

For each size of nut or screw head a fitting spanner should be used.

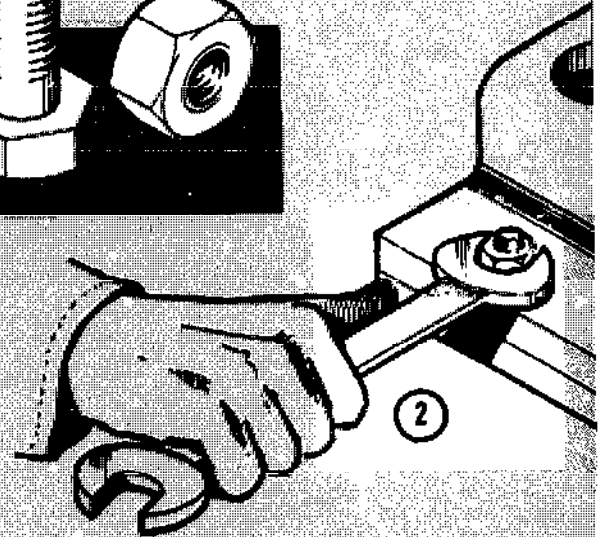
The width of the nut gap is indicated on the jaw either in millimetres or in inches.

The bar is at an angle of  $15^\circ$  to the jaw so that a turning angle of  $30^\circ$  is sufficient if space is limited. The spanner can then be used in two ways.

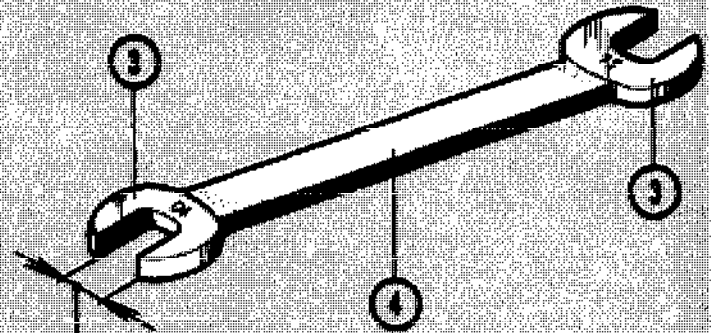
1 Bolt and nut



2 Tightening a nut



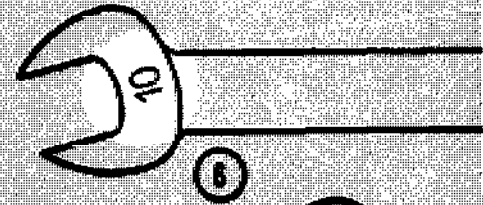
3 Jaw



4 Centre bar



5 Nut gap

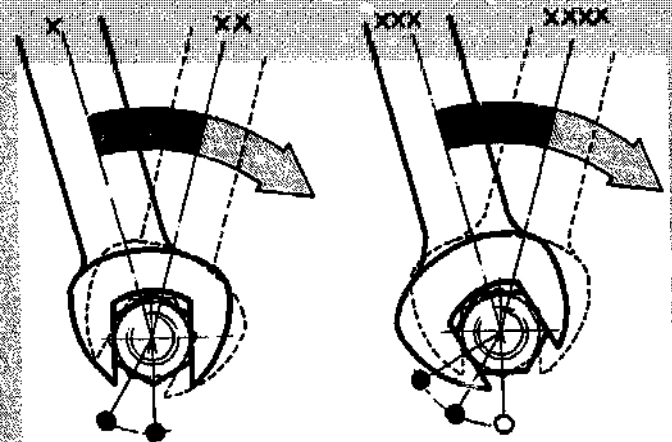


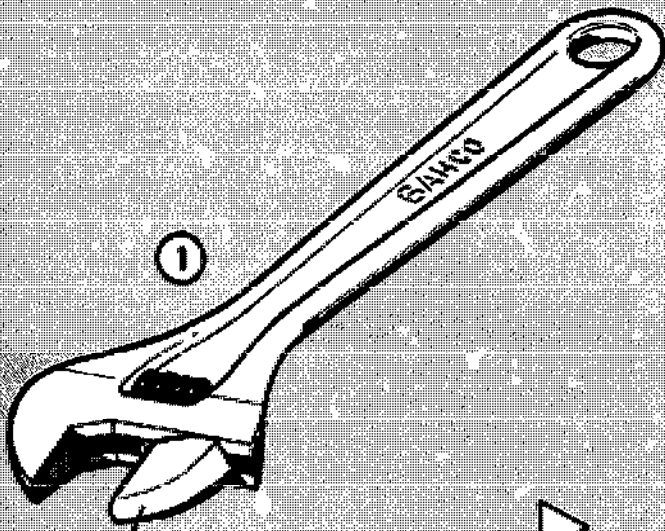
6 Nut gap size in mm.

7 Nut gap size in inches



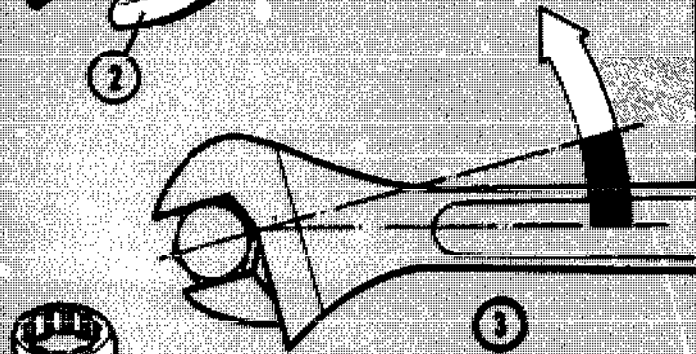
8 Position for tightening in two ways



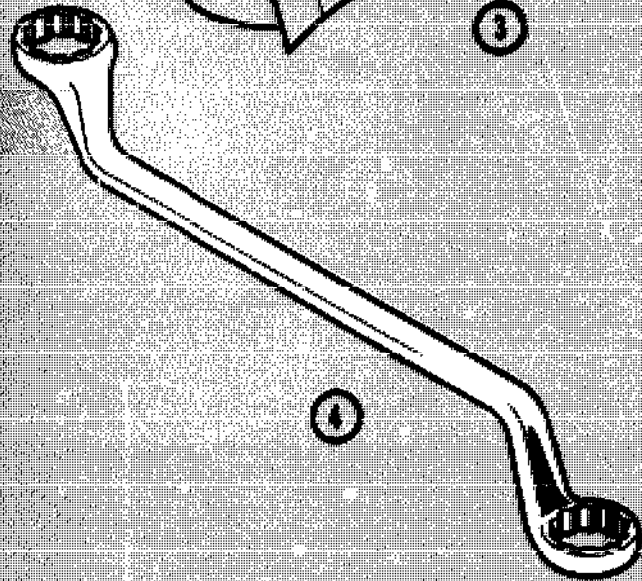


1  
Adjustable  
spanner  
(adjustable  
wrench)

In an ADJUSTABLE SPANNER the jaw width can be adjusted so that fewer spanners are needed.

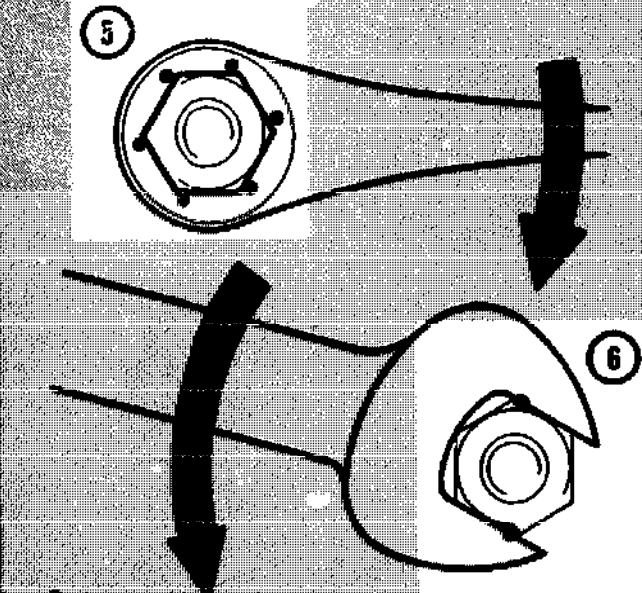


2  
Adjustable  
jaws



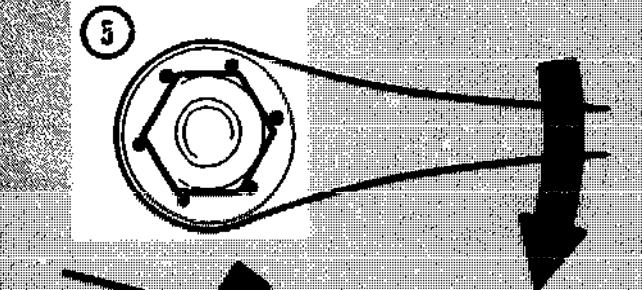
3  
Position  
for  
loosening

The bar of an adjustable spanner is also at an angle of  $15^{\circ}$  to the jaws.



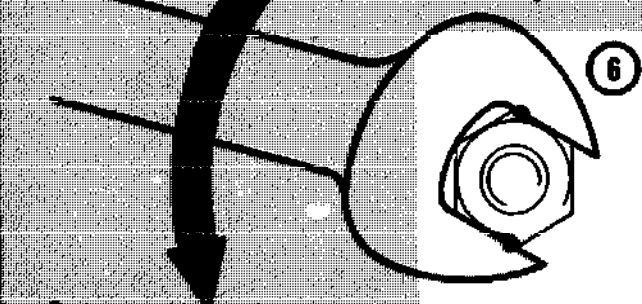
4  
Ring  
spanner  
(box  
spanner)

Usually RING SPANNERS are double ended. The holes are hexagonal or dodecagonal.



5  
Ring  
spanner  
grips at  
six places

Ring or box spanners grip the nut at six places, so the chance of slipping and damage is smaller. Therefore a ring spanner is safer.



6  
Open end  
spanner  
grips at  
two places

**SOCKET WRENCHES** consist of a handle and a square key part on which different sockets can be fitted.

On one side of the socket is a hexagonal or dodecagonal opening fitting the screw head or nut. On the other side is a square opening fitting the square key part of the handle.

Handles come in different types.

There also are fixed socket wrenches.

1  
Handle

2  
Square key part

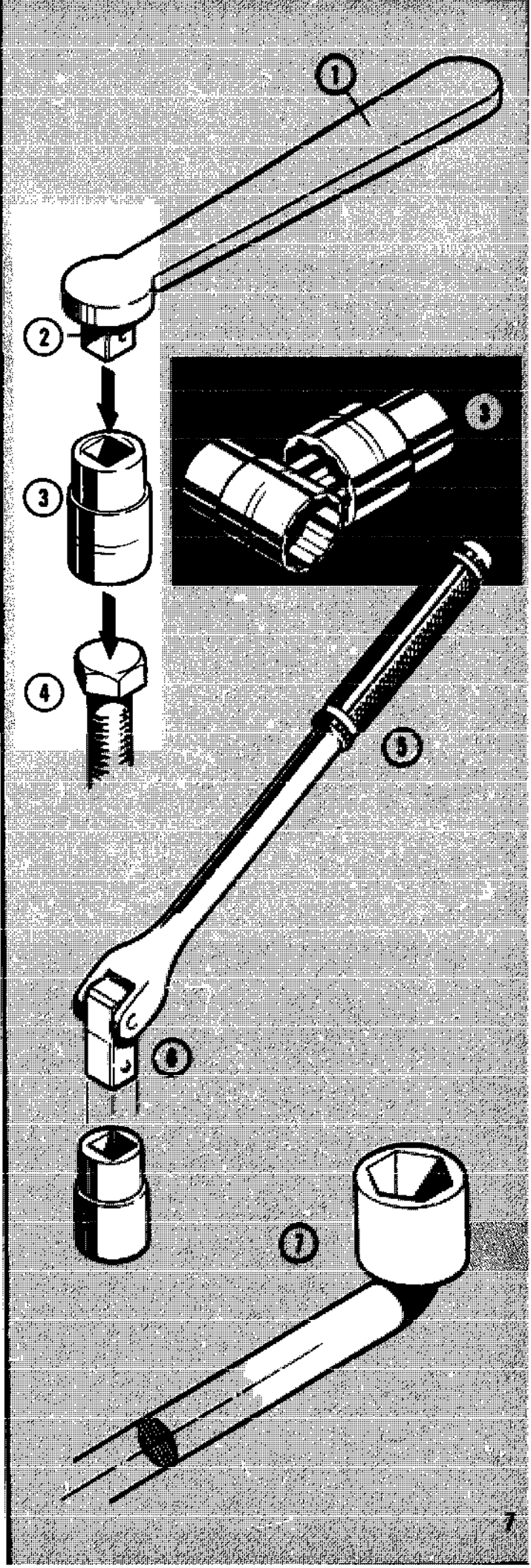
3  
Sockets

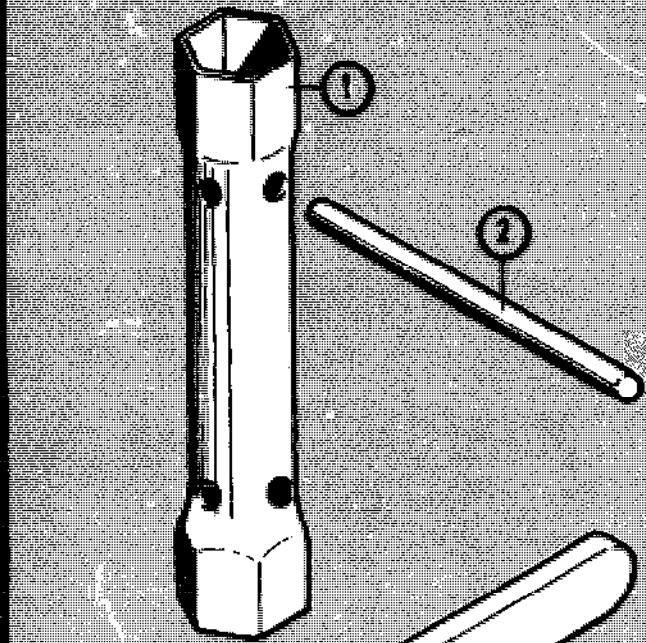
4  
Bolt

5  
Handle for use with hinged key

6  
Hinged square key

7  
Fixed socket wrench



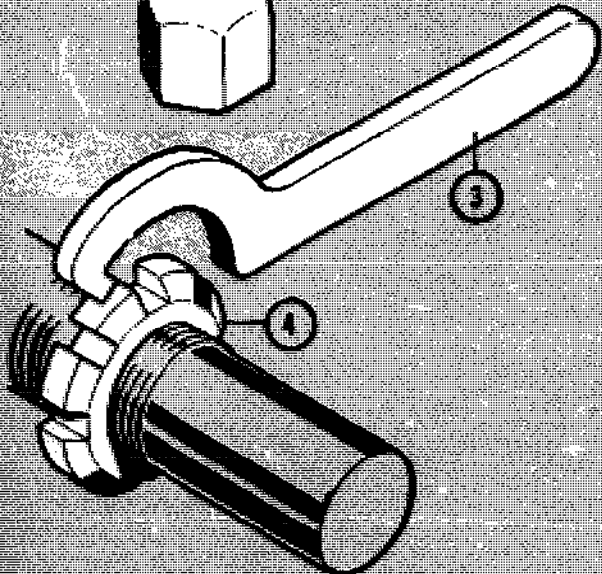


1  
Tubular box  
spanner

A TUBULAR BOX SPANNER has a hexagonal opening at both ends.

2  
Tommy bar

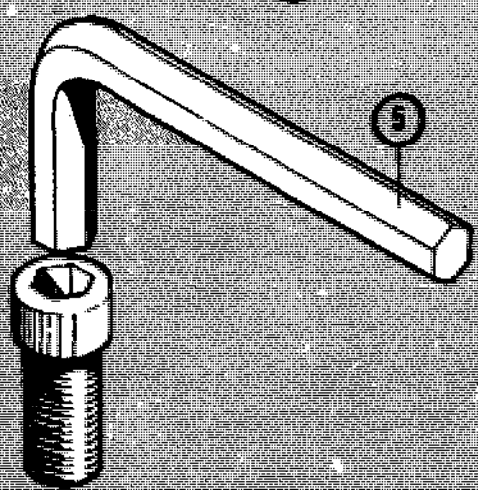
To turn the spanner a detachable tommy bar is slid into two holes. These spanners are used in difficult places.



3  
Hook  
spanner

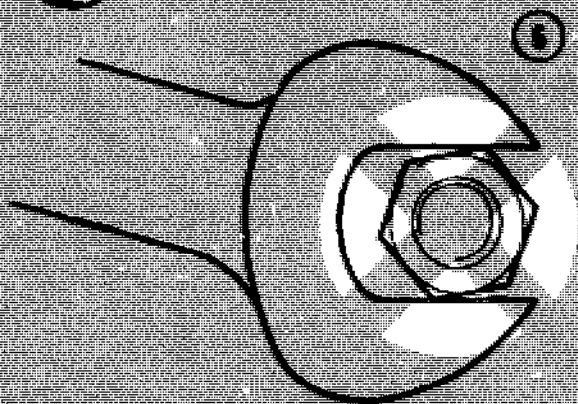
HOOK SPANNERS are used for tightening or loosening ring nuts.

4  
Ring nut



5  
Hexagon  
wrench  
key

Socket head screws have a hexagonal opening in the head. Such a screw is turned by means of a HEXAGONAL WRENCH KEY.



6  
Use the  
right  
spanner

Never use worn out spanners, or spanners of which the size of the nut gap is too wide. They may slip off the nut or bolt and cause accidents, or damage heads or nuts.



## WRENCHES, PLIERS, ETC.

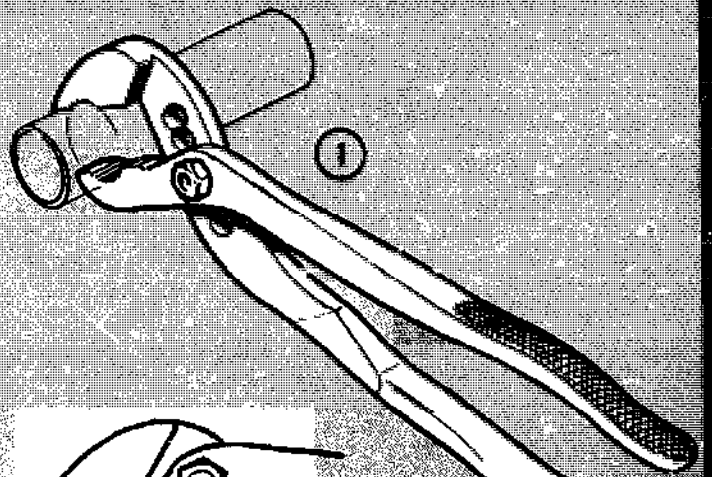
Pliers and grips are used for:  
holding,  
tightening and loosening,  
bending,  
cutting.

The pipe wrench has an adjustable pivot point enabling pipes of different sizes to be gripped.

Combination pliers can be used for various purposes:  
bending,  
cutting,  
holding pipes.

Sometimes the handles are covered with rubber or plastic. This type of pliers is used by electricians to protect them against dangerous shocks when working on live parts.

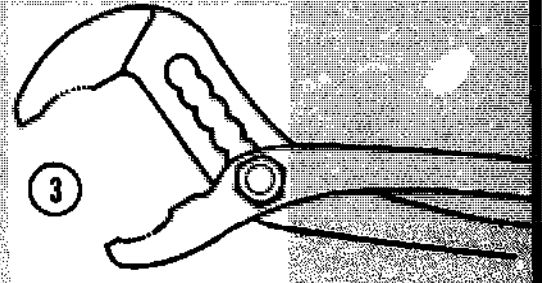
1  
Pipe wrench



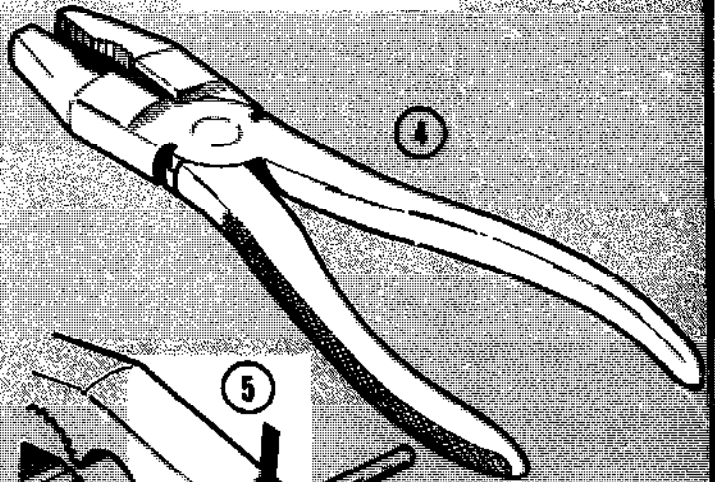
2  
Smallest position



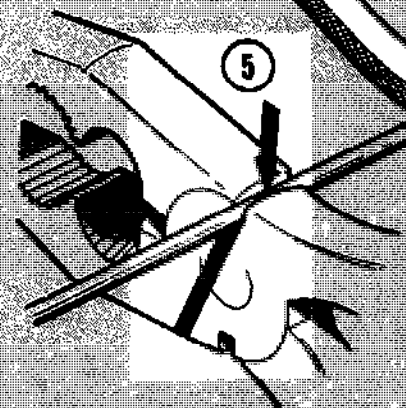
3  
Largest position



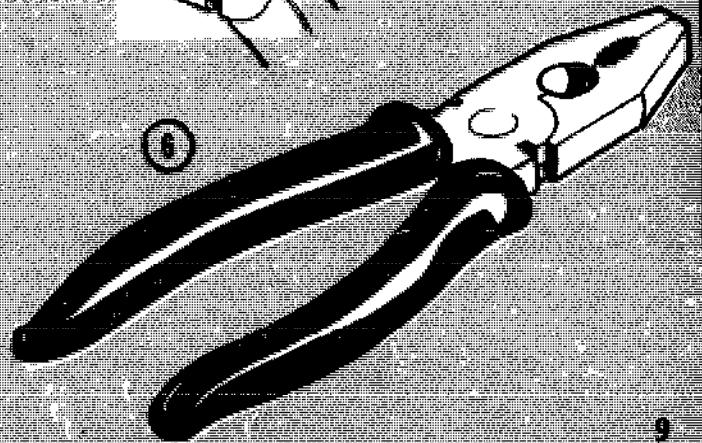
4  
Combination pliers



5  
Cutting a wire



6  
Insulated combination pliers



1  
Flat-nosed  
pliers

Flat-nosed pliers are used  
for light bending work.

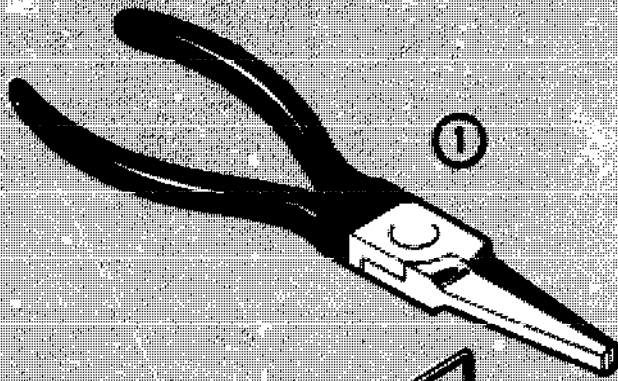
2  
Round-nosed  
pliers

Round-nosed pliers are used  
for bending curved and round  
shapes like eyes in metal  
wire.

3  
Pincers

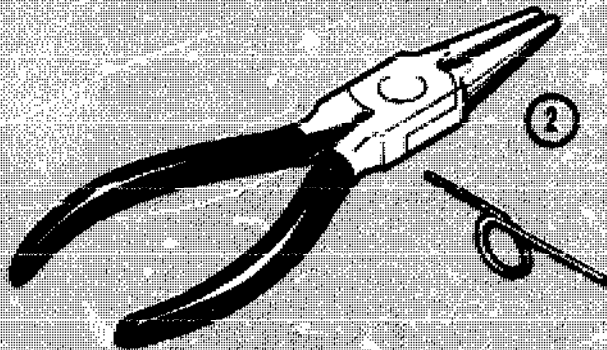
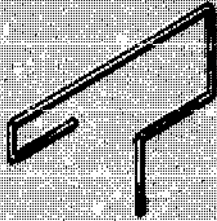
Pincers are used for  
removing nails and for  
cutting wire.

4  
Using a  
pair of  
pincers  
for  
removing  
a nail



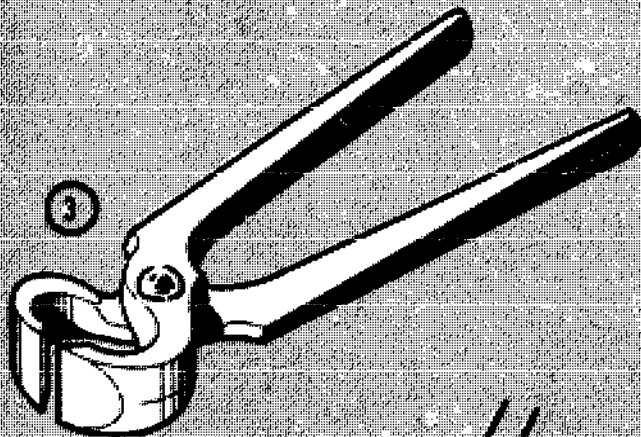
1  
Flat-nosed  
pliers

Flat-nosed pliers are used  
for light bending work.



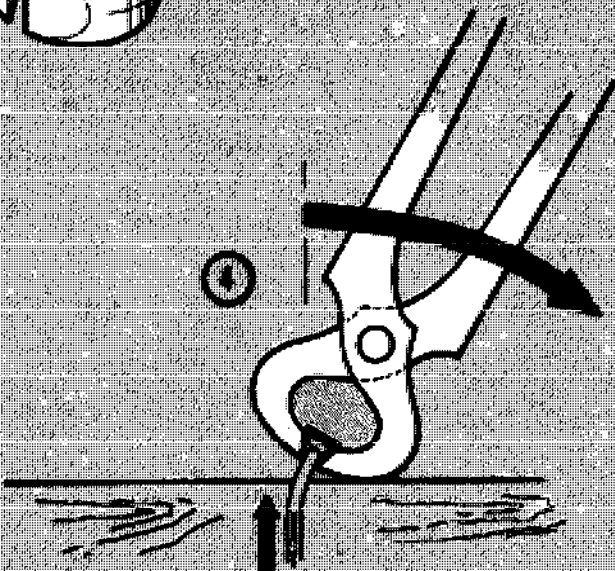
2  
Round-nosed  
pliers

Round-nosed pliers are used  
for bending curved and round  
shapes like eyes in metal  
wire.



3  
Pincers

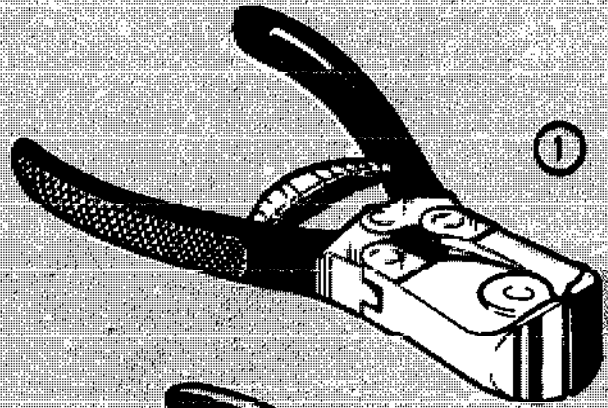
Pincers are used for  
removing nails and for  
cutting wire.



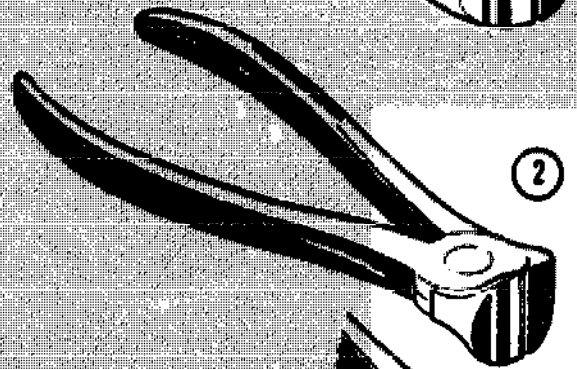
4  
Using a  
pair of  
pincers  
for  
removing  
a nail

Nippers are used for cutting wires. The lever type nippers can be used for cutting hard spring steel wire because greater force can be exerted.

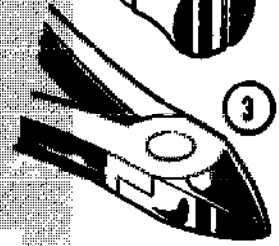
1  
Lever type  
top cutting  
nippers



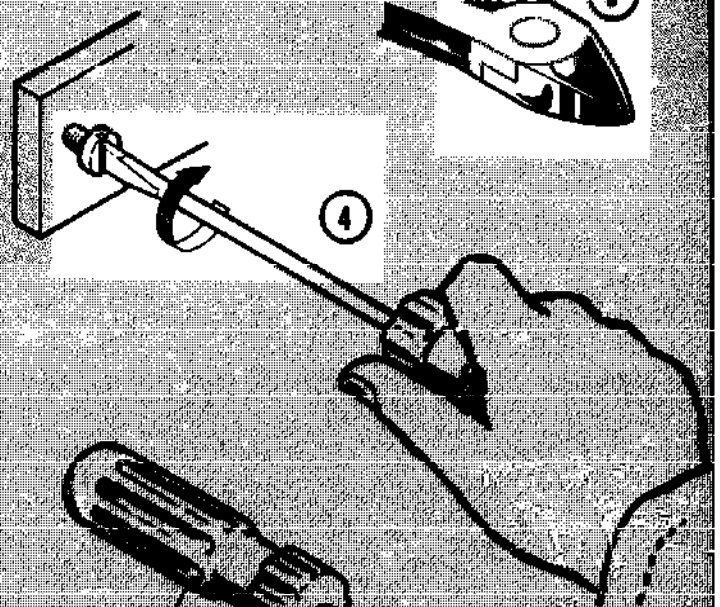
2  
Top cutting  
nippers



3  
Side cutting  
nippers



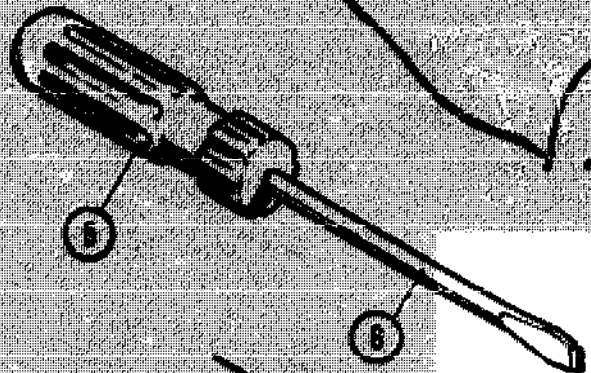
4  
Using a  
screwdriver



### SCREWDRIVERS

A screwdriver is used for fastening and loosening slotted screws. The slot of a screw is in the head.

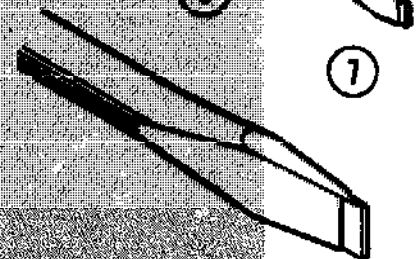
5  
Handle



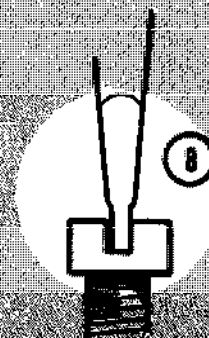
6  
Shank



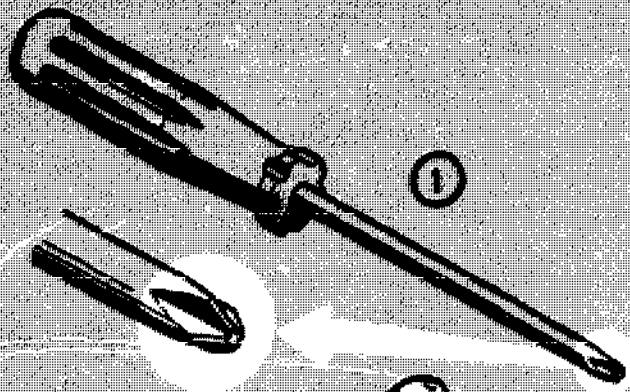
7  
Blade



8  
Shape of  
blade

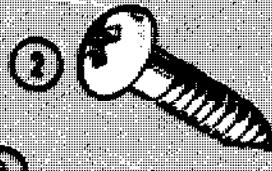
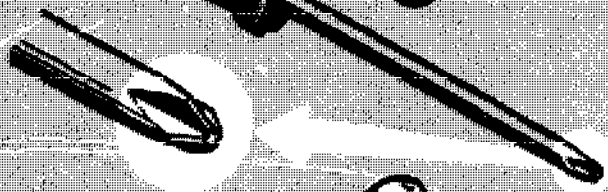


Always use a screwdriver fitting the slot in the screw head.



1  
Phillips  
screwdriver

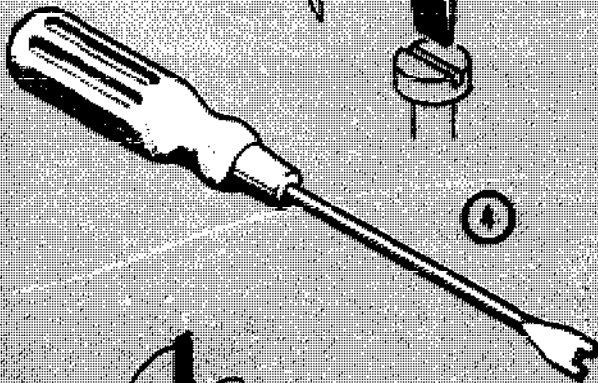
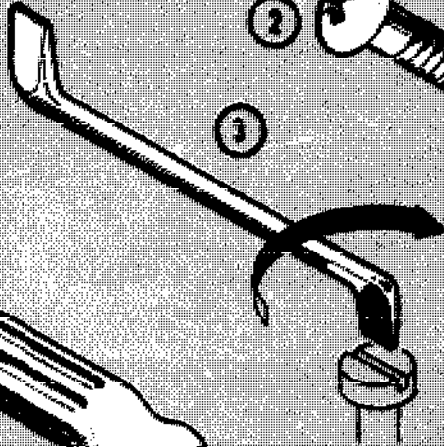
Screw heads with a cross-shaped socket are called Phillips heads. Special Phillips screwdrivers are used for them.



2  
Screw with  
Phillips  
head

3  
Offset  
screwdriver

In difficult places that cannot be reached by a common screwdriver an offset screwdriver may be used.



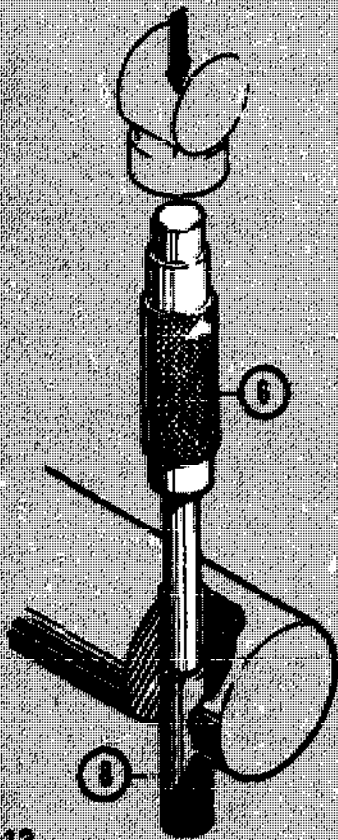
4  
Forked  
screwdriver

Forked screwdrivers are used for special purposes, for instance for slot nuts.



5  
Slot nut

### DRIFTS AND PUNCHES



6  
Drift

The drift is used for removing pins.

7  
Punch

The punch is used for making holes in thin sheet metal.

8  
Pin to be  
removed

## INTEMS PICTORIAL SYSTEM

## FILING

Filing is an operation through which the surface of a workpiece can be moulded by removal of very small particles (filings).

A file is a metal bar with a great number of teeth cut into it.

The sharp point on the end of a file is called the tang.

The length of the file containing the teeth is called the cutting length.

If one of the edges is not cut this is called the safe edge.

The handle is fitted on the tang.

On the handle is a steel ring, the ferrule, to prevent the handle from cracking.

1  
Filing

2  
Double cut  
file

3  
Tang

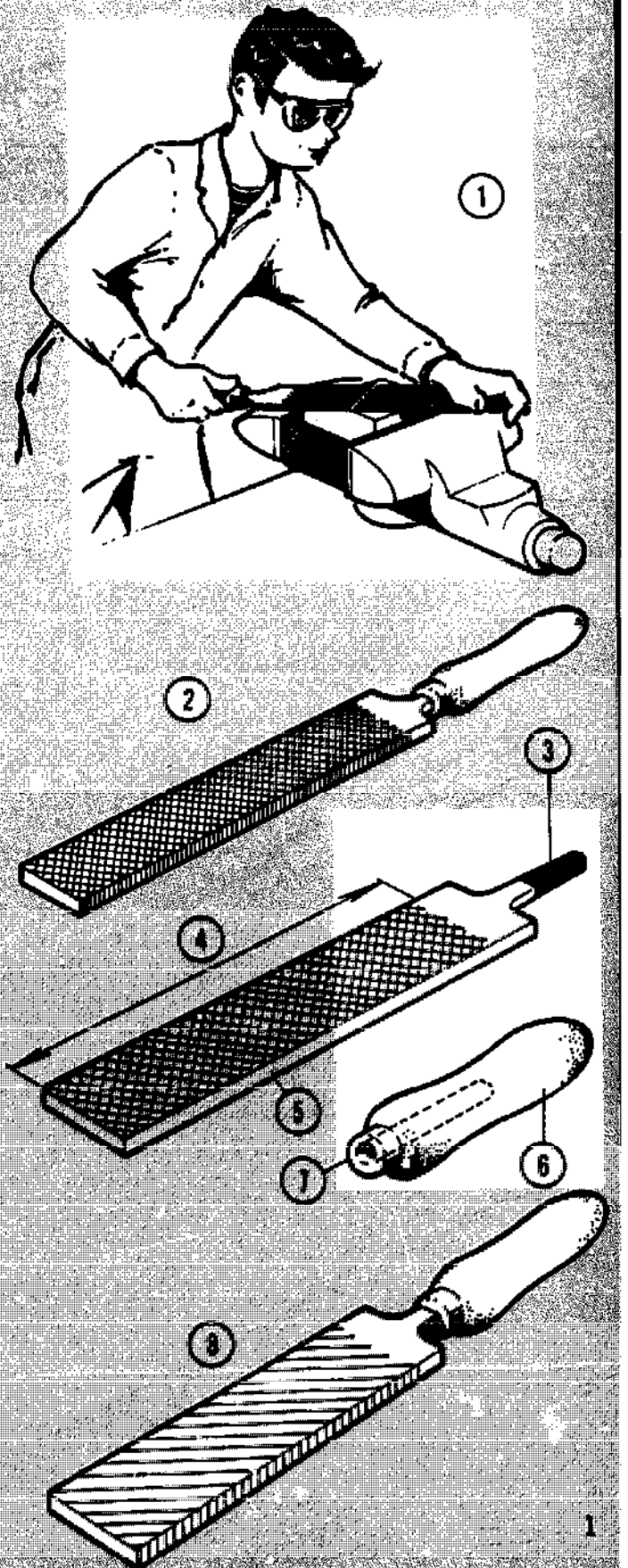
4  
Cutting  
length

5  
Safe edge

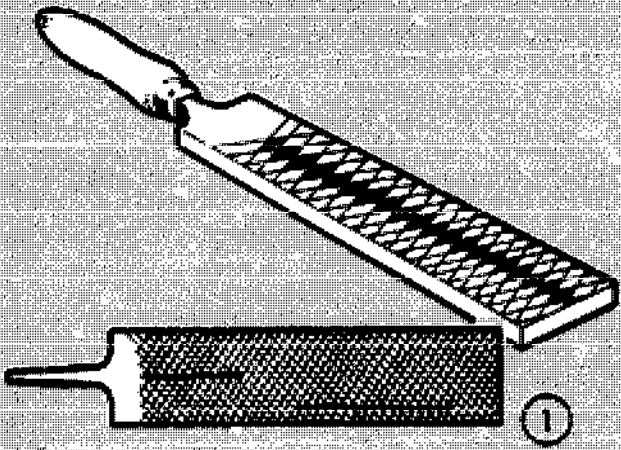
6  
Handle

7  
Ferrule

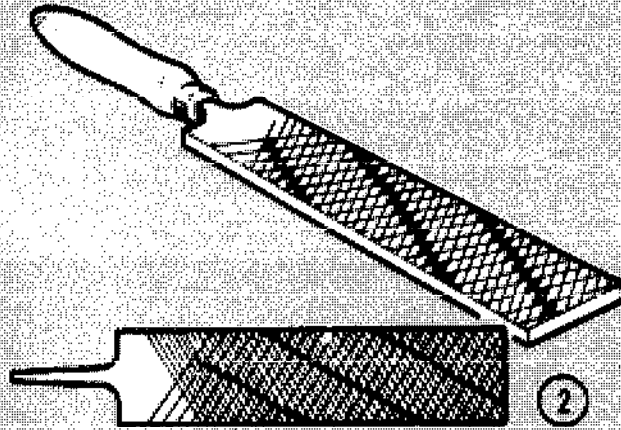
8  
Single cut  
file



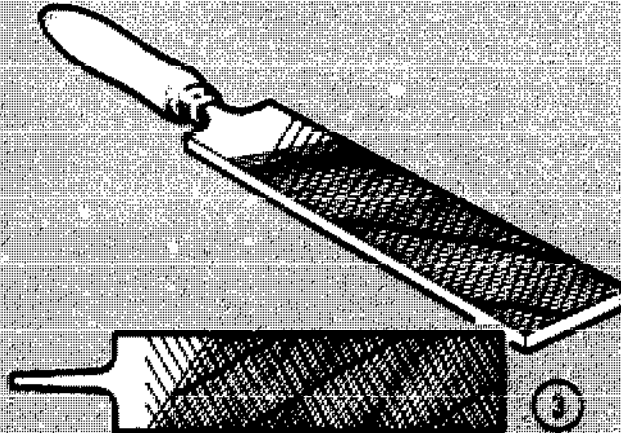
Depending on the way in which the cut is made, the patterns of the teeth have different names.



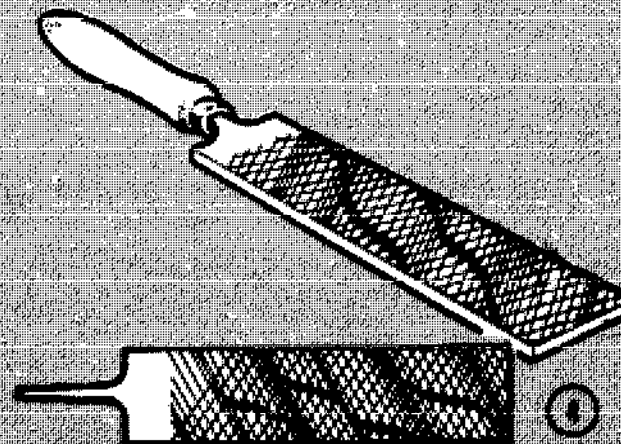
Straight track.



Right hand track.



Left hand track.



Wavy track.

Filing is frequently carried out to make surfaces level, and also for producing the surfaces illustrated in the figures 2 - 8.

By moving the file across the surface of the work we remove tiny particles called filings.

Surfaces at right angles.

Parallel surfaces.

Surfaces at an angle.

Surfaces with a specified degree of smoothness.

Fits between two parts.

See next page (4).

1  
Filings

2

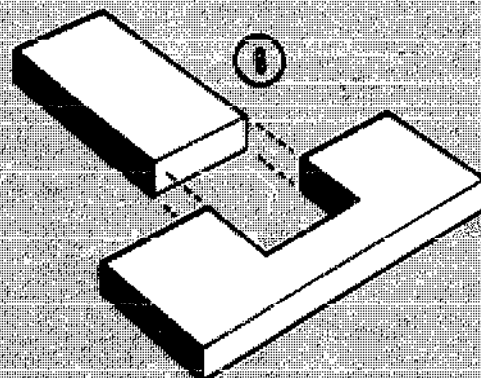
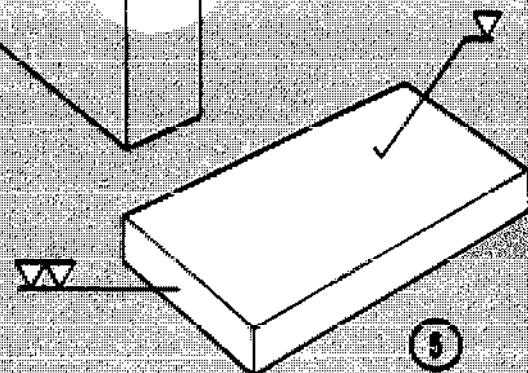
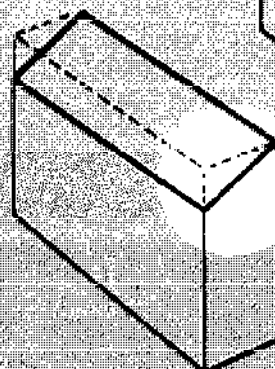
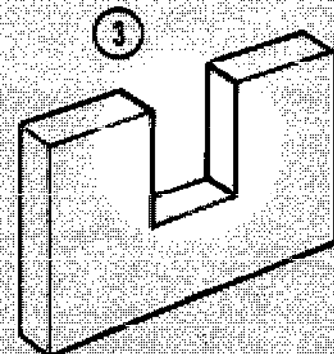
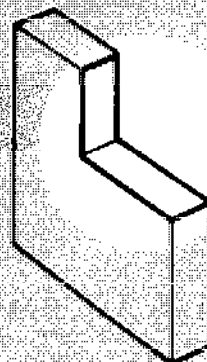
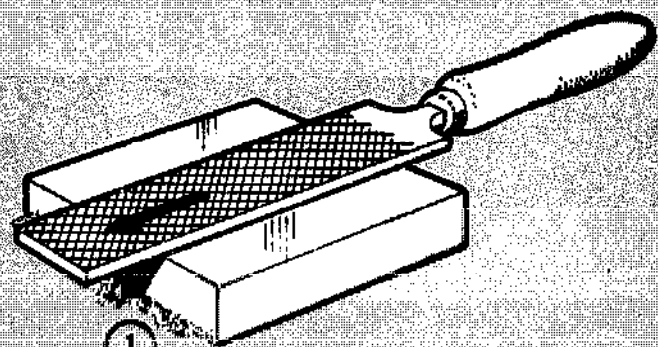
3

4

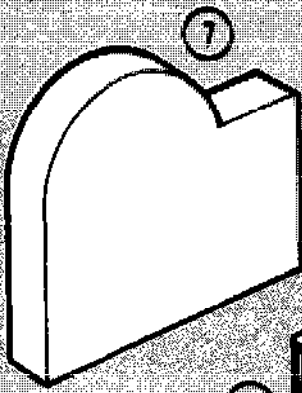
5

6

7 and 8

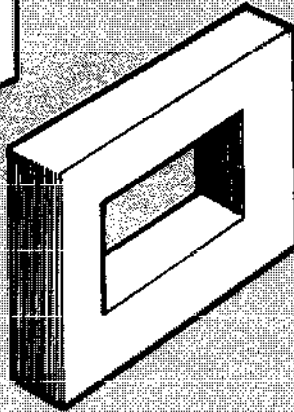






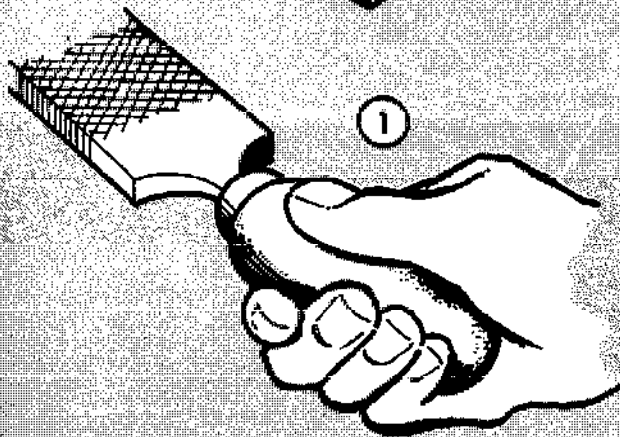
7

Rounds.



8

Inner cut-outs.



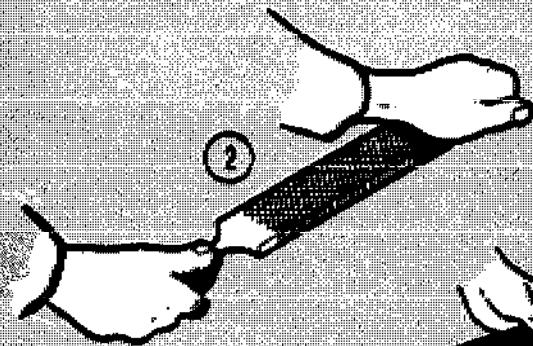
1

### HANDLING THE FILE

The thumb should rest lightly on the handle. By pushing with the palm the file is moved forward across the work, the left hand pressing on the end of the file.

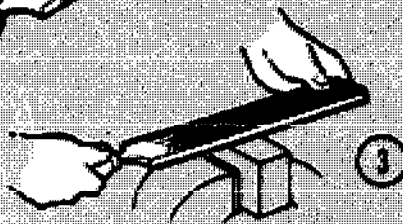
The file teeth will stay sharper if you do not press during the backward stroke.

Figures 2 to 5 show the position of the hands for some special operations.



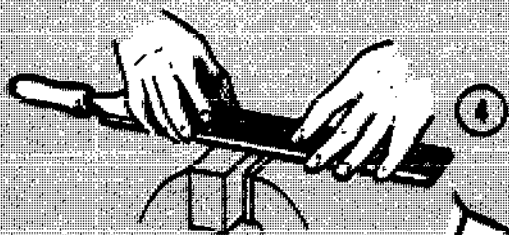
2

For heavy work.



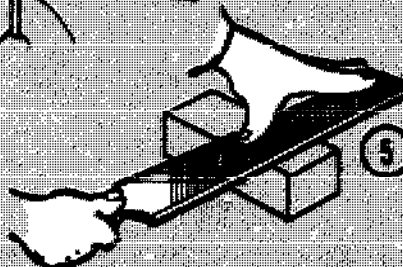
3

For light work.



4

For finishing off.



5

For removing local unevennesses.

For narrow surfaces the file is held at an angle of 15 degrees.

For large surfaces the file should be used crosswise, i.e. the strokes should alternate in direction.

Curved surfaces are first given their rough outline. Then they are filed accurately to shape.

The method of filing shown here is a combination of straight and rotating movements.

For curved inner surfaces a half-round file is used.

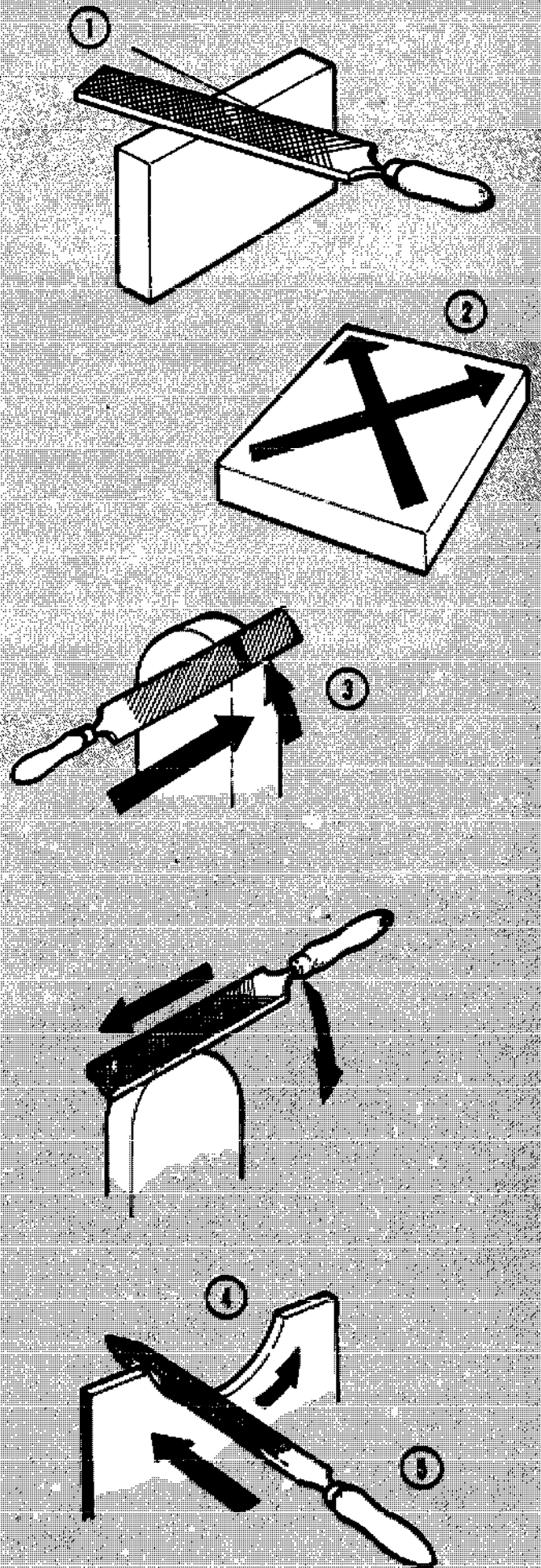
1  
Angle 15°

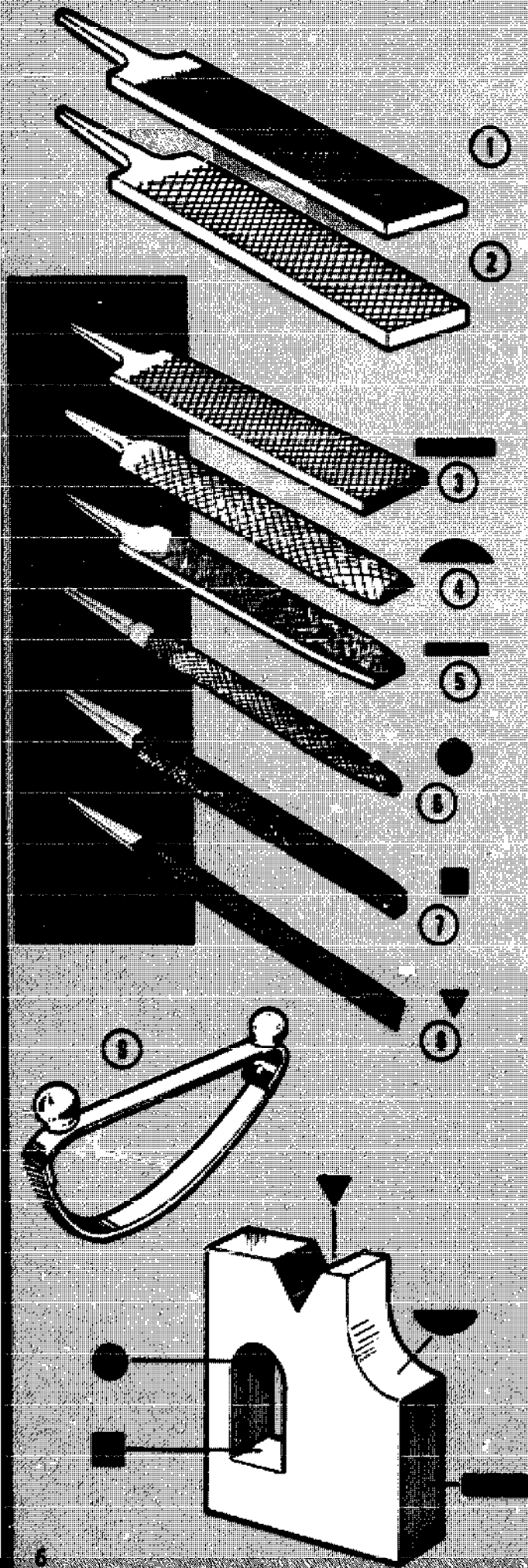
2  
Crosswise  
filing

3  
Curved outer  
surfaces

4  
Curved inner  
surfaces

5  
Half-round  
file





1  
Smooth file

2  
Bastard file

3  
Hand flat  
file

4  
Half-round  
file

5  
Flat file

6  
Round file

7  
Square file

8  
Three-square  
file

9  
Curved file  
with holder

The coarseness of a file depends on the number of teeth per cm or inch.

A smooth file has more teeth per cm or inch than a bastard file.

Files are classified according to their sections.

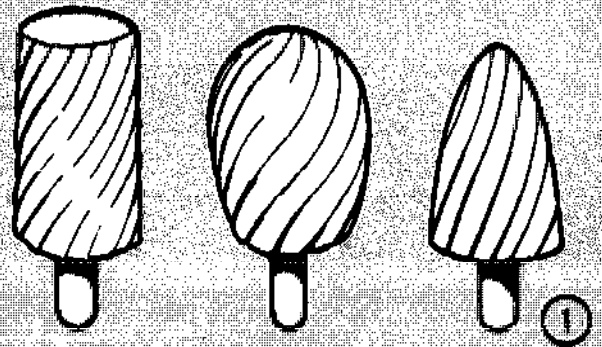
The curved file is much used in the car industry.

Some types of work for which the various files are used.

# MACHINE FILING

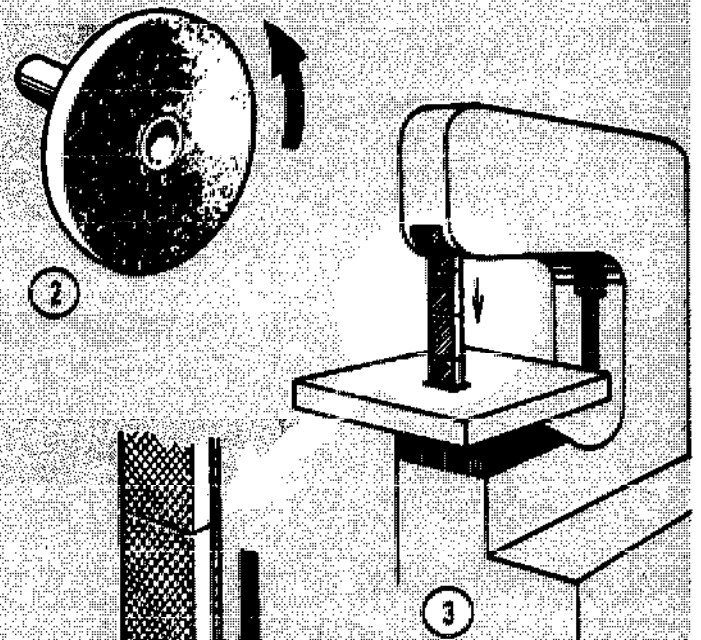
Rotary files are power tools and can, for instance, be inserted in the chuck of a power drill. They come in various shapes.

1 Rotary files



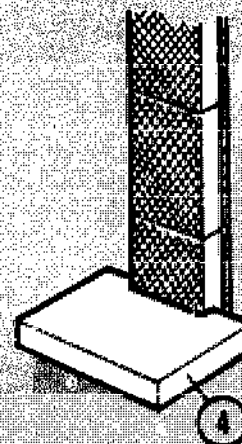
There are two types of filing machines; illustrated in figs. 3 and 5.

2 Rotary filing disc



The band runs in one direction.

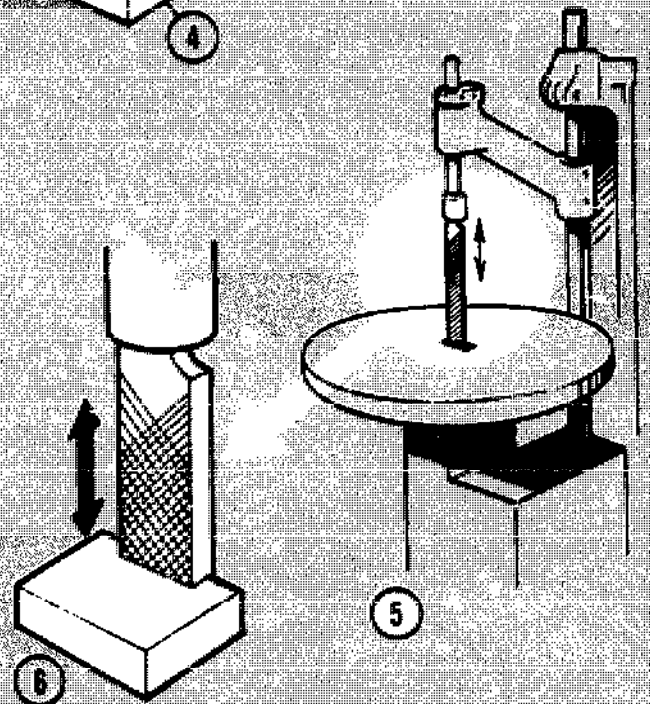
3 Filing machine with endless band



An enlarged part of the filing band with the workpiece is shown here.

4 Workpiece

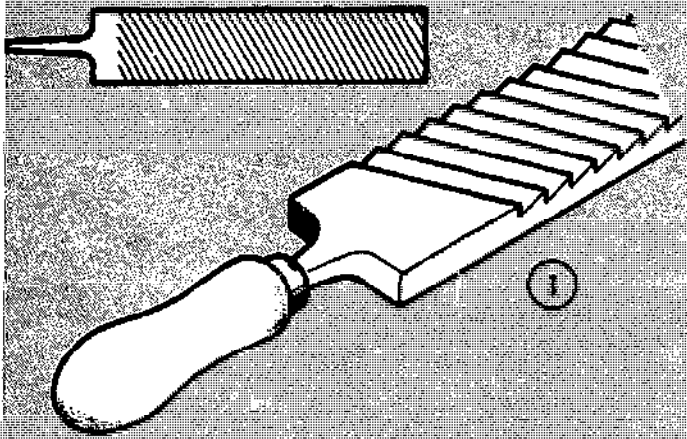
5 Filing machine with a reciprocating file



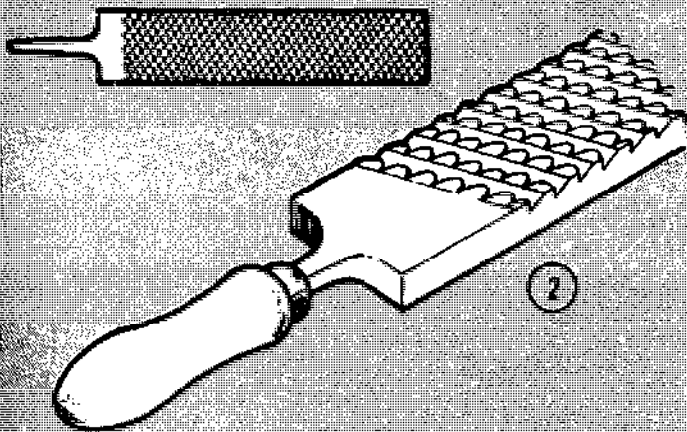
An enlarged part of the reciprocating file with the workpiece.

6 Workpiece

Some special types of files are illustrated in the figures 1 - 4.

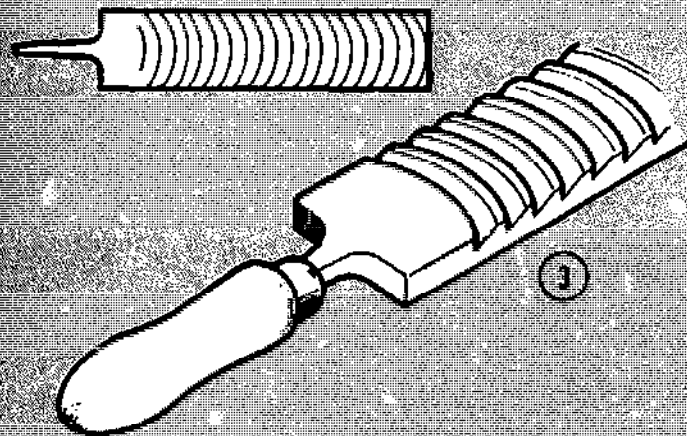


1  
File with  
single cut



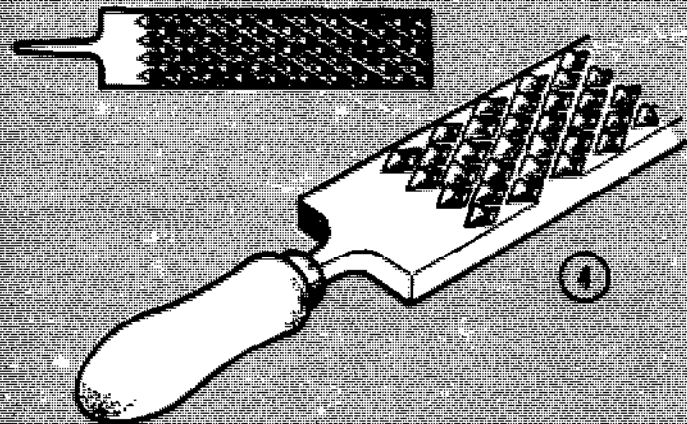
2  
File with  
double cut

The great number of small teeth can be clearly seen here.



3  
Milled

The teeth on this vixen file are milled.



4  
Rasp

For filing soft materials such as lead, tin, wood etc. a rasp is used.

The production of a work-piece showing the operational stages and the types of files used.

Hand flat file.

Half-round file.

Three-square file.

Square file.

Round file.

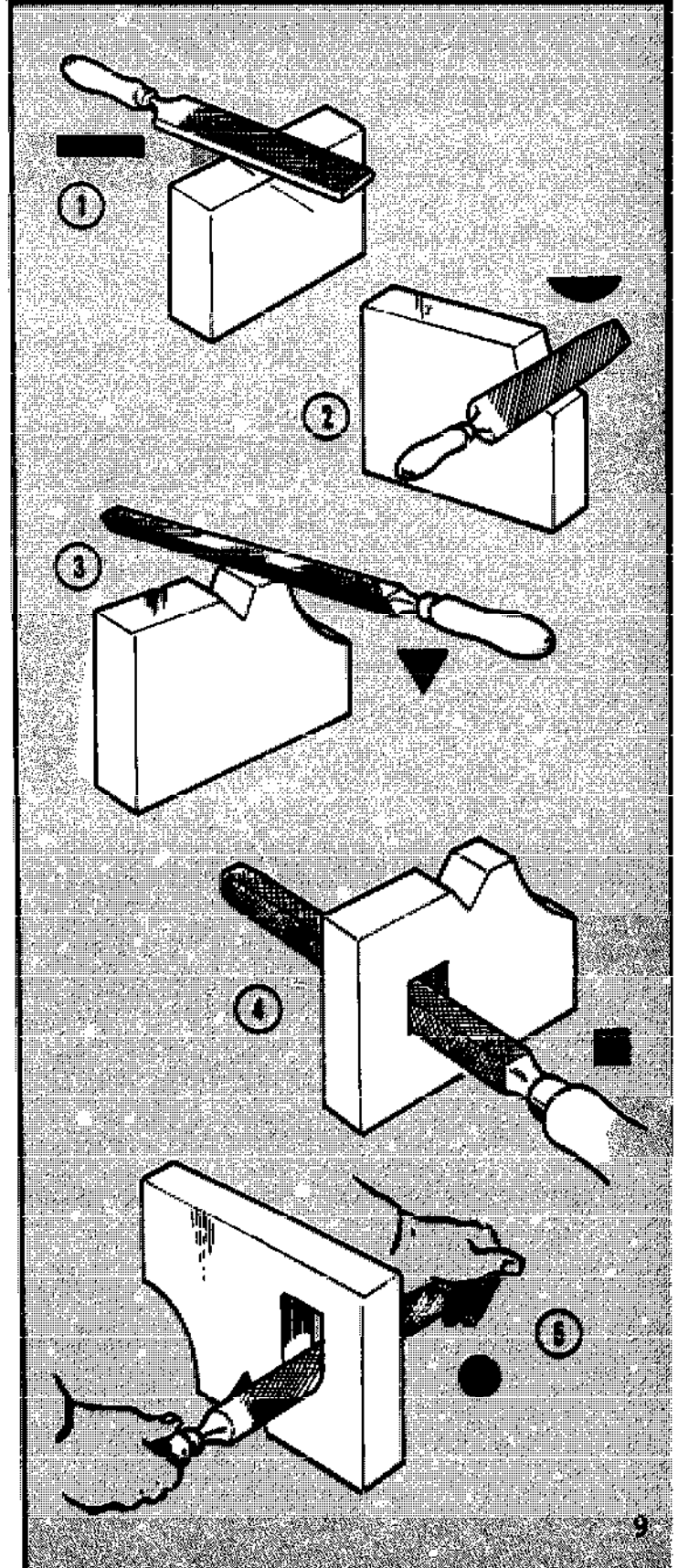
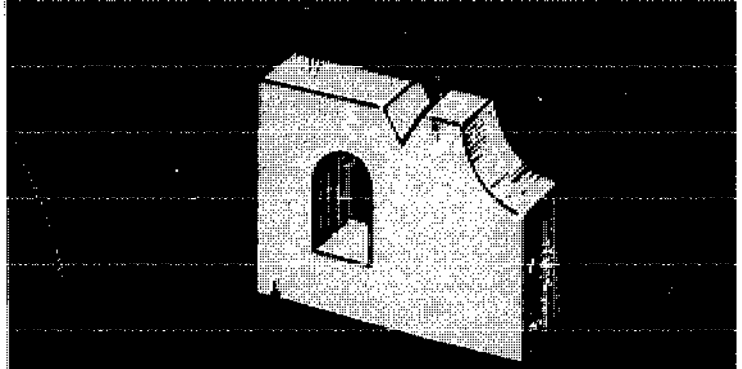
1  
Flat outer  
surface

2  
Curved  
inner  
surface

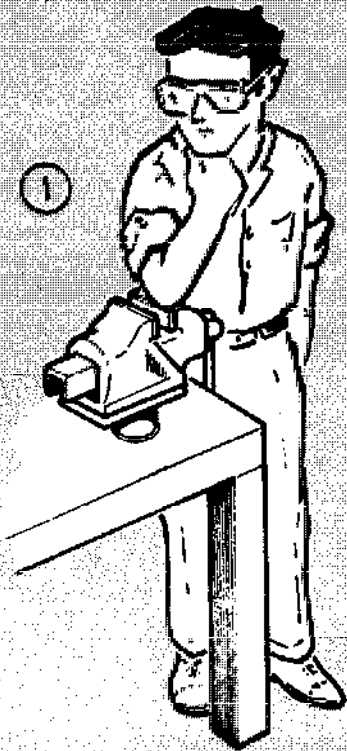
3  
Triangular  
recess

4  
Square hole

5  
Rounded  
hole

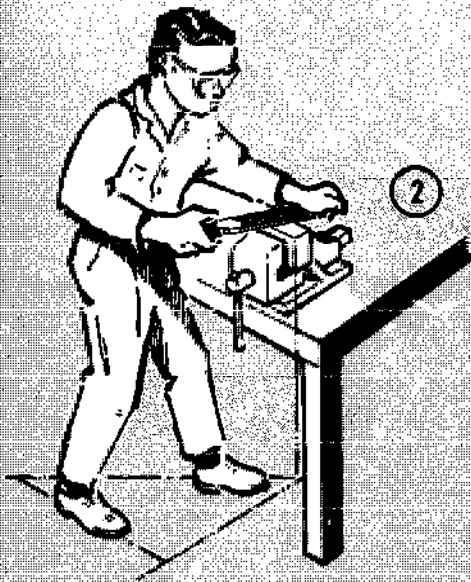


## USE OF VICE



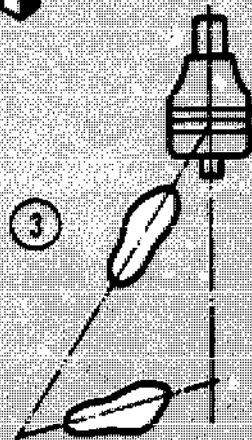
1  
Height of  
vice

For convenient working the vice should be at the correct height. When the fist is pressed against the chin, the elbow should touch the top of the vice.



2  
Working  
position  
when filing

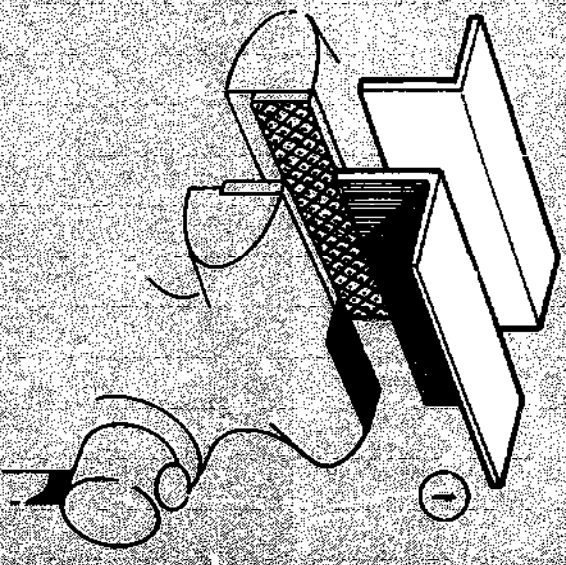
Note the position of the feet in figs. 2 and 3.



3  
Position of  
feet

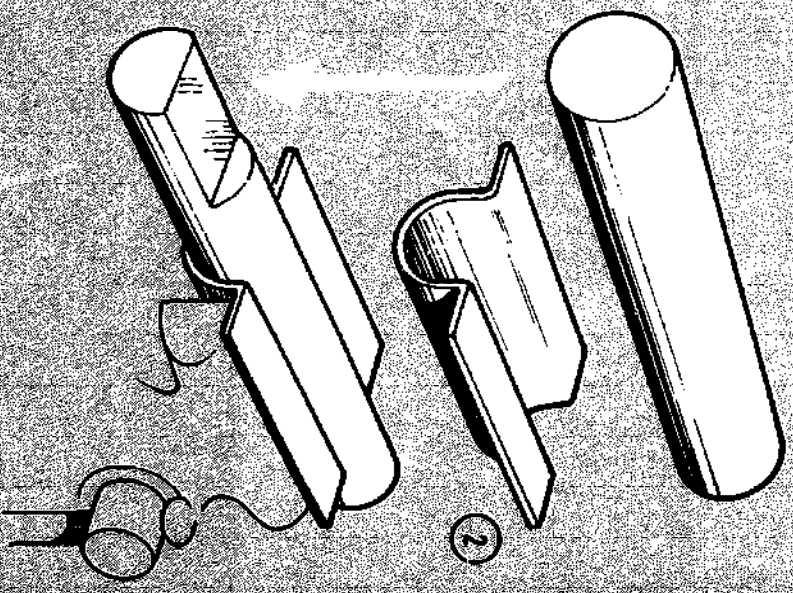
To prevent the jaws and finished surfaces from being damaged, jaw caps of some soft material should be used. Keep jaw caps meticulously clean!

1  
Jaw caps



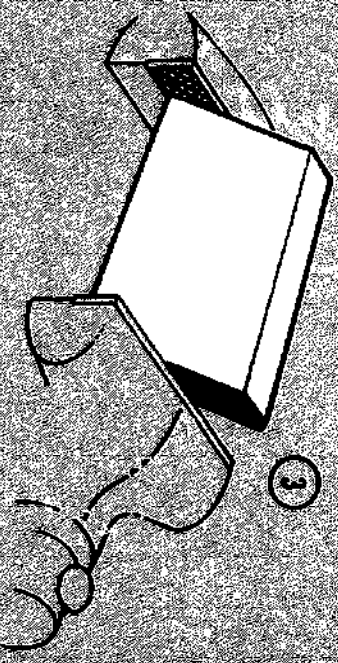
For holding round bars a special jaw cap may be used.

2  
Jaw cap  
for  
shafts



If surfaces have to be filed at an angle the work may be held in a slanting position.

3  
Workpiece  
in a  
slanting  
position





1  
Channel  
section

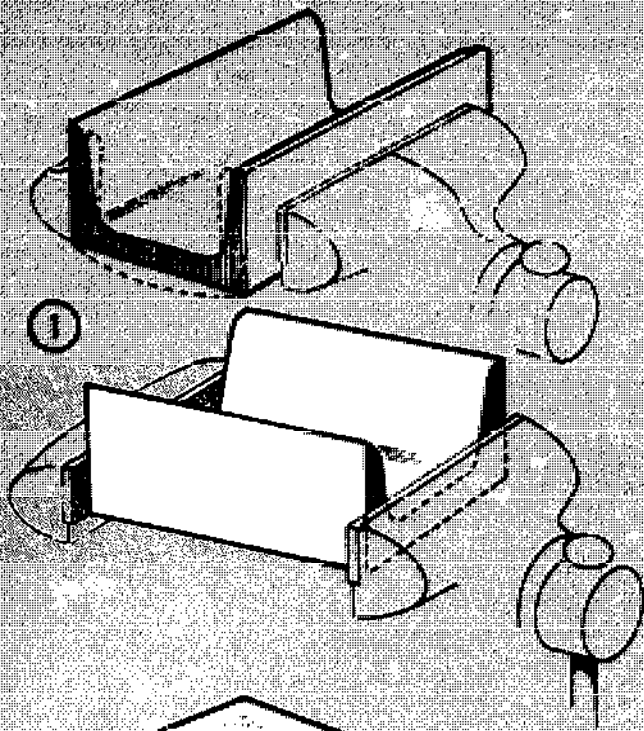
To prevent distortion  
channel sections should  
preferably be held length-  
wise.

2  
Wooden  
packing

In a box-shaped component  
with a slot cut into one  
side, distortion is  
prevented by inserting a  
wooden packing.

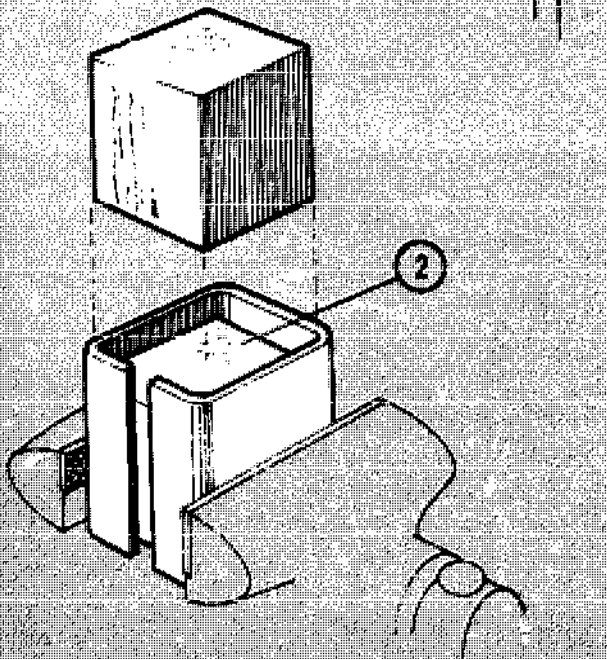
3  
Wooden  
backing  
piece

Thin materials are mounted  
between tacks on a wooden  
packing, but the heads of  
the tacks must not project  
above the material.



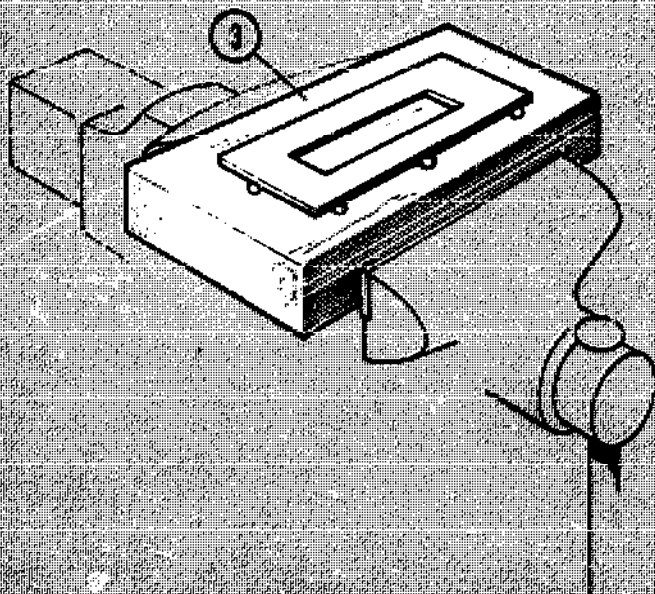
1  
Channel  
section

To prevent distortion channel sections should preferably be held lengthwise.



2  
Wooden  
packing

In a box-shaped component with a slot cut into one side, distortion is prevented by inserting a wooden packing.



3  
Wooden  
backing  
piece

Thin materials are mounted between tacks on a wooden packing, but the heads of the tacks must not project above the material.

A recently filed surface should not be touched by hand or filing will be made more difficult.

Scale is removed with the edge of an old file.

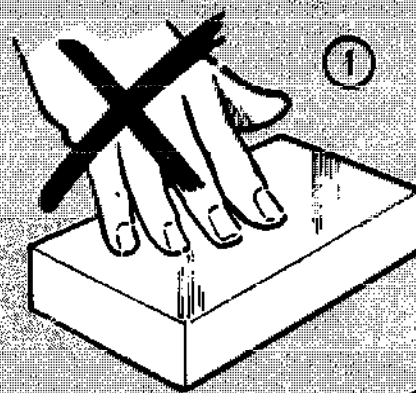
In the course of time filings will clog between the teeth of the file.

These filings may be removed with a file brush.

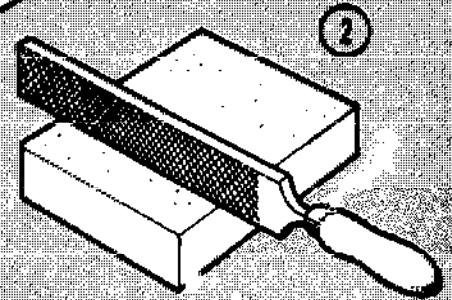
The file brush is not recommended for new files, because the strong steel wires of the brush would quickly wear off the keen edge on the new file teeth.

Instead, a piece of soft material such as brass may also be used for this purpose. This cleaning should be frequently repeated.

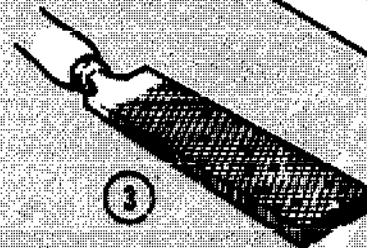
1  
Do not touch!



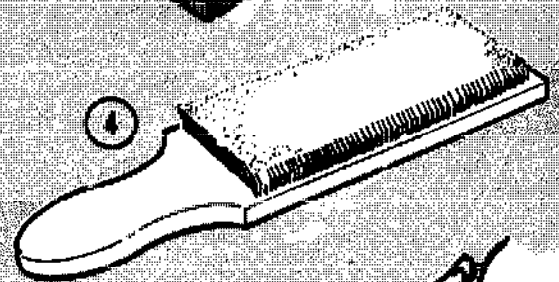
2  
Removing scale



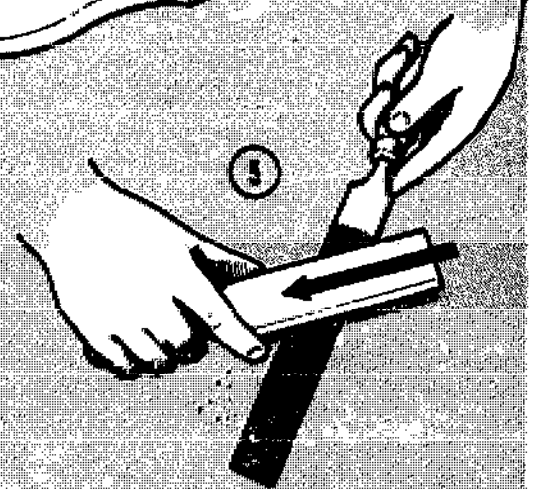
3  
Clogged file



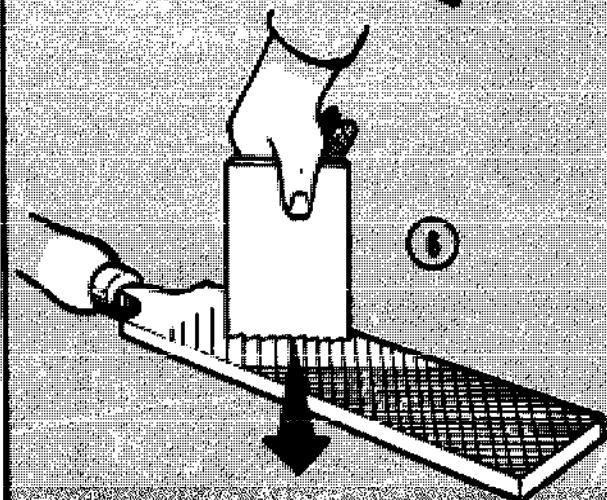
4  
File brush



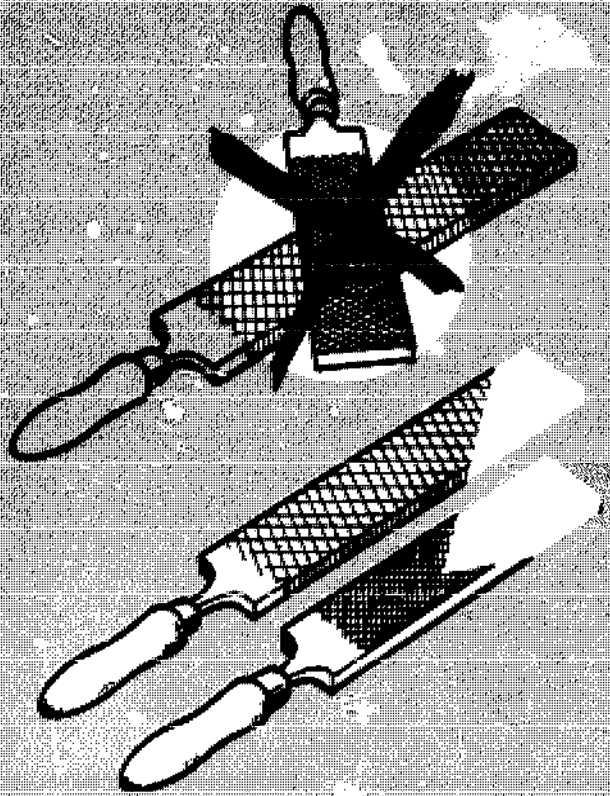
5  
Brushing a file



6  
Use of soft material

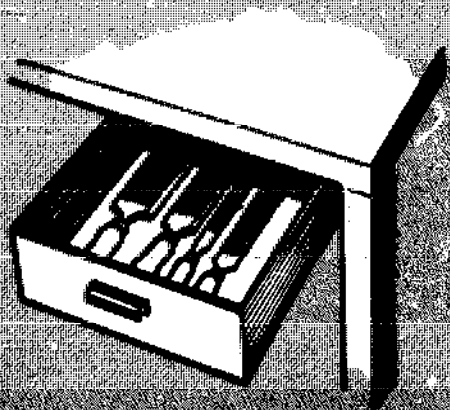
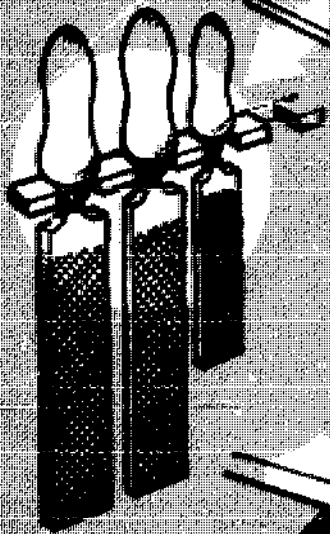
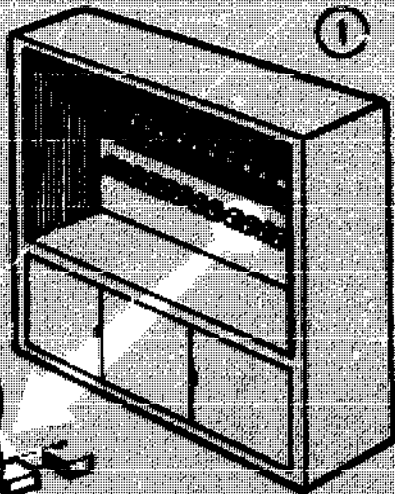


Never place files on top of each other! Keep them apart!



1  
File storing cabinet

For storing files, special cabinets are very useful.



When stored in drawers, files should be kept apart.

Wear goggles when filing.

Never use a file without handle. The handle should be fitted with a ferrule to prevent it from cracking and splitting.

Never use cracked file handles.

File handles will fit better when the tang has been burred beforehand. The tang is heated and provided with some burrs by means of a cold chisel.

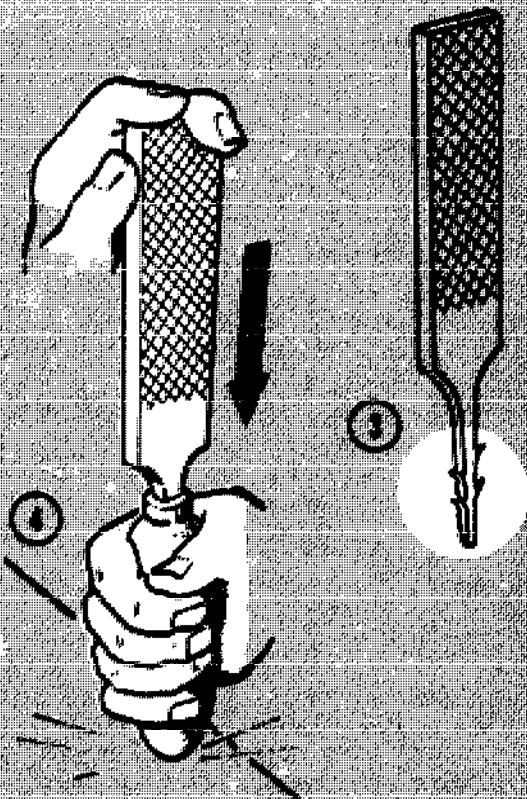
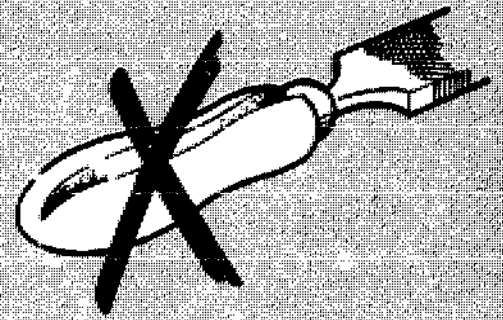
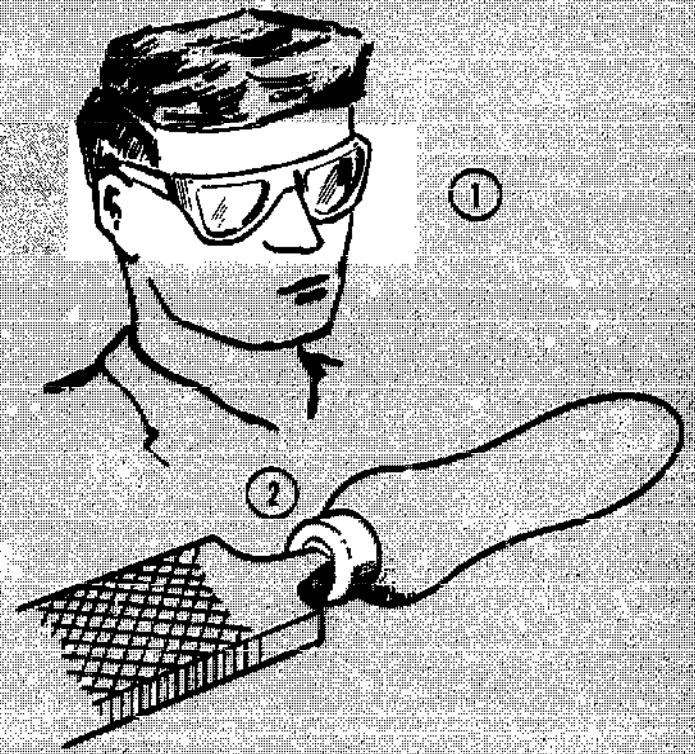
Drive on the handle as illustrated in fig. 4. This method prevents splitting beyond the ferrule. The burrs will stick into the wood.

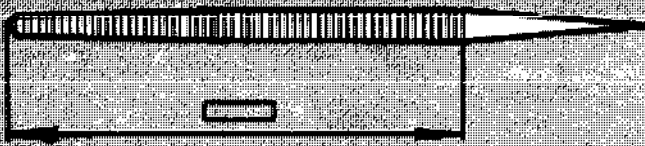
1  
Goggles

2  
Steel  
ferrule

3  
File with  
burred  
tang

4  
Correct way  
of fitting  
a handle



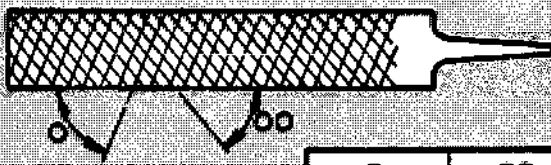


1

1  
Sizes of  
file  
handles

Use a handle of the right size. Sizes fitting different files are given in the table.

	X	XX	XXX
4"	80 mm	20 mm	5 mm
6"	100 ..	26 ..	7 ..
8"	110 ..	28 ..	9 ..
10"	120 ..	30 ..	12 ..
12"	130 ..	32 ..	15 ..



2

2  
Angles of  
file cuts

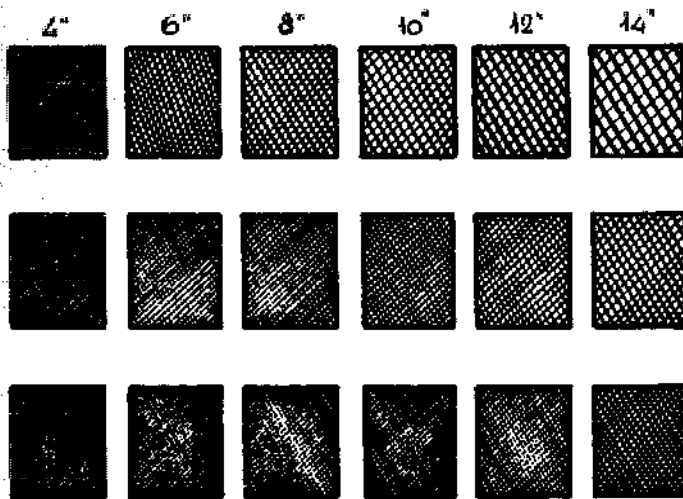
In this table the angles of file cuts are given.

0	00
77°	45—55°
67°	45—55°
55°	45—55°
71°	54°

3

3  
Degrees of  
smoothness

These squares show the cuts on files with different degrees of smoothness.



Bastard  
(No. 1)

Top row: bastard files.

Second cut  
(No. 2)

Middle row: second cut files.

Smooth file  
(No. 3)

Bottom row: smooth files.

4

4  
Number of  
teeth

Finally a table giving the number of teeth per cm for different smoothnesses. L = length.

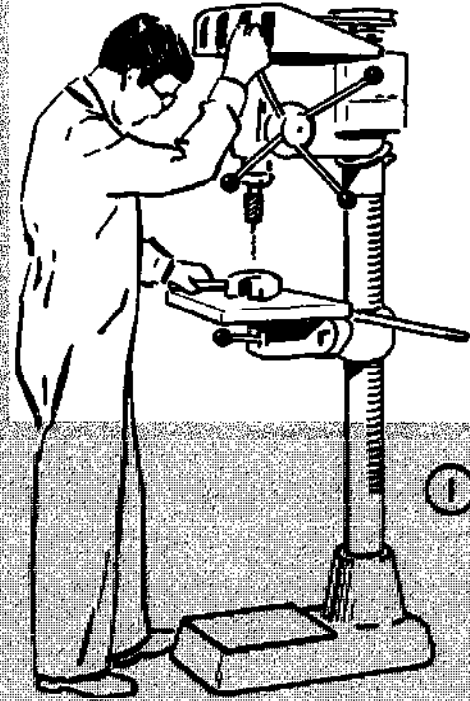
L	4" 100 mm	6" 150 mm	8" 200 mm	10" 250 mm	12" 300 mm	14" 350 mm
No. 1	14	11	10	9	8	7.5
No. 2	22	18	16	14	12	11.5
No. 3	31	25	22	20	18	16

## INTEMS PICTORIAL SYSTEM

## DRILLING

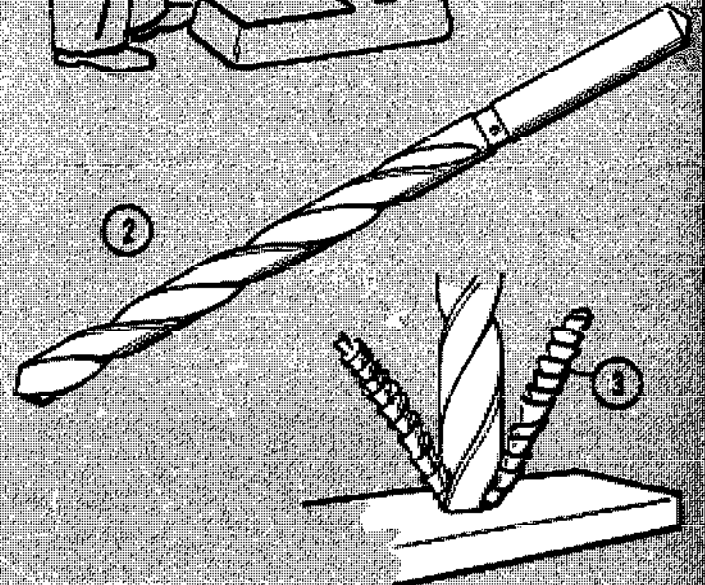
Drilling is an operation for making round holes.

1  
Drilling with drilling machine



The twist drill, shown here, is held in the drilling machine. When the machine is started the drill turns.

2  
Twist drill

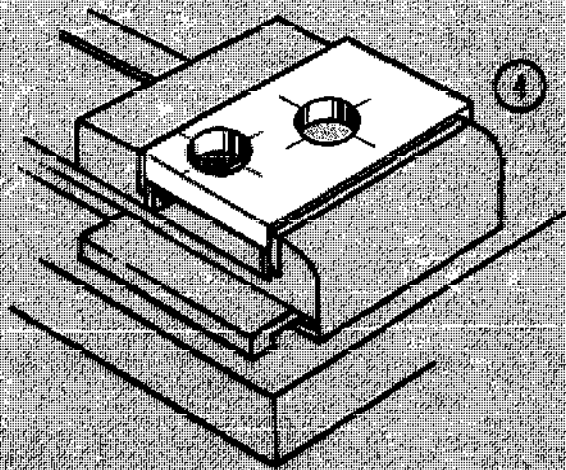


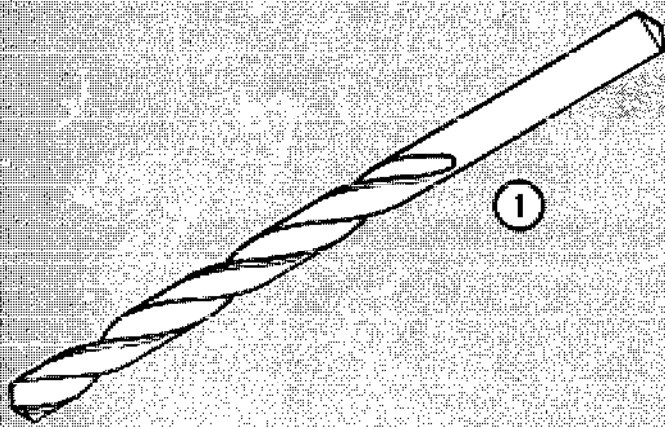
When the drill is pressed on to the work the material will be cut away. Two curling chips are formed.

3  
Chips

The material has been cut away by the drill and two holes have been produced.

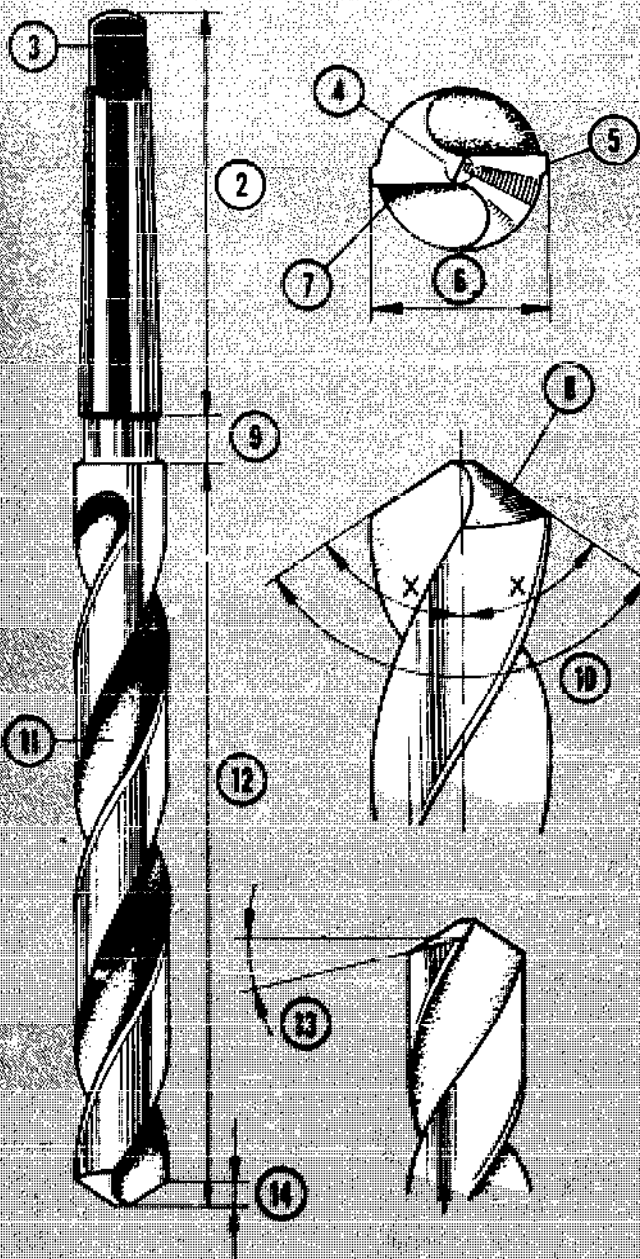
4  
Result





1  
Drill with  
parallel  
shank

We see two parts on the twist drill. The grooved part (the grooves are called flutes) is called the body. The smooth part is called the shank.



2  
Taper shank  
3  
Tang  
4  
Core or web  
5  
Land  
6  
Body  
clearance  
diameter  
7  
Cutting  
edge (also  
called lip)  
8  
Point angles  
at X equal  
9  
Recess  
10  
Included  
point  
angle  
11  
Flute  
12  
Body  
13  
Lip  
clearance  
angle  
14  
Point

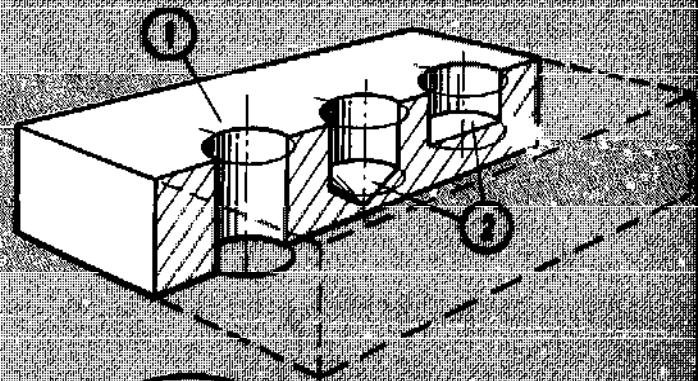
Drills may have parallel shanks (fig. 1) or taper shanks (fig. 2). Terms used in connection with twist drills are given in the drawings.

The included point angle is usually  $118^\circ$  for general use.



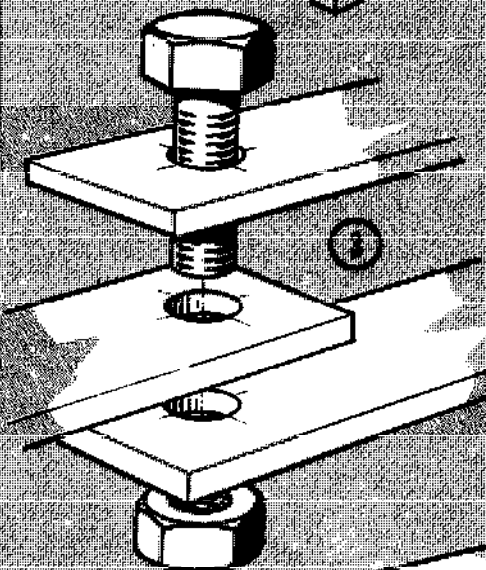
Drilled holes may be either through holes or blind holes.

- 1 Through holes
- 2 Blind holes



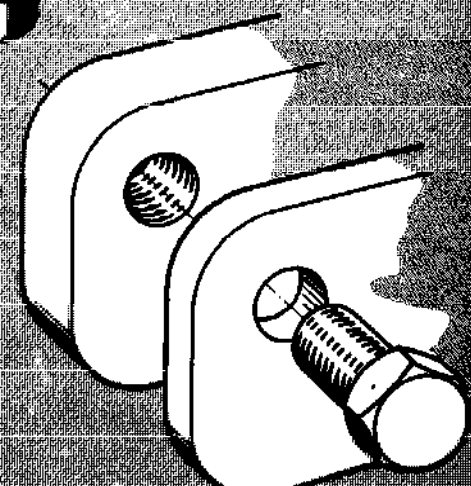
Holes may be drilled for passing bolts or rivets through them.

- 3 Bolt holes



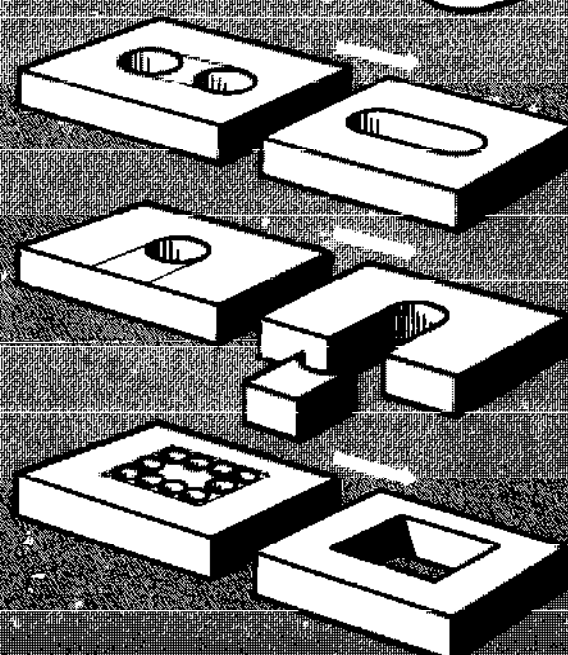
Holes are also frequently drilled as a preliminary to further operations such as:

- 4 Tap holes

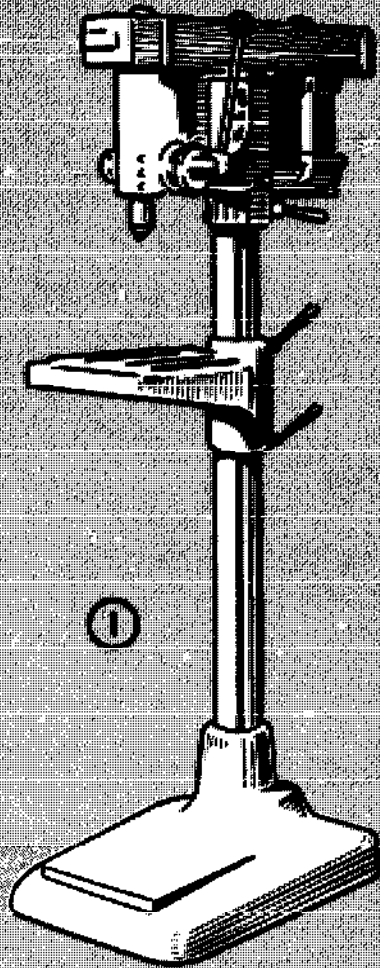


Screw-thread tapping (fig.4).

Making slots or inner rounds.



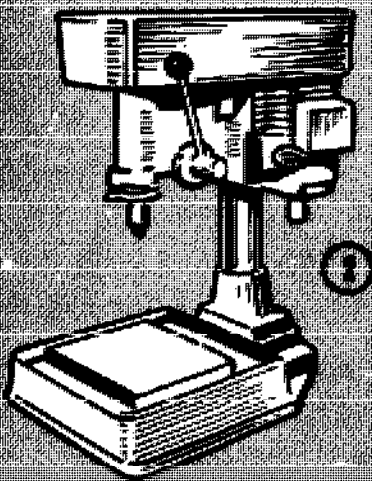
Rough shaping when material has to be removed.



1  
Vertical  
spindle  
driller

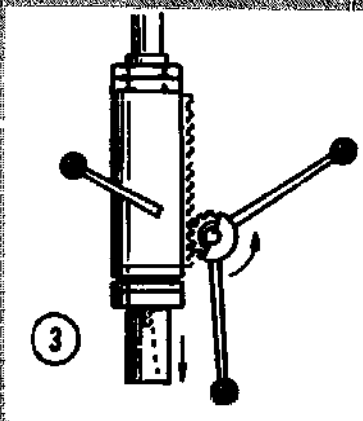
There are various types of drilling machines.

The vertical spindle driller, shown here, has a table which can be moved upward and downward along the spindle. The head unit, which is in a fixed position on top of the spindle, contains the driving mechanism.



2  
Bench drill

The bench drill is fastened to the work bench or to a special base.



3  
Feed

The downward movement of the drill is called the feed. It is effected by means of a handle.

The transmission from the electric motor to the drill is usually by means of a V-belt. This is an endless belt with a V-shaped section.

All the components used for driving the drill are shown separately here. Pulleys are fitted on the motor and on the spindle for the V-belt.

When the motor is started the spindle, with the twist drill, is driven.

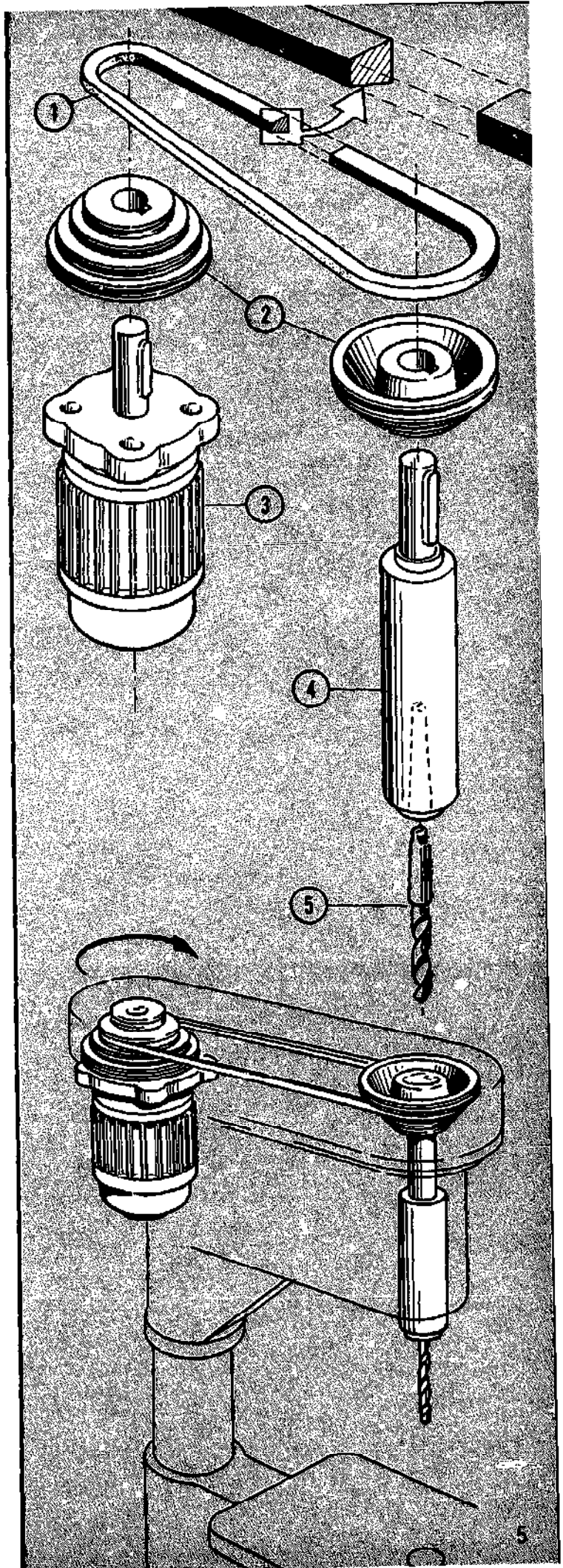
1  
V-belt

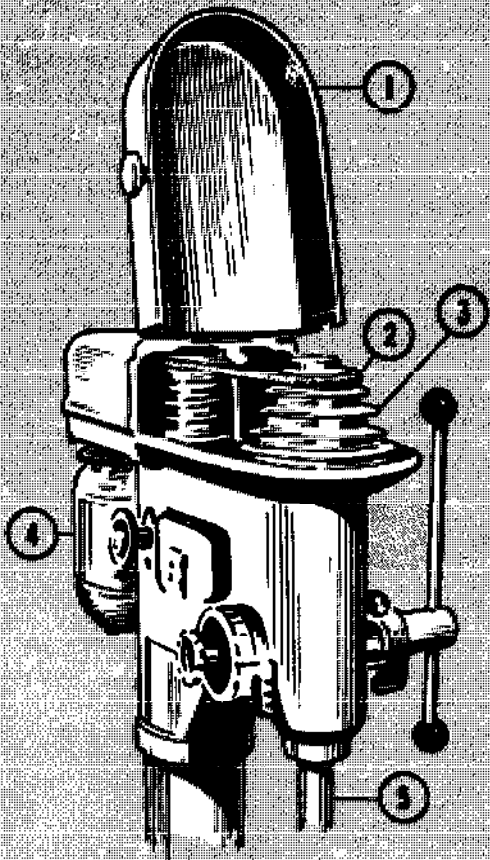
2  
Pulleys

3  
Electric  
motor

4  
Spindle

5  
Twist drill





1  
Guard

The head of a drilling machine is shown here with open guard.

2  
V-belt  
3  
Pulley

The two pulleys and the V-belt are clearly visible.

4  
Motor

At the rear is the motor.

5  
Spindle

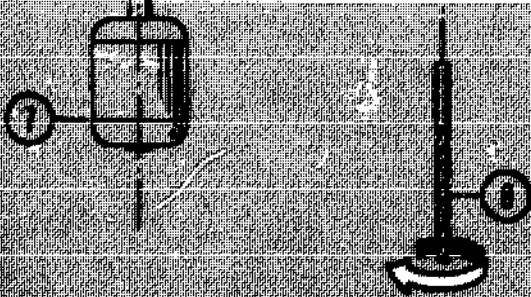
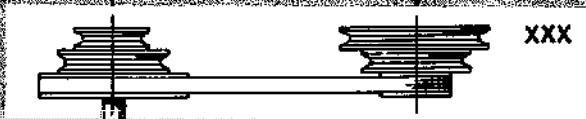
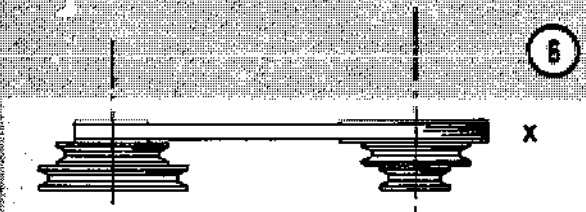
6  
Different  
drilling  
speeds

By moving the V-belt from one set of pulleys to another, different drilling speeds are obtained. The speeds are indicated on the machine.

X Drill speed smaller than motor speed.

XX Drill speed = motor speed.

XXX Drill speed greater than motor speed.



7  
Motor

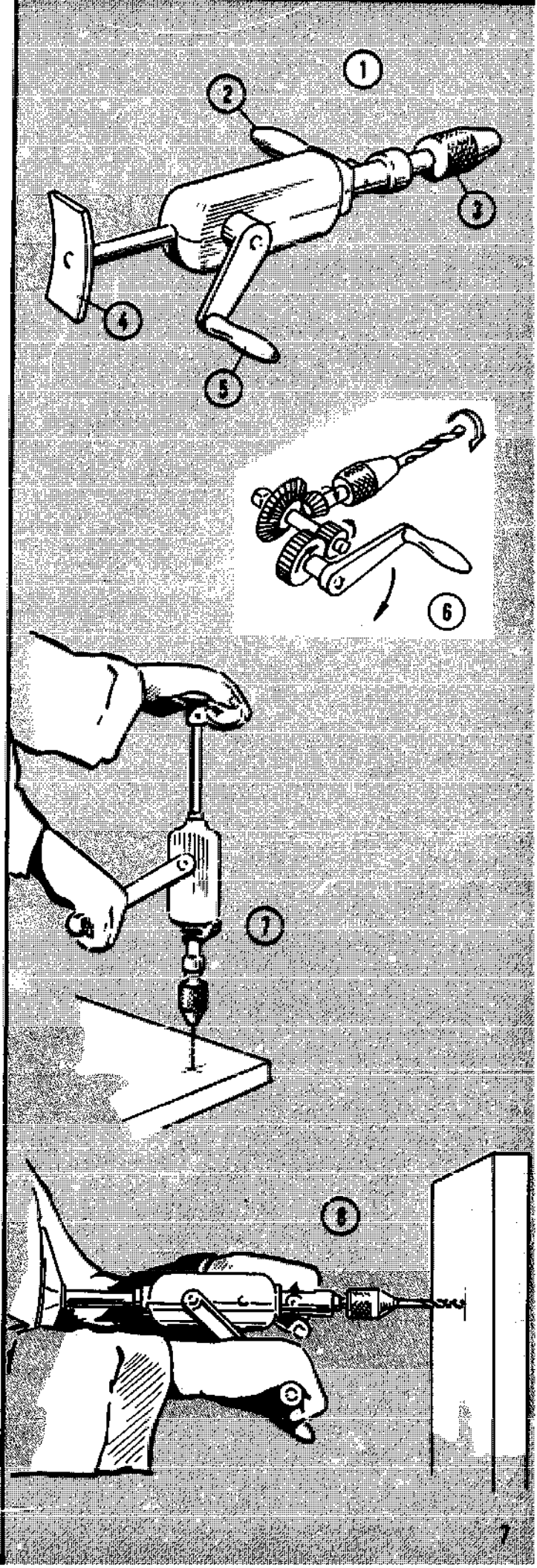
8  
Drill

If the work cannot be held in a drilling machine a hand drill is used.

The drill shown in fig. 1 is manually operated.

The twist drill is held in a chuck.

- 1 Hand drill
- 2 Handle
- 3 Chuck
- 4 Rest
- 5 Operating handle



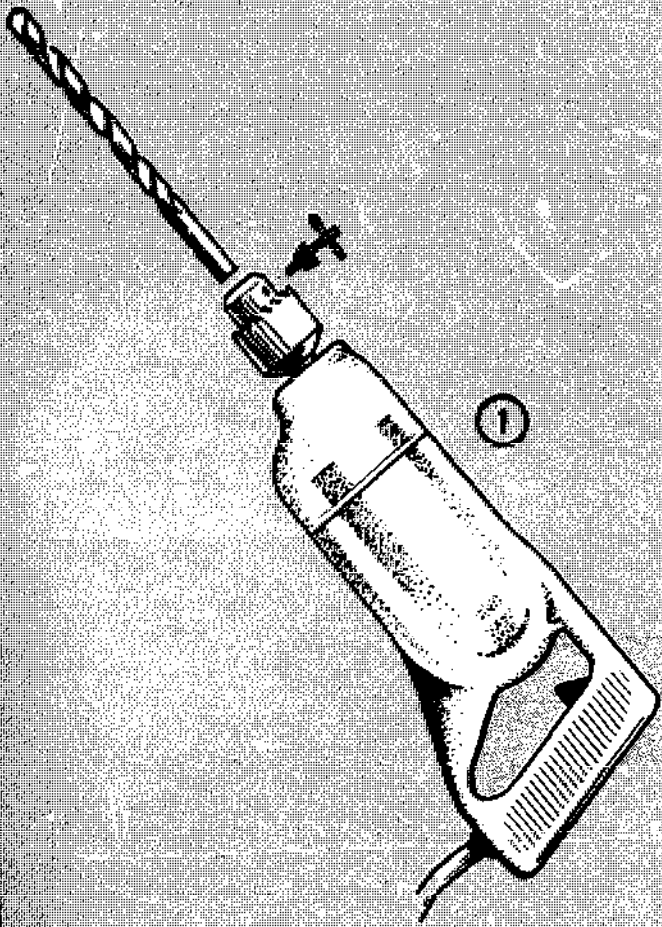
6 How the drive is transmitted

7 Vertical drilling

8 Horizontal drilling

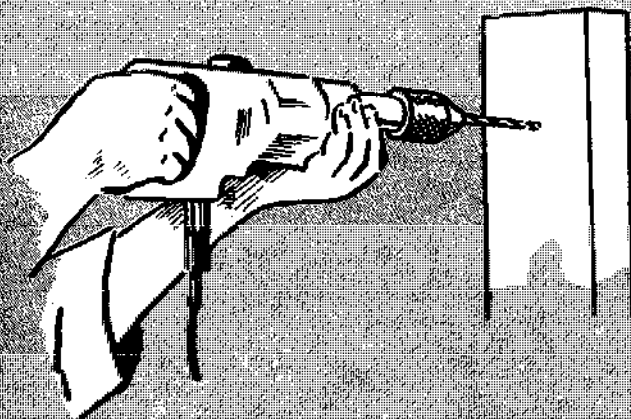
Position for vertical drilling. One hand is used for turning the operating handle and the other for pressing the drill down.

Position for horizontal drilling.



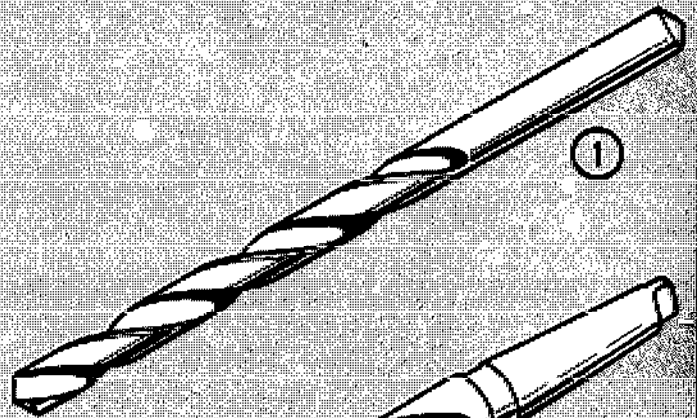
1  
Electrically  
driven hand  
power drill

Instead of a manually-  
operated drill an electri-  
cally driven hand power  
drill may be used. The  
twist drill is held in a  
chuck. The motor is started  
and stopped by pressing or  
releasing a button.

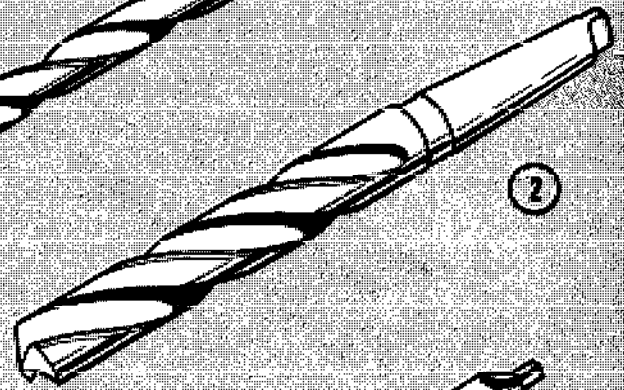


A twist drill may have a parallel shank or a taper shank.

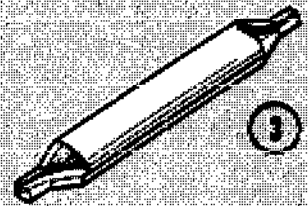
1 Parallel shank drill



2 Taper shank drill

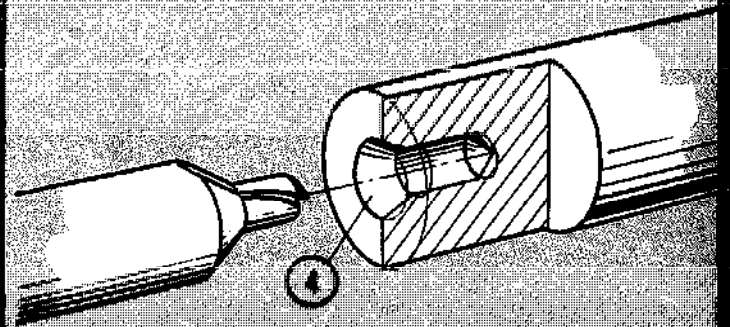


3 Centre drill



There are various other types and shapes, such as the centre drill for drilling centres in shafts.

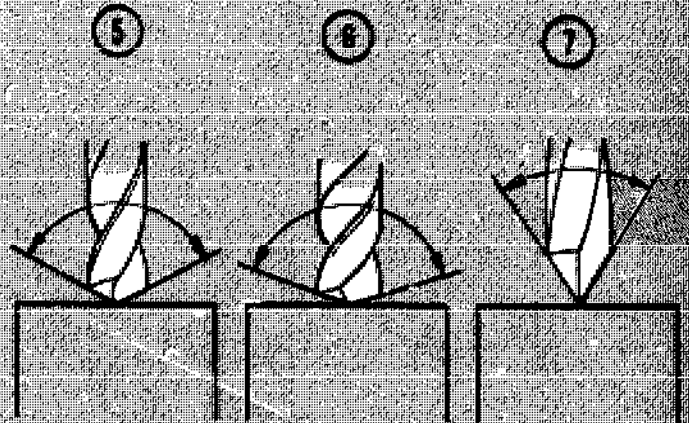
4 Using a centre drill

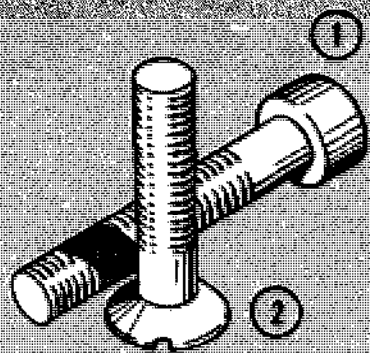


There are also special types of drills for different materials. Notice the point angles.

Drills for:

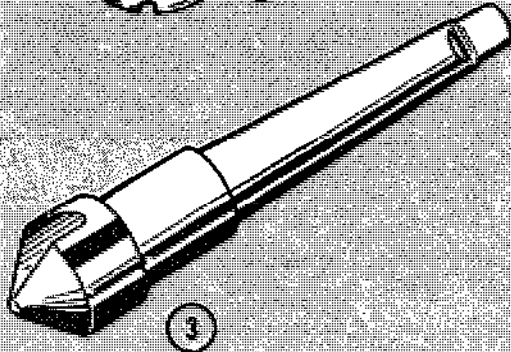
- 5 Steel
- 6 Aluminium
- 7 Plastics





1  
Screw with  
cylindri-  
cal head

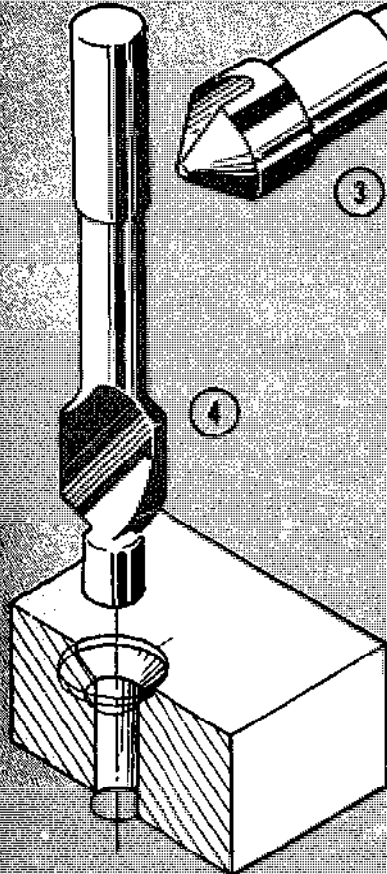
To be able to countersink or counterbore drilled holes for screws with a round head, special drills are used.



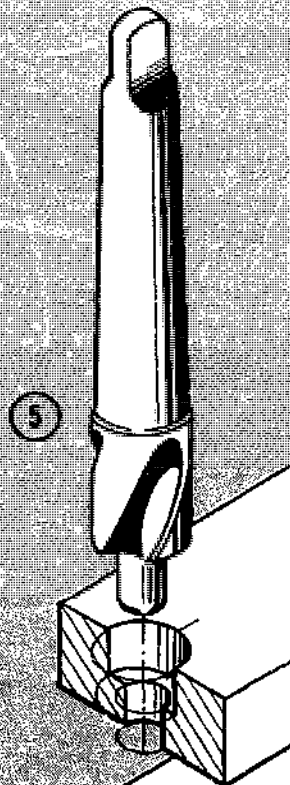
2  
Screw with  
countersunk  
head

3  
Countersink

The tapered enlargement at the top of a hole for a screw with a countersunk head is made with a countersink.



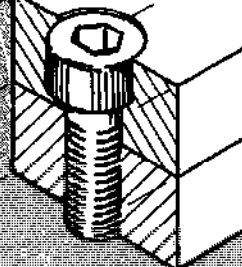
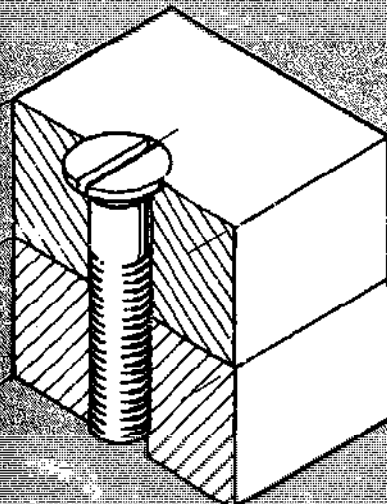
4  
Countersink  
with pilot



5  
Counterbore  
with pilot

To counterbore a drilled hole for a screw with a cylindrical head a counterbore is used.

At the lower end of the counterbore there is usually a cylindrical part to guide the counterbore in the drilled hole.





A taper shank drill fits into the spindle socket.

Small drills are held by means of an arbor (also called sleeve).

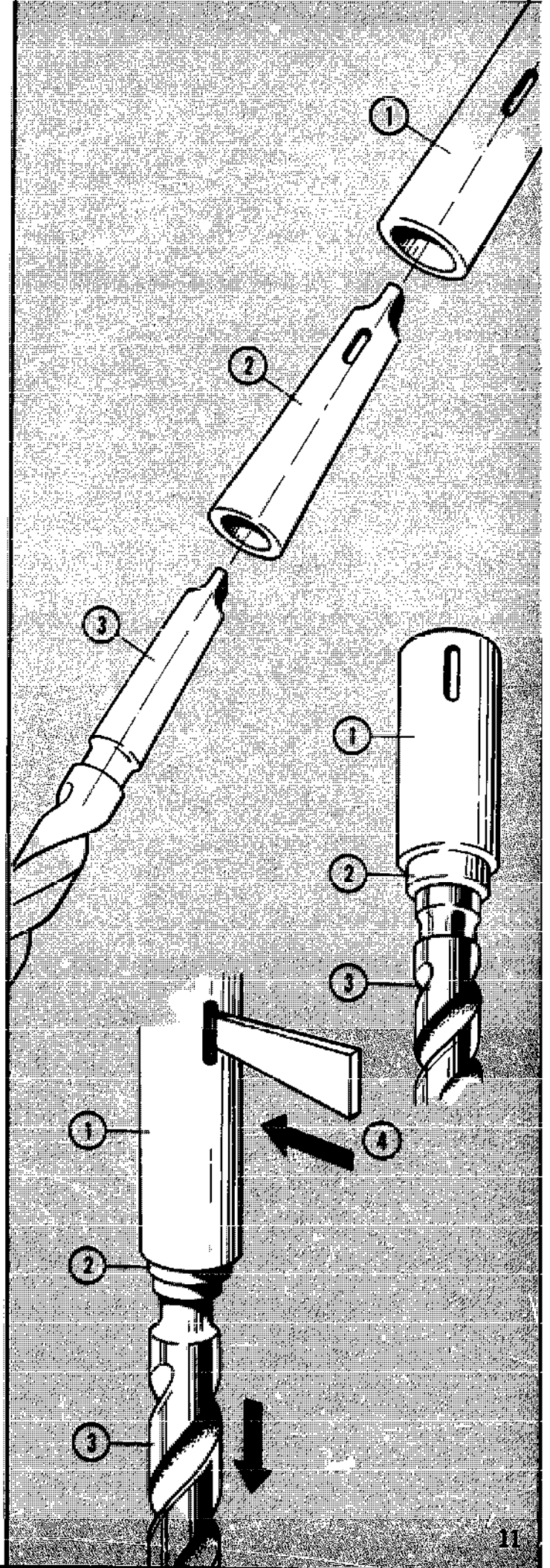
The drill is removed by means of a drill drift inserted through a slot in the spindle.

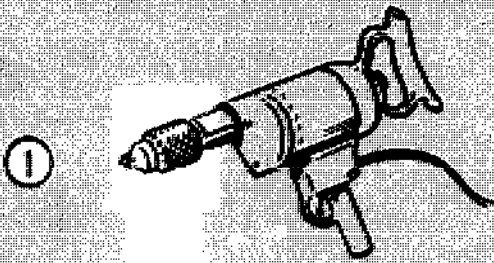
1  
Spindle

2  
Arbor  
(sleeve)

3  
Drill

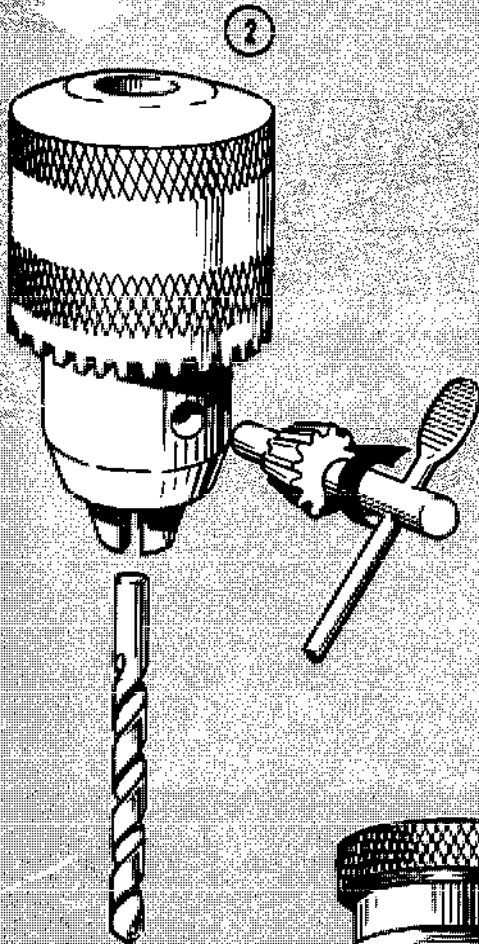
4  
Drill drift





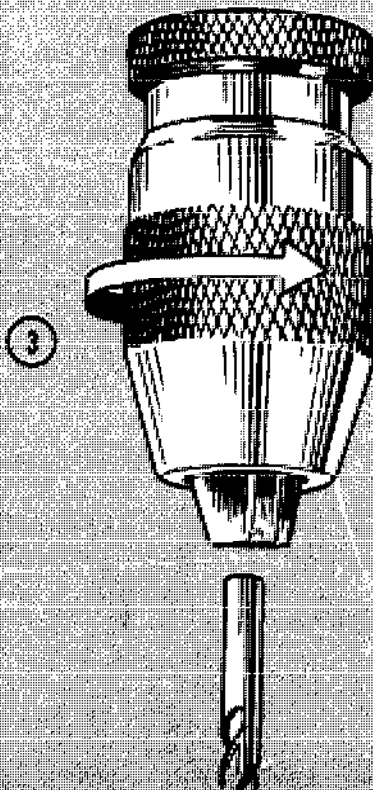
1  
Chuck

A different system is needed for holding a parallel shank type drill.



2  
By means of a pinion key

In the first system shown the drill is held by three jaws which are tightened or loosened by means of the pinion key.



3  
By means of a knurled ring

In the second system the chuck jaws are adjusted by turning the knurled outer ring.

To prevent the work from being hurled round by the turning drill it must be clamped. Clamping is necessary to prevent accidents and for keeping the workpiece in its place.

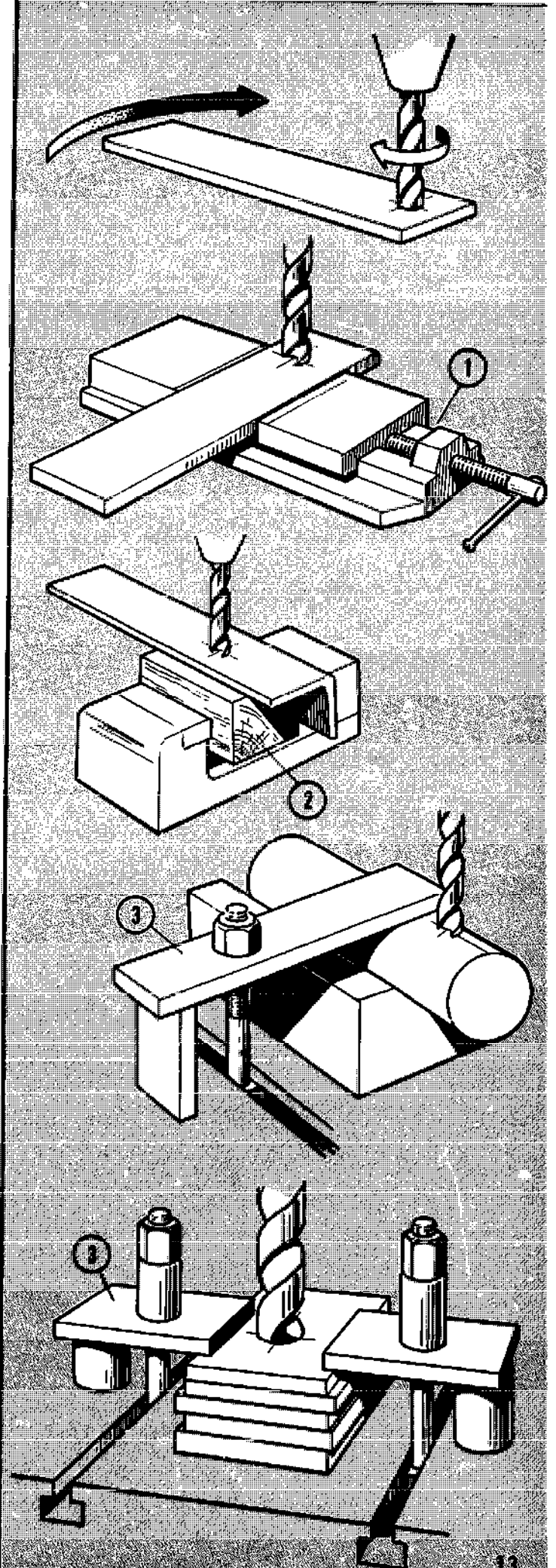
If necessary use pieces of wood under the work (packings) to prevent the vice or table from being damaged by the drill.

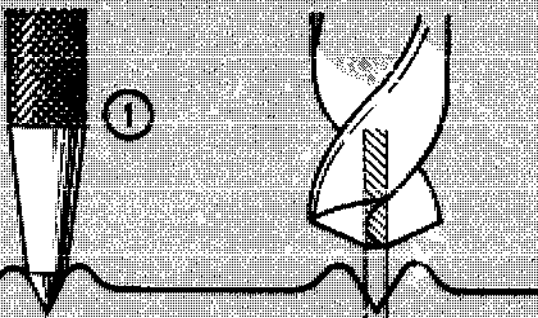
The work may be held in a machine vice (fig. 1) or clamped on the drilling table by clamps or dogs (fig. 3). In the latter case the screw holding the dog should be as near the work as possible.

1  
Machine vice

2  
Wooden  
packing

3  
Dog





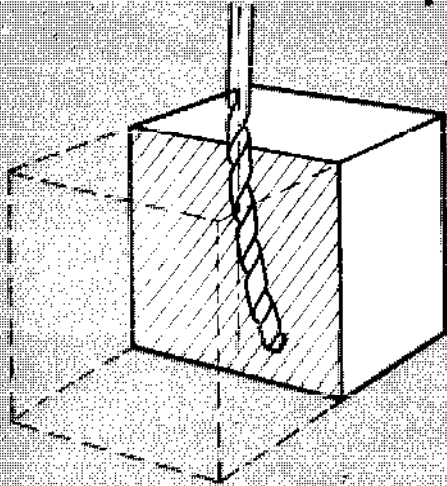
1  
Centre punch

Before drilling is started a centre is punched. This centre should be wider than the drill core.



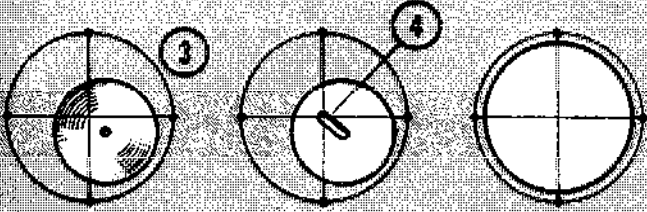
2  
Core of drill

If a drill is inaccurately ground the chances are that it will run out of centre. This is most likely to happen with thin drills.



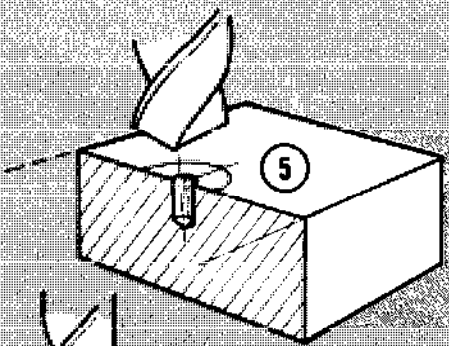
3  
Decentralised drill  
4  
Cut groove

If the decentralising occurs at the beginning it may be remedied by cutting a groove in the direction into which the drill is to be moved.



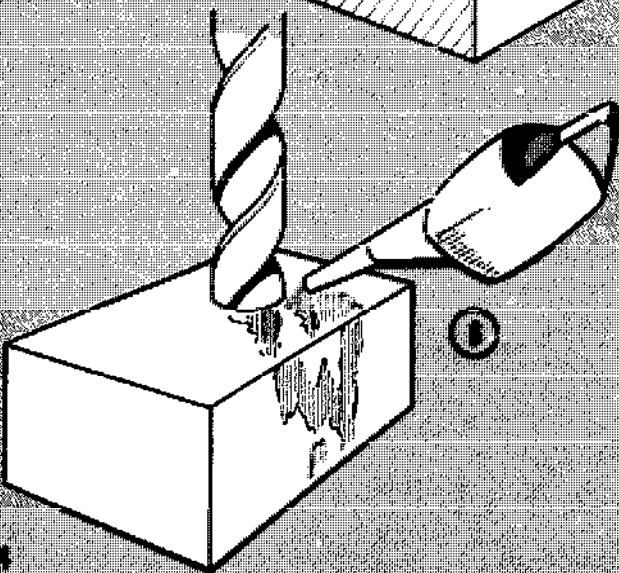
5  
Pre-drilled

Large holes should be pre-drilled, i.e. a smaller hole is first drilled.



6  
Cutting lubricant

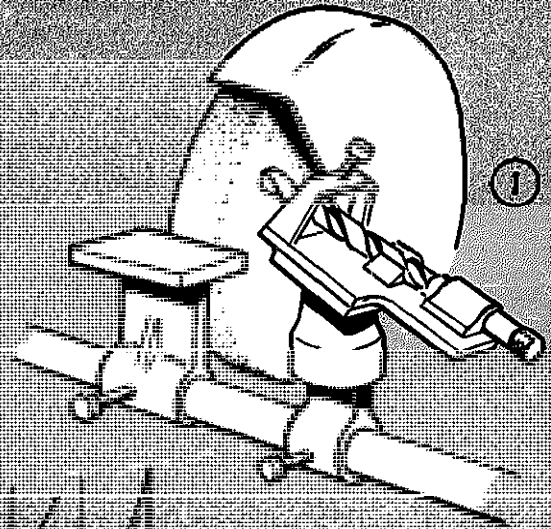
Always use a cutting lubricant where this is specified.



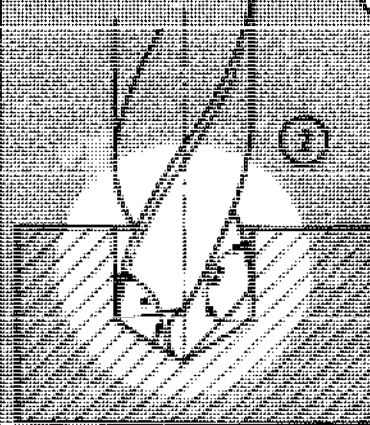
To keep a drill in good working condition correct re-sharpening is of the utmost importance. Re-sharpening should be done on a grinding wheel, if possible with the drill held in a special holder.

The following point grinding inaccuracies may occur:

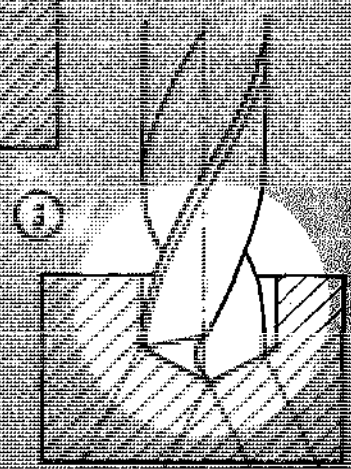
1  
Drill point  
grinding  
device



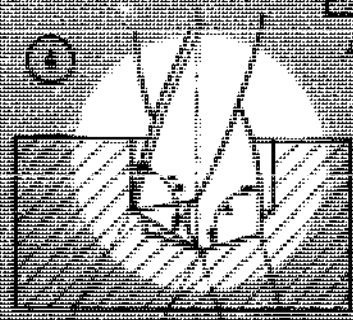
2  
Unequal  
point  
angles



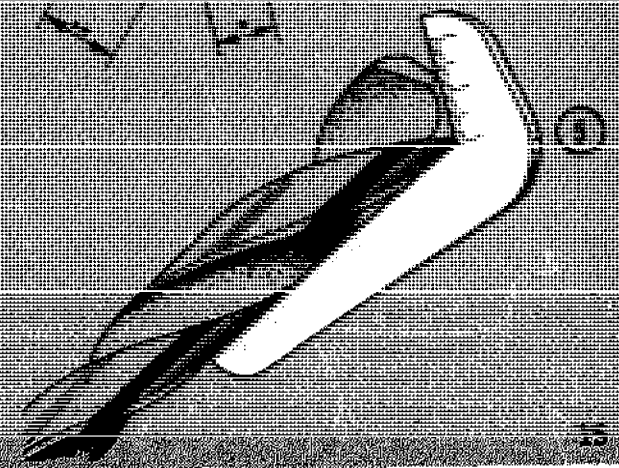
3  
One lip  
longer than  
the other



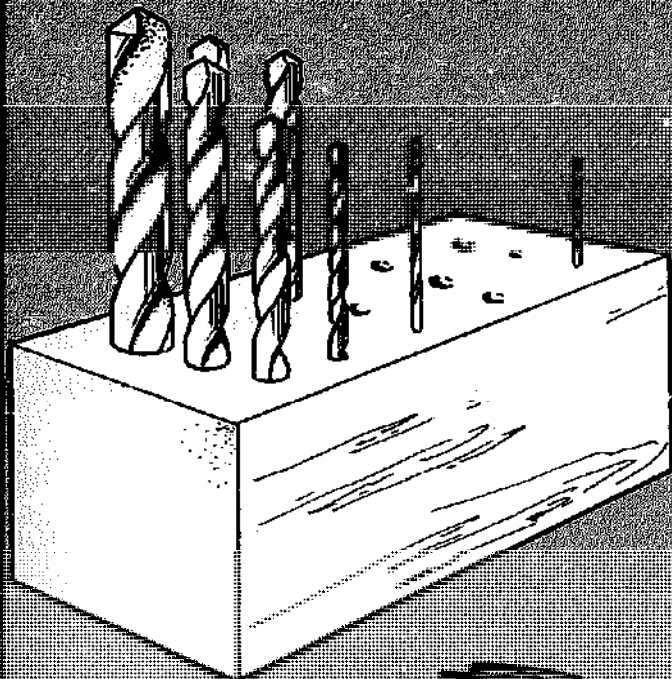
4  
Unequal  
point angle  
and one lip  
longer than  
the other



5  
Point angle



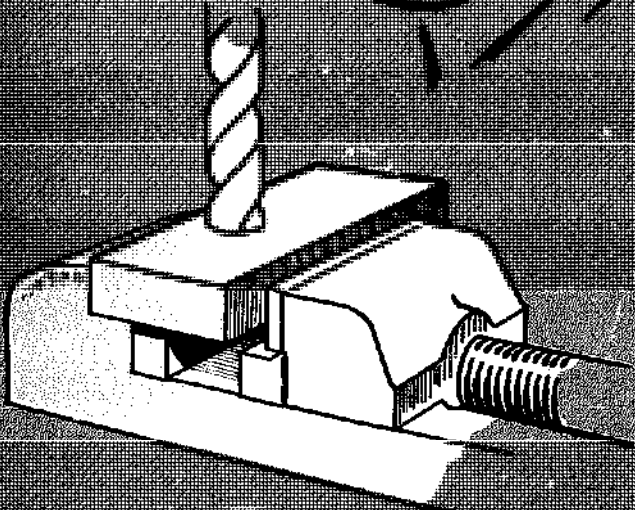
This may be tested with a point angle gauge.



To protect the drills from being damaged they are kept in blocks with the proper holes drilled into them.



Always wear goggles when drilling.



The work should always be clamped.



And... remember that a hair cut is less painful than having it torn out by a drilling machine spindle!

## INTEMS PICTORIAL SYSTEM

## SAWING

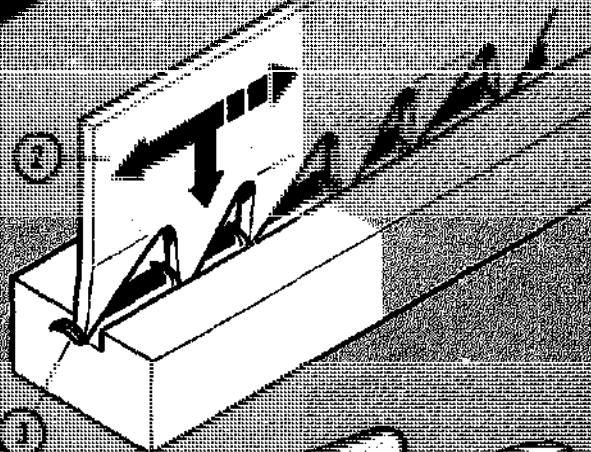
The saw moves to and fro, making a reciprocating movement. At the same time a downward pressure is exerted on the saw, but only with the to movement.

1  
Sawing

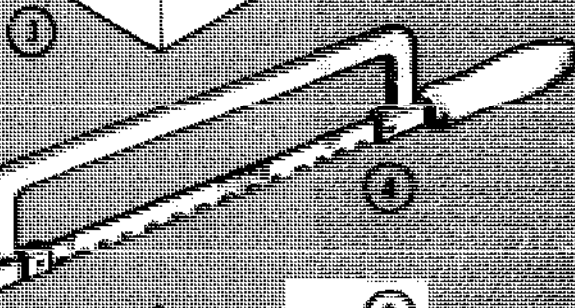


On the blade of the saw are teeth. These teeth cut small chips from the material while sawing.

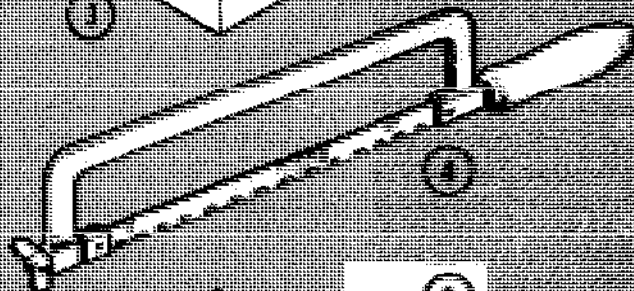
2  
Blade



3  
Chip

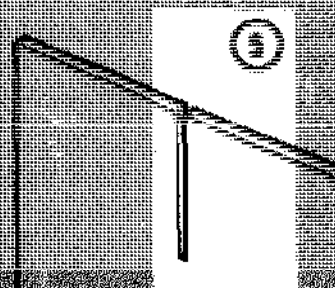


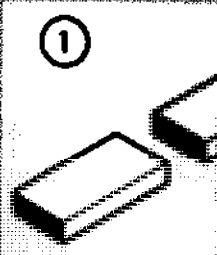
4  
Hack saw



By sawing a cut is left in the material.

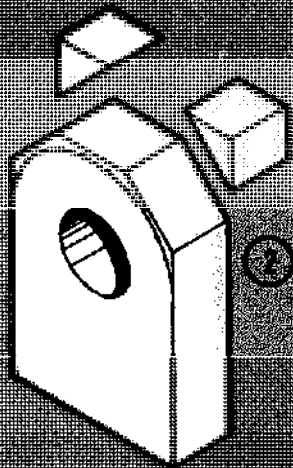
5  
Cut





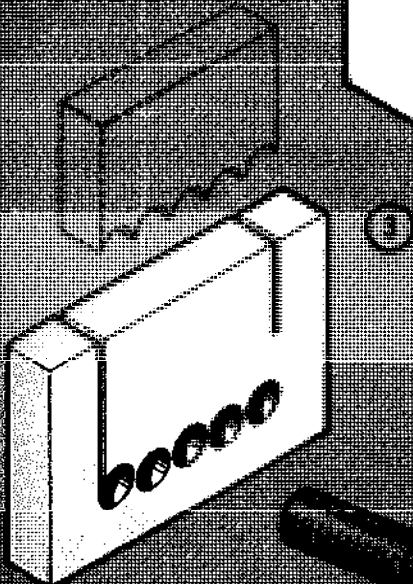
1  
Shortening

Sawing has many uses.  
Shortening material.



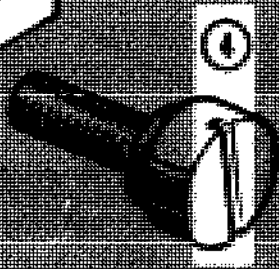
2  
Rough  
shaping

Rough outside shaping.



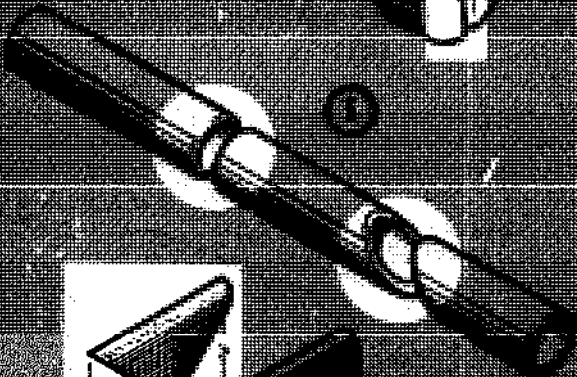
3  
Rough  
shaping

Rough shaping of recesses  
combined with drilling.



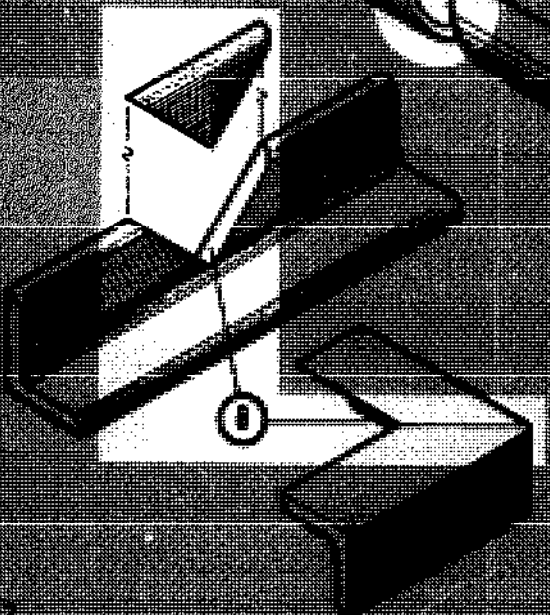
4  
Slotting

Slotting in screw heads.



5  
Cutting off

Cutting off pipes.



6  
Mitres

Mitring steel sections.



When we study a saw blade we see that it is thickest where the teeth are.

The reason is that the teeth have been slightly bent outwards, alternately to the left and to the right.

This is to prevent the saw blade from getting hot and jamming in the cut.

Hacksaws with fine teeth have a wavy cutting edge.

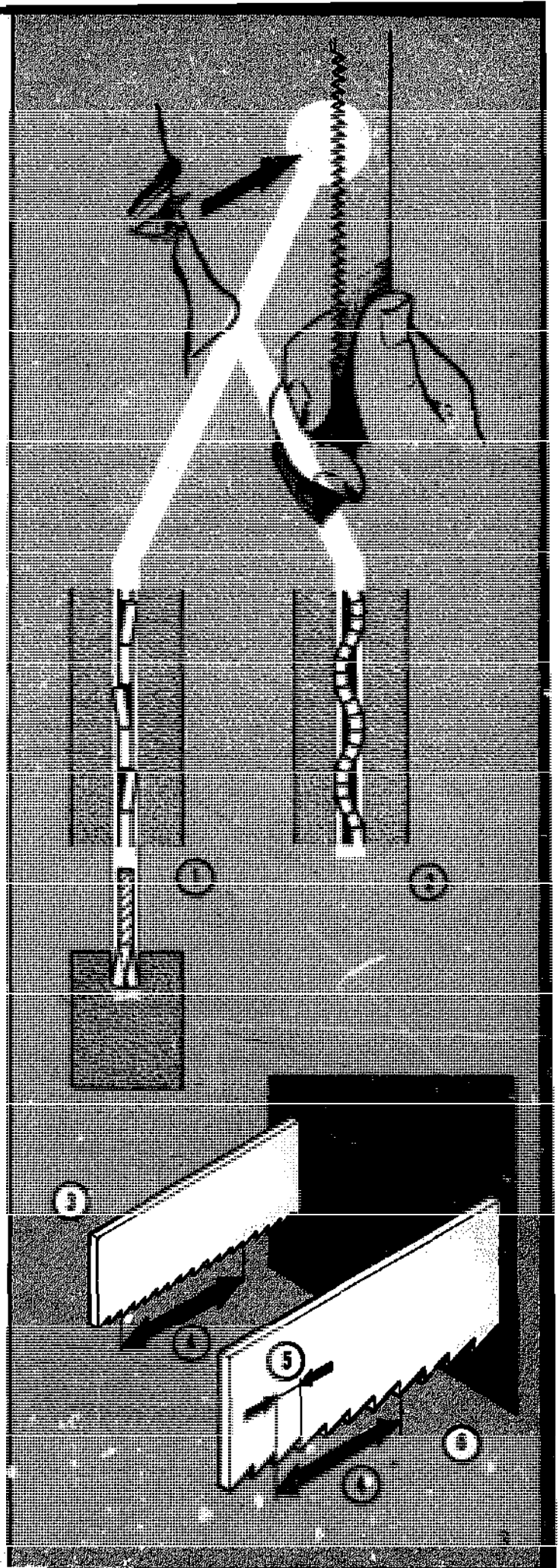
The set of a saw may be regular (standard) or wave.

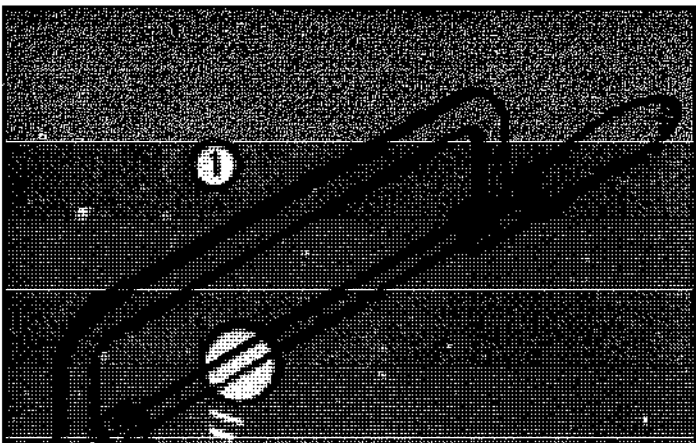
The coarseness or fineness of a saw is indicated by the number of teeth per inch.

The distance between two teeth is called the pitch.

- 1 Regular set
- 2 Wave set

- 3 Fine-toothed
- 4 One inch
- 5 Pitch
- 6 Coarse-toothed



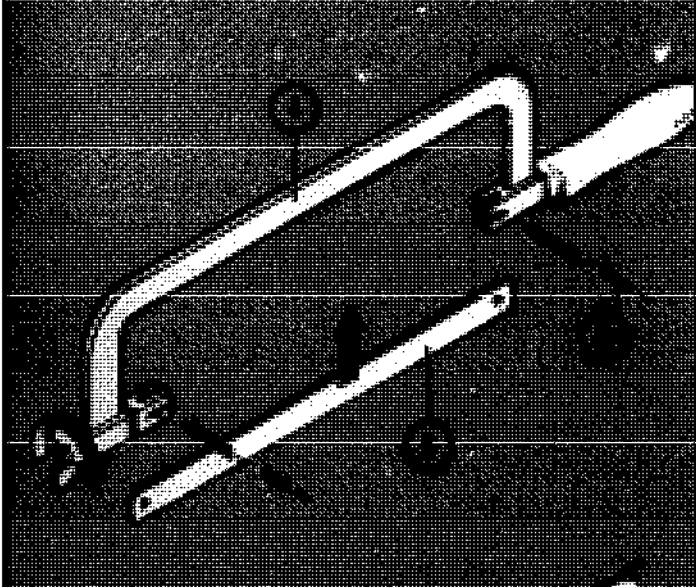


1  
Hacksaw

The blade should be fitted in the frame in such a way that the teeth point forward, that is away from the worker.



2  
Correct  
3  
Wrong



4  
Saw frame

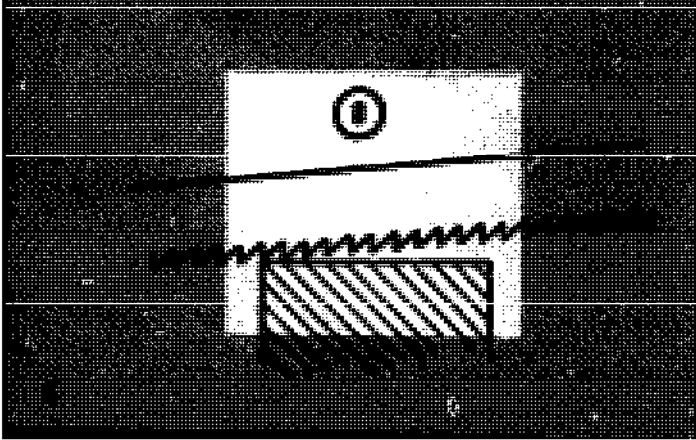
The saw blade is fitted into the frame by means of two pins and is tensioned by means of the wing nut at the end. The saw should not be tensioned too much.

5  
Pin

6  
Blade



7  
Holding the  
saw

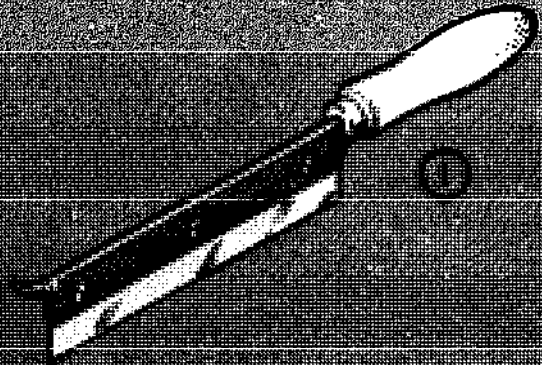


8  
Start in  
this way

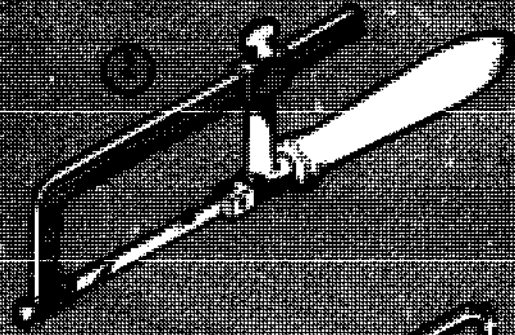
When starting to saw, hold saw at a small angle to prevent the teeth from breaking.

A number of special types of saws are shown on this page.

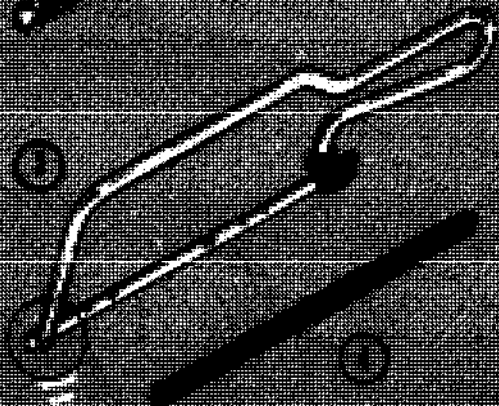
1  
Backsaw



2  
Adjustable  
instrument  
saw



3  
Junior saw

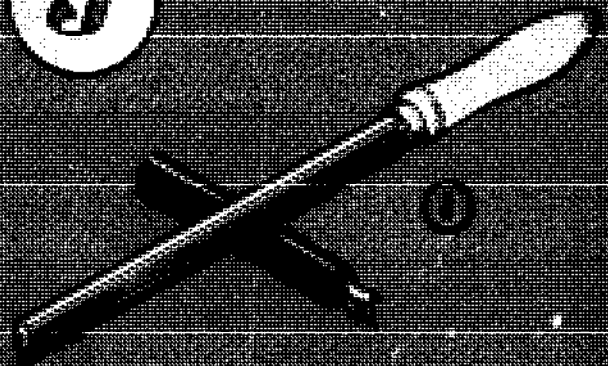


4  
Junior saw  
blade



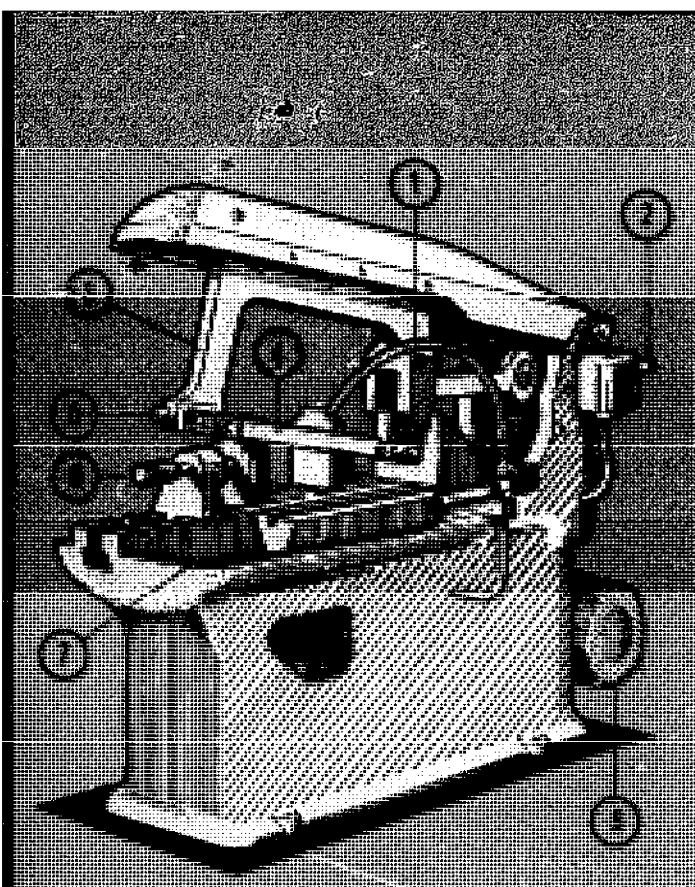
Used for slitting the insulation of electric cables.

5  
Cable slit-  
ting saw



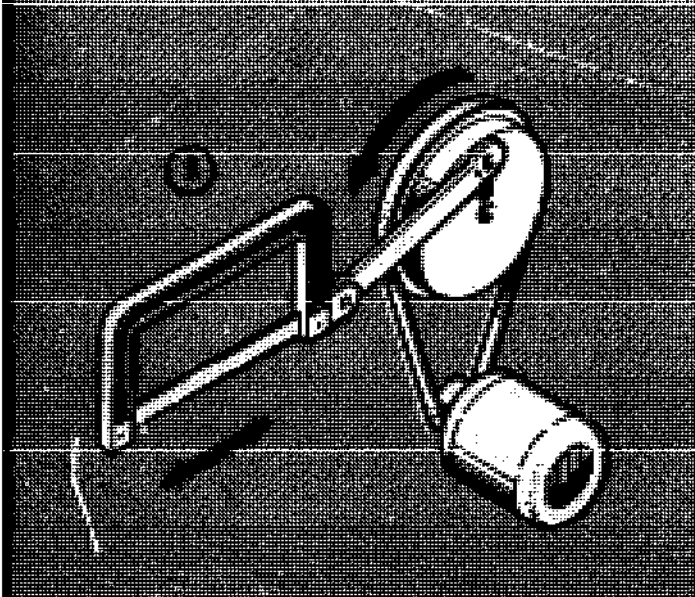
6  
Compass saw



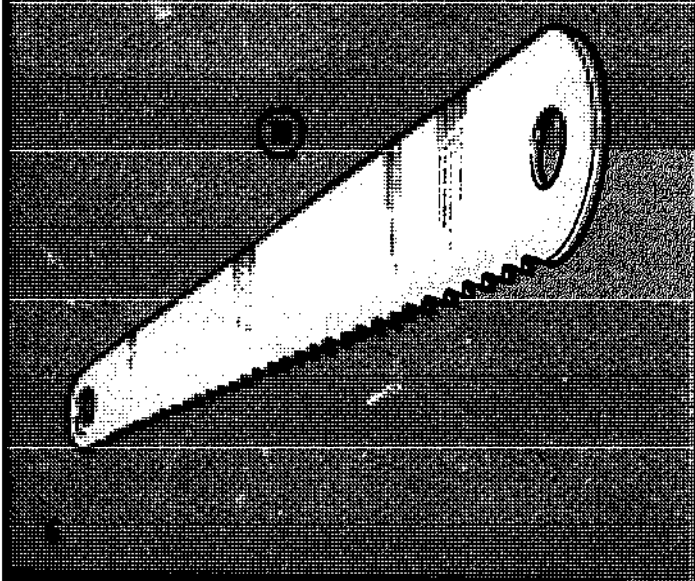


- 1 Tube for coolant
- 2 Switch
- 3 Saw frame
- 4 Blade
- 5 Tensioning screw
- 6 Vice jaw
- 7 Coolant pan

8 Motor



9 Principle of operation



10 Blade

Besides the hand hacksaw there are various mechanical saws. On this page a power hacksaw is shown.

These machines usually have a pulling stroke. (notice the teeth)

A choice may be made from various types of blades. Some data are given on the last page of this lesson.

Another type of power saw is a circular sawing machine, in which a rapidly turning disc carries the teeth.

Circular saws may  
 - have a static blade. The work is pressed against the blade and fed towards it (top figure);  
 - have a movable blade, the work being stationary (second figure).

Circular saw blades may be coarse-toothed or fine-toothed.

Sometimes the teeth are inserted one by one into the blade.

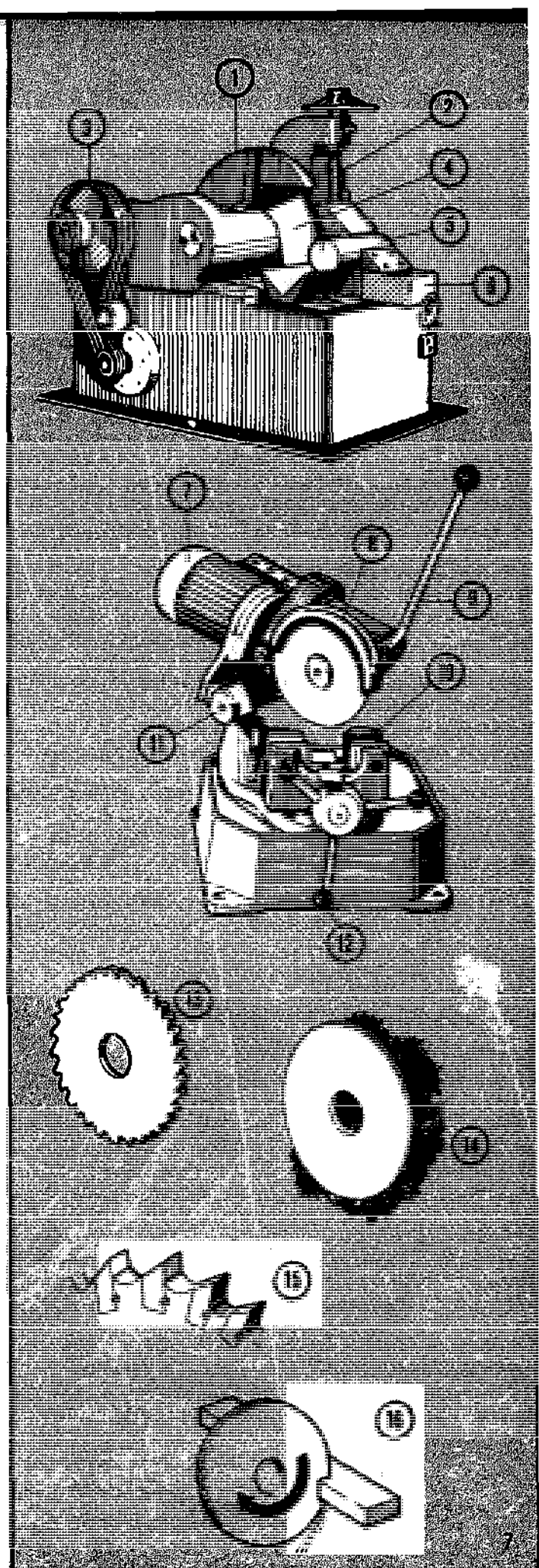
Yet another method of sawing is called abrasive cutting. The coarse abrasive wheel rotates at very high speed and softens the work locally. The softened material is slung away by the wheel.

- 1 Guard
- 2 Clamping device
- 3 Drive
- 4 Circular saw blade
- 5 Work
- 6 Support

- 7 Motor
- 8 Guard
- 9 Feed lever
- 10 Clamp
- 11 Pivot

- 12 Clamping device
- 13 Coarse toothed
- 14 Fine toothed

- 15 Inserted teeth
- 16 Principle of abrasive cutting



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Circular saws may  
 - have a static blade. The work is pressed against the blade and fed towards it (top figure);  
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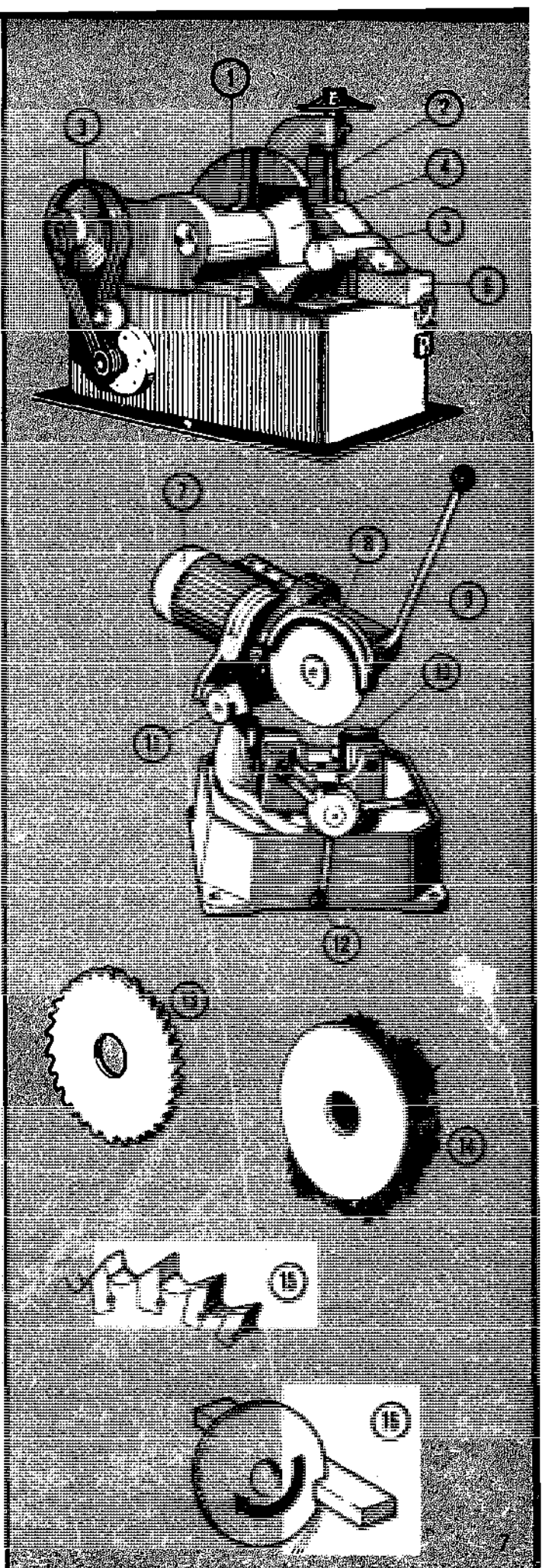
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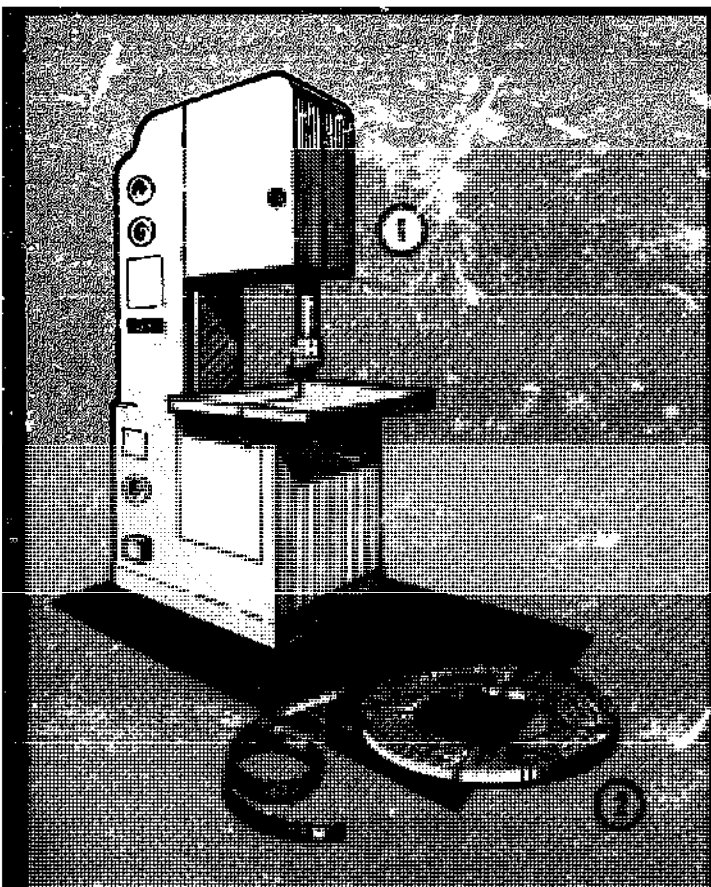
- 1 Guard
- 2 Clamping device
- 3 Drive
- 4 Circular saw blade
- 5 Work
- 6 Support

- 7 Motor
- 8 Guard
- 9 Feed lever
- 10 Clamp
- 11 Pivot

- 12 Clamping device
- 13 Coarse toothed
- 14 Fine toothed

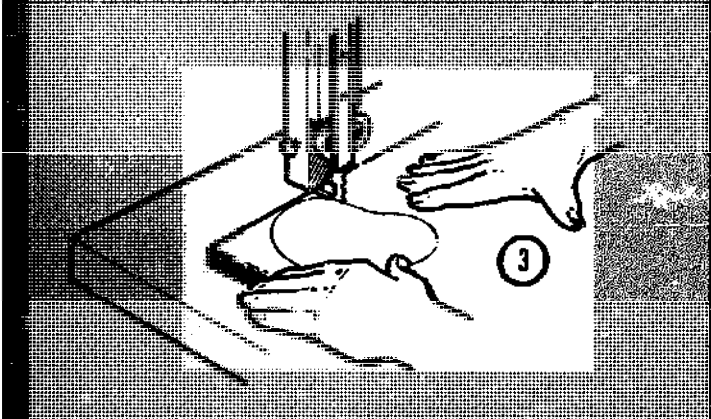
- 15 Inserted teeth
- 16 Principle of abrasive cutting





1  
Band-sawing  
machine

In a band-sawing machine the saw blade is an endless band. At the top and at the bottom are large wheels. The band is led round these wheels and one wheel transmits the motion.

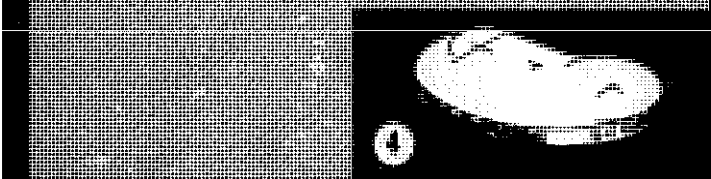


2  
Saw band

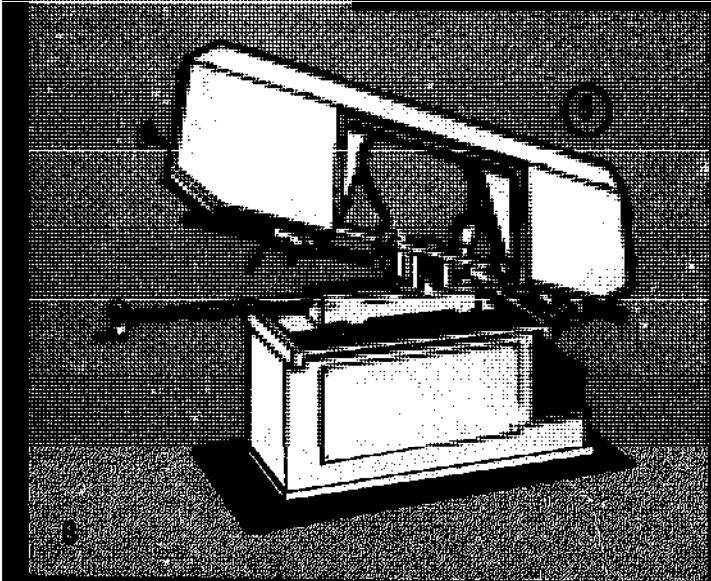
Saw bands are sold in coiled bundles. The saw band is put on the machine, the right length is cut off and the band is welded together. When holes are to be sawn the band also requires to be welded.

3  
Using the  
band saw

Rounded shapes can be cut with this type of saw.



4  
Workpiece



5  
Horizontal  
band saw

For any material the proper blade should be chosen. At least three teeth should be simultaneously in contact with the material.

For thick and soft materials a coarse-toothed saw is used.

For thin and hard materials a fine-toothed saw is used.

For the first cuts the saw should be guided by the thumb above the teeth.

1  
At least  
three teeth

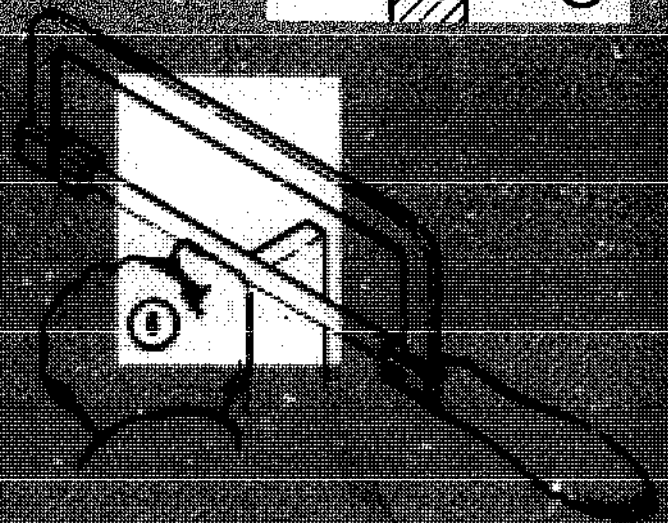
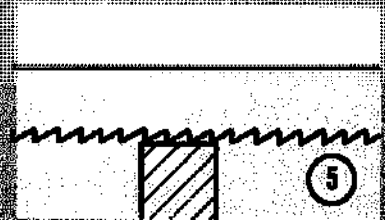
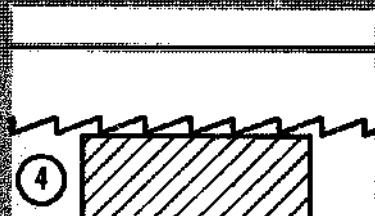
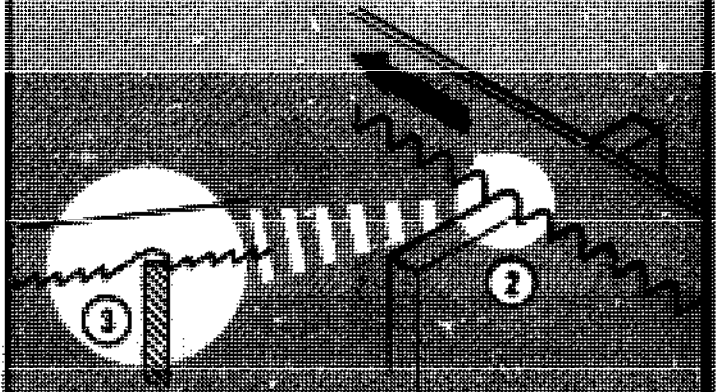
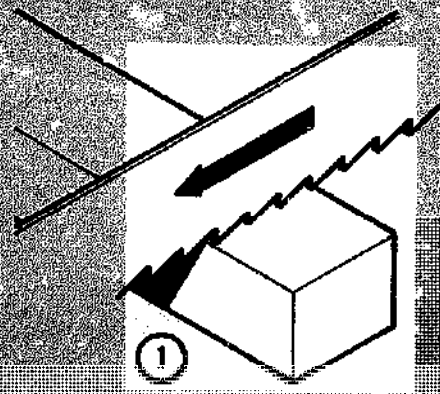
2  
Wrong !

3  
Broken teeth

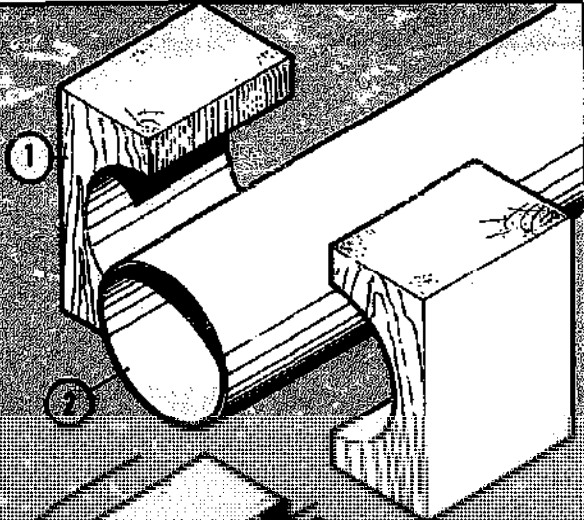
4  
Coarse-  
toothed

5  
Fine-toothed

6  
Guiding the  
saw

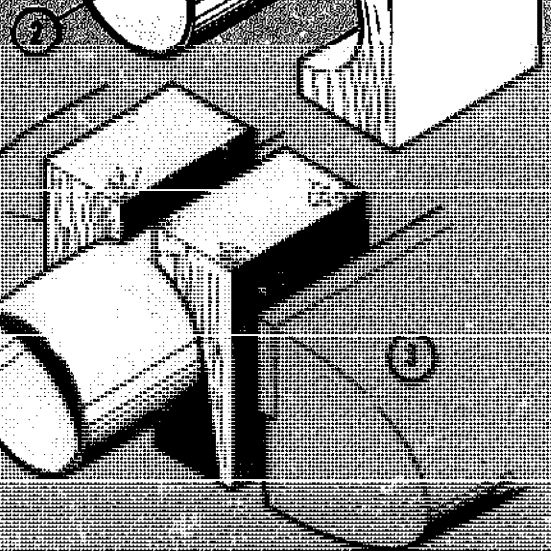




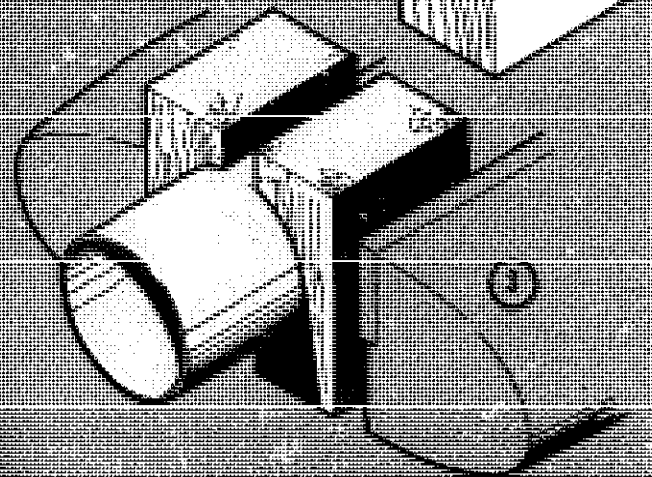


1  
Wooden  
packing

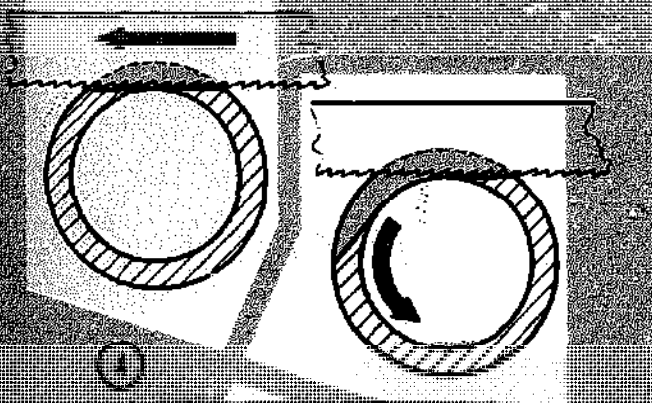
For sawing, thin-walled pipe should be clamped in such a way that the pipe is not distorted. So use wooden packings !



2  
Thin-walled  
pipe

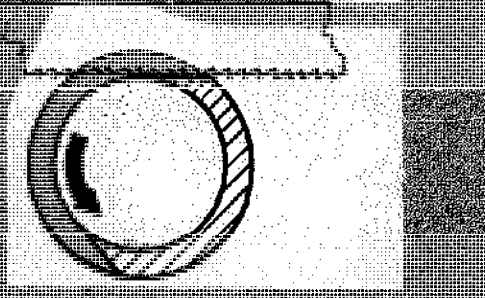


3  
Clamping



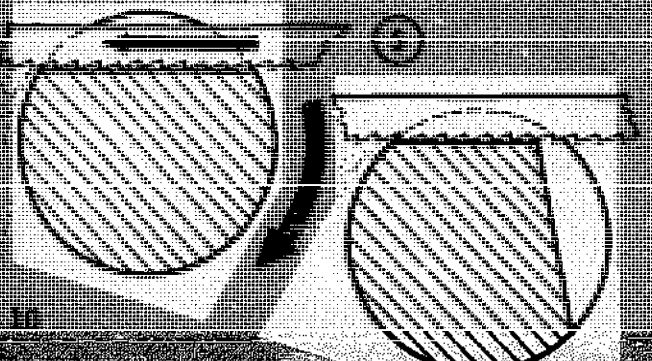
4  
Turn pipe  
regularly

The pipe should also be turned regularly so that several teeth are always cutting at the same time.



5  
Thick  
material

Thick material should first be cut over about a quarter of its thickness. Then the material should be given a quarter turn before the cutting is continued.



If long cuts have to be made the blade can be set at right angles to the frame.

Always clamp the work in such a way that the cut is vertical.

Thin sheet material is clamped on a wooden block.

Keep saw in such a way that at least three teeth are cutting at the same time.

Clamp work in such a way that the blade cannot touch parts below cut.

1  
Blade at right angles to the frame

2  
Vertical cut

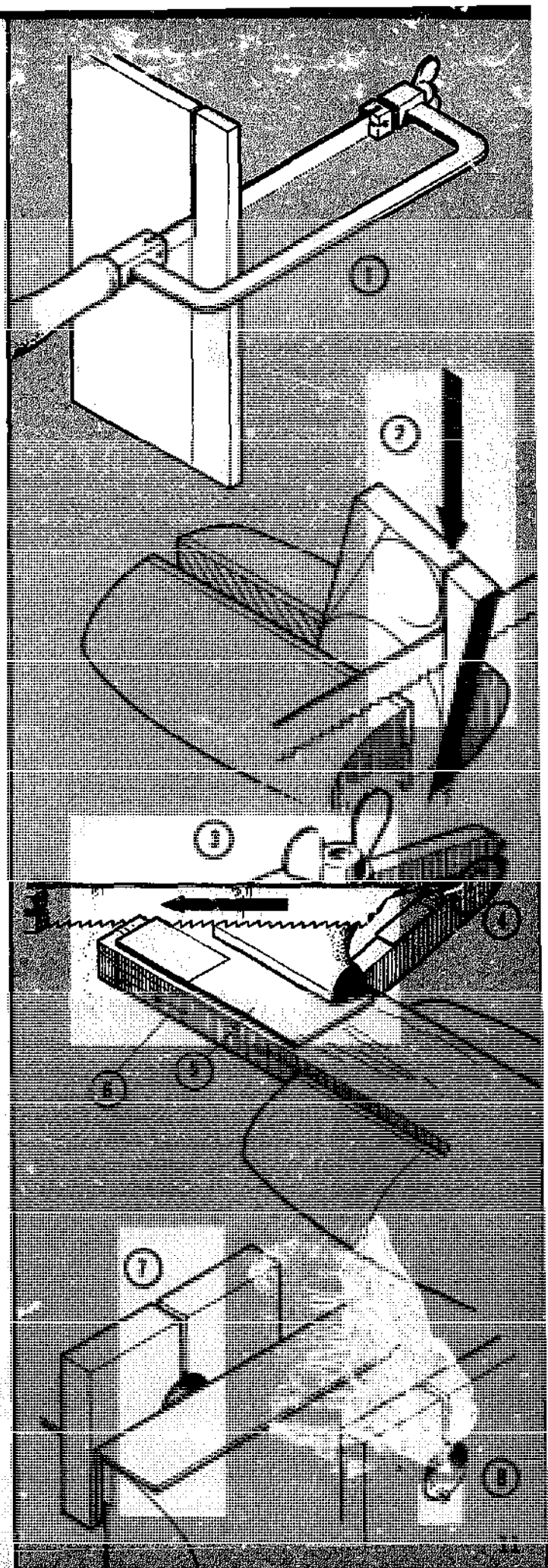
3  
Thin material on wood

4  
Hand vice

5  
Thin sheet metal  
6  
Wooden block

7  
Cut ends in hole

8  
Saw has slipped





1  
Goggles

When sawing use goggles.



2  
Length in inches

Data for sizes and uses of saw blades are given below:



3  
Width in inches



4  
Thickness in millimetres



5  
Number of teeth per inch



6  
Number of strokes per minute



7  
Materials

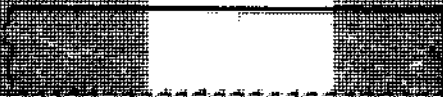
(2)	(3)	(4)	(5)
12"	5/8"	0.65	18-22-24-32
12"	3/4"	0.65	14-18-24-
12"	1"	1.25	10-14
12"	1 1/4"	1.60	6-10
14"	1"	1.25	10-14
14"	1 1/4"	1.60	6-10
14"	1 3/4"	2.00	4-6
16"	1"	1.25	10-14
18"	1 1/4"	1.60	4-6-10
17"	1"	1.25	10-14
17"	1 1/4"	1.60	4-6-10
18"	1 1/4"	1.60	6-10
18"	1 1/2"	2.00	4-6
18"	1 3/4"	2.25	4-6
21"	1 1/2"	1.60	6-10
21"	1 3/4"	2.00	4-6
21"	1 3/4"	2.25	4-6
24"	1 3/4"	2.25	4-6



8  
22 teeth per inch



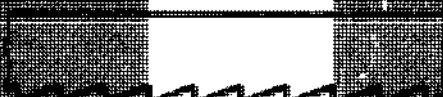
9  
14 teeth per inch



10  
10 teeth per inch



11  
6 teeth per inch



12  
4 teeth per inch

(8)	(9)	(7)
6-10	90-120	Mild steel
6-10	60-90	Construction steel
6-10	90	High speed steel
4-10	120-135	Stainless steel
4-10	120-135	Nickle steel
4-10	90-135	Cast iron
4-6	120-135	Brass
10-14	120	Bronze
		Aluminium
		Pipes-light steel sections

## INTEMS PICTORIAL SYSTEM

## CHIPPING, CHISELLING, GRINDING

Chipping (or chiselling) means cutting away metal by means of a hammer and a chisel.

In figure 1 the man is chipping. He holds a hammer in his right hand and a chisel in his left hand.

Another way to use hammer and chisel (without cutting away metal chips) is cutting off.

The cold chisel is so named because it is used to cut the metal while it is cold.

Chisels are made from special chisel steel, forged to shape, hardened and tempered. The cutting end should be hard but not brittle. The other end of the chisel (the head) must be soft.

The cutting edge is ground to the required cutting angle. While being ground the chisel should be cooled with water.

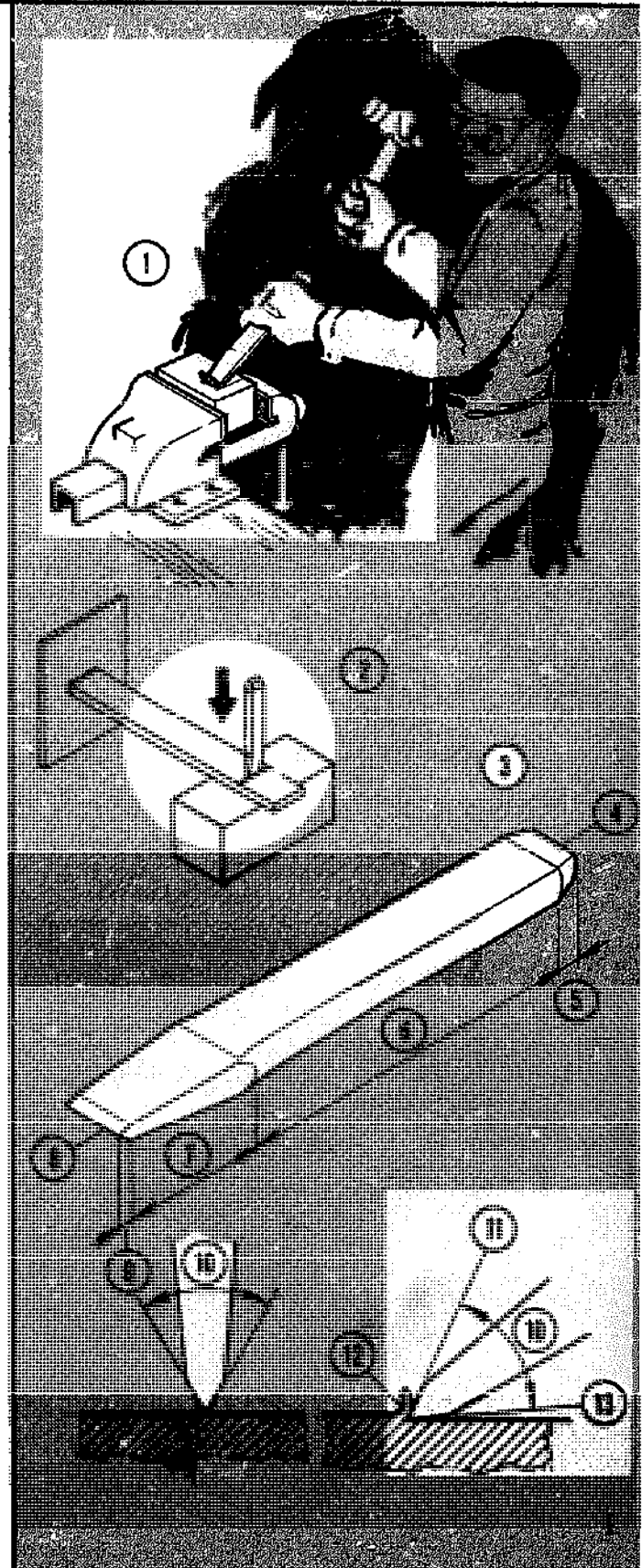
1  
Chipping

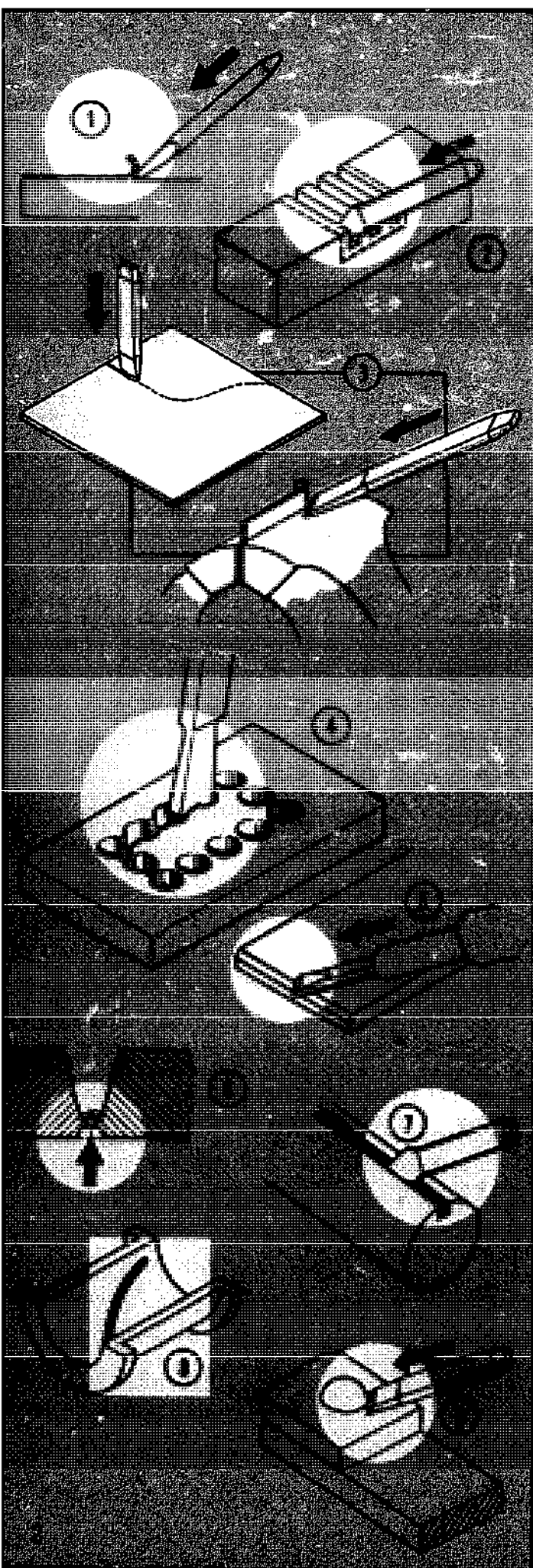
2  
Cutting off

3  
Cold chisel  
4  
Striking  
end

5  
Head  
6  
Stock  
7  
Nose  
8  
Blade

9  
Cutting  
edge  
10  
Cutting  
angle  
11  
Cutting  
surface  
12  
Chip  
13  
Clearance  
angle





Some USES OF CHISELLING are:

1  
Outsides

a. rough shaping of outsides.

2  
Insides

b. rough shaping of insides.

3  
Sheet metal

c. shaping sheet metal.

4  
Waste  
between  
holes

d. removing waste between  
holes.

5  
Bevelled or  
chamfered  
edges

e. making bevelled edges on  
material to be welded.

6  
Counter

f. making a weld seam with  
a backing run (or sealing  
run).

7  
Keyway

g. cutting keyways and oil  
grooves.

8  
Oil groove

9  
Rivet head

h. cutting away rivet heads  
and nuts.

## HOLDING THE CHISEL

The chisel is held at an angle to the material.

When the head is hit with a hammer the cutting edge penetrates the material.

On the cutting end of a chisel we find the following angles

rake,  
cutting angle,  
clearance angle.

The position of the chisel is very important. If the clearance angle is very small or even zero, then the chisel slips off.

If the clearance angle is too large the chisel digs in too far.

Only the correct position of the chisel gives a good cutting action and a smooth surface.

1  
Position of  
chisel

2  
Hammer

3  
Chisel

4  
Rake

5  
Cutting  
angle

6  
Clearance  
angle

7  
Too flat

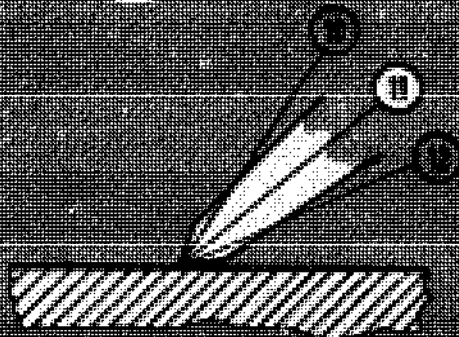
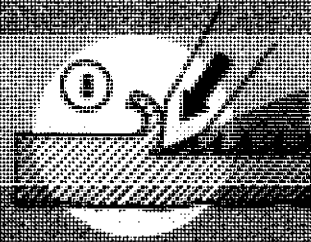
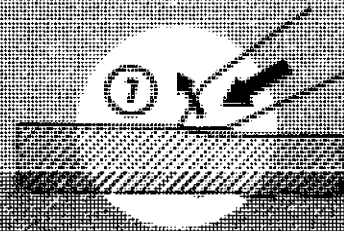
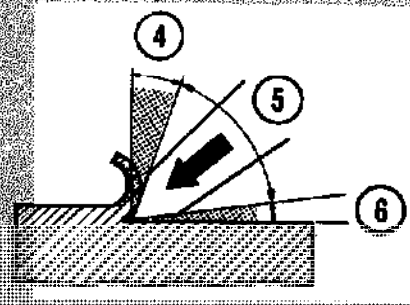
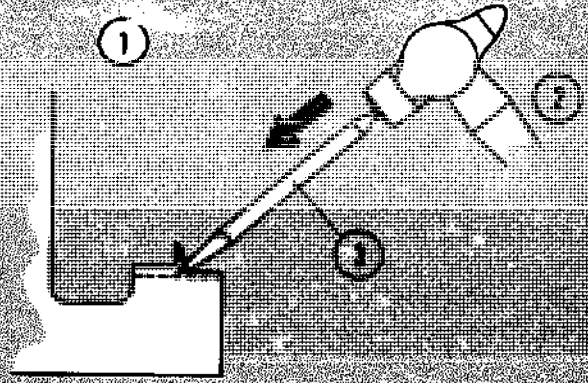
8  
Too high

9  
Right

10  
Too high

11  
Right

12  
Too flat



## COLD CHISELS

The chisels most commonly used are shown here.

1  
Flat chisel

a. Flat chisel.  
Used for facing, deburring  
on castings and welds.

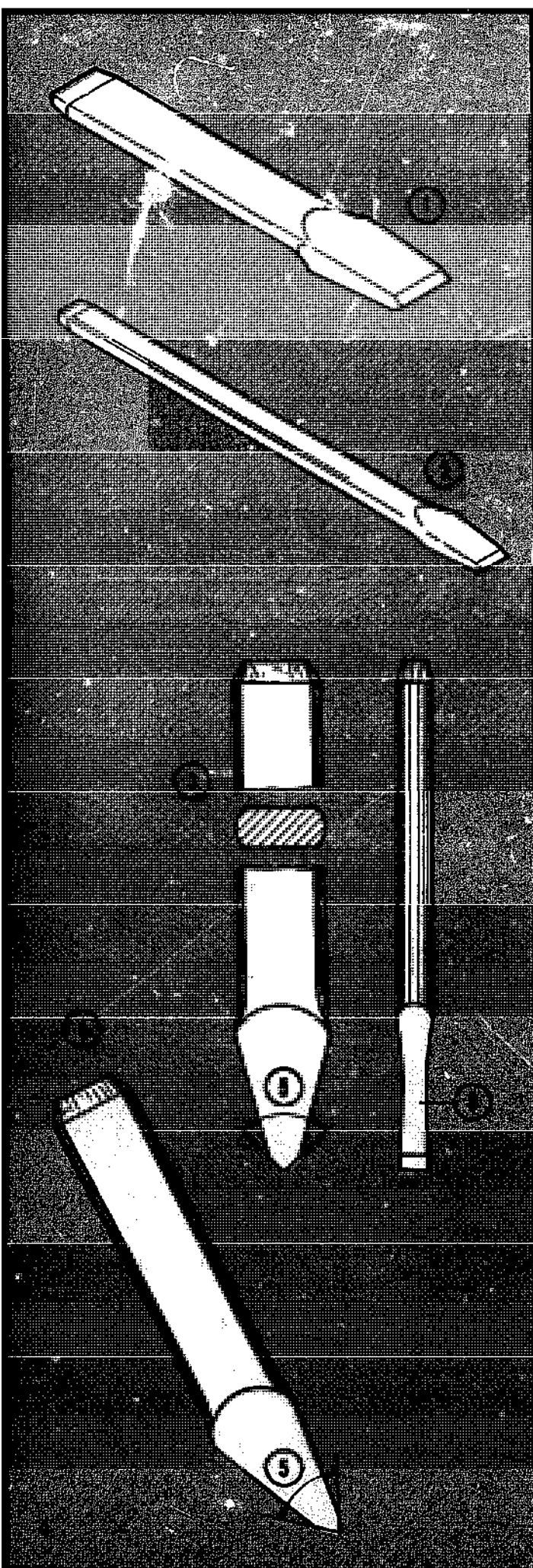
2  
Flat chisel

3 and 4  
Cape chisel  
or  
cross-cut  
chisel

b. Cape chisel.  
Used for cutting keyways  
and grooves and slots.  
The blade narrows behind  
the cutting edge to pre-  
vent the chisel from  
binding in a slot.

5  
Cutting  
angle

6  
Narrowing



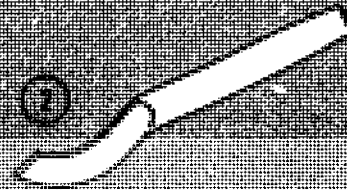
c. Half-round chisel.  
Used for cutting curved  
grooves in sheet steel.

1  
Half-round  
chisel



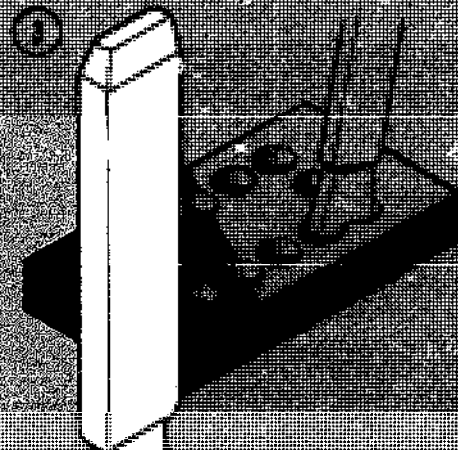
d. Oil groove chisel.  
Used for cutting oil  
grooves in machine parts.

2  
Oil groove  
chisel



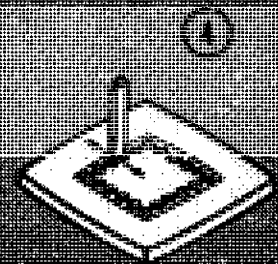
Finally there are punches  
for removing material  
between drilled holes when  
recesses and large holes  
have to be made.

3  
Punching  
chisel



The work would be distorted  
if an ordinary chisel would  
be used for this job.

4  
Wrong.  
Work is  
distorted



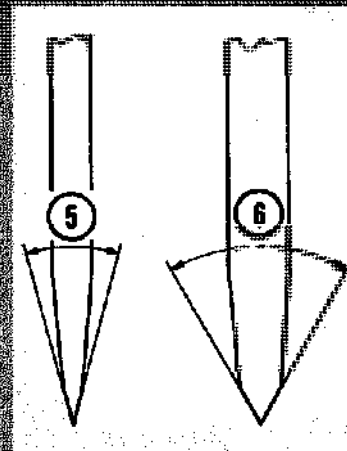
The correct cutting angle  
depends on the material to  
be chiselled.

For soft materials such as  
aluminium a sharp cutting  
angle ( $30^{\circ}$ ) is required.

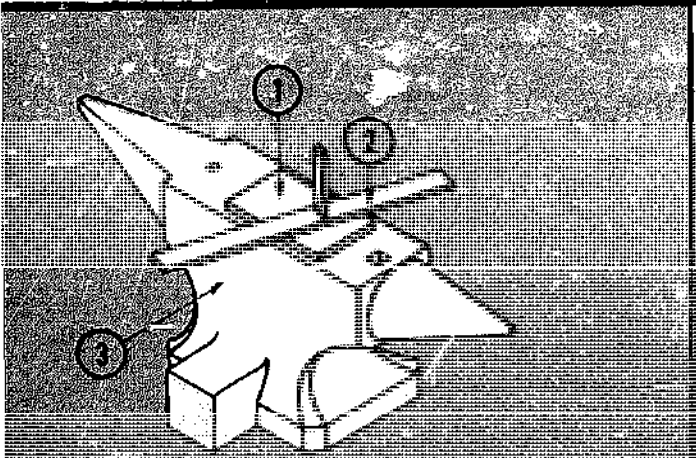
5  
For soft  
material  
 $30^{\circ}$

For steel, which is much  
harder, the cutting angle  
is about  $60^{\circ}$ .

6  
For hard  
material  
 $60^{\circ}$



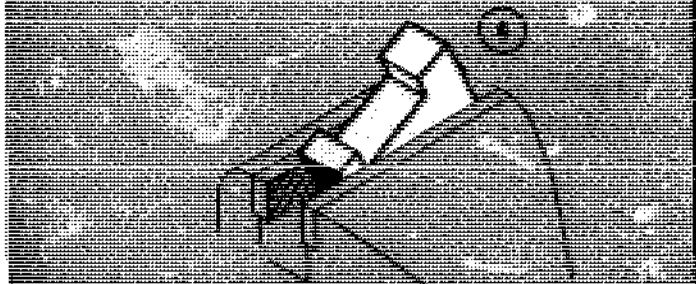




- 1 Packing block
- 2 Workpiece
- 3 Anvil

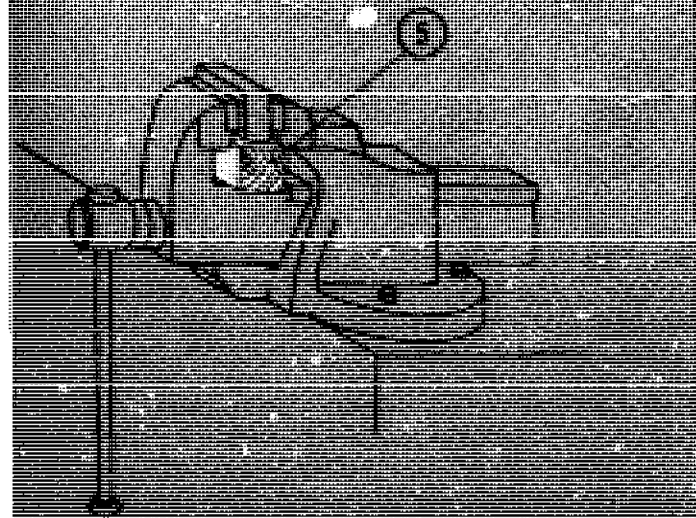
**HOLDING THE WORK.**

Material to be cut off is put on a heavy base such as an anvil. To avoid damage a packing block of wrought iron is used.



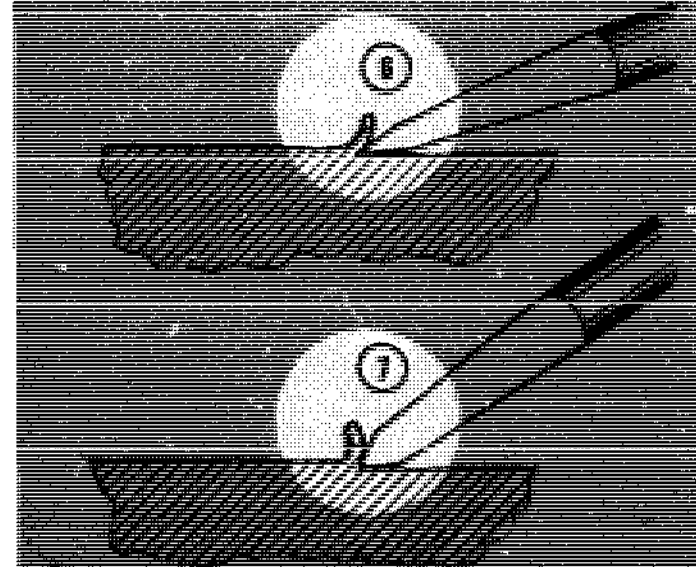
- 4 Work slips down

Small jobs are clamped in the vice.



- 5 Wooden packing block

To prevent the work from slipping down, a wooden packing block is placed underneath.



- 6 Soft material
- 7 Hard material

**CHOOSING A CHISEL.**

The choice of a chisel depends on the material to be cut.

Therefore

a sharp cutting angle for soft metal.

a large cutting angle for hard metals.

For accurate and light work a sharp, slender chisel should be used.

For heavy work the chisel should be large.

The hammer should always be held at the extreme end of the handle.

Always watch the cutting edge when cutting, and not the striking end. Hold the chisel in such a way that one continuous chip is removed. The chip should not be too thick - about 1 mm is right.

Surfaces broader than the cutting edge of the chisel are chiselled as shown in fig. 5.

Adapt your speed and force in such a way that you can go on chiselling for a long time.

### CUTTING SHEET METAL

Use a chisel with curved cutting edge. This is the only one to give a straight line. If necessary a continuous shallow groove is first cut and later cut through.

Always use a packing block under the workpiece.

1  
Light work

2  
Heavy work

3  
Holding the hammer

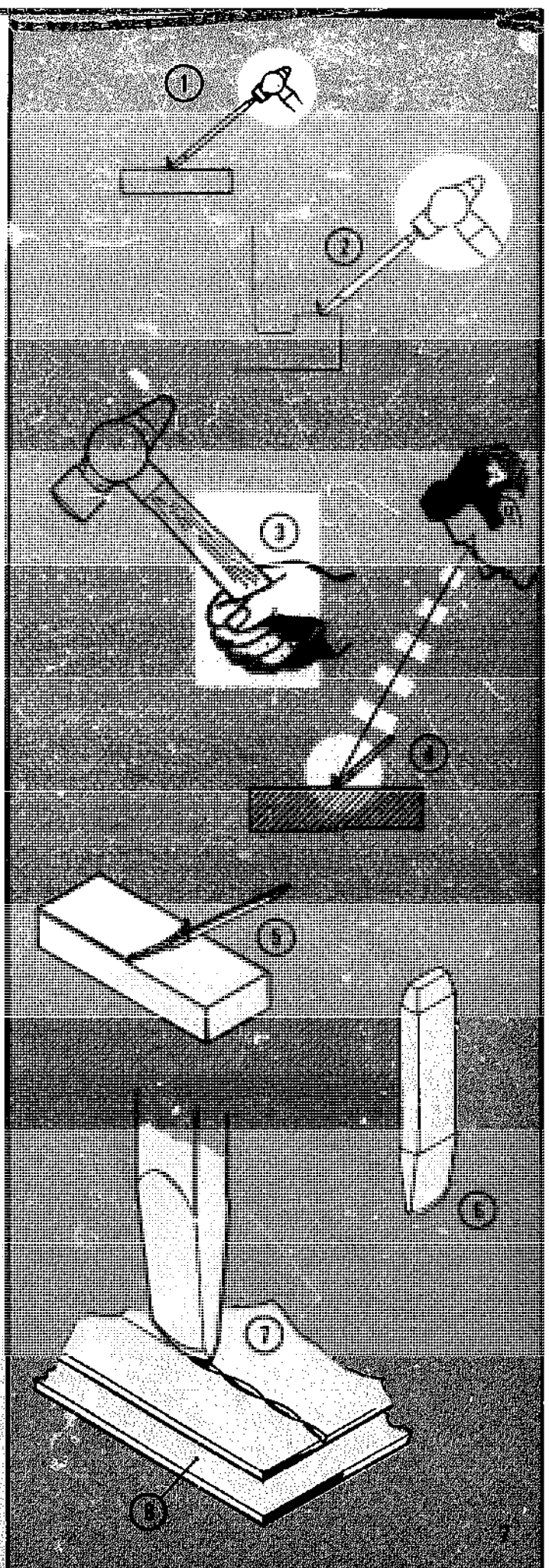
4  
Watch the cutting edge

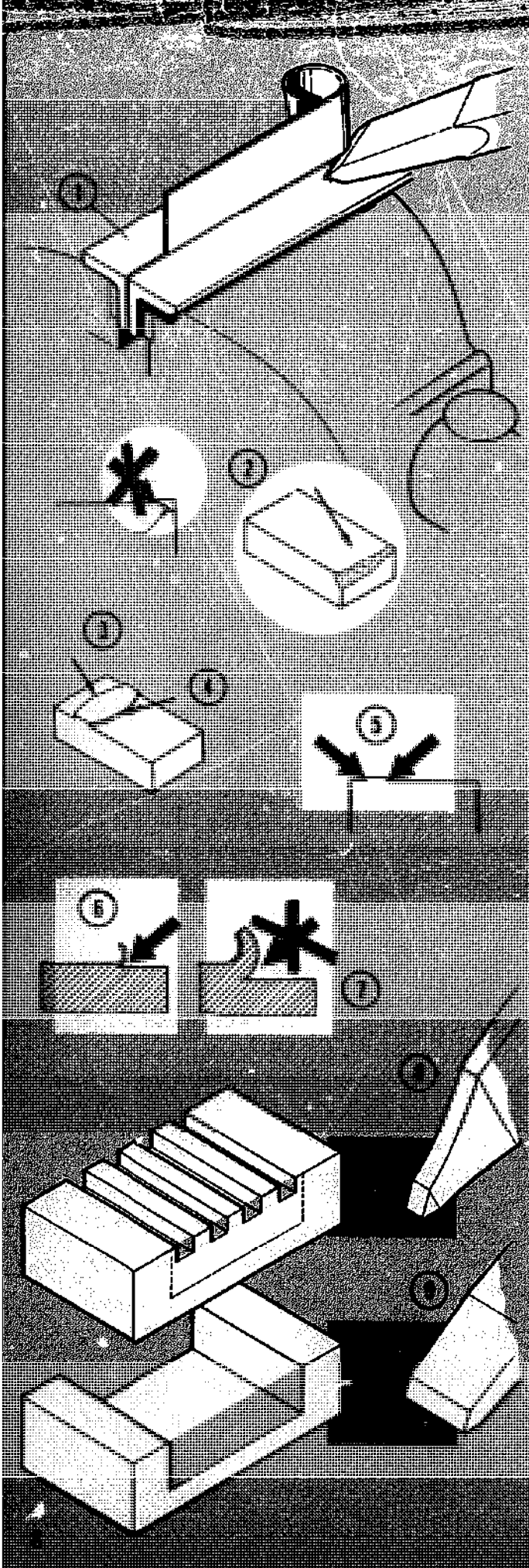
5  
Broad surfaces

6  
Curved cutting edge

7  
Cutting sheet metal

8  
Packing block





1  
Angle  
sections

When chiselling in the vice the cutting edge rests on it. Clamp the work between angle sections to avoid damaging the jaws of the vice.

2  
Fracture

Brittle material should be cut in such a way that the edges cannot break.

Therefore chipping should always be done from two sides.

3  
First cut

First a cut should be given from the edge.

4  
Definite  
cut

5  
Correct

6  
Good chip

Cut evenly with the right thickness of chip.

7  
WRONG.  
Chip too  
thick

8  
Grooving  
chisel

The grooving chisel is a cross-cut chisel.

9  
Flat chisel

If much of the stock has to be removed, cut first channels with the cross-cut chisel.

## CHIPPING

Now and then press cutting edge in wad of waste cotton soaked in oil.

### SHARPENING A CHISEL

When grinding a chisel see to it that the least possible amount of steel is ground away.

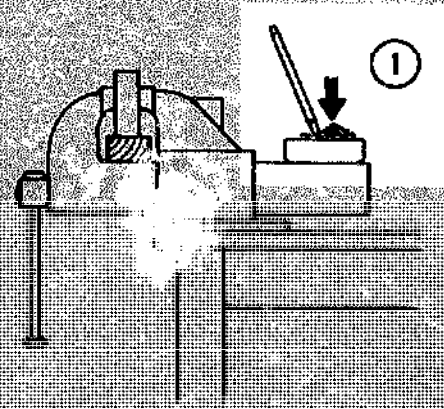
The cutting edge must not grow too hot. Therefore the chisel should be cooled during grinding. If the cutting edge has turned blue the chisel should be hardened again.

Hammer out if blade is too thick.

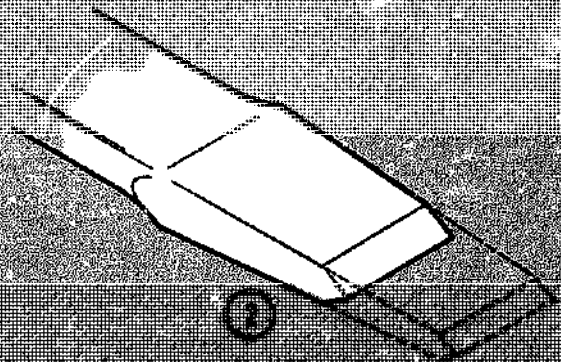
### SAFETY

The slogan for chipping is: SAFETY FIRST. Therefore always wear goggles and place a chip guard in front of the work to catch the chips.

1  
Oil soaked  
cotton



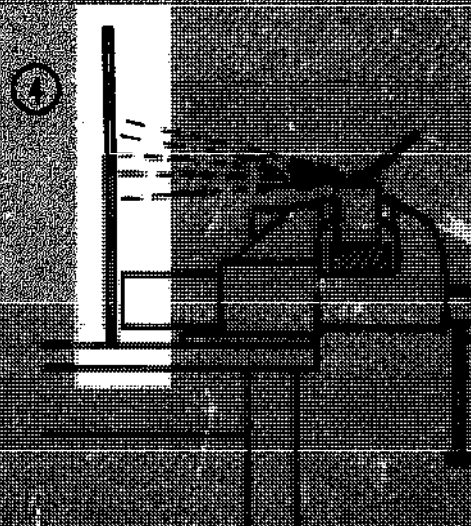
2  
Blade too  
thick

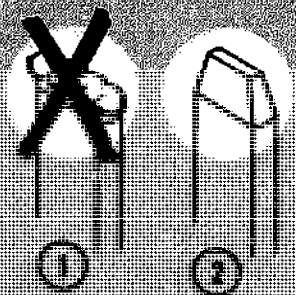


3  
Goggles



4  
Chip guard



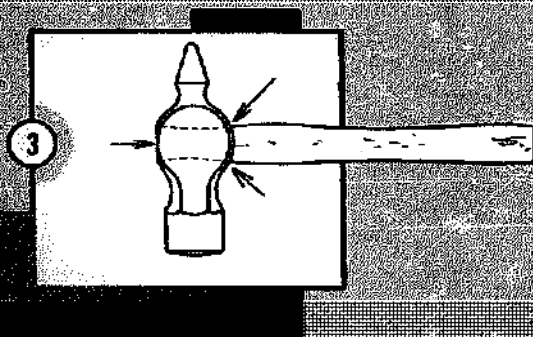


1  
Mushroom  
head

At regular intervals remove burrs from head, so that no "mushroom head" is formed.

2  
Correct head

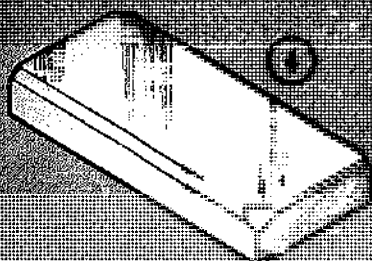
Keep face of hammer clean to prevent it from glancing off the work. Check that handle of hammer fits immovably in head.



3  
Rigidly  
attached  
hammer

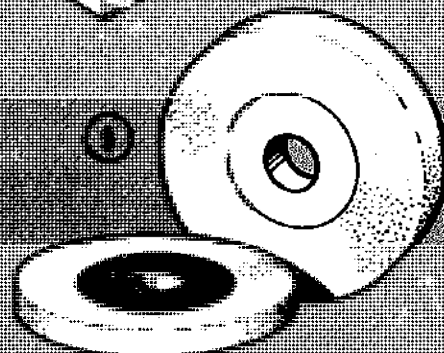
**GRINDING TOOLS**

Cutting tools like chisels or drills grow dull by use. They have to be resharpened regularly. To this end grindstones and oilstones are used.



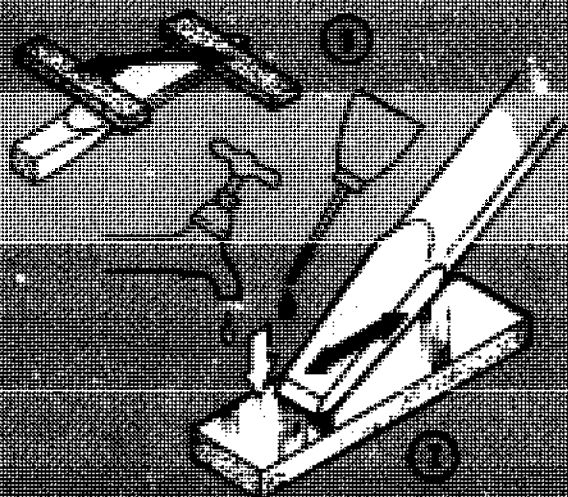
4  
Oilstone

Oilstones are used to give all sorts of cutting tools an extremely accurate and smooth cutting edge. To this end a natural siliceous stone is used. Oilstones should be handled with care and kept in a wooden box.



5  
Grinding  
wheel

Instead of oilstones, grinding wheels may be used. These wheels are made artificially and consist mainly of abrasive grains bonded together.



6 and 7  
Sharpening  
with oil-  
stones

During sharpening oil or water is applied. Either the stone is moved across the tool or the tool across the stone.

## GRINDING

Grinding wheels are mounted on a grinder, or grinding machine.

Most grinders have a tool rest, which supports the tool to be ground.

Chisels are ground on a grinding wheel. When a chisel has been reground many times, the cutting end becomes too thick to be useful. To reshape it, it should be hammered out.

Chisels with a straight cutting edge are usually ground on the side of the grinding wheel. This is better than using the face because of the danger of grinding a hollow cutting edge.

For grinding screwdrivers the face can be used.

1  
Grinder

2  
Tool rest

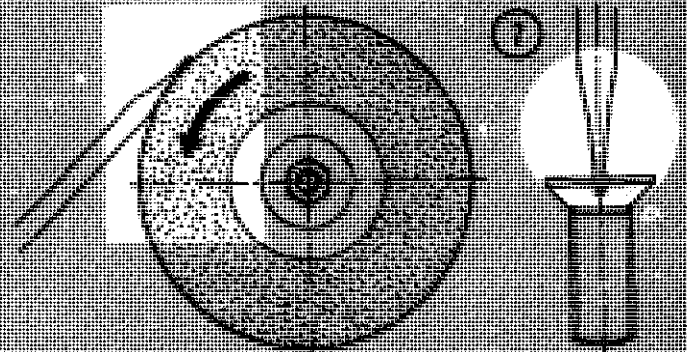
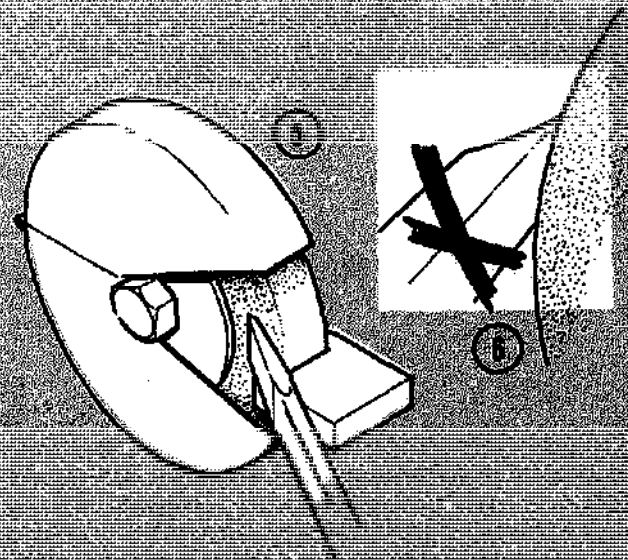
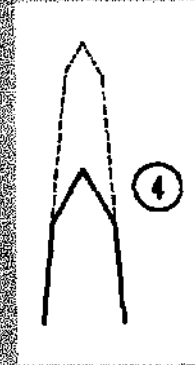
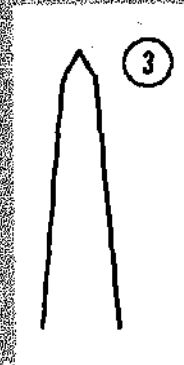
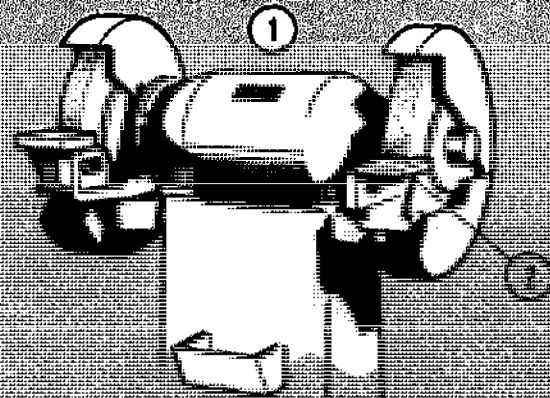
3  
Good chisel

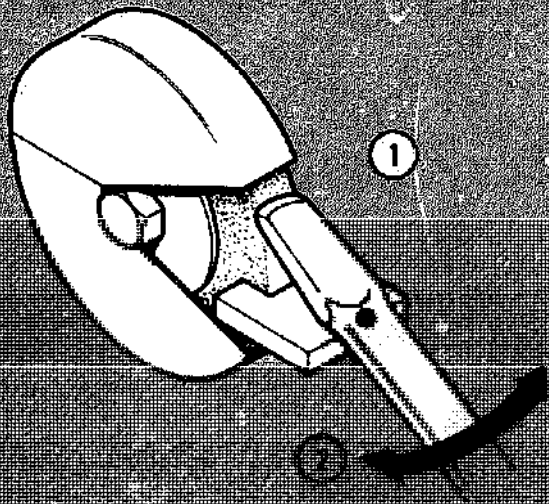
4  
Useless chisel

5  
Grinding a chisel with straight cutting edge

6  
WRONG!  
Hollow point

7  
Grinding a screwdriver

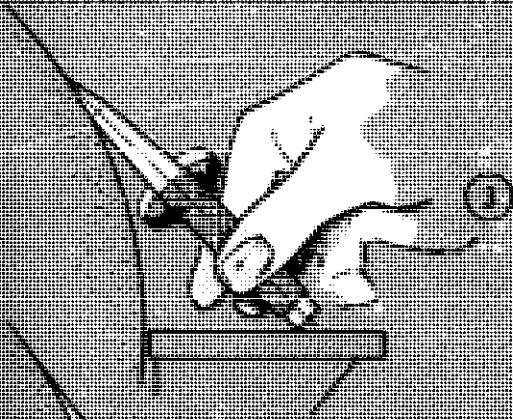




1  
Grinding a curved cutting edge

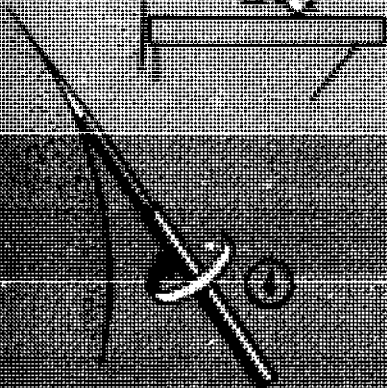
In figure 1 the way of grinding curved edges on half-round chisels is shown.

2  
Movement on the hand



3  
Grinding a punch

How centre punches are ground is shown in fig. 3. The point of the punch should be on the centre line of the grinding wheel. Grinding is done by hand. The punch is turned slowly but continuously between forefinger and thumb.



4  
Grinding a scriber

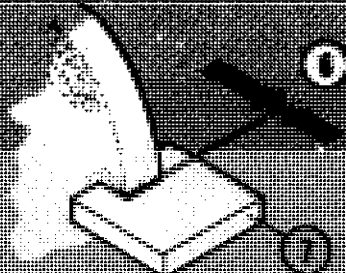
Scribers should be quite sharp to do their job well. Grinding is done in the same way as for centre punches but more care is needed because scribers are so thin. Light sharpening can also be done on the oilstone.



5  
Goggles

**SAFETY**

Always wear goggles when grinding.



6  
Gap  
7  
Tool rest

Place the tool rest as close to the grinding wheel as possible and use it.

## INTEMS PICTORIAL SYSTEM

## WELDING

Welding is joining two metals by melting them locally, together with filler metal.

There are two main groups of methods:

- a. GAS WELDING, where the heat is produced by a flame through a blow pipe, using oxygen and some other gas as fuel. The other gas is normally acetylene.
- b. ARC WELDING, where the heat is produced by striking an electric arc between the metals to be welded and an electrode.

In gas welding the filler metal is applied as wire or a rod.

In arc welding the electrode itself is melted away as filler metal.

1  
Welded  
joint

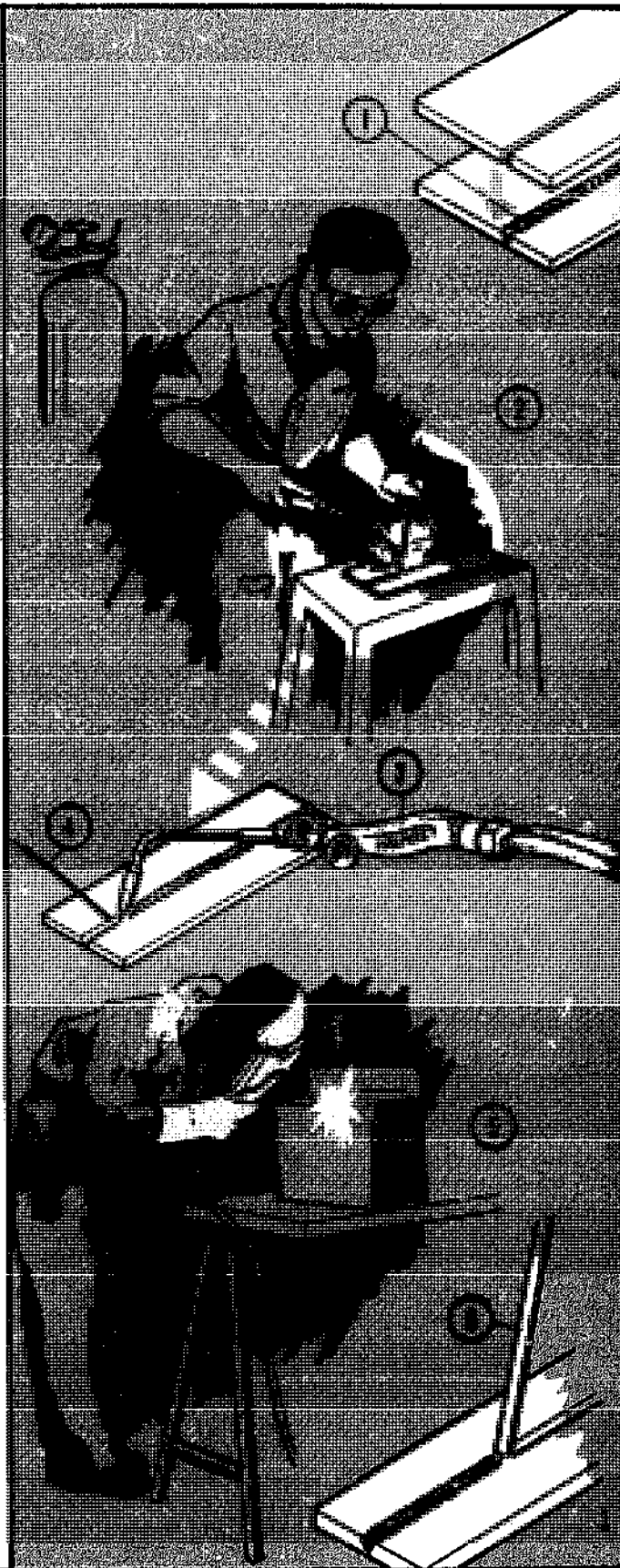
2  
Gas welding

3  
Blow pipe  
(welding  
torch)

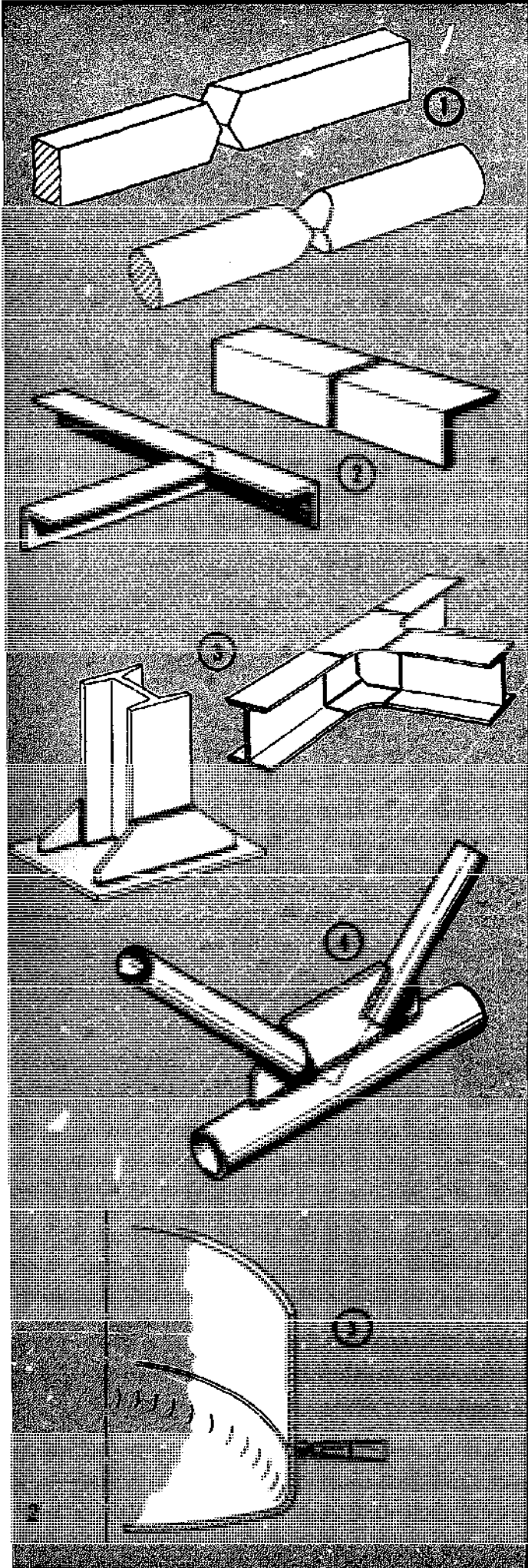
4  
Filler  
metal

5  
Arc welding

6  
Electrode







1  
Bars

Among other applications of welding are the joining of:

- round or square sectioned bars,
- angles and sections,
- pipes,
- sheets.

These are only very few of the possibilities.

2  
Angles and sections

In principal gas- and arc welding can mostly be used with the same result. The following division in the use can be made:

#### ARC WELDING

is suitable for a wide field of applications e.g.

- steel plate
- steel structures
- piping (wall thickness 5 mm and more)
- aluminium (expensive method in large factories)
- other metals (as stainless steel, nickel)

3  
Sections and sheets

4  
Pipes

#### GAS WELDING

is suitable for welding of

- thin steel sheet
- complicated piping
- aluminium (cheap method in small workshop)
- some other metals (stainless steel, copper (brasses especially), nickel (restricted)).

5  
Plates and sheets

Gas welding is used when no electric energy is available.

For arc welding the electrode is fitted into an electrode holder which is electrically connected by a cable to one of the two terminals of the welding set. The workpiece is electrically connected to the other terminal of the welding set by means of an earth (ground) clamp and earth (ground) lead.

When the electrode is brought into contact with the workpiece the electrical circuit is closed. By drawing the electrode away from the workpiece a very hot arc is formed which melts the metal.

The electrode has a coating, which melts into a slag (4). This slag forms a layer on the molten metal. This layer protects the metal against oxidation.

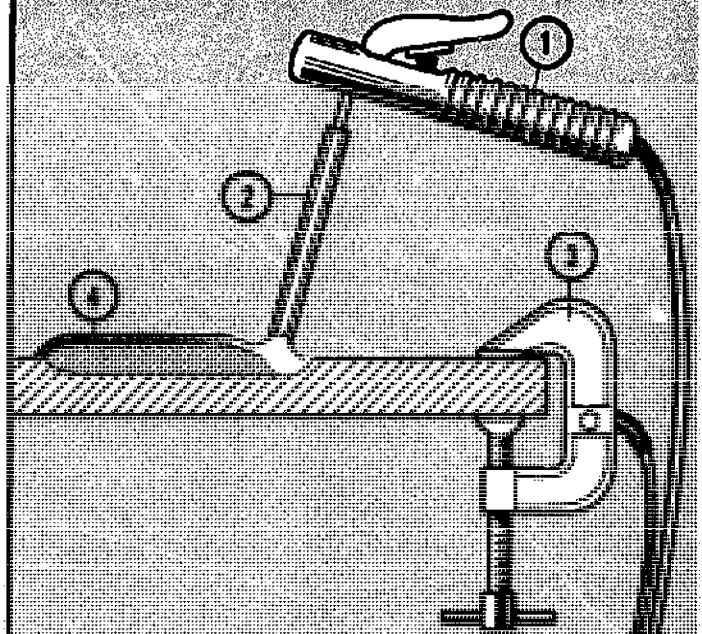
As there are many types of electrodes which should be kept apart and always dry, an electrode cabinet is very useful.

The electric arc radiates ultra-violet rays which can damage the eyes and hands. Therefore always use a face shield and gloves.

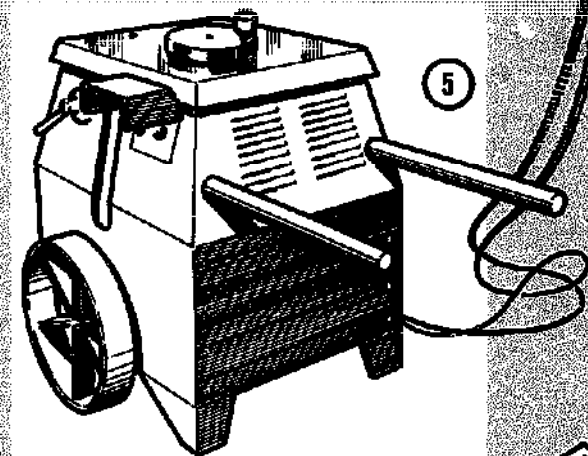
When gas welding wear welding goggles. Leather gloves and apron are worn as a protection against rays, sparks and spatter of molten metal.

Steel brush and chipping hammer are tools for cleaning welds.

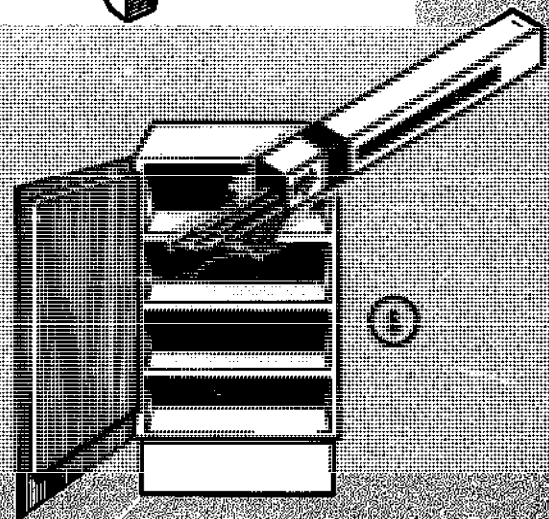
- 1 Electrode holder
- 2 Electrode
- 3 Connection to workpiece by means of ground clamp
- 4 Slag



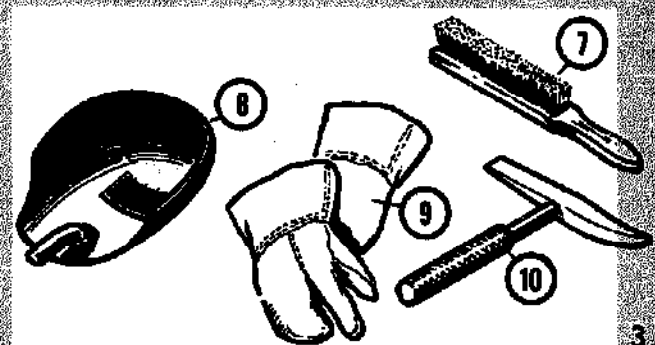
- 5 Arc welding transformer (a.c.)

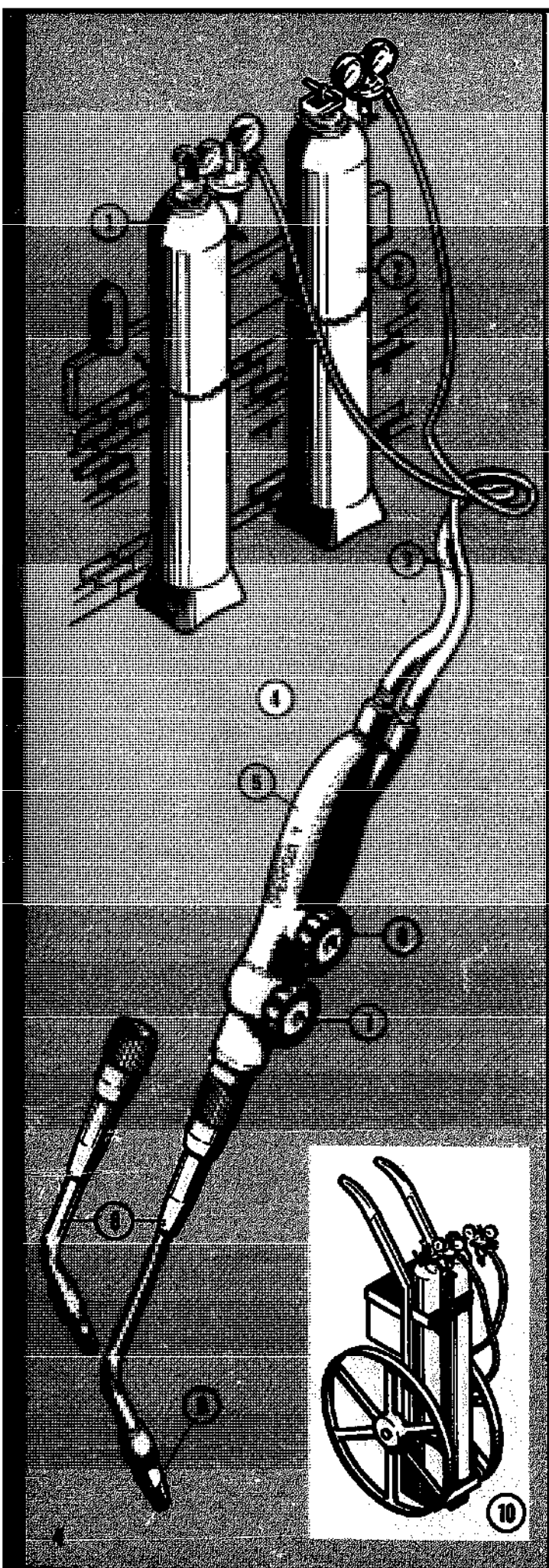


- 6 Electrode cabinet



- 7 Steel wire brush
- 8 Face shield
- 9 Gloves
- 10 Chipping hammer





1  
Oxygen  
cylinder  
2  
Acetylene  
cylinder

3  
Hoses to  
the torch

4  
Blow pipe  
or welding  
torch

5  
Handle

6  
Acetylene  
valve

7  
Oxygen  
valve

8  
Blow pipe  
head

9  
Nozzle

10  
Trolley

For gas welding the flame is usually produced by burning a mixture of acetylene and oxygen.

These gases are kept under pressure in steel cylinders.

On the top of the cylinders are regulators to reduce the pressure of the gases to a suitable working pressure in the blow pipe.

From the regulators the gases are fed to the blow pipe or torch through hoses.

In the torch the gases come together and the mixture is lighted at the tip or nozzle.

For good work it is extremely important that the flame is correctly adjusted.

This adjusting is done by means of the two valves on the torch. Usually the oxygen valve is nearest to the nozzle.

The blow pipe head is interchangeable, because for different plate thicknesses different heads are necessary.

Dependent on the work, various nozzles are used.

For easy transport the cylinders may be placed on a special trolley.

Depending on the thickness of the material various types of joints are made. The principal types are shown on this page and the page overleaf. Some data are given here:

**SQUARE BUTT WELD  
(welded one side)**

plate thickness max. 3 mm  
 gap  $\frac{1}{2}$  plate thickness  
 position of electrode see fig. 2.

**SQUARE BUTT WELD  
(welded both sides)**

plate thickness 3-6 mm  
 gap  $\frac{1}{2}$  plate thickness

The weld is completed in two runs. After the first one the workpiece is turned over, the root of the bead gouged and cleaned before the second run is made.

**SINGLE-V BUTT WELD**

plate thickness 5-16 mm  
 included angle  $60^\circ$   
 root gap ca. 3 mm

The V-joint is completed in several runs. Before each following run the previous one must be cleaned first by removing the slag.

Sometimes a sealing run (after the weld is completed) or a backing run (after one or more previous runs) is made. Therefore the backside of the weld is gouged, cleaned and finished by one run. This is done in case of stringent requirements.

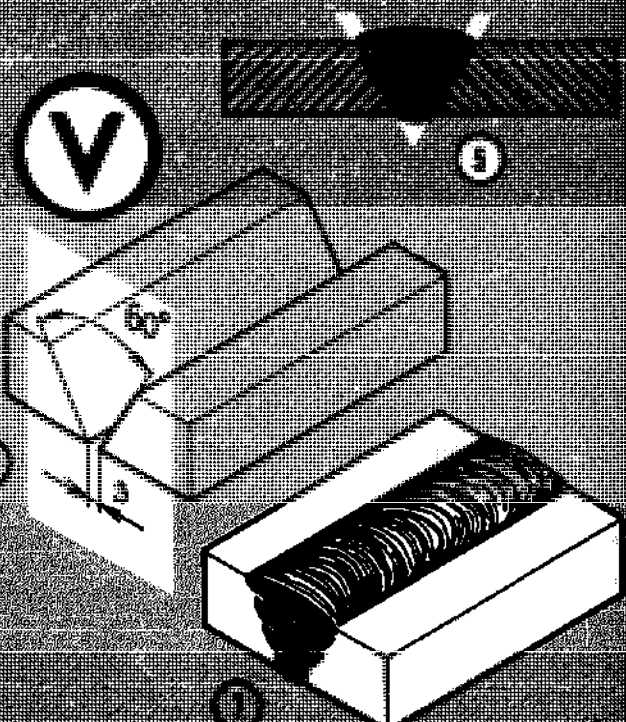
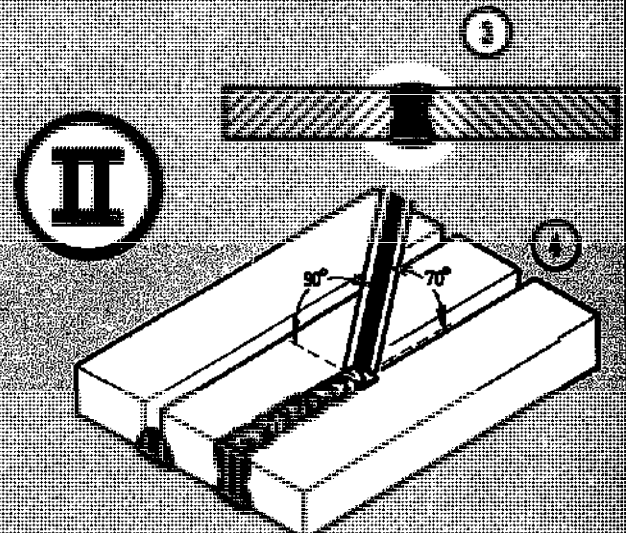
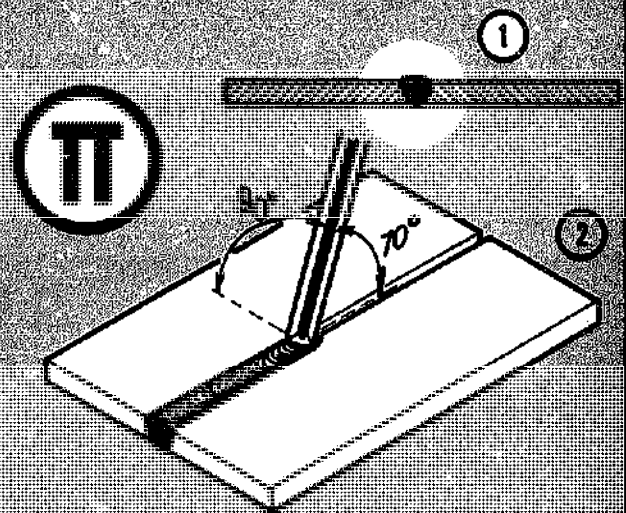
- 1 Square butt weld (welded one side)  
 2 Position of electrode

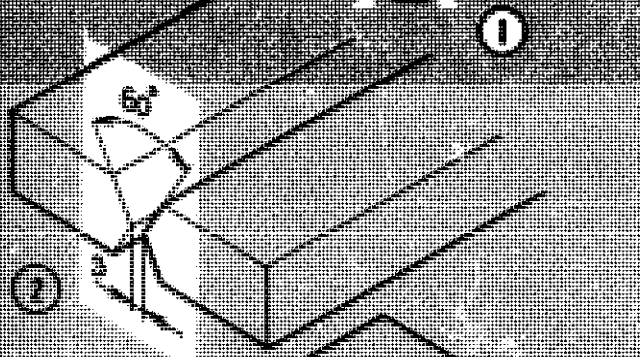
- 3 Square butt weld (welded both sides)  
 4 Position of electrode

- 5 Single V-butt weld

- 6 Preparation

- 7 Welding

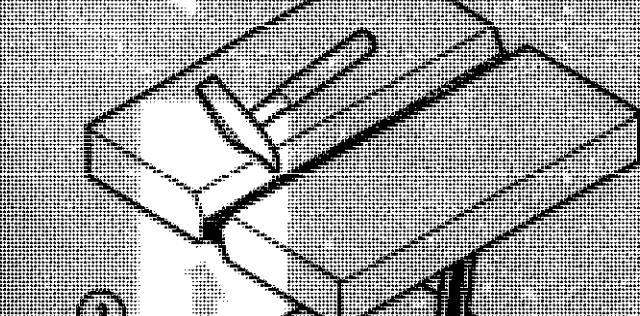




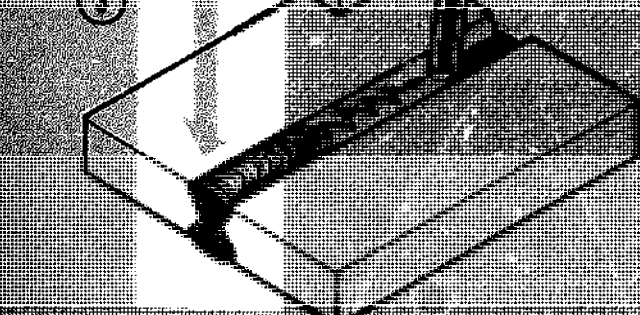
1 Double-V butt weld

**DOUBLE-V BUTT WELD**

plate thickness 10-25 mm  
included angle 60°  
root gap 3 mm

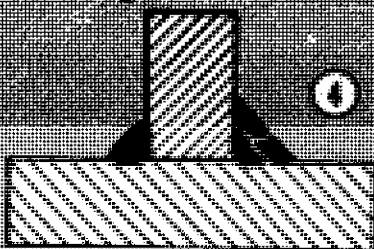


2 Preparation



3 Welding

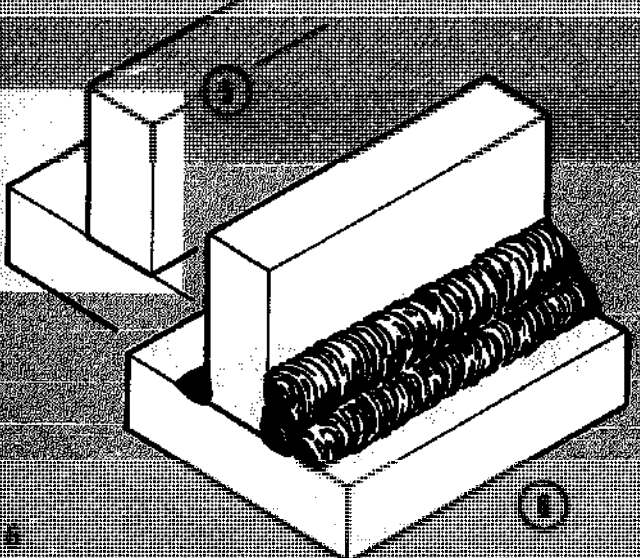
Here too the weld is completed in several runs, always cleaning in between. When one or two runs have been made the workpiece is turned over, the backside gouged and cleaned and the welding proceeded. The joint should be completed by welding both sides alternately.



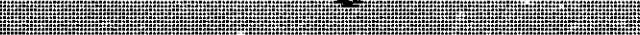
4 Double fillet weld

**DOUBLE FILLET WELD**

plate thickness 10-20 mm  
root gap none



5 Preparation



6 Welding

Dependant on the plate thickness each side of the weld is made in one or several runs. With more runs, welding is done alternately and before starting a new run the previous one must be cleaned first.

In fig. 1 the distance between electrode tip and workpiece after the arc has been struck is shown. The penetration depends on the plate thickness of the electrode, the length of the arc, the position of the electrode and the welding current.

In figures 2, 3 and 4 three beads, produced with the same welding current but on different plate thicknesses, are shown. In fig. 5 the effect of arc length and position of electrode is shown.

Gas welding is done either leftward or rightward.

Leftward welding is mostly done on thin plates.

Rightward welding on thick plates.

The flame should be correctly adjusted. If all the oxygen is used for burning the acetylene, the flame is called neutral. It is mostly used for steel. (Also for stainless steel and aluminium).

An excess of acetylene (fig. 11) is used in the flame for welding some non-ferrous metals.

In fig. 12 a flame with an excess of oxygen is shown. (Used for brasses).

- 1 Distance of electrode to work
- 2 Plate 1/2"
- 3 Plate 3/8"
- 4 Plate 1/4"

- 5 Position of electrode

- 6 Broad steel wire brush: wrong!
- 7 Narrow steel wire brush: correct!

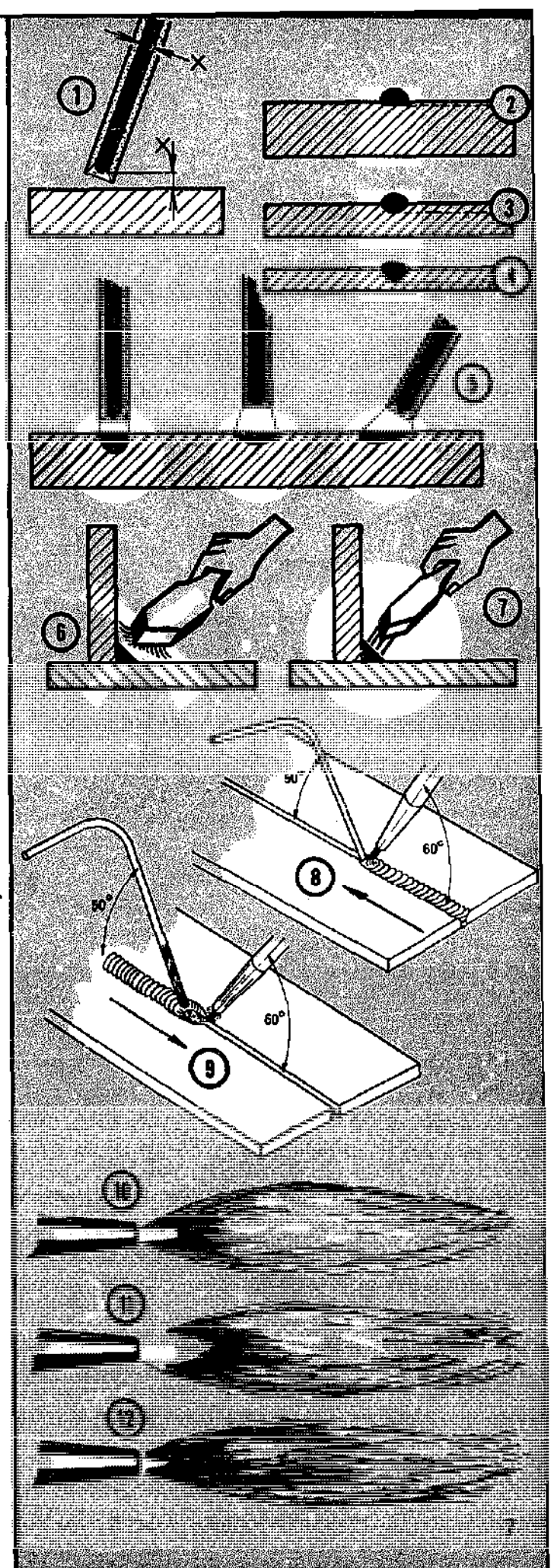
- 8 Leftward (or forward welding)

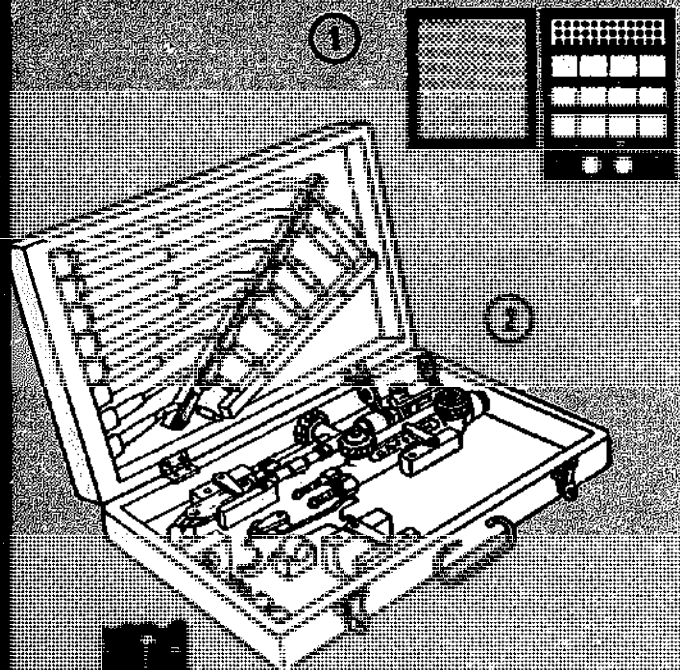
- 9 Rightward (or backward welding)

- 10 Neutral flame

- 11 Excess of acetylene (carburizing flame)

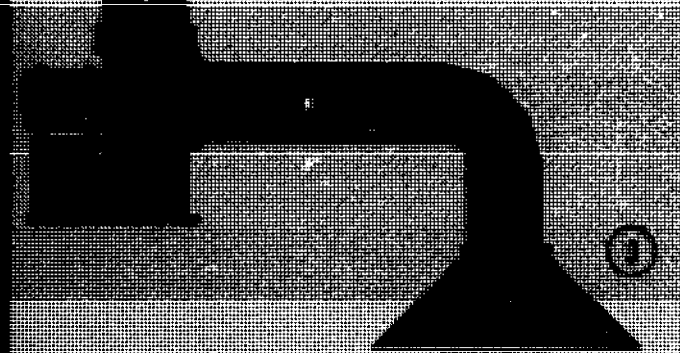
- 12 Excess of oxygen (oxydizing flame)





1  
Electrode cabinet

Store electrodes in an electrode cabinet. They remain dry there and the types are separated.



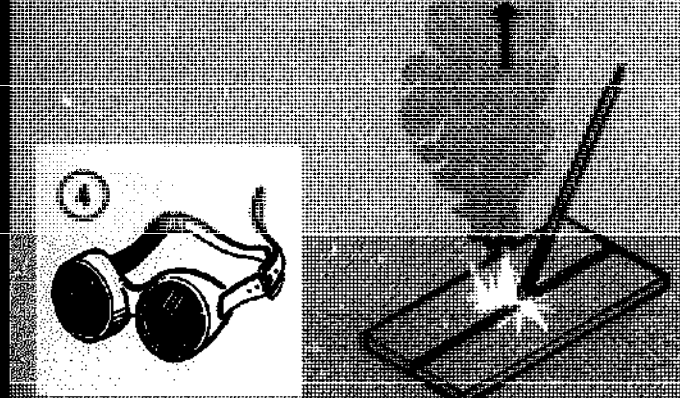
3  
Exhaust system

The torches are usually kept in a special box. The smallest torch is for thin metals, the largest for thick metals. Nozzles are specified by a number.

Always put torches and accessories back in their places after use.

**SAFETY**

It is advisable that the fumes formed in continuous welding should be removed by means of an appropriate exhaust system.



4  
Welding goggles

During gas welding always wear goggles, gloves and apron against rays and spatter.



5  
Face shield

During arc welding use a face shield and gloves against harmful rays; also an apron against spatter.