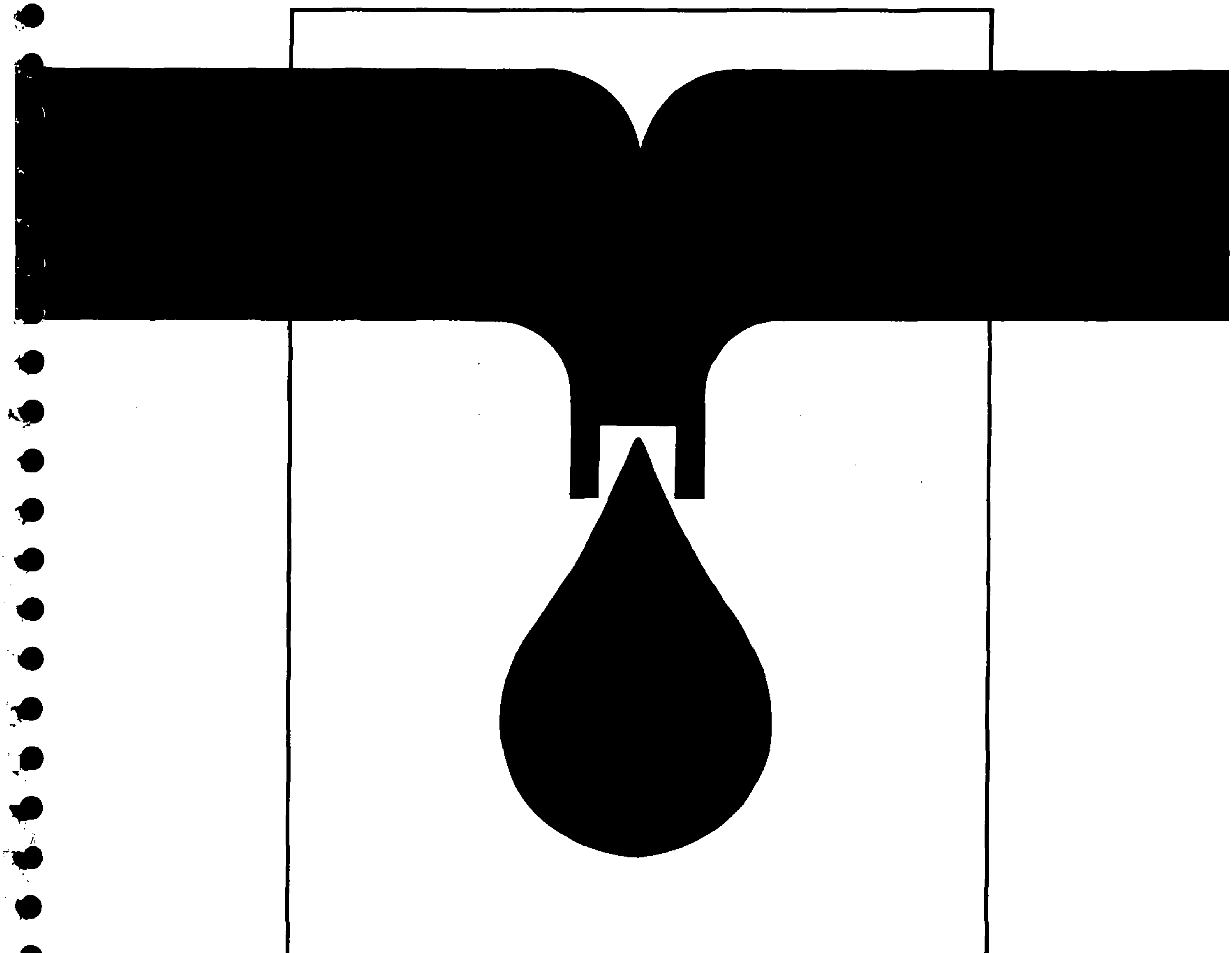
TRAINING MODULES FOR WATERWORKS PERSONNEL



Special Skills

3.1

Basic skills in workshop technology

Foreword

Even the greatest optimists are no longer sure that the goals of the UN "International Drinking Water Supply and Sanitation Decade", set in 1977 in Mar del Plata, can be achieved by 1990. High population growth in the Third World combined with stagnating financial and personnel resources have led to modifications to the strategies in cooperation with developing countries. A reorientation process has commenced which can be characterized by the following catchwords:

- use of appropriate, simple and – if possible – low-cost technologies,
- lowering of excessively high water-supply and disposal standards,
- priority to optimal operation and maintenance, rather than new investments,
- emphasis on institution-building and human resources development.

Our training modules are an effort to translate the last two strategies into practice. Experience has shown that a standardized training system for waterworks personnel in developing countries does not meet our partners' varying individual needs. But to prepare specific documents for each new project or compile them anew from existing materials on hand cannot be justified from the economic viewpoint. We have therefore opted for a flexible system of training modules which can be combined to suit the situation and needs of the target group in each case, and thus put existing personnel in a position to optimally maintain and operate the plant.

The modules will primarily be used as guidelines and basic training aids by GTZ staff and GTZ consultants in institution-building and operation and maintenance projects. In the medium term, however, they could be used by local instructors, trainers, plant managers and operating personnel in their daily work, as check lists and working instructions.

45 modules are presently available, each covering subject-specific knowledge and skills required in individual areas of waterworks operations, preventive maintenance and repair. Different combinations of modules will be required for classroom work, exercises, and practical application, to suit in each case the type of project, size of plant and the previous qualifications and practical experience of potential users.

Practical day-to-day use will of course generate hints on how to supplement or modify the texts. In other words: this edition is by no means a finalized version. We hope to receive your critical comments on the modules so that they can be optimized over the course of time.

Our grateful thanks are due to

Prof. Dr.-Ing. H. P. Haug
and
Ing.-Grad. H. Hack

for their committed coordination work and also to the following co-authors for preparing the modules:

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It is my sincere wish that these training modules will be put to successful use and will thus support world-wide efforts in improving water supply and raising living standards.

Dr. Ing. Klaus Erbel
Head of Division
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Eschborn, May 1987

Basic skills in workshop technology

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Basic skills in workshop technology

1. Inspection and measurement

Inspection is the process of checking whether the object to be inspected corresponds to the required dimensions or to the required geometrical form. Inspection is classified into measurement and gauging.

Measurement of a workpiece is by comparing the length of the workpiece with the calibrated scale of a linear measuring instrument. The required length is termed the magnitude to be measured and the calibrated scale corresponds to the unit in which measurements are to be performed. Differing magnitudes can be measured using the same measuring instrument.

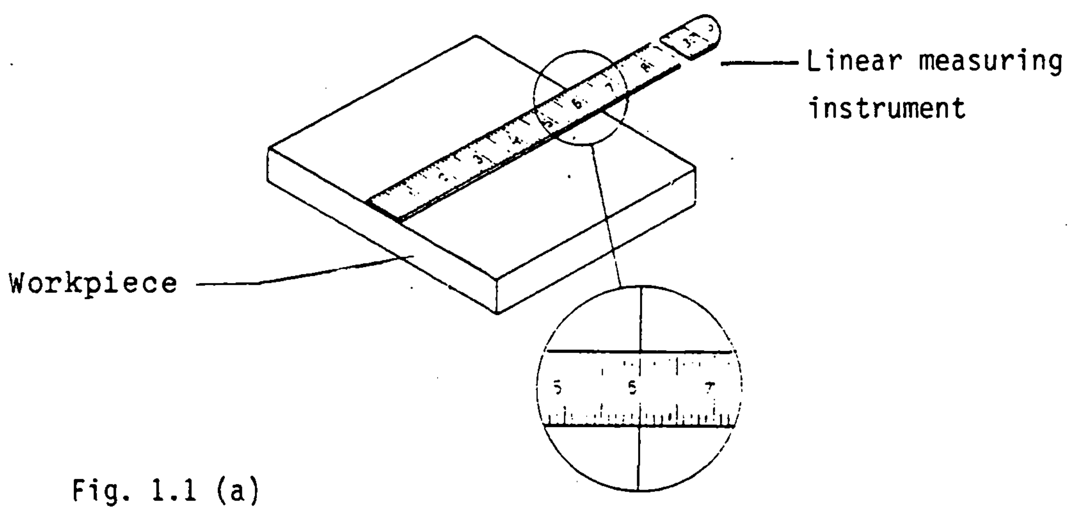


Fig. 1.1 (a)

Measurement is the process of comparing the magnitude to be measured on an object with the units on the measuring instrument. The magnitude to be measured is the required length or length ratio (angle). Measurement involves finding out how often the unit is contained in the magnitude to be measured.

Gauging of a workpiece is performed by comparing the length of the workpiece (e.g. diameter) with the fixed dimension of a gauge (plug gauge). Varying magnitudes to be measured require different gauges.

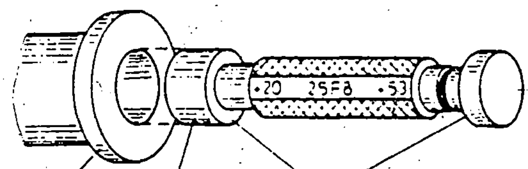


Fig. 2.1 (a)

Gauging is the process of comparing an object under inspection with a gauge which corresponds to a certain, fixed dimension.

Linear measuring instruments

Folding rules (inch rules) of wood, plastic or metal are 1 m or 2m long. The hinges make it possible to fold up the inch rule but reduce somewhat accuracy of measurement. The folding rule is provided with a millimetre scale and is available with an additional inch scale, if required. 1 inch = 1" = 25.4 mm. In lagging work, the "circumference rule" has proven its worth (see Fig. 2.2). The circum ference is read off the appropriate scale and to this is added the allowance for the seam in order to obtain the size of blank for the sheet metal cladding.

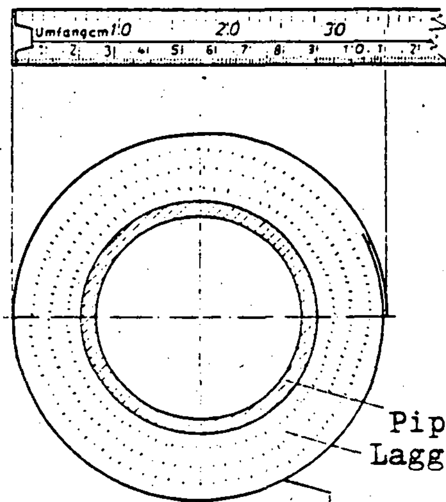


Fig. 2.2 (b)

Calipers

are adjustable measuring instruments for transferring dimensions from workpiece to scale. It should be possible to set the calipers without requiring excessive force and they should retain the dimension. They are used in particular for measuring pipe diameters in combination with a rule. Fig. 3.1 shows various calipers and application examples.

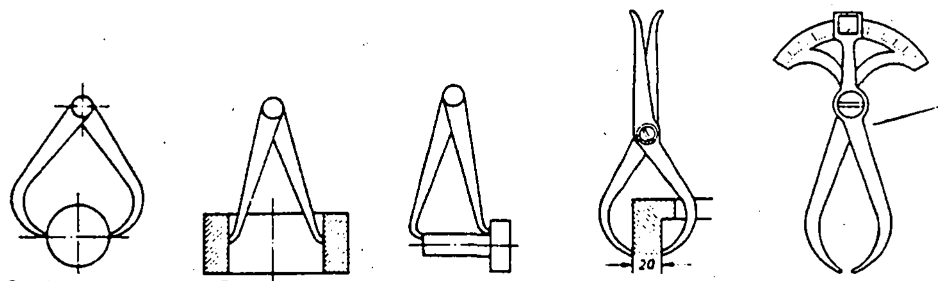
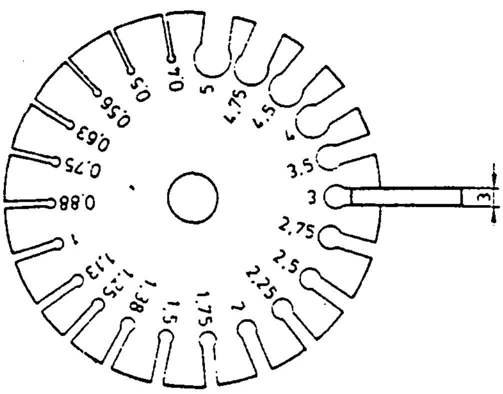


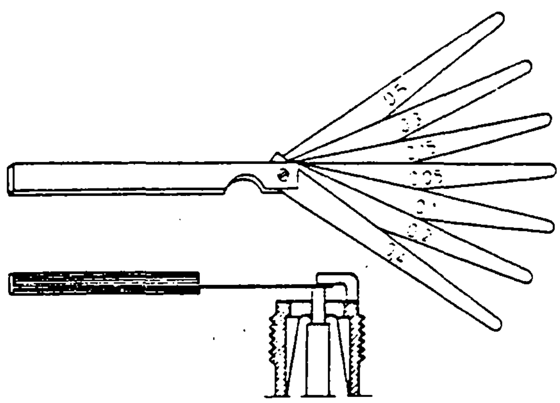
Fig. 3.1 (b)

Gauges

For measurements of the same type which repeat, use is made of gauges. Sheet metal thicknesses can be measured with a sheet metal gauge by inserting the sheet into the appropriate slot and reading off the value marked. Wire gauges are used in a similar way to measure wire and twist drill diameters, and feeler gauges are used for setting valves and bearing play.



Sheet metal gauge



Feeler gauge

Fig. 3.2 (a)

Fig. 3.3 (a)

The vernier caliper gauge
is a precision instrument which to a certain extent combines calipers and scale. This instrument is used for measuring thicknesses, external and internal diameters (wires, twist drills, pipes) and depths. The dimensions can be read off to an accuracy of 1/10 or 1/20 mm.

The vernier of the gauge is an auxiliary scale on the cursor (see Fig. 4.1). The decimal vernier shown in Fig. 5.1 is 9 mm long and is subdivided into 10 equal parts. Each vernier division is 0.1 mm less than 1 mm. This enables tenths of millimetres to be read off. The method of reading the vernier caliper gauge is explained in Fig. 5.2. The scale division to the left of the vernier on the millimetre scale indicates the whole millimetres. That subdivision of the vernier which is in line with a full milimeter division on the main scale indicates the tenths of millimetres. These are then added to the whole millimetres.

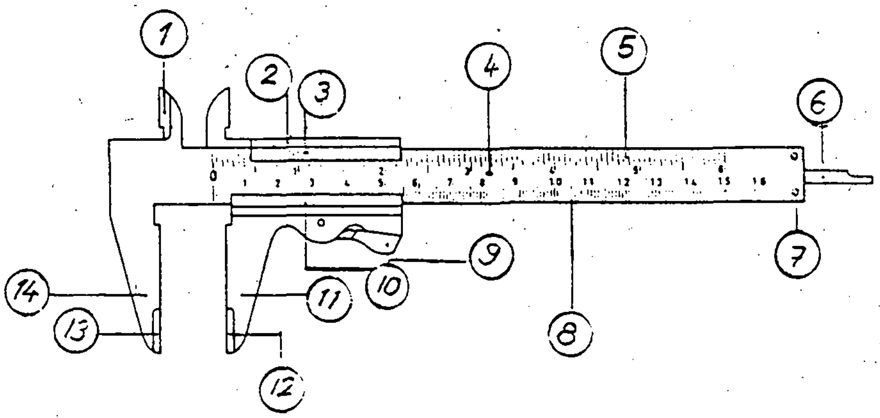


Fig. 4.1 Vernier caliper gauge (b)

1	Measurement jaws
2	Slider with vernier and movable jaw
3	Vernier
4	Scale
5	Inch divisions
6	Depth gauge
7	Stop for depth gauge
8	Millimetre divisions
9	Locking clamp
10	Vernier
11	Movable jaw
12	Knife edge
13	Knife edge
14	Fixed jaw

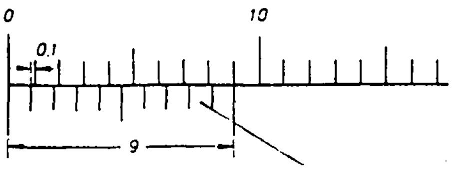
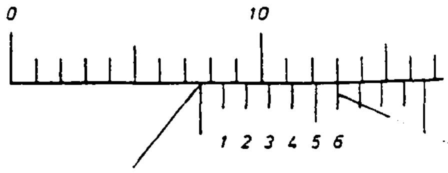


Fig. 5.1 Decimal cursor (b)

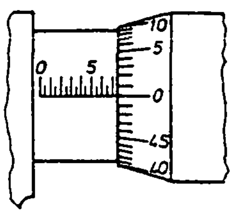


Zero division indicates 7 mm
Vernier indicates 0.6 mm
Reading = 7.6 mm

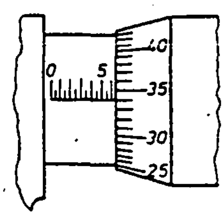
Fig. 5.2 Reading off the vernier caliper gauge (b)

The micrometer

has a high accuracy of measurement. Usually it can be read off to the nearest 1/100 mm and it has a measuring range of 25 mm. The micrometer is suitable, for example, for the exact measurement of sheet metal thicknesses.



Reading: 7.50 mm

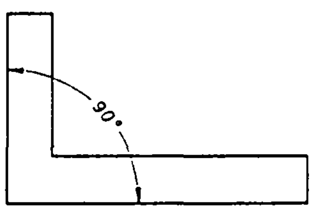


Reading: 6.34 mm

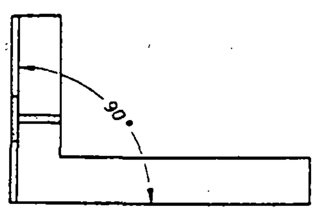
Fig. 5.3 Reading off the micrometer (b)

Angular measurement

In order to measure or determine angles which occur frequently (in particular 90°) fixed measuring instruments are used.



Thin steel square



Try square

Fig. 5.4 Steel squares (b)

Fig. 6.1 shows an adjustable measuring instrument: the bevel. This may be adjusted to any angle and then transferred. Angles of pipe bends which deviate from 90° are determined with the aid of a folding rule (see Fig. 6.4). The numerical value of the millimetre scale to which the opened leg of the folding rule points is noted, Upon subsequently opening the folding rule to the same millimetre value, the measured angle results. If the folding rule is provided with an additional degrees scale for angle measurement, it is possible to read off the magnitude of the angle in degrees.

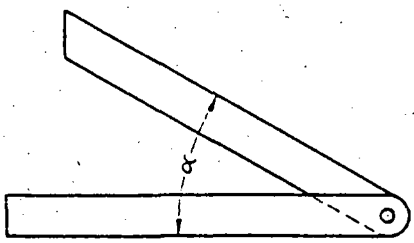


Fig. 6.1 Bevel
(b)

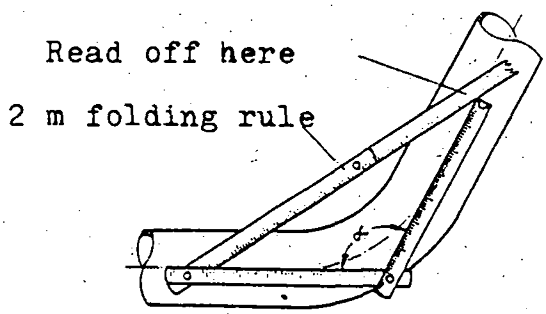


Fig. 6.2 Angle measurement with the folding rule
(b)

The plumb bob
serves to determine the direction of the vertical. It comprises a cord and the weight. The plumb is used, for instance, when attaching drain-pipe clamps in line.

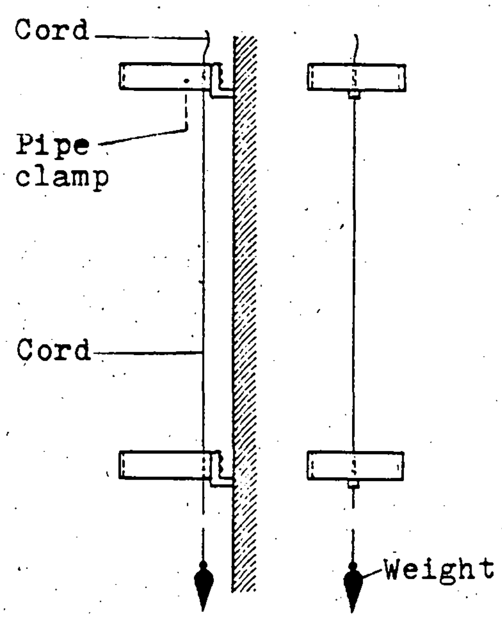
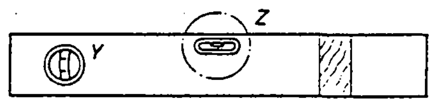


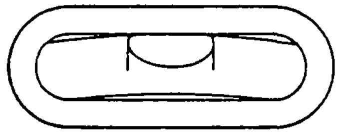
Fig. 6.3 Plumb bob
(b)

The hose levelling instrument
is a useful device if levels have to be transmitted over long distances. If in pipework, pipes are to be installed at a gradient, the height of drop can be read off directly with the aid of the hose levelling instrument in millimetres and centimetres (see Module 0.2, Page 23).

The spirit level

This instrument is used to check that surfaces are horizontal or vertical, e.g. when erecting pumps, installing piping etc.
In order to measure gradients when installing piping, spirit levels with an integrated gradient scale are used.
The spirit level is of metal or wood. The level glass is used for measurement. This is a curved glass tube filled with alcohol or ether, which is closed off at the ends and provided with line markings. An air bubble floats on top of the free-flowing liquid. This will always occupy the highest point within the tube. If the level is horizontal, the bubble is in the middle. If, in addition, the vertical position is to be determined, a spirit level with two level glasses is required (Fig. 7.1). Test for accuracy: If the spirit level indicates that a surface is vertical or horizontal, it is rotated through 180°. The air bubble must then again be in the middle.
Surfaces should be cleaned of mortar and the like prior to placing the spirit level. The measuring range of a spirit level can be extended by placing it on a stadia (straightedge) of appropriate length, whose two sides must be exactly parallel.





Detail Z

Fig. 7.1 (B) Spirit level
Z = Level glass for horizontal measurement
Y = Level glass for vertical measurement

2. Marking out and centre punching

Marking out (drawing)

When marking out by drawing (e.g. with a pencil), the tool is softer than the workpiece and a mark appears.

Marking out by scribing

When marking out by scribing (with a scriber of tool steel with hardened tip), the tool is harder than the workpiece and a scribed line appears. During scribing, the harder material scratches the softer material.

When marking out with the scriber, a thin line is produced at high accuracy. However, the drawback is that the workpieces may become scratched and damaged. Thus when marking out galvanized, lead-plated or tin-plated steel sheet, the corrosion protection layer becomes damaged. The bending lines on aluminium and zinc sheets should not be marked out due to the notch effect, which could cause breaks in the bends of the sheet. For these reasons, unnecessary scribed lines are to be avoided and where possible, only the cutting lines should be marked out with the scriber. All other lines are to be marked out in pencil. Steel sheet with a layer of scale (black sheet) on which the scriber could skid are marked out with a brass pointer.

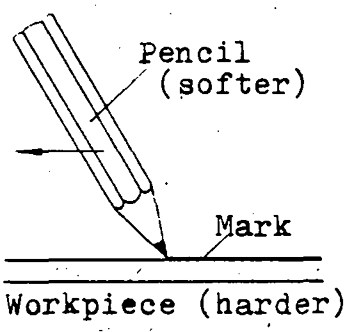


Fig. 8.1 Marking out by
(b) drawing

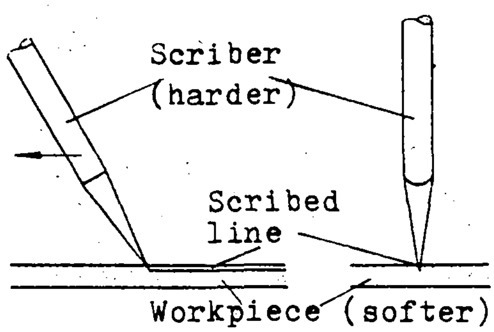


Fig. 8.2 Marking out by scribing
(b)

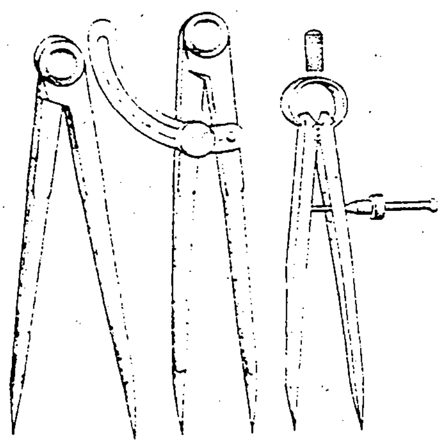


Fig. 8.3 Dividers
(b) Spring dividers on the right.

When marking out by scribing or drawing, the scriber or pencil is moved along a steel rule or square (Fig. 5.4), at its bottom edge for precise work. In order to mark out circles, dividers are used (Fig. 8.3). Spring dividers are suitable for exact subdivision of lines, e.g. for division into twelve equal parts. For large-radius circles and blanks, beam trammels are used (Fig. 9.1).

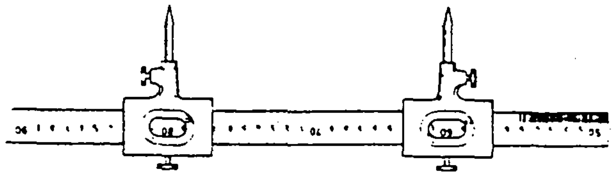


Fig. 9.1 Beam trammels (b)

The centre punch

Using this tool, important parts are marked on the workpiece, e.g. centres of circles, drilled holes as well as the position of bends on galvanized sheets. The centre punch is of tool steel and is provided with a conical, hardened tip. When placing, the centre punch is first inclined, for a clear view of the point that has been marked out or which is to be punched. When the punch tip is placed on the workpiece, it is rotated square and then hit with the hammer. The indentation thus formed in the material serves as a guide for the dividers or twist drill (Fig. 9.2). For this reason, for drilling the indentation should be deep. In contrast, centres of circles should only be lightly centre-punched if the centre-punched point of the sheet is to be used. Otherwise the workpiece would be damaged.

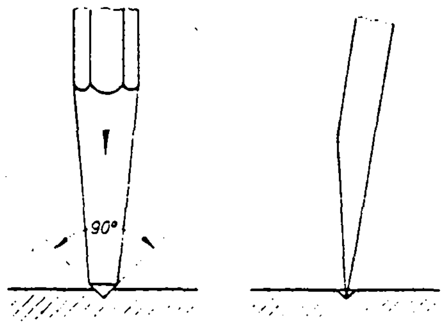


Fig. 9.2 Centre punching and placing of dividers (b)

There are various possibilities for using the centre punch:

Permanent marking of scribed lines and their intersections.

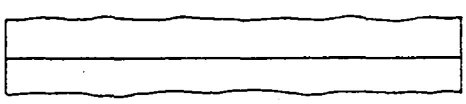


Fig. 9.3 Scribed line (a)

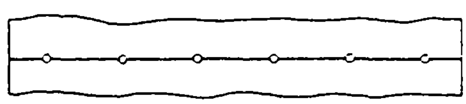


Fig. 9.4 Scribed line with centre-punched holes (a)

Check of work in progress (inspection marks).

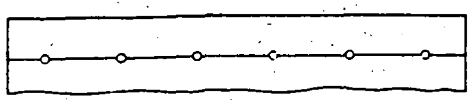


Fig. 10.1 Check of work (a)

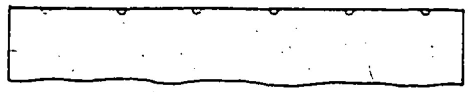


Fig. 10.2 Finished condition (half of mark visible) (a)

Guiding the drill tip when starting drilled holes.

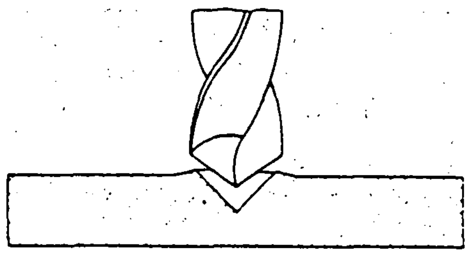


Fig. 10.3 (a)

3. Chiselling

The chisel is made of tool steel. The parts of the chisel are the shank, the blade with the cutting edge (wedge-shaped) and the tapered ball-ended head. The force required for chiselling is generated by hammer blows to the head of the chisel. The shape of the chisel depends on its application. There are thus various types of chisel.

The flat chisel (Fig. 11.1) serves for parting thicker metallic workpieces, e.g. strip steel, and for removing rivet heads. The hewing chisel is a flat chisel with a rounded cutting edge. This is used for punching out heavy-gauge sheet metal. The cross-cut or cape chisel (Fig. 11.2) has a short cutting edge. This is used for chiselling out narrow grooves
For chipping work in masonry, a stone chisel (Fig. 11.3) or the stone borer (Fig. 11.4) is used. The cutting edge of the stone borer consists of a row of small chisels arranged in a circle. During chiselling, a circular hole is formed for a pipe penetration. The rock dust is forced into the hollow centre of the stone borer.

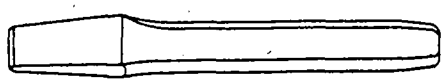


Fig. 11.1 Flat chisel (b)

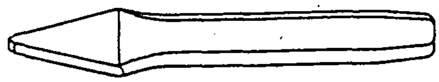


Fig. 11.2 Cross-cut or cape chisel (b)

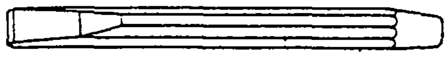


Fig. 11.3 Stone chisel (b)

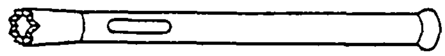


Fig. 11.4 Stone borer (b)

Blunt chisels may be resharpened. Excessive heating up of the chisel cutting edge is prevented by continually cooling it down in water. A chisel that is excessively blunt or which is chipped can regain its original shape by forging. The forging temperature depends on the type of steel. After forging, blade and cutting edge of the chisel are ground at the grinding wheel and then hardened. In order to reduce brittleness, the chisel must be tempered.

4. Sawing

Sawing is a chip-removal shaping process. It serves to part materials and can be done manually or by machine.

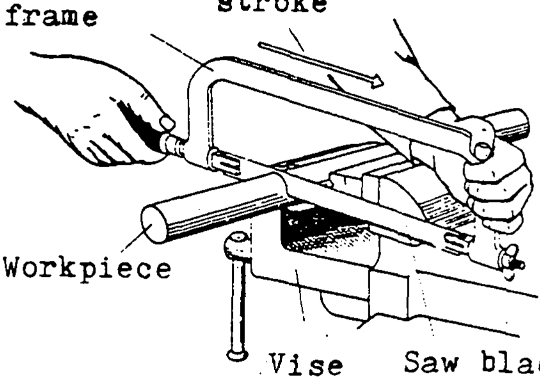


Fig. 11.5 (b)

By moving the saw in the direction of cutting and simultaneously applying pressure, a row of chisel-shaped cutting edges (sawteeth) penetrate the material and remove small chips. The chips are collected in the gaps between the teeth and are carried out of the sawn slot.

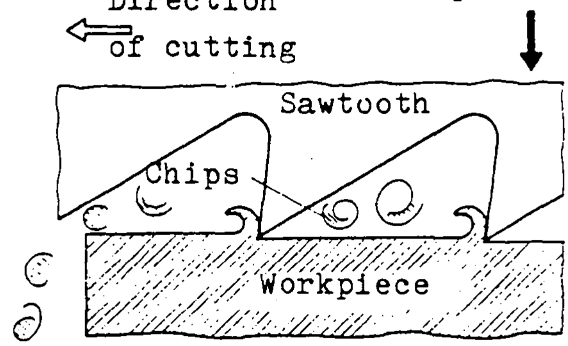


Fig. 11.6 (b)

Saws cut in an alternating or uniform direction of motion.

Hacksaws work in an alternating direction of motion. The saw removes metal only in the direction of cutting. On the return stroke, no cutting takes place which means a loss of time.

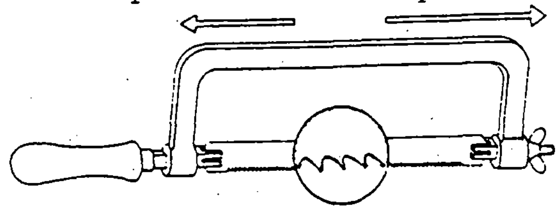


Fig. 12.1 (b)

Circular saws and bandsaws work with a uniform direction of rotation. The saw removes metal continuously. There is no return stroke and thus no time is lost.

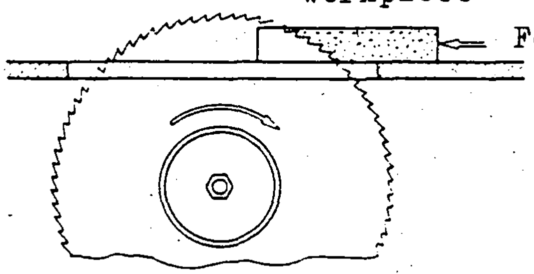


Fig. 12.2 (b)

The saw blade is provided with a row of numerous, small, wedge-shaped cutting edges. During sawing, the teeth engage the workpiece one after the other and cut through it. The chips are forced into the teeth gaps and guided out of the kerf (saw cut). A radius in the teeth gaps has the advantage that the chips from softer materials do not clog so easily. Normally the teeth are so arranged that they cut only in one direction (Fig. 13.1).
Free cutting of the saw blade.
As the blade penetrates more deeply into the material the rubbing action will be such that it binds or sticks in the slit. In order for the saw to cut freely, it must generate a kerf which is wider than the blade thickness. Thus the teeth have a set, i.e. they are bent alternately to the left and right (as in a hand saw). Alternatively, they may be swaged, so that they are thicker than the blade (see Fig. 13.2). Circular saw blades are ground out below the line of teeth or wider teeth inserts of high-speed steel or carbide are used. Teeth with a wave set

(Fig. 13.3) also provide a wider kerf.

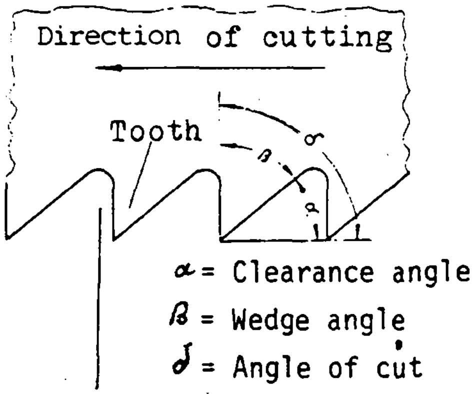


Fig. 13.1 Saw blade

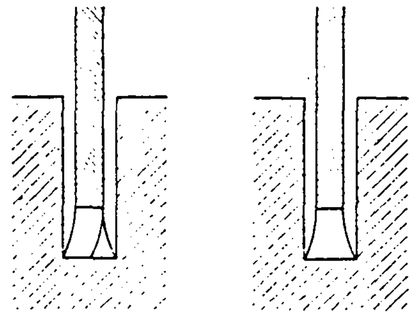


Fig. 13.2 Free cutting of the saw blade

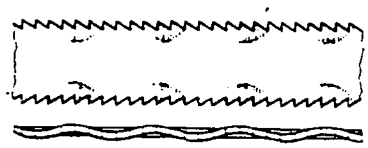


Fig. 13.3 Double-sided toothed blade with wave set

Blades are classified into those with coarse, medium and fine tooth pitch. The pitch is specified by giving the number of teeth per 1" (25.4mm) length. For instance, hacksaws for hand use are supplied with 16, 22 and 32 teeth per inch. In order to saw soft materials and for long cuts, a large chip space, i.e. large teeth gaps, is required. This requires large teeth, which means a coarser pitch. For short cuts, (e.g. in thin-walled pipes) however, large teeth dig in easily in which case a finer pitch is better, this applying also to hard materials.

Sawing by hand

For metalwork, usually the hacksaw is used (Fig. 14.1). The saw blade is set into the clamp blocks and the wing nut is tightened. Normally sawing takes place when pushing the saw away. The blade is then to be so inserted that the teeth point away.
The blade must be securely clamped for sawing. After completing work, the wing nut is slackened off somewhat in order to relieve the frame. Both sides of double-sided blades (Fig. 13.3) can be used. The blade handsaw (Fig. 14.2) has a coarser pitch. It is used for sawing wood and lead pipes.

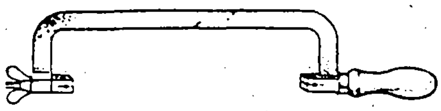


Fig. 14.1 Hacksaw (b)

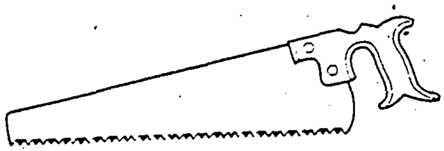


Fig. 14.2 Blade handsaw (b)

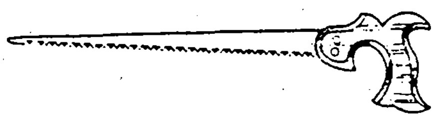


Fig. 14.3 Pad or keyhole saw (b)

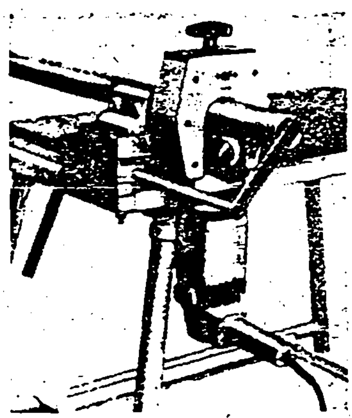


Fig. 14.4 Pipe saw (b)

The pad or keyhole saw (Fig. 14.3) is suitable for cutting out holes and for sawing insulating board and facings of expanded polystyrene.

Electrically-driven power saws have a better performance. For metalwork, power hacksaws are used, these having an adjustable stroke and cutting pressure. Their disadvantage is that each working stroke is followed by an idle stroke. To prevent the blade wearing, it is raised for the return stroke. In contrast, circular saws cut continuously. They serve to part off thick workpieces of metal or wood. With the bandsaws used in woodworking, it is also possible to cut round curves of large radius.
The electrically-powered pipe saw (Fig. 14.4) serves for parting off metal and plastic pipes. The pipes to be cut are clamped in the vie. For sawing, the circular saw blade is swivelled around the pipe and its wall is cut through.

By the use of form cutters, it is also possible to prepare standardized welding chamfers.

Wood is sawn by hand if it is impossible or not economic to use machines. Sawing jobs which frequently arise are: cutting to length, curve work and cutting out connection pieces.

For hand sawing work, mainly bow saws are used. Among these are the framed bow saw.

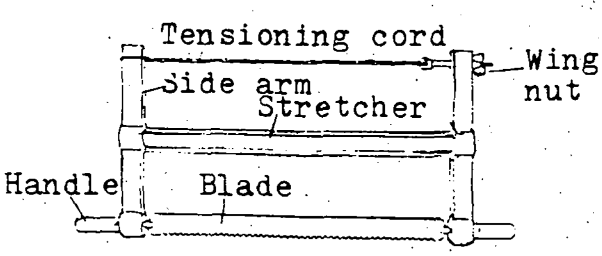


Fig. 14.5 Framed bow saw (c)

This consists of the saw blade and the saw frame. The blade is tensioned with the tensioning cord and wing nut.
For cutting to length or cross-cutting of boards and planks, saws are used whose teeth are filed at a slight angle in the push direction. Most suitable for ripping or cutting along the grain are teeth with a cutting angle of about 100°. Among the untensioned saws are the blade handsaw, the dovetail back saw and the pad or keyhole saw. Due to the wide blade of the blade handsaw, it is possible to obtain relatively straight saw cuts when cutting broad panels. The dovetail back saw is used for smaller and precise sawing work, e.g. for thin plywood.

5. Filing

In filing and rasping, the material is cut with many small wedge-shaped cutters. These work in the push-direction and for this reason pressure is applied only for the forwards motion. According to their manufacture, chiselled and milled files are differentiated, as are single-cut and double-cut files.

In order to file soft metals (e.g. soft solder) single-cut milled files are used. The cut is at an angle of about 70° to the file axis (Fig. 15.1) or is curved. The cutting angle of the milled tooth is less than 90°. This gives it its cutting action. The teeth gaps are large and with a big radius, so that the file does not clog so easily (see Fig. 16.1).
For filing harder materials, usually double-cut chiselled files are used. The two cuts cross each other (Fig. 15.2). The cutting angle of the chiselled tooth is greater than 90° (Fig. 16.2). This tooth does not cut but has rather a scraping action. Moreover its wedge angle ß is larger than for the soft metal files.

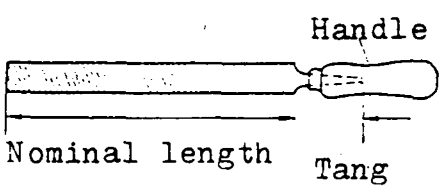


Fig. 15.1 Single-cut file (b)

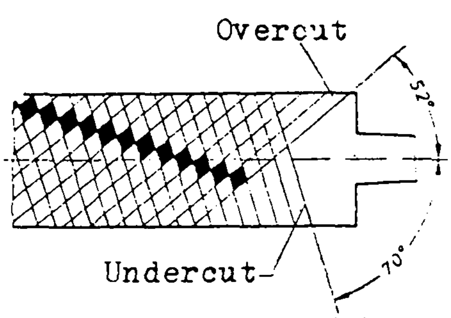


Fig. 15.2 Cross-cut (b)

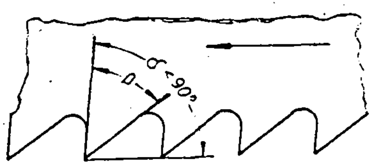


Fig. 16.1 Milled file (b)

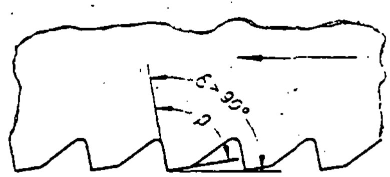


Fig. 16.2 Chiselled file (b)

Types of file according to shape and size

Files also have to be differentiated according to their cross-sectional shape and their size (length). Selection depends on the job in hand.

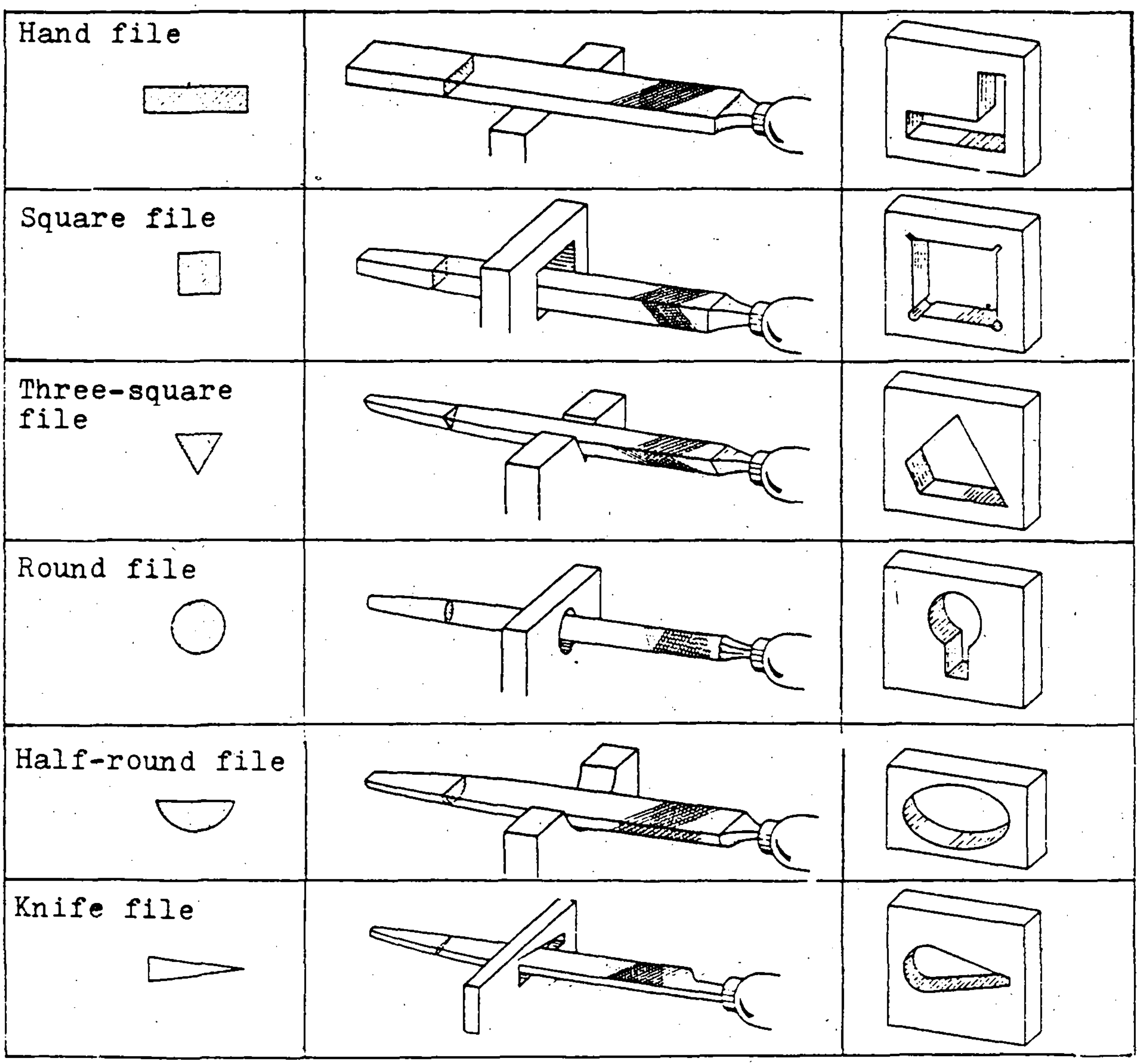


Fig. 16.3 (a)

Special files - For file work on small workpieces, e.g. in jigs, fixtures and tooling, needle, warding and riffler files are used. These particularly small files are also available in many cross-sectional shapes.

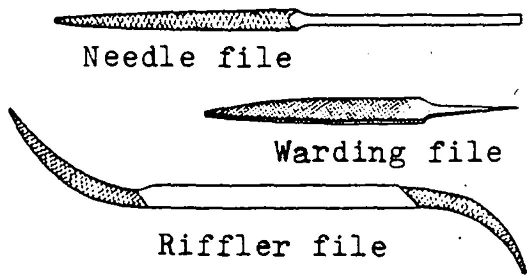
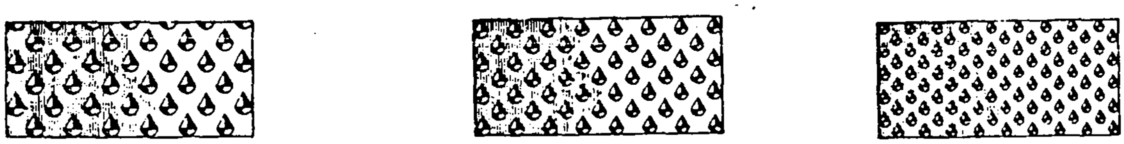


Fig. 17.1 Special files (a)

Rasps are used for woodworking and for soft metals (lead). The rasp teeth are punched in the form of pits.



Bastard   Semi-finishing   Finishing

Fig. 17.2 Rasp teeth (b)

6. Scraping

Workpiece surfaces machined by filing, planing or turning still clearly exhibit machining marks. Scraping is a metal-removal fine-working process with which pre-machined workpieces achieve a high surface finish and accuracy. During scraping, the proportion of the bearing surface (high points) is increased. Scraping is time-consuming and is therefore very cost-intensive. Flat and hollow shaping are differentiated.

Finishing a flat surface by flat scraping

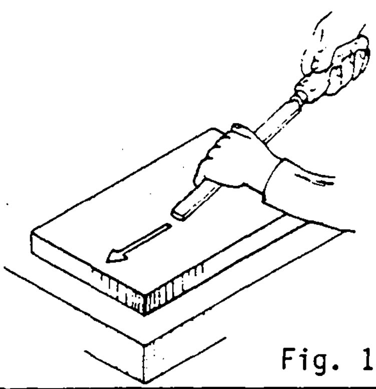


Fig. 17.3 (a)

Finishing a concaved surface by hollow scraping

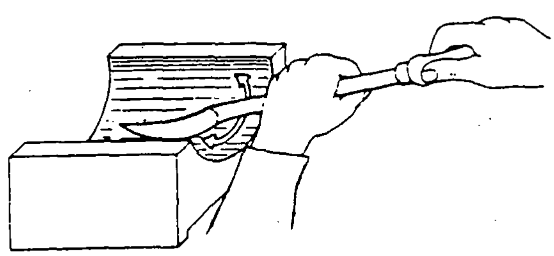


Fig. 17.4 (a)

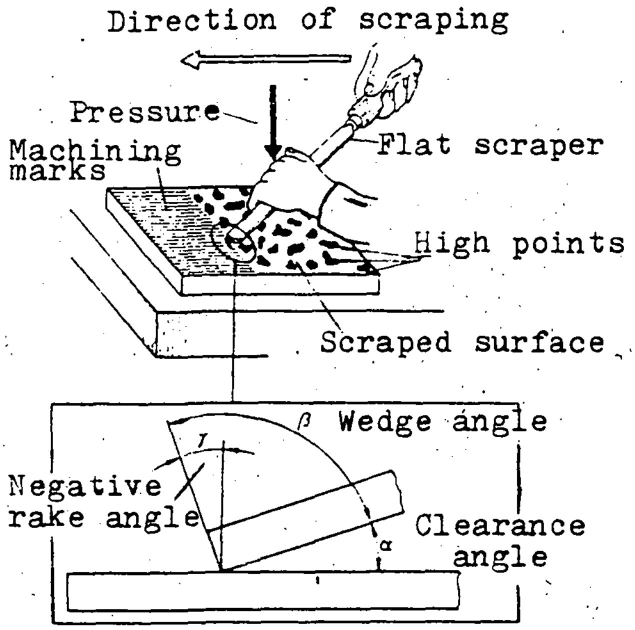


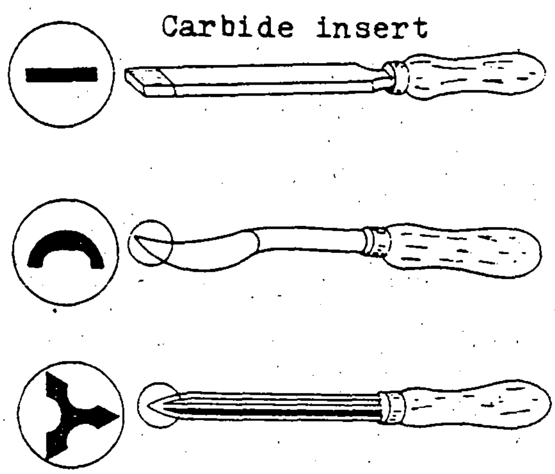
Fig. 18.1 (a)

During scraping, the scraper is held such that a so-called "negative" rake angle results. The effect of this is that only fine chips are removed: the tool scrapes and does not cut.

In the case of flat surfaces, the high points are smeared with marking substance from a straight edge or surface plate, and for curved surfaces from shafts. For this purpose, the marking tools are smeared with an oily, non-drying dye.

Then the high points are scraped away and the marking process repeated until the required number of high points is obtained.

Tools:

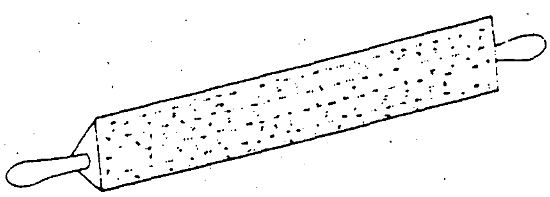


Flat scraper: scraping of flat surfaces, e.g. machine guideways, marking-out plates, measuring instruments

Curved bearing scraper: precision working of concave surfaces, e.g. bearing shells during repair work

Three-square scraper: deburring edges

Fig. 18.2 (a)



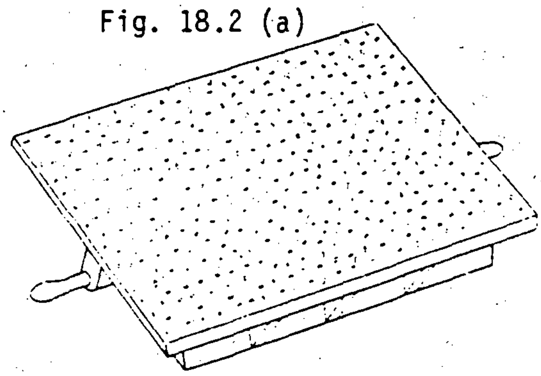


Fig. 18.3 Levelling straight edge (a) Fig. 18.4 Surface plate (a)

7. Shearing

Shearing is a non-metal-removing parting process. It serves for parting and cutting to length of materials for subsequent machining.

The advantages over comparable metal-removing parting processes are savings in labour and material as well as elimination of subsequent working.

1. Pressure plate
2. Cutting force
3. Upper shearing blade
4. Lever 5. Hand force
6. Workpiece
7. Lower shearing blade

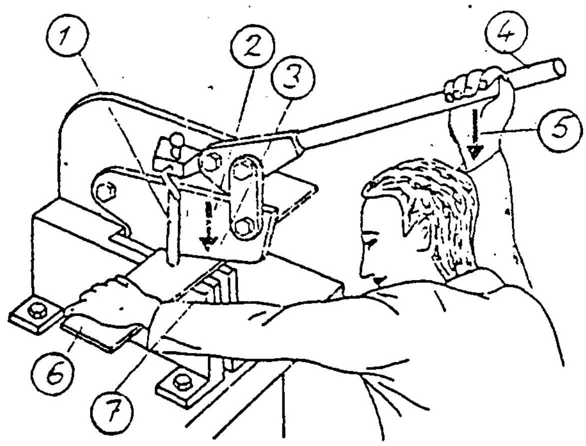


Fig. 19.1 (a)

Essentially, a distinction is made between two shearing methods, which may be executed manually or by machine: parting and cutting out blanks.

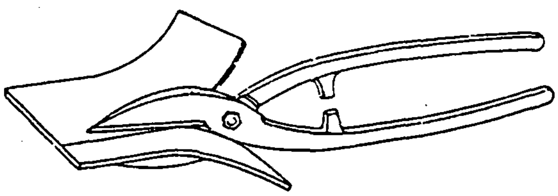


Fig. 19.2 Parting (a)

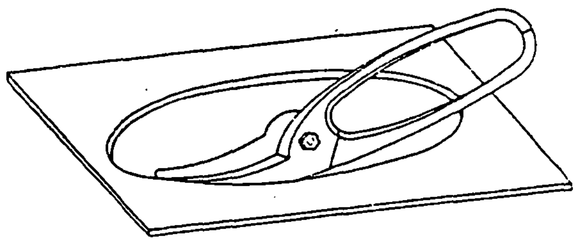


Fig. 19.3 Cutting out a blank (a)

During shearing, two cutting edges move against each other. They penetrate into the workpiece and notch it.

As the cutting force increases, the weakened cross-section ruptures and shears through.

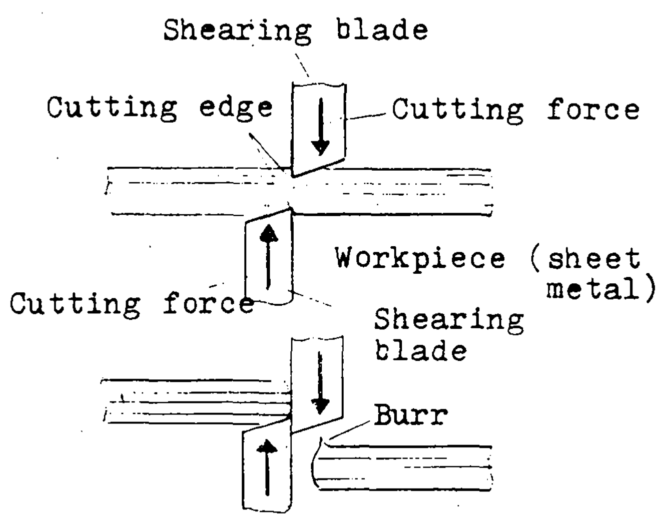


Fig. 19.4 (a)

Angles of shearing blades

The cutting edges of the two shearing blades, which have the same shape, have - as is the case for metal-cutting tools - a wedge form.
The shearing surface is relieved by the clearance angle = 2 . . . 3° in order to reduce friction between blade and material.

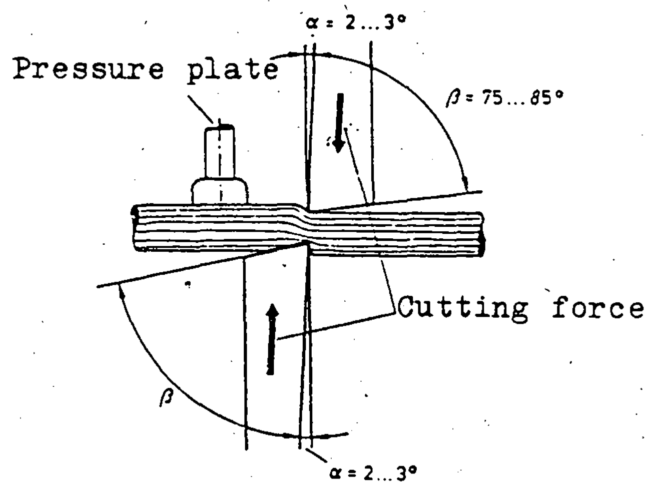


Fig. 20.1 (a)

Blade clearance

The two cutting edges are moved past each other at close proximity in order to prevent burr formation at the workpiece. In order to reduce friction, a narrow blade clearance is left between the cutting edges in the case of large power shears and thick material. The blade clearance depends on the thickness of the workpiece and on the material.

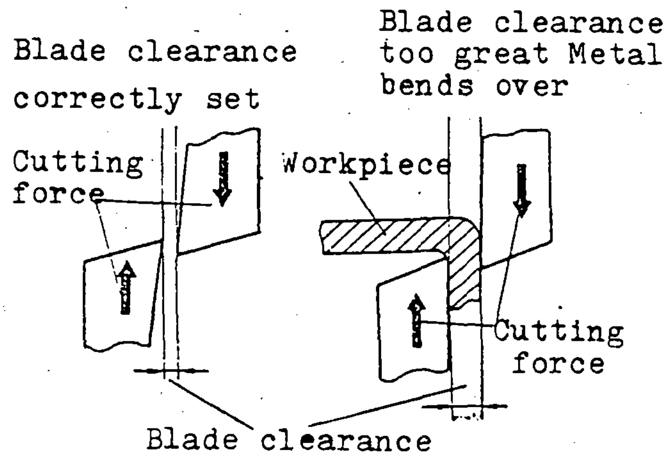


Fig. 20.2 (a)

Lever action

For shearing, large forces are required, these being generated in the case of hand snips and shears by a lever ratio.

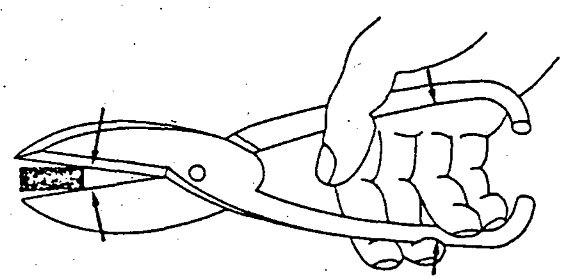


Fig. 20.3 (a)

A distinction is made between hand snips and shears and power shears. Hand shears are suitable for sheet metal up to a thickness of about 1.5 mm. For heavier-gauge sheet metal, lever and power shears are employed.

Guillotine shears are used for long cuts in light-gauge sheet metal panels. The curved blades ensure, that the shearing angle remains approximately the same over the entire length of cut.

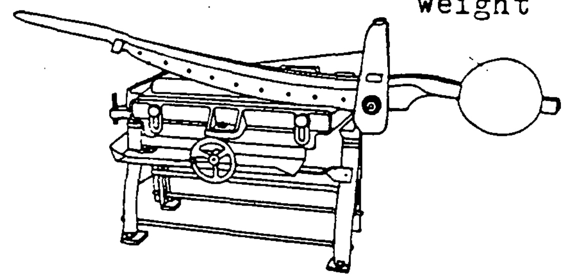


Fig. 21.1 (a)

8. Bending

In bending, the outside of the bend is elongated and here the material is strained or stretched. In contrast, the inside is shortened and here the material is compressed. The central axis remains unchanged in length, this line being the neutral fibre. For a small bending radius r, the neutral fibre is shifted somewhat to the inside of the bend.

Upon exceeding the capacity of the material to stretch or compress, cracks form around the outside (see Fig. 21.2) and folds on the inside. Thus a sufficiently large bending radius r must be selected. The more ductile and tougher the material is, the smaller the permissible bending radius may be. The thicker the sheet metal or pipe is, the greater the bending radius must be.

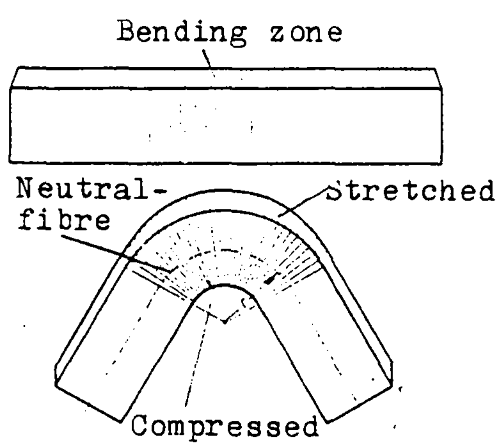


Fig. 21.2 Bending process (b)

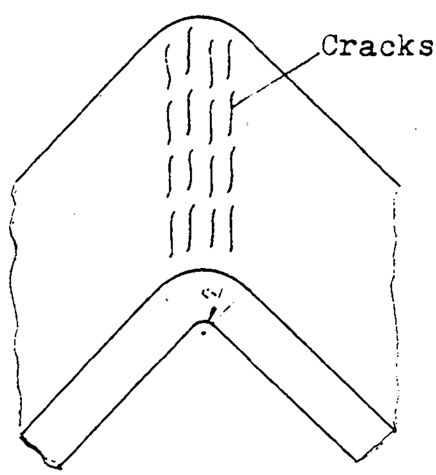


Fig. 21.3 Sheet metal bent too sharply (b)

For a large bending radius, the bending of sheet metal is termed roll bending (Fig. 22.3) and for a small bending radius it is termed folding (Fig. 22.1). The development or blank length of a metal sheet to be folded is approximately equal to the length of the neutral fibre. In the bending example given in Fig. 22.2, the development length is equal to the sum of the outside dimensions of the metal sheet as folded minus the bending contraction. The contraction is equal to the bending radius r in each case.

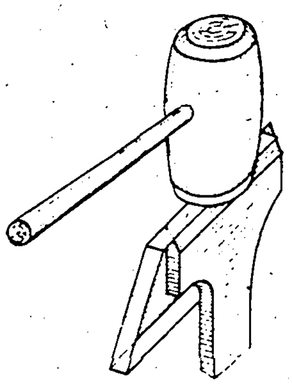
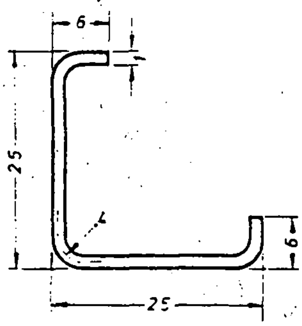
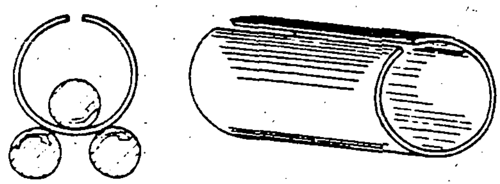


Fig. 22.1 Folding over the hatchet stake (b)



$$l = 6 + 24 + 6 - 3 \cdot 4$$
$$l = 62 - 12 = 50 \text{ mm}$$

Fig. 22.2 Sheet metal section. Length of development (b)



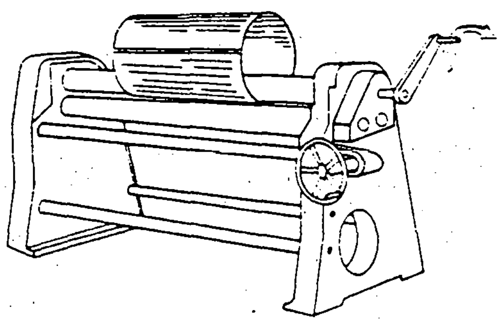


Fig. 22.3 Roll bending (a)

Wire bending

Eyes, hooks and rings of thin wire are bent using round-nosed pliers. For a large bending diameter, the wire is guided through the appropriate slots of the rounding machine. Thicker wires are bent around a suitable mandrel or over the anvil horn, using a hammer if necessary.

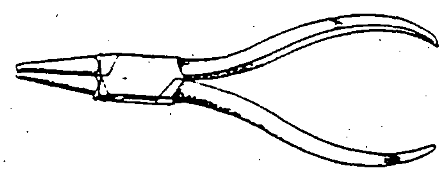


Fig. 22.4 Round-nosed pliers (b)

8.1 Bending pipes

The greater the pipe diameter, the greater is the difference in length between the outside and the inside of the bend and thus the more the material has to be stretched on the outside and compressed on the inside. The pipe tries to minimize these loadings and will then assume a flat section - in particular for thin pipe walls - or it buckles.

However, the circular cross-section should be retained. Thus pipes of larger diameter are packed with sand. Before doing so, the bending sand should be sieved and heated up to red heat. Thus foreign particles, such as small pieces of wood, are removed and the humidity is evaporated. Damp sand would generate steam upon heating the tube, which would drive out the wooden bungs.
After filling, the bending sand must be packed tight. This is done by tapping the pipe (starting at the bottom) or using a vibratory device. The pipe ends are closed off with wooden bungs. Usually, pipes of larger diameter are heated up in order to facilitate bending.

Before bending, copper pipes are soft annealed in the zone of bending and then bent when cold. Steel pipes are bent at about 900°C (bright red heat). Thereby, the material inside the bend is heated up somewhat more than that on the outside, so that it will not be excessively stretched and weakened on the outside.
Pipes with a longitudinal weld should be subjected to as low a loading as possible during bending. Thus the weld is best positioned at the neutral fiber.

The bending radius must be sufficiently large for the bend not to rupture on the outside and not to form folds on the inside. The bending radius of steel and copper pipes should not be less than 3 times the bore (3 d). Better is a bending radius of 4 d.
A variety of bending devices enable rapid and straightforward bending of the pipes when cold and without requiring packing. For copper pipes and small-diameter wicu pipes, bending tongs are suitable. For large-diameter steel and copper pipes, pipe bending machines supported on a frame are used (Fig. 24.1). The appropriate bending segment for the pipe diameter concerned is mounted

in the device and the lateral jaws inserted in the corresponding openings. A certain bending radius is always obtained (about $3 \cdot d$ to $4 \cdot d$).

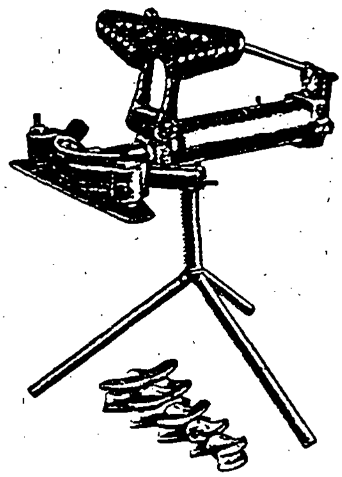


Fig. 24.1 Pipe bending machine

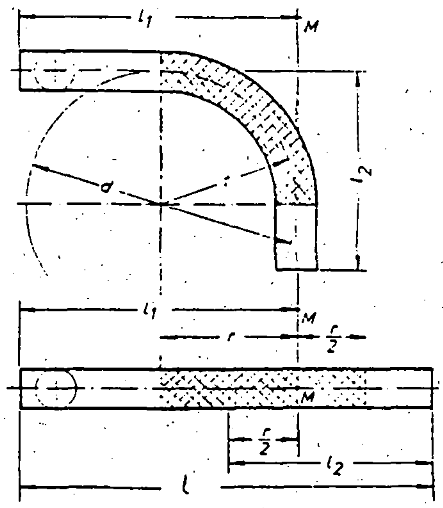


Fig. 24.2 90° pipe bend, straight length with bending length

Determination of the arc length (bending length, annealing length) for a 90° pipe bend (refer to Fig. 24.2).

Circumference of the complete circle	$U = 3.14 . d$
approximate value	$U \sim 3 \cdot d$
	$U \sim 6 \cdot r$
Quadrant = arc length	$l_B \sim \frac{6}{4} \cdot r$
arc length	$l_B \sim 1.5 \cdot r$

Bending length 1.5 x Bending radius

Marking out the bending length on the straight pipe (see Fig. 24.2)

1. Mark off length l_1 to point m.
2. Mark length r (= bending radius) from point M backwards on l_1.
3. Half this length r.
4. Add $\frac{r}{2}$ to point M on l_2.

Rule of thumb for 90° pipe bends:
Go back 2/3 arc length from point M,
add 1/3 arc length to point M.

Determination of the straight length l of the pipe:

Subtract length $\frac{r}{2}$ from length l_1 and add l_2 (see Fig. 24.2).

Straight length l = length l_1 + length l_2 - half bending radius $\frac{r}{2}$

$$l = l_1 + l_2 - \frac{r}{2}$$

9. Forging

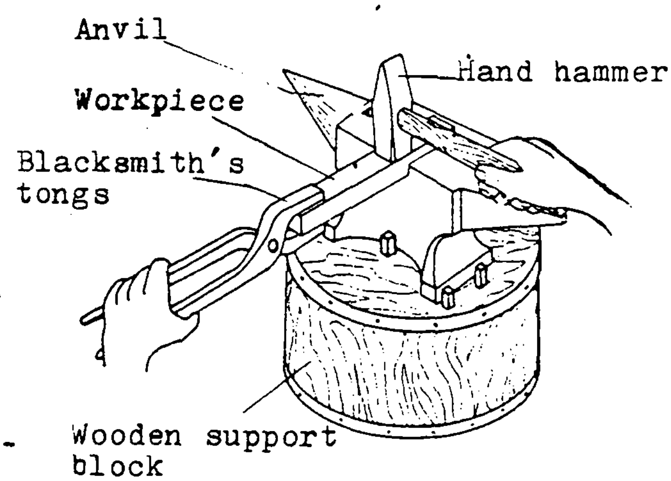


Fig. 25. 1 (a)

Forging is the non-machining shape-changing processing of metals when red hot by blows or pressure. The most important forgeable material is steel. In particular, its forgeability depends on its carbon content. Metals are heated to their forging temperature prior to the forging operation, so that they become more ductile and can be more easily shaped. The workpiece shape is imparted by hammer forging or by die forging.

Forging can be performed by hand or with the aid of various types of forging machine.

Hand-forging operations

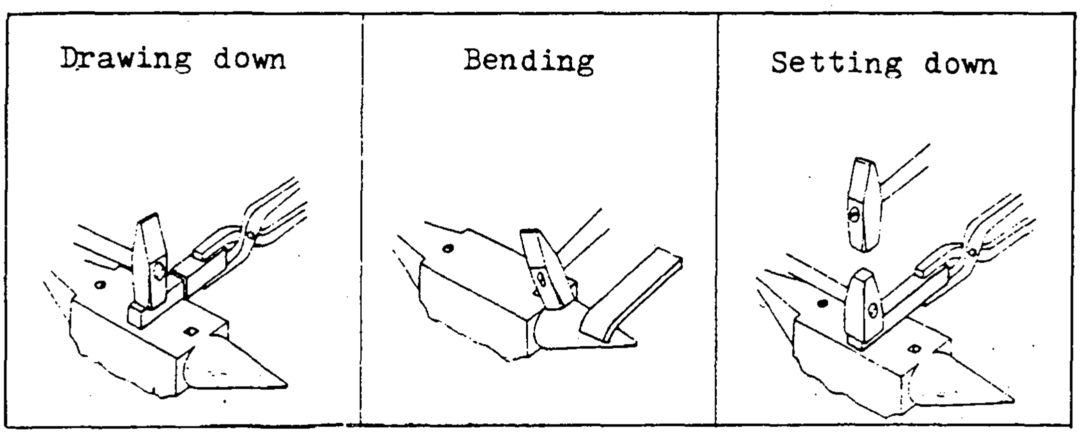


Fig. 25.2 (a)

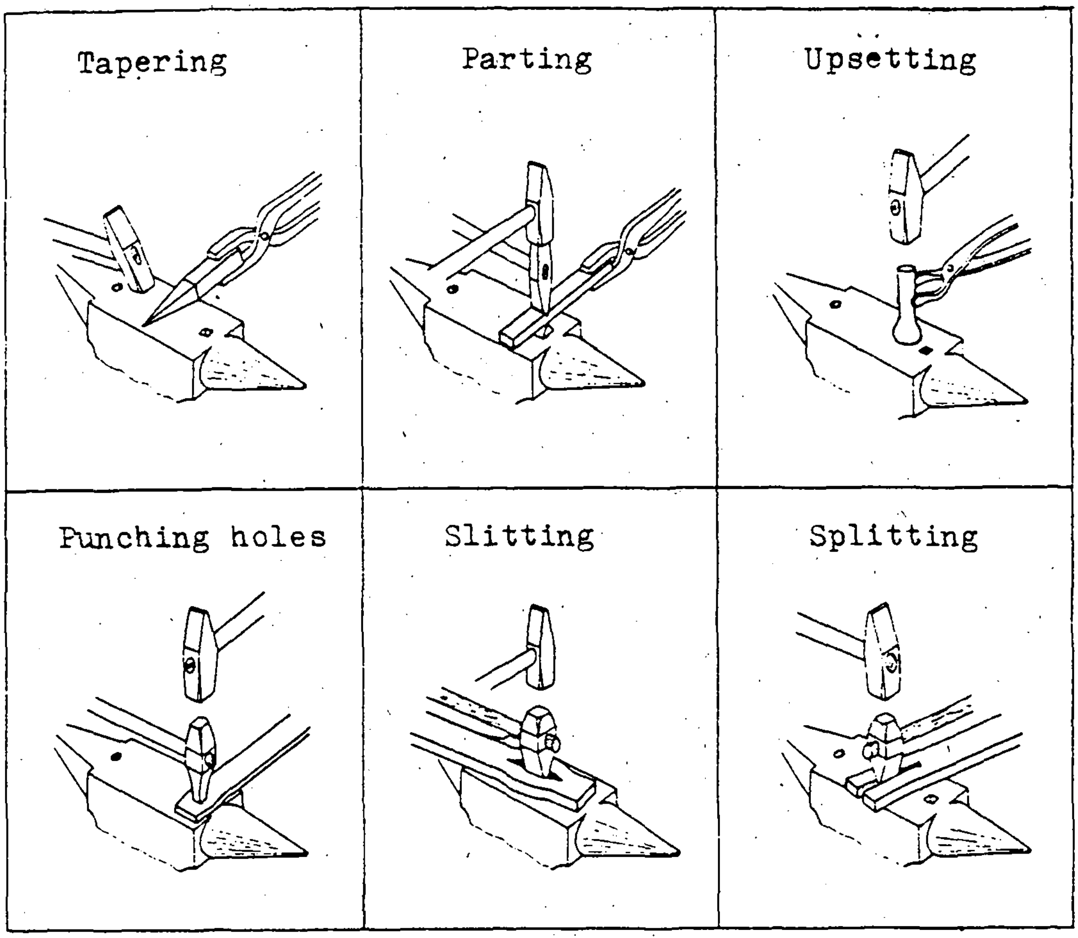


Fig. 26.1 (a)

Tools and equipment for hand forging

The Smith's Hearth

In order to heat up manually forged workpieces, open hearths suffice. Coal is set alight in the fire pot. Combustion air is supplied via a blower. As the forging temperature can only be regulated with difficulty in the open hearth, usually gas-operated hearths or oil- or gas-fired furnaces are used.

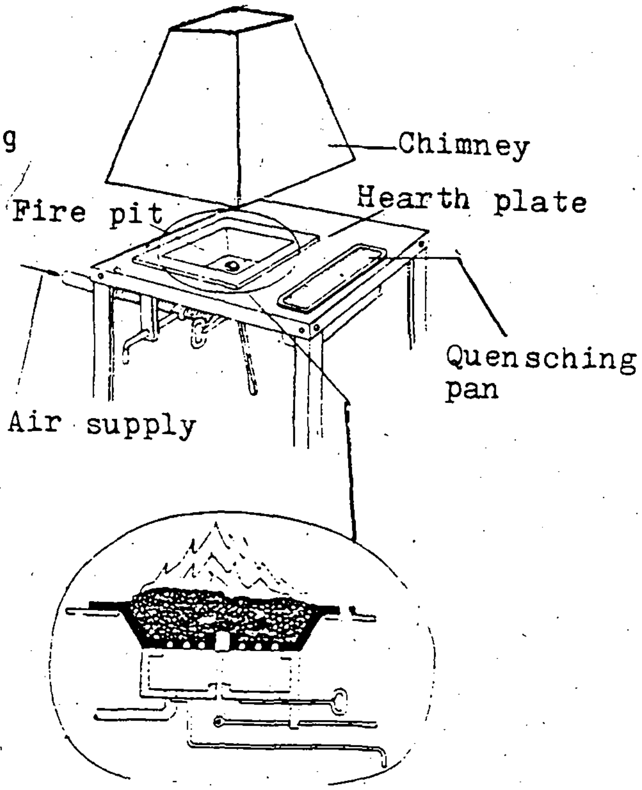


Fig. 26.2 (a)

Anvil
The anvil is a heavy, solid casting with a hardened and ground steel face. It is usually securely mounted on a wooden support for damping vibrations. The working height is about 80 cm. Suitable tools can be accommodated in the hardy holes.

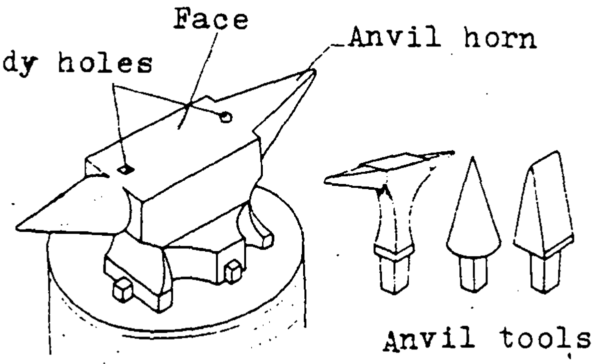


Fig. 27.1 Anvil (a)

Swage block
The swage block serves as a support for making holes and for upsetting operations and for accommodating anvil tools.

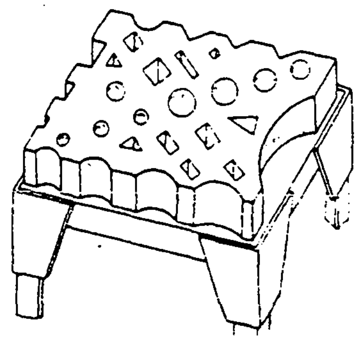


Fig. 27.2 Swage block (a)

Blacksmith's tongs
The blacksmith's tongs are used to grasp workpieces securely and to guide them. The shape of the tong jaws is matched to the cross-section of the workpiece.

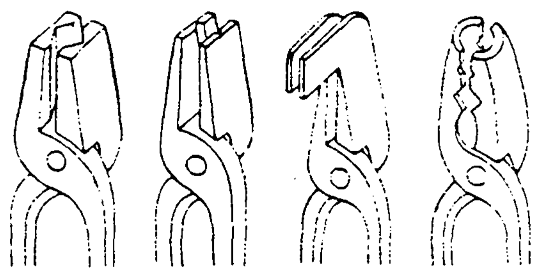


Fig. 27.3 Blacksmith's tongs (a)

Hammers
For light forging work, a one-handed hammer is used (weight 1-2 kg). Larger workpieces are worked with sledge or straight pein hammers, which may weigh up to 12 kg.

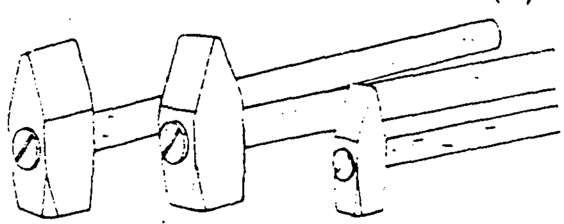


Fig. 27.4 Hammers (a)

Other anvil tools

Anvil tools serve to impart particular shapes to the workpiece. They are placed in contact with the part and struck with the hammer. Their handles should be fitted only loosely and not wedged, so that the hand holding the tool is not injured by shocks.

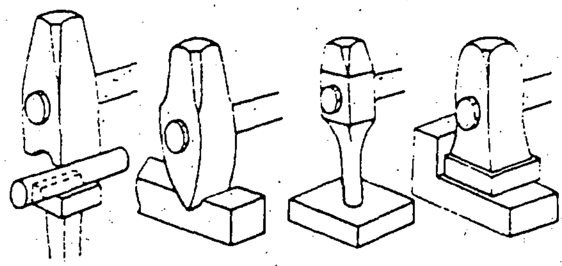


Fig. 28.1 Anvil tools (a)

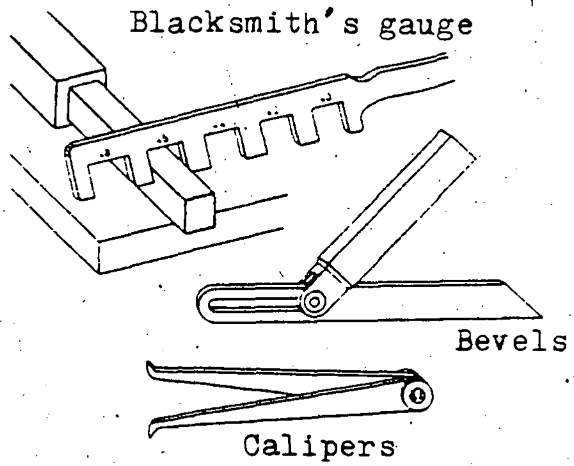


Fig. 28.2 Measuring instruments (a)

Measuring instruments

The measuring instruments used for checking dimensions are matched to the process. They are neither very exact nor are they sensitive to heat. Steel rules, sheet-metal gauges, calipers, try squares and bevels are used.

The following rules must be observed during forging:

Always wear protective clothing such as apron, gloves, high shoes and, if appropriate, head and face protection. These protect against burns and parts flying around the workshop.

Only use low-sulphur coal for the forge. Sulphur causes steel to become brittle. Extinguish the outside layer of coal with water, so that the fire always burns from the inside to the outside. Select the forging temperature depending on the material. Usually forging temperatures are specified by the material suppliers. In each case an initial forging temperature and a final forging temperature are specified. Forging may only be performed within these limits.

- If the temperature is too high, the material will burn in atmospheric oxygen.
- If forging is performed at too low a temperature, it becomes brittle and cracks.

10. Drilling

Drilling is the term for production of a hole of circular cross-section with the aid of a cutting tool, the drill. Usually the workpiece is held stationary whilst the drill moves. Thereby the drill performs a rotating cutting motion together with a feed in the axial direction and thus cuts through the material.

The twist drill finds most wide-spread use due to its particular advantages. Fig. 29.1 shows the tool and names its individual parts. The helical grooves or flutes ensure adequate removal of chips. The land corresponds to the nominal diameter, and serves to ensure good guidance in the workpiece. The drill is relieved behind the land, in order to reduce friction at the hole wall. The twist drill has an almost uniform cross-section along a large part of its length.

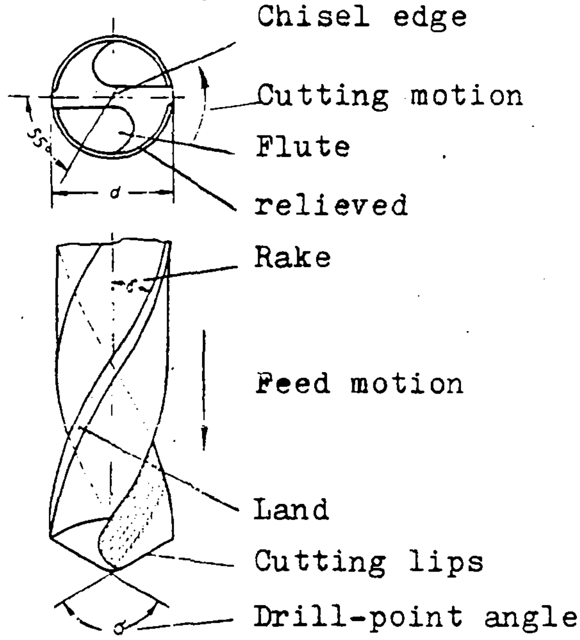


Fig. 29.1 Twist drill (b)

This makes it possible to regrind worn or broken-off drills, without changing the diameter.

The drills are made of steel. Drills of high-speed steel may only be used at higher cutting speeds. For machining very hard materials such as masonry and concrete, drills with soldered carbide inserts are used (Fig. 29.2).

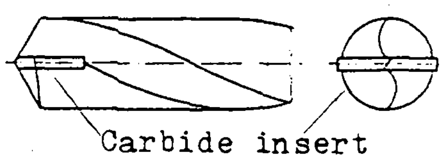
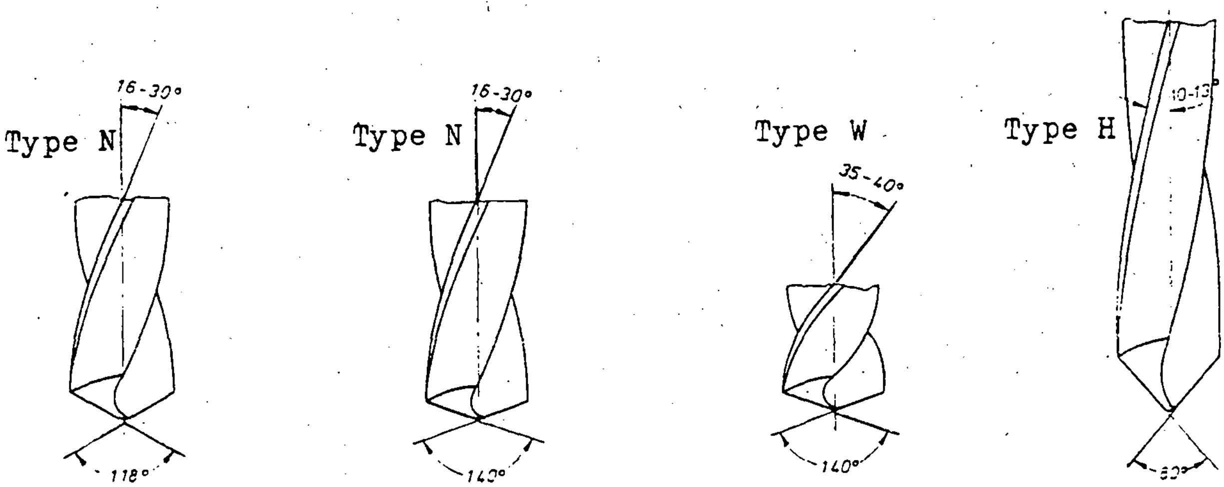


Fig. 29.2 Twist drill with (b) carbide inserts

Maximum drilling performance is only assured if the twist drill is provided with the most favorable rake angle γ (Gamma) and drill-point angle σ (Sigma). For the various materials encountered, 3 types are used. Type N is used for drilling normal materials, type H for hard and brittle materials and type W for soft materials. The types differ in their rake angle. In addition, they are ground to various drill-point angles according to the materials to be drilled. Fig. 30.1 shows the twist drills to be used for individual materials.



Steel, gray cast iron, malleable cast iron, brass	Stainless steel aluminium alloy	Copper aluminium	Marble Slate

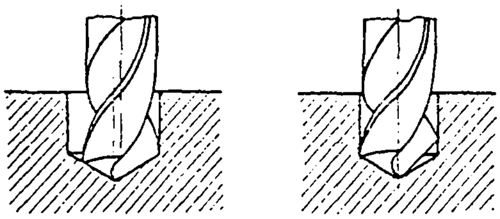
Fig. 30.1 Twist drill types and drill-point angles for different materials. (b)

Twist drills must be ground very precisely and symmetrically in order to obtain good drilling performance and accurate dimensions. The required drill-point angle and the chisel point angle of 55° must be maintained. For larger drill diameters, the chisel edge requires a heavy feed force. For this reason the web is ground out at the drill point: web thinning.

Grinding errors. If the cutting lips are ground to different lengths, the centering tip lies outside of the drill axis and an enlarged hole diameter is the result. If the cutting lips are ground to different angles, only one lip cuts and wears rapidly. The non-uniform loading of the drill tends to cause it to wander (see Fig. 31.1).

It is recommended that a twist drill grinding attachment be used; this can be set to the required drill-point angle. Correct grinding of the twist drill is checked with the aid of a drill grinding gauge (see Fig. 31.2).

The shank of the drill where it is clamped is straight for small diameters. Hand drills are provided with an appropriate drill chuck. The twist drill should be inserted till it bottoms in the chuck, where possible, so that it does not slip during drilling. In the geared rim drill chuck, the drill is clamped by means of a key. Quick-release drill chucks clamp automatically due to the resistance to which the drill is subjected during the drilling operation. The drill must be clamped exactly centrally. Thus check for true-running.



Cutting lips of unequal length

Unequal cutting angles

Fig. 31.1 Errors in drill grinding (b)

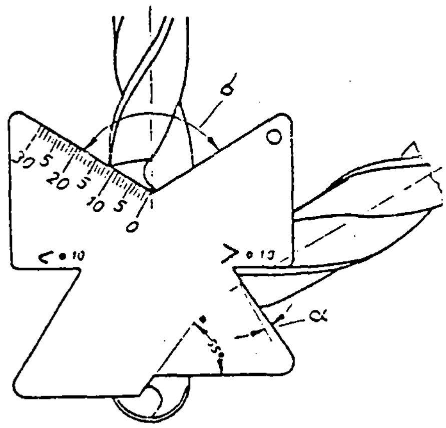


Fig. 31.2 Drill grinding gauge (b)

Thicker drills have a taper shank in order to ensure precise true-running. The drill is inserted into the female taper of the drilling spindle and is held centrally by adhesion between the two taper surfaces. If the female taper of the machine is too great for the drill shank, a drill is inserted with the aid of a drill sleeve (Fig. 31.3). It must be ensured that all taper surfaces are clean and free of drillings. The drill is extracted with the aid of the

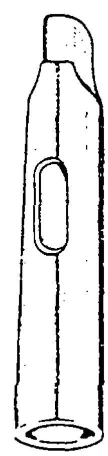
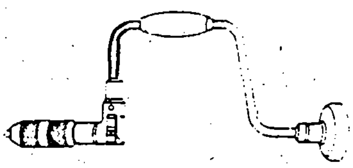


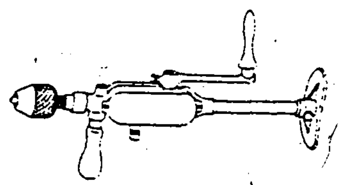
Fig. 31.3 Drill sleeve (b)

wedge-shaped drift.

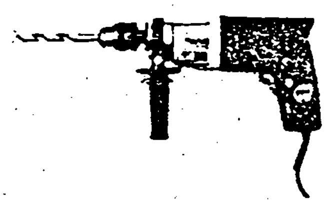
Drilling machines. If there is no electrical power outlet available, braces or hand drills with gearing are used. The drill is made to rotate by cranking by hand. If possible, electrical drills are used due to their higher powers.



Brace



Hand drill with gearing



Power hand drill

Fig. 32.1 Hand drills with manual drive (a)

Fig. 32.2 (a) Hand-held electrically powered drill

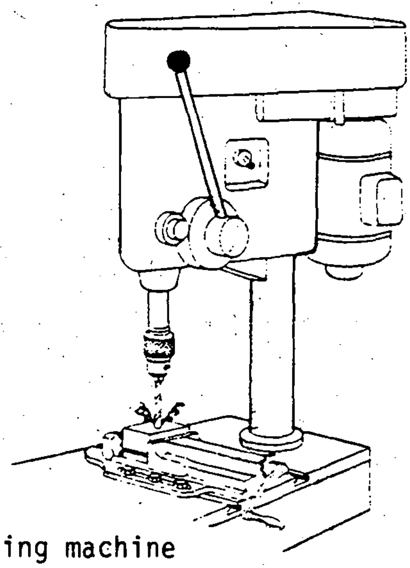


Fig. 32.3 Bench drilling machine

Percussion drilling machines are used for drilling wall panels, masonry and concrete. The drill can be set to normal drilling or to percussion drilling. During percussion drilling, the drill is made to perform an axial percussion motion by two slotted discs which slide against each other. Thereby about 20 blows per revolution ensure the best percussion drilling results. For percussion drilling, carbide-tipped percussion twist drills are used.

The electrical percussion drill is used in percussion operation for drilling through masonry for pipe installation.

Special carbide percussion twist drills, and for larger diameters up to 90 mm, carbide drill bits are used in the drilling machine. For cutting in stone, special chisels can be clamped into the percussion drill; these have a hammer action without rotation. Also it is possible to use rapid core drill anchors in the machine. This tool has a ring of wedge-shaped cutters, so that it drills out its own anchor hole (see Fig. 84.1).

Drilling in wood

In order to produce pinned and doweled joints, holes must be drilled. For this purpose, various types of wood drills are available. Their shape corresponds to the particular requirements.

They all penetrate the work like a screw and produce the required hole according to their geometry. Thus, the hand gimlet bit is particularly suitable for predrilling nail and screw holes. The twist auger has the best drilling characteristics, as it is provided on both sides with spurs and cutting edges and thus single-sided lever action is eliminated.

All wood drills rotate clockwise. They must be well taken care of and., in particular, the cutting edges require protection. In addition to the hand drills, power drills are used. Their high speeds make possible clean, precise and rapid working. For smaller drill diameters, the speed is higher and for drills with a greater diameter, lower speeds are appropriate.

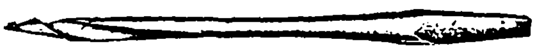


Fig. 33.1 (d) Gimlet bit

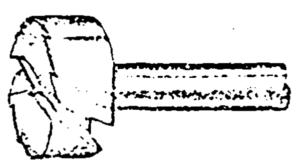


Fig. 33.3 (d) Forstner bit with toothed rim

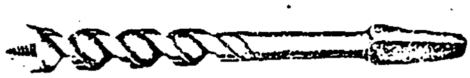


Fig. 33.2 (d) Twist auger

11. Countersinking and counterboring

Countersinking and counterboring are chip-removal machining methods. Working of materials by these methods is performed on drilling and milling machines with multi-cutter tools, whose principle of working is similar to twist drills.

These processes are defined as follows: counterboring is the production of a cylindrical recress, and countersinking of a cone-shaped recess, for accommodating bolt, screw and rivet heads.

Deburring of bores

Boring out of predrilled and precast bores.

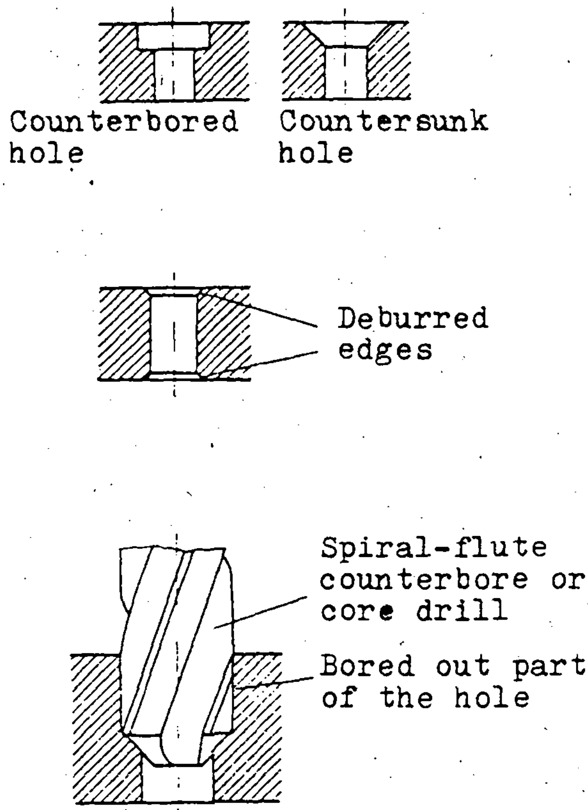


Fig. 34.1 (a)

Counterboring/countersinking tools

Piloted counterbore

Piloted counterbores are provided with a short cylindrical guide pin, whose diameter is usually equal to that of the through-hole for the screw body. The diameter of the cutter section is somewhat greater than the head of the cheese-headed screw for which it is intended.

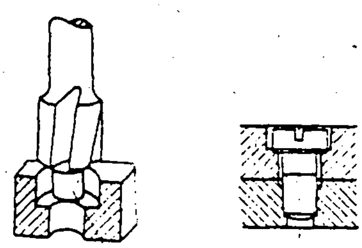
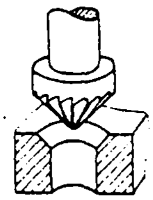


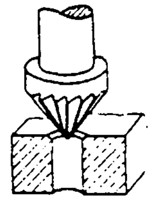
Fig. 34.2 (a)

Countersinks

Countersinks with various included angles of taper are used. Usual are 60° (deburring), 75° (rivet heads) and 90° (screw heads).



Countersunk hole for rivet or screw head



Deburring a hole

Fig. 35.1 (a)

Spiral-flute counterbore or core drill

Spiral-flute counterbores are very similar to twist drills but have three or more cutting edges. As these counterbores are used solely for boring out existing holes, the cutting edges do not extend to the center of the tool. Such counterbores have a very high cutting performance, as several cutting edges engage simultaneously.

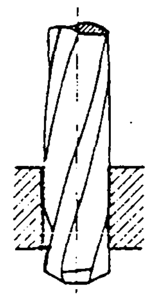
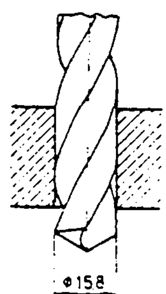


Fig. 35.2 (a)

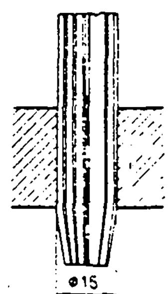
12. Reaming

Reaming serves to produce dimensionally-accurate and smooth-walled cylindrical bores by means of a small depth of cut.

A small predrilled hole is reamed out with the reamer either manually or with the drilling machine.



Predrille hole



Reamed hole

Fig. 35. 3 (a)

The reamer, which is provided with several cutting edges around its periphery, executes a feed motion along the tool axis in addition to its rotary motion. Thereby, fine chips are removed from the hole wall. The walls are smoothed, and the bore becomes more exactly circular with precise dimensions.

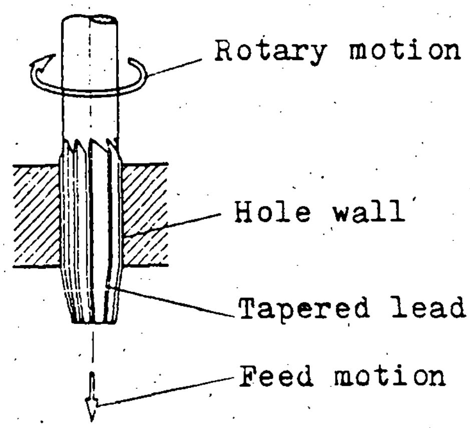


Fig. 36.1 (a)

Reaming tools

Design of the reamer

Reamers consist of the cutting part and the shank. The front part of the reamer is termed the lead, is tapered, and serves to cut the material. The straight section is responsible for guiding the reamer in the bore and smooths the hole walls.

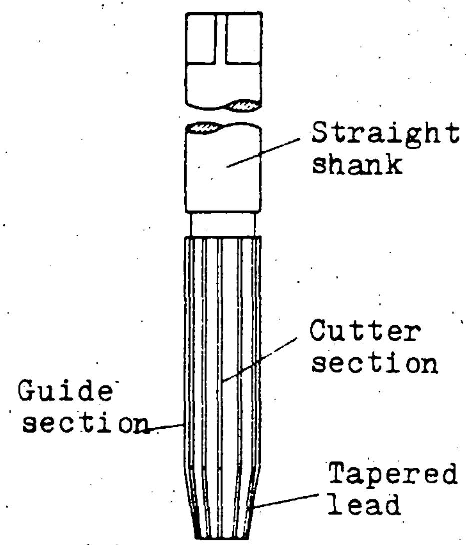


Fig. 36.2 (a)

The selection of the reaming allowance z depends on the finished diameter of the hole:

d_F	Reaming allowance z
up to 5 mm	0.1 - 0.2 mm
5 - 20 mm	0.2 - 0.3 mm
20 - 50 mm	0.3 - 0.5 mm

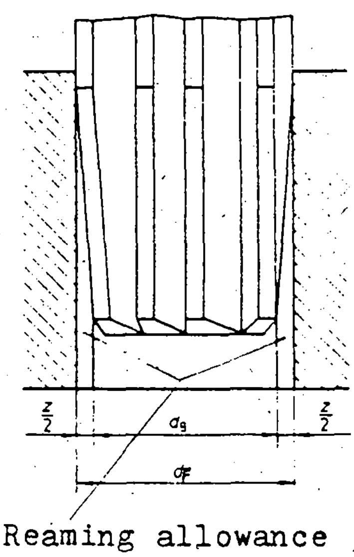


Fig. 36.3 (a)

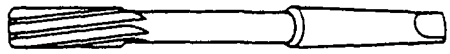
Cutting speed and coolant-lubricant

In order to obtain an optimum surface finish and a long service life of the reamer, coolant-lubricant should be employed.
In addition, too large a cutting speed should not be selected.
For machine reamers, about 1/3 of the drill speed is selected.

Types

Fig. 37.1 (a) Hand reamer with helical flutes

Hand reamers



Machine reamer

Fig. 37.2 (a) Machine reamer (standard type)

Taper reamer

Taper reamers are used mainly fort reaming out holes for taper dowels.

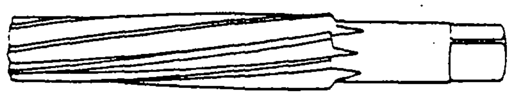


Fig. 37.3 (a) Taper reamer

13. Thread cutting

Specification dimensions of the thread

Threads are specified by five dimensions:
The major diameter d is usually the thread designation.
The minor diameter d_3 defines the dimension of the cylinder that is enveloped by the thread.
The effective diameter or pitch diameter d_2 lies between the major and minor diameters and is of importance when measuring the thread.

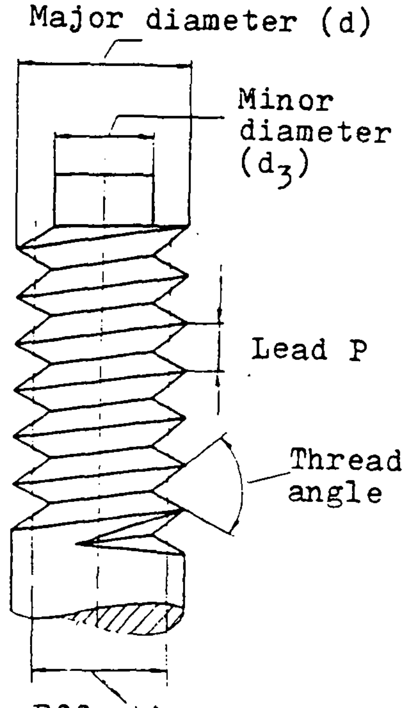


Fig. 37.4 (a)

The thread angle specifies the inclination of the two thread flanks with respect to each other.

The lead P is the distance from flank fo flank of the same thread start.

Types of thread

There are many types of thread, whose designations, geometries and symbols for specifying dimensions are specified in DIN 202. From these, the following three types of thread are particularly important:

- Metric Thread -

Major diameter d, minor diameter d_3 and effective diameter d_2 as well as lead P are specified in mm, the thread angle being 60°. The designation for a thread of 10 mm major diameter is: M 10.

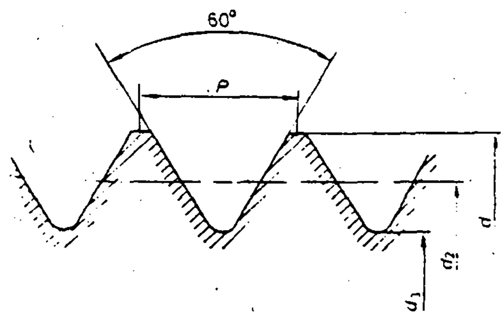


Fig. 38.1 Metric thread (a)

- Whitworth Thread -

Major diameter d, minor diameter d_3 and effective diameter d_2 are measured in inches. The lead P is specified in threads per inch, the thread angle is 55°. Designation of a Whitworth thread of major diameter 3/4": 3/4".

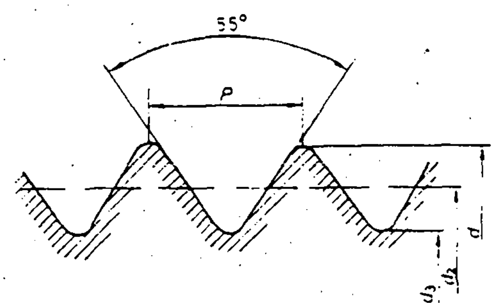


Fig. 38.2 Whitworth thread (a)

For inch threads, lead is specified in "threads per inch", in order to avoid fractional inch dimensions when specifying lead.

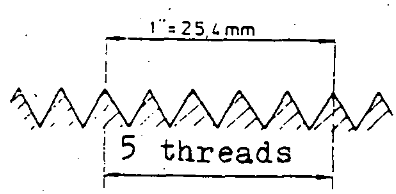


Fig. 38.3 (a)

Thread cutting by hand - internal threads (female threads) -
Cutting of internal threads usually involves small-diameter metric threads. Internal threads are usually cut with a set of taps, with which the full depth of thread is attained in two or three steps. A set of taps for blind holes consists of taper or first-cut tap, a second tap and a plug or bottoming tap. For through-holes, taper and bottoming taps suffice. The taps of a set are indicated by rings below the squared end. These rings signify: 1 ring = taper tap, 2 rings = second tap, 3 rings or without rings = bottoming tap. The cut metal is removed via straight or helical flutes in the tap. Cutting oil can facilitate working, whilst lubricating oil is not suitable. The hole to be drilled prior to tapping has a diameter which must at least correspond to the minor diameter of the thread. Predrilled holes which are too small result in heavy pressure and possible breakage of the tap.

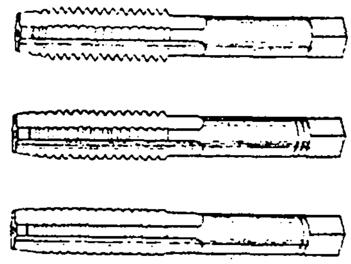


Fig. 39.1 (a) Set of hand taps

- External thread (Male thread) -
Dies - The cutting edges of the die are formed by holes in the thread, which at the same time serve to accommodate the chips.

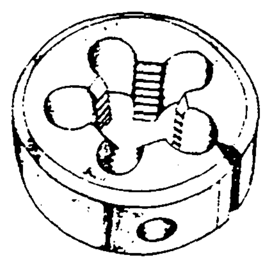


Fig. 39.2 Die
(b)

The first two threads of the die are tapered and perform the cutting work. The following threads essentially serve to smooth the thread.

As the number of threads is the same for several thread diameters, it is possible to use one die stock for various thread sizes without changing jaws, as this stock has adjustable cutting and guide jaws.

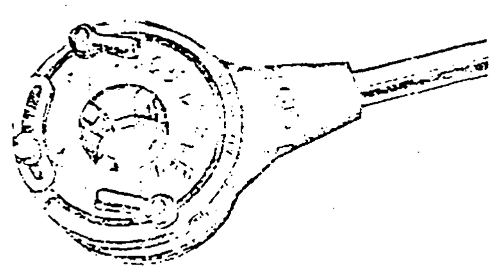
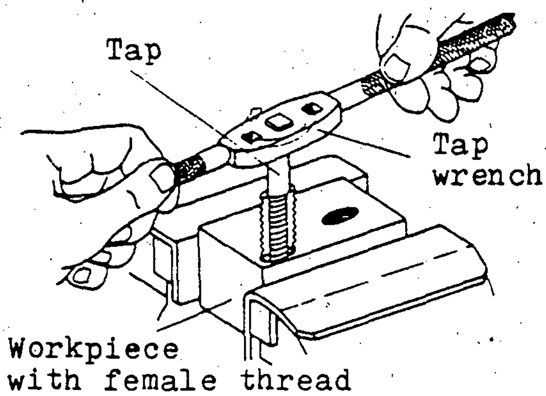


Fig. 39.3 Ratchet die stock with adjustable die jaws
(b)

The appropriate die jaws must be inserted into the cutting head and set to the correct clearance. Coarse and fine adjustments ensure a precise thread diameter. This facility is important if it is required that a thread be cut in several operations. The radial die jaws are securely held by a locking device, which prevents opening of the die stock.



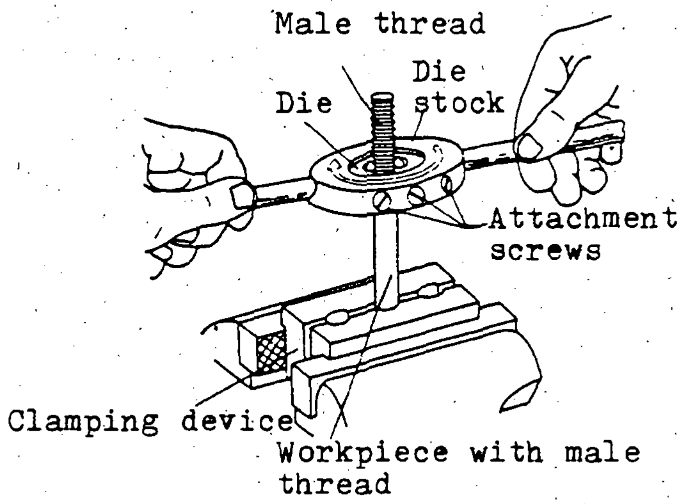


Fig. 40.1 Thread cutting by hand (a)   Workpiece with male thread

14. Bolted fastenings

In the assembly department, the individual parts must be fitted together to make up assembly groups. For this purpose, various techniques have been developed. In assembly, a distinction is made between permanent and non-permanent connections. The most important non-permanent connection is the attachment of components by threaded fasteners.

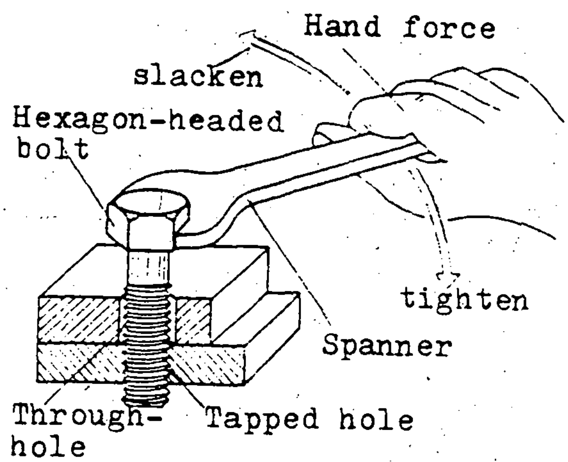


Fig. 40.2 (a)

Nuts and bolts are standard parts manufactured in large quantities. They are classified according to geometry, dimensions and material.

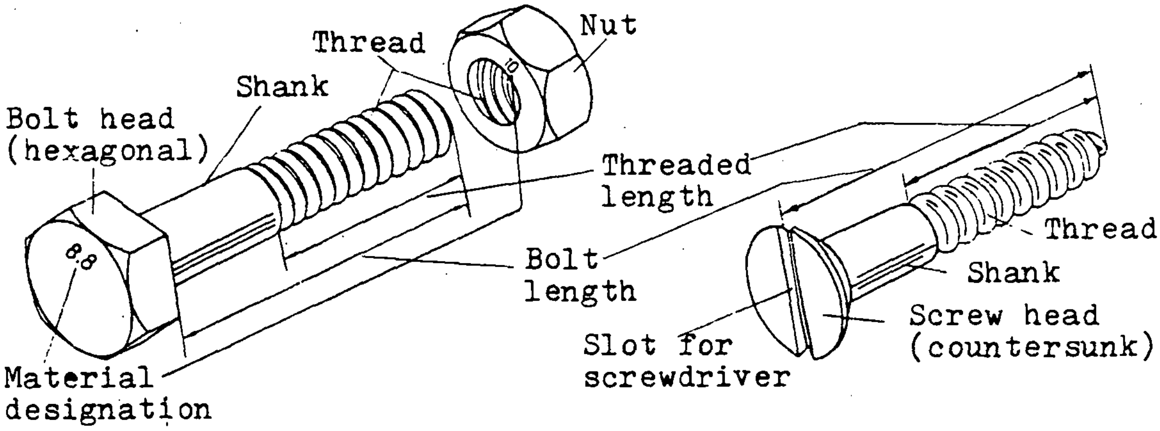
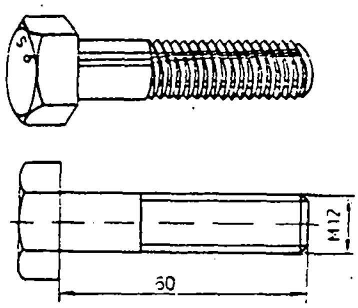
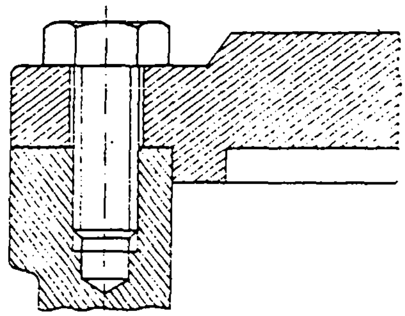


Fig. 41.1 Hexagon-headed bolt with nut and wood screw (a)

Types of screw and their applications

- Hexagon-headed bolt -



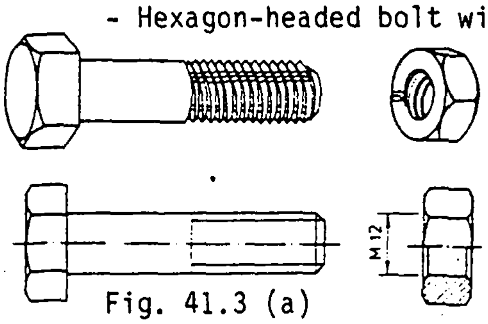


Designation: Hex. Hd. bolt
M 12 x 60 DIN 931 - 5.6

Fig. 41.2 (a)

Application: connection of machine components. Female thread is provided in the machine component.

- Hexagon-headed bolt with nut -



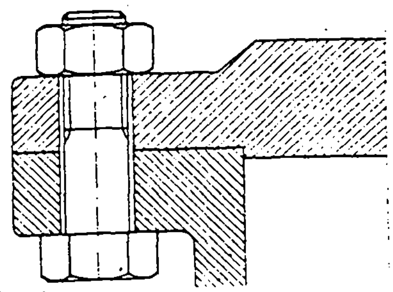
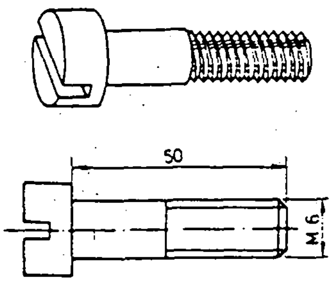


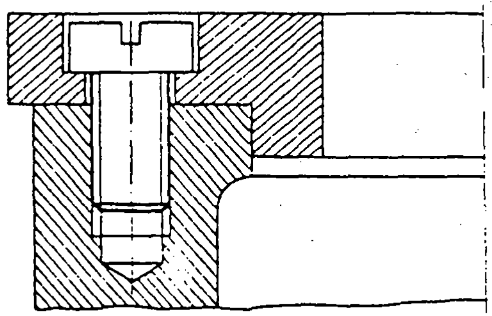
Fig. 41.3 (a)

Designation for nut:
Nut
M 12 DIN 555 - 10

Application: connection of machine components in which only through-holes are provided

- Cheese-head screw with slot -

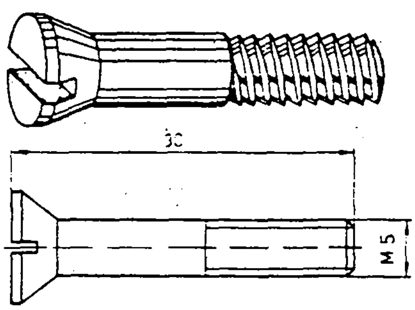


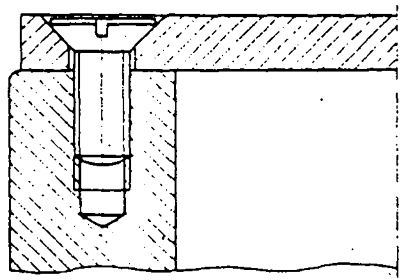


Designation:
Cheese-head screw
M 6 x 50 - DIN 64 - 5.6
Fig. 42.1 (a)

Application: only suitable for lightly-loaded connections, as these screws can only be tightened with the screwdriver.

- Countersunk screw with slot -

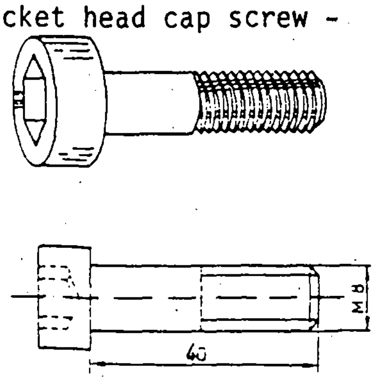




Designation:
Countersunk screw
M 5 x 30 DIN 936 - 5.6
Fig. 42.4 (a)

Application: for subsidiary bolted connections subjected to low load. The cone-shaped head centers the component. In addition, a smooth surface is obtained as the screw heads do not project.

- Socket head cap screw -



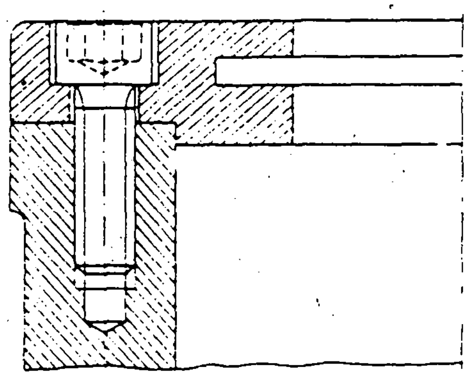
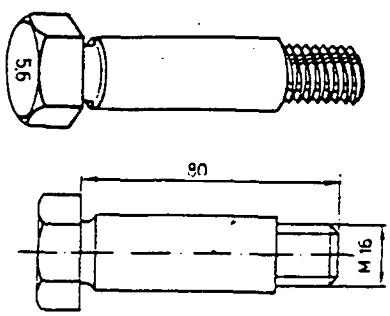


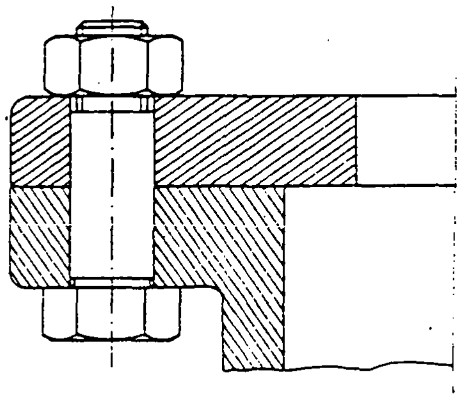
Fig. 42.3 (a)

Designation:
Socket head cap screw
M 8 x 40 DIN 912 - 10.9
to Fig. 42.3

Application: High-strength connection of machine components. The female thread is provided in the component. The screw head is recessed, so that a smooth surface results.
The socket head cap screw is tightened with a hexagon socket wrench (Allen key).

- Hexagon fit bolt -





Designation:
Hexagon fit bolt
M 16 x 80 DIN 609 - 5.6
Fig. 43.1 (a)

Application: The ground cylindrical fit shank enables precise fitting of machine components. The through-holes are reamed, in order for precise matching to the diameter of the fit bolt.

- Square head bolt -

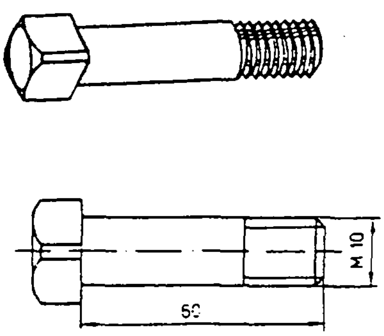
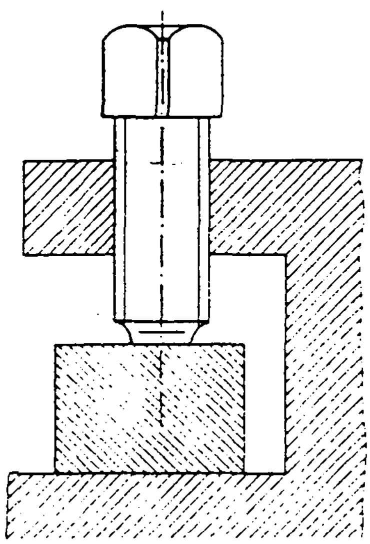
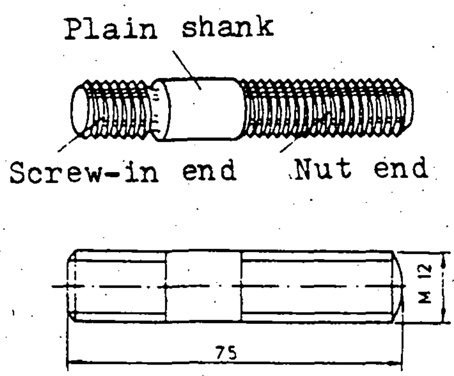


Fig. 43.2 (a)



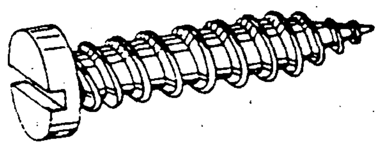
Designation:
Square head bolt
M 10 x 60 DIN 479 - 5.6
to Fig. 43.2

- Stud bolt -

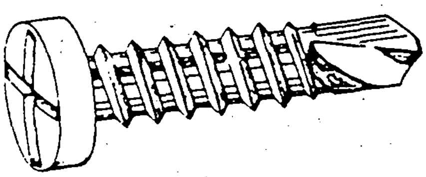


Designation:
Stud bolt
M 12 x 75 DIN 938 - 8.8
Fig. 44.1 (a)

- Self-tapping screw -

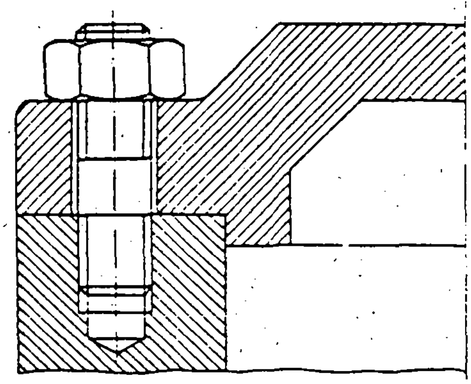


Designation:
Self-tapping screw
4.2 x 20 DIN 7971

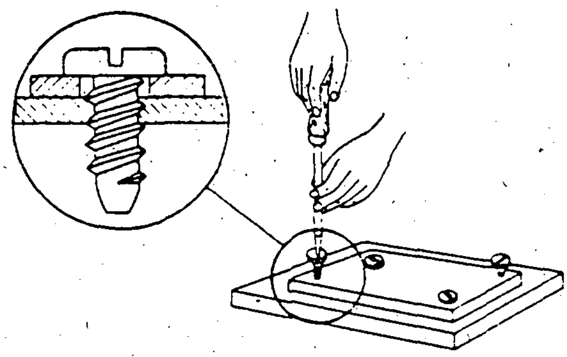


Self-drilling sheet-metal screw: screw starting hole is drilled by the screw itself.
Fig. 44.2 (a)

Application: For setting and locking of components, for instance, locking of turning tools in toolholders.



Application: Stud bolts remain with the screwed-in end in place in a component. This means, for instance, that if a cover is often removed, the female thread of the machine body will not be damaged.



Application: Self-tapping screws are used for joining sheet metal up to 2 mm thickness. They have a similar thread to wood screws. As they are screwed in, they cut their own thread, so that tapping is not necessary.

Thread locking devices

Thread locking devices are subjected to many types of loading during operation. Due to vibrations and cyclic loading, nuts and bolts may unintentionally work loose. The installation of thread locking devices prevents this.

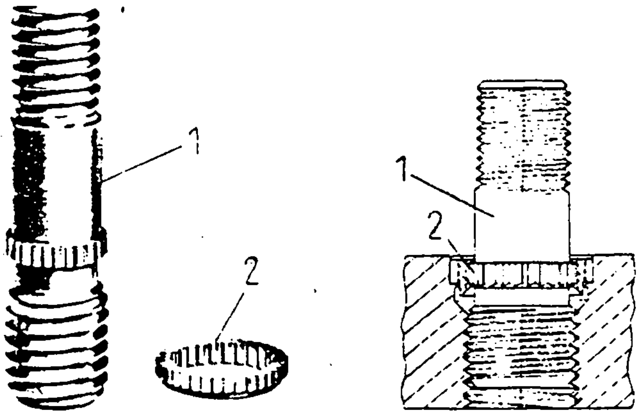
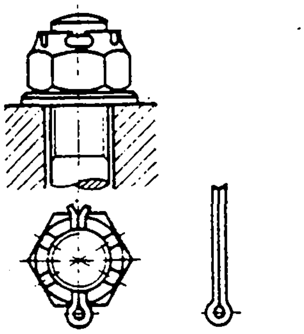


Fig. 45.1 Stud bolt with positively-locking housing lock (e)

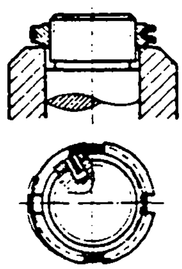
1 = Stud bolt
2 = Locking ring

The shank of the stud bolt is splined. After the bolt has been screwed in, an internally and externally splined ring is slid over the bolt splines and its external splines are forced into the housing.

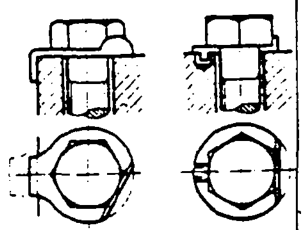
Castle nut with split pin



Hooked circlip



Tab washer



Locking with wire

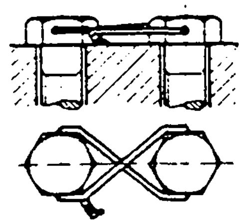
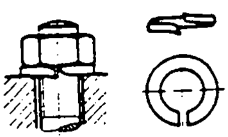
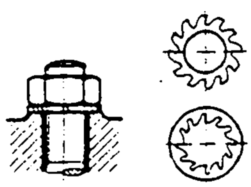


Fig. 45.2 Positive locking arrangements (e)

Spring lock washer



Internally and externally serrated lock washers



Locknut

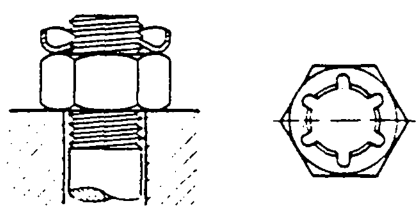


Fig. 45.3 Frictional locking arrangements (e)

Lock nuts (jam nuts)   Spring lock nut (compression stop nut)

Fig. 46.1 Locking arrangements in which forces act on the threads (e)

Tools for making bolted connections

The selection of the tools used for making bolted connections depends essentially on the form and size of the bolt or screw head.

Double open-ended spanner for square and hexagon headed bolts (DIN 3110)

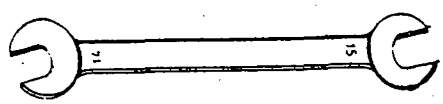


Fig. 46.2 (a)

Widths across flats for screws with metric threads in mm

M 3	M 4	M 5	M 6	M 8	M 10	M 12	M 14	M 16	M 20	M 24	M 30	M 36
5.5	7	8	10	13	17	19	22	24	30	36	46	55

Ring spanner with twelve internal corners, flat (DIN 837) or offset (DIN 838), for square and hexagon headed bolts.

Tubular box spanner for inaccessible hexagon-head bolts.

Torque spanner (wrench) with interchangeable sockets which are hexagonal or have twelve internal corners.

Excessive tightening can overload bolts and cause them to shear off. If they are not tightened enough, bolted connections may work loose. Using a torque wrench, the specified tightening torques (force x lever arm) can be held precisely.

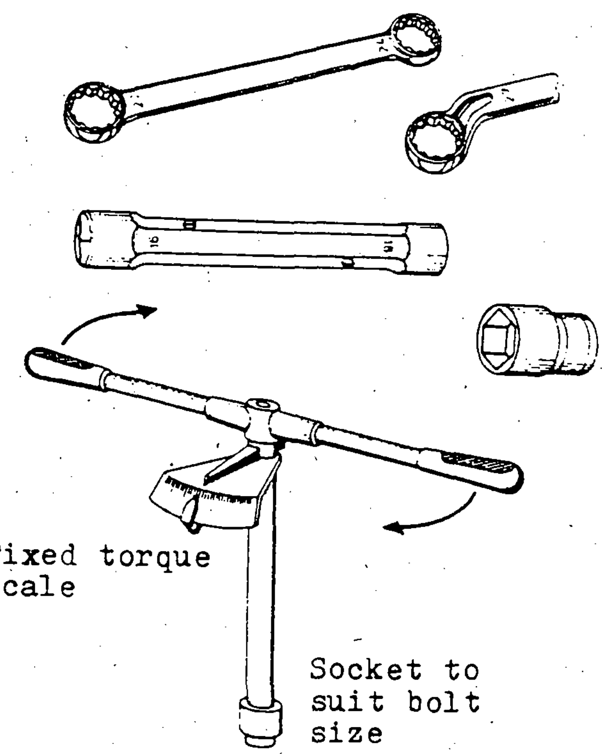
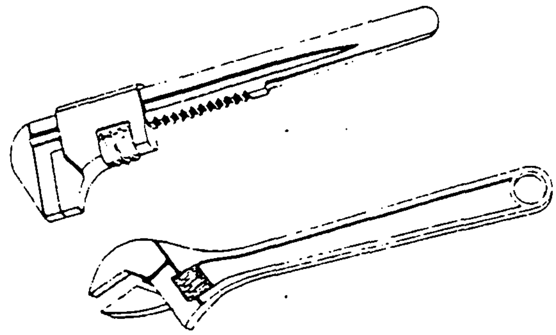
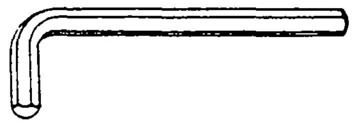


Fig. 46.3 - 46.5 (a)

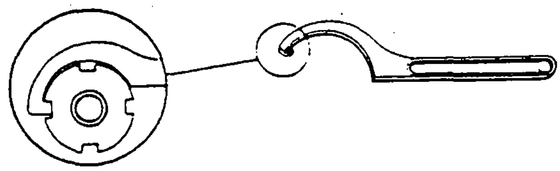
Adjustable spanner for square or hexagon headed bolts.



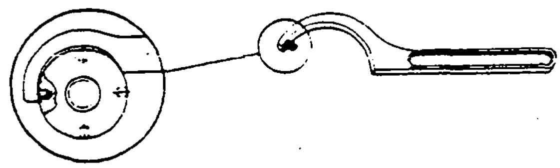
Hexagon socket wrench (Allen key) DIN 911 for socket head cap screws



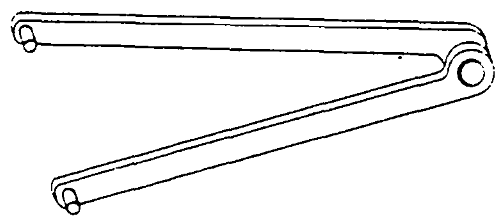
Hook spanner with nose for engaging slotted nuts



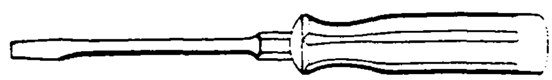
Hook spanner with pin for engaging capstan nuts



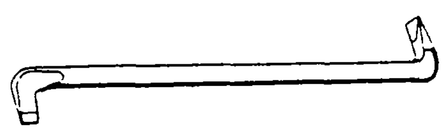
Adjustable face spanner for ring nuts with holes drilled in one face



Screwdriver for slotted screws



Offset screwdriver for inaccessible positions



Screwdriver for Phillips screws

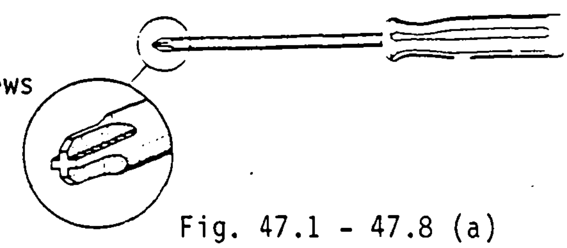


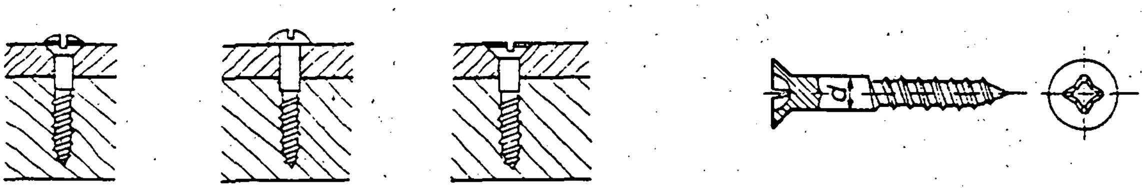
Fig. 47.1 - 47.8 (a)

14.1 Screwed fastenings in wood

Wood screws make possible a secure joint, which can, however, in contrast to nails, be released when required. The holding force of the screw is considerably greater than that of nails, as the thread of the screw cuts into the wood.

Types of wood screw

Slotted rounded countersunk head, round head, countersunk head — Countersunk wood screw with crosshead (Phillips recess)



DIN 95 DIN 96 DIN 97 DIN 7995 - 7997

Fig. 48.1 (c)

The screws are made of steel, brass and aluminium alloys.

Designation of the wood screw:

4 x 30 DIN 97 St

- 4 → Thickness in mm
- 30 → Length in mm
- DIN 97 → Type of screw
- St → Material:steel

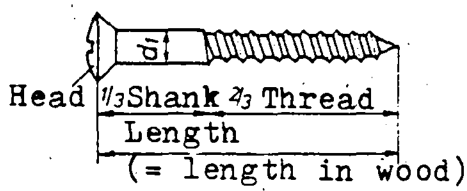


Fig. 48.2 Wood screw (c)

15. Riveting

Riveting serves to produce permanent joints between several parts, in particular steel plates and profile sections.

As a rule, rivets are produced from straight pins and have a variety of head forms.

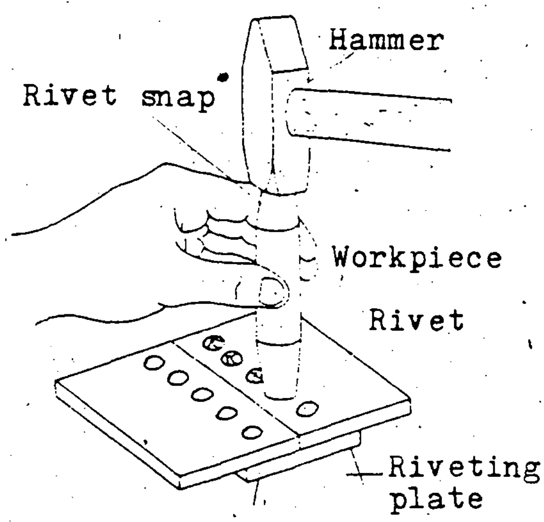


Fig. 48.3 (a)

Riveted joints can fulfil various tasks:

- Loading for strength (e.g. in bridge-building),
- Loading for leak-tightness (e.g. in containers).

Riveting can be performed cold or hot, and manually or by machine.

When joining workpieces by rivets, the work is performed in various stages:

The parts to be joined are pre-drilled and placed together.

The rivet is inserted and the set head is held by the holding-up tool.

The rivet set presses all parts securely together.

The closing head is preformed with the hammer.

The rivet snap (header) imparts the correct shape to the closing head.

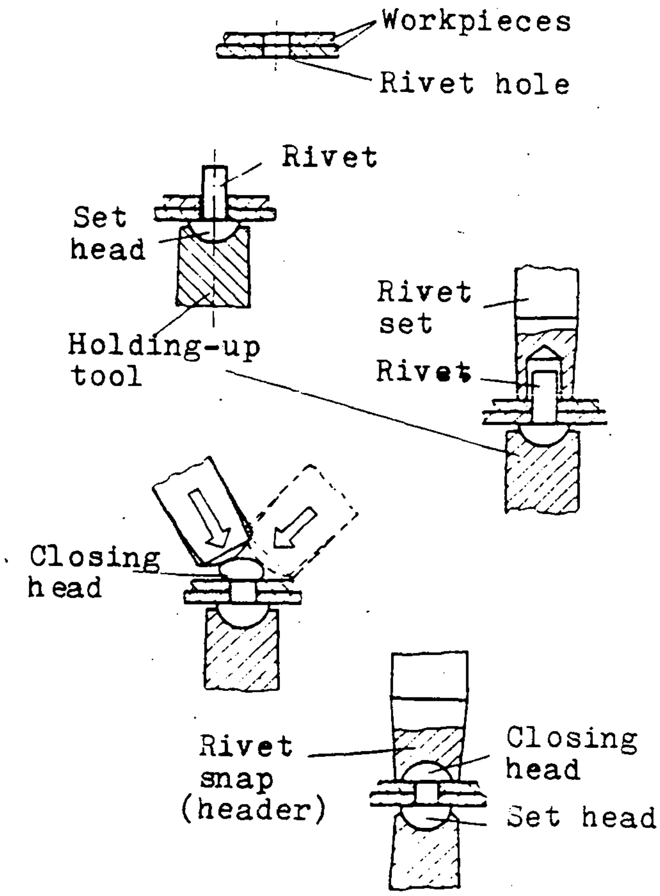


Fig. 49.1 (a)

Types of rivet - riveted joints

A riveted joint is termed a permanent joint, as it cannot be separated without destroying the rivet.

Rivets are premanufactured pins of steel, copper, alurinium and other metallic materials, which can be readily formed when cold or hot.
They differ in head shape, rivet diameter (d_1) and rivet length (1).

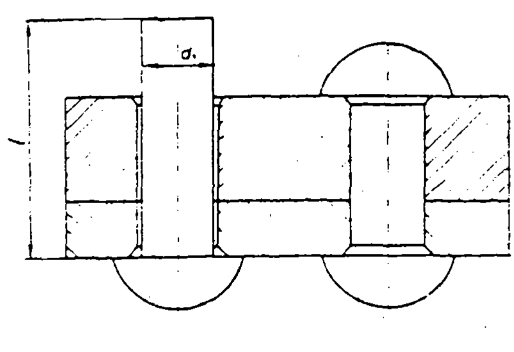


Fig. 49.2 (a)

16. Welding

During welding, materials of the same type are permanently joined to each other when in a liquid or pasty condition under the influence of heat. Steels, light metals and plastics are the principal materials welded.

16.1 Gas welding

During gas welding, the workpieces to be joined and a filler material are heated up at the point of join (point of welding) until they melt by means of a gas flame at about 3000°C. Thereby the workpieces fuse (weld) together to make up a single workpiece. This joining technique is termed gas fusion welding.

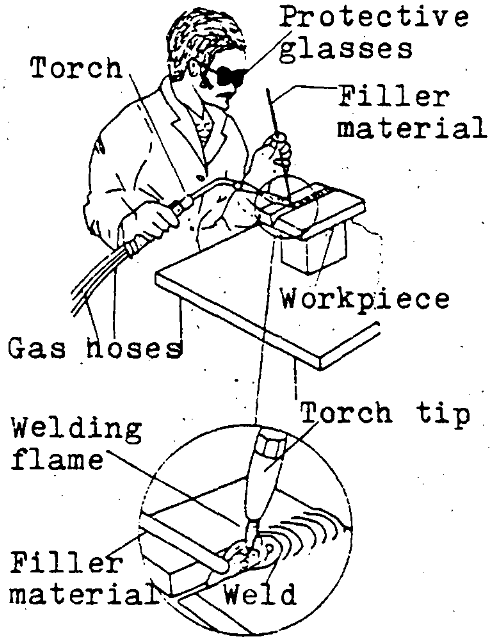


Fig. 50.1 (a)

Procedure

The necessary fusion heat is generated by a welding flame whose temperature is about 3000°C.

Thereby, a fuel gas, usually acetylene, is mixed with oxygen in the welding torch and burnt at the torch mouthpiece.
At the correct mixture ratio, the flame has a characteristic appearance: immediately at the torch tip, a sharply-defined flame cone forms. The maximum flame temperature of about 3200°C is attained about 3 - 4 mm in front of the cone.

For gas welding, there are two welding techniques:

Rightwards welding
The welding torch is slowly moved from left to right. The flame forces the molten metal against the finished seam which is thus kept hot. This technique is employed for heavier-gauge materials (over 3 mm) and results in a weld with good penetration.

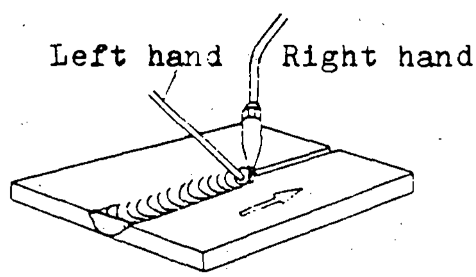


Fig. 50.2 (a)

Leftwards welding

The torch is moved from right to left. The rod is moved ahead of the flame. The weld pool is blown forwards and the weld cools down rapidly. Leftwards welding is therefore suitable for welds of less than 3 mm thickness.

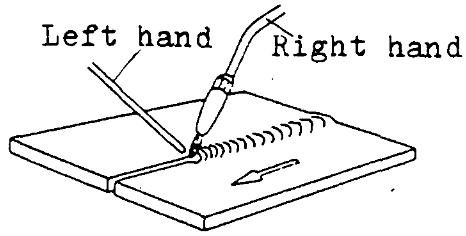
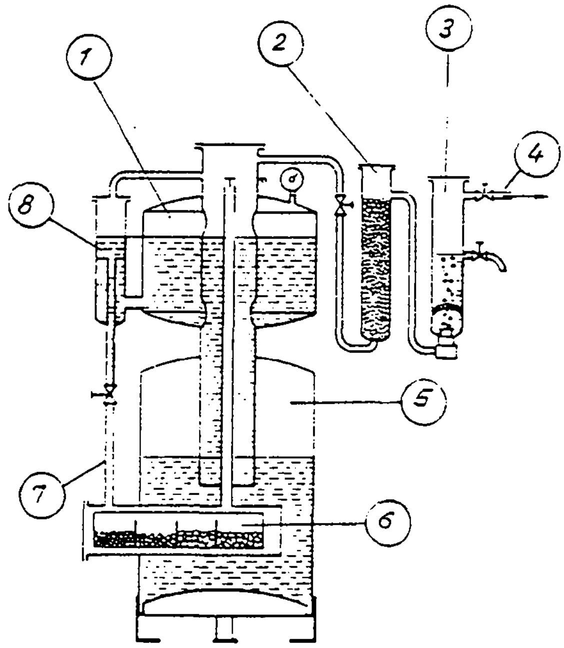


Fig. 51.1 (a)

Tools and equipment for gas welding

Gas generator

Within the generator, calcium carbide (Ca_2C) is made to combine with water (H_2O). Thereby acetylene gas (C_2H_2) is produced by chemical reaction. Most such devices operate automatically, i.e. when gas is no longer removed, generation of gas is stopped. Safety valves prevent impermissible levels of pressure. This precaution is necessary as acetylene gas decomposes explosively at pressures greater than 1.5 bar.



1. Gas collection space
2. Purifier
3. Water back-pressure valve
4. Gas outlet
5. Air cushion
6. Drawer containing carbide
7. Water inlet pipe
8. Water

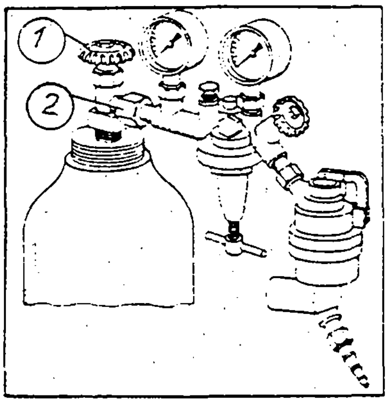
Fig. 51.2 (a)

Gas cylinders

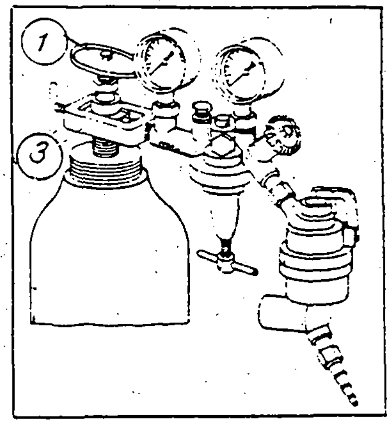
The fuel gas and oxygen are stored in the gas cylinders. In order to be able to store as much gas as possible in one cylinder, they are kept under pressure.

Oxygen:	Pressure: 150 - 200 bar	Acetylene:	Pressure: 15 bar
	Content: 6000 - 10000 l		Content: 6000 l

Regulator for an oxygen cylinder



Regulator for an acetylene cylinder



1. Cylinder valve   2. Threaded connection   3. Clamp connection

Fig. 52.1 (a)

Pressure reduction valve

As the working pressure at the welding torch has to be less than the cylinder pressure, the gases are removed via a pressure reduction valve. The pressure reduction valve reduces the cylinder pressure to an adjustable working pressure at the torch. For oxygen, the working pressures are about 2 - 3 bar and for acetylene 0.2 - 0.7 bar.

1. Cylinder pressure gauge
2. Working pressure gauge
3. Adjusting screw for working pressure
4. Hose valve
5. Dry back-flow pressure valve

(The working pressure gauges indicate pressures above atmospheric pressure)

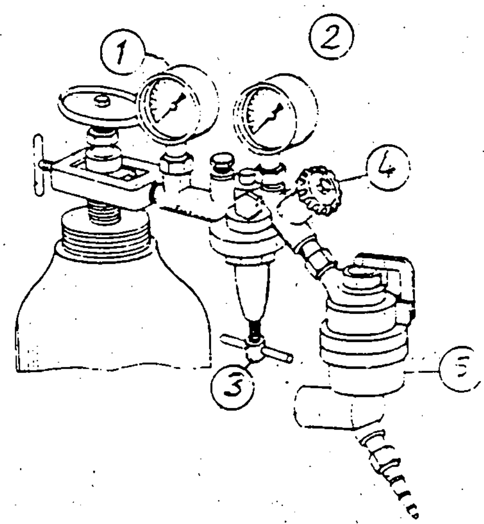


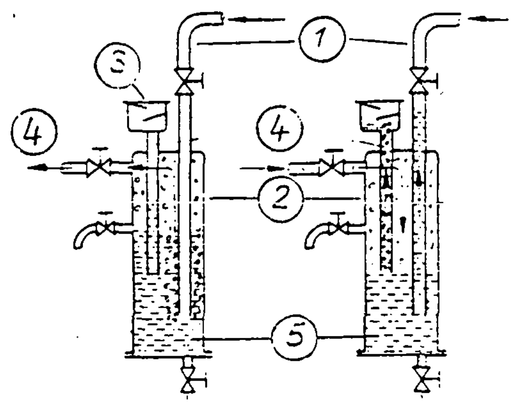
Fig. 52.2 (a)

Safety back-pressure valve

Safety back-pressure valves are installed to reliably prevent all explosions from the torch (flame blow-backs) reaching the acetylene generator or the acetylene cylinder. Moreover, the ingress of oxygen or air is to be prevented. Safety back-pressure valves must therefore be connected in the fuel gas supply at the generator (principal back-pressure-valve) and at each place of work (working back-pressure valve).

A distinction is made between water and dry back-pressure valves.

In the case of the water back pressure valve, low-pressure back-pressure valve, gas enters via a supply pipe below water level. As gas is lighter than the sealing water, it bubbles upwards and collects ready for extraction for use in the gas storage volume. In the event of flame blow-backs, the acetylene gas in the gas-storage volume will burn. The pressure increases and forces water into the supply pipe and into the relief pipe. The water level drops until the lower end of the relief pipe is free enabling the combustion gases to escape into the atmosphere.



1. Gas supply
2. Gas-storage volume or blow-back
3. Relief pipe
4. Gas extraction
5. Water-filled volume

Fig. 53.1 (a)

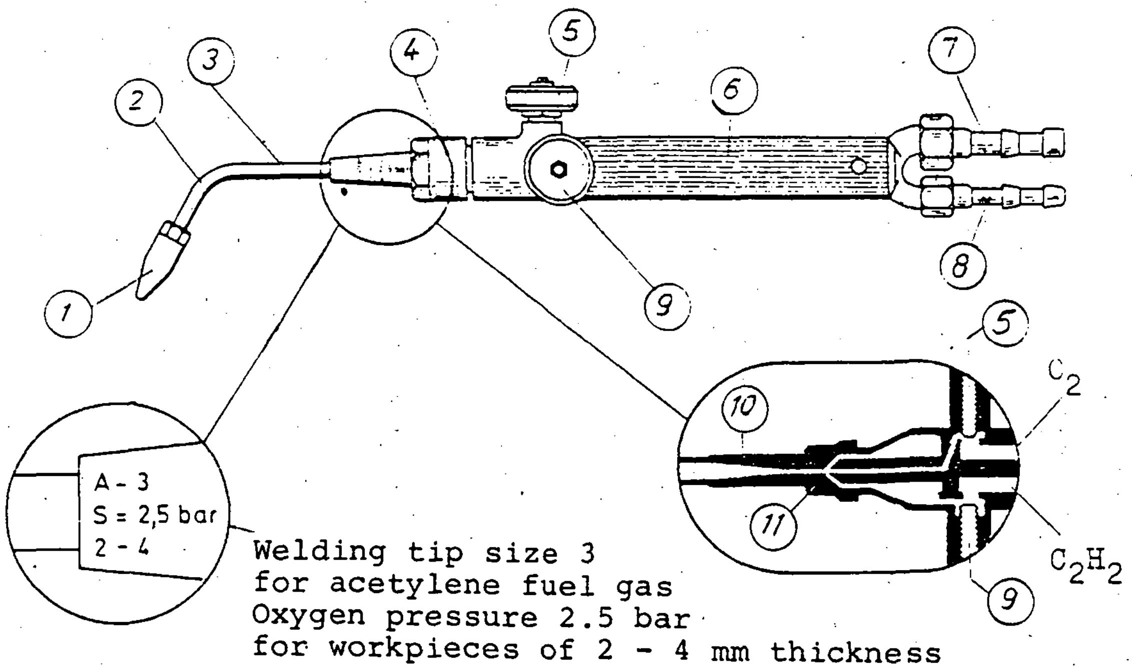
Water back-pressure valves serve no useful purpose if the water content is insufficient. Thus the water level must be checked regularly according to regulations.

Dry back-pressure valves do not have this disadvantage. Flame blow-backs and ingress of oxygen are reliably prevented by means of various filters and valves. Thus today usually dry back-pressure valves are installed at the working place.

Welding torch

The purpose of the welding torch is to heat up workpieces and filler material to melting temperature. For this purpose, the acetylene fuel gas and oxygen are intensively mixed at a certain ratio within the handle of the torch and then burnt at the tip of the torch at high temperature (approx 3200°C).

Welding torch



1. Torch tip (copper nozzle)
2. Welding insert
3. Mixing pipe
4. Union nut
5. Shut-off valve for oxygen
6. Handle
7. Acetylene connection
8. Oxygen connection
9. Shut-off valve for acetylene
10. Mixing nozzle
11. Injector

Fig. 54.1 (a)

In order to attain favourable combustion and thus enable a high welding temperature, acetylene and oxygen must be well mixed together. The intensive mixing of the two gases takes place in the welding torch with the aid of the so-called injector and the mixing nozzle, after first opening the oxygen valve and then the acetylene valve. The principle is as follows:

- The oxygen flowing by at higher pressure (2.5 bar) draws the acetylene under low pressure (0.5 bar) out of the inlet line.
- Both gases swirl together and mix in the mixing nozzle and in the mixing pipe.

When extinguishing the welding torch, first the acetylene valve and then the oxygen valve are closed. This sequence must be kept to, as otherwise blow-back occurs.

Gas hoses

Acetylene and oxygen are supplied to the welding torch via hoses. On account of the differing operating pressures and in order to avoid mix-ups, the hoses have differing dimensions and identification colours. The hoses are made of rubber and reinforced with fabric.

Welding tongs (clamping tongs)
Welding tongs are employed as an aid in order to fix the workpieces in the welding position. Their design corresponds to the shape of the workpieces.

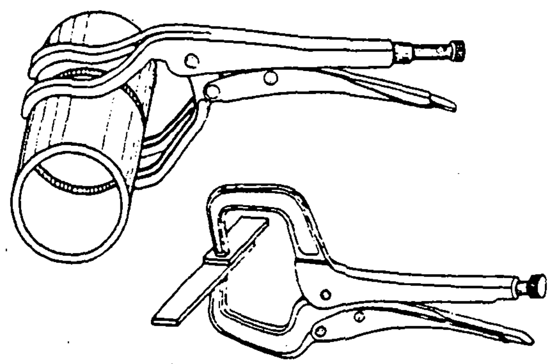


Fig. 55.1 (a)

Welder's clothing

Working with flammable gases and the risks thereby involved require wearing of suitable work clothing. The overalls should be of flame-resistant fabric, in order to prevent their being set alight by red-hot metal and slag spatter. Do not wear plastic clothing.
Included in regulation work clothing are closed safety shoes and appropriate head coverings, usually a protective helmet.

Accident prevention measures:

It is particularly important that the following rules be observed:

- Smoking, naked flames and exposed lights are strictly forbidden in the vicinity of gas generators. Explosion-protected lighting and spark-free tools are regulation.
- Check the water level in the safety back-pressure valve daily. If required replenish the water level to the mark. If there is insufficient water, the device is no use whatsoever and there will be a high risk of explosions.
- If fuel gases escape, explosive gas mixtures will be formed. Thus repair leaks immediately. Never check for leaks with a naked flame. Brush on soapy water.

- Never expose gas cylinders to high temperature. Protect them from the direct rays of the sun.

  There is a risk of explosions in the event of impermissible pressure increase and chemical decomposition of acetylene.
- Prevent the gas cylinders from toppling over, e.g. by attachment at the wall by means of straps or chains or in the cylinder trolley.
- Cylinders must never be used upright unless they are fastened.
- Oxygen cylinders and oxygen regulators (shut-off valves, pressure-reduction valves, fittings) must be kept free of oils and greases, otherwise there is a danger of fire or explosion.
- Oxygen may not be used for blast-cleaning, cooling or ventilation. Although the odourless oxygen does not itself burn, it enhances the combustion of all flammable materials. Thus in addition to a danger of explosions, there is also the risk of severe burns, e.g. due to sudden burning of articles of clothing.
- The gases generated during welding are a health hazard. Ensure ventilation is adequate in welding workshops. If necessary, extract welding gases by fans.
- In the event of inadequate sealing between handle and welding tip, as well as if the mixing ratio between oxygen and acetylene is incorrect, flame blow-backs can occur in the torch which can continue into the hose and up to the gas cylinder, with a resultant danger of explosion.

In the event of flame blow-backs in the torch act immediately:

- Close the acetylene valve and the oxygen valve at the torch.
- If appropriate, also close the valves at the gas cylinders.
- Allow the hot welding torch to cool down. Check for correct functioning before using it again. If necessary, dismantle the torch and clean it.
- Have your working clothing cleaned regularly. Even flame-resistant overalls become flammable if contaminated with oil.

16.2 Arc welding

In arc welding, the melting heat required at the point of welding is generated by an electric arc between welding electrode and the workpiece. Thereby temperatures of about 4000°C are reached in the electric arc. Arc welding can be performed manually or with welding machines. A special form of arc welding is welding with shielding gases (inert-gas arc welding).

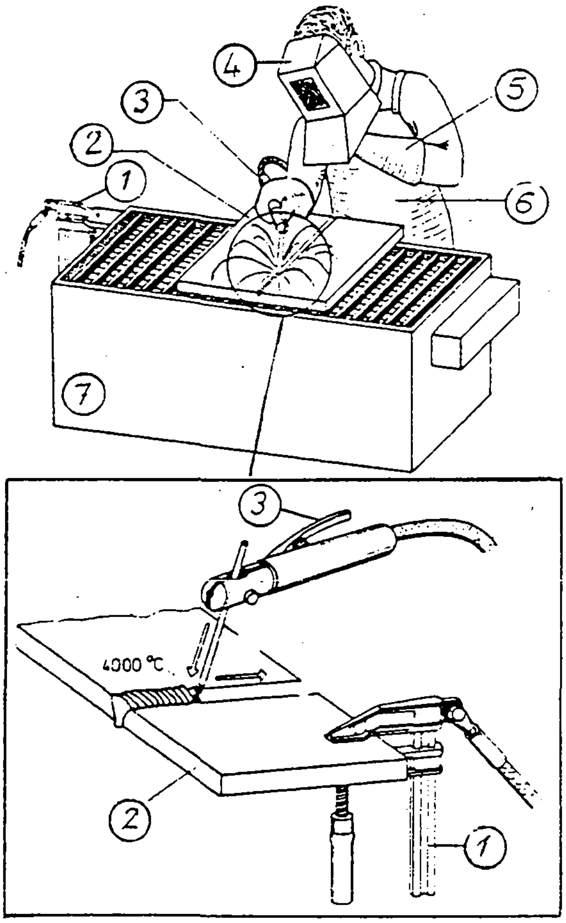
Manual arc welding

When performing arc welding manually, the welding electrode is guided by hand along the weld with the aid of the electrode holder.

The necessary welding temperature for melting the workpieces is generated by an arc between the tip of the electrode and the workpiece.

The high arc temperature of about 4000°C is generated by the flow of a heavy electrical current of 50 - 300 ampere (A).

This welding current cannot be taken directly from the lighting or power mains system, as the voltage of 220 or 380 is much too high and is thus a hazard to life. In order to attain a safe voltage of 20 to 40 V, the welding current must be generated in special electrical machines. For welding, AC or DC power supplies may be used.



1. Earthing clamp
2. Workpiece
3. Electrode holder
4. Guard
5. Protective gloves
6. Leather apron
7. Welding table with grating and fume extraction from underneath

Fig. 57.1 (a)

Workpiece and electrode holder are connected to the two poles of the welding machine. When striking the arc, the electrode must momentarily touch the workpiece. Upon lifting the electrode, an arc is generated which bridges the air gap. Within the vicinity of the arc, the material of the workpiece and the electrode become molten due to the high temperature. Thereby drops fall from the electrode and fill up the welding joint.

Sources of welding current

The welding transformer

reduces the mains voltage whilst the current is correspondingly increased. Essentially, the tranformer consists of a laminated core with two windings; the iron core supports a thin primary winding for the mains current and a thick secondary winding for the welding current. Transformers supply AC. They are suitable for welding unalloyed steels.

The welding rectifier

consists of a transformer which transforms the mains voltage followed by a rectifier set which permits current to flow only in one direction. The device thus supplies DC. Thus both unalloyed and alloyed steels can be welded.

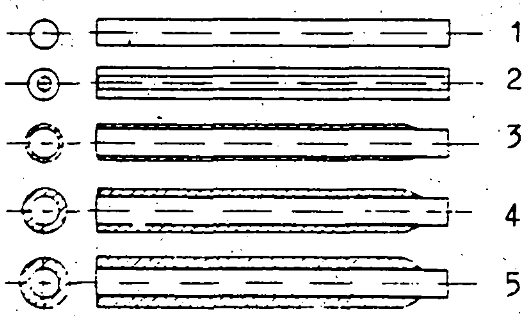
The rotary welding apparatus

consists of a current generator driven by a motor. This is either a 3-phase AC electric motor or a petrol or diesel engine (site generating set). The rotary welding apparatus supplies DC.

Filler material - welding electrode

During welding, the workpieces are connected at the point of welding by molten material. As a rule, filler material is necessary in order to fill up the welding joint. In arc welding, the welding electrode also serves as filler material, as the electrode fills up the welding joint as it melts.

Due to the high arc temperature of over 4000°C, there is a risk of the liquid material burning under the influence of atmospheric oxygen. For this reason, welding electrodes are coated with other materials.



1 = Bare wire electrode "o"
2 = Cored electrode "oo"
3 = Thinly-coated "d"
4 = Medium-coated "m"
5 = Very-heavily coated "s"

Fig. 58.1 (a)

During welding, the coating melts and vaporizes.

This has the following advantages:

- Atmospheric oxygen is kept clear of the liquid welding pool by a gas envelope, thus preventing oxidation.
- The hot gas envelope ensures a stable arc and thus produces conditions for satisfactory welding.
- The slag floating on the molten pool protects the liquid material against oxidation.

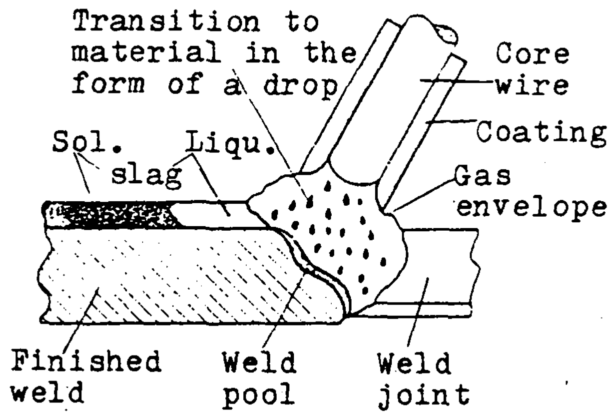


Fig. 59.1 (a)

- Solidified slag on the completed weld ensures that cooling takes place only slowly. Internal welding strains are thus reduced.

Designation of welding electrodes is standardized (DIN 1913). The coded designation of the electrodes and the data on the packaging give information on the welding procedure.

Example of a standard designation:

"Rod electrode E 51 3 2 RR 11 200 - ϕ 4 x 450 Lg"

E 51 3 2 RR 11 200- ϕ 4 x 450 Lg

- ϕ 4 x 450 Lg — Electrode dimensions:
  - Core wire diameter 4 mm
  - Core wire length 450 mm
- 200 — Yield: 200%
- 11 — Electrode class: 11
  - States from which tables applications, welding position and suitable current can be taken
- RR — Coating: RR rutile coated, heavy
- 2 — Id. no. for enhanced notch impact resistance as per table
- 3 — Id. no. for strain and notch impact resistance, which can be read from tables
- 51 — Tensile strength: 510 - 650 N/mm^2 yield limit = 380 N/mm^2
- E — code for the welding process, in this case arc welding

On the original packing usually the type of current, the recommended polarity (i.e. whether the electrode should be connected to the plus or the minus pole of the rectifier source) as well as approximate values on the current to be set are stated.

Selection of the electrode depends on the following influence parameters:

Core wire

- The material of the core wire should correspond to that of the workpieces to be welded.
- The diameter of the core wire depends on the thickness of the workpieces to be welded. The thicker the workpieces, the thicker the electrode.

Coating:

Composition and thickness of the electrode coating influence:

- the workpiece transition from the electrode to the workpiece,
- the capacity to bridge the welding gap, so that the molten material does not run out of the welding joint,
- the appearance of the finished weld,
- the fusion depth of the filler material into the material of the workpiece.

As correct selection of welding electrodes is very difficult, the recommendations of the electrode manufactures should be followed.

Accident prevention measures

During electric-arc welding, the welder must protect himself and his surroundings from the injurious effects of light and ultra-violet radiation. The welding places must therefore be reliably screened off by non-flammable protective partitions.

Prior to commencing welding, the welder must check that all welding lines (cables) are in good order. Any damaged cables should immediately be repaired by the electrician responsible. Any negligence in this respect is a danger to life.

Defects in the insulation of the electrode holder could result in dangerous electric shocks. Replace holder immediately.

Never carry out welding work without protective glasses or protective visor. Dazzling of the eyes can result in severe injuries. For electric-arc welding, a darker glass must be chosen as current is increased. In order to protect against ultraviolet light and flying metal and slag particles, always wear protective gloves and leather apron.

When welding in enclosed spaces, ensure adequate extraction of gases and vapours and provide a sufficient supply of fresh air.

During interruption of welding, as a rule, the welding current generator will be kept switched on. In this condition of no loading, the voltage between the pole clamps, that is between the connected workpiece and the electrode holder, could be lethal.

In the order to prevent possibly lethal electric shocks, the welder must therefore never complete the circuit by touching the material and non-insulated parts of the electrode simultaneously.

From this there result the following rules which must be observed for preservation of health and life:

- Use only regulation, undamaged welding cables.
- There must be no damage to the insulation of the electrode holder. Immediately replace defective welding tongs.
- Always grasp the electrode holder with leather gloves.
- When interrupting welding, never keep the electrode holder under your arm. There is a danger of electric shock due to moisture. Use the bracket for hanging the torch.
- Arc welding in rain and if the workpieces are wet is a danger to life.
- During welding, never place parts on the metal or wet surfaces without using wood or rubber insulation.
- When welding inside containers, more stringent safety regulations of the Trades Associations apply. This work may therefore only be performed by welders who have been specially trained.

16.3 Inert-gas arc welding

When performing arc welding manually, the point of welding is protected by an envelope of gas against oxidation due to atmospheric oxygen. This gas envelope is generated by evaporation of components in the electrode coating.
In inert-gas arc welding, the welding electrode is not coated.
In order to prevent oxidation of the molten weld pool in this case, a shielding gas is supplied directly at the point of welding. In contrast to air, shielding gases do not form damaging compounds at the point of weld. The gas envelope of the shielding gas thus protects the point of welding by preventing it from contact with air. As shielding gases, the inert gases argon and helium are used, in addition to gas mixtures which contain, among other gases, carbon dioxide CO_2. In order to supply the inert gas sparingly to the point of welding, electrode holders of special design are used. According to the inert gas and type of electrode, a distinction is made between various processes.
Due to the high temperature rise, the electrode holder is cooled using water.

TIG process
(Tungsten Inert Gas process)
The electrode consists of the heat-resistant metal tungsten (melting point 3380°C). Argon is used as the shielding gas.
The filler material is supplied in the form of non-coated welding rods.

1. Argon supply
2. Tungsten electrode
3. Electric arc
4. Direction of welding
5. Welding pool
6. Joint
7. Inert gas envelope
8. Filler material

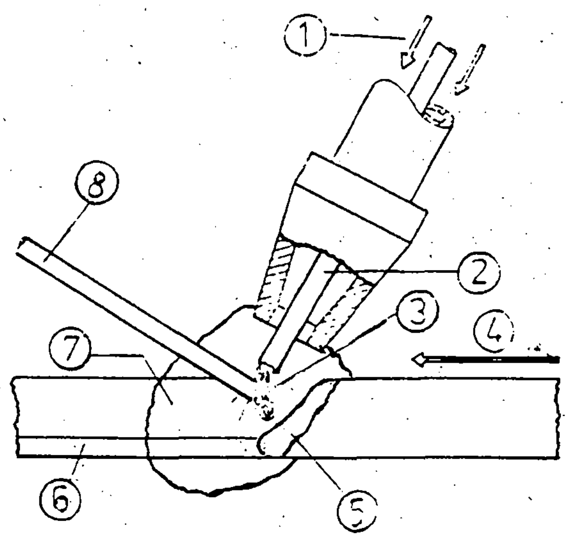


Fig. 62.1 (a)

MIG process (Metal Inert Gas process)

A non-coated welding wire, which is fed automatically through the welding gun (electrode holder), serves as electrode and filler material.
A mixture of helium and argon gases serves as shielding gas.

This process has the advantage that only one hand is required for welding.

The inert gases used in inert-gas arc welding are very costly. For this reason, it is only employed if normal arc welding cannot be used. Thus it is usually metals which cannot be welded easily, such as high-alloy steels (e.g. stainless steel), aluminium, copper and titanium which are welded under an inert gas shield.

1. Welding wire
2. Inert gas
3. Cooling water
4. Electric arc
5. Direction of welding
6. Welding joint
7. Welding pool
8. Protective gas envelope

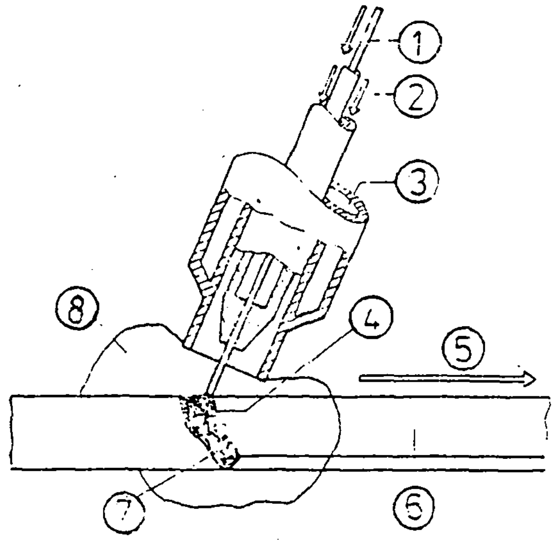


Fig. 63.1 (a)

17. Soldering and brazing

In soldering or brazing, the same or different metals are joined to each other by a metal alloy which readily melts - referred to as solder in the soldering process - under the influence of heat. The welding point of the solder or brazing material is thereby always much lower than the melting point of the metals to be joined.

1. Soldering iron
2. Workpiece
3. Solder

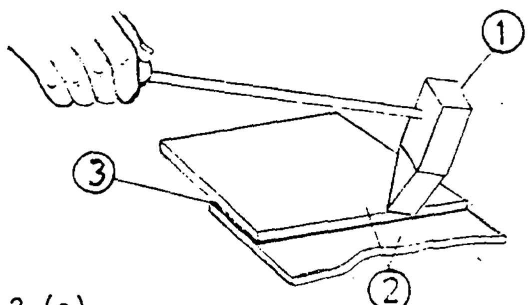


Fig. 63.2 (a)

The metallic parts to be joined are heated together to the prescribed soldering temperature. The soldering temperature depends on the solder used. The source of heat is, according to the soldering process, the soldering iron, the soldering torch or the welding torch.

Upon reaching the soldering temperature (working temperature), the solder melts and fills up the narrow space - soldering gap - between the two workpieces. By the addition of a so-called "flux", the workpiece surfaces at the place of join become metallically blank, which helps the solder to flow into the solder gap.

The solder and the parts to be joined form an alloy at the surface, the strength of which is greater than that of the solder. After the soldering point has cooled down, the solder solidifies. The workpieces remain rigidly joined.

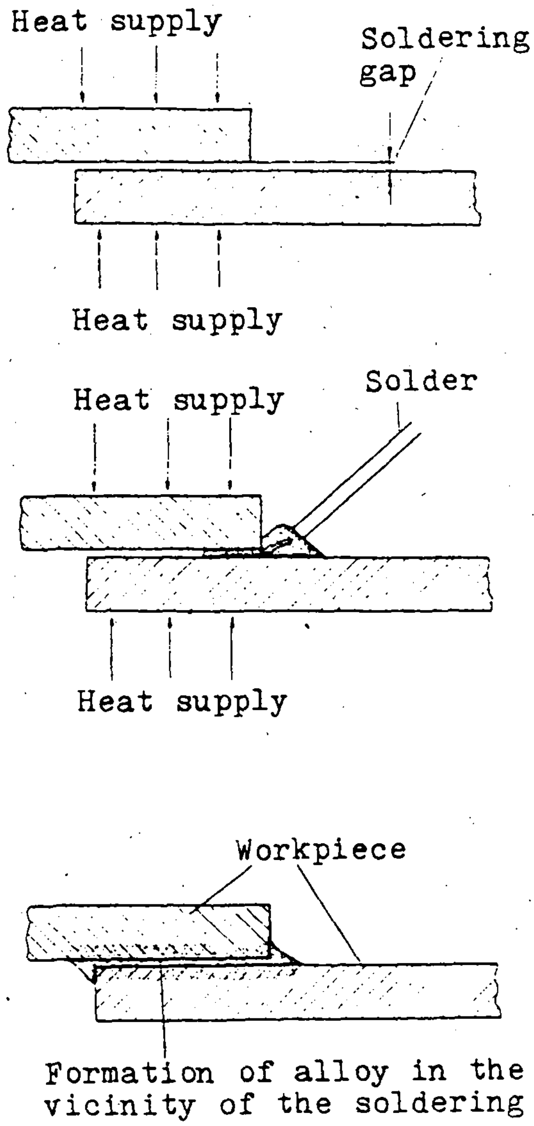


Fig. 64.1 (a)

Correctly-performed soldered joints are durable, resistant to corrosion, leak-tight and inconspicuous, whilst at the same time having a high strength.

Soldering and brazing processes

According to the melting point of the solder, the following processes can be differentiated:
Melting temperature of the solder below 330°C
Types of solder: Tin-lead solder (tin solder), aluminium soft solder, special solders (with cadmium and bismuth)

Revised:

Application: For low-strength soldered connections, e.g. on parts of tin, zinc, lead, copper, brass, red brass, bronze, soft steel, aluminium and aluminium alloys with special soft solder.

Silver soldering and brazing:

Welding temperatures of the joining metal greater than 500°C

Types of solder: silver solder, spelter (brazing)

Applications: For high-strength joints, e.g. on parts of steel, cast steel, malleable cast iron, in some cases, grey cast iron, brass, copper, nickel, carbides, aluminium and its alloys (with special solders).

Soldering tools - auxiliary materials

Soft soldering requires only a few specialized tools.

Hatchet-type soldering irons of copper must be heated up in a gas flame or forging furnace.

1. Handle
2. Soldering iron

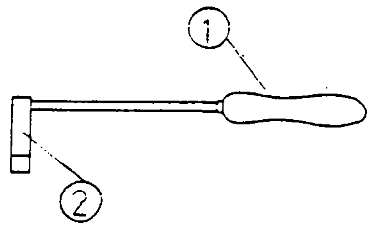


Fig. 65.1 (a)

Petrol soldering irons have an intergral heat source (pertrol - compressed-air torch).

1. Soldering iron
2. Torch
3. Setting screw
4. Petrol tank
5. Air pump
6. Pre-heating shell

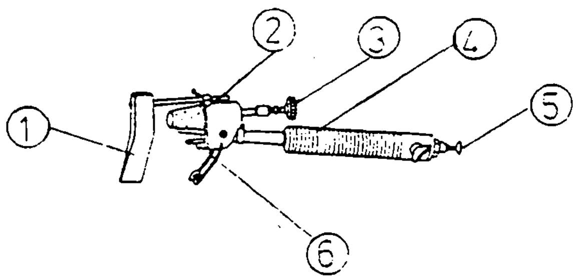


Fig. 65.2 (a)

Propane soldering torches produce a high rate of heating and are therefore suitable for large-area soft-soldering work in addition to smaller brazing tasks.

1. Soldering iron
2. Torch
3. Handle
4. Setting valve
5. Shut-off valve
6. Propane gas cylinder
7. Gase hose

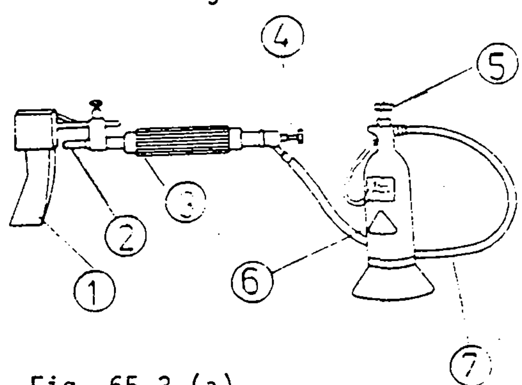


Fig. 65.3 (a)

Electrical soldering irons are heated up by an electrical heating element.

1. Heating head
2. Soldering tip
3. Handle
3. Electrical lead

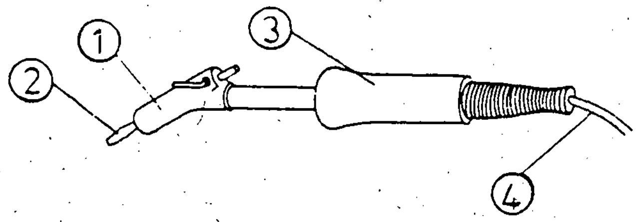


Fig. 66.1 (a)

Soldering lamps (blow torches) are only required for large soldering tasks. They can to some extent be used for brazing work.
Heat source: Petrol/compressed-air torch.

1. Torch
2. Setting screw
3. Air pump
4. Handle
5. Petrol tank
6. Pre-heating shell

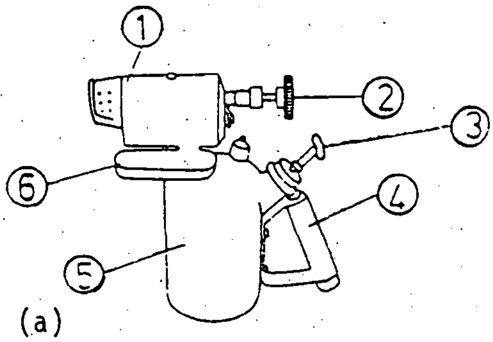


Fig. 66.2 (a)

Mains gas or acetylene torches, in which compressed air or oxygen is mixed with the gas, are used only for brazing work. They differ only in unimportant details from conventional welding torches.

1. Mixture setting screws
2. Handle
3. Gas supply (hose connections)
4. Torch tip

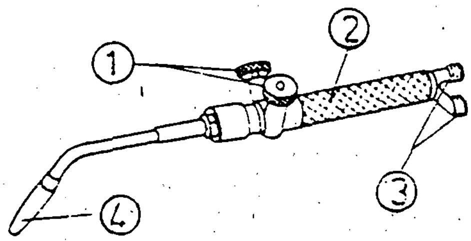


Fig. 66.3 (a)

Solders (see Module 2.1)

Capillary solder joints

An important application of flame soldering is installation of copper pipes. For capillary solder joints as per DIN 1786, and special fittings, copper pipes are required. The parts fit together exactly with allowance for the soldering gap. The square-cut pipe end is deburred. Then the outside of

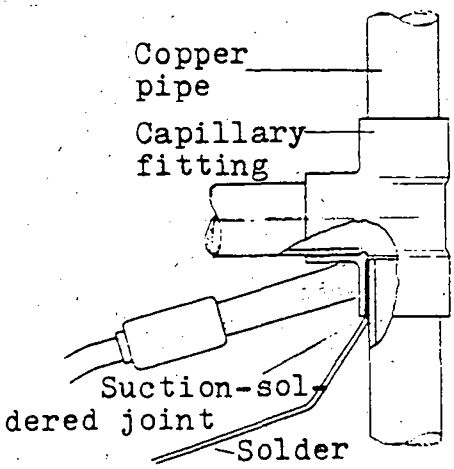


Fig. 66.4 (b)

the pipe end and the inside of the soldering socket are rubbed metallically blank with steel wool. Soldering grease is then applied to the pipe end. The pipe is inserted into the soldering socket and warmed all over with the torch flame, which is not applied directly, until the soldering rod - held at the edge of the fitting - melts. Solder is drawn into the soldering gap by capillary action.

Accident prevention meeasures:

- Soldering solution contains hydrochloric acid, which attacks the eyes, skin and clothes. Take care when handling this flux.
- Put down hot soldering irons such that there is no danger of accidents or fires. Use fire-resistant surfaces.
- Top up petrol soldering torches only when they are cold. Topping up in the vicinity of naked flames or red-hot objects is dangerous, due to the risk of explosions.

After topping up, securely tighten the screw plug of the petrol container. Carefully wipe away any spilt fuel.

- For those soldering devices with a naked flame, take care that hair and clothes are not set alight.
- During brazing, acetylene, propane and natural gas are used as combustion gases. These gases are highly explosive at certain mixture ratios with air. Thus when brazing, the same working regulations and safety measures have to be observed as for gas welding (see Section entitled "Welding").

18. Flame cutting

At the welding torch, first of all, a normal welding flame is produced, the flame cone of which is used to heat up the workpiece at the point of parting until it glows. As soon as the material at the starting point of the cut glows yellow, the cutting oxygen is released and can emerge at high pressure from the cutting nozzle. Thereby the steel at the kerf burns to form iron oxide. The combustion residues are blown clear from the kerf.

Principal areas of application:

- Cutting out components of heavy plate steel,
- Preparation of welds,
- Scrapping steel structures (e.g ships).

1. Cutting oxygen valve
2. Fuel gas and heating oxygen valves
3. Wheel nozzle guide
4. Nozzle
5. Kerf
6. Burnt steel
7. Workpiece

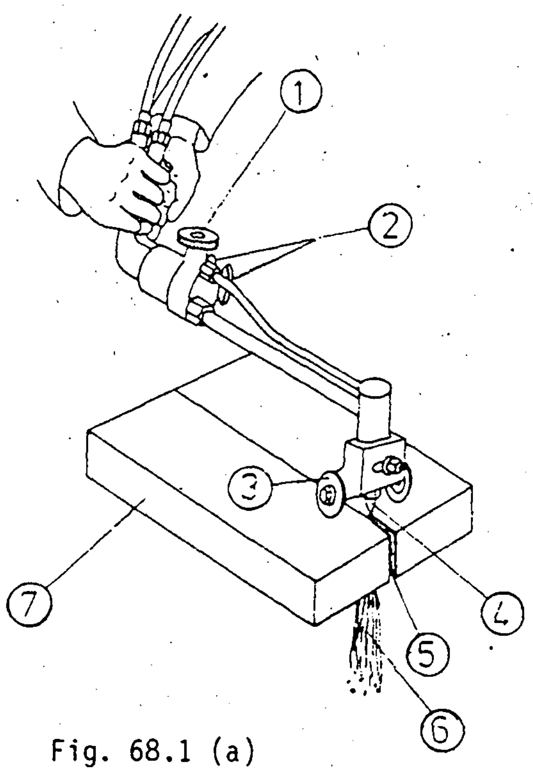


Fig. 68.1 (a)

Tools and equipment used in flame cutting - auxiliary materials

Hand-held torch

In principle, the cutting torch has the same design as an injector welding torch. It thus has a mixing system for mixing fuel gas and oxygen. This mixture is ignited at a ring-shaped heating nozzle and set in the same way as for the welding torch.

The cutting torch has an additional oxygen supply line. Using a quick-acting valve, the cutting oxygen can be released via the cutting nozzle which is positioned in the middle of the ring nozzle.

1. Tip with cutting and heating nozzle
2. Cutter head
3. Cutting oxygen pipe
4. Cutting oxygen valve
5. Preheating oxygen valve
6. Handle
7. Oxygen connection
8. Fuel gas connection
9. Fuel gas valve
10. Wheel nozzle guide
11. Mixing tube

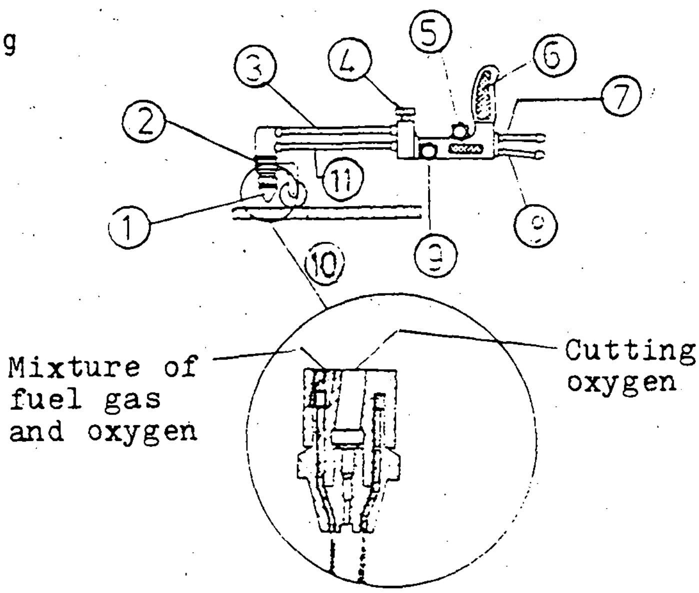


Fig. 68.2 (a)

Flame cutting accessories

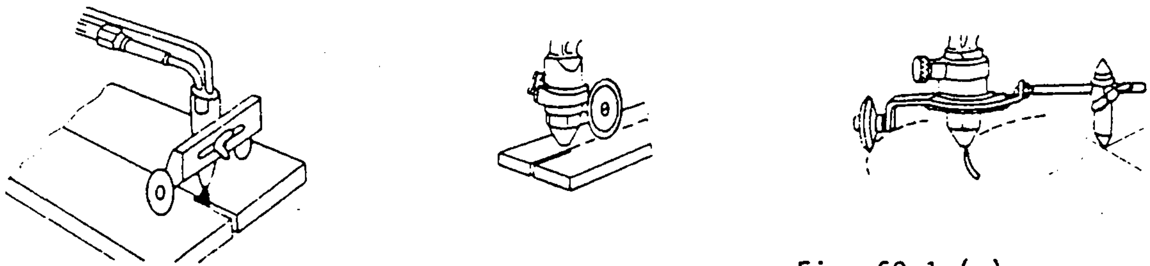


Fig. 69.1 (a)

Wheel nozzle guide for keeping the cutting torch at a constant clearance from the workpiece

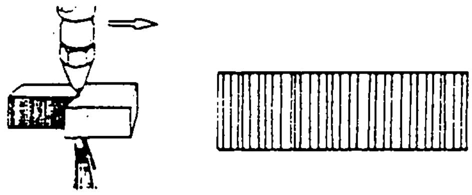
Torch guide wheel for guiding the torch along marking-out lines

Trammels for flame cutting circular workpieces

Torch travel rate

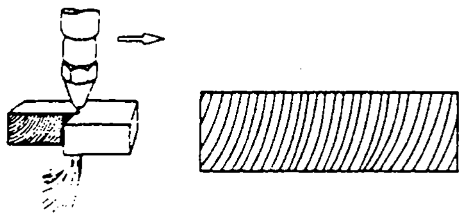
The torch must be guided at a uniform speed corresponding to the plate thickness

Correct torch speed
(straight cutting lines)



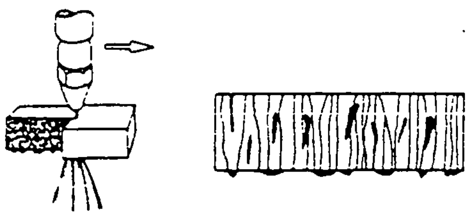
Correct

Torch speed too fast
(curved cutting lines)



Too fast

Torch speed too slow
(exit side of the torch jet melted and burnt)



Too slow

Fig. 69.2 (a)

Accident prevention measures:

- When flame cutting, the accident prevention regulations for handling gases must be observed (see Section on "Gas welding").
- During flame cutting, red-hot slag and metal particles are blown at high speed out of the kerf.

Avoid fire hazard by using fireproof surfaces, e.g. catch trays, steel plates, or sand.

- For inclined and horizontal flame cuts, the red-hot parts may fly a few metres through the air. Protect other workers in the vicinity by setting up guard partitions.
- When flame cutting, it is particularly important that fire-resistant clothing be worn. Wear protective glasses similar to those used when gas welding.

19. Turning

Chip-removal machining by turning is one of the most important manufacturing processes. By means of turning, it is possible to produce workpieces whose cross-sections are mostly circular. The workpiece held in a clamping device is made to rotate by the machine. An appropriate tool - the turning tool - is moved against the workpiece as it rotates and cuts off chips of material.

1. Clamping device (chuck)
2. Workpiece (rotating part)
3. Chip
4. Tool (turning tool)
5. Clamping device (tailstock)

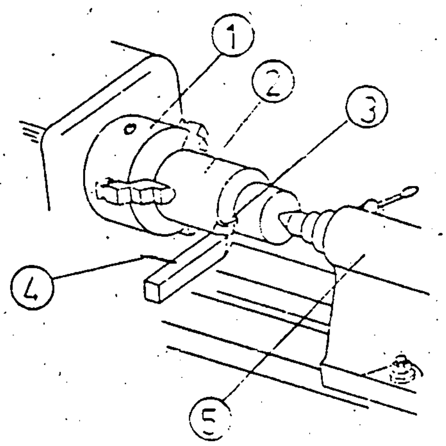


Fig. 70.1 (a)

The various shapes of turned parts are produced by different turning operations. According to whether the parts are machined internally or externally, turning can be termed external or internal. In general, the turning tool is set to the level of the centres, using the tailstock centre as a guide. It is important to set the tool precisely to centre when machining small-diameter workpieces, when recessing, thread-cutting and form-turning.
In the table below, the various turning operations with the corresponding turning tools are shown.

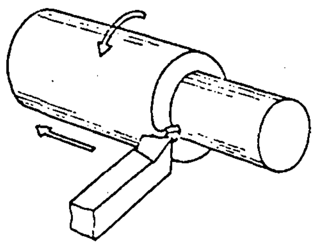
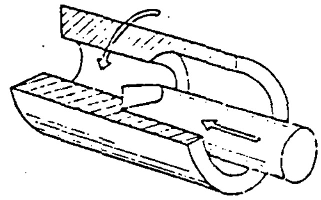
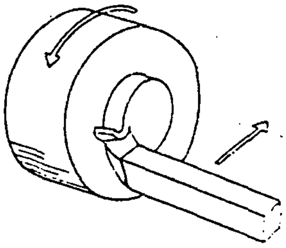
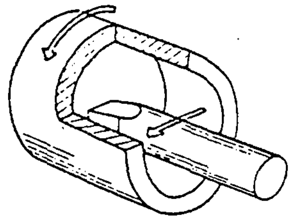
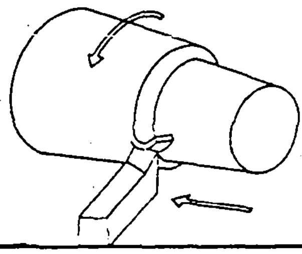
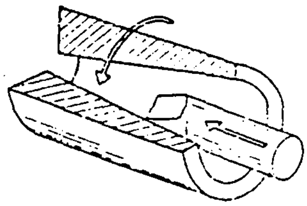
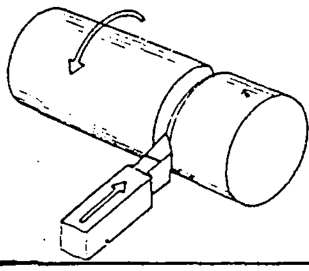
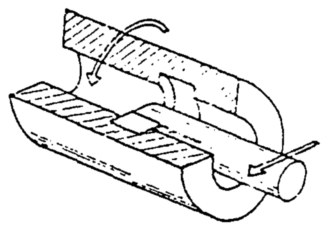
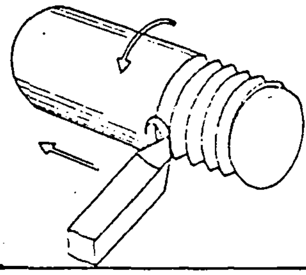
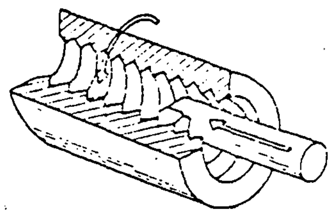
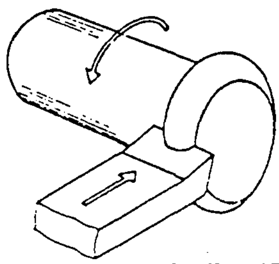
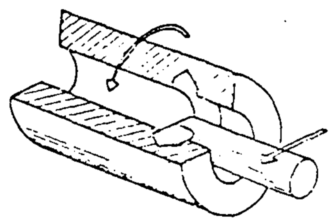
	External turning	Internal turning
Plain or cylin-drical turnig		
Surfacing or face turning		
Taper turning		
Recessing or grooving		
Thread cutting		
Profile turning		

Fig. 71.1 (a)

It is also possible, to perform other manufacturing operations, such as drilling, cuontersinking, counterboring, reaming, and thread cutting with taps and dies.

For turning work which often recurs, a variety of turning tool forms, cutting tips and cutting materials have been developed. Important types have been compiled by ISO (International Standards Organization).

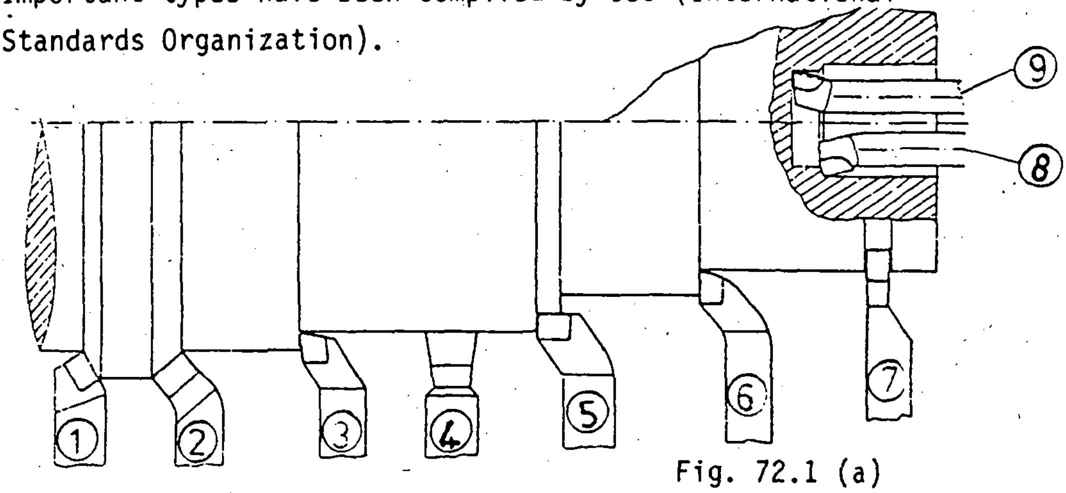


Fig. 72.1 (a)

1. Straight turning tool, left-hand ISO 1 DIN 4971
2. Cranked turning tool, right-hand ISO 2 DIN 4972
3. Offset square nose turning tool, right-hand ISO 3 DIN 4978
4. Wide finishing tool ISO 4 DIN 4976
5. Offset facing tool, right-hand ISO 5 DIN 4977
6. Offset knife or side tool ISO 6 DIN 4980
7. Parting or recessing tool, right-hand ISO 7 DIN 4981
8. Boring tool, right-hand ISO 8 DIN 4973
9. Square nose boring tool ISO 9 DIN 4974

Materials for turning tools (cutting edge materials)

Their performance depends mainly on the material selected for the cutting edge

Cutting edge material	Properties	Cutting speed for steel
High speed steels	Hard and tough, cutting temperature up to 600°C, less expensive than carbides	30 - 60 m/min
Carbides	Very hard, but impact-sensitive, cutting temp. up to 900°C	40 - 200 m/min

For cutting speed calculation, refer to Module 01, Page 28.

Turning tool angles
As for all metal-removal tools, the general principles of cutting-edge geometry apply.

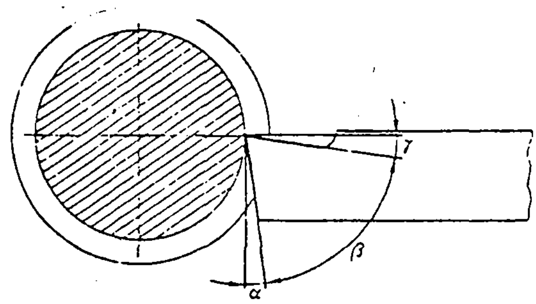


Fig. 73.1 (a)

Approximate values for turning tool angles

Materials machined	High-speed steels			Carbides		
	α	β	γ	α	β	γ
Soft steel	8°	64°	18°	5°	75°	10°
Alloy steel	8°	74°	8°	5°	75°	10°
Grey cast iron	8°	82°	0°	5°	85°	0°
Non-ferrous metals	6°	82°	2°	5°	75°	10°
Light metals	10°	40°	40°	10°	60°	20°
Plastics	12°	66°	12°	12°	66°	12°

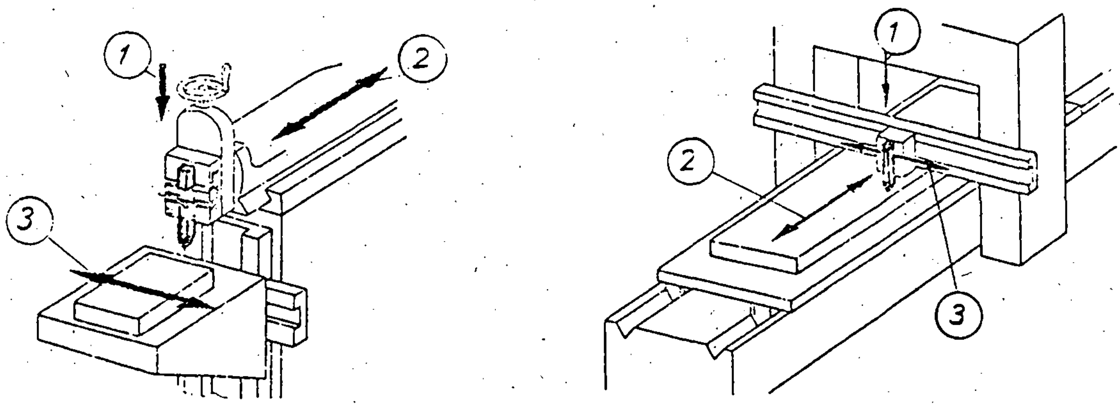
Table 73.1

20. Planing - shaping

Planing and shaping are processes related to turning. This is made clear by comparing planing and shaping tools with turning tools. Any turning tool can also be used as a planing or shaping tool.

The processes differ from turning in that the cutting motion is linear. If the cutting motion is executed by the tool (shaping and slotting machines), then the process is termed shaping or slotting (Fig. 74.1). In planing (planing machine), the workpiec which is clamped to the planer table, executes the cutting motion, whereas feed and depth-of-cut motion are executed by the tool.

(Fig. 74.2).



1. Depth-of cut motion 2. Cutting motion 3. Feed

Fig. 74.1 Shaping (f) Fig. 74.2 Planing (f)

The metal removal process at the cutting edge is similar to turning, and thus the same principles apply.

The cutting speed for these operations is limited as each working stroke of the tool (shaping) or of the workpiece (planing) has to be followed by a return stroke to the starting position. Thereby, the masses to be accelerated at the start of each stroke and to be braked at the end may be considerable. Moveover the tool has only one cutting edge, in contrast to the milling cutter.

Planing and shaping will be economic if it is possible to machine many parts of the same shape arranged in a row or long workpieces on the planing machine. Using the shaper, simple and cheap tools con be employed to produce a wide variety of shapes. They are therefore particularly suitable for use in repair shops and for one-off manufacture.

When clamping the workpieces, ensure that their longitudinal axis is along the direction of cutting, in order to limit the non-machining time during approach and overrun.

Planing wood

By means of planing, smooth and flat wooden surfaces are obtained.

The principle parts of the plane are the stock (usually of wood, or rarely of metal) and the blade (possibly with a back or cap iron). The blade is clamped with a wedge (or an adjustment screw for metal stocks).

1. Horn 2. Shavings outlet
3. Wedge support 4. Wedge
5. Blade with back iron
6. Hand protector 7. Striker
8. Stock 9. Sole 10. Mouth

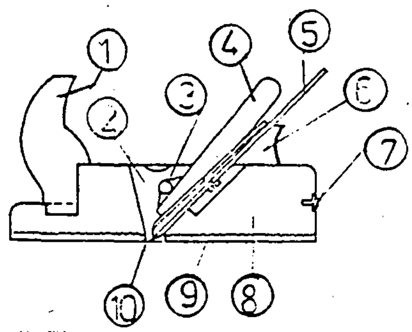


Fig. 75.1 (g) Plane with back iron (section)

1. Wedge 2. Blade
3. Stock 4. Sole
5. Shavings outlet

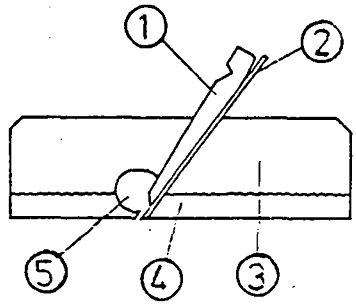


Fig. 75.2 (g) Sims plane (section)

Principle of operation of the plane

The plane's principle of operation is based on the one-sided wedge shape of the cutting edge of the iron, the working position (cutting angle) of the iron in the stock and the shape or design of the stock. The essential difference between planing and using an adze is that the shaving does not tear into the wood in the direction of the grain, but is continuously broken by the pressure of the stock on the wood. Thus the splitting action of the plane is transformed into a continuous cutting action.

As the cutting angle increases, the cutting action of the plane decreases and is transformed to a scraping action, i.e. the shaving breaks off earlier, causing the resistance during planing to increase.

Also affecting the plane's operation are the throat and the depth of penetration of the cutting edge (= projection of the cutting edge from the sole). If the throat is too wide, the shaving breaks too late, it will push the plane upwards and digs in. Excessive penetration depth of the cutting edge also causes ripping up of the wood.

21. Milling

Milling is a metal-cutting process with a cutting edge of geometrically-defined shape for the production of plane and curved surfaces, grooves, helical grooves and threads. Whereas during turning the rotary cutting motion is executed by the workpiece, in milling the tool rotates.

Milling machines

Vertical milling machine
This machine is employed mainly for face milling. The cutter spindle is mounted vertically in the milling head. This can be swivelled, thus enabling the spindle to be inclined. The cutter and feed drives are the same as for the shaping machine.

1. Milling head
2. Milling table
3. Column

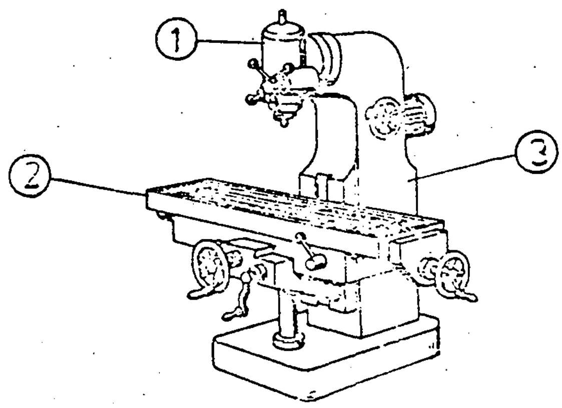


Fig. 76.1 (f)

Horizontal milling machine

1. Cutter spindle
2. Milling table
3. Column

This machine is suitable for general milling tasks. Its characteristic feature is the horizontally-mounted cutter spindle.

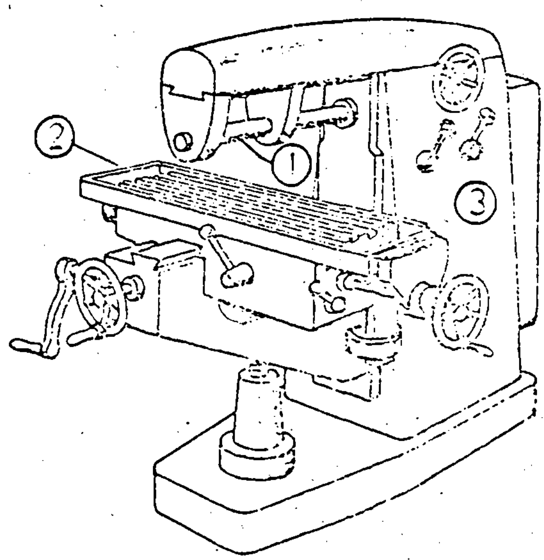


Fig. 76.2 (f)

The most common milling cutters with application examples for metal.

1. Plain milling cutter
2. Shell end mill
3. Side and face milling cutter
4. Vee-form cutter
5. Dovetail cutter
6. Form side and face milling cutter
7. Inserted-tooth cutter
8. Circular saw
9. End mill
10. Slotting end mill cutter
11. Keyway-cutter for Woodruff keys
12. T-groove cutter

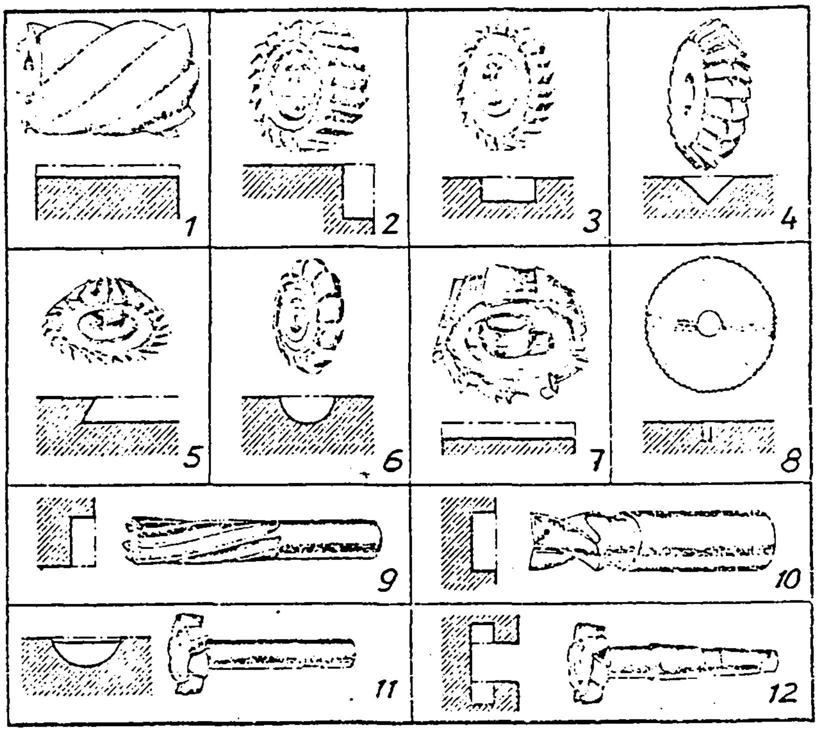


Fig. 77.1 (k)

Clamping workpieces

Workpieces must be clamped rigidly and securely, as dimensional accuracy and cleanness of working in addition to operational safety depend on this. If the workpiece is not securely clamped, it may be thrown out of the fixture by the force of the cutter. If incorrect tightening of the clamping screws causes the workpieces to distort, they will spring back upon slackening the clamps. The machined surface does not have the required geometry and location with respect to the other surfaces. For workpieces which disort under heavy cuts, it is therefore recommended that the clamping screws be slackened prior to taking the finishing cut and only retightened as much as necessary.

For horizontal milling machines, the machine vice is used most frequently for clamping workpieces. The size and shape of the clamping jaws or the profiles of the guides may vary. One clamping jaw can be fixed, and the other movable, or both may be movable. Additionally, the upper part of the vice may be located so as to swivel in a guide on the lower part, to be then secured with clamping screws in any desired position.

22. Grinding

Grinding is a metal-removing production operation in which a tool with many cutting edges is used, whose number, cutting geometry and location in the tool are not defined.

From the many grinding processes, a brief description of grinding by hand will be given.

The grinding process:
Many small, sharp-edged abrasive grains project from the surface of a grinding wheel. These act as cutting edges. The abrasive is scraped along the surface of the workpiece (or vice-versa) at a moderate contact pressure. During grinding, the cutting edges wear down and become dulled: they then have to be pressed on harder. When the contact pressure exceeds the strength of the bond, the abrasive grains break away and new, keen-edged grains appear.
When grinding by hand, the contact pressure can be modified as required. If the contact pressure is too high, the workpiece may become annealed.

1. Bond
2. Sharp cutting edges
3. Contact pressure
4. Rest
5. Grindings

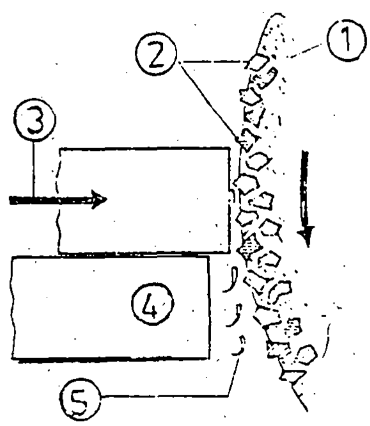


Fig. 78.1 (1) Swarf formation during grinding

Abrasive
Abrasives are manufactured to various grain sizes or grits.

Coarse grits have a high metal-removal rate, but produce a rough surface (for roughing work)
Fine grits have a low metal-removal rate, but produce a high-quality surface finish (for grinding harder materials, and particularly suitable for finishing work).

Forms of abrasive

Emery paper, abrasive cloth and grinding belts are inexpensive grinding aids which are easy to handle for grinding offhand. They serve to clean and grind surfaces metallically blank and are available to all grits. The bond is selected for the intended purpose: for fine-work (wet grinding) water-resistant abrasives are necessary. High metal-removal rates are achieved with grinding belts with synthetic resin bonds.

Grindstones of sandstone occur naturally and are used for wet sharpening of fine tools. Oil stone serves to sharpen fine cutting edges.

Grinding wheels: In the first instance, their shape depends on whether the edge or the face is to be used for grinding. Straight grinding wheels are only used at their periphery, except for sharpening work. With cup wheels, work is performed only on the face. Cup wheels of large diameter and broad grinding surfaces for high metal-removal rates are in the form of segmental wheels.

Grinding points are clamped into high-speed hand grinders or flexible shafts and are suitable for working inaccessible surfaces.

Hand-grinding devices

These devices, which are driven by a mobile electric motor via a flexible shaft, are suitable for fitting work.
Special devices enable high-speed grinding with synthetic resin wheels up to 100 m/s. These self-supporting synthetic wheels perform about 3 times as well as standard grinding wheels and are used particularly for fettling welds, parting of small components etc.
Using flexible rubber-bonded grinding wheels and bakelite-bonded vulcanised fibre wheels, flat and curved surfaces can be ground.

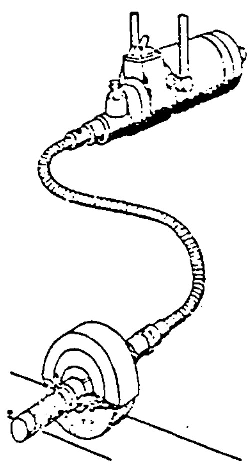


Fig. 79.1 (m) Grinder with flexible shaft

Angle grinders

The universal angle grinder serves for parting and grinding as well as for removing rust from steel and castings. Their high drive power of about 1 kW and high speeds of about 8000 min^{-1} enable the use of synthetic resin bonds.

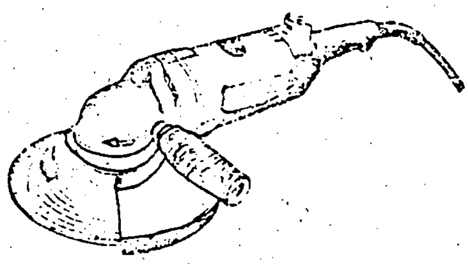


Fig. 80.1 (k) Angle grinder

Particular care must be taken when using cut-off wheels. The operator must have a firm stance and must not tilt the wheel, as it cannot take side loadings.

Bench grinder

1. Adjustable rest
2. Eye shields
3. Guards

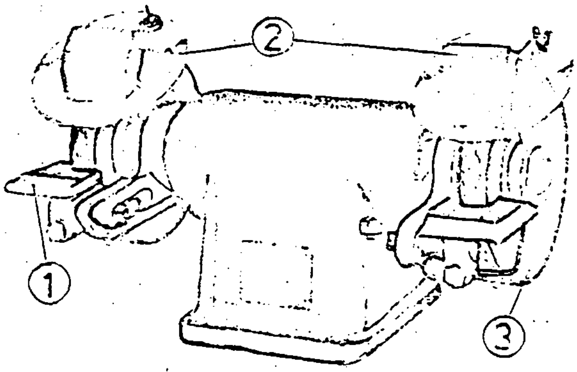


Fig. 80.2 (k) Bench grinder

Using the bench grinder tools are ground by hand. When doing so, the tool rest must be as close as possible to the grinding wheel, since if the gap is too great, the workpiece may jam between the rest and the grinding wheel and cause the wheel to burst.

According to the accident prevention regulations, the guard must cover 3/4 of the side face of the grinding wheel.

Mounting the grinding wheel

Grinding wheels run at high speeds and any mistakes in mounting will have serious consequences. First check to see that the wheel is not cracked (sounding out). Then check that the wheel bore matches the shaft. If the bore is too great, a bush is inserted. A small amount of play should be left for centring the wheel between the flanges. By holding a piece of chalk against the wheel as it slowly turns, any out-of-balance is found, which is then remedied by tapping with a rubber hammer (with the nut not too tight). Out-of-balance wheels impair performance and can result in breakage of the wheel. If the wheel runs true, the ring nut is tightened. A compressible washer compensates for unevenness and results in uniform contact. Grinding wheels should not be loaded in bending: they are brittle and break easily.

1. Grinding wheel
2. Compressible washer
3. Ring nut
4. Internally-recessed flange
5. Lead bush

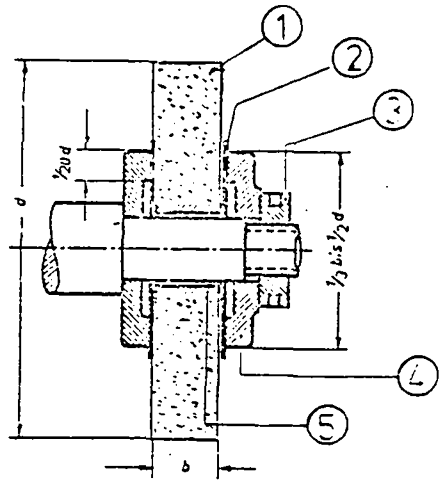


Fig. 81.1 (1)

Belt grinder

1. Swivelling arm
2. Abrasive belt
3. Toothed pulley of rubber
4. Electric motor

With the aid of wide grinding belts, clean surfaces can be obtained in sheet-metal work.

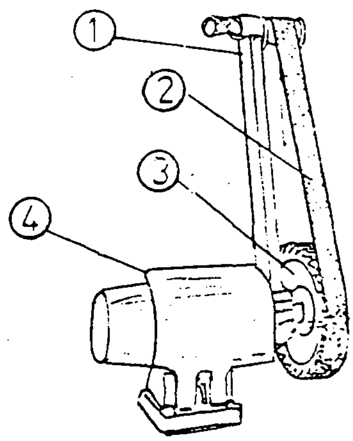


Fig. 81.2 (1) Belt grinder

In a somewhat modified form, belt grinders can also be used for working wood.

23. Using wall-plugs, expansion bolts and dowels

Wall-plugs and expansion bolts are used mainly for attaching objects by means of screws or bolts to, for instance, masonry. This type of attachment is non-permanent, as the bolts or screws can be removed without damaging them.
In order to achieve secure attachment with wall-plugs and expansion bolts, a few points must be observed or must apply:

1. The bore-hole must match the plug diameter.
2. The screw or bolt length must be sufficient to reach the end of the plug, whereby the thickness of the object to be attached must be allowed for.
   The diameter of the screw or bolt must match the corresponding size of plug, whereby both depend on the weight of the object to be attached.
3. The masonry must be capable of withstanding the expansion pressure of the plug.

For the bore-hole, not only is the dimensional accuracy of the drill of importance but also the characteristic of the wall material. Important factors are, for instance, the roughness of the bore wall and the strength of the wall material. A plug would not hold in a completely smooth hole (such as in steel), as in this case there is no anchorage force. The plug material must be compressible in order to adjust to the wall of the hole. The expansion forces which arise as the screw or bolt is screwed in are lower the less that the plug material is displaced by the screw or bolt. (The largest permissible screw or bolt for the plug frequently results in twice the retention force as the smaller screw or bolt). It is also important for displacement of the plug material that the screw or bolt reaches to the end of the plug.
The retention forces of a wall-plug or expansion bolt also depend on the shearing strength of the plug material and of the masonry work. For a plug or bolt with a conventional expansion action, the retention force is less in aerated concrete than in conventional concrete, as the shearing strength in the former material is lower. This of course only applies if the plug material, as already mentioned, is elastic (and not metal).

When handling plastic wall-plugs, air humidity must also be taken into account when determining the retention forces. This can affect their mechanical properties, according to the type of plastic concerned. When handling the wall-plug, the plastic material plays a decisive part. Some can be screwed in relatively easily, but for some more force must be applied when screwing in the bolt. The retention force of a non-permanent connection, i.e. that of wall-plugs, depends on these various factors.

1. Wall-plug length = Minimum installation depth
2 = Bolt-in depth
3 = Bore-hole depth
4 = Object to be attached

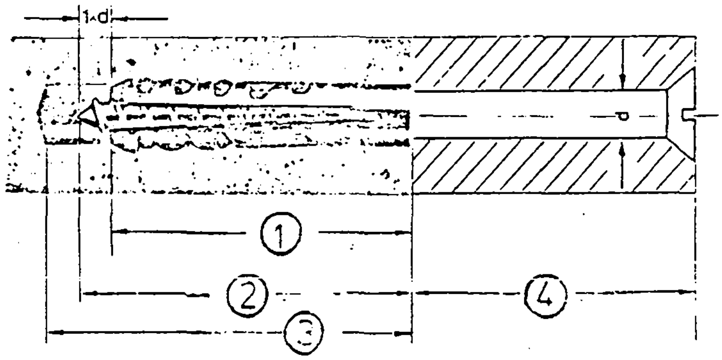


Fig. 83.1 (n) Section through plastic wall-plug when installed

For particularly heavy loads, special expansion bolts of steel, brass and malleable cast iron have been developed. They are suitable for attaching very heavy objects to concrete masonry. Secure attachment is achieved by parallel expansion of the 3-part expansion segments by the taper pieces at each end.

These expansion bolts are particularly resistant to climatic conditions and have a long life.

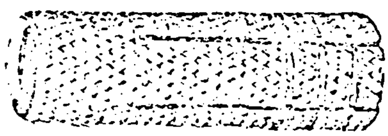


Fig. 83.2 (o) Brass expansion bolt

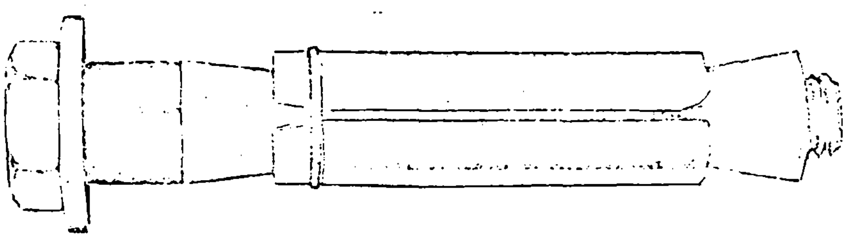


Fig. 83.3 (o) Heavy-duty expansion bolt with hexagon-headed bolt

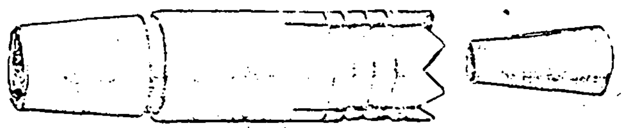


Fig. 84.1 (o) Rapid core drill anchor with applications in concrete and natural sandstone

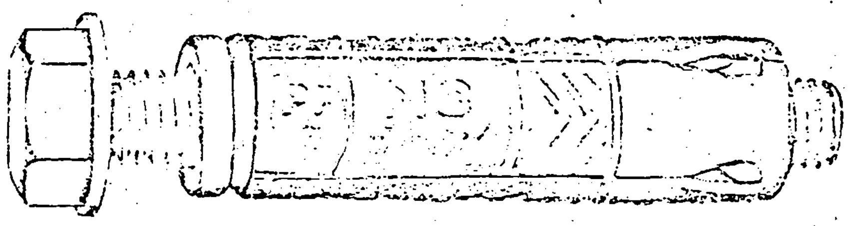


Fig. 84.2 (O) Machine expansion bolt - with galvanized bolts and washers, mainly for floor anchorages

Wood dowels

Dowels for wood connections are smoothed or serrated rods of beech wood to various diameters and lengths.

Due to the serrations and the swelling tendency, these dowels achieve a snug fit to the dowel-hole walls. Moreover, the serrations allow excess glue to emerge from the hole. Dowels result in a secure connection and are suitable both for butt joints and for mitred joints in solid wood, coreboard and chipboard.

24. Care of tools and equipment

Proper care and maintenance of tools and measuring instruments can considerably increase their service life.

The following basic rules should be observed:

- Always keep tools such that the cutting edges cannot come intc contact with ha:d objects, and if necessary protect them with covers (e.g. taps).
- After use, clean the tools and protect them against corrosion, e.g. by applying a thin layer of non-acidic grease.

- Tools must be protected against humidity, dust and temperature fluctuations.
- Measuring instruments should only be picked up with clean hands. After use, they should be cleaned with a soft rag and a thin layer of grease applied. They should be stored in special wooden boxes in a room at normal temperatures.
- Measuring instruments should not be exposed to direct heat (from the sun, heating installation or fire) and should not be placed on machines or workpieces, but on wood or a cloth.

25. References and sources of illustrations

Below is a list of the references used and of the sources of the illustrations in Module 3.1.
Texts from the literature listed have in some cases been reproduced word-for-word.

a) Jung Pohl Schröder	Fachpraxis Metall Girardet Essen
b) Ohl/Lindemann	Grundlagen der Blechbearbeitung u. Installationstechnik Herrmann Schrödel Verlag
c) Sonntag Kraus	Grundstufe Bau Handwerk und Technik
d) Fachkunde Schreiner	Europa Lehrmittel (March 77)
e) Greven	Technologie Otto Maier Ravensburg 1973
f) Lehrbuch für Metall-berufe	Jänecke Hanover 1972
g) Batran-Frey-Jusfeld-Köhler	Fachstufen Bau Ausbau Zimmerer Technologie Handwerk u. Technik
h) Fachkunde für Schreiner	Europa Lehrmittel (Febr. 80)
k) Fachkunde für Metall-berufe	Europa Lehrmittel (Spring 79)
l) Fachkunde für Bauschloss.	Klett Stuttgart
m) Gerling	Rund um die Werkzeugmaschinen Westermann 67
n) Fischerdübel Handbuch	
o) Tox-Dübeltechnik	

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The government-owned GTZ operates in the field of Technical Cooperation. Some 4,500 German experts are working together with partners from some 100 countries in Africa, Asia and Latin America in projects covering practically every sector of agriculture, forestry, economic development, social services and institutional and physical infrastructure. – The GTZ is commissioned to do this work by the Government of the Federal Republic of Germany and by other national and international organizations.

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- provision of materials and equipment for projects, planning work, selection, purchasing and shipment to the developing countries
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TRAINING MODULES FOR WATERWORKS PERSONNEL

List of training modules:

Basic Knowledge

0.1 Basic and applied arithmetic
0.2 Basic concepts of physics
0.3 Basic concepts of water chemistry
0.4 Basic principles of water transport
1.1 The function and technical composition of a watersupply system
1.2 Organisation and administration of waterworks

Special Knowledge

2.1 Engineering, building and auxiliary materials
2.2 Hygienic standards of drinking water
2.3a Maintenance and repair of diesel engines and petrol engines
2.3b Maintenance and repair of electric motors
2.3c Maintenance and repair of simple driven systems
2.3d Design, functioning, operation, maintenance and repair of power transmission mechanisms
2.3e Maintenance and repair of pumps
2.3f Maintenance and repair of blowers and compressors
2.3g Design, functioning, operation, maintenance and repair of pipe fittings
2.3h Design, functioning, operation, maintenance and repair of hoisting gear
2.3i Maintenance and repair of electrical motor controls and protective equipment
2.4 Process control and instrumentation
2.5 Principal components of water-treatment systems (definition and description)
2.6 Pipe laying procedures and testing of water mains
2.7 General operation of water main systems
2.8 Construction of water supply units
2.9 Maintenance of water supply units Principles and general procedures
2.10 Industrial safety and accident prevention
2.11 Simple surveying and technical drawing

Special Skills

3.1 Basic skills in workshop technology
3.2 Performance of simple water analysis
3.3a Design and working principles of diesel engines and petrol engines
3.3b Design and working principles of electric motors
3.3c –
3.3d Design and working principle of power transmission mechanisms
3.3e Installation, operation, maintenance and repair of pumps
3.3f Handling, maintenance and repair of blowers and compressors
3.3g Handling, maintenance and repair of pipe fittings
3.3h Handling, maintenance and repair of hoisting gear
3.3i Servicing and maintaining electrical equipment
3.4 Servicing and maintaining process controls and instrumentation
3.5 Water-treatment systems: construction and operation of principal components: Part I - Part II
3.6 Pipe-laying procedures and testing of water mains
3.7 Inspection, maintenance and repair of water mains
3.8a Construction in concrete and masonry
3.8b Installation of appurtenances
3.9 Maintenance of water supply units Inspection and action guide
3.10 –
3.11 Simple surveying and drawing work

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