CONTENT

Chapters	Page No.

SECTION – A

1 CARPENTERY AND PAINTING SHOP

LEARNING OBJECTIVES

- Introduction to Wood Work
- Preparation of Dovetail Joint
- Preparation of Mitre Joint
- Preparation of Lengthening Joint
- Demonstration of Job Showing the Use of Different Saws and other Tools
- Demonstration of Various Methods of Painting Various Items

1.1 INTRODUCTION TO WOOD WORK

As you all are aware, wood as a forest product had been in use by mankind for building and household works right from the beginning of civilization. Even today wood is an important and preferred material for several applications in buildings such as doors, windows and paneling of walls, roofs and floors for decoration and insulation against heat and sound. Quality furniture's, cabinet works and show cases are still made from wood only. In terms of strength to weight ratio, wood is generally stronger and lighter than many other alternative engineering materials. Besides being cheaper and readily available, wood is handled easily and converted into different usable forms with the help of simple tools and cheaper labor. This is what is of our importance, when protected and treated properly; the life of wood can be increased considerably. There are some treatments that make the wood fire resistant. Such treated wood is used for decoration purposes in prestigious buildings. That's why the wood and wood working is very essential and interesting to study.

1.1.1 Wood-working

Wood-working involves processing of wood by hand and machines for making articles of different shapes and sizes.
Wood- working is further divided into

a) Carpentry and Joinery
b) Pattern making

Carpentry deals with the use of various wood-working tools and machines and Joinery involves making of different types of joints for assembling two or more wood pieces together to form an assembly of a product.
Pattern making specifically deals with the types and making of wooden pattern for use in the making of castings (or cast products) of ferrous and nonferrous metals.

1.1.1 Material Used

Timber is the basic material used for any class of wood working. The wood obtained from a fully-grown tree is cut and is prepared for engineering purposes. The wood is known as timber.

1.1.2 Timber

Timber is the general name given to that wood which is good and suitable for engineering and building purposes. A good timber is strong, durable, dense, hard and free from defects and is not easily subjected to decay. It has good resistance against shock and shear loadings. It also shows good fire resistance. It takes up polishing well. A good timber is obtained from full grown or matured exogenous trees (those having annular rings) by sawing their trunks into different market forms (called converted **timber**).

Preference for timber over other engineering materials goes for the following advantages associated with the timber. Timber is one such unique material, which possesses an indispensable combination of several qualities like good strength and durability, lightweight, sound proof, heat proof and economical.

1. Equally suitable for both load bearing and non-load bearing structures.
2. Results in cheaper and faster construction on account of low material cost and ease in cutting or processing the wood using simpler tools and machines and cheaper labour.
3. Attractive grains and the capability of timber for taking polish very well have increased its aesthetic value. Because of this feature, timber suits well for making doors, windows, furniture's , cabinets and for making many other household articles.

Being heat-proof and sound- proof, timber is used for paneling of walls, floors, and roofs in cinema halls, auditoriums, dancing halls and other prestigious buildings. It gives good houses, which are comfortable in both winter and summer seasons.

4. Timber, when treated properly, is fire resistant and has very long life.
5. It has a good resale value as well.

1.1.3 Selection of a Timber

One should ponder over following factors while selecting timber. Although, the selection of a good timber is based on several factors but sometimes it becomes desirable to consider only one or two important factors in view of specific use of the timber in service. In general, the main factors that influence the selection of timber include,

1. Durability
2. Lightness,
3. Elasticity,
4. Hardness,
5. Ease of working,
6. Types of grain and texture,
7. Resistance to impact,
8. Shock loading and
9. Fire and the ability to take polish

1.1.5 Common Types of Indian Timber

1. Teak is strong, durable, takes very smooth polish and is used for elegant and costly works of furniture and building components like doors and windows. It is stronger than shisham and hence less wide sections of this wood can be used for doors and windows without warping.

2. Shisham is dark brown in colour and has well marked coarse grains. It is strong and used for furniture, building components like doors and windows, carriages and bridge piles.

3. Sal is hard, close grained, heavy and durable. It is used for railway sleepers, bridges, frames for doors and windows in buildings and ship construction.

4. Babool is close grained, tough and pale-red coloured wood. It is used for tool handles and building works.

5. Chir is soft wood and used for interior works in houses.

6. Deodar is strong, durable and is used for railway sleepers and house building.

7. Kail is a close grained, moderately hard and durable wood. It is used where deodar is used.

8. Mango is coarse and open grained wood and is used as a cheaper alternative for doors and inferior furnitures.

9. Mulberry is strong, tough and elastic wood. It is used for making tennis and badminton rackets, hockey sticks, bats and other sports goods.

10. Tun is light and close grained wood and takes good polish. It is used for furniture.

11. Mahogony has straight grains and red brown colour and is very durable when dry. It has some oil which prevents the attack of insects. It is used for cabinet work, fine furniture and ship building.

12. Walnut is light coloured, fine grained and moderately hard and take very good polish. It is used for decoration works cabinet work, fine furniture.

13. Bamboo is used for scaffolding and roofing works in buildings. Common foreign woods used in India are: Ash, Burma teak, Beech, Oak and Pine.

As you all know that wood is a plant product, so it would obviously have moisture that results in shrinkage, splitting or wrapping of wood. Excessive moisture content gives rise to various types of defects that ultimately reduce the life of timber.

1.1.6 Seasoning of Wood

In the process of wood seasoning, unwanted or extra moisture contained in the wood is taken away to get rid off the sap, presence of which results in shrinkage, splitting or warping of the wood. Decaying may also occur. Most seasoned woods have moisture contents reduced to about 12%. Now the question arises how to drive away the extra moisture contained in the wood?

1.1.7 Common Methods of Wood Seasoning

Common methods of wood seasoning are:

1. Natural or Air seasoning
2. Artificial or kiln seasoning
3. Other methods of seasoning.

1. Natural or air seasoning

Natural or air seasoning gives the best-seasoned wood. The method is also the cheapest among all methods of seasoning. However, it takes much longer time, one to five years; harder wood and thicker sections take more time. In this method, the timber balks (roughly sawn squared logs) are stacked under a shed avoiding direct exposure to sun and rains but ensuring a free circulation of air through the stack of the balks. The stacking is done on a leveled platform, which carries on its top a layer of cinder ash or sand to avoid direct contact of balks with the ground. A proper arrangement is made for the drainage of water from the shed. The stacked balks should be turned upside down from time to time to help accelerating the rate of drying and also to ensure uniform evaporation of moisture from all sides to the balk.

2. Artificial or kiln seasoning

It is the quickest method of seasoning. The timber balks are stacked over trolleys, which are taken to hot chambers or kilns, wherein the balks remain for nearly two weeks under the controlled conditions of temperature and humidity. Hot air or steam is circulated in the kiln, which accelerates the evaporation of moisture from the balks yet maintaining proper humidity levels in the kiln. Depending upon the type or class of wood and the size of balks, the temperature and rate of flow of air inside the kiln are controlled along with the humidity, which is varied by the spray of steam. The moisture content in balks or timber logs is brought down to about 12%, which is the normal moisture content in most seasoned woods. There are solar seasoning kilns also in which heat in specially designed chambers is developed by exposing kilns also in which heat in specially designed chambers is developed by exposing them to solar radiations and temperature can be attained to about 70°C. Humidity is maintained by spray of water.

3. Other methods of seasoning

The other methods of seasoning are those, which are less common in practice. These include water seasoning, boiling, chemical or salt seasoning and electrical seasoning. Water Seasoning involves immersing of timber in water as soon as it is cut. It is kept in that position for about two weeks. After taking the timber out of water, it is dried in open air. The method is suitable for that wood which is very green and has lot of sap. Water seasoning makes the wood less susceptible to attack by worms or decay by rot. It also becomes less liable to warp and crack.
Boiling involves keeping the timber in boiling water or steam for about four hours. The wood is late dried very slowly in air. The method increases the strength and elasticity of the wood. Chemical or Salt Seasoning involves soaking the green wood in saturated salt solution and later seasoned in the normal way by keeping the wood in the open. Salt treatment helps in reducing external splitting of the wood. Electrical Seasoning involves the use of high frequency alternating current. The method is very costly and hence seldom used.

1.1.8 Defects of Woods

The most common problem in manufacturing wood products is wood defect. The most important thing for making quality wood products is to be able to correctly identify and when possible eliminate these defects quickly, efficiently and with minimum waste. Defects may be naturally occurring or can be man-made. Natural defects can be due to many reasons such as environmental factors, growth patterns, soil composition, etc.

Man-made defects can occur at many points - from the felling of the tree, transport, storage, sawing, drying, etc. The machine operator must learn to understand these problems and decide the best method to solve them.

Following are some of the most common defects found in wood:

1. Split

Is a longitudinal separation of the fibres, which extended to the opposite face or adjoining edge of a piece of sawn timber.

2. Checks

Are small separation of the wood fibres in a longitudinal direction, not penetrating as far as the opposite or adjoining side of a piece of sawn timber, they usually result from strains developing during seasoning; Surface (or Seasoning) Checks, and End (or Heart) Checks are distinguished.

3. Honeycomb

This is nothing but the development of cracks in the interior of a piece of wood due to drying stresses, usually along the wood rays, often not visible at the surface. This defect occurs when thick timber is dried too quickly in a seasoning-kiln.

4. *Cup*

It is the curved surface formed on the wooden piece across its width.

5. *Spring*

Is the curvature of a piece of sawn timber in the plane of its wide face: known as Crook or Free Side Bend.

6. *Wane*

Is the lack of wood on any face or edge of a piece of sawn timber, usually caused by a portion of the original rounded surface of a long remaining on the piece; bark may or may not be present.

7. *Diamond*

A distortion due to differential shrinkage in drying that causes a piece of timber originally square (or rectangular) in cross section to become diamond-shaped. This defect occurs when the rays pass through diagonal corners of the square (or rectangle) and is caused by the difference between tangential and radial shrinkage which in many timbers is in the proportion of about 2:1.

8. *Twisting*

In the spiral distortion of a piece of sawn timber; it may be accompanied by either bowing or spring, or both.

9. *Bow*

The curvature of a piece of sawn timber in the direction of its length, cf. spring and Curvature.
Defects that exist in timber make the planer's job more difficult and create a need for secondary machinery to produce quality products. It would be nice to be able to feed any piece of rough timber into a molder and produce a perfect product, free from defects, but this seldom happens.

10. *Knots*

These are the impressions left behind by the broken limbs or branches of a tree and are in the form of hard dark spots. The annual rings in the knots are formed normal to the annual rings in the stem, which, besides reducing the strength of the wood, also creates difficulty in working on the wood. Hence, the wood with large or loose knots should not be used as such knots are the sources of weakness. The knots already existing in the wood before the tree falls are called dead knots. Due to decaying of tissues in course of time, dead knots become loose and fall out leaving a cavity in the wood. When separation of a branch takes place after the felling of tree, the knot formed is called 'Live Knot'. These are usually free from decay and do not, therefore, get loosened and separated. These, however, present difficulty in working on the wood.

11. Shakes

Shakes of different types are caused in an over matured tree i.e. when a tree is not felled at the right time upon attaining maturity. With the lapse of time the cohesion in wood grains is lost due to the evaporation of moisture, gum, resins or oil present in a tree. These results in the burning of tissues and shrinkage of interior of the trees causing radial or circular rupture in the tissues creating cavities called 'shakes'. Heart Shakes are the cavities, which start from the pith and extend towards the sapwood (Star Shakes are those cavities, which grow under the bark and extend towards the centre. When the shakes or cavities appear between the annular rings, these are called Cup Shakes Frequent excessive wind pressures causing bending of a tree and reduction in the adhesion between successive annular rings also result in the formation of cup shakes.

12. Twisted fibres (or irregular grains)

The fibers of a tree get twisted due to wind action in the branches. The twisted fibers have different inclinations with the wood axis i.e., the fibers are no more parallel to the axis of the wood. Twisted fibers offer difficulty in working and a smooth surface is not obtained.

13. Ring galls

This defect is caused due to the growth of sap wood over a wound caused by the falling or breaking of a branch. The new sap wood that grows over the wound does not unite with the parent wood and creates a cavity between the two and thus a place for starting the decay. Defects occurring during conversion and seasoning. The defects which occur during the conversion and seasoning of the wood include: shakes, distortion, case-hardening and honey-combing. The main causes for these defects are improper methods adopted and inadequate care exercised during the conversion and seasoning of the wood.

14. Shakes

When a tree is felled carelessly on the ground, a great impact thus created harms the interior of the tree by developing radial cracks or shakes. Similarly, during seasoning, when outer skin of the wood dries up quickly, uneven shrinkage takes place which also may cause shakes.

15. Distortion

Non-uniform seasoning is the cause of distortion in seasoned wood balks, Shrinkage starts in most woods when their moisture contents fall below 25 per cent. Hence, if seasoning is not uniform and the wood is sawn in thinner sections, distortion takes place in the sawn planks on account of shrinkage. Distortion may be in the form of twisting, bowing or crooking.

16. Case-hardening

It is also caused due to uneven drying during seasoning. Since the outer portion of wood dries earlier and quicker than the core, it causes shrinkage in the outer tissues and sets up drying stresses that result in the hardened outer surface of the wood.

17. *Honey combing*

It sometime occurs as a result of chemical seasoning. Due to the presence of hygroscopic substance (which absorbs moisture easily) in the outer tissues of the timber, the interior of the timber gets dried quicker than the outer surface of the timber. This sets up internal stresses resulting into the information of circular and radial cracks producing honey comb structure in the wood.

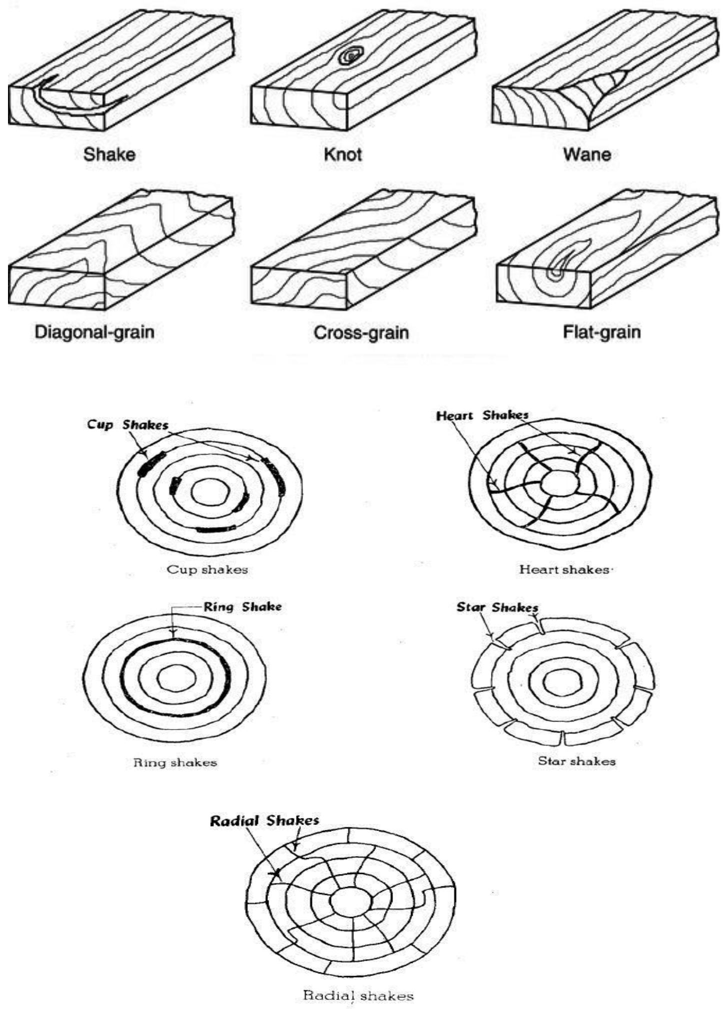


Fig.1. Defects of wood

1.1.9 Preservation of Timber

Preservation of timber is very important for increasing its life. It is always better to keep the wood dry to avoid the attack of fungi and other insects. Timber should be preserved from white ants, which are most destructive for wood. Hence proper preservation of wood is desirable by applying suitable type of preservatives which help increasing durability and life of timber preservatives for wood are available in the form of oils or chemicals.

1.1.10 Characteristics of a Good Preservative

A good preservative must have following qualities:

1. It should be poisonous for fungi and insects but should be safe to the user.

2. It should be cheap and readily available.

3. It should penetrate well into the wood.

4. It should not corrode metal fastenings (screws, bolts etc.) used for joining wood. Also it should not be injurious to wood.

5. It should be lasting and not washed away by rain or deteriorated by the action of heat or light on the wood.

6. It application should in no way hamper the use of polishing or painting on the wood.

7. It may be added here that the wood should be properly seasoned before applying the preservative as presence of moisture in the wood hinders the preservative to penetrate in the wood.

1.1.11 Types of Preservatives

Main types of preservative include:

a) Preservative Tar Oils,
b) Water Soluble Chemical Salts,
c) Solvent Chemicals,
d) Fire-proofing treatment.

Now we will discuss them in detail.

a. Preservative tar-oils

Oils named as 'creosotes' are obtained from distillation of, coal tar or wood tar. Creosotes are most widely used oil preservatives for exterior use on railway sleepers and piles. Pure coaltar is also sometimes used as preservative. It is highly viscous and is applied always hot. The coal-tar derivatives, namely, carbolenum and solegnum are quite commonly used preservatives. Carbolenum is a strong antiseptic and disinfectant material which penetrates the wood of its own when applied with brush. It saves wood from white ants and prevents dry rot. Solegnum also saves wood from white ants. It can be mixed up with pigments of different shades to make timber attractive in appearance. It is applied hot with a brush.

b. Water soluble chemical salts

Include zinc chloride, sodium fluoride, copper sulphate etc. Zinc chloride is the most commonly used wood preservative in places where humidity is high and fire protection for timber is needed. Sodium fluoride is highly toxic to fungi. Similarly, copper sulphate is also highly toxic to fungi. It is soluble in water and hence is a temporary type of preservative. The preservative is available in the form of powder and by dissolving it in water; it can be applied on wood by spraying or soaking the timber in the solution. The water- soluble Chemicals are cheaper than creosotes and the treated wood can be subsequently painted or polished.

c. Solvent chemicals

Include toxic chemical salts such as copper and zinc salts dissolved in spirit or a volatile oil. Nepthol and Phenol are also used. After the treatment applied on the wood, the oil evaporates and the wood surface is painted, waxed or polished. These preservatives are costlier but give very good results.

d. Fire proofing treatment

Is also a type of preservative treatment done to enhance the resistance of wood against fire? The wood is treated by chemicals such as sodium arsenate, borax, and ammonium sulphate.

1.1.12 To Apply the Preservatives

After knowing the importance and the types of preservative, we need to apply that on the surface of wood.

1. Brushing and Spraying,
2. Dipping or Soaking process (Non-pressure process) and
3. Pressure Treatment.

Brushing and Spraying of preservatives is only a surface treatment and the effective life of treatment is short. Two to four coats of the preservatives are applied by brushing or spraying. If the treatment is repeated on the wood after an interval of two to three years, the life of the treated wood is enhanced considerably.

Dipping or Soaking process, often called 'Non-pressure process', involves the use of preservative tank sunk into the ground to facilitate loading and unloading of timber into the tank. The timber is stacked in the tank filled with preservative and held down in position by the hanging bars from the top.

The preservative is heated to about WC and maintained at this temperature for one to two hours. The process enables better penetration of the preservative.

Pressure treatment is adopted for treating the timber on a large scale basis. In this process, timber is placed in steel cylinders (autoclaves) and the preservative is applied onto the wood under pressure in the airtight autoclaves. Timber pieces are piled in bogies that is run into the autoclave and positioned there with entrance door of the autoclave closed during the application of preservative.

1.1.13 Auxiliary Materials used in Carpentry

Carpentry work involves the direct use of various materials (besides the wood) mostly for the purpose of joining wooden pieces for making an assembly or for protection, preservation and giving desired finish to the wood.

The materials used in carpentry work other than the wood, are called auxiliary materials' which include different types of nails, screws, glues, paints and varnishes.

Nails and screws Iron fastenings in the form of nails and screws most frequently used for joining wooden pieces. Nails are always driven by hammering and screws are driven with the help of screw driver. Screwed joints are stronger and preferred over nail joints. Few types of nails and screws are shown in figure below:

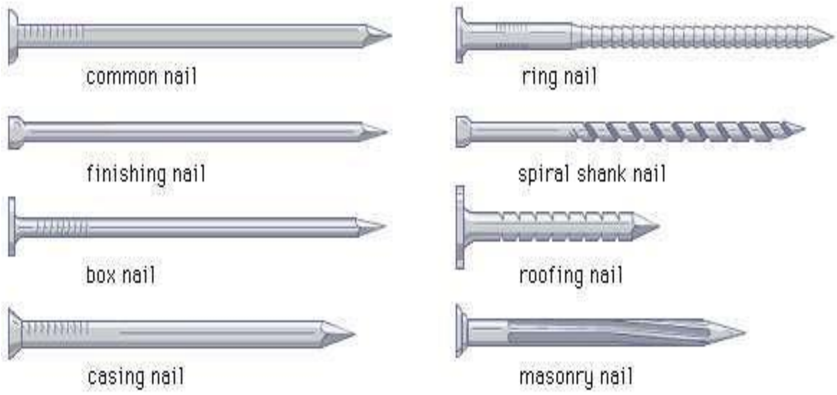


Fig.2. Different types of nail

Nails are made from drawn wires of low carbon steel, brass or copper. Nails are also made from malleable iron rods. Wire nails of drawn steel wires may be of round or oval cross-section, the later are tough and do not split the wood. Circular nails are used for temporary Joints or unimportant work like making of packing cases. Cut or clasp nails are cut from the malleable iron rods and have better holding power than the round wire nails.

Nails are mainly used for reinforcing glued joints but these can be used for fastening or assembling different parts of wood without the use of glue. Nails are designated by their length and gauge. Spikes are the wire nails longer than 130 mm. These are used for joining thicker sections of wood.

Wooden screws are different from, the screws used for assembling metal parts. The screw has a tapered threaded section for easy penetration of the screw in the wood whereas the threaded portion of a screw used for joining metals is uniform in section throughout the threaded length as a metal screw moves into a hole which is already threaded such as a nut or tapped hole. Screws are made from bright drawn mild steel wires, copper or brass. Generally, for wood-work, flat head and round head screws are more commonly used.

1.1.14 Wood Screws (Coach Screw)

The coach screw with its head square or hexagonal, Dowels are wooden parts. A number of corresponding holes are drilled at appropriate locations along the two mating edges of a joint and dowels are driven through the holes thus making a rigid assembly.

Fig.3. Different types of screw

Bolts and nuts are used for joining either very heavy wooden piece as in case of wooden roof trusses and columns or for having a special featured joint, such as a hinge joint case of folding type furniture and other collapsible wooden structures. Glues or adhesives are also known as cements. Glue is quite frequently used for joining wooden pieces.

a) Edge to edge for increasing either width or length or
b) Face to face for increasing thickness of the final wooden assembly. The glues are of following types:

1. Synthetic Resin Glues
2. Casein Glues
3. Vegetable Glues
4. Blood Albumin Glues
5. Animal Glues
6. Contacts Cement.

Synthetic resin glues are the formations from the formaldehyde Uric acid. Examples include plastic-resin glue (in powder form) and polyvinyl-resin glue (in liquid form), the latter being a fast setting glue and gives good strength. The plastic-resin glue finds its application in the ply wood works. For satisfactory working- of the glued wood-assembly in humid conditions, preference is given to the use of resorcinol resin glue.

Casein, glue is a milk derivative. It is produced chemically also. It is available in powder form and for use; it can be made in paste form by using water. It is the commonly used glue for joining plywood and is water resistant also. It is susceptible to mycological attack. Vegetable glues are prepared from the starch of soybean, ground nuts, roots or corn of trees. The glue is moderately moisture resistant. It is highly viscous and is not commonly preferred by carpenters. It finds application in plywood industry.

1.2 PREPARATION OF DOVETAIL JOINT

(Job-I-Preparation of dovetail joint.)

A dovetail joint or simply dovetail is a joint technique most commonly used in woodworking joinery. Noted for its resistance to being pulled apart (tensile strength), the dovetail joint is commonly used to join for example the sides of a drawer to the front. A series of pins cut to extend from the end of one board interlock with a series of tails cut into the end of another board. The pins and tails have a trapezoidal shape. Once glued, a wooden dovetail joint requires no mechanical fasteners.

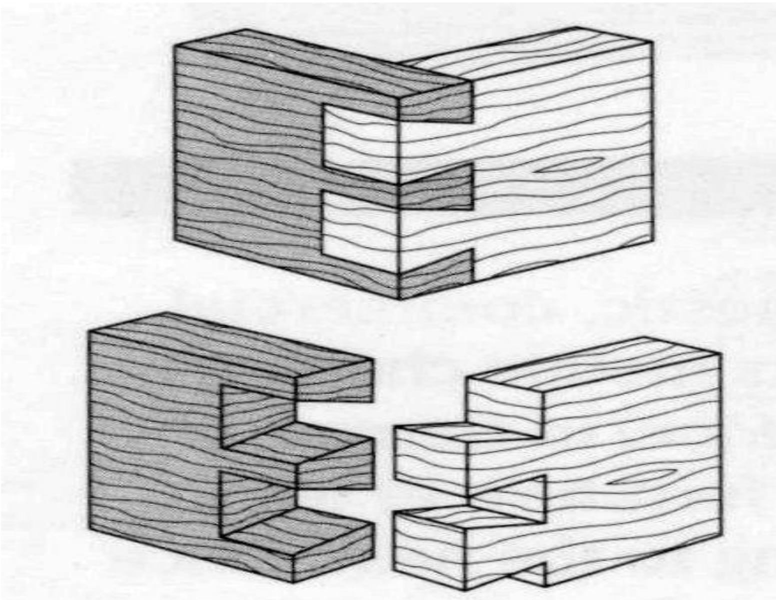


Fig.4. Dovetail joint ration

1.2.1 Types of Dovetails

In the diagrams here given are shown the two treatments of the joint in ordinary use. That represented, in its divided state, in diagrams A and B is called the lap-dovetail, which shows when complete the jointing on one side only: and that represented, in a similarly divided state, in diagrams C and D is the common-dovetail, which displays its construction on both sides of the corner.

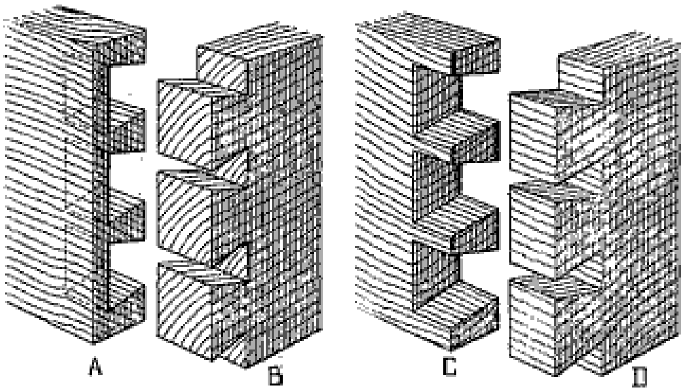


Fig.5. Types of dovetail joint

The lap-dovetail joint is invariably used in the fronts of properly made drawers or furniture of a similar and well-finished character. The common dovetail is used where strength is required and appearance is of loss importance in the furniture: it is quite suitable if closely made for work that is to be painted. It may be said, however, that from an artistic point of view, and when the display of truthful construction is desired, there is nothing to be said against carefully made dovetail joints of this common form. This form may be described first.

1. Common dovetail join

When the boards to be dovetailed have been dressed to the required thickness, and their ends properly planed true and square, a marking- gauge must be set so as to scratch a light line along each side of the ends of both pieces, about a twentieth of an inch farther from their edges than the thickness of the wood: this excess is to allow a final dressing off when the joint has been glued. The next process is to carefully draw on the piece D the forms of the dovetails, setting out the measurements uniformly, and using a try square & mitre square, the mitre being adjustable, in marking the lines for the saw-cuts. When this has been done, the piece must be fixed vertically in the bench-vise, and the cuts accurately made with the dovetail saw, down to the gauge marks on both sides.

The piece must now be removed from the vise, laid flat, and the proper portions cut out with a small firmer-chisel. Should any irregularities obtain where sawn, they must be pared true with a chisel.

The other piece of wood (which has to be cut as shown at C) must surface of the bench, and the dovetailed end of the piece D laid accurately in position upon it. The shapes of all the dovetails must now be closely scratched on the end of the uncut piece with a sharp marking awl. When all the additional lines have been scratched, down to the gauge marks on both sides, using the try-square as a guide, the cuts may be made, and the larger pieces removed with a firmer- chisel. Care must be taken in sawing to keep free of the dovetail lines scratched on the end of the piece, otherwise a loose joint may be made, without any means of altering it on the other hand, a too tight joint can very easily be put right with the chisel.

2. *Lap dovetail*

In forming the lap-dovetail joint exactly the same process must be adopted in forming the end of the piece B as described above in connection with the piece D, with this exception, that the gauge marks must be made at a distance from its edges equal to the thickness of the piece A, less the thickness of its lap, as clearly indicated in the diagram. The same gauge that marked the depth of the cuttings in the piece B must now be drawn along the end of the piece A, so as to define its lap, and the limit of its dovetail sinkings.

The finished dovetails of the piece B must be accurately adjusted upon the end of the piece A, and their forms scratched thereon, in the manner already described for the piece C. After-scratching the inner straight lines of the sinkings, down to a gauge-line marking the depth of the sinkings, a trifle more than the thickness of the piece B, the sinkings (or "pockets", as they are sometimes called) can be cut out. A certain amount of the cutting may be done with the dovetail-saw, but the chief amount must be done with firmer-chisels, care being taken to secure a neat and tight joint. Glue both pieces, and gently drive the joint tight, using a piece of flat board between the hammer and the joint. When the glue is dry, the end of the piece A must be carefully dressed off flush with the face of the piece B.

1.3 PREPARATION OF MITRE JOINT

Job-II Preparation of mitre joint.)

Two of the common modes are shown in the diagrams below. At A, B, and C are shown the forms (in perspective) of the three portions required to construct a feathered mitre joint. The ends of the pieces A and B have to be accurately cut at the angle of 450. This can be readily done with dovetail saws and a mitre box.

For rough work, the ends as left by the saw will be sufficient; but for fine work, the ends should be shot perfectly true with the trying plane laid on its side on a mitre block against which the wood can be held at the true angle.

The cut ends of the pieces A and B should be laid tightly together between two flats pieces of wood, and fixed in the bench vise, and saw cuts made across the joint to receive the feather-piece shown at C.

Where great strength is required, the feather should be of a substantial thickness, as indicated; and in this case two saw-cuts will be necessary, and the wood between them must be removed. In light work, the feather need not be more than sufficient to fill a single thick saw- cut. Some hard wood veneer is commonly used for this purpose. In all cases the grain of the feather should run in the direction indicated at C.

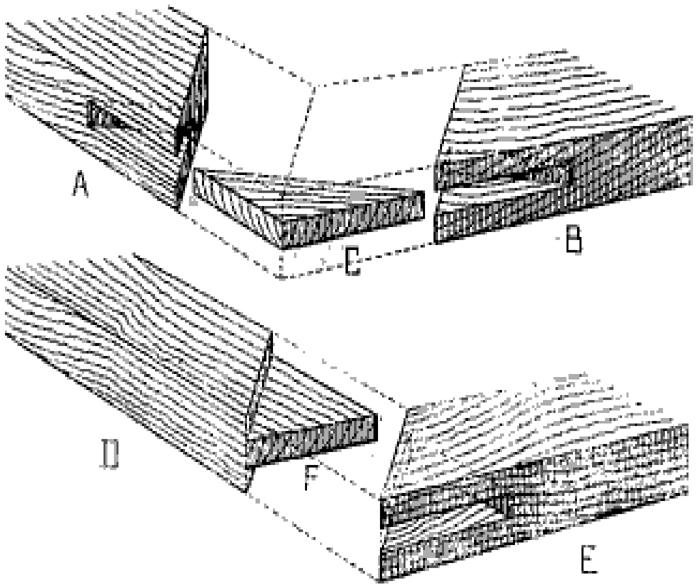


Fig.6. Mitre joint

At D, E, and F are shown the forms of the pieces required in the construction of the mortise and tenon mitre joint. This joint is so clearly indicated as to call for no detailed description. It will be seen that the tenon F, cut at the angle of 450, at the end of the piece D, takes the place of an independent feather: this fits tightly into the open mortise in the mitred end of the piece E.

1.4 PREPARATION OF LENGTHENING JOINT

(Job-III Preparation of lengthening joint.)

If you are working on a big project, it may be necessary to join two pieces of timber together to gain a longer length. Smaller projects also often require a section of wood grafting. There are several methods of joining timber, dependent on the strength and finish required.

a) Bolted joint

For a strong face to face joint use coach bolts in conjunction with timber connectors (metal washers with toothed edges). Drill three holes along the centre of the sides of both timbers, aligning with the adjoining timber. Use the timber connectors between the two pieces of timber to be joined. Insert the bolts making sure the timber connectors are on the bolts when pushed between the two timbers. Use washers and nuts at the other end to tighten the joint. The timber connector's bite into the wood as the joint is tightened, increasing the strength of the union.

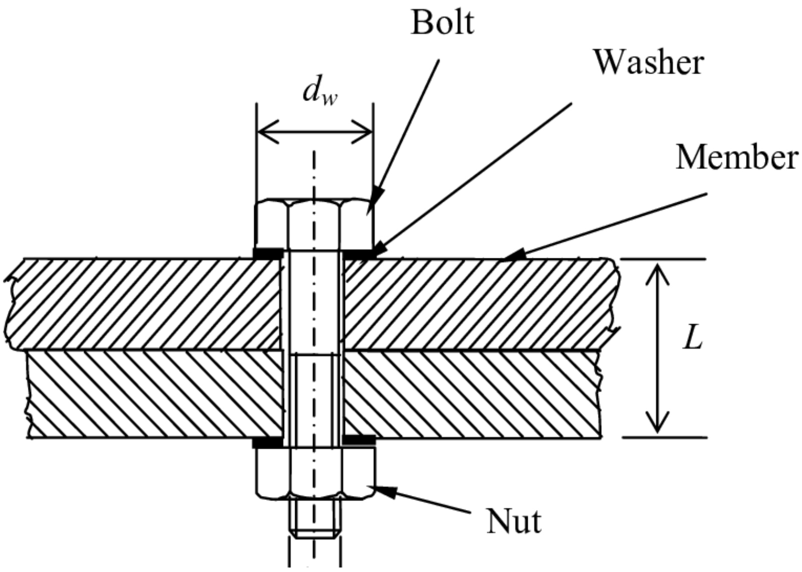


Fig.7 Bolted Joint

b) Joining plates

If the two timbers to be joined are meeting end on end, use two wooden plates to hold the union together like a sandwich. The two wooden plates must be strong enough to support the join. Measure the width of the timber to be joined. Use timber plates that are 4 times longer than that width. The timber plates should be the same width as the timber but half its thickness. Glue all the surfaces together before drilling holes in the construction and either screw or coach bolt the whole section together in strategic points staggered across the surface of the plates.

c) Lapped joint

This type of joint is more suitable for lengthening lighter structures and is the easiest method of joining two timbers. Measure the timbers and mark the halfway positions on each. The laps should be cut to half the thickness of the timber, one cut reflecting the other in the second timber. The two shoulders made must but exactly against the end of the joining pieces. Glue all the surfaces together before drilling holes in the construction and screw the sections together in strategic points staggered across the surface grain to avoid splitting.

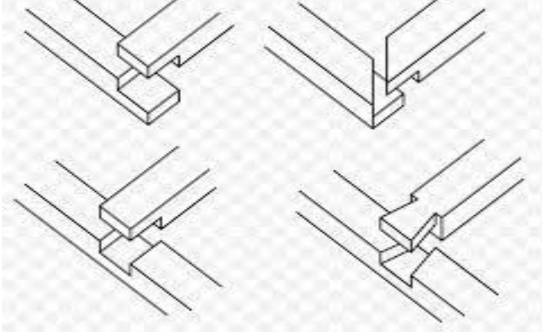


Fig.8 Lapped joint

d) Scarf joint

This type of joint is only suitable for lengthening lighter structures such as in cabinet making. For the greatest strength, make the scarf length 8 times longer than the width of the timber. Measure the timbers and mark the scarf positions on each. The splayed faces must be measured, cut and planed accurately to perfect the bond. The faces must butt exactly together. Glue all the surfaces together and screw the sections together for added strength.

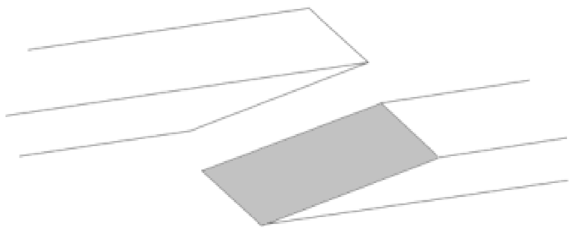


Fig.9 Scarf joint

e) Splayed lap joint

This type of joint is a variation on the lapped joint. The difference is that the lap is cut in the thickness of the timber instead of the width of the timber. The splayed lap joint is suitable for joining timber directly onto a joist or timber wall, giving it extra support. It is suitable for use when the timbers need to keep a straight edge in order to be used to support hardboard or chipboard sheeting. The length of the joint should be equal to the width of the timber. To help resist the chance of the joint being pulled apart, cut the splays along the grain of the wood. Check that they butt together exactly before securing. Nail the lower section of timber diagonally through to the joint or timber wall. But the joining length of timber into position and nail it diagonally through the top.

f) Spliced joint

This type of joint is used when appearance is of prime importance, particularly in furniture repairs. Use a fine tooth saw to cut a V shape in one section of wood. The joining section must be cut and planed to make a perfect fit if the repair is to be successful. It is worth spending time getting the exact fit before fixing the two pieces together. When ready glue and clamp the pieces together until the glue sets. If the join is in a vulnerable location, screws can be used to add extra strength.

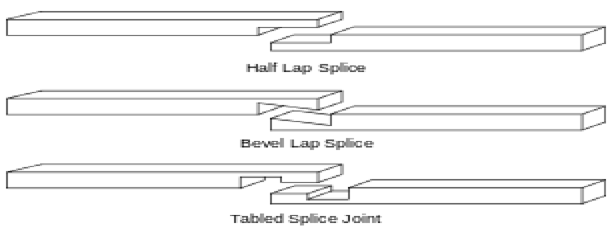


Fig.10 Spliced joint

1.5 DEMONSTRATION OF JOB SHOWING THE USE OF DIFFERENT SAWS AND OTHER TOOLS

a) Mortise & marking gauges

Two gauges are absolutely necessary; namely the marking gauge and the mortise gauge. The best shape of the former is shown in the picture below. It is the Stanley gauge, No. 165 ; and has, in addition to its scale of six inches, which enables its marking-point to be accurately set to any dimension (when the position of its head is reversed), a most ingenious appliance which enables it to be used on convex or concave edges: the small section, with the dotted lines, shows how this is accomplished.

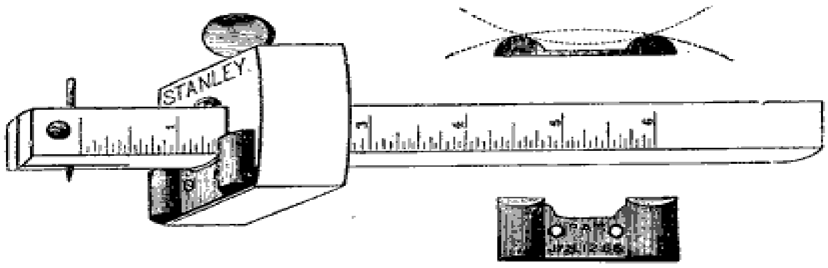


Fig.11

The mortise gauge is shown in the picture below. It has one fixed and one movable marking-point, enabling it to be set to the width of the mortise and to the distance of the same from the edge of the piece to be mortised. The vintage Stanley gauge, No. 71, combines both the single-marking and the double-marking tools, being furnished with two sliding bars, one of which is graduated in inches: this is a very complete and handy tool.

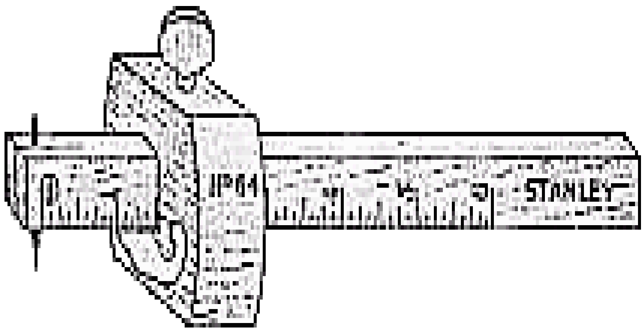


Fig.12

b) Woodworking squares : Try & mitre square

Info on how to use try and mitre squares for woodworking. This handy tool, the try square, is absolutely indispensable, being called into play at almost every stage of the simplest woodworking processes. It is desirable that the amateur joiner should possess two squares, one having a blade 4 inches long, for ordinary edge-squaring and small work, and the other, having a blade 12 inches long, for squaring and marking planks or broad surfaces and ends.

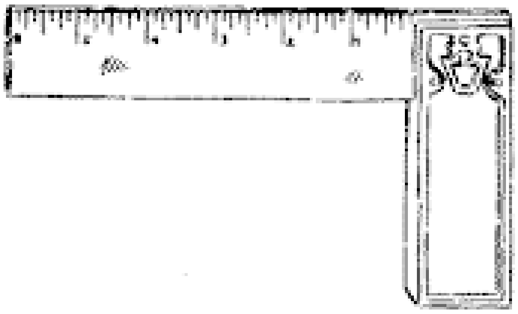


Fig.13Try and mitre square

The mitre square tool is also of great use in marking and testing mitre joints. Though not indispensable to the joiner who possesses a mitre box and mitre shooting board it is a very desirable tool when accurate woodworking and joining work is aimed at. It is very useful in marking angles of 450 correctly.

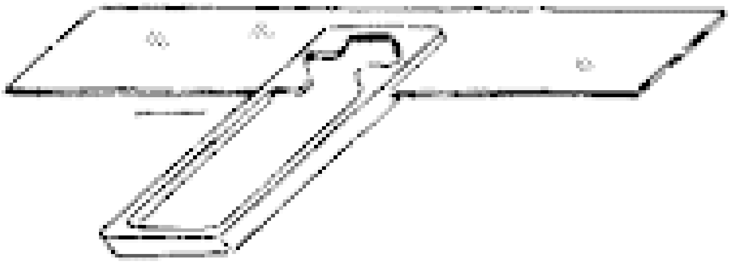


Fig.14 Marking and testing mitre joints

The marking awl is a desirable tool to use with the squares ; and, indeed, for general marking purposes.

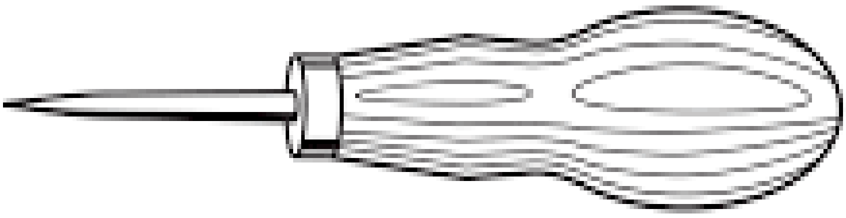


Fig.15 Marking Awl

c) RIP saws

This is a saw of the form shown in the accompanying pictures, measuring 26 inches in length and having about twenty teeth in every 4 inches. It is properly used for cutting across the grain; but it can be used for “ripping", or cutting along the grain, under ordinary conditions. There is a saw, of similar form, specially made for the latter operation, designated the ripper or ripsaw: it differs from hand saws in the shape and set of its teeth. The extent of the set varies according to use to which the saw is put, and the class of wood it is employed to cut: handsaws have a greater amount of set than the ripper; and saws used for hard woods require a smaller amount of set than the ordinary saws used for pine and other soft woods. If the amateur can afford it, we would advise him to obtain the saws, ripper and hand.

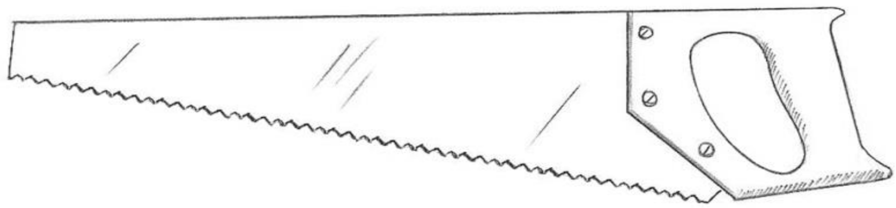


Fig.16 RIP saw

In using either of the saws, the handle must be gripped firmly with the right hand, so as to control its direction while making its cut. On starting a cut, at a line marked on the wood, the entry of the saw should be guided by a slight pressure of the thumb of the left hand, bearing on the side of the saw just above its teeth. When the cut has been properly started, the thumb can be removed, and the left hand will then be free to hold the wood steady in any required manner.

In "ripping" planks or pieces of wood of a few feet in length, a pair of carpenter's trestles will be required; and these will allow a knee to be placed on the plank to hold it steady, if necessary, either in ripping or cross-cutting. There is one matter that should be observed; namely, while making a cut, the saw must be allowed to eat its own way; hardly any pressure should be applied with the view of hastening the operation. In ripping a long plank, it may be found that the cut closes on the saw and prevents its easy action : when this is the case, a thin wedge of wood should be pressed into the end of the cut, so as to open it enough to release the saw. As it is all-important that the amateur should be able to use the saws properly from the first, we may repeat the advice, already given, that he should obtain a few lessons from some experienced workman.

d) Tenon saws

The tenon saw, which is of the form shown in the picture, is, as its name implies, commonly used for cutting tenons, but is equally useful for cutting any small work either across or along the grain. It will be seen in the illustration that it has a bar along its back : this is a folded piece of iron or brass, necessary to prevent the saw from buckling while being used. The available blade measures about 14 inches long and 4 inches broad, and has, as a rule, from nine to twelve teeth to the inch.

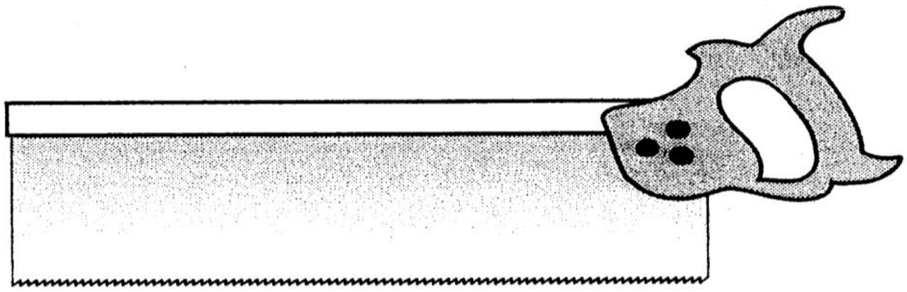


Fig.17 Tenon saw

In using this saw, the handle must be firmly grasped, so as to give full command of the blade while cutting. At the commencement of the cut, the handle end must be held slightly raised, so that the entry of the saw may be made with its front end; after which the blade may be gradually brought to the horizontal position. In cutting am tenon lengthwise, the piece of wood must be fixed vertically in the bench-vise. In completing the tenon, by cross-cutting away the side pieces, the piece must be laid flat on the bench, and held against the bench-stop, or adjusted to the square cut in a mitre box. The latter is more likely to favour accurate cutting in the hands of an inexperienced saws are properly used in the mitre-box. The teeth of this saw have a very slight set.

e) Dovetail saws

Dovetail saws are similar in form to tenon saws, but of a much smaller size, and having very fine teeth in the blades: it commonly measures 8 inches in length and 3 inches in breadth of blade. As its name implies, its chief use is for cutting dovetails for the formation of dovetail joints, as described in the following section. This saw is, at the same time, very useful for cutting small work requiring great accuracy: in this direction it is more convenient than the larger tenon saws. The teeth of the dovetail saw are extremely fine, and have only sufficient set to prevent the saw being friction-bound in the cut.

f) Bow saw

In modern hardware store vernacular a bow saw is a metal-framed saw in the shape of a bow with a coarse wide blade. This type of saw is also known as a swede saw. It is a rough tool used for cutting tree trunks and the like. The traditional meaning of a bow saw is a woodworking tool used for straight or curved cuts. In European vocabulary it is synonymous with frame saw. In English and American vocabulary it denotes a toothed blade suspended between two long narrow handles called "cheeks” that are supported and separated by a narrow stretcher in the center of the handles, making an H shape. In this context it is known also as a buck saw and has a wide blade for roughly cutting wood. A finer version of the saw uses a narrow blade (1/4" or less) with handles that allow you to hold the saw and rotate the blade. In this context it is also known as a turning saw. The blade is kept in tension with a turnbuckle or a twisted cord that is attached to the opposite ends of the handles. If a cord is used, the cord is twisted with a toggle attached to one loop of the cord, adding tension. The toggle hits the center rod, which keeps the cord from untwisting.

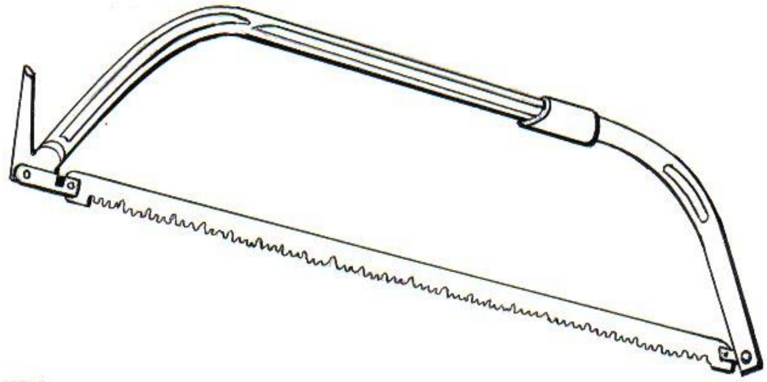


Fig.18 Bow saw

g) Band saw

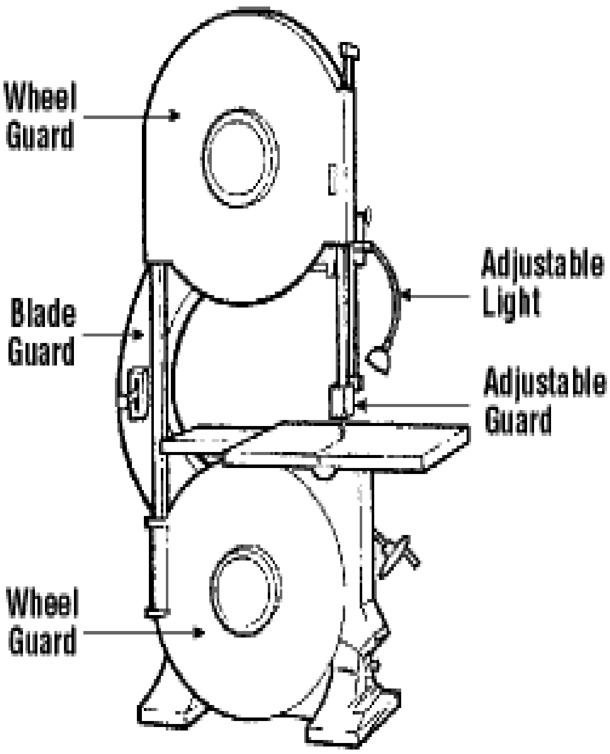


Fig. 19

A **band saw** uses a blade consisting of a long, narrow, strait band of toothed metal, and may be powered by wind, water, steam, electrical motor or animal power. The band rides on two connectors in vertical direction. Band saws can be used for woodworking, metal working, or for cutting a variety of other materials, and are particularly useful for cutting irregular shapes. The radius of a curve that can be cut on a particular saw is determined by the width of the band.

h) Circular saw

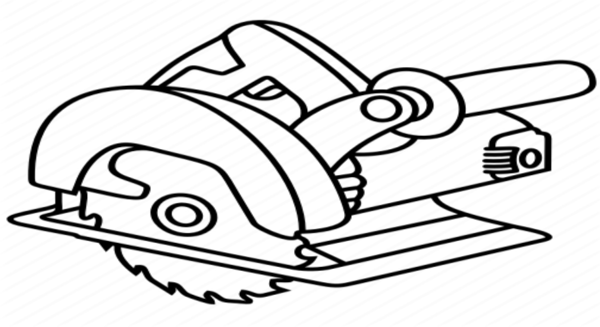
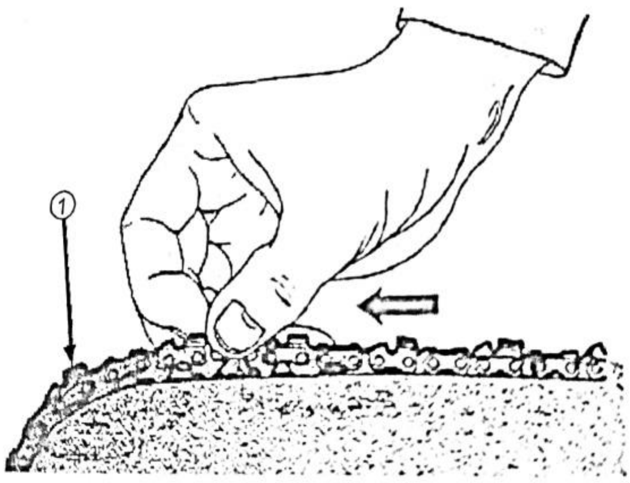


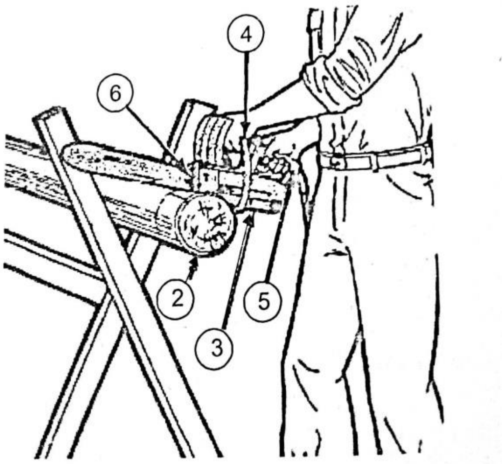
Fig.20

The circular saw is a metal disc or blade with saw teeth on the edge as well as the machine that causes the disk to spin. It is a tool for cutting wood or other materials and may be hand held or table mounted. While today they are almost exclusively powered by electricity larger ones, such as those in "saw mills", were traditionally powered by water turning a large wheel. Most of these saws are designed to plastics or metal although there are purpose-made circular saws specially designed for particular materials.

i) The electric chain saw



1. Make sure power source is disconnected. Before using, ensure that the chain teeth (1) are in the proper position (saw should cut in direction of arrow).
2. Check the teeth to make sure they are sharp and undamaged.
3. Ensure that the work (2) is stationary and well secured to prevent slippage or movement.



4. Connect chain saw to power source.
5. Stand to the left of the saw (3) with your left hand on the front handle (4) and your right hand on the rear handle (5).
6. With your weight evenly distributed, depress trigger to start Saw
7. Cut with the spike bar (6) set firmly against the wood and apply light pressure.
8. Continue to guide the chain saw through the work until cut is completed.

1.4 DEMONSTRATING OF VARIOUS MEHTODS OF PAINTING VARIOUS ITEMS

Job-V Preparation of surface before painting
Job-VI Application of primer coat
Job-VII Painting wooden items by brush/roller/spray.

The final stage of most construction projects is the application of protective coatings, or "painting." As with all projects, you should follow the plans and specifications for surface preparation and application of the finish coat. The specifications give all the information you need to complete the tasks. But, to have a better understanding of structural coatings, you need to know their purposes, methods of surface preparation, and application techniques.

1.6.1 Purposes of Structural Coatings

The protection of surfaces is the most important consideration in determining the maintenance cost of structures. Structural coatings serve as protective shields between the base construction materials and elements that attack and deteriorate them. Regularly programmed structural coatings offer long-range protection, extending the useful life of a structure.

a) Preventive maintenance

The primary purpose of a structural coating is protection. This is provided initially with new construction and maintained by a sound and progressive preventive maintenance program. Programmed painting enforces inspection and scheduling. A viable preventive maintenance program will help ensure that minor problems are detected at an early stage-before they become major failures later. An added advantage derived from preventive maintenance is the detection of faulty structural conditions or problems caused by leakage or moisture.

Resistance to moisture from rain, snow, ice, and condensation constitutes perhaps the greatest single protective characteristic of paint, the most common type of structural coating. Moisture causes metal to corrode and wood to swell, warp, or rot. Interior wall finishes of buildings can be ruined by moisture entering through neglected exterior surfaces. Porous masonry is attacked and destroyed by moisture. Therefore, paint films must be as impervious to moisture as possible to provide protective, water-proof film over the surface to which they are applied. Paint also acts as a protective film against acids, alkalies, material organisms, and other damaging elements.

b) Sanitation and cleanliness

Painting is an essential part of general maintenance programs for hospitals, kitchens, mess halls, offices, warehouse, and living quarters. Paint coatings provide smooth, non-absorptive surfaces that are easily washed and kept free of dirt and foodstuffs. Adhering foodstuffs harbor germs and cause disease. Coating rough or porous areas seals out dust and grease that would otherwise be difficult to remove. Odorless paints are used in these areas because conventional paint solvent odors are obnoxious to personnel. In food preparation areas, the odors may be picked up by nearby food.

c) Fire retardance

Certain types of structural coatings delay the spread of fire and assist in confining a fire to its area of origin. Fire-retardant coatings should not be considered substitutes for conventional paints. The use of fire-retardant coatings is restricted to areas of highly combustible surfaces, and must be justified and governed by the specific agency's criteria. Fire-retardant coatings are not used in buildings containing automatic sprinkler systems.

d) Camouflage

Camouflage paints have special properties, making them different from conventional paints. Their uses are limited to special applications. Do not use camouflage paints as substitutes for conventional paints. Use this paint only on exterior surfaces to render buildings and structures inconspicuous by blending them in with the surrounding environment.

e) Illumination and visibility

White and light-tinted coatings applied to ceilings and walls reflect both natural and artificial light and help brighten rooms and increase visibility. On the other hand, darker colors reduce the amount of reflected light. Flat coatings diffuse, soften, and evenly distribute illumination, whereas gloss finishes reflect more like mirrors and may create glare. Color contrasts improve visibility of the painted surface, especially when paint is applied in distinctive patterns. For example, white on black, white on orange, or yellow on black can be colours seen at greater distances than single colors or other combinations of colours.

f) Identification and safety

Certain colors are used as standard means of identifying objects and promoting safety. For example, fire protection equipment is painted red. Containers for Kerosene, gasoline, solvents, and other flammable liquids should be painted a brilliant yellow and marked with large black letters to identify their contents. The colors of signal lights and painted signs help control traffic safely by providing directions and other travel information.

1.6.2 Methods

The common methods of applying paint are brushing, rolling, and spraying. The choice of method is based on several factors, such as speed of application, environment, type and amount of surface, type of coating to be applied, desired appearance of finish, and training and experience of painters. Brushing is ideal for small surfaces and odd shapes or for cutting in corners and edges. Rolling and spraying are efficient on large, flat surfaces. Spraying can also be used for round or irregular shapes.

Local surroundings may prohibit the spraying of paint because of fire hazards or potential damage from over-spraying (accidentally getting paint on adjacent surfaces). When necessary, adjacent areas not to be coated must be covered when spraying is performed. This results in loss of time and, if extensive, may offset the speed advantage of spraying. Brushing may leave brush marks after the paint is dry. Rolling leaves a stippled effect. Spraying yields the smoothest finish, if done properly. Lacquer products, such as vinyls, dry rapidly and should be sprayed. Applying them by brush or roller may be difficult, especially in warm weather or outdoors on breezy days. The painting method requiring the most training is spraying. Rolling requires the least training.

1.6.3 Wood Preservatives

There are three destructive forces against which most wood protective measures are directed: biological deterioration (wood is attacked by a number of organisms), fire, and physical damage.

In this section, we'll deal with protecting wood products against biological deterioration. Damage to wood buildings and other structures by termites, wood bores, and fungi is a needless waste. The ability of wood to resist such damage can be greatly increased by proper treatment and continued maintenance. Wood defects are also caused by improper care after preservation treatment. All surfaces of treated wood that are cut or drilled to expose the untreated interior must be treated with a wood preservative.

1.6.4 Application Methods

There are two basic methods for treating wood: pressure and non-pressure. Pressure treatment is superior to non-pressure, but costly and time consuming. Building specifications dictate which method to use.

a) Pressure

The capacity of any wood to resist dry rot, termites, and decay can be greatly increased by impregnating the wood with a general purpose wood preservative or fungicide. It's important to remember that good pressure treatment adds to the service life of wood in contact with wood preservative or fungicide. It's important to remember that good damp ground. It does not, however, guarantee the wood will remain different timber species do not treat with equal ease. Different woods serviceable throughout the life of the building it supports. Woods o have different capacities for absorbing preservatives or other liquids.

In any given wood, sapwood is more absorbent than heartwood. Hardwoods are, in general, less absorbent than softwoods. Naturally, the extent to which a preservative protects increases directly with the depth it penetrates below the surface of the wood. As we just mentioned, the best penetration is obtained by a pressure method.

b) Non-pressure

Non-pressure methods of applying preservatives to a surface include dipping, brushing, and spraying. Figure.21 shows how you can improvise long tanks for the dipping method.

Absorption is rapid at first, then much slower. A rule of thumb holds that in 3 minutes wood absorbs half the total amount of preservative it will absorb in 2 hours. However, the extent of the penetration depends upon the type of wood, its moisture content, and the length

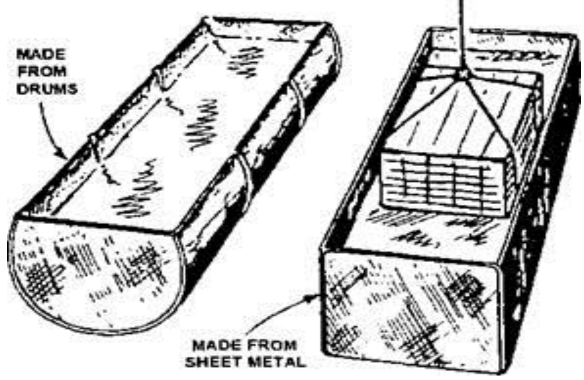


Fig.21 Improvised tanks for dip treating lumber

of time it remains immersed. Surface application by brush or spray is the least satisfactory method of treating wood from the standpoint of maximum penetration. However, it is more or less unavoidable in the case of already installed wood, as well as treated wood that has been cut or drilled to expose the untreated interior.

1.6.5 Preparation of Wood Surface

Before being painted, a wood surface should be closely inspected for loose boards, defective lumber, protruding nail heads, and other defects or irregularities. Loose boards should be nailed tight, defective lumber should be replaced, and all nail heads should be counter sunk.

A dirty wood surface is cleaned for painting by sweeping, dusting- and washing with solvent or soap and water. In washing wood, take care to avoid excessive wetting, which tends to raise the grain. Wash a small area at a time, then rinse and dry it immediately. Wood that is to receive a natural finish (meaning not concealed by an opaque coating) may require bleaching to a uniform or light color. To bleach, apply a solution of 1 pound of oxalic acid to 1 gallon of hot water. More than one application may be required. After the solution has dried, smooth the surface with fine sandpaper.

1.6.6 Types of Coatings

As a Builder, you must consider many factors when selecting a coating for a particular job. One Important factor is the type of coating, which depends on the composition and properties of the ingredients. Paint is composed of various ingredients, such as pigment, nonvolatile vehicle, binder, and solvent, or thinner. Other coatings may contain only a single ingredient.

1.6.7 Paint

In this section, we'll cover the basic components of paint pigment, vehicles, and solvents and explain the characteristics of different types of paint.

1.6.8 Composition

Paint is composed of two basic ingredients: pigment and a vehicle. A thinner may be added to change the application characteristics of the liquid.

a) Pigment

Pigments are insoluble solids, ground finely enough to remain suspended in the vehicle for a considerable time after thorough stirring or shaking. Opaque pigments give the paint its hiding, or covering, capacity and contribute other properties (white lead, zinc oxide, and titanium dioxide are examples). Color pigments give the paint its color. These may be inorganic, such as chrome green, chrome yellow, and iron oxide, or organic, such as toluidine red and phthalocyanine blue. Transparent or extender pigments contribute bulk and also control the application properties, durability, and resistance to abrasion of the coating. There are other special-purpose pigments such as those enabling paint to resist heat, control corrosion, or reflect light.

b) Vehicles or binders

The vehicle, or binder, of paint is the material holding the pigment together and causing paint to adhere to a surface. In general, paint durability is determined by the resistance of the binder to the exposure conditions. Linseed oil, once the most common binder, has been replaced, mainly by the synthetic alkyd resins. These result from the reaction of glycerol phthalate and oil and may be made with almost any property desired. Other synthetic resins, used either by themselves of mixed with oil, include phenolic resin, vinyl, epoxy, urethane, polyester, and chlorinated rubber. Each has its own advantages and disadvantages. When using these materials, it is particularly important that you exactly follow the manufacturers' instructions.

c) Solvents or thinners

The only purpose of a solvent, or thinner, is to adjust the consistency of the material so that it can be applied readily to the surface. The solvent then evaporates, contributing nothing further to the film. For this reason, the cheapest suitable solvent should be used. This solvent is likely to be naphtha or mineral spirits. Although turpentine is sometimes used, it contributes little that other solvents do not cost much more.

1.6.9 Types of Paint

Paints, by far, comprise the largest family of structural coatings you will be using to finish products, both interior and exterior. In the following section, we'll cover some of the most commonly encountered types.

a) Oil-based paints

Oil-based paints consist mainly of a drying oil (usually linseed) mixed with one or more pigments. The pigments and quantities of oil in oil paints are usually selected on the basis of cost and their ability to impart to the paint the desired properties, such as durability, economy, and color. An oil-based paint is characterized by easy application and slow drying. It normally chalks in such a manner as to permit recoating without costly surface preparation. Adding small amounts of varnish tends to decrease the time it takes an oil based paint to dry and to increase the paint's resistance to water. Oil-based paints are not recommended for surfaces submerged in water.

b) Enamel

Enamels are generally harder, tougher, and more resistant to abrasion and moisture penetration than oil-based paints. Enamels are obtainable in flat, semi-gloss, and gloss. The extent of pigmentation in the paint or enamel determines its gloss. Generally, gloss is reduced by adding lower cost pigments called extenders, typical extenders are calcium carbonate (whiting), magnesium silicate (tale), aluminum silicate (clay), and silica. The level of gloss depends on the ratio of pigment to binder.

c) Epoxy

Epoxy paints area combined resin and a polyamide hardener that are mixed before use. When mixed, the two ingredients react to form the end product. Epoxy paints have a limited working, or pot, life, usually one working day. They are outstanding in hardness, adhesion, and flexibility plus, they resist corrosion, abrasion, alkali, and solvents. The major uses of epoxy paints are as tile-like glaze coatings for concrete or masonry, and for structural steel in corrosive environments. Epoxy paints tend to chalk on exterior exposure; low gloss level and fading can be anticipated. Otherwise, their durability is excellent.

d) Latex

Latex paints differ from other paints in that the vehicle is an emulsion of binder and water. Being water-based, latex paints have the advantage of being easy to apply. They dry through evaporation of the water. Many latex paints have excellent durability. This makes them particularly useful for coating plaster and masonry surfaces. Careful surface preparation is required for their use.

e) Rubber-based

Rubber-based paints are solvent thinned and should not be confused with latex binders (often called rubber-based emulsions). Rubber-based paints are lacquer-type products and dry rapidly to form finishes highly resistant to water and mild chemicals. They are used for coating exterior masonry and areas that are wet, humid, or subject to frequent washing, such as laundry rooms, showers, washrooms, and kitchens.

f) Portland cement

Portland cement mixed with several ingredients acts as a paint binder when it reacts with water. The paints are supplied as a powder to which the water is added before being used. Cement paints are used on rough surfaces, such as concrete, masonry, and stucco. They dry to form hard, flat, porous films that permit water vapor to pass through readily. When properly cured, cement paints of good quality are quite durable. When improperly cured, they chalk excessively on exposure and may present problems in repainting.

g) Aluminum

Aluminum paints are available in two forms: ready mixed and ready to mix. Ready-mixed aluminum paints are supplied in one package and are ready for use after normal mixing. They are made with vehicles that will retain metallic brilliance after moderate periods of storage. They are more convenient to use and allow for less error in mixing than the ready-to-mix form. Ready-to-mix aluminum paints are supplied in two packages: one containing clear varnish and the other, the required amount of aluminum paste (usually two-thirds aluminum flake and one-third solvent). You mix just before using by slowly adding the varnish to the aluminum paste and stirring. Ready-to-mix aluminum paints allow a wider choice of vehicles and present less of problem moisture in the closed container. When present, moisture may react with the aluminum flake to form hydrogen gas that pressurizes the container. Pressure can cause the container to bulge or pop the cover off the container. Check the containers of ready- paints for bulging.

If they do, puncture the covers carefully before opening to relieve the pressure. Be sure to use dry containers when mixing aluminum paints.

h) Surface preparation

Surface preparation is a critical step in coating operations, regardless of the type of substrate. As previously reviewed, there are unique aspects to wood surfaces relating to surface degradation and moisture content. Once these issues have been resolved, surface preparation can be addressed. As always, grease, oil, dirt or other debris should first be cleaned from surfaces. Methods of surface preparation for new existing wood are whether existing surfaces have been previously painted. The surface condition of the wood to which the finish is to be applied can substantially affect the performance and hence the life expectancy of the finish. The following procedures should prove helpful.

i) New wood

New wood should be protected from the weather before, during and after construction. It is seldom necessary to carry out extensive surface preparation providing the wood has not weathered for more than two weeks and is clean and dry. If it has been contaminated by dirt, oil and other foreign substances they must be removed.

For smooth-planed, flat-grained cedar, some surface preparation may be desirable. On flat-grained wood, the surface should be scuff-sanded with 50-60 grit sandpaper. This procedure will greatly increase the coatings performance but will not detract from a smooth finish. Surface preparation is not necessary for textured cedar.

j) Weathered new wood

Weathered new wood that has been exposed to the elements for longer than 2 weeks may have a degraded surface that is unsuitable for painting. Preparing the surface by sanding, brushing, and washing before applying the finish is recommended.

k) Paint finishes

Paint finishes must be removed if the old surface is severely peeled blistered, or if cross- grain checking has occurred because of excessive paint builds up. The removal of a film- forming finish is also necessary if a penetrating stain or water repellent finish is to be applied to previously painted or solid color stained surface. Note that changing from a film forming to a penetrating finish sometimes does not give satisfactory results because residual paint inhibits absorption Finishes can be removed by sanding, wet sandblasting, pressurized water spray, electrically heated paint removers and chemicals. Although quick and easy, sandblasting and pressurized water spray are not recommended unless extreme care is taken to avoid damage to the wood's surface. Special precautions to ensure worker safety must be taken if the old paint is of the lead based type.

l) Weathered water-repellent preservative finishes

Weathered water-repellent preservative finishes should be cleaned with a non-ferrous bristle brush to remove loose fibers and dirt. If the surface is soiled, it may be scrubbed with a mild detergent solution. If mildew is present, it should be controlled. The surface should be thoroughly rinsed and allowed to dry completely before refinishing.

Caution: - Never mix bleach with detergent containing ammonia as the fumes can be harmful or fatal.

m) Weathered penetrating stains

Weathered penetrating stains on mildew-free surfaces are relatively easy to refinish. Excessive scraping or sanding is not required. A stiff, non-ferrous bristle brush may be used to remove surface dirt, dust and loose wood fibers before applying the stain.

n) The truth about "Mill Glaze"

Western Red Cedar is classified as a durable wood species, dimensionally stable, and suitable for a wide variety of coatings and finishes. It is these characteristics that make Western Red Cedar suitable for exterior use for many outdoor applications.

It has been proven through field studies and research that Western Red Cedar is an excellent substrate for coatings and finishes. When comparisons are made between Western Red Cedar and other wood species, Western Red Cedar outperforms them all.

Poor practices at construction sites, building design, and improper installation all have a negative impact on the performance of Western Red Cedar and coatings applied to it.

Many of the uninformed have attributed some coating failures on Western Red Cedar to “Mill Glaze". They state that a varnish like glazing of extractives, resins, and sap will develop on the surface of the wood during the planning process interfering with the adhesion of the coating.

Western Red Cedar does not contain any sap or resins that can migrate to the surface. Western Red Cedar does contain extractives that make it resistant to insects and decay but they are not resinous or sap like. If Western Red Cedar became hot during the planning process, the surface would show burn marks. Researchers at the U.S. Forest Products.

Laboratory has not been able to duplicate paint failure by "glazing at the surface".

The typical scenario where a coating company will cite mill glaze as the cause for coating failure on Western Red Cedar siding is:

- No primer
- One coat of solid color stain
- Spray applied
- Siding left exposed to the weather 4 weeks or more

- No building paper
- House with little or no overhang
- Siding delivered and stored unprotected on the ground where it took on moisture
- Siding not back-primed
- Blistering paint with water in the blisters

It is proven that textured surfaces hold coatings better than smooth surfaces. If the smooth face of Western Red Cedar is the graded face and the exposed face, light sanding will improve the performance of any finish.

STUDENT ACTIVITY

1. Write notes on common types of Indian timber.

2. Write notes on selection of a timber.

SUMMARY

- Carpentry deals with use of various wood- working tools and machines.
- Timber is the basic material used for any class of wood working. The wood obtained from a fully- grown tree is cut and is prepared for engineering proposes. The wood is known as timber.
- Preservation of timber is very important for increasing its life. It is always better to keep the wood dry to avoid the attack of fungi and other insects.
- Carpentry work involves the direct use of various materials (besides the wood) mostly for the purpose of joining wooden pieces for making an assembly or for protection, preservation and giving desired finish to the wood.
- A dovetail joint or simply dovetail is a joint technique most commonly used in woodworking joinery.
- The protection of surfaces is the most important consideration in determining the maintenance cost of structures.
- The primary purpose of a structural coating is protection. This is provided initially with new construction and maintained by a sound and progressive preventive maintenance program.
- Paint is composed of two basic ingredients: pigment and a vehicle. A thinner may be added to change the application characteristics of the liquid.
- Pigments are insoluble solids, ground finely enough to remain suspended in the vehicle for a considerable time after thorough stirring or shaking.

SELF-ASSESSMENT QUESTIONS

Q1. What is difference between wood and timber?

Q2. Mention common defects of wood.

Q3. What are the characteristics of a good preservative of timber?

Q4. Give method of preparation of Dovetail joint.

Q5. Explain method of preparation of mitre joint.

Q6. Describe method of preparation of lengthening joint.

Q7. Describe preparation of surface before painting.

Q8. Write short notes on:-

- **a)** Common methods of wood seasoning
- **b)** Types of preservatives
- **c)** Application of primber coat
- **d)** Selection of timber.

SECTION – B

2 FITTING SHOP

LEARNING OBJECTIVES

- Drill
- Taps and Dies
- Using a Hand Tap
- Care and Maintenance of Measuring Tools
- Height Gauge
- Files
- Preparation of Job Involving Threads
- Using a Pipe Threading Set
- Care of Pipe Cutters and Threading Sets

2.1 DRILL

(Description and demonstration of various types of drill, tapes and dies, Selection of dies, types of tapes, tapping, dieing and drilling operations.)

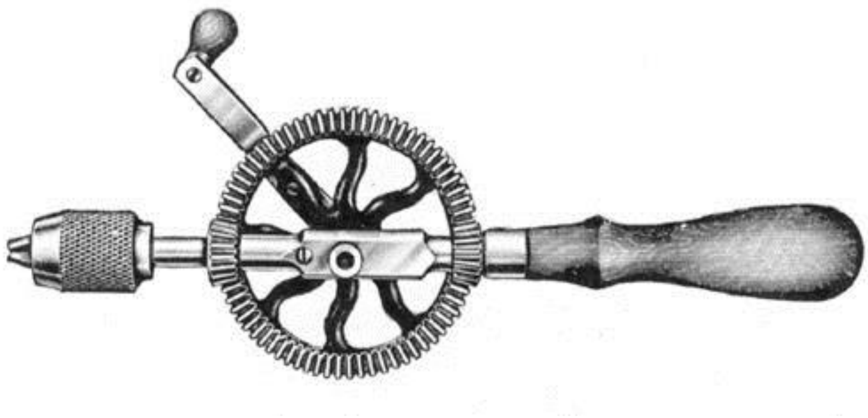


Fig.1

Various types of the drills are used to make the hole in wood or metal sheet. Drill is applied at the drill machine for that purpose.

a) Brace drill

The brace drill is made up of the following parts: head (1), crank (2), crank handle (3), ratchet mechanism (4), and chuck (5). The brace is used to drill holes in wood and with a screwdriver bit, remove and install screws.

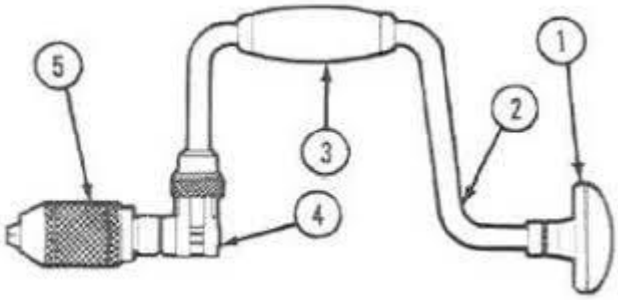


Fig.2

b) Breast drill

The breast drill is made up of the following parts: breast plate. (1), drive handle (2), speed shifter (3), side handle (4), speed gears (5), pinion gears (6), and chuck (7). The adjustable breast plate provides a base for the user to lean against while using the drill. The speed shifter provides a means of selecting high speed or low speed. This allows the operator to start a hole at slow speed, 1:1 ratio, preventing marring of the surface, then shifting to high speed, 3-1/2:1 ratio, to finish drilling the hole. To change from low speed to high speed, move the drive handle and speed gears from the bottom hole to the top hole. High speed position is illustrated. Some drills have a slot instead of two holes. The side handle provides a way to steady the drill and insure that the bit is boring a straight hole. The speed gears determine the speed at which the drill rotates. They are connected through linkage to the pinion gears. The pinion gears turn the chuck and drill. The breast drill is used to drill holes in wood, plastic, concrete, and small gage sheet metal.

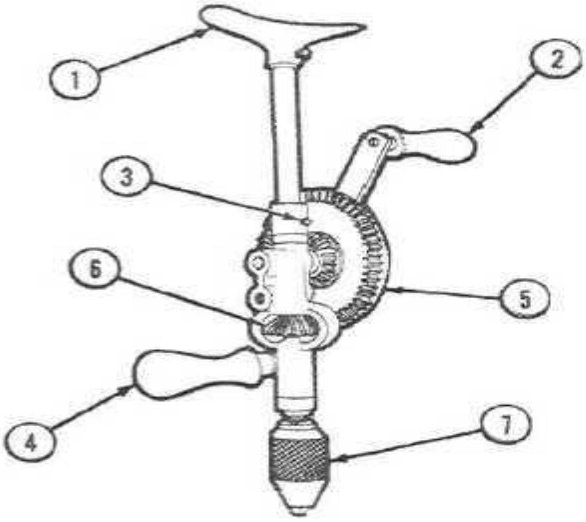
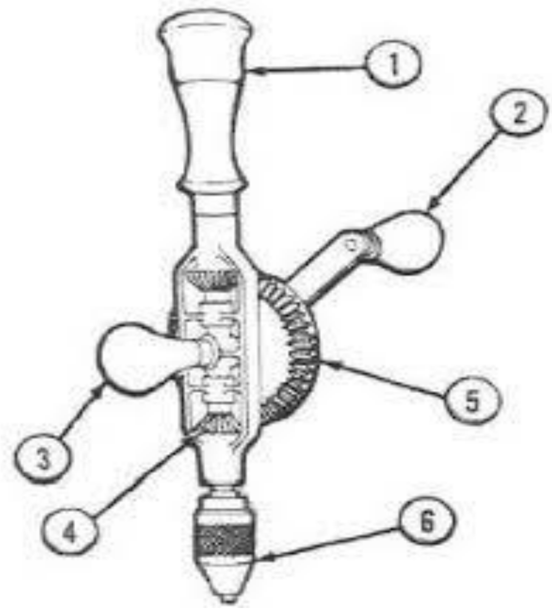


Fig.3

c) Hand drill

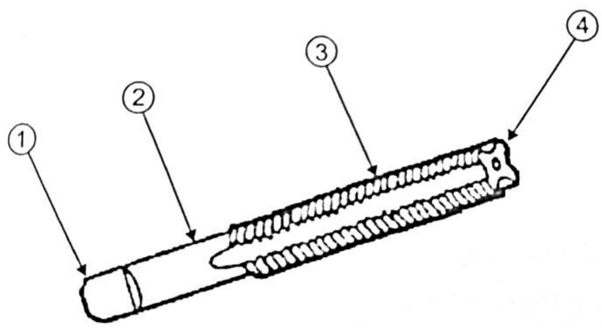
The hand drill is made up of the following parts: handle (1), drive handle (2), side handle (3) pinion (4), gear wheel (5) and chuck (6). The handle provides a storage area for drill bits. The side handle may be used to steady the drill when drilling in soft wood. The pinion turns the chuck and drill. Through mechanical linkage, the gear wheel transfers the driving force from the drive handle to the chuck. Hand drills are used to drill holes in wood and sheet metal.



2.2 TAPS AND DIES

Taps and dies are used to cut threads in metal, plastics or hard rubber. The taps are used for cutting internal threads, and the dies are used to cut external threads.

2.2.1 Taps



Taps are made of hardened steel and have the following parts: a square end (1) a round shank (2) a body (threaded) section (3) and a chamfer (4). The square end is used to turn the tap with either a straight or T- handled tap wrench. The shank is a smooth, rounded section which is immediately behind the threaded section. The body (threaded) section contains four flutes which have threads cut into their upper edges. They have a hollow section near the center to permit metal shavings to fall away from the cutting edges. The chamfer is the non- threaded end of the tap. It allows the tap to be positioned squarely in the metal to be threaded without engaging the threads of the tap.

a) Taper (starting) hand tap

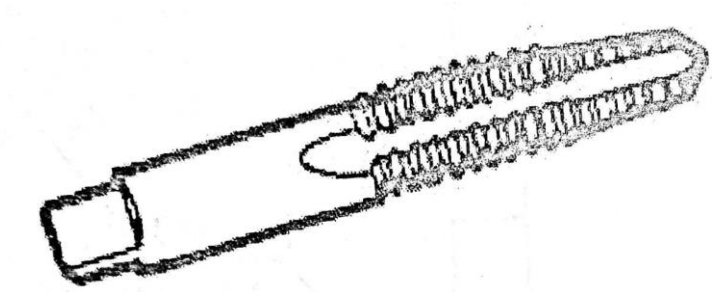


Fig.6

The taper (starting) hand tap has a chamfer (non-threaded) length equal to eight to ten threads. The taper hand tap is used to start tapping operations.

b) Bottoming hand tap

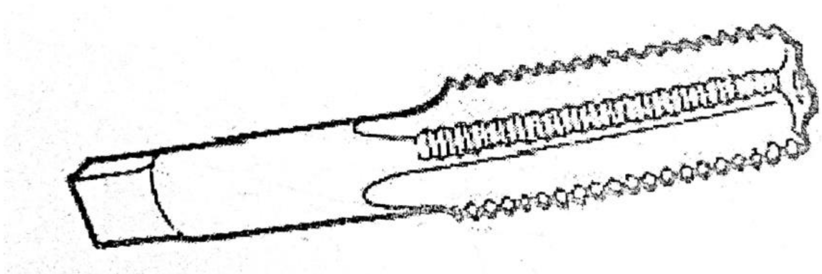


Fig. 7

The bottoming hand tap has a chamfer length equal to one to one and one-half thread. This tap is used for threading the bottom of a blind hole only after the taper and plug taps have been used. This tap is also used when tapping hard materials.

c) Plug/Pipe hand tap

The pipe tap has a tapered diameter which increases at a rate of ¾ inch per foot. All the threads on the pipe tap are designed to cut pipe. The pipe tap is used for cutting pipe fittings and in other places where extremely tight fits are required.

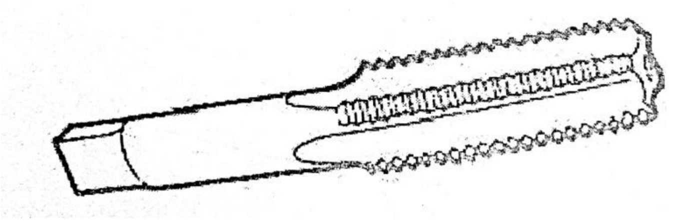


Fig.8

d) Boiler hand taps

There are two types of boiler taps, straight and tapered. Straight boiler taps range in size from 1/2 inch to 1-1/2 inches in diameter and have a chamfer for starting the tap.

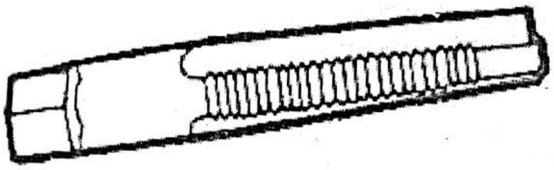


Fig.9

Tapered boiler taps have tapered diameters which increase at a rate of ¾ inch per foot.

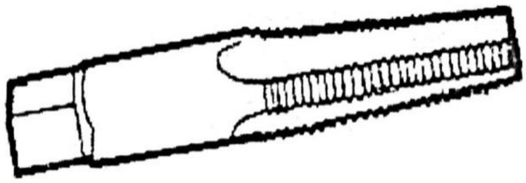


Fig.10

e) Staybolt taps

Fig.11

Staybolt taps are used in boiler, locomotive, and railroad shops for tapping holes in the outer and inner plates or shells of boilers. The staybolt tap has two separate threaded areas. The first is for cutting threads and the second is for guiding the tap into another piece of metal for threading by the cutting threads. The spindle-type staybolt has an adjustable spindle which changes the distance between the cutting threads and the guide threads.

f) Mud hand taps (washout tap)

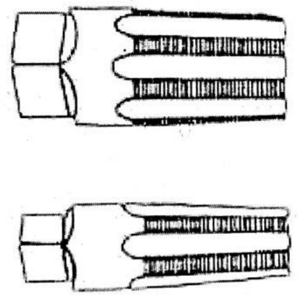


Fig.12

The mud or washout tap has six flutes, tapers 1-1/4 inch per foot, and has 12 threads per inch. It is used for cutting American National or V- form threads in mud plug drain holes.

2.2.2 Dies

a) Rethreading die

Rethreading dies are used to restore bruised (rounded) or rusty threads on screws and bolts. The rethreading die is hexagonal in shape and may be turned with a socket, box, open-end, or any other wrench that will fit. They are available in American Coarse and Fine Threads Rethreading dies are available in a variety of sizes and are usually assembled in sets with a case.

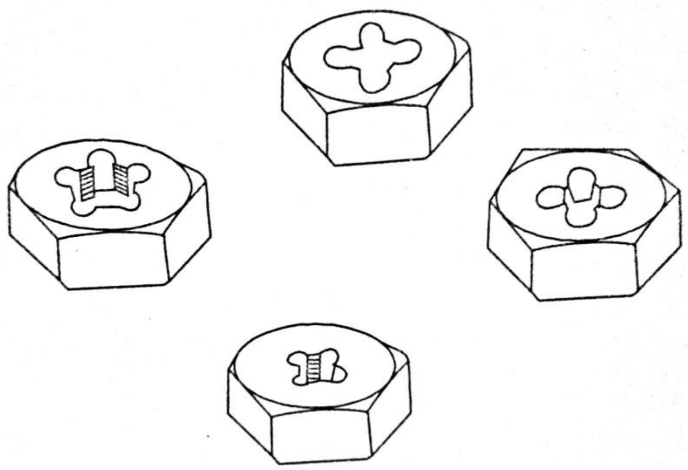


Fig.13

b) Two-piece collet die

The two-piece collet die consists of the two die sections, the collet cap, and collet guide. The die sections are placed inside the cap and held in place by the guide. Adjustment of the die is done by turning setscrews on either end of the internal slot. They are used to cut American Standard Coarse and Fine Threads and are available in assorted sizes.

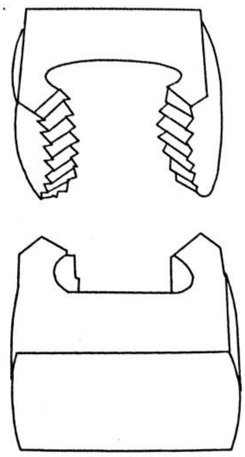


Fig.14

c) Round split adjustable die

The round split adjustable die (1), or button die, may be adjusted through the screws on the holder. Adjustment on the open type is done by turning the three screws on the holder. One expands the die while the other two compress the die. Adjustment of the screw type (2) is done by turning a fine-pitch screw that either forces the die jaws apart or allows them to spring together. The round split adjustable dies are used to cut American Standard Coarse and Fine Threads. A die holder or handle is needed for proper operation of round split adjustable dies.

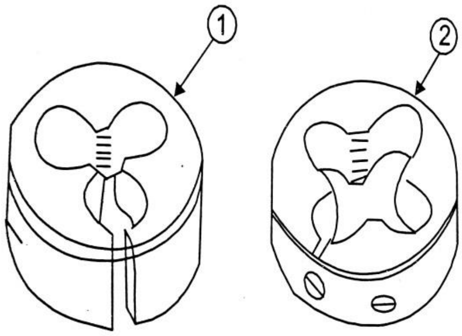


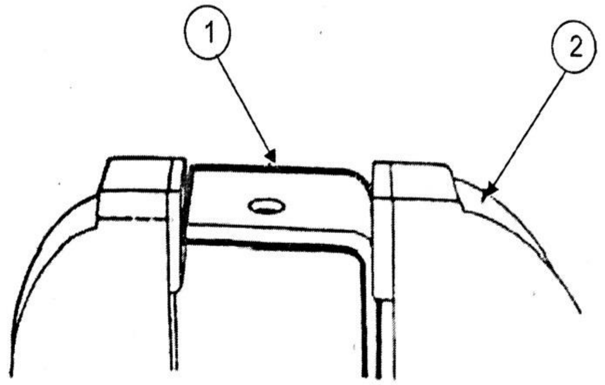
Fig.15

2.3 USING A HAND TAP

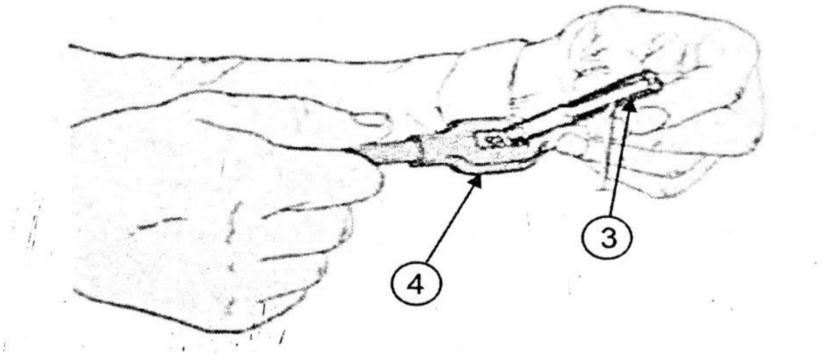
Job-I Making internal and external threads on a job by taping and dieing operation (manually) and precautions.

The following procedures may also be followed when using a taper tap or a bottoming hand tap.

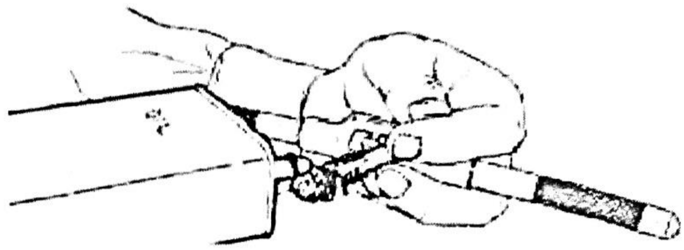
1. Clamp a steel plate (1) securely in a vise (2). Drill and ream a hole of desired size.



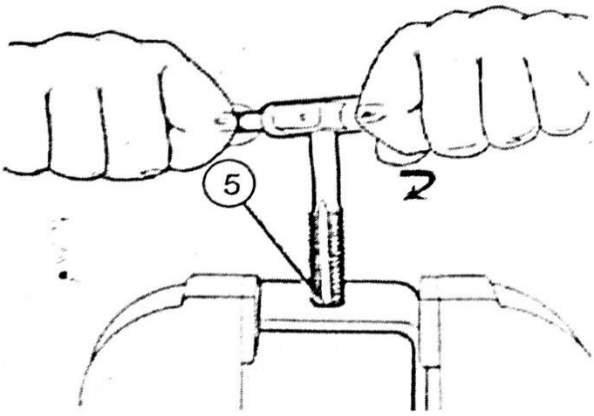
2. Select tap (3) and secure in tap wrench (4).



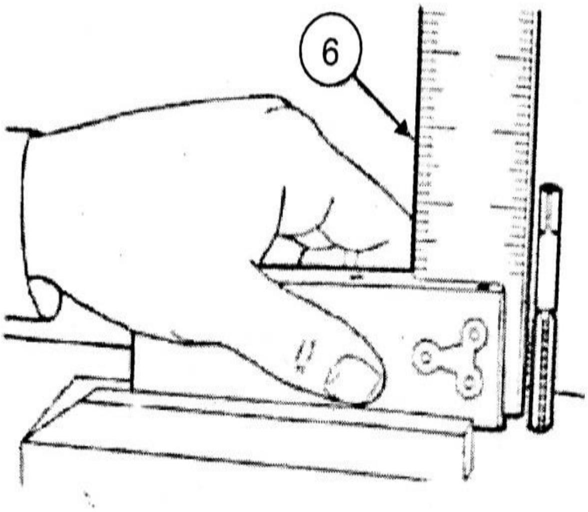
3. Apply cutting oil to the tap and the hole for left-hand threads.



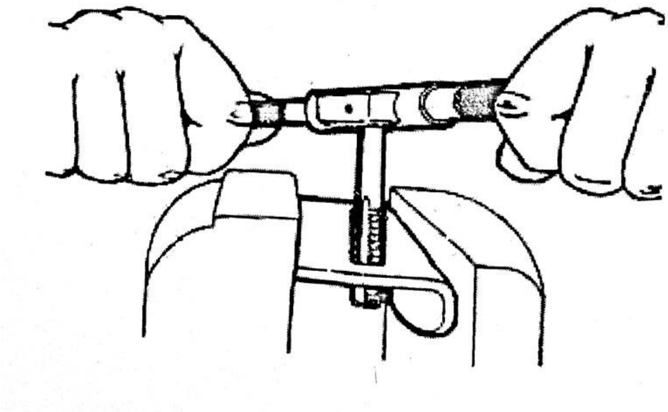
4. Place point of the tap in hole (5) and rotate clockwise for right- hand threads or rotate left- handed tap counterclockwise for left- hand threads.



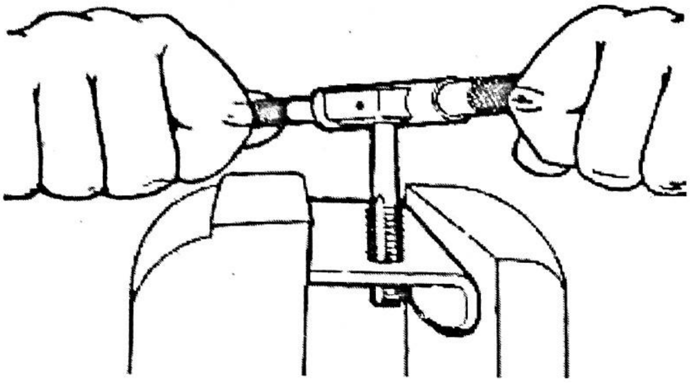
5. Remove tap wrench and, using a square (6), check tap for squareness. Check at least two different positions on the tap.



6. Replace the tap wrench and continue tapping operation is not necessary to apply pressure, as the threads will be pulled through at all times.



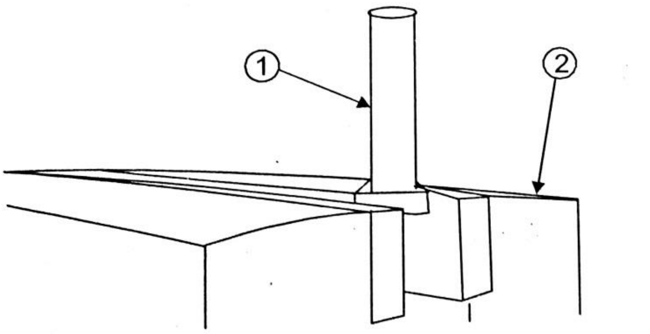
7. Remove tap by turning in the opposite direction. Wipe excess oil and metal shavings from metal plate. Check newly-cut threads with screw pitch gage before inserting screw or stud.



2.3.1 Using a Die and Diestock

Note: Work to be threaded must be clean and free of burrs.

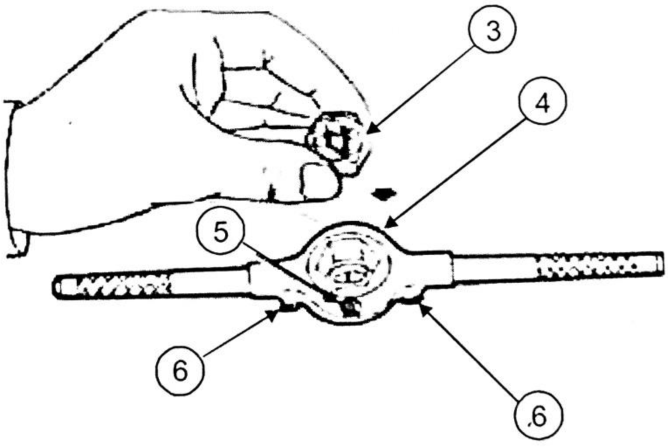
1. Secure the work (1) firmly in a vise (2).



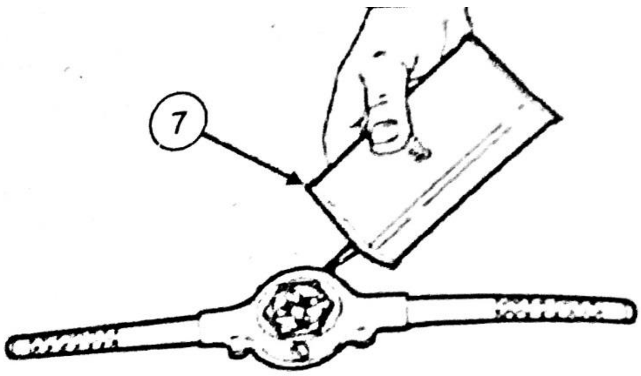
Caution

After assembling die to diestock, make sure setscrew is tight. Die could fall out of diestock causing damage to die.

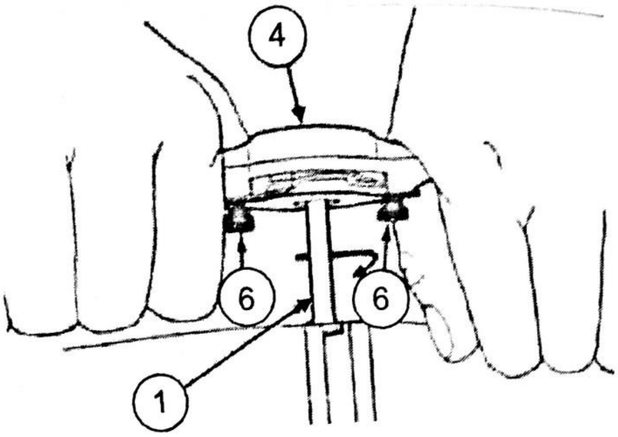
2. Assemble die (3) and diestock (4). Tighten setscrew (5). Loosen the two thumbscrews (6) to adjust diestock (4).



3. Apply cutting oil (7) to the die and to the work.



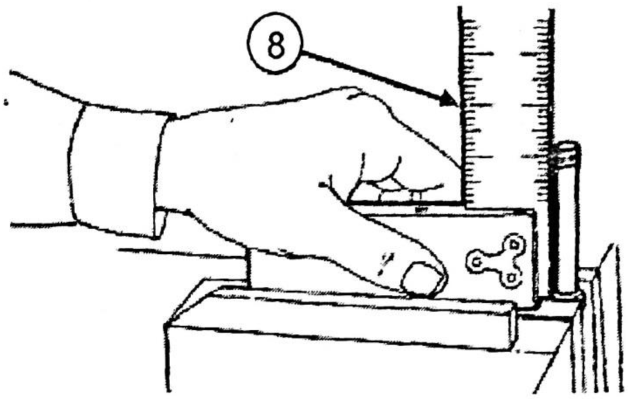
4. Position the diestock (4) over the work (1).



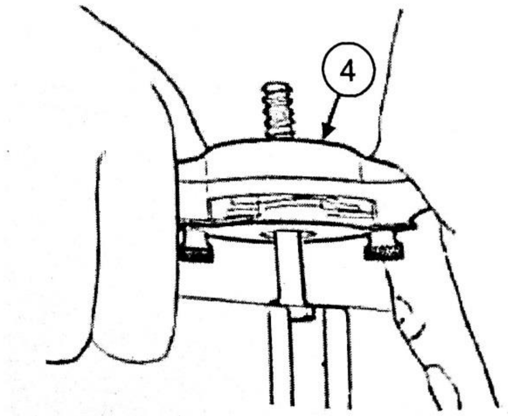
5. Tighten thumbscrews (6) securing diestock to work.

6. Rotate the diestock (4) clockwise, slowly but firmly, until the die takes hold.

7. Use square (8) to check squareness after several threads have been cut.

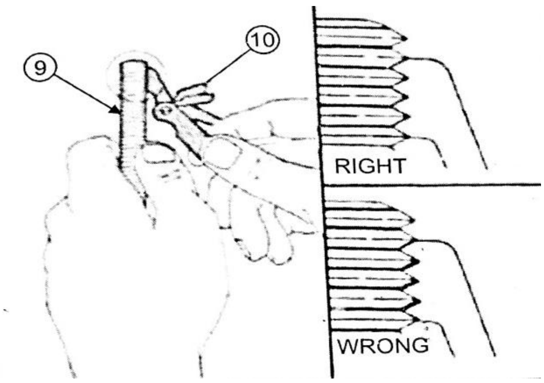


8. Turn the diestock (4) one turn forward and one-quarter turn backward. Repeat this procedure until desired thread length has been cut.

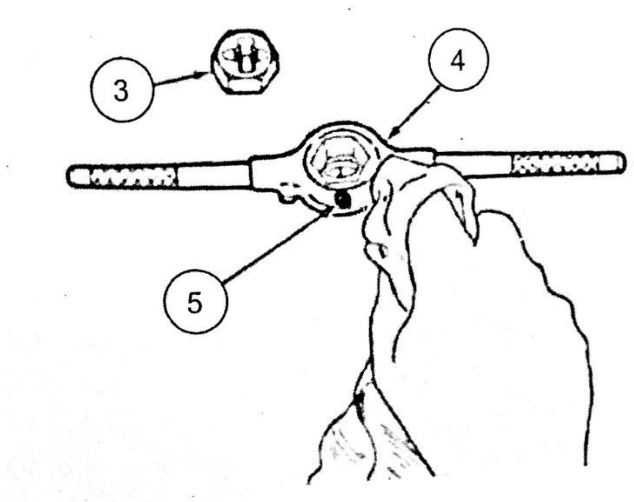


9. Carefully back the diestock (4) off the threads by turning in a counterclockwise direction.

10. Clean threads (9) with a clean rag and check with a screw pitch gage (10) before using.



11. Disassemble die (3) and diestock (4) by loosening setscrew (5). Wipe clean with a rag.



2.3.2 Care of Taps

1. Do not attempt to sharpen taps.

2. Keep cutting edges lightly oiled.

3. Wipe excess oil and metal shavings from tap and tap wrench.
4. Store them in a case or wrap individually in cloths to protect cutting surfaces.

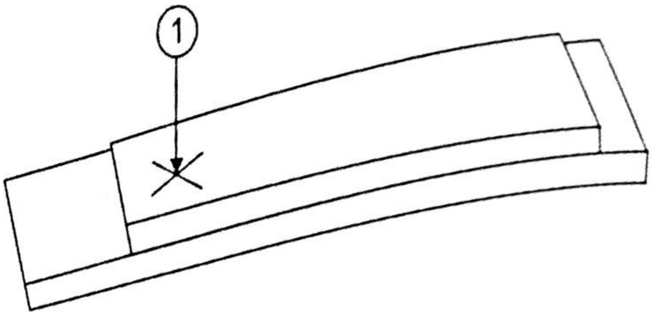
2.3.3 Care of Dies

1. Do not attempt to sharpen dies.
2. Keep cutting surfaces clean and lightly lubricated.
3. Store in a case or wrap individually in cloths where they will not come in contact with other tools.

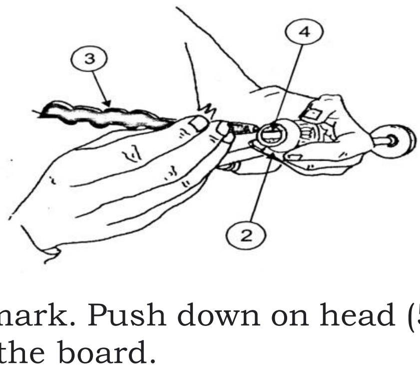
JOB - II Drilling Practice of Soft Metals (Using a Brace Drill)

The following procedure is for a bit of a fixed size from 1/4 inch up to a inch maximum.

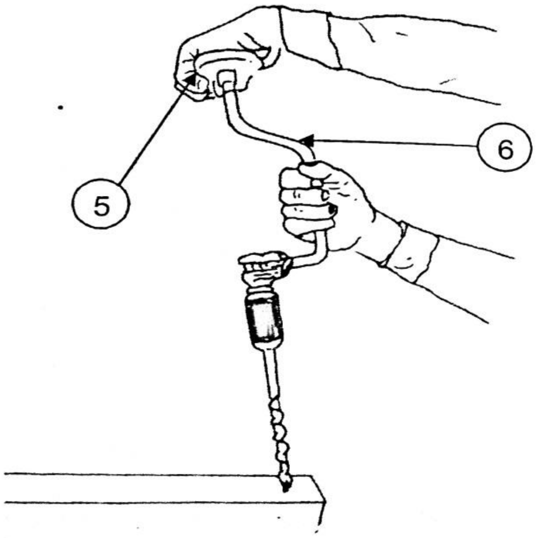
1. Mark (1) with a pencil where hole is to be drilled.



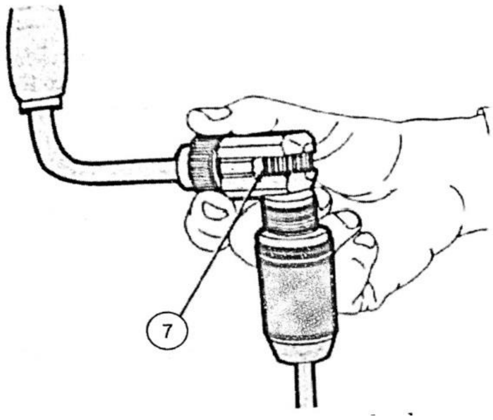
2. Open chuck (2) and insert bit (3) between jaws (4). Tighten chuck (2), securing bit (3).



3. Center bit over pencil mark. Push down on head (5) and turn crank (6) until bit goes through the board.



4. Reverse the ratchet mechanism (7), then turn crank an pull up on head to remove bit.



5. Open chuck and remove bit. Close chuck.

2.4 CARE AND MAINTENANCE OF MEASURING

No matter how small the job, safety must be practiced all times. A tool may be efficient, essential, time-saving or even convenient; but it is also dangerous. When any hand tool you must use it correctly, following methods prescribed in this manual. You must also Tool habits be alert for any conditions that might endanger yourself fellow workers. Take the time necessary to acquaint yourself with the safety guidelines in this chapter. Remember, you are the most important part of safety procedures. There will undoubtedly be a safety program to follow for the shop or area in which you will be working. The following general safety rules are furnished as a guide.

1. **Support** your local safety program and take an active part in safety meetings.

2. **Inspect** tools and equipment for safe conditions before starting work.
3. **Advise** your supervisor promptly of any unsafe conditions or practices.
4. **Learn** the safe way to do your job before you start.
5. **Think** safety, and ACT safety at all times
6. **Obey** safety rules and regulations-they are for your protection.
7. **Wear** proper clothing and protective equipment.
8. **Conduct** yourself properly at all times-horseplay is prohibited.
9. **Operate** only the equipment you are authorized to use.
10. **Report** any injury immediately to your supervisor. In addition to the above, there are other good tool habits which will help you perform your work more efficiently as well as safely.

2.4.1 Tool Habits

"A place for everything and everything in its place" is just commonsense. You cannot do an efficient, fast repair job if you have to stop and look around for each tool that you need. The following rules, if applied, will make your job easier.

1. **Keep Each Tool in its Proper Storage Place.** A tool is proper place; you will know where it is when you need it.
2. **Keep Your Tools in Good Condition.** Keep them free of rust, nicks, burrs, and breaks.
3. **Keep Your Tool Set complete.** If you are issued a tool box, each tool should be placed in it when not in use. If possible, the box should be locked and stored in a designated area. Keep an inventory list in the box and check it after each job. This will help you to keep track of your tools.
4. **Use Each Tool Only on the Job for which it was designed.** If you use the wrong tool to make an adjustment, the result will probably be unsatisfactory. For example, if you use a socket wrench that is too big, you will round off the corners of the wrench or nut. If this rounded wrench or nut is not replaced immediately, the safety of your equipment may be endangered in an emergency.
5. **Keep Your Tools within Easy Reach and Where They cannot Fall on the Floor or on Machinery.** Avoid placing tools anywhere above machinery or electrical apparatus. Serious damage will result if the tool falls into the machinery after to section chief. The equipment is turned on or running. Return broken tools
6. **Never use Damaged Tools. Notify your supervisor of broken or damaged tools.** A battered screwdriver may slip and spoil the screw slot or cause painful injury to the user. A gage strained out of shape will result

in inaccurate measurements. Remember, a worker's efficiency is often a direct result of the condition of the tools being used. Workers are often judged by the manner in which they handle and care for their tools. You should care for hand tools the same way you care for personal property. Always keep hand tools clean and free from dirt, grease, and foreign matter. After use, return tools promptly to their proper places in the tool box. Those used most frequently can be reached easily without sorting through the entire contents of the box. Avoid accumulating unnecessary items.

2.4.2 Safety Rules (Power Tools)

Safety is a very important factor in the use of power tools and cannot be overemphasized. By observing the following safety guidelines, you can ensure maximum benefits from the tools you use and reduce to a minimum the chances of serious injury.

1. Never operate any power equipment unless you are completely familiar with its controls and features.
2. Inspect all portable power tools before using them. See that they are clean and in good condition.
3. Make sure there is plenty of light in the work area. Never work with power tools in dark areas where you cannot see clearly.
4. Before connecting a power tool to a power source, be sure the tool switch is in the "OFF" position.
5. When operating a power tool, give it your FULL and UNDIVIDED ATTENTION.
6. DO NOT DISTRACT OR IN ANY WAY DISTURB another person while they are operating a power tool.
7. Never try to clear a jammed power tool until it is disconnected from the power source.
8. After using a power tool, turn off the power, disconnect the power source, wait for all movement of the tool to stop, and then remove all waste and scraps from the work area. Store the tool in its proper place.
9. Never plug the power cord of a portable electric tool into a power source before making sure that the source has the correct voltage and type of current called for on the nameplate of the tool.
10. Do not allow power cords to come in contact with sharp objects, nor should they kink or come in contact with oil, grease, hot surfaces, or chemicals.
11. Never use a damaged cord. Replace it immediately.
12. Check electrical cables and cords frequently for overheating. Use only approved extension cords, if needed.

13. See that all cables and cords are positioned carefully so they do not become tripping hazards.

14. Treat electricity with respect. If water is present in the area of electrical tool operation, be extremely cautious and if necessary, disconnect the power tool.

2.4.3 Micrometer

Micrometers are instruments used to measure distances to the nearest one-thousandth of an inch. The measurement is usually expressed or written as a decimal.

a) Reading a standard micrometer

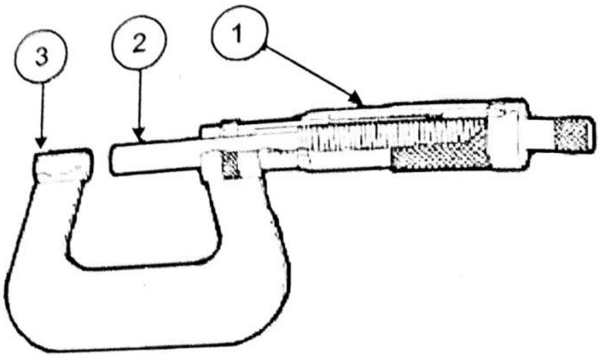


Fig.16

Reading a micrometer is only a matter of reading the micrometer scale or counting the revolutions of the thimble and adding to this any fraction of a revolution. The micrometer screw has 40 threads per inch. This means that one complete and exact revolution of the micrometer screw (1) moves the spindle (2) away from or toward the anvil (3) exactly 1/40 or 0.025 inch.

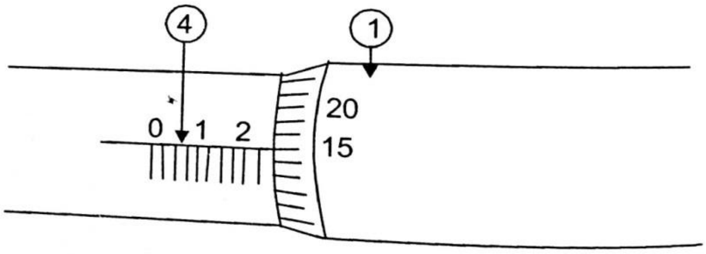


Fig.17

The lines on the barrel (4) conform to the pitch of the micrometer screw (1), each line indicating 0.025 inch, and each fourth line being numbered 1, 2, 3, and so forth. The beveled edge of the thimble is graduated into 25 parts, each line indicating 0.001 inch, or 0.025 inch covered by one complete and exact revolution of the thimble. Every fifth line on the thimble is numbered to read a measurement in thousandths of an inch.

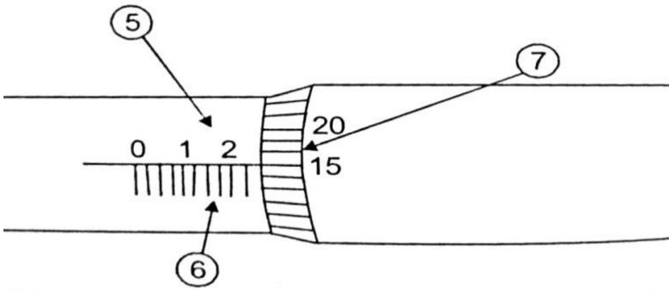


Fig.18

b) To read a measurement as shown above

1. Read highest figure 18, visible on barrel (5) = 2 = 0.200 in.
2. Number of lines visible between the No. 2 and thimble edge (6)=1 = 0.025 in.
3. The line on the thimble that coincides with or has passed the revolution or long line in the barrel (7)=16 = 0.016 in.
4. TOTAL = 0.241 in.

c) Reading a vernier micrometer

Reading the vernier micrometer is the same as reading the standard micrometer. An additional step must be taken, to add the vernier reading to the dimensions. This allows for precise measurements which are accurate to ten-thousandths (10,000) of an inch. This scale furnishes the fine readings between the lines on the thimble rather than making an estimate as you would on a standard micrometer.

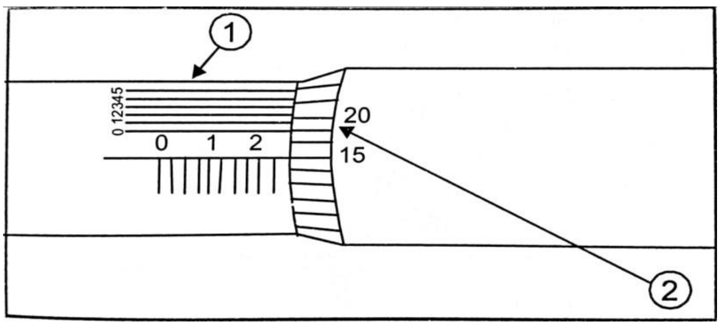


Fig.19

The ten spaces on the vernier (1) are equivalent to 9 spaces on the thimble (2). Therefore, each unit on the vernier scale is equal to 0.0009 inch and the difference between the sizes of the units on each scale is 0.0001 inch.

d) To read a measurement as shown above

1. Read highest figure B 20, viaible on barrel (3) 2- 0.200
2. Number of lines visible between the No. 2 and thimble edge (4) = 30 = 0.75.

3. The line on the thimble that coincides with or is nearest the in revolution or long line in the barrel (5)-11=0.011 in.

4. The line on the vernier scale that coincides with the line on the thimble (6) - 2 = 0.0002 in.

5. TOTAL = .2862 in.

e) Care of micrometers

1. Coat metal parts of all micrometers with a light coat of oil to prevent rust.

2. Store micrometers in separate containers provided by manufacturer.

3. Keep graduations and markings on all micrometers clean and legible.

4. Do not drop any micrometer. Small nicks or. Scratches can cause inaccurate measurements.

2.5 HEIGHT GAUGE

A height gauge is used in the layout of jigs and fixtures. On a bench, it is used to check the location of holes and surfaces. It accurately measures and marks off vertical distances from a plane surface. The vernier height gauge is a caliper with a special base (1) to adapt it for use on a surface plate. Height gauges are available in several sizes. Most common are the 10, 18, and 24-inch gauges in English measure. The most common metric gauges are the 25 and 46-centimeter sizes. Height gauges are classified by the dimension they will measure above the surface plate. Like the vernier caliper, height gauges are graduated in divisions of 0.025 inch. Its vernier scale is divided into 25 units for reading thousandths of an inch.

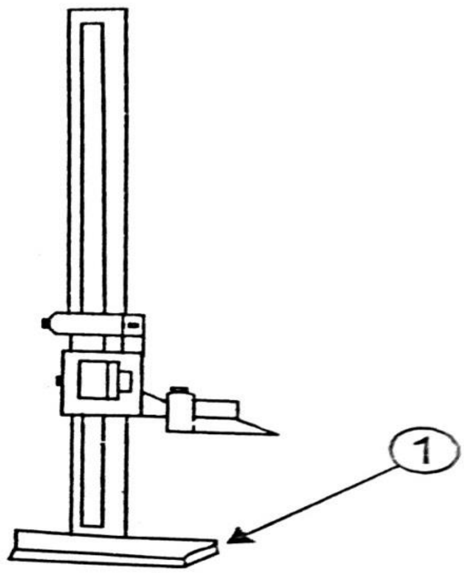


Fig.21

2.5.1 Carpenter's Square

The carpenter's square is made up of two parts: the body or blade, and the tongue. It has inches divided into eighths, tenths, twelfths, and sixteenths.

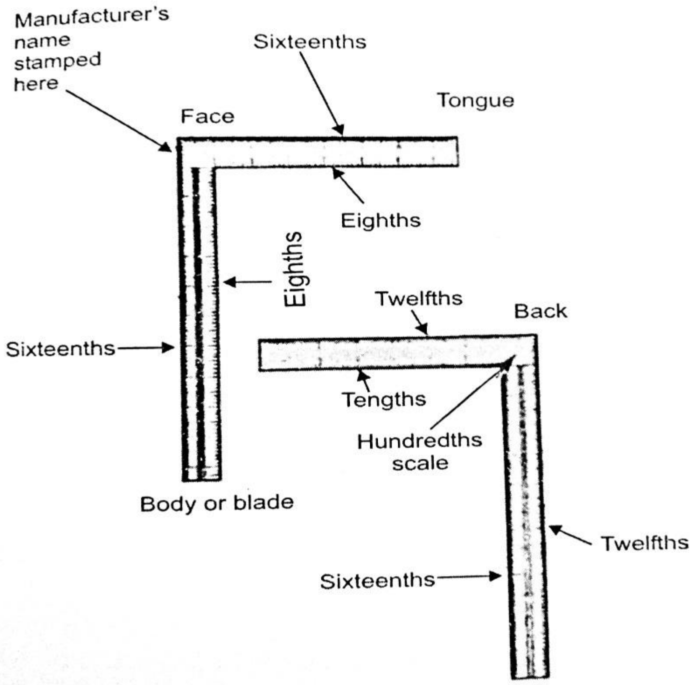


Fig.22

Try Square

Try Square The try square is made of a steel or wood stock (1) and a blade (2). The blade is from 2 to 12 inches long and is graduated in eighths. The try square is used to set or check lines which are at right angles (90 degrees) to each other.

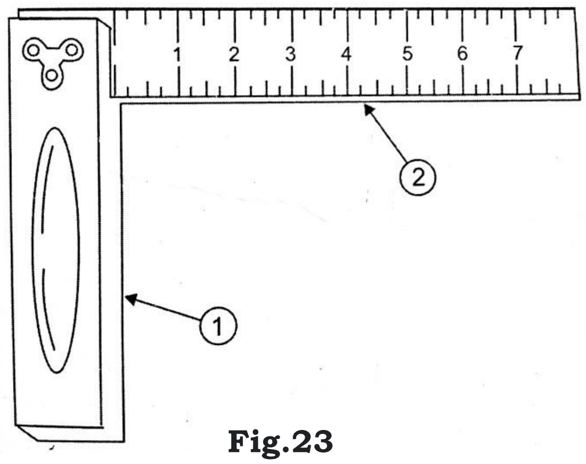
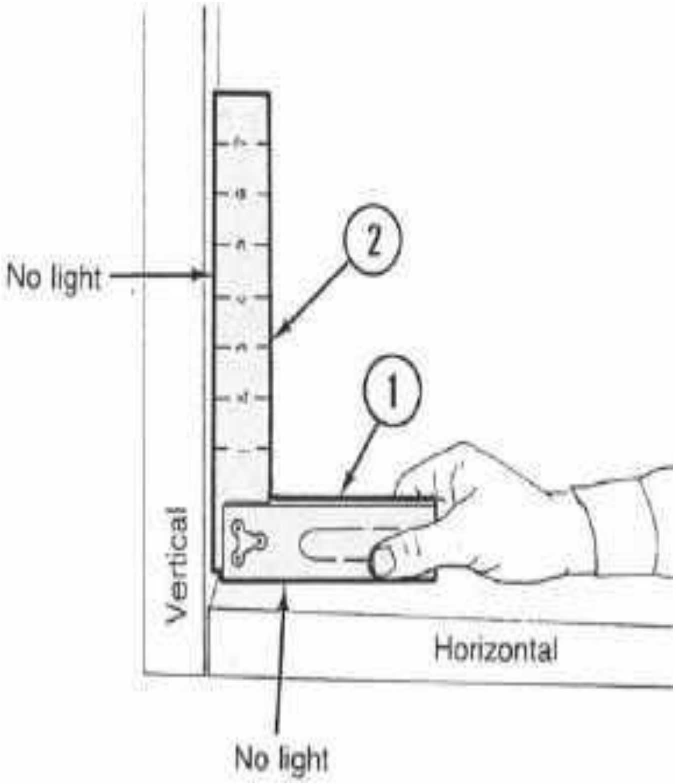


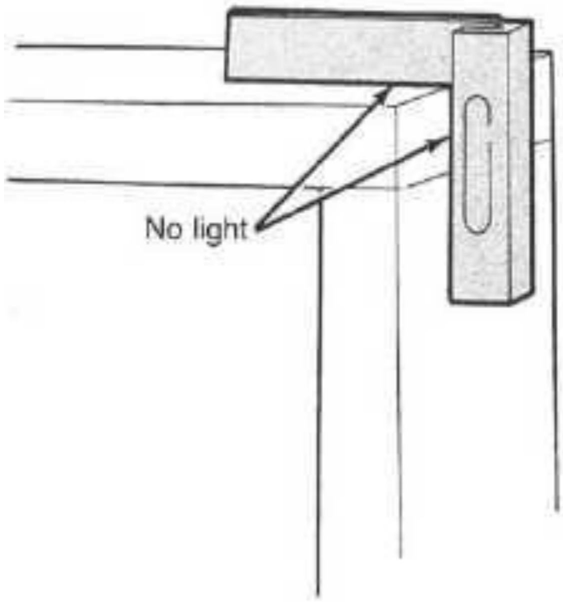
Fig.23

a) Using a try square

1. To check a square joint, place the stock against a horizontal section and the blade (2) against a vertical section. Light must not be seen around blade edge. If light is seen, the work is not square.



2. To check the end of a board, place stock on vertical edge and extend blade over the end. Light must not be seen around blade edge. If light is seen, the work is not square.



2.6 FILES

Job - III Preparation of a job by filling on non-ferrous metal

Files are used for cutting, smoothing off or removing small amounts of metal, wood, plastic or other material. Every file has five parts: the point (1) edge (2), face or cutting teeth(3), heel or shoulder (4) and tang (5). The tang is used to attach the handle on American pattern files. The tang is shaped into a handle and is usually knurled on Swiss pattern files.

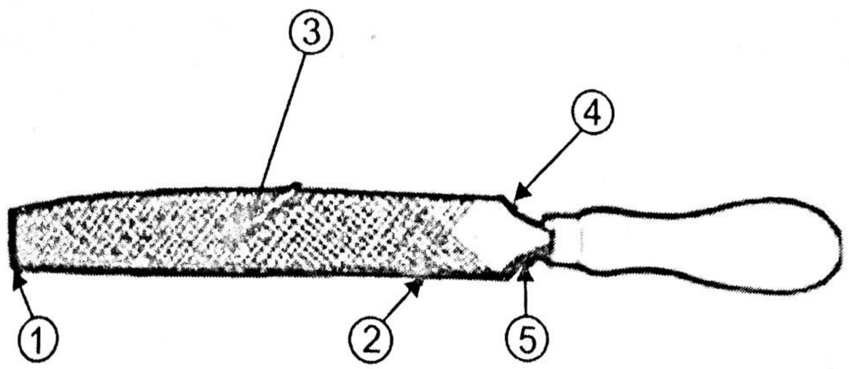


Fig. 24

a) Mill file

Mill files are tapered to the point in width and thickness for about one third of their lengths. They are single-cut with one uncut edge. They are used to sharpen mill or circular saws, and for draw-filing or finishing metals.

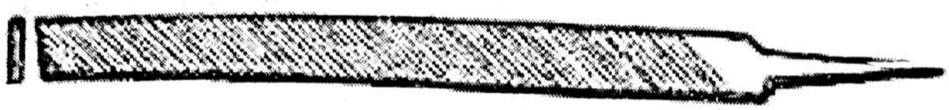


Fig. 25

b) Pillar file

Pillar files are similar to hand files in general shape, but are much narrower. They are double-cut with one uncut edge. Pillar files are used to file in slots and keyways.

Fig.26

c) Round file

Round files taper slightly toward the point. Bastard-cut files 6 inches and longer are double-cut. The second-cut files, 12 inches and longer, are double cut. All others are single-cut. Round files are used for filing circular openings or concave surfaces.

Fig.27

d) Square file

Square files taper slightly toward the point on all four sides and are double-cut. They are used for filing rectangular slots and keyways.

Fig.28

e) Taper file

Taper files, or triangular files, are tapered toward the point on all three sides. They are used for filing saws having 60 degree angle teeth. Taper files come in regular, slim, extra slim and double extra slim and usually are single-cut.

Fig.29

f) Three-square file

Three-square files are tapered toward the point on all three sides and are double-cut. They are used for filing internal angles, and for cleaning out square corners.

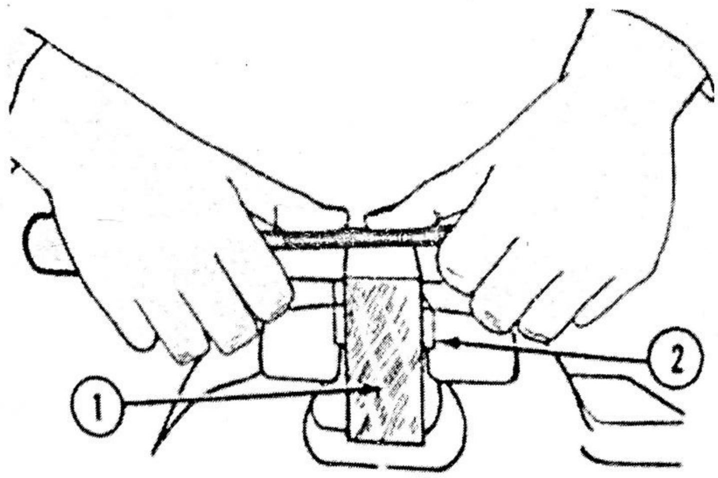
Fig.30

2.6.1 Safety

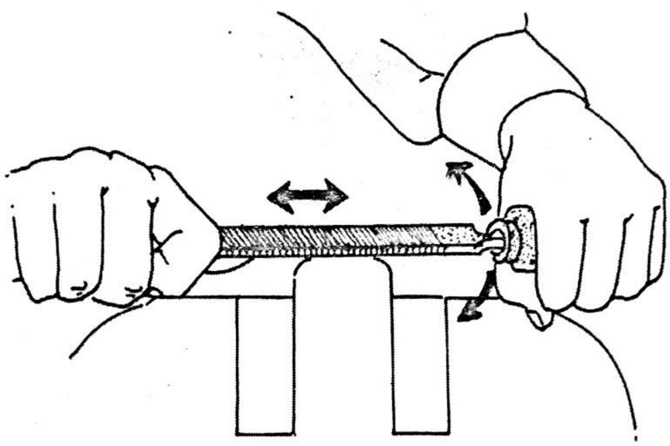
1. If a file is designed to be used with a handle, do not it without the handle. Holding tang in your hand while filing can cause serious injury.
2. Do not use a file for prying. The tang end is soft it bends easily. The body of the file is hard and the brittle.
3. Do not hammer on a file. This is very dangerous because the file may shatter.

2.6.2 Method of Filing

1. Clamp the work (1) securely in a vise so that the area to be filed is horizontal and is parallel to and projecting slightly above the vise jaws (2).



2. Hold the file handle in one hand, thumb on top, and hold the end of the file with the fingers of the other hand.
3. When filing hard metals, apply pressure on the forward stroke only. Unless the file is lifted from the work on the return stroke, it will become dull much sooner than it should.



4. When filing soft metals, using pressure on the return stroke helps keep the cuts in the file clean.

5. Use a rocking motion when filing round surfaces.

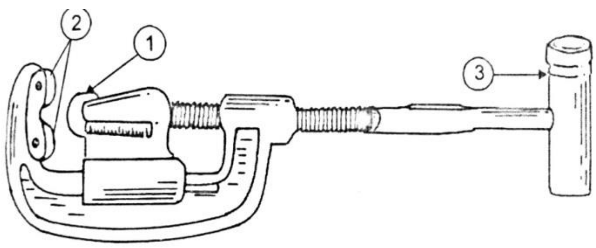
6. When using a new file, applying too much pressure will cause the teeth to break off. Do not force the file. File slowly, lightly, and steadily. Too much speed and too much pressure cause the file to rock, rounding off the corners of the work.

2.7 PREPARATION OF JOB INVOLVING THREADS

Job-V Preparation of job involving threads on GI pipe/PVC pipe (Description and demonstration of various types of drill, tapes and dies, selection of dies, types of tapes, tapping, dieing and drilling operations)

a) Pipe cutters

There are two sizes of pipe cutters. One size can cut from 1/8 to 2 inches, while the other can cut from 2 to 4 inches. The pipe cutter has a cutting blade (1) and two pressure rollers (2) which are adjusted and tightened by turning the handle (3). Pipe cutters are used to cut steel, brass, copper, wrought iron and lead pipe.

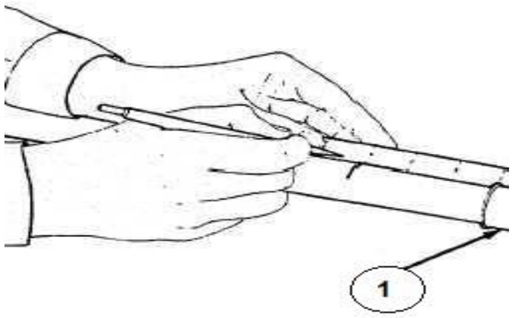


b) Pipe threading set

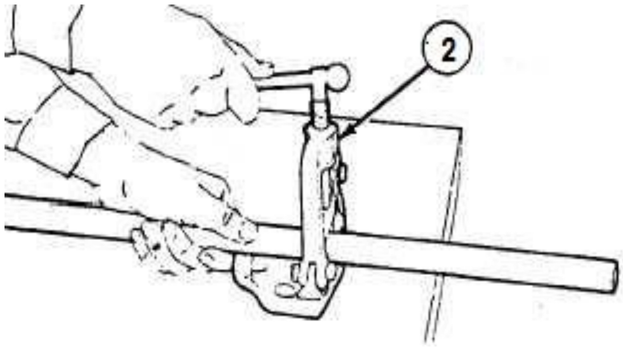
The pipe threading set contains an assortment of cutting dies (1) handle or wrench (2) a collar (3), and locking screws (4). The cutting dies may range from 1/8-inch to 2 inches in diameter. The threading set is used to cut American Standard Pipe threads on steel, brass, copper, wrought iron, and lead pipe.

c) Using a pipe cutter

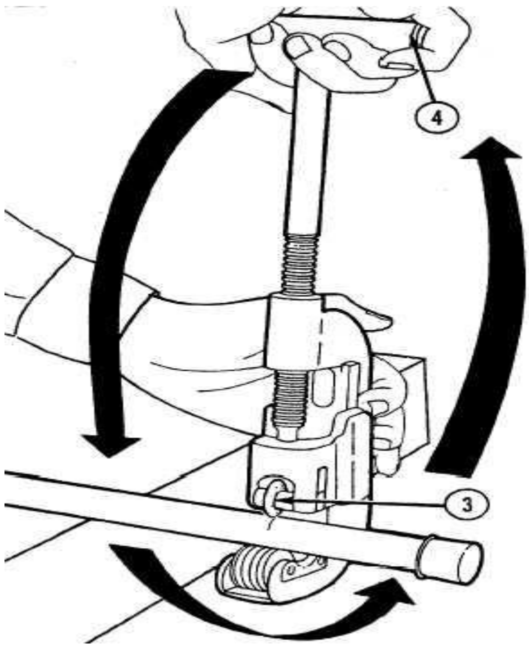
1. Measure from end of pipe (1) and make a mark where you want to cut.



2. Fasten pipe securely in a pipe vise (2). Be sure mark is clear so that it can be cut. Pipe must be supported on both ends to keep it from bending.



3. Open the jaws of the pipe cutter enough to allow the pipe cutter to be placed around the pipe. Adjust so that the cutting blade (3) is on the line.



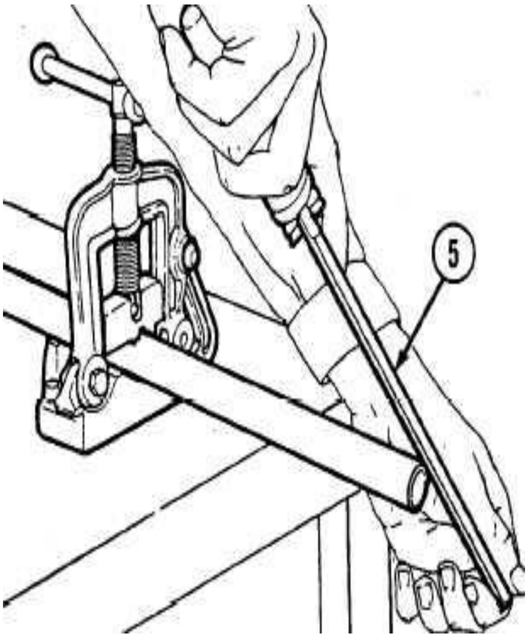
4. Tighten the handle (4) until cutting blade makes contact with pipe.

5. Then turn the handle (4) 1/4 of a turn more clockwise.

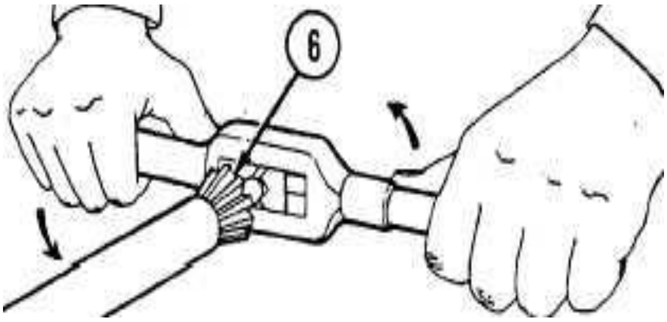
6. Now turn the whole cutter one turn around the pipe (counterclockwise).

7. Repeat steps 5 and 6 until the pipe is cut through.

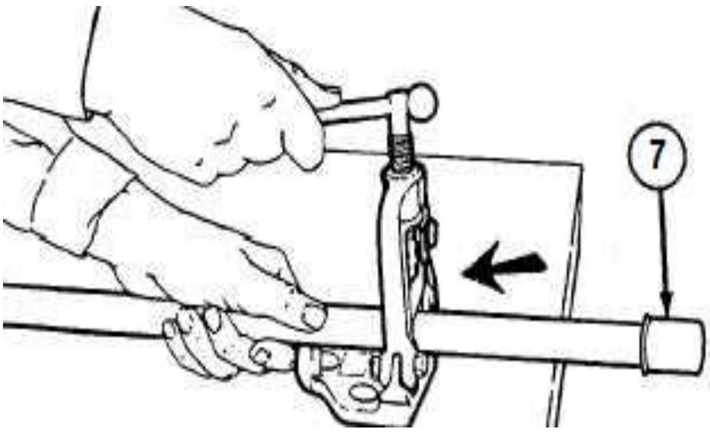
8. Remove the shoulder (the rough edge left by cutting) from the outside of the pipe with a file (5).



9. Remove the burr from the inside of the pipe with a pipe reamer (6).

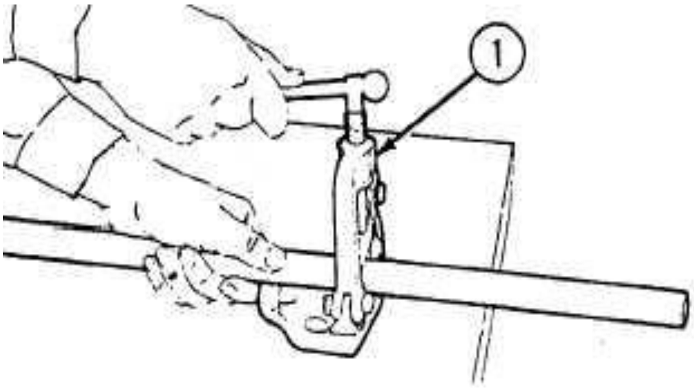


10. Place protective cap (7) on cut pipe end and remove from vise.

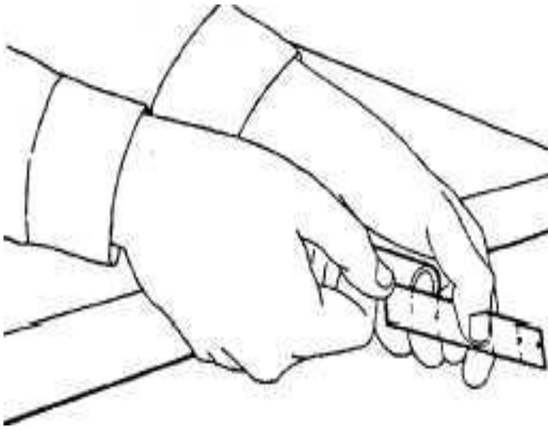


2.8 USING A PIPE THREADING SET

1. Clamp pipe securely in pipe vise (1) with tend to be threaded extending beyond the edge of the vise jaws as shown

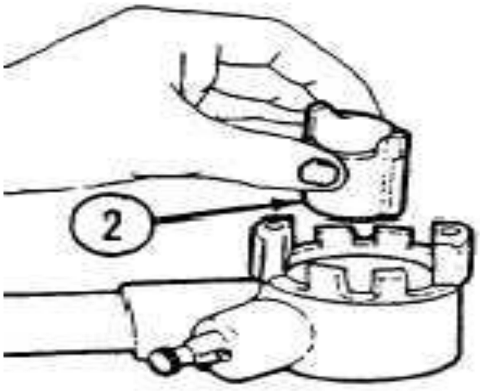


2. Measure inside pipe diameter to determine the proper die.

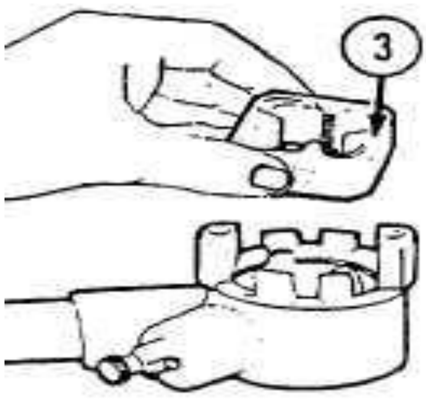


3. Inspect the die for nicks, and be sure that it is sharp. Assemble die on ratchet die stock as shown in steps 4, 5, and 6.

4. Insert collar (2).

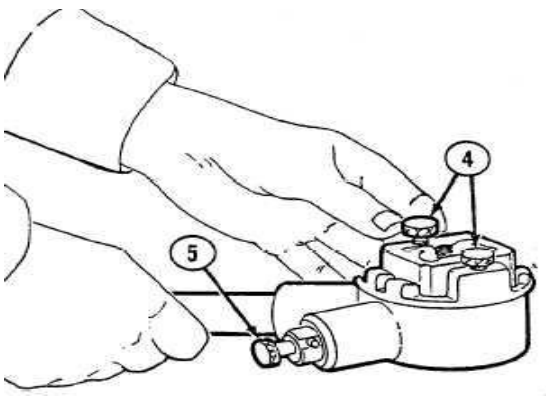


5. Insert cutting die (3) over top of collar.

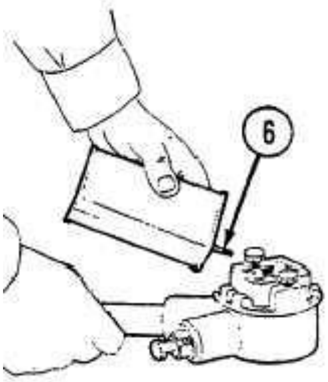


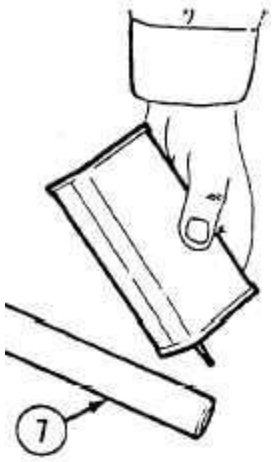
6. Secure in place with locking screws (4).

7. Set ratchet to turn in a counterclockwise direction by pulling out ratchet control knob (5) and turning it 180 degrees. The ratchet permits cutting threads on pipes where it. Is not possible to turn the handle 360 degrees. It is set for clockwise or counter clockwise rotation by pulling out and turning the ratchet control knob (4) from one detent to the other.

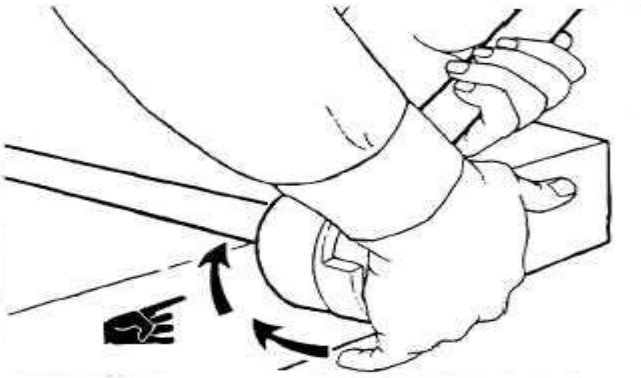


8. Apply cutting oil (6) to die and to end of pipe (7) to prevent overheating of dies and damaging of threaded surface.

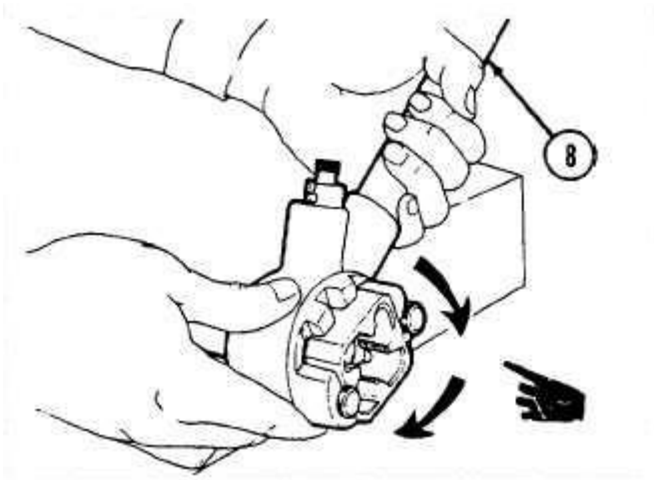




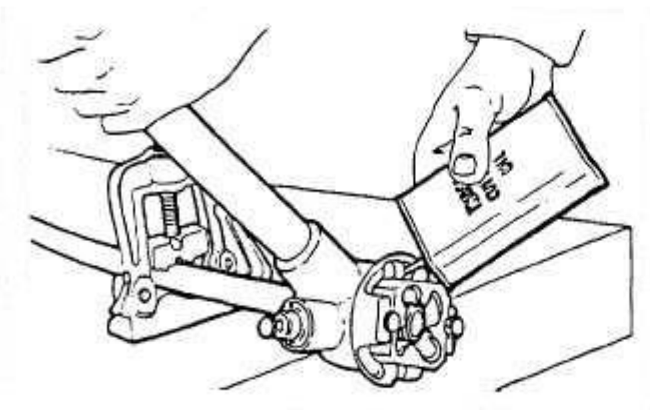
9. Slide cutting die over end of pipe to be threaded and apply light pressure with the heel of your hand.



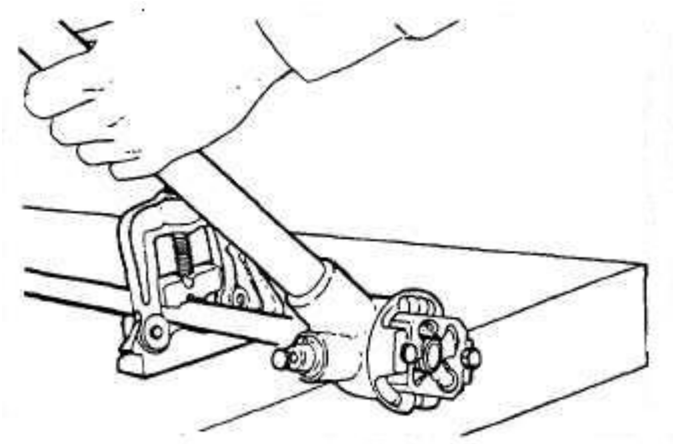
10. Start die with short strokes of the ratchet handle (8). Be sure the die is going on the pipe squarely.



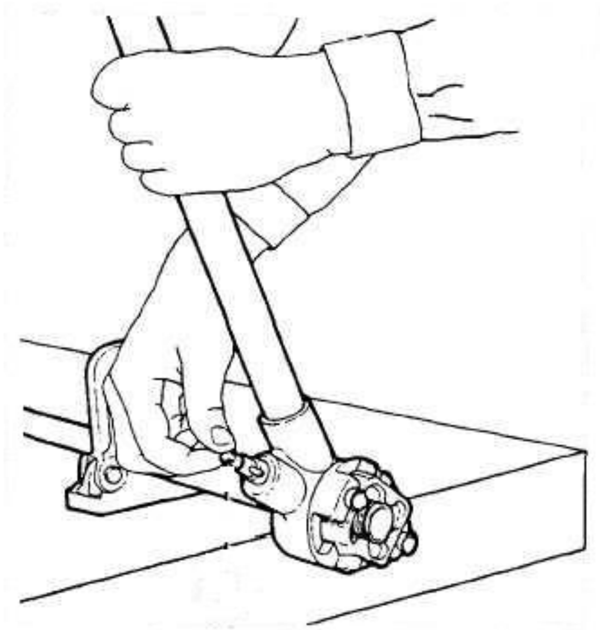
11. After a full turn of the die, apply another coat of cutting oil.



12. After two more turns on the die, back off one turn and apply a coat of cutting oil. Note: If metal shavings become clogged in the die, remove the die and clean it with a piece of cloth.

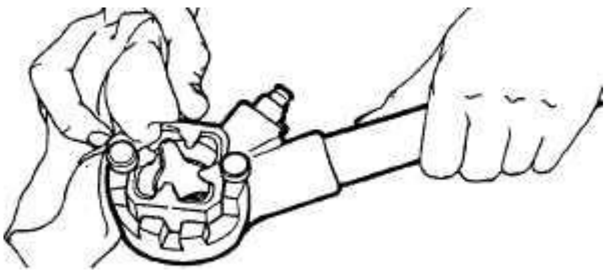


13. Keep repeating until desired thread length is obtained.

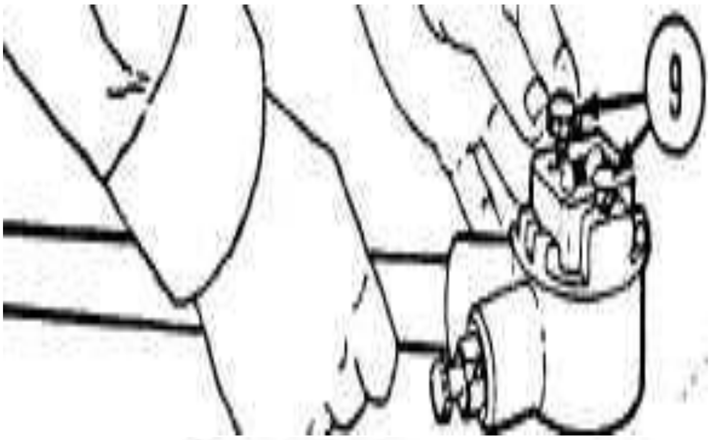


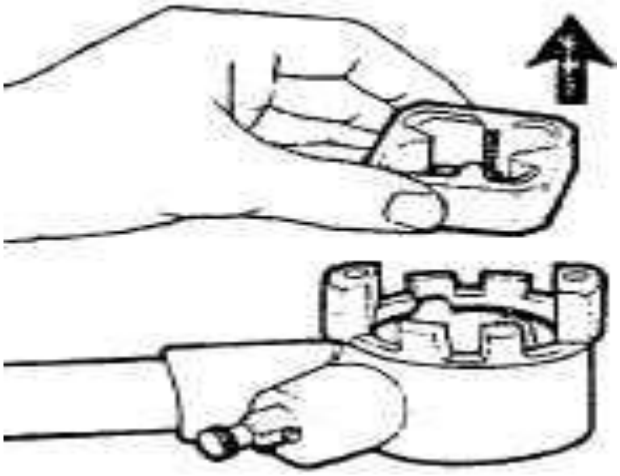
14. Reverse ratchet by pulling ratchet control knob (5) from detent and turning it 180 degrees. Then back up the cutting die.

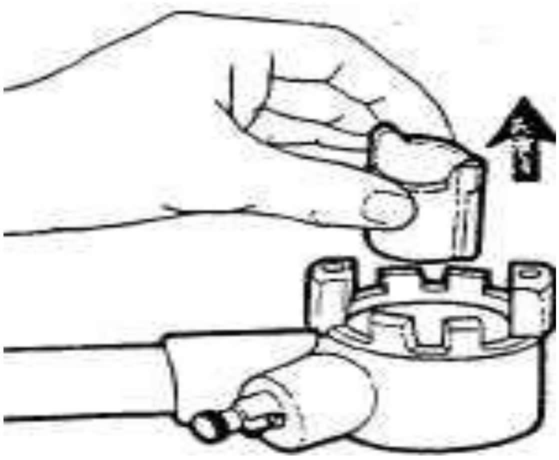
15. Wipe excess oil and metal shavings from die and ratchet handle.



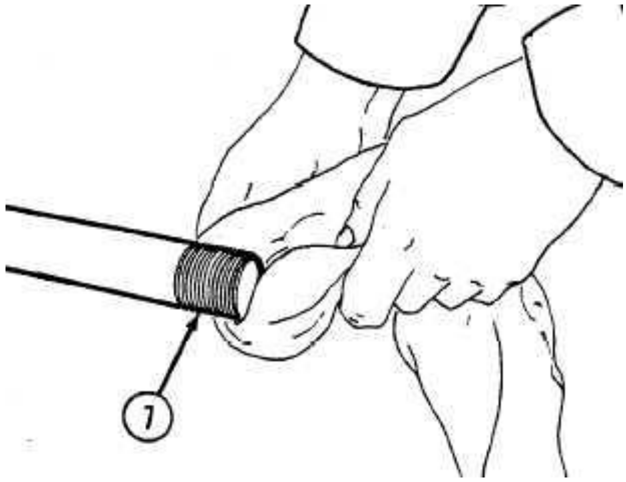
16. Disassemble the die from the ratchet handle as shown, by removing locking screws (9). Remove die and collar from ratchet head.


9

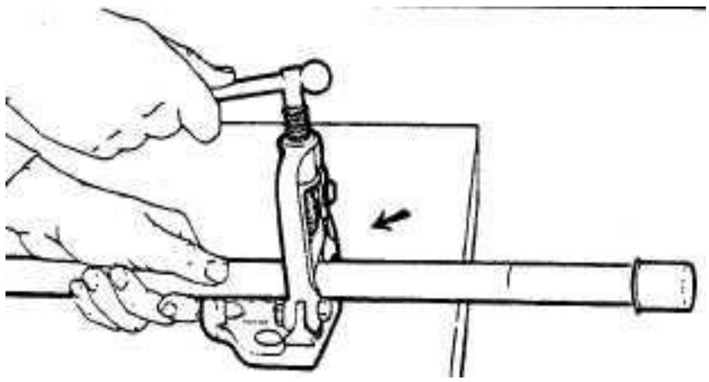




17. Wipe excess oil and shavings from threaded end of pipe (7).

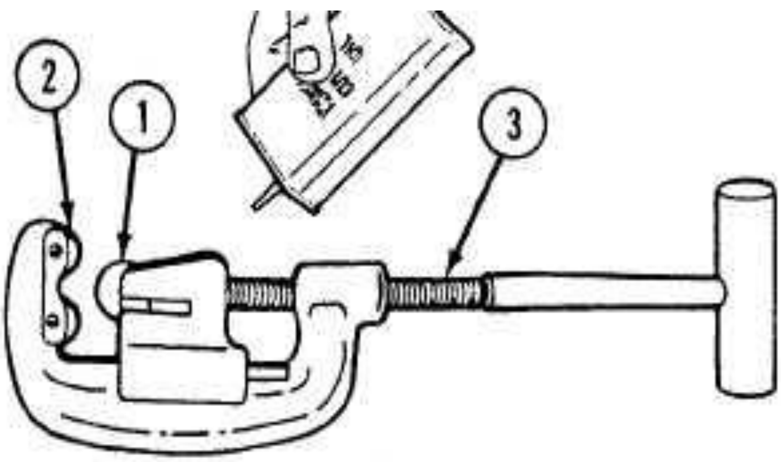


18. Place cap, if available, over threads and remove the pipe from the vise.



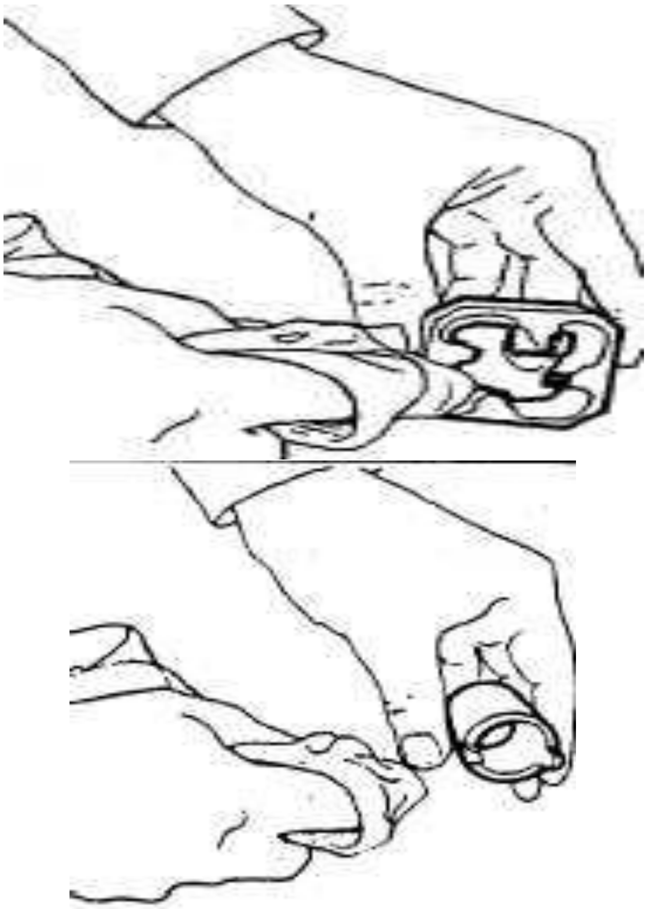
2.9 CARE OF PIPE CUTTERS AND SETS

1. Clean and lightly oil the cutter wheel (1) roller guide (2) and adjusting screw (3).



2. Store on a rack or in a box which protects the cutting wheel.

3. Wipe off excess cutting oil and clean metal shavings from the cutting die edges and collar.



4. Store in a case or box which will protect the cutting dies.

STUDENT ACTIVITY

1. Mention different types of drill.

2. Write uses of files.

SUMMARY

- Taps and dies are used to cut threads in metal, plastics or hard rubber. The taps are used for cutting internal thread.
- Rethreading dies are used to restore bruised (rounded) or rusty threads on screws and bolts.
- Safety is a very important factor in the use of power tools and cannot be overemphasized.
- Micrometers are instruments used to measure distances to the nearest one-thousandth of an inch. The measurement is usually expressed or written as a decimal.
- A height gauge is used in the layout of jigs and fixtures. On a bench, it is used to check the location of holes and surfaces.
- The carpenter's square is made up of two parts: the body or blade, and the tongue. It has inches divided into eighths, tenths, twelfths, and sixteenths.

SELF-ASSESSMENT QUESTIONS

Q1. Explain different types of drill.

Q2. Describe making of internal and external threads on a job by taping and dieing operation and precautions.

Q3. Describe the care and maintenance of measuring tools.

Q4. Explain the care of pipe cutters and threading sets.

Q5. Write short notes on

- **a.** Breast Drill
- **b.** Taps and Dies
- **c.** Safety rules in the use of power tools.
- **d.** Micrometer.

SECTION – C

3 WELDING SHOP

LEARNING OBJECTIVES

- Gas Welding
- Operation and Maintenance of Oxygas Equipment
- Equipment Setup
- Maintaining the Equipment
- Oxygas Welding Techniques
- Common Welding Joints Generally Made by Gas Welding
- Proper Edge Preparation and Fit-up
- Welding Procedures
- Shielded Metal-Arc Welding and Wearfacing
- Demonstration of various Methods Adopted for Painting Steel Items

Introduction of the gas welding, gas welding equipment, adjustment of different types of flames, demonstration and precautions about handling welding equipments.

3.1 GAS WELDING

(Job-I Practice in handling gas welding equipment and welding practice.)

This chapter discusses equipment and materials used in gas welding. Information is provided on the operation and maintenance of oxyacetylene and oxy-MAPP equipment.

Oxyacetylene and oxy-MAPP (methylacetylene - propadiene) welding are two types of gas welding processes. They require a gas fueled torch to raise the temperature of two similar pieces of metal to their fusion point that allows them to flow together. A filler rod is used to deposit additional metal. The gas and oxygen are mixed to correct proportions in the torch, and you can adjust the torch to produce various types of flames. A properly made gas weld is consistent in appearance, showing a uniform deposit of weld metal.

Complete fusion of the sidewalls is necessary to forma good joint. Some of the factors you must consider when making a gas weld are as follows: edge preparation, spacing and alignment of the parts, temperature control (before, during and after the welding process), size of the torch tip, size and type of the filler rod, flame adjustment, and rod and torch manipulation.

In some cases, fluxes are needed to remove oxides and slag from the molten metal and to protect the puddle from atmospheric contamination. When you join sections of plate by gas welding, the edges of the plate at the joint are uniformly melted by the heat from the torch. When welding heavier sheets and plates, you have to use filler metals. The edges of the heavier plate are beveled to permit penetration to the base of the joint. Both the filler metal and the base metal are melted, and as they solidify, they form one continuous piece.

For welding light sheet metal, filler metal is usually not necessary. The edges of light sheet metal are flanged at the joint so they flow together to form one solid piece when you melt them.

a) Oxygas welding equipment

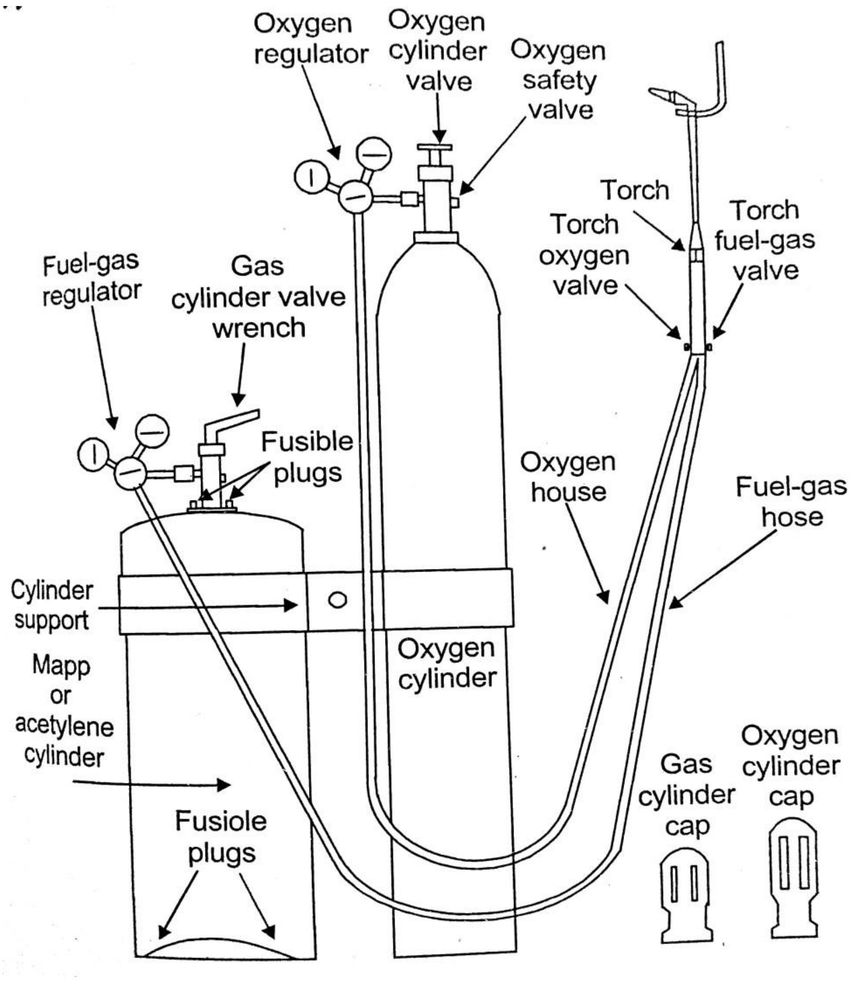


Fig.1

An oxygas welding outfit is basically the same as an oxygas cutting outfit with exception of the torch. The welding outfit usually consists of a cylinder of acetylene or MAPP gas, a cylinder of oxygen, two regulators, two lengths of hose with fittings, and a welding torch with tips.

An oxygas welding outfit also is called a welding rig. This equipment consists of tip cleaners, cylinder trucks, clamps, and holding Safety apparel, which includes goggles, hand shields, gloves, leather aprons, sleeves and leggings, is essential and should be worn as required.

Oxygas welding equipment, like cutting equipment, may be stationary or portable. A portable oxygas outfit, as shown in Fig.1, is an advantage when it becomes necessary to move the equipment. To perform your welding duties, you must be able to set up the welding equipment and make the adjustments required to perform the welding operation Thus it is important that you understand the purpose and function of the basic pieces of equipment that makeup the welding outfit.

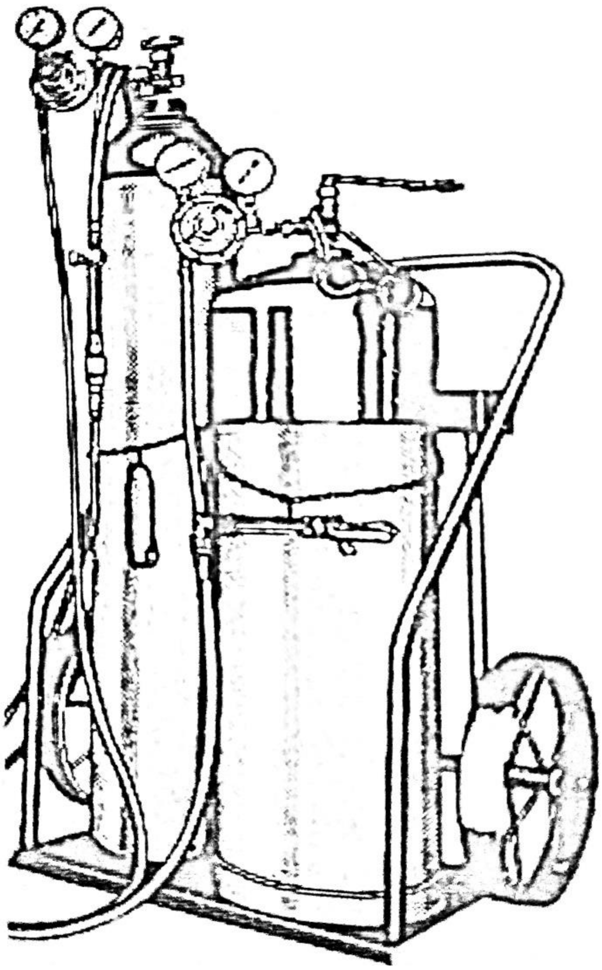


Fig. 2

b) Welding torches

The oxygas welding torch mixes oxygen and fuel gas in the proper proportions and controls the amount of the mixture burned at the welding tip. Torches have two needle valves: one for adjusting the oxygen flow and the other for adjusting the fuel gas flow. Other basic parts include a handle (body), two tubes (one for oxygen and another for fuel), a mixing head, and a tip. On some models the tubes are silver- brazed to the head and the rear end forgings, which are, in turn, fitted into the handle. Welding tips are made from a special copper alloy and are available indifferent sizes to handle a wide range of uses and plate thicknesses. Two general types of welding torches are used:

a) Low pressure
b) Medium pressure

The low-pressure torch is also known as an injector torch. The fuel-gas pressure is 1 psi (pound per square inch) or less. The oxygen pressure ranges between 10 to 40 pounds, depending on the size of the torch tip. A jet of relatively high-pressure oxygen produces the suction necessary to draw the fuel gas into the mixing head. The welding tips may or may not have separate injectors in the tip. Atypical mixing head for the low-pressure (or injector) torch is shown in Fig.3. Medium-pressure torches are often called balanced pressure or equal- pressure torches because the fuel gas and the oxygen pressure are kept equal. Operating pressures vary, depending on the type of tip used.

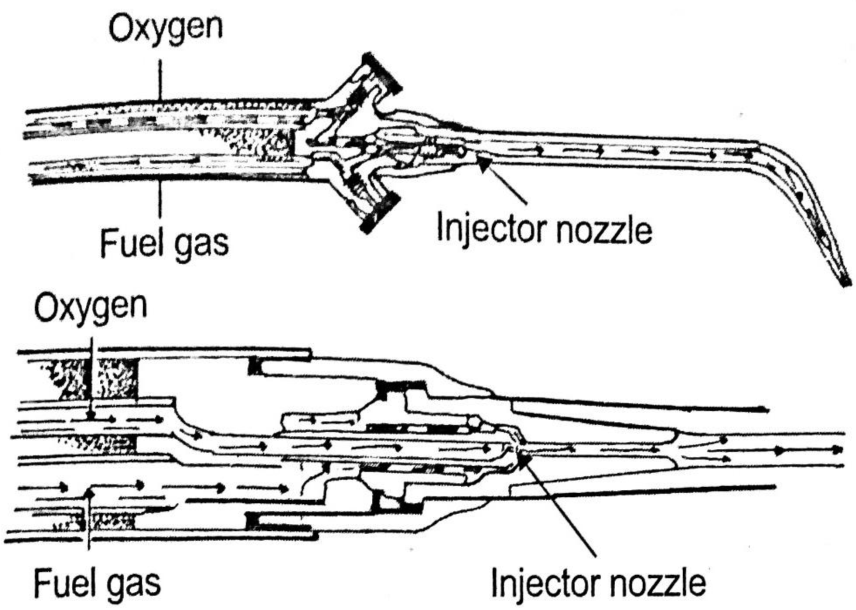


Fig.4. Equal-pressure welding torch

A typical equal-pressure welding torch, also called a general purpose torch, is shown in figure.4. The medium pressure torch is easier to adjust than the low pressure torch and since equal gas pressures are used, you are less likely to get a flashback.

Welding TIPS and MIXERS are designed in several ways, depending on the manufacturer. Some torch designs have a separate mixing head or mixer for each tip. Other designs have only one mixer for several tips. Tips come in various types; some are one piece hard, copper tips and others are two piece tips that include an extension tube to make the connection between the tips on the mixing head.

When used with an extension tube, removable tips are made of hard copper, brass or bronze. Tip sizes are designated by numbers and each manufacturer has own arrangement for classifying them. Tip sizes differ in the diameter of the hole.

c) Filler rods

The term filler rod refers to a filler metal used in gas welding, brazing, and certain electric welding processes in which the filler metal is not a part of the electrical circuit. The only function of the filler rod is to supply filler metal to the joint. Filler rod comes in wire or rod form that is often referred to as "welding rod."

As a rule, filler rods are uncoated except for a thin film resulting from the manufacturing process. Filler rods for welding steel are often copper-coated to protect them from corrosion during storage. Most rods are furnished in 36-inch lengths and a wide variety of diameters, ranging from 1/32 to 3/8 inch. Rods for welding cast iron vary from 12 to 24 inches in length and are frequently square, rather than round. You determine the rod diameter for a given job by the thickness of the metal you are joining.

Except for rod diameter, you select the filler rod based on the specifications of the metals being joined. These specifications may be federal, military, or navy specifications. This means that they apply to all federal agencies, the Military Establishment, or the Navy, respectively. Filler metals are presently covered by one or more of these three types' specifications. Eventually, all Navy specifications will be rewritten as military (MIL) specifications. For that reason, some of the specifications for welding materials presented in this section may subsequently be published as military, rather than navy specifications.

Many different types of rods are manufactured for welding ferrous and nonferrous metals. In general, welding shops stock only a few basic types that are suitable for use in all welding positions. These basic types are known as general- purpose rods.

d) Different types of flames and applications

1. Oxy- acetylene flame:

Oxy- acetylene flame can be defined as a phenomenon produced at the surface of the nozzle tip (of the welding torch) where two gases (oxygen and acetylene) meet and undergo combustion with evolution of heat and light. The chemical reaction for complete combustion is as follows:

$$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$$

The structure of the flame is shown below. There are three different cones in an oxy- acetylene flame.

a) Inner or luminous cone is formed right at the front of torch tip. This is the cone where two gases burn with a brilliant light and the primary chemical reaction takes place in this zone as follows:

$$C_2H_2 \quad + \quad O_2 \quad \rightarrow \quad 2CO \quad + \quad H_2 \quad + \quad \text{Heat}$$

(acetylene) (oxygen) (carbon monoxide) hydrogen

The temperature in the luminous inner cone may vary from 3200°C to 3500°C for different types of flame with maximum temperature occurring at the pale blue tip (vertex) of the cone. A neutral flame has well defined white inner cone. In oxidizing flame, the inner cone is purple in colour and is shorter than the inner core of neutral flame.

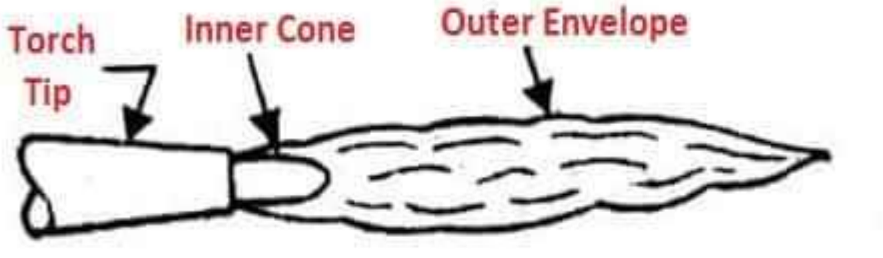
b) Outer cone envelops the inner cone and provides a reducing atmosphere that helps protecting molten weld metal against oxidation during welding. Oxygen from atmosphere is derived within this zone to complete secondary chemical reaction as below:

$$2CO + O_2 \rightarrow 2CO_2 \text{ (Carbon dioxide)}$$
$$2H_2 + O_2 \rightarrow 2H_2O \text{ (Water vapour)}$$

Any free oxygen available at the welding point is also absorbed in this cone, thus giving a reducing atmosphere. The temperature in this cone may be upto 2100°C and at the tip of the cone, it is about 1280 °C.

c) Secondary luminous cone exists only in a carburising flame and surrounds the luminous inner cone while extending into the outer cone. This happens because of the excess quantity of acetylene.

Among the three types of oxy-acetylene flames, the neutral and oxidizing flames have only two cones (inner cone and outer cone) but the carburising flame has all the three cones discussed above. Three distinct flame settings are used, neutral, oxidizing and carburizing.



Neutral Flame

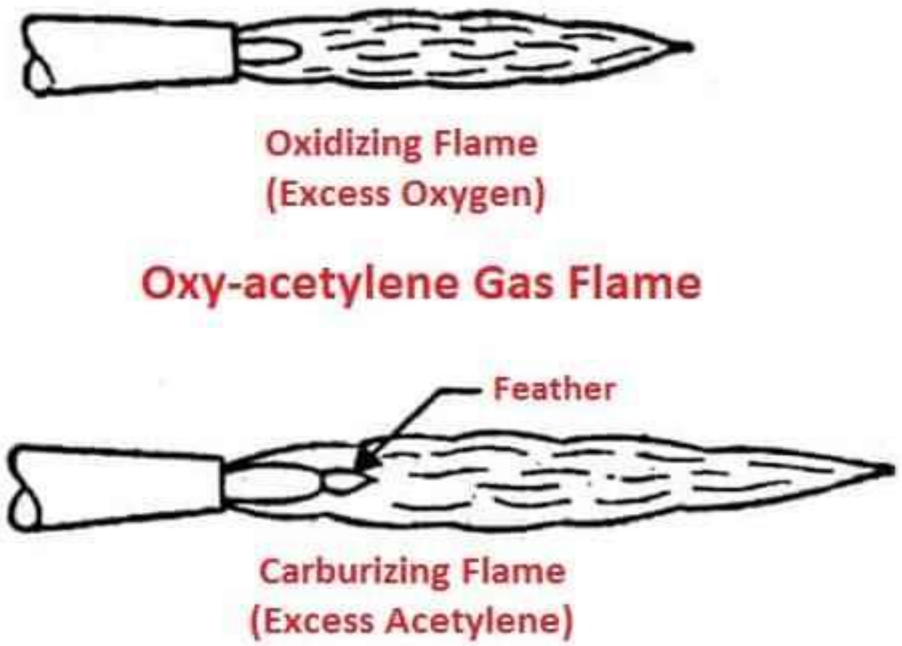


Fig.5

Welding is generally carried out using the neutral flame setting which has equal quantities of oxygen and acetylene. The oxidizing flame is obtained by increasing just the oxygen flow rate while the carburizing flame is achieved by increasing acetylene flow in relation to oxygen flow. Because steel melts at a temperature above 1,500°C, the mixture of oxygen and acetylene is used as it is the only gas combination with enough heat to weld steel. However, other gases such as propane, hydrogen and coal gas can be used for joining lower melting point non-ferrous metals, and for brazing and silver soldering.

Neutral flame is used for most welding operations and is highly suited for welding mild steels and cast irons, stainless steel, copper and aluminum. Even during flame cutting of steels, the pre-heating flame may be a neutral flame.

2. Oxydising flame:

It is obtained when oxygen is burnt in excess of acetylene. The inner cone is shorter and pointed with a sharp hissing sound. It gives maximum temperature among all the three oxy-acetylene flames. Since oxygen is a rapid supporter of combustion, when oxidising flame is fed to red hot steel, the iron present in steel bums up rapidly. The oxidising flame is, therefore, not used for general welding purposes (at least for welding ferrous metals, steels and cast irons).

Applications

The oxidising flame is used where maximum temperature is desired or in situation where oxidising effect is not harmful, rather proves beneficial, for example, a slightly oxidising flame is used in welding of non- ferrous metals particularly copper base metals as brasses and bronzes and zinc base metals, where it is desirable to have oxidising flame giving oxide film to check vaporisation of zinc and also to reduce further oxidation after oxide film is formed. This flame is also used for pre-heating purposes during flame cutting of steels.

3. Carburising flame:

It is obtained by burning acetylene in excess of oxygen. It has three cones, wherein the secondary luminous cone is extra in comparison to the two other types of flame. The secondary luminous cone gives reducing effect in the welding area.

Applications

A carburizing flame is mostly used for welding aluminum, monel metal, stainless steel, white metal, die cast metals and several other non-ferrous metals besides the high carbon steels. The carburizing flame prevents excessive formation of oxides on non-ferrous metals, which interfere with proper fusion of metal since oxides of non-ferrous metals have very high melting points because of which they are difficult to melt by oxy-acetylene flames. Carburizing flame gives a slight casehardening effect on certain steels. It is also used for hard facing of steels with satellite rods.

4. Flashback:

A flashback occurs when the flame disappears from the tip of the torch and travels back in the hose. The flame makes a hissing sound at that time. The remedy is that both the gases should be shut off immediately to avoid combustion within the torch. The torch should be allowed to cool before relighting. The flashback may be caused by a clogged barrel or mixer passage and excessive pressure oxygen. Sometimes, accumulation of organic oxides in oxygen hose may also trigger the flashback.

d) Gas Welding Fluxes

During the process of welding, oxygen may combine with the molten metal (at the point of welding) and form oxides which when entrapped in the weld joint, make the joint weaker. Fluxes are used to avoid this entrapment of oxides in the molten weld pool. Fluxes are the chemical compounds used in gas welding to prevent dissolving or to facilitate removal of oxides and other undesirable substances from the weld pool. Fluxes are used both in welding and soldering (or brazing) and accordingly these are categorized as welding fluxes or soldering fluxes.

During welding, flux chemically reacts with the oxides and forms a slag that floats over and covers the molten metal pool saving it from atmospheric oxygen. The fluxes used in welding are either in the form of powder, paste or liquid. These may be directly applied on the surface of the base metal to be welded or by dipping the heated end of the filler rod in the flux frequently

during welding. The slag formed on the weld bead is removed by chipping, filing or grinding after the welding operation is over.
Borax and salt (sodium chloride) are two compounds generally used by welders as flux. No flux is used for gas welding of steels in general various fluxes used for welding different metals are given below.

Fluxes for cast iron are composed of boric acid, soda ash and sodium chloride. Flux for stainless steel and alloy steels contains borax, boric acid, fluorspars, Flux for aluminum and its alloys are composed of lithium chloride, sodium chloride and potassium chloride.

Flux for copper and its alloys are borax-based fluxes containing borax (fused), boric acid, magnesium silicate, lime etc. Flux for magnesium and its alloys contain sodium chloride, potassium, magnesium chloride, barium chloride. Fluxes are used in hard facing also; for example, dehydrated borax is used in stellate depositing on carbon steel.

e) Leftward (or Forehand) welding

It is the oldest method practiced by welders. In this method, welding is started from the right hand side end of the weld joint. The welding torch is held at an angle of 30 to 45 foots with the work-piece. The flame spreads on the work-piece joint and thus pre-heats the area ahead of the torch flame cone under which welding takes place. The flame is given a circulatory, rotational or side-to-side motion to obtain uniform fusion on each side of the workpiece plates. The filler rod (or welding rod) is held at about 300 to the work-piece. It is important that the cone of the flame should never go outside the 'puddle', which is a small pool of molten metal created due to the intense heat of the flame.

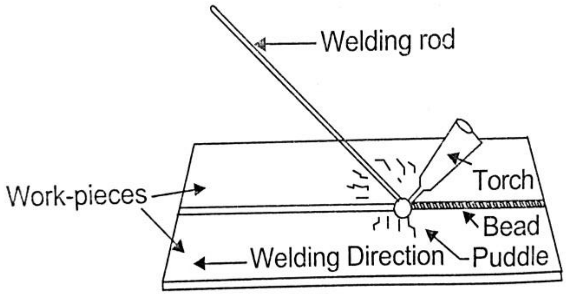


Fig.6

The forehand welding is usually employed for thin jobs upto 5mm thickness because when welding jobs are over 6.5mm thick, good penetration is not obtained and hence the quality of weld decreases as job thickness increases. For plates thicker than 3 beveling of the plate edges to produce V-joint is needed.

Good welding bead with nice appearance are the qualities of this method. The forehand welding, however, needs careful manipulation of torch to safeguard against excessive heating of base metal resulting into too much mixing of base metal and filler rod metal. Also, in this method, the view of the joint edges is interrupted which slows down the process.

f) Rightward (or Backhand) welding

The essentials of the technique are shown in figure. The torch and welding rod are held at an angle of 30 foots to 45 foots with the workpiece. In this case, the flame is directed back on the weld portion, which has just been completed. The welding rod is given a circulatory motion while the torch moves in a straight line. The method is suitable for welding thicker sections over 5 mm. No edge preparation is needed up to 8 mm thick plates. With proper edge preparation, plate's up to 16 mm thickness can be welded in one pass. A larger size-welding torch is used in this method. Since the welding torch is moved in a straight line, the molten pool of metal below the flame is least agitated and hence the oxidation losses on the weld metal are reduced.

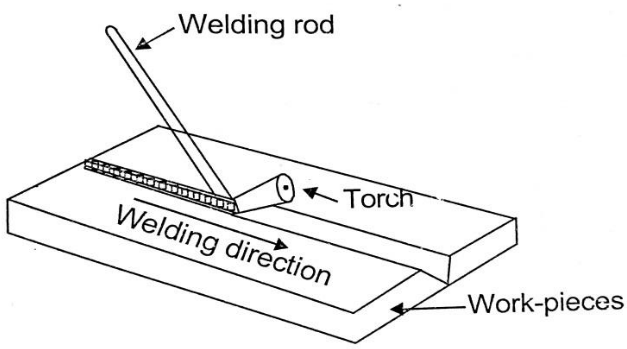


Fig. 7

Benefits of backhand Welding are as follows

i. In backhand welding, the flame is directed on the just welded bead, the flame thus gives an annealing effect on the weld metal relieving the welding stresses to a great extent.

ii. The direction of flame helps the welder in forming good bead and better penetration since the molten pool is clearly visible and better control on the weld is thus obtained.

iii. The technique is suitable for welding thicker sections, over 5 mm and upto 25 mm.

iv. Welding speeds are about 20% higher than leftward welding.

v. Gas consumption is reduced by 15 to 25%.

vi. It provides better shielding against oxidation.

3.2 OPERATION AND MAINTENANCE OF OXYGAS EQUIPMENT

This section discusses basic procedures involved in setting up oxygas, equipment, lighting off, adjusting the flame, and securing the equipment Information also is provided on the maintenance of oxygas welding equipment.

3.2.1 Selecting the Welding Torch Tip Size

Welding torch tip size is designated by a number stamped on the tip. The tip size is determined by the size of the orifice. There is no standard system of numbering welding torch tip sizes; each manufacturer has own numbering system. In this manual, the tip size is given in the number drill orifice size. Number drills consist of a series of 80 drills, number 1 through 80. The diameter of a number 1 drill is 0.2280 of an inch and the diameter of a number 80 drill is 0.0135 of an inch.

Note: As the drill size number increases, the size of the drill decreases. Once you become familiar with the use of a specific manufacturer's torch and numbering system, it becomes unnecessary to refer to orifice number drill size. The orifice size determines the amount of fuel gas and oxygen fed to the flame; therefore, it determines the amount of heat produced by the torch. The larger the orifice, the greater the amount of heat generated.

If the torch tip orifice is too small, not enough heat will be available to bring the metal to its fusion temperature. If the torch tip is too large, poor welds result from the following: the weld is made too fast, control of the welding rod melting is difficult, and the appearance and quality of the weld is unsatisfactory.

3.3 EQUIPMENT SETUP

Select the correct tip and mixing head (depending on torch manufacturer), and connect them to the torch body. Tighten the assembly by hand, and then adjust to the proper angle. After the desired adjustment has been made, tighten the tip. On some types of equipment, the tip is tightened with a wrench, while on other types, only hand tightening is required.

3.3.1 Torch Lighting and Flame Adjustment

When lighting the torch and adjusting the flame, you should always follow the manufacturer's directions for the particular model of torch being used. This is necessary because the procedure varies somewhat with different types of torches and, in some cases, even with different models made by the same manufacturer. After lighting the torch, you adjust the flame according to the type of metal being welded.

The carburizing flame is best used for welding high-carbon steels, for hard facing, and for welding non-ferrous alloys, such as Monel. A neutral flame is the correct flame to use for welding most metals. When steel is welded with this flame, the puddle of molten metal is quiet and clear, and the metal flows without boiling, foaming, or sparking.

The welding flame should always be adjusted to neutral before either the oxidizing or carburizing flame mixture is set. The oxidizing flame has a limited use and is harmful to many metals. When applied to steel, the oxidizing flame causes the molten metal to foam and produce sparks. The major use of the flame is that of the slightly oxidizing flame used to braze steel and cast iron. A stronger oxidizing flame is used for fusion welding brass and bronze. You determine the amount of excess oxygen to use by watching the molten metal.

3.4 MAINTAINING THE EQUIPMENT

For welding equipment to operate at peak efficiency and give useful service, you must perform the proper maintenance and upkeep on it. Your responsibilities involve the maintenance and care of oxygas welding equipment. You will not be required to make major repairs to welding equipment; but when major repairs are needed, it is your responsibility to see that the equipment is removed from service and turned in for repair. This section briefs you on some of the common types of maintenance duties that you will be required to perform.

a) Torch gas leaks

At times the needle valves may fail to shut off when hand tightened in the usual manner. When this happens, do not use a wrench to tighten the valve stem. Instead, open the valve and try to blow the foreign matter off the valve seat, using the working gas pressure in the hose. If this fails, it will be necessary to remove the stem assembly and wipe the seat clean. Reassemble the valve and try closing it tightly by hand several times. If these measures fail to stop the leak, you should have the parts replaced or the valve body reseated. These repairs should be made only by qualified personnel.

When there is leakage around the torch valve stem, you should tighten the packing nut or repack it if necessary. For repacking, you should use only the packing recommended by the manufacturer of the torch.

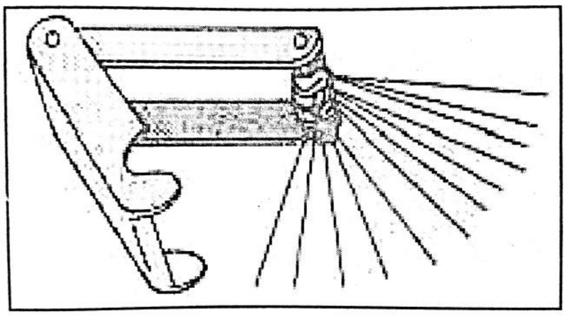


Fig.8

Do not use any oil. If the valve stem is bent or badly worn, replace it with a new stem. Before you use a new torch for the first time, it is a good idea to check the packing nut on the valves to make sure it is tight. The reason is that some manufacturers ship torches with these nuts loose.

Leaks in the mixing head seat of the torch cause oxygen and fuel, gas leaks between the inlet orifices leading to the mixing head. This problem causes improper gas mixing and results in flashbacks. The problem can be corrected by having the seat in the torch head reamed and by truing the mixing head seat. Usually, you must send the equipment to the manufacturer for these repairs.

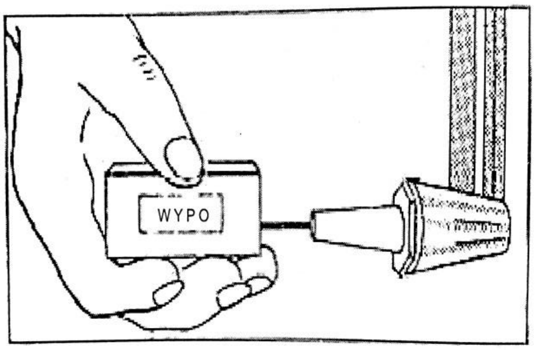


Fig.9 A welding tip cleaner in use

b) Welding torch tips

Welding tips are subject to considerable abuse and you must keep the orifice smooth and clean if the tip is to perform satisfactorily. When cleaning a welding tip, you must be careful and ensure you do not enlarge or scar the orifice.

Carbon deposits and slag must be re-moved regularly to ensure good performance. Avoid dropping a tip because the seat that seals the joint may be damaged. Also, the flame end of the tip also may receive damage if it is allowed to come in contact with the welding work, bench, or firebricks. This damage roughens the end of the tip and causes the flame to burn with a "fishtail."

Special welding tip cleaners have been developed to remove the carbon or slag from the tip orifice. The cleaner consists of a series of broach like wires that correspond in diameter to the diameter of the tip orifices.

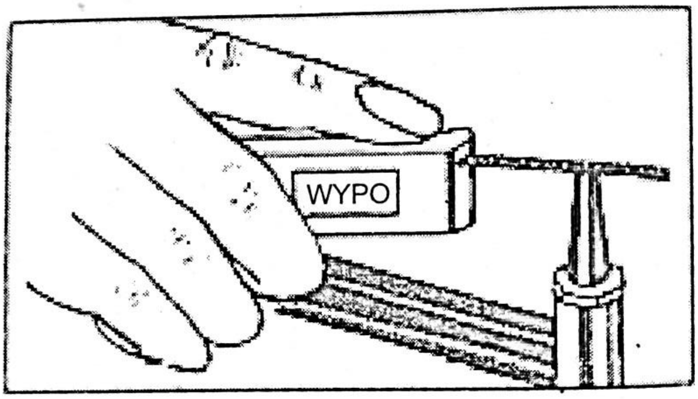


Fig.10 Reconditioning the orifice end of a torch tip

These wires are packaged in a holder, which makes their use safe and convenient. Figure 10 shows a tip cleaner in use. Some welders prefer to use a number drill the size of the tip orifice to clean welding orifices. A number drill must be used carefully so the orifice is not enlarged, bell-mouthed, reamed out of round, or otherwise deformed.

The flame end of the tip must be clean and smooth. The surface must beat right angles to the center line of the tip orifice to ensure a proper shaped flame. A4- inch mill file or the file in the tip cleaner can be used to recondition the surface, as shown in Fig.10.

Recondition the tip if it becomes rough and pitted or the orifice is bell mouthed. An easy method to use involves placing a piece of emery cloth, grit side up, on a flat surface; hold the tip perpendicular to the cloth, and rub the tip back and forth just enough to true the surface and to bring the orifice back to its original diameter.

c) Regulator leaks

With regulators, gas leakage between the regulator seat and nozzle is the most common type of trouble. You often hear this problem referred to as regulator creep. This problem can be detected by the gradual rise in pressure on the working-pressure gauge without moving the adjusting screw. Frequently, this trouble is caused by worn or cracked seats. It also can be caused by foreign matter lodged between the seat and the nozzle. It is important that you have leaking regulators repaired at once; otherwise, injury to personnel or equipment damage could result. This is particularly dangerous with fuel-gas regulators because fuel gas at a high pressure in a hose becomes an explosive hazard. To ensure the safety of personnel and equipment, ensure that regulators with such leaks are removed from service and turned in for repair.

3.5 OXYGAS WELDING TECHNIQUES

Oxygas welding maybe did using either the forehand or the backhand method. Each of these techniques has special advantages and you should become skillful with both. The deciding factor that determines whether a technique is considered forehand or backhand is the relative position of the torch and rod during welding, not the direction of welding. The best method to use depends upon the type of joint, joint position, and the need for heat control on the parts to be welded

3.6 COMMON WELDING JOINTS GENERALLY MADE BY GAS WELDING

(JOB-II Preparation of butt joint by gas welding. JOB-III Preparation of small cot conduit pipe frame by electric arc welding/gas welding. JOB-IV Exercise job on spot/seam welding machine.)

The details of a joint, which includes both the geometry and the required dimensions, are called the joint design. Just what type of joint design is best suited for a particular job depends on many factors, although welded joints are designed primarily to meet strength and safety requirements, there are other factors that must be considered. A few of these factors are as follows:

Whether the load will be in tension or compression and whether bending, fatigue, or impact stresses will be applied

1. How a load will be applied; that is, whether the load will be steady, sudden, or variable
2. The direction of the load as applied to the joint.
3. The cost of preparing the joint

Another consideration that must be made is the ratio of the strength of the joint compared to the strength of the base metal. This ratio is called joint efficiency.

An efficient joint is one that is just as strong as the base metal. Normally, the joint design is determined by a designer or engineer and is included in the project plans and specifications. Even so, better understanding the joint design for a weld enables you to produce better welds.

a) Butt joints

The **square butt joint** is used primarily for metals that are 3/16 inch or less in thickness. The joint is reasonably strong, but its use.

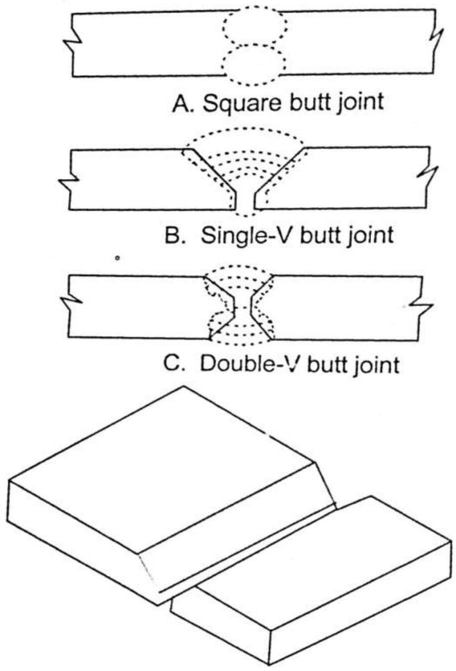


Fig. 11

Is not recommended when the metals are subject to fatigue or impact loads. Preparation of the joint is simple, since it only requires matching the edges of the plates together; however, as with any other joint, it is important that it is fitted together correctly for the entire length of the joint. It is also important that you allow enough roots opening for the joint. Figure 11 shows an example of this type of joint.

When you are welding metals greater than 3/16 inch in thickness, it is often necessary to use a grooved butt joint. The purpose of grooving is to give the joint the required strength. When you are using a grooved joint, it is important that the groove angle is sufficient to allow the electrode into the joint; otherwise, the weld will lack penetration and may crack. However, you also should avoid excess beveling because this wastes both weld metal and time. Depending on the thickness of the base metal, the joint is either single-grooved (grooved on one side only) or double-grooved (grooved on both sides). As a welder, you primarily use the single-V and double-V grooved joints.

The **single-V butt joint** (Fig.11, view B) is for use on plates 1/4 inch through 3/4 inch in thickness. Each member should be beveled so the included angle for the joint is approximately 60 degrees for plate and 75 degrees for pipe. Preparation of the joint requires a special beveling machine (or cutting torch), which makes it more costly than a square butt joint. It also requires more filler material than the square joint; how-ever, the joint is stronger than the square butt joint. But, as with the square joint, it is not recommended when subjected to bending at the root of the weld.

The **double-V butt joint** (Fig.11, view C) is an excellent joint for all load conditions. Its primary use is on metals thicker than 3/4 inch but can be used on thinner plate where strength is critical. Compared to the single-V joint, preparation time is greater, but you use less filler metal because of the narrower included angle. Because of the heat produced by welding, you should alternate weld deposits, welding first on one side and then on the other side. This practice produces a more symmetrical weld and minimizes war page. Remember, to produce good quality welds using the groove joint, you should ensure the fit- up is consistent for the entire length of the joint, use the correct groove angle, use the correct root opening, and use the correct root face for the joint. When you follow these principles, you produce better welds every time. Other standard grooved butt joint designs include the bevel groove, J-groove, and U-groove.

b) Corner joints

The **flush corner joint** (Fig.12, view A) is designed primarily for welding sheet metal that is 12 gauge or thinner. It is restricted to lighter material, because deep penetration is sometimes difficult and the design can support only moderate loads.

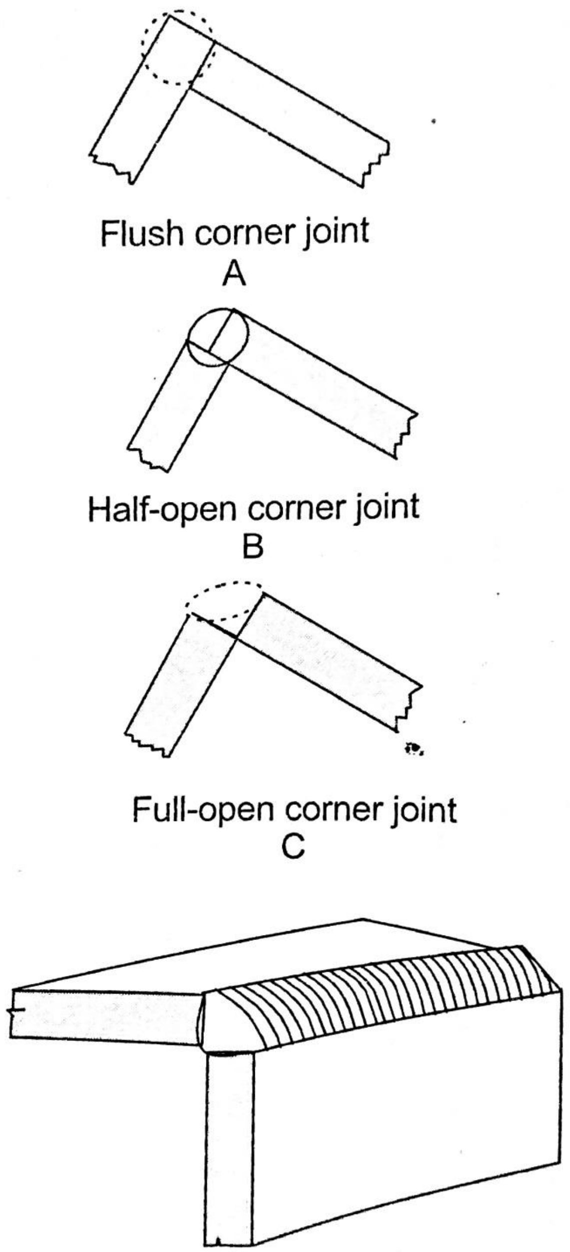


Fig. 12

The **half-open corner joint** (Fig.12, view B) is used for welding materials heavier than 12 gauge. Penetration is better than in the flush corner joint, but its use is only recommended for moderate loads.

The full-open corner joint (Fig.12, view C) produces a strong joint, especially when welded on both sides. It is useful for welding plates of all thicknesses.

c) Tee joints

The square tee joint (Fig.13, view A) requires a fillet weld that can be made on one or both sides. It can be used for light or fairly thick be placed on each side of the vertical plate.

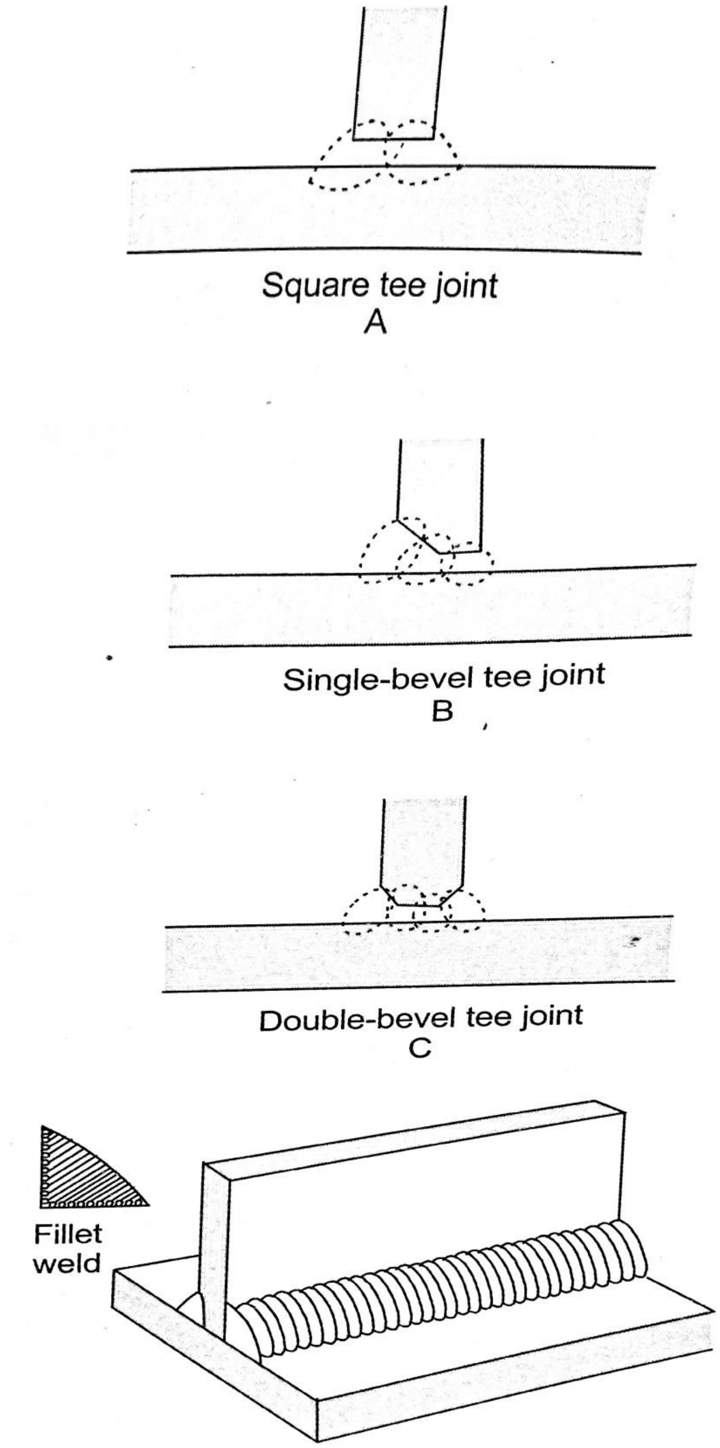


Fig. 13

The **single-bevel tee joint** (Fig. 13, view B) can withstand more severe loadings than the square tee joint, because of better distribution of stresses. It is generally used on plates of 1/2 inch or less in thickness and where welding can only be done from one side.

The **double-bevel tee joint** (Fig.13, view C) is for use where heavy loads are applied and the welding can be done on both sides of the vertical plate.

d) Lap joints

The **single-fillet lap joint** (Fig.14, view A) is easy to weld, since the filler metal is simply deposited along the seam. The strength of the weld depends on the size of the fillet. Metal up to 1/2 inch in thickness and not subject to heavy loads can be welded using this joint. When the joint will be subjected to heavy loads, you should use the **double fillet lap joint** (Fig.14, view B). When welded properly, the strength of this joint is very close to the strength of the base metal.

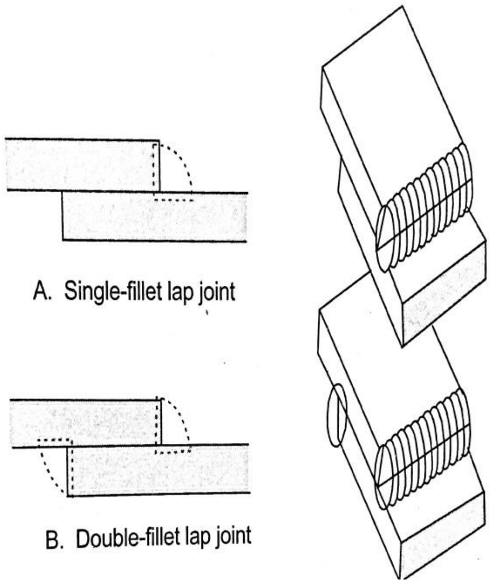


Fig.14

e) Edge joints

The **flanged edge joint** (Fig.15, view A) is suitable for plate 1/4 inch or less in thickness and can only sustain light loads. Edge preparation for this joint may be done, as shown in either views B or C.

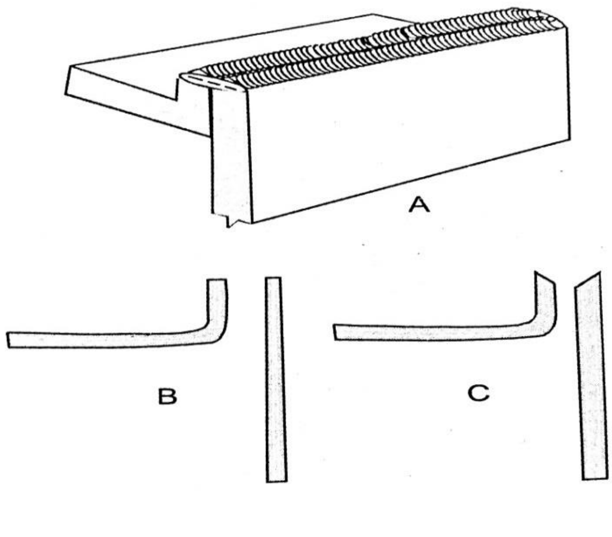


Fig.15

3.7 PROPER EDGE PREPARATION AND FIT-UP

As discussed, proper edge preparation and fit-up are essential to good quality welds. By making certain the edges are properly beveled and spacing is adequate, you can restrict the effects of distortion. Additionally, you should use tack welds, especially on long joints. Tack welds should be spaced at least 12 inches apart and run approximately twice as long as the thickness of the weld.

a) Control the heat input

You should understand that the faster a weld is made, the less heat is absorbed by the base metal. As you gain welding experience, it will become easier for you to weld a seam with the minimum amount of heat by simply speeding up the welding process. Regardless of your to control heat input. An intermittent weld (sometimes called a skip weld) is often used instead of one continuous weld. When you are using an intermittent weld, a short weld is made at the beginning of the joint. Next, you skip to the center of the seam and weld a few inches. Then, you weld at the other end of the joint. Finally, you return to the end of the first weld and repeat the cycle until the weld is finished. Another technique to control the heat input is the back-step method. When using this technique, you deposit short weld beads from right to left along the seam.

b) Preheat the metal

Expansion and contraction rates are not uniform in a structure during welding due to the differences in temperature throughout the metal. To control the forces of expansion and contraction, you preheat the entire structure before welding. After the welding is complete, you allow the structure to cool slowly.

c) Limit the number of weld passes

You can keep distortion to a minimum by using as few weld passes as possible. You should limit the number of weld passes to the number necessary to meet the requirements of the job.

d) Use jigs and fixtures

Since holding the metal in a fixed position prevents excessive movements, the use of jigs and fixtures can help prevent distortion. A jig or fixture is simply a device used to hold the metal rigidly in position during the wielding operation.

e) Allow for distortion

A simple remedy for the distortion caused by expansion and contraction is allowed for it during fit- up. To reduce distortion, you angle the parts to be welded slightly in the opposite direction in which the direction in which the contraction takes place. When the metal cools, contraction forces pull the pieces back into position. There is more to being a good welder then just being able to lay a good bead. There are many factors that must be considered.

3.8 WELDING PROCEDURES

There are many factors involved in the preparation of any welded joint. The detailed methods and practices used to prepare a particular well-meant are called the **welding procedure.**

A welding procedure identifies all the welding variables pertinent to a particular job or project. Generally, these variables include the welding process, type of base metal, joint design, welding position, type of shielding, preheating and post heating Requirements, welding machine setting, and testing requirements.

3.9 SHIELDED METAL-ARC WELDING AND WEARFACING

a) Manual shielded metal-arc welding

Arc welding provides you the ability to join two metals by melting them with an arc generated between a coated-metal electrode and the base metal. The temperatures developed by the arc can reach as high as 10000°F. The arc energy is provided by a power source that generates either direct or alternating current. The electrodes that carry the current produce a gas that shields the arc from the atmosphere and supplies filler metal to develop the weld shape.

b) Arc-welding equipment

A wide variety of welding equipment is available, and there are many differences between the makes and models of the equipment produced by the manufacturers. However, all types of arc-welding equipment are similar in their basic function of producing the high-amperage, low-voltage electric power required for the welding arc. In this discussion, we are primarily concerned with the typical items of arc-welding equipment, rather than the specific types. For specific information about the equipment your battalion or duty station has available, consult the manufacturer's instruction manual. For additional operational information and safety instruction, have your leading welding petty officer explain the operation to you. The basic parts of a typical shielded metal-arc welding outfit include a welding machine, cables, electrode holder (stinger), and electrodes. The Steelworker also requires a number of accessories that include a combination chipping hammer and wire brush, welding table (for shop work), C-clamps, and protective apparel.

3.9.1 Equipment Operation and Maintenance

Learning to arc weld requires you to possess many skills. Among these skills are the abilities to set up, operate, and maintain your welding equipment.

a) Welding area requirements

In most factory environments, the work is brought to the welder. In the Sea bees, the majority of the time the opposite is true. You will be called to the field for welding on building, earth moving equipment, well drilling pipe, ship to shore fuel lines, pontoon cause- ways, and the list goes on. To accomplish these tasks, you have to become familiar with your equipment and be able to maintain it in the field. It would be impossible to give detailed maintenance information here because of the many different types of equipment found in the field; therefore, only the highlights will be covered.

b) Welding machine operation and maintenance

You should become familiar with the welding machine that you will be using. Study the manufacturer's literature and check with your senior petty officer or chief on the items that you do not understand. Machine setup involves selecting current type, polarity, and current settings. The current selection depends on the size and type of electrode used, position of the weld, and the properties of the base metal. Cable size and connections are determined by the distance required to reach the work the size of the machine, and the amperage needed for the weld. Operator maintenance depends on the type of welding machine used. Transformers and rectifiers require little maintenance compared to engine-driven welding machines. Transformer welders require only to be kept dry and a minimal amount of cleaning. Internal maintenance should only be done by electricians due to the possibilities of electrical shock Engine-driven machines require daily maintenance of the motors. In most places you will be required to fill out and turn in a daily inspection form called a "hard card" before starting the engine. This form is a list of items, such as oil level, water level, visible leaks, and other things, that affect the operation of the machine. Transportation departments are the ones who usually handle these forms. After all of the above items have been checked, you are now ready to start welding.

Before you start to weld, ensure that you have all the required equipment and accessories. Listed below are some additional welding rules that should be followed.

1. Clear the welding area of all debris and clutter.

2. Do not use gloves or clothing that contains oil or grease.

3. Check that all wiring and cables are installed properly.

4. Ensure that the machine is grounded and dry.

5. Follow all manufacturers' directions on operating the welding machine.

6. Have on hand a protective screen to protect others in the welding area from FLASH bums.
7. Always keep fire-fighting equipment on hand.
8. Clean rust, scale, paint, or dirt from the joints that are to be welded.

3.10 DEMONSTRATION OF VARIOUS METHODS ADOPTED FOR PAINTING STEEL ITEMS

(JOB-VI Painting steel items by brush/roller/spray.)

The final stage of most construction projects is the application of protective coatings, or “painting”. As with all projects, you should follow the plans and specifications for surface preparation and application of the finish coat. The specifications give all the information you need to complete the tasks. But, to have a better understanding of structural coatings, you need to know their purposes, methods of surface preparation, and application techniques.

3.10.1 Purposes of Structural Coatings

The protection of surfaces is the most important consideration in determining the maintenance cost of structures. Structural coatings serve as protective shields between the base construction materials and elements that attack and deteriorate them. Regularly programmed structural coatings offer long-range protection, extending the useful life of a structure.

a) Preventive maintenance

The primary purpose of a structural coating is protection. This is provided initially with new construction and maintained by a sound and progressive preventive maintenance program. Programmed painting enforces inspection and scheduling. A viable preventive maintenance program will help ensure that minor problems are detected at an early stage before they become major failures later. An added advantage derived from preventive maintenance is the detection of faulty structural conditions or problems caused by leakage or moisture.

Resistance to moisture from rain, snow, ice, and condensation constitutes perhaps the greatest single protective characteristic of paint, the most common type of structural coating. Moisture causes metal to corrode and wood to swell, warp, or rot. Interior wall finishes of buildings can be ruined by moisture entering through neglected exterior surfaces. Porous masonry is attacked and destroyed by moisture. Therefore, paint films must be as impervious to moisture as possible to provide a protective, waterproof film over the surface to which they are applied. Paint also acts as a protective film against acids. alkalies, material organisms, and other damaging elements.

b) Sanitation and cleanliness

Painting is an essential part of general maintenance programs for hospitals, kitchens, mess halls, offices, warehouses, and living quarters. Paint coatings provide smooth, non-absorptive surfaces that are easily washed and kept free of dirt and foodstuffs. Adhering foodstuffs harbor germs and cause disease. Coating rough or porous areas seals out dust and grease that would otherwise be difficult to remove. Odorless paints are used in these areas because conventional paint the odors maybe picked up by nearby food. solvent odors are obnoxious to personnel in food preparation areas.

c) Fire Retardance

Certain types of structural coatings delay the spread of fire and assist in confining a fire to its area of origin. Fire retardant coatings should not be considered substitutes for conventional paints. The use of fire- retardant coatings is restricted to areas of highly combustible surfaces and must be justified and governed by the specific agency's criteria. Fire- retardant coatings are not used in buildings containing automatic sprinkler systems.

d) Camouflage

Camouflage paints have special properties, making them different from conventional paints. Their uses are limited to special applications. Do not use camouflage paints as substitutes for conventional paints. Use this paint only on exterior surfaces to render buildings and structures inconspicuous by blending them in with the surrounding environment.

e) Illumination and visibility

White and light-tinted coatings applied to ceilings and walls reflect both natural and artificial light and help brighten rooms and increase visibility. On the other hand, darker colors reduce the amount of reflected light. Flat coatings diffuse, soften, and evenly distribute illumination, whereas gloss finishes reflect more like mirrors and may create glare. Color contrasts improve visibility of the painted surface, especially when paint is applied in distinctive patterns. For example, white on black, white on orange, or yellow on black can be seen at greater distances than single colors or other combinations of colors.

f) Identification and safety

Certain colors are used as standard means of identifying objects and promoting safety. For example, fire protection equipment is painted red. Containers for kerosene, gasoline, solvents, and other flammable liquids should be painted a brilliant yellow and marked with large black letters to identify their contents. The colors of signal lights and painted signs help control traffic safely by providing directions and other travel information.

3.10.2 Methods

The common methods of applying paint are brushing, rolling, and spraying. The choice of method is based on several factors, such as speed of application, environment, type and amount of surface, type of coating to be applied, desired appearance of finish, and training and experience of painters. Brushing is the slowest method, rolling is much faster, and spraying is usually the fastest by far. Brushing is ideal for small surfaces and odd shapes or for cutting in corners and edges. Rolling and spraying are efficient on large, flat surfaces. Spraying can also be used for round or irregular shapes.

Local surroundings may prohibit the spraying of paint because of fire hazards or potential damage from over spraying (accidentally getting paint on adjacent surfaces). When necessary, adjacent areas not to be coated must be covered when spraying is performed. This results in loss of time and, if extensive, may offset the speed advantage of spraying.
Brushing may leave brush marks after the paint is dry. Rolling leaves a stippled effect. Spraying yields the smoothest finish, if done properly. Lacquer products, such as vinyl, dry rapidly and should be sprayed. Applying them by brush or roller may be difficult, especially in warm weather or outdoors on breezy days. The painting method requiring the most training is spraying. Rolling requires the least training.

3.10.3 Surface Preparation

The most essential part of any painting job is proper surface preparation and repair. Each type of surface requires specific cleaning procedures. Paint will not adhere well, provide the protection necessary, or have the desired appearance unless the surface is in proper condition for painting. Exterior surface preparation is especially important because hostile environments can accelerate deterioration.

a) Metals

As a Builder, you are most likely to paint three types of metals: ferrous, nonferrous, and galvanized. Improper protection of metals is likely to cause fatigue in the metal itself and may result in costly repairs or even replacement. Correct surface preparation, prior to painting, is essential.

b) Ferrous metal

Cleaning ferrous metals, such as iron and steel, involves the removal of oil, grease, previous coatings and dirt. Keep in mind that once you prepare a metal surface for painting, it will start to rust immediately unless you use a primer or pretreatment to protect the surface.

c) Nonferrous metal

The nonferrous metals are brass, bronze, copper, tin, zinc, aluminum, nickel, and others not derived from iron ore. Nonferrous metals are generally cleaned with a solvent type of cleaner. After cleaning, you should apply a primer coat or a pretreatment.

d) Galvanized metal

Galvanized iron is one of the most difficult metals to prime properly. The galvanized process forms a hard, dense surface that paint cannot penetrate. Too often, galvanized surfaces are not prepared properly, resulting in paint failure. Three steps must be taken to develop a sound paint system.

1. Wash the galvanized surface with a solvent to remove grease waxes, or silicones. Manufacturers sometimes apply these to resist "white rust" that may form on galvanized sheets stored under humid conditions. Mineral spirits or acid washes should definitely not be used at this stage.

2. Etch the surface with a mild phosphoric acid wash. Etching increases paint adhesion and helps overcome the stress forces generated by expansion and contraction of the galvanized coating. After acid washing the surface, rinse it with clean water and allow drying. When using acid, remember the situation can represent actual or potential danger to yourself and other employees in the area. Continuous and automatic precautionary measures minimize safety problems and improve both efficiency and morale of the crew.

3. Apply a specially formulated primer. Two basic types of primer are in common use: zinc-bound and cementitious-resin. The zinc-bound type is used for normal exposure. Most types of finish can be used over this type of primer. Latex emulsion paints provide a satisfactory finish. Oil-based products should not be used over cementitious-resin primers. A minimum of two coats of finish is recommended over each type of primer.

STUDENT ACTIVITY

1. Write short note on filler rods.

2. What do you mean by welding procedure?

SUMMARY

- Oxyacetylene and oxy-MAPP (methylacetylene- propadiene) welding are two types of gas welding processes. They require a gas-fueled torch to raise the temperature of two similar pieces of metal to their fusion point that allows them to flow together.
- An oxygas welding outfit also is called a welding rig.
- The oxygas welding torch mixes oxygen and fuel gas in the proper proportions and controls the amount of the mixture burned at the welding tip.
- The term filler rod refers to a filler metal used in gas welding, brazing, and certain electric welding processes in which the filler metal is not a part of the electrical circuit.
- During the process of welding, oxygen may combine with the molten metal (at the point of welding) and form oxides which when entrapped in the weld joint, make the joint weaker.
- When lighting the torch and adjusting the flame, you should always follow the manufacturer's directions for the particular model of torch being used.
- For welding equipment to operate at peak efficiency and give useful service, you must perform the proper maintenance and upkeep on it.
- The square butt joint is used primarily for metals that are 3/16 inch or less in thickness. The joint is reasonably strong, but its use is not recommended when the metals are subject to fatigue or impact loads.
- The primary purpose of a structural coating is protection. This is provided initially with new construction and maintained by a sound and progressive preventive maintenance program.
- Painting is an essential part of general maintenance programs for hospitals, kitchens, mess halls, offices, warehouses, and living quarters.
- The most essential part of any painting job is proper surface preparation and repair.

SELF-ASSESSMENT QUESTIONS

1. Explain the process of gas welding and handling gas welding equipment.
2. Explain the process of preparation of butt joint by gas welding.
3. Explain shielded metal-Arc welding and wear facing process,
4. Discuss in detail the various methods adopted for painting steel items.
5. Write short notes on:
   - **a)** Oxy-acetylene flame
   - **b)** Welding joint
   - **c)** Welding torches
   - **d)** Applications of oxydising flame.

SECTION – D

4 ELECTRIC SHOP

LEARNING OBJECTIVES

- Importance of three phase wiring and its effectiveness
- Two watt meter Method of Power measurement in a three phase circuit
- Connecting single energy meter and testing it, reading and working out the power and costing of energy in a single phase circuit.

4.1 IMPORTANCE OF THREE PHASE WIRING AND ITS EFFCTIVENESS

(Job-I Laying out of 3 phase wiring for an electric motor or any 3 phase machine. Estimating and costing power consumption)
(Job-II Connecting single energy meter and testing it, reading and working out the power and costing of energy)

This section describes the two main types winding of electric motors: DC and motors. Fig.1 shows the most common electric motors. These are categorized based on the input supply, construction, and operation mechanism, and are further explained below.

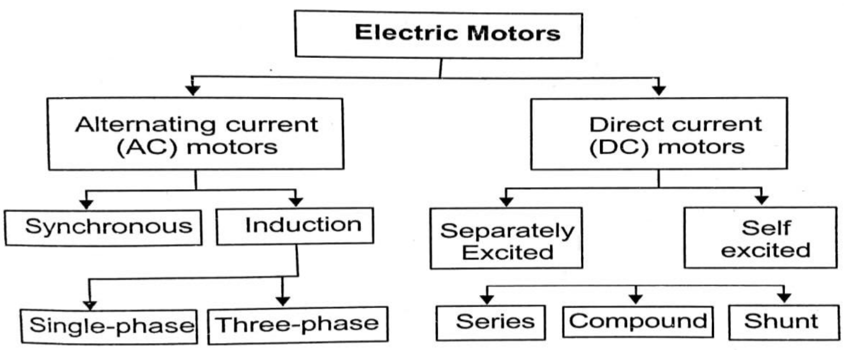


Fig.1. Classification of the Main Types of Electric Motors

Induction motor has been discussed so it is better to discuss the D.C. motor.

To analyze the performance of a d.c machine one should at least be aware of the fact that:

Number of parallel paths in armature, a = P for LAP winding and a = 2 for WAVE winding.

4.1.1 D.C Machine Armature Winding

Armature winding of a D.C machine is always closed and of *double layer* type. Closed winding essentially means that all the coils are connected in series forming a closed circuit. The junctions of the consecutive coils are terminated on copper bars called commutator segments. Each commutator segment is insulated from the adjacent segments by mica insulation. For reasonable understanding of armature winding, let us first get acquainted with the following terminologies.

i. A **coil** has two coil sides occupying two distinct specified slots. Generally two maximize induced voltage in a coil, the spacing between them should be close to 180° electrical. This essentially means if at a given time one coil side is under the center of the north pole, the other coil side should be under the center of the south pole.

ii. **Coil span** is nothing but the spacing between the two coil sides of a coil. The spacing is expressed in terms of number of slots between the sides. If S be the total number of slots and P be the total number of poles then coil span is S/P. For 20 slots, 4 poles winding, coil span is 5. Let the slots be numbered serially as 1, 2,.., 20. If one coil side is placed in slot number 3, the other coil side of the coil must occupy slot number 8 (= 3 + 5).

iii. A **Double layer winding** means that each slot will house two coil sides (obviously belonging to two different coils). Physically one coil side is placed in the lower portion of the slot while the other is placed above it. It is because of this reason such an arrangement of the winding is called a double layer winding. In the n slot, coil side in the upper deck is numbered as n and the coil side in the lower deck is numbered as n'. In the 5th slot upper coil side is numbered as 5 and the lower coil side is numbered 5'. In the winding diagram, upper coil side is shown with firm line while the lower coil side is shown with dashed line.

   Remembering that a coil has two coil sides, for a double layer winding total number of coils must be equal to the total number of slots.

iv. **Numbering a coil:** A coil is so shaped, that when it is placed in appropriate slots, one coil side will be in the upper deck and the other side will be in the lower deck. Suppose S = 20 and P = 4, then coil span is 5. Let the upper coil side of this coil be placed in slot number 6, the other coil side must be in the lower deck of slot number 11. The coil should now be identified as (5 - 11'). In other words coil sides of a coil are numbered depending on the slot numbers in which these are placed. A typical single turn and multi turn coils are shown in Fig.2.

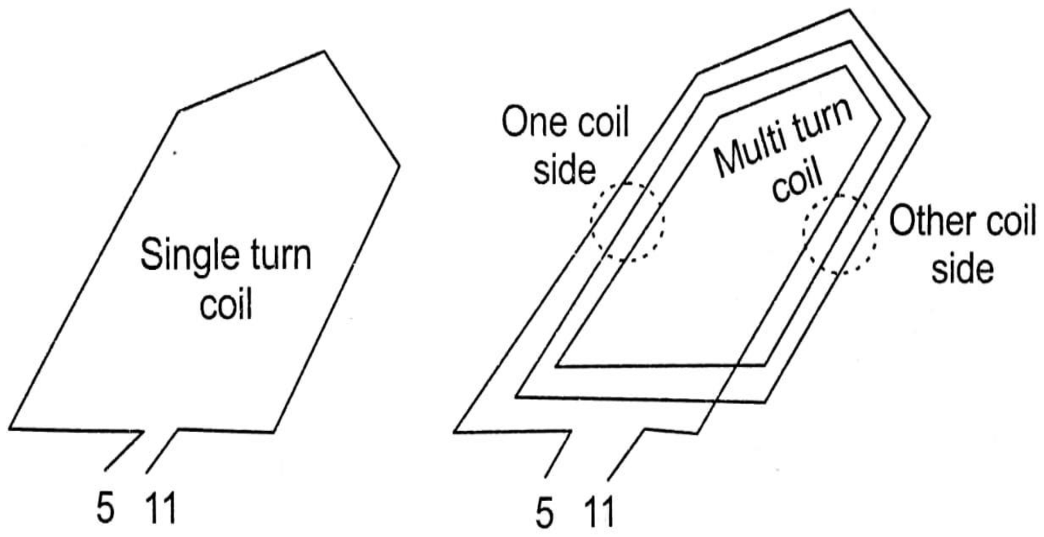


Fig.2. Single turn & Multi turn coil

v. On a **Commutator segment** two coil sides (belonging to two different coils) terminate. 2S being the total number of coil sides, number of commutator segments must be equal to S, number of slots. Commutator segments can also be numbered as 1,2,.,20 in order to identify them clearly.

vi. **Commutator pitch:** As told earlier, the free ends of the coil sides of a coil (say, 6-11') are to be terminated on to two specific commutator segments. The separation of coil sides of a coil in terms of number of commutator segments is called the commutator pitch y_c. In fact the value of y_c decides the types of winding (lap or wave) which will result. For example, in case of lap winding $y_c = 1$.

4.1.2 Armature winding: General procedure

1. Type of winding (lap or wave), total number of slots S and total number of poles P will be given.
2. Calculate coil span (= S/P).
3. Calculate commutator pitch y_c. For lap winding $y_c = \pm1$ and for 2(S1) wave winding $y_c = \frac{2(S\pm1)}{P}$
4. We have to complete the windings showing the positions of coil sides in slots, interconnection of the coils through commutator segments using appropriate numbering of slots, coil sides and commutator segments.
5. Finally to decide and place the stationary brushes on the correct commutator segments.

4.1.3 Developed Diagram

Instead of dealing with circular disposition of the slots and the commutator segments, it is always advantageous to work with the developed diagram of the armature slots and the commutator segments as elaborated in Fig.3. In the Fig.3, actual armature with 8 slots and 8 commutator segments are shown.

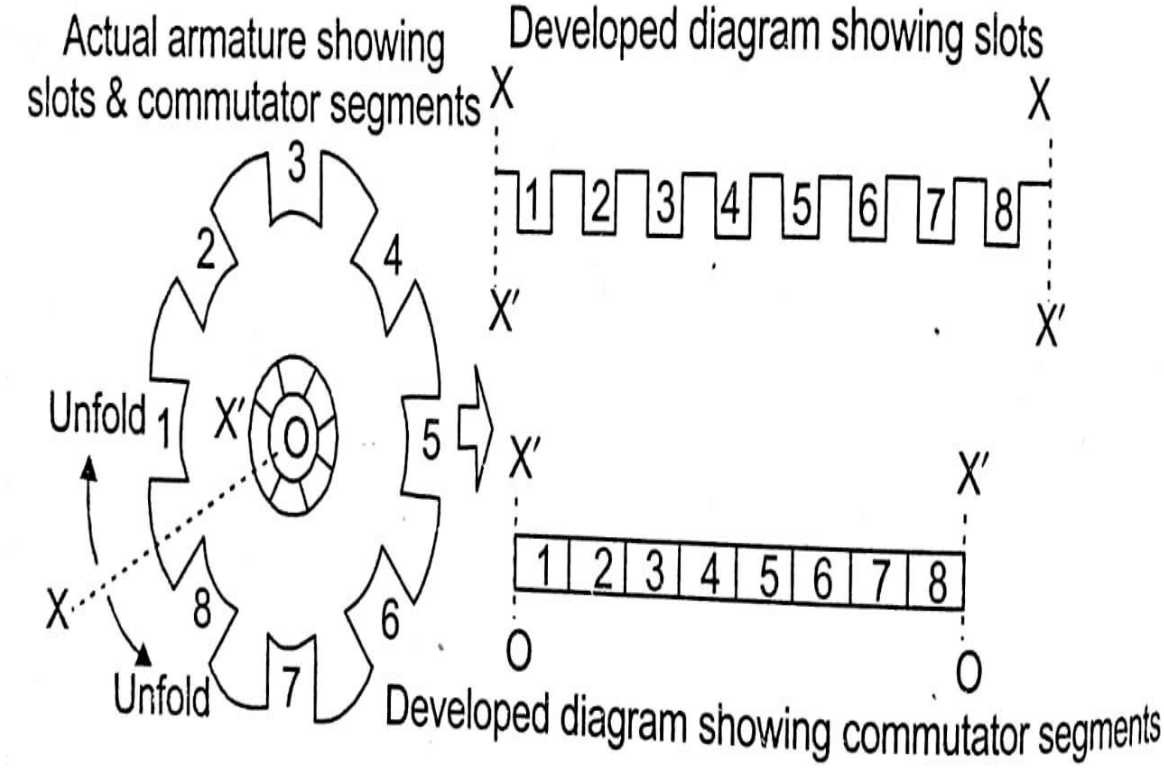


Fig.3. Actual and developed diagram of armature and commutator

Imagine the structure to be cut radially along the line XX'O and unfolded along the directions shown to make it straight. It will result into straight and rectangular disposition of the slots and commutator segments.

4.1.4 Lap Winding

Suppose we want to make a lap winding for a P = 4 pole D.C machine having a total number slots S = 16. So coil span is 16/4 = 4. Commutator pitch of a progressive lap winding is $y_c = +1$. In Fig.3 only the slots and commutator segments are shown in which it is very difficult to show the coil sides and hence coil connections. To view the coil sides/coils, we must look below from above the slots as depicted in Fig.4. Once we number the slots, the numbering of the coil sides gets fixed and written. The upper coil side present in slot number 1 is shown by firm line and named 1 while lower coil side is shown by a dashed line (just beside the upper coil side) and named as 1'.

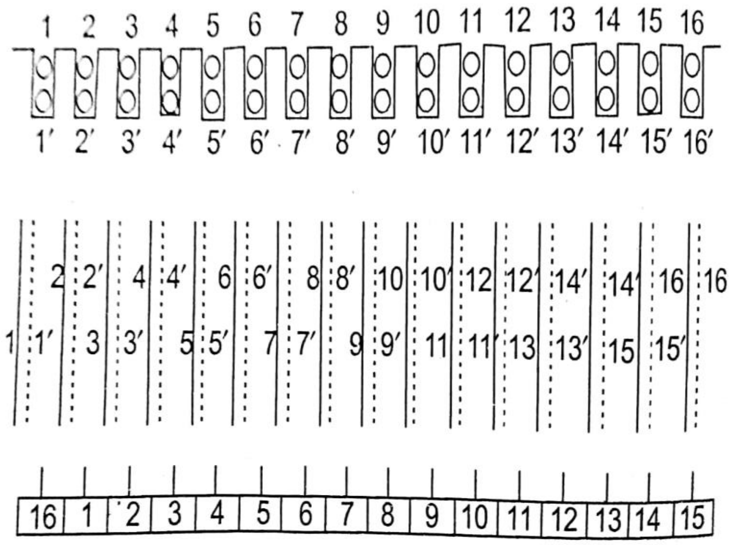


Fig.4. Developed diagram of the armature showing slots, coil sides & Commutator

Let us now see how coils can be drawn with proper termination on the commutator segments. Since the coil span is 4, the first coil has sides 1 and 5' and the identification of the coil can be expressed as (1-5'). Let us terminate coil side 1 on commutator segment 1. The question now is where to terminate coil side 5'? Since the commutator pitch y_c is +1, 5' to be terminated on commutator segment 2 (= y_c + 1). In D.C armature winding all coils are to be connected in series. So naturally next coil (2-6') should start from commutator segment 2 and the coil side 6' terminated on segment 3 as shown in Fig.5. It may be noted that in a lap winding there exist a single coil between any two consecutive commutator segments.

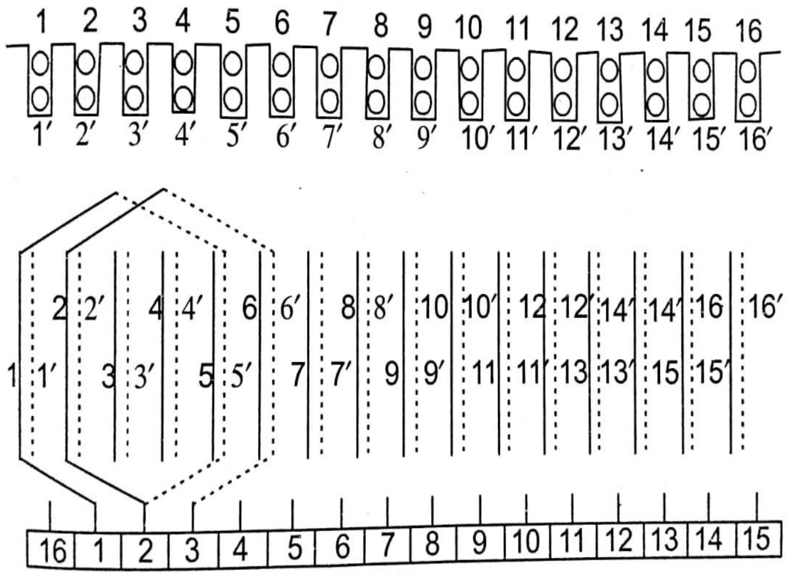


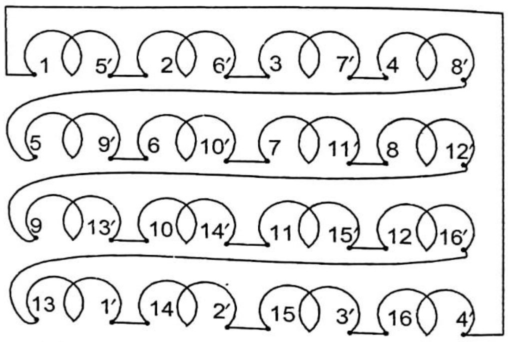
Fig.5. Starting a lap winding

It can be seen that the second coil 2-6' is in the lap of the first coil 1-5', hence the winding is called lap winding. The winding proceeds from left to right due to our assumption that y_c = +1. Such a winding is called *progressive simplex lap winding*. It can be easily shown that if y_c, is chosen to be -1, the winding would have proceeded from right to left giving rise to a *retrogressive lap winding*. One can make first a winding table and then go for actual winding. By now it is clear that to go ahead with winding, two information are essential; namely the number of coil sides of a coil and the number of commutator segments where the free ends of the coil sides will be terminated. In a winding table (look at Fig.6) these two information are furnished.

The complete progressive lap winding is shown in Fig. 7. To fix up the position of the brushes, let us assume the instant when slots 1,2,3 and 4 are under the influence of the north pole which obviously means slots 5 to 8 are under south pole, slots 9 to 12 are under north pole and slots 13 to 16 under south pole. The poles are shown with shaded areas above the active lengths (coil sides) of the coils. Considering generator mode of action and direction of motion from left to right (1-5', 2 - 6', 3 - 7' and 4 – 8') are in the clockwise directions with 8' +ve and 1' -ve. In the same way, 5 is +ve, 12' is -ve; 16' is +ve and 9 is-ve; 13 is +ve and 4' is -ve. Therefore, two +ve brushes may be placed on commutator segment numbers 5 and 13. Two numbers of –ve brushes may be placed on commutator segment numbers 1 and 9. Two armature terminals A_2 and A_1 are brought out after shorting the +ve brushes together and the -ve brushes together respectively. Thus in the armature 4 parallel paths exist across A_2 and A_1. Careful look at the winding shows that physical positions of the brushes are just below the center of the poles. Also worthwhile to note that the separation between the consecutive + ve and the -ve brushes is one pole pitch (16/4 = 4) in terms of commutator segments.

Coil	Commutator segments where the coil ends terminated
1 - 5′	1, 2
2 - 6′	2, 3
3 - 7′	3, 4
4 - 8′	4, 5
5 - 9′	5, 6
6 - 10′	6, 7
7 - 11′	7, 8
8 - 12′	8, 9
9 - 13′	9, 10
10 - 14′	10, 11
11 - 15′	11, 12
12 - 16′	12, 13
13 - 1′	13, 14
14 - 2′	14, 15
15 - 3′	15, 16
16 - 4′	16, 1

(a) Winding table



(b) Simplified representation of the coil connection

Fig.6. Winding table and coil connections

In fact for a P polar machine using lap winding, number of parallel paths a = P. Will it be advisable to put only a pair of brushes in the armature? After all a pair of brushes will divide the armature into two parallel paths.

Let, the total number of slots = S

The total number of poles = P

So total no. of commutator segments = S

Total no. of coils = S (double layer winding)

No. of coils between two consecutive commutator segments = 1 (simplex lap winding)

Number of commutator segments between consecutive +ve and -ve brushes = S/P

So Number of coils between the +ve and -ve brushes = S/P

If only a pair of brushes is placed, then armature will be divided in to two parallel paths consisting of S/P coils in one path and (P-1)$\frac{S}{P}$ coils in the other path.

So, current distribution in the paths will be unequal although emf will be same. A little consideration shows another pair of brushes can be put (Fig. 7) producing 4 identical parallel paths. Therefore, in a lap winding number of brushes must always be equal to the number of poles. Lap winding is adopted for low voltage, high current D.C Machines.

4.1.5 Wave Winding

In this winding these coil sides of a coil is not terminated in adjacent commutator segments, i.e., $y_c \neq 1$. Instead y, is selected to be closely equal to two pole pitch in terms of commutator segments. Mathematically y_c = 2S/P. Let us attempt to make a wave winding with the specifications S = 16 and P = 4. Obviously, coil span is 4 and y_c=8.

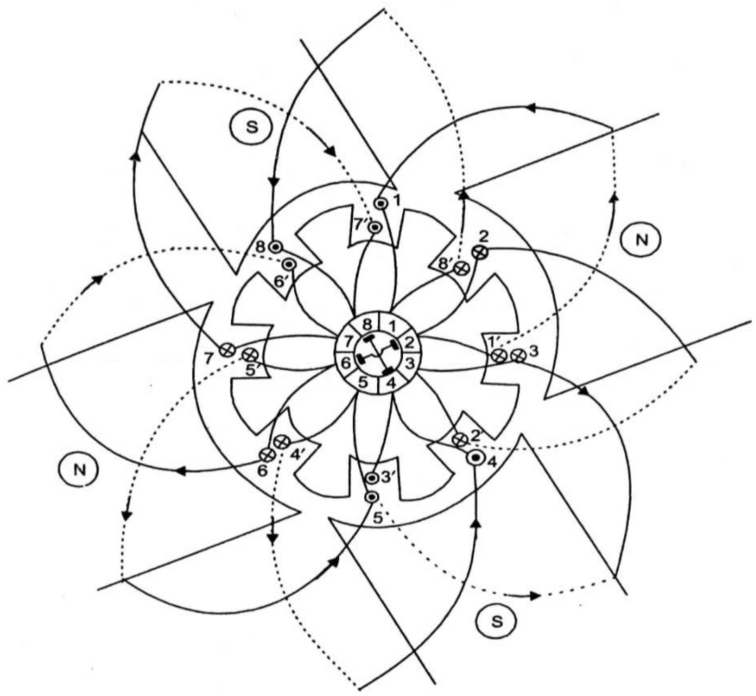


Fig.7. Lap winding, polar diagram

The first coil is (1-5') and is terminated on commutator segments 1 and

9. The second coil (9-13') to be connected in series with the first and to be terminated on commutator segments 9 and 1 (i.e., 17'). Thus we find the winding gets closed just after traversing only two coils and it is not possible to carry on with the winding. Our inability to complete the wave winding will persist if 25 remains a multiple of P. is because of this reason expression for commutator pitch yc, is modified to $y_c=2(S\pm1)/P$. In other words, number of slots, should be such that $2(S\pm1)$ should be multiple of P. It can be shown that if +ve sign is taken the result will be a progressive wave winding and if -ve sign is taken the result will be retrogressive wave winding.

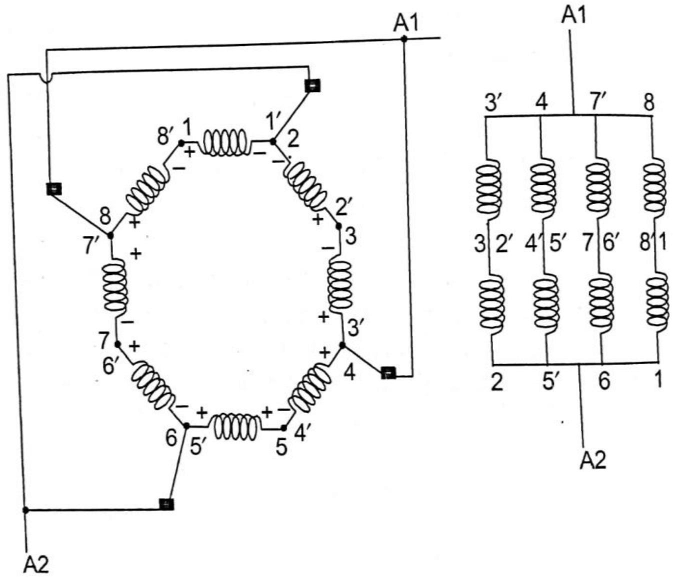


Fig.8. Parallel paths across armature terminals

4.2 TWO-WATTMETER METHOD OF POWER MEASUREMENT IN A THREE-PHASE CIRCUIT

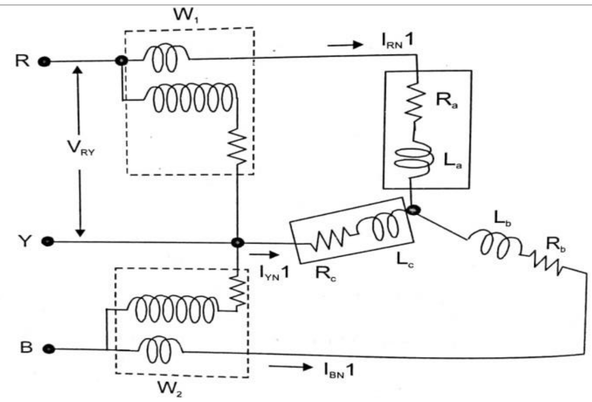


Fig.9

The connection diagram for the measurement of power in a three-phase circuit using two wattmeters, is given in Fig.9. This is of the circuit connection-- star or delta. The circuit may be unbalanced one, balanced type being only a special case. Please note the connection of the two wattmeters. The current coils of the wattmeters, 1 and 2, are inn series with two phases, R and B, with the pressure or voltage coils being connected across R-Y and B Y respectively. Y is the third phase, in which no current coil is connected.

If star connected circuit is taken as an example, the total instantaneous power consumed in the circuit is,

$$W = i_{RN'} \cdot v_{RN'} + i_{YN'} \cdot v_{YN'} + i_{BN'} \cdot v_{BN'}$$

To calculate the cost W is multiplied by the total time and applied charges per unit.

4.3 CONNECTING SINGLE ENERGY METER AND TESTING IT, READING AND WORKING OUT THE POWER AND

An instrument that is used to measure either quantity of electricity or energy, over a period of time is known as energy meter or watt- hour meter. In other words, energy is the total power delivered or consumed over an interval of time t may be expressed as:

$$W = \int_0^t v(t)\, i(t)\, dt$$

If voltage is expressed in volts, current in amperes and t in seconds, the unit of energy is joule or watt second. The commercial unit of electrical energy is kilowatt hour (KWh). For measurement of energy in a.c. circuit, the meter used is based on “electro-magnetic induction" principle. They are known as induction type instruments. The measurement of energy is based on the induction principle is particularly suitable for industrial or domestic meters on the account of lightness and robustness of the rotating element. Moreover, because of smallness of the variations of voltage and frequency in supply voltage, the accuracy of the induction meter is unaffected by such variations. If the waveform of the supply is badly distorted, the accuracy, however, is affected. Basically, the induction energy meter may be derived from the induction watt-meter by substituting for the spring control and pointer an eddy current brake and a counting train, respectively. For the meter to read correctly, the speed of the moving system must be proportional to the power in the circuit in which the meter is connected.

4.3.1 Basic Operation

Induction instruments operate in alternating- current circuits and they are useful only when the frequency and the supply voltage are approximately constant. The most commonly used technique is the shaded pole induction watt- hour meter, shown in fig.10.

The rotating element is an aluminum disc, and the torque is produced by the interaction of eddy currents generated in the disc with the imposed magnetic fields that are produced by the voltage and current coils of the energy meter.

Power measured is given by:

$$P = V\ I\ \cos\theta$$

Where

θ = **deflection shown by meter.**

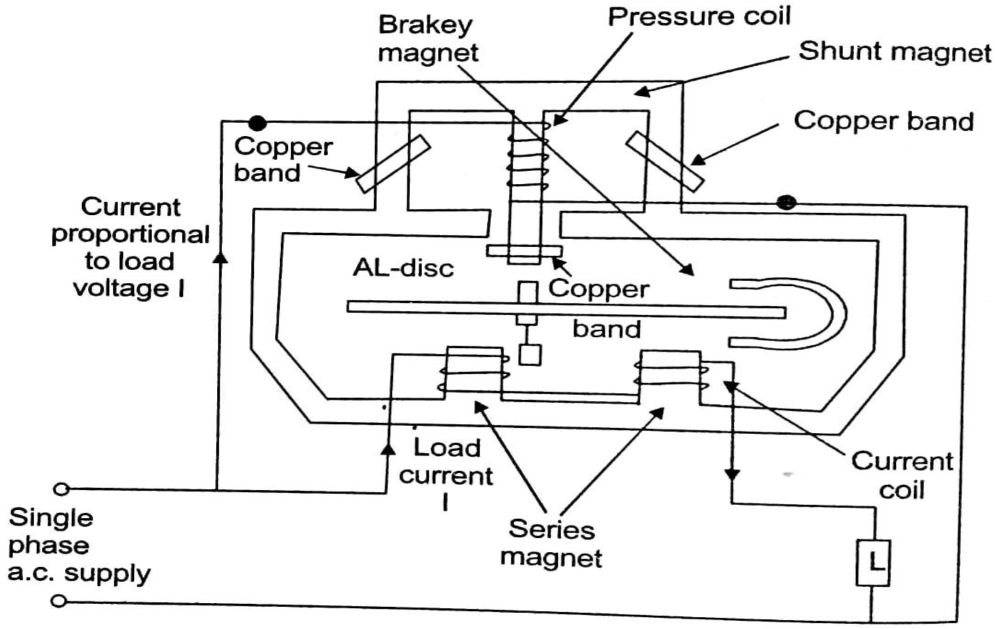


Fig.10.

STUDENT ACTIVITY

1. What is coil span?

2. What is double layer winding?

SUMMARY

- Armature winding of a D.C machine is always closed and of double layer type. Closed winding essentially means that all the coils are connected in series forming a closed circuit.
- A coil has two coil sides occupying two distinct specified slots.
- Coil span is nothing but the spacing between the two coil sides of a coil.
- A Double layer winding means that each slot will house two coil sides (obviously belonging to two different coils).

SELF-ASSESSMENT QUESTIONS

1. Describe layout of 3 phase wiring for an electric motor and estimate the power consumption.

2. Give basic operation with diagram of two-wattmeter method of power measurement in a three-phase circuit.

3. What do you mean by wave winding?

4. Write short notes on:

   a. Lap winding

   b. Armature winding

   c. Double layer winding.

SECTION – E

5 ELECTRIC SHOP

LEARNING OBJECTIVES

- Wire Rope
- Various Types of Plugs, Sockets, Connectors Suitable for General Purpose Audio Video Use.
- Various Types of Switches Such as Normal/Miniature Toggle, Slide, Puch Button Plano Key, Rotatory, SPST, SPDT, DPST, DPDT.
- Various types of Protective Devices such as: Fuses, Circuit Breakers and Relay
- Demonstrate the Skill to Make Facilities Solder Joint
- Installation and Soldering of Printed Circuit Components
- Soldering of PCB Components
- Application of Solder and Soldering Iron Tip
- Component Desoldering
- Motorized Vacuum/ Pressure Method

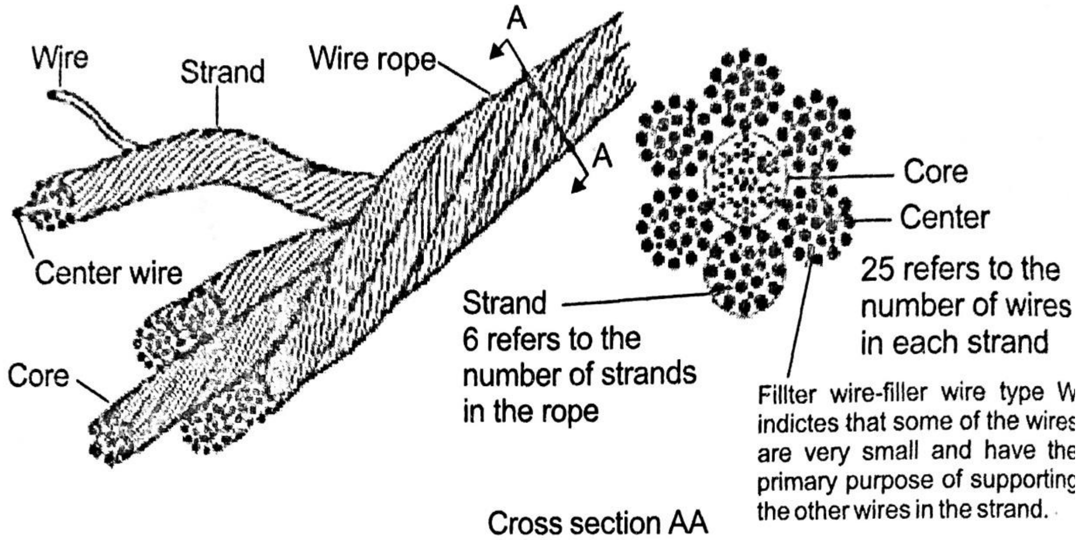
5.1 WIRE ROPE

Wire rope may be manufactured from many grades and types of steel and alloys. They may be constructed from nonferrous materials or coated wires. Some of the more common grades with the differing designations are as follows:

a) Improved plow steel- monitor steel- purple grade- Level-3 steel

b) Extra improved plow steel- monitor AA grade- purple plus- Level 4 steel

A. Terminology



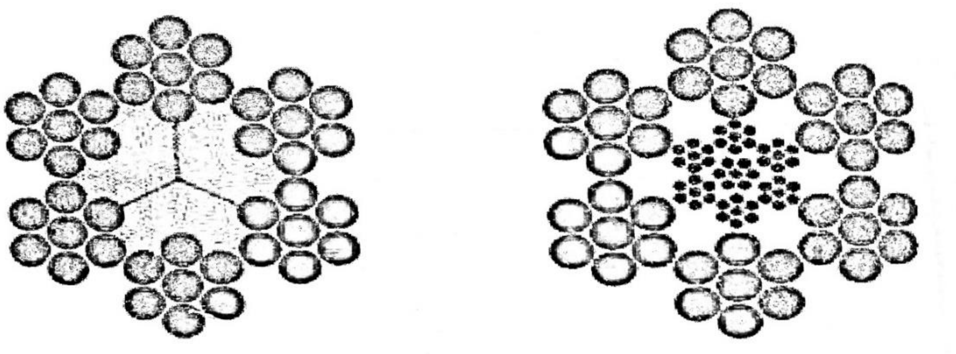
General view

General and cross sectional views showing general structure and terminology of wire ropes. Wire rope shown is a class 6 × 19, of the 6 × 25 filler wire type W construction. The rope is made up of six 25 wire strands. The strands are each laid 12-6-6-1; that is 12 outer wires, six filler wires, six inner wires, one center wire

Fig.1

B. Cores for wire rope

The core is the central member about which the main strands are laid. The principal function of the core is to provide a bearing for the strand. This foundation maintains the proper lateral position of the strands and permits their relative longitudinal motion in adjusting the distribution of stress. Figure 2 shows the three common types of cores used in wire rope.



FIBER CORE (FC)
Natural fibers such as sisal, cotton and jute, synthetic filaments such as polypropylene

INDEPENDENT WIRE ROPE CORE (IWRC)
A small wire rope used as a core in a larger rope

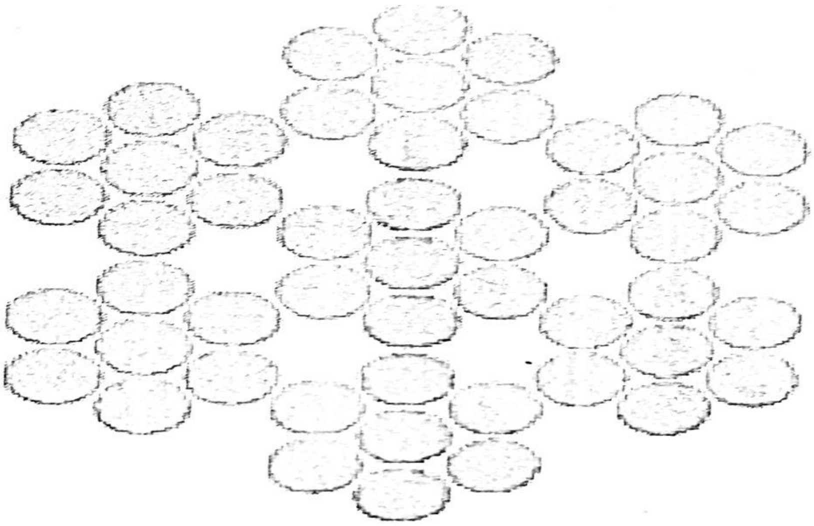


Fig.2

C. Wire rope lays

The lay direction of a wire rope is the direction in which the strands rotate around the rope, as seen receding from the observer and viewed from above. The lay direction of outer wires of a single strand is determined in the same manner. Figure 3 shows the various lay combinations.

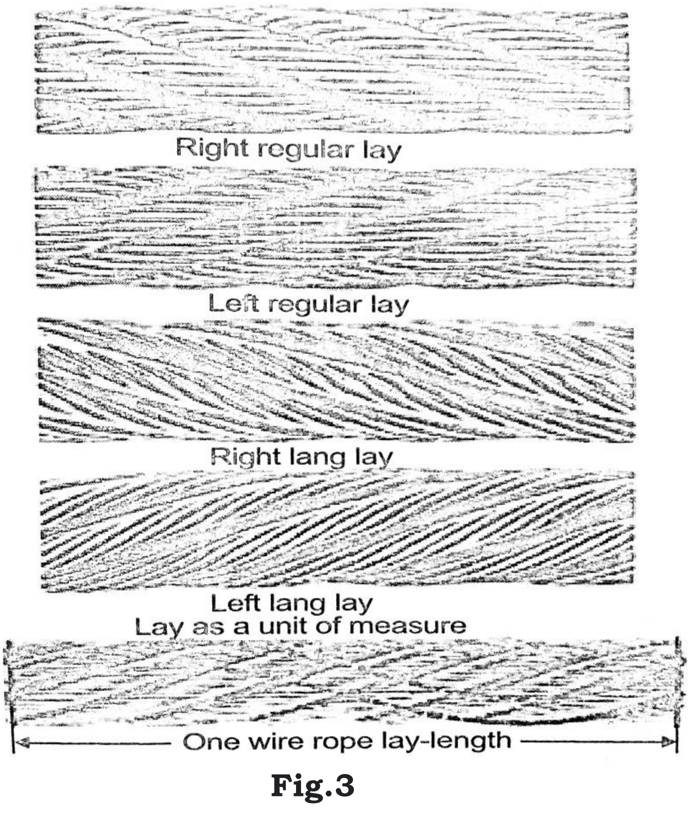


Fig.3

The lay as a unit of measure is the length a single strand extends in making one complete turnaround the rope. Lay length is measured in a straight line parallel to the center-line of the rope; not by following the path of the strand.

D. Rope diameter

Figure 4 shows the right and wrong way to measure rope diameter.

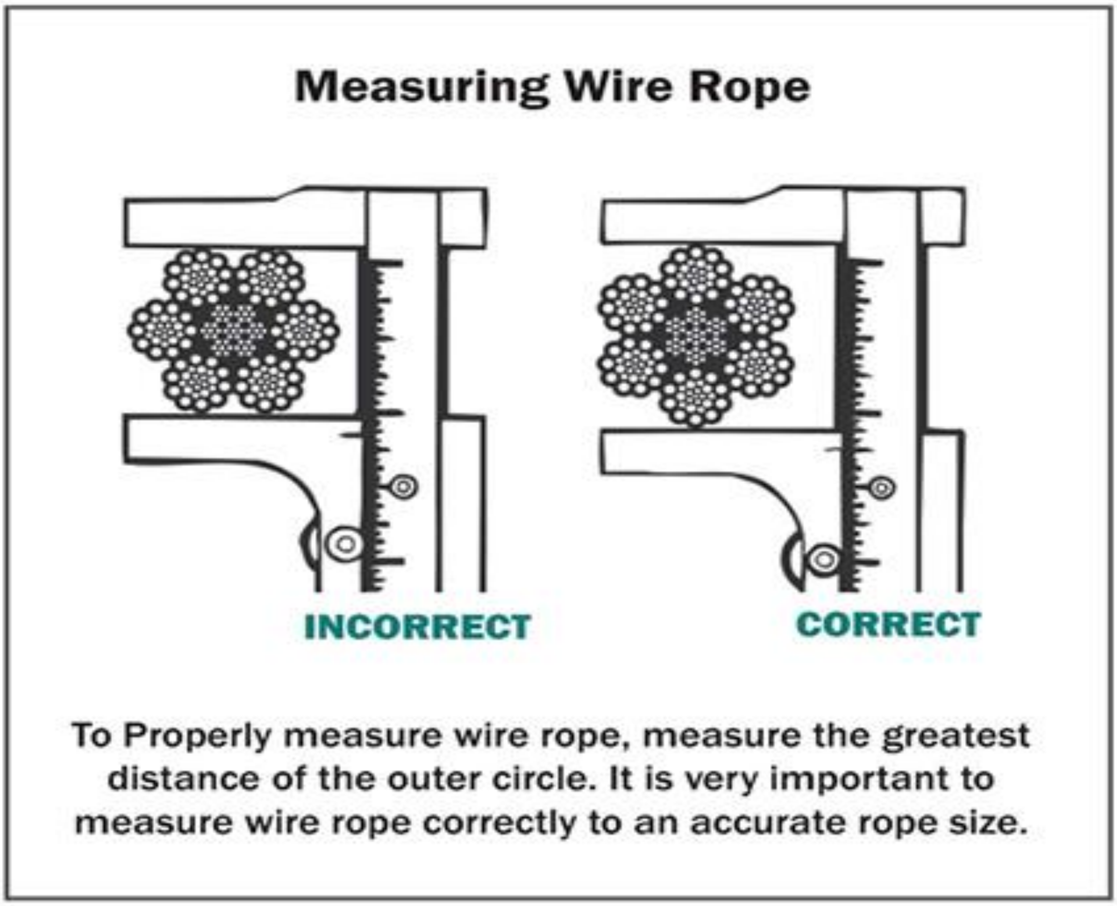
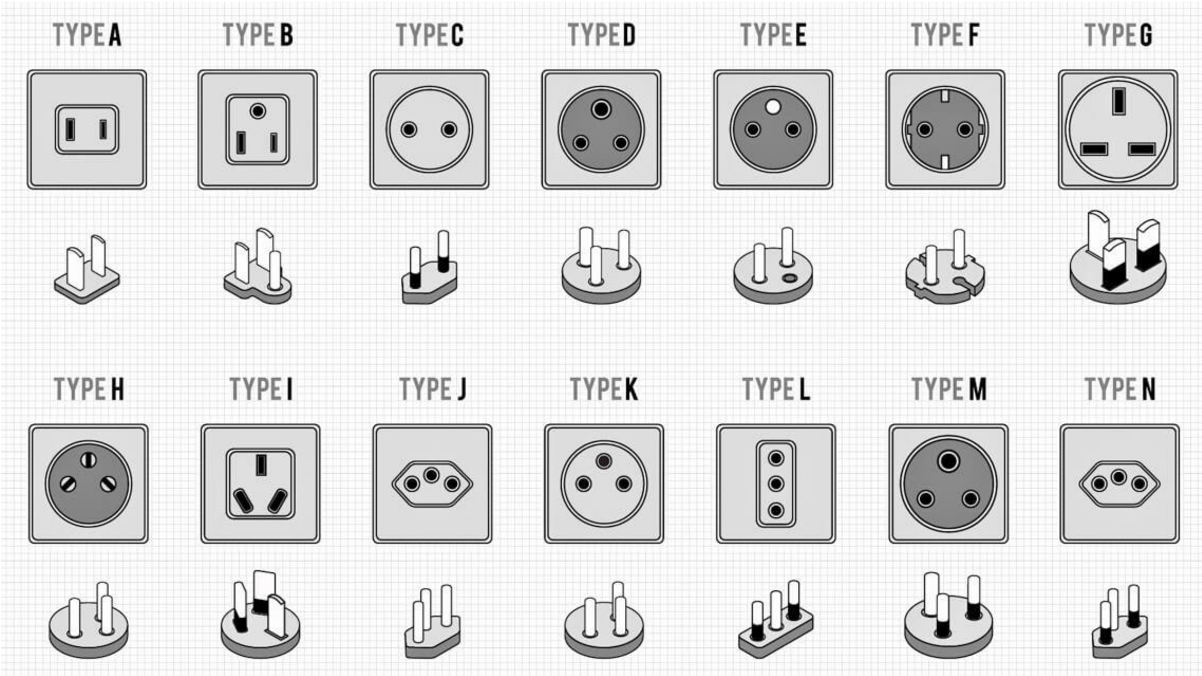


Fig.4

E. Rope class

Wire rope is designed by class: 6x7 (6 strands, 7 wires); 6x19 (6 strands, 19 main wires per strand); 6x37 (6 strands, nominally 37wires per strand). When "nominally" is used, the number of wires per strand may vary significantly (i.e., 6x19 nominal may have from 9 to 26 wires per strand).

5.2 VARIOUS TYPES OF PLUGS, SOCKETS, CONNECTORS SUITABLE FOR GENERAL PURPOSE AUDIO VEDIO USE



5.2.1 AC Power Plugs and Sockets

AC power plugs and sockets are devices that connect appliances, portable light fixtures, and other electrically-operated devices to the commercial power supply so that electric power can flow to them.

Power plugs are male electrical connectors that fit into female electrical sockets. They have contacts that are pins or blades that connect mechanically and electrically to holes or slots in the socket. Plugs usually have a live or hot contact, a neutral contact, and an optional earth or Ground contact. Many plugs make no distinction between the live and neutral contacts, and in some cases they have two live contacts. The contacts may be steel or brass, and may be zinc, tin or nickel plated.

Power sockets, power receptacles, or power outlets are female electrical connectors that have slots or holes which accept the pins or blades of power plugs inserted into them and deliver electricity to the plugs. Sockets are usually designed to reject any plug which is not build to the same electrical standard. Some sockets have a pin that connects to a hole on the plug, for a ground contact.

5.2.2 The Three Contacts

In most countries, household power is single-phase electric power, with two or three wired contacts at each outlet:

1. The **live wire** (also known as phase, hot or active contact), carries the source Voltage phase alternating current from the power grid via the electrical service panel to the household loads.

2. The **neutral wire** or "return" returns current to the source.

3. The **earth wire** (known as ground in American English) is only intended to carry electric current when the connected equipment develops an insulation (safety) fault, and should otherwise never carry a voltage. It is generally connected to metal cases and other parts of the equipment which may come into contact with humans. Electromagnetic interference filters and surge protectors dispose of unwanted electric charges via the earth wire.

5.2.3 Polarized Plugs

Polarized plugs and sockets are used for safety reasons Polarized connectors are used to maintain the identity of the neutral conductor in the connected equipment. This is important so that switches, for example, interrupt only the live wire of the circuit. Polarization is maintained by the shape, size, or position of plug pins and socket holes to ensure that a plug fits only one way into a socket.

If the neutral wire was interrupted instead, while the device would deactivate (due to the opening of the electrical circuit), its internal wiring would still be energized. This can present a shock hazard if the device is opened, because the human body would create a circuit- a path to a voltage different than that of the live wire. Interchange of the hot and neutral wires in the behind-the-walls household wiring can thus create a safety hazard.

5.2.4 Plugs and Sockets in Present Use

1. Type A (North American/Japanese 2- pin)

Standardized by the U.S. National Electrical Manufacturers Association and adopted by 38 other countries, this simple plug with two flat can thus create a safety hazard, parallel pins, or blades, is used in most of North America and on the east coast of South America on devices not requiring a ground connection, such as lamps and "double-insulated" small appliances. NEMA 1 15 sockets have been prohibited in new construction in the United States and Canada since 1962, but remain in many older homes and are still sold for replacement use only. Type A plugs are still very common because they are compatible with type B sockets.

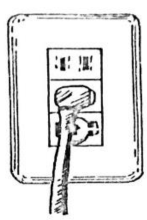


Fig.5

Japanese unearthed sockets with a grounding post for a washing machine.
JIS C 8303, Class II (Japanese 15 A/100 V ungrounded)

2. Type B (American 3-pin or U-ground)

The type B plug has two flat parallel blades like type A, but has a round ground or earthing pin. It is rated for 15 amperes at 125 volts. The ground pin is longer than the live and neutral blades, so the device is grounded before the power is connected. The neutral blade in the type B socket is wider than the live one to prevent polarized type A plugs being inserted upside-down. Type B plugs often have both pins narrow since the ground pin enforces polarity.

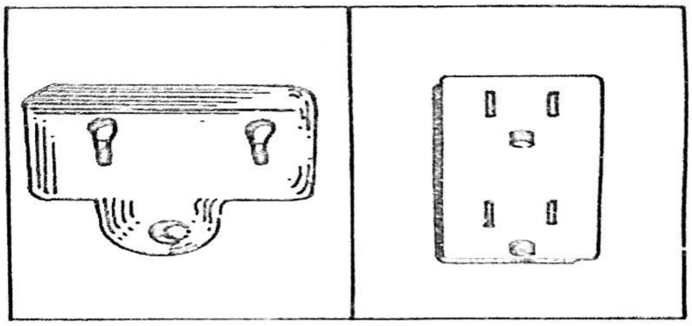


Fig.6

Looking directly at a type B outlet with the ground at the bottom, the neutral slot is on the left, and the live slot is on the right. They may be installed with the ground at the top or on either side.

3. Type C (European 2-pin)

This two-pin plug is probably the single most widely used international plug, popularly known as the Europlug. The plug is unearthed and has two rounds, 4 mm pins, which usually converge slightly. It can be inserted into any socket that accepts 4 mm round contacts spaced 19 mm apart.

Fig. 7

This plug is intended for use with devices that require 2.5 A or less. Because it can be inserted in either direction into the socket, live and neutral are connected at random.

Fig.8

This plug also has two round pins but the pins are 4.8 mm in diameter like types E and F and the plug has a round plastic or rubber base that stops it being inserted into small sockets intended for the Europlug. Instead, it fits only into large round sockets intended for types E and F. The base has holes in it to accommodate both side contacts and socket earth pins. It is used for large Class II appliances. Used in South Korea for all domestic non-earthed appliances, it is also defined in Italian standard CEI 23-5.

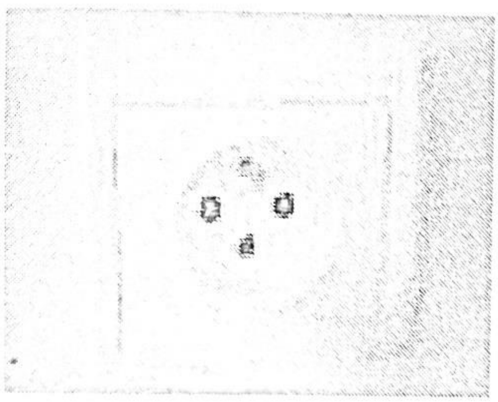


Fig.9

In the United Kingdom and Ireland, there is a special version of the type C plug for use with shavers (electric razors) in bath or shower rooms. It has 5 mm diameter pins 16.6 mm apart, and the sockets for this plug can often take unearthed CEE 7/16, US and/or Australian plugs as well. Sockets are often able to supply either 230 V or 115 V. In wet zones, they must contain an isolation transformer compliant with BS 3535.

4. Type D (Old British 3-pin)

Fig.10. D Plug

India and Pakistan have standardized on a plug which was originally defined in British standard BS 546. It has three large round pins in a triangular pattern. The BS 546 standard is also used in parts of the Middle East (Kuwait, Qatar) and parts of Asia and the Far East that were electrified by the British.

Fig.11. M Plug

This plug is sometimes referred to as type M, but it is in fact merely the 15 A version of the plug above, though its pins are much larger at 7.05 mm x 21.1 mm. Live and neutral are spaced 25.4 mm apart, and earth is 28.6 mm away from each of them. Although the 5 A version is standard in India, Pakistan, Sri Lanka, Nepal, and Namibia, the 15 A version is also used in these countries for larger appliances. Some countries like South Africa use it as the main domestic plug and socket type, where sockets always have an on-off switch built into them. The Type M is almost universally used in the UK for indoor dimmable theatre and architectural lighting installations. It is also often used for non-dimmed but centrally controlled sockets within such installations. The main reason for doing this is that fused plugs, while convenient for domestic wiring (as they allow 32 A socket circuits to be used safely), are not convenient if the plugs and sockets are in hard-to-access locations (like lighting bars) or if using chains of extension leads (since it is hard to figure out which fuse has blown). Both of these situations are common in theatre wiring.

5. French type E

Earthing in the E socket is done by a round male pin permanently mounted in the socket. Sockets are installed with the earth pin upwards and wired with left as live and right as neutral. The plug itself is round with two round pins measuring 4.8 x 19 mm, spaced 19 mm apart and a hole for the socket's earth pin.

As with German plug below this plug will fit some other types of socket either easily or with force. However, there is no earth connection with such sockets. Also in some cases forcing the plug in may damage the socket.

Fig. 12

6. Type F (German 2-pin, side clip earth)

Fig.13

The type F plug, defined in CEE 7/4 and commonly called a "Schuko plug", is like type E except that it has two earthing clips on the sides of the plug instead of a female earth contact. The Schuko connection system is symmetrical and allows live and neutral to be reversed. The socket also accepts Europlugs and CEE 7/17 plugs. It supplies up to 16 amperes. Above that, equipment must either be wired permanently to the mains or connected via another higher power connector.

"Schuko" is an abbreviation for the German word Schutzkontakt, which means "Protective (that is, earthed) contact".

Schuko sockets are unpolarized. Wiring polarity is not standardised in most of the countries that use this socket type (see the main Schuko article for details).

7. Type E and F hybrid

In order to bridge the differences between sockets E and F, the CEE 7/7 plug was developed. It has earthing clips on both sides to connect with CEE 7/4 socket and a female contact to accept the earthing pin of the type E socket. It's also used in Spain and Portugal. Nowadays, when appliances are sold with type E/F plugs attached, the plugs are CEE 7/7 and non-rewirable. This means that the plugs are now identical between countries like France and Germany, only the sockets are different.

Fig.14

Type E and F plugs that are not compatible with both types of socket are only found if a cheap replacement plug has been attached to a cord that originally had another plug. Better-quality replacements are standard CEE 7/7 and are compatible with both Schuko and French standard sockets.

8. Type G (British 3-pin)

Fig. 15

This plug, commonly known as a "13-amp plug", is a large plug that has three rectangular prongs forming a triangle. Live and neutral are 4 x 6 x 18 mm spaced 22 mm apart. 9 mm of insulation over the base of the pins prevents accidental contact with a bare connector while the plug is partly inserted. Earth is 4 x 8 x 23 mm.

The plug is unusual in that it has a fuse inside, for protection, in addition to a circuit breaker in the distribution panel. The fuse is required to protect the cord, as British wiring standards allow very high-current circuits to the socket. Accepted practice is to choose the smallest standard fuse (3 A, 5 A, or 13 A) that will allow the appliance to function. Using a 13 A fuse on an appliance with thin cord is considered bad practice. The fuse is 1 inch long, conforming to standard BS 1362.

9. Type H (Israeli 3-pin)

This plug, defined in SI 32 (IS16A-R), is unique to Israel and is incompatible with all other sockets. It has three flat pins to form a Y-shape. "Live and "Neutral" are spaced 19 mm apart. The Type H plug is rated at 16 A but in practices the thin flat pins cause the plug to overheat when connecting large appliances. In 1989, the SI 32 was revised to use three round 4 mm pins in the same locations as the older standard.

Fig.16

Sockets made since 1989 accept both flat and round pins in order to be compatible with both old and new plugs. This also allows the Type H socket to accommodate type C plugs which are used in Israel for non-grounded appliances. Older sockets, from about the 1970s, have both flat and round holes for "Live" and "Neutral" in order to accept both Type C and Type H plugs. As of 2008, "pure Type H sockets (which accept only old standard Type H plugs) are very rare in Israel.

10. Type I (Australian/New Zealand & Chinese/Argentinian 2/3-pin)

Fig.17

This plug, used in Australia, New Zealand, Fiji and Papua New Guinea, has an earthing pin, and two flat pins forming an upside down V- shape. The flat blades measure 6.5 x 1.6 mm and are set at 30° to the vertical at a nominal pitch of 13.7 mm.

Australian wall sockets almost always have switches on them for extra safety, as in the UK. An unearthed version of this plug with two angled power pins but no earthing pin is used with small double insulated appliances, but the power (wall) outlets always have three pins, including an earth pin.

11. Type J (Swiss 3- pin)

Switzerland has its own standard which is described in SEV 1011. (ASE1011/1959 SW10A-R) this plug is similar to the type C europlug (CEE 7/16), except that it has an earth pin off to one side. Swiss sockets can take swiss plugs or Europlugs (CEE 7/16). This connector system is rated for up to 10 amperes. There is also a less common variant with 3 square pins rated for 16 A. Above 16 A, equipment must either be wired permanently to the electrical supply system with appropriate branch circuit protection, or connected to the main with an appropraiate high power industrial connector.

Fig.18. Type J plug and connector

Switzerland also has a two-pin plug, with the same pin shape, size and spacing as the SEV 1011's live and neutral pins, but with a more flattened hexagonal form. It fits into both Swiss sockets (round and hexagonal) and CEE 7/16 sockets, and is rated for up to 10 A.

12. Type K (Danish 3-pin)

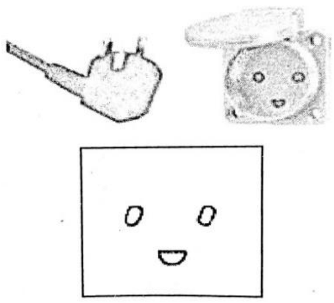


Fig. 19

This Danish standard plug is described in the Danish Plug Equipment Section 107-2-D1 Standard sheet (SRAF1962/DB 16/87 DN10A-R). The plug is similar to the French type E except that it has an earthing pin instead of an earthing hole (and vice versa on the socket). This makes the Danish socket more unobtrusive than the French socket which is a cavity into the wall to protect the earthing pin from mechanical damage (and to protect from touching the live pins).

The Danish socket will also accept the type C CEE 7/16 Europlug or type E/F CEE 7/17 Schuko- French hybrid plug. Type F CEE 7/4 (Schuko), type E/F CEE 7/7 (Schuko- French hybrid), and earthed type E french plugs will also fit into the socket but should not be used for appliances that need earth contact. The current rating on both plugs is 10 A.

Traditionally all Danish sockets were equipped with a switch to prevent touching live pins when connecting/disconnecting the plug. Today, sockets without switch are allowed, but then it is a requirement that the sockets have a cavity to prevent touching the live pins. However, the shape of the plugs generally makes it difficult to touch the pins when connecting/ disconnecting.

13. Type L(Italian 3- pin)

The Italian earthed plug/ socket standard, CEI 23-16/ VII, includes two models rated at 10 A and 16 A that differ in contact diameter and spacing. Both are symmetrical, allowing the live and neutral contacts to be inserted in either direction. CEE 7/16 (type C) unearthed Europlugs are also in common use, and standardized in Italy as CEI 23-5. Appliances with CEE 7/7 Schuko French plugs are often sold in Italy, but not every socket will accept them, since the pins of the CEE 7/7 Schuko- French plugs are slightly thicker than the Italian ones.

Fig. 20

14. Type M (see D)

Type M is sometimes used to describe the 15 A version of the old British type D, used in South Africa and elsewhere. See type D for details.

Fig.21

5.2.5 Multi- standard Sockets

Sockets that take a variety of incompatible plug types are often seen in developing countries where electrical standards are either lacking or unenforced. These sockets may accept both 120 V and 240 V plugs raising a significant risk of devices being damaged by the wrong voltage. Sometimes they have one or more earth holes to allow 3- pin plugs, but there is a good chance that the ground contact may not actually connected to earth and the ground contact certainly will not mate with Schuko or French plugs. Great care should be taken to avoid incompatible voltage and grounding connections when using such outlets. Multi- standard devices designed to auto-adapt to different voltage and frequency standards, and devices which do not require a ground contact are best used with these sockets.

5.2.6 Banana Connector

Fig.22. Adapter between a female BNC connector and banana plugs

Fig.23. Typical banana plugs connected to loudspeaker

A **banana connector** (commonly banana plug for the male, banana jack for the female) is a single-wire (one conductor) electrical connector used for joining wires to equipment. The plugs are frequently used to terminate patch cords for electronic test equipment. They are also used as the plugs on the cables connecting the amplifier to the loudspeakers in a hi-fi sound system.

The plug was invented in 1924 by Richard Hirschman (former Richard Hirschman GmbH & Co.).

The plug consists of a cylindrical metal pin about 25 mm (one inch) long, with a diameter of 4 mm, which can be inserted into a matching 4 mm socket to make an electrical contact. While it is also called a 4 mm connector (likewise 4 mm plug or 4 mm jack, as above), there are also other sizes used for other applications. The pin has one or more lengthwise springs that bulge outwards slightly. These press against the slides of the socket, improving the electrical contact and preventing the pin from falling out. The curved profile of these springs is probably the origin of the name "banana plug". The other end of the plug has a hole that accepts a length of flexible insulated equipment wire, which is either screwed or soldered into place. An insulating plastic cover is usually fitted over this end.

The wide end of a 4 mm plug often has a 4 mm hole drilled in it, either transversely or axially, to accept the pin of another 4 mm plug. This type is called a stackable 4 mm plug.

For high voltage use, a special sheathed version of the banana plugs the male and female connectors to avoid accidental contact. The sheathed male plug will not work with an unsheathed female socket, but an unsheathed male plug will fit a sheathed female socket.

The plastic housing is often extended to contain two banana plugs, allowing simultaneous connection of a signal line and a ground (earth) line. The housing may allow the connection of individual wires, a permanently attached coaxial cable providing both signal and ground. By convention, multiple full-sized banana connectors are spaced on 3/4 inch centers.

Individual banana plugs and jacks are commonly color-coded red and black but are available in a wide variety of colors. Dual banana plugs are usually black with some physical feature such as a molded ridge marked "Gnd" indicating the relative polarity of the two plugs. Besides plugging into specific banana jacks, banana plugs may plug into *five-way or universal* binding posts on audio equipment.

5.2.6.1 Miniature connectors

A miniaturized version of the banana connector was also produced. About 1/3 the size of the standard connector, these were useful in high-density applications but never achieved the same sort of popularity as the larger banana connectors. They are substantially more fragile than the larger connectors. Multiple miniature banana connectors are usually spaced on inch centers.

5.2.6.1 Electrical safety

An exposed banana plug can obviously present electrical hazards if the wire to which it is attached is energized. The hazards include electric shock, electrocution, burns from accidental short circuits, and damage to the attached equipment. Where electrical safety is an issue, due to the presence of higher voltages and/or currents, various kinds of protected plugs and sockets are available. These have sliding covers on plugs and/or other devices to protect the user from accidental contact with live conductors, but are still largely compatible with the original design.

5.2.7 RCA Connector

An RCA jack, also referred to as a phono connector or CINCH/AV connector, is a type of electrical connector that is commonly used in the audio/video market. The name "RCA" derives from the Radio Corporation of America, which introduced the design by the early 1940s to allow mono phonograph players to be connected to amplifiers.

Fig.24

For many other applications it began to replace the older jack plugs used in the audio world when component high fidelity started becoming popular in the 1950s. The corresponding plug is called an RCA plug or a phono plug.

In the most normal usage, cables have a standard plug on each end, consisting of a central male connector, surrounded by a ring. The ring is often segmented for flexibility. Devices mount the jack, consisting of a central hole with a ring of metal around it. The ring is slightly smaller in diameter and longer than the ring on the plug, allowing the plug's ring to fit tightly over it. The jack has a small area between the outer and inner rings which is filled with an insulator, typically plastic (very early versions, or those made for use as RF connectors used ceramic).

Fig.25. High-quality audio grade RCA connectors

As with many other connectors, the RCA has been adopted for other uses than originally intended, including as a power connector, an RF connector, and as a connector for loudspeaker cables. Its use as a connector for composite video signals is extremely common, but provides poor impedance matching. RCA connectors and cable are also commonly used to carry SPDIF-formatted digital audio, with plugs colored orange to differentiate them from other typical connections.

Connections are made by pushing the cable's plug into the female jack on the device. The signal carrying pin protrudes from the plug, and often comes into contact with the socket before the grounded rings meet, resulting in loud hum or buzz if the audio components are powered while making connections. Continuous noise can occur if the plug partially falls out of the jack, breaking ground connection but not the signal. Some variants of the plug, especially cheaper versions, also give very poor grip and contact between the ground sheaths due to their lack of flexibility.

5.2.7.1 Advantages and disadvantages

One problem with the RCA jack system is that each signal requires its own wire. Even the simple case of attaching a cassette deck may need four of them, two for input, and two for output. In any common setup this quickly leads to a mess of cables, which is made worse if one considers more complex signals like component video (a total of three for video and two for analog audio or one for digital coaxial audio).

There have been numerous attempts to introduce combined audio/ video connectors for direct signals, but in the analog realm none of these have ever become universal, except in Europe where the SCART connector is very successful. For a time the 5-pin DIN plug was popular for bi-directional stereo connection between A/V equipment, but it has been entirely displaced on modern consumer devices. Though RF modulators inherently transmit combined A/V signals in video applications, they depend on broadcast television systems and RF connectors which are not universal worldwide; RF signals are also generally inferior to direct signals due to protocol conversion and the RF limitations of the three major analog TV systems (NTSC, PAL and SECAM).

For audio signals, an RCA connection is called unbalanced, and a true balanced connection is generally preferred in certain applications because it allows for the use of long cables while reducing susceptibility to external noise.

5.2.8 DIN Connector

Fig.26. Five-pin male DIN connector

A DIN connector is a connector that was originally standardized by the Deutsches Institut für Normung (DIN), the German national standards organization. there are DIN standards for a large number of different connectors, therefore the term "DIN connector" alone does not unambiguously identify any particular type of connector unless the document number of the relevant DIN standard is added (e.g. "DIN 41524 connector").

In the context of consumer electronics, the term "DIN connector" commonly refers to a member of a family of circular connectors that were initially standardized by DIN for analog audio signals. Some of these connectors have later also been used in analog video applications and for digital interfaces such as MIDI or the IBM PS / 2 computer keyboard and mouse cables. The original DIN standards for these It exists as a panel-mounting female version, and line- mounted male connectors are no longer in print and have been replaced with the equivalent international standard IEC 60130-9.

5.2.8.1 Circular radio connectors

All male connectors (plugs) of this family of connectors feature a 13.2 mm diameter metal shield with a notch that limits the orientation in which plug and socket can mate. A range of connectors of the same form that differ only in their pin configuration exist and have been standardized originally in DIN 41524 (3- and 5-pin), DIN 45322 (5-pin at 60), DIN 45326 (8-pin), DIN 45329 (7-pin), and other standards for a range of different applications.

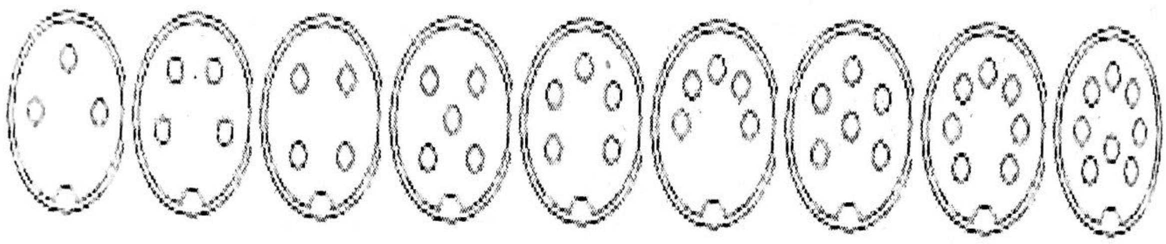


Fig. 27

The plugs consist of a circular shielding metal skirt protecting a number of straight round pins. The skirt is keyed to ensure that the plug is inserted with the correct orientation and to prevent damage to the pins. The basic design also ensures that the shielding is connected between socket and plug prior to any signal path connection being made.

There are seven common patterns, with any number of pins from three to eight. Three different five-pin connectors exist, known as 180°, 240°, and 270° after the angle of the arc swept between the first and last pin (see figures above). There are also two variations of the seven-pin and eight-pin connectors, one where the outer pins form 360° and one where they form 270°. There is some limited compatibility, for example a three-pin connector will fit any 180° five-pin socket, engaging three of the pins and leaving the other two unconnected, but a five-pin connector will fit some but not all three-pin sockets. As well, a 180° 5-pin plug will fit into a 7-pin or 8-pin socket.

5.2.8.2 Loudspeaker connector

A polarized two-pin unshielded connector, designed for connecting loudspeaker to a power amplifier (or other device; many of the earlier shoebox style tape recorders used them), is known as the DIN 41529 loudspeaker connector.

It exists as a panel and female versions. The male version has a central flat pin, and circular pin mounted off- centre. It is now mainly found on older equipment, such as 16 mm movie projectors. The Becker radio used in many Mercedes- Benz automobiles uses this connector. The same connector is used on some halogen lamps to connect the bulb to the power supply. While all other versions of the DIN plug are generally very reliable, the two- pin DIN plug is considered inferior in some ways- the lack of the outer sheath means far less force is required to disconnect the plug accidentally, makes it more prone to bending

Fig.28. Speaker DIN line socket (left) and plug (right)

or shifting of the pins during use, and also not as solidly seated in its socket-worn two- pin speaker plugs on audio equipment are notorious for being very unreliable, often requiring only the slightest nudge to break contact. There are also a three and four pin version of this loudspeaker connector used by for example Band and Olufsen.

5.9.1 BNC Connector

Fig.29. Male 50 ohm BNC connector

The **BNC (Bayonet Neill Concelman) connector** is a very common type of RF connector used for terminating coaxial cable.

5.2.9.1 Applications

The BNC connector is used for RF signal connections, for analog and Serial Digital Interface video signals, amateur radio antenna connections, aviation electronics and many other types of electronic test equipment. It is an alternative to the RCA connector when used for composite video on commercial video devices, although many consumer electronics devices with RCA jacks can be used with BNC only commercial video equipment via a simple adapter. BNC connectors were commonly used on 10 base 2 thin Ethernet networks, both on cable interconnections and network cards; though these have largely been replaced by newer Ethernet devices whose wiring does not use coaxial cable.

5.2.9.2 Specifications

BNC connectors exist in 50 and 75 ohm versions. Originally all were 50 ohm and were used with cables of other impedances, the small mismatch being negligible at lower frequencies. The 75 ohm types can be recognized by the reduced or absent dielectric in the mating ends. The different versions are designed to mate with each other, although the impedance mismatch will lead to signal reflections. Typically, they are specified for use at frequencies up to 4 and 2 GHz, respectively.

5.2.10 UHF Connectors

Domestic antenna plugs and sockets are devices that connect the TV set to the TV antenna so that TV signals can flow to them.

Fig.30. TV aerial socket and plug

Fig.31. Aerial socket on a television set

Antenna plugs are male antenna connectors that fit into female antenna sockets.

Antenna sockets are female antenna connectors that have slots or holes which accept the pins or blades of antenna plugs inserted into them and deliver or receive TV signal to or from the plugs. Sockets are generally mounted on the TV set or in the wall. Sockets are usually designed to reject any plug which is not built to the same standard. Some sockets have one or more pins that connect to holes in the plug.

a) Belling-Lee

The **Belling-Lee connector** or IEC 169-2 connector, more often simply known as TV aerial plug or PAL connector, is the traditional European antenna connector for TV sets and FM- radio receivers. It is the oldest coaxial RF connector still commonly used today. It connects a reveiver to a terrestrial VHF/UHF roof antenna, antenna amplifier, or CATV network, via a coaxial cable.

It was invented at Belling & Lee Ltd in Enfield, England, around 1922, at the time of the first BBC broadcasts. It was originally only intended for medium frequency broadcasts, where accurate impedance matching of an antenna connector is not a concern.

b) Miniature Belling Lee

Fig.32. Miniature belling lee plug

There is also a Miniature Belling Lee connector which was used for internal connections inside some equipment (including BBC RC5/3 Band II receiver and the STC AF101 Radio Telephone). It is not known who made them or any other name for the connector. It looks similar to a standard Belling Lee plug but is about half the size. The standard Belling Lee plug is about 33 mm long and 9.5 mm diameter (mating surface), the Miniature Belling Lee is about 17 mm long and 4.4 mm diameter. Amalgamated Wireless Australasia (AWA) used miniature Belling & Lee connectors, internally, in their 25M series Land Mobile two-way radios in the early 1970s. The socket is a Belling & Lee L1465/CS whilst the plug is a Belling & Lee 1465/PF.

5.2.11 Electrical Connector

An electrical connector is a conductive device for joining electrical circuits together. The connection may be temporary, as for portable equipment, or may require a tool for assembly and removal, or may be a permanent electrical joint between two wires or devices. There are hundreds of types of electrical connectors. In computing, an electrical connector can also be known as a physical interface. Connectors may join two lengths of flexible wire or cable, or may connect a wire or cable to an electrical terminal.

5.2.11.1 Properties of electrical connectors

An ideal electrical connector would have a low contact resistance and high insulation value. It would be resistant to vibration, water, oi, pressure. It would be easily mated/unmated, unambiguously preserve circuits. Desirable properties for a connector also include easy the orientation of connected circuits, reliable, carry one or multiple identification, compact size, rugged construction, durability (capable many connect/ disconnect cycles), rapid assembly, simple tooling, and low cost. No single connector has all the ideal properties. The proliferation of types is a reflection of the differing importance placed on the design factors.

5.2.11.2 Types of electrical connectors

1. Terminal blocks (Terminal strips)

A terminal is a simple type of electrical connector that connects two or more wires to a single connection point. Wire nuts are another type of single point connector. Terminal blocks of various types.

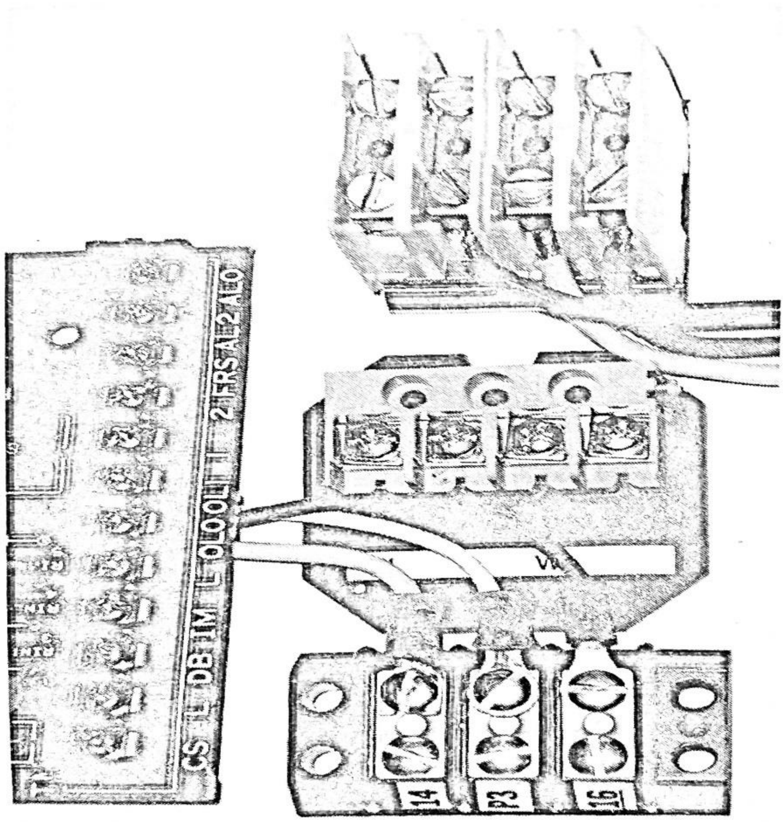


Fig.33. Crimp-on terminals

Terminal blocks (also called terminal boards or strips) provide a convenient means of connecting individual electrical wires. They are usually used to connect wiring among various items of equipment within an enclosure or to make connections among individually enclosed items. Since terminal blocks are readily available for a wide range of wire sizes and terminal quantity, they are one of the most flexible types of electrical connector available. Some disadvantages are that connecting wires is more difficult than simply plugging in a cable and the terminals are generally not very well protected from contact with persons or foreign conducting materials.

One type of terminal block accepts wires that are prepared only by removing (stripping) a short length of insulation from the end. Another type accepts wires that have ring or spade terminal lugs crimped onto the wires. Printed circuit board (PCB) mounted terminal blocks allow individual wires to be connected to the circuit board. PCB mounted terminal blocks are soldered to the board, but they are available in a pull-apart version that allows the wire connecting half of the block to be unplugged from the part that is soldered to the PCB.

Most types of crimp- on terminals (or lugs) are attached to wires to allow the wires to be easily connected to screw terminals and fast- on or quick-disconnects terminals. There are also crimp- on terminals for connecting two wires together either permanently or with disconnect capability. Crimp- on terminals is attached by inserting the stripped end of a stranded wire into the tubular portion of the terminal. The tubular portion of the terminal is then compressed tightly around the wire or crimped by squeezing it with a special crimping plier.

2. Insulation displacement connectors

Since stripping the insulation from wires is time-consuming, many connectors intended for rapid assembly use insulation displacement connectors so that insulation need not be removed from the wire. These generally take the form of a fork-shaped opening in the terminal, into which the insulated wire is pressed and which cut through the insulation to contact the conductor within. To make these connections reliably on a production line, special tools are used which accurately control the forces applied during assembly. If properly assembled, the resulting terminations are gas-tight and will last the life of the product. A common example is the multi-conductor flat ribbon cable used in computer disk drives; to terminate each of the many (approximately 40) wires individually would be slow and error-prone, but an insulation displacement connector can terminate all the wires in (literally) one stroke. Another very common use is so-called "punch down" blocks used for terminating telephone wiring.

Insulation displacement connectors are usually used with small conductors for signal purposes and at low voltage. Power conductors carrying more than a few amperes are more reliably terminated with other means, though “hot tap" press-on connectors find some use in automotive applications for additions to existing wiring.

Fig.34

3. Plug and socket connectors

Plug and socket connectors are usually made up of a male plug and a female socket. Plugs generally have one or more pins or prongs that are inserted into openings in the mating socket. The connection between the mating metal parts must be sufficiently tight to make a good electrical connection and complete the circuit.

4. 8P8C connectors

Fig.35

8P8C is short for "eight positions, eight conductors", and so an 8P8C modular connector (plug or jack) is a modular connector with eight positions, all containing conductors. The 8P8C modular plugs and jacks look very similar to the plugs and jacks. It neither uses all eight conductors (but only two of them for wires plus two for shorting a programming resistor) nor does it fit into 8P8C because the true RJ45 is "keyed". The connector is probably most famous for its use in Ethernet and widely used on CAT5 cables.

5. D- subminiature connectors

Fig.36

The D-subminiature electrical connector is commonly used for the RS 232 serial port on modems and IBM compatible computers. The D-subminiature connector is used in many different applications, for computers, telecommunications, and test and measurement instruments.

6. USB connectors

The Universal Serial Bus is a serial bus standard to interface devices, founded in 1996. It is currently widely used among PCs, Apple Macintosh and many other devices. There are several types of USB connectors, and some have been added as the specification has progressed. The most commonly used is the (male) series "A" plug on peripherals, when the cable is fixed to the peripheral. If there is no cable fixed to the peripheral, the peripheral always needs to have a USB "B" socket. In this case a USB "A" plug to a USB "B" plug cable would be needed. USB "A" sockets are always used on the host PC and the USB "B" sockets on the peripherals.

Fig.37

It is a 4-pin connector, surrounded by a shield. There are several other connectors in use, the mini-A, mini- B and mini-AB plug and socket (added in the On-The-Go Supplement to the USB 2.0 Specification).

7. Power connectors

Power connectors must protect people from accidental contact with energized conductors. Power connectors often include a safety ground connection as well as the power conductors.

In larger sizes, these connectors must also safely contain any arc produced when an energized circuit is disconnected or may require interlocking to prevent opening a live circuit.

8. Radio frequency connectors

Connectors used at radio frequencies must not change the impedance of the transmission line of which they are part, otherwise reflections and losses will result. A radio-frequency connector must not allow external signals into the circuit, and must prevent leakage of energy out of the circuit. At lower radio frequencies simple connectors can be used with success, but as the radio frequency increases (so that the dimensions of the connector are getting close to a small fraction of one wavelength, connector design becomes increasingly critical. At UHF and above, silver-plating of connectors is common to reduce losses.

5.3 VARIOUS TYPES OF SWITCHES SUCH AS NORMAL/MINIATURE TOGGLE, SLIDE, PUSH BUTTON PLANO KEY, ROTATORY, SPST, SPDT, DPST, DPDT

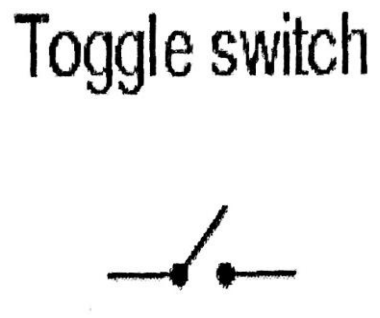
5.3.1 Electrical Switch

An electrical switch is any device used to interrupt the flow of electrons in a circuit. Switches are essentially binary devices; they are either completely on ("closed") or completely off ("open"). There are many different types of switches, and we will explore some of these types in this topic.

5.3.2 Types of Switches

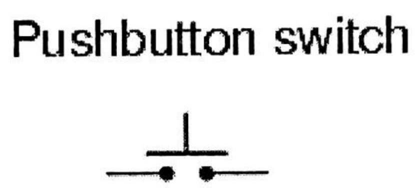
The simplest type of switch is one where two electrical conductors are brought in contact with each other by the motion of an actuating mechanism. Other switches are more complex, containing electronic circuits able to turn on or off depending on some physical stimulus (such as light or magnetic field) sensed. In any case, the final output of any switch will be (at least) a pair of wire-connection terminals that will either be connected together by the switch's internal contact mechanism (“closed"), or not connected together ("open"). Any switch designed to be operated by a person is generally called a hand switch, and they are manufactured in several varieties:

1. Toggle switches



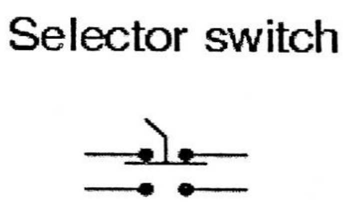
Toggle switches are actuated by a lever angled in one of two or more positions. The common light switch used in household wiring is an example of a toggle switch. Most toggle switches will come to rest in any of their lever positions, while others have an internal spring mechanism returning the lever to a certain normal position, allowing for what is called "momentary" operation.

2. Pushbutton switches



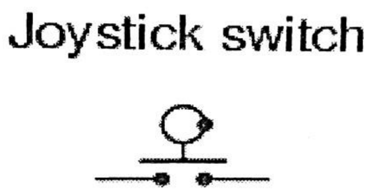
Pushbutton switches are two-position devices actuated with a button that is pressed and released. Most pushbutton switches have an internal spring mechanism returning the button to its "out," or "unpressed," position, for momentary operation. Some pushbutton switches will switches will stay in their "in," or "pressed," position until the button is pulled back out. This last type of pushbutton switches usually has a mushroom-shaped button for easy push-pull action.

3. Selector switches/Rotatory switches



Selector switches are actuated with a rotary knob or lever of some sort to select one of two or more positions. Like the toggle switch, selector switches can either rest in any of their positions or contain spring- return mechanisms for momentary operations.

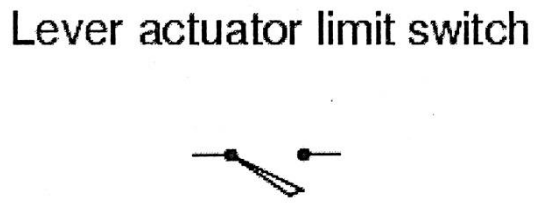
4. Joystick switch



A joystick switch is actuated by a lever free to move in more than one actuated depending on which way the lever is pushed, and sometimes by how far it is pushed. The circle-and-dot notation on the switch symbol represents the direction of joystick lever motion required to actuate the contact. Joystick hand switches are commonly used for crane and robot control.

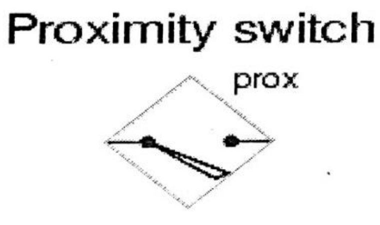
Some switches are specifically designed to be operated by the motion of a machine rather than by the hand of a human operator. These motion-operated switches are commonly called limit switches, because they are often used to limit the motion of a machine by turning off the actuating power to a component if it moves too far. As with hand switches, limit switches come in several varieties:

5. Lever actuator limit switch



These limit switches closely resemble rugged toggle or selector hand switches fitted with a lever pushed by the machine part. Often, the levers are tipped with a small roller bearing, preventing the lever from being worn off by repeated contact with the machine part.

6. Proximity switches

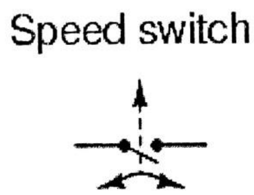


Proximity switches sense the approach of a metallic machine part either by a magnetic or high- frequency electromagnetic field. Simple proximity switches use a permanent magnet to actuate a sealed switch mechanism whenever the machine part gets close (typically 1 inch or less). More complex proximity switches work like a metal detector, Proximity switch emerging a coil of wire with a high frequency current, and electronically monitoring the magnitude of that current. If a metallic part (not necessarily magnetic) gets close enough to the coil, the current will increase, and trip the monitoring circuit. The symbol shown here for the proximity switch is of the electronic variety, as indicated by the diamond- shaped box surrounding the switch. A non-electronic proximity switch would use the same symbol as the lever-actuated limit switch.

Another form of proximity switch is the optical switch, comprised of a light source and photocell. Machine position is detected by either the interruption or reflection of a light beam. Optical switches are also useful in safety applications, where beams of light can be used to detect personnel entry into a dangerous area.

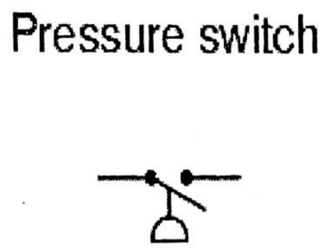
In many industrial processes, it is necessary to monitor various physical quantities with switches. Such switches can be used to sound alarms, indicating that a process variable has exceeded normal parameters, or they can be used to shut down processes or equipment if those variables have reached dangerous or destructive levels. There are many different types of process switches:

7. Speed switches



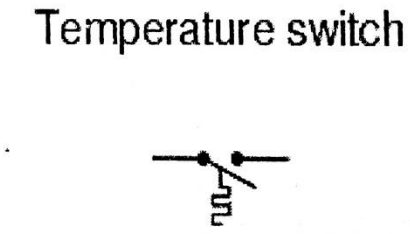
These switches sense the rotary speed of a shaft either by a centrifugal weight mechanism mounted on the shaft, or by some kind of non- contact detection of shaft motion such as optical or magnetic.

8. Pressure switches



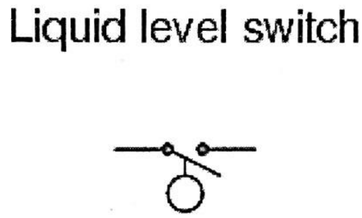
Gas or liquid pressure can be used to actuate a switch mechanism if that pressure is applied to a piston, diaphragm, or bellows, which converts pressure to mechanical force.

9. Temperature switches



An inexpensive temperature- sensing mechanism is the "bimetallic strip" a thin strip of two metals, joined back- to- back, each metal having a different rate of thermal expansion. When the strip heats or cools, differing rates of thermal expansion between the two metals causes it to bend. The bending of the strip can then be used to actuate a switch contact mechanism. Other temperature switches use a brass bulb filled with either a liquid or gas, with a tiny tube connecting the bulb to a pressure- sensing switch. As the bulb is heated, the gas or liquid expands, generating a pressure increase which then actuates the switch mechanism

10. Liquid level switches

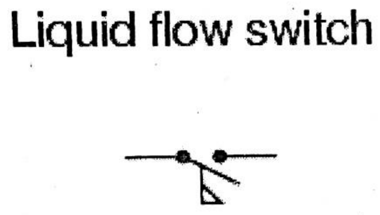


A floating object can be used to actuate a switch mechanism when the liquid level in a tank rises past a certain point. If the liquid is electrically conductive, the liquid itself can be used as a conductor to bridge between two metal probes inserted into the tank at the required depth. The conductivity technique is usually implemented with a special design of relay triggered by a small amount of current through the conductive liquid.

In most cases it is impractical and dangerous to switch the full load current of the circuit through a liquid. Level switches can also be designed to detect the level of solid materials such as wood chips, grain, coal, or animal feed in a storage silo, bin, or hopper. A common design for this application is a small paddle wheel, inserted into the bin at the desired height, which is slowly turned by a small electric motor. When the solid material fills the bin to that height, the material prevents the paddle wheel from turning. The torque response of the small motor than trips the switch mechanism.

Another design uses a "tuning fork” shaped metal prong, inserted into the bin from the outside at the desired height. The fork is vibrated at its resonant frequency by an electronic circuit and magnet/electromagnet coil assembly. When the bin fills to that height, the solid material dampens the vibration of the fork, the change in vibration amplitude and/or frequency detected by the electronic circuit.

11. Liquid flow switch



Inserted into a pipe, a flow switch will detect any gas or liquid flow rate in excess of a certain threshold, usually with a small paddle or Liquid flow switch vane which is pushed by the flow. Other flow switches are constructed as differential pressure switches, measuring the pressure drop across a restriction built into the pipe.

5.3.3 Switch Contact Design

A switch can be constructed with any mechanism bringing two conductors into contact with each other in a controlled manner. This can be as simple as allowing two copper wires to touch each other by the motion of a lever, or by directly pushing two metal strips into contact. However, a good switch design must be rugged and reliable, and avoid presenting the operator with the possibility of electric shock. Therefore, industrial switch designs are rarely this crude.

The conductive parts in a switch used to make and break the electrical connection are called contacts. Contacts are typically made of silver or silver-cadmium alloy, whose conductive properties are not significantly compromised by surface corrosion or oxidation. Gold contacts exhibit the best corrosion resistance, but are limited in current-carrying capacity and may "cold weld" if brought together with high mechanical force. Whatever the choice of metal, the switch contacts are guided by a mechanism ensuring square and even contact, for maximum reliability and minimum resistance.

Contacts such as these can be constructed to handle extremely large amounts of electric current, up to thousands of amps in some cases. The limiting factors for switch contact capacity are as follows:

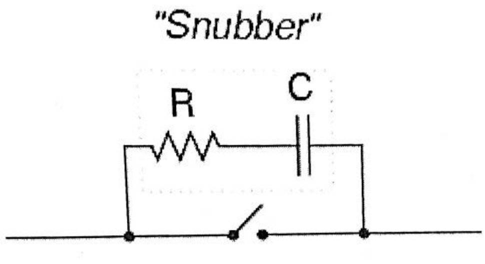
1. Heat generated by current through metal contacts (while closed).
2. Sparking caused when contacts are opened or closed.
3. The voltage across open switch contacts (potential of current jumping across the gap).

One major disadvantage of standard switch contacts is the exposure of the contacts to the surrounding atmosphere. In a nice, clean, control- room environment, this is generally not a problem. However, most industrial environments are not this benign. The presence of corrosive chemicals in the air can cause contacts to deteriorate and fail prematurely. Even more troublesome is the possibility of regular contact sparking causing flammable or explosive chemicals to ignite.

When such environmental concerns exist, other types of contacts can be considered for small switches. These other types of contacts are sealed from contact with the outside air, and therefore do not suffer the same exposure problems that standard contacts do.

It is common to find general-purpose switch contact voltage and current ratings to be greater on any given switch or relay if the electric power being switched is AC instead of DC. The reason for this is the self-extinguishing tendency of an alternating-current arc across an air gap. Because 60 Hz power line current actually stops and reverses direction 120 times per second, there are many opportunities for the ionized air of an arc to lose enough temperature to stop conducting voltage peak. DC, on the other hand, is a continuous, uninterrupted flow of electrons which tends to maintain an arc across an air gap much better. Therefore, switch contacts of any kind incur more wear when switching a given value of direct current than for the same value of alternating current. The problem of switching DC is exaggerated when the load has a significant amount of inductance, as there will be very high voltages generated across the switch's contacts when the circuit is opened (the inductor doing its best to maintain circuit current at the same magnitude as when the switch was closed).

With both AC and DC, contact arcing can be minimized with the addition of a "snubber" circuit (a capacitor and resistor wired in series) a parallel with the contact, like this:



A sudden rise in voltage across the switch contact caused by the contact opening will be tempered by the capacitor's charging action (the capacitor opposing the increase in voltage by drawing current). The resistor limits the amount of current that the capacitor will discharge through the contact when it closes again. If the resistor were not there, the capacitor might actually make the arcing during contact closure worse than the arcing during contact opening without a capacitor. While these additions to the circuit helps mitigate contact arcing, it is not without disadvantage: a prime consideration is the possibility of a failed (shorted) capacitor/resistor combination providing a path for electrons to flow through the circuit at all times, even when the contact is open and current is not desired. The risk of this failure, and the severity of the resulting consequences must be considered against the increased contact wear (and inevitable contact failure) without the snubber circuit.

The use of snubbers in DC switch circuits is nothing new: automobile manufacturers have been doing this for years on engine ignition systems, minimizing the arcing across the switch contact "points" in the distributor with a small capacitor called a condenser. As any mechanic can tell you, the service life of the distributor's "points" is directly related to how well the condenser is functioning.

With all this discussion concerning the reduction of switch contact arcing, one might be led to think that less current is always better for a mechanical switch. This, however, is not necessarily so. It has been found that a small amount of periodic arcing can actually be good for the switch contacts, because it keeps the contact faces free form small amounts of dirt and corrosion. This minimum amount of electric current necessary to keep a mechanical switch contact in good health is called the wetting current.

Normally, a switch's wetting current rating is far below its maximum current rating, and well below its normal operating current load in found that a small amount of periodic arcing can actually be good for a properly designed system. However, there are applications where a mechanical switch contact may be required to routinely handle currents below normal wetting current limits (for instance, if a mechanical selector switch needs to open or close a digital logic or analog electronic circuit where the current value is extremely small). In these applications, is it highly recommended that gold-plated switch contacts be specified? Gold is a "noble" metal and does not corrode as other metals will. Such contacts have extremely low wetting current requirements as a result. Normal silver or copper alloy contacts will not provide reliable operation if used in such low-current service.

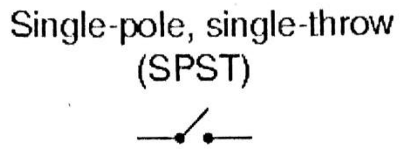
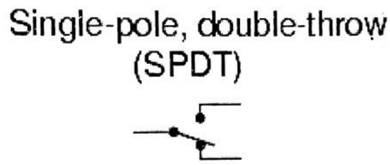
5.3.4 Contact Arrangements

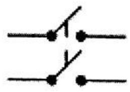
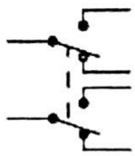
A pair of contacts is said to be 'closed' when there is no space between them, allowing electricity to flow from one to the other. When the contacts are separated by an insulating air gap, an air space, they are said to be 'open', and no electricity can flow at typical voltages, Switches can be and are classified according to the arrangement of their contacts in electronics fields- but electricians in the electrical wiring service business and their electrical supplier industries use different nomenclature, such as "one-way", "two-way", "three-way" and "four-way" switches-which have different meanings in North American and British cultural regions as is delineated in the table below.

Some contacts are normally open (Abbreviated "n.o." or "no") until closed by operation of the switch, while others are normally closed (n.c. or "nc") and opened by the switch action, where the abbreviations given are commonly used on electronics diagrams for clarity of operation in assembly, analysis or troubleshooting. The serve to synchronize meaning with possible mistakes in wiring assembly, where wiring part of switch one way and part another (usually opposite) way will pretty much guarantee things won't work as designed.

A switch with both types of contact is called a changeover switch or "make-before-break" switch contact, whereas most switches have a spring loaded action which momentarily disconnect the load and so are "break-before-make" types by contrast- which type is used could be important, if for example, the switch selects two different power sources instead of switching circuit loads, or the circuit load will not and cannot tolerate any interruption in applied power.

The terms pole and throw are also used to describe switch contact variations. A pole is a set of contacts, the switch's electrical terminals A throw is one of two or more positions (the nomenclature is also single applied to rotary switches, which can have many throw positions) to the number positions the switch handle or rotor can take when connecting between the common lead of the switch and a pole or poles. A throw position which connects no terminals (poles), has a mis- match between positions and positions which connect terminals, but are quite useful to turn things "Off" or for example, alternatively select between two scaled modes of operation. (e.g. Bright illumination, moderate illumination, no illumination).

Electronics specification and abbreviation	**Expansion of abbreviation**	**Description**
SPST	Single pole, single throw	A simple on –off switch: The two terminals are either connected to anything. An example is a light switch. Single- pole, single- throw 
SPDT	Single pole, double throw	A simple changeover switch: C (COM, Common) is connected to L1 or to L2. Single-Pole, double-throw 
SPCO SPTT. C.o.	Single pole changeover or Single pole, centre off or Single Pole, Triple Throw	Similar to SPDT. Some suppliers use SPCO/SPTT for switches with a stable off position in the centre and SPDT for those without.

DPST	Double pole, single throw	Equivalent to two SPST switches controlled by a single mechanism. Double-pole, single-throw Double-pole, single-throw (DPST) 
DPDT	Double pole, double throw	Equivalent to two SPDT switches controlled by a single mechanism: A is connected to B and D to E, or A is connected to C and D to F. Double-pole, double-throw (DPDT) 
DPCO	Double pole changeover of Double pole, centre off	Equivalent to DPDT. Some suppliers use DPCO for switches with a stable off position in the centre and DPDT for those without.
		DPDT switch internally wired for polarity-reversal applications: only four rather than six wires are brought outside the switch housing; with the above, B is connected to F and C to E; hence A is connected to B and D to C, or A is connected to C and D to B.

These terms give rise to abbreviations for the types of switch which are used in the electronics industry such as "single-pole, single-throw" (SPST) (the simplest type, "on or off") or "single-pole, double-throw" (SPDT), connecting either of two terminals to the common terminal.

Switches with larger numbers of poles or throws can be described by replacing the “S” or “D” with a number or in some cases the letter "T" (for “triple”). In the rest of this article the terms SPST, SPDT and intermediate will be used to avoid the ambiguity in the use of the word "way”.

5.3.5 Make-Before-Break, Break-Before-Make

In a multi-throw switch, there are two possible transient behaviors as you move from one position to another. In some switch designs, the new contact is made before the old contact is broken. This is known as make-before-break, and ensures that the moving contact never sees an open circuit (also referred to as a shorting switch). The alternative is break-before-make, where the old contact is broken before the new one is made. This ensures that the two fixed contacts are never shorted to each other. Both types of design are in common use, for different applications.

5.4 VARIOUS TYPES OF PROTECTIVE DEVICES SUCH AS: FUSES, CIRCUIT BREAKERS AND RELAY

5.4.1 Circuit Protection Devices

Electricity, like fire, can be either helpful or harmful to those who use it. A fire can keep people warm and comfortable when it is confined in a campfire or a furnace. It can be dangerous and destructive if it is on the loose and uncontrolled in the woods or in a building. Electricity can provide people with the light to read by or, in a blinding flash, them. While we take advantage of the tremendous benefits electricity can provide, we must be careful to protect the people and systems that use it. It is necessary then, that the mighty force of electricity be kept under control at all times. If for some reason it should get out of control, there must be a method of protecting people and equipment. Devices have been developed to protect people and electrical circuits from currents and voltages outside their normal operating ranges. Some examples of these devices are discussed in this chapter. While you study this chapter, it should be kept in mind that a circuit protection device is used to keep an undesirably large current, voltage, or power surge out of a given part of an electrical circuit.

5.4.2 Introduction

An electrical unit is built with great care to ensure that each separate electrical circuit is fully insulated from all the others. This is done so that the current in a circuit will follow its intended path. Once the unit is placed into service, however, many things can happen to alter the original circuitry. Some of the changes can cause serious problems if they are not detected and corrected. While circuit protection devices cannot correct an abnormal current condition, they can indicate that an abnormal condition exists and protect personnel and circuits from that condition. In this chapter, you will learn what circuit conditions require protection devices and the types of protection devices used.

5.4.3 Circuit Conditions Requiring Protection Devices

As has been mentioned, many things can happen to electrical and electronic circuits after they are in use. Some of the changes in circuits can cause conditions that are dangerous to the circuit itself or to people living or working near the circuits. These potentially dangerous conditions require circuit protection. The conditions that require circuit protection are direct shorts, excessive current and excessive heat.

A. Direct short

One of the most serious troubles that can occur in a circuit is a DIRECT SHORT. Another term used to describe this condition is a SHORT CIRCUIT. The two terms mean the same thing and, in this chapter, the term direct short will be used. This term is used to describe a situation in which some point in the circuit, where full system voltage is present, comes in direct contact with the ground or return side of the circuit. This establishes a path for current flow that contains only the very small resistance present in the wires carrying the current. According to Ohm's law, if the resistance in a circuit is extremely small, the current will be extremely large. Therefore, when a direct short occurs, there will be a very large current through destroy their eyesight. It can help save people's lives, or it can kill the wires. Suppose, for instance, that the two leads from a battery to a motor came in contact with each other. If the leads were bare at the point of contact, there would be a direct short. The motor would stop running because all the current would be flowing through the short and none through the motor. The battery would become discharged quickly (perhaps ruined) and there could be the danger of fire or explosion.

The battery cables in our examples would be large wires capable of carrying heavy currents. Most wires used in electrical circuits are smaller and their current carrying capacity is limited. The size of cost factors, and the amount of current the wire is expected to carry under normal operating conditions. Any current flow greatly in excess of normal, such as there would be in the case of a direct short, would cause a rapid generation of heat in the wire. If the excessive current flow caused by the direct short is left unchecked, the heat in the wire will continue to increase until some portion of the circuit burns. Perhaps a portion of the wire will melt and open the circuit so that nothing is damaged other than the wire involved. The probability exists, however, that much greater damage will result. The heat in the wire can char and burn the insulation of the wire and that of other wires bundled with it, which can cause more shorts. If a fuel or oil leak is near any of the hot wires, a disastrous fire might be started.

B. Excessive current

It is possible for the circuit current to increase without a direct short. If a resistor, capacitor, or inductor changes value, the total circuit impedance will also change in value. If a resistor decreases in ohmic value, the total circuit resistance decreases. If a capacitor has a dielectric leakage, the capacitive reactance decreases. If an inductor has a partial short of its winding, inductive reactance decreases. Any of these conditions will cause an increase in circuit current. Since the circuit wiring and components are designed to withstand normal circuit current, an increase in current would cause overheating (just as in the case of a direct short). Therefore, excessive current without a direct short will cause the same problems as a direct short.

C. Excessive heat

As you have read, most of the problems associated with a direct short or excessive current concern the heat generated by the higher current. The damage to circuit components, the possibility of fire, and the possibility of hazardous fumes being given off from electrical components are consequences of excessive heat. It is possible for excessive heat to occur without a direct short or excessive current If the bearings on a motor or generator were to fail, the motor or generator would overheat. If the temperature around an electrical or electronic circuit were to rise(through failure of a cooling system for example), excessive heat would be a problem. No matter what the quickly (perhaps ruined) and there could be the danger of fire or wire used in any given circuit is determined by space considerations, cause, if excessive heat is present in a circuit, the possibility damage, fire, and hazardous fumes exists.

5.4.4 Circuit Protection Devices

All of the conditions mentioned are potentially dangerous and require the use of circuit protection devices. Circuit protection devices are used to stop current flow or open the circuit. To do this, a circuit protection device must ALWAYS be connected in series with the circuit it is protecting. If the protection device is connected in parallel, current will simply flow around the protection device and continue in the circuit. A circuit protection device operates by opening and interrupting current to the circuit. The opening of a protection device shows that something is wrong in the circuit and should be corrected before the current is restored. When a problem exists and the protection device opens, the device should isolate the faulty circuit from the other unaffected circuits, and should respond in time to protect unaffected components in the faulty circuit. The protection device should NOT open during normal circuit operation. The two types of circuit protection devices discussed in this chapter are fuses and circuit breakers.

5.4.5 Fuses

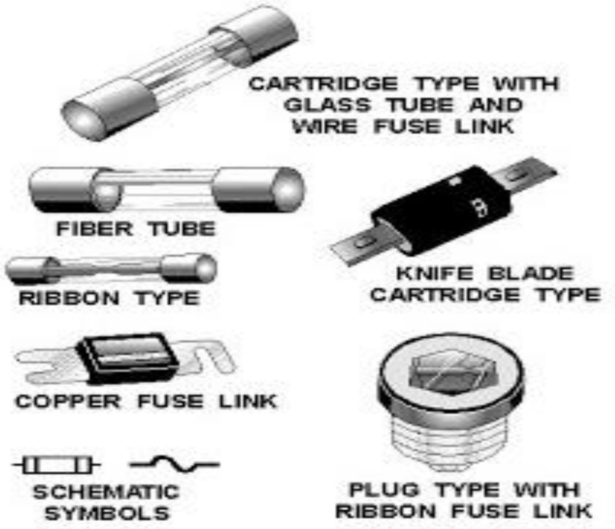


Fig. 2.1. Typical fuses and schematic symbols

A fuse is the simplest circuit protection device. It derives its name from the Latin word “fuses, “meaning “to melt. " Fuses have been used almost from the beginning of the use of electricity. The earliest type of fuse was simply a bare wire between two connections. The wire melt before the conductor it was protecting was harmed. Some “copper fuse link " types are still in use, but most fuses no longer use copper as the fuse element (the part of the fuse that melts). After changing from copper to other metals, tubes or enclosures were developed to hold the melting metal. The enclosed fuse made possible the addition of filler material, which helps to contain the area that occurs when the element molts. For many low power uses, the finer material is not required. A simple class tube is used. The use of a glass tube gives the added advantage of being able to see when a fuse is open Fuses of this type are commonly found in automobile lighting circuits Fig. 38 shows several fuses and the symbols used on schematics.

5.4.6 Circuit Breakers

While a fuse protects a circuit, it is destroyed in the process of opening the circuit. Once the problem that caused the increased current or heat is corrected, a new fuse must be placed in the circuit. A circuit protection device that can be used more than once solves the problems of replacement fuses. Such a device is safe, reliable, and tampers proof. It is also resettable, so it can be reused without replacing any parts. This device is called a CIRCUIT BREAKER because it breaks (opens) the circuit. The first compact, workable circuit breaker was developed in 1923. It took 4 years to design a device that would interrupt circuits of 5000 amperes at 120 volts ac or de. In 1928 the first circuit breaker was placed on the market. A typical circuit breaker and the appropriate schematic symbols are shown in Fig. 39

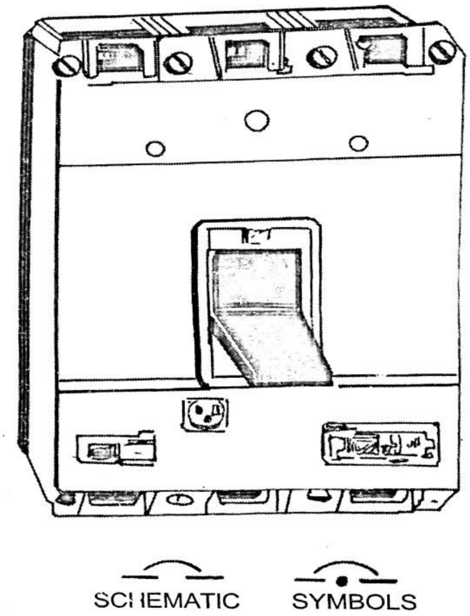


Fig.39. Typical circuit breaker and schematic symbols.

5.4.7 Fuse Types

Fuses are manufactured in many shapes and sizes. In addition to the copper fuse link already described, Fig.38 shows other fuse types. While the variety of fuses may seem confusing, there are basically only two types of fuses: plug- type fuses and cartridge fuses. Both types of fuses use either a single wire or a ribbon as the fuse element (the part of the fuse that melts). The condition (good or bad) of some fuses can be determined by visual inspection. The condition of other fuses can only be determined with a meter.

a) Plug-type fuses

The plug-type fuse is constructed so that it can be screwed into a socket mounted on a control panel or electrical distribution center. The fuse link is enclosed in an insulated housing of porcelain or glass. The construction is arranged so the fuse link is visible through a window of mica or glass. Figure 40 shows a typical plug-type fuse.

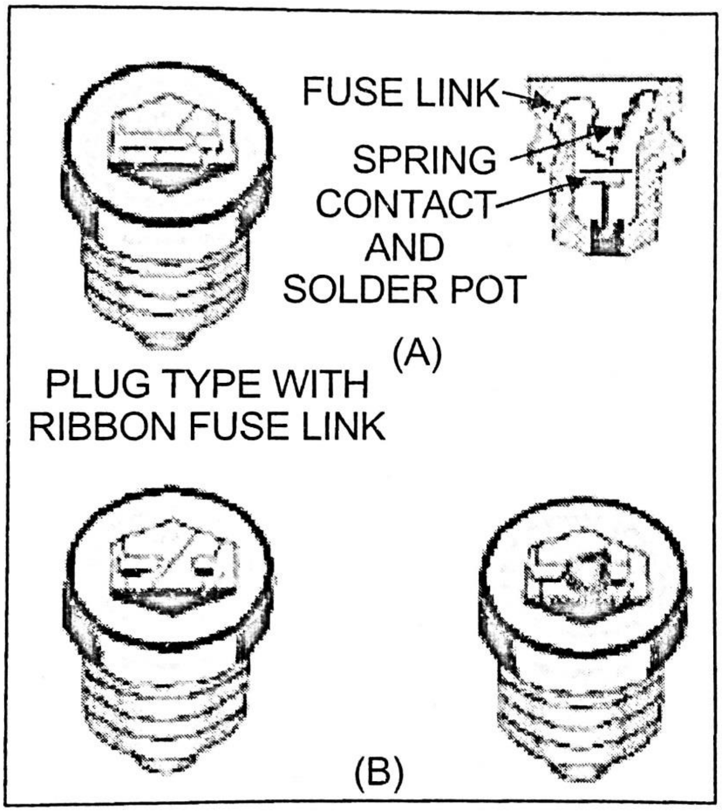


Fig.40. Plug-type fuses

Figure 40, view A, sows a good plug-type fuse. Notice the construction and the fuse link. In Fig. 40, view B, the same type of fuse is shown after the fuse link has melted. Notice the window showing the indication of this open fuse. The indication could be either of the ones shown in Figure 40, view B. The plug-type fuse is used primarily in low-voltage, low-current circuits. The operating range is usually up to 150 volts and from 0.5 ampere to 30 amperes. This type of fuse is found in older circuit protection devices and is rapidly being replaced by the circuit breaker.

b) Cartridge fuse

The cartridge fuse operates exactly like the plug- type fuse. In the cartridge fuse, the fuse link is enclosed in a tube of insulting material with metal ferrules at each end (for contact with the fuse holder). Some common insulating materials are glass, bakelite, or a fiber tube filled with insulating powder.

Fig.41 shows a glass- tube fuse. In fig.41, view A, notice the fuse link and the metal ferrules. Fig.41, view B, shows a glass- tube fuses that is open. The open fuse link could appear either of the ways shown in Fig.41.view B.

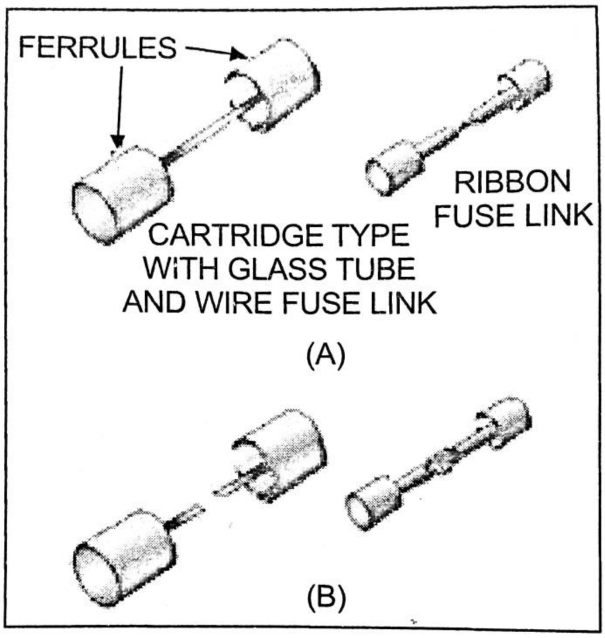


Fig.41. Cartridge-tube fuse.

Cartridge fuses are available in a variety of physical sizes and are used in many different circuit applications. They can be rated at voltages up to 10,000 volts and have current ratings of from 1/500 0.002) ampere to 800 amperes. Cartridge fuses may also be used to protect against excessive heat and open at temperatures of from 165° F to 410°F (74°C to 210°C).

5.4.8 Fuse Ratings

You can determine the physical size and type of a fuse by looking at it, but you must know other things about a fuse to use it properly. Fuses are rated by current, voltage, and time-delay characteristics to aid in the proper use of the fuse. To select the proper fuse, you must understand the meaning of each of the fuse ratings.

a) Current rating

The current rating of a fuse is a value expressed in amperes that represents the current the fuse will allow without opening. The current rating of a fuse is always indicated on the fuse. To select the proper fuse, you must know the normal operating current of the circuit. If you wish to protect the circuit from overloads (excessive current), select a fuse rated at 125 percent of the normal circuit current. In other words, if a circuit has a normal current of 10 amperes, a 12.5 ampere fuse will provide overload protection. If you wish to protect against direct shorts only, select a fuse rated at 150 percent of the normal circuit current. In the case of a circuit with 10 amperes of current, a 15 ampere fuse will protect against direct shorts, but will not be adequate protection against excessive current.

b) Voltage rating

The voltage rating of a fuse is not an indication of the voltage the fuse is designed to withstand while carrying current. The voltage rating indicated the ability of the fuse to quickly extinguish the arc after the fuse element melts and the maximum voltage the rating indicates the ability of the fuse to quickly extinguish the area will block. In other words, once the fuse has opened any voltage less than the voltage rating of the fuse will not be able to "jump" the gap of the fuse. Because of the way the voltage rating is used, it is a maximum rms voltage value. You must always select a fuse with a voltage rating equal to or higher than the voltage in the circuit you wish to protect.

c) Time delay rating

There are many kinds of electrical and electronic circuits that require protection. In some of these circuits, it is important to protect against temporary or transient current increases. Sometimes the device being protected is very sensitive to current and cannot withstand an increase in current. In these cases, a fuse must open very quickly if the current increases. Some other circuits and devices have a large current for short periods and a normal (smaller) current most of the time. An 126 electric motor, for instance, will draw a large current when the motor beam starts, but normal operating current for the motor will be much smaller. A fuse used to protect a motor would have to allow for this large so be temporary current, but would open if the large current were to continue. Fuses are time delay rated to indicate the relationship between the current through the fuse and the time it takes for the fuse to open. The three time delay ratings are delay, standard, and fast.

d) Delay

A delay, or slow-blowing, fuse has a built-in delay that is activated all when the current through the fuse is greater than the current rating of the fuse. This fuse will allow temporary increases in current (surge) without opening. Some delay fuses have two elements; this allows a very long time delay. If the over- current condition continues, a delay fuse will open, but it will take longer to open than a standard or a fast fuse. Delay fuses are used for circuits with high surge or starting currents, such as motors, solenoids, and transformers.

e) Standard

Standard fuses have no built-in time delay. Also, they are not designed to be very fast acting. Standard fuses are sometimes used to protect against direct shorts only. They may be wired in series with a delay fuse to provide faster direct short protection. For example, in a circuit with a 1-ampere delay fuse, a 5-ampere standard fuse may be used in addition to the delay fuse to provide faster protection against a direct short. A standard fuse can be used in any circuit where surge currents are not expected and a very fast opening of the fuse is not needed. A standard fuse opens faster than a delay fuse, but slower than a fast rated fuse. Standard fuses can be used for automobiles, lighting circuits, or electrical power circuits.

f) Fast acting/slow acting fuse

Fast fuses are designed to open very quickly when the current through the fuse exceeds the current rating of the fuse. Fast fuses are used to protect devices that are very sensitive to increased current. A fast fuse will open faster than a delay or standard fuse. Fast fuses can be used to protect delicate instruments or semiconductor devices. Fig.42 will help you understand the differences between delay, standard, and fast fuses. Fig. 42 shows that, if a. l-ampere rated fuse had 2 would open in about .7 second, a standard rated fuse would open in about 1.5 seconds, and a delay rated fuse would open in about 10 seconds. Notice that in each of the fuses, the time required to open the fuse decreases as the rated current increases.

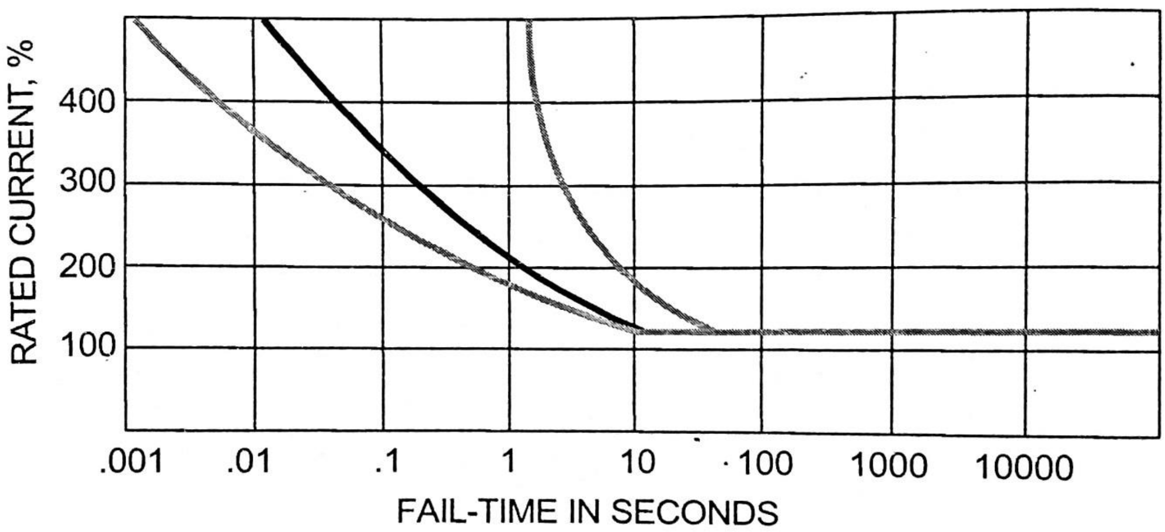


Fig. 42. Time required for fuse to open

5.4.9 Thermal Fuse

A thermal fuse is a cutoff which uses a one-time fusible link. Unlike the thermostat which automatically resets itself when the temperature drops, the thermal fuse is more like an electrical fuse: a single-use device that cannot be reset and must be replaced when it fails or is triggered. A thermal fuse is most useful when the overheating is a result of a rare occurrence, such as failure requiring repair (which would also replace the fuse) or replacement at the end of service life.

One mechanism is a small meltable pellet that holds down a spring. When the pellet melts, the spring is released, separating the contacts and breaking the circuit. The NEC sefuse SF/E series and Microtemp G4A series, for example, use pellets that contain Copper, Berylium, and Silver.

Thermal fuses are usually found in heat-producing electrical appliances such as coffeemakers and hair dryers. They function as safety devices to disconnect the current to the heating element in case of a malfunction (such as a defective thermostat) that would otherwise allow the temperature to rise to dangerous levels, possibly starting a fire.

Unlike electrical fuses or circuit breakers, thermal fuses only react to excessive temperature, not excessive current, unless the excessive current is sufficient to cause the thermal fuse itself to heat up to the trigger temperature.

Unlike electrical fuses or circuit breakers, thermal fuses only react to excessive temperature, not excessive current, unless the excessive current is sufficient to cause the thermal fuse itself to heat up to the trigger temperature.

5.4.10 Relays

The RELAY is a device that acts upon the same fundamental principle as the solenoid. The difference between a relay and a solenoid is that a relay does not have a movable core (plunger) while the solenoid does. Where multipole relays are used, several circuits may be controlled at once. Relays are electrically operated control switches, and are classified according to their use as POWER RELAYS or CONTROL RELAYS. Power relays are called CONTACTORS; control relays are usually known simply as relays. The function of a contractor is to use a relatively small amount of electrical power to control the switching of a large amount of power.

The contactor permits you to control power at other locations in the equipment, and the heavy power cables need be run only through the power relay contacts. Only lightweight control wires are connected from the control switches to the relay coil. Safety is also an important reason for using power relays, since high power circuits can be switched remotely without danger to the operator. Control relays, as their name implies, are frequently used in the control of low power circuits or other relays, although they also have many other uses.

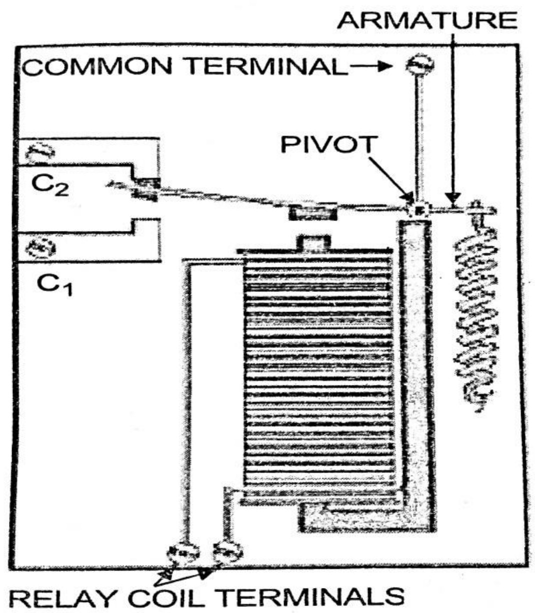


Fig.43. Relay construction.

In automatic relay circuits, a small electric signal may set off a chain reaction of successively acting relays, which then perform various functions.

In general, a relay consists of a magnetic core and its associated coil, contacts, springs, armature and the mounting. Fig.43 illustrate the construction of a relay. When the coil is energized, the flow of current through the coil creates a strong magnetic field which pulls the armature downward to contact C1, completing the circuit from the common terminal to C1. At the same time, the circuit to contact C2, is opened.

A relay can have many different types of contacts. The relay shown in Fig.43 has contacts known as "break-make" contacts because they break one circuit and make another when the relay is energized. Figure 44 shows five different combinations of relay contacts and the names given to each.

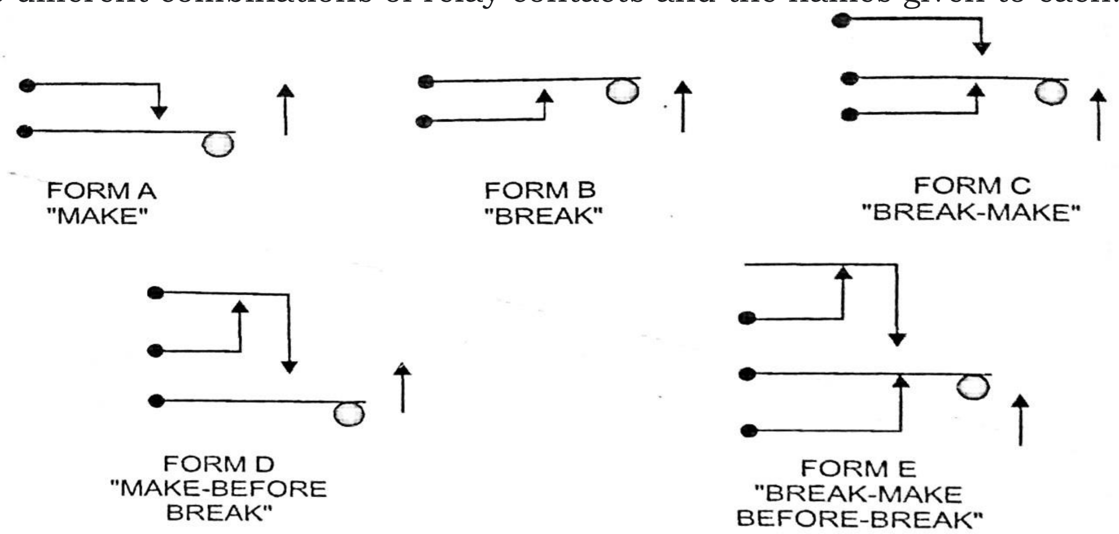


Fig.44. Contact combinations.

5.5 DEMONSTRATE THE SKILL TO MAKE FACILITIES SOLDER JOINT

(Demonstration the skill to remove components/wires by unsoldering Demonstration the skill to assemble component on board, chassis, tape strips.
JOB-I Desolder remove and clean all the components, wires from a given equipment. JOB-II-Soldering iron.
JOB-III-Temperature controlled soldering iron.
JOB-IV-Desoldering strip.)

5.5.1 Soldering

The most fundamental skill needed to assemble any electronic project is that is soldering. The idea is simple: to join electrical parts together to form an electrical connection, using a molten mixture of lead and tin (solder) with a soldering iron. A large range of soldering irons is available- which one is suitable for you depends on your budget and how serious your interest in electronics is.

A solder gun is a pistol-shaped iron, typically running at 100W or more, and is completely unsuitable for soldering modern electronic components: they're too hot, heavy and unwieldy for micro-electronics use.

Soldering irons are best used along with a heat-resistant bench-type holder, so that the hot iron can be safely parked in between use. Soldering stations already have this feature, otherwise a separate soldering iron stand is essential, preferably one with a holder for tip- cleaning sponges. Now let's look at how to use soldering irons properly, and how to put things right when a joint goes wrong.

5.5.2 What is Solder?

Solder is an alloy (mixture) of tin and lead, typically 60% tin and 40% lead. It melts at a temperature of about 200°C. Coating a surface with solder is called 'tinning' because of the tin content of solder. Lead is poisonous and you should always wash your hands after using solder.

Solder for electronics use contains tiny cores of flux, like the wires inside a mains flex. The flux is corrosive, like an acid, and it cleans the metal surfaces as the solder melts. This is why you must melt the solder actually on the joint, not on the iron tip. Without flux most joints would fail because metals quickly oxidise and the solder itself will not flow properly onto a dirty, oxidised, metal surface.

The best size of solder for electronics is 22swg (swg = standard wire gauge).

5.5.3 Parameters

a) Voltage: most irons run from the mains at 240V. However, low voltage types (e.g. 12V or 24V) generally form part of a "soldering station" and are designed to be used with a special controller made by the same manufacturer.

b) Wattage: Typically, they may have a power rating of between 15-25 watts or so, which is fine for most work. A higher wattage does not mean that the iron runs hotter - it simply means that there is more power in reserve for coping with larger joints.

This also depends partly on the design of the "bit" (the tip of the iron). Consider a higher wattage iron simply as being more "unstoppable" when it comes to heavier-duty work, because it won't cool down so quickly.

c) Temperature control: the simplest and cheapest types don't have any form of temperature regulation. Simply plug them in and switch them on. Thermal regulation is "designed in" (by physics, not electronics). They may be described as "thermally balanced" so that they have some degree of temperature "matching" but their output will otherwise not be controlled. Unregulated irons form an ideal general purpose iron for most users, and they generally cope well with printed circuit board soldering and general interwiring. Most of these "miniature" types of iron will be of little use when attempting to solder large joints (e.g. very large terminals or very thick wires) because the component being soldered will "sink" heat away from the tip of the iron, cooling it down too much. (This is where a higher wattage comes in useful.)

This is desirable especially during more frequent use, since it helps to ensure that the temperature does not "overshoot" in between times, and also guarantees that the output will be relatively stable. Some irons have a bimetallic strip thermostat built into the handle which gives an audible "click" in use: other types use all-electronic controllers, and some may be adjustable using a screwdriver.

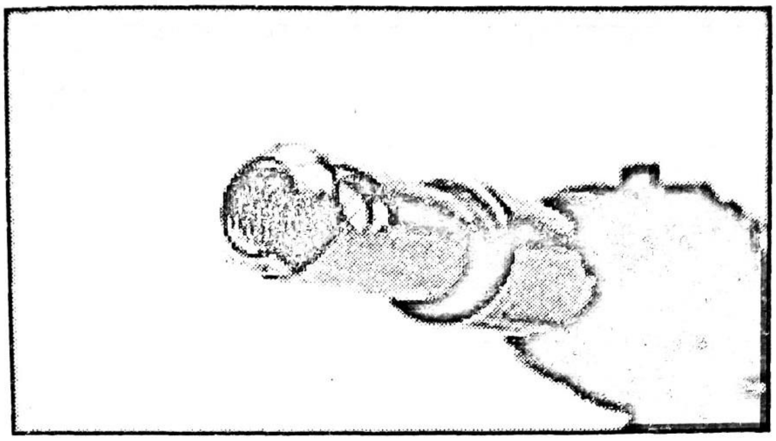
d) Anti-static protection: if you're interested in soldering a lot of static-sensitive parts (e.g. CMOS chips or MOSFET transistors), more advanced and expensive soldering iron stations use static- dissipative materials in their construction to ensure that static does not build up on the iron itself. You may see these listed as "ESD safe" (electrostatic discharge proof). The cheapest irons won't necessarily be ESD-safe but never the less will still probably perform perfectly well in most hobby or educational applications, if you take the usual anti-static precautions when handling the components. The tip would need to be well earthed (grounded) in these circumstances.

e) Bits: it's useful to have a small selection of manufacturer's bits (soldering iron tips) available with different diameters or shapes, which can be changed depending on the type of work in hand. You'll probably find that you become accustomed to, and work best with, a particular shape of tip. Often, tips are iron-coated to preserve their life, or they may be bright-plated instead. Copper tips are seldom seen these days.

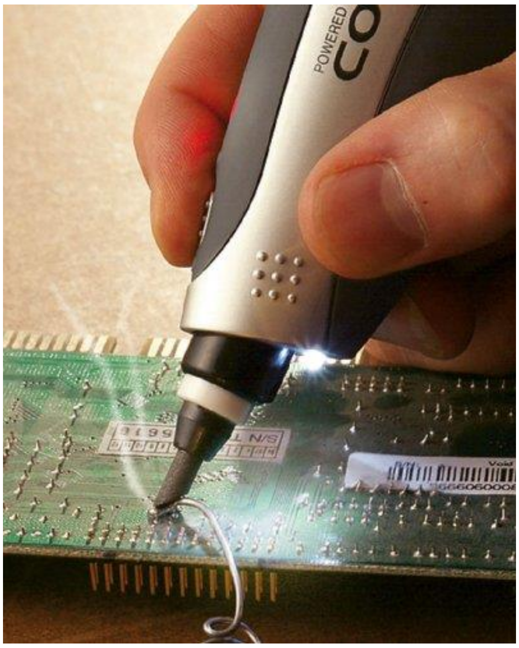
f) Spare parts: it's nice to know that spare parts may be available, so if the element blows, you don't need to replace the entire iron. This is especially so with expensive irons. Check through some of the larger mail-order catalogues.

5.5.4 Types of Soldering Iron

You will occasionally see gas-powered soldering irons which use butane rather than the mains electrical supply to operate. They have a catalytic element which, once warmed up, continues to glow hot when gas passes over them. Service engineers use them for working on repairs where there may be no power available, or where a joint is tricky to reach with a normal iron, so they are really for occasional "on the spot" use for quick repairs, rather than for mainstream construction or assembly work. One example is the Maplin PG509, given a full review with photographs here.



Another technique is the proprietary "Coldheat" battery powered soldering iron that we reviewed here. There are a number of reasons why this should only be used with extreme care (if at all) on electronic circuit boards.



5.5.5 How to Solder

Turning to the actual techniques of soldering, firstly it's best to secure the work somehow so that it doesn't move during soldering and affect your accuracy. In the case of a printed circuit board, various holding frames are fairly popular especially with densely populated boards: the idea is to insert all the parts on one side ("stuffing the board"), hold them in place with a special foam pad to prevent them falling out, turn the board over and then snip off the wires with cutters before making the joints. The frame saves an awful lot of turning the board over and over, especially with large boards. Other parts could be held firm in a modeller's small vice, for example.

Solder joints may need to possess some degree of mechanical strength In some cases, especially with wires soldered to, say, potentiometer switch tags, and this means that the wire should be looped through the tag and secured before solder is applied. The down side is that it is more difficult to de- solder the joint (see later) and remove the wire afterwards, if required. Otherwise, in the case of an ordinary circuit board, components' wires are bent to fit through the board, inserted flush against the board's surface, splayed outwards a little so that the part grips the board, and then soldered.

It's generally better to snip the surplus wires leads off first, to make the joint more accessible and avoid applying a mechanical shock to the P.C.B. joint.

Parts which become hot in operation (e.g. some resistors), are raised above the board slightly to allow air to circulate. Some components, especially large electrolytic capacitors, may require a mounting clip to be screwed down to the board first; otherwise the part may eventually break off due to vibration.

The perfectly soldered joint will be nice and shiny looking, and will prove reliable in service. I would say that:

1. Cleanliness
2. Temperature
3. Time
4. adequate solder coverage

are the key factors affecting the quality of the joint. A little effort spent now in soldering the perfect joint may save you - or somebody else - a considerable amount of time in troubleshooting a defective joint in the future. The basic principles are as follows.

5.6 INSTALLATION AND SOLDERING OF PRINTED CIRCUIT COMPONENTS

In every PCB (printed card board), there are specific locations for every component. Parts should always be remounted or reassembled in the same position and with termination methods used by the original manufacturer. This approach ensures a continuation of the original reliability of the system.

High reliability connections require thoroughly cleaned surfaces, proper component lead formation and termination, and appropriate placement of components on the board. The following paragraphs describe the procedures for properly installing components on a board including the soldering of these components.

a) Termination area preparation

The termination areas on the board and the component leads are thoroughly cleaned to remove oxide, old solder and other contaminants. Old or excess solder is removed by one of the desoldering techniques. A fine abrasive, such as an oil- free typewriter erase, is used to remove oxides. This is not necessary if the area has just been desoldered. All areas to be soldered are cleaned with a solvent and then dried with a lint-free tissue to remove cleaning residue.

b) Component lead preparation

Component leads are formed before installation. Both machine and hand-forming methods are used to form the leads. Improper lead formation causes many repairs to be unacceptable. Damage to the SEALS (point where lead enters the body of the component) occurs easily during the forming process and results in component failure. Consequently, lead-forming procedures have been established. To control the lead-forming operation and ensure conformity and quality of repairs, the technician should ensure the following:

The component is centered between the holes, and component leads are formed with proper bend-radii and body seal-to-bend distance. The possibility of straining component body seals during lead forming is eliminated. Stress relief loops are formed without straining component seals while at the same time providing the desired lead-to-lead distances. Leads are measured and formed for both horizontal and vertical component mounting. Transistor leads are formed to suit standard hole spacing.

c) Lead-forming specifications

Component leads are formed to provide proper lead spacing. The minimum distance between the seal (where the lead enters the body of the component) and the start of the lead bend must be no less than twice the diameter of the lead, as shown in Fig. 45.

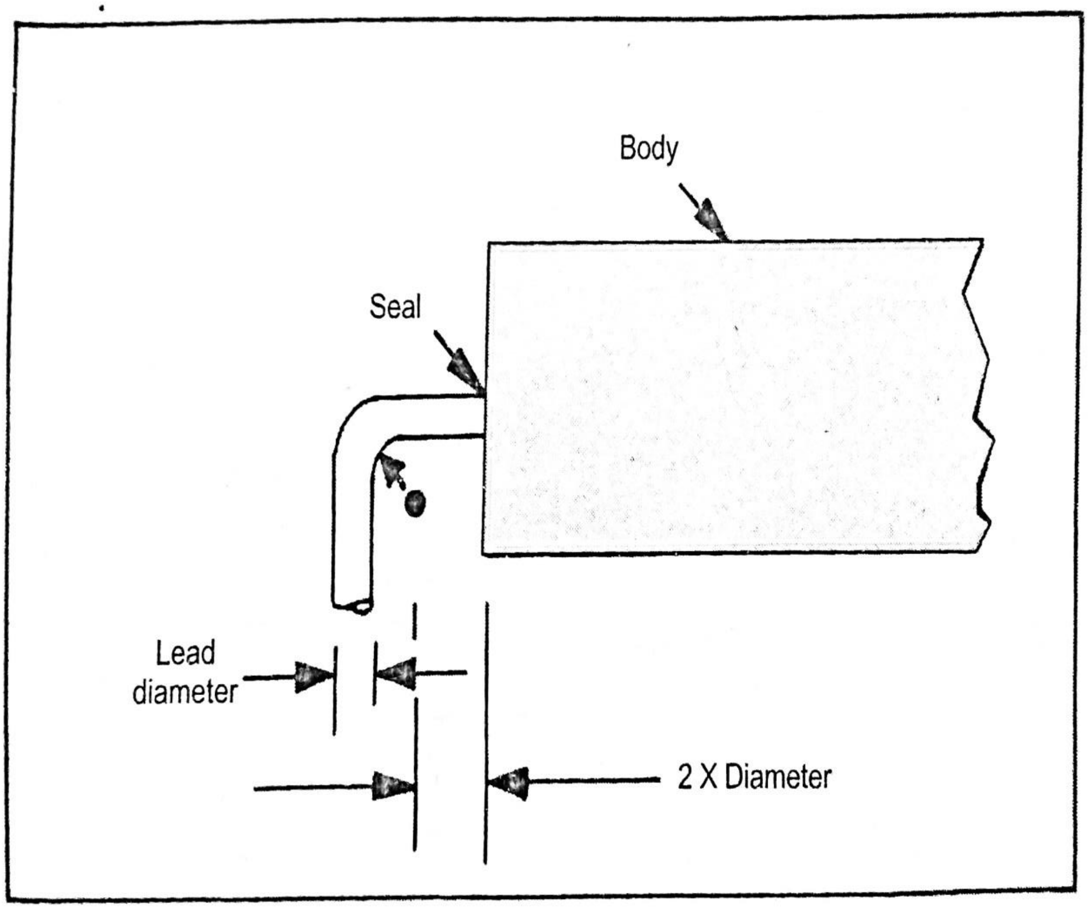


Fig.45. Minimum distance lead bend to component body

Leads must be approximately 90 degrees from their major axis to ensure free movement in whole terminations, as shown in Fig. 46.

In lead-forming, the lead must not be damaged by nicking. Energy from the bending action must not be transmitted into the component body.

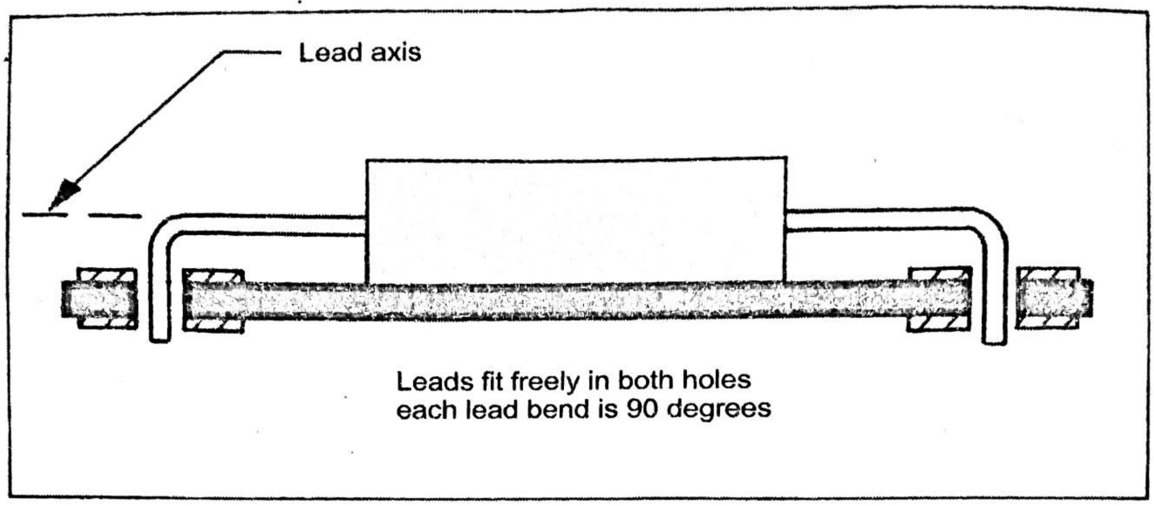


Fig.46. Ideal lead formation

d) Component placement

Where possible, parts are remounted or reassembled as they were in the original manufacturing process. To aid recognition, manufacturers use a coding system of colored dots, bands, letters, numbers, and signs. Replacement components are mounted to make all identification markings readable without disturbing the component. When components are mounted like the original, all the identification markings are readable from a single point.

Component identification reads uniformly from left to right, top to bottom, unless polarity requirements determine otherwise, as shown in Fig. 47. To locate the top, position the board so the part number may be read like a page in a book. By definition, the top of the board is the edge above the part number.

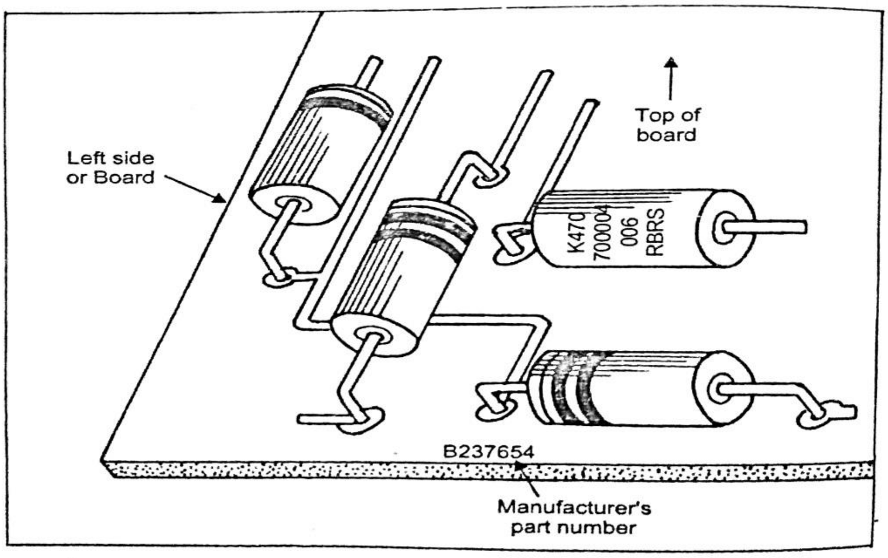


Fig.47

When possible, component identifications markings should be visible after installation. If you must choose between identification and electrical value markings, the priority of selection is as follows:

1. electrical value,
2. reliability level, and
3. part number

Components are normally mounted parallel to and on the side opposite the printed circuitry and in contact with the board.

e) Formation of proper lead termination

After component leads are formed and inserted into the board, the proper lead length and termination are made before the lead is soldered. Generally, if the original manufacturer clinched (either full or semi) the component leads; the replacement part is reinstalled with clinched leads.

When clinching is required, leads on single- and double-sided boards are securely clinched in the direction of the printed wiring connected to the pad. Clinching is performed with tools that prevent damage to the pad or printed wiring. The lead is clinched in the direction of the conductor by bending the lead. The leads are clipped so that their minimum clinched length is equal to the radius of the pad. Under no circumstances does the clinched lead extend beyond the pad diameter. Natural spring back away from the pad or printed wiring is acceptable. A gap between the lead end and the pad or printed wiring is acceptable when further clinching endangers the pad or printed wiring. These guidelines ensure uniform lead length.

5.7 SOLDERING OF PCB COMPONENTS

The fundamental principles of solder application must be understood and observed to ensure consistent and satisfactory results. As discussed in topic 2, the soldering process involves a metal-solvent action that joins two metals by dissolving a small amount of the metals at their point of contact.

a) Solderability

As the solder interacts with the base metals, a good metallurgical bond is obtained and metallic continuity is established. This continuity is good for electrical and heat conductivity as well as for strength. Solderability measures the ease with which molten solder wets the surfaces of the metals being joined. WETTING means the molten solder leaves a continuous permanent film on the metal surface. Wetting can only be done properly on a clean surface. All dirt and grease must be removed and no oxide layer must exist on the metal surface. Using abrasives and/or flux to remove these contaminants produces highly solderable surfaces.

b) Heat source

The soldering process requires sufficient heat to produce alloy- or metal-solvent action. Heat sources include CONDUCTIVE, RESISTIVE, CONVECTIVE, and RADIANT types. The type of heat source most commonly used is the conductive- type soldering iron. Delicate electronic assemblies require that the thermal characteristics of a soldering iron be carefully balanced and that the iron and tip be properly matched to the job. Successful soldering depends on the combination of the iron tip temperature, the capacity of the iron to sustain temperature, the time of iron contact with the joint, and the relative mass and heat transfer characteristics of the object being soldered.

c) Selection of proper tip

The amount of heat and how it is controlled are critical factors to the soldering process. The tip of the soldering iron transfers heat from the iron to the work. The shape and size of the tip are mainly determined by the type of work to be performed. The tip size and the wattage of the element must be capable of rapidly heating the mass to the melting temperature of solder. After the proper tip is selected and attached to the iron, the operator may control the heat by using the variable-voltage control. The most efficient soldering temperature is approximately 550 degrees Fahrenheit. Ideally, the joint should be brought to this temperature rapidly and held there for a short period of time. In most cases the soldering action should be completed within 2 or 3 seconds. When soldering a small-mass connection, control the heat by decreasing the size of the tip.

Before heat is applied to solder the joint, a thermal shunt is attached to sensitive component leads (diodes, transistors, and ICs). A thermal shunt is used to conduct heat away from the component. Because of its large heat content and high thermal conductivity, copper is usually used to make thermal shunts. Aluminum also has good conductivity but smaller heat content; it is also used to conduct heat, especially if damage from the physical weight of the clamp is possible. Many types, shapes, and sizes of thermal shunts are available.

5.8 APPLICATION OF SOLDER AND SOLDERING IRON TIP

Before solder is applied to the joint, the surface temperature of the parts being soldered is increased above the solder melting point. In general, the soldering iron is applied to the point of greatest mass at the connection. This increases the heat in the parts to be soldered. Solder is then applied to a clean, fluxed, and properly heated surface. When properly applied, the solder melts and flows without direct contact with the heat source and provides a smooth, even surface that feathers to a thin edge.

Molten solder forms between the tip and the joint, creating a heat bridge or thermal linkage. This heat bridge causes the tip to become part of the joint and allows rapid heat transfer. A solder (heat) bridge is formed by melting a small amount of solder at the junction of the tip and the mass being soldered as the iron is applied. After the tip makes contact with the lead and the pad and after the heat bridge is established, the solder is applied with a wiping motion to form the solder bond. The completed solder joint should be bright and shiny in appearance. It should have no cracks or pits, and the solder should cover the pad. Examples of preferred solder joints are shown in Fig. 48. They are referred to as full fillet joints.

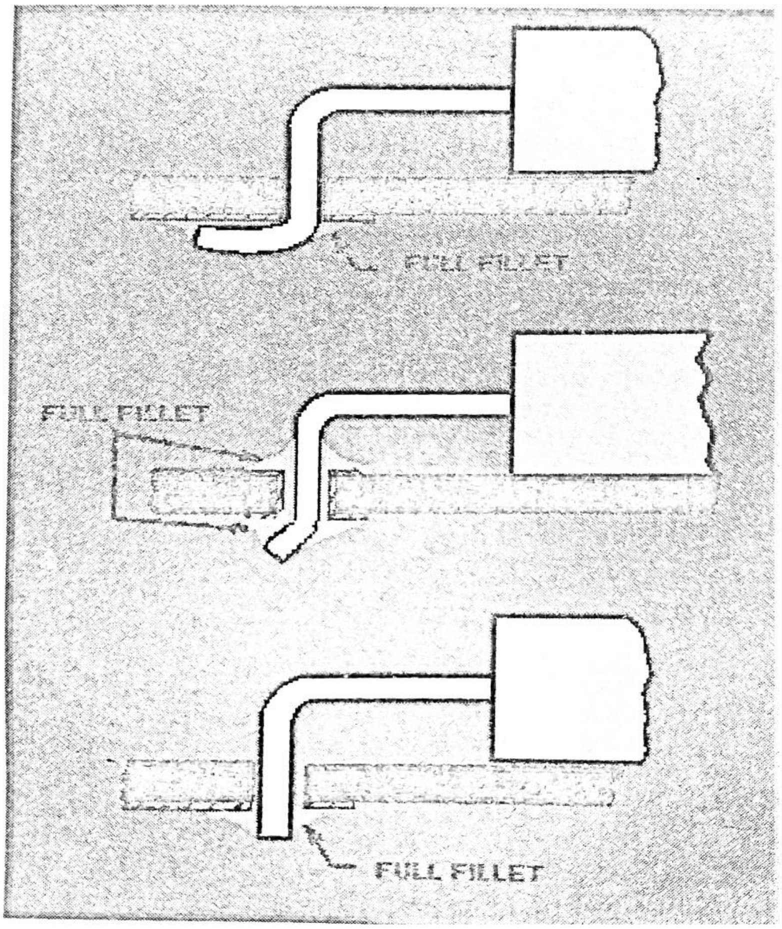


Fig.48. Preferred solder joint

When a solder joint is completed, solvent must be used to remove all flux residue. The two most highly recommended solvents, in the order of their effectiveness, are 99.5 percent pure ethyl alcohol and 99.5 percent pure isopropyl alcohol.

5.9 COMPONENT DESOLDERING

Most of the damage in printed circuit board repair occurs during disassembly or component removal. More specifically, much of this damage occurs during the desoldering process. To remove components for repair or replacement, the technician must first determine the type of joint that is used to connect the component to the board. The technician may then determine the most effective method for desoldering these connections.

Three generally accepted methods of solder connection removal involve

1. The use of solder wick,
2. A Manually controlled vacuum Plunger, or
3. A motorized solder extractor using continuous vacuum and/or pressure.

Of all the extraction methods currently in use, continuous vaccum is the most versatile and reliable. Desoldering becomes a routine operation and the quantity and quality of desoldering work increases with the use of this technique. Now we will study them in detail.

1. Solder wicking

In this technique, finely stranded copper wire or braiding (wick) is saturated with liquid flux. Most commercial wick is impregnated with flux; the liquid flux adds to the effectiveness of the heat transfer and should be used whenever possible. The wick is then applied to a solder joint between the solder and a heated soldering iron tip, as shown in Fig.49. The combination of heat, molten solder, and air spaced in the wick creates a capillary action and causes the solder to be drawn into the wick.

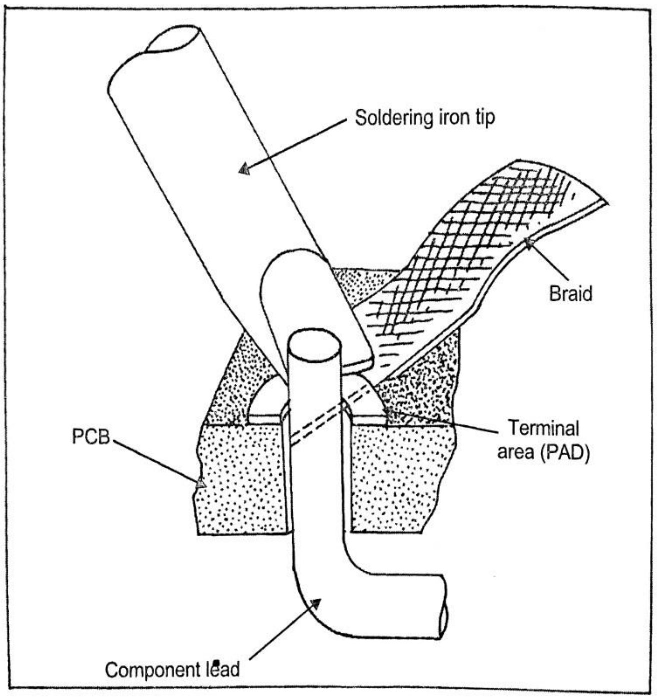


Fig.49. Solder wicking

This method should be used to remove surface joints only, such as those found on single-sided and double-sided boards without plated-through holes or eyelets. It can also remove excessive solder from flat surfaces and terminals. The reason is that the capillary action of the wicking is not strong enough to overcome the surface tension of the molten solder or the capillary action of the hole.

2.Manually Controlled Vacuum Plunger

The second method of removing solder involves a manually controlled and operated, one- shot vacuum source. This vacuum source uses a plunger mechanism with a heat resistant orifice. The vaccum is applied through this orifice.

Figure 50 shows the latest approved, manual-type desoldering tool. This technique involves melting the solder joint and inserting the solder-extractor tip into the molten solder over the soldering iron tip. The plunger is then released, creating a short pulse of vacuum to remove the molten solder. Although this method offers a positive vacuum rather than the capillary force of the wicking method, it still has limited application. This method will not remove 100 percent of the solder and may cause circuit pad lifting because of the extremely high vacuum generated and the jarring caused by the plunger action.

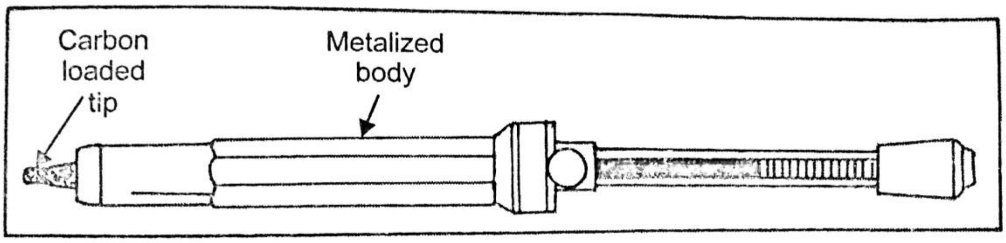
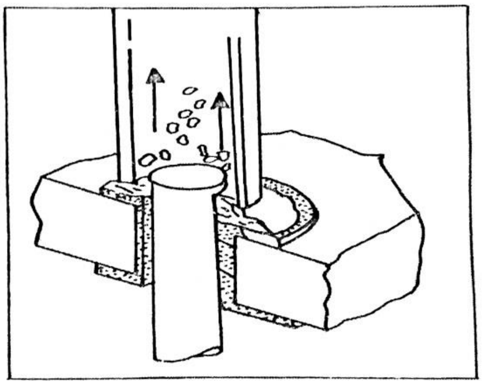


Fig.50. Manual desoldering tool

Because 100 percent of the solder cannot be removed, the extraction method is not usually successful with the plated-through solder joint. The component lead in a plated-through hole joint usually rests against the side wall of the hole. Even though most of the molten solder is removed by a vacuum, the small amount of solder left between the lead and side walls causes a SWEAT JOINT to form. A sweat joint is a paper-thin solder joint formed by a minute amount of solder remaining on the conductor lead surfaces.

5.10 MOTORIZED VACUUM/ PRESSURE METHOD

The most effective method for solder joint removal is motorized vacuum extraction. The solder extractor unit, described in topic 2, is used for this type of extraction.



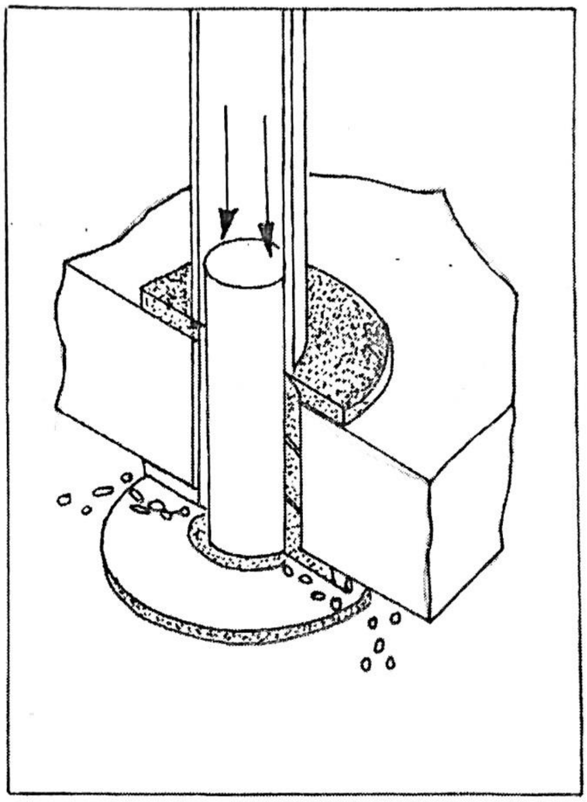
(A) VACUUM MODE

Fig.51. Motorized vacuum/pressure solder removal. Vacuum Mode

This method provides controlled combinations of heat and pressure or vacuum for solder removal. The motorized vacuum is controlled by a foot switch and differs from the manual vacuum in that it provides a continuous vacuum. The solder extraction device is a coaxial, in line instrument similar to a small soldering iron. The device consists of a hollow-tipped heating element, transfer tube, and collecting chamber (in the handle) that collects and solidifies the waste solder. This unit is easily maneuvered, fully controllable, and provides three modes of operation (Fig.51):

1. Heat and vacuum
2. Heat and pressure, and
3. Hot-air jet.

Some power source models provide variable control for pressure and vacuum levels as well as temperature control for the heated tubular tip. The extraction tip and heat source are combined in one tool. Continuous vacuum allows solder removal with a single heat application. Since the slim heating element allows access to confined areas, the technician is protected from contact with the hot, glass, solder-trap chamber. Continuous vacuum extraction is the only consistent method for overcoming the resweat problem for either dual or multiplied devices terminating in through-hole solder joints.



(B) PRESSURE MODE

Fig.52. Motorized vacuum/pressure solder removal. PRESSURE MODE

a) Motorized vacuum method

In the motorized vacuum method, solder is observed, the vacuum is activated by the technician causing the solder to be withdrawn from the joint and deposited into the chamber. If the lead is preclipped, it may also be drawn into a holding chamber. To prevent SWEATING (reforming a solder joint) to the side walls of the plated- through hole joint, the lead is "stripped" with the tip while applying the vaccum. This permits cool air to flow into and around the lead and side walls causing them to cool.

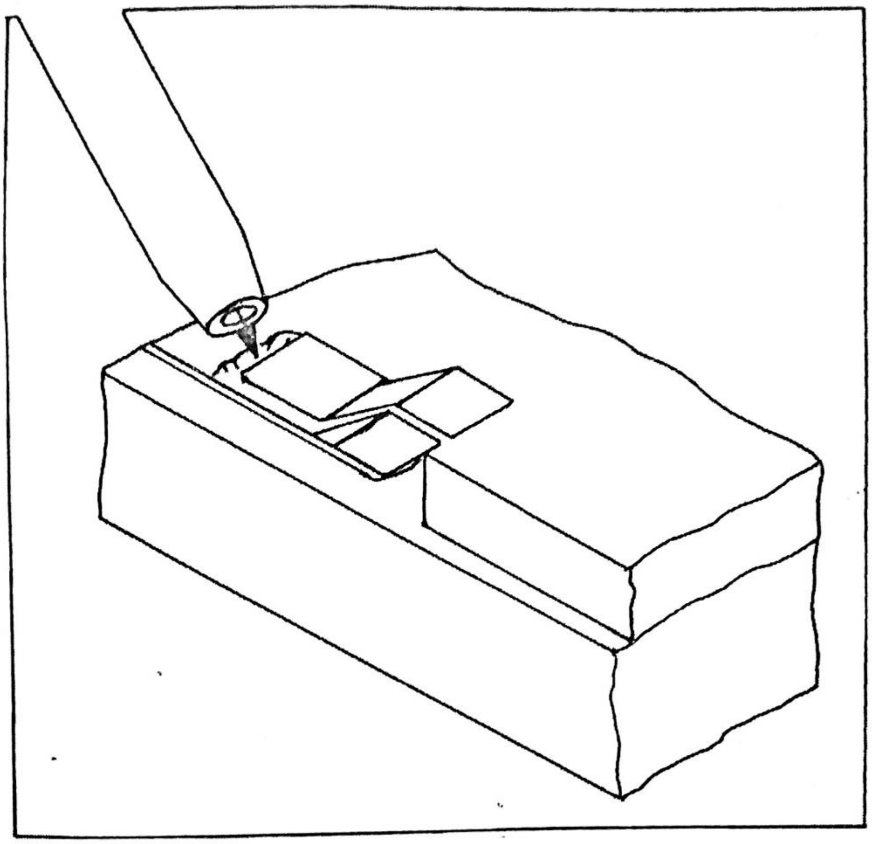


Fig. 53. Motorized vacuum/pressure solder removal. Hot Aie Jet Mode

b) Motorized pressure method

In the pressure method, the tip is used to apply heat to a pin for melting a sweat joint. The air pressure is forced through the hole to melt sweat joints without contacting the delicate pad. This method is seldom used because it is not effective in preventing sweating of the lead to the hole nor for cooling the workpiece.

c) Hot-air jet method

The hot-air jet method uses pressure- controlled, heated air to transfer heat to the solder joint without physical contact from a solder iron. This permits the reflow of delicate joints while minimizing mechanical damage.

When the solder is removed from the lead and pad area, the technician can observe the actual condition of the lead contact to the pad area and the amount of the remaining solder joint. From these observed conditions, the technician can then determine a method of removing the component and lead.

With straight-through terminations, the component and lead may be lifted gently from uncoated boards with pliers or tweezers. Working with clinched leads on uncoated boards requires that all sweat joints be removed and that the leads be unclenched before removal.

The techniques that have been described represent the successful methods of desoldering components. As mentioned at the beginning of this section, the 2M technician must decide which method is best suited for the type of solder joint. Two commonly used but unacceptable methods of solder removal are heat-and-shake and heat-and-pull methods.

In the heat-and-shake method, the solder joint is melted and then the molten solder is shaken from the connection: In some cases, the shaking action may include striking the assembly against a surface to shake the molten solder out of the joint. This method should never be used because all the solder may not be removed and the solder may splatter over other areas of the board. In addition, striking the board against a surface can lead to broken boards, damaged components and lifted pads or conductors.

The heat-and-pull method uses a soldering iron or gang-heater blocks to melt individual or multiple solder joints. The component leads are pulled when the solder is melted. This method has many shortcomings because of potential damage and should NOT be attempted. Heating blocks are patterned to suit specific configurations, but when used on multiple-lead connections, the joints may not be uniformly heated. Uneven heating results in plated-through hole damage, pad delamination, or blistering. Damage can also result when lead terminations are pulled through the board.

When desoldering is complete, the work piece must undergo a careful physical inspection for damage to the circuit board and the remaining components. The technician should also check the board for scorching or charring caused by component failure. Sometimes MEASLING is present. Measling is the appearance of light-colored spots. It is caused by small areas of fiberglass strands that have been damaged by epoxy over curing, heat, abrasion, or internal moisture. No cracks or breaks should be visible in the board material. None of the remaining components should be cracked, broken, or show signs of overheating. The solder joints should be of good quality and not covered by loose or splattered solder, which may cause shorts. The technician should examine the board for nicked, cracked, lifted, or delaminated conductors and lifted or delaminated pads.

STUDENT ACTIVITY

1. What is power plugs?

2. What is power socket?

SUMMARY

- The core is the central member about which the main strands are laid. The principal function of the core is to provide a bearing for the strand.
- Power plugs are male electrical connectors that fit into female electrical sockets. They have contacts that are pins or blades that connect mechanically and electrically to holes or slots in the socket.
- A banana connector (commonly banana plug for the male, banana jack for the female) is a single-wire (one conductor) electrical connector used for joining wires to equipment. The plugs are frequently used to terminate patch cords for electronic test equipment.
- The BNC connector is used for RF signal connections, for analog and Serial Digital Interface video signals, amateur radio antenna connections, aviation electronics and many other types of electronic test equipment.
- Antenna sockets are female antenna connectors that have slots or holes which accept the pins or blades of antenna plugs inserted into them and deliver or receive TV signal to or from the plugs.
- An electrical switch is any device used to interrupt the flow of electrons in a circuit. Switches are essentially binary devices: they are either completely on ("closed") or completely off ("open").
- A fuse is the simplest circuit protection device. It derives its name from the Latin word "fuses," meaning "to melt." Fuses have been used almost from the beginning of the use of electricity.
- A thermal fuse is a cutoff which uses a one-time fusible link. Unlike the thermostat which automatically resets itself when the temperature drops, the thermal fuse is more like an electrical fuse: a single-use device that cannot be reset and must be replaced when it fails or is triggered.
- The most fundamental skill needed to assemble any electronic project is that of soldering.
- Solder is an alloy (mixture) of tin and lead, typically 60% tin and 40% lead. It melts at a temperature of about 200°C.

SELF-ASSESSMENT QUESTIONS

1. What do you mean by wire rope? Discuss various terminology used in wire rope.
2. What are polarized plugs?
3. What is banana connector?
4. Describe RCA connector and give its advantages and Disadvantages.
5. Give applications of BNC connector.
6. What is UHF connector and where these can be used?
7. Describe various types of switches.
8. Describe various types of protective devices.
9. What is relay and where they can be used?
10. What is solder? Describe the method of soldering.
11. Describe the installation and soldering of printed circuit components.
12. Describe the method of soldering of PCB components.
13. Write short notes on
    a) Component desoldering
    b) Thermal fuse
    c) Circuit breakers
    d) DIN connector.