Topic	Level
7.3 Tools Common hand tool types; Common power tool types; Operation and use of precision measuring tools; Lubrication equipment and methods. Operation, function and use of electrical general test equipment;	3

TRAINING NOTES

7.3 Tools

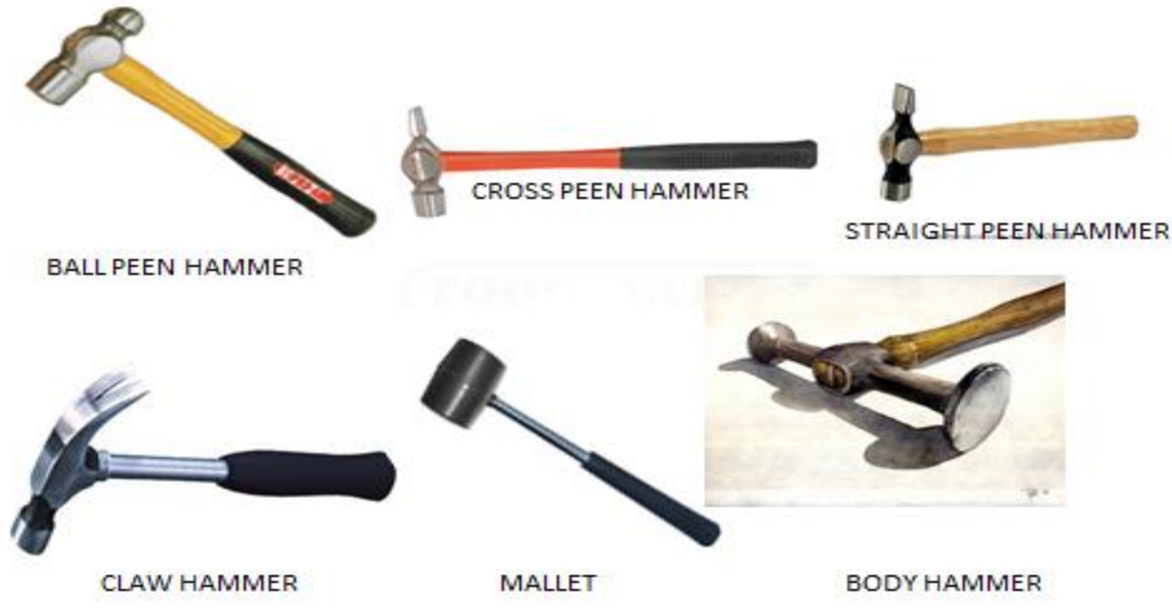
Common hand tool types; · Common power tool types; Operation and use of precision measuring tools; · Lubrication equipment and methods. Operation, function and use of electrical general test Equipment.

HAMMERS: A hard hammer is one that is made of carbon steel and forged to shape and size. It is heat-treated to make the striking faces hard. A soft hammer may have the entire head made of a soft metal such as lead, Babbitt, copper, or brass. Soft-faced hammers have only their striking surfaces made of plastic, rubber, or rawhide. The faces are either clamped or press fitted on the metal hammerhead. A hard hammer is used for striking punches, cold chisels, steel letters, and figures. It is also used for forging hot metal, riveting, bending, straightening, Peening, stretching, and swaging. Soft hammers are used when striking finished or semifinished work pieces to prevent marring the finished surfaces. For example, soft hammers are commonly used for seating a workpiece in a machine vise or tapping finished work being set up for a machining or layout operation.

- The hammers most commonly used by machinists are the ball-peen , the straight- peen and the cross-peen .
- The flat face of the ball-peen is used for general work such as striking punches; rounded (ball) end is used for riveting and Peening.
- The straight-peen, which has a peen-end parallel to the axis of the handle, is used for stretching and drawing out metal when forging.
- The cross-peen, which has a peen-end at right angles to the hammer handle, is used for riveting, stretching, and drawing metal.
- A hammer handle should be gripped near the end so that full leverage

- may be obtained when swinging the hammer. A solid blow is difficult to deliver when the handle is gripped too close to the head of the hammer. The amount of force with which the hammer strikes depends, in part, on the length of the handle and the weight of the head. To get the most advantage of the handle's length it should be held as far from the head as· possible.

- The size of a hard hammer is specified by the weight of the head without the handle. Ball-peen hammer sizes range from 2 oz to 3 lb. Sizes of soft-faced hammers is specified by the diameter of the face and the length of the head and range from %-in. diameter to 3-in. diameter. Faces are specified in degrees of hardness from super soft to extra hard.



PUNCHES: A hand punch is a tool held by hand against a workpiece.The end in contact with the work piece is shaped to do a particular job, whereas the other end is flat so that it could be struck easily by a hammer.

Punches come in many sizes and shapes to do a variety of jobs. Although most punches are made of hardened and tempered tool steel for greater strength and longer wear, it is sometimes necessary to use punches made of a soft metal such as brass to prevent damage to parts being assembled or disassembled.

The punches used most often by the machinist are · the· drift punch, pin punch, prick punch, center punch, and automatic center punch.

- A drift punch is a long, tapered punch used for loosening straight pins, taper pins, rivets, and other small parts being disassembled. The gradual, uniform taper end provides strength needed to withstand the powerful impact of the punch against the pins or parts being loosened.

- The diameter at the small end should be slightly smaller than the diameter of the part to be knocked loose. The punch end should be located squarely on the part and held firmly against the part. The head of the punch should then be struck squarely, using a quick sharp blow with a hard hammer. Once the part has been loosened, the drift punch should not be used because the tapered end will become wedged in the hole. A drive-pin punch should be used to drive the pin through the hole.

- Drive-pin punches are used to set in place or remove straight and taper pins and some types of small parts requiring a drive fit. The diameters of the punch ends are made slightly smaller than the nominal size so that the punch will not bind in the

hole. For use on precision parts, the punch ends should be smooth, flat, and square, to avoid damaging the parts. Smaller diameter punches require greater care to prevent bending or breaking. When assembling or removing pins, the work must be correctly supported as in a V block. To install a taper pin, a punch slightly larger in diameter than the large diameter of the pin is used .To remove a pin, it is better to hit the punch with a quick sharp blow of the hammer than to hit it a number of light taps because this will mushroom the pin, making it difficult to remove

- A prick punch is made of hardened tool steel and ground to a slender point having a 30° to 60° included angle (Fig. 3-14). It is used to mark lightly or indent the intersections of layout lines, to locate hole centers, and to provide a small center mark for divider points when laying out circles or spacing dimensions. A lightly made prick punch mark can be moved to correct an error by tilting the punch and striking it with the hammer.

- A center punch is similar to a prick punch in appearance except for the point, which is ground to a 90° included angle .The center punch is used to enlarge a prick-punch mark so a drill can be started in the exact location. A center-punch mark is deeper and larger than a prick-punch mark. When used correctly, the point of the center punch is placed in the prick-punch mark. The punch, hand held in a vertical position, is struck squarely once with a hammer.

- The automatic center punch makes punch marks of a uniform size without the use of a hammer. The knurled cap may be turned to control the depth of the punch mark. To make a punch mark it is only necessary to locate the punch point and push down. When used with a spacing attachment, this tool can lay out uniformly spaced dimensions rapidly.

SCREWDRIVERS

- A screwdriver is a hand tool that is designed to turn screws. The shank is made of steel set into a wooden or plastic handle. The blade is shaped or flattened to fit recesses in the heads of screws or bolts. Screwdrivers are made in many sizes. A stubby screwdriver helps to start screws where space is limited.

- A heavy-duty screwdriver is of average length but is made with a heavy blade and a square shank. The shape of the shank permits the use of a wrench to assist in tightening a screw. Heavy (thick) material is used so that the blade and shank will resist being twisted when a wrench is used.
- A Phillips screwdriver is specially designed to fit the heads of Phillips screws. It differs from other screwdrivers in that the end of the blade is fluted instead of flattened. It is made in several sizes. Each size is numbered and relates the diameter of the blade with the point number. For example, a No. 2 point has a 1/2-in.-diameter shank.
- A double-ended offset screwdriver is used for turning screws in awkward places where there is not enough room to use a regular screwdriver.
- A screwdriver blade should be ground so that the faces will be almost parallel with the sides of the screw slot as in. The end of the blade should be made as thick as the slot in the screw will permit. A blade ground to a chisel point has a tendency to slip out of the screw slot and, also, to leave a ragged edge on the slot. Excessive heat at the time of grinding, indicated by a blue color appearing on the blade, will draw the temper of the steel and cause the blade to become soft. This will result in the end of the blade being bent out of shape when a heavy pressure is applied when reconditioning a screwdriver blade; grind the end of the tip first to square it with the shank. Next, grind the blade to the thickness required by holding it on the grinding wheel, as shown in. Usually, the radius of the grinding wheel will produce a satisfactory end on the blade.

- 

PLIERS

- The word pliers are a plural name for a single tool. Pliers are made in many styles and are used to perform as many different operations. Figure 3-26 shows the common slip-joint (or combination) pliers. They are used for holding and gripping small articles in situations where it may be inconvenient or unsafe to use hands. It is not good practice to use pliers in place of a wrench.
- Long-nose pliers are made, as the name m implies, with a long tapering nose, or jaws. This tool can be used for placing and removing small items in narrow spaces. It is also preferred for electrical and radio repair work.

- Diagonals are a special type of pliers used exclusively for cutting and stripping electrical wire. Diagonals should never be used to cut steel wire or rods or in place of snips to cut or notch sheet metal. Such use will destroy the cutting edge and damage the tool's joint.

CLAMPING AND HOLDING DEVICES

Many devices have been designed to hold work securely while it is being measured or machined. Some of them are for one specific piece of work; others are of a more general nature. These include many types of clamps and vises.

- A C clamp is an all-purpose clamp, made in the shape of the letter C. In general use for all kinds of work, it is made in many sizes.

- A toolmakers' clamp consists of two flat steel jaws, which may be adjusted to fit a piece of work by means of a screw passing through the center of each jaw. Another screw in the end of one jaw is used to exert pressure on the other jaw. This pressure tightens the opposite ends of the jaws. It is used by toolmakers for holding small parts both at the bench and at machines. This tool is also known as a parallel clamp. Care must be taken to keep the jaws in a parallel position. Otherwise the clamp screws may seem to be tight but will not be holding the work tightly because they are just being tightened one against the other.

- A toolmakers' hand vise is a small steel vise with two interchangeable blocks. The choice of block to be used depends on the size of the article to be held by the vise. It is used by toolmakers at the bench for small machining operations such as drilling or tapping.

- A bench vise, usually swivel-based as in is the kind most favored for general shop work. It is securely fastened to the bench with bolts. The faces of the jaws are usually lightly serrated and hardened to ensure a firm grip on the work. Finished surfaces should be protected when placed in the vise by using brass or copper jaw caps. Tightening the vise· by hammering on the handle is poor practice. When it is necessary to hammer a piece of work held in a vise, it is best to support the work by


DRILL VISE


PIPE VISE


PIN VISE


C CLAMP


TOOLMAKERS CLAMP

-

placing a block of wood or metal under it to prevent the work from being driven down through the jaws of the vise.

- V-blocks with clamps, either singly or in pairs, as in, are used to hold cylindrical work securely during the laying out of measurements or for machine operations.

WRENCHES

A wrench is a tool for turning nuts or bolts. It is usually made of steel. There are many kinds of wrenches. They may consist of a slot, socket, pins, or movable jaws for grasping the nut, with the rest of the tool serving as a handle for applying pressure

1. SINGLE ENDED
   A single-ended wrench is one that is made to fit one size of nut or bolt. This is the most inexpensive type of wrench and is quite efficient in ordinary situations.

2. DOUBLE ENDED
   A double-ended wrench has two openings, one at each end of the handle, to fit two different sizes of nuts or bolt heads.

3. CLOSED ENDED
   A closed-end wrench is similar to a single-ended wrench, but, because it entirely encloses a nut, there is little danger of the wrench slipping off the nut or of the jaws spreading apart. For these reasons, it is preferred for some jobs is also known as a box wrench.

4. Adjustable wrench
   An adjustable wrench has a movable jaw, which makes it adjustable to various sizes of nuts. A heavy type of adjustable wrench is the monkey wrench .When using this type of tool, point the jaws in the direction of the force applied. This will prevent the jaws from springing apart, and the wrench will be less likely to slip off a nut. The movable jaw should be adjusted so that it is tight against a flat surface of the part to be turned. It is not good practice to use a wrench as a hammer.

5. lever-jaw wrench

A lever-jaw wrench is a combination gripping tool with adjustable jaws, which may be locked in place. It may be used as a wrench, clamp, pliers, or vise.

6. combination wrench
   A combination wrench has two types of openings of the same size. One end has a box type opening with the opposite end designed as an open end. It is a very practical wrench because it can be used in places where the space for movement is limited; if one end will not work conveniently, the other end will.

7. Check-nut wrench
   A check-nut wrench is a thin, single ended or double-ended wrench used for turning checks or jam nuts. The thinness of these nuts, often used in narrow spaces, requires the use of a thin wrench. These wrenches are not intended for hard use. The openings are offset at an angle of 15°.

8. *Tool-post* wrench
   A tool-post wrench is a combination box and open-end wrench. The open end is straight rather than offset. The square box end is designed to fit tool-post screws and setscrews on lathes and other machine tools. It is ruggedly designed to withstand wear and hard use.

9. Square box wrench
   A square box wrench is a single-head closed-end wrench having a rather short handle. It is widely used for square-head setscrews on tool holders for the lathe and other machine tools. The square opening is made at an angle of 22 1/2 for convenience.
10. T-handle tap wrench
   A T-handle tap wrench (sometimes called a T-tap is used to hold and turn small taps up to about 1/2 in. It usually has two inserted jaws, which can be adjusted to fit the the tap. The chuck when tightened holds the tap securely. This type of wrench is made in several sizes, each size having a capacity for several sizes of taps. This wrench may also be made with a long shank for tapping holes that are difficult to reach. It is also useful for turning small hand reamers.

11.Adjustable tap wrench

An adjustable tap wrench is a straight type of wrench having a solid V-shaped opening in the center. A sliding member; or adjustable jaw, operated by one of the handles makes it possible to hold taps of various sizes. This type of wrench is made in many sizes to turn taps and reamers of all sizes.

12.12-point box wrench

A 12-point box wrench is designed with 12 notches, or points, inside a closed end. The points of a nut may be gripped by any one of the notches of the wrench, which permits the turning of a nut where only a short pull of the wrench is possible.

13.T-socket wrench

A T-socket wrench is made in the form of a T. The hole, or socket, in the end is made in a variety of shapes such as square, hexagonal, or octagonal. It is generally used on jobs where there is insufficient space to permit the use of an ordinary wrench. The handle may be removed from the hexagon-shaped head of the wrench to permit the use of another wrench to turn it when more pressure is required than can be applied with the handle.

14.Offset socket wrench

An offset socket wrench is made with the same variety of sockets as a T-socket wrench. It is designed to be used on nuts requiring great leverage or in place where a T-socket wrench cannot be .used.

15.Pin hook spanner wrench

A pin hook spanner wrench is designed, in to fit around the edge of large round nuts, which have holes in them to fit the pins of the wrench.

16.Adjustable-hook spanner wrench

An adjustable-hook spanner wrench used on round nuts having notches or slots cut on their periphery to receive the hook at the end of the wrench. Being adjustable, it will fit many sizes of nuts.

17. Adjustable pin-face wrench

An adjustable pin-face wrench is designed, as with two arms, each having a pin in one end this tool is used to adjust nuts that are enclosed so that an ordinary wrench cannot be placed around them. A nut in this situation is made with holes around the face to accommodate the pins in the ends of the adjustable legs of the wrench.

18. Strap wrench
A strap wrench is used for turning cylindrical parts or pipes, removing bezels, or holding or revolving any job on which the surface finish must be preserved.

19. Pipe wrench
A Stillson-type pipe wrench is designed with adjustable jaws that are serrated, making it possible to grip round pipe and other cylindrical parts. The serrated edges tend to cut into the metal being gripped, so care should be used to protect plated or finished surfaces being turned with this kind of wrench.

*20.*Hex *key wrench*
A hex key wrench, sometimes called an *Allen wrench*, is made of hexagon-shaped stock to fit the holes in the head of setscrews or socket-head screws. They· are available in many sizes.

21. Socket wrenches are round box type wrenches having two openings. One opening is a square hole into which the various driving attachments used for turning the socket wrench are plugged. The socket end has an opening with angular notches to fit bolt heads and nuts. This notched opening is made with either4, 6, 8, or 12 points. The 6- and 12-point sockets are used for hexagon-head bolts and nuts, while the 4- and 8- point sockets are used for square-head bolts and nuts. A ratchet wrench may be either of the socket type or the open-end type. The handle turns the interchangeable sockets through .a ratchet mechanism. This mechanism may be adjusted to operate. In the clockwise or the counterclockwise direction so that the ratchet wrench may be used to tighten or loosen nuts or bolts. The sockets may be standard or extra deep sockets. For hard-to-reach nuts or bolts, extension bar sockets can be used. Sockets have a lock-on feature in the form of a small hole on the side of the square hole into which a small spring-loaded ball in the driving attachment fits. When the socket is pushed on the

drive attachment and the hole and ball are aligned, the ball is forced into the hole, thus preventing the socket from dropping off.

22.Torque wrench

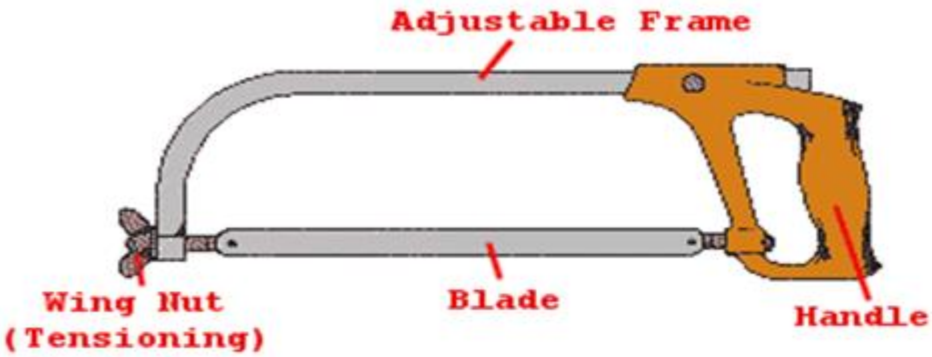
Torque wrenches are used when it is necessary to know the amount of turning or twisting force being applied to a nut. The amount of force is usually indicated on a dial, or scale, which is mounted on the wrench handle .On some models the amount of torque required can be preset on the dial, and an indicator will signal when that amount of
Force is reached.

- **HACKSAWS AND SAWING**
  The hacksaw receives a lot of use by the machinist working at a bench, as well as by workers in general. It is a hand tool especially designed for cutting metal. It consists of a metal frame, in the ends of which are metal clips to hold the cutting blade. One clip is threaded on one end for a wing nut, which is used for tightening the blade in the frame. There are *many* other styles of hacksaws. The frame is adjustable to suit various lengths of blades.

- A hacksaw blade is a piece of thin steel about 0.027 in. thick, 1/2 in. wide; it varies in length 6 to 12 in. On one edge of the blade are serrations known as teeth.

- Hacksaw blades are made with a hole in each end to fit over pins in the clips at each end of the hacksaw frame. The length of a blade is the distance from the center of the hole in one end of the blade to the center of the hole in the opposite end.

- No. Blades for hacksaws are manufactured with teeth *of* different sizes ranging from 14 to 32 teeth per inch. The set of a saw means the bending to one side or the other of the teeth of a saw. The standard practice is to bend the teeth alternately; that is, one tooth is turned to the right side, the next one to the left side, and so on, as in. The teeth are actually turned very little. Sometimes, in the case *of* fine toothed saw blades, the teeth are set alternately in pairs. This is known as double-alternate setting.



Adjustable Frame
Wing Nut
(Tensioning)
Blade
Handle

-

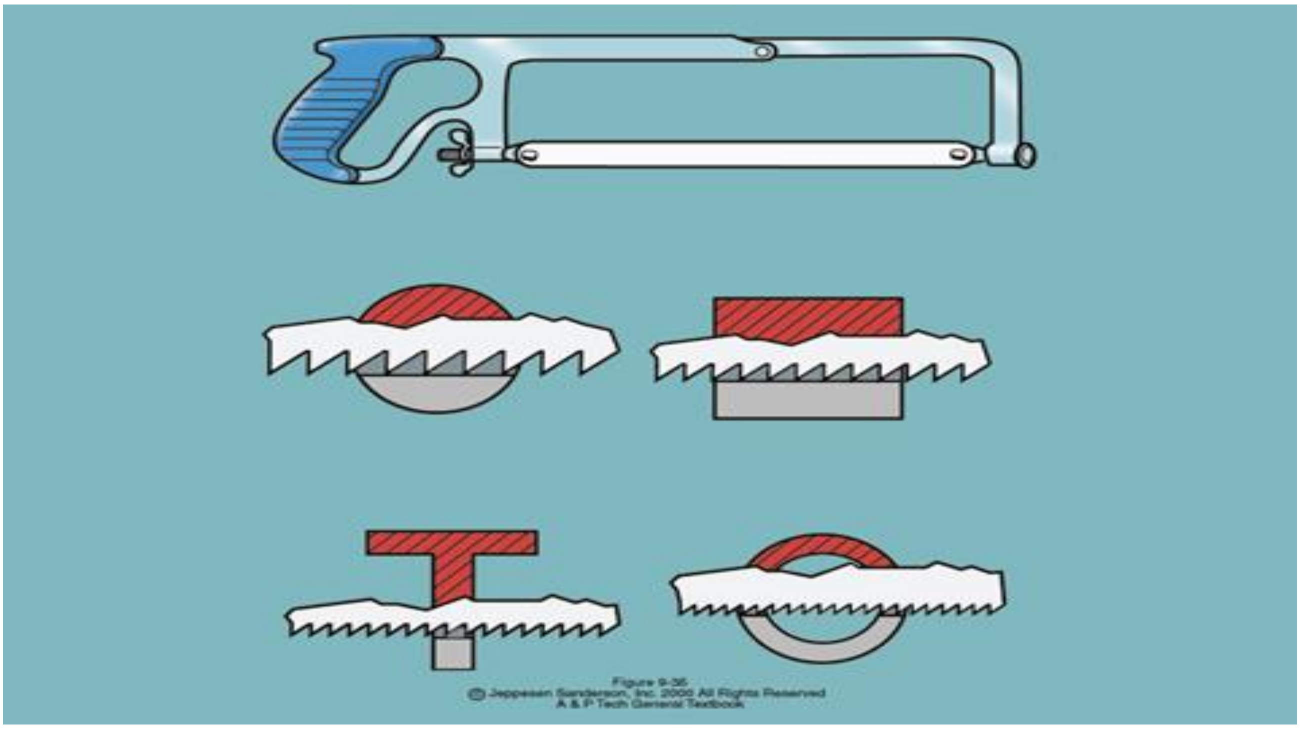


Figure 9-36
© Jeppesen Sanderson, Inc. 2000 All Rights Reserved
A & P Tech General Textbook

- Hacksaw blades are made of high grades of steel such as tool steel, high-speed steel, or tungsten alloy steel. An all-hard blade is one that has been hardened all over. All- hard saw blades are used for cutting materials such· as steel, cast iron, and brass. They are used particularly when cutting solid stock where a straight, even cut is desired. A flexible-back blade is one in which only the part where the teeth are cut is hardened, the rest of the blade remaining relatively soft. Flexible-back blades are preferred for cutting the softer metals such as tin, copper, aluminum, and Babbitt, and, in particular, for cutting tubing and various structural shapes with thin cross· sections. In the process of cutting such materials, there is a tendency for the blade to be twisted or pulled out of line. The flexible blade will yield under these conditions, whereas an all-hard blade will break.

- The work piece that is to be cut should be placed in a vise so that as much as possible of the surface may be presented to the edge of the blade. Avoid starting to saw on a corner. Corners have a tendency to strip teeth from the blade. The work should be held securely and adjusted so that the cutting will take place close to the end of the vise jaw. This will prevent chattering or vibrating of the work, which is hard on the nerves of the workman and on the teeth of the saw blade. Figure 3-71 shows the correct and incorrect ways of placing material in a vise.

- Clamp thin stock between two pieces of wood or soft steel, and then saw through all three together. Thin stock that is not supported in this manner will bend under the pressure of the saw.

- It has been found through experience that all materials do not cut equally well with the same size of saw teeth. The greatest efficiency is obtained by using a blade with teeth of the proper size for a given operation. The size of the teeth on a saw blade is referred to as the pitch.

- Use a blade with 14 teeth per inch for sawing machine steel, cold-rolled steel, and structural-steel units having thick sections. The main advantage of the coarse pitch is that it makes the saw free- and fast-cutting, and for that reason is preferred where a smooth cut is not important.

- Use an 18-pitch blade for sawing any solid stock, including such materials as aluminum, Babbitt, cast iron, high-speed steel, tool steel, and so forth. This pitch of blade is recommended for general use where a smooth cut surface is required.

- Use a 24-pitch blade for cutting pipe, tin, brass, Copper, small structural-steel units, and sheet metal over 18 gage. Although a fire-pitch blade cuts slowly, if a coarser blade is used for such items, the comparatively thin stock will tend to strip the teeth from the saw blade. There is less danger of stripping the teeth when two or more teeth are in contact with the work at all times.

- Use a 32-pitch blade for cutting small tubing, conduit, and sheet metal less than 18- gage thickness. These very thin materials require *a* very fine pitch to prevent the stripping of the teeth.

- No. The teeth are designed to cut in one direction only. For this reason, the pressure on the saw should be released during the return stroke, to avoid damage to the teeth.

- Under ordinary conditions, 50 to 60 strokes per minute is satisfactory. About 60 strokes per minute should be the maximum. Hard materials should not be sawed as fast as this, for **it** will unnecessarily dull the blade. In cutting hard material such as drill rod, for example, it is very effective to saw slowly and to use greater pressure than one would use for ordinary materials.

- Practice these hack sawing rules:

A. Use a blade with teeth of the correct pitch for the job to be done.
B. Saw as close as possible to the point where the work is clamped, to prevent chattering.
C. Do not cut too fast.
D. Relieve the pressure on the saw on the return stroke.
E. Do not press too hard on the work.
F. Reduce pressure on the forward stroke when the blade is almost through the cut.

- **FILES AND FILING**

Filing is a method of removing small amounts of material from the surface of a piece of metal or other solid substance. In some respects, the operation compares to smoothing a piece of wood with a chisel or plane. Just as there are many types of chisels and planes to suit many different operation's with wood, so there are many types of files designed for specific types of work and for various kinds of metal.

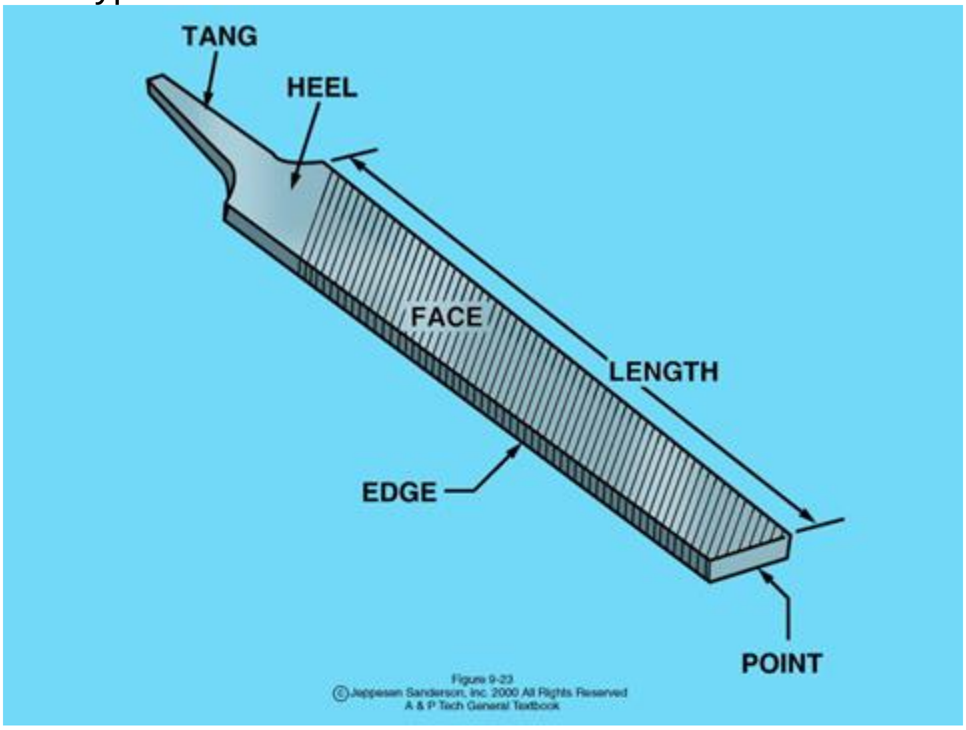
- A file is a hardened-steel cutting tool having parallel rows of cutting edges, or teeth, on its surfaces. On the two wide surfaces, the rows ·are usually diagonal to the edge. One end of the file is shaped to fit into a wooden handle.
- The principal parts of a file are, They are the tang, heel, face, edge, and tip. TANG
- The length of a file is the distance from the heel to the tip.
- The safe edge of a file is the one on which no teeth have been cut. This edge keeps one side of a piece of work safe while an adjacent surface is being filed.
- With one exception, no. Files normally taper in width from the heel to the tip. The exception is known as a blunt file.
- They are divided into two classes: single-cut and double-cut.

Single-cut files have rows of teeth running in one direction across their wide surfaces. Double-cut files have rows of teeth the same as single-cut files and, in addition, have a second row of teeth cut diagonally, to the first row, as in. Single-cut files do not remove stock as fast as double-cut files, but the surface finish produced by the use of single-cut files is smoother.

- Both classes of files are made in similar grades, or pitch, such as dead-smooth, smooth, second-cut, bastard, coarse, rough. The degree of roughness on small files is indicated by numbers from 00 to 6, with 00 being the roughest.
- The smaller the file, the finer the pitch.

1. The mill file, which is single-cut, is used mostly in smooth and second-cut grades. It derives its name from the fact that it was first used for filing mill saws. It is also used for work on a lathe, for draw filing, and for finishing various compositions of brass and bronze. This type of file produces a fine finish. It is available in lengths of from 6 to 16 in.

2. Most flat files are double-cut and are preferred in bastard and second-cut grades. They are used by machinists, machinery builders, ship and engine builders, repairmen, and toolmakers, when a fast-cutting file is needed. This type of file



produces a comparatively rough finish. It is usually available in lengths of from 6 to 18 in.

3. The pillar file is similar to the flat file, except that it is narrower; one or both edges are safe Rough Bastard Second Cut Smooth edges. The pillar file is used for filing slots and keyways and for filing against shoulders. It is available in lengths of from 6 to 16 in.
4. The square file has a cross section that is square and has double-cut teeth on all four sides I is used for filing small square or rectangular holes, for finishing the bottoms of narrow slots, and so forth. The grade commonly used is bastard, 4 to 16 in. in length.
5. The round file has a circular cross section. It is generally tapered. The small sizes are often called rattail files. It is used for enlarging round holes, for rounding irregular holes, and for finishing fillets. The grade commonly used is bastard, 4 to 16 in. in length.
6. The three-square file shown in, commonly called the three-cornered file, is triangular in section, with angles of 60°. It tapers to the point, the corners are left sharp. It is double-cut on all three sides and single-cut on the edges. It is generally used for filing internal angles that are less than 90°, for clearing out square corners and for filing taps, cutters, and so forth. The bastard and second-cut grades are preferred. It is available in 4 to 16 in. lengths. Three cornered files are also used for sharpening saws, either by hand or held in a machine.

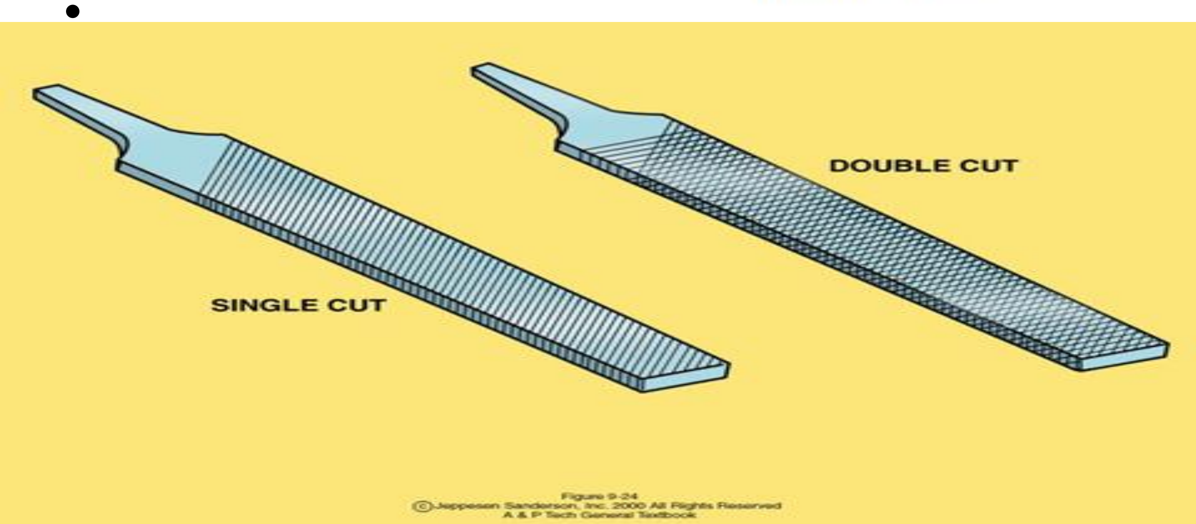
7. The half-round file so named because one half is flat, the other half rounded, is a double cut file that is used when filing concave surfaces. The bastard grade is used mostly, in lengths of from 6 to 16 in.
8. The knife file shown in is made knife shaped, the included angle of the sharp edge being approximately 10°. This file tapers to the point in width and thickness, and is double-cut on both flat sides, and single-cut on both edges. It is used for finishing the sharp corners of many kinds of slots and grooves. The grade preferred is bastard, in lengths of from 6 to 12 in.
9. A warding file is rectangular in section, but tapers to a narrow point in the width. It is used on mostly by locksmiths for filing notches in keys and locks. It is made double- cut and is available in sizes of from 4 to 12 in. in length. The 4-in. file is only 3/64 in. thick.

10. Swiss pattern files are similar to ordinary files but are made to more exacting measurements .The points of Swiss pattern files are smaller, and the tapered files have longer tapers. They are also made in much finer cuts. They are primarily finishing tools, used for removing burrs left over from previous finishing operations; truing up narrow grooves, notches, and keyways; rounding out slots and cleaning out corners; smoothing small parts; doing the final finishing on all sorts of delicate and intricate pieces. The grades vary from *00,* the coarsest, to 6, the finest.
11. The Swiss pattern crossing file has a double circular section, one side having the same radius as the half-round file and the other side having a flatter curve, or larger radius. It tapers to the point in both width and thickness and is double cut on both sides.
    These files are available in all grades from 00 to 6, in lengths of from 3 to 1 O in.
12. Needle files are members of the Swiss pattern family. They usually come in sets of assorted shapes. This type of file is used by tool and die makers, and also by watch- and clockmakers. One end of the file is knurled so that a separate handle is not needed. These files are available in grade 0, 2, 4, and 6 and in lengths of 4, 5 1/2 and 6 1/2 in.

- Files are generally made with convex surfaces; that is, they are thicker in the middle than at the ends. This is done to prevent all the teeth from cutting at the same time because that would require too much pressure on a file and make it hard to control. A flat surface could not be obtained if the face of the file were straight because there is a tendency to rock the file. The convex surface helps to overcome the results of rocking. · The convexity of files also serves another purpose. The pressure applied to a file to make it bite into the work also bends the file a little, and if the file in its 58 natural state were perfectly flat, it would be concave during the cutting operation. This would prevent the production of a flat surface because the file would cut away more at the edges of the work than in the center and thus leave a convex surface.

- Grasp the handle in the right hand so that it rests Again pane of the hand, with the thumb placed on top. Place the left hand at the end of tl1e file and let the fingers curl under It is important to have the body in the correct position because the muscles must move freely. The left foot should point forward and the right foot brought up close enough to the left to give the necessary balance. When filing, the body should

•



lean forward on the beginning of the forward stroke and then return to the original position at the finish of the stroke.

- The downward pressure should be released during the return stroke in order to avoid dulling the file by wearing away the back of the teeth.

- A file cuts best after it has cut about 2,500 strokes, or after it has removed about 1 cu in. of material because, at that time, most of the cutting edges will be in contact with the work. It must be remembered, however, that after continued use, the worn- down edges will continue to cut less and less until the life of the file is gone.

- Draw filing is the operation of pushing and pulling a file sidewise across the work.

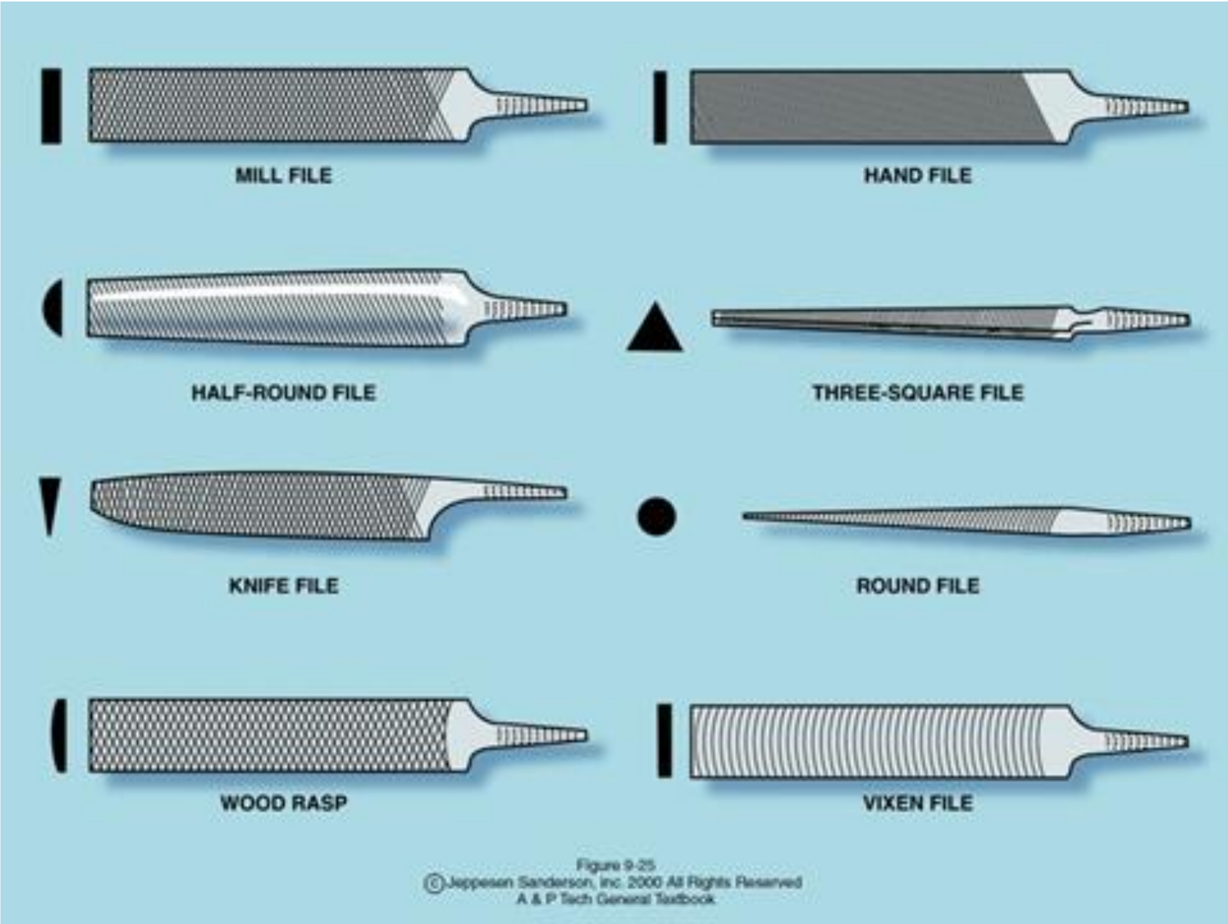
- Crossing the stroke means changing the angle at which one is holding a file by about 45°. This will show the high spots and also tend to keep the work flat.

- A large double-cut bastard, or double-cut coarse tooth, file should be used to remove stock rapidly.

- For ordinary finishing work, a 10-in. single-cut smooth file is preferred.

- When filing soft metals, narrow surfaces, or corners, small particles of the material being filed tend to become clogged in the gullets between the teeth of the file. This is called *pinning* a file. Pinning reduces the efficiency of the file and causes scratches on the surface of the work.

- A file may be cleaned with a file brush. One side of the brush has fine wires, which are used to loosen the embedded material. The other side has bristles, which are used to finish the job. In the handle of the file brush is a piece of metal, called a scorer, which is used to remove pinnings that cannot be loosened by the wires. Brush in. the direction of the file teeth.



MILL FILE
HAND FILE
HALF-ROUND FILE
THREE-SQUARE FILE
KNIFE FILE
ROUND FILE
WOOD RASP
VIXEN FILE
Figure 9-25
© Jeppesen Sanderson, Inc. 2000 All Rights Reserved
A & P Tech General Textbook

CHISEL:

- A chisel is a tool made from-hexagon- or octagon shaped tool steel, commonly called chisel-steel. If a size convenient for handling. One end is shaped for the cutting operation. The other end is left blunt to receive the blows from a hammer. Chisels are usually forged to the required shape, then annealed, hardened, and, tempered. Finally, a cutting edge is ground.

- Annealing relieves the internal strains of the metal, which develop during the forging operation and thus makes a chisel tough and strong. The hardening of the metal makes it possible for a chisel to maintain a sharp cutting edge. Tempering reduces the brittleness of the metal so that the cutting edge of the chisel is less liable to be fractured. All these processes annealing, hardening, and tempering-are known as heat treatments.

- No. Only the cutting end, and usually for a distance of 1 in. from the end. It is better for the opposite end to remain relatively soft, to avoid its being chipped by the blows of the hammer.

- A flat cold chisel is the most common type of chisel. It is used to chip flat surfaces and to cut thin sheet metal. It is called a *cold chisel* because it is used to cut metals that have not been heated in, a furnace.

- A cape chisel is a narrow chisel shaped. It is used mostly to chip grooves and keyways.

- A round nose chisel is used to rough out small concave surfaces such as a filleted corner. It is also used on drill-press work to cut a small groove in the sloping edge of a hole that is off center, for the purpose of drawing the drill back to place, concentric with the layout.

- A diamond-point chisel is used to cut V-shaped grooves or to chip in sharp corners.

- A hammer, weighing from 1 to 1 % lb, a chisel selected for the particular job to be done, goggles, and safety guard are the essential tools. The hammer should be held at the extreme end, grasped by the thumb, second, and third fingers, with the first and fourth fingers closed loosely around the handle. It may thus be swung more steadily and more freely, without tiring the hand as much as when the handle is grasped rigidly by all four fingers. The chisel should be held with the head of the chisel about 1 in. above the thumb and first finger and gripped firmly with the second and third fingers. The first finger and thumb should be slack because the muscles are· then relaxed, and the fingers and hand are less likely to be injured if struck with the hammer. The edge of the chisel should be held on the point where the cut is desired, at an angle that will cause the cutting edge to follow the desired finished surface After each blow of the hammer, the chisel must be reset to the proper position for the next cut.

- The correct cutting angle depends upon the hardness of the material to be cut. An angle of70° is suitable for iron and steel. For soft metals, the angle should be less The use of a chisel with a cutting angle of 90° or larger will tend to remove stock by pushing it off instead of cutting it off .

- A mushroom head on a chisel is a head that has been hammered until the end spreads out to resemble a mushroom. A mushroom head should always be ground off and the cutting edge sharpened before using the chisel. The mushroomed part of the head of the chisel may break off when struck by a hammer, and the flying particles of steel may injure someone. The ragged edge may also injure the hand of the person holding the chisel.

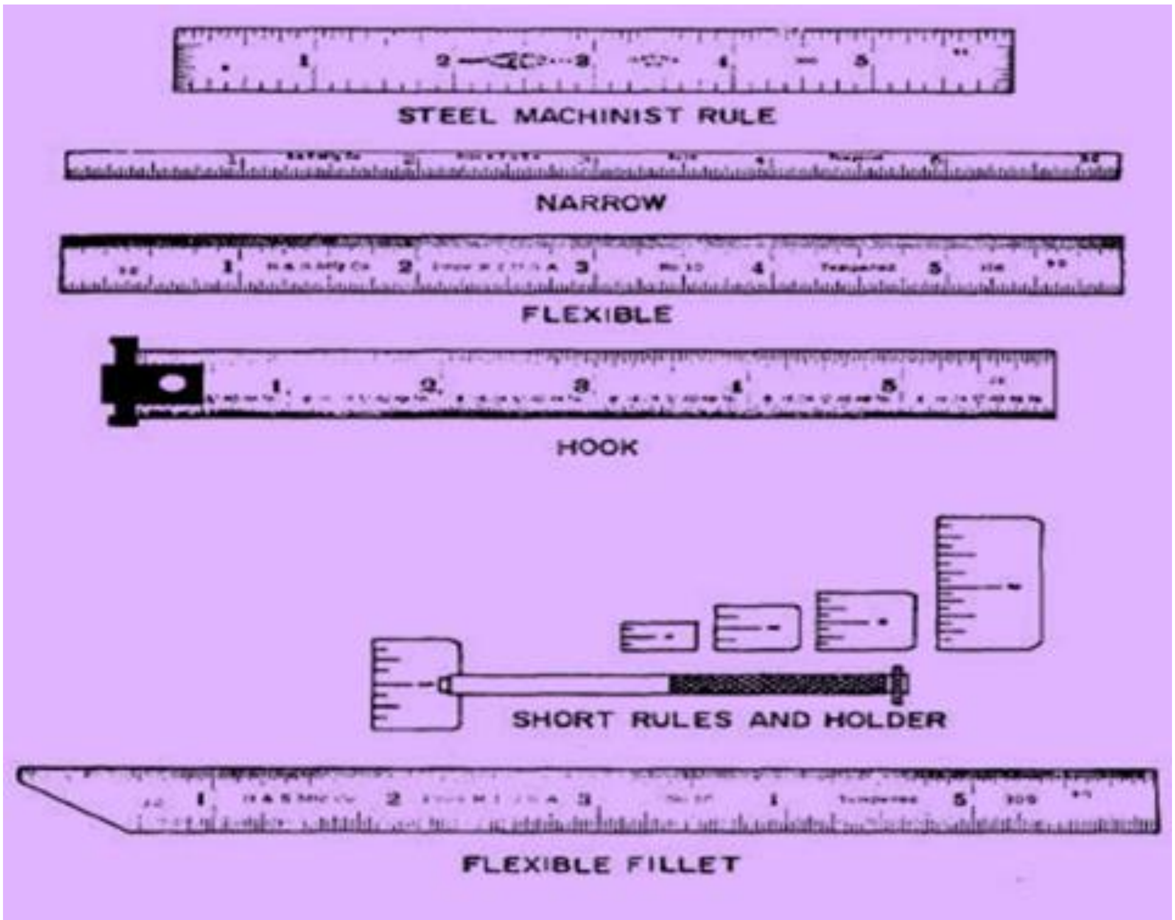
(1} Always wear goggles.
(2) Roll up sleeves.
(3) Be sure chisel has no mushroom head.
(4) Hold the chisel correctly.
(5) Hold the hammer at the end of the handle.
(6) Be sure the work piece is securely held in the vise.

Basic measuring and layout tools

- Steel rules are measuring tools that depend largely on the user's ability to read and line up the subdivisions marked on the rule. They are not intended for accuracy in terms of thousandths of an inch. With practice over a period of time, an able machinist can measure within three to five thousandths of an inch. Steel rules are one of the most widely used measuring tools for such work as laying out, checking stock sizes, and setting dividers and calipers. Lines, called graduations, which are inscribed on the face of the rule, subdivide the inches into fractional or decimal parts of an inch Several types of steel rules are generally available to suit the preferences of individual machinists.
- No. Some rules have four sets of graduations, one on each edge. Many combinations are available. Manufacturers have standard combinations, which are identified by a number from 1 to 12.Number 4 is the most popular, with eighths and sixteenths on one side, and thirty seconds and sixty-fourths on the other side. The most common steel rule used *in* a tool room is made of tempered steel about 3164 in. thick, % in. wide, and 6 in. long, with No. 4 graduations. The same style may be obtained in lengths from 1 to 144 in. and in a choice of graduations. The graduations sometimes inscribed on the end of the rule are handy for measuring a narrow space. (See
- A flexible steel rule is made of tempered spring steel about 1/64 in. thick, 1/2in. wide, and 6 in. long. It is available in many graduations, Nos. 3 and 4 being most popular. It is also available in other lengths. This type of rule is for general use and for measuring curved work.
- A narrow rule is made of tempered steel about 3/64 in. thick, 3/16 in. wide, and 4 to 12 in. long. Second third fourth corner it has graduation combinations Nos. 10 or 11 and is useful for measuring in small openings and spaces.

- A hook rule, , has a hook attached to one end, which makes it easy to take measurements from an inside edge when it is not convenient to see the end of the rule. Hook rules are made in many sizes. A narrow hook rule is made for measuring in holes as small as 3/8in. in diameter .A hook rule may also be used for measuring outside dimensions.

- A shrink rule is a tempered-steel rule similar in size and appearance to a standard rule. It has No. 4 graduations. It differs from other rules in that the inch markings on the face are slightly longer than actual inches. It is used by patternmakers. Patterns



•

for castings are deliberately made larger than the required castings to allow for the shrinkage of the molten metal as it cools to a solid. If .the shrink rule is used, the pattern will automatically be made larger than the actual size *of* the final casting.
Because the amount of shrinkage is not the same for all metals, shrink rules are made from 1/10to 7/6 in. per ft oversize.

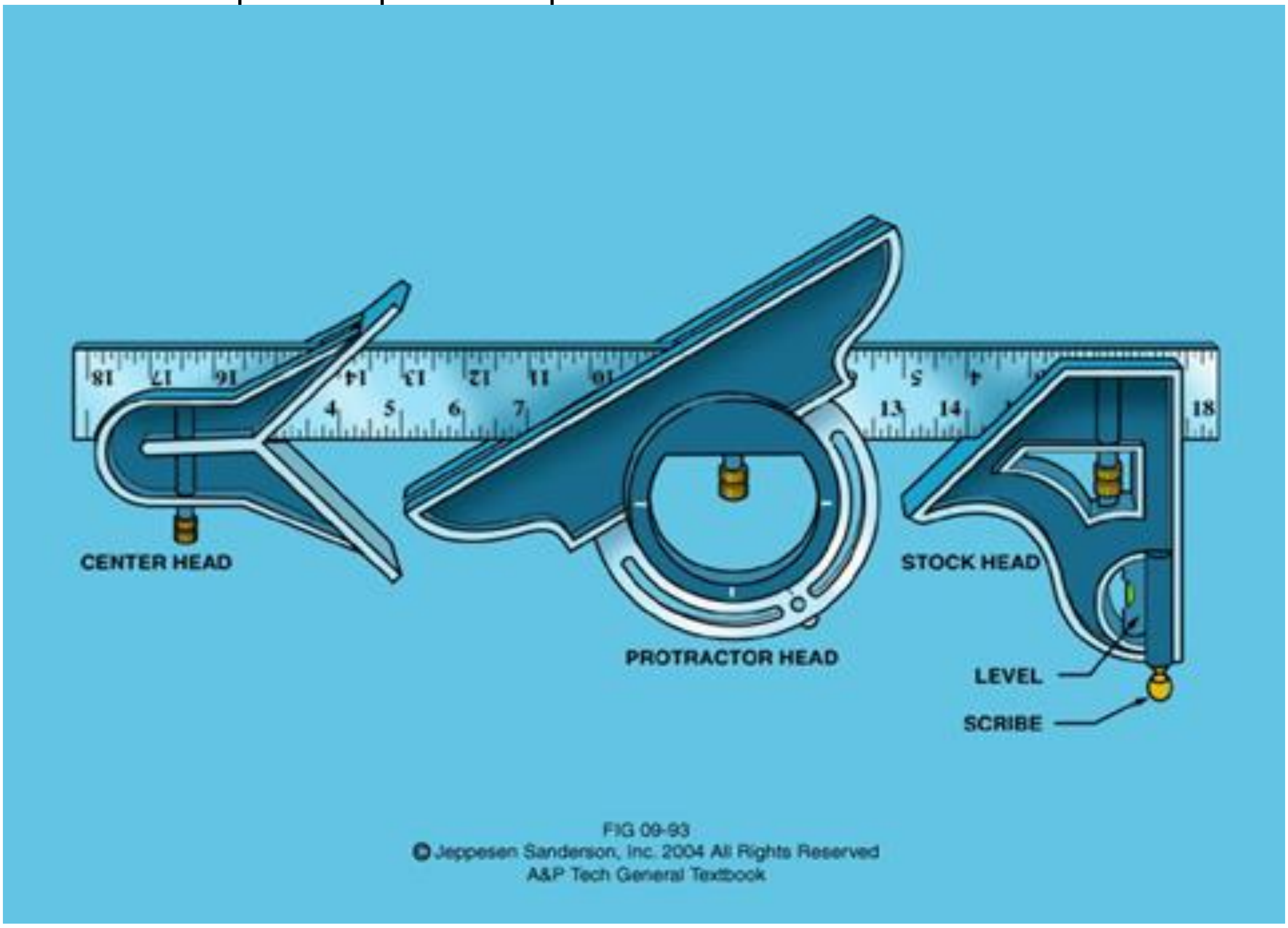
- A short rule is usually one of a set of small rules made for measuring in small spaces where it is inconvenient to use any other rule .The set of rules consists of a 1/4, 3/8,1/2,3/4and 1 in. rule, together with a holder. The rule may be held at any angle. It is secured by turning the knurled nut at the end of the holder. '

- A slide caliper rule is made with a narrow rule that slides inside a groove in the side of a wider rule. It may be used to make internal and external measurements. It is provided with a screw that will lock the slide in place as required. The narrow nibs at the end of the jaws will enter a hole as small as 1/8-in. diameter.

- A rule depth gage consists of a steel head that has a slot to receive a narrow rule. The rule is held in position by a knurled nut. It is designed to measure the depth of small holes and slots.

- A combination set consists of a rule, a square, a center head, and a protractor. The rule is made of tempered steel with a groove cut the length of one side along which the other parts may slide. Each part is provided with a knurled nut for locking it i.nto position. The rule has No. 4 or 7 graduations and is available in lengths of from 9 to 24 in. This tool may be used as a rule, a square, a depth gage, or a protractor. It is also used for marking miters and for locating the center on circular stock.

- A bevel protractor is a tool for measuring angles within one degree. It consists ·of a steel rule, a blade, and a protractor head. The protractor head has a revolving turret graduated to read from 0° to 180° in opposite directions. The head may be a reversible type with shoulders on both sides of the blade or a nonreversible type with a single shoulder. Most bevel protractors contain a spirit level, which is useful when measuring angles in relation to a horizontal or vertical plane. A plain steel protractor



may be more convenient to use for laying out and checking angles on some types of work.

Universal and combination bevels are useful tools for checking and transferring angles that would be difficult to measure with an ordinary protractor, the bevel may be set to the desired angle using a protractor, or it may be set to the work piece, and then checked against the protractor setting to determine accuracy. A combination bevel serves the same purpose as the universal bevel but has a wider range of applications.

- Outside calipers are used to measure outside diameters. A rule may be used to measure the diameter of the end of a bar, but it is not practical to measure diameters in between the ends. To measure an outside diameter with calipers, they are first set to the approximate diameter of the stock. Then the calipers Are held at right angles to the center line of the work, and moved back and forth across the center line, while they are being adjusted, until the points bear lightly on the work. This is called "getting the feel." When the tool has been adjusted properly, the diameter may be read from a rule.

- Inside calipers are used to measure inside diameters, widths of slots, and the like. To measure the diameter of a hole, open the calipers to the approximate size, then hold one leg of the calipers against the wall of the hole and turn the adjusting screw until the other leg just touches the opposite side. The calipers should be moved back and forth, to feel the proper contact. The size of the opening is then read from a rule, 4- 28, or from a micrometer.
- When a measurement has to be transferred from outside to inside calipers, both calipers are held so that they are in tile position. With the extreme point of one leg of the inside calipers placed on the extreme point of one leg of the outside calipers, adjust the inside calipers until the two extreme points touch lightly. Care must be taken not to force
- A thickness gage is actually a set of gages consisting of thin strips of metal of various thicknesses from 0.0015 in. up to 0.200 in. thick. Combinations of thickness sizes or leaves may be mounted in a steel case or holder. The individual leaves are marked with the thickness size. Such a gage is widely used for measuring and checking bearing clearances; adjusting tappets, spark plug gaps, jig and fixture parts; and for

many other purposes where a specified clearance must be maintained. Accuracy in using
these gages requires a sense of feel.

- **Screw-pitch gage**

A screw-pitch gage is a gage for quickly determining the pitch, or number of threads per inch, on a threaded part or in a tapped hole. Such a gage consists of a number of le::ives mounted in a case or holder. Each leaf has a specified number of teeth, which corresponds to a definite pitch and form of thread. The number of threads per inch and the double- depth of the thread is usually marked on each leaf. To check the pitch, it is only necessary to match the teeth in the gage with the threaded part.

- **Laying out work** means accurately inscribing clean, sharp lines on the blank workpiece to show center lines, shape, or form of the finished workpiece, locations of centers for holes, circles for hole sizes, angles, arcs or curves, and slots. Dimensions for the lines to be inscribed on the metal are taken from the blueprint or sketch of the part to be made.
- Several tools are designed especially for marking lines, and many general-purpose tools are used for both layout and inspection of work. Some of the more commonly used tools for marking lines are scribers, dividers, trammels, surface gages, and height gages. Other general-purpose tools used in the layout process are surface plates, angle plates, squares, protractors, steel rules, clamps, prick punches, small hammers, V blocks, and straightedges.
- The type of workpiece to be laid out and the degree of accuracy required will largely determine which tools should be used. When dimensions and tolerances are specified in fractional parts of an inch, tools such as a steel rule, surface gage, scriber, and dividers may be used. When dimensions are specified in decimals, with tolerances of a few thousandths of an inch, precision tools such as a vernier height gage, gage blocks, and vernier protractor are required.
- **surface plate**

A surface plate is a very important and expensive piece of equipment used for laying out and inspecting workpieces. The importance of a surface plate is that it provides a true, smooth, plane surface from which accurate measurements may be made. These plates are made of either cast iron or granite. Cast iron plates are machined very smooth and handscraped to provide a true flat surface. Granite plates are lapped to a fine finish and a degree of accuracy measured in millionths of an inch.

Some granite is .almost as hard as a diamond. It cannot rust, corrode, or stain; it is resistant to temperature changes; it is nonmagnetic; and it retains 81 its original accuracy much longer than cast iron plates. When worn, it can be restored to the original accuracy.

Rough work and tools such as files should never be placed on a precision surface plate. Finished workpieces and acc'essories must be carefully cleaned to remove grit, dirt, and chips before being placed on the surface plate. When not in use, the plate is usually protected by a wood cover.

- **Angle plates**

Angle plates are precision tools made of CcJSt iron, tool steel, or granite .They are widely used as a fixture for holding work to be laid out, machined, or inspected. The faces *are* at right angles and may have threaded holes, slots, and fitted clamps for holding workpieces. Toolmaker's clamps and C clamps are also used to hold the work. Angle plates are generally used on surface plates and machine tool tables. Cast iron plates (Fig. 4-44) are surfaces ground and hand scraped to a high degree of accuracy.

Hardened tool-steel angle plates a surface -ground very accurately ,accuracy and finish.

- **Scriber**
- A scriber is a sharp, pointed steel tool used to scribe lines on metal being laid out. three styles of scribers in.common use. The scriber point is usually made from carbon tool steel, hard*ened* and tempered, then honed on an oilstone to a needle point so it will produce a fine sharp line. Scribers having tungsten carbide points are also available.

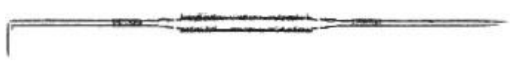


Figure 3-3. Scriber.

- Because the point of a scriber is very thin, sharp, and hard, especially tbose made of tool steel, it may break easily if too much pressure is applied. The amount of pressure used should be just enough to make a clear, clean line. When scribing a line, the scriber should be moved over the work only once. Scribing over the first line two or three times usually produces an unsatisfactory line or lines and is called *shoddy workmanship.* When scribing ; line using a steel rule, the scriber should be tilted at a slight angle away from the rule so the point will be against the bottom edge of the rule. The scriber must also be tilted in the direction it is being drawn over the workpiece.

Divider

- A divider consists of a pair of steel legs adjusted by a screw and nut and held together by a circular spring at one end, in which is inserted a handle. It is available in sizes from 2 to 8 in. The size is the length of the legs from the pivot to the point.
- Dividers are used for measuring the distance between points, for transferring a measurement directly from a rule, and for scribing circles and arcs on metal. Scribing a circle with dividers.
- The center of the circle should first be located and marked with a prick punch. Adjust the legs of the divider to the required measurement (radius of the circle), as in Fig. 4-
51. Set the point of one leg in the pricked center. Then, holding the handle between forefinger and thumb, scribe short arcs on opposite sides of the center. Measure the distance between arcs. If the distance is not equal to the required diameter, make the necessary adjustment of the divider before scribing the complete circle.
- **Trammel**

A trammel, also called a *beam compass* is a type of divider preferred for scribing large circles. It consists of a steel bar and two legs. In the end of each leg is a steel point. The legs are locked on the bar to tightening a knurled nut on the top of the leg. One of the legs has an adjusting screw attached to it. In setting the trammel to a required dimension, one leg is secured to one end of the bar; the other leg, with the adjusting screw, is moved from the first leg to approximately the correct distance. The adjusting screw is tightened to the bar, but the leg is not. By turning the adjusting screw, the loose leg is then adjusted for an accurate measurement, after which it, also, is locked on the bar. A V-shaped or a ballshaped point may be used in one leg so that circles may be scribed from a hole. The bars are available in Lengths of from 6 to 20 in.

- **Hermaphrodite caliper**

A hermaphrodite caliper has two legs, which work on a hinge joint. One leg is similar to a leg of a divider and the other is similar in shape to a leg of an inside caliper. Hermaphrodite calipers may be used to scribe arcs, or as a marking gage in layout work. To set hermaphrodite calipers to a rule, adjust the scriber leg until it is slightly shorter than the curved leg. Then, with the curved leg set on the end of a rule, adjust the scriber leg to a point opposite the required line on the rule, as illustrated in. A line parallel to the edge would be scribed.

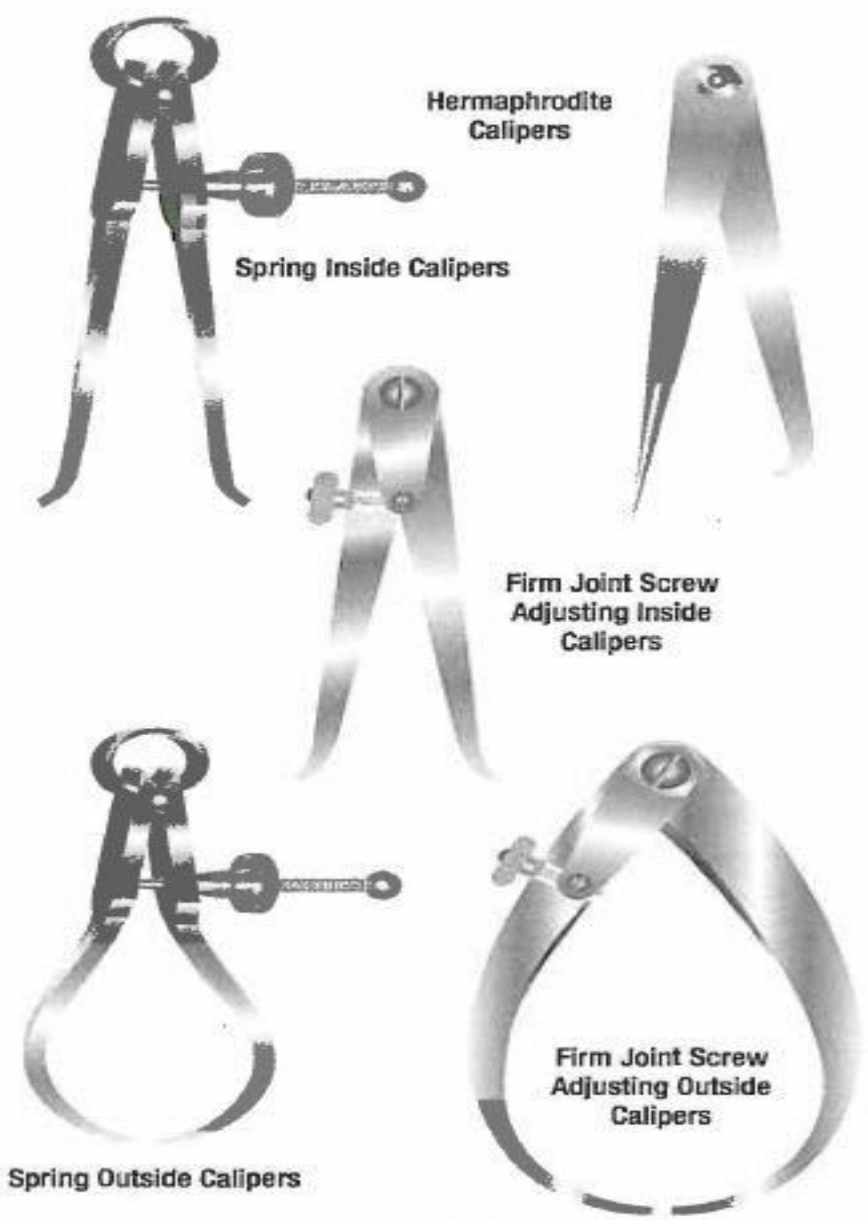


Figure 3-4. Calipers.

Surface gage

A surface gage is a tool consisting of a steel base with a rotating clamp, which holds a steel spindle. On the spindle is clamped a scriber.

The base has a V-shaped groove, which makes it convenient for use on cylindrical work A linear guide is provided by two gage pins, which may be pushed down through the base. The spindle may be rotated to any required position, even below the flat surface of the base. A rocker-adjusting screw is used so that the spindle may be adjusted to the exact dimension required.

- A surface gage is used for scribing lines on layout work and for checking parallel surfaces. Preferred ways for setting the scriber to a definite dimension · are shown. The combination square in preference to a rule alone because either may be held securely without wobbling. Set the square or rule holder on the layout table, being sure that the rule is resting on the table and is clamped securely to the head of the square or rule holder. Then set the spindle of the gage at a convenient angle, place the scriber on the spindle at the approximate height desired, and, finally, adjust the point of the scriber to the exact measurement by· means of the adjusting screw on the base of the gage.
- **Universal precision gage**

A universal precision gage is an adjustable type of gage originally used for setting cutting tools on shapers and planers. However, it has many other applications, such as use in measuring slots and openings, transferring indicator readings, and scribing layout lines and as a height gage. .

- **Squaring a workpiece**

Squaring work is the operation of making and checking work surfaces that must be perpendicular, or at right angles (90°), to each other. This niay be done by filing or machining. Squaring work is one of the major operations a machinist or toolmaker must perform on many jobs. There are a variety of squares designed to handle any job down to the tiniest part. For larger work there are squares up to 36 in. long. Checking or testing for squareness is an important part of the squaring operation. This requires knowledge of the methods to be used and certain skills in using a square. The selection of the correct type and size of square, the preparation of the workpiece, and the correct way to hold and apply the square are all important.

- The following simple rules and illustrations explain how small workpieces may be checked for squareness.

A. Clean the work and remove all burrs and rough edges with a file before using a square

B. Wipe the blade and beam of the square to remove all dirt, chips, and oil.

C. Face the source of light so it will aid in detecting errors. You can judge the squareness by the line of light visible between the blade and work.

D. If you are right-handed, hold the work in your left hand and grasp the beam of the square with the right .band. Place the inside of the beam against the work so it is seated in full contact with the side and a small space is left between the blade and top surface of the work.

E. Lower the blade by sliding the square downward until the blade touches the top surface very lightly.

F. If the angle is not square, light will be seen at one end or the other.

G. When testing inside surfaces hold the beam down firmly and move it toward the surface to be tested. Tissue paper or.cellophane may be used as a feeler at the top and bottom to tell if the blade is making contact, placed between blade and work. When the paper feeler is tight when tested at the bottom, and tight when moved to the top, the work is square within the thickness of the paper feeler. The same procedure may be used by placing the work and square on a surface plate.

Types of squares commonly used for Layout, setup, and inspection of work

The types of squares commonly used for layout, setup, and inspection of workpi_eces are combination square, try square, double square, diemaker's square, and hardened steel square.

Combination square. A combination square is a widely used tool for laying out, squaring, and checking work. It consists of a square head and a steel rule. It differs from other squares because it has a 45° miter face in addition to the 90° face. The head may be made of hardened steel or cast iron and can be moved along the rule and clamped securely at any desired measurement or strip should be rather narrow -at the end. Parts of a combination square Position. The head is made in various sizes for rule lengths from 4 to 24 in.

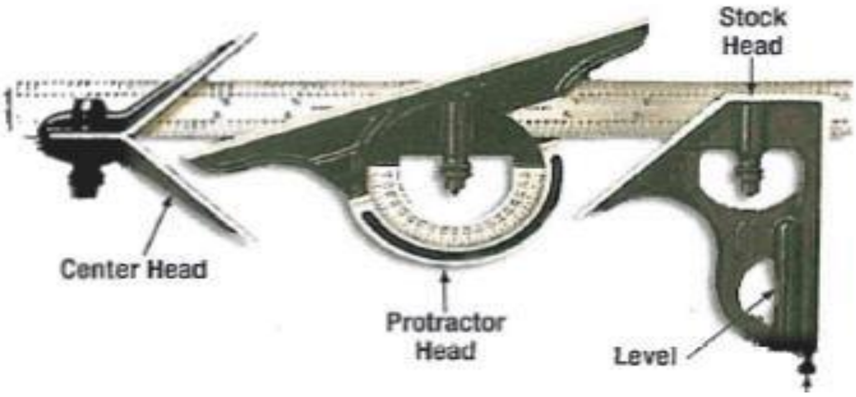
Try square

A try square is a small, light square that has hardened steel blade without graduations. The blade is firmly held onto the beam by means of a special clamp screw.· It is used for checking the squareness of many types of small work when extreme accuracy is not required.

MICROMETER CALIPERS

There are four types of micrometer calipers, each designed for a specific use: outside micrometer, inside micrometer, depth micrometer, and thread micrometer.

Micrometers are available in a variety of sizes, either 0 to ½ inch, 0 to 1 inch, 1 to 2 inch, 2 to 3 inch, 3 to 4 inch, 4 to *5* inch, or *5* to 6 inch sizes. In addition to the micrometer inscribed with the measurement markings, micrometers equipped with electronic digital liquid crystal display (LCD) readouts are also in common use. The AMT will use the outside micrometer more often than any other type. It may be used to measure the outside dimensions of shafts, thickness of sheet metal stock, the diameter of drills, and for many other applications. The smallest measurement which can be made with the use of the steel rule is one sixty-fourth of an inch in common fractions, and one one-hundredth of an inch in decimal fractions. To measure more closely



than this (in thousandths and ten-thousandths of an inch), a micrometer is used. If a dimension given in a common fraction is to be measured with the micrometer, the fraction must be converted to its decimal equivalent.

All four types of micrometers are read in the same way.

Micrometer Parts

The fixed parts of a micrometer are the frame, barrel, and anvil. The movable parts of a micrometer are the thimble and spindle. The thimble rotates the spindle which moves in the threaded portion inside the barrel. Turning the thimble provides an opening between the anvil and the end of the spindle where the work is measured. The size of the work is indicated by the graduations on the barrel and thimble.

Reading A Micrometer

The lines on the barrel marked 1, 2, 3, 4, and so forth, indicate measurements of tenths, or

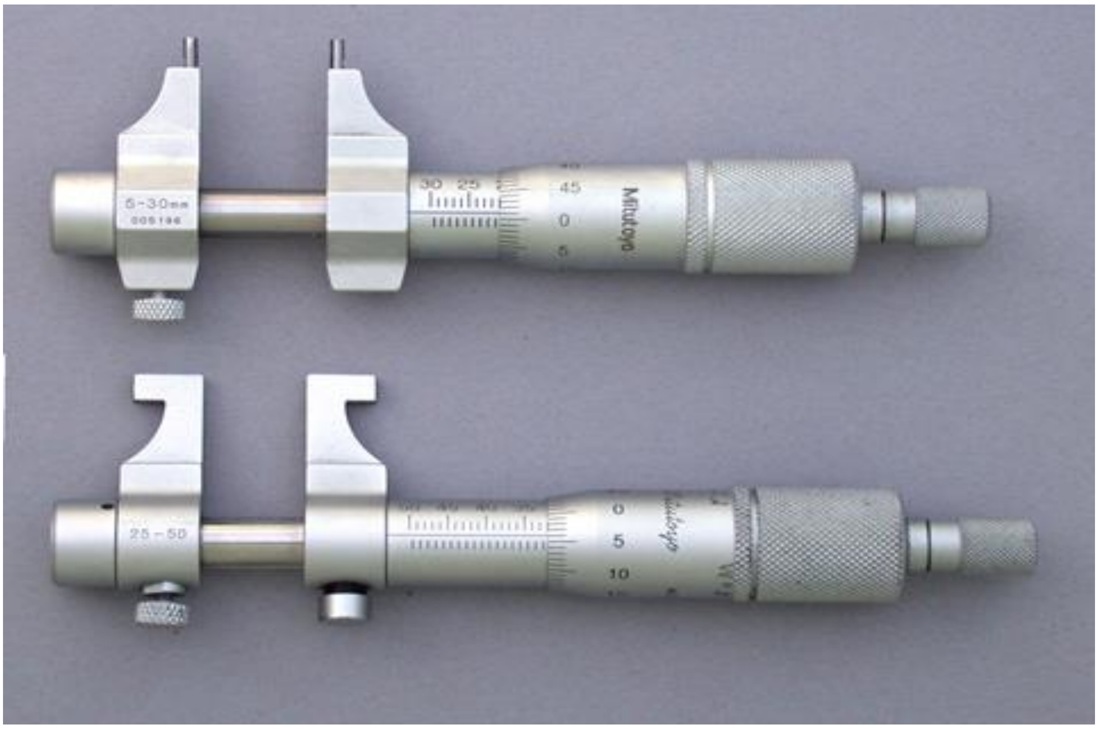
0.100 inch, 0.200 inch, 0.300 inch, 0.400 inch, respectively.

Each of the sections between the tenths divisions (between 1, 2, 3, 4, and so forth) is divided into four parts *of0.025* inch each. One complete revolution of the thimble (from zero on the thimble around to the same zero) moves it one of these divisions *(0.025* inch) along the barrel.

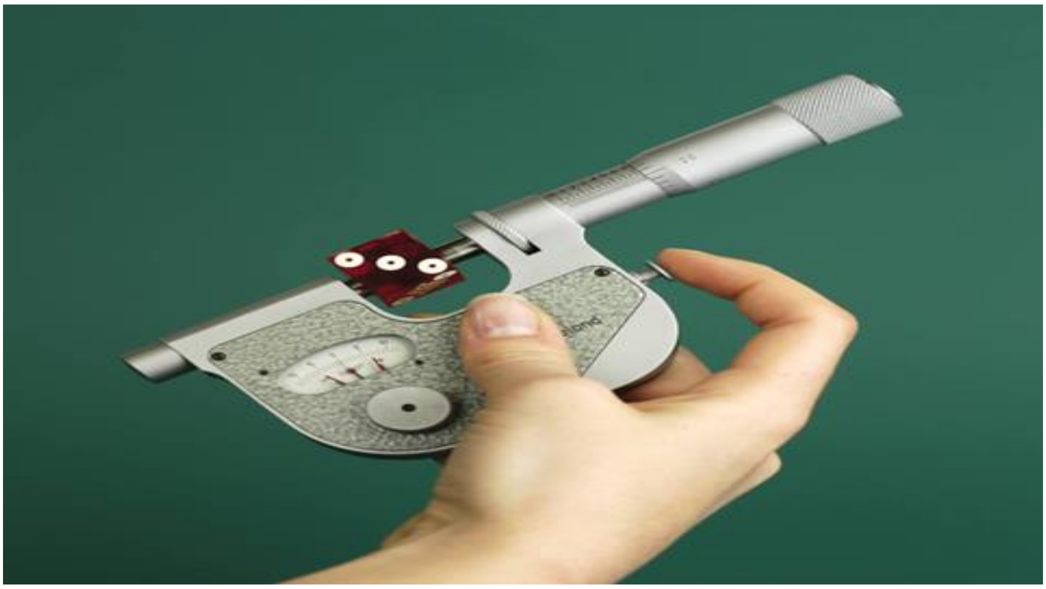
The bevel edge of the thimble is divided into *25* equal parts. Each of these parts represents one twenty-fifth of the distance the thimble travels along the barrel in moving from one of the *0.025* inch divisions to another.

Thus, each division on the thimble represents one onethousandth (0.001) of an inch. These divisions are marked for convenience at every five spaces by 0, *5,* 10, 15, and 20. When *25* of these graduations have passed the horizontal line on the barrel, the spindle (having made one revolution) has moved *0.025* inch.

The micrometer is read by first noting the last visible figure on the horizontal line of the barrel representing tenths of an inch. Add to this the length of barrel between the thimble and the previously noted number. (This is found by multiplying the number of graduations by *0.025* inch.) Add to this the number of divisions on the bevel edge of the thimble that coincides with the line of the graduation. The total of the three figures equals the measurement.



5-30mm
Mitutoyo
25-50



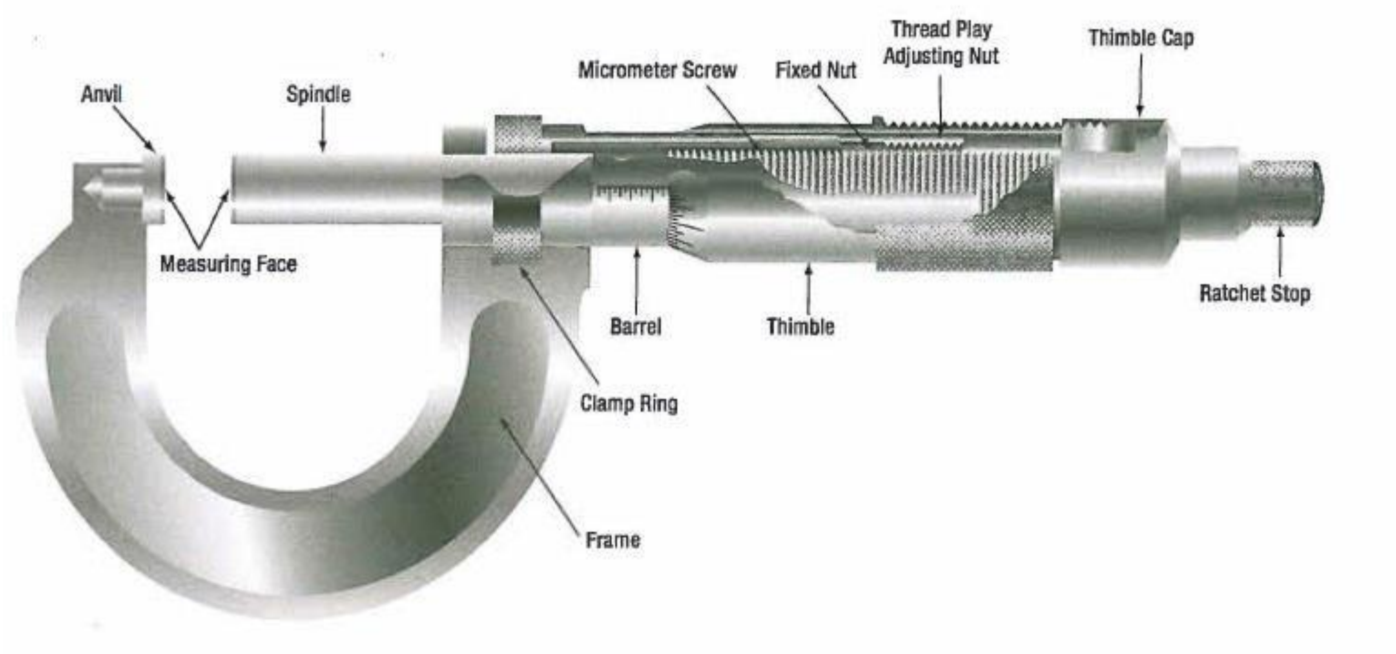
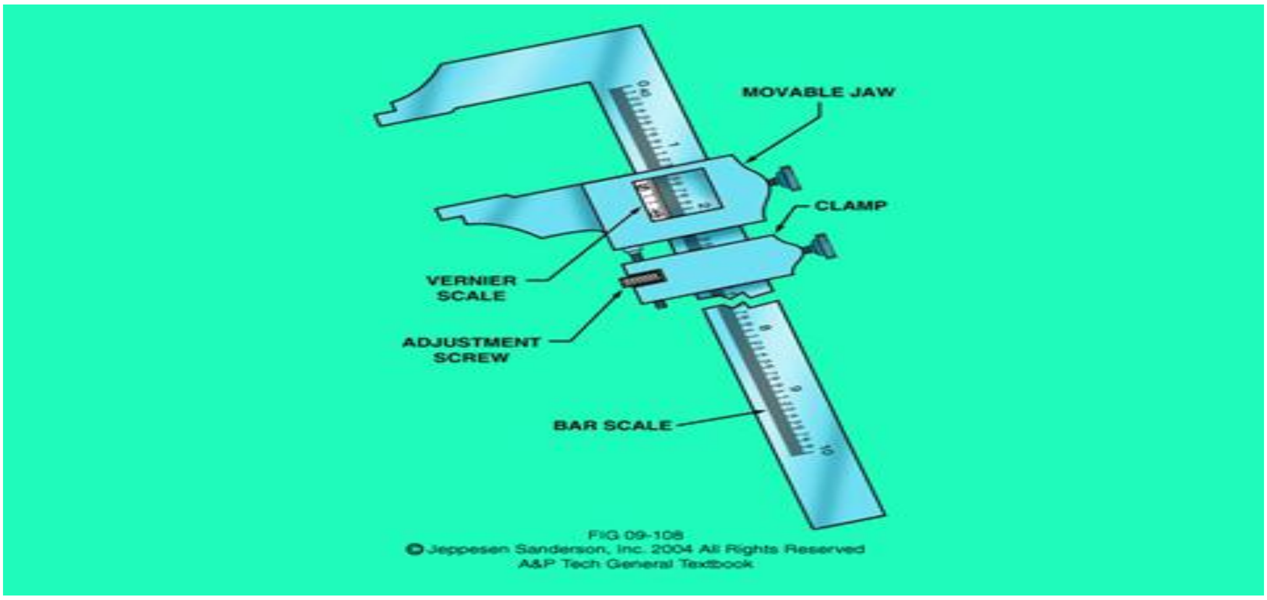


Figure 3-6. Outside micrometer parts.

Vernier Scale

Some micrometers are equipped with a vernier scale that makes it possible to directly read the fraction of a division that is indicated on the thimble scale.
Typical examples of the vernier scale as it applies to the micrometer are shown in All three scales on a micrometer are not fully visible without turning the micrometer, but the examples are drawn as though the barrel and thimble of the micrometer were laid out flat so that all three scales can be seen at the same time. The barrel scale is the lower horizontal scale, the thimble scale is vertical on the right, and the long horizontal lines (O through 9 and O) make up the vernier scale. In reading a micrometer, an excellent way to remember the relative scale values is to remember that the 0.025 inch barrel scale graduations are established by the lead screw (40 threads per inch). Next, the thimble graduations divide the 0.025 inch into 25 parts, each equal to 0.001 inch. Then, the vernier graduations divide the 0.001 inch into 10 equal parts, each equal to 0.0001 inch.
Remembering the values of the various scale graduations, the barrel scale reading is noted. The thimble scale reading is added to it; then the vernier scale reading is added to get the final reading. The vernier scale line to be read is always the one aligned exactly with any thimble graduation.



DIAL INDICATOR

A variation of the micrometer is the dial indicator, which measures variations in a surface by using an accurately machined probe mechanically linked to a circular hand whose movement indicates thousandths of an inch, or is displayed on a liquid crystal display (LCD) screen. A typical example would be using a dial indicator to measure the amount of runout, or bend, in a shaft. If a bend is suspected, the part can be rotated while resting between a pair of machined V-blocks. A dial indicator is then clamped to a machine table stand, and

the probe of the indicator is positioned so it lightly contacts the surface. The outer portion of the dial is then rotated until the needle is pointed at zero. The part is then rotated, and the amount of bend is displayed on the dial as the needle fluctuates. The total amount of the fluctuation is the runout.
Another common use for the dial indicator is to check for a warp in a rotating component such as a brake disc. In some cases, this can be done with the brake disc installed on the airplane, with the base clamped to a stationary portion of the structure. In either case, it is imperative that the dial indicator be securely fastened so that the movement of the indicator itself induces no errors in measurement.

SLIDE CALIPERS

Often used to measure the length of an object, the slide caliper provides greater accuracy than the ruler. It can, by virtue of its specially formed jaws, measure both inside and outside dimensions. As the tool's name implies, the slide caliper jaw is slid along a graduated scale, and its jaws then contact the inside or outside of the object to be measured. The measurement is then read on the scale located on the body of the caliper, or on the LCD screen. Some slide calipers also contain a depth gauge for measuring the depth of blind holes.

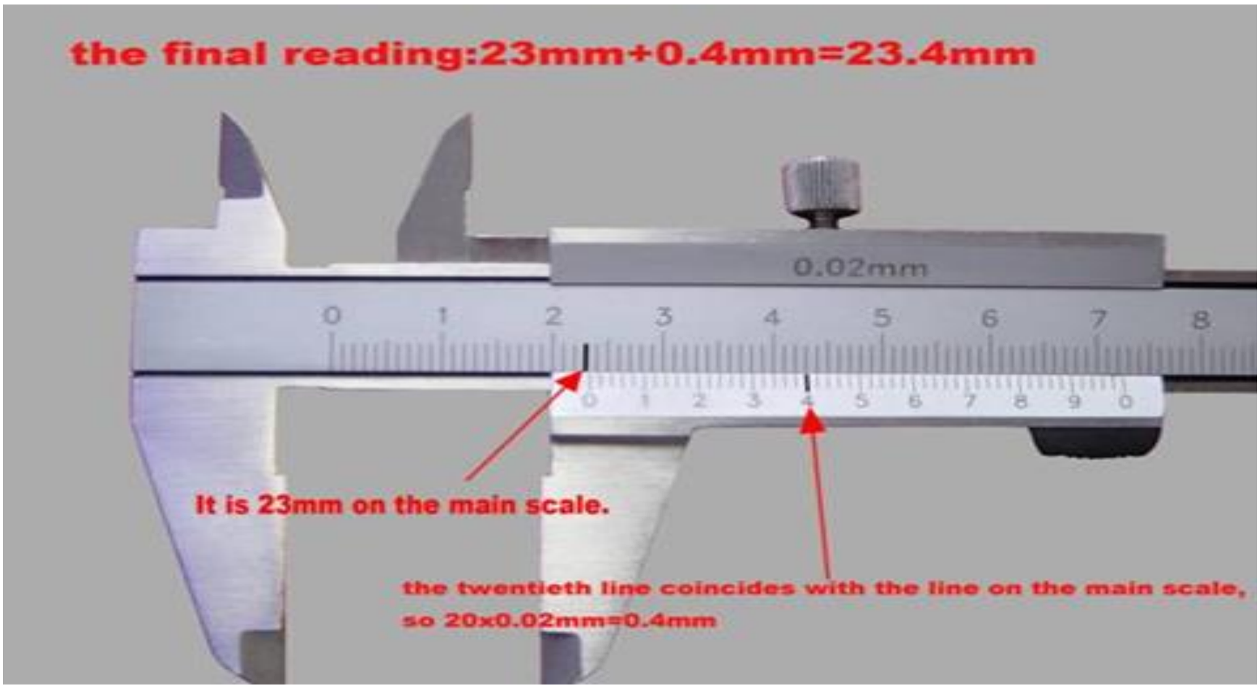


Figure 3-10. Dial indicator.

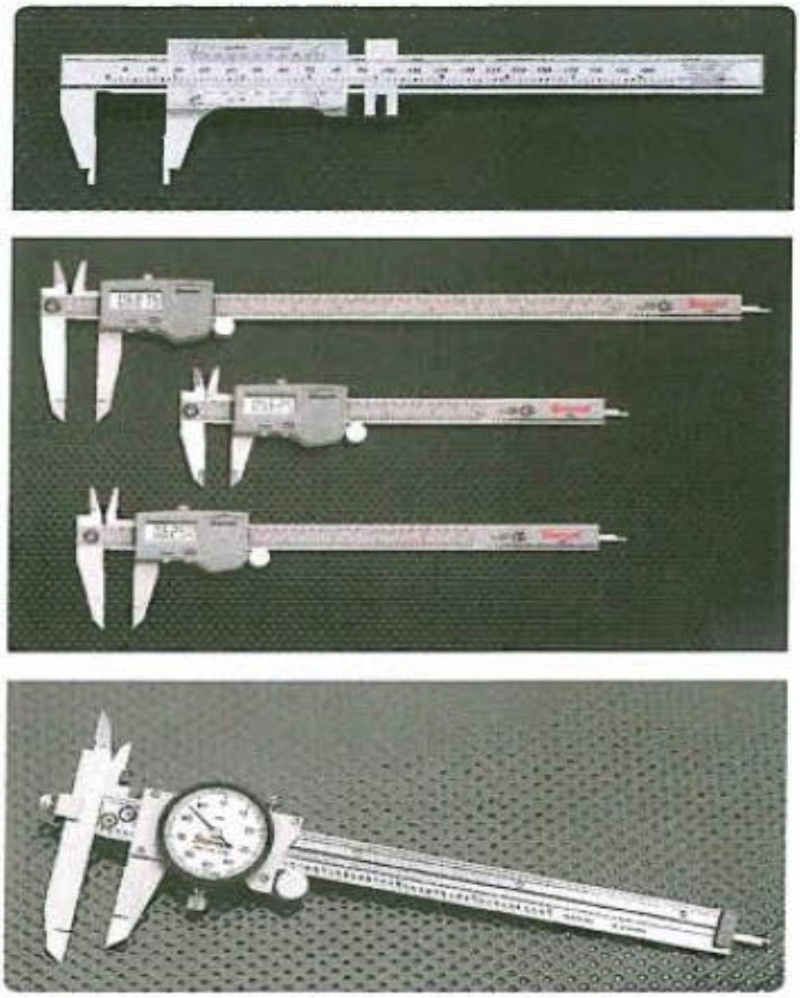


Figure 3-11. Various types of slide calipers.

CIRCULAR-CUTTING SAWS

The circular cutting saw cuts with a toothed, steel disk that rotates at high speed. Handheld or table mounted and powered by compressed air, this power saw cuts metal or wood. To prevent the saw from grabbing the metal, keep a firm grip on the saw handle at all times.

Check the blade carefully for cracks prior to installation causing serious injury.

KETT SAW

The Kett saw is an electrically operated, portable circular cutting saw that uses blades of various diameters. Since the head of this saw can be turned to any desired angle, it is useful for removing damaged sections on a stringer.

The advantages of a Kett saw include:

1. Can cut metal up to 3/16-inch in thickness.
2. No starting hole is required.
3. A cut can be started anywhere on a sheet of metal.
4. Can cut an inside or outside radius.

The pneumatic circular cutting saw, useful for cutting out damage, is similar to the Kett saw.

RECIPROCATING SAW

The versatile reciprocating saw achieves cutting action through a push and pull (reciprocating) motion of the blade. This saw can be used right side up or upside down, a feature that makes it handier than the circular saw for working in tight or awkward spots. A variety of blade types are available for reciprocating saws; blades with finer teeth are used for cutting through metal. The portable, air-powered reciprocating saw uses a standard hacksaw blade and can cut a 360° circle or a square or rectangular hole.

Unsuited for fine precision work, this saw is more difficult to control than the pneumatic circular cutting saw. A reciprocating saw should be used in such a way that at least two teeth of the saw blade are cutting at alltimes. Avoid applying too much downward pressure on the saw handle because the blade may break.

Figure 3-38. Kett saw.

Figure 3-39. Pneumatic circular saw.

Figure 3-40. Reciprocating saw.

DRILLING

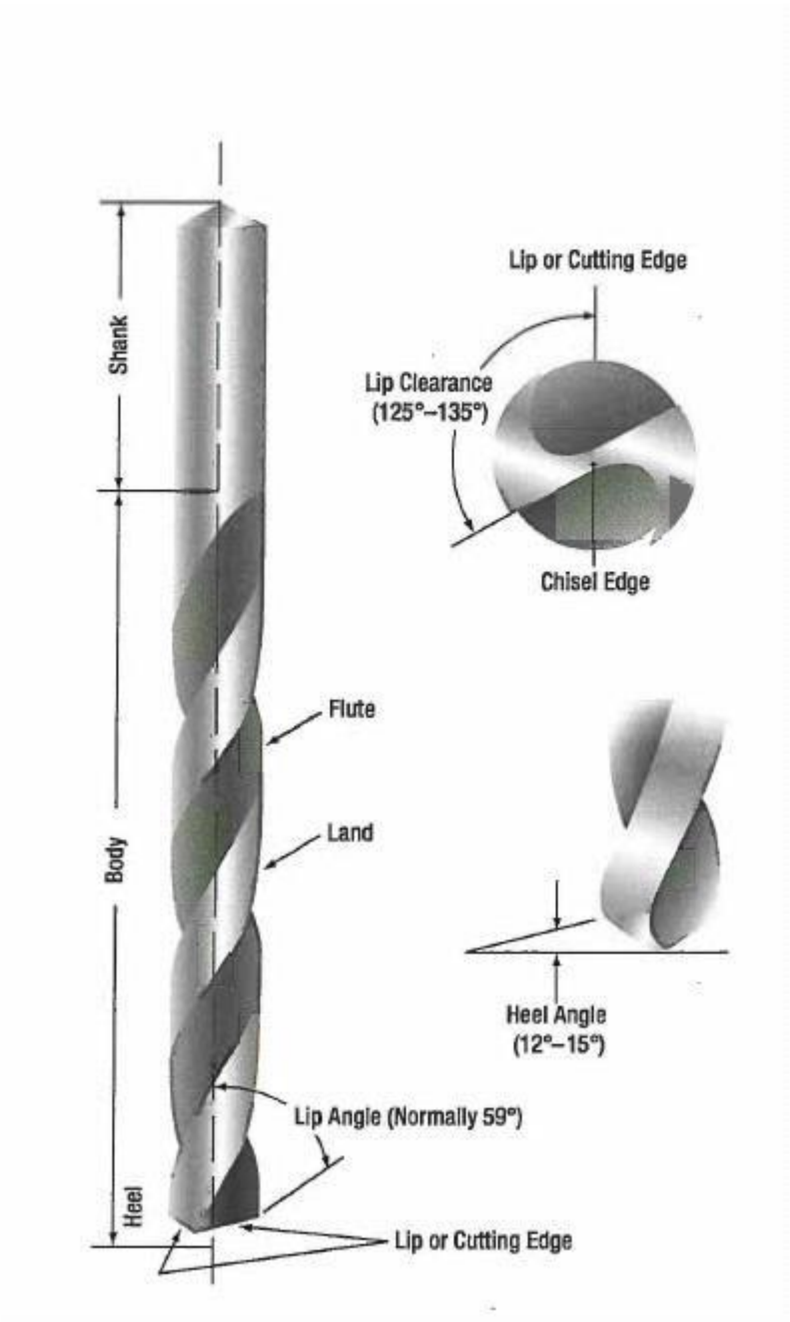
Drilling holes is a common operation in the airframe repair shop. Once the fundamentals of drills and their uses are learned, drilling holes for rivets and bolts on light metal is not difficult. While a small portable power drill is usually the most practical tool for this common operation in airframe metalwork, sometimes a drill press may prove to be the better piece of equipment for the job.

PORTABLE POWER DRILLS

Portable power drills operate by electricity or compressed air. Pneumatic drill motors are recommended for use on repairs around flammable materials where potential sparks from an electric drill motor might become a fire hazard. Because of this, most power drills used in aviation maintenance work are pneumatic.

When using the portable power drill, hold it firmly with both hands. Before drilling, be sure to place a backup block of wood under the hole to be drilled to add support to the metal structure. The drill bit should be inserted in the chuck and tested for trueness or vibration. This may be visibly checked by running the motor freely. A drill bit that wobbles or is slightly bent should not be used since such a condition causes enlarged holes. The drill should always be held at right angles to the work regardless of the position or curvatures.

Tilting the drill at any time when drilling into or withdrawing from the material may cause elongation (egg shape) of the hole. When drilling through sheet metal, small burrs are formed around the edge of the hole. Burrs must be removed to allow rivets or bolts to fit snugly and to prevent scratching. Burrs may be removed with a bearing scraper, a



countersink, or a drill bit larger than the hole. If a drill bit or countersink is used, it should be rotated by hand. Always wear safety goggles while drilling.

DRILLS

There are generally three types of portable drills used in aviation for holding and turning twist drills. Holes ¾ inch in diameter and under can be drilled using a hand drill. This drill is sometimes called an "egg beater." Electric and pneumatic power drills, often called drill motors, are available in various shapes and sizes to satisfy almost any requirement.

Pneumatic powered drills are preferred for use around flammable materials and, therefore, around aircraft. Sparks from an electric drill are a fire and explosion hazard.

TWIST DRILLS

A twist drill, or drill bit, is a pointed tool that is rotated to cut holes in material. It is made of a cylindrical hardened steel bar having spiral flutes (grooves) running the length of the body, and a conical point with cutting edges formed by the ends of the flutes. Twist drills are made of carbon steel or high-speed alloy steel. Carbon steel twist drills are satisfactory for general work and are relatively inexpensive. The more expensive high-speed twist drills are used for the tough materials such as stainless steels. Twist drills have from one to four spiral flutes. Drills with two flutes are used for most drilling; those with three or four are used principally to follow smaller drills or to enlarge holes. The principal parts of a twist drill are the shank, the body, and the heel. The drill shank is the end that fits into the chuck of a hand or power drill. The two shank shapes most commonly used in hand drills are the straight shank and the square or bit stock shank. The straight shank generally is used in hand, breast, and portable electric or pneumatic drills; the square shank is made to fit into a carpenter's brace. Tapered shanks generally are used in machine shop drill presses. The metal column forming the core of the drill is the body. The body clearance area lies just back of the margin; it is slightly smaller in diameter than the margin, to reduce the friction between the drill and the sides of the hole. The angle at which the drill point is ground is the lip clearance angle. On standard drills used to cut steel and cast iron, the angle should be 59° from the axis of the drill. For faster drilling of soft materials, sharper angles are used. The diameter of a twist drill may be given in one of three ways: (1) by fractions, (2) letters, or (3) numbers. Fractionally, they are classified by sixteenths of an inch (from 1/16 to 3½ inch), by thirty-seconds (from ½2 to 2½ inch), or by sixty-fourths (from %4 to 1¼ inch). For a more exact measurement, a letter system is used with decimal equivalents: A (0.234

inch) to Z (0.413 inch). The numbering system of classification is the most accurate: No. 80 (0.0314 inch) to No. 1 (0.228 inch). Drill sizes and their decimal equivalents are shown in The twist drill should be sharpened at the first sign of dullness. For most drilling, a twist drill with a cutting angle of 118° (59° on either side of center) will be sufficient; however, when drilling soft metals, a cutting angle of 90° may be more efficient. Typical procedures for sharpening drills are as follows:

A. Adjust the grinder tool rest to a height for resting the back of the hand while grinding.
B. Hold the drill between the thumb and index finger of the right or left hand. Grasp the body of the drill near the shank with the other hand.
C. Place the hand on the tool rest with the centerline of the drill making a 59° angle with the cutting face of the grinding wheel. Lower the shank end of the drill slightly.

D. Slowly place the cutting edge of the drill against the grinding wheel. Gradually lower the shank of the drill as you twist the drill in a clockwise direction. Maintain pressure against the grinding surface only until you reach the heel of the drill.
E. Check the results of grinding with a gauge to determine whether or not the lips are the same length and at a 59° angle.

Alternatively, there are commercially available twist drill grinders available, as well as attachments for bench grinders which will ensure consistent, even sharpening of twist drills.

DRILL LUBRICATION

Normal drilling of sheet material does not require lubrication, but lubrication should be provided for all deeper drilling. Lubricants serve to assist in chip removal, which prolongs drill life and ensures a good finish and dimensional accuracy of the hole. It also prevents overheating. The use of a lubricant is always a good practice when drilling castings, forgings or heavy gauge stock. A good lubricant should be thin enough to help in chip removal but thick enough to stick to the drill. For aluminum, titanium and corrosion-resistant steel, a alcohol based lubricant is the most satisfactory. Cetyl alcohol is a nontoxic fatty alcohol chemical produced in liquid, paste and solid forms. Solid stick and block forms quickly liquefy at drilling temperatures. For steel, sulfurized mineral cutting oil is superior.

Sulfur has an affinity for steel, which aids in holding the cutting oil in place. In the case of deep drilling, the drill should be withdrawn at intervals to relieve chip packing and to ensure the lubricant reaches the point. As a general rule, if the drill is large or the material hard, use a lubricant.

REAMERS

Reamers are used to smooth and enlarge holes to exact size. Hand reamers have square end shanks so that they can be turned with a tap wrench or similar handle.

A hole that is to be reamed to exact size must be drilled about 0.003 to 0.007 inch under size. A cut that removes more than 0.007 inch places too much load on the reamer and should not be attempted. Reamers are made of either carbon tool steel or highspeed steel. The cutting blades of a high-speed steel Straight Reamer reamer lose their original keenness sooner than those of a carbon steel reamer; however, after the first super keenness is gone, they are still serviceable. The highspeed reamer usually lasts much longer than the carbon steel type.

Reamer blades are hardened to the point of being brittle and must be handled carefully to avoid chipping them.

When reaming a hole, rotate the reamer in the cutting direction only. Do not back a reamer out of a hole by rotating it opposite the cutting direction. Turn the reamer steadily and evenly to prevent chattering, or marking and scoring of the hole walls.

Reamers are available in any standard size. The straight fluted reamer is less expensive than the spiral fluted reamer, but the spiral type has less tendency to chatter.

Both types are tapered for a short distance back of the end to aid in starting. Bottoming reamers have no taper and are used to complete the reaming of blind holes.

For general use, an expansion reamer is the most practical. This type is furnished in standard sizes from

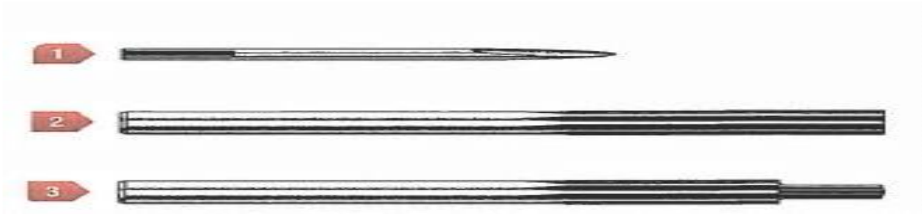
¼ inch to 1 inch, increasing in diameter by ½2-inch increments.

Taper reamers, both hand and machine operated, are used to smooth and true taper holes and recesses. Reamers, used for enlarging holes and finishing them smooth to a required size, are made in many styles. They can be straight or tapered, solid or expansive, and come with straight or helical flutes.

1. Three or four fluted production bullet reamers are customarily used where a finer finish and/or size is needed than can be achieved with a standard drill bit.
2. Standard or straight reamer.
3. Piloted reamer, with the end reduced to provide accurate alignment.

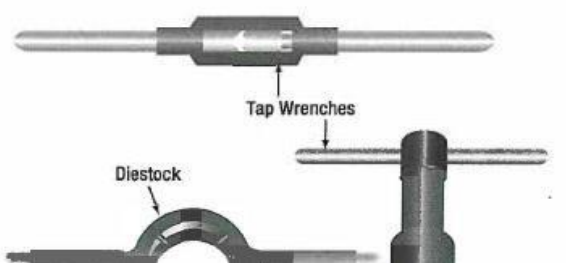
The cylindrical parts of most straight reamers are not cutting edges, but merely grooves cut for the full length of the reamer body. These grooves provide a way for chips to escape and a channel for lubricant to reach the cutting edge. Actual cutting

is done on the end of the reamer. The cutting edges are normally ground to a bevel of 45° ± 5°.
Reamer flutes are not designed to remove chips like a drill. Do not attempt to withdraw a reamer by turning it in the reverse direction because chips can be forced into the surface, scarring the hole.



TAPS AND DIES
A tap is used to cut threads on the inside of a hole, while a die is for cutting external threads on round stock.
hey are made of hard tempered steel and ground to anexact size
There are four types of threads that can be cut with standard taps and dies.
They are: National Coarse, National Fine, National Extra Fine, and National Pipe.
Hand taps are usually provided in sets of three taps for each diameter and thread series. Each set contains a taper tap, a plug tap, and a bottoming tap. The taps in a set are identical in diameter and cross section; the only difference is the amount of taper.The taper tap is used to begin the tapping process, because it is tapered back for 6 to 7 threads. This tap cuts a complete thread when it is cutting above the taper. It is the only tap needed when tapping holes that extend through thin sections. The plug tap supplements the taper tap for tapping holes in thick stock. The bottoming tap is not tapered. It is used to cut full threads to the bottom of a blind hole.
Dies may be classified as adjustable round split die and plain round split die. The adjustable split die has an adjusting screw that can be tightened so that the die is spread slightly. By adjusting the die, the diameter and fit of the thread can be controlled.
Of thread fits cannot be obtained with this type. There are many types of wrenches for turning taps, as well as turning dies. The T-handle, the adjustable tap wrench, and the die stock for round split dies are a few of the more common types. The use of suitable lubricant, also know as cutting fluid, is essential with most tapping and reaming operations. Recommended lubricants for some common materials are:
- Carbon steel: petroleum or synthetic cutting fluid.
- Alloy steel: petroleum cutting fluid mixed 10% with kerosene.
- Cast iron: no lubricant required. Use is blasts to clear chips.

• Aluminum: kerosene mixed with 20% petroleum cutting fluid.
• Brass: kerosene or mineral spirits
Bronze: kerosene mixed with 15% petroleum cutting fluid.



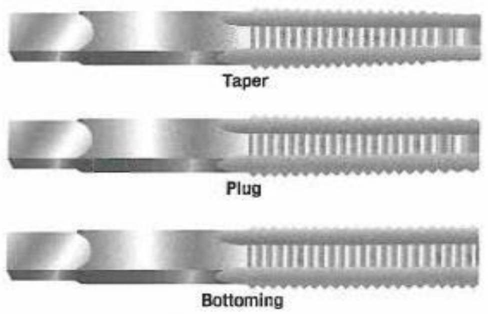


Figure 3-72. Hand taps.

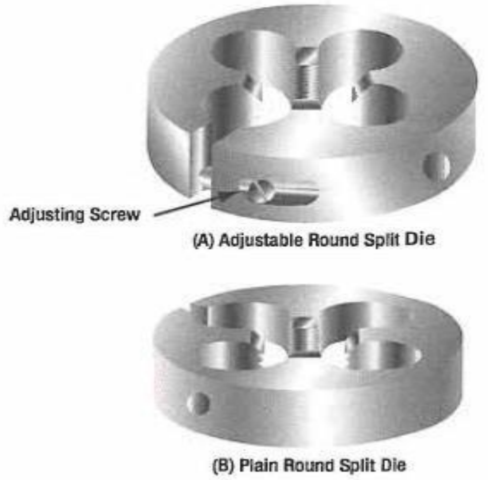


Figure 3-73. Types of dies.

LUBRICATION EQUIPMENT

There are tools for lubricating various aircraft parts.
Some oil-lubricated parts are lubricated via a dispensing spout on an oil storage container. These are often long, sometimes flexible delivery spouts designed for placing drops of oil exactly where required. If the oil is in an aerosol type can under pressure, it may be dispensed simply by pressing the spray nozzle. Often a straw is inserted in the nozzle for

pinpointing the direction of the spray. Occasionally, application of oil to an aircraft part is with a brush.
Grease is the required lubricant for many aircraft parts.
From hinges to bearings to jackscrews, tracks, and doors, there are numerous locations on the aircraft that must receive regular servicing with grease. Most of the locations are fitted with Zerk fittings. These fittings are mounted in the structure surrounding a particular bearing surface that needs grease. A tiny spring-loaded ball check valve inside the :fitting allows easy servicing with a grease gun.
By seating the grease gun tip onto the head of the Zerk :fitting, the ball is pushed back as grease is pumped past it onto the bearing surface. When the tip is removed the spring seats the ball protecting the bearing surfaces from contamination. There are many variations of the Zerk grease fitting which include both protruding and flush :fittings. The type used in a particular location is chosen by the manufacturer based on clearances and accessibility.
Note that it takes a different grease gun tip to grease through a flush mounted :fitting than a regular protruding :fitting.
Most shops have numerous grease guns set up with particular greases and both types of tips. It is critical that only the manufacturer specified grease be used in any lubrication operation.
Hand powered and pneumatic powered grease guns are used. The powered guns simply attach to shop air. When the trigger is pulled, air pressure pushed the grease out of the gun and into the :fitting and bearing. Most shops that maintain transport category aircraft use pneumatic grease guns.

ELECTRICAL GENERAL TEST EQUIPMENT OPERATION, FUNCTION AND USE

DC MEASURING EQUIPMENT

Understanding the functional design and operation of electrical measuring instruments is very important, since they are used in repairing, maintaining, and troubleshooting electrical circuits. The best and most expensive measuring instrument is of no use unless the technician knows what is being measured and what each reading indicates. The purpose of the meter is to measure quantities existing in a circuit. For this reason, when a meter is connected to a circuit, it must not change the characteristics of that circuit. Meters are either self-excited or externally excited. Those that are self-excited operate from a power source within the meter. Externally excited meters get their power source from the circuit

that they are connected to. The most common analog meters in use today are the voltmeter, ammeter, and ohmmeter. All of which operate on the principles of electromagnetism.The fundamental principle behind the operation of the meter is the interaction between magnetic fields created by a current gathered from the circuit in some manner.

This interaction is between the magnetic fields of a permanent magnet and the coils of a rotating magnet.

The greater the current through the coils of the rotating magnet, the stronger the magnetic field produced. A stronger field produces greater rotation of the coil. While some meters can be used for both DC and AC circuit measurement, only those used as DC instruments are discussed in this section. The meters used for AC, or for both AC and DC, are discussed in the study of AC theory and circuitry.

D ‘ARSONVAL METER MOVEMENT

This basic DC type of meter movement, first employed by the French scientist, d'Arsonval, in making electrical measurement, is a current measuring device, which is used in the ammeter, voltmeter, and ohmmeter. The pointer is deflected in proportion to the amount of current through the coil. Basically, both the ammeter and the voltmeter are current measuring instruments, the principal difference being the method in which they are connected in a circuit. While an ohmmeter is also basically a current measuring instrument, it differs from the ammeter and voltmeter in that it provides its own source (self-excited) of power and contains other auxiliary circuits.

CURRENT SENSITIVITY AND RESISTANCE

The current sensitivity of a meter movement is the amount of current required to drive the meter movement to a full-scale deflection. A simple example would be a meter movement that has lmA sensitivity. What this indicates is that meter movement will require lmA of current to move the needle to a full-scale indication. Likewise a half scale deflection will require only O.SmA of current. Additionally, what is called movement resistance is the actual DC resistance of the wire used to construct the meter coil.

A standard d 'Arsonval meter movement may have a current sensitivity of lmA and a resistance of 50.0. If the meter is going to be used to measure more than lmA then additional circuitry will be required to accomplish the task. This additional circuitry is a simple shunt resistor. The purpose of the shunt resistor is to bypass current that exceeds the lmA limitation of the meter movement.

DAMPING

To make meter readings quickly and accurately, it is desirable that the moving pointer overshoot its proper position only a small amount and come to rest after not more than one or two small oscillations. The term "damping" is applied to methods used to bring the pointer of an electrical meter to rest after it has been set in motion. Damping may be accomplished by electrical means, by mechanical means, or by a combination of both.

Electrical Damping

A common method of damping by electrical means is to wind the moving coil on an aluminum frame. As the coil moves in the field of the permanent magnet, eddy currents are set up in the aluminum frame. The magnetic field produced by the eddy currents opposes the motion of the coil. The pointer will therefore swing more slowly to its proper position and come to rest quickly with very little oscillation.

M echanical Damping

Air damping is a common method of damping by mechanical means.A vane is attached to the shaft of the moving element and enclosed in an air chamber. The movement of the shaft is retarded because of the resistance that the air offers to the vane.

Effective damping is achieved if the vane nearly touches the walls of the chamber.

A BASIC MULTIRANGE AMMETER

Building upon the basic meter previously discussed is the more complex and useful multirange meter, which is more practical. The basic idea of a multirange ammeter is to make the meter usable over a wide range of voltages.

In order to accomplish this, each range must utilize a different shunt resistance. The example given in this text is that of a two-range meter. However, once the basics of a two range multirange ammeter are understood, the concepts can easily be transferred to the design of meters with many selectable ranges.

.PRECAUTIONS

The precautions to observe when using an ammeter are summarized as follows:

1. Always connect an ammeter in series with the element through which the current flow is to be measured.
2. Never connect an ammeter across a source of voltage, such as a battery or generator. Remember that the resistance of an ammeter, particularly on the higher ranges, is extremely low and that any voltage, even a volt or so, can cause very high current to flow through the meter, causing damage to it.
3. Use a range large enough to keep the deflection less than full scale. Before measuring a current, form some idea of its magnitude. Then switch to a large enough scale or start with the highest range and work down until the appropriate scale is reached. The most accurate readings are obtained at approximately half-scale deflection.
4. Observe proper polarity in connecting the meter in the circuit. Current must flow through the coil in a definite direction in order to move the indicator needle up scale. Current reversal because of incorrect connection in the circuit results in a reversed meter deflection and frequently causes bending of the meter needle. Avoid improper meter connections by observing the polarity markings on the meter.

THE VOLTMETER

The voltmeter uses the same type of meter movement as the ammeter but employs a different circuit external to the meter movement.

VOLTMETER SENSITIVITY

Voltmeter sensitivity is defined in terms of resistance per volt (O/V). The meter used in the previous example has a sensitivity of20 k O and a full scale deflection of 1 volt.

MULTIPLE RANGE VOLTMETERS

The simplified voltmeter has only one range (1 volt), which means that it can measure voltages from O volts to 1 volt. In order for the meter to be more useful, additional multiplier resistors must be used. One resistor must be used for each desired range.

VOLTMETER CIRCUIT CONNECTIONS

When voltmeters are used, they are connected in parallel with a circuit. If unsure about the voltage to be measured, take the first reading at the high value on the meter and then progressively move down through the range until a suitable reading is obtained. Observe that the polarity is correct before connecting the meter to the circuit or damage will occur by driving the movement backwards.

THE OHMMETER

The meter movement used for the ammeter and the voltmeter can also be used for the ohmmeter. The function of the ohmmeter is to measure resistance.

INFLUENCE OF THE VOLTMETER IN THE CIRCUIT

When a voltmeter is connected across two points in a circuit, current will be shunted. If the voltmeter has low resistance, it will draw off a significant amount of current. This will lower the effective resistance of the circuit and change the voltage readings. When taking a

voltage measurement, use a high resistance voltmeter to prevent shunting of the circuit. a deflection of the pointer proportional to the value of the external resistance being measured.

ZERO ADJUSTMENT

When the ohmmeter leads are open the meter is at a full scale deflection, indicating an infinite (=) resistance or an open circuit. When the leads are shorted as shown in figure "zero adjustment," the pointer will be at the full right hand position, indicating a short circuit or zero resistance. The purpose of the variable resistor in this figure is to adjust the current so that the pointer is at exactly zero when the leads are shorted. This is used to compensate for changes in the internal battery voltage due to aging.

MEGGER (MEGOHMMETER)

The megger, or megohmmeter, is a high range ohmmeter containing a hand-operated generator. It is used to measure insulation resistance and other high resistance values. It is also used for ground, continuity, and short circuit testing of electrical power systems. The chief advantage of the megger over an ohmmeter is its capacity to measure resistance with a high potential, or "breakdown" voltage. This type of testing ensures that insulation or a dielectric material will not short or leak under potential electrical stress.

The megger consists of two primary elements, both of which are provided with individual magnetic fields from a common permanent magnet: (1) a hand-driven DC generator, G, which supplies the necessary current for making the measurement, and

(2) the instrument portion, which indicates the value of the resistance being measured. The instrument portion is of the opposed coil type. Coils A and B are mounted on the movable member with a fixed angular relationship to each other and are free to turn as a unit in a magnetic field. Coil B tends to move the pointer counterclockwise and coil A, clockwise. The coils are mounted on a light, movable frame that is pivoted in jewel bearings and free to move about axis 0.

AC MEASURING INSTRUMENTS

A DC meter, such as an ammeter, connected in an AC circuit will indicate zero, because the meter movements used in a d 'Arsonval type movement is restricted to direct current. Since the field of a permanent magnet in the d'Arsonval type meter remains constant and in the same direction at all times, the moving coil follows the polarity of the current. The coil attempts to move in one direction during half of the AC cycle and in the reverse direction during the other half when the current reverses

The current reverses direction too rapidly for the coil to follow, causing the coil to assume an average position.
Since the current is equal and opposite during each half of the AC cycle, the direct current meter indicates zero, which is the average value. Thus, a meter with a permanent magnet cannot be used to measure alternating voltage and current.
For AC measurements of current and voltage, additional circuitry is required.
The additional circuitry has a rectifier, which converts AC to DC. There are two basic types of rectifiers: One is the half-wave rectifier and the other is the full-wave rectifier. Both of these are depicted in block diagram form.

ELECTRODYNAMOMETER
METER MOVEMENT

The electrodynamometer can be used to measure alternating or direct voltage and current. It operates on the same principles as the permanent magnet moving coil meter, except that the permanent magnet is replaced by an air core electromagnet. The field of the electrodynamometer is developed by the same current that flows through the moving coil. Because this movement contains no iron, the electrodynamometer can be used as a movement for both AC and DC instruments. Alternating current can be measured by connecting the stationary and moving coils in series. Whenever the current in the moving coil reverses, the magnetic field produced by the stationary coil reverses. Regardless of the direction of the current, the needle will move in a clockwise direction.
However, for either voltmeter or ammeter applications, the electrodynamometer are too expensive to economically compete with the d 'Arsonval type movement.

3.58MOVING IRON VANE METER

The moving iron vane meter is another basic type of meter. It can be used to measure either AC or DC.
Unlike the d'Arsonval meter, which employs permanent magnets, it depends on induced magnetism for its operation. It utilizes the principle of repulsion between two concentric iron vanes, one fixed and one movable, placed inside a solenoid. A pointer is attached to the movable vane.

When current flows through the coil, the two iron vanes become magnetized with north poles at their upper ends and south poles at their lower ends for one direction of current through the coil.

VA METERS

Multiplying the volts by the amperes in an AC circuit gives the apparent power: the combination of the true power (which does the work) and the reactive power (which does no work and is returned to the line). Reactive power is measured in units of vars
(Volt-amperes reactive) or kilovars (kilovolt-amperes reactive, abbreviated kVAR). When properly connected, wattmeters measure the reactive power. As such, they are called varmeters.

WATTMETER

Electric power is measured by means of a wattmeter.
Because electric power is the product of current and voltage, a wattmeter must have two elements, one for current and the other for voltage. For this reason, wattmeters are usually of the electrodynamometer type.
The movable coil with a series resistance forms the voltage element, and the stationary coils constitute the current element. The strength of the field around the potential coil depends on the amount of current that flows through it. The current, in turn, depends on the load voltage applied across the coil and the high resistance in series with it. The strength of the field around the current coils depends on the amount of current flowing through the load. Thus, the meter deflection is proportional to the product of the voltage across the potential coil and the current through the current coils.
The effect is almost the same (if the scale is properly calibrated) as if the voltage applied across the load and the current through the load were multiplied together.

FREQUENCY MEASUREMENT/OSCILLOSCOPE

The oscilloscope is by far one of the more useful electronic measurements available. The viewing capabilities of the oscilloscope make it possible to see and quantify various waveform characteristics such as phase relationships, amplitudes, and durations. While oscilloscopes come in a variety of configurations and presentations, the basic operation is typically the same. Most oscilloscopes in general bench or shop applications use a cathode- ray tube (CRT), which is the device or screen that displays the waveforms.
The CRT is a vacuum instrument that contains an electron gun, which emits a very narrow and focused beam of electrons. A phosphorescent coat applied tothe back

of the screen forms the screen. The beam is electronically aimed and accelerated so that the electron beam strikes the screen. When the electron beam strikes the screen, light is emitted at the point of impact.

The heated cathode emits electrons. The magnitude of voltage on the control grid determines the actual flow of electrons and thus controls the intensity of the electron beam. The acceleration anodes increase the speed of the electrons, and the focusing anode narrows the beam down to a fine point.

The surface of the screen is also an anode and will assist in the acceleration of the electron beam.

The purpose of the vertical and horizontal deflection plates is to bend the electron beam and position it to a specific point of the screen.

-----------------------------------*THE END***-----------------------------------**

Signature of the Instructor **Signature of Training Manager**