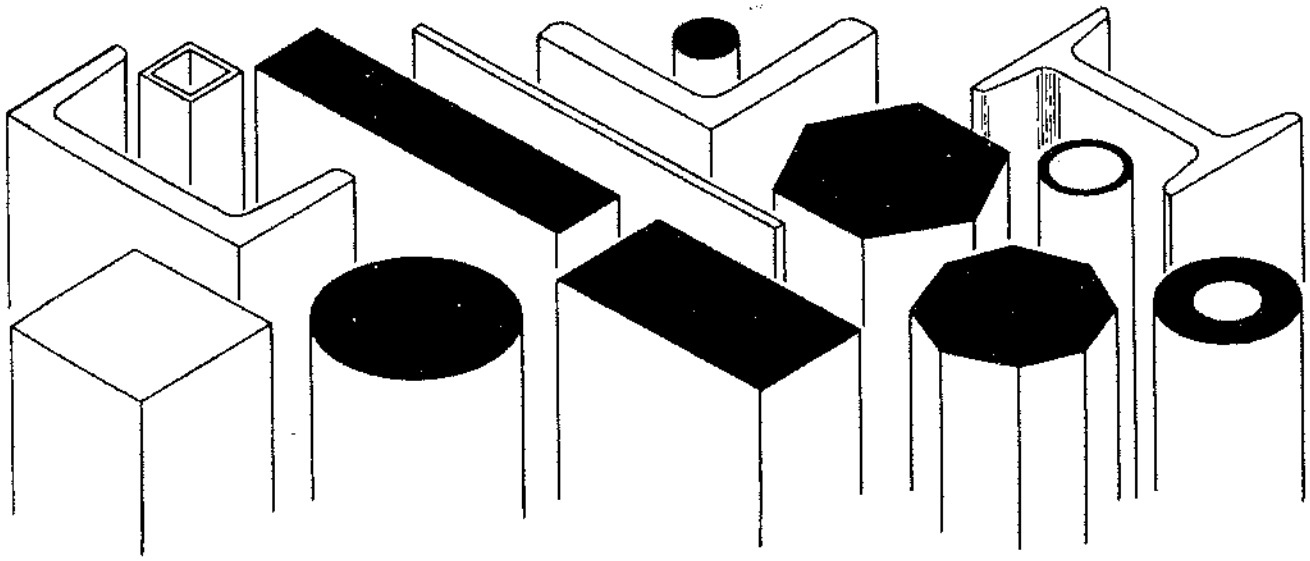
IDENTIFYING, CUTTING, DRILLING, SHAPING, AND FILING METAL

Metals play a prominent part in our everyday lives. Almost everything we eat, see, feel, hear, smell, and touch has used metal in its manufacture. Many times metals are thought of and described as being strong, hard, tough, and capable of withstanding tremendous heat before melting. These characteristics are true for many metals, but some do not have these features. For example, mercury is fluid at room temperature.

Metals are available in a large range of shapes and sizes, and are developed for specific uses. Skyscraper buildings are a reality because of structural steel. The transportation industry depends on metal for vehicles, rails, and reinforcement for concrete highways. The high technology of electronics and computers relies extensively on copper wire, silver connectors, and other metal components. Most agricultural machines and equipment are made of steel and other metals.



In making products in industry, or projects in the school laboratory, it is important to know which metal, or metals, is best suited for a particular job. Characteristics such as: holding an edge, resisting corrosion, conducting electricity, weight, hardness, and workability must be considered when working with metal.

1. Identifying Metals

Because many metals look so much alike, several methods of identification have been developed. They include identification by chemical composition, mechanical properties, their ability to meet a standard specification, and their ability to be fabricated into an identified part or shape.

Metals are classified as ferrous or nonferrous. Ferrous metals contain iron; nonferrous metals do not contain iron. A distinction must be made because there are specific uses for each. Most metals are not used in their pure metallic state. They are usually combined with one or more other metals. An alloy is a mixture of two or more metals. Alloys are made to improve the strength or some other quality of the original metals. Carbon is added to iron to make steel.

a. Ferrous Metals

Ferrous metals are mostly iron. Iron is refined from iron ore which is mined throughout the world. It is in abundant supply and relatively inexpensive; therefore, used extensively. Ferrous metals rust easily and must be protected by coatings that resist corrosion. Ferrous metals are easy to identify because they are magnetic and give off sparks when ground on an emery wheel. Iron is the most useful metal for making tools and machinery. Its usefulness is increased with the addition of carbon to make steel. It also can become very corrosion resistant when combined with other metals.

(1) Cast Iron

Cast iron is a widely used, hard, brittle metal that has excellent wear resistance. It is grainy and not easily shaped or bent. It contains three to four percent carbon and is not malleable (workable). Parts with odd shapes can be made by pouring molten iron into a mold called a casting. When the metal cools and the form is removed, the item is said to be made of cast iron. Pure cast iron will break before it will bend.

Cast iron can be heat-treated to be somewhat workable. The result is iron with a ductile outer layer. Ductile means that the metal can be bent slightly without breaking. The combination of the cast iron core and ductile metal outer layer is called malleable cast iron.

(2) Wrought Iron

Wrought iron is almost pure iron (most of carbon removed). It is very malleable and can be bent, shaped, welded, drilled, sawed, and filed. It resists rust and is popular for use in making ornamental iron works, nails, wire, pipe, rivets, horseshoes, and furnace smoke stacks.

(3) Steel

Steel is an alloy of iron and carbon or other alloying elements. When carbon is the alloying element, the steel is called carbon steel. Carbon steels are classified by the percentage of carbon that they contain. Low carbon steels contain less than .30 percent carbon. They are easy to work, can be welded, but cannot be hardened. Low carbon steel is available as band iron, black iron sheet, bars, and rods. Medium carbon steels contain .30 to .60 percent carbon. Hammer heads are made from medium carbon steels. High carbon steels contain .60 to 1.50 percent carbon. Many products that must be heat treated are manufactured from high carbon steels.

When elements other than carbon, such as chromium, manganese, molybdenum, nickel, tungsten, and vanadium are used to make steel harder, tougher, and stronger, the resulting metals are called alloy steels.

Chromium is added when toughness, hardness, and wear resistance are desired. Chromium steel is used extensively for automobile and aircraft parts.

Manganese purifies steel and adds strength and toughness. Manganese steel is used for parts that must stand shock and hard wear.

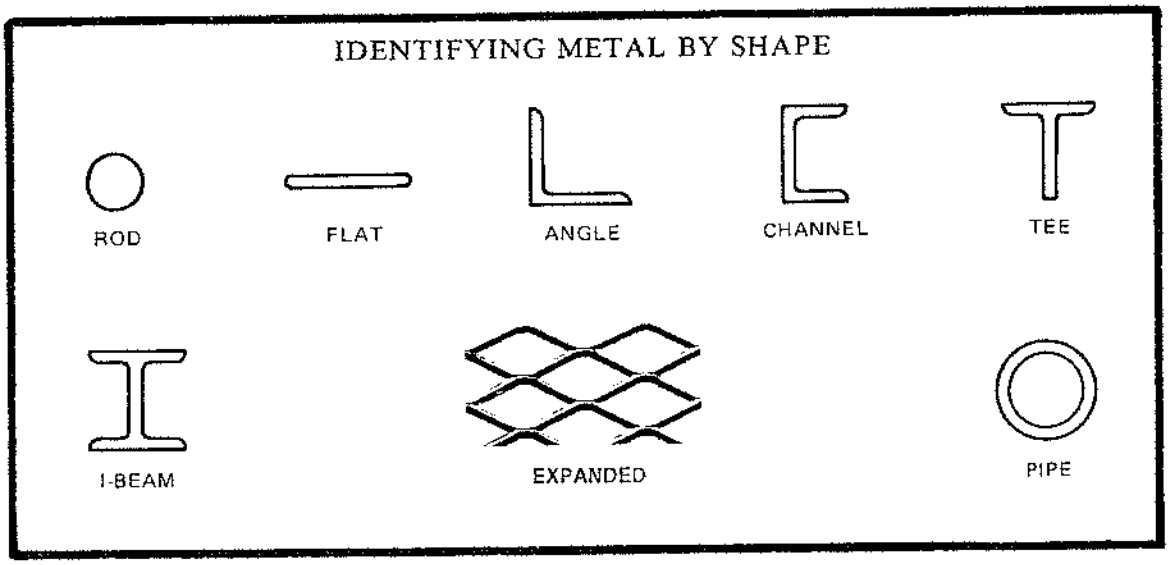
Molybdenum is the alloying element added when the steel must remain tough at high temperatures.

Nickel imparts toughness and strength to steel and allows the metal to resist rust and withstand shock. Most armor plate is nickel steel.

Tungsten makes steel self-hardening. Tools made from tungsten steel need no special hardening treatment and will withstand heat. It is used extensively for making cutting tools.

Vanadium as an alloying element makes steel that has a fine grain texture and is tough, strong, and not brittle.

Mild steel is the workhorse of metals. It is made by adding small amounts of carbon with iron. Mild steel is tough, strong, ductile, and malleable. It is rolled into many shapes such as flat bands, angles, channels, tees, I-beams, rods, and pipe. Common shapes used in most agricultural mechanics laboratories are illustrated here.



Tool steel contains a specific amount of carbon which permits it to be hardened. Tool steel can also be annealed. Anneal means to heat a metal to the proper temperature and then slowly cool it. The process of annealing softens and toughens steel. Tool steel can be hardened by heating to the proper temperature and then rapidly cooling the steel. The degree of hardness is determined by controlling the temperature of the metal and the speed of cooling after heating. Only tool steel can be tempered. Tempering is carefully controlled reheating and cooling of steel after it has been shaped. Tempering results in a specified degree of hardness, relieves stress, and prevents cracking in steel. Tool steel can generally be identified by the exploding sparkling nature of the sparks given off when the metal is ground.

Stainless steel is made by adding nickel and chromium to steel. It is very tough, won't rust, and resists corrosion of all types. Stainless steel is used for milk tanks, kitchen equipment, and factory equipment where food is being processed.

Plated steel is steel that has been coated with a metal such as tin or zinc to make it rustproof. Most steel for roofs and siding is coated with zinc. Zinc-coated steel is referred to as galvanized steel. The rust resistance of galvanized steel depends upon the thickness of the zinc coating. Galvanized steel sheets, pipe, buckets, and tanks must be handled with care in the shop. When heated or welded, the zinc gives off a poisonous gas. Therefore, such operations must be performed with great care in a well-ventilated area.

b. Nonferrous Metals

There are many metals that do not have iron as their basic ingredient. These metals, known as nonferrous metals, offer specific properties, or a combination of properties, that make them ideal for tasks where ferrous metals are not suitable. Some nonferrous metals are light in weight. They are more expensive than ferrous metals on a per weight basis and their supply is rather limited. Nonferrous metals are often used with iron based metals in the finished product. Nonferrous metals include the following:

(1) Aluminum

Aluminum is identified by its toughness, light weight, and silver-white color. Pure aluminum is very soft and malleable. Other materials such as silicon, manganese, and magnesium are added to give aluminum more strength and other qualities. Special techniques are used to weld aluminum. Aluminum is used for building siding and roofing, motor castings, wire, and electrical conductors.

(2) Copper

Copper is not as light in weight as aluminum and is second to silver as a conductor of electricity. It is primarily used in electric motors, electrical wiring, and plumbing systems. Copper makes up the bulk of the metal in the alloys brass and bronze. Brass is made of 60 to 90 percent copper with the balance being zinc. It is used primarily for hardware. Bronze is copper and zinc with approximately 10 percent tin added. It is used for bearings in machinery.

(3) Magnesium

Magnesium is the lightest of the structural metals. Desirable characteristics include: high strength to weight and excellent machinability. For added strength, it is often alloyed with aluminum, zinc, manganese, and combinations of these metals. Extreme care must be taken when machining magnesium because the chips are highly flammable and cannot be extinguished with conventional fire fighting techniques. It is used in building incendiary bombs, ladders, and chain saws.

(4) Lead, Tin, and Zinc

These metals are primarily used for coating applications. Lead is used in paints, storage batteries, and as electrical wire covering. Tin and zinc are soft metals used to plate other metals for rust proofing. Zinc alloys are used to make small engine blocks, carburetors, portable tools, and small parts for automobiles. Tin is used to make bronze, solder, babbitt, and pewter.

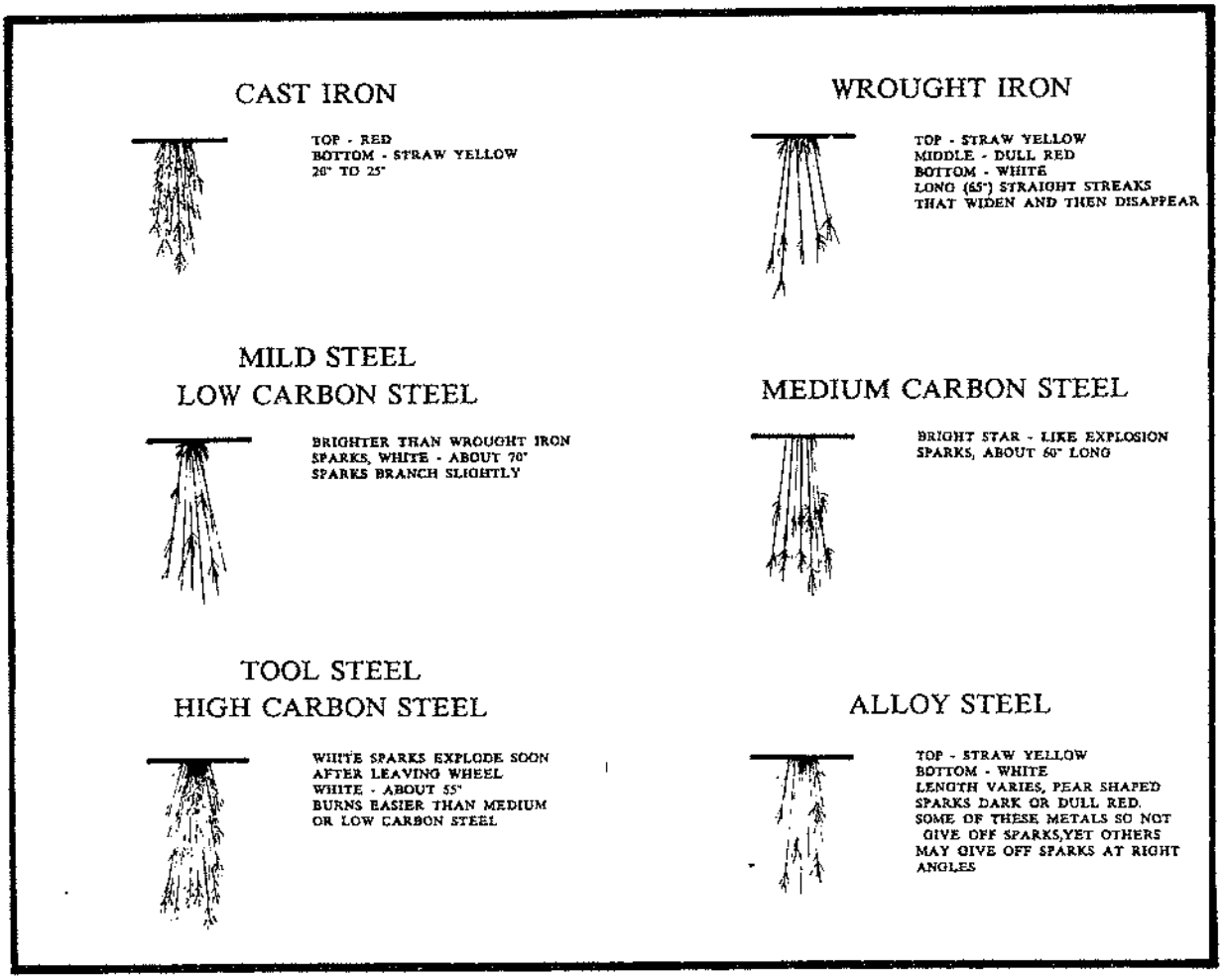
A summary of the characteristics and major uses of selected metals and alloys is given in the following chart:

METAL	ORIGIN	CHARACTERISTICS	MAJOR USES
Cast iron	Iron ore	Forms into any shape; brittle	Machinery parts; engine blocks
Wrought iron	Iron ore	Malleable; tough; rust-resistant	Decorative fences; railings
Mild steel	Iron ore	Malleable; ductile; tough	Structural steel
Tool steel	Iron ore	High carbon; heat treatable; expensive	Tools; tool bits
Stainless steel	Iron ore, nickle, and chromium	Very corrosion resistant; bright appearance; hard; tough	Food handling equipment; milktanks; restaurant equipment

CHART CONTINUED

Galvanized steel	Steel; zinc	Zinc coated steel	Water tanks; towers; fencing; roofing; siding
Aluminum	Ore	Light; tough; relatively soft; good electrical conductor; silver-white color	Roofing; siding; truck bodies; automobiles; electric wires and cables
Copper	Ore	Tough; malleable; corrosion resistant; excellent heat and electrical conductor; reddish brown color	Pipe; electrical wire and cables; rain spouts and gutters; electrical equipment; bronze; brass
Brass	Copper and zinc	Soft; malleable; corrosion resistant	Water valves; boat accessories; ornaments
Bronze	Copper, zinc, and tin	Soft; malleable; corrosion resistant	Ornaments
Lead	Ore	Soft, very heavy; bluish gray	Batteries; cable coverings; shot; solder
Tin	Ore	Very malleable; corrosion resistant; silver color	Plating; bronze; solder

Metals can also be identified by using the spark test. This test involves the holding of the metal lightly against an emery stone and observing the characteristics of the spark stream. As the carbon unites with oxygen in the air, it begins to burn; therefore, the more carbon the metal contains, the greater the amount of sparks will be observed. Observations should include: colors of the spark stream, shape of the spark after it leaves the wheel, number and quantity of sparks, length of the spark stream, and position of the spark at the emery stone. The following illustration depicts the use of the spark test to identify selected metals.

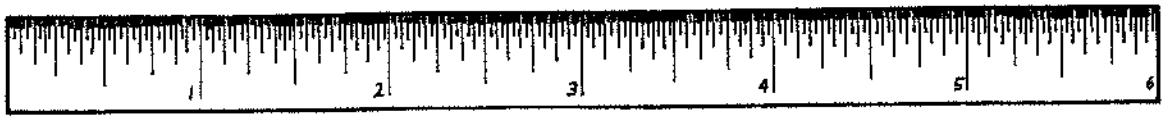


2. Cutting Cold Metal

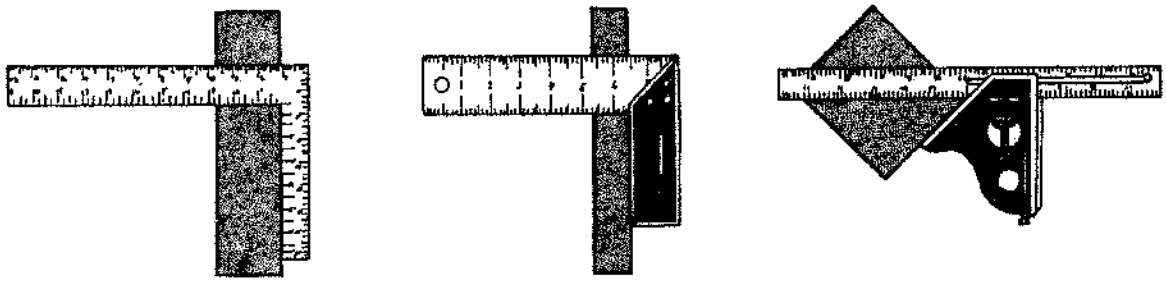
Cold metal is usually cut with a hacksaw (power and manual), cold chisel, bolt cutter, or tin snips. A bolt cutter is used to cut small round stock (less than 3/8 inch). Large stock is sawed, and bar stock is either sawed or cut with a cold chisel. Sheet metal is usually cut with tin snips.

a. Layout tools are used to measure and mark metal stock before cutting, shaping, and doing other types of work with cold metal. The most common measuring devices and their uses are:

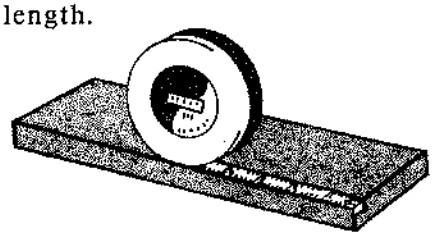
(1) The metal worker's rule is made to measure metal. It is six inches long and is graduated in 1/64, 1/32, 1/8, 1/4, 1/2, and one inch increments.



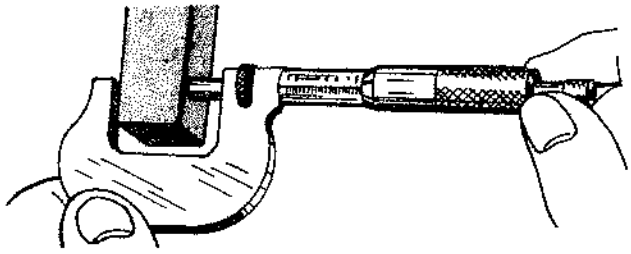
(2) The framing square, try square, and combination square are important measuring devices for metal work.



(3) The push-pull rule and steel tape are used when it is necessary to make long measurements. The most common push-pull rule is 20 feet and the steel tape is from 25 to 100 feet in length.

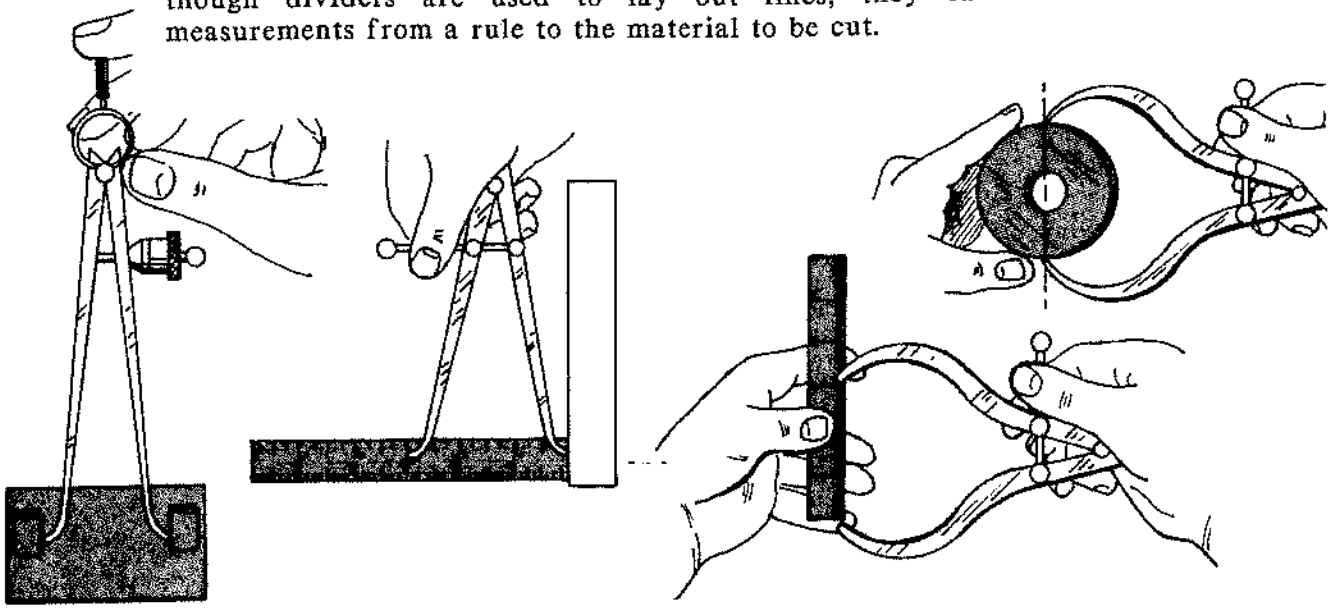


(4) Micrometers should be used when a high degree of accuracy is needed in measuring metal. Measurements can be made to the thousandth of an inch when using this tool.



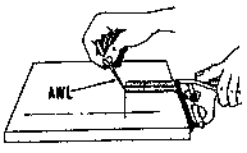
(5) Calipers, both outside and inside types, are used to make fine measurements when working with metal. The caliper is usually used with a rule, micrometer, vernier, or slide caliper. The measurement is first made of the object, and this

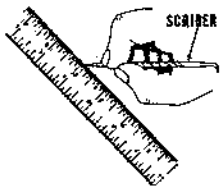
measurement is transferred to a graduated measuring tool for a reading in inches or fraction of an inch. The caliper does not have dimension numbers. Even though dividers are used to lay out lines, they can be used to transfer measurements from a rule to the material to be cut.



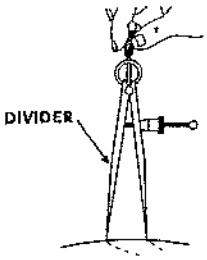
(6) Special marking devices are needed in metal work. The combination square can be used as a marking gauge in the same way it is used to lay out wood stock. It has a marker (a small steel scratch awl with fine point) located in the head of the square. Scratch awls are usually used with straight edges. The fine needle point can be placed against the end or edge of the measuring tool for accuracy. The double scribers are also very important marking tools. They are made of high carbon steel so that they can be used to mark all metals. The scriber is used the same way as the awl.

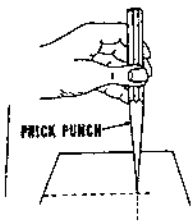
(7) Dividers are essential tools in metal work. They are used mainly for marking circles. However, they can also be used to divide circles and mark equal lengths. They are sharpened in such a way that either of the two metal points can be used to sit on the metal or scratch the metal.



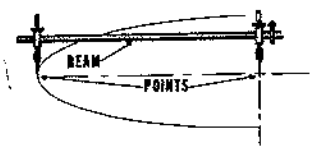


(8) Prick and center punches are used as marking tools on metal. The center punch is used to mark the center of a hole and to make an indentation in the metal for a drill bit. A prick punch is sharp pointed (15-degree angle to its center); therefore, it is used for layout work by locating hole centers, marking reference points, and marking lines.

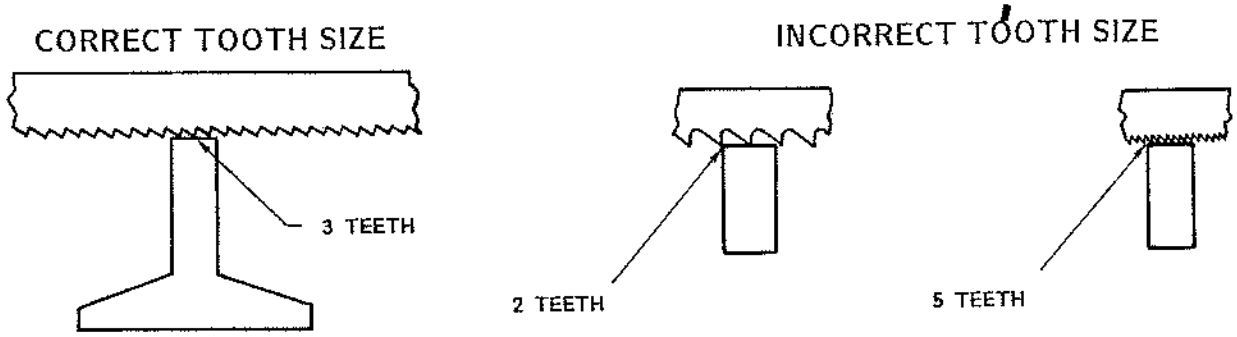




(9) Trammels or beam compasses are used to mark large circles or make arcs that have large radii. They can be used similarly to dividers except on a smaller scale. A trammel is made up of two points on a single beam. For metal work, the beam is usually made of metal.



b. Cutting the stock with a hacksaw is one of the most common ways of cutting cold metal. The length of blades may vary from 8 to 12 inches, and they are 1/2 inch wide and .025 inch thick. Blades are available in 14, 18, 24, and 32 teeth per inch.



(1) Suggestions for using the blade are:

When cutting mild steel or cast iron over 1/8 inch thick, use a coarse blade (18 teeth per inch).

Hard steel, pipe, and heavy sheet metal can be cut with a medium blade (24 teeth per inch).

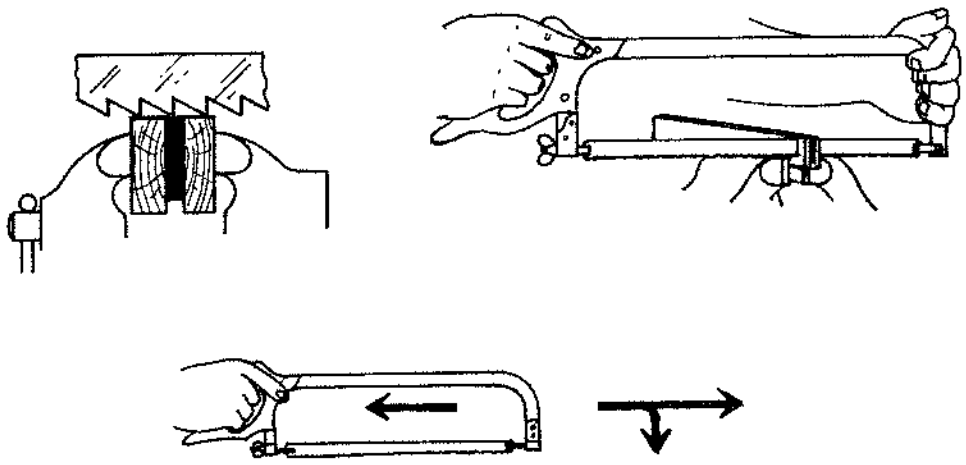
Thin sheet metal and tubing should be cut with a fine blade (32 teeth per inch).

High speed blades are usually not necessary for ordinary work. A high carbon or tungsten-alloy blade is tough enough to resist breaking and does most jobs of a hacksaw. The high carbon blade is less expensive than an alloy or high-speed blade.

Blades are inserted in the frame by pointing the teeth away from the handle. Tighten the blade in the frame and then retighten after it has been used for a short time.

(2) The steps to follow in making the cut with a hacksaw include:

Mark the metal to be sawed and place it in a vise. The mark should be placed near the jaws, especially if the metal is thin. It may be necessary to use boards between the vise jaws to prevent scarring the work. Mark over the original mark with a file.



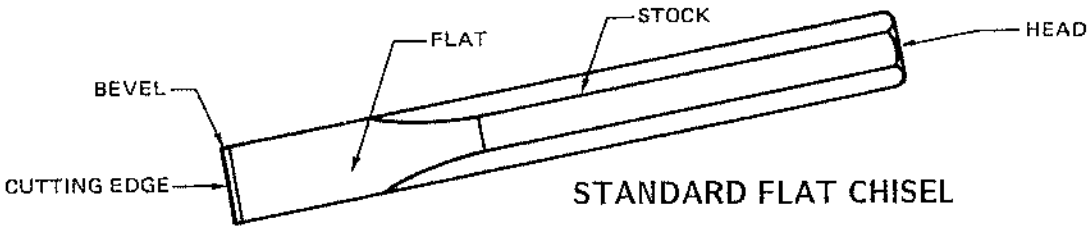
Hold the saw with both hands and start the cut by pulling it toward the body (backward stroke). The kerf may be started without filing a notch on the metal. As the saw is pulled backward a very small amount of pressure should be applied.

The right amount of pressure should be applied as the saw is pushed forward. No pressure should be used on the back stroke after the saw begins cutting.

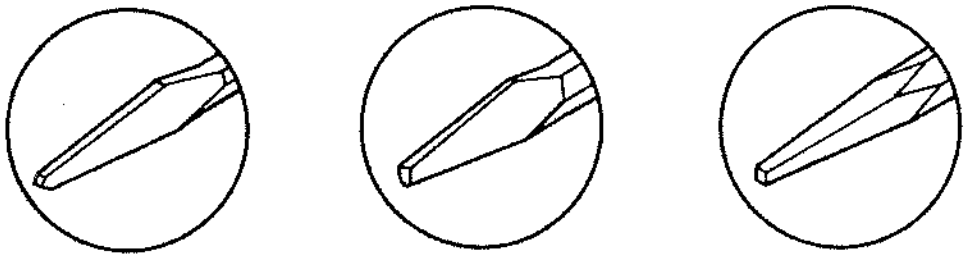
Steady strokes from 40 to 50 per minute are considered the correct speed for sawing.

Never start a new blade in an old cut. The teeth are set; therefore, the cut is narrower than the new blade. One stroke may ruin the teeth.

c. Cold chisels are used mainly to cut light metals and fasteners. There are four common types of cold chisels used for cutting metal: standard flat, diamond point, cape, and round nose. The most commonly used is the standard flat chisel. It is used to cut sheet metal, bolts, nuts, rivets, and rods. The diamond point chisel is used for cutting triangle grooves or for making square corners in grooves. The cape chisel is used to cut out rectangular grooves or channels. The round nose chisel is used to cut out rectangular grooves or channels. The round nose chisel is used similarly to the diamond point in that oil grooves or channels can be made by its use. It cuts an oval groove. Another special kind of chisel used to cut thick sheet metal (oil drums) is the chipping chisel.



STANDARD FLAT CHISEL


CAPE CHISEL

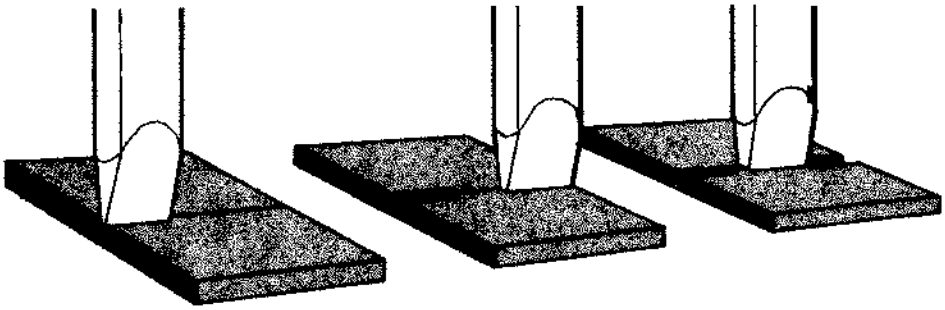
ROUND NOSE CHISEL

DIAMOND POINT CHISEL

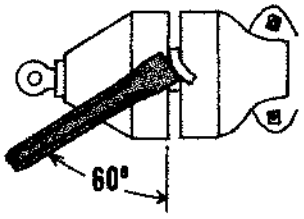
(1) Steps in cutting flat metal are:

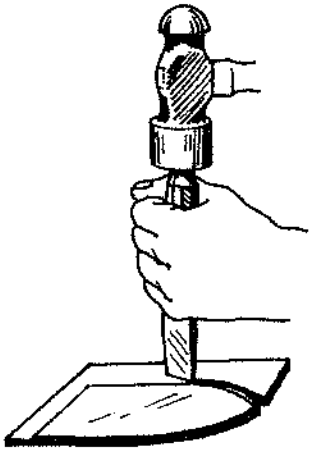
Mark the metal with an awl, soapstone, scriber, or chalk. A straight edge should be used to make a straight line.

Place the flat chisel at one side of the metal to start the shearing point; at the same time place the cutting edge at an angle to the work. Drive the chisel with either a machinist's or ball peen hammer. Hold the chisel loosely about the middle when striking the blows. After some practice the chisel head can be hit with heavy blows without hitting the hand.



Place metal less than 1/8 inch thick in a vise and cut with a flat chisel by holding the chisel at about a 60-degree angle to the work. The cut should be just above the jaws of the vise. The point of a standard flat chisel is sharpened at about a 70-degree angle. Soft metals and sheet metal can be cut more rapidly if the chisel is sharpened to a 45-degree angle.





Cut thick metal by placing it on the cutting ledge of an anvil. Thick metal is cut in the same way as thin metal, except that it is turned over and the same cut is made on the reverse side. After the cut is completed on both sides without cutting through the metal, it may be bent back and forth until it breaks.

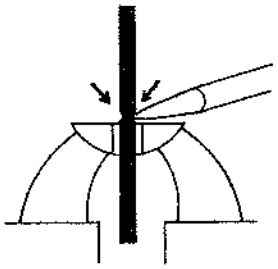
(2) Steps in cutting round stock are:

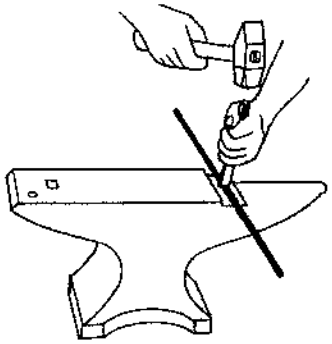
After the stock is marked, it should either be clamped in a vise or held on the cutting ledge or shoulder of the anvil for making the cut.

The rod or round iron should be cut from both sides, each cut being 1/3 the distance through the rod.

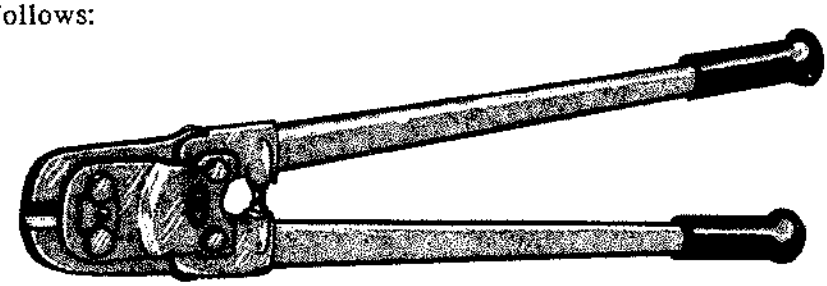
Break the rod at the point of the cut by bending it back and forth across the vise jaws or over the edge of the anvil.

After some practice the chisel head can be hit with heavy blows without hitting the hand. Grasp the chisel above the bevel and hold loosely in order that the hand will not be endangered if the hammer slips off the chisel head.



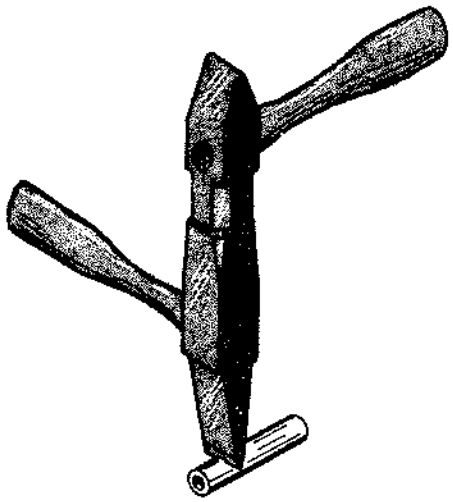


One of the fastest methods of cutting round stock from about 3/16 to 3/4 inch thick is to use a bolt cutter. The jaws are made of alloy-steel which will cut hard or soft bolts, rods, chains, and heavy gauge wire. This metal cutting tool should be used properly; that is, the bolt or rod cutting capacity should be observed. Usually capacity information is stamped on the handle. The procedure for using a bolt cutter is as follows:



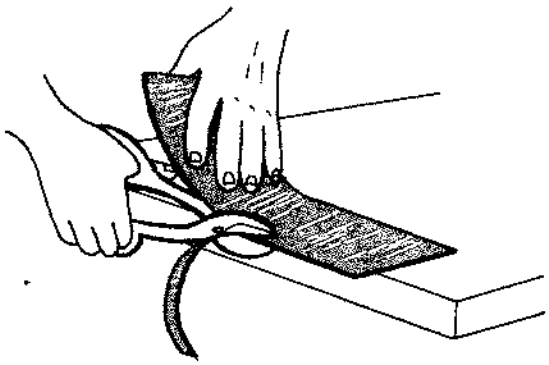
Spread or pull the handles apart wide enough so that a rod or bolt can be placed as far back in the jaws as possible; then pull the handles together without twisting the cutter. When using a large heavy duty cutter place one handle against the floor or ground and use both hands to apply pressure on the other handle. Note: Special hardened steel should not be cut in the bolt cutter.

Cold cutters are used sparingly in cold metal work. They function the same as cold chisels except for the fact that the cold cutter resembles an anvil hardy on one end and a hammer on the other end. This type cutter is equipped with a handle which is used to keep the cutter on the metal while it is being hit with a large machinist's hammer. It takes two people to use a cold cutter, whereas one can cut metal with a cold chisel. The procedure for using a cold cutter is as follows:



Mark the metal and place it on the anvil shoulder for cutting. Strike the cold cutter head with the hammer until the metal is cut about 1/3 through the stock. Turn the cut underneath and make another cut in line with the first cut. The cutting job is easier when a second person holds the cold cutter handle. After cuts are made, bend the metal back and forth over the edge of the anvil until it breaks.

d. Tinner's snips or aviation snips may not be recognized as metal cutting tools. Snips are used mainly to cut sheet metal. The most common snips are: straight (for straight cutting) and curved (for cutting inside curves or arcs). The cutting procedure when using snips is as follows:

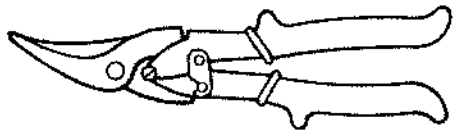


After the stock is laid out, insert the sheet metal to the back of the blades. The cutting edge of the upper blade should be over the line of cut before squeezing the handles.

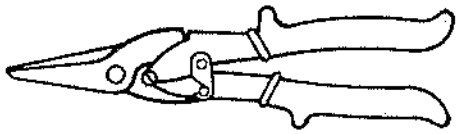
Stop and take a new cutting stroke before squeezing the handles together. If the blades are forced completely together, burrs and nicks will appear on the finished cut.

When cutting large pieces of metal, allow the piece on the right to bend down and at the same time pull up on the left piece to provide free space for operating the snips. A left-handed person should use a left-hand snip; therefore, the piece of metal pulled up during the cutting process would be on the right.

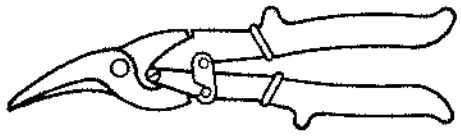
Curves and circles should be cut with hawk's bill scroll snips. Stove pipes, cans, and vent pipes should be cut by using double cutting snips. This type of snips has three blades.



FOR LEFT-HAND CURVES



FOR STRAIGHT CUTS



FOR RIGHT-HAND CURVES

e. Special information for cutting tool steel and thin metal is as follows:

(1) It is advisable to test tool steel to determine whether or not it is in the softened stage before attempting to cut it. The saw blade or chisel may be dulled if the steel is too hard. Usually tool steel is nicked with a high carbon hacksaw blade. Tool steel can be broken by sawing about one-fourth the way through the rod or bar and then breaking it in a vise with the hammer. Heavy hammer blows should be directed toward the backside of the vise.

(2) Very thin metal may be cut with a hacksaw by placing it between two boards in a vise. The cut should be made through the boards and metal. The boards and metal can be clamped to a table top instead of being placed in a vise. Sheet metal is cut with metal snips and metal cutting shears. Snips are used very often in cutting this metal. Sheet metal of 20 gauge or less can be cut with the scissor-like tool if it is soft.

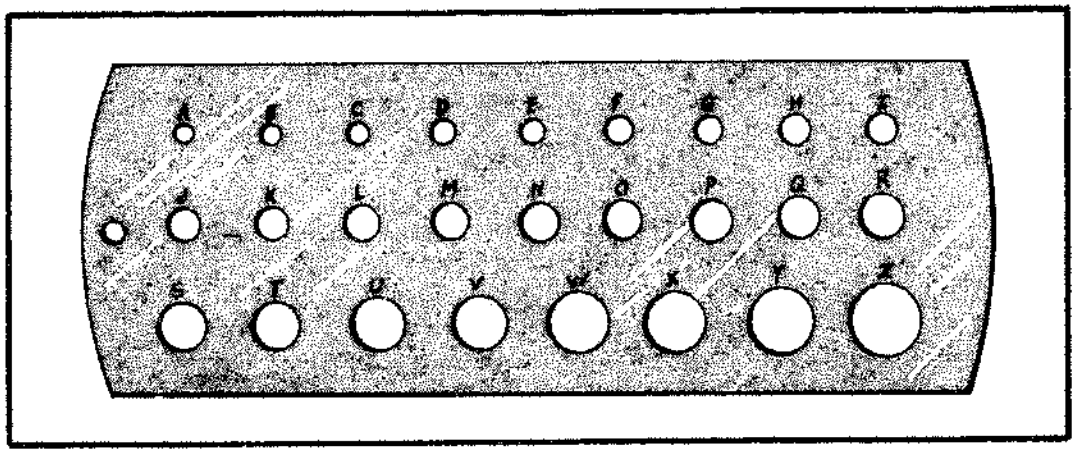
3. Drilling Cold Metal

One of the most important tools in any metal shop is the drill. It is true that one of the most widely used methods of putting together metal is welding it; but bolts, screws, and rivets also play a very important part in agricultural construction and repair. Drilling holes in cold metal, therefore, is necessary in the machinery industry and in the farming operation. Most shops are equipped with both hand and power drilling equipment.

a. Determining the Size of a Twist Drill

(1) Fractional - This drill measurement is most commonly used in agricultural mechanics. Diameters of drill bits are determined by fractions of an inch. For example, they range in size from 1/64" to one inch in diameter.

(2) Alphabetical - The sizes of drills are also determined by letters A through Z. The letters represent fractional measurements (.234" to .413").



(3) Numerical - Alphabetical and numerical drills are often used by machinists. Drills #80 to #1 range in sizes from .0135" to .228". The #1 drill (.228") is a few thousandths smaller than 1/4 inch, and the #80 drill is just larger than a human hair.

There are several types of drill gauges, but the types to check fractional, alphabetical, and numerical sizes are made of a flat or sheet type metal or plastic materials. Bits used by machinists are usually sized by numbers 80 to 1 and letters A to Z.

b. Determining the Cutting Speed of a Twist Drill

The speed of a drill is calculated by determining how many feet the outer surface of a drill will travel per minute. If the standard cutting speed for a high carbon steel bit is 30 feet per minute while drilling mild steel, then the outside surface of the bit would travel 30 feet in the steel per minute. Thus, if the bit were laid on its side and rolled on the floor, it would cover a space of 30 feet.

Example: The circumference of a circle = the diameter multiplied by 3.1416 (pi). Drills are measured in terms of inches; therefore, to change inches to feet, the size of drill multiplied by 3.1416 divided by 12 equals the number of feet the drill will travel in one minute. A 1/2 inch drill traveling at 229 revolutions per minute equals approximately 30 feet per minute.

.5 x 3.1416 x 229 divided by 12 = 29.976 feet per minute

Recommended drill speeds for mild steel are as follows:

	Revolutions per Minute	
Diameter of Drill (Inches)	Carbon Steel (30 ft. per min.)	High-Speed Steel (60 ft. per min.)
1/16	1833	3667
1/8	917	1833
3/16	611	1222
1/4	458	917
5/16	367	733
3/8	06	611
7/16	262	524
1/2	229	458
5/8	183	367
3/4	153	306
7/8	131	262
1	115	229

High-speed twist drills are used to cut harder metal than can be cut by carbon steel twist drills. High-speed drills are identified by a marking (HS or high-speed) on the shank. The carbon steel may not be identified by a marking on the bit.

c. Selecting Cutting Lubricants for Different Metals

Cutting lubricants usually serve two main functions when drilling metals. A good cutting oil may serve as a coolant to take the heat from the drill and as a liquid to float metal chips away while the cut is being made. If ordinary machine oil is used, it will interfere with the cutting by excessive lubrication; therefore, special cutting oils should be used, especially if a lot of drilling is done at one time. Excessive heat will draw the temper from the drill and soften it.

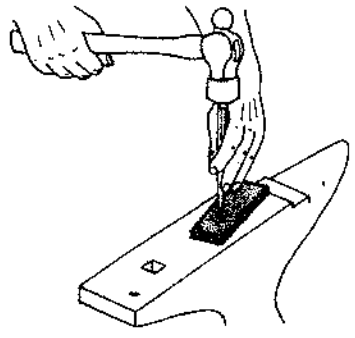
Lubricants recommended for cutting different kinds of metals are listed below:

Metals	Lubricants
Wrought iron, malleable iron, tool steel, and carbon steels	Emulsifiable oils, sulfurized oils, or mineral-lard oils
Gray cast iron	Emulsifiable oils or dry
Brass or bronze	Mineral-lard oils, mineral oils or emulsified oils
Copper	Mineral-lard oils or dry
Aluminum alloys	Mineral-lard oils, mineral oils or kerosene
Magnesium alloys	Mineral oils or dry

Lard oils are sometimes mixed with lubricating oils to form a cutting oil. Soluble and sulfurized type oils are prepared as cutting oils for drilling holes and cutting metals.

d. Procedure for Drilling Cold Metal

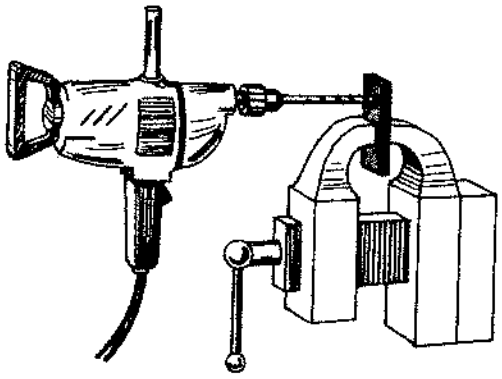
(1) Use a scribe or scratch awl and mark a cross (+) on the metal at the center of the hole where the metal is to be drilled.

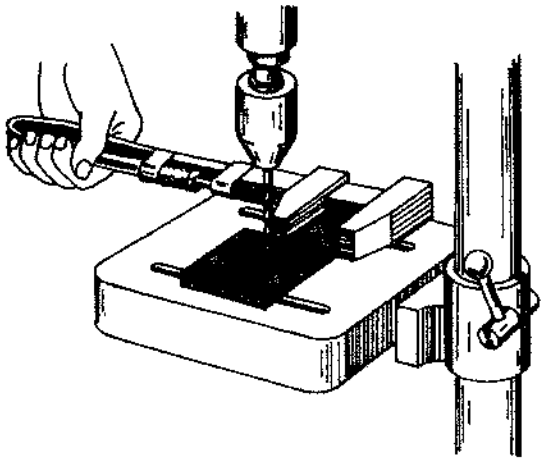


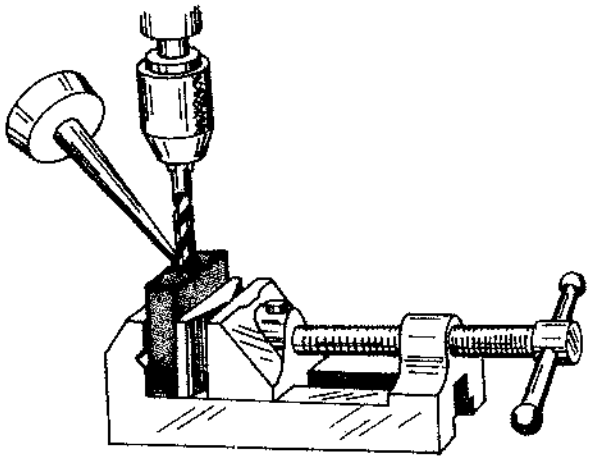
(2) Dent the metal where the two lines cross by using a center punch. Check the dent to see if it is centered where the two lines cross, then strike the punch with a heavy blow to form a large dent for the drill. A large center punch should be used for large drills. A proper type of punch mark will prevent the bit from slipping on the metal. If a prick punch is used, enlarge the dent with a center punch.

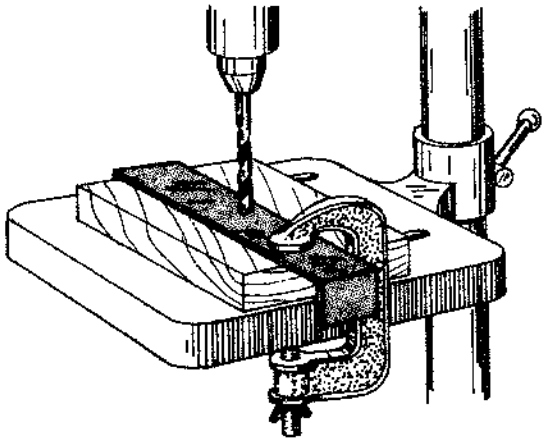
(3) Select the proper type of twist drill and check the size by using a drill gauge if necessary, then place the twist drill firmly in the chuck either by hand for a keyless chuck, or by the use of a key for a keyed chuck.

(4) The stock must be held firmly when drilling holes; otherwise, the drill and material may be damaged and/or the operator injured. When using power equipment to drill holes, the methods to hold stock are: drill press vise, the hand and V-block, C-clamp, monkey wrench, and machinist's vise.







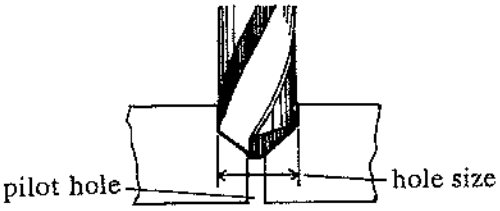


(5) Lubricate both the drill and hole while drilling with a cutting lubricant that is recommended for the metal.

(6) Apply steady pressure to the drill so that a smooth even cut is made as the bit passes through the metal. Hold back on the pressure as the bit passes through the stock.

(7) Operate the drill at the proper speed. Large drills should be operated at lower rpm than small drills. If a large drill is turned too slowly, the cutting edges will be dulled due to wear. However, if the drill is operated at too high speed, the cutting edges will burn.

(8) To drill large holes more easily, use the two drill method. Select a drill the size of the web of the large drill and make the first hole (pilot hole), then follow with the large drill.



(9) Remove chips and shavings with a brush, blunt tool, or air when drilling a hole. If flutes become clogged with either chips or shavings, the drill body may be twisted or broken. In order to properly clean the flutes, remove the drill from the hole, brush the flute clean, and reenter for drilling. Steel produces shavings and cast iron produces chips during the drilling process. Safety precautions should be observed at all times to prevent eye or other injuries.

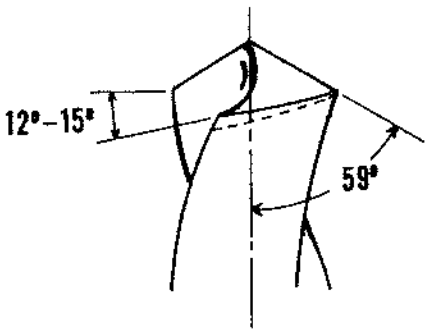
e. Other Considerations When Drilling Cold Metal

When using any type of hand drill the first precaution to observe is to hold the drill straight unless slanted or holes at an angle are to be drilled. If leaning or side pressure is applied the drill may break or be damaged.

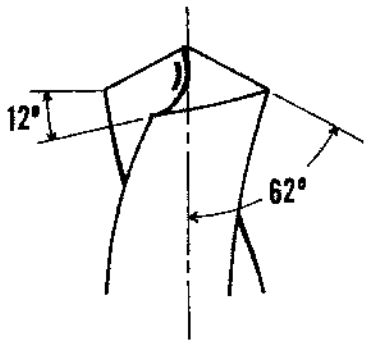
Drilling stocks must be placed in a position that will not permit springing or shifting while the hole is being drilled. If the metal springs or shifts the bit will likely break.

The drill will stay sharper longer when drilling steel if enough pressure is applied to make the drill cut "curly" shavings. Pressure is lessened just before the drill cuts through the metal.

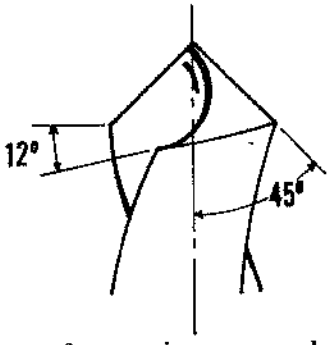
Drills are sharpened or ground according to the metal to be cut. The best cutting point for steel and cast iron is a 59-degree angle. The lip clearance is 12 to 15 degrees. Heat-treated steels are drilled with drills that have a greater cutting angle (62-degrees) and a lip clearance of about 12 degrees. Soft cast iron, wood, certain fiber materials, plastics, and hard rubber can be drilled with a sharper pointed drill than is used on hard metals. A drill with an angle of 45 degrees and a 12-degree lip clearance is recommended.



steel & cast iron



heat-treated steel



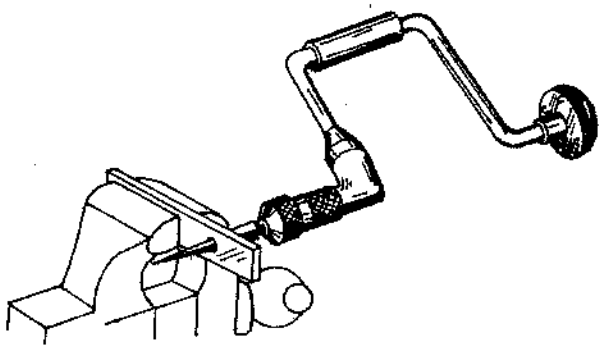
soft cast iron, wood certain fiber material, plastic & hard rubber

Very thin metal can be drilled without bending it out of shape if it is clamped in a vise between two pieces of lumber while drilling the hole.

The drill press is a very important power tool for drilling thick or hard metal. Much more pressure can be applied by using a drill press than by using hand drills; therefore, it is used more than any other drilling tool. One of the limitations in using the drill

press is its limited mobility. It cannot be moved and used in different places as can the hand drill.

f. Enlarging Existing Holes in Cold Metal



A tapered reamer should be used on both sides of the metal stock. Most reamers cut rapidly, so light pressure is applied on the brace or drill handle.

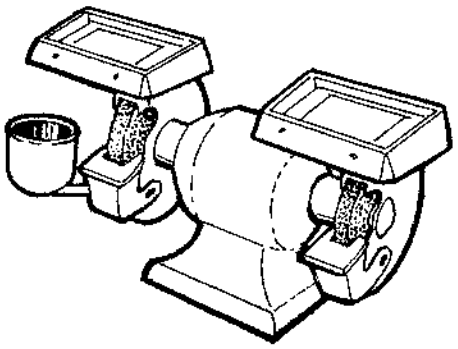
A tapered punch can be used on mild steel if the hole is to be enlarged no more than 1/16 inch and the stock is not too thick. The punch should be used in both sides of the hole.

A larger drill may be used if pressure is applied very slowly. If too much pressure is applied the drill may seize or bite into the metal and break.

A rat-tail or round file may be used if a very small amount of metal is to be removed. If the hole is to be enlarged on one side, the file may be the only tool to use.

4. Grinding Cold Metal

There are three different kinds of grinding and conditioning equipment used in most shops. In addition to the most important piece of equipment, the bench grinder, a carborundum stone (oilstone) and different types of files are used. The three different types of grinders are:



Bench - Bench or table top type for light work

Portable - Hand type for light grinding

Pedestal - Floor type for general grinding

a. Most shops are equipped with either the bench or pedestal grinder. However, the wet grinder (flow of water or other types of coolants pumped to the wheel) is used in larger shops where shaping as well as sharpening is part of the metal work. Information on selecting and conditioning a grinding wheel is as follows:

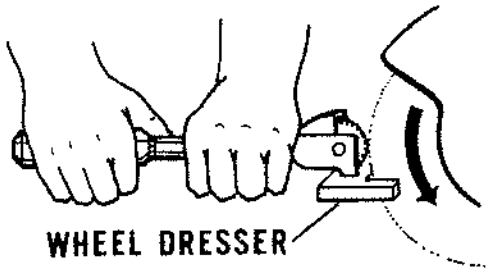
(1) Grinding wheels turn at a surface speed (distance rim of wheel will roll on floor in one minute) of 4000 to 6500 feet per minute (fpm). The popular size 6- and 8-inch diameter wheel size bench grinders may be rated in revolutions per minute (rpm). A slow speed grinder may turn at 1725 rpm, and a high speed grinder turns at 3450 rpm. There is less chance in burning or overheating the cutting edge of tools with a slow speed grinder. The fast speed usually produces a smoother finish.

(2) Grinding wheels may be selected according to the size of grain in the wheel and the grade of softness. Grade variation is caused by the amount and strength of material that holds the cutting particles together. There is also less chance in drawing temper from tools when using soft-grade wheels.

(3) There are several problems encountered in the use of the grinding wheel, but the two problems that most frequently occur are wheel loading and shape changing. If the wheel is properly used, it remains free of soft materials such as wood, rubber, aluminum, brass, copper, bronze, lead, tar, paint, glue, and clay materials. A wheel that contains one or more of these materials usually becomes glazed. If the wheel is improperly used it will lose its squareness across the face.

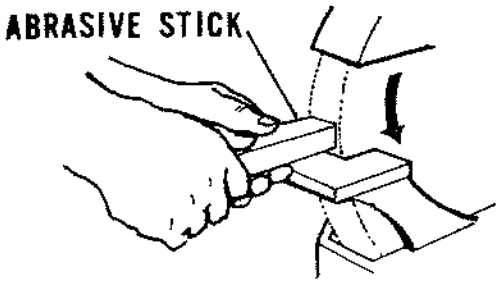
(4) A wheel can be restored to the proper condition by removing the glaze or loaded surface with a dresser or abrasive stick. The most commonly used dressers are as follows:

Huntington Dresser - The wheel is shaped as foreign material is removed. The star-shaped cutters are held against the wheel as it rotates toward the dresser.



Diamo-Carbo Dresser - The diamo-carbo dresser is a tube filled with a very hard abrasive that removes the particles from the rotating wheel as pressure is applied against the handle of the dresser.

Diamond Dresser - A diamond set in the tube of the dresser removes foreign material and grains of abrasive as it is held against the wheel.



Abrasive Stick - A grinding wheel is dressed (cleaned and squared) when the abrasive stick is pressed against the face of the wheel. An old piece of a grinding wheel may be used in the place of an abrasive stick.

b. Sharpening Tools by Grinding

The edges or points of many cutting tools are made of hard metal (high carbon); therefore, files cannot be used successfully to shape the cutting edges to a fine point so they can be honed. In fact, if files are used on very hard metal, the file teeth will be damaged to the extent that the file can no longer be used on soft metal.

A neater sharpening job can be done on such tools as wood chisels and plane blades when using an electric grinder. If a blade or tool is to be hollow ground a grinder must be used to make the curved-in surface. A flat surface is formed when using a flat file.

A more polished and smooth surface is realized when using a fine grit wheel than when using a standard file. Also, a faster tool conditioning job is performed with a grinding wheel than with a file.

c. Operation of the Grinder

Use the grinder shield and wear goggles to protect the eyes from metal and grit.

Grind on the side of the wheel only if a special side grinding wheel is used; otherwise, the shape of the wheel may be spoiled and the edge tool burned.

Set the tool rest near the wheel and at the proper angle before starting the grinder. Turn the wheel by hand to make sure it clears the tool rest.

Prevent tool overheating by moving the tool back and forth over the wheel and dip it into warm water. High speed steel often cracks when dipped into cold water.

Consider the use of the grinder the first step in sharpening a tool. The cutting edge is formed by whetting the tool on an oilstone.

5. Bending and Shaping Cold Metal

Much of the ornamental iron work is accomplished through working with cold metal. There are numerous projects that can be made in the agricultural mechanics shop by bending and shaping cold metal. Some of these projects are braces for farm equipment, gate and door hardware, shelf framing and supports, metal projects requiring ornamental design, and hardware for truck and trailer beds.

Flat iron and bars up to 3/8 inch in thickness can be bent and shaped without heating. Round iron up to about 5/8 inch in diameter can be bent. Thick metal, both flat and round iron, should be heated before bending. It takes less physical strength to bend and shape hot metal than cold metal. If the metal is too thick, or too hard, extra stress is placed upon the vise, jigs, and other equipment used to shape it. Good judgment, therefore, must be used in determining whether heat is necessary for shaping the metal.

The most common tools used to shape cold metal include:

Blacksmith's vise	Sledge hammer
Machinist's vise	Blacksmith's hammer
Anvil	Machinist's hammer
Bending jigs	Monkey wrench
Measuring tools	Marking tools
Piece of pipe and rod	Ball peen hammer

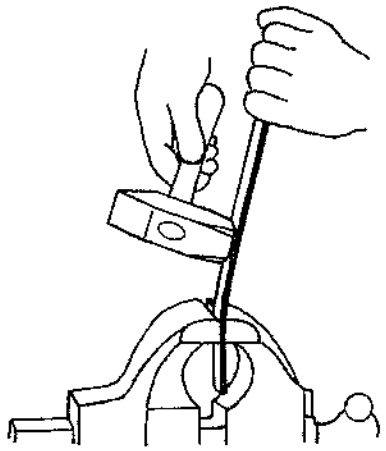
Tools for shaping metal may be of different sizes. Flat iron less than 1/4 inch thick can be bent with a 1-1/2-pound hammer very easily, but when the iron exceeds 1/4 inch in thickness, a 2-1/2-pound hammer may be necessary to shape the metal. It is very important to use the proper size jig; otherwise, it may be damaged if the metal exceeds the size recommended for the jig.

Generally, metal bending and shaping requires the use of heavy duty blacksmith's or machinist's vises. The sledge hammer should not be used against a vise, and it should not be used on the anvil if the weight exceeds the weight of a heavy machinist's hammer. Heavy duty monkey wrenches are preferred to light weight wrenches.

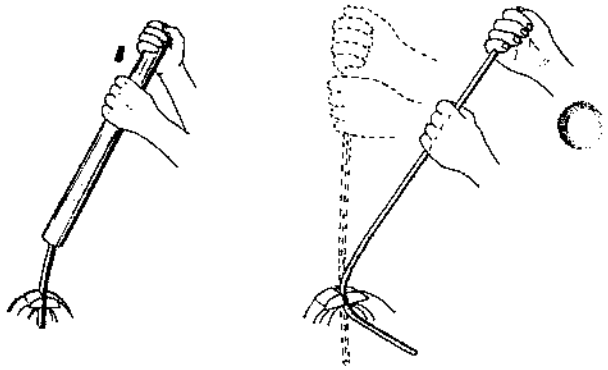
a. A procedure for bending cold metal is as follows:

(1) Measure and mark the metal to be bent. Place the mark above the vise jaw one-half the thickness of the metal. Half of the bend will be made below the mark and half above. Fillers can be used on each side of the vise jaws to protect the metal.

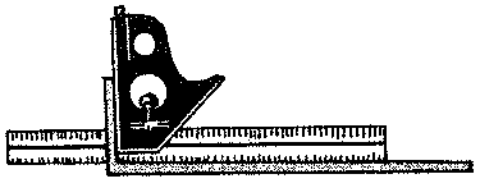
(2) Bend long bars or straps of metal by pulling downward on the end, and finish the bend by hammering with a machinist's or ball peen hammer.



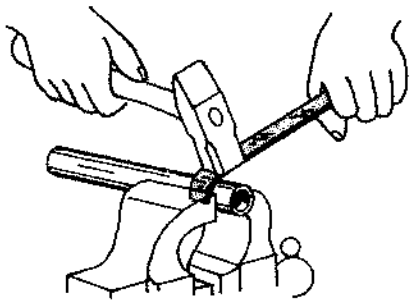
(3) Bend short pieces by slipping a pipe over the end and pull downward. Short or heavy pieces can be bent by using only the hammer and heavy duty vise. Heavy and short pieces can also be bent by sawing about one-third the distance through the bar or rod and placing the cut just above the jaws or where the bend is to be made. After the bend is made the cut is welded.



(4) If a large curve is to be made in a bar or rod, place the metal between loose jaws and bend slightly as the metal is slipped through the vise jaws.

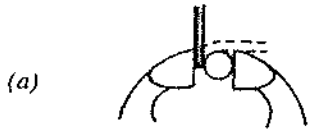


(5) Check the degree of angle with a try square, combination, T-bevel, or a template after making the bend. If the angle is smaller than 90 degrees and a 90-degree angle is desired, the angle can be corrected on an anvil.



(6) Make a round bend (an eye) by selecting a round stock (pipe or rod) the same diameter as the eye desired. Fabricate the eye by using the following steps:

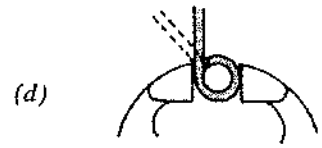
(a) Place the flat metal and round stock in the vise. The flat metal should extend at least half the distance of the round stock diameter. Bend the metal over the stock by pulling downward with one hand and hammering the metal with the other hand. Bend until the metal is level with the vise jaws.



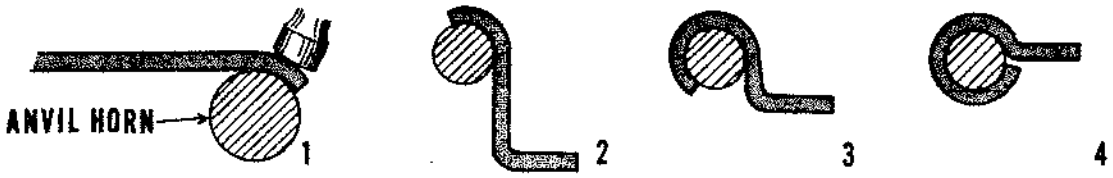
(b) Loosen the vise grip and extend the bent end of the flat stock to the bottom and center of the round stock and repeat the bending step.

(c) Loosen the vise grip again and place the U-shaped end of the flat stock around the shaping stock and at the top edge of the vise jaws, and repeat the bending step for the third time. Each time the flat stock is placed in the vise, the straight part should be parallel to the vise jaws.

(d) After the eye is formed, loosen the grip once more to set the flat stock parallel to the jaws. Bend the flat stock enough to put the eye in the center of the long part of the stock.

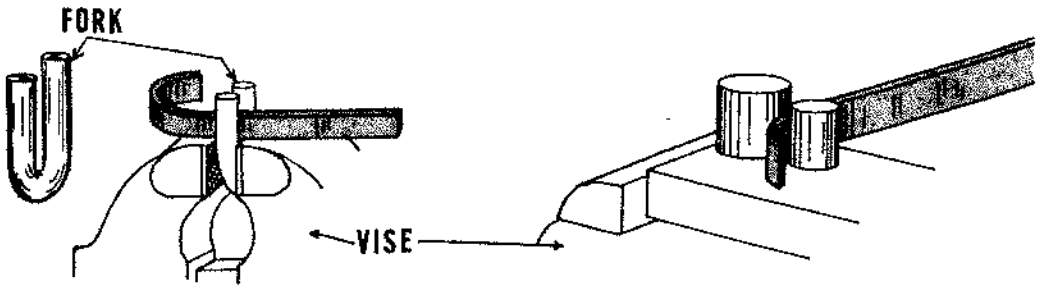


(c) Mild steel can be bent by using an anvil and hammer. Bend the metal by using the following method:



Start the bend by hammering the iron on the end as it is held against the anvil horn. Continue hammering and at the same time move the iron to the smaller part of the horn. Make an "L" bend after the eye is about two-thirds finished, and continue bending the iron until the end touches the "L" bend, forming a complete circle.

(7) Metal bending forks and jigs are very useful for making certain types of bends when working with thin metal. A pattern or actual size sketch is very important when using bending forks or jigs. Steps in using these bending and shaping methods are as follows:



(a) Use a piece of string or copper wire by starting at one end of the drawn object and follow the pattern through curves and bends to the opposite end. This method of measurement will determine the length of metal needed.

(b) Start the end bend on an anvil. Shape and peen the ends if necessary.

(c) Place the bending fork or jig in a vise and secure firmly.

(d) If the posts are adjustable on the jig, adjust to the thickness of the stock to be bent.

(e) The curves and angles are formed with bending forks or jigs by the use of hands, pipe, and hammer. Slip a pipe over the iron if it is necessary to use this type of leverage, to give extra support when applying pressure. Usually, stock that is more than 1/4 inch thick must be bent in a vise.

b. A procedure for twisting cold metal is as follows:

(1) Select a metal stock longer than the exact measurement needed because twisting shortens the stock. Flat or square pieces of thin metal can be twisted without heating.

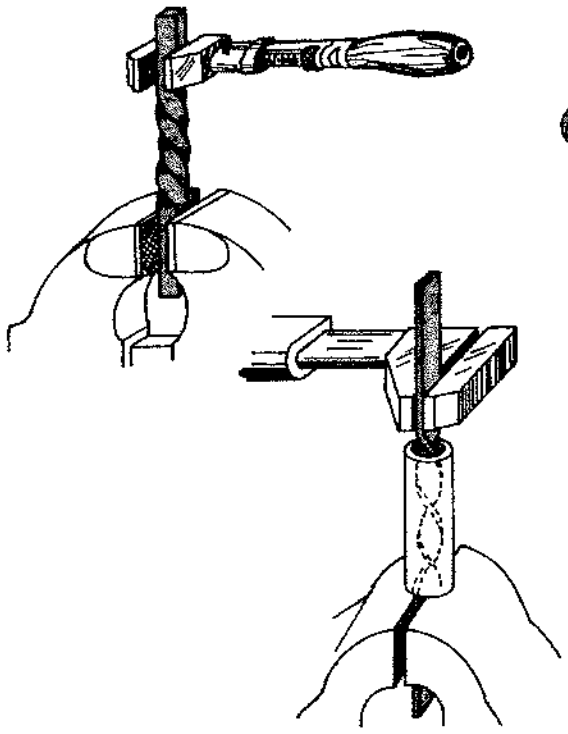
(2) Mark the beginning and end of the twist with a center punch or chalk before clamping the stock in the vise.

(3) Clamp the stock in the vise so that the bottom mark will show just above the jaws. The twist should extend to the mark or top of the jaws.

(4) Place a monkey wrench just above the top mark with jaws tight and turn until the desired number of twists are completed. Proper twisting will strengthen the metal, whereas excessive twisting tends to weaken the metal.

(5) Long metal stock may have a tendency to bend; therefore, use a close fitting piece of pipe slipped over the stock. The pipe should be the length of the twist.

(6) Cut the stock to the desired length after twisting it.



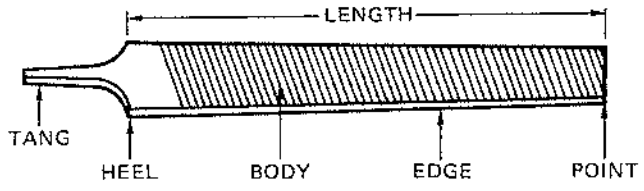
Metal ends are usually shaped with a hammer and anvil, plus the use of a file or grinder. To flatten the ends of flat iron, the metal end is placed on the anvil face, and the end is shaped or flattened with a ball peen hammer.

6. **Filing Cold Metal**

The file is used for smoothing and shaping metals. Shaping actually includes three types of file use: sharpening of tools, smoothing metal surfaces, and cutting metal to the desired form and dimensions. A regular mill file can also be used to test the hardness of metal. The degree of hardness will determine the type of metal cutting tool and/or the type of hacksaw blade to use for making the cut.

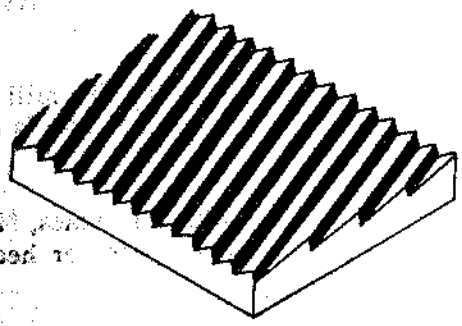
a. Files are selected according to their many uses. The use of a file determines the size, type of teeth, coarseness, and shape.

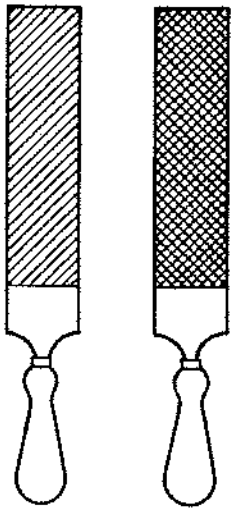
(1) File Sizes - File sizes are determined by the length of the file (in inches) excluding the tang or the distance from the point to the heel. A 10-inch mill file is used for general purposes. A 12-inch flat file is best for rough work and will last longer than a 10-inch file.



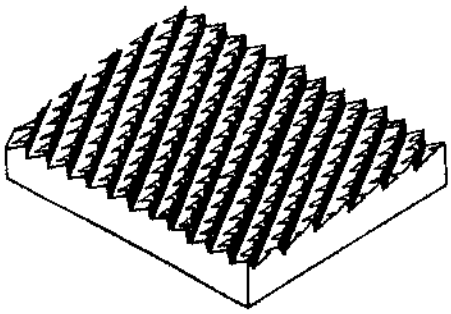
(2) File Teeth - There are two major kinds of file teeth, single-cut and double-cut. Single-cut files have chisel-like teeth running at an angle across the belly and body of the file. Double-cut files have two sets of teeth or chisel cuts that cross each other. Single-cut files cut slower than double-cut files, and they leave a smoother surface.

SINGLE CUT

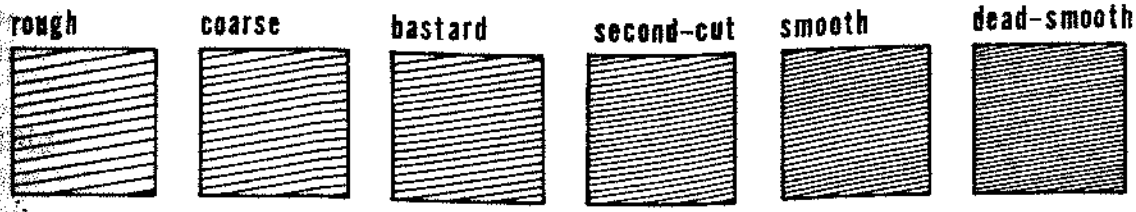




DOUBLE CUT

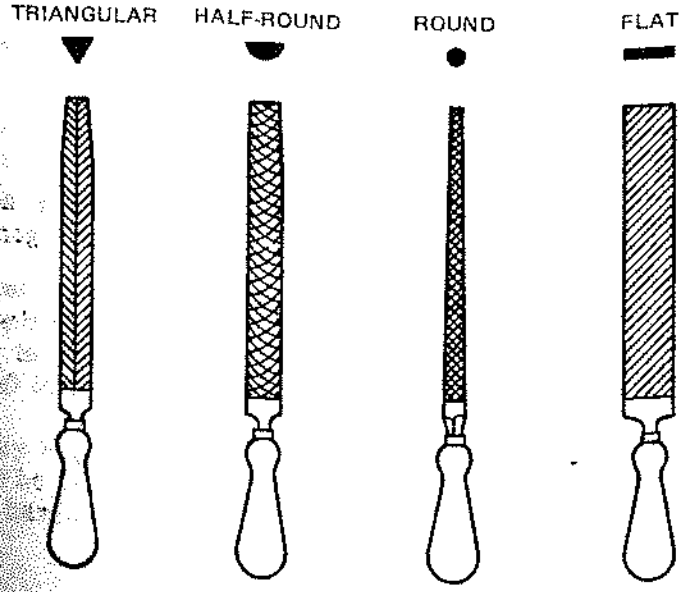


(3) Grades of Teeth Coarseness - The grade of coarseness is determined by the distance between the rows of teeth. For example, the longest spacing is called rough, and the least spacing is dead-smooth. Naturally, the coarseness changes with the length. A long file is coarser than a short file.



TEETH SPACING OF SINGLE-CUT FILES

(4) File Shapes - The shape or style is also determined by the different uses. The most common are mill, flat, square, round, half-round, and taper or three corner files. A description of these files is as follows:



(a) Mill files are made only with single-cut teeth and range in size from 4 to 16 inches. They are used for drawfiling and finishing work such as finishing brass and bronze metals.

(b) Flat files are double cut and about 4 to 16 inches in length. They are tapered similar to the mill file and are the most commonly used of all files for general work.

(c) Square files have four filing edges instead of two as found on the mill and flat files. They are tapered or blunt and double-cut. This kind of file is used for filing corners and slots and for surface filing.

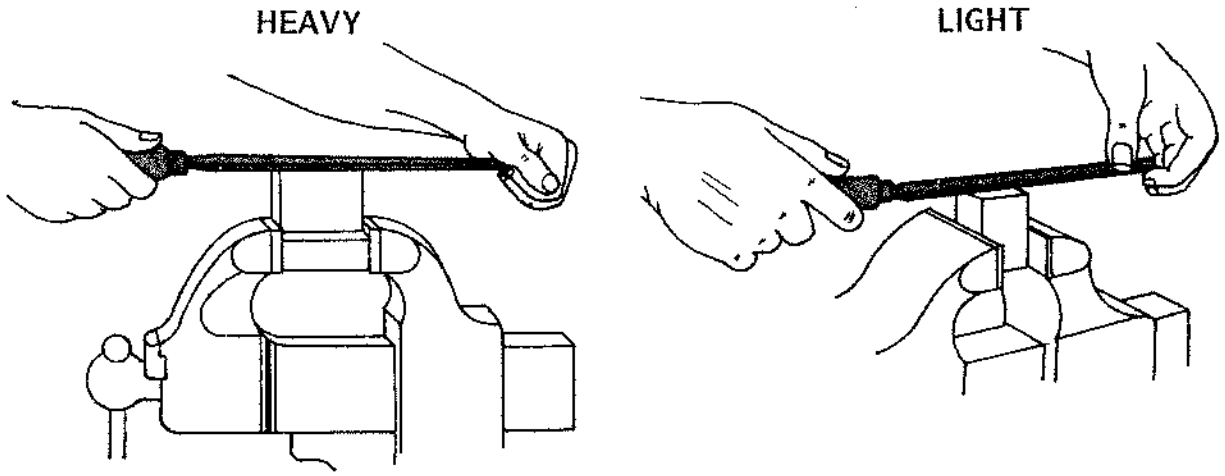
(d) Round files are single or double cut. They are used for enlarging holes, filing curves, and forming fillets. These files are tapered from shoulder or heel to point.

(e) Half-round files have one flat side and one partly round side (about one-third of a circle). This type of file is double-cut, and it can be used to file either flat or curved surfaces.

(f) Tapered files are found in many shapes. The triangle, contour, and crosscut files are the most popular. They are double cut and are used to file corners that are less than 90 degrees and also to file saws.

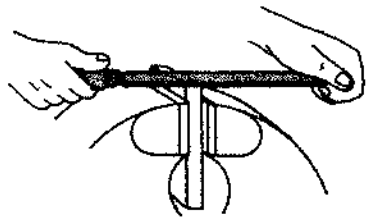
b. There is a correct way and many incorrect ways to hold a file for both heavy and light filing.

(1) Heavy Filing - The handle is held in one hand by placing the thumb or forefinger on top of the file handle and gripping the point with the fingers and back part of the thumb.



(2) Light Filing - The handle may be held the same way as in the heavy filing method. The file point is held between the first two fingers and thumb, applying light to moderate pressure as needed.

c. The steps to follow when using a file to shape metal are:



(1) Clamp the stock (metal) slightly above the jaws of the vise to eliminate vibration while filing. The area being filed should be about elbow height or slightly below.

(2) Select the proper type file to cut the stock. For example, if the surface is to be filed flat, select a flat file.

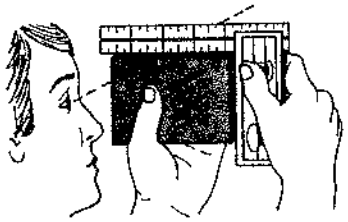
(3) Stand slightly to one side of the work, yet facing it so that the right amount of pressure can be applied on the forward stroke.

(4) Use moderate speed strokes. However, hard metal is filed more slowly with more pressure than mild or soft metal. About 30 strokes per minute may be appropriate.

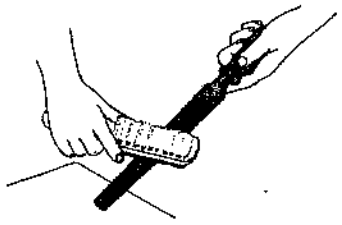
(5) Except for drawfiling, hold the file at a 90-degree angle to the side of the stock when making filing strokes on flat metal.

(6) Make a slow, full-length stroke by placing the file on the stock and pushing it forward; lift it on the back stroke. Moving the file back, permitting it to slide over the metal, will dull the teeth faster than pushing the file forward. If there is a possibility of the file slipping off the stock on the forward stroke and marking or damaging the jaws of the vise, the stock should be clamped between two pieces of lumber.

(7) Check the stock with a square during the filing process to see if a proper cut is being made. A 90-degree cut is easily checked by using a try square. It may be necessary to file the stock by holding and pushing the file in a diagonal position to keep the surface flat.

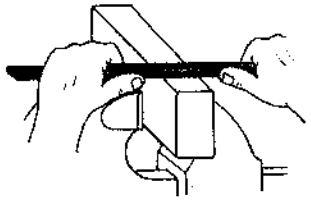


(8) Clean the file periodically while it is being used. Cleaning tools are a wire brush or file card. Hard-to-get chips can be removed with a clean wire. Some of the chips can be removed by tapping the file on the work bench. Cleaning can be aided by starting the file body at a different place on each forward stroke.



d. Drawfiling is a method of filing long, flat surfaces and rods. It is also used to smooth rods that may require considerable hammering. The method is as follows:

(1) After the stock has been clamped high enough in the vise to clear the fingers, grasp each end of the file, placing it on the stock with each thumb clearing the stock by about 3/4 inch. Use a mill file which is single-cut.



(2) Apply steady pressure as the file is pushed forward. Release the pressure on the return stroke. Actually, when drawfiling, the file is pushed sideways for cutting. Always hold the file flat while the moderately slow strokes are being made on the stock. It may be necessary to clean the file often when drawfiling mild or soft metals.

e. It is important to test metal for hardness before attempting to file it. Generally, it is advisable to place the metal stock in a vise in order to run the file over its surface an inch or two to determine metal hardness. Cutting characteristics of five different types of metal include:

(1) Extremely Hard Metal - The file will slide over the metal, leaving the file dull and shiny. The file must be harder than the material being cut, and it should not be used on hardened steel.

(2) Hard Metal - The file may barely cut into the metal, but it is dulled if considerable pressure is applied.

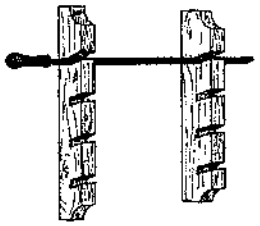
(3) Medium Hard Metal - This type of metal can be filed without dulling the file immediately.

(4) Soft Metal - The file teeth bite into the metal very easily and become clogged with metal particles. Soft metal is cut without dulling the file. Very little pressure is applied to the file when cutting soft metal.

(5) Cast Iron - The outer surface of cast iron is considered very hard; therefore, an old file should be used to cut through the outer surface before using a new file. If scale is present, it should be removed with a chisel and hammer before attempting to file the surface.

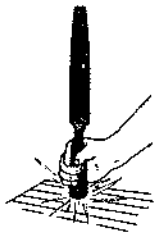
f. A file requires special care if it is to be used over a long period of time. The following suggestions may be observed:

(1) Store files in racks away from other metals. If they rub or fall against other files or tools, the teeth may be damaged. Files are very brittle and may be broken if allowed to fall on concrete floors.



(2) Keep files away from oils, paints, and caulking compounds, as these materials clog the teeth. Also, the file may corrode if placed in a humid or moist location for a long period of time.

(3) A file should never be used without a well seated handle on the tang. Recheck the seating before storing.



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SUGGESTED STUDENT ACTIVITIES

DISCUSSION: Respond to each of the following in the space provided.

1. Explain how metals affect our everyday lives.

2. Name four methods of identifying metals.

3. Define ferrous metals and give several examples.

4. Define nonferrous metals and give several examples.

5. Name at least five metal shapes and one agricultural use for each.

6. How are measuring tools used in cold metal work? Give examples.

7. Discuss metal cutting using the following tools:

Hacksaw

Cold Chisel

Bolt Cutter

Cold Cutter

Snips

8. Discuss drilling cold metal.

9. Discuss grinding cold metal.

10. Discuss bending and shaping cold metal.

11. Discuss filing cold metal.

FILL IN THE BLANK: Complete the following statements using the correct word or words.

1. The _____ test, performed by holding a piece of metal against a grinding wheel, is sometimes used in the shop to determine types of metal.
2. Brass is an alloy of _____ and _____.
3. Low carbon steels contain less than _____ percent carbon.
4. High carbon steels contain _____ to _____ percent carbon.
5. _____ steel is made by adding nickel and chromium to steel.
6. _____ iron is used in ornamental iron works.
7. Cast iron is used to make _____.
8. Structural steel is primarily _____ steel.
9. Tool bits are made from _____ steel.
10. Food handling equipment is made from _____ steel.
11. Metal roofing and siding is made from _____ steel.
12. Electrical wire is made from _____ and _____.
13. Lead and tin are used in making _____.
14. Tin snips are sometimes referred as _____ snips.
15. When using a hacksaw, at least _____ teeth should be cutting the surface at one time.
16. Hacksaw blades are selected by length and teeth per _____.
17. A hacksaw cuts on the _____ stroke only.
18. In selecting files, single cut and double cut refer to _____ design.
19. _____ is performed by pushing or pulling a file at a 90 degree angle to the metal.
20. A file should never be used without a well seated _____ on the tang.
21. Common files shapes include _____, _____, _____, _____, _____, and _____.
22. Cold metal may be twisted by clamping the metal in vise and using a _____ _____.
23. When performing cold metal skills, proper clothing and eye protection devices should be worn and all _____ precautions should be observed.

SHORT ANSWER: Define, identify, and/or give a use for each of the following in the space provided.

1. Alloy

2. Malleable

3. Ductile

4. Tempering

5. Annealing

6. Tool steel

7. Mild steel

8. Galvanized steel

9. Cape chisel

10. Bolt cutter

11. Aviation snips

12. Fractional twist drill measurement

13. Formula to determine twist drill cutting speed