Elementary Wrought Iron

Blowing a Bessemer converter

(Courtesy Jones & Laughlin Steel Corp., Pittsburgh, Pa.)

ELEMENTARY WROUGHT IRON

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THE BRUCE PUBLISHING COMPANY

New York MILWAUKEE *Chicago*

Printed in the United States of America

(Third Printing — 1935)

DEDICATED TO
R. MARGARET and J. BRUCE BOLLINGER
in the hope that this humble effort
may inspire them
to greater achievement

INTRODUCTION

This is the age of steel!

And steel has made possible the giant we call machinery!

A moment's consideration will show how dependent modern civilization is on machinery and the products of machinery. Think back to the time when primeval man tilled the soil with a sharpened stick; when transportation meant carrying the burden on the backs of men who walked to their destination; and when "necessities" consisted of a "house" made of rude logs or stones, with leaves or skins for beds, and stones or stumps for tables and chairs; when man's "power" consisted of brute muscular force alone; and when his "geography" included only the neighboring hills and valleys.

Compare him now with the man of today! Truly, modern man is a towering giant in the comparison! Look at his broad fields and luxurious mansions; at his locomotives, automobiles, and flying machines. See how, with a light touch of his hand, he can put into operation electric power equal to that of a whole tribe of men. Observe that he wanders wherever he wills, and that the whole world comprises his sphere of activity.

Would this be possible without the miracle of steel?

This little book is written to point out to industrial-arts men the possibilities of metal work as an industrial-arts subject.

It is true that courses have been offered before and that texts have been written before, but these courses and texts were either all forge work, all sheet-metal work, or all machine work. The present book calls for a shop layout which may be termed a general metal shop; one in which a number of metal-working activities are represented. Thus, while most of the projects in this book are forge work, many of them involve some bench-metal work, sheet-metal work, lathe work, or pipe fitting. Some problems involve only one of these activities, some several, and a few all of them. Here, indeed, is an opportunity to present to the students a broad and comprehensive insight into the metal-working industry.

The projects selected are not the chains, clevises, and gate hooks so common in forge work, nor the abstract tool operations built into the strictly machine-shop courses. Here are live projects like hammer heads and hack-saw frames; magazine baskets and end tables; fern stands, andirons, and candlesticks; desk lamps, table lamps, and bridge lamps; and a goodly number of others. The writer believes that these projects will prove every bit as universally popular as are the present-day woodworking projects.

Another interesting feature of the book is its arrangement. At the beginning is a concise discussion of the properties of iron and steel, to be supplemented by reference to other texts which treat this topic in full.

Then come carefully worked out descriptions of some twenty-four operations, which are the basic operations necessary to the making of the projects. This does not include instruction in lathe practice.

Then follow the projects, divided into five groups of more or less increasing difficulty. For the first twenty-five or thirty of these projects, the order of procedure has been worked out at some detail in the text. In the description of the later articles, only new points and points of major difficulty are explained. After mastering the operations by making the earlier projects, the student is to plan his own procedure on the later and more difficult projects.

Attention also is called to the use of so-called "forms" in the making of a great many of the projects. A craftsman would shape each piece over the anvil, and thus make each piece an "original." For the average beginning student, however, this sort of work is very difficult and rather uninteresting. It is suggested instead that pupils shape their first work over previously prepared forms, and that only after they have acquired some facility at this task should they be asked to shape "originals." Using forms over which to shape curves corresponds very much to using jigs and fixtures in modern industry; it is the modern or "mass-production" method of making wrought-iron pieces. Their use saves time, makes the task easier, produces more accurate results, and heightens the interest of the student in his work.

The writer wishes to take this occasion to thank the friends and fellow teachers who have helped in the preparation of the material and in the selection and development of the projects.

J. W. BOLLINGER

TABLE OF CONTENTS

Elementary Wrought Iron

MATERIALS AND TOOLS

Iron Ore. Iron ore is found in many parts of the world, but is mined only in regions where the ore is sufficiently abundant to make the operation profitable. The chief sources of iron ore in the United States are Minnesota near the upper end of Lake Superior and the city of Duluth, and the Appalachian mountains near the city of Birmingham, Alabama.

Pig Iron. Iron ore is refined in a blast furnace. The ore, together with some limestone and coke, is placed in the furnace, where the iron melts. The melted iron then is drawn off into molds, forming pig iron, so called because the slabs of iron resemble pigs. Pig iron melts at about 2100 degrees F.

Cast Iron. Some of the pig iron is remelted and poured into previously prepared sand molds to assume various shapes which later become parts of machines. This iron is known as cast iron, which cannot be hardened or welded, but machines easily, and is comparatively brittle and breakable. It contains a large amount of carbon, varying from 1.5 to 4.5 per cent, and such impurities as silicon, phosphorous, and sulphur. Cast iron melts at about 2100 degrees F.

Wrought Iron. Wrought iron is made from pig iron, in a puddling furnace which burns most of the impurities out of the iron. Consequently, we find wrought iron almost entirely free from carbon. It bends very readily into a great number of forms, and is known for its extreme toughness. Good wrought iron should bend through 180 degrees back double on itself without breaking. When broken, it presents a characteristic fibrous appearance. It can be welded more easily than any other form of iron, but cannot be hardened to any appreciable extent. The melting point of wrought iron is about 2700 degrees F.

Machinery or Mild Steel. Mild steel is made from pig iron by several different processes, most important of which are the Bessemer and the open-hearth processes. The name "steel" alone does not sufficiently describe the metal, as there are on the market a great variety of grades, each with varying characteristics. Perhaps the best way of telling something about the steel is to know the percentage of carbon it contains. "Low-carbon steel" contains from .015 to .025 per cent carbon and generally is used for parts of machinery where great strength is not of supreme importance. Mild steel has very largely displaced wrought iron because it is less expensive, and because it can be readily bent to shape. It can be welded, but not quite so easily as wrought iron. It machines easily, but cannot be hardened to any appreciable extent. When broken, it presents a crystalline or granular appearance. It melts at about 2400 degrees F.

A somewhat better grade of steel is known as "medium-carbon steel," which is somewhat stronger than low-carbon steel. It is more difficult to bend, to weld, and to machine than mild steel, and contains from .06 to .25 per cent carbon.

High-Carbon or Tool Steel. Steel that contains from .07 to 1.6 per cent carbon is known as "high-carbon steel" or "tool steel." This steel possesses the valuable characteristic of becoming very hard if it is heated to a red heat and suddenly cooled in water or quenching oil. The higher the carbon content, and the more sudden the cooling, the greater the degree of hardness that may be attained. Because of this quality, this steel is used for making tools of all kinds. By choosing steel of the right carbon content, tools possessing various degrees of hardness and toughness may be made. Steel containing from .90 to 1.0 per cent carbon is best for general use. Tool steel does not bend readily, must be softened or annealed before it can be machined, and is most difficult to weld. Operation X describes how to harden tool steel, and Operation Y how to temper it.

Alloy Steels. Modern metallurgists have found by adding certain other substances, such as nickel, chromium, copper, manganese, tungsten, etc., to steel, that still other grades of steel may be produced, each with its own peculiar characteristics and uses.

The Emery-Wheel Test. One of the simplest ways of finding approximately the carbon content of a piece of steel is by means of the emery-wheel test. Hold the material against an emery wheel, and observe the kind of sparks thrown off. Wrought iron, with practically no carbon, gives off bright red sparks that shoot off in straight lines. Pieces of steel, with higher and higher carbon content, throw off sparks which become more and more yellow in color, show a greater and greater tendency to branch off at various angles, and explode in regular showers of sparks. High carbon steel, therefore, has a decidedly different type of spark from that produced by wrought iron. By experimenting with various pieces of steel of which the carbon content is known, it will soon become an easy matter to determine the approximate carbon content of any piece of steel.

Commercial Shapes. Steel is made into a great variety of shapes by rolling the heated metal between large rollers that have grooves of the desired shape cut into them. Common shapes are angle irons, I beams, T beams, channel irons, rails, etc., which are used in structural-iron work. Besides these shapes, a great many sizes of flat, square, round, hexagonal, and octagonal bars are made.

The United States Steel Corporation, with offices and factories at Pittsburgh, Pa., is the chief manufacturer of iron and steel in the United States.

THE ANVIL AND THE FORGE

The Anvil. The anvil, Figure 1, has been used by blacksmiths in its present form for several hundred years. It usually is made of wrought iron or a special grade of steel. The nose A is rounded, and is used for making round bends. The flat space between the nose and the face B is soft, and is used for cutting stock with a chisel. The face D is made of tool steel, hardened and tempered, and welded in place. At C, part of the edge of the face has been rounded off for making small curves. The square hole E, called the "hardie hole," is for holding the anvil tools. The round or pritchel hole F is for making bolts, for punching holes, and the like. Care must be taken not to batter the face of the anvil with the hammer or the anvil tools.

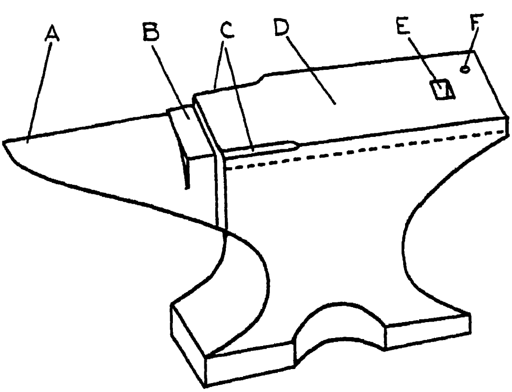


Fig. 1. A, Nose or horn; B, flat place; C, rounded corner; D, face; E, hardie hole; F, pritchel hole

The Anvil Tools. The most common anvil tools, Figure 2, are the hardie and the handle cold chisel A for cutting; the anvil hot chisel and the handle hot chisel B for cutting hot iron; the top and bottom fuller C for drawing out stock; and the top and bottom swage D for smoothing round material. Fullers and swages are made in several sizes.

Special hammers, Figure 3, that are used in connection with the anvil are the 10-pound sledge A for striking heavy blows; the 3-in. square flatter B used together with the sledge for smoothing material after it has been worked; and the 1- or 1½-in. square set hammer C used for forming shoulders or set-offs.

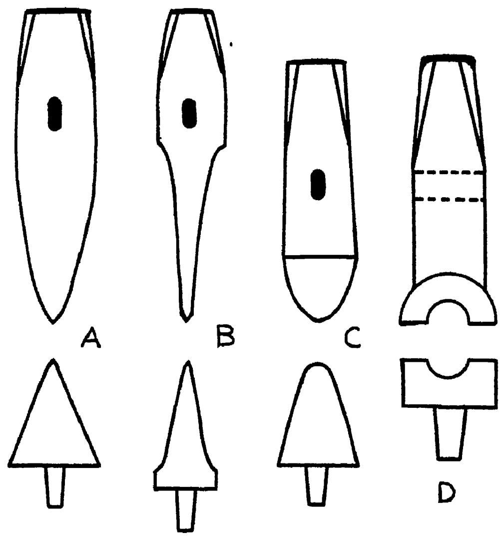


Fig. 2. A, Handle cold chisel and hardie; B, handle hot chisel and anvil hot chisel; C, top and bottom fuller; D, top and bottom swage

The Forge. A blacksmith's forge, Figure 4, consists essentially of a fire pot in which blacksmith's coal is burned. A blower is used to force air into the fire by way of the tuyere in order to increase the intensity of the fire. A hood is placed over the fire to carry off the smoke. The hood can be brought down so as to

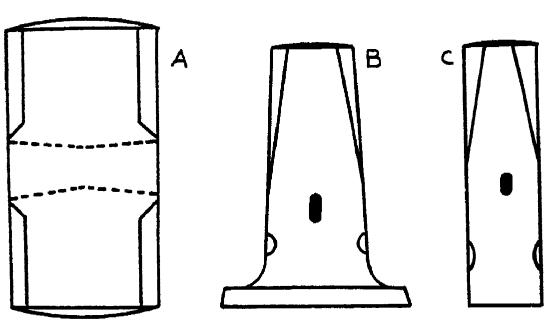


Fig. 3. A, Sledge hammer; B, 3-in. flatter; C, set hammer

cover the forge all around with the exception of an opening in front, so that none of the smoke can escape into the room.

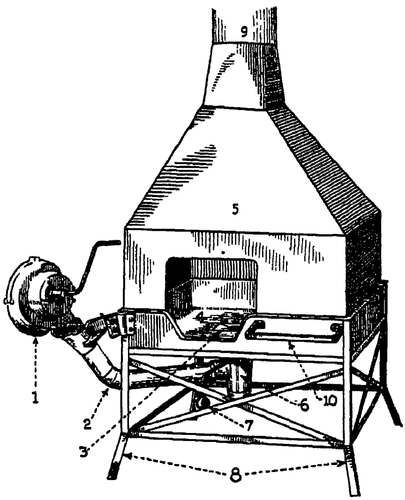


Fig. 4. Forge. 1, Blast fan; 2, blast pipe; 3, tuyere; 4, hearth; 5, hood; 6, ash dump; 7, ash-dump lever; 8, base; 9, smoke pipe; 10, tool rack. The back of the hood has a pivoted door to allow for heating very long pieces of iron.

The forge is used to heat iron or steel in preparation for bending to shape, or for making a weld. It also is used for hardening and tempering tool steel, and for melting certain metals as babbitt, aluminum, lead, and others.

The Forge Tools. Forge tongs, Figure 5, are made with tool-steel jaws, to which mild-steel handles have been welded. They are used for holding material that is being heated or for holding the heated metal while it is being worked on. The most commonly used tongs are the flat tongs A, the hollow-bit tongs B, the pick-up tongs C, and the link tongs D. Tongs must be so chosen that

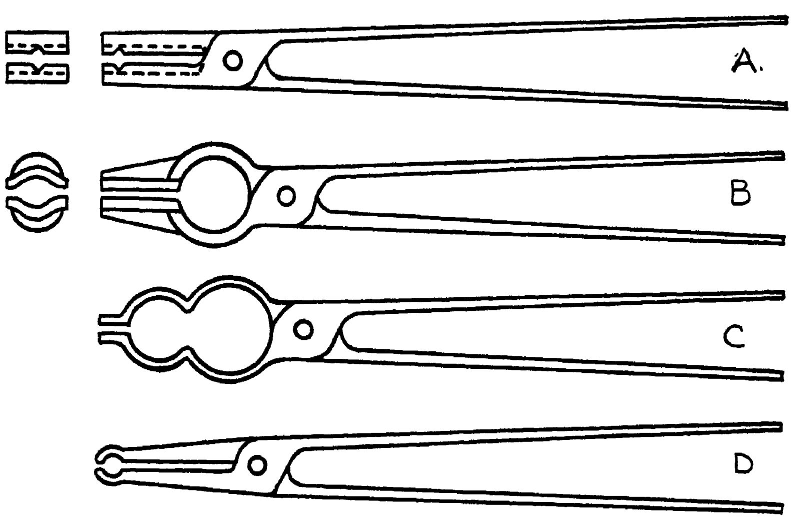


Fig. 5. A, Flat tongs; B, hollow-bit tongs; C, pick-up tongs; D, link tongs

Lewis Hine, Photo

The smith, a mighty man is he.
—*Longfellow*

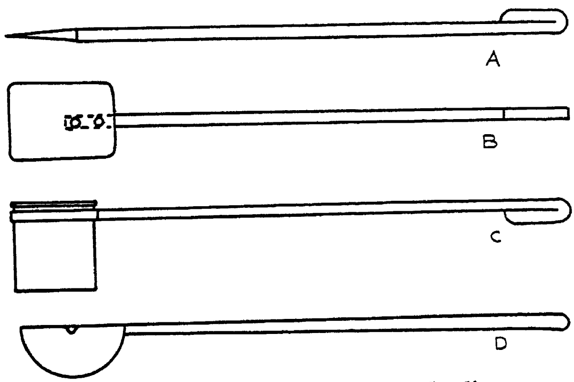


Fig. 6. A, Poker; B, shovel; C, dipper; D, ladle

they fit the work, otherwise there is danger of the work being thrown out of the tongs and injuring the operator and persons working near by. If the tongs do not fit, heat the jaws to a red heat, place the work between them, and hammer the jaws until they do fit. The jaws should then be re-hardened.

Other convenient tools are the poker A, the shovel B, the water dipper C, and the melting ladle D, Figure 6.

OPERATIONS

Operation A

BUILDING A FORGE FIRE

1. Examine the coal supply. Blacksmith's coal is a good grade of bituminous coal. It is usually very lustrous, and will readily break into small pieces after a mild blow with a hammer. Do not use an inferior grade of coal.

2. Rake away all coal and coke from around the tuyere opening; be certain to throw away all clinkers and other impurities.

3. Place a piece of paper and several handfuls of wood shavings over the tuyere; set fire with a match.

4. As the shavings begin to burn, add a small amount of coke to the fire, and turn on a mild blast of air. Add more coke until a fire of the right size has been built.

5. Bank the outer edge of the fire with green coal that has been slightly dampened. As this green coal becomes heated, some of the gases are driven off, causing the coal to change to coke. As the hot bed of coal is being used up, add some of this newly formed coke from around the edge, and rake more green coal in place, so that the process of forming coke may be continuous as the fire burns.

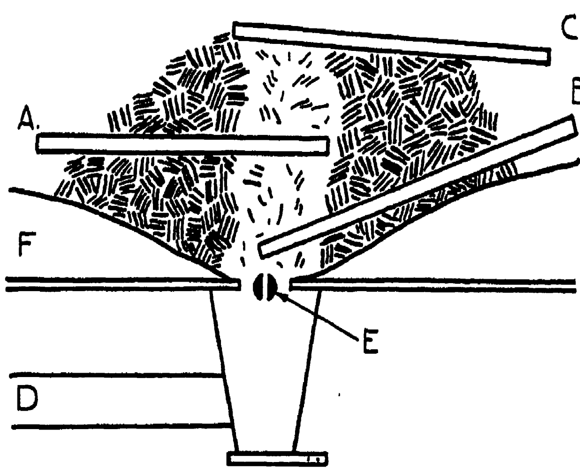


Fig. 7. A, Correct position; B, C, incorrect position; D, air-blast inlet; E, tuyere; F, fire clay

6. Build the fire as nearly as possible according to the size and shape of the iron to be heated. To keep the fire from spreading out over too large an area, quench part of it with water. To build a fire that is longer than it is wide, bank the narrow sides with green coal, or quench the coal there with water.

7. Place the iron in the fire in a horizontal position, as at A, Figure 7. Do not poke it down toward the tuyere, nor lay it on top of the fire, as at B and C. The idea is to have a good bed of live coal between the tuyere and the iron, so that the air blast becomes thoroughly heated before coming into contact with the iron. This is especially important when heating tool steel for hardening, or when heating wrought iron for welding. The metal will heat much faster if it is covered with a bed of coal. It is advisable to heat the iron slowly, so as to allow the interior portions to become as hot as the outside portions. It is poor practice to permit the iron to "soak" or remain in the fire with the blast turned off.

8. The amount of air used in the fire is important. For ordinary purposes the ideal condition is to supply just as much air as is necessary to consume the coal. If too much air is used, the fire becomes an "oxydizing" fire; that is, the surplus oxygen tends to unite with whatever is at hand, so that if a piece of steel is in this sort of fire, a large amount of iron oxide or scale will form on the iron. Or, the oxygen unites with the carbon in tool steel, which "decarbonizes" or softens the steel.

If not enough air is used, the fire becomes a "reducing" fire. In this case, due to the shortage of oxygen, none of the harmful oxydizing tendencies are present. In fact, some oxygen is taken away from any iron oxide or carbon compounds which may be present. Such a fire is best suited for welding or for working tool steel.

9. Wrought iron or mild steel is best worked at a temperature just below the welding heat. Tool steel should never be worked above a bright cherry-red heat, because iron, and particularly tool steel, which is heated to too high a temperature, will "burn" and become very brittle and practically useless. Burned tool steel shows a rough pitted surface, and evidences a coarse crystalline structure upon being broken. Tool steel should be thoroughly annealed or softened after being worked in preparation for hardening and tempering.

10. Irregular pieces should be handled carefully in order to heat them to a uniform temperature throughout. One way is to remove the metal from the fire and cool off the thinner portions in water or oil.

Another is to place the thicker parts in the hottest fire, or the thin portions over coke that has not yet fully ignited.

11. When a fire is to be left unused for a short time, it may be preserved by banking it with green coal.

12. Do not attempt to do any work with a poor fire. As a blacksmith keeps his fire, so will his work be.

Operation B

MEASURING AND LAYING OFF

Rule and Scratch Awl. Measurements on metal usually are made with a machinist's rule and a scratch awl. When using the rule, it should be set upright on its edge with the markings touching the work, as in Figure 8, in order to insure accurate measurements. Because of its sharp point, a scratch awl will make a mark about $\frac{1}{64}$-in. wide, which is much more accurate than a mark made with a lead pencil.

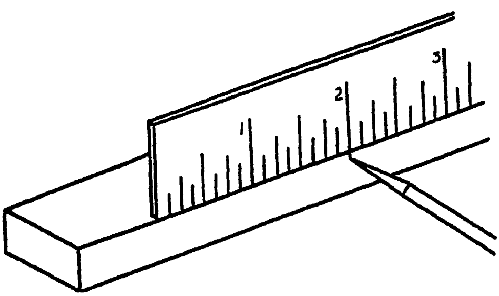


Fig. 8. Measuring with rule and scratch awl

Occasionally, the surface on which measurements are to be made is coated with chalk or with a marking solution, so that the markings can be more easily seen.

Dividers. 1. Dividers may be used for drawing circles or arcs of circles on metal. A light center-punch mark is made to locate the center of the circle.

2. Dividers are also used to measure material of irregular shape. This is done by setting the points a certain distance apart, say ¾ in., and stepping this distance off along the edge to be measured. The length would be the number of divisions times ¾ in. When measuring a drawing or a piece of curved bar iron, the measurement should be taken along the center line of the piece. (See Fig. 9.) This method is particularly useful in determining the amount of stock necessary for making curved or irregular pieces.

3. Dividers also may be used for spacing a circle or other lines into a definite number of equal parts. Set the dividers by guess at what is estimated to be the size of the part it is desired to find, then

step this distance off on the line. If the dividers are not properly set, change the adjustment and make more trials until the correct spacing is obtained.

Center Punch. 1. A center punch is used to begin the center of a hole that is to be drilled. Locate the center by means of two intersecting scratch-awl lines, place the point of the center punch at the intersection, and strike it a light blow with a hammer, as in Figure 10. If the mark does not coincide with the intersection of the lines, the mark may be moved by tilting the center punch sidewise in the direction in which the mark is to be moved, and striking another blow with the hammer.

2. Center-punch marks are also used for marking iron at the place at which a bend is to be made while the iron is hot.

Calipers. Calipers are used for measuring circular objects. Outside calipers are used for measuring the diameter of rods and cylin-

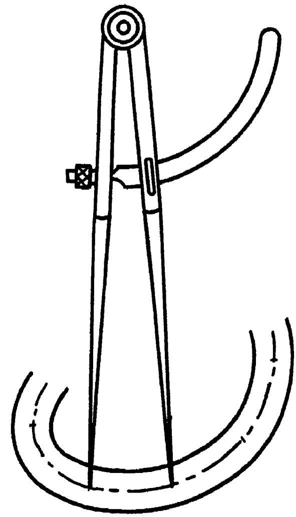


Fig. 9. Measuring a curved bar of iron with a pair of dividers

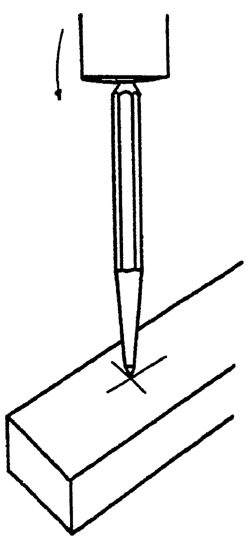


Fig. 10. Beginning a hole with a center punch

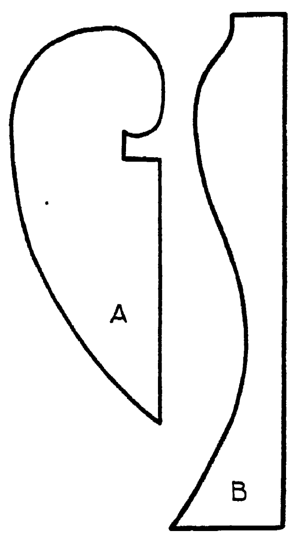


Fig. 11. Templates for testing curves

ders; inside calipers, Figure 52, for measuring openings. These tools are most often used in lathe work. The workman who uses calipers must develop a very fine sense of touch, so that he can tell by the "feel" of the instrument whether his measurement is accurate or not.

Templates for Testing Curves. Templates are used to test the contour of a curved surface or piece of iron. The curve on the template is the standard which the workman tries to reach when shaping the metal. Two such templates are shown in Figure 11; the one at A is for testing the curve of the heart-shaped ornament on the heart-design magazine rack, Figure 74, and the one at B is for testing the lower part of the legs for the telephone table, Figure 70. The best templates are made of metal, preferably No. 26 galvanized iron.

a) The contour of a template may be developed as follows: Make a full-size mechanical drawing of the part as shown in the text. Draw the squares on the galvanized iron as shown in the plate, and then trace out the curve. Cut along the edge of the curve, and the template is complete. It should be marked, telling which curve it is intended to test with it.

b) A template also may be developed by tracing the contour of a completed piece of work on the galvanized iron.

c) Instead of cutting the curve on the template, trace out the curve by making a series of light center-punch marks along the lines. This kind of template is used chiefly for testing curves involving scrolls.

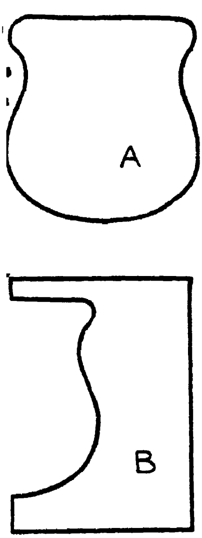


Fig. 12. Templates for lathe work

Templates for Lathe Work. Templates may be used for testing curved work made on the lathe. Figure 12 shows two templates which may be used for testing the contour of the tulip for the tulip-design candlestick, Figure 93.

To use template A, set the outside calipers on the template at the place at which it is desired to test the diameter of the work on the lathe; cut the work down until the calipers pass over it readily. Continue in this manner until the whole piece has been made.

To use the template B, cut the stock down to the correct diameter at two places, then cut the remainder of the stock down until the template fits at all points.

Templates for Spacing Holes on Rings. For laying off equally distant spaces on a circle, or for laying off holes the same distance apart on rings, the spacing templates shown in Figure 13 may be provided. They consist of sets of concentric circles, with equally spaced lines running through the center.

When laying off holes for the rings on the taboret, Figure 65, or on the fern stands, Figure 81, these spacing templates should be used.

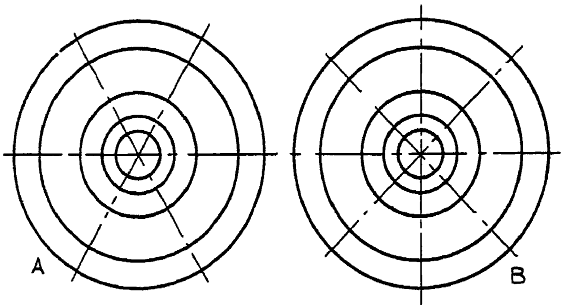


Fig. 13. Templates for spacing holes on rings

Templates for Laying Off Holes. Templates for laying off holes are helpful when a large number of pieces are to be drilled in the same way; for example, in laying off the holes in the legs of the kitchen stool, Figure 63. Such templates are made to fit over the piece, or against some well-defined starting point. Thus, in making the above template, it might be made to fit over the angle iron and up against the foot end of the leg.

Templates for Testing the Length of Duplicate Parts. Where a large number of duplicate parts of the same length are to be made, a template may be so designed as to serve in gauging the length of each piece as it is made.

Operation C

CUTTING

The Hack Saw. The hack saw, Figure 14, is used for cutting iron and other metals. The blade is placed in the frame with the teeth pointed away from the handle.

1. Start the saw into the work with the help of a file mark or a chisel cut.

2. Select a blade having the number of teeth best suited to the work in hand. A blade having 18 or 20 teeth per inch will be found suitable for average use. Draw the blade up tight in the frame.

3. Grasp the handle of the frame with one hand, and place the fingers of the other hand on the adjusting screw at the head end of the frame. This will make it possible to guide the saw with both hands.
4. Cut at the rate of about 35 strokes per minute.
5. Use the entire length of the blade.

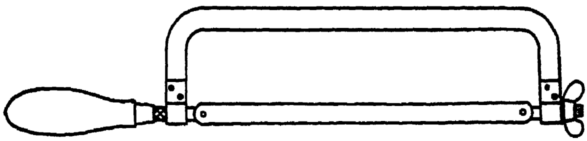


Fig. 14. Hack Saw

6. Release the pressure on the saw at the return or backward stroke.
7. When cutting thin material, it is easier on the saw if the cut is taken across the widest dimension of the stock.

Shears. Various kinds of shears are manufactured for cutting bar iron. (See the manufacturer's description for directions on how to use the shears.)

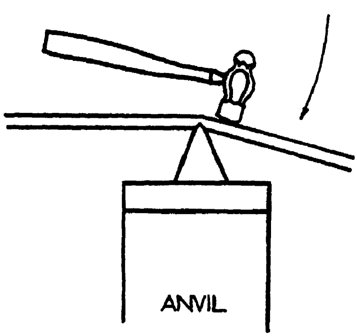


Fig. 15. Striking the final blows

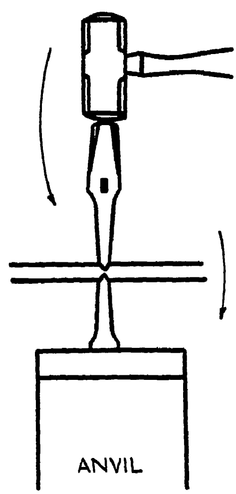


Fig. 16. Cutting heavy stock

The Cold Chisel. The cold chisel, Figure 50, may be used for cutting sheet metal and thin bar iron, for cutting off rivet heads, and for chiseling out slots and grooves.

The Anvil Tools. The hardie is the most commonly used anvil tool for cutting. It is placed in the hardie hole of the anvil, the stock to be cut is laid across it and struck with a hammer until the cut is almost complete. The final blows are struck so that the hammer will not hit the cutting edge of the hardie, as shown in Figure 15.

The handle cold chisel and the handle hot chisel are used in connection with the hardie and the hot anvil chisel for cutting heavy stock. (Fig. 16.) The final blows should be struck with a hammer, as shown in Figure 15.

The Emery Grinder. The emery grinder is used to remove small amounts of surplus stock, and to help give a piece of material more nearly its final form after it has been worked on the forge. The grinder is a dangerous machine, and should not be played with. The operator should wear goggles to protect his eyes from flying particles of metal or grit.

Files. Common shapes of files are flat, half round, square, round or rat-tail, and triangular. File teeth are classified according to size into coarse, bastard, second cut, and smooth. On some files the teeth are formed by grooves running across the file in one direction. These are called single-cut files. When the grooves run in two directions they are known as double-cut files.

Files cannot be sharpened. They should not be dropped nor struck, as they are very brittle and break easily. They should never be rubbed one over another. as this ruins the teeth.

1. Clamp the metal in the vise, between two projecting jaws of soft iron or copper.

2. Select a file of the proper degree of coarseness. Grasp it by the handle with one hand, and rest the other hand on its front end. Move the file forward for the cutting stroke. (Fig. 17.)

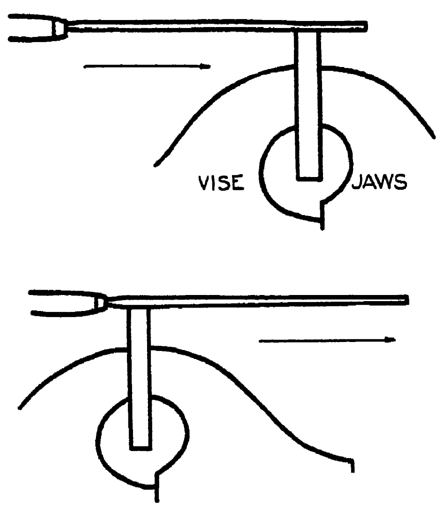


Fig. 17. Moving the file forward for the cutting stroke

3. Use the entire length of the file.

4. Release the pressure or raise the file up from the work on the return or backward stroke.

5. Learn: (*a*) To hold the file perfectly level on the entire stroke.

b) To leave the work true and flat after filing.

c) To remove the exact amount of material; no more, no less.

d) To shape a curve with a file so that it will be smooth and graceful.

Draw-Filing. Draw-filing is the process of finish-filing a piece of work, when the file is to produce the final surface or finish which the piece of work is to have.

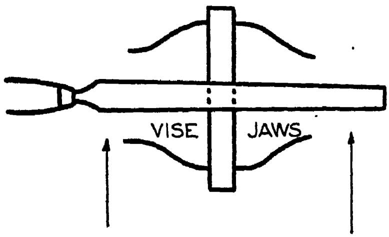


Fig. 18. Moving file back and forth over work for draw-filing

1. Use a single-cut or mill file.
2. Grasp the file with one hand at each end, hold it at right angles to the direction in which the cut is to be taken, and move it steadily back and forth over the work. (Fig. 18.)

Emery Cloth. See Operation Z on "finishes."

The Metal-Working Lathe. The lathe and its operation is a special subject and is not included in the scope of this text. Lathe manufacturers supply descriptive material on how their lathes are to be operated.

Operation D

TAPERING

Tapering is the process of drawing a taper on a piece of work, which means that it gradually decreases in size. Thus, a bar may be ½ in. in diameter, but a portion near one end may become gradually smaller and smaller until the end is ⅛ in. in diameter. This portion is said to be tapered.

To Draw a Taper on a Square Bar. 1. Hold the metal on the anvil at an angle equal to about half the amount of the slant it is desired to produce on the piece. Hammer the upper side. Hold the work with the end touching the edge of the anvil, as at B, Figure 19, so that the hammer blows will not fall on the anvil and scar it.

2. Turn the work over a quarter revolution, and hammer part of the taper on these two sides.

3. Turn the metal back to the first side, and repeat the operation until the desired amount of taper has been produced. Finish the tapered surfaces with the help of the flatter and sledge, as at C, Figure 19.

To Draw a Taper on a Round Bar. 1. Hammer the portion to be tapered until it is square; then draw the taper square, as described above.

2. Hammer the work on the four corners of the taper to make the

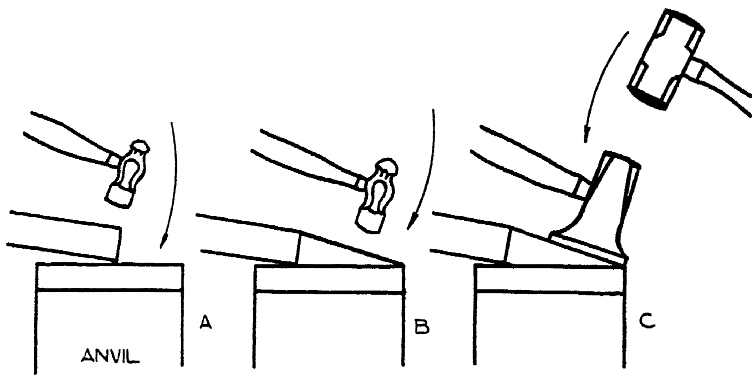


Fig. 19. Drawing a taper on a square bar

tapered end eight-sided. Hammer just enough to make the tapered part round.

Discussion of Method Used. Figure 20 illustrates what happens

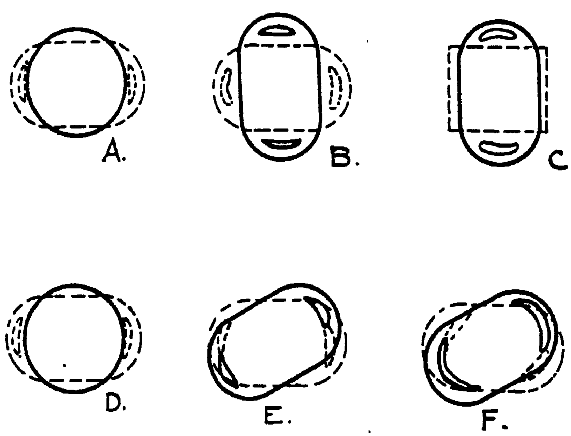


Fig. 20. Formation of cracks when drawing a taper correctly and incorrectly

when a bar of iron is tapered. When the round bar is hammered flat on two sides, there is a tendency for the metal to draw away from the center and to form cracks near the outside, as at A. At B, the work has been turned through a quarter revolution, and the other two sides have been hammered flat. This closes up the first two cracks, but tends to form two others. At C, the work has been turned back to its previous position as at A. If the work is now turned alternately and hammered as described, it will finish up square, with practically no cracks in it.

At D, E, and F, is shown the tendency when the work is revolved only a small amount as the hammering continues. It will be seen that the cracks tend to become larger and longer. If this procedure is continued, the surface will tend to break away from the center and leave the work structurally weak and liable to breakage.

Operation E

UPSETTING

Upsetting is the process of thickening a piece of metal by heating it and beating it back on itself.

When cutting stock, additional material must be allowed for upsetting, as this operation shortens the stock. The amount to be allowed may be determined by cutting a trial piece, and measuring it before and after upsetting.

1. Heat the portion to be upset to almost the welding heat.
2. (*a*) Drop the piece end downward on the anvil, or (*b*) ram it against the side of the anvil, or (*c*) clamp it securely in the vise and strike blows endwise on the piece, as in Figure 21.

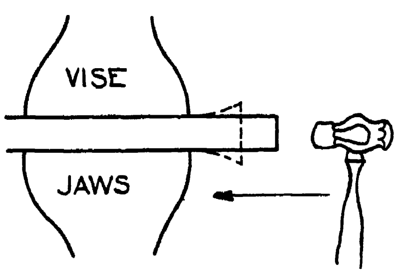


Fig. 21. Direction of hammer blows to be used in upsetting stock

3. Straighten any part that may have become bent; then beat the upset portion so that it is symmetrical at all points.
4. To upset a portion other than the end, heat this portion, cool off the other parts adjacent, and proceed as above.

Operation F

FLARING

The term "flaring" will be used to designate the operation of flattening a piece of material and causing it to flare outward at the sides. Thus, a piece of stock may be ½ in. in diameter, but one end may have been flattened and spread gradually to perhaps 1 in. wide and $\frac{3}{16}$ in. thick at the widest place. This flattened part is said to flare outward.

1. Upset the end of the stock to be flared.
2. Lay the iron on the anvil and hammer it out flat.

If just ordinary blows are used to flatten the metal, it will spread out uniformly in all directions. By striking blows so that they fall in the same direction as when upsetting the stock, the width of the flare will increase much faster than the length. (Fig. 22.) Finish by smoothing with the flatter and sledge.

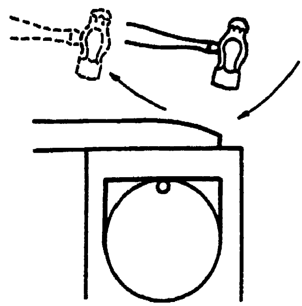


Fig. 22. Direction of hammer blows to be used in flaring stock

Operation G

TWISTING

1. Mark off the beginning and end of the twist.
2. Clamp the material in the vise with one mark even with the top of the vise jaws; grasp the iron with a monkey wrench at the other mark. Use the other hand to hold the metal at some distance above the monkey wrench, in order to help guide the iron and avoid bending it out of straight.

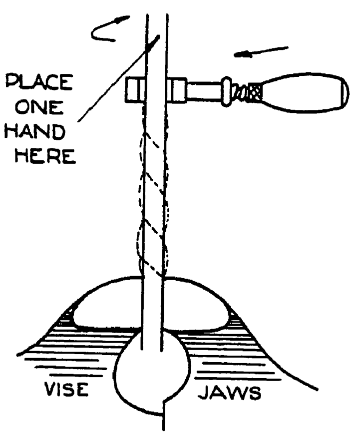


Fig. 23. Twisting a bar

3. Twist in the direction desired, and make the number of revolutions and parts of revolutions wanted.
4. Bars of small size may be readily turned cold. Large sizes should be heated to a uniform temperature, in order that the metal will twist a like amount everywhere.
5. If the metal needs to be lined up after twisting it, clamp it in the vise and pull it into line by hand, or strike it a blow with a lead mallet. Test with a straightedge.

To "Take Out" a Twist. If for some reason a twist is made in the wrong place, heat the twisted portion and proceed as before, reversing the direction of the twist. Smooth the metal with the flatter and sledge.

Twisting a Round Bar. To make a twist in a round bar, flatten out the bar at the place where the twist is to be made with the flatter and sledge. The flattened place should merge gradually into the round. The procedure is then just as that given in the foregoing; use a pipe wrench instead of a monkey wrench.

Operation H

MAKING BENDS OVER THE ANVIL

Bending operations on iron of any size must be done while the iron is hot. It is quite necessary for a uniform bend to heat the entire section to a uniform temperature. Otherwise the hottest part will be softer and will bend more than a part which is not as hot. Heat only the part to be bent; cool off the parts to be left as they are.

Mild steel can be worked best at a temperature just below welding heat. Tool steel should never be worked above a cherry-red heat.

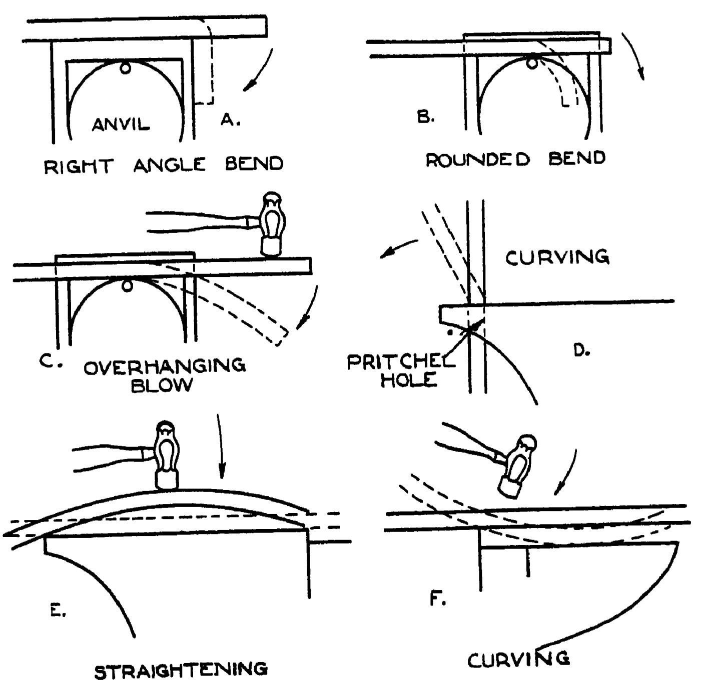


Fig. 24. Making bends over an anvil

1. How to make a right-angle bend over the anvil is shown at A, Figure 24.
2. Making circular bends is shown at B, C, and F.
3. The pritchel hole or the hardie hole may occasionally be used for bending or straightening iron in the same way as described for the bending fork in Operation M.
4. The flat face of the anvil may be used for straightening as shown at E.

Making Bends in the Vise. It is sometimes more convenient to make bends in the vise, instead of over the anvil.

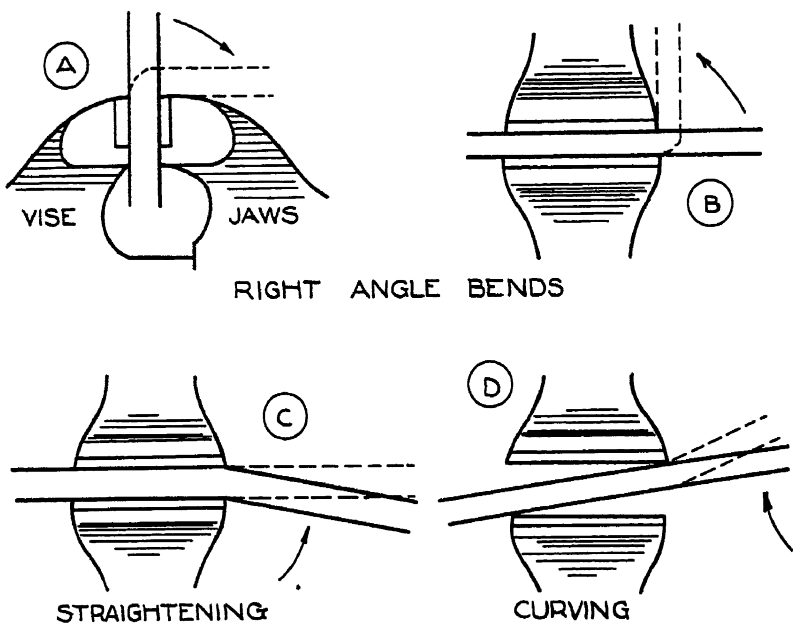


Fig. 25. Making bends in a vise

1. How to make right-angle bends in the vise is shown at A and at B, in Figure 25.
2. A bar of iron can be straightened by clamping it in the vise and bending it in the right direction, as at C.
3. The vise jaws occasionally may be used in the same manner as the bending fork in Operation M, as at D.
4. Sometimes a bend may be made more satisfactorily by clamping a short length of round stock in the vise and making a bend over it.

Operation J

SHAPING AN EYE

To Shape a Bent Eye. 1. Make a mechanical drawing of the eye required, and determine the amount of stock needed.

2. Bend the stock at right angles, as shown at A, Figure 26.

3. Bend the material over the nose of the anvil, or around a piece of rod of the desired diameter, until the end of the metal touches at

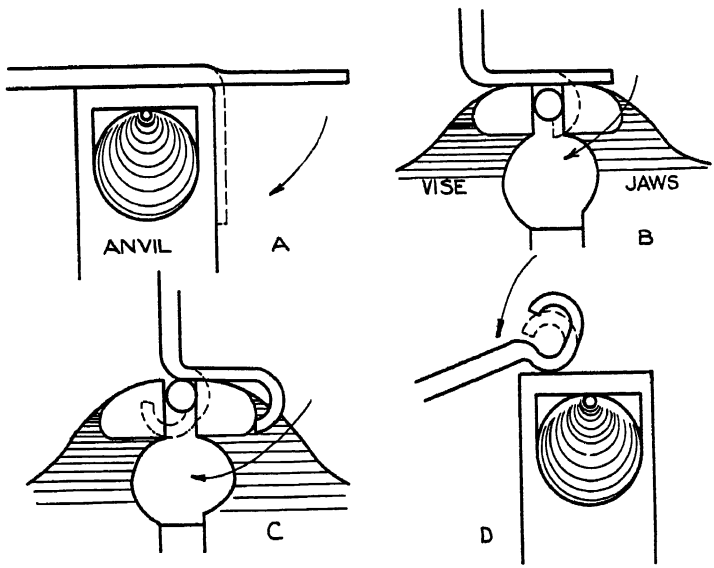


Fig. 26. Shaping an eye

the right-angle bend. The completed eye should be centered with reference to the center line of the rod.

To Shape a Welded Eye. 1. Upset the end of the stock.

2. Form a scarf on the end, as shown in Figure 49, Operation W on "Welding."

3. Bend to shape as described above.

4. Weld the scarfed end to the rod. Smooth the joint with the help of a top and bottom fuller.

To Shape a Punched or Drilled Eye. 1. Upset the end of the stock to an amount sufficient to make the eye of the size required.

2. Flatten and flare the end to the width and thickness specified.

3. Punch out the hole with a tapered punch over the pritchel hole of the anvil, or drill the hole on the drill press.

Operation K

SHAPING A RING

1. Calculate the amount of stock required by measuring with a pair of dividers the center line of the drawing of the ring.

If the ring is to be welded, add sufficient material to allow for upsetting and scarfing, as described in Operation W on "Welding."

2. If the ring is to be welded, begin by forming the scarfs on the ends.

3. Grasp the stock in the center with the link tongs, and bend part of one end over the anvil as at A, Figure 27.

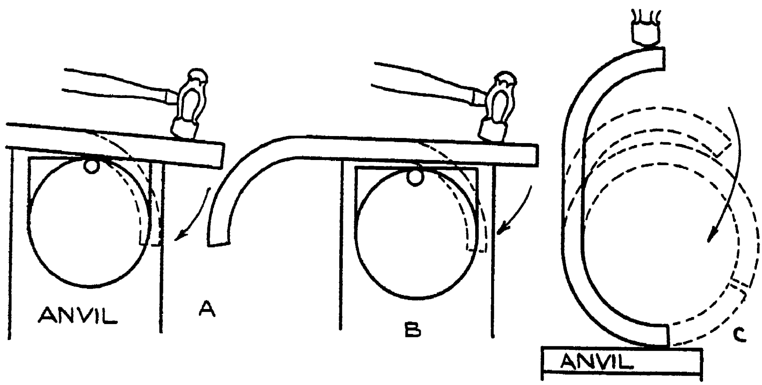


Fig. 27. Shaping a ring

4. Bend the other end round as at B.

5. Place the ring on the face of the anvil, and close up the ends as at C.

To Shape a Link. This procedure is similar to that for shaping a ring. Bend over only a small portion of both ends as before, and then make a small bend in the center so as to bring the ends together.

Flat Rings. 1. Flat rings may be joined by making a half-lap joint at the ends. Cut in halfway on each end and on opposite sides of the stock, an amount sufficient for an overlap of about ½ in.

2. Curve the ring as described above. It may also be curved in the bending fork. (Operation M.)

3. Rivet the ends together with countersunk rivets. (Operation S.)

If the ring is to be part of a project, such as a fern stand, Figure 81, the ends of the ring may be riveted together with the same rivet that holds the leg to the ring.

Flat Rings Made of Large Pipe. Excellent flat rings can be had by purchasing pipe of the diameter desired, as 2 in., 3 in., etc., and cutting it up into rings of the desired width.

Operation M

MAKING BENDS IN THE BENDING FORK

The bending fork consists of a thick base of steel with two steel prongs projecting upward, as at A, Figure 28.

These prongs may be made of various sizes of iron placed in differ-

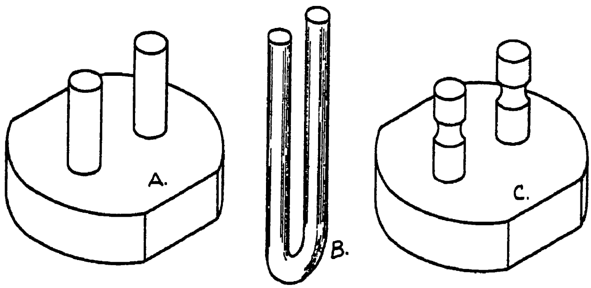


Fig. 28. Bending forks

ent distances apart, depending on the size of the material to be curved.

For small work, a piece of tool-steel rod may be bent to a U shape as at B, and clamped in a vise. For round work, shape the prongs as at C.

A temporary bending fork may be made by clamping two rods of the same size, the right distance apart, in a vise.

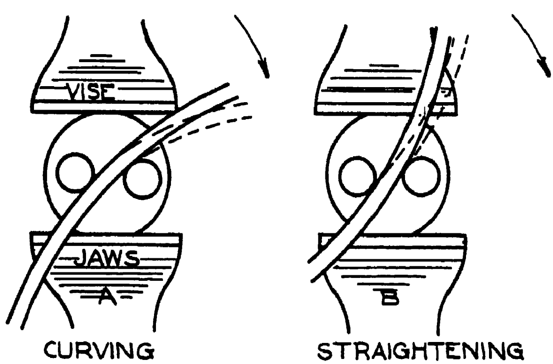


Fig. 29. Bending material in a bending fork

1. Select a bending fork best suited to the work in hand.
2. Place the work in position between the prongs, and bend the material a small amount in the direction desired as at A, Figure 29.

3. Move the metal a short distance along, and make another small bend. Continue the process until the required curve has been obtained.

4. The bending fork may be used either for curving or for straightening, as shown in Figure 29.

Operation N

BENDING WITH THE USE OF FORMS

Bending Duplicate Parts. In shaping any of the projects in the text comprised of several duplicate parts, always be sure that the parts are exactly alike as each step is accomplished. Make one bend on each of the pieces at a time and then compare them. When the pieces are alike, carry them through the next step and compare them again. Continue in this fashion until all the shaping has been accomplished.

An experienced craftsman would shape all duplicate pieces over the anvil. However, the student will work more rapidly and produce more accurate work with the help of forms over which to shape them.

Forms are heavy bars of iron used in shaping such parts. It is easier to make one simple form of say ⅜ by 1½-in. material and shape these parts over it, than to try and shape them separately over the anvil. After a form has once been made, it can be used for shaping a large number of pieces. Or, if desired, it can be changed to fit another curve, so that it would not be necessary to have a large number of forms on hand.

To Make a Simple Form. 1. Make a full-size drawing of the curve it is desired to shape, and then draw the form as it will have to be to fit inside the curve. The form has the same curve as would be made for a template as described in operation B.

2. The easiest way to hold the metal on the form while the metal is being bent, is to clamp the form and the metal together in the vise. (Fig. 30.) Estimate the amount of stock required, allowing several inches extra.

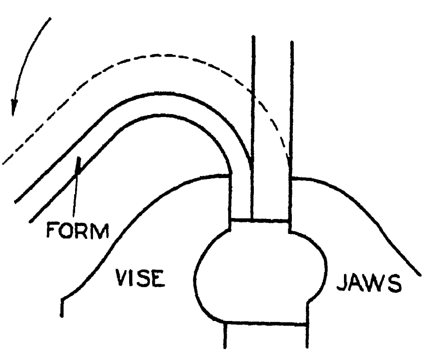


Fig. 30. **Form and metal clamped together in vise**

3. Bend the form over the anvil, or in a large bending fork, until the curve corresponds to the curve on the drawing or on the template.

To Use a Simple Form. 1. Test the form with the template or with the mechanical drawing to make sure that the form has the correct curve.

2. Place the form and the heated metal in the vise, and clamp the ends together as in Figure 30.

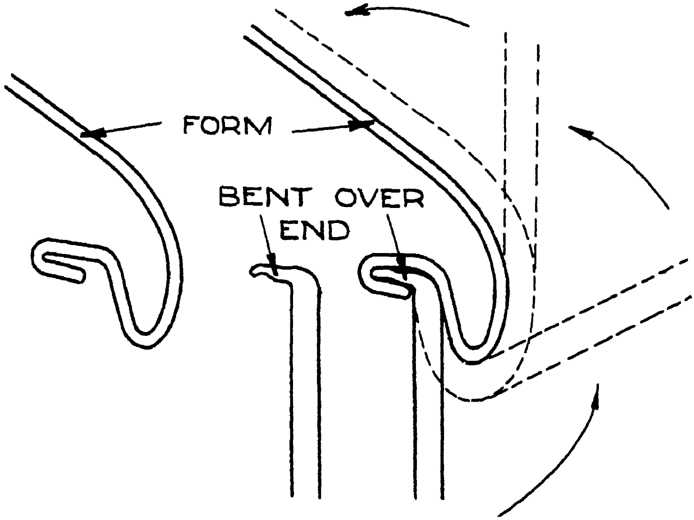


Fig. 31. Shaping lower end of legs of cage standard in Fig. 111

3. Pull the metal down until it fits over the form at all points, as shown by the dotted lines in Figure 30.

4. Cool the metal and the form. Check the curve on the metal with the curve on the template.

A Simple Form With a Hooked End. In a few cases a form with a hooked end may be necessary. Figure 31 shows how to shape the lower end of the legs for the cage standard, Figure 111. The procedure is similar to that described above.

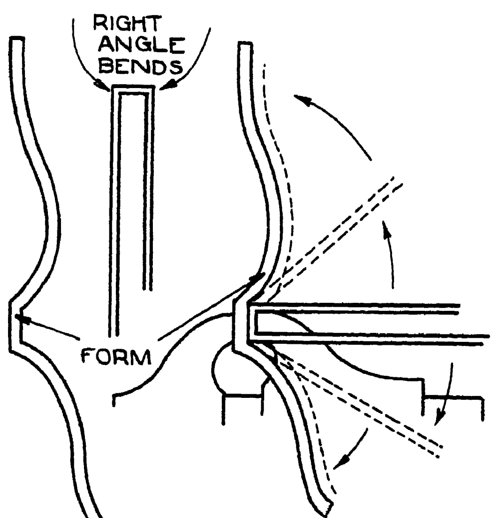


Fig. 32. Bending lower part of legs of fern stand in Fig. 81

Compound Forms. A compound form is one over which a series of curves running in different directions may be made. Such a form is made in the same way as a simple form is made.

1. A form for shaping the lower part of the legs for the cross-bar design fern stand, Figure 81, is shown in Figure 32. The stock is first

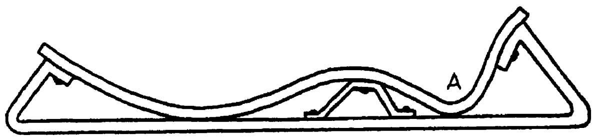


Fig. 33. Compound form for shaping legs of telephone table in Figure 70

bent at right angles as shown. (See Project 33 for dimensions.) The stock and the form are then clamped together in the vise and the bends made as shown by the dotted lines.

2. A compound form for shaping the legs for the curved-design telephone table, Figure 70, is shown in Figure 33. The legs are first bent over the anvil or in the bending fork until they fit into the form at A. Each leg is then clamped in place at A with a C clamp, and the bends on both sides are made. As the bending progresses, more and more C clamps are applied until the entire curve has been made.

Operation O

BENDING SCROLLS OVER SCROLL FORMS

The scroll is one of the most common types of decoration used in ornamental ironwork. Its beauty is due to the fact that unlike the circle it is a curve of ever-changing direction; there are no two points on it which have the same radius. The curves in Figure 34 begin at the center; as they pass each radial line, their radii increase by an additional unit. By changing the size of the unit, or by increasing the number of radial lines, a large number of different spiral curves can be developed.

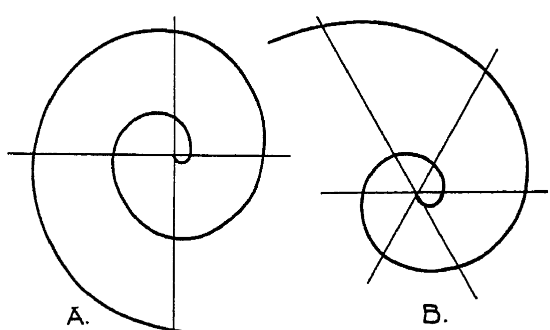


Fig. 34. Developing spiral curves

To Make a Scroll Form. 1. Make a full-size drawing of the scroll it is desired to bend. Draw in the size of the iron to be used.

2. The scroll form will not have exactly the same shape as the finished scroll, because the scroll is to be bent around the outside of the scroll form. Or, stating it otherwise, the scroll form fits inside the completed scroll. Draw the scroll form.

3. Measure the length of stock required, and allow several inches extra. Use 3/8 by 1½-in. material.

4. The most important part of the scroll form is the center or inside end. When the scroll form is to be used, the metal to be bent should be caught on the end of the scroll form by means of a hook shaped on the end of the metal for this purpose. The end of the scroll form must be so shaped as to receive this hook. In most instances, this hook will be a part of the finished scroll, so that additional care will be required.

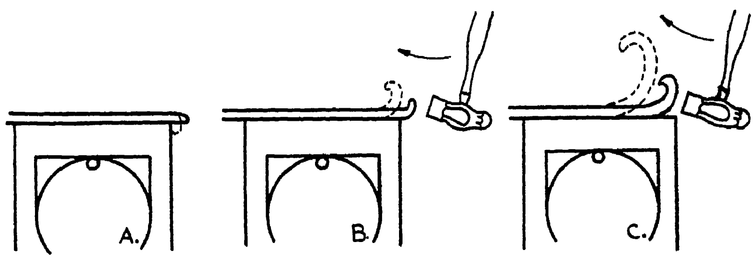


Fig. 35. Making a scroll form

5. Thin out an inch or two of the stock for the scroll form. Bend the hook over the rounded edge of the anvil as at A, Figure 35.

6. Thin out the end, and bend over a hook on a trial piece of the kind of iron that is to be shaped over the scroll form, and see whether it will catch on the hook on this form. Do not proceed until this step has been accomplished satisfactorily.

7. Continue shaping the scroll form by laying the metal down on the anvil and striking blows as illustrated at B and C, Figure 35. Test out the end to see whether the trial piece will still catch. Test the shape of the scroll with the drawing. Continue until the desired curve has been obtained.

Part of the shaping of the scroll form may also be done with the aid of a large bending fork.

To Bend a Scroll Over a Scroll Form. 1. Determine by trial the amount of stock needed for shaping the scroll.

2. Thin out the end of the stock for an inch or two, and start a hook by bending the metal over the rounded edge of the anvil as at A, Figure 35. Bring the stock on around as illustrated at B and C.

3. Test the hook to determine whether it will catch on the inside end of the scroll form. Occasionally it will be necessary to bend over as much as ½ in. of the end to form the hook, most of which will need to be cut away after the rest of the scroll has been formed.

4. If more than one scroll is to be shaped, bend the hook over on all the pieces and compare them.

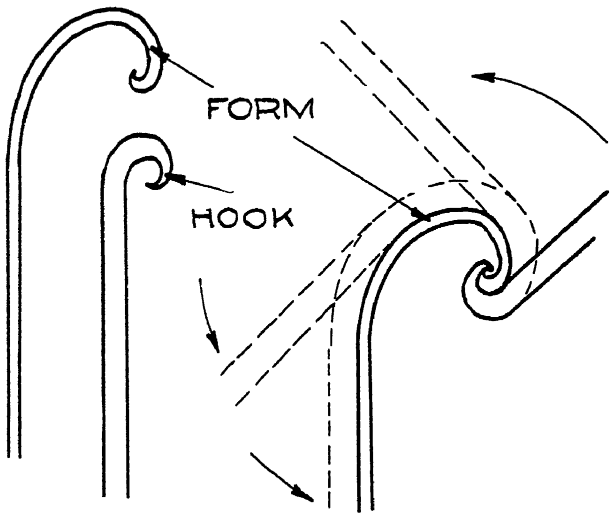


Fig. 36. Bending a scroll over a scroll form

5. To complete the operation, heat the portion to be shaped, cool the hook in water to prevent it from "pulling out," catch the material in the form, and bring it around until it fits down on the form at all points. (Fig. 36.)

When a great number of scrolls are to be made rapidly and with great accuracy, it is advisable to make a scroll form as illustrated at A, Figure 36*a*. Get a short length of heavy angle iron, about ⅜ by 3 by 3 in. Mount the scroll form, prepared as described above, on one side of this angle iron by means of a bolt and brace, or by welding it in place with an oxyacetylene torch. Prepare a clamping handle as illustrated, and rivet it to the angle iron so that it will swing freely.

To use this scroll form, clamp it in a vise, thin out the end of the iron to be curved, bend this end a small amount, and place it against the scroll form. Hold it there by means of the clamping handle, and bend it on around as at B, Figure 36*a*.

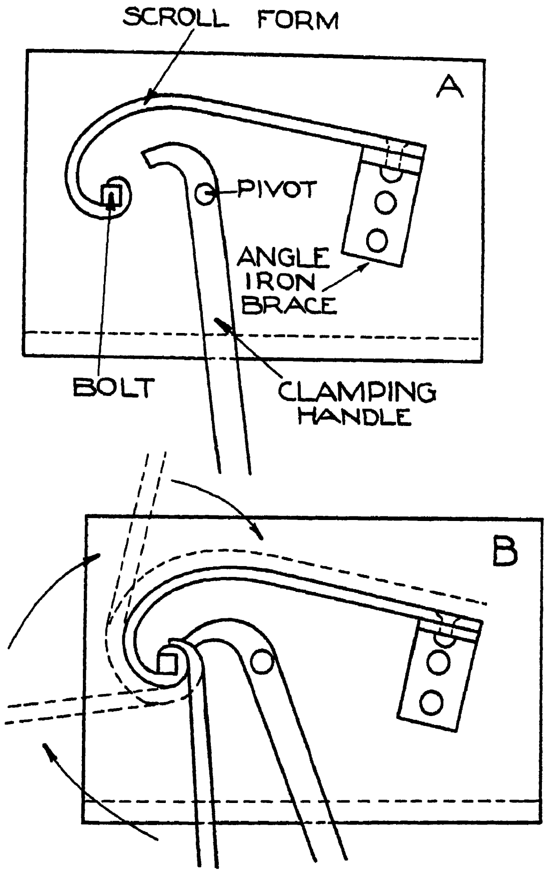


Fig. 36a.

Operation P

RAISING

"Raised" bases or "raised" candle cups are used on almost all the candlesticks and on most of the electric-light projects described herein.

Only two thicknesses of metal are used, Nos. 24 and 16.

The Cut-Edge Block Method. 1. Prepare the block by cutting one edge of the end grain to the shape it is desired to produce on the stock.

2. Cut a piece of sheet iron about 1 in. bigger all around than the

finished size is to be. This is to stiffen the edges when the metal is being beaten down into the grooved block.

3. Draw a circle to show where the raised portion is to begin. Lay the metal on the block with part of the circle over the cut edge of the block. With the ball end of a hammer, strike blows on the stock so as to raise the edge. Move the metal along, and continue until the entire circle has been gone over.

4. Strike blows nearer the center of the work, and follow around the circle again. Continue until the metal has taken on the form of the edge of the block.

5. Striking the metal as described above will cause it to stretch and harden. Anneal the iron occasionally to prevent it from breaking.

6. Trim off the excess material and smooth the edge.

The Hollowed-Out Block Method. Hollow out the end grain of a block of wood on the lathe to the shape it is desired to give the base, and proceed to hammer it from the edge inward until the metal fits into the block.

Method Using Different Sizes of Pipe Collars. Instead of hollowing out a block of wood, it is possible to use large pipe collars of different sizes, and raise the metal by working from the outside to the center, striking blows with a rounded wooden mallet. (Fig. 37.)

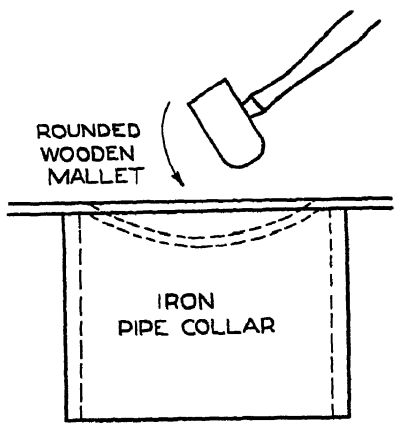


Fig. 37. Raising metal over a pipe collar

Operation O

MAKING ROSETTES AND LEAF ORNAMENTS

Rosettes and ornamental leaves occasionally are added to a piece of work to further decorate it. Too much of this kind of artificial decoration should not be used, as it tends to lessen the beauty of the design.

All ornaments described in the text are made of No. 24 sheet iron.

The Four-Leaf Clover. The four-leaf clover A, Figure 38, generally is used where two pieces are joined by means of a rivet. The same rivet that fastens the pieces together also holds the ornament in place.

The design is drawn inside a square, as illustrated, and cut out with a pair of tin shears. After being fastened in place, the leaves may be bent together slightly.

Four-leaf clovers may be enameled green, with gold-bronze trim, or may be finished to harmonize with the finish on the rest of the work.

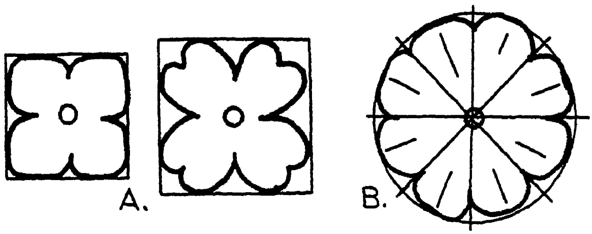


Fig. 38. Patterns for leaf and rosette ornaments

The Rosette. The rosette, or a form very similar to it, is used in much the same manner as the four-leaf clover.

1. Draw a circle of the desired size. In this circle, draw four equally distant lines that intersect at the center.

2. With a tin shears, scallop the edges as shown at B, Figure 38.

3. To make the design look more realistic, use a blunt-edged cold chisel to make dents in the flower at the places where the petals are supposed to meet. (Fig. 39.)

4. To make the petals seem more realistic, turn the rosette over, and make dents in the center of the petals as described above. (Fig. 39.)

5. Rosettes are usually painted red, with gold or black-bronze trim.

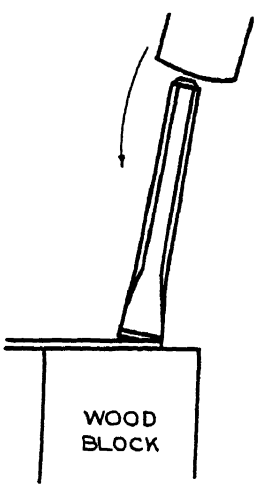


Fig. 39. Making dents in petals

Leaf Ornaments. Leaf ornaments are generally used on parts of a design which otherwise would be rather long and monotonous. See the leaf-design fern stand, Figure 81.

1. Draw the design on the sheet metal, and cut it out with a pair of tin shears.

2. To make the leaf appear more realistic, make marks with a blunt-edged chisel to represent the veins of the leaf, as in Figure 39.

3. Curve the leaf to harmonize with the curve of the part it is desired to ornament, and rivet it in place with a ⅛-in. rivet.

4. Leaf ornaments are usually finished in dark green with gold or black-bronze trim.

The Flower Ornament. This ornament is used at the base of an upright part of a design, to smooth the break between the upright member and a flat member. Thus, such an ornament might find suitable application between the base and the upright of a candlestick or table lamp, or it might be used to enhance the design at the joint between a light fixture and its support.

1. Draw a circle having the same diameter as the upright it is desired to ornament. Draw another circle enough larger to make the petals as long as has been decided upon. Draw two intersecting lines as center lines for the petals. Draw the petals. Notice that two opposite petals are smaller, in order to fit inside the larger ones when all the petals are bent up. (Fig. 40.)

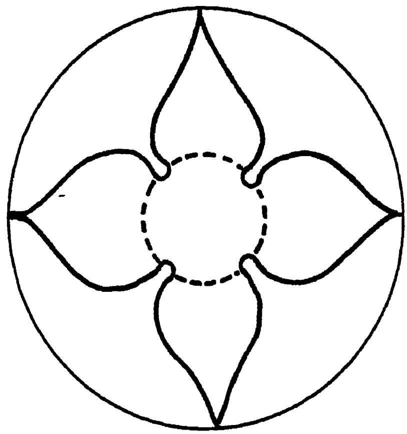


Fig. 40. Pattern for a flower ornament

2. Bend the flower to shape over a rounded length of rod having the same diameter as that of the part over which the flower is to fit.

3. These ornaments are fastened in place by clamping them between the base and the upright part of the design.

When they are to be fastened to the base of an electric-light fixture, drill an $\frac{11}{32}$-in. hole through the center, and file the hole out until the flower can be screwed in place over the $\frac{1}{8}$-in. pipe nipple.

4. These ornaments are finished to harmonize with the rest of the work.

Operation R

DRILLING

Description of Drills. Metal-working drills are made of high-grade tool steel. They consist of three essential parts: the shank, the body or flutes, and the point.

1. The shank of the drill, Figure 41, is the end by which the drill is held in the machine or tool which operates the drill. Straight-shank

drills are used in a drill holder or drill chuck. Only small sizes of drills up to about ½ in. in diameter, are made with straight shanks.

Tapered-shank drills fit into similarly tapered openings in the spindle of the drill press or lathe.

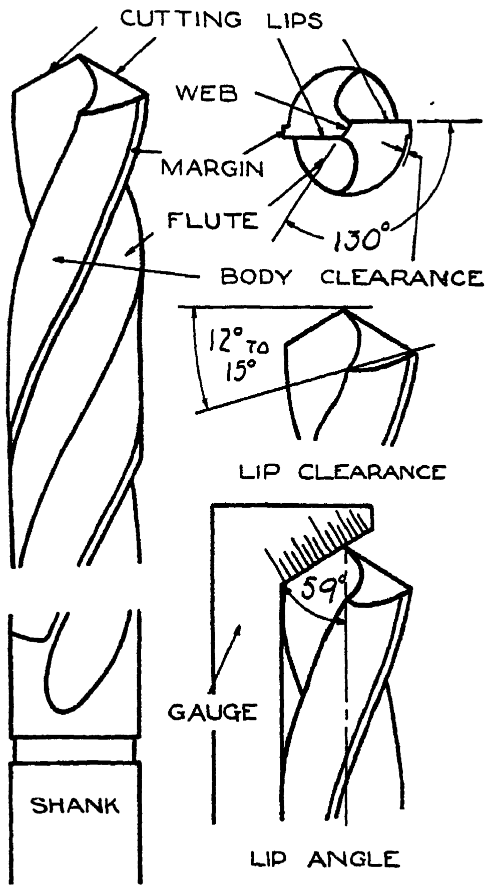


Fig. 41. Details of metal-working drill

2. The body of the drill has spiral grooves or "flutes" cut in it. These flutes serve to form the cutting edges at the point, and as a means of escape for chips. Lubricating oil reaches the cutting lips by way of the flutes. Observe the margin and the body clearance, Figure 41, which make for ease in drilling. The section between the flutes is called the "web." The web becomes thicker near the shank of the drill.

3. The point of the drill is that part which does the cutting. It consists of the cutting lips and the sharpened end of the web.

4. Drills are made in a great number of sizes.

Sharpening a Drill. 1. The lips of the cutting edge must be ground to an angle of 59 degrees with the axis of the drill. (Fig. 41.) Unless both lips are ground to the same angle, only one of the lips will cut, causing the drill to break.

2. The two cutting lips must be the same length. If one of the lips is longer, the hole made will be larger than the diameter of the drill. Gauges for testing the angle and the length of the cutting lips may be had. (Fig. 41.)

3. The cutting lips must have "lip clearance," that is, the surface behind the cutting edge must be ground away to an angle of from 12 to 15 degrees, so that when the drill is rotated the cutting edges will dig into the material being drilled.

4. The angle made by the lip surfaces at the web should be 130 degrees for the best cutting.

The Drill Press. A drill press has essentially a rotating spindle fitted to receive the shank of the drill, a lever or handwheel for feeding the drill into the work, a drill-press table or vise for holding the work, and a pair of cone pulleys, or a motor rheostat for changing the speed at which the drill is rotated.

Rotating the Drill. The "peripheral speed" of a drill is the distance traveled by the extreme outer end of one of the cutting lips. Thus, if the drill is 1 in. in diameter, this point would travel 3.14 in. per revolution; at 100 revolutions per minute the distance traveled by this point would be 314 in., or a little better than 26 ft. per minute.

1. For average conditions, the best cutting speed for mild steel is 30 ft. per minute, for cast iron 35, and for brass 60 ft. per minute. Under different circumstances, this speed may have to be increased or decreased, depending on the good judgment of the operator.

2. At about 30 ft. per minute, the following are satisfactory spindle speeds for different sizes of drills:

1/8" drill, 920 r.p.m.	1/2" drill, 215 r.p.m.
3/16" drill, 630 r.p.m.	3/4" drill, 150 r.p.m.
1/4" drill, 460 r.p.m.	1" drill, 110 r.p.m.
3/8" drill, 310 r.p.m.	1 1/4" drill, 90 r.p.m.

When the drill rotates too slowly, progress will be unnecessarily slow. When the drill rotates too fast, it will become hot and "burn" at the point.

Feeding the Drill Into the Work. The drill should be fed into the work as fast as is possible without danger of bursting the drill. It is particularly important to *release* the pressure on the feed lever when the drill is just about to break through the bottom of the hole. If this is not done, the lips of the drill will catch in the work and cause the drill to break.

Holding the Work. The work to be drilled must be held securely. If the work is allowed to shift as it is being drilled, the drill will bend and break.

For drilling round stock, a pair of V-shaped blocks will be found helpful in holding the work. The drill should pass through the axis of the work.

To protect the drill-press table from becoming full of holes, place a piece of scrap wood between the work and the table.

Starting a Drill. 1. Carefully lay off lines intersecting at the center of the hole to be drilled. Make a mark with a center punch, in order to guide the drill into the work. (Fig. 10.)

2. When accurately placed holes are desired, follow this procedure: Lay off the center as before. Make a light center-punch mark at this point. With a pair of dividers draw a circle the size of the hole to be

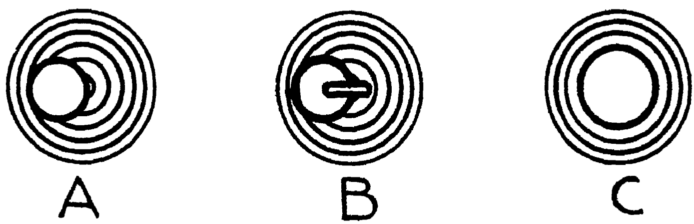


Fig. 42. Making holes with a drill

drilled. Draw several other concentric circles. Now make the center-punch mark deeper. Start the point of the drill into the material. Observe whether the circle made corresponds to one of the circles drawn.

If the hole made by the drill is not concentric with the circle drawn, the drill may be "drawn over." Chisel out a small groove on the side of the hole toward which the drill is to be moved, as at B, Figure 42. Run the drill into the hole a little farther and examine the circle made. Repeat this operation until the drill is properly centered. This must be accomplished before the entire length of the cutting lips has entered the material.

Pilot Holes. When drilling large holes, or when drilling holes close together, it is customary to drill "pilot" or "lead" holes about the size of the web of the large drill, before proceeding to drill the large hole.

Holes Out of Line. 1. File the holes out with a small rat-tail or round file.

2. Place the two pieces of metal together as they should be, clamp them together, and (*a*) run a drill through both pieces, or (*b*) ream the holes out with a reamer.

Operation S

RIVETING

Rivets are made of soft iron, and can be had in a variety of sizes and lengths, and with various shapes of heads. Round-head rivets are perhaps the most common.

1. Select the right diameter rivet. Do not use a rivet so large as to weaken the pieces being joined, nor so small as not to be strong enough.

2. Use a rivet long enough to project beyond the pieces being joined for a distance equal to the diameter of the rivet. If too little projects, the head will not shape up large enough; if too much, the end of the rivet will bend over out of shape.

3. Lay off the holes accurately. Drill them $\frac{1}{64}$ or $\frac{1}{32}$ in. larger in diameter than the size of the stem of the rivet. The tighter the rivets fit, the less upsetting will be needed to make the rivets hold; if the holes are too large, the rivets will bend over out of shape.

4. If the holes do not line up, see Operation R on drilling, under "holes out of line."

5. Place the rivet in position. To protect the head of the rivet, place it over another rivet set clamped in the vise, or over a metal block with specially prepared hollows in it to receive the rivet head. (See A, Fig. 43.)

6. Occasionally it will be found convenient to have a very short-stemmed rivet set, to set on the anvil, and another set with an off-set or shoulder in it, to get at otherwise inaccessible rivets.

7. Upset the stem of the rivet until the rivet fills up the hole. Shape the head (*a*) with a rivet set and hammer, as at A, Figure 43, or (*b*) with the ball of the machinist's hammer, as at B, Figure 43.

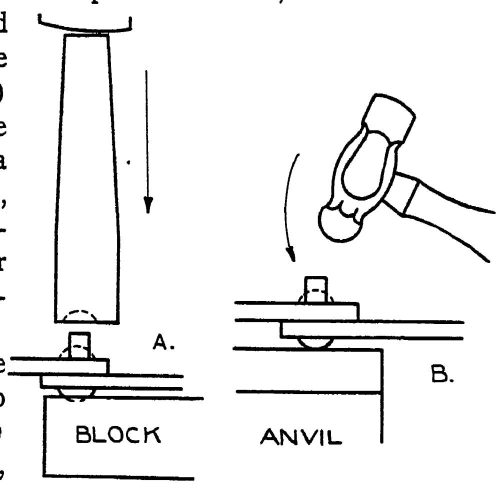


Fig. 43. Riveting

8. Test the joint to make sure that it will hold.

To Remove a Rivet. 1. Chisel off the head of the rivet and drive the rivet out with a long tapered punch.

2. Or, chisel or saw the two pieces apart and punch out the parts of the rivet.

3. When the rivet will not punch out, run a smaller size drill into the rivet until it works loose.

Operation T

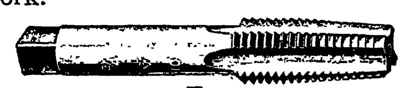
THREADING

Threading is the process of cutting threads on rods or in openings. A thread is a coiled or helical groove. Bolts and nuts make use of threads as a means of fastening.

Sizes of Threads. In order that threaded parts will fit together, several standard threads have been agreed upon. Some of the most important are U. S. S. or United States Standard; S. A. E. or Society of Automobile Engineers; and standard threads for pipe fittings.

U. S. S.			S. A. E.			Pipe		
Size	Threads per in.	Drill	Size	Threads per in.	Drill	Size	Threads per in.	Drill
1/4"	20	3/16"	1/4"	28	7/32"	1/8"	27	21/64"
3/8"	16	21/64"	3/8"	24	21/64"	1/4"	18	29/64"
1/2"	13	13/32"	1/2"	20	7/16"	3/8"	18	19/32"
5/8"	11	33/64"	5/8"	18	9/16"	1/2"	14	23/32"
3/4"	10	5/8"	3/4"	16	43/64"	3/4"	14	15/16"
1"	8	27/32"	1"	14	29/32"	1"	11 1/2	1 3/16"

Description of Taps. A tap is a tool used for cutting threads in an opening. It has threads cut on it just like a bolt, but in addition there are four flutes running across the threads. (Fig. 44.) The edges formed by the flutes and threads are the cutting edges of the tap. Part of the thread is cut away on the end of the tap to aid in starting the tap into the work.



Tap

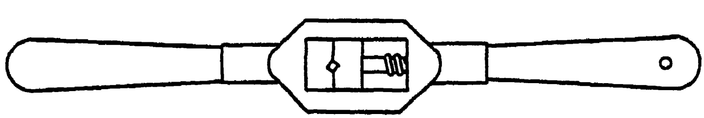


Fig. 44. Tap wrench

A bottoming tap is one on which only a small number of threads have been cut away, to be used for cutting threads almost to the bottom of the hole.

A special form of tap wrench is illustrated in Figure 44. A small tap wrench may readily be made as described in Project 5, and Figure 51.

Using a Tap. 1. Be sure the opening drilled for the threads is the correct size. (See the table under "Sizes of Threads.")

2. Clamp the work in a vise so that the tap may be placed in the hole in an upright position.

3. Place a few drops of oil into the hole.

4. Move the tap around from left to right for about a half revolution; reverse the direction for about a quarter revolution; "go forward two steps and backward one." Repeat until the entire hole has been threaded. Take out the tap occasionally to remove the chips.

5. As soon as it feels as though the bottom of the hole has been reached, remove the tap, and finish with a bottoming tap.

To Sharpen a Tap. Hold the tap against the emery grinder, so as to cut the teeth at the same slant as they were ground by the manufacturer. Give the teeth clearance by grinding away a small portion of the surface immediately behind the cutting points. It is very necessary to have all four cutting edges ground exactly alike.

To Remove a Broken Tap. 1. Heat the part which contains the broken tap, to the critical temperature of the tap, and allow the material to cool off slowly so as to soften the tap.

2. Drill a small hole into the tap.

3. Insert an "ezy-out" or special left-hand tap; as this left-hand tap is worked into the broken tap, it tends to work the broken tap loose.

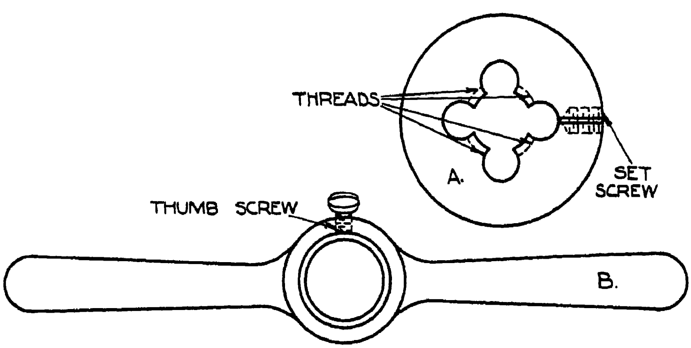


Fig. 45. Threading Dies

Description of Threading Dies. A thread-cutting die consists essentially of a cutter with threads on the inside, and with flutes cut across the threads in the same manner as in the case of the tap. Some dies consist of two matched cutters instead of one. Most dies are adjustable for size within narrow limits by means of a small setscrew (Fig. 45, A.) Part of the threads are cut away on one end in the same way as on the tap, in order to make it easier to start the die on the work.

A special form of wrench called a "die stock" is illustrated at B, Figure 45.

Using a Thread-Cutting Die. The directions for using a thread-cutting die are the same as those for using a tap. Figure 46 illustrates the method of using the thread-cutting die.

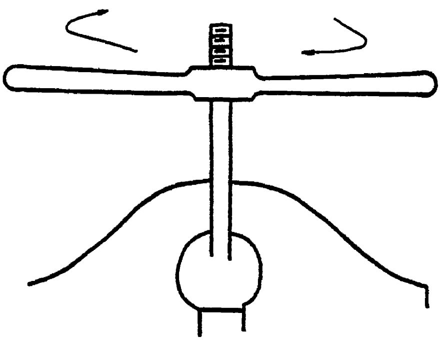


Fig. 46. Using a thread-cutting die

Bolts and Nuts. Bolts and nuts in a great variety of sizes and lengths may be obtained for almost any purpose desired.

Pipe Taps and Dies. Pipe taps and dies are similar to other taps and dies, except that the threaded parts taper a little. This is done so that pipe fittings may be drawn up tight and leak-proof.

Homemade Short Nipples for Electric-Light Fixtures. In making the various projects described in the text involving the use of electric-light fixtures, it will be necessary to have ⅛-in. short nipples by means of which to fasten the fixtures to the lamp. Homemade short nipples may be made by threading a section of ⅛-in. pipe with a ⅛-in. pipe die, and cutting the pipe off to whatever length may be needed.

Operation U

FASTENING WITH CLIPS

Clips are bands of metal bent around two or more pieces of metal in order to hold the pieces together.

1. Choose the size of stock out of which it is desired to make the clips, as ⅛ by ½ in. or ⅛ by ¾ in., and so on. Cut as many pieces as are wanted of one kind, and bend each one step at a time as described in the following:

2. In the vise, bend over at right angles a length equal to one half the widest measurement of the pieces that are to be joined. (Fig. 47.) Thus, if the pieces to be connected measure ⅜ by 1 in., this first bend would measure ½ in. from the inside corner.

3. Secure a piece of material ⅜ in. thick, and a few inches long. Place the bent part of the clip next to this ⅜-in. piece so that the clip

projects up ⅜ in., inside measurement. Place another piece of thick material next to the clip, and fasten the three pieces in the vise together, so that the thick pieces project above the vise jaws not less than ½ in. (See B, Fig. 47.) Bend the clip over the ⅜-in. piece.

4. Measure off 1 in. on the inner surface of the long side of the clip, then ⅜ in. more, then ½ in., and then from $\frac{1}{16}$ to $\frac{3}{16}$ in. extra for the

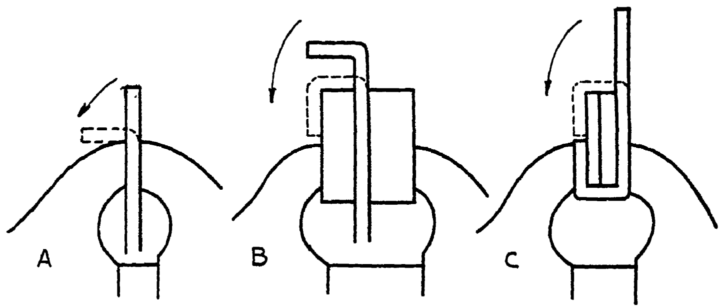


Fig. 47. Steps in making a clip

curves. Cut off the excess material at the last measurement. The clip is now ready to be clamped in the vise together with the pieces to be joined. The end of the clip is bent around the stock with a hammer, as at C, Figure 47.

Operation V

BRAZING

Brazing is the process of joining two pieces of metal by melting them together at the joint with spelter or brass.

1. Shape the parts so that they fit.
2. File and polish the parts at the place where the joint is to be made.
3. Clamp or wire, or otherwise fasten the pieces together temporarily, and as securely as possible, in preparation for brazing.
4. Examine the forge fire. Have a good deep fire and a good supply of coke on hand. Use only enough air to produce a "reducing" fire.
5. Heat the metal at the joint until it becomes red. Apply a small amount of powdered borax to the joint with a long-handled spoon.
6. As soon as the borax melts and flows over the joint, place a small amount of spelter or brass on the joint. Continue heating until the brass or spelter melts.
7. Remove the material from the fire and allow it to cool.
8. Remove the temporary fastening, and file the joint smooth.

Operation W

WELDING

Welding is the process of joining two pieces of iron by raising them to a welding heat and sticking and beating them together with a hammer.

1. Examine the fire. It should be free from clinkers. A large bed of live coal should be prepared, and a good reserve supply of coke should be on hand. Only a moderate draft should be used, in order to maintain a "reducing" fire.

2. The iron to be welded should be heated slowly, so that the interior may become as thoroughly heated as the outside.

3. As the metal approaches the welding heat, scale will form on the outside, which will interfere with the welding operation. To dissolve this scale, with a long-handled spoon place some powdered borax or prepared welding compound on the place where the joint is to be made.

4. Continue heating until the outside of the iron presents a sticky, molten appearance, and the *first* sparks begin to fly out from the surface. These are evidence that the metal has reached the welding heat.

5. Strike the metal against the anvil to remove the dross, place the pieces in position on the anvil, and press them together with a few light blows of the hammer. Work very rapidly.

If the operation does not succeed the first time, a second heat may be taken, but the more often the pieces are heated the more difficult it will be to make the weld.

6. Finish the joint by hammering and smoothing the outside.

A Practice Fagot Weld. The student should practice making fagot welds before attempting to do any other welding.

A fagot weld usually is one in which a short length of the end of a piece of iron is bent back on itself and welded to form a lump or bulge on the end. (Fig. 48.)

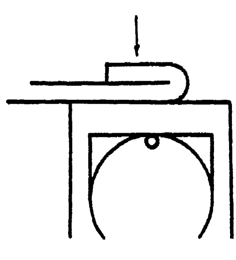


Fig. 48. A fagot weld

1. Make a center-punch mark at the place where the bend is to be made, heat to a cherry red, and bend the iron back on itself.

2. Get everything in readiness to make the weld. Place the anvil in an easily accessible position, and have the hammer placed within reach. Have the flux (powdered borax or prepared welding compound) and the long-handled spoon conveniently placed, and lay the proper tongs within

reach. Rehearse the motions to be gone through, so that no time will be lost at the critical moment.

3. Follow directions as given above. When making the weld, begin hammering at the end of the piece, and work toward the end of the bent-over part. This is to prevent the formation of scale pockets.

The Lap Weld. The lap weld is the most common type. It consists of two pieces which overlap when welded together.

1. Upset the ends to be welded as at A, Figure 49.

2. Shape the "scarfs" or overlapping ends as illustrated at B and C.

The scarfs are about one and one-half times the thickness or diameter of the bar in length, and are so shaped that, when placed together, only the centers touch. When the pieces are welded the centers will adhere first, and so prevent the formation of scale pockets.

3. Follow directions as given above.

4. Flat pieces may be smoothed with the hammer and sledge; round pieces between the top and bottom swages.

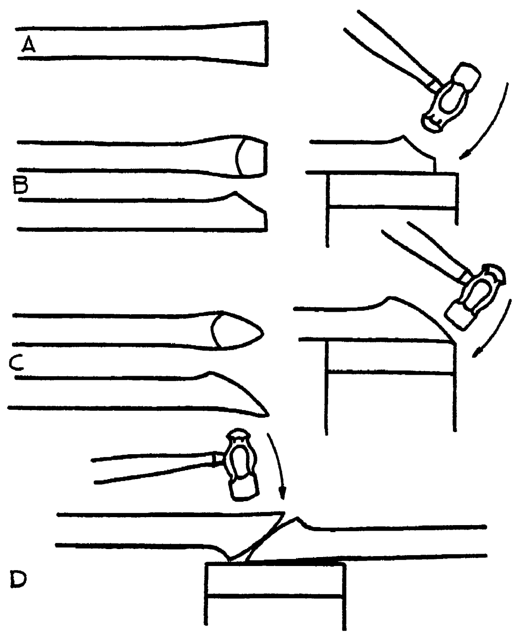


Fig. 49. Making a lap weld

Operation X

HARDENING TOOL STEEL

1. Be sure the steel has been brought to its final shape.

2. Examine the fire. Use only enough blast to maintain a reducing fire.

3. Anneal the metal before hardening.

Failure to thus remove strains set up by the shaping operations is likely to cause a crack when the steel is being quenched.

To soften the metal, heat it slowly to the "hardening heat" described in the following, and bury it in a large bed of ashes or lime until cool. The longer it requires for the steel to cool, the softer it will become.

4. Prepare the quenching bath. This may consist of high-grade quenching oil or of pure water.

For rapid cooling and to produce a high degree of hardness, pure cold water is best. Care must be exercised, however, not to cool the steel so rapidly as to form a crack.

5. Determining the "hardening heat." This temperature ranges from 1350 to 1500 degrees, and varies for different grades of steel.

a) The compass needle, which is ordinarily attracted by iron that has been placed in its vicinity, is no longer attracted by the metal as soon as the steel reaches the hardening temperature.

b) The electric pyrometer actually measures the temperature to which the steel is being heated.

It has been observed that as the heat increases, the temperature rises uniformly to a certain point, at which point the temperature of the steel remains constant for a time, and then rises again. This rest period is known as the "critical point" and is the hardening or quenching heat of the steel. During this rest period, certain complex chemical changes take place in the steel, which, when made permanent by sudden cooling, give a very hard and brittle quality to the steel.

c) Judging the temperature by the color to which the steel has been heated, is the method of the amateur.

To determine the proper color of red, heat a trial piece, observe its color at various points, and quench it in the quenching bath. Test the steel at different places with a good-quality file. At the place where the material can just barely be cut by the file, the steel has been successfully hardened, and the color to which it was heated at that point indicates the hardening heat of the steel. If the file does not cut the steel, the chances are that it was heated beyond the critical point and has been "burned" or spoiled.

Another method is to heat a trial piece until various colors of red appear along its length, and then quench it in the bath. Place the steel in the vise, with about ½ in. of the end which was heated to the brightest red projecting above the vise jaws. Break off this end with a hammer, and observe the texture of the steel at the fracture. Break off another ½ in. of this end, and again observe the texture. Steel that has been "burned" is very coarse-grained and brittle and has large, noticeable crystals. Steel that has been properly hardened shows a fine, close grain. Steel that has been annealed has a moderately finegrained texture. The color of red to which the section of steel was heated, which showed the fine, close-grained texture, was the color which indicated the hardening heat of the steel.

6. Heat the metal to the hardening temperature and dip it in the quenching bath. Stir it around continually, or, if water is being used, plunge the metal in and draw it out, until it is cool. Test for hardness with a file.

If the pieces to be heated are irregular in shape, the thinner parts will become heated more rapidly than the thicker. To avoid this, place the metal so that the thin portion is over a piece of coke which has not yet fully ignited, and so that the thick portion is in the hottest part of the fire. Another method is to remove the steel, quench the thin part, and reheat the whole piece until a uniform temperature has been reached.

Operation Y

TEMPERING TOOL STEEL

Tempering, as applied to tool steel, is the process of reducing the extreme hardness and brittleness of hardened steel to that particular degree of hardness and toughness required for the specific use to which the tool is to be put. Thus, if a chisel were to be used immediately after it has been hardened, it would soon break. The operation of tempering removes some of the brittleness and makes the steel tougher, so that the chisel woud bend rather than break.

The tempering temperatures of tool steel range from 400 to 600 degrees. The particular temperature that the metal has reached is indicated by the color of the oxide which appears on the polished surface of the steel. The colors as they appear are listed on the chart following. The more the steel is heated, the less brittle and the more tough it

Guide for Tempering Carbon-Steel Tools

Tool	Temperature	Color of oxide
Engraving tools for wood and steel; hammer faces; lathe tools.	420°	Very pale yellow.
Milling cutters; taps and thread-cutting dies; punches; reamers.	460°	Straw yellow
Twist drills; auger bits; hack saws; pocketknives.	480°	Deep straw
Plane irons; axes; sledges; ball-peen hammers; rock drills.	500°	Dark brown
Dental and surgical instruments; cold chisels; rivet sets; shear knives.	530°	Purple
Cold chisels for soft work; battering tools; screw drivers.	565°	Blue
Springs.	600°	Dark blue

becomes, and, unfortunately, the less hard. That particular combination of hardness and toughness that is best suited to the use to which the tool is to be put is the best that can be accomplished.

1. Polish the part of the tool to be tempered so as to remove the scale and expose the steel.

2. Determine the proper degree of hardness and toughness desired for the tool, according to the chart on page 46.

3. Heat the steel until the proper color of oxide appears on the surface, by

a) holding the steel in the tongs over a good bed of live coke until the proper color appears;

b) placing the metal on a previously heated metal slab or inside a heated piece of large pipe;

c) placing the work over a gas furnace, Bunsen burner, or blow-torch;

d) placing the work in a so-called commercial "muffle" furnace, or in a previously heated tempering bath of oil.

In the school shop, when tempering a tool of irregular shape, the job is best done over a Bunsen burner. The metal can be so placed that the flame strikes it in the thickest part, and the metal also can be moved around so as to bring all of it to the same color at the same time.

4. After the steel reaches the desired color, quench it in the quenching bath as was done during the hardening operation.

Hardening and Tempering as One Operation. In the case of the cold chisel, heat about 3 or 4 in. to the hardening temperature. Cool about 1 in. of the end by moving the steel up and down in the quenching bath. As soon as this end of the metal is no longer red, polish one of the flat surfaces. The heat still remaining in the unquenched portion will now gradually mount into the cooled part, so as to again heat it and carry it through the different tempering temperatures, as may be seen by the colors as they run up toward the edge. When the proper color appears, the entire tool is quenched.

Operation Z

FINISHES

The Smoke Finish. The smoke finish was used by blacksmiths as an inexpensive finish on articles where no elaborate finish was needed. It was produced by coating the slightly heated metal with a film of rosin or lubricating oil and heating the metal until this film caught fire and burned off, leaving behind a protective coat of black.

Flat Black Paint. Flat black paint is now used instead of a smoke finish. Cold chisels, center punches, ice tongs, etc., may be so finished.

Flat black paint also is suitable for a great many of the articles of furniture described in the text. A piece of work finished in flat black, with a bit of gold bronzing powder added here and there, has a simple charm about it which makes it pleasing in almost any home setting.

1. Brush the paint on evenly. Stroke out all "runs" or streaks; be sure to cover the entire surface.
2. Allow the paint to dry at least 24 hours, and apply a second coat.
3. If it is desired to apply gold bronze, prepare a small V-shaped trough out of a piece of heavy paper or sheet iron. After the paint has set for about 15 minutes, put a *very* small quantity of the bronzing powder into the trough, and blow the powder on the painted surface at intervals. Continue until the surface has been covered as desired.

Enamel Finish. Instead of flat black, a great variety of colored enamel finishes may be used, if desired. In connection with these, a number of colored bronzing powders may be used. The colors employed should be such as to make the piece of work harmonize as nearly as possible with the furnishings in the room where the work is to be placed.

The directions for applying enamel are the same as for applying flat black paint.

Lacquer Finish. Lacquer is a comparatively new kind of finish, which dries within half an hour. Various colors of brushing lacquer may be obtained and used with excellent results.

The directions for applying the lacquer are the same as for applying flat black paint, except that it is necessary to work rapidly. A second coat may be applied, according to the directions of the manufacturer.

Commercial lacquering is done by "spraying" the lacquer on the work with spray guns. A number of inexpensive hand or electrically operated spray guns have been put on the market, which do satisfactory work.

Polished Steel or Natural Finish. Some tools are finished by polishing the surfaces and covering these with clear lacquer or with a thin film of lubricating oil to prevent rust.

Polishing With Emery Cloth. 1. Grind the work on the emery grinder, file and drawfile it with a smooth mill file, and polish with No. ½ emery cloth.

Where a large amount of polishing is to be done, the following equipment will be found helpful:

a) Replace the stone of a small hand-driven emery grinder with a disk made of pine 2 in. thick and 12 in. in diameter. Cut a groove ½ in. deep and 1 in. wide across the edge of this disk, and prepare a wood block to fit loosely into this groove. Wrap a long strip of emery cloth 2 in. wide around the edge of the disk, allowing the ends to overlap in the groove. Fasten this strip by wedging down the ends with the small wood block held in place by two screws.

b) A disk polisher may be made out of another disk of wood of the same size as the foregoing. Cut a sheet of emery cloth to a diameter 1 in. larger than the disk. Then prepare a welded, flat, iron ring which fits snugly on the circumference. The emery cloth is fastened by driving the iron ring over the edge of the wheel, forcing the emery cloth down over the circumference. Two countersunk wood screws should be used to hold the ring in place.

The Hammered Finish. This finish was used in the olden days when modern finishes were not yet known. It is still in use, and looks well on quite a number of the pieces of furniture described in the text.

It is important to remember that the markings must be put on *before* the pieces are bent to shape. The text does not indicate at which step this should be done, but leaves it entirely to the student.

1. Three kinds of markings may be made on the metal.

a) To produce round marks, use the ball end of the machinist's hammer, and strike the metal as desired.

b) On flat or square stock, markings running crosswise may be made with the peen of a cross-peen hammer. This produces long, narrow markings.

c) Prepare punches with various-shaped ends, as oval-shaped, heart-shaped, and cross-shaped, and produce markings by placing them on the material and striking them with a hammer.

2. Blacken the iron all over by coating it with linseed oil and placing it in the fire just long enough to burn off the oil.

3. Polish the surfaces with emery cloth so that the deep places are left black and the high places become steel gray and glossy.

4. Give the entire surface two coats of clear lacquer to prevent rust.

A. Tools

1. CENTER PUNCH

The center punch, Figure 50, is used by metal workers primarily to mark the center for drilling a hole.

Lathe Method:

1. Cut the stock and grind the ends square.
2. To shape the blunt end, speed up the lathe and file off the sharp corner at an angle of 45 degrees.
3. To turn the tapered point, set the swivel rest at an angle of 93 degrees and clamp the longitudinal feed in position so that the tool carriage cannot move. Feed the cutting tool *into* the work with the cross-feed lever, and feed it *along* the work with the handle on the swivel rest. Begin at the outer end, and work toward the headstock of the lathe.

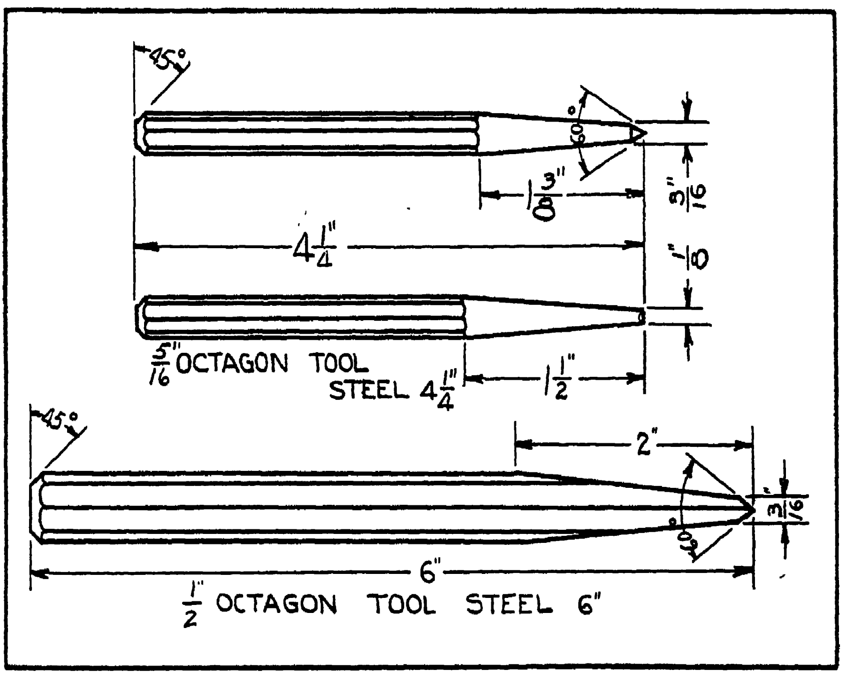


Fig. 50. Top: Center punch
Center: Nail set
Bottom: Cold chisel

4. File and polish the taper, and shape the point with a file.
5. Harden and temper the tapered end.

Forge Method:

1. Cut off the stock and grind the ends square.
2. Grind off the corners of the blunt end to an angle of 45 degrees.
3. Taper the end (Operation D), and grind the point.
4. Anneal the tapered end; then harden and temper it.
5. Polish the taper, and paint the rest flat black.

2. NAIL SET

The nail set, Figure 50, is used by woodworkers to drive the heads of finishing nails below the surface of the wood.

1. Directions for making the nail set are the same as for making the center punch, with the exception of the point.

2. To cut the hole on the end of the nail set on the lathe, grind a special tool with a very small semicircular end and with considerable clearance on all sides. Set the tool exactly at center and feed it into the work with the longitudinal feed.

3. To shape the hole on the end of the nail set on the forge, heat the end and make a deep mark on the end with a center punch.

3. COLD CHISEL

The cold chisel, Figure 50, is used for cutting away waste material and for cutting off rivets.

1. Standard sizes are: ¼-in. cutting edge, length 4 in.
   ⅜-in. cutting edge, length 5 in.
   ½-in. cutting edge, length 6 in.
   ¾-in. cutting edge, length 7 in.
2. Draw the taper on two sides only.
3. Harden and temper the tapered end.
4. Grind the cutting edge.
5. File and polish the flat sides, and paint the rest of the chisel flat black.

4. SMALL MACHINIST'S CLAMP

This clamp, Figure 51, has a capacity of 1¼ by 2 in., and is used for holding together parts which are being marked off, drilled, or assembled.

1. Draw the taper on the ends, on one side only.
2. Mark off and center-punch the holes; be sure to get them spaced alike on both pieces.
3. Drill the holes in one rod with a $\frac{7}{32}$-in. drill, so that the bolts will slip through readily.
4. Drill the holes in the other rod $\frac{9}{64}$ in., and thread with a $\frac{3}{16}$—24 tap.
5. Give the clamp a polished-steel finish.

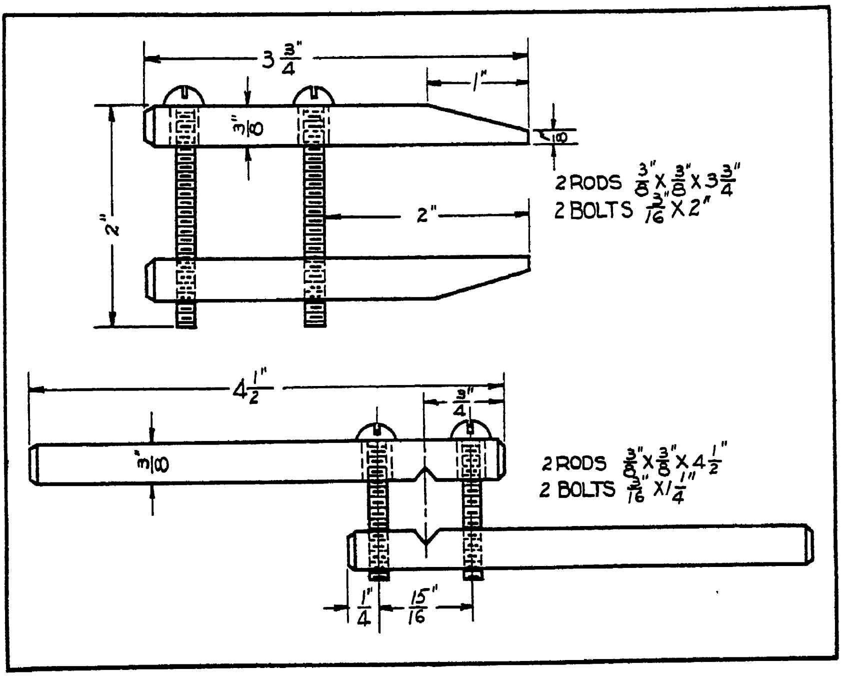


Fig. 51. Top: Small machinist's clamp
Bottom: Simple tap wrench

5. SIMPLE TAP WRENCH

A tap wrench, Figure 51, is used for holding taps for cutting threads.

1. Directions for making the tap wrench are the same as for making the machinist's clamp, Project 4.
2. After assembling, mark off and file the V-shaped grooves with a small triangular file. The grooves must be exactly opposite each other, and must form a square when the rods are parallel.

6. COMBINATION MARKING GAUGE AND DEPTH GAUGE

A depth gauge is used to measure the depth of small holes. A marking gauge is used in woodwork to scribe a line at a fixed distance from an edge. (Fig. 52.)

1. Grind one end of the measuring rod perfectly square.
2. Bend the other end over the rounded edge of the anvil, and sharpen this end to produce the cutting edge.

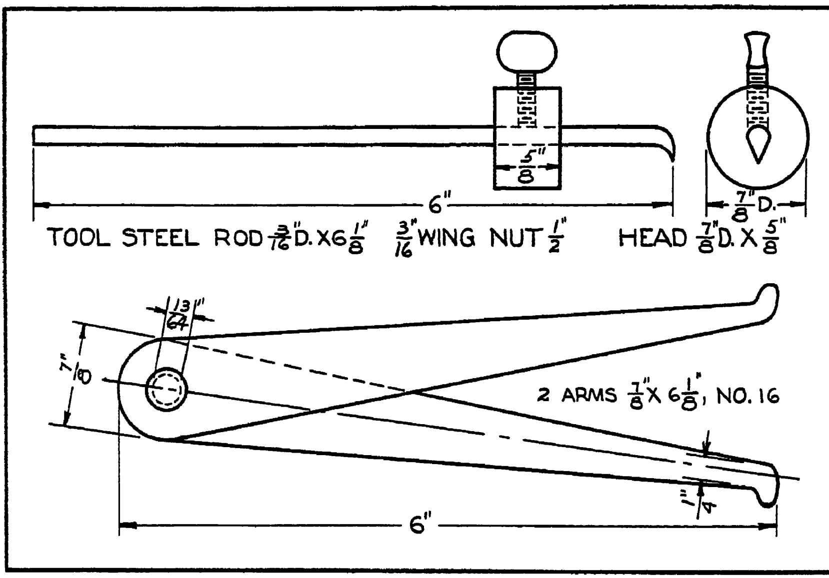


Fig. 52. Top: Combination marking gauge and depth gauge
Bottom: Firm-joint calipers

3. Harden both ends, and draw the temper to a straw color.
4. Square up the ends of the piece called "head" on the lathe. Drill a $\frac{13}{64}$-in. hole for the rod to pass through.
5. Drill a $\frac{9}{64}$-in. hole through the side of the head, and thread it with a $\frac{3}{16}$—24 tap. A $\frac{3}{16}$-in. wing nut is to hold the head in position.
6. Give the gauge a polished-steel finish.

7. FIRM-JOINT CALIPERS

Calipers, Figure 52, are used for measuring circular objects, either inside or outside. The joint is riveted, and is just loose enough to permit the arms to move by applying a moderate amount of pressure.

1. The arms may be made of No. 16 sheet iron, or preferably by

flattening a piece of ½-in. octagon tool steel down to $\frac{1}{16}$ by ⅞ in. with flatter and sledge.

2. Shape the taper, making the pieces ⅞ in. at one end, and $\frac{3}{16}$ in. at the other. Round the wide ends.

3. Bend the small ends over the rounded edge of the anvil.

4. Drill the $\frac{13}{64}$-in. holes. Place a $\frac{3}{16}$ by ¼-in. rivet through the holes, and shape the heads with a hammer and a No. 2 rivet set. Make the joint of the proper degree of stiffness.

5. Give the calipers a polished-steel finish.

8. WRECKING BAR

A wrecking bar, Figure 53, is used to pry open boxes and crates, and to draw out the nails.

To make a larger wrecking bar than the one shown in the drawing,

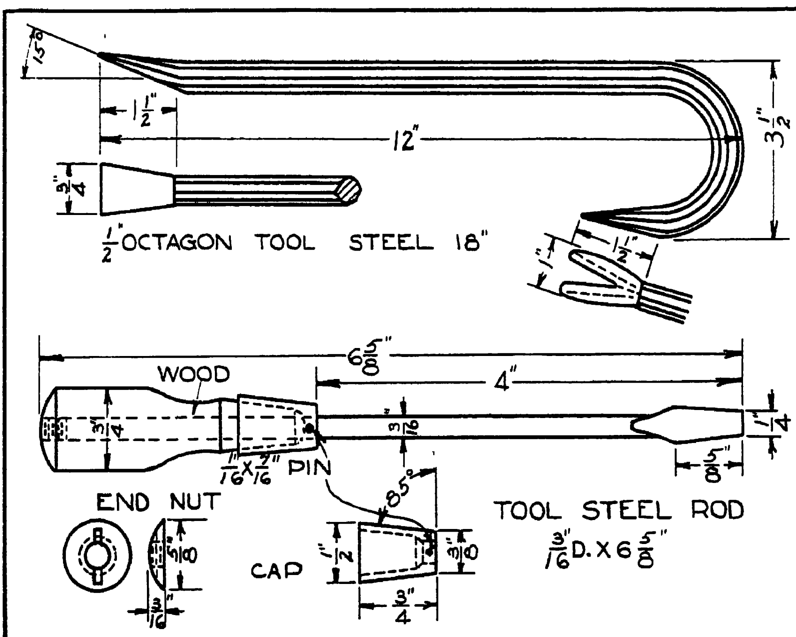


Fig. 53. Top: Wrecking bar
Bottom: Screw driver

use ⅝-in. octagon steel and cut it 24 in. long. Other dimensions should be larger in proportion.

1. Draw a taper on each end, as for a chisel.

2. To shape the claw, begin by making a deep file mark or saw cut where the cut is to be made. Place a scrap piece of boiler plate over the anvil to protect the face from becoming scarred. Heat the steel, place it on the piece of boiler plate, put the handle cold chisel into the mark, and strike it several hard blows with the sledge. (Fig. 54.) Be sure the iron is hot enough, or there will be danger of cracking it.

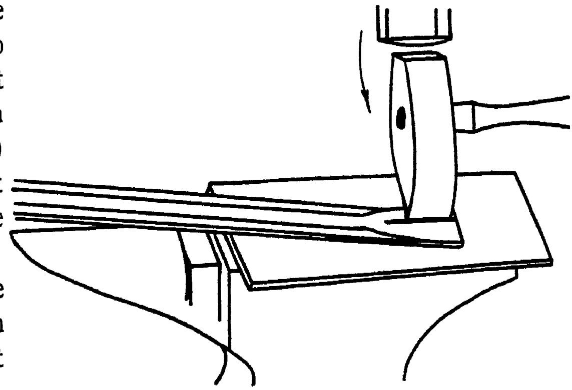


Fig. 54. Marking the cut for the claw end of a wrecking bar

3. Finish shaping the slot with an extra slim taper saw file. The slot should taper to a point, and the sides should slant V-shaped, like the slot in a claw hammer.

4. Prepare a simple form for curving the claw end of the wrecking bar, (Operation N). The claw is on the inside of the curve.

5. Harden and temper both ends to a full blue color.

6. Polish the flattened surfaces of both ends, and paint the rest of the tool flat black.

9. SCREW DRIVER

Next to the hammer and the hatchet, the screw driver is perhaps the most useful tool to have about the house.

A great number of sizes of screw drivers are to be had, depending upon the use to which the tool is to be put. The screw driver to be described is a small electrician's screw driver. (Fig. 53.) A larger one would be made in the same way.

The Cap. 1. Clamp the piece of cold-rolled steel in the universal chuck in the lathe. Drill a hole into the end with a drill the same diameter as the tang of the screw driver.

2. To enlarge this opening to receive the wooden handle, set the swivel rest at 85 deg., and turn the taper with the inside boring tool.

3. With the swivel rest set as before, turn the taper on the outside. Polish the outside, and cut off the excess stock.

The Blade or Tang. 1. Select a piece of tool-steel rod of the size desired. Observe that in the drawing the tang runs the entire length of the screw driver.

2. Thread about 1/4 in. of one end. In this case, use $\frac{3}{16}$—24 U.S.S. threads.

3. Form the taper for the blade. The wide surfaces of the taper should be parallel for a short distance, so that the screw driver will not slip out of the slot in the screw.

4. Harden the blade end, and draw the temper to a full blue color.

The End Nut. 1. Place a piece of stock in the lathe, and drill a hole in the end, of the proper size for cutting threads of the same kind as were cut on the end of the blade. Cut the threads.

2. Shape the surface of the nut which is to fit into the palm of the hand. Cut the slot in the end with a hack saw. Cut the nut off with a cutting-off tool.

The Wooden Handle. A very nice handle can be made out of walnut wood. The woodworking department may cooperate in making the handle, or it may be cut on the metal-working lathe.

Assembling. 1. (*a*) Rivet the cap to the blade with the help of a pin. Or, (*b*) braze the cap and the tang together. (*c*) Thread the cap and the tang, screw them together, and sweat solder into the joint.

2. Drive the handle over the tang and into the cap.

3. Screw the end nut on, and smooth this end.

4. Polish the tang, the cap, and the nut. Stain and varnish the handle.

10. ICE PICK

The ice pick and ice scraper in Figure 55 are a combination that will readily find a place in the home.

The directions for making the ice pick are very similar to those for making the screw driver. Work out your procedure, and have the instructor check it.

11. ICE SCRAPER

1. Drill two 1/4-in. holes where the inner ends of the teeth are to be. Cut out the teeth with a hack saw, and file them to shape.

2. Drill three 1/8-in. holes for rivets.

3. Harden the end, and draw it to a purple color.

4. The handle is made of walnut wood or red fiber board. Rivet the handle in place with 1/8-in. copper harness maker's rivets.

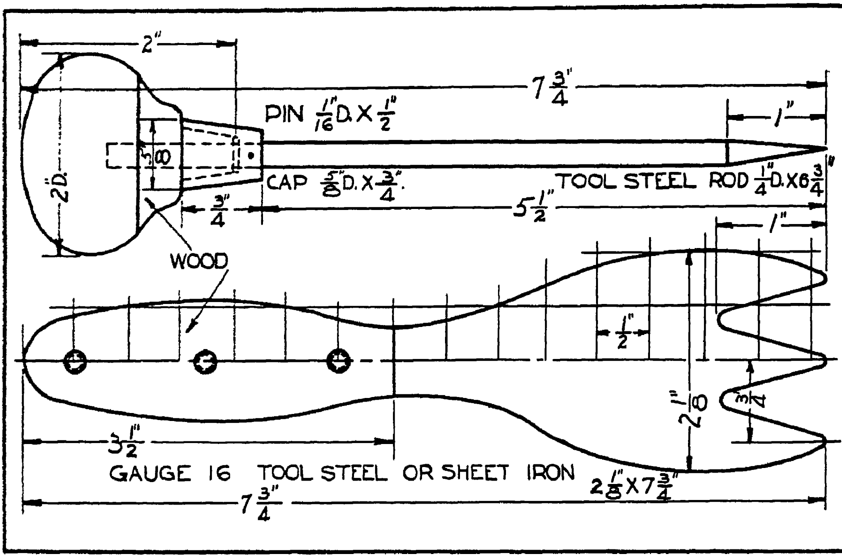


Fig. 55. Top: Ice pick
Bottom: Ice scraper

12. HACK-SAW FRAME

A hack saw is a very useful tool to have in the home. The frame illustrated in Figure 56 is for a 9-in. blade, and is rather narrow to permit using the saw in a narrow space.

The Frame. Manufacturers make frames out of malleable iron, or adjustable ones out of sheet steel. The frame shown in the drawing will do very well, if carefully made.

1. Prepare a special form, and bend the ends over it in the vise.

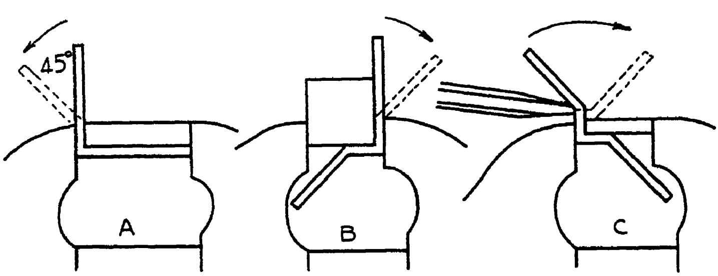


Fig. 57. Shaping a hack-saw-frame guide

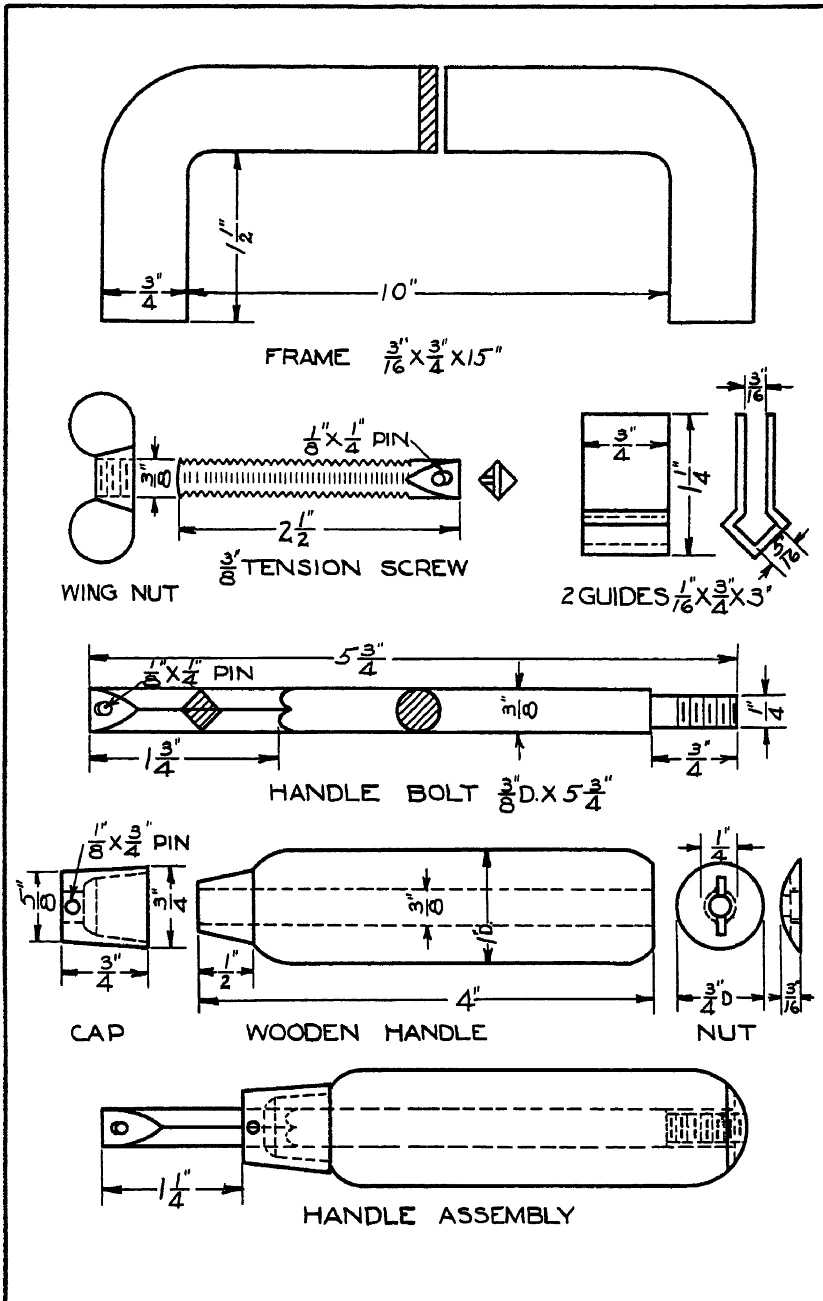


Fig. 56. Hack-saw frame

The Guides. 1. Bend each of the pieces at right angles in the center.

2. Place the guide in the vise along with a piece of 3/8 by 1 1/2-in. stock, as at A, Figure 57. Bend one end as shown.

3. Place the guide in the vise along with a piece of 1 by 1-in. material, as at B. The bend begins 3/8 in. from the inside corner.

4. Place the guide in the vise again, this time with a piece of 5/16 by 1-in. iron. Make the bend as at C with the help of a blunt-edged chisel.

5. The last bend is made in the vise over a piece of iron 5/16 by 5/16 in., with the help of the blunt-edged chisel.

6. Place one guide over each end of the frame, and rivet each one in position with 1/8-in. rivets.

The Front Assembly. 1. The 3/8-in. wing nut should be purchased.

2. The tension screw on manufactured hack saws is casehardened. The best school-shop procedure is to make the screw out of tool steel, so that it may be hardened and tempered.

The teeth are ground and filed off on four sides, to make a 5/16-in. square, but sufficient threads are left so that the wing nut can still be made to work.

3. The end on which the pin is to be fastened is ground down rounding to 3/32 in. in thickness.

4. To fasten the pin in place, drill a 3/64-in. hole to receive the pin. Grind about 1/8 in. of the end of the pin down to 3/64 in. diameter, drive it into the hole, and rivet it on the other side. The pin can now move neither in nor out. Bend the pin toward the wing nut a bit. Be sure that the blade fits flat against the ground surface behind the pin.

The Handle Assembly. 1. The handle bolt is ground and filed 5/16 in. square on the end. It is ground down for the pin, and the pin is fitted as for the tension screw above. The other end of the handle bolt is cut down to 1/4 in. diameter and threaded.

2. The cap is made in the same way as the cap for the screw driver, Project 9, except that it is drilled 7/32 in., and filed out to 5/16 in. square. It is fastened to the handle bolt either by means of a pin, or by brazing it.

3. The directions for making the end nut are the same as those given for making the screw driver, Project 9.

4. The walnut handle is made in connection with the woodworking department, or it may be turned out on the metal-working lathe.

5. Stain and varnish the handle. Paint the rest of the frame flat black.

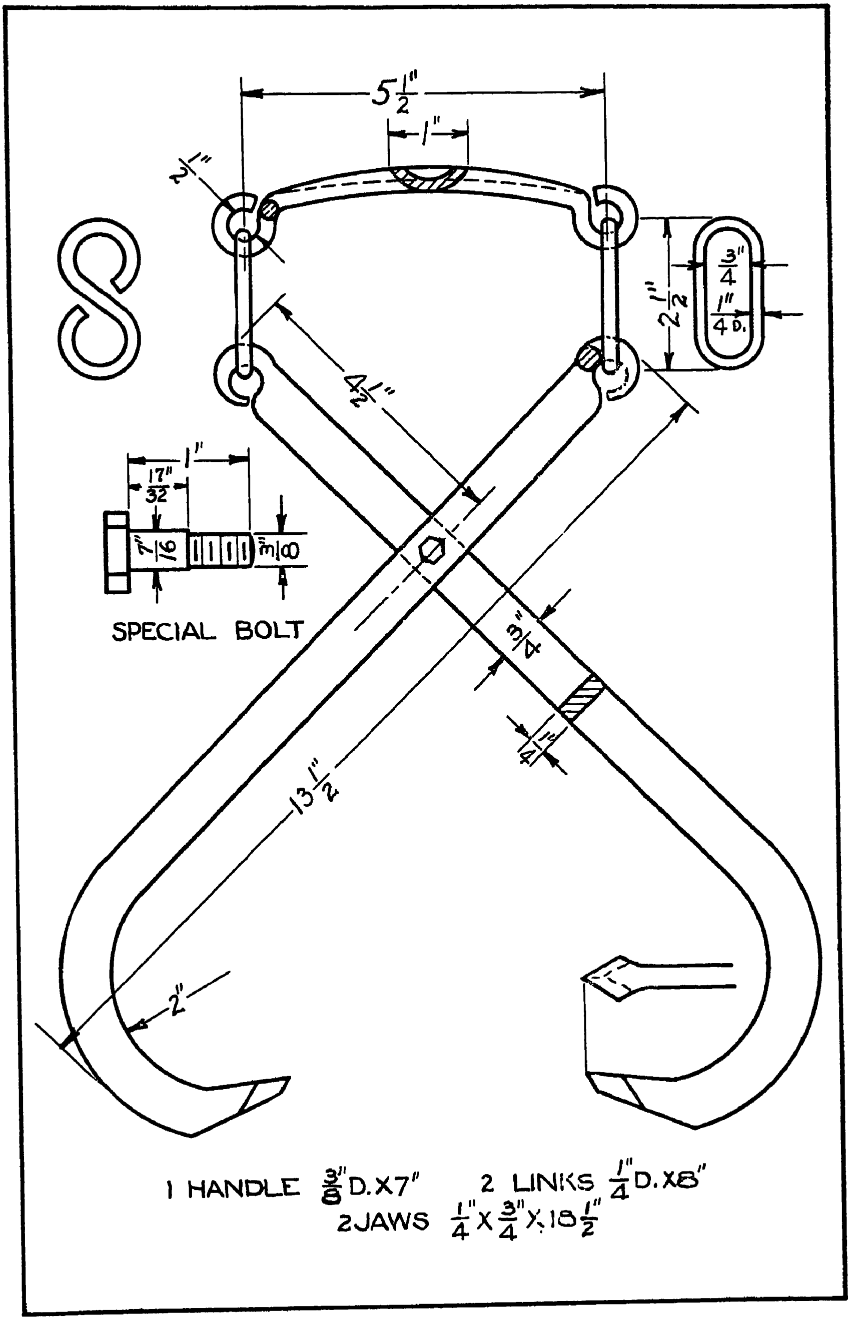


Fig. 58. Ice tongs

13. ICE TONGS

A pair of ice tongs, Figure 58, is a useful article in the home. To make a good pair, however, requires quite a little skill.

The Links. (See Operation K.) The S-shaped link illustrated, is serviceable and is much easier to make than a welded link. Links that were parts of an old chain may be used.

The Handle. 1. Flatten about 4½ in. of the center of the rod to a thickness of $\frac{3}{32}$ in. and a width of 1 in. Curve this part to fit the hand, as shown.

2. Draw the ends down to ¼ in. in diameter. (Operation D.)

3. Bend the eyes part way to shape, put a link in place, and close up the eye. The link should fit loosely.

The Tongs. The points on manufactured tongs are casehardened. Points made of mild steel can be made to serve.

1. Upset the ends, and shape the points as illustrated.
2. Curve the pointed ends over a simple form.
3. Draw a rounded taper on the end of each of the tongs. Bend the eyes to shape, put the links in place, and close up the eyes.
4. Locate the hole for the pivot. Hold the tongs together at various places, and try to open and close them. If the tongs are made as shown in the drawing, this point will be 4½ in. from the eye end of the tongs. Drill the $\frac{7}{16}$-in. holes to receive the bolt.
5. Make the special bolt on the lathe. Plan your own procedure. When this bolt is used, the nut on the bolt may be drawn up tightly, and still allow sufficient freedom to move the tongs easily.

14. RIVETING-HAMMER HEAD

Figure 59 illustrates a small riveting hammer, which can be very easily made.

A larger size hammer measures 1 by 1 by 4½ in; the hole is 2½ in. to the center from the face end, and measures ⅝ by 1 in. The taper on the end is 1¾ in. long. The hammer requires a 12-in handle.

One method of procedure, preferred by some workmen, is to shape the hole in the bar of steel first, then to shape the tapered end, and then to cut off the excess stock at the head end. The following method is better adapted to school use.

1. Cut the stock and grind the ends square.
2. Shape the tapered end.
3. Shape the little tapered surfaces near the face of the hammer.
4. Drill a $\frac{7}{16}$-in. hole, as indicated. To make the hole oval-shaped,

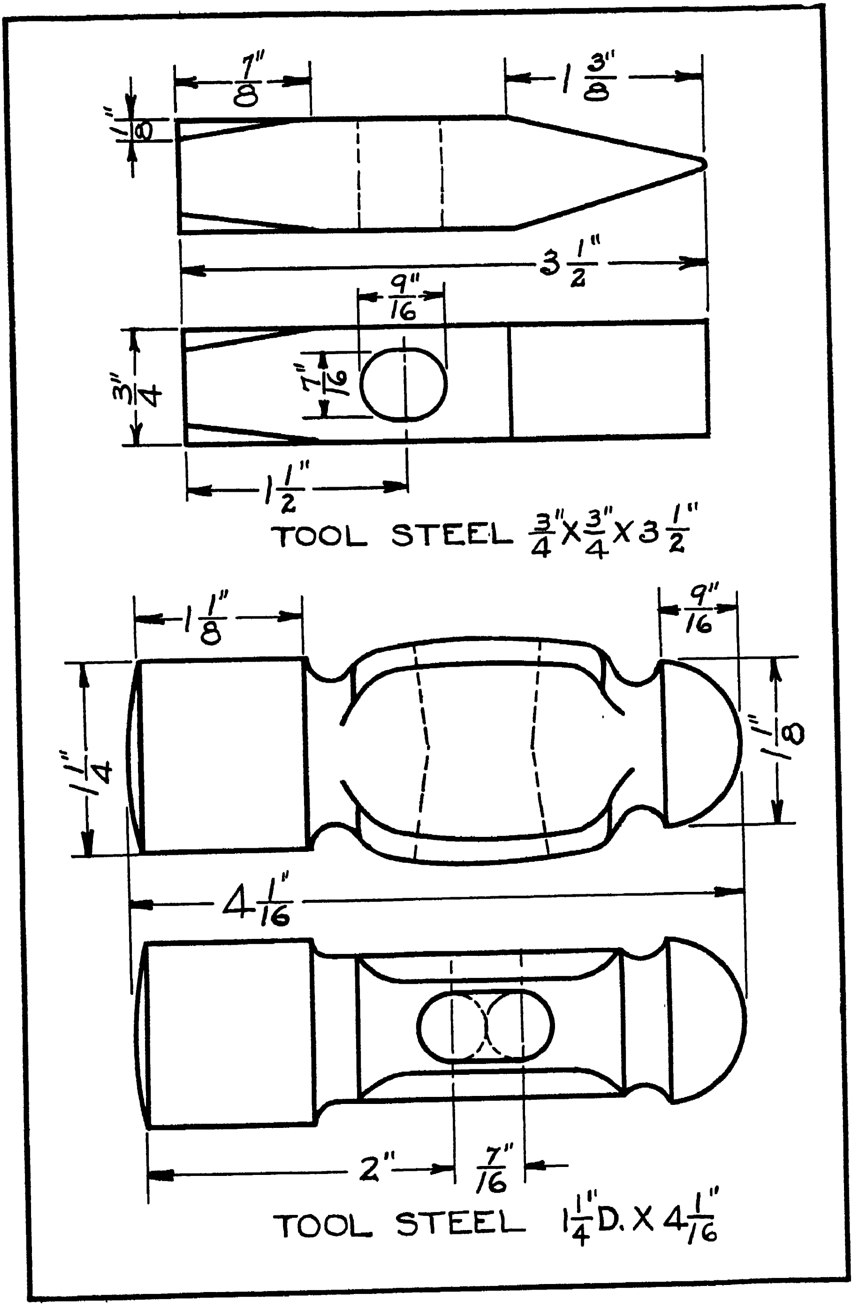


Fig. 59

Top: Riveting-hammer head.—Bottom: Machinist's-hammer head it may be either filed out with a round file, or it may be shaped by driving a specially prepared oval-shaped tapered punch into the hole, after the drilling has been done.

5. A hammer head must be tempered so that the ends are hard and the center tough.

a) Grasp the head at the hole with the pick-up tongs. Cool the face by dipping it up and down in the quenching bath. Turn the hammer over, and quench the other end. Reverse and cool the face more; continue until both ends are no longer red. Polish one entire side with emery cloth, and observe the color move from the still hot center outward. When the straw color nears the face end, quench the entire hammer.

b) Another procedure is to cool off the entire hammer, and draw the temper over a Bunsen burner. Apply heat to the middle of the hammer, and observe the colors move outward. When the center has turned blue and the ends straw color, quench the entire hammer.

6. Polish the entire head.

7. Fasten a 10-in. machinist's-hammer handle in place by means of a wedge.

8. Give the entire hammer two coats of transparent lacquer.

15. MACHINIST'S-HAMMER HEAD

Almost any workman can make use of a machinist's hammer. (Fig. 59.)

One method of procedure for making a hammer head, followed by some hammersmiths, is to drill only one hole for the handle, and to spread this hole out by means of an oval-shaped tapered punch; then flatten the center section, keeping the punch in place to prevent spoiling the hole; then fullering the two grooves between the top and bottom fuller; then hammering and grinding the ball; and finally cutting away the excess stock at the head end of the hammer. The following method is recommended for school use:

1. Cut the stock and grind the ends smooth, as shown at A, Figure 60.

2. Place the metal in the lathe, and cut the groove near the head end, as at B. Cut the face to a ball shape. Cut the groove near the ball end, and shape the ball as at C.

3. To flatten the middle section of the hammer, place a short length of 3/8 by 1½-in. iron on the anvil, place the hammer head over this piece of iron, place a 1½-in. set hammer on the hammer head, and

strike the set hammer with a sledge, as at D. Several heats will be necessary. Finish by annealing the entire hammer head.

4. Drill the pilot holes and the $\frac{7}{16}$-in. holes as illustrated. Chisel and file out the waste material. Finish shaping the hole with a specially prepared oval-shaped tapered punch by driving the punch in from each side.

5. Harden and temper the head so that the center is tough and the ends are hard. (See step 5, Project 14.)

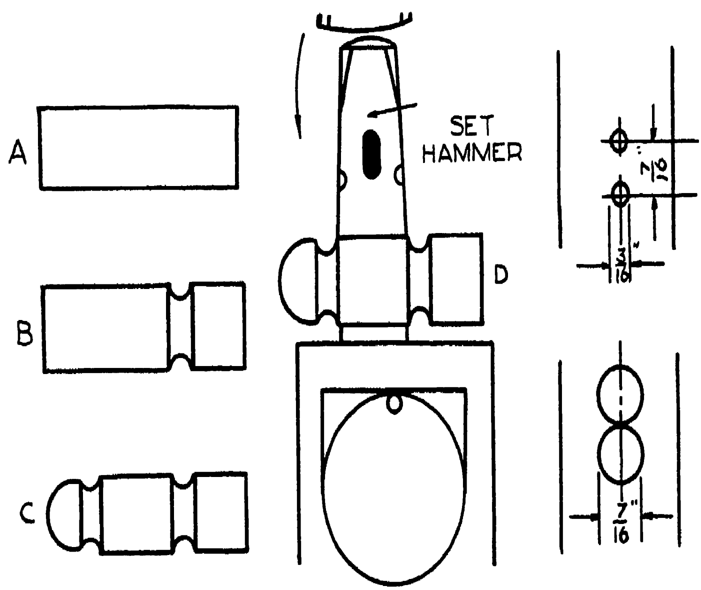


Fig. 60. Steps in making a hammer head

6. Polish all but the center section of the hammer head.

7. Fasten a 12-in. machinist's-hammer handle in place by means of a wedge.

8. Lacquer the polished parts of the head and handle, using clear lacquer. Paint the center part of the hammer flat black.

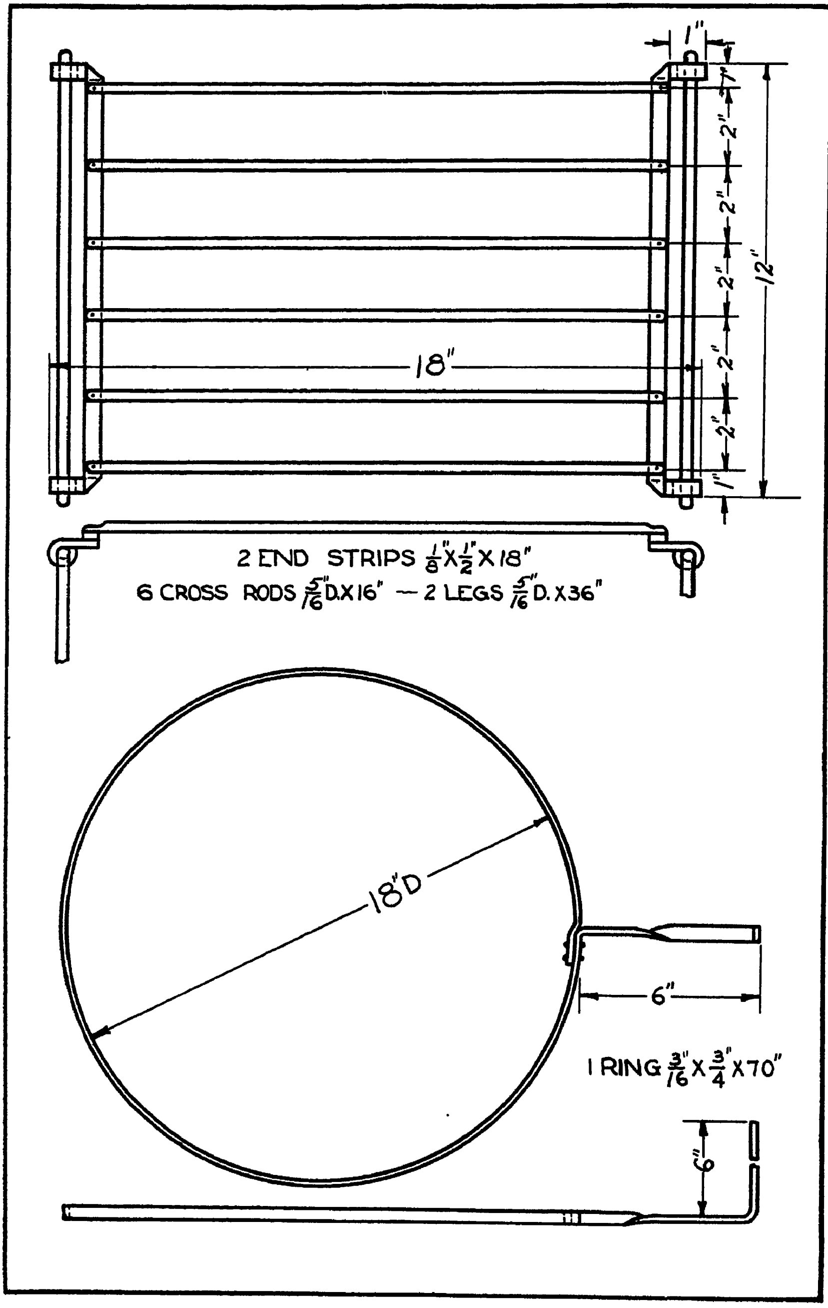


Fig. 61. Top: Portable camp-fire grate
Bottom: Basketball goal

B. Articles of Furniture and Miscellaneous

16. PORTABLE CAMP-FIRE GRATE

The camp-fire grate, Figure 61, is light and folds up flat. Set up, with its four legs pressed into the ground, it serves to hold the pots and pans in which the camp supper is being prepared.

1. The ends of the two cross strips are folded over at right angles in the vise, as illustrated at A, Figure 62. Curve the ends under to form the eyes, as at B, through which the legs are to be put. Drill the holes on the cross rods for riveting.

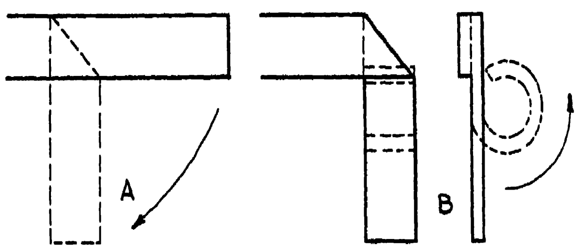


Fig. 62. Folding over ends of cross strips

2. Flatten the ends of the cross rods. Drill the rivet holes the same distance apart on each rod; then rivet the rods in place.

3. Point the ends of the pieces for the legs. Bend 18 in. of one end over at right angles. Put the pieces through the eyes, and bend the other ends.

4. Paint the entire grate flat black.

17. BASKETBALL GOAL

Put up outdoors at home, the basketball goal shown in Figure 61 has many admirers.

1. *a*) Prepare a circular form of ⅜ by 1½-in. iron, having an outside diameter of 18 in. Clamp the ring and one end of the metal together in the vise, and bend the metal around the ring.

b) Shape the ring in the bending fork.

2. Rivet the ends together.

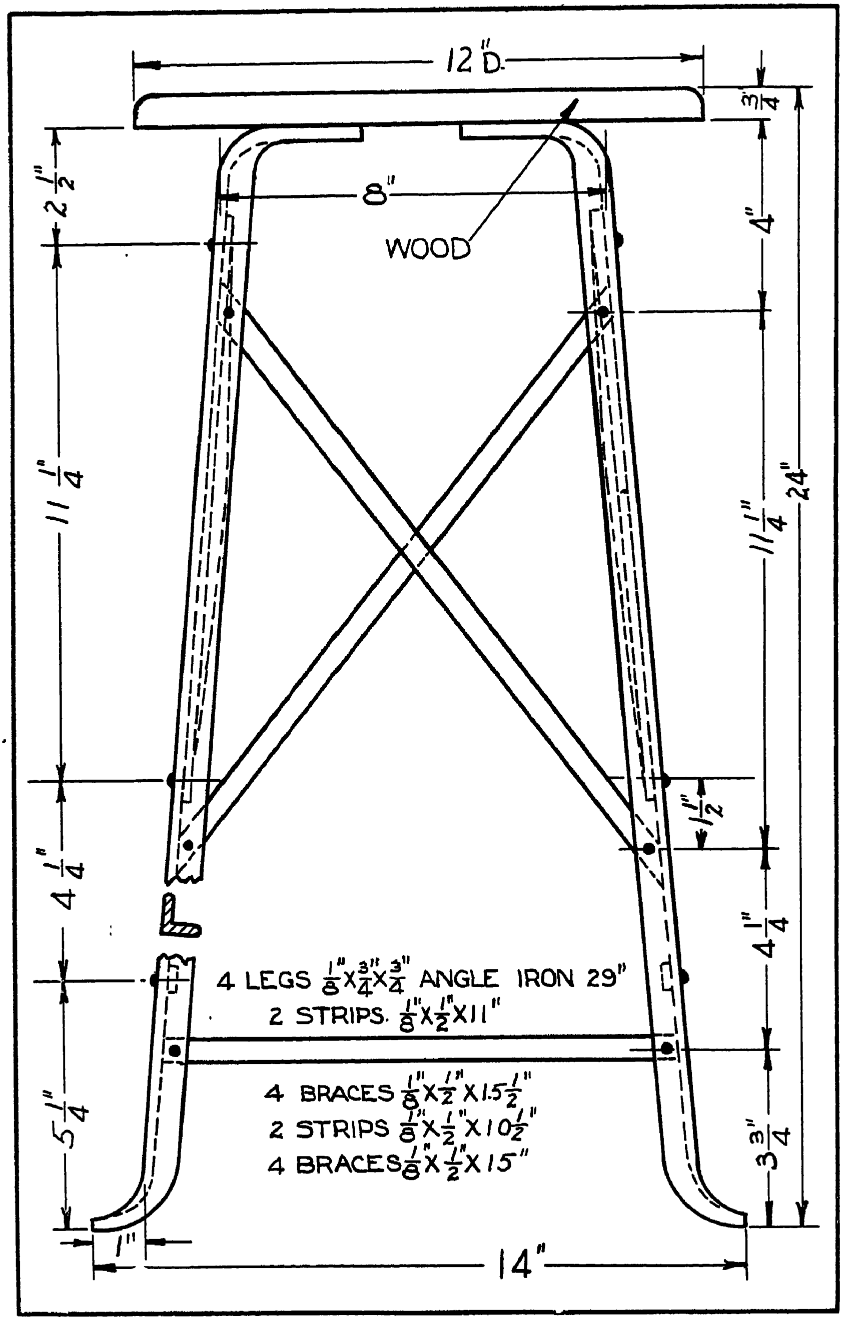


Fig. 63. Kitchen stool

3. Bend the rest of the iron as illustrated. Drill four ¼-in. holes for fastening the goal to the wall.

4. Braces running from opposite sides of the ring slantwise down to the wall, may be added.

5. Paint the completed job flat black.

18. KITCHEN STOOL

Figure 63 shows a stool which mother will find very useful in the kitchen. The stool is sturdily built, and when enameled white will harmonize with almost any kitchen furnishings.

The Top. The top is made of strong oak or birch in connection with the woodworking department.

The Legs. 1. Bend the feet by laying the iron edge downward over the nose of the anvil, flattening the sides and curving them to shape, as shown at A, Figure 64.

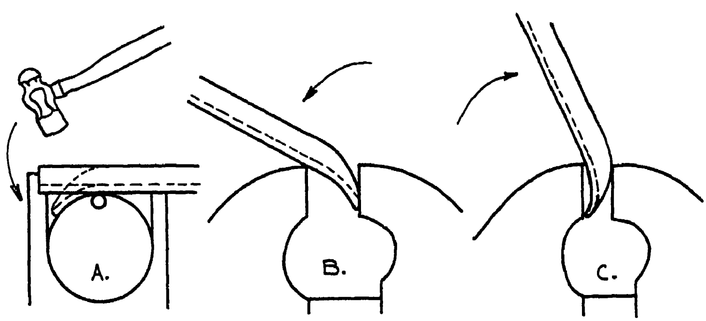


Fig. 64. Steps in bending the feet of the stool

Lay the legs against the back of the bench, measure 23 in. from the foot end, and make a mark. Flatten the angle iron at this end, and make the bend in a direction opposite to that in which the foot was bent. Be sure to get all four legs exactly the same length. Make a gauge for testing the length.

3. Lay the four legs on the bench with the feet resting against the back of the bench. Measure up 3¾ in., then 4¼ in., then 11¼ in. on the left side of the angle on two of the legs, and on the right side of the angle on the other two legs. Drill $\frac{3}{16}$-in. holes in the center of the side at each of these marks.

4. On the sides which have not been drilled, measure up 5¼ in., then 4¼ in., and then 11¼ in., and drill $\frac{3}{16}$-in. holes as before.

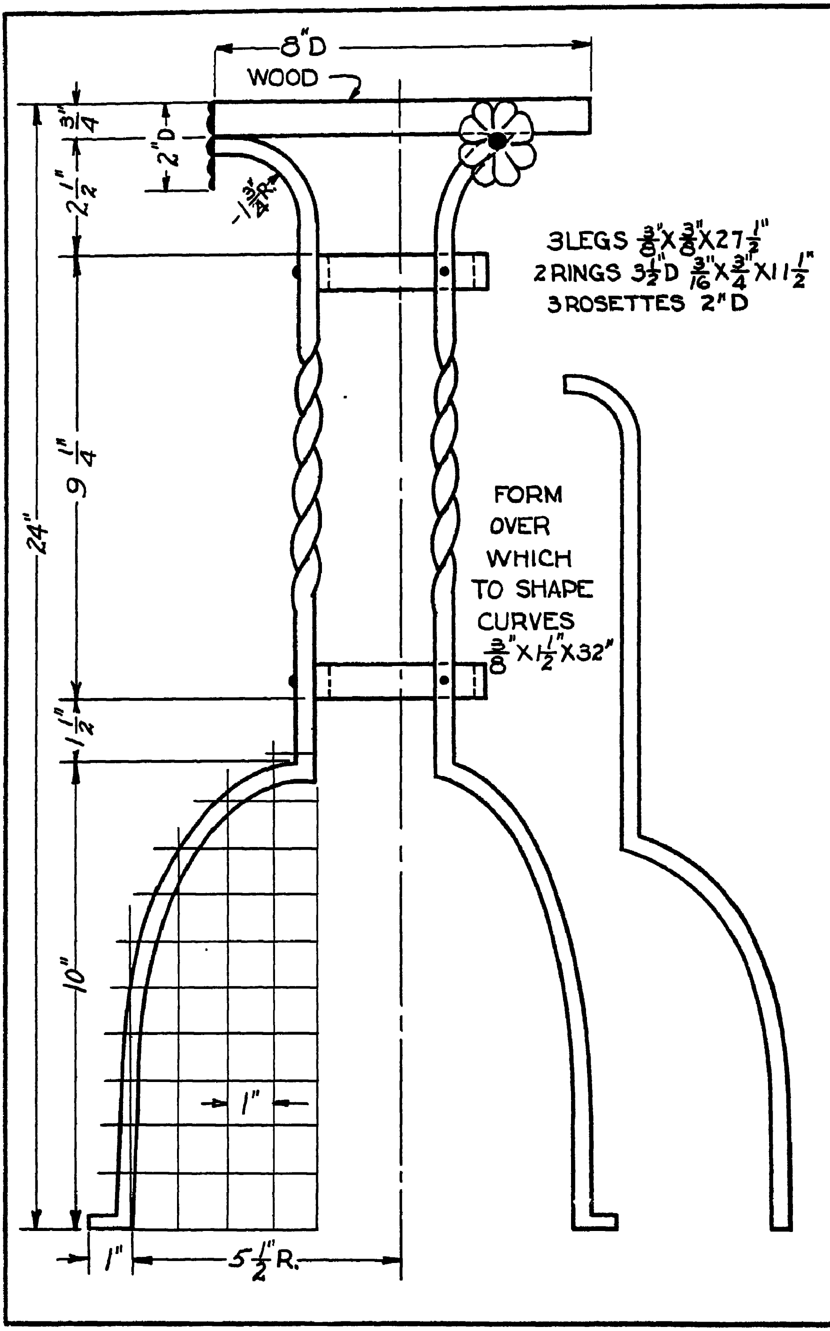


Fig. 65. Taboret

5. Drill three or four $\frac{7}{32}$-in. holes through the top ends of the legs, for fastening the top in place later.

The Strips and Braces. 1. Cut the strips and braces as shown in the drawing. Drill a $\frac{3}{16}$-in. hole $\frac{1}{4}$ in. from each end of the strips, and $\frac{3}{8}$ in. from each end of the braces. Grind off opposite corners of the braces so that they will fit in place.

2. Begin by assembling two opposite sides. Use $\frac{3}{16}$ by $\frac{1}{2}$-in. rivets. Fasten the top in place with 1-in. No. 8 blued screws.

Give the stool four coats of white enamel. Sandpaper the stool carefully between coats with No. 4/0 sandpaper.

The modern tendency is to use more color in the kitchen. The stool may be enameled or lacquered in color to suit the furnishings in the home.

19. TABORET

This taboret, Figure 65, will serve to set a fern or flower pot on, or it can be used as a pedestal for a statuette, a vase, or other ornament.

1. The top is made of some light wood, in conjunction with the woodworking department.

2. Prepare a form over which to shape the legs, as shown in the drawing.

3. Make a right-angle bend in the pieces for the legs, 13 in. from one end.

4. Clamp the leg and the form together in the vise, as shown in Figure 66. Bend the 13-in. part of the leg until it fits over the form at all points.

5. Bend over 1 in. of the curved end of the leg, and hammer it out to form a foot.

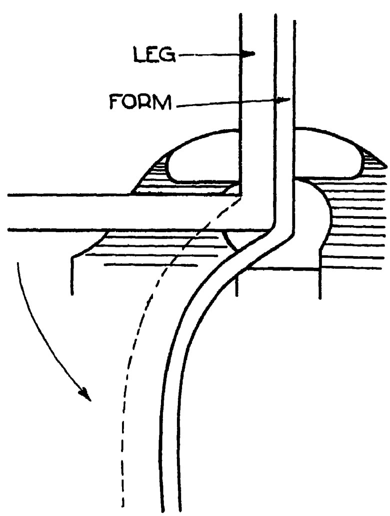


Fig. 66. Form and leg of taboret clamped in vise to make the bend

6. Clamp the leg and the form together in the vise, as shown in Figure 67, and bend the leg until it fits over the form as shown by the dotted lines. The leg will have to be bent to one side a trifle in order to pass the curved part of the form.

7. Mark off and drill the holes $\frac{3}{16}$ in.

8. Twist the legs as shown.

9. Make the rings, space the holes out equally, and drill them $\frac{3}{16}$ in.

10. Rivet the legs to the rings, using $\frac{3}{16}$-in. rivets.

11. Make the rosettes.

12. Drill a $\frac{3}{16}$-in. hole ¾ in. deep into the end of the leg, and thread

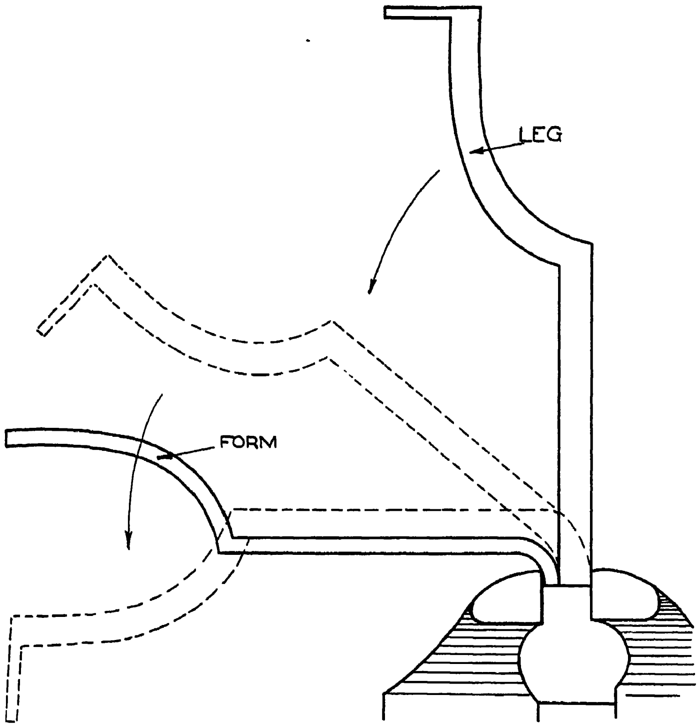


Fig. 67. Form and leg clamped to make bend under taboret top

with a No. 12—24 tap. Fasten the rosettes in place with 12—24 ½-in. machine screws.

13. Drill a $\frac{3}{16}$-in. hole through the leg about ¾ in. from the rosette, and fasten the top to the taboret with 1¼-in. wood screws.

14. Enamel or lacquer the job to harmonize with the furnishings of the room into which the taboret is to be put.

20. END TABLE

1. The student may wish to work out his own design for the top of large wrapping paper, and check it with the instructor. The top of the end table shown in Figure 68. If so, cut the design out of a piece

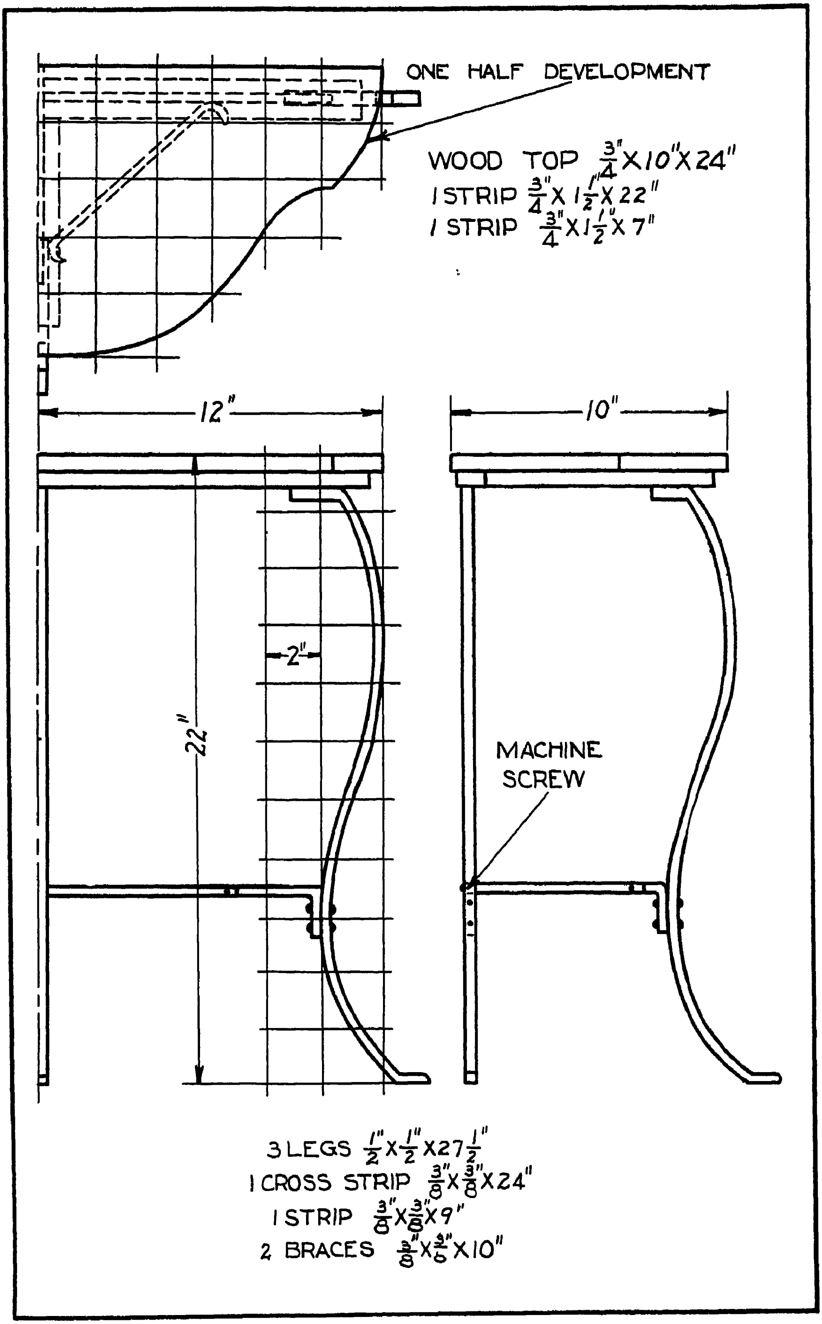


Fig. 68. End table

may be made of walnut or mahogany and given a stained and varnished finish, or it may be made of white pine and enameled or lacquered. Fasten the strips in place with glue and screws.

2. It is possible to work out a number of different designs for shaping the legs. The curve shown in the drawing is made with the help of a template and a large bending fork. Drill three holes into the upper end for fastening the leg to the top.

3. Bend over the ends of the 24-in. cross strip in Figure 69 so that the cross strip fits between the two back legs. Rivet it to the legs with

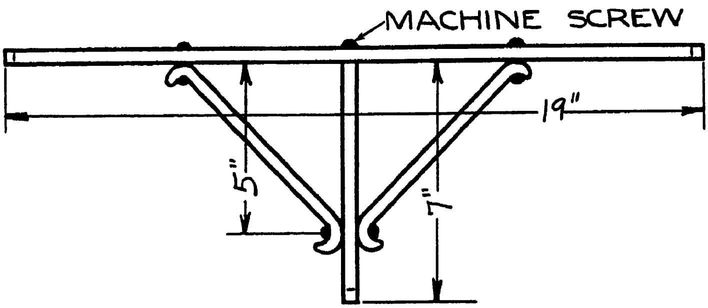


Fig. 69. Braces riveted in place

two $\frac{3}{16}$-in. rivets. The cross strip may be twisted previous to riveting, if desired.

4. The 9-in. strip runs from the center of the long cross strip to the front leg. It is fastened to the cross strip by means of a No. 12—24 1-in. machine screw, and to the leg by means of rivets.

5. The braces are curved at the ends as shown in Figure 69, and are riveted in place with $\frac{3}{16}$-in. rivets. They may be twisted if desired.

6. Stain and varnish the top, and paint the iron flat black. Or, enamel or lacquer the whole table in colors to suit.

21. TELEPHONE TABLE

Twisted Design

This is a handy table on which to set a telephone, or for many other uses. (Fig. 70.)

1. The top is made out of a board 16 by 18 in., hexagonal or six-sided. It is made in conjunction with the woodworking department. A kind of wood should be chosen which can be given the same finish as the rest of the furniture in the home. The top may be completed separate from the rest of the problem.

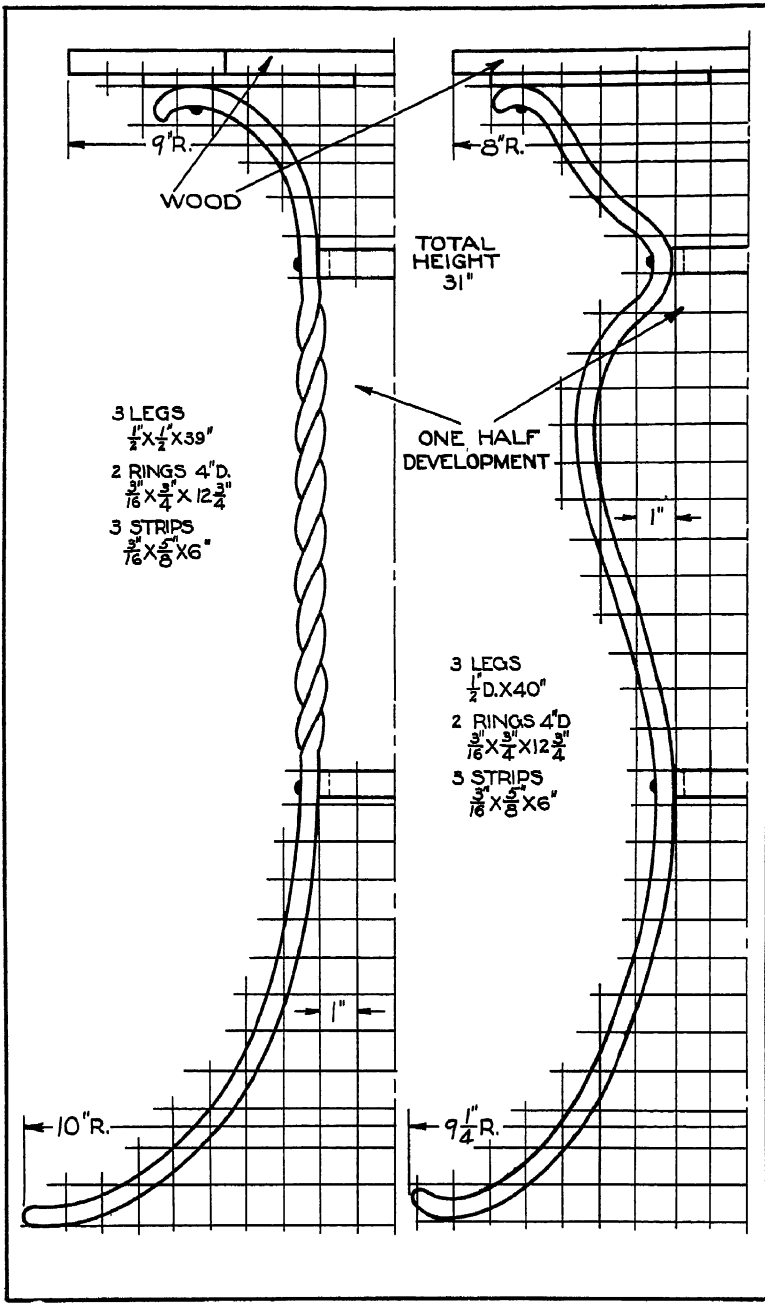


Fig. 70.

Telephone table, twisted design — Telephone table, curved design

2. Bend the legs with the help of a template and a large bending fork. Make the twist as described under Operation G.

3. Drill $\frac{3}{16}$-in. holes for riveting the rings in place, and for fastening the legs to the top. To help hold the legs to the top more securely, rivet a 6-in. piece of $\frac{3}{16}$ by $\frac{5}{8}$-in. iron to the top of each of the legs, and fasten this strip to the top by means of wood screws.

4. Make the rings. Drill the holes $\frac{3}{16}$ in.

5. Rivet the strips to the legs, and rivet the legs to the rings. Fasten the top in place.

6. Paint the legs flat black with gold-bronze trim.

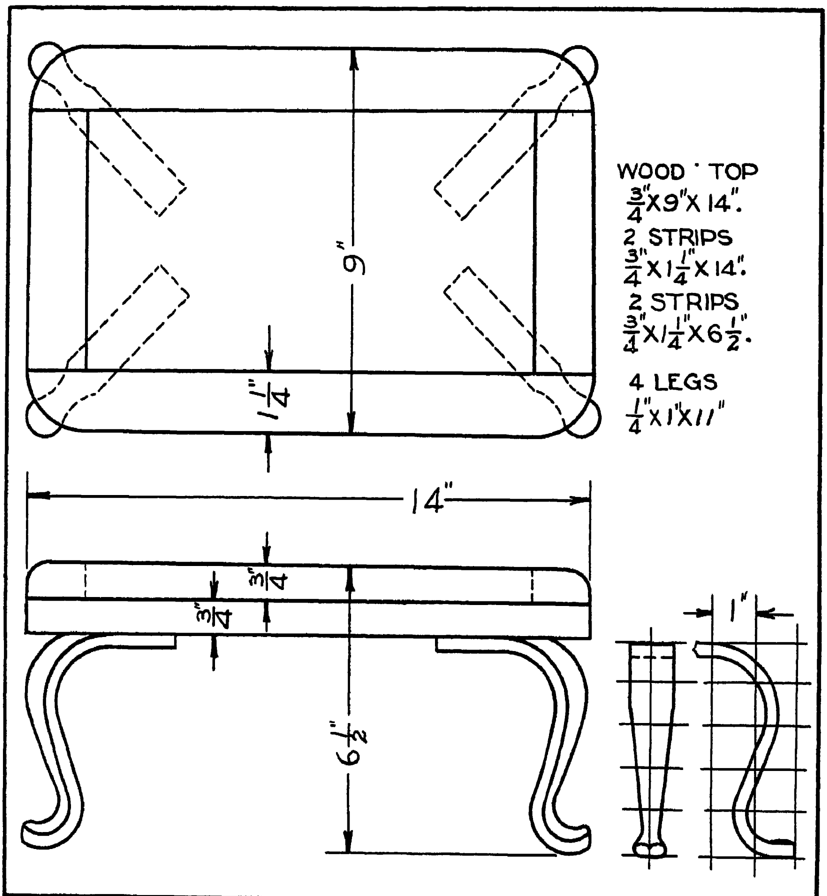


Fig. 71. Footstool

22. TELEPHONE TABLE

Curved Design

The directions for making this table are the same as for making the table described under Project 21. (Fig. 70.)

1. The top for this table is round and is 16 in. in diameter.
2. Bend the legs with the help of a template and a large bending fork. Or, prepare a special compound form, as discussed under Operation N, Figure 33.

23. FOOTSTOOL

Most every home can make use of a footstool (Fig. 71), especially if it can be upholstered to match the other furnishings in the home.

1. Upset the end of the stock, and spread it out to form a flat round foot. Narrow down the part behind the foot to form an "ankle" by hammering the iron between the top and bottom fuller, or by hammering it over the nose of the anvil.
2. Curve the lower part of the leg over the nose of the anvil. Curve the rest of the leg, so that it is 5 in. high, or use a form.
3. Drill three ¼-in. holes into the legs. Fasten the legs to the wood by means of ¼ by 1½-in. stove bolts. Use a flat washer and a lock washer with each bolt.
4. Glue and screw the strips around the edges of the top. Round the corners. These strips are used to help brace the top, and to help produce a thicker cushion.
5. Stuff the seat with excelsior, horsehair, kapok, or cotton, and cover with a sheet of burlap. Fasten the outside covering to the stool by means of a band or gimp, with upholstering tacks.
6. Paint the legs and the underpart of the stool flat black.

24. NOVEL SMOKER'S STAND

This attractive smoker's stand, Figure 72, is welcomed by any dad who is fond of smoking. A smoker's stand may also be made with a base as in Project 55, or Project 57, paragraph *b*.

A smoker's tray 4 in. in diameter should be purchased.

1. Make the dents to produce a hammered finish.
2. Almost the entire base and a large part of the top of the piece called "stem" can be shaped over forms similar to scroll forms, Operation O. The rest of the shaping, or all of it, can be done with the help of a template and a bending fork. Rivet or braze the bottom to the stem.

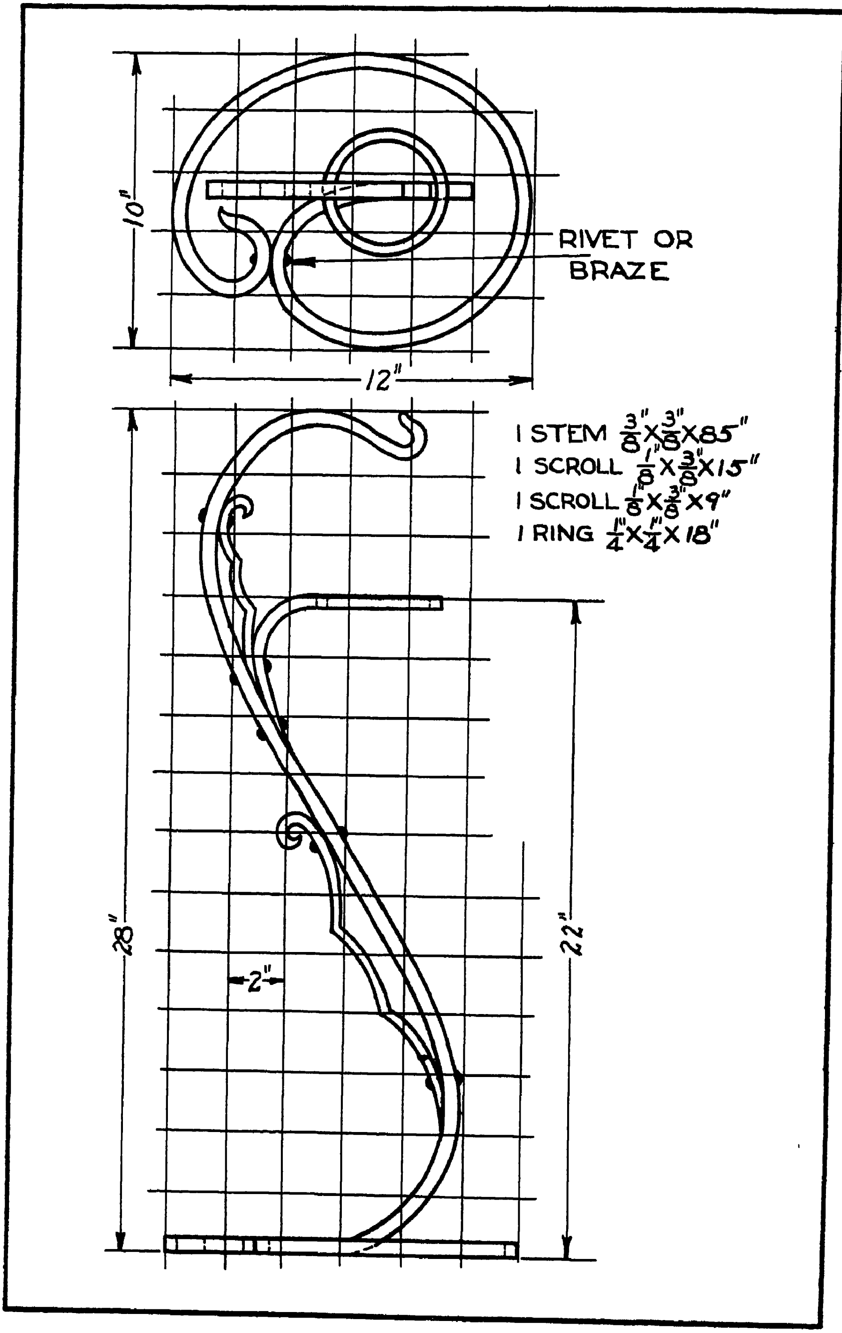


Fig. 72. Novel smoker's stand

3. Shape the two scroll ornaments.

4. The material for shaping the ring to hold the 4-in. tray is cut 18 in. long. Only about 12 in. of this is needed for making the ring proper; the material remaining is used to make the arm for fastening the ring to the stem. If a larger tray is to be used, consult the instructor for directions in making the ring.

5. Assemble the stand, using 1/8-in. rivets.

6. Complete the hammered finish. (Operation Z.)

25. MAGAZINE BASKET

With Twist Ornamentation

This magazine basket, Figure 73, is light, durable, and ornate, and may be carried from place to place.

This problem is attractive with a hammered finish.

1. Make the dents to produce a hammered finish.

2. Take the pieces for the legs, the center brace, and the handle and thin out the ends. Grind the ends to the shape of a spear point, and curve them as illustrated. File the ends of the legs rounded on the bottom, so that they will not scratch the floor after the magazine basket is completed.

3. Find the center of the legs and of the center brace; measure 2 in. on each side of the center and bend the ends so that the curved parts face *inward*. The twist in the legs is 2 in. long, and begins 1½ in. from the bend. After the legs are twisted, the curved portions will face *outward*. Three 3/16-in. holes are drilled in each of these pieces, one in the center of the straight section, and one ¼ in. from each bend.

4. Find the center of the handle and of the side pieces; make the measurements as indicated in the drawing. Make the bends in the vise. The curved portions of the ends of the handle face *inward*. Lay off two twists on each side. Straighten the pieces, should they become warped by twisting. Drill a 3/16-in. hole ¼ in. from the end on the part which is to be fastened to the legs. Drill a 3/16-in. hole ¼ in. from the ends of the pieces for the sides, for fastening the center brace.

5. Rivet the handle to the legs, and make sure that all pieces stand straight. Rivet the sides to the legs, and the center brace to the sides. Clamp the 4-in. part of a leg in the vise, and pull the sides and legs outward as shown in the drawing. Tighten the rivets if necessary.

6. Complete the hammered finish. (Operation Z.)

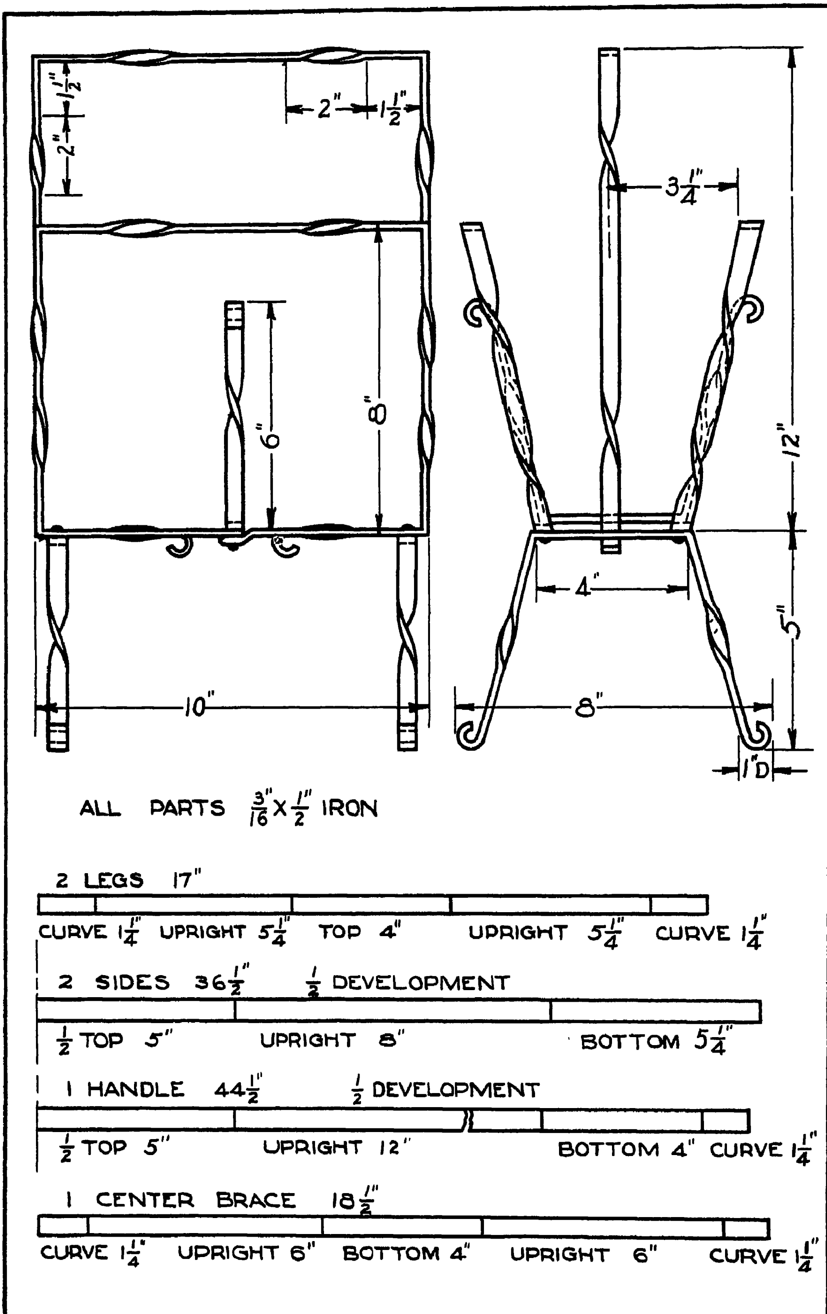


Fig. 73. Magazine basket with twist ornamentation

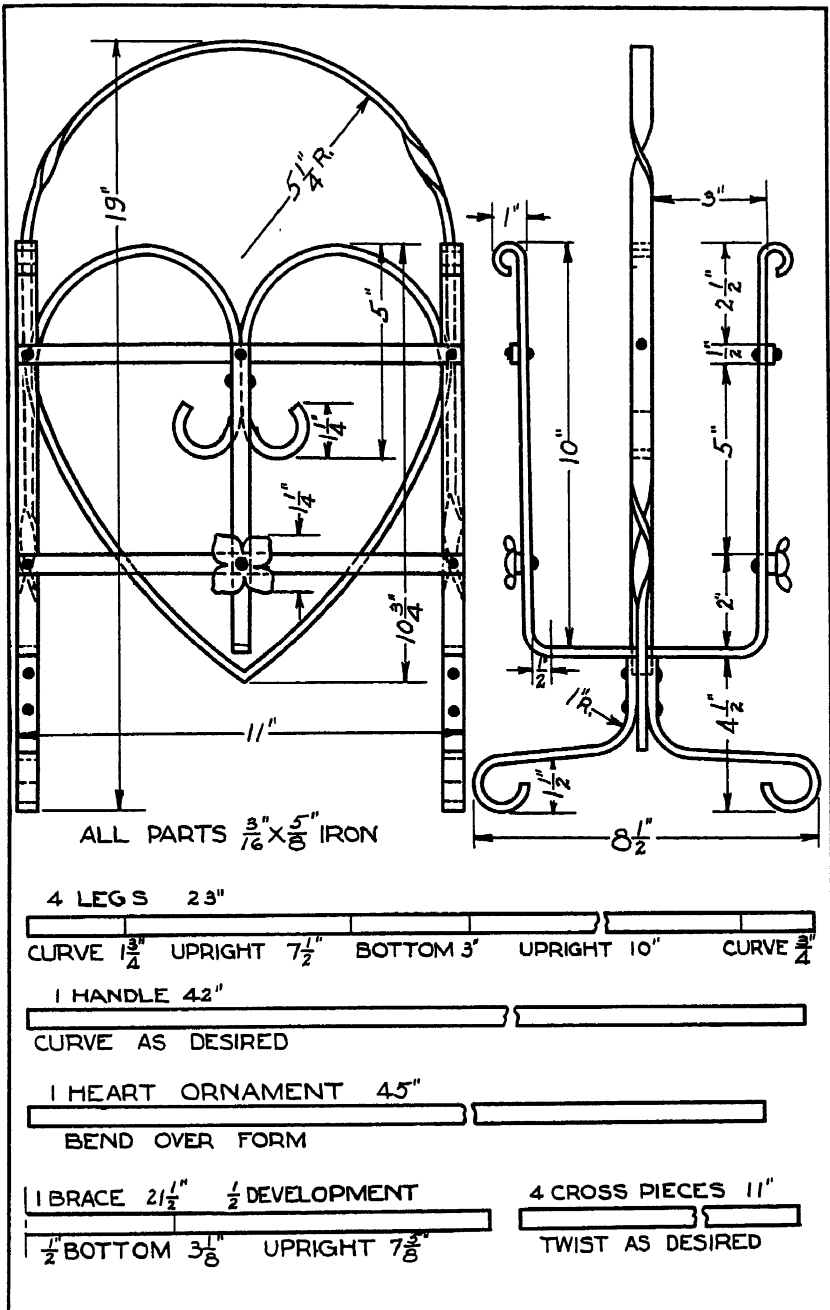


Fig. 74. Magazine basket with heart ornament

26. MAGAZINE BASKET

With Heart Ornament

This magazine basket, Figure 74, is a bit larger and heavier than Project 25. It also looks attractive in a hammered finish.

1. Make the dents to produce a hammered finish.

2. Curve the ends of the pieces for the legs as shown at B, Figure 75. Make the right-angle bend in the vise as at C. Prepare two simple forms, and make the bends as shown at D and E. Place the four legs

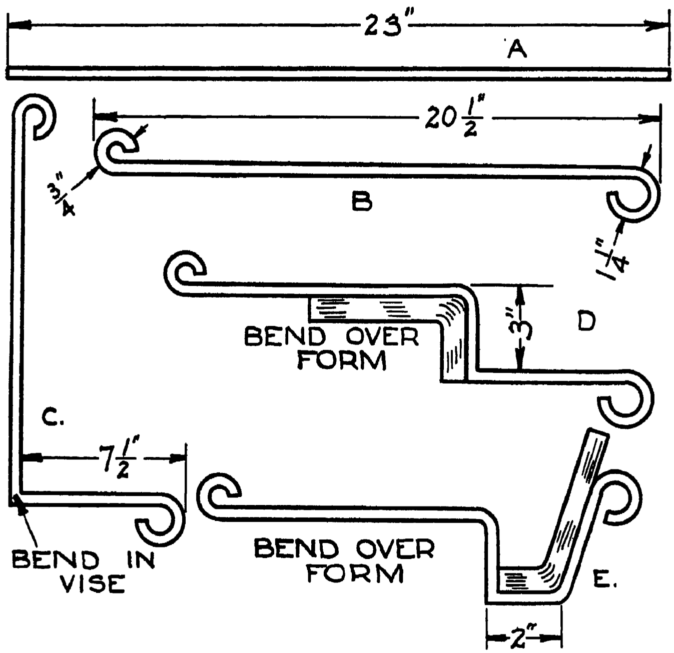


Fig. 75. Making bends in legs for magazine basket

together in the position they are to occupy, and mark off two holes in each. Drill them $\frac{3}{16}$ in. File the ends of the legs rounded on the bottom, so that the legs will not scratch the floor after the magazine basket is completed.

3. Make the bend in the center of the handle with a $5\frac{1}{4}$-in. radius. Twist the ends so that they fit between the legs, as shown. Clamp the legs and the handle together, and mark off the holes on the ends of the handle. Drill the holes $\frac{3}{16}$ in., and rivet the handle and the legs together.

4. Make a template for half of the heart ornament, as at A, Figure

11, and curve the iron according to the template. Rivet the ends together, and the heart to the handle.

5. Drill one of the four crosspieces with a $\frac{3}{16}$-in. hole $\frac{5}{16}$ in. from the ends, and one in the center. Mark these holes off on the other pieces and drill them. Drill holes in the upper parts of the legs, and rivet the crosspieces in place.

6. Make the two four-leaf clovers 1¼ in. square.

7. Bend the brace, place it in position to mark off the holes, drill the holes, and rivet it and the four-leaf clovers to the crosspieces.

8. Complete the hammered finish.

27. FOOT SCRAPER

Goat's-Horn Design

Foot scrapers, Figure 76, were used in the days before sidewalks and paving were common, to scrape the mud off the pedestrian's shoes. They are used nowadays mostly as ornaments for the front porch. They should be put out of the way so that they will not be stumbled over.

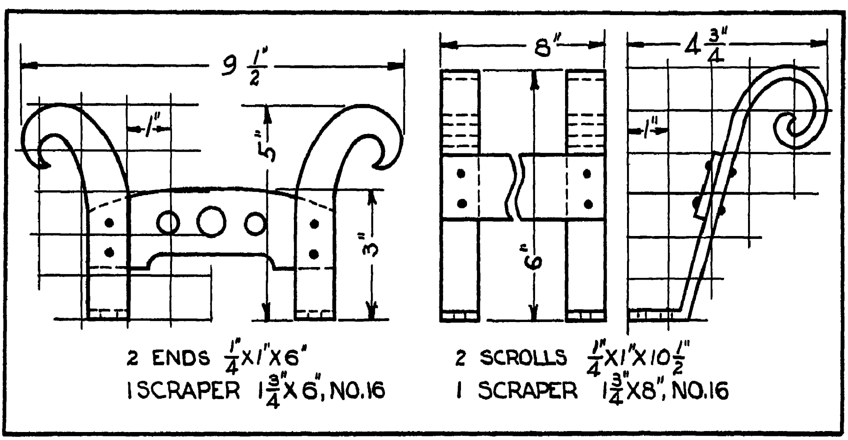


Fig. 76

Foot scraper, goat's-horn design — Foot scraper, scroll design

The edge on which the scraping is to be done should be rounded, not sharp; it is desired to scrape the shoes, not cut them.

If the porch floor or steps are made of wood, drill ¼-in. holes into the foot scraper for fastening it to the wood. Use four ¼ by 1½-in. lag screws.

If the porch or steps are concrete, drill four 3/8-in. holes into the foot scraper for fastening it down.

a) Drive some short lengths of 2 by 4-in. wood into the ground next to the concrete, and fasten the foot scraper to these blocks with 3/8 by 2-in. lag screws.

b) Chisel holes into the concrete with a cold chisel, or better, with a star drill. Plug these holes up with pieces of wood, and fasten the foot scraper to these pieces with 3/8 by 2-in. lag screws.

The foot scraper should be given two coats of flat black paint.

1. Cut a piece of metal 12 in. long for making the ends; draw the taper on one side of each end of this piece; curve the horn shape over the nose of the anvil and compare these curves with a template previously made; cut the iron in halves, and bend over 1 1/2 in. of each part so that the two will form a pair.
2. Cut, grind, and file the scraper to the shape shown.
3. Lay off the holes, and rivet the pieces together with 1/4-in. rivets.

28. FOOT SCRAPER

Scroll Design

The general directions for making this scraper, Figure 76, are the same as for Project 27.

1. Shape the scrolls over a scroll form.
2. Cut out the scraper, and drill the holes.
3. Rivet the pieces together with 1/4-in. rivets.

29. DOOR KNOCKER

Pear Design

Door knockers, as the name implies, are for knocking on doors. (Fig. 77.) They were used before the day of the electric doorbell, and are still used as an ornament for the front door.

1. Make a full-size drawing of the design of the back on paper or on sheet metal, to serve as a template.
2. Trace the design on the sheet iron. Make a series of light center-punch marks along this line, so that the design will not be lost.
3. Cut out the design by drilling holes at the inside curves, and by using the shears, hack saw, grinder, and file.
4. Drill the hole and shape the ball on the lathe.
5. Slide the ball on the piece for the knocker. Upset and flatten the ends of this piece. Bend the iron to shape with the help of the

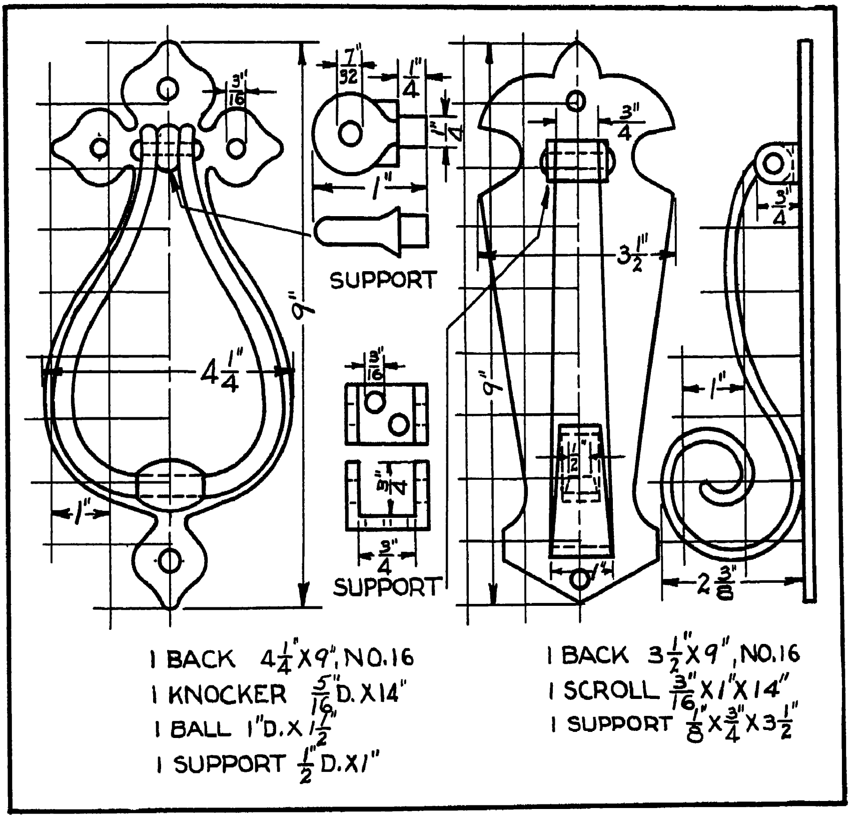


Fig. 77

Door knocker, pear design — Door knocker, scroll design

bending fork; be sure to keep the ball in the center. Drill a 3/16-in. hole in the ends for the rivet.

6. The support or eye is made by upsetting the end of a short piece of stock, ½ in. diameter, flattening and rounding the end, and turning down a portion of it to ¼ in. diameter on the lathe. Cut off the excess stock at this end.

7. Drill a ¼-in hole for riveting the support to the back. To keep the support from turning in this hole, file the hole out oval shaped, then when the support is riveted in place, the riveted portion will also be oval shaped, and so cannot turn. This hole also should be countersunk so that the head of the rivet will not project. (Fig. 78.)

8. Drill the hole in the support 7/32 in., and rivet the knocker in

place with a $\frac{3}{16}$-in. rivet. The rivet will then be tight in the knocker part, but will swing freely in the support.

9. Drill the holes in the back for fastening the knocker to the door.

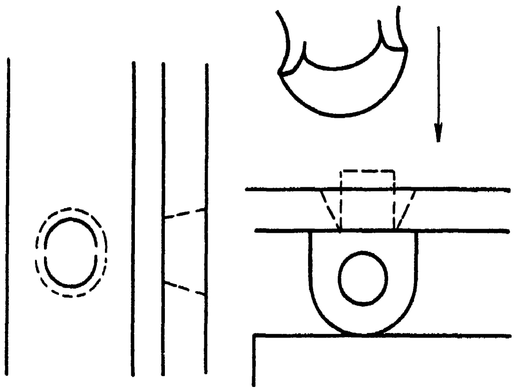


Fig. 78. Riveting the support to the back

10. The knocker looks well in a hammered or a flat black finish. It may also be copper plated, at a commercial plating works, and finished in one of the various finishes for copper.

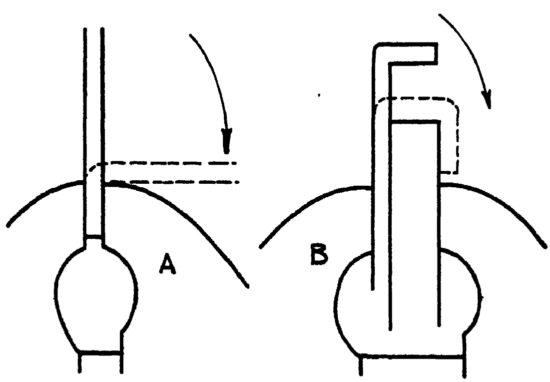


Fig. 79. Shaping the U piece

30. DOOR KNOCKER

Scroll Design

1. The directions for making the back are the same as for Project 29, paragraphs 1, 2, and 3. (Fig. 77.)

2. The iron for the scroll is 1 in. wide at the widest place, ¾ in. wide at the top, and ½ in. wide at the inner end. Shape the end over a scroll form. Curve the upper end to fit over a $\frac{3}{16}$-in. rivet after the manner shown in Figure 35.

3. Shape the U piece or support over a piece of ¾-in. iron as shown in Figure 79. Drill two $\frac{3}{16}$-in. holes for fastening the U piece to the

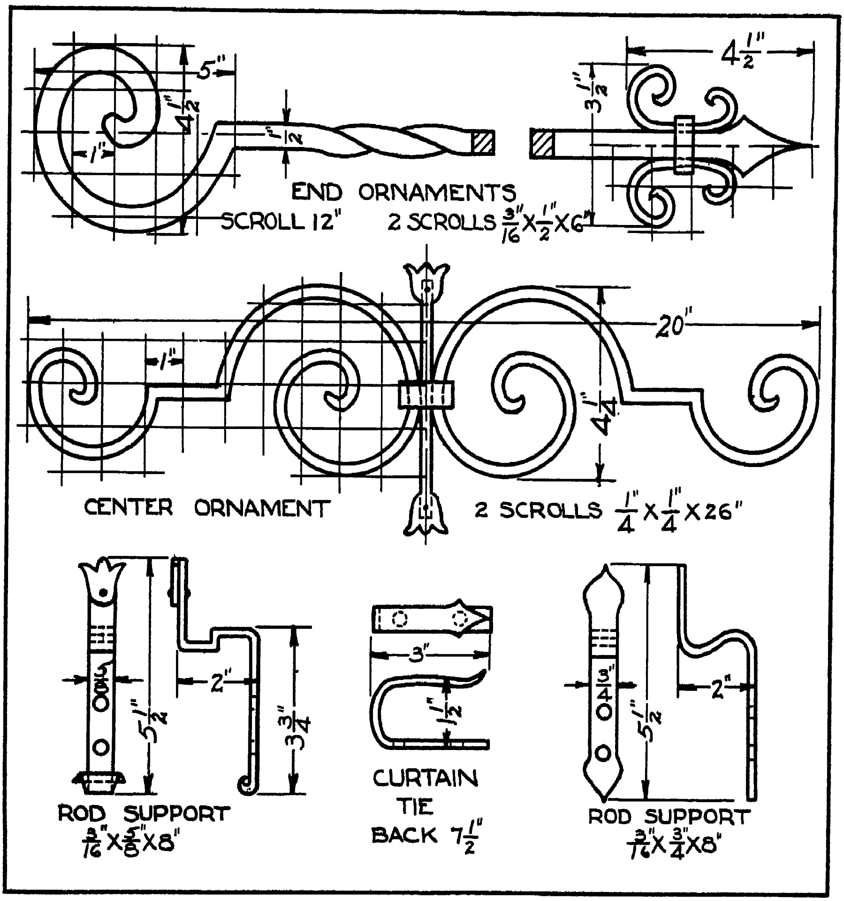


Fig. 80. Drapery rods and accessories

back, with countersunk rivets. Drill the $\frac{3}{16}$-in. hole for the rivet to fasten the scroll knocker in place.

4. Rivet the knocker to the U piece with a $\frac{3}{16}$-in. rivet.

5. This knocker looks well in a hammered or flat black finish.

31. DRAPERY RODS AND ACCESSORIES

Drapery rods of wrought iron are attractive ornaments for the home. A set consists of the rod and the two finials (all in one piece), a pair of supports for the rod, and a pair of curtain tie backs. An ornament may also be placed in the center of the rod. (Fig. 80.)

The size of stock will depend, of course, on the size of the window and the length of the rod to be used. Rods for windows up to 3 ft. in width may be made of $\frac{5}{16}$-in. stock. Rods for windows from 3 to 6 ft. should be $\frac{3}{8}$ or $\frac{7}{16}$ in., and will require three supports, an additional one in the center. Longer windows will need $\frac{1}{2}$-in. stock, and perhaps two additional supports.

When several sizes of windows are to be provided for, an average size of stock should be decided upon and used on all the windows. For the longer windows, additional supports will then be necessary.

In determining the length of rod necessary for the drapes, place the supports in place on the window, and then measure the length needed. The dimensions given on the drawing are for the finial ornaments alone.

The drapes are hung from the rod by means of wire rings $1\frac{1}{2}$ in. in diameter, which are put in place before the ends are shaped. When a center ornament is used, these rings must be spaced and put in position first. The rings had best be purchased; they may be made, however, by winding a coil of No. 9 wire over a rod of the right diameter, and then cutting each coil apart. The ends may be brazed together, or left with just a plain butt joint. Other smaller wire rings, about $\frac{1}{2}$ in. in diameter, are sewed to the drapes and slipped into the larger rings.

1. The scroll finial is shaped over a scroll form.
2. The spear point is shaped by flattening the end of the bar and hammering and grinding it to shape. The scrolls are formed over scroll forms, or over the anvil, as shown in Figure 35. These scrolls are held to the spear end by means of a clip.
3. The center ornament is shaped over a scroll form. The tulip ends are cut out of No. 16 sheet iron and are riveted to the center rod. The center rod and the two scrolls are held together by means of a clip. The center ornament is fastened to the rod by means of stove bolts or machine screws.
4. The rod supports should be so shaped that the rod fits snugly in place. In some cases it may be necessary to drill the rod supports and the rod, and hold them together by means of a pin or machine screw.
5. Drapery rods look well in a hammered or flat black finish.

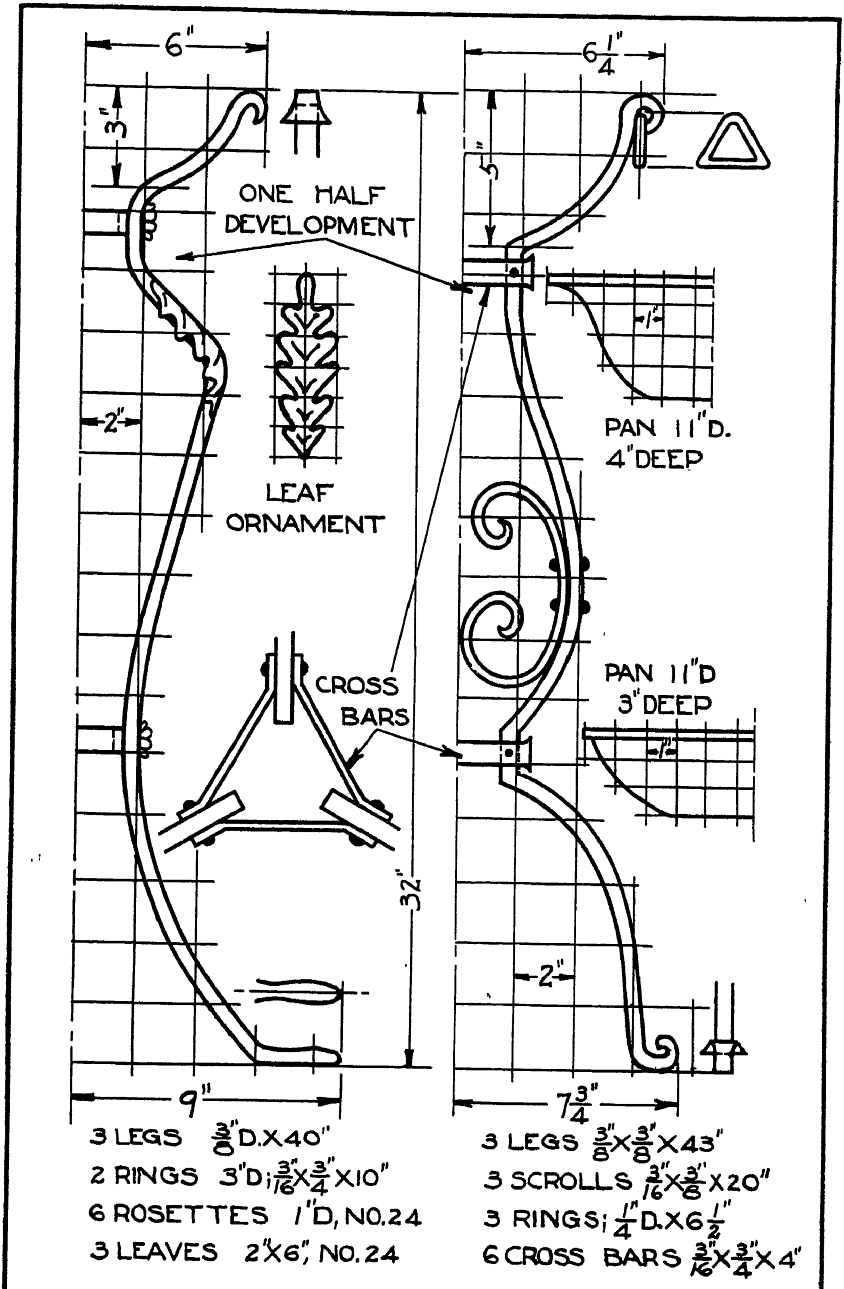


Fig. 81

Fern stand with leaf ornaments — Fern stand, cross-bar design

32. FERN STAND

With Leaf Ornaments

A fern stand, Figure 81, is a useful as well as an ornamental piece of furniture and will readily find a place in the home.

With both drawings is shown the kind of pan that will fit the stand; these pans are to be purchased, of course. It is advisable to purchase the pan before beginning to make the stand. If a special type of pan or jardiniere is to be used, make a full-size drawing of it with two of the legs with which it is to be used. It is then possible to judge from the drawing whether the completed project will be in proportion and whether it will look pleasing or not.

The foregoing directions apply equally well to the making of aquariums, Projects 34 and 35.

With but slight changes, either of the fern-stand designs can be converted into aquariums, and vice versa. The ambitious student will find that a multitude of different designs for the legs can be worked out, and he will want to make his own design.

1. Make the rings. (Operation K.)
2. Make a template showing the shape of the leg.
3. Shape the ends as illustrated.
4. Shape the curve with the help of a compound form, or in the bending fork.
5. Place all three legs against the back of the bench, and lay off the holes for the rivets. Drill the holes $\frac{3}{16}$ in.
6. Cut out the ornamental leaves. (Operation Q.)
7. The fern stand looks well in a hammered or flat black finish. It also may be enameled or lacquered green.

33. FERN STAND

Cross-Bar Design

1. The same general directions apply to making this stand, Figure 81, as for Project 32. Work out your own procedure and have the instructor check your work.
2. The easiest way to shape the curve is over a compound form, Figure 32, Operation N. After shaping the flared scroll at the foot, measure 12 in. to the first right-angle bend, and 1½ in. to the next right-angle bend. Make these bends in the vise. The curves may then be shaped over the form as illustrated.

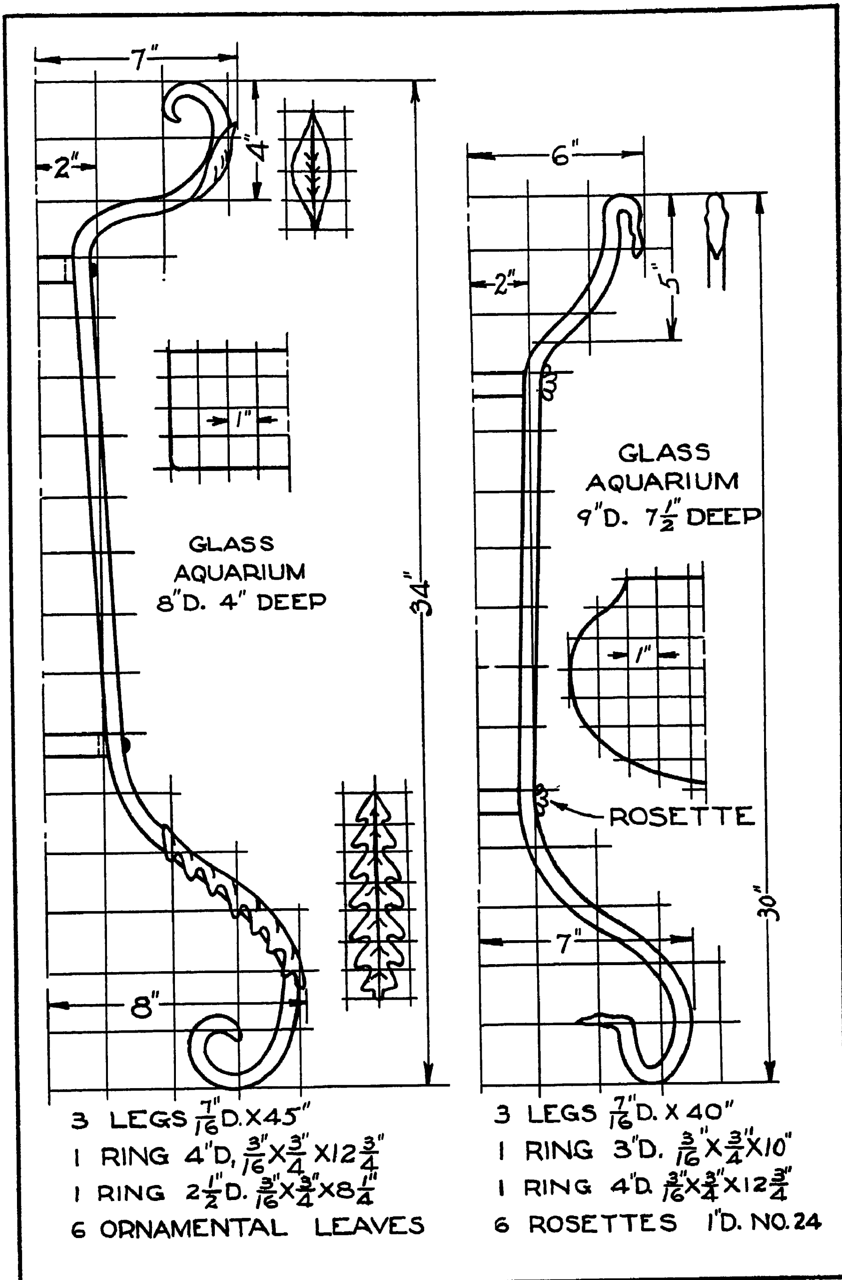


Fig. 82

Aquarium stand with leaf ornaments

Aquarium stand with rosette ornaments

34. AQUARIUM STAND

With Leaf Ornaments

1. The same general directions apply for making this aquarium stand, Figure 82, as for Project 32. Work out your own procedure.
2. The ends are shaped over scroll forms.

35. AQUARIUM STAND

With Rosette Ornaments

1. The same directions apply for making this aquarium stand, Figure 82, as for Project 32. Work out your own procedure.
2. The lower end is best shaped over a form with a bent-over end, as shown in Figure 31, Operation N.

C. Andirons and Fireplace Accessories

36. ANDIRONS

Ring Design

Andirons and other fireplace equipment are heritages that have come down to us from olden times. Such equipment is not now essential to home comfort as it was in those early days, but we still find these articles serving as ornaments, and lending character and romance to the home.

Andirons are always made in pairs. The back runners, on which the logs are to be burned, must be made sturdy enough so that they will not bend under the load when heated by the fire.

1. The post in Figure 83 is made of 3/8 by 1½-in. iron cut 26 in. long. The feet are made by cutting 6 in. down the center of the leg, and spreading the pieces out as shown. The feet must rest flat on the floor, and the post must stand up straight.

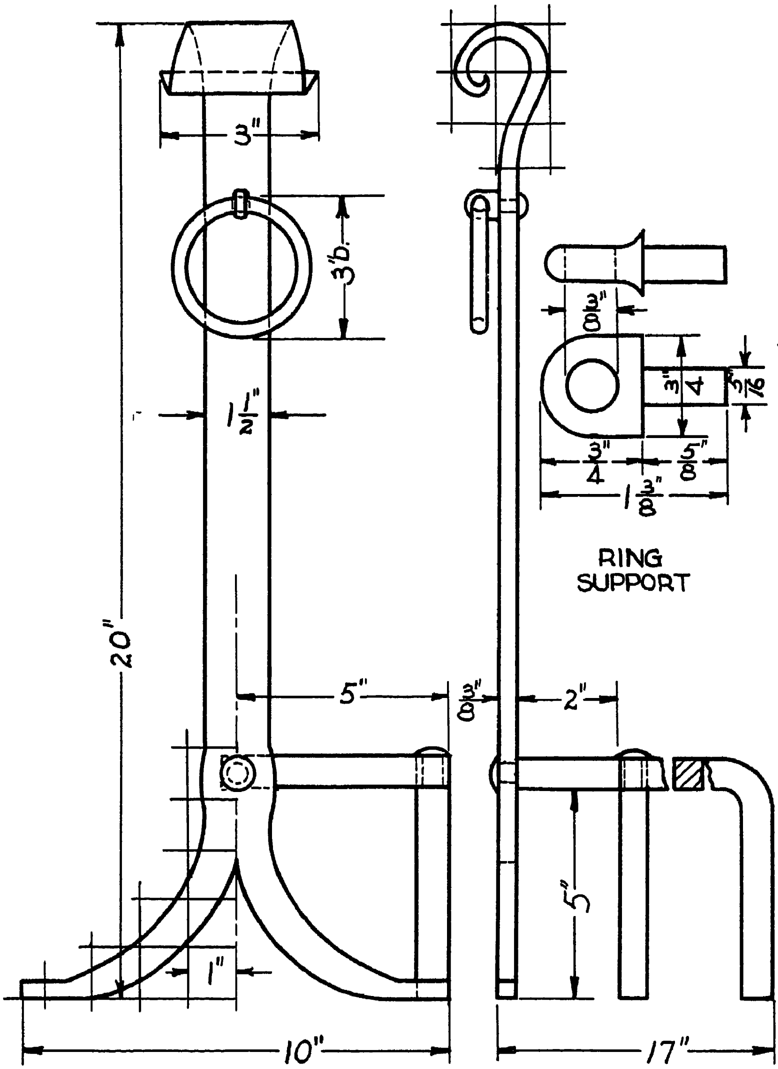
2. Upset and flare the upper end to 3 in. in width and about 3/32 in. in thickness. Bending of the scroll is started over the rounded edge of the anvil, as shown in Figure 35, Operation O.

3. The support or eye is made by upsetting the end of a short piece of stock 5/8 in. in diameter, flattening and rounding the end, and turning down a portion of it to 5/16 in. diameter on the lathe. Cut off the excess stock at this end.

4. Drill a 5/16-in. hole for riveting the support to the post. To keep the support from turning in this hole, file the hole out oval shaped. (See Fig. 78.)

5. The ring is 3 in. in diameter, and is shaped over the nose of the anvil. The ends are brought together to form a butt joint inside the support. It is not necessary to braze or weld this joint.

6. One end of the back runner is turned down to a 5/8-in. shoulder on the lathe, so that the back runner may be riveted to the post. File the hole oval shaped. (Fig. 78.) The runner is bent so that the andirons may be placed close together for burning short lengths of timber. To brace the runner, a short piece of ¾ by ¾-in. stock is riveted



1 POST 3/8" X 1 1/2" X 26"
1 BACK RUNNER 3/4" X 3/4" X 27"
1 RING 3"D, 5/16" D. X 9 1/2"
1 LEG 3/4" X 3/4" X 6"

Fig. 83. Andirons, ring design

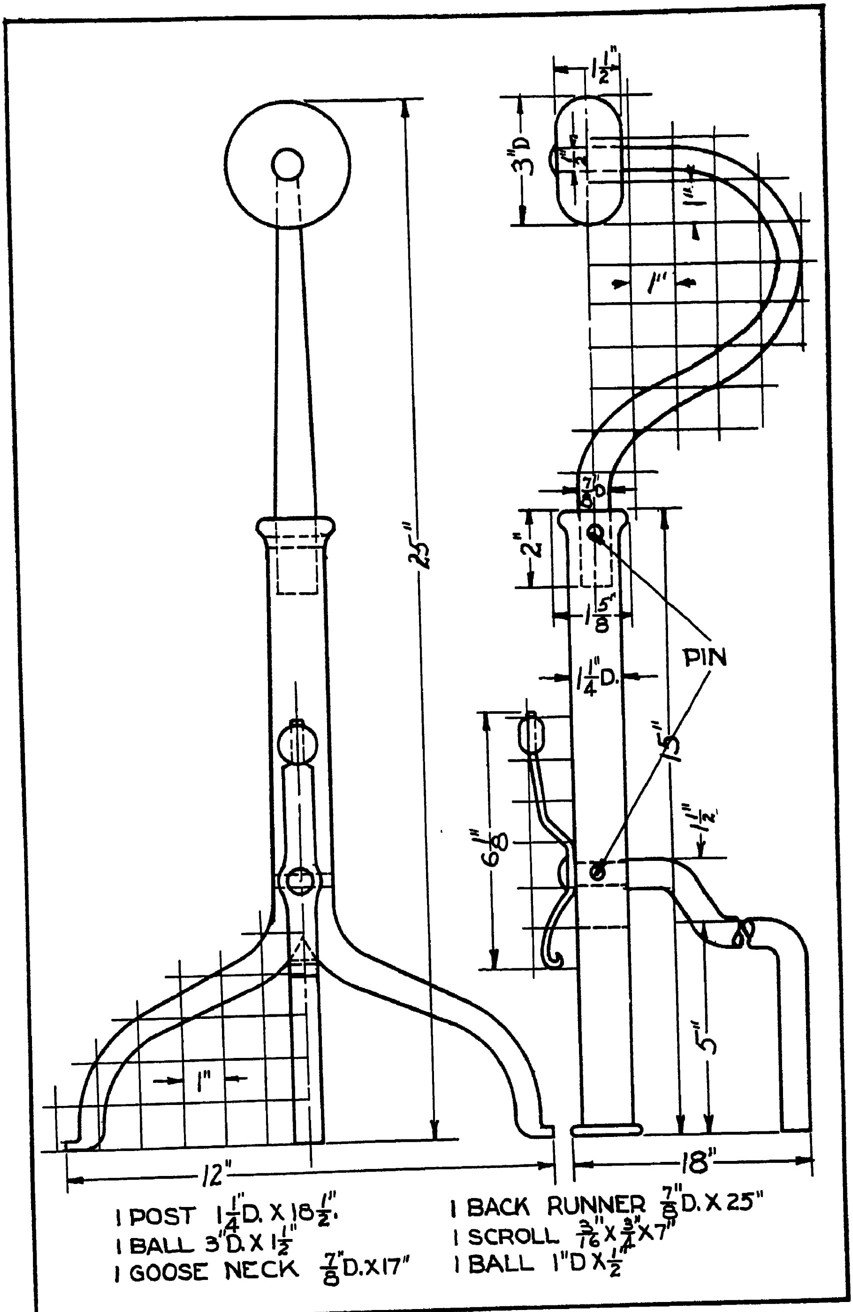


Fig. 84. Andirons, gooseneck design

to it, as shown in the drawing. Either of the designs for back runners shown in Project 37 or 38 may be adapted to these andirons.

7. The most suitable finish for these andirons is two coats of flat black paint.

37. ANDIRONS

Gooseneck Design

1. Upset the upper end of the post in Figure 84. Drill a hole 7/8 in. in diameter and 2 in. deep into this end. Make a saw cut 8 in. long in the other end and spread the pieces to shape over the anvil. Shape the feet.

2. The piece for the gooseneck tapers from 7/8 to 1/2 in. in diameter. This taper can be formed on the anvil, but the job will prove difficult and tedious. It will be much easier and more instructive to do this work on the lathe by the set-over tailstock method. Set the tailstock center over $\frac{3}{16}$ in. The instructor will furnish special directions for this job.

3. Curve the gooseneck to shape over the anvil or over a simple form. Drive the end into the post, and fasten it in place with one or two pins.

4. The ball on the end of the gooseneck is cut off a large size cast-iron dumb-bell, or other iron. Drill a 1/2-in. hole through the center, and drive it on the tapered end of the gooseneck. Rivet the end.

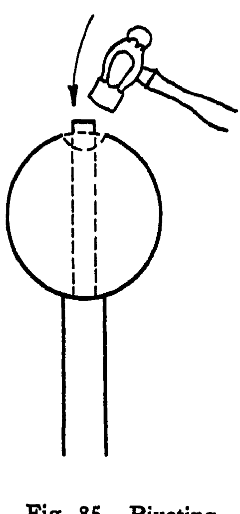


Fig. 85. Riveting the ball in place

5. The scroll pieces are put on both for ornament and for utility. They are used primarily to hold a poker, Project 39. The ends which receive the ball are first hammered to 1/4 in. in diameter, trued up on the lathe, and then bent to shape. To shape the hole for the back runner, drill two 1/4-in. holes next to each other, and spread this hole to 5/8-in. diameter with a special tapered punch.

6. Turn the ball on the lathe, and rivet it in place on the end of the scroll, as in Figure 85.

7. The back runners are cut to 5/8 in. in diameter for 1 5/8 in. of their length, which end is to be used in riveting the scroll and the runner to the post. A pin may be used to make this joint

more secure. Before the runners are riveted in place, they should be bent to the shape shown.

8. The most suitable finish for these andirons is two coats of flat black paint.

38. ANDIRONS

Twisted Design

1. Upset the base of the post in Figure 86 to 1¼ in. square. Taper the rest of the post from 1 to ½ in. square. Shape the spear-point end. Mark off the twist with center-punch marks; heat this section to a uniform red heat, and twist through one complete revolution, one post from left to right, and the other from right to left. Drill a $\frac{7}{16}$-in. hole 2 in. into the base of the post, and thread with a ½-in. S.A.E. tap.

2. Shape the scrolls, and rivet them to the post. Plan your own procedure.

3. Shape the base curves over a compound form, or with the help of a large bending fork and a template. Drill a $\frac{17}{32}$-in. hole for the bolt to pass through; file shallow grooves where the base of the post touches the curve.

4. Measure 1⅜ in. to the center of the $\frac{17}{32}$-in. hole in the back runner. Bolt the runner, the base curve, and post together; mark off the place where the runner is to be bent up; take all the pieces apart and bend the back runner in the vise. This ½-in. bolt will hold the entire andiron together.

5. The most suitable finish for these andirons is two coats of flat black paint.

39. FIREPLACE SET

Poker, Shovel, Tongs, and Stand

The pieces of this set are made out of iron ⅜ in. in diameter, according to the drawing, Figure 87. If this set is to be made to accompany the andirons in Project 38, it should be made of $\frac{7}{16}$ by $\frac{7}{16}$-in. square stock, and twisted. If the set is to accompany the andirons in Project 36, shape small flared scrolls on the handle end instead of the ball ornament shown in the drawing.

The Poker. 1. Turn 1¼ in. of the end down to $\frac{5}{16}$ in. in diameter. Shape the ball on the lathe, and rivet it to the poker as shown in Figure 85. Shape the taper, and form the curve as on the drawing.

The Shovel. 1. Shape the handle in the same way as the poker

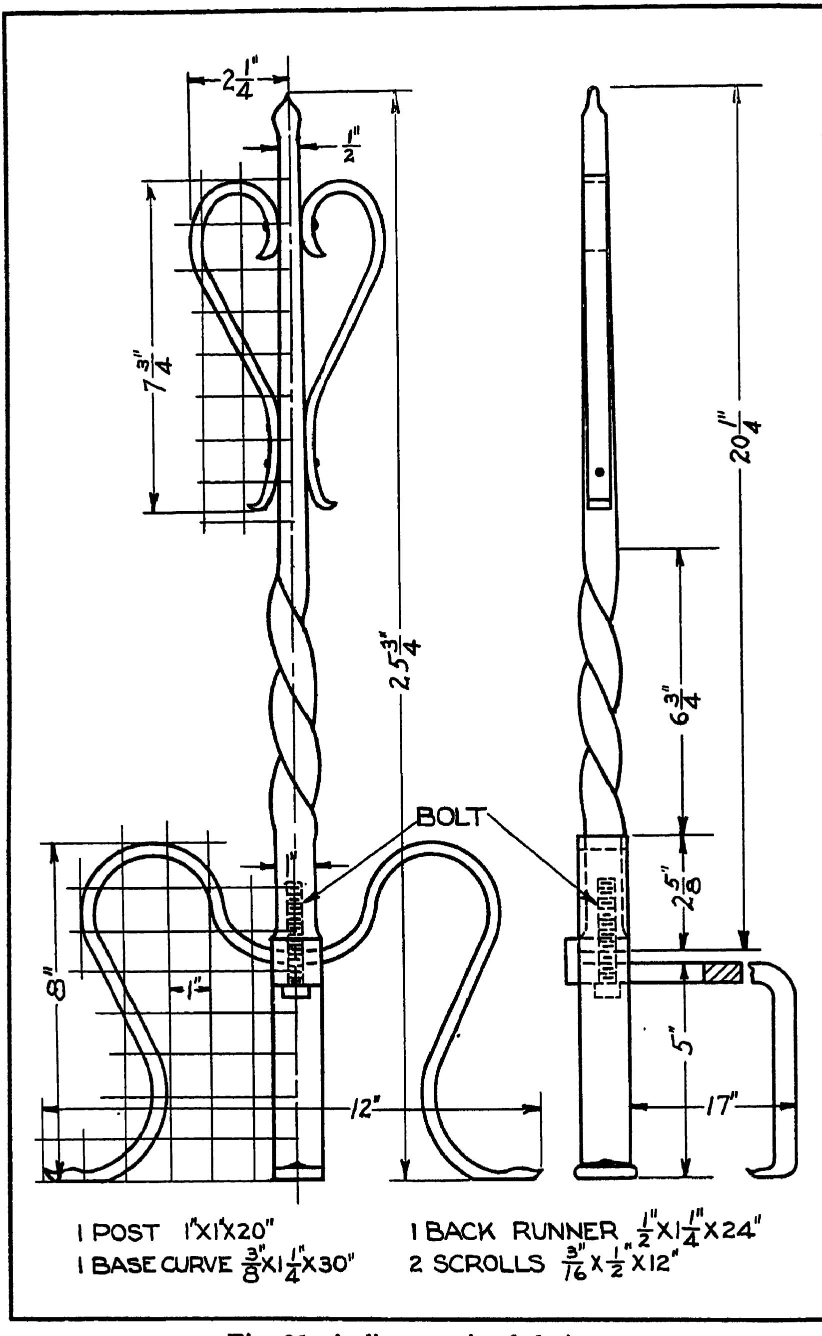


Fig. 86. Andirons, twisted design

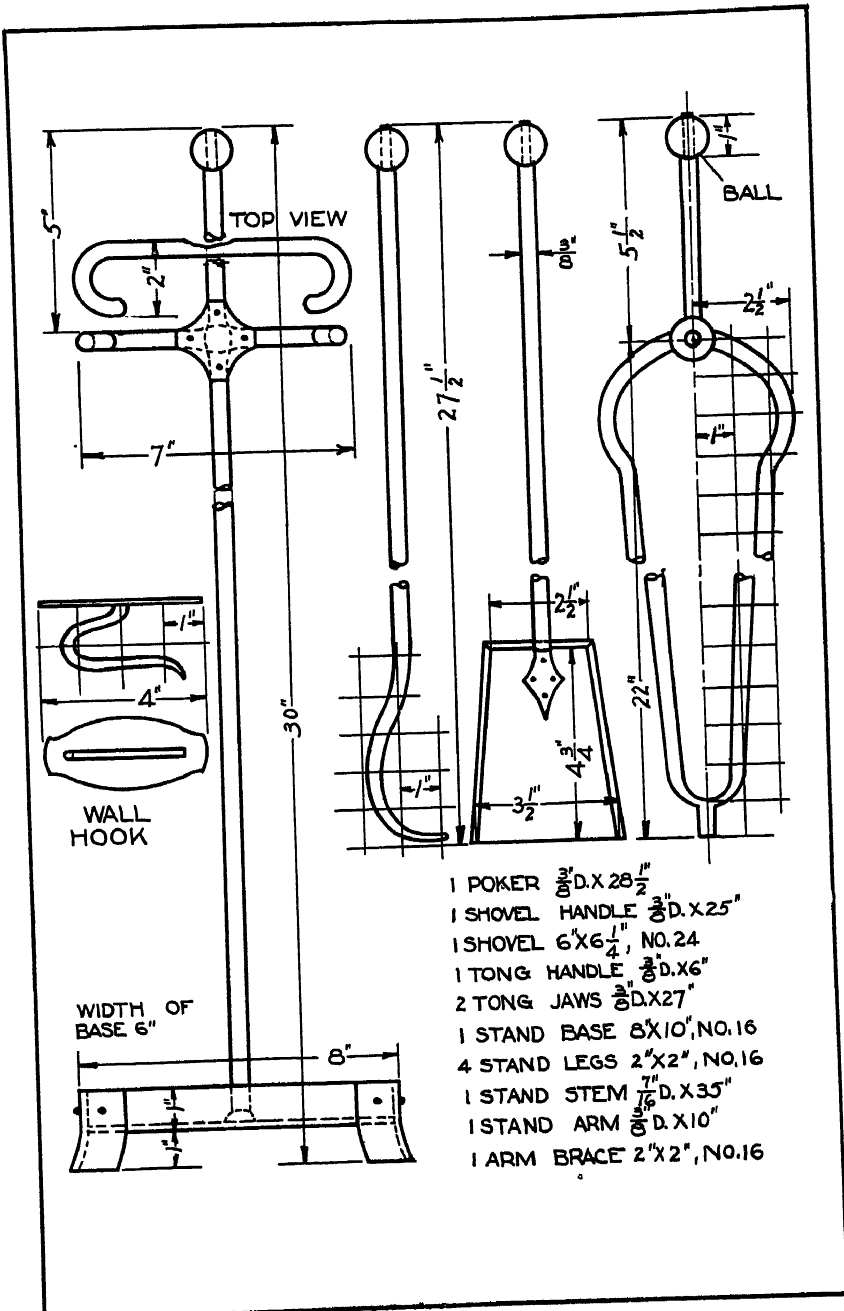


Fig. 87. Fireplace set—stand, poker, shovel, and tongs

handle was shaped. Make a drawing of the pattern for the shovel as in Figure 88, and cut away the excess material. Bend over the ¼-in. wide edges marked "hem." Bend up the back, the sides, and the parts marked "lap." Rivet the laps to the back and the handle to the shovel with ⅛-in. rivets.

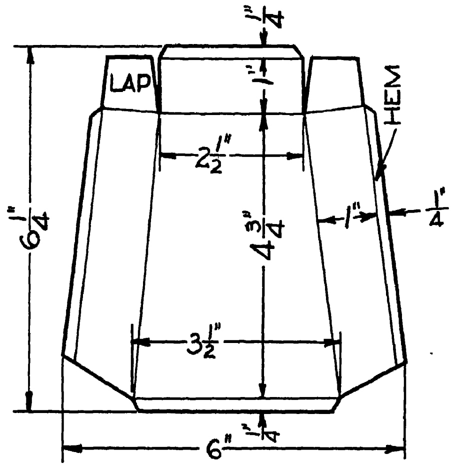


Fig. 88. Pattern for the shovel

The Tongs. 1. Shape the handle in the same way as the poker handle was shaped. Upset the other end of the handle, and flare it out to ¾ in. round and $\frac{3}{16}$ in. thick, as illustrated at B, Figure 89.

2. Shape the upper end of the pieces for the tongs in the same way as for the handle, except that it will be necessary to make a ⅛-in. offset, as shown at A and at C, Figure 89. Plan your own procedure from the information given.

3. Make a special bolt as shown at D, Figure 89. When using this

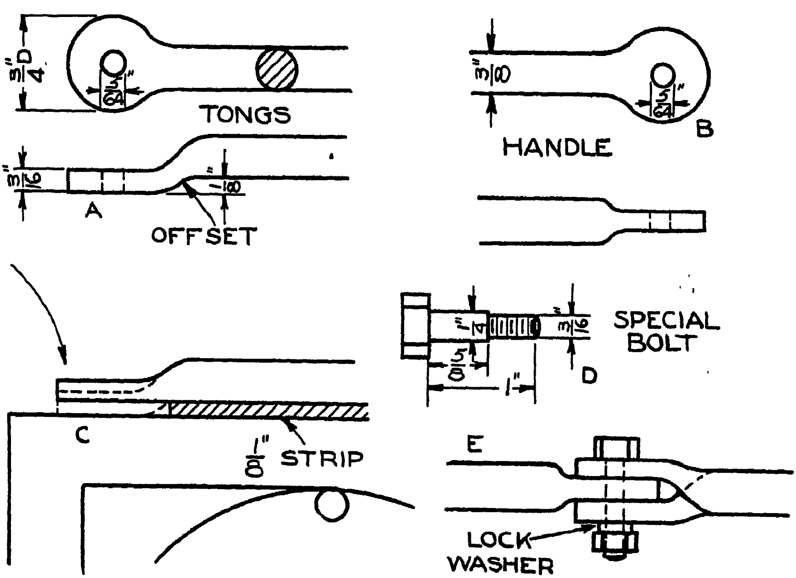


Fig. 89. Steps in making the tongs

bolt, it will be possible to draw the nut up tightly on the bolt, and still permit the tongs to swing freely. The lock washer provides sufficient tension to hold the tongs in position.

4. Shape the lower end of the tongs as illustrated. Plan your own procedure, and check with the instructor.

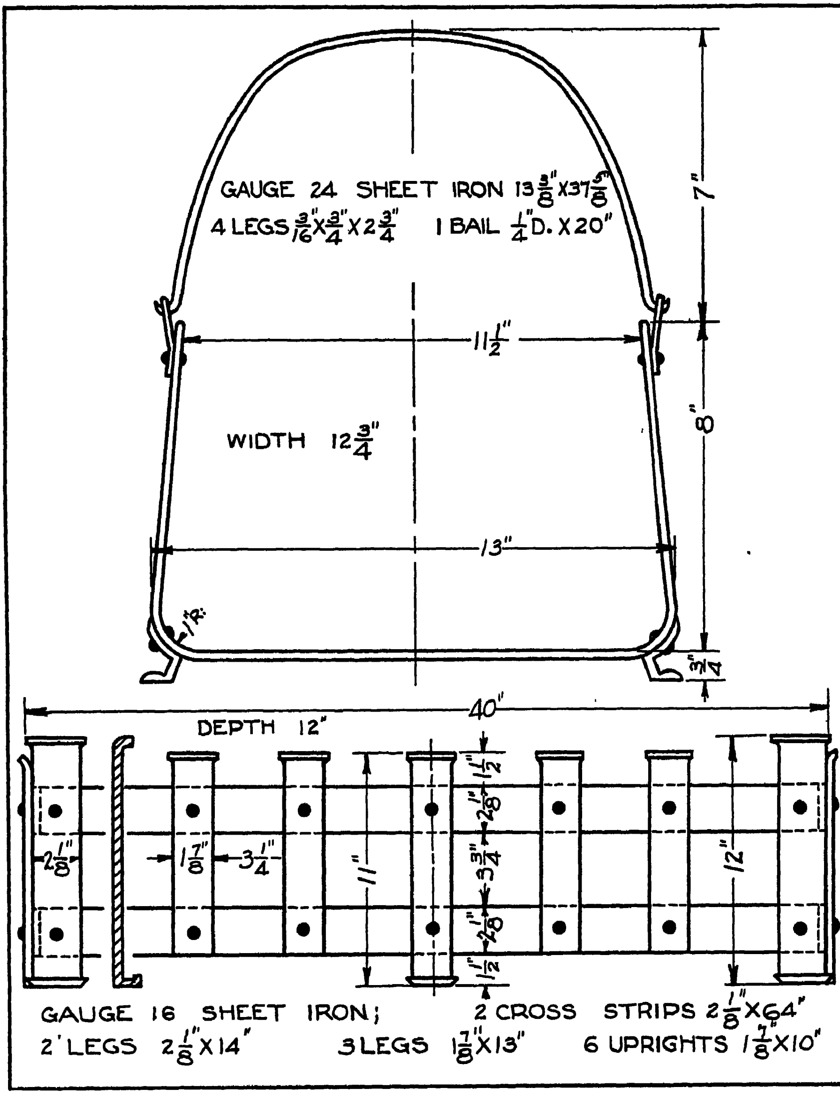


Fig. 90. Top: Log holder
Bottom: Fireplace fender

The Stand. 1. Cut the base 8 by 10 in.; cut out a 1-in. square at each corner; bend the 1-in. sides up square at the corners. Cut the legs, bend them, and rivet them as illustrated.

2. The stem is cut 35 in. long, when the part which is riveted to the base extends straight across the bottom of the sheet-iron base, dividing the base in half. Instead of this, that part of the stem which fastens to the base may be made circular in shape, scroll shaped, or some other pleasing shape. In this case, the metal for the stem must be cut longer.

If desired, two braces may be made, running from the stem to the base.

3. The stand arm, of which the top and front views are shown in the drawing, ought to be welded to the stem. If it cannot be welded, it may be fastened by means of the arm brace and ⅛-in. rivets, as shown.

The Wall Hook. 1. The wall hook may be made for holding the poker, in place of putting the poker on the stand. It is fastened to the wall by chiseling out small holes in the cement between the bricks, plugging these holes up with wood, and driving the screws into the wood.

The parts of the fireplace set look well in a flat black finish.

40. LOG HOLDER

1. Cut a piece of No. 24 gauge sheet iron to the size specified in Figure 90. Round the corners, using a 2-in. radius. Wire all around the edge with No. 9 wire, or rivet some ⅛ by ½-in. iron bands around the edge, making the ends of the two pieces meet at the ears for the bail. Bend the sheet of iron to shape.

2. Bend the feet to shape as shown in Figure 91. Rivet these feet to the sheet metal with two ⅛-in. rivets each.

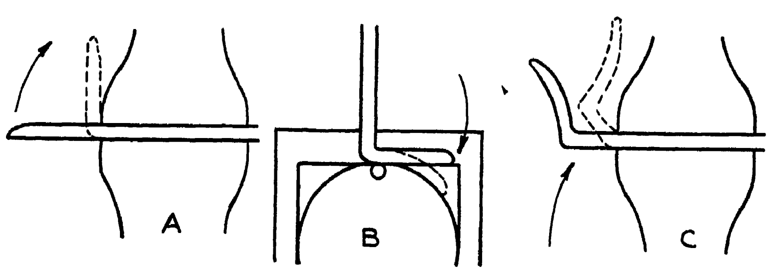


Fig. 91. Bending the feet of the log holder

3. The ears which hold the bail are triangles with sides of the same length, and with the corners rounded off. They are made of No. 16 gauge sheet iron. A $\frac{5}{16}$-in. hole is drilled to receive the bail. Make a small groove in each ear running upward from the hole. The bail will slip into this groove and so remain in an upright position.

4. The log holder looks well in a flat black finish.

41. FIREPLACE FENDER

This fender, Figure 90, consists of two cross strips with legs and uprights riveted to them with large $\frac{1}{4}$-in. rivets. Work out your own procedure and check with the instructor.

D. Candlesticks

GENERAL DIRECTIONS

Candlesticks are no longer a necessity, as they were before the use of gas and electric light. Nevertheless, they are still in almost universal use as ornaments, both on the mantel of the fireplace, and on the banquet table. Their presence brings charm and romance to the home.

When purchasing candles, it is advisable to take the candlestick along and try different candles to find out which look most pleasing.

Candlesticks are usually made in pairs.

Turning and Shaping. Special directions for operating the lathe are given by the instructor, and no work should be done on the lathe without his full consent.

When cutting stock to be worked on the lathe, it is almost always necessary to cut the material from 1 to 2 in. longer. The work is held in the lathe partly by clamping this extra stock in the chuck.

Shaping operations on the lathe can be greatly facilitated by the use of templates. (Operation B.)

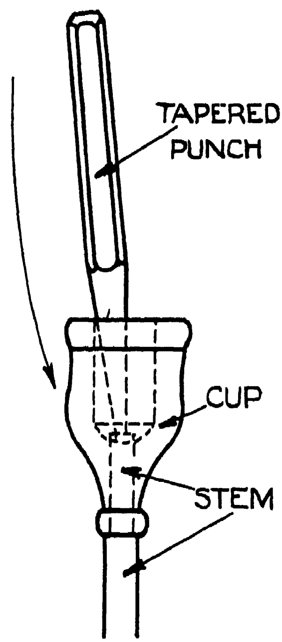


Fig. 92. Riveting the cup to the stem

Fastening a Candlestick Cup to a Candlestick Stem. (*a*) Drill the hole for the candle $\frac{5}{8}$ or $\frac{3}{4}$ in. in diameter. Drill a $\frac{1}{4}$-in. hole the rest of the way through the cup. Turn a sufficient length of the stem down to $\frac{1}{4}$ in. in diameter on the lathe to project up inside the cup not more than $\frac{1}{8}$ in. Rivet the cup to the stem with the help of a short tapered punch. (Fig. 92.) If the stem fits snugly, only a small amount of upsetting will be necessary to make the joint hold.

b) Another method is to screw the cup on the stem. Drill the hole for the candle $\frac{5}{8}$ or $\frac{3}{4}$ in. in diameter. Drill a $\frac{7}{32}$-in. hole the rest of the way through the cup and thread this hole with ¼-in. S.A.E. tap. Cut the stem down to ¼ in. diameter as before; thread this part and screw the parts together.

c) Still another method is to drill the cup as in the preceding para-

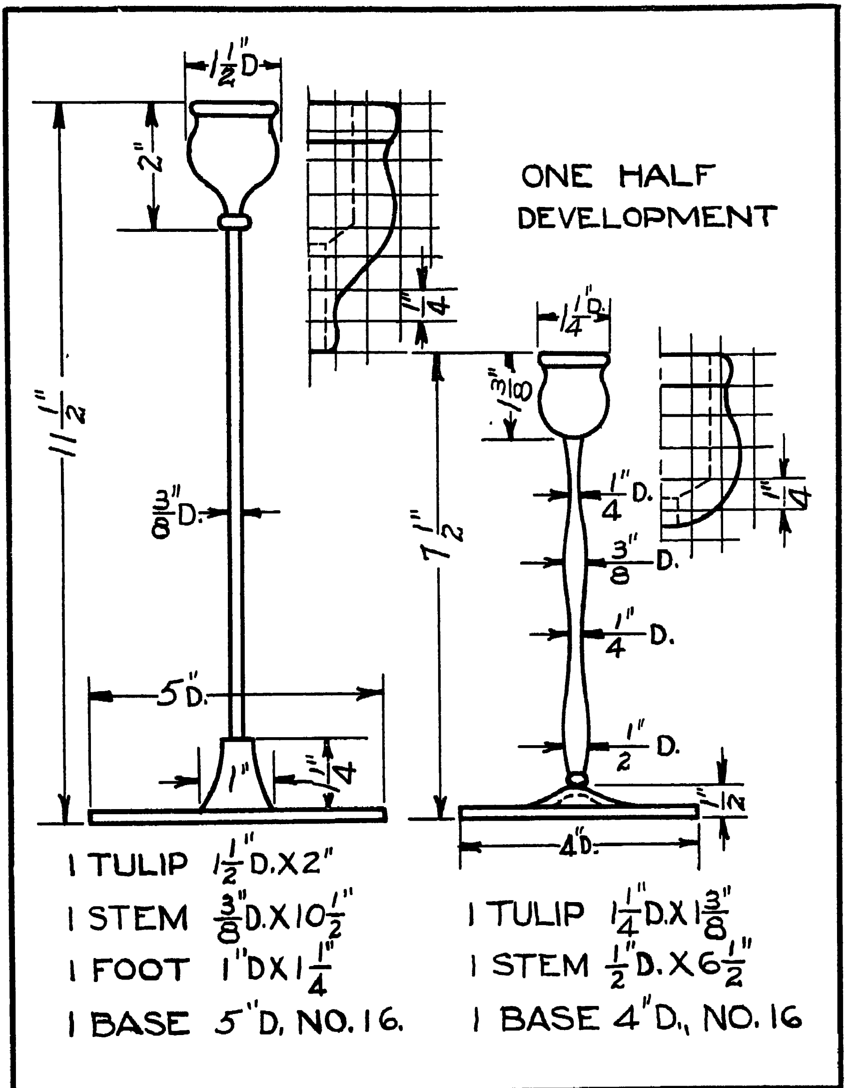


Fig. 93

Single candlestick, tulip design, 11½ in. tall

Single candlestick, tulip design 7½ in. tall graph and then drill a $\frac{3}{16}$-in. hole $1\frac{1}{4}$ in. into the stem; thread this hole with a 12—24 tap, and fasten the cup in place with a 12—24 machine screw.

Finishes for Candlesticks. The finish recommended for turned candlesticks is silver plating or nickel plating, to be done by a commercial plating company. Candlesticks which are not turned look well in the hammered finish. Another finish is to spray them with lacquer or a bronzing mixture colored to resemble antique copper of various kinds. Colored brushing lacquers with gold-bronze trim may also be used.

42. SINGLE CANDLESTICK

Tulip Design, $11\frac{1}{2}$ in. Tall

1. Shape the cup (Fig. 93). Fasten it to the stem as described at the beginning of this section on "candlesticks." Drill a $\frac{3}{16}$-in. hole $1\frac{1}{4}$ in. into the other end of the stem, and thread it with a 12—24 tap.
2. Make the part called "foot." Drill a $\frac{13}{64}$-in. hole through this piece.
3. Cut the base. Drill a $\frac{13}{64}$-in. hole through the center, and countersink this hole on the underneath side of the piece.
4. Fasten the base and the foot to the stem with a 12—24 f.h. machine screw, 2 in. long.

43. SINGLE CANDLESTICK

Tulip Design, $7\frac{1}{2}$ in. Tall

1. Shape the cup and the stem (Fig. 93) with the help of a template.
2. Cut the base. Raise it as illustrated and described under Operation P, Figure 37. Drill a $\frac{13}{64}$-in. hole through the center.
3. Fasten the cup to the stem as described at the beginning of this section on "candlesticks." Drill a $\frac{3}{16}$-in. hole into the other end of the stem, thread it with a 12—24 tap, and fasten the stem to the base with a 12—24 machine screw. Test the candlestick with a square to make sure that it stands straight.

44. SINGLE CANDLESTICK

Rosette Design

1. The directions for making this candlestick, Figure 94, are similar to those for Project 42. Work out your own procedure.
2. The rosette is made as described under Operation Q.

45. SINGLE CANDLESTICK

Scroll Design

1. The rose cup, Figure 94, is made as described under "flower ornaments." Operation Q. The saucer and the base are flat discs, with eight or twelve "wrinkles" around the circumference, as illustrated.

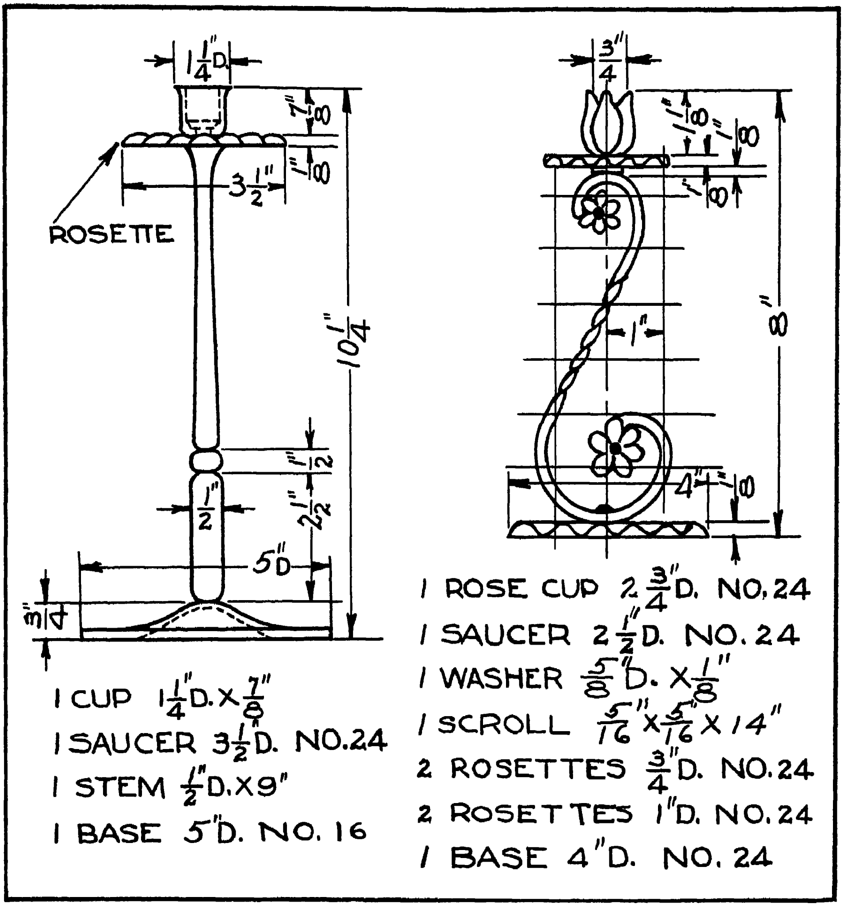


Fig. 94
Single candlestick, rosette design — Single candlestick, scroll design

2. The washer is made on the lathe. A 1/8-in. hole is drilled through the center.

3. The scroll is shaped over scroll forms. The inner ends of the scroll are made quite thin, and are bent with round-nose pliers so that 3/16-in. rivets will pass through easily.

4. The rosettes are riveted together through the ends of the scroll with $\frac{3}{16}$-in. rivets. The base is fastened to the scroll with a $\frac{1}{8}$ by $\frac{3}{8}$-in. stove bolt. The cup, the saucer, and the washer, are fastened to the scroll with a $\frac{1}{8}$ by $\frac{3}{4}$-in. stove bolt.

5. This candlestick may be coated with a bronzing mixture to resemble antique copper. It also looks well in a hammered finish, Operation Z.

46. CANDLE SCONCE

A candle sconce is hung on the wall. This sconce may also be made with two or three arms, instead of with one as shown in the drawing, Figure 95.

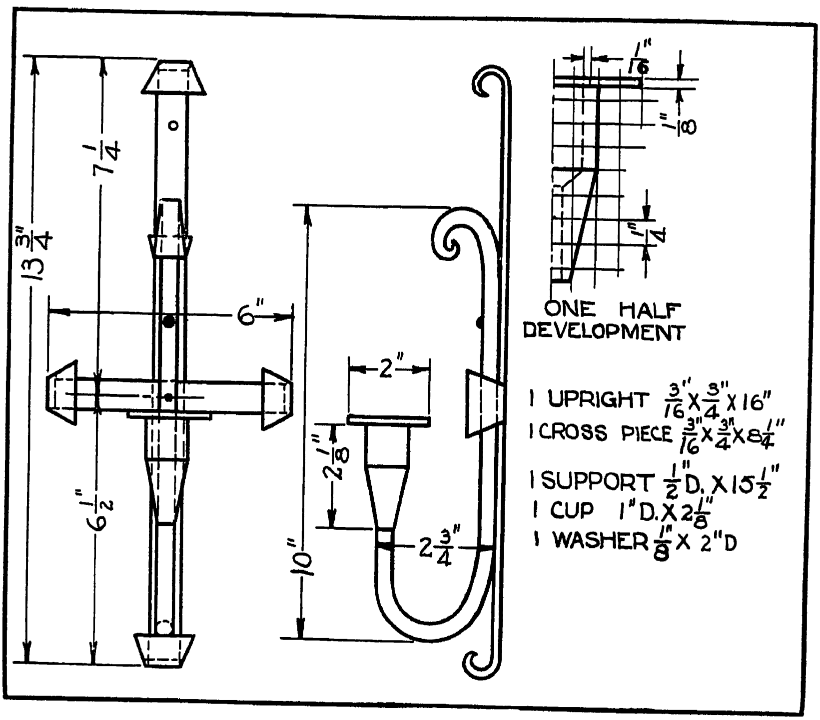


Fig. 95. Candle sconce

1. Shape the scrolls. Flatten the upright and the crosspiece where they are to be joined so that they will fit together flat. Drill two $\frac{1}{8}$-in. holes through both pieces and rivet them together.

2. Decide on which method, described at the beginning of this section on "candlesticks," will be used to fasten the cup to the support, and prepare the end of the support. Shape the scroll, make the bend, and rivet the support to the back with two $\frac{3}{16}$-in. rivets.

3. Turn the upper end of the candle cup down as shown in detail at A and B, Figure 96. Drill out the hole in the washer until it is ⅞ in. in diameter and until it fits snugly over the ridge on the candle

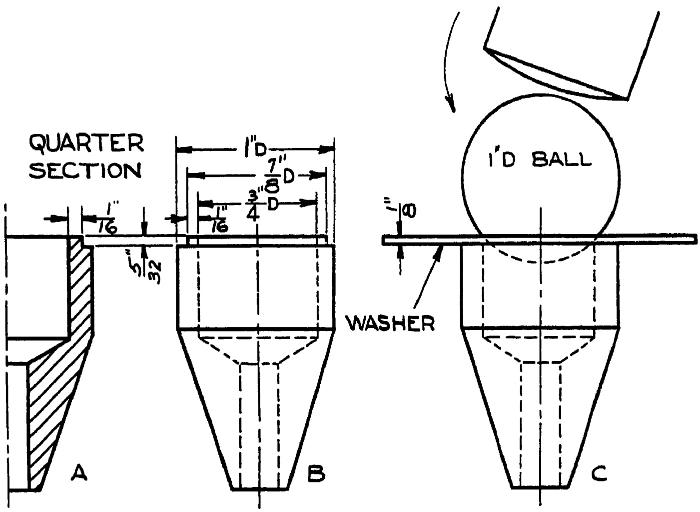


Fig. 96. Turning down upper end of candle cup and spreading the ridge

cup. Countersink the washer slightly on the upper side. Place a ball 1 in. in diameter into the cup, as at C, and hammer the ball until it spreads the ridge on the cup over the washer into the countersunk portion. It may be necessary to heat the cup previous to doing the riveting.

4. Fasten the cup to the support.

5. Polish the cup and lacquer it. Give the rest of the sconce a hammered finish.

47. TWO-ARM CANDLESTICK

Twisted Design

If a pair of the candlesticks shown in Figure 97 are made, one pleasing way to change the design is to make one arm higher than the other.

1. Bend over the lower ends of the two pieces for the supports to

form feet. Clamp these feet in the vise, and twist the two pieces as shown. Shape the curves in the bending fork.

2. Make the base as described under Operation P.
3. Use a template for shaping the cups.

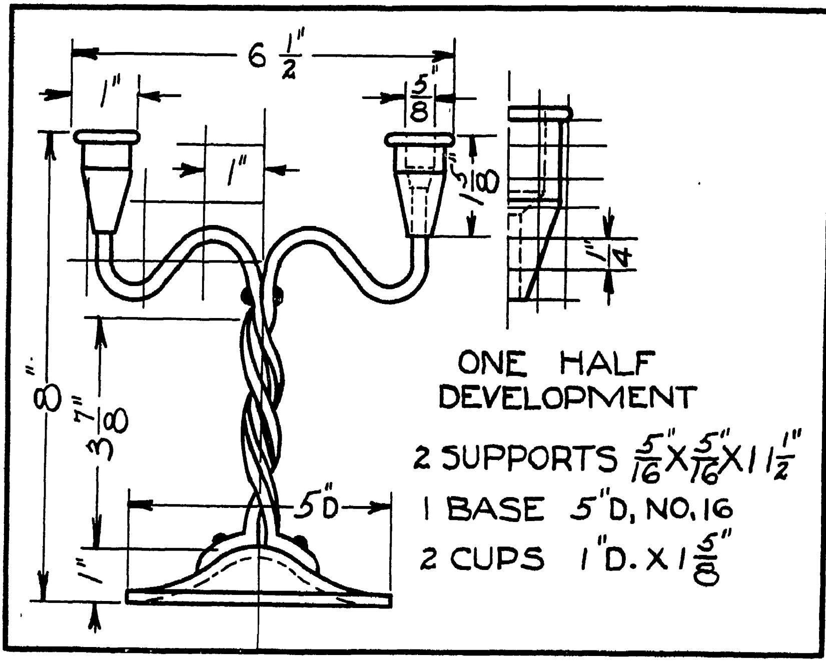


Fig. 97. Two-arm candlestick, twisted design

4. Rivet the feet to the base. Fasten the cups to the supports as described at the beginning of this section on "candlesticks."

5. Polish the cups and coat them with transparent lacquer. Give the rest of the candlestick a hammered finish.

48. TWO-ARM CANDLESTICK

Scroll Design

1. Shape the base of the candlestick in Figure 98 as described in Operation P.

2. Shape the flower ornament as described in Operation Q.

3. Shape the cups and the upright with the help of templates, as described in the beginning of this section on "candlesticks."

4. Shape one end of the scroll, slip the scroll through the hole in

the upright, and shape the other end. Make a right-angle bend in the scroll form so that the form will not interfere with the upright.

5. Bolt the upright to the base. Fasten the cups to the scroll with ⅛-in. stove bolts, and then fasten the scroll to the upright with a ⅛-in. pin.

6. Polish the cups, and coat them with transparent lacquer. Give the rest of the candlestick a hammered finish.

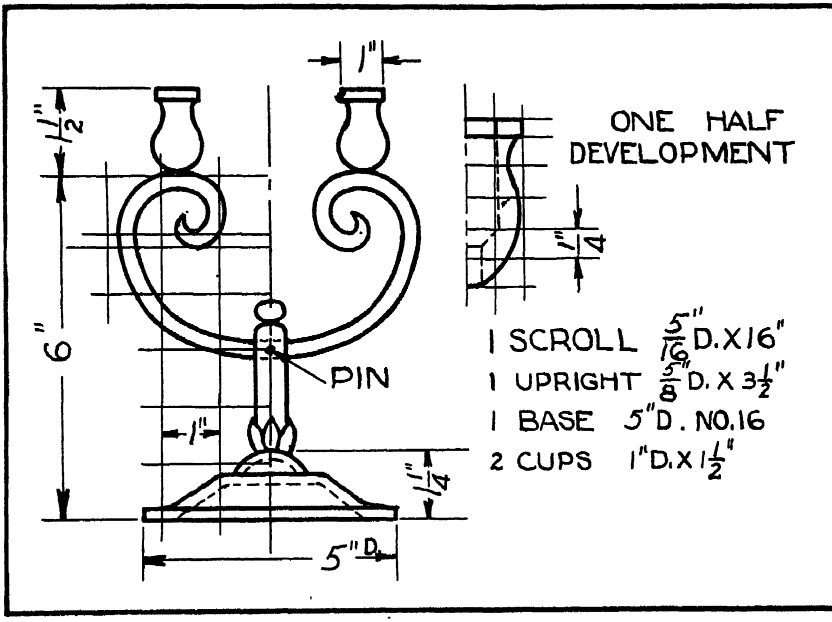


Fig. 98. Two-arm candlestick, scroll design

49. THREE-ARM CANDLESTICK

With Heart Ornaments

The candlestick in Figure 99 also may be made with the three arms the same height, or with each arm at a different height, somewhat in the fashion of a step.

1. Shape the base as described in Operation P.

2. Drill both ends of the upright with a $\frac{7}{32}$-in. drill, and thread with a ¼-in. S.A.E. tap. Fasten the upright to the base with a bolt.

3. Cut the pieces for the stem and for the scrolls. Prepare the ends for attaching the cups, as described at the beginning of this section on "candlesticks." Thread the other end of the stem so that it

may be screwed into the upright. Shape the scrolls on the other end of the other pieces. Make the right-angle bend in these pieces, place them in position on the stem, and mark off two holes on each piece. Rivet the three pieces together with two ⅛-in. rivets, and shape the rest of the curve on the scroll pieces.

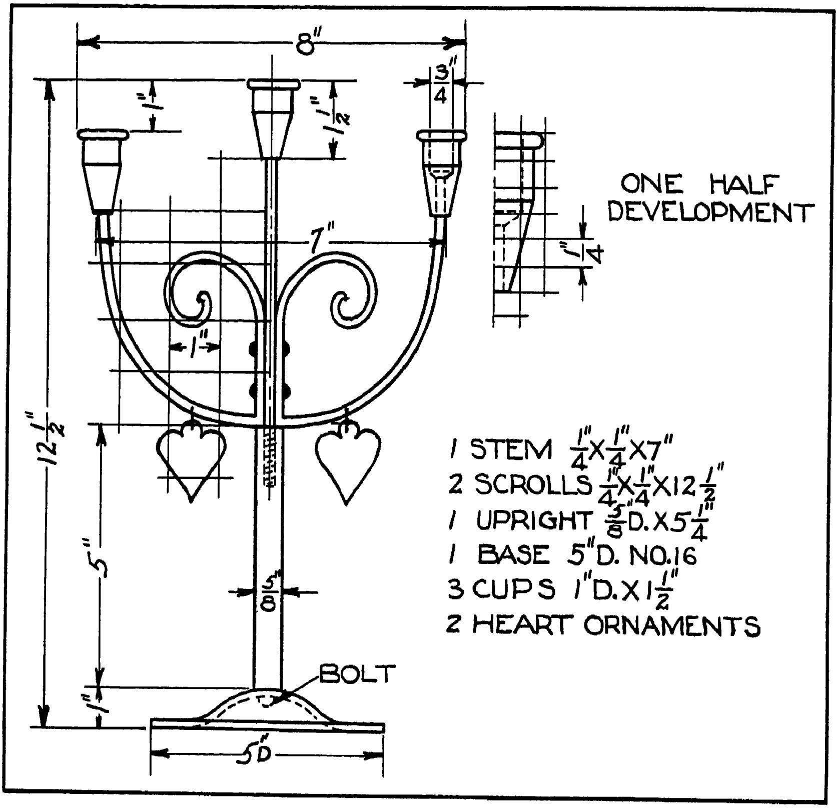


Fig. 99. Three-arm candlestick, heart ornaments

4. Use a template to shape the cups, and fasten them in place.
5. Make the heart ornaments of No. 24 gauge sheet iron, and fasten them to the candlestick by means of small rings made of stovepipe wire.
6. Fill the underneath side of the base with lead.
7. Polish the cups and coat them with transparent lacquer. Give the rest of the candlestick a hammered finish.

50. THREE-ARM CANDLESTICK

With Prism Ornaments

1. Shape the base of the candlestick in Figure 100 as described in Operation P. Space the circumference into 8 or 10 equal divisions, and

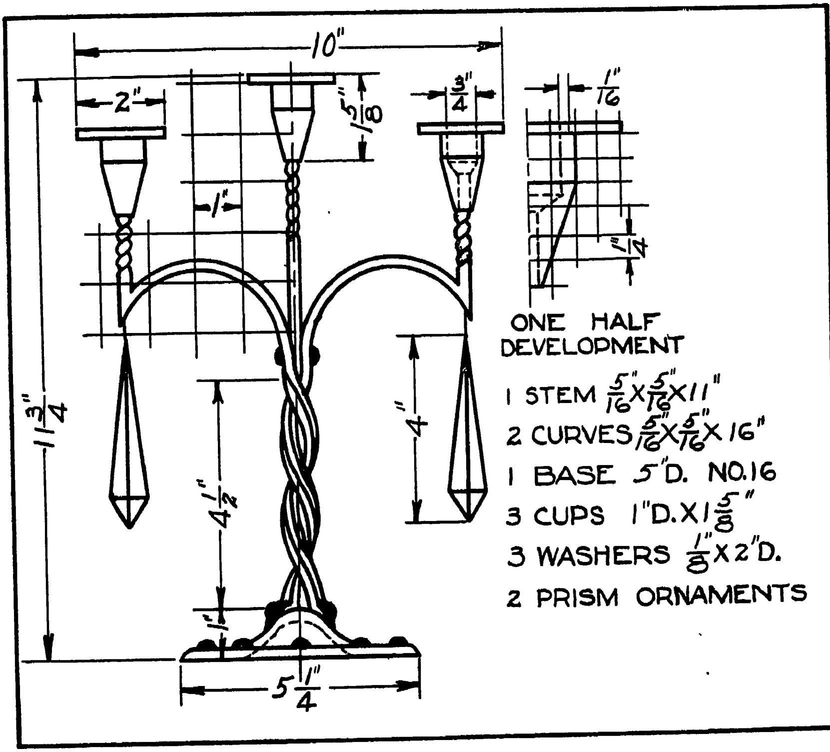


Fig. 100. Three-arm candlestick with prism ornaments

put rivets through the base at these divisions so that the heads show on top.

2. Turn ½ in. of the lower end of the stem down to ¼ in. in diameter, and thread with a ¼-in. S.A.E. tap.

3. Prepare the ends of the stem and of the two curves for attaching the cups, as described at the beginning of this section on "candlesticks."

4. Make a bend 2 in. from the end of the curves. Make a short fagot weld at this bend, and then hammer the welded part to a short tapered point. Shape the rest of the curve.

5. Twist the upper ends of the stem and the curves.

6. Clamp the stem and the two curves together in the vise, place a large monkey wrench 4½ in. up from the vise, and twist the three pieces through one and a half revolutions.

7. Place the lower ends of the three pieces together in the vise and bend the two outside pieces down to form a right-angle bend at the shoulder in the center stem.

8. The pieces are fastened to the base as shown in Figure 101.

9. Make the cups as described under Project 46, paragraph 3, and Figure 96.

10. The glass prisms are hung from the curves by means of rings made out of stovepipe wire. These prisms may also be made of iron, and polished.

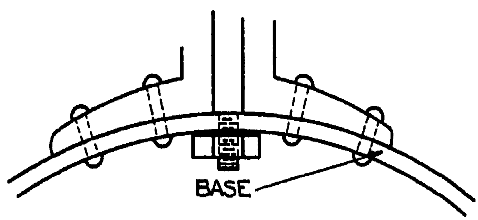


Fig. 101. Pieces fastened to base

11. Polish the cups and give them a coat of transparent lacquer. Give the rest of the candlestick a hammered finish.

E. Lamps

GENERAL DIRECTIONS

Fixtures. Electric lamps of any kind are rather expensive to make, because of the electric fixtures that must be purchased.

Sockets are, of course, one item. A popular type of socket called a "candle fixture," because of its resemblance to a candle, is shown on many of the lamps in the text. A regular "droplight fixture" may be substituted.

The bulbs should have a candlepower suitable to the size of the lamp, and those used with candle fixtures should be "flame shaped."

Wire or lamp cord is another item. After allowing ample wire to be used inside the lamp, enough more should be provided to reach from the location of the lamp in the home to the electric outlet.

A plug must be provided to connect the wire with the wall socket.

Shades should be selected after the job has been completed. The best plan is to take the completed lamp to the store where the shade, or wire frame to be covered at home, is to be purchased, and try out several shades.

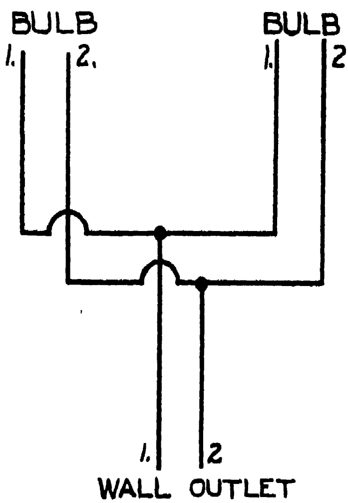


Fig. 102. Wiring for floor-lamp fixture for two bulbs

Wiring a Fixture. To open a droplight socket, push on the part marked "press," and work the socket until it opens. Remove the insulation from about 1 in. of the end of each of the wires with a knife. Place one of the wires under each of the screws in the socket, so that when the screw is tightened it will tend to wrap the wire around it tighter.

The outside of a candle fixture slips off easily; the wiring is done as for a droplight fixture.

A floor-lamp fixture for two bulbs is wired as shown in Figure 102. Scrape off the insulation, and solder a short length of wire to each of the wires in the cord. Cover the joint with electrician's tape. One wire from each of the two wires in the cord must be connected with each socket, as shown by the numbering in the drawing. The electricity comes in and divides at one of the joints, goes through both bulbs, and returns and unites again at the other joint, completing the circuit.

Fastening a Fixture to a Lamp. All electric-light fixtures are threaded with 1/8-in. pipe taps. All lamps must be provided with a short 1/8-in. nipple, to which to fasten the fixture.

a) Drill the pipe cap, or other iron, at the place where the fixture is to be put with a 21/64-in. drill, and start a 1/8-in. pipe tap into the hole. Run the threaded end of a short piece of 1/8-in. pipe into the hole so as to have it project about 1/4 in. for fastening the fixture in place. The pipe should draw up tight. Saw off the excess pipe, and ream out the hole in the pipe.

b) Instead of using a short length of 1/8-in. pipe, use a homemade short nipple, the making of which is described under "threading," Operation T.

c) If the pipe tap has been run into the opening too far, it will be impossible to draw the pipe nipple up tight. In this case, the nipple may be held in place by screwing 1/8-in. pipe lock nuts on it so as to clamp the pipe cap or other iron between them.

Drawing the Lamp Cord Through the Pipe. On those lamps which have the lamp cord running through a piece of pipe, which is part of the lamp, no rivets may be put through the pipe permanently until after the lamp cord has been drawn through.

The procedure is to drill all the holes for rivets, put the rivets in place temporarily until all the pieces have been made and fitted together, and then remove the rivets, draw the wire through the pipe, replace the parts, and rivet them together permanently. Pull the wire through the pipe with the help of a piece of stovepipe wire. To prevent the rivets from cutting the wire inside the pipe, they should be ground to a point so as to push the wire aside.

Fastening Pipe and Pipe Fixtures Together so that the threads will not show. Ordinarily, when connecting pipe and pipe fixtures, a few threads always show, due to the fact that the pipe threads are tapered. This is standard plumbing practice. But, if pipe is to be used as part of a lamp, it will be objectionable to have these threads show. To do away with this, thread the pipe in the regular way, and then reverse the die and run it over the pipe again. This is contrary to standard practice, but it cuts the threads down to a uniform size all along the length of the threaded part, and makes it possible to draw the pipe and the pipe fixture together so that the threads will not show.

Finishes for Lamps. All the lamps described look well in a hammered finish. A flat black finish with an occasional touching up of gold bronzing powder also looks well on some of the lamps.

Testing the Completed Lamp. After completing the lamp, and before taking it out of the shop, secure a bulb from the instructor and test each socket to make sure that it lights as it should.

51. DESK LAMP

With Twisted Ornament

The lamp shown in Figure 103 is intended to be used on a small desk. It may also be placed in a bedroom for use at night, or for the

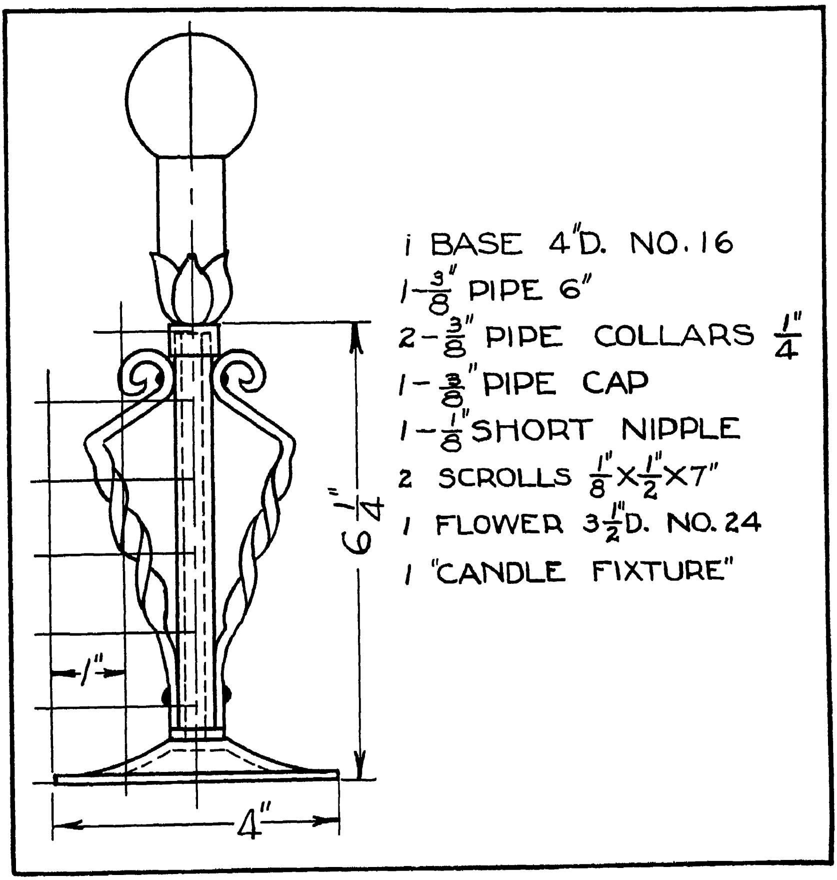


Fig. 103. Desk lamp, with twisted ornament

student who "reads himself to sleep," or mother can use it on her dressing table. A pair of these lamps are very ornamental when placed on each end of the mantel shelf.

1. Making the raised base is described under Operation P. Drill a 1⅛-in. hole through the center.
2. Secure a ⅜-in. pipe collar and cut off two pieces ¼ in. wide. Fasten the pipe to the base as shown in Figure 104.
3. Shape the twisted ornaments, and fit the rivets.
4. Making the flower ornament is described under Operation Q.

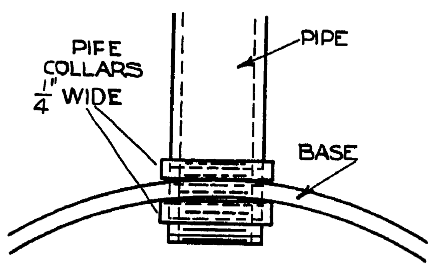


Fig. 104. Fastening pipe to base

5. Assemble the lamp as described at the beginning of this section on "lamps." The wire runs through the pipe and comes out through an opening in the base.

52. DESK LAMP

With Scroll Ornament

The directions for making this lamp (Fig. 105) are the same as for Project 51.

The ring placed around the pipe at the center rivet is made of ⅛ by ½-in. stock cut 2 in. long.

53. TWO-BULB LAMP

With a Ring Ornament

The lamp shown in Figure 106 can be readily turned into a two-arm candlestick.

This lamp can be used in the same way as the desk lamps, Projects 51 and 52. It also looks well in the center of the mantel shelf, in the center of an end table, or on a telephone table. No shades are needed.

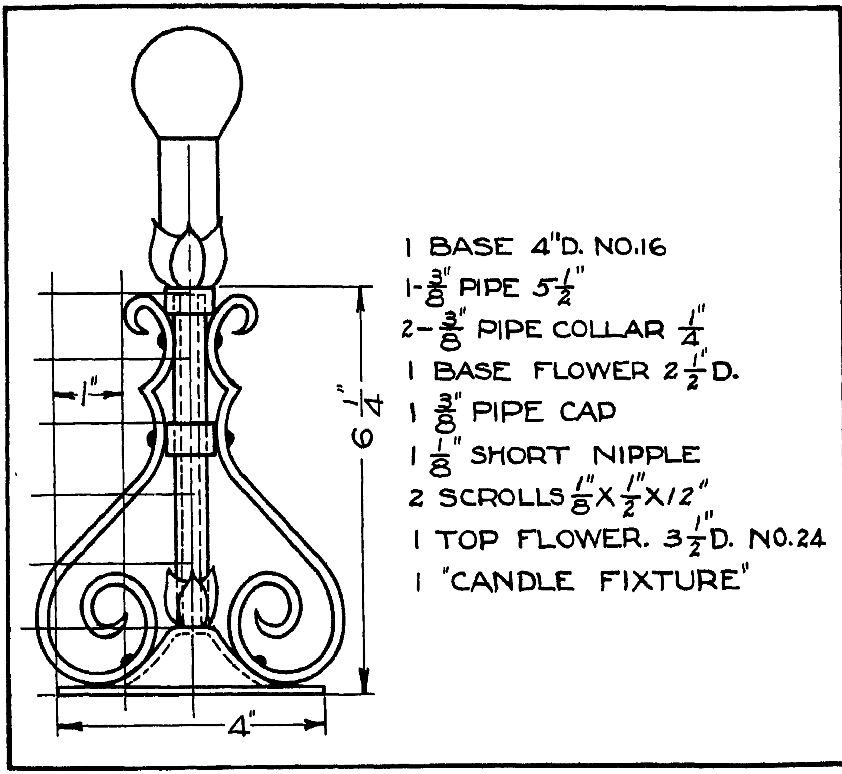


Fig. 105. Desk lamp, with scroll ornaments

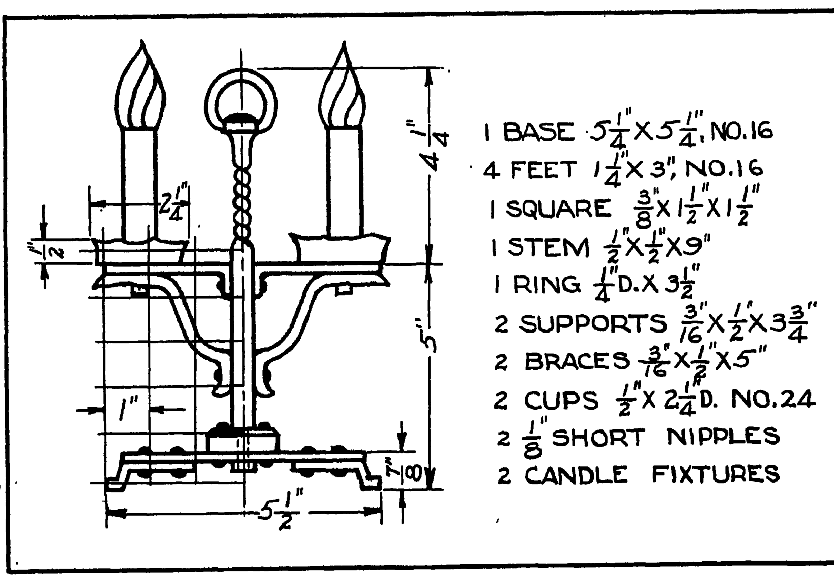


Fig. 106. Two-bulb lamp, with ring ornament

1. The base and four feet are made as shown in Figure 107. The rivet heads serve as part of the ornamentation.

2. The 1½ by 1½-in. square is also riveted to the base, with rivets serving to help ornament the lamp.

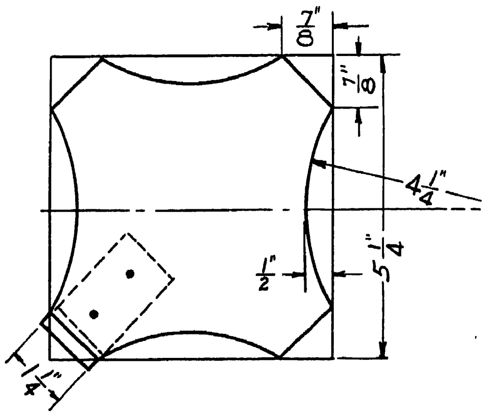


Fig. 107. Pattern for base and four feet

3. Turn ¾ in. of the stem down to ⅜ in. in diameter, thread it, and fasten the stem to the base by means of a nut. Upset the upper end to ⅝ in. square. Thin out a portion of the stem just behind the upset part to ⅜ in. square. Heat this section and twist it through one and one-half revolutions. Drill a $\frac{5}{16}$-in. hole through the upset end, and slip the ring in place.

4. Rivet the two supports and the braces to the stem. Fasten the ⅛-in. short nipples in place by screwing a lock nut on each end. These lock nuts will also serve to clamp the cups, the supports, and the braces together.

5. Making the cups is described under Operation P.

6. Assemble the lamp as described at the beginning of this section on "lamps." The wire runs through a hole in each support; the joint is immediately behind the stem.

54. TWO-BULB LAMP

With Scroll Ornament

The lamp shown in Figure 108 can be readily turned into a two-arm candlestick. It may be used in the same way as Project 53.

1. Make the base as described under Operation P.

2. The cross arm is fastened to the base by means of two $\frac{3}{16}$-in. rivets.

3. Bend the piece for the handle in the center, clamp the ends in the vise, and spread the handle by driving a tapered punch between the pieces. Rivet the two uprights to the handle. Fasten the ⅛-in. short nipples in place by screwing a lock nut on each end. These lock nuts

will also serve to clamp the cups, the cross arm, and the uprights together. The scrolls are riveted in place.

4. Make the cups as described under Operation P.

5. Assemble the lamp as described at the beginning of this section on "lamps." The wire runs between the lower ends of the scrolls and the base to the joint, and on to the plug and the wall socket.

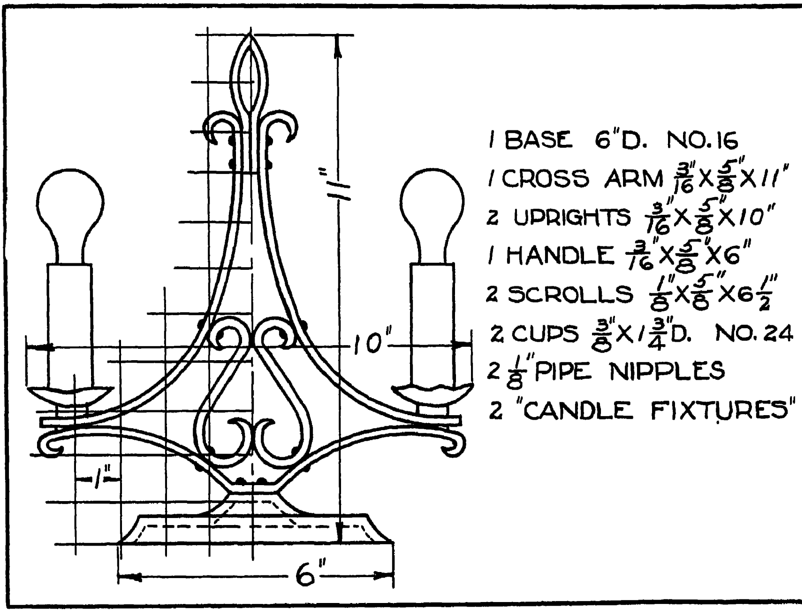


Fig. 108. Two-arm lamp, with scroll ornament

55. TABLE LAMP

With Four-Leaf Cluster Ornament

The lamp shown in Figure 109 is large enough to light up an ordinary-size living room. It requires a table-lamp fixture for two sockets, and one large table-lamp shade.

1. Shape the legs in the bending fork, or with a form.

2. Drill two holes in one of the legs as indicated on the drawing somewhat as in Figure 112. Clamp this leg and another leg to the pipe with a C clamp, and drill the two holes on through the pipe and the other leg. Previous to drilling the holes, test the pipe with a steel square to make sure that it stands straight. Fit the other two legs to the pipe in the same way.

3. The four-leaf cluster is made in the same way as the flower ornament, Operation Q. Drill a hole into the four-leaf cluster and into the rosette, so that each one can be screwed on the threads of the pipe to hold it in place.

4. Assemble the lamp as described at the beginning of this section on "lamps."

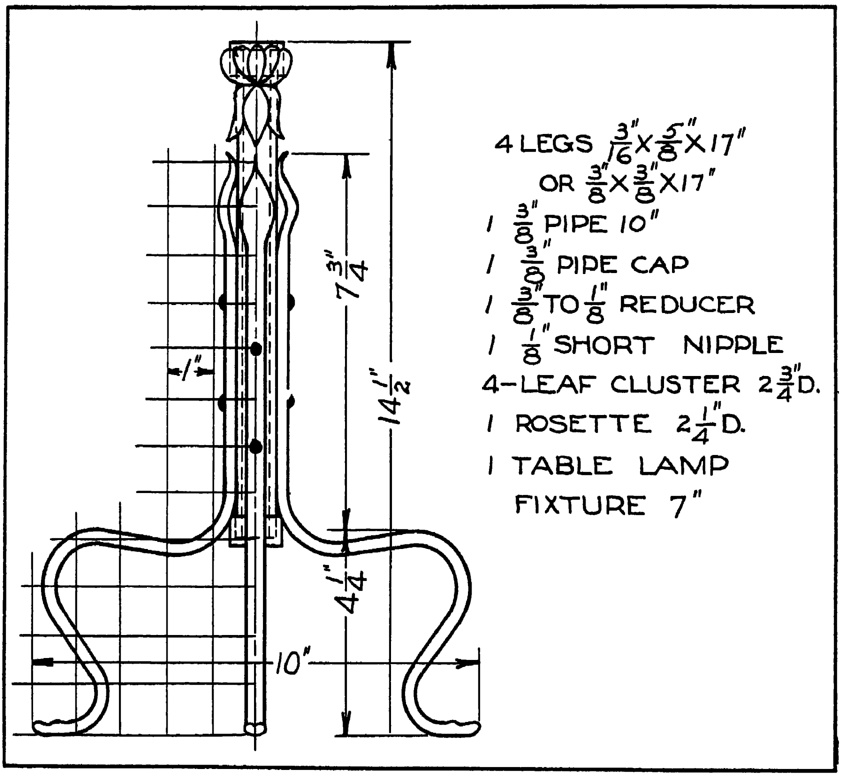


Fig. 109. Table lamp with four-leaf cluster ornament

56. TABLE LAMP

With Teardrop Ornaments

1. Shape the legs of the lamp in Figure 110 over a special scroll form; after forming, bend the inner ends as shown in the drawing with a pair of round-nose pliers. The short scroll appendages are welded to the legs, or riveted with countersunk rivets.

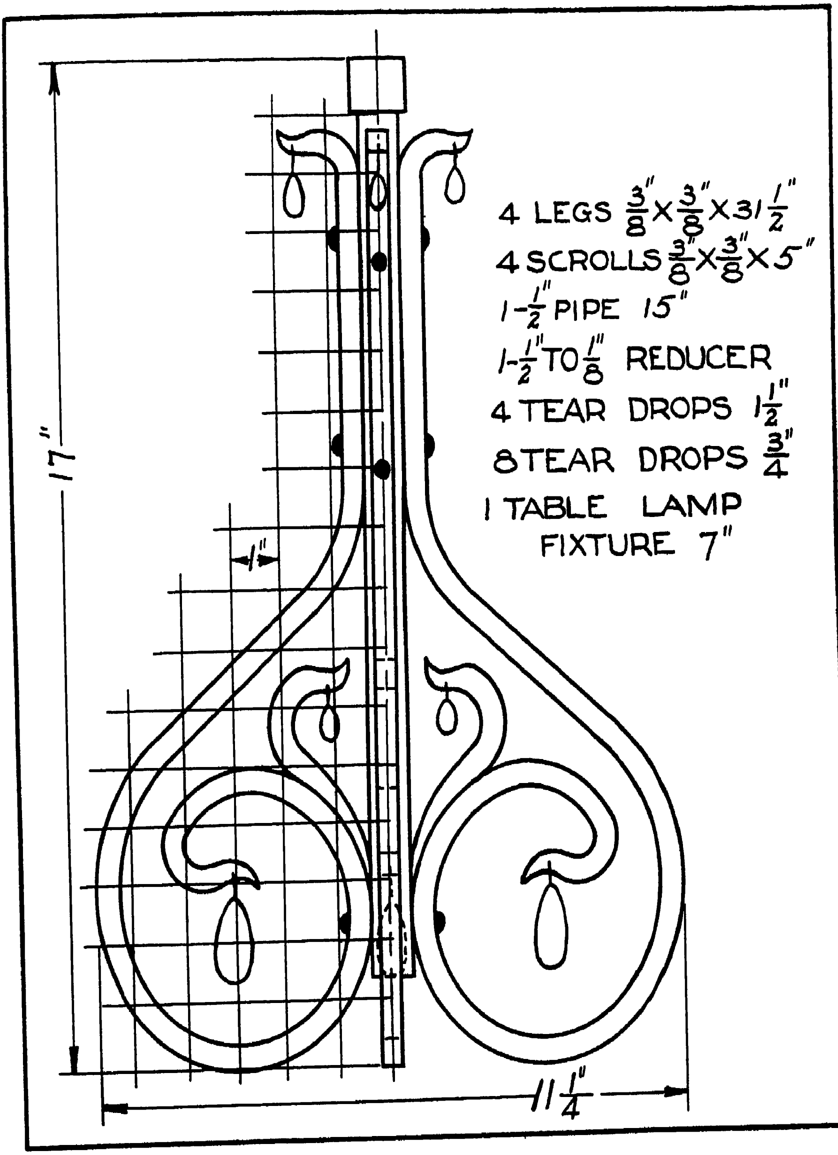


Fig. 110. Table lamp, teardrop ornaments

2. Drill two holes in one of the legs as indicated on the drawing somewhat as in Figure 112. Clamp this leg and another leg to the pipe with a C clamp, and drill the two holes on through the pipe and the other leg. Previous to drilling the holes, test the pipe with a steel square and make sure that the pipe stands straight. Drill the lower hole in one of the legs; mark off and drill this hole through the pipe; mark off and drill this hole on through the other leg. Fit the other two legs to the pipe in the same way.

3. Assemble the lamp as described at the beginning of this section on "lamps."

4. The teardrop ornaments may be turned on the lathe.

57. TABLE LAMP

With Scroll Design

a) **A Massive Table Lamp** designed like the bridge-lamp base in Project 61, Figure 117, may be made to the following dimensions.

Cut the two base pieces out of ½ by ¾-in. stock, each 17 in. long. The over-all length, after forming the flared scrolls, is 11 in.; the over-all height of the base pieces when assembled, is 2½ in.

Cut the four braces out of $\frac{3}{16}$ by ⅝-in. stock, each 22 in. long. If desired, these braces may be shaped like the braces in Project 62, in which case the stock should be cut 1½ in. longer.

Cut a piece of ½-in. pipe 15 in. long. The total height of the lamp, not counting a 7-in. table-lamp fixture, is 18 in.

b) **A Moderate-Size Table Lamp** designed like the bridge-lamp base in Project 61, Figure 117, may be made to the following dimensions.

Cut the two base pieces out of stock ⅝ in. in diameter, each 15 in. long. The over-all length, after forming the flared scrolls, is 9½ in.; the over-all height of the base pieces when assembled, is 2 in.

Cut four braces out of $\frac{3}{16}$ by ½-in. stock, each 18 in. long.

Cut a piece of ⅜-in. pipe 12 in. long. The total height of the lamp, not counting a 7-in. table-lamp fixture, is 14½ in.

58. CAGE STANDARD

While a cage standard is not a lamp, the standard shown in Figure 111 is made in almost exactly the same way as one kind of lamp, which is considered sufficient reason for placing this project in this part of the book.

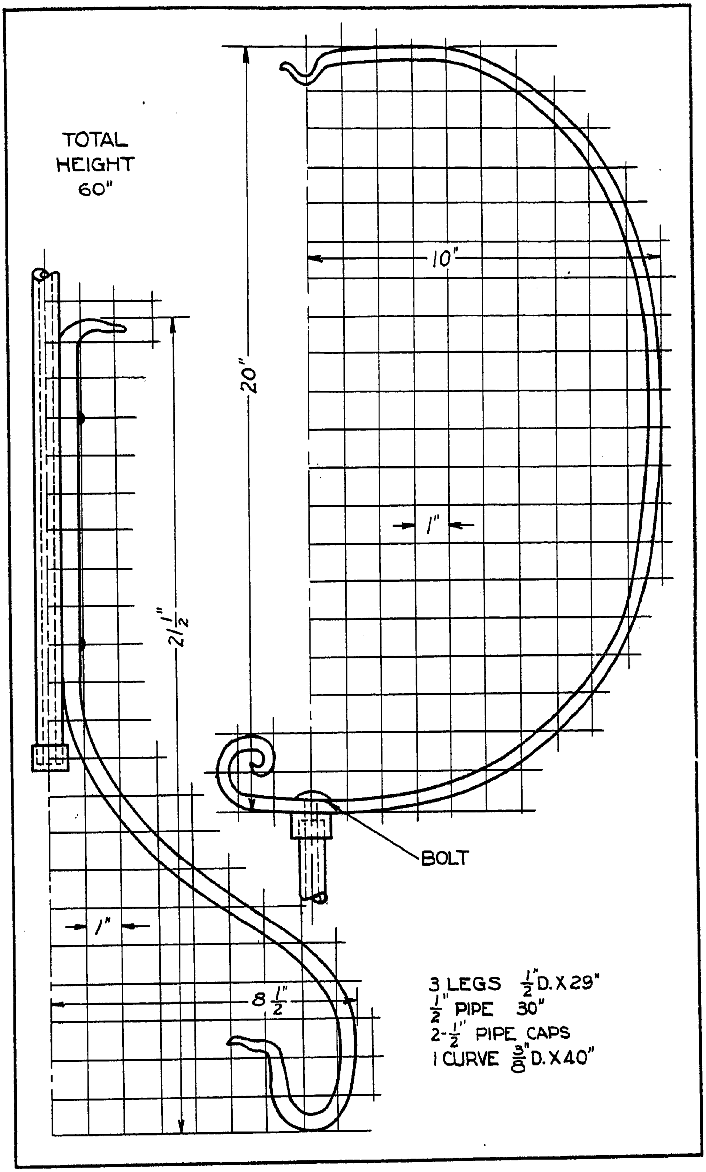


Fig. 111. Cage standard

The base of the standard may very readily be turned into a base for a floor lamp.

1. The legs are shaped over a bent-over form, as described under Operation N, and Figure 31.

2. Place one of the legs inside a carpenter's square, as shown in Figure 112, and mark off the two holes as indicated. Rivet the leg to the pipe. Place a second leg inside the square, and lay off each hole ½ in. higher up than the holes that were drilled into the first leg. Place this second leg in position on the pipe, one third the distance around the pipe away from the first leg; fasten it in place with a C clamp, and test the pipe to see whether it stands straight. Drill the holes on through the pipe, and rivet the leg in place. Drill the holes in the third leg each ½ in. higher than the holes that were drilled in the second leg, and proceed with this leg in the same way as with the second leg.

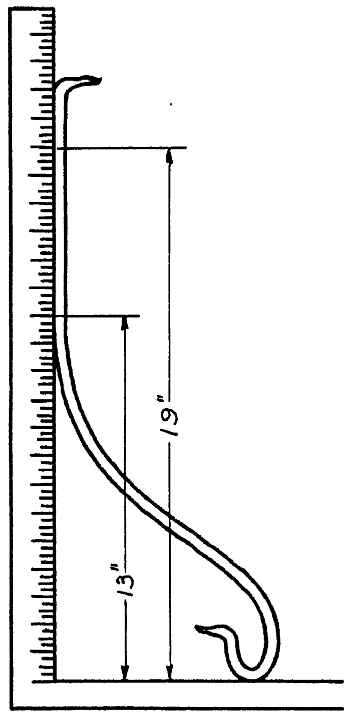


Fig. 112. Leg placed inside of carpenter's square

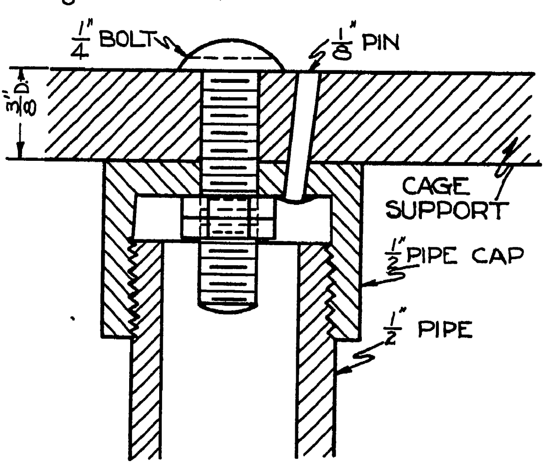


Fig. 113. Cage support bolted to pipe cap

3. Shape the curve which is to support the cage, as in the drawing.

4. The curve is bolted to the pipe cap as shown in Figure 113. To prevent the curve or cage support from rotating around this bolt, a small ⅛-in. pin is riveted in place as shown.

5. Instead of shaping the curve with a scroll end, as shown in the drawing, this end may be curved on around and carried down through the cap into the pipe. (Fig. 114.) To hold this design of cage support to the cap, thread the lower end, put a ⅛-in. pin in place as shown, and make a special nut out of ½-in. stock, long enough so that it will be possible to draw the nut up tight against the pipe cap with a pipe wrench.

6. The cage support should be enameled or lacquered to match the finish on the cage for which it is to be used. If possible, bring the cage to the shop and apply the same kind of finish to both the cage and cage standard.

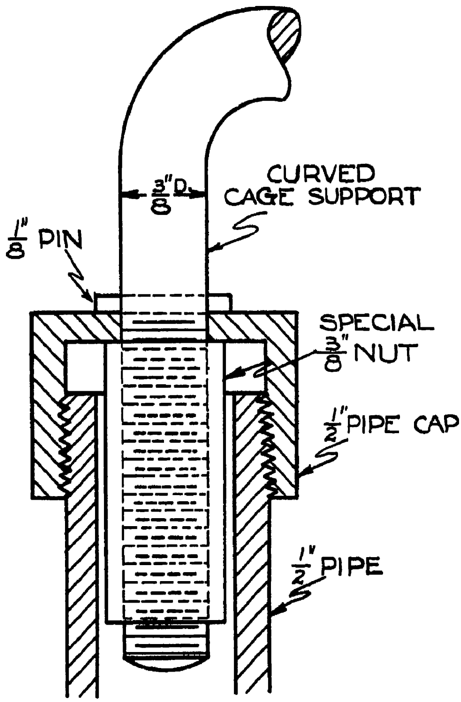


Fig. 114. Curved cage support carried down through cap

59. BRIDGE LAMP

With Prism Ornament

The base for the lamp shown in Figure 115 may readily be made into a floor-lamp base.

This bridge operates by sliding the arm, made of ¼-in. pipe, up and down, or around, inside the ½-in. pipe, and clamping it in the position desired by means of the thumbscrew in the ½-in. cap.

1. The legs are made over scroll forms. They are fitted to the pipe as described under Project 58, paragraph 2. The legs must not be riveted on permanently, however, until after the wire has been drawn through the pipe. See the beginning of this section on "lamps."

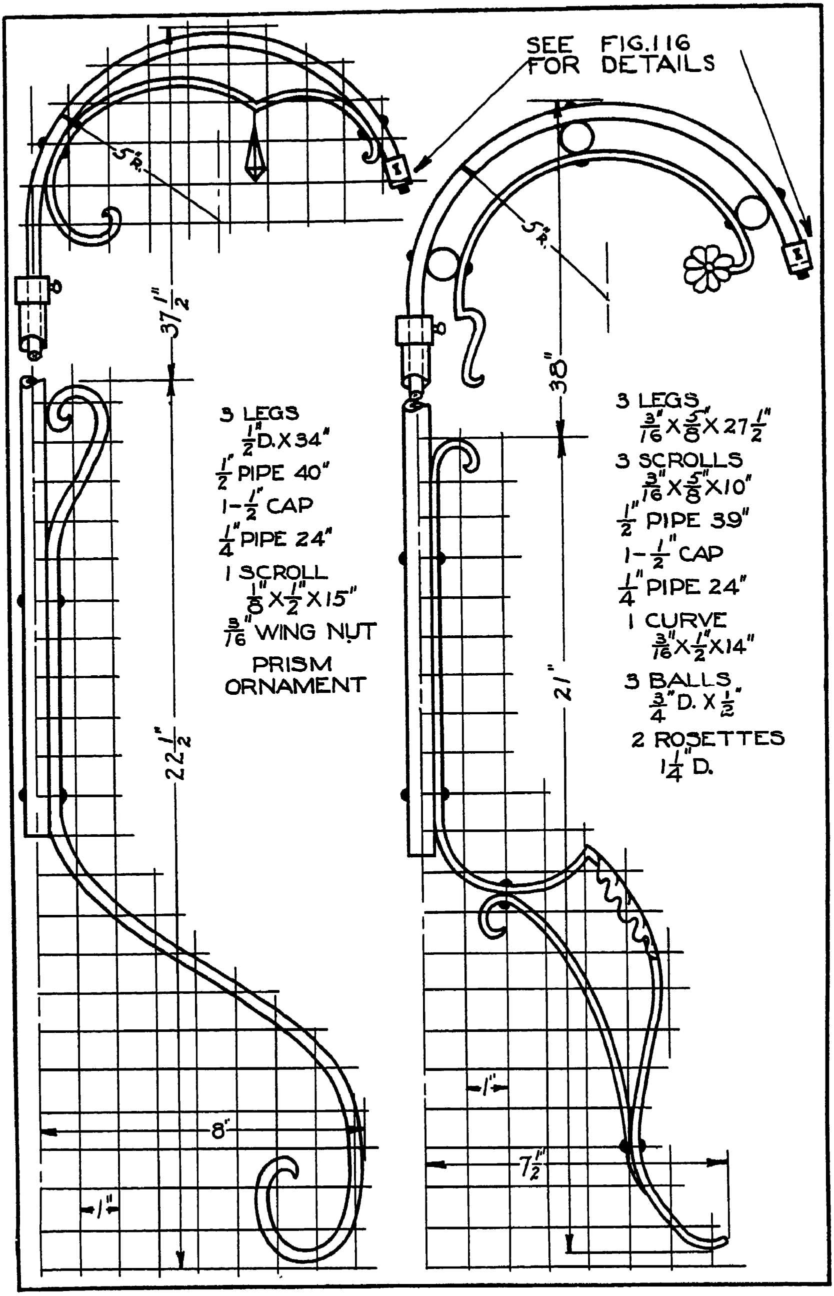


Fig. 115

Bridge lamp with prism ornament — Bridge lamp with rosette ornament

2. The ¼-in. pipe must be heated, and bent carefully over a simple form. Carelessness will cause the weld in the pipe to open up.

3. The scroll is riveted to the ¼-in. pipe, after the wire has been drawn through.

4. The method of attaching the lamp socket to the ¼-in. pipe is shown in detail in Figure 116. The thumbscrew and the wing nut are to be purchased. It may be necessary to file off some of the threads on this thumbscrew in order that there will be space enough for the wire to pass by. Shape the U piece, and put the ⅛-in. nipple in place.

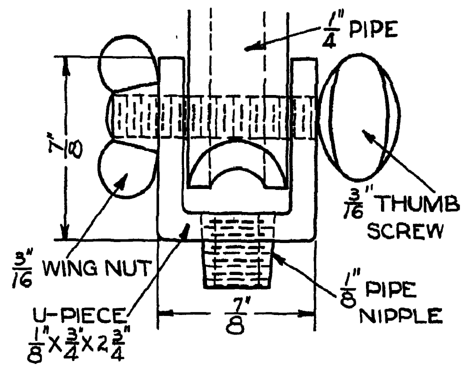


Fig. 116. Method of attaching lamp socket to pipe

60. BRIDGE LAMP

With Rosette Ornament

1. The directions for making this bridge lamp (Fig. 115) are very similar to those for Project 59. Plan your own procedure, and have the instructor check your work.

61. BRIDGE LAMP .

With Spring-Design Bridge

62. BRIDGE LAMP

With Scroll-Design Bridge

The directions which follow apply to making either of the lamps shown in Figures 117 and 118. Plan your own procedure, and have the instructor check your work.

It is possible to interchange the base, the braces, the bridge, or the finial ornaments on these two lamps. Any combination may be readily used to make a base for a floor lamp.

The two base pieces should be welded at the center. If they cannot be welded on the forge, they should be welded by the oxyacetylene method at a commercial welding plant. If neither of these is possible, make a half-lap joint at the center, and fasten these base pieces and the ½-in. pipe cap together with a ¼-in. stove bolt. If the half-lap

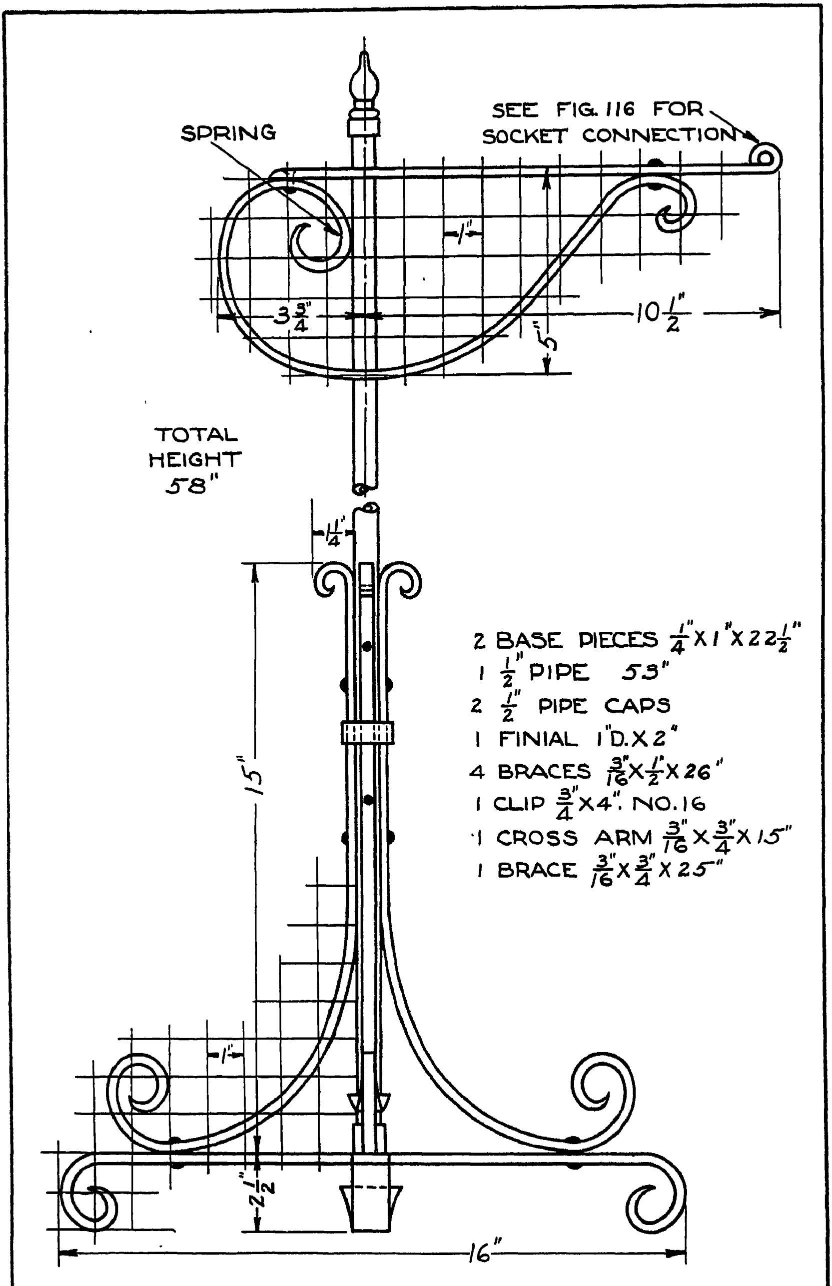


Fig. 117. Bridge lamp with spring-design bridge

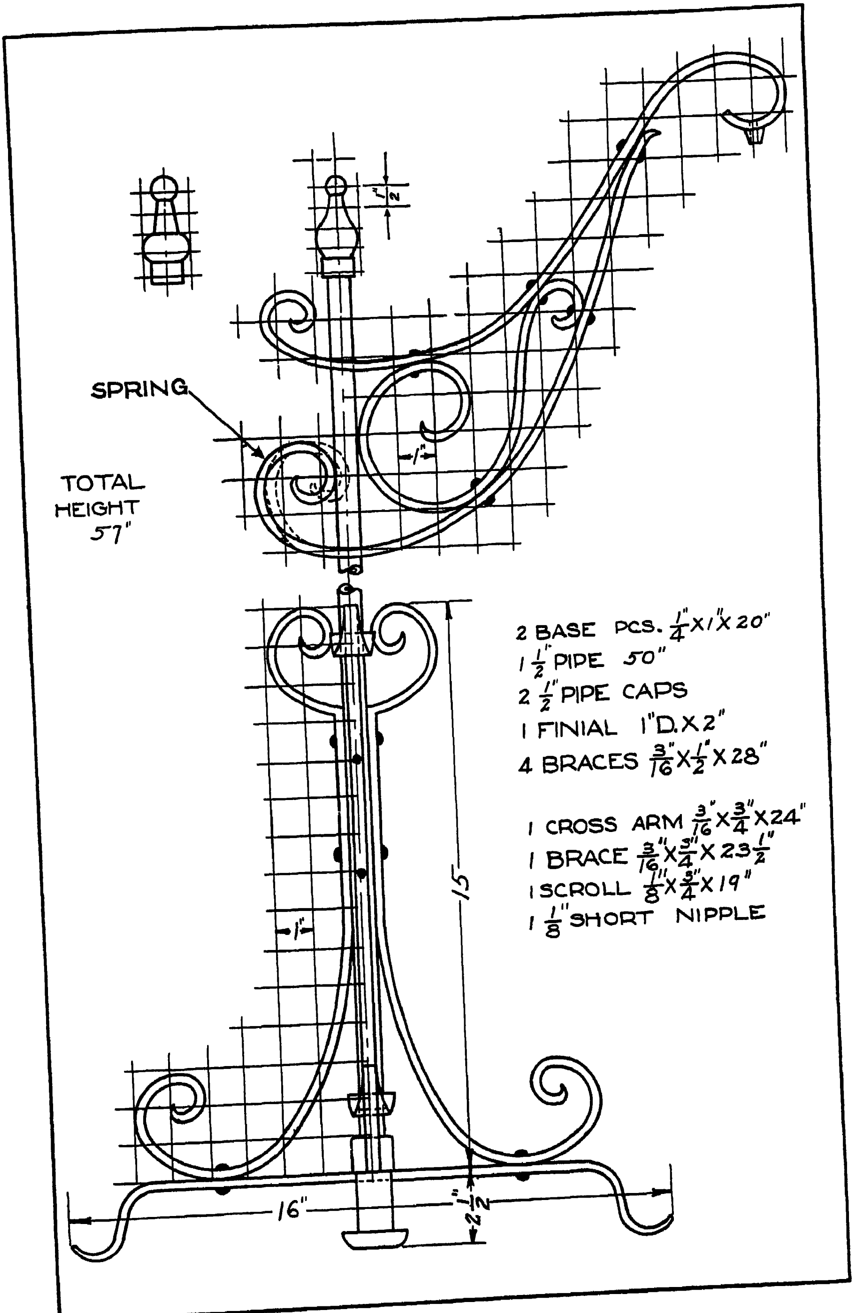


Fig. 118. Bridge lamp with scroll-design bridge

joint is well made, and if the four braces are riveted in place securely, the job will hold.

The following procedure is recommended:

1. *a*) Upset and flare the ends of the base pieces, and form them over a scroll form. Make the joint in the center as described at the bottom of page 129.

The base pieces also can be made out of ⅝-in. D iron.

b) Upset and bend over the ends. Make the joint in the center.

2. *a*) Upset the braces, flare them out, and form them over a small scroll form. Bend the rest of the curve with a bending fork. Set one of the braces up in a carpenter's square as shown in Figure 119, and mark off the holes as indicated. Set another brace up in the square, and mark off the 4¾-in. hole. Rivet these two braces to the base on opposite sides of the pipe. Clamp the two braces to the pipe with a C clamp; test the pipe with a square to make sure that it stands straight; drill the holes on through the pipe and the other brace; put the rivets in place temporarily. Drill the holes in the third brace 9 and 13 in. up, and fit this and the other brace to the base and the pipe as was done with the first two braces.

b) The scrolls on the ends of the braces for the second lamp are made on opposite sides of the piece. After the scrolls have been formed, measure 3½ in. from the outer end to the right-angle bend; shape the curve in a small bending fork. With changes for the dimensions locating the holes, the method of putting the braces in place is the same as described above.

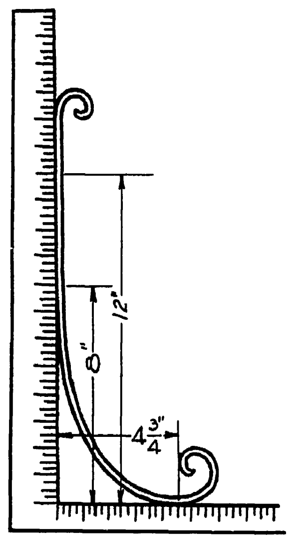


Fig. 119. Brace set up in carpenter's square

3. *a*) The holes in the cross arm and in the brace, through which the pipe extends, are shaped as follows: Mark off and drill three ¼-in. holes right next to each other; chisel out the holes to form one long hole, and drive a long tapered punch through the hole until the metal has been spread out wide enough to allow the piece to slide over the pipe easily.

Rivet the cross arm and the brace together, so that the end of the brace bears against the pipe enough to hold the bridge in any desired position on the pipe. Or, rivet a small ring around the pipe below the bridge, so that the bridge may ride on this ring and still be movable from side to side. Since the bridge would not be adjustable up and down with this arrangement, the spring would be unnecessary.

Or, rivet the bridge to the pipe standard, at the height desired.

b) The holes in the cross arm and brace for the scroll-design bridge, through which the pipe extends, are made in the same manner as described in the foregoing.

The bridge may be held in position on the pipe standard by one of the methods described in paragraph 3*a* above.

4. The finial ornaments are made on the lathe. They are fastened to a ½-in. pipe cap with a machine screw; the cap is screwed on the pipe.

5. The wire enters the pipe just above the base, and comes out just below the finial to connect with the socket on the bridge.

63. BRIDGE LAMPS

Welded Designs

A design similar to this may be used in making a cage standard.

1. The upright and the legs of the lamps in Figure 120 are welded together on the forge. If they cannot be so welded, they should be welded by the oxyacetylene method at a commercial welding works. If they are to be welded on the forge, one procedure is as follows:

a) Lay the three pieces together and wrap them with wire. Place them in the fire, raise them to the welding heat, and weld the three legs together at the end. Weld the upright to this welded end of the legs. Spread the legs.

b) Another method: Cut a piece long enough for two legs; bend the piece back double on itself in the center; form a fagot weld about 2 in. long. Cut a piece long enough for the upright and the third leg, and weld this piece to the fagot weld on the other piece. Spread the legs.

2. Shape the legs according to one of the designs shown in the drawing.

3. To form the holes in the pieces for the bridge through which the upright is to pass, drill two $\frac{3}{16}$-in. holes right next to each other; chisel out the waste stock so as to form one long hole, and spread the metal by driving a small tapered punch into this hole until the piece slides up and down on the upright readily.

4. Plan your own procedure for making the rest of the lamp.

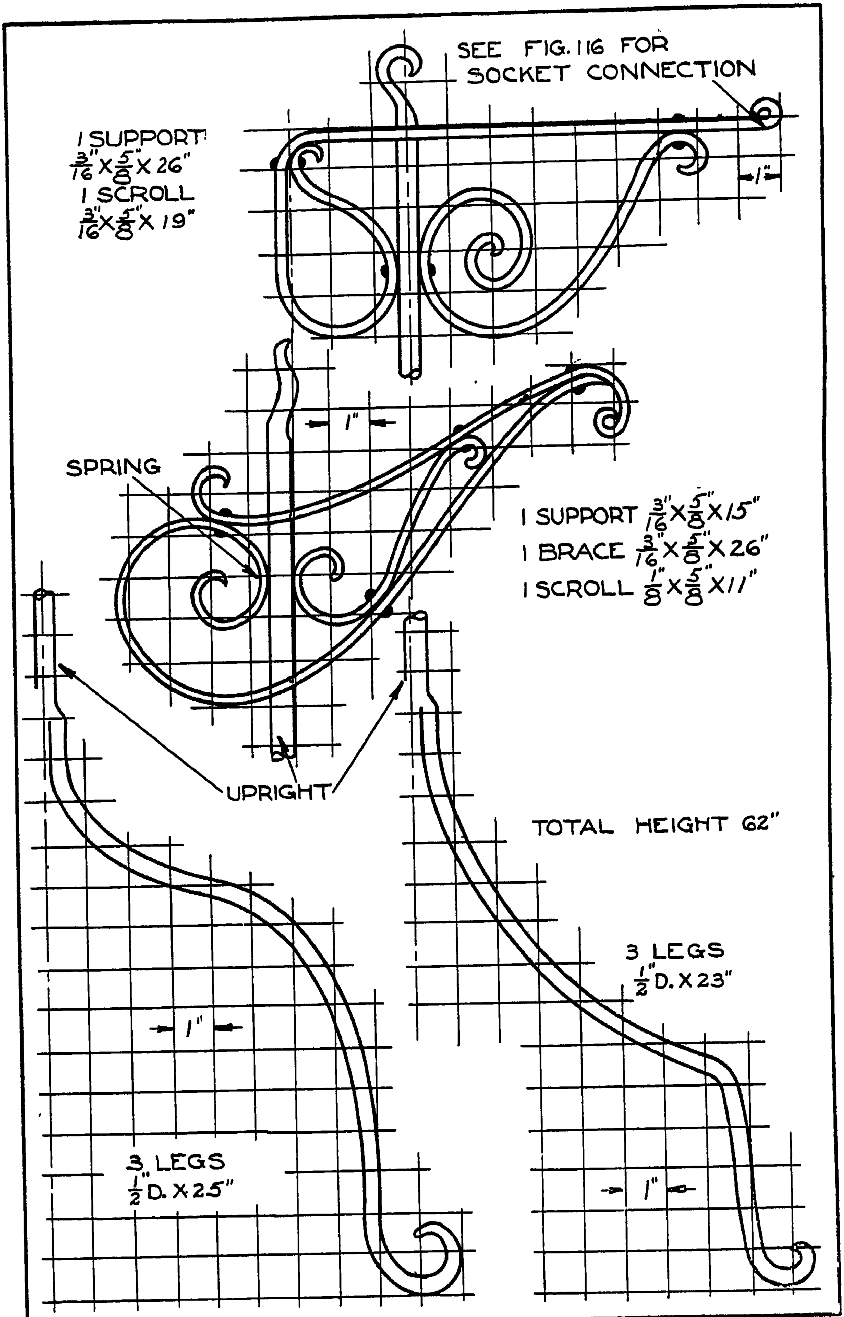


Fig. 120. Bridge lamps, welded design

F. Filler-Ins

64. BILL FILE

1. The base for the bill file shown in Figure 121 is turned on the lathe.

2. **Riveting the Wire in Place.** Drill through the metal about $\frac{1}{64}$ in. smaller than the diameter of the wire; file the end of the wire down until it can be driven through the hole so as to allow about $\frac{1}{8}$ in. of the wire to project out on the other side; rivet this end of the wire.

65. PAPER WEIGHT

The base of the paper weight in Figure 121 is filed square as shown; and the wire is fastened in place as described under Project 64. The upper end of the wire is bent around a rod twice to form a coil. Prepare a card bearing the words "DO NOT PARK HERE" or "KEEP SMILING," and mount this card in the coil of the paper weight.

66. GOOD-LUCK HORSESHOE

The horseshoe shown in Figure 121 should be nickel plated and may be presented to newly weds.

67. HAMMER FOR A WATCH CHARM

File the hammer head shown in Figure 121 to shape; fasten the wire in place as described for Project 64. Have the hammer electroplated and attach it to your watch chain or watch fob.

68. THE "KNOCKER'S DELIGHT"

The directions for making the sledge hammer are the same as for Project 64. It should be electroplated and given to your acquaintance who is "always knocking the other fellow."

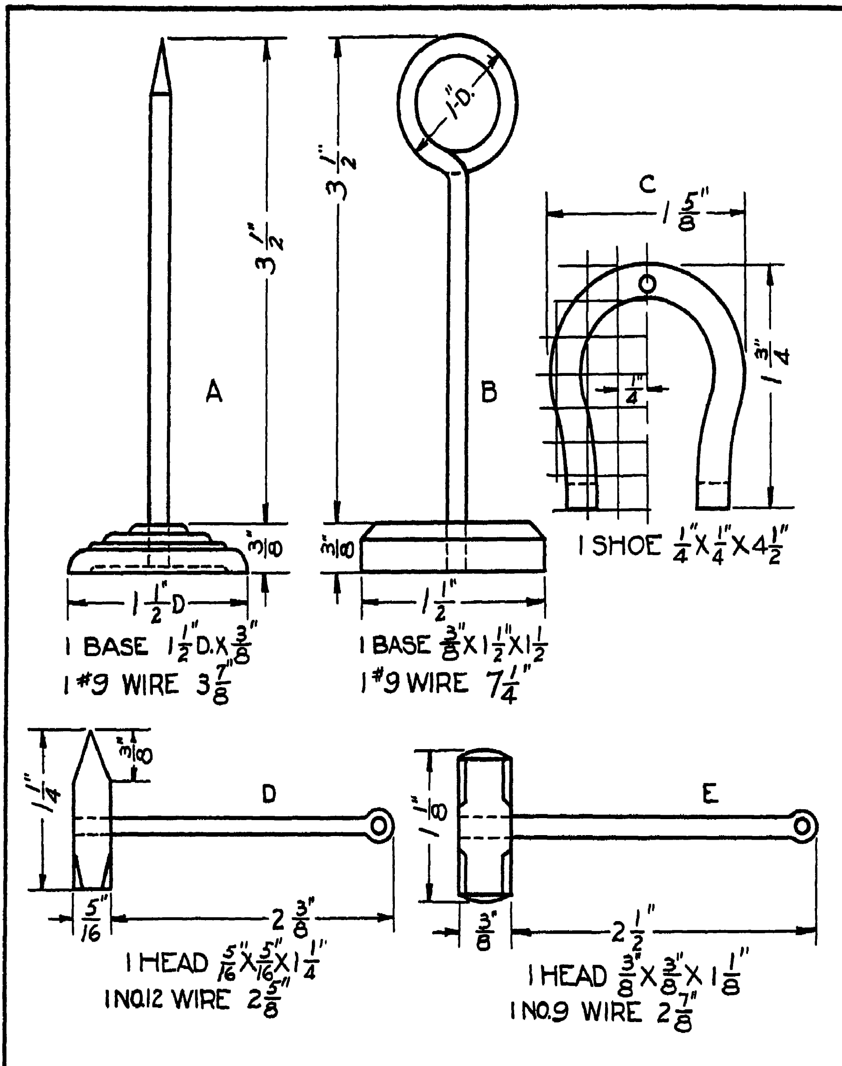


Fig. 121. A, Bill file; B, paper weight; C, good-luck horseshoe; D, hammer for a watch charm; E, "knocker's delight"

INDEX