CHAPTER 2

LAYOUT AND FABRICATION OF SHEET-METAL AND FIBER-GLASS DUCT

As a Steelworker you are required to operate sheet-metal tools and to apply basic sheet-metal layout techniques. In many Naval Construction Force (NCF) projects, sheet metal is used to protect the exterior of buildings by using flashing, gutters, and at times, complete sheet-metal roofing systems. Other items made from sheet metal are dust collection systems, machinery guards, lockers, and shelving.

Although many of the parts and fittings used in sheet-metal work are stock items, which are simply installed or assembled, Steelworkers are required to fabricate parts and fittings frequently in the shop or to modify them to fit irregularities in the project design. Therefore, you must have knowledge not only in laying out patterns but also have the skills required to cut, bend, shape, assemble, and install the finished sheet-metal products. This chapter describes some of the methods of measuring, marking, cutting, forming, and joining as well as installing sheet-metal sections, duct systems, and fiber-glass ducts. In addition, the use of various hand tools and power tools required in sheet-metal layout and fabrication is provided.

SHEET-METAL LAYOUT AND CUTTING TOOLS AND EQUIPMENT

Numerous types of layout tools, cutting tools, and forming equipment are used when working with sheet metal. This section will describe the uses of the layout and cutting tools and the operation of the forming equipment.

LAYOUT TOOLS

The LAYOUT of metal is the procedure of measuring and marking material for cutting, drilling, or welding. Accuracy is essential in layout work. Using erroneous measurements results in a part being fabricated that does not fit the overall job. This is a waste of both time and material. In most cases, you should use shop drawings, sketches, and blueprints to obtain the measurements required to fabricate the job being laid out. Your ability to read and work from blueprints and sketches is paramount in layout work. If you require information on blueprints, you will find chapters 1-3 and 8 of *Blueprint Reading and Sketching*, NAVEDTRA 10077-F1, an excellent reference.

Layout tools are used for laying out fabrication jobs on metal. Some of the more common layout tools that you will use in performing layout duties are as follows: scriber, flat steel square, combination square, protractor, prick punch, dividers, trammel points, and circumference rule.

Scriber

Lines are scribed on sheet metal with a SCRATCH AWL, coupled with a STEEL SCALE or a STRAIGHTEDGE. To obtain the best results in scribing, hold the scale or straightedge firmly in place, and set the point of the scriber as close to the edge of the scale as possible by tilting the scriber outward. Then exert pressure on the point and draw the line, tilting the tool slightly in the direction of movement (fig. 2-1). For short lines, use the steel scale as a guide. For longer lines, use a circumference rule or a straightedge. When you have to draw a line between two points, prick punch each point. Start from one prick punch mark and scribe toward the center.

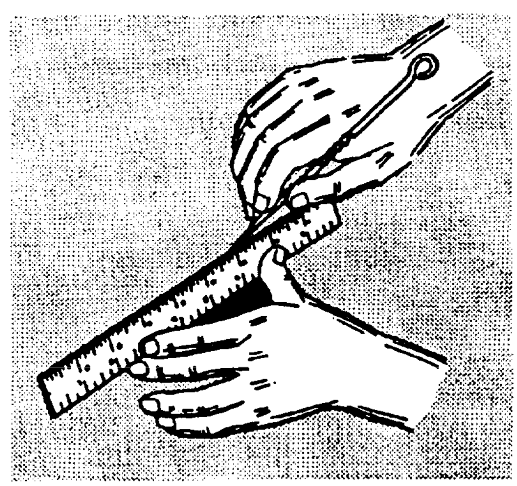

Figure 2-1—Scribing a line.

Complete the line by scribing from the other prick punch mark in the opposite direction.

Flat Steel Square

The FLAT STEEL SQUARE is a desirable tool for constructing perpendicular or parallel lines. In the method of layout, known as parallel line development, the flat steel square is used to construct lines that are parallel to each other as well as perpendicular to the base line. This procedure is shown in figure 2-2. Simply clamp the straightedge firmly to the base line. Slide the body of the square along the straightedge, and then draw perpendicular lines through the desired points.

Before using the flat steel square or at least at periodic intervals, depending on usage, see that you check it for accuracy, as shown in figure 2-3. When the square is off, your work will be off correspondingly no matter how careful you are.

Combination Square

The COMBINATION SQUARE can be used to draw a similar set of lines, as shown in figure 2-4. An edge of the metal upon which you are working is used as the base line, as shown in the figure. One edge of the head of the combination square is 90 degrees and the other edge is 45 degrees. Combination squares are

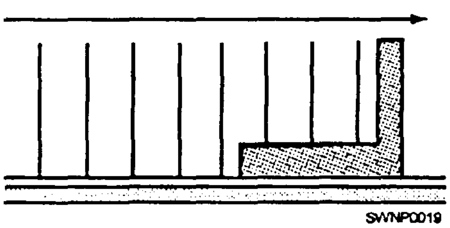

Figure 2-2.—Using a swuare to cinstruct perpendicular and parallel lines.

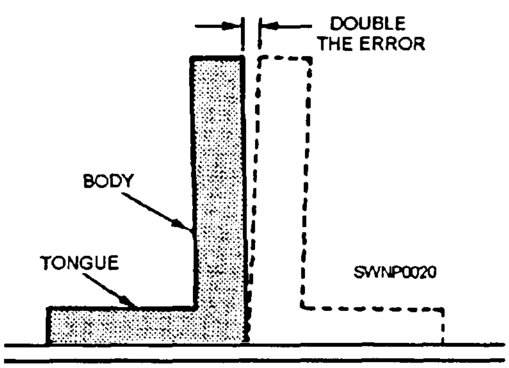

Figure 2-3.—Checking a square for accuracy.

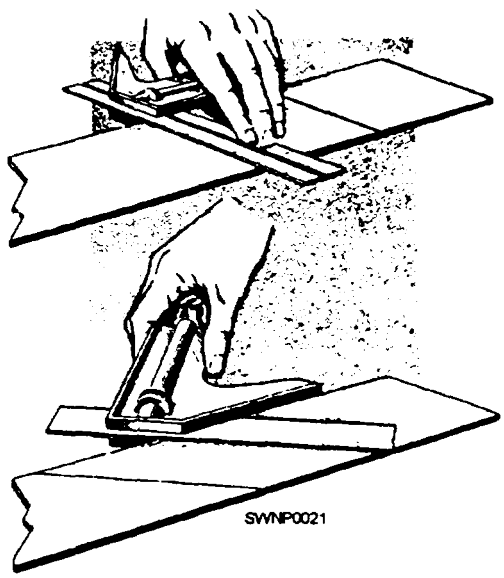

Figure 2-4.—Using the combination square

delicate instruments and are of little value if you handle them roughly. Store your squares properly when you have finished using them. Keep them clean and in tiptop shape, and you will be able to construct 90-degree angles, 45-degree angles, and parallel lines without error.

Protractor

To construct angles other than 45 degrees or 90 degrees, you will need a PROTRACTOR. Mark the vertex of the angle of your base line with a prick punch. Set the vertex of your protractor on the mark and then scribe a V at the desired angle (assume 700). Scribe the line between the vertex and the point located by the V, and you have constructed an angle of 70 degrees.

Prick Punch

When you locate a point and mark it with the PRICK PUNCH, be sure to use alight tap with a small ball peen hammer, ensuring it is on the precise spot intended to mark. The smaller the mark you make (so long as it is visible), the more accurate that mark becomes.

Dividers

You should use DIVIDERS to scribe arcs and circles, to transfer measurements from a scale to your layout, and to transfer measurements from one part of the layout to another. Careful setting of the dividers is of utmost importance. When you transfer a measurement from a scale to the work, set one point of the dividers on the mark and carefully adjust the other leg to the required length, as shown in figure 2-5.

To scribe a circle, or an arc, grasp the dividers between the fingers and the thumb, as shown in figure 2-6. Place the point of one leg on the center, and swing the arc. Exert enough pressure to hold the point on center, slightly inclining the dividers in the direction in which they are being rotated.

TrammelPoints

To scribe a circle with a radius larger than your dividers, you should select TRAMMEL POINTS. The method of adjusting the points, as shown in figure 2-7, is to set the left-hand point on one mark, slide the right-hand point to the required distance, and tighten the thumbscrew. The arc, or circle, is then scribed in the same manner as with the dividers.

Constructing a 90-degree, or right, angle is not difficult if you have a true, steel square. Suppose that you have no square or that your square is off and you need a right angle for a layout. Breakout your dividers, a scriber, and a straightedge. Draw a base line like the one labeled AB in figure 2-8. Set the dividers for a distance greater than one-half AB; then, with A as a center, scribe arcs like those labeled C and D. Next, without changing the setting of the dividers, use B as a center, and scribe another set of arcs at C and D. Draw a line through the points where the arcs intersect and you have erected perpendiculars to line AB, forming four 90-degree, or right, angles. You have also bisected or divided line AB into two equal parts.

Constructing a right angle at a given point with a pair of dividers is a procedure you will find useful when making layouts. Figure 2-9 shows the method for constructing a right angle at a given point.

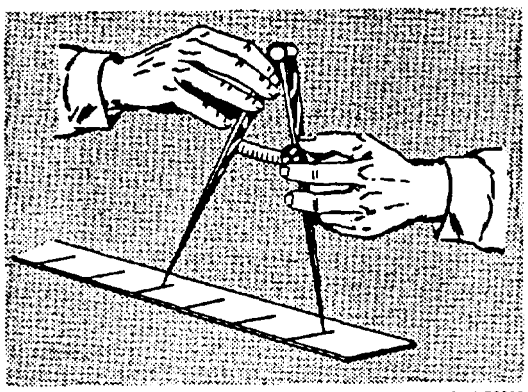

Figure 2-5.—Setting the dividers

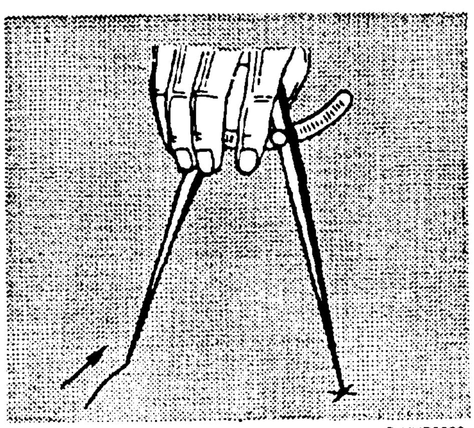

Figure 2-6.—Scribing an acr/circle with dividers

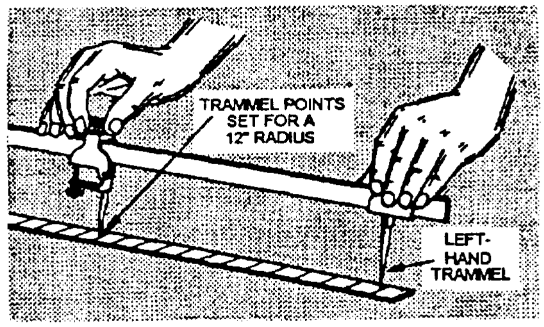

Figure 2-7.—Setting trammel points.

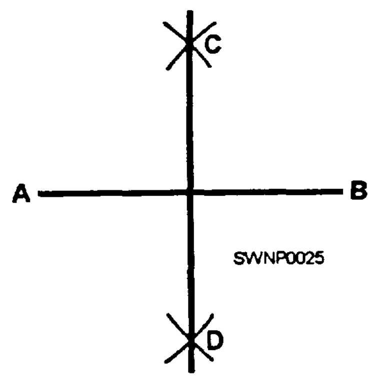

Figure 2-8.—Constructing a 90-degree angle by bisecting a line.

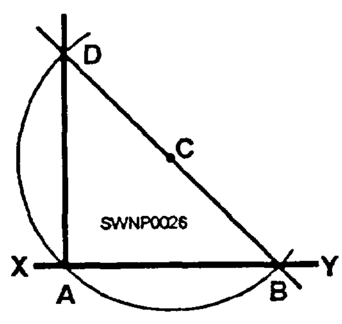

Figure 2-9.—Constructing a 90-degree angle at a given point

Imagine that you have line XY with A as a point at which you need to fabricate a perpendicular to form a right angle. Select any convenient point that lies somewhere within the proposed 90-degree angle. In figure 2-9 that point is C. Using C as the center of a circle with a radius equal to CA, scribe a semicircular arc, as shown in figure 2-9. Lay a straightedge along points B and C and draw a line that will intersect the other end of the arc at D. Next, draw a line connecting the points D and A and you have fabricated a 90-degree angle. This procedure may be used to form 90-degree comers in stretch-outs that are square or rectangular, like a drip pan or a box.

Laying out a drip pan with a pair of dividers is no more difficult than fabricating a perpendicular. You will need dividers, a scriber, a straightedge, and a sheet of template paper. You have the dimensions of the pan to be fabricated: the length, the width, and the height or depth. Draw a base line (fig. 2-10). Select a point on this line for one comer of the drip pan layout. Erect a perpendicular through this point, forming a 90-degree angle. Next, measure off on the base line the required length of the pan. At this point, erect another perpendicular. You now have three sides of the stretch-out. Using the required width of the pan for the other dimensions, draw the fourth side parallel to the base line, connecting the two perpendiculars that you have fabricated.

Now, set the dividers for marking off the depth of the drip pan. You can use a steel scale to measure off the correct radius on the dividers. Using each comer for a point, swing a wide arc, like the one shown in the second step in figure 2-10. Extend the end and side lines as shown in the last step in figure 2-10 and complete the stretch-out by connecting the arcs with a scriber and straightedge.

Bisecting an arc is another geometric construction that you should be familiar with. Angle ABC (fig. 2-11) is given. With B as a center, draw an arc cutting the sides of the angle at D and E. With D and E as centers and a radius greater than half of arc DE, draw arcs intersecting at F. A line drawn from B through point F bisects angle ABC.

Two methods used to divide a line into a given number of equal parts are shown in figure 2-12. When the method shown in view A is to be used, you will need a straightedge and dividers. In using this method, draw line AB to the desired length. With the dividers set at any given radius, use point A as center and scribe an arc above the line. Using the same radius and B as center, scribe an arc below the line as shown. From

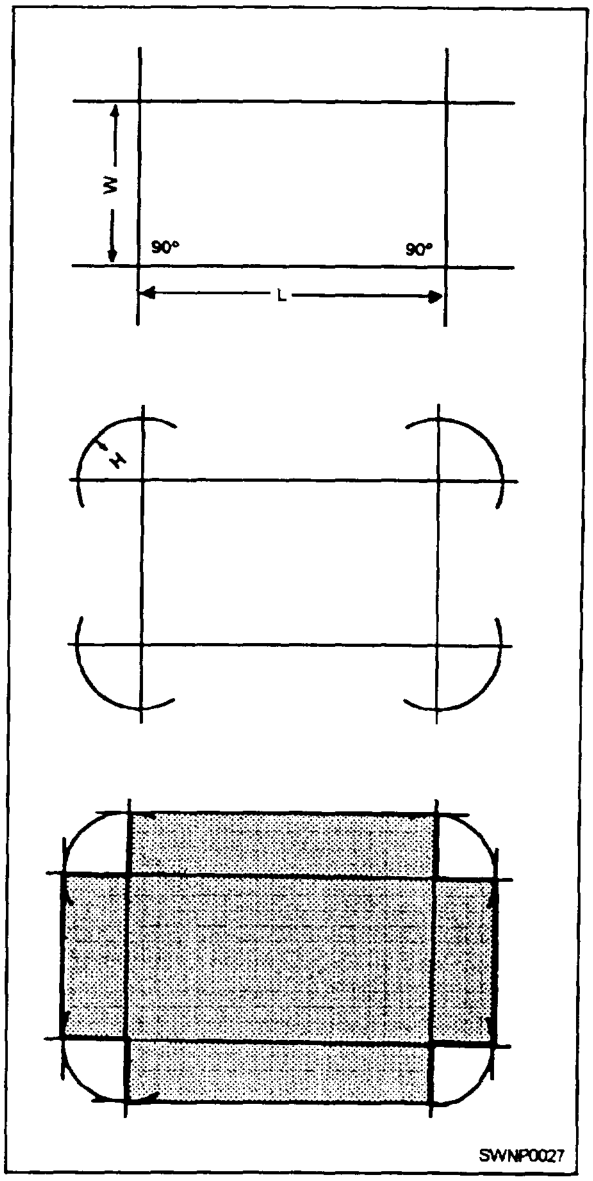

Figure 2-10.—Laying out a drip pan with dividers.

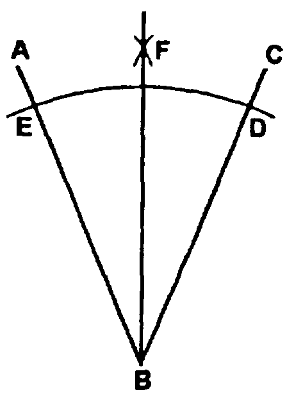

Figure 2-11.—Bisecting an arc.

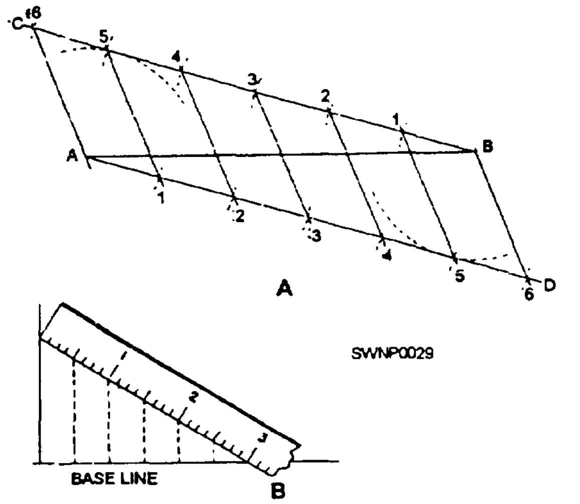

Figure 2-12.—Two methods used to divide a line into equal parts.

point A, draw a straight line tangent to the arc that is below point B. Do the same from point B. With the dividers set at any given distance, start at point A and step off the required number of spaces along line AD using tick marks-in this case, six. Number the tick marks as shown. Do the same from point B along line BC. With the straightedge, draw lines from point 6 to point A, 5 to 1, 4 to 2, 3 to 3, 2 to 4, 1 to 5, and B to 6. You have now divided line AB into six equal parts.

When the method shown in view B of figure 2-12 is used to divide a line into a given number of equal parts, you will need a scale. In using this method, draw a line at right angles to one end of the base line. Place the scale at such an angle that the number of spaces required will divide evenly into the space covered by the scale. In the illustration (view B, fig. 2-12) the base line is 2 1/2 inches and is to be divided into six spaces. Place the scale so that the 3 inches will cover 2 1/2 inches on the base line. Since 3 inches divided by 6 spaces = 1/2 inch, draw lines from the 1/2-inch spaces on the scale perpendicular to the base line. Incidentally, you may even use a full 6 inches in the scale by increasing its angle of slope from the baseline and dropping perpendiculars from the full-inch graduation to the base line.

To divide or step off the circumference of a circle into six equal parts, just set the dividers for the radius of the circle and select a point of the circumference for a beginning point. In figure 2-13, point A is selected for a beginning point. With A as a center, swing an arc through the circumference of the circle, like the one shown at B in the illustration. Use B, then, as a point, and swing an arc through the circumference at C. Continue to step off in this manner until you have divided the circle into six equal parts. If the points of intersection between the arcs and the circumference are connected as shown in figure 2-13, the lines will intersect at the center of the circle, forming angles of 60 degrees.

If you need an angle of 30 degrees, all you have to do is to bisect one of these 60-degree angles by the method described earlier in this chapter. Bisect the 30-degree angle and you have a 15-degree angle. You can construct a 45-degree angle in the same manner by bisecting a 90-degree angle. In all probability, you will have a protractor to lay out these and other angles. But just in case you do not have a steel square or protractor, it is a good idea to know how to construct angles of various sizes and to erect perpendiculars.

Many times when laying out or working with circles or arcs, it is necessary to determine the circumference of a circle or arc. For the applicable mathematical formula, refer to appendix II of this text.

Circumference Rule

Another method of determining circumference is by use of the circumference rule. The upper edge of the circumference rule is graduated in inches in the same manner as a regular layout scale, but the lower edge is graduated, as shown in figure 2-14. The lower edge gives you the approximate circumference of any circle within the range of the rule. You will notice in figure 2-14 that the reading on the lower edge directly below the 3-inch mark is a little over 9 3/8 inches. This

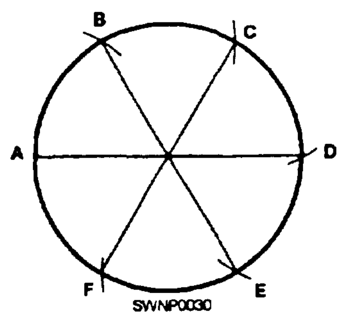

Figure 2-13.—Dividing a circle into six equal parts

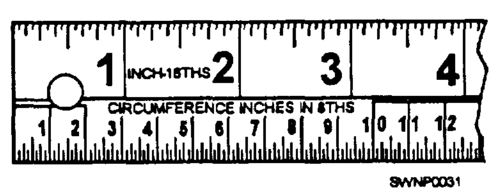

Figure 2-14.—Circumference rule.

reading would be the circumference of a circle with a diameter of 3 inches and would be the length of a stretch-out for a cylinder of that diameter. The dimensions for the stretch-out of a cylindrical object, then, are the height of the cylinder and the circumference.

CUTTING TOOLS

Various types of HAND SNIPS/HAND SHEARS are used for cutting and notching sheet metal. Hand snips are necessary because the shape, construction, location, and position of the work to be cut frequently prevents the use of machine-cutting tools.

Hand snips are divided into two groups. Those for straight cuts are as follows: straight snips, combination snips, bulldog snips, and compound lever shears. Those for circular cuts are as follows: circle, hawk's bill, aviation, and Trojan snips. These snips are shown in figure 2-15. The following is a brief description of each type of snip.

STRAIGHT SNIPS (fig. 2-15, view A) have straight jaws for straight line cutting. To ensure strength, they are not pointed. These snips are made in various sizes and the jaws may vary from 2 to 4 1/2 inches. The overall length will also vary from 7 to 15 3/4 inches. The different size snips are made to cut different thicknesses of metal with 18 gauge steel as a minimum for the larger snips. These snips are available for right- or left-hand use.

COMBINATION SNIPS (fig. 2-15, view B) have straight jaws for straight cutting but the inner faces of the jaws are sloped for cutting curves as well as irregular shapes. These snips are available in the same sizes and capacities as straight snips.

BULLDOG SNIPS (fig. 2-15, view C) are of the combination type, They have short cutting blades with long handles for leverage. The blades are inlaid with special alloy steel for cutting stainless steel. Bulldog snips can cut 16 gauge mild steel. The blades are 2 1/2 inches long and the overall length of the snip varies from 14 to 17 inches.

COMPOUND LEVER SHEARS (fig. 2-15, view D) have levers designed that give additional leverage to ease the cutting of heavy material. The lower blade is bent to allow the shears to be inserted in a hole in the bench or bench plate. This will hold the shear in an upright position and make the cutting easier. The cutting blades are removable and can be replaced. The capacity is 12 gauge mild steel. It has cutting blades that are 4 inches long with an overall length of 34 1/2 inches.

CIRCLE SNIPS (fig. 2-15, view E) have curved blades and are used for making circular cuts, as the name implies. They come in the same sizes and capacities as straight snips and either right- or left-hand types are available.

HAWK'S BILL SNIPS (fig. 2-15, view F) are used to cut a small radius inside and outside a circle. The narrow, curved blades are beveled to allow sharp turns without buckling the sheet metal. These snips are useful for cutting holes in pipe, in furnace hoods, and in close quarters work. These snips are available with a 2 1/2-inch cutting edge and have an overall length of either 11 1/2 or 13 inches and have a 20 gauge mild steel capacity.

AVIATION SNIPS (fig. 2-15, view G) have compound levers, enabling them to cut with less effort. These snips have hardened blades that enable them to cut hard material. They are also useful for cutting circles, for cutting squares, and for cutting compound curves and intricate designs in sheet metal. Aviation snips come in three types: right hand, left hand, and straight. On right-hand snips, the blade is on the left and they cut to the left. Left-hand snips are the opposite. They are usually color-coded in keeping with industry standards-green cuts right, red cuts left, yellow cuts straight. Both snips can be used with the right hand. The snips are 10 inches long and have a 2-inch cut and have a 16 gauge mild steel capacity.

TROJAN SNIPS (fig. 2-15, view H) are slim-bladed snips that are used for straight or curved cutting. The blades are small enough to allow sharp turning cuts without buckling the metal. These snips can be used to cut outside curves and can also be used in place of circle snips, hawk's bill snips, or aviation snips when cutting inside curves. The blades are forged high grade steel. These snips come in two sizes: one has a 2 1/2-inch cutting length and a 12-inch overall length and the other has a 3-inch cutting length and a 13-inch overall length, They both have a 20 gauge capacity.

Modern snips are designed to cut freely with a minimum curling of the metal. The snips are generally held in the right hand at right angles to the work (fig, 2-16). Open the blades widely to obtain maximum leverage. Do not permit the ends to close completely at the end of a cut or a rough

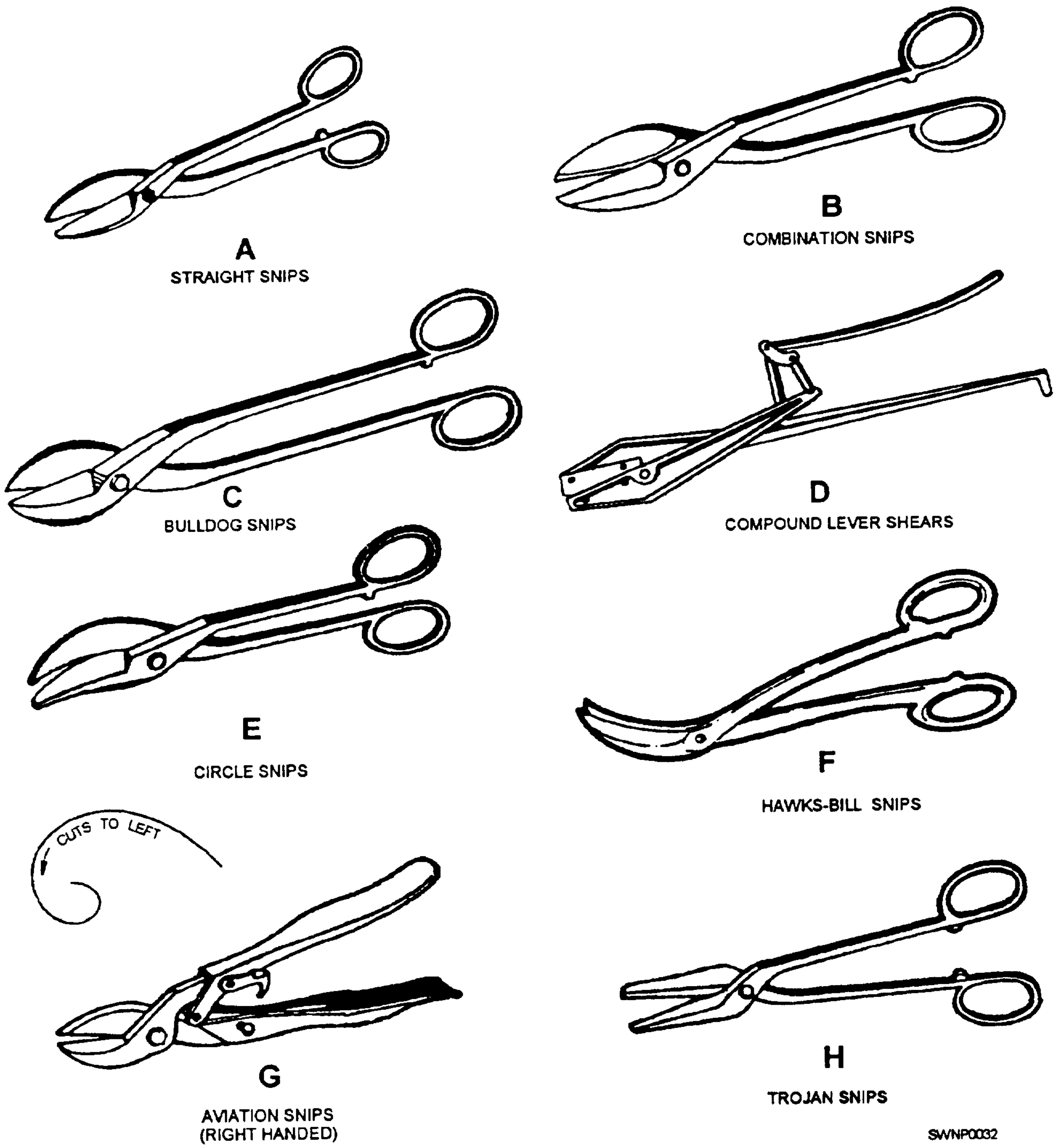

Figure 2-15.—Hand snips.

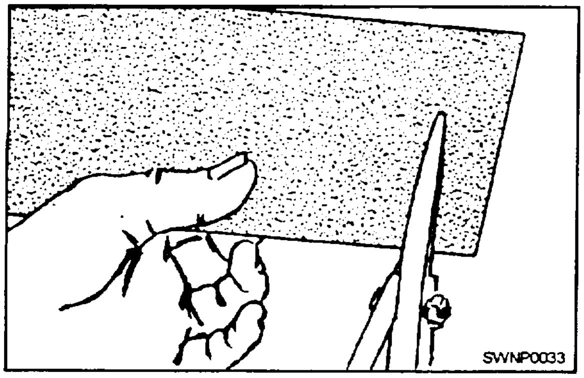

Figure 2-16.—Proper method of cutting with snips.

edge will result. Cut circular sections from the right side (fig. 2-17).

When making internal circular cuts, you make a small opening near the center of the opening, insert the snips, and cut from the upper side, gradually increasing the radius of the cut until the opening is completed (fig. 2-18).

Large sheet-metal sections are cut on SQUARING SHEARS that are discussed later in this chapter.

The COMBINATION NOTCHER, COPER, and SHEAR (fig. 2-19) is ideal for notching corners or the edge of sheet metal. The blades are adjustable for conventional notching or for piercing, starting inside the blank.

PORTABLE POWER SHEARS make it possible to do production work. They are designed to do straight or circular cutting (fig. 2-20).

Small diameter openings can be made with a SOLID PUNCH (fig. 2-21) or a HOLLOW PUNCH

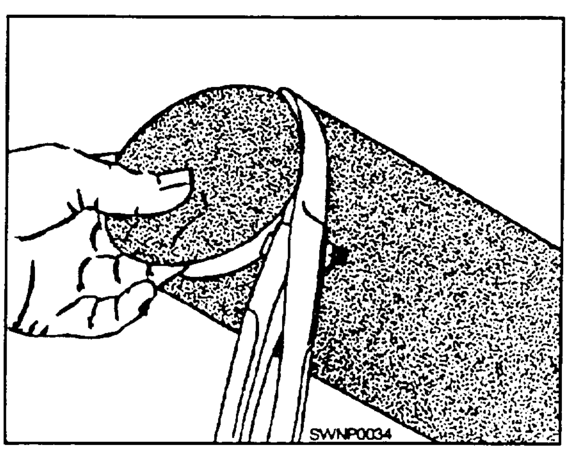

Figure 2-17.—Making a circular cut.

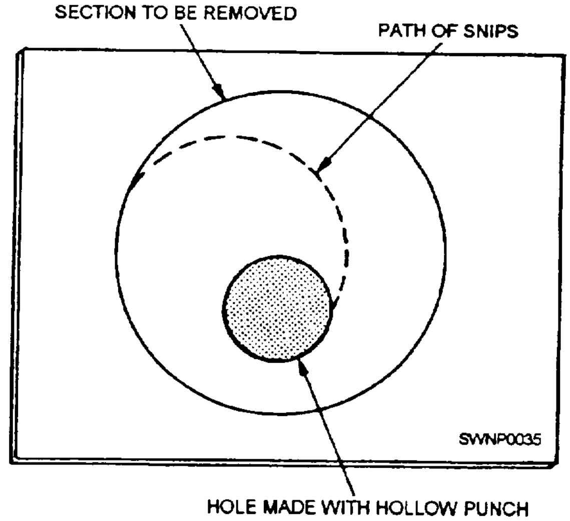

Figure 2-18.—Making an internal circular cut.

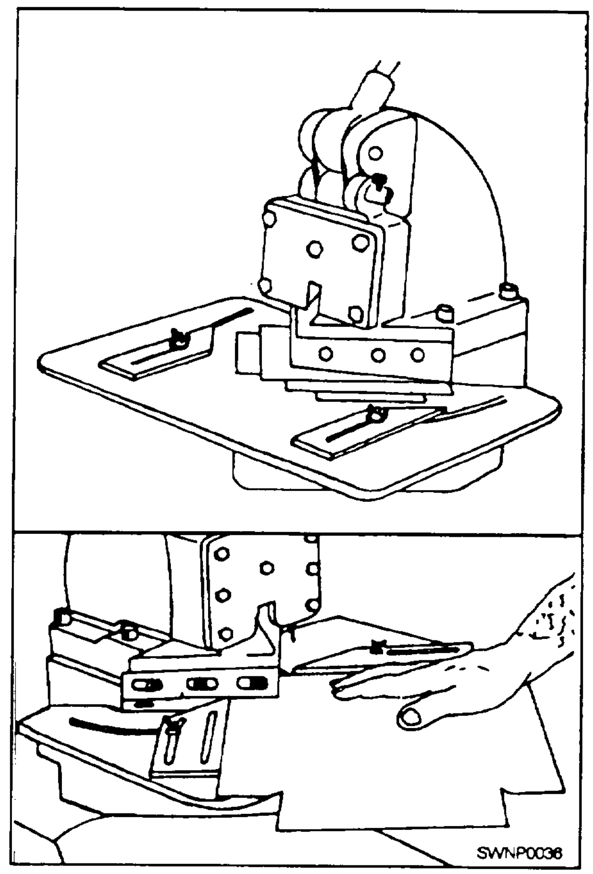

Figure 2-19.—Combination notcher, coper, and shear.

(fig. 2-22). Locate the position of the hole; select the correct size punch and hammer; then place the metal section on a lead cake or on the end grain of a block of hard wood (fig. 2-23). Strike the punch firmly with

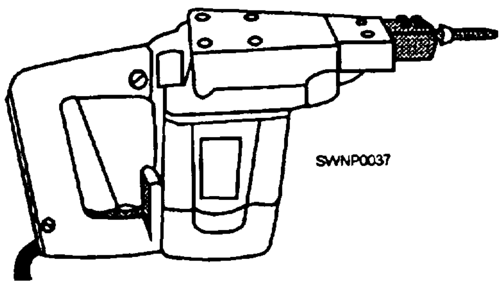

Figure 2-20.—Portable power shears

Figure 2-21.—Solid punch.

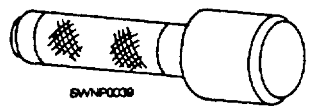

Figure 2-22.—Hollow punch.

the hammer. Turn the punched section over so the burred section is up, then smooth it with a mallet.

FOOT-ACTUATED SQUARING SHEARS (fig. 2-24) make it possible to square and trim large sheets. Do not attempt to cut metal heavier than the designed capacity of the shears. The maximum capacity of the machine is stamped on the manufacturer's

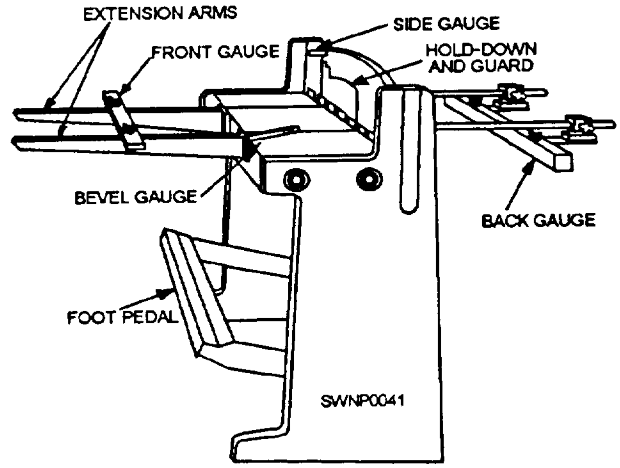

Figure 2-24.—Foot-actuated squaring shears.

specification plate on the front of the shears. Check the gauge of the metal against this size with a SHEET-METAL GAUGE (fig. 2-25). This figure shows the gauge used to measure the thickness of metal sheets. The gauge is a disc-shaped piece of metal, having slots of widths that correspond to the U.S. gauge numbers from O to 36. Each gauge number is marked on the front and the corresponding decimal equivalent marked on the back.

Do NOT cut wire, band iron, or steel rods with the squaring shears.

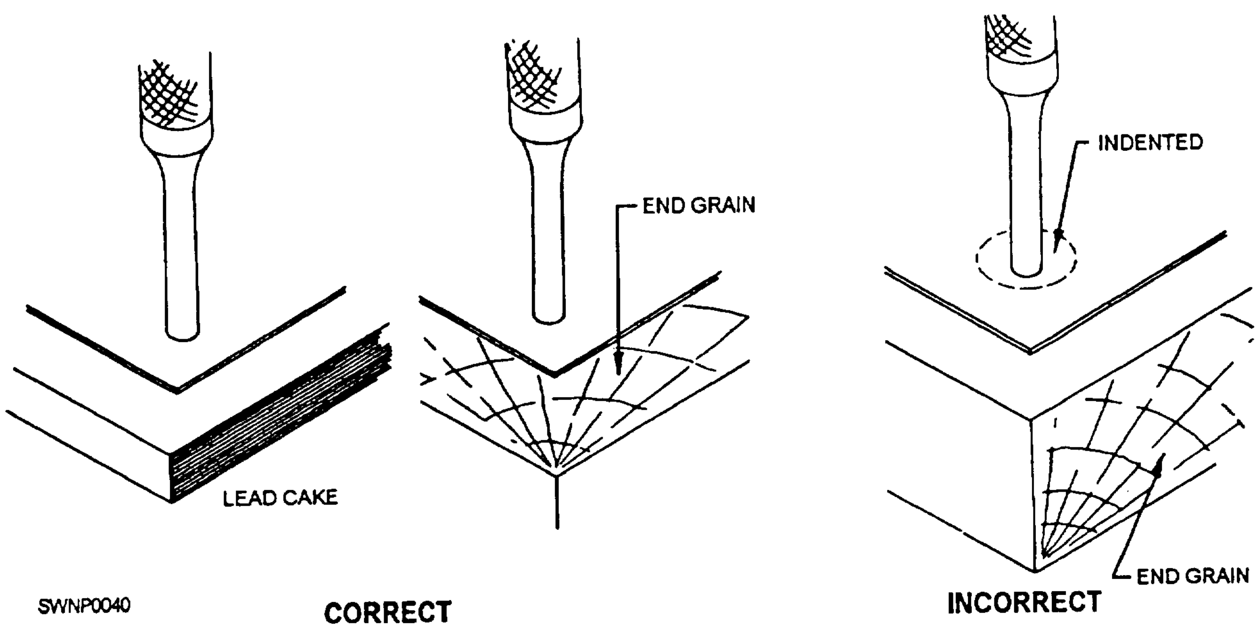

Figure 2-23.—Correct method of backing sheet metal for making a hole with a punch.

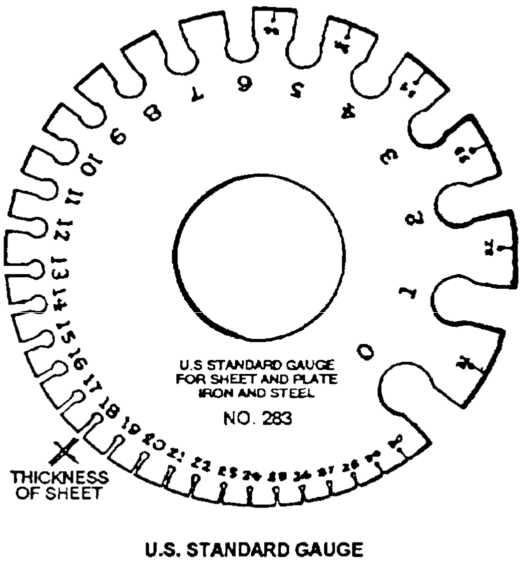

Figure 2-25.—Sheet-metal guage.

The length of the cut is determined by the position of the BACK GAUGE when the metal is inserted from the front of the shears. The FRONT GAUGE controls the length of the cut when the metal sheet is inserted from the rear. The front gauge is seldom used and is usually removed from the shears. A BEVEL GAUGE permits angular cuts to be made.

To make a cut, set the back gauge to the required dimension by using the graduated scale on the top of the extension arms or on the graduated section on the bed top. Hold the piece firmly against the SIDE GAUGE with both hands until the HOLD-DOWN comes into position, and apply pressure to the FOOT PEDAL.

NOTE: KEEP HANDS CLEAR OF THE BLADE AND FEET FROM BENEATH THE FOOT PEDAL.

RING AND CIRCULAR SHEARS (fig. 2-26) are intended for cutting inside and outside circles in sheet metal. The CLAMPING HEAD is positioned for the desired diameter and the blank is inserted. Lower the CUTTING DISC and make the cut.

SHEET-METAL BENDING AND FORMING EQUIPMENT

Sheet metal is given three-dimensional shape and rigidity by bending. Sheet metal can be formed by hand or with various special tools and machines. several techniques are described in the following sections.

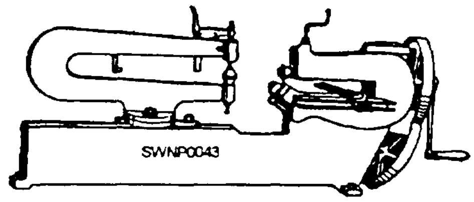

Figure 2-26.—Ring and circular shears

Stakes

METAL STAKES allow the sheet-metal craftsman to make an assortment of bends by hand Stakes come in a variety of shapes and sizes. The work is done on the heads or the horns of the stakes. They are machined, polished, and, in some cases, hardened Stakes are used for finishing many types of work; therefore, they should NOT be used to back up work when using a chisel. The following is an assortment of the most common stakes that are used within the NCF and Public Works Departments (fig. 2-27):

1. SQUARE STAKES (fig. 2-27, view A) have square-shaped heads and are used for general work Three types are used: the coppersmith square stake with one end rounded, the bevel edge square stake that is offset, and the common square stake. Some of the edges are beveled and this allows them to be used for a greater variety of jobs.

2. The CONDUCTOR STAKE (fig. 2-27, view B) has cylindrical horns of different diameters and is used when forming, seaming, and riveting pieces and parts of pipes.

3. The HOLLOW MANDREL STAKE (fig. 2-27, view C) has a slot in which a bolt slides allowing it to be clamped firmly to a bench. Either the rounded or the flat end can be used for forming, seaming, or riveting. There are two sizes available with an overall length of either 40 or 60 inches.

4. The BLOW HORN STAKE (fig. 2-27, view D) has two horns of different tapers. The apron end is used for shaping blunt tapers and the slender-tapered end is used for slightly tapered jobs.

5. The BEAKHORN STAKE (fig. 2-27, view E) is a general-purpose stake. The stake has a round-tapered horn on one end and a square-tapered horn on the other end. This stake is used for riveting and shaping round or square work

6. The DOUBLE-SEAMING STAKE WITH FOUR INTERCHANGEABLE HEADS (fig. 2-27, view F) has two shanks and either one can be installed

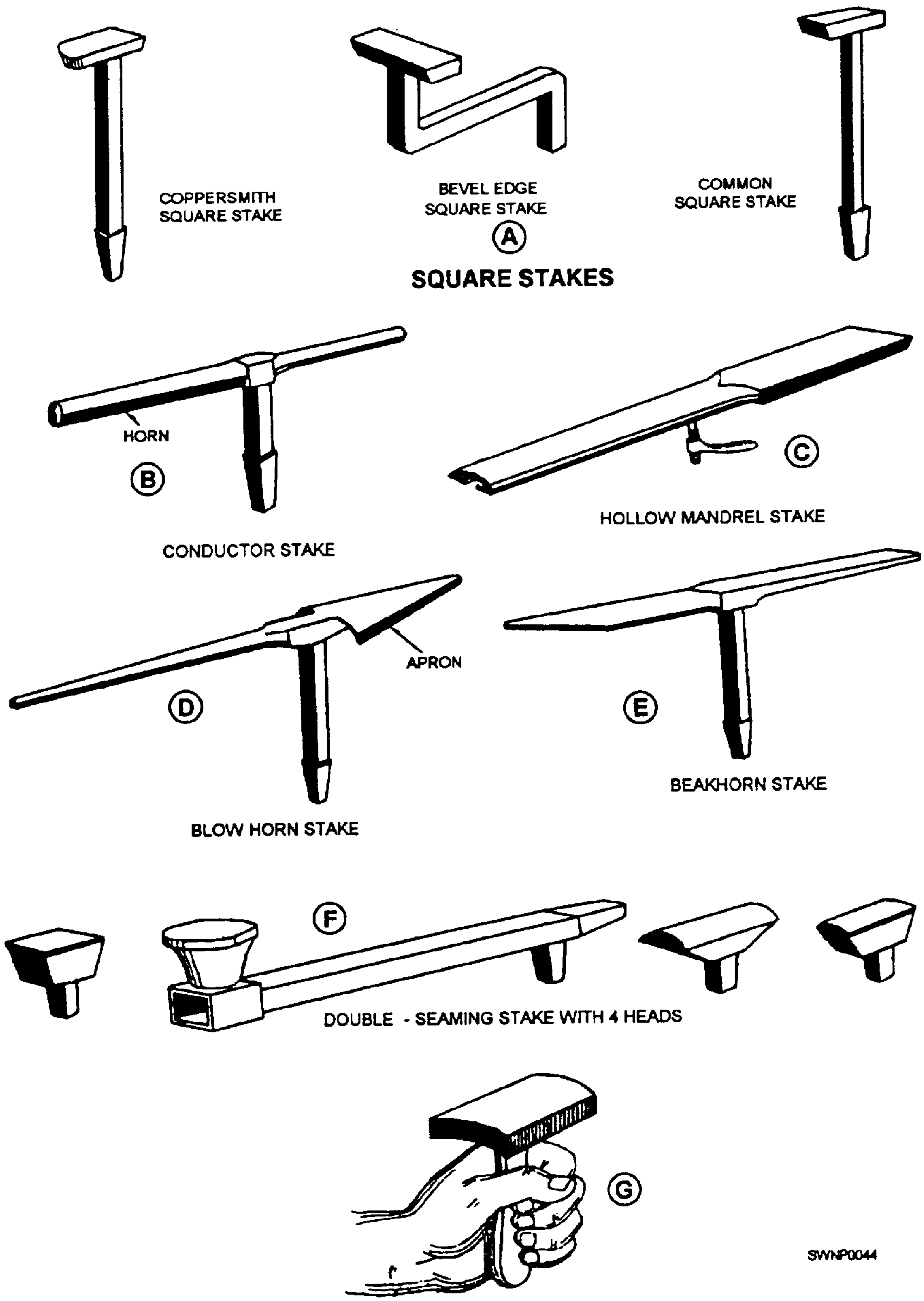

Figure 2-27.—Metal stakes

in a bench plate, allowing the stakes to be used vertically or horizontally. This stake is used for double seaming large work of all types and for riveting.

7. The HAND DOLLY (fig. 2-27, view G) is a portable anvil with a handle that is used for backing up rivet heads, double seams, and straightening.

Other Forming Tools

Stakes are designed to fit in a BENCH PLATE (fig. 2-28). The bench plate is a cast-iron plate that is affixed to a bench. It has tapered holes of different sizes that support the various stakes that can be used with the plate. Additionally, there is another type of bench plate that consists of a revolving plate with different size holes which can be clamped in any desired position.

The SETTING HAMMER (fig. 2-29) has a square, flat face and the peen end is single-tapered. The peen is for setting down an edge. The face is used to flatten seams. Setting hammers vary in size from 4 ounces to 20 ounces and their use is determined by the gauge of the metal and the accessibility of the work.

A WOOD MALLET (fig. 2-30) provides the necessary force for forming sheet metal without marring the surface of the metal.

Narrow sections can be formed with the HAND SEAMER (fig. 2-31). Its primary use is for turning a flange, for bending an edge, or for folding a seam. The width of the flange can be set with the knurled knobs on the top of the jaw.

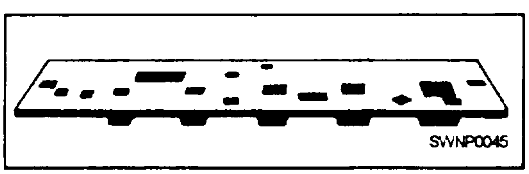

Figure 2-28.—Bench plate.

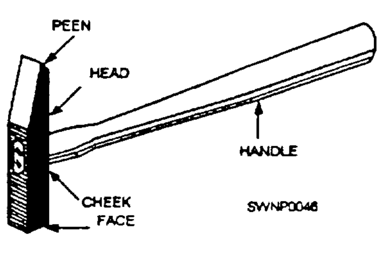

Figure 2-29.—Setting hamer.

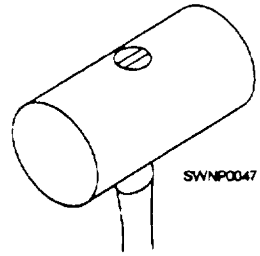

Figure 2-30.—Wood mallet

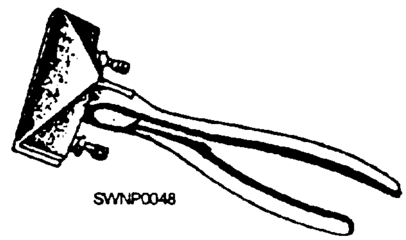

Figure 2-31.—Hand seamer.

Forming and Bending Machines

Many machines have been designed to perform precise sheet-metal bending operations. They include the bar folder, several types of brakes, roll forming machines, and combination rotary machines. These machines are described next.

BAR FOLDER.— The BAR FOLDER (fig. 2-32) is designed to bend sheet metal, generally 22 gauge or lighter. Bar folders are used for bending edges of sheets at various angles, for making channel shape (double-right angle folds), and for fabricating lock seams and wired edges. Narrow channel shapes can be formed but reverse bends cannot be bent at close distances. The width of the folder edge is determined by the setting of the DEPTH GAUGE (fig. 2-33). The sharpness of the folded edge, whether it is to be sharp for a hem or seam or rounded to make a wire edge, is determined by the position of the WING (fig. 2-34). Right-angle (90°) and 45-degree bends can be made by using the 90-degree and 45-degree ANGLE STOP.

Hemmed edges are made in the following manner (fig. 2-35):

1. Adjust the depth gauge for the required size, and position the wing for the desired fold sharpness.

2. Set the metal in place, setting it lightly against the gauge fingers.

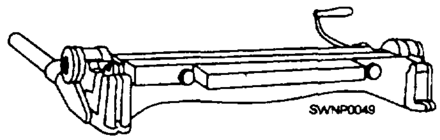

Figure 2-32.—Bar folder.

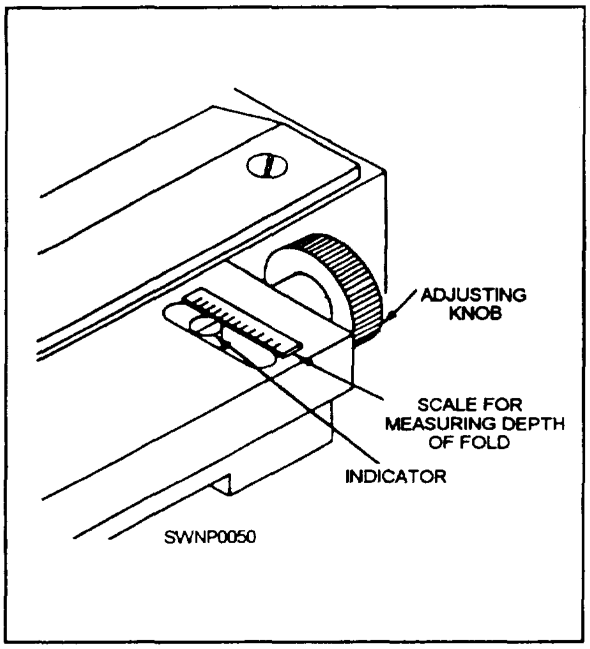

Figure 2-33.—Fold size depth gauge.

3. With the left hand holding the metal, pull the handle as far forward as it will go. Return the handle to its original position.

4. Place the folded section on the beveled section of the blade, as close to the wing as possible. Flatten the fold by pulling the handle forward rapidly.

BRAKES.— Large sheet-metal sections are formed by using bending brakes. These machines produce more uniform bends than can be made by hand and require significantly less effort. The two most commonly used brakes are the cornice brake and the finger brake.

A CORNICE BRAKE is shown in figure 2-36. Two adjustments have to be made before using the machine.

1. Adjust the UPPER JAW or CLAMPING BAR vertically for the gauge of sheet metal to be bent. The clamping device holds the work solidly in position, provided it is correctly adjusted. For example, if the clamping device is set for 18 gauge sheet metal and you

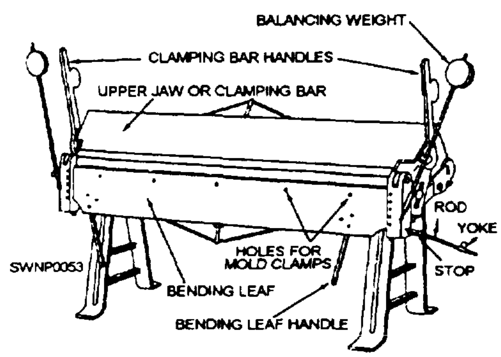

Figure 2-36.—Cornice brake.

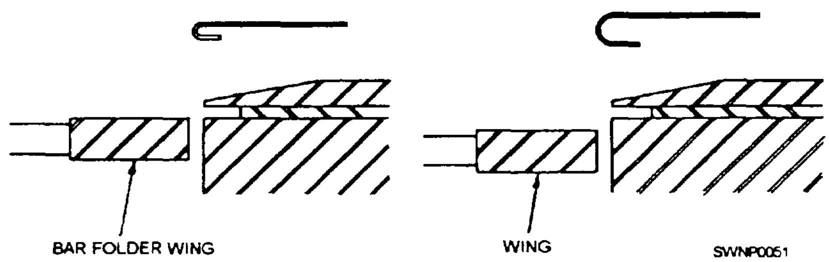

Figure 2-34.—Wing setting determines the tightness of fold.

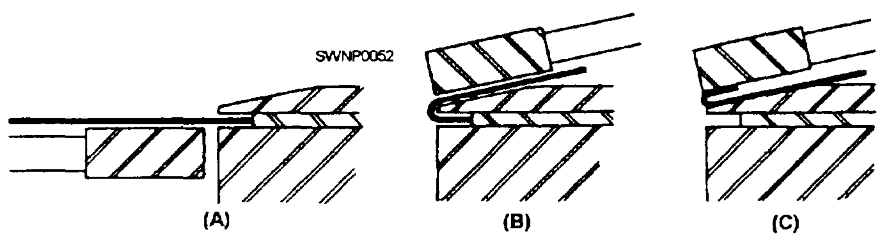

Figure 2-35.—Making a hemmed edge.

bend 24 gauge sheet metal at that setting, the sheet will slip and the bend will be formed in the wrong position. When you try to bend 18 gauge sheet metal when the machine is set for 24 gauge sheet metal, you can break the clamping bar handle. The pressure to lock the clamping bar should NEVER be too strong. With a little practice you will be able to gauge the pressure correctly.

2. Adjust the upper jaw horizontally to the correct position for the thickness of the metal and for the radius of the bend to be made.

CAUTION

If the upper jaw is adjusted to the exact thickness of the metal, the bend will be sharp or it will have practically no bend radius. If it is set for more than the thickness of the metal, the bend will have a larger radius; if the jaw is set for less than the thickness of the metal, the jaws of the machine may be sprung out of alignment and the edges of the jaws may be damaged.

After these two adjustments have been made, the machine is operated as follows:

1. Scribe a line on the surface of the sheet metal to show where the bend will be.

2. Raise the upper jaw with the clamping handle and insert the sheet in the brake, bringing the scribed line into position even with the front edge of the upper jaw.

3. Clamp the sheet in position. Ensure that the scribed line is even with the front edge of the upper jaw. The locking motion will occasionally shift the workpiece.

4. Once you are satisfied that the metal is clamped correctly, the next step is to lift the bending leaf to the required angle to form the bend. If you are bending soft and/or ductile metal, such as copper, the bend will be formed to the exact angle you raised the bending leaf. If you are bending metal that has any spring to it, you will have to raise the bending leaf a few degrees more to compensate for the spring in the metal. The exact amount of spring that you will have to allow for depends on the type of metal you are working with.

5. Release the clamping handle and remove the sheet from the brake.

The brake is equipped with a stop gauge, consisting of a rod, a yoke, and a setscrew. You use this to stop the bending leaf at a required angle. This feature is useful when you have to fabricate a large number of pieces with the same angle. After you have made your first bend to the required angle, set the stop gauge so that the bending leaf will not go beyond the required angle. You can now fabricate as many bends as you need.

The cornice brake is extremely useful for making single hems, double hems, lock seams, and various other shapes.

It is impossible to bend all four sides of a box on a conventional brake. The FINGER BRAKE, sometimes referred to as a BOX AND PAN BRAKE (fig. 2-37), has been designed to handle this exact situation . The upper jaw is made up of a number of blocks, referred to as "fingers." They are various widths and can easily be positioned or removed to allow all four sides of a box to be bent. Other than this feature, it is operated in the same manner as a cornice brake.

ROLL FORMING MACHINE.— When cylinders and conical shapes are being formed, no sharp bends are obviously required; instead, a gradual curve has to be formed in the metal until the ends meet. Roll forming machines have been invented to accomplish this task. The simplest method of forming these shapes is on the SLIP ROLL FORMING MACHINE (fig. 2-38). Three rolls do the forming (fig. 2-39). The two front rolls are the feed rolls and can be adjusted to accommodate various thicknesses of metal. The rear roll, also adjustable, gives the section the desired curve. The top roll pivots up to permit the cylinder to be removed without danger of distortion. Grooves are machined in the two bottom

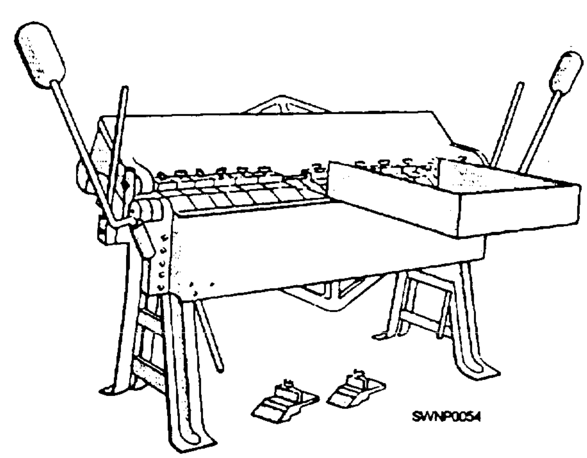

Figure 2-37.—Finger brake.

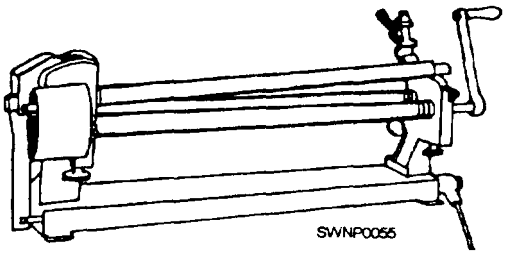

Figure 2-38.—Slip roll forming machine.

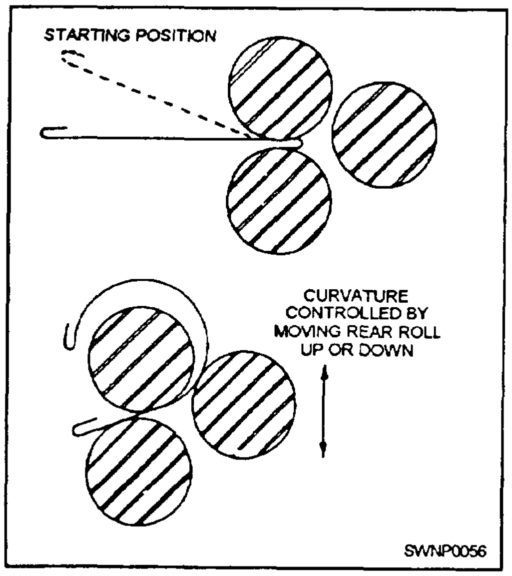

Figure 2-39.—Forming cylinders on rolling forms.

rolls for the purpose of accommodating a wired edge when forming a section with this type edge or for rolling wire into a ring.

COMBINATION ROTARY MACHINE.— Preparing sheet metal for a wired edge, turning a burr, beading, and crimping are probably the most difficult of sheet-metal forming operations to perform. When production dictates, large shops will have a machine for each operation. However, a COMBINATION ROTARY MACHINE (fig. 2-40) with a selection of rolls will prove acceptable for most shop uses.

Wiring an Edge.—The wire edge must be applied to tapered shapes after they are formed. This is accomplished by turning the edge on the rotary machine. Gradually, lower the upper roll until the groove is large enough for the wire. The edge is pressed around the wire with the rotary machine (fig. 241).

The wire edge can be finished by hand if a rotary machine is not available. The edge is formed on the

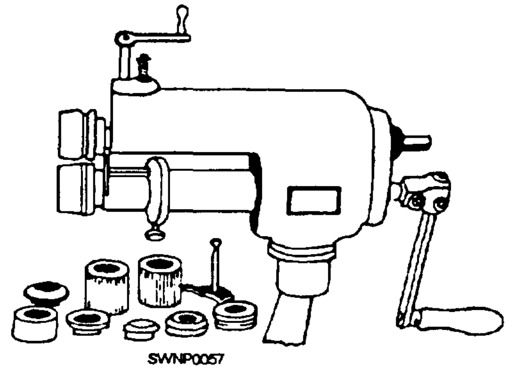

Figure 2-40.—Combination rotary machine with extra forming rolls.

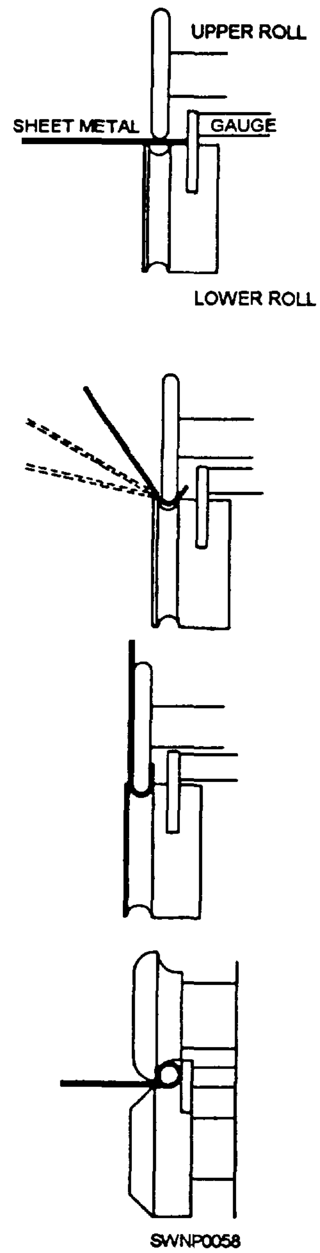

Figure 2-41.—Turning a wire edge with a rotary machine.

bar folder and forced into place around the wire with a setting hammer or pliers (fig. 2-42).

Turning a Burr.— A BURR, in sheet-metal language, is a narrow flange turned on the circular section at the end of a cylinder (fig. 2-43). Before you cut the section, remember that additional material must be added to the basic dimensions of the object for the burr. Figure 2-44 shows how to calculate the additional material.

After the rotary machine has been adjusted to turn the proper size burr, the work is placed in position and the upper roll lowered. Make one complete revolution of the piece, scoring the edge lightly. Lower the upper roll a bit more, creating more pressure, and make another turn. Continue this operation, raising the disc slightly after each turn until the burr is turned to the required angle (fig. 2-45).

This procedure is also used to turn the burr on the bottom of the cylinder for a double seam (fig. 2-46). The two pieces are snapped together, the burr set down, and the seam completed (fig. 2-47).

NOTE: Because turning a burr is a difficult operation, you should turn several practice pieces to develop your skill before turning the burr on the actual piece to be used.

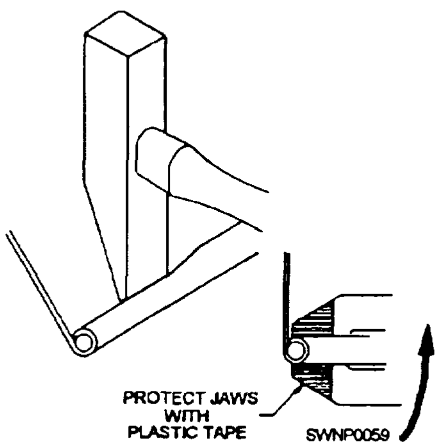

Figure 2-42.—Setting a wire edge with a setting hammer or pliers.

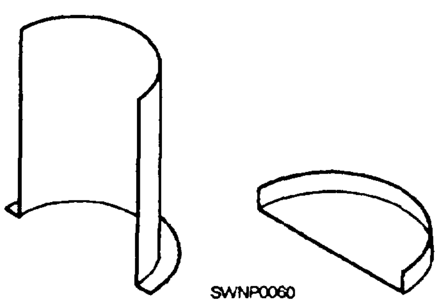

Figure 2-43.—Burrs turned on a cylindrical section.

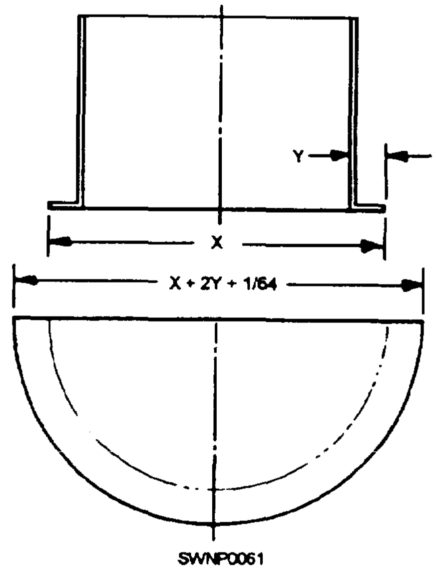

Figure 2-44.—Calculating the material needed for a double seam.

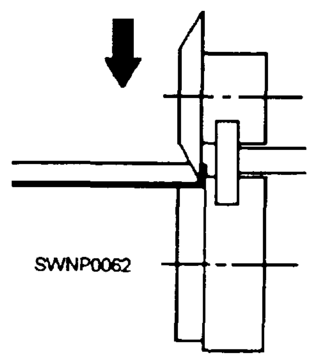

Figure 2-45.—Turning a burred edge.

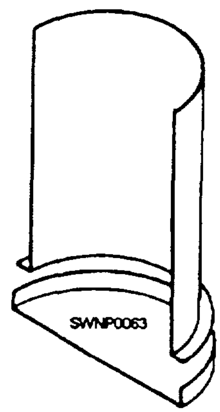

Figure 2-46.—Fitting burred sections together.

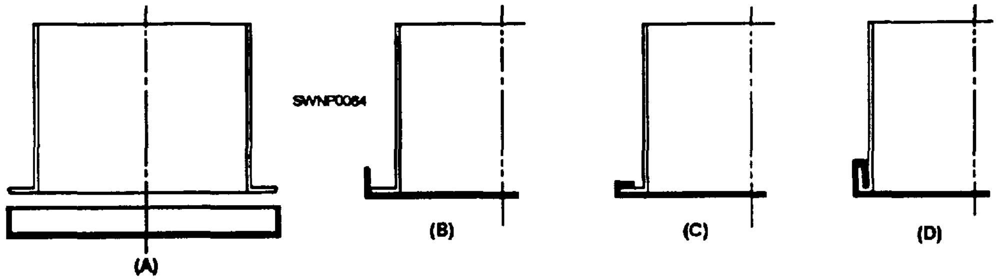

Figure 2-47.—Making a double seam on a cylindrical section.

Beading. — BEADING (fig. 2-48) is used to give added stiffness to cylindrical sheet-metal objects for decorative purposes, or both. It can be a simple bead or an ogee (S-shaped) bead. They are made on the rotary machine using beading rolls.

Crimping.— CRIMPING (fig. 2-49) reduces the diameter of a cylindrical shape, allowing it to be slipped into the next section. This eliminates the need for making each cylinder with a slight taper.

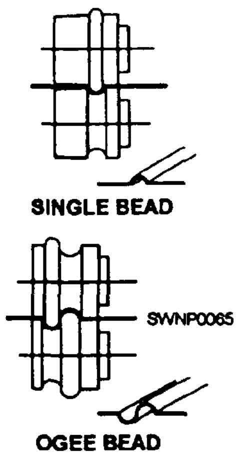

Figure 2-48.—Turning a bead with a rotary machine.

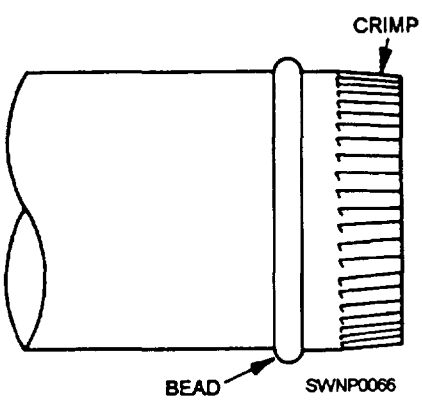

Figure 2-49.—A crimped section.

SHEET-METAL DEVELOPMENT

In sheet-metal development work, some fabrication or repair jobs can be laid out directly on sheet metal. This development procedure, known as SCRATCHING, is used when the object to be made requires little or no duplication.

When a single part is to be produced in quantity, a different development procedure is used. Instead of laying out directly on the metal, you will develop a PATTERN, or TEMPLATE, of the piece to be fabricated and then transfer the development to the metal sheet. The second development procedure is what we are primarily concerned with in this section.

Special attention is given to the three primary procedures commonly used in developing sheet-metal patterns. They are parallel line, radial line, and triangular development. We will also discuss the fabrication of edges, joints, seams, and notches.

PARALLEL LINE DEVELOPMENT

Parallel line development is based upon the fact that a line that is parallel to another line is an equal distance horn that line at all points. Objects that have opposite lines parallel to each other or that have the same cross-sectional shape throughout their length are developed by this method

To gain a clear understanding of the parallel line method, we will develop, step by step, a layout of a truncated cylinder (fig. 2-50). Such apiece can be used

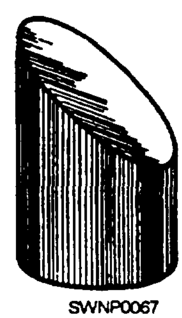

Figure 2-50.—Truncated cylinder.

as one half of a two-piece 0degree elbow. This piece of sheet metal is developed in the following procedure:

1. First, draw a front and bottom view by orthographic projection (fig. 2-51, view A).

2. Divide half the circumference of the circle (fig. 2-51, view A) into a number of equal parts. The parts should be small enough so that when straight lines are drawn on the development or layout between division points, they will approximate the length of the arc. Project lines from these points to the front view, as shown in figure 2-51, view B. These resulting parallel lines of the front view are called ELEMENTS.

3. Lay off the base line, called the STRETCH-OUT LINE, of the development to the right of the front view, as shown in figure 2-51, view C.

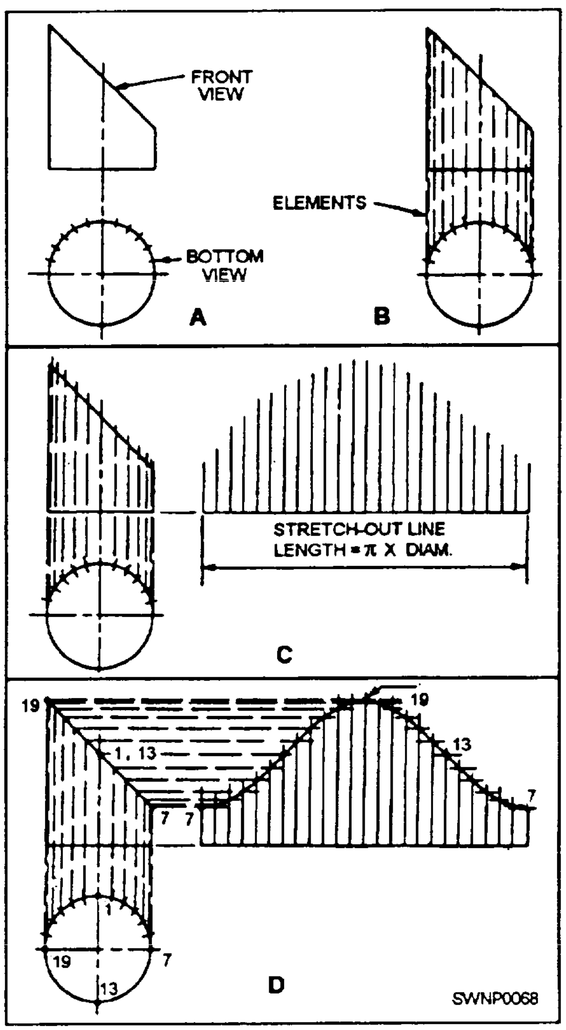

Figure 2-51.—Development of a truncated cylinder.

4. Divide the stretch-outline into twice the number of equal parts equal to each division of the circumference on the half circle of the orthographic view (fig. 2-51, view C).

5. Erect perpendicular lines at each point, as shown in figure 2-51, view C.

6. Using a T-square edge, project the lengths of the elements on the front view to the development (fig. 2-51, View D).

7. Using a curve (french or other type), join the resulting points of intersection in a smooth curve.

When the development is finished, add necessary allowances for warns and joints, then cut out your patterns.

RADIAL LINE DEVELOPMENT

The radial line method of pattern development is used to develop patterns of objects that have a tapering form with lines converging at a common center.

The radial line method is similar in some respects to the parallel line method. Evenly spaced reference lines are necessary in both of these methods. But, in parallel line development, the reference lines are parallel—like a picket fence. In radial line development, the reference lines radiate from the APEX of a cone—like the spokes of a wheel.

The reference lines in parallel line development project horizontally. In radial line development, the reference lines are transferred from the front view to the development with the dividers.

Developing a pattern for the frustum of a right cone is a typical practice project that will help you get the feel of the radial line method. You are familiar with the shape of a cone. A right cone is one that, if set big-side-down on a flat surface, would stand straight up. In other words, a centerline drawn from the point, or vertex, to the base line would form right angles with that line. The frustum of a cone is that part that remains after the point, or top, has been removed.

The procedure for developing a frustum of a right cone is given below. Check each step of the procedure against the development shown in figure 2-52.

1. Draw a cone ABC with line ED cutting the cone in such a way that line ED is parallel to the base line BC. EDCB is called a frustum.

2. With center O and radius OB, draw the half-plan beneath the base line BC. Divide the

half-plan into an equal number of parts and number them as shown.

3. With vertex A as a center and with dividers, set a distance equal to AC and draw an arc for the stretch-out of the bottom of the cone.

4. Set the dividers equal to the distance of the step-offs on the half-plan and step off twice as many spaces on the arcs as on the half-plan; number the step-offs 1 to 7 to 1, as shown in the illustration (fig. 2-52).

5. Draw lines connecting A with point 1 at each end of the stretch-out. This arc, from 1 to 7 to 1, is equal in length to the circumference of the bottom of the cone.

6. Now, using A for a center, set your dividers along line AC to the length of AD. Scribe an arc through both of the lines drawn from A to 1.

The area enclosed between the large and small arcs and the number 1 line is the pattern for the frustum of a cone. Add allowance for seaming and edging and your stretch-out is complete.

TRIANGULAR DEVELOPMENT

Triangulation is slower and more difficult than parallel line or radial line development, but it is more practical for many types of figures. Additionally, it is the only method by which the developments of warped surfaces may be estimated. In development by triangulation, the piece is divided into a series of triangles as in radial Line development. However, there is no one single apex for the triangles. The problem becomes one of finding the true lengths of the varying oblique lines. This is usually done by drawing a true, length diagram.

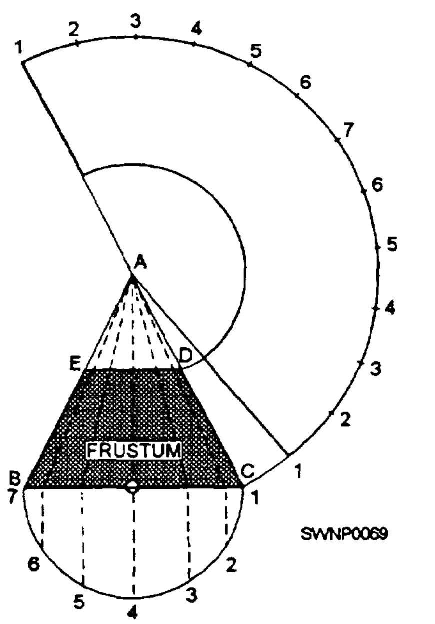

Figure 2-52.—Radial line development of a frustum of a cone.

An example of layout using triangulation is the development of a transition piece.

The steps in the triangulation of a warped transition piece joining a large, square duct and a small, round duct are shown in figure 2-53. The steps are as follows:

1. Draw the top and front orthographic views (view A, fig. 2-53).

2. Divide the circle in the top view into a number of equal spaces and connect the division points with AD (taken from the top part of view D, fig. 2-53) from point A. This completes one fourth of the development. Since the piece is symmetrical, the remainder of the development may be constructed using the lengths from the first part.

It is difficult to keep the entire development perfectly symmetrical when it is built up from small triangles. Therefore, you may check the overall symmetry by constructing perpendicular bisectors of AB, BC, CD, and DA (view E, fig. 2-53) and converging at point O. From point O, swing arcs a and b. Arc a should pass through the numbered points, and arc b should pass through the lettered points.

FABRICATION OF EDGES, JOINTS, SEAMS, AND NOTCHES

There are numerous types of edges, joints, seams, and notches used to join sheet-metal work. We will discuss those that are most often used.

Edges

Edges are formed to enhance the appearance of the work, to strengthen the piece, and to eliminate the cutting hazard of the raw edge. The kind of edge that you use on any job will be determined by the purpose, by the sire, and by the strength of the edge needed.

The SINGLE-HEM EDGE is shown in figure 2-54. This edge can be made in any width. In general, the heavier the metal, the wider the hem is made. The allowance for the hem is equal to its width (W in fig. 2-54).

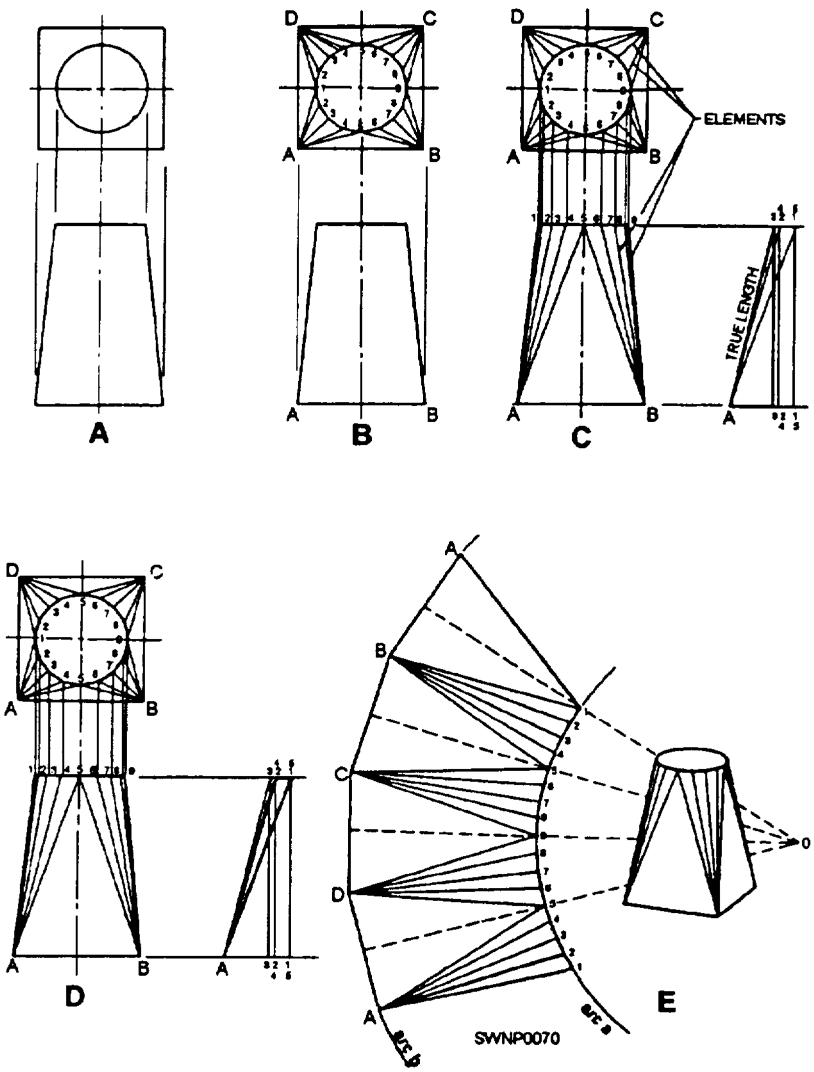

Figure 2-53.—Traingular development of a transition piece.

The DOUBLE-HEM EDGE (fig. 2-55) is used when added strength is needed and when a smooth edge is required inside as well as outside. The allowance for the double-hem edge is twice the width of the hem.

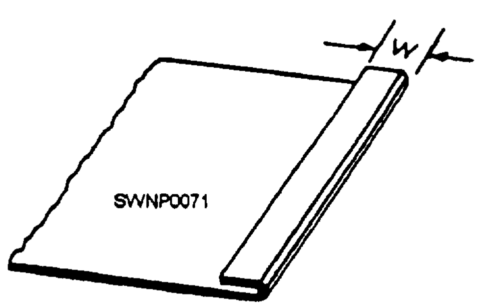

Figure 2-54.—Single-hem edge.

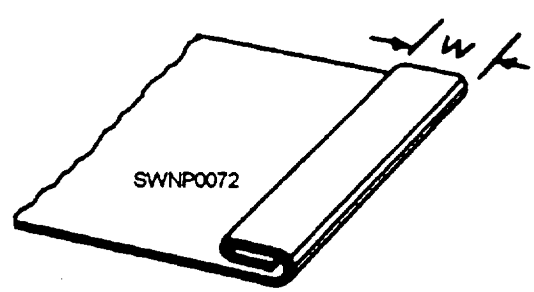

Figure 2-55.—Double-hem edge

A WIRE EDGE (fig. 2-56) is often specified in the plans, Objects, such as ice-cube trays, funnels, garbage pails, and other articles, formed from sheet metal are fabricated with wire edges to strengthen and stiffen the jobs and to eliminate sharp edges, The

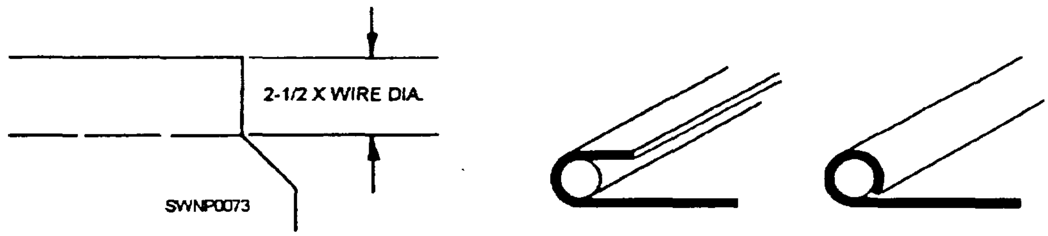

Figure 2-56.—Development of a truncated cylinder.

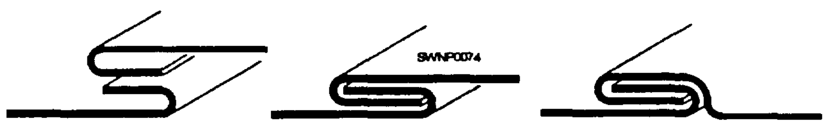

Figure 2-57.—Making a grooved seam joint.

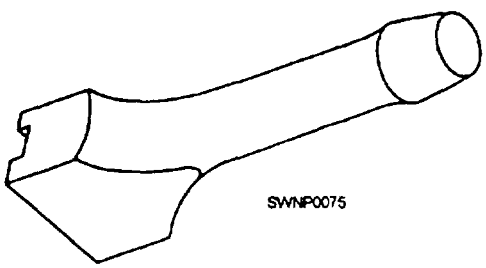

Figure 2-58.—Hand groover.

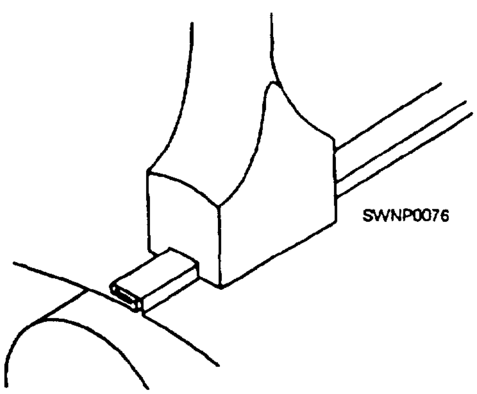

Figure 2-59.—Locking a grooved seam with a hand groover.

allowance for a wire edge is 2 1/2 times the diameter of the wire used As an example, you are using wire that has a diameter of 1/8 inch. Multiply 1/8 by 2 1/2 and your answer will be 5/16 inch, which you will allow when laying out sheet metal for making the wire edge.

Joints

The GROOVED SEAM JOINT (fig. 2-57) is one of the most widely used methods for joining light- and medium-gauge sheet metal. It consists of two folded edges that are locked together with a HAND GROOVER (fig. 2-58).

When making a grooved seam on a cylinder, you fit the piece over a stake and lock it with the hand groover (fig. 2-59). The hand groover should be approximately 1/16 inch wider than the seam. Lock the seam by making prick punch indentions about 1/2 inch in from each end of the seam.

The CAP STRIP SEAM (fig. 2-60, view A) is often used to assemble air-conditioning and heating ducts. A variation of the joint, the LOCKED CORNER SEAM (fig. 2-60, view B), is widely accepted for the assembly of rectangular shapes.

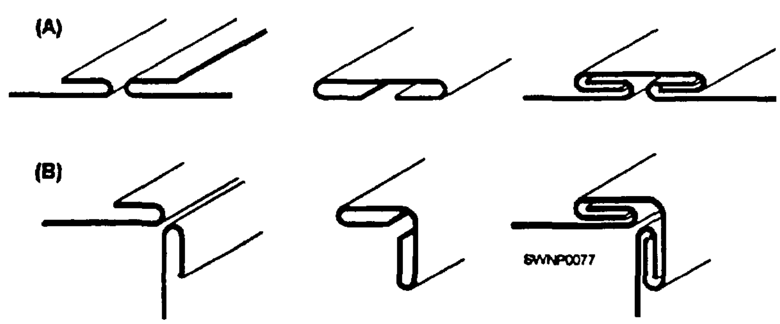

Figure 2-60.—(A) Cap strip seam, (B) Locked corner seam

A DRIVE SLIP JOINT is a method of joining two flat sections of metal. Figure 2-61 is the pattern for the drive slip. End notching and dimensions vary with application and area practice on all locks, seams, and edges.

"S" joints are used to join two flat surfaces of metal. Primarily these are used to join sections of rectangular duct. These are also used to join panels in air housings and columns.

Figure 2-62 shows a flat "S" joint. View A is a pattern for the "S" cleat. View B is a perspective view of the two pieces of metal that form the flat "S" joint. In view C, note the end view of the finished "S" joint.

Figure 2-63 shows a double "S" joint. View B is the pattern for the double "S" cleat. View A is one of two pieces of metal to be joined. Note the cross section of a partially formed cleat and also the cross section of the finished double "S" joint. his is a variation of the simple flat "S" and it does not require an overlap of metals being joined.

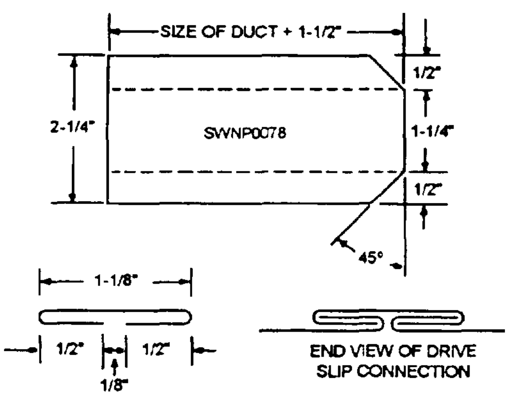

Figure 2-61.—Drive slip pattern and connections

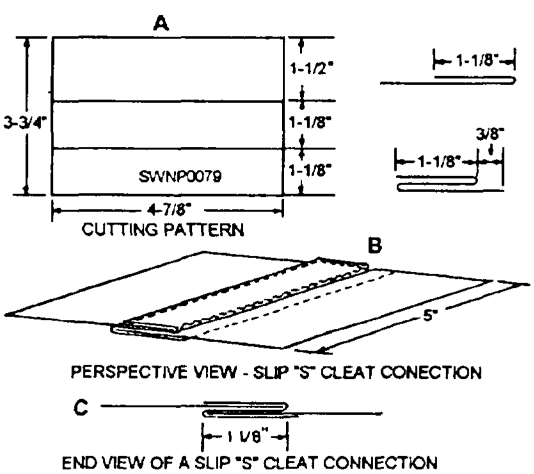

Figure 2-62.—"S" joint or slip pattern and connections.

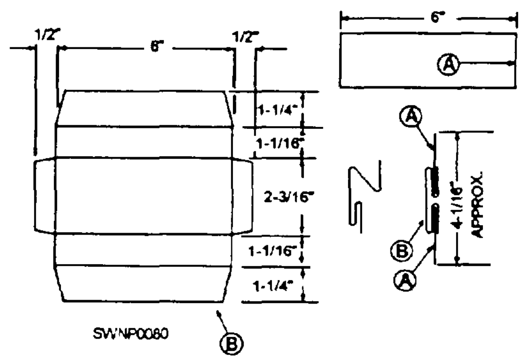

Figure 2-63.—Double "S' joint (cleat) pattern.

Figure 2-64 shows a standing "S" joint. View B is the pattern for the standing "S" cleat. View A is one of the two pieces of metal to be joined. Note the cross section of the finished standing "S" cleat and standing "S" joint.

Seams

Many kinds of seams are used to join sheet-metal sections. Several of the commonly used seams are shown in figure 2-65. When developing the pattern, ensure you add adequate material to the basic dimensions to make the seams. The folds can be made by hand; however, they are made much more easily on a bar folder or brake. The joints can be finished by soldering and/or riveting.

When developing sheet-metal patterns, ensure you add sufficient material to the base dimensions to make the seams. Several types of seams used to join sheet-metal sections are discussed in this section.

There are three types of lap seams: the PLAIN LAP seam, the OFFSET LAP seam, and the CORNER LAP seam (fig. 2-66). Lap seams can be joined by drilling and riveting, by soldering, or by both riveting and soldering. To figure the allowance for a lap seam, you must first know the diameter of the rivet that you plan to use. The center of the rivet must be set in from the edge a distance of 2 1/2 times its diameter; therefore, the allowance must be five times the diameter of the rivet that you are using. Figure 2-67 shows the procedure for laying out a plain lap and a comer lap for seaming with rivets (d represents the diameter of the rivets). For comer seams, allow an additional one sixteenth of an inch for clearance.

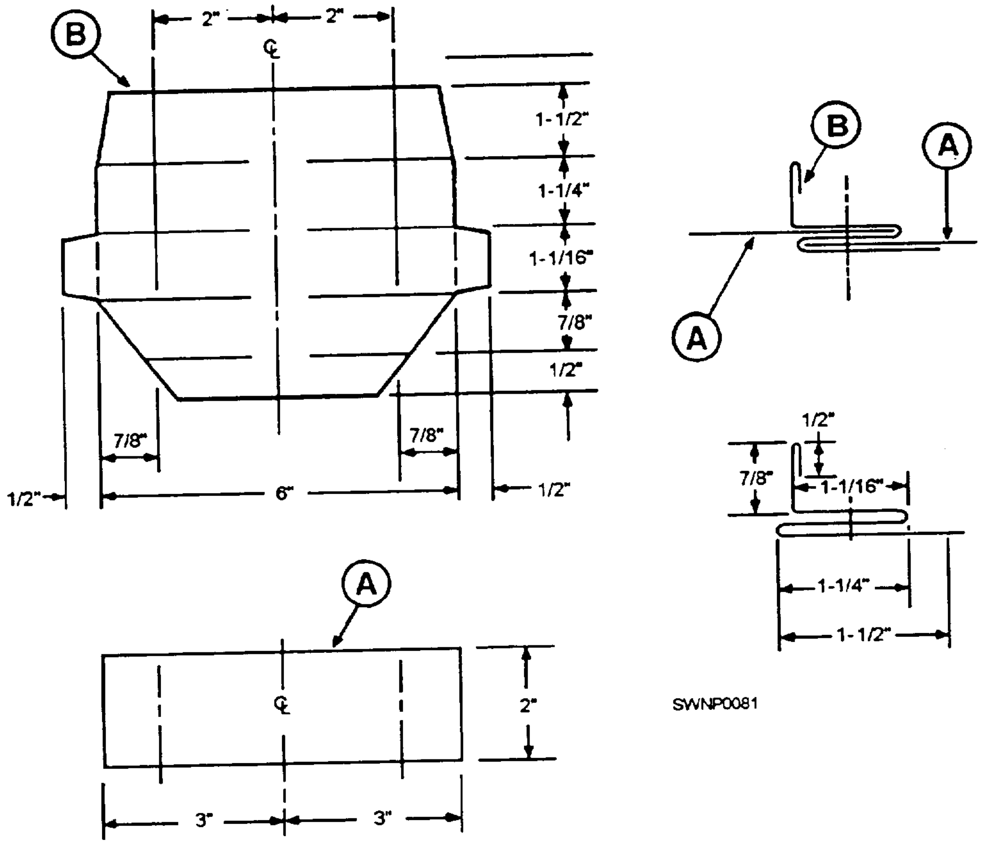

Figure 2-64.—Standing "S" cleat pattern.

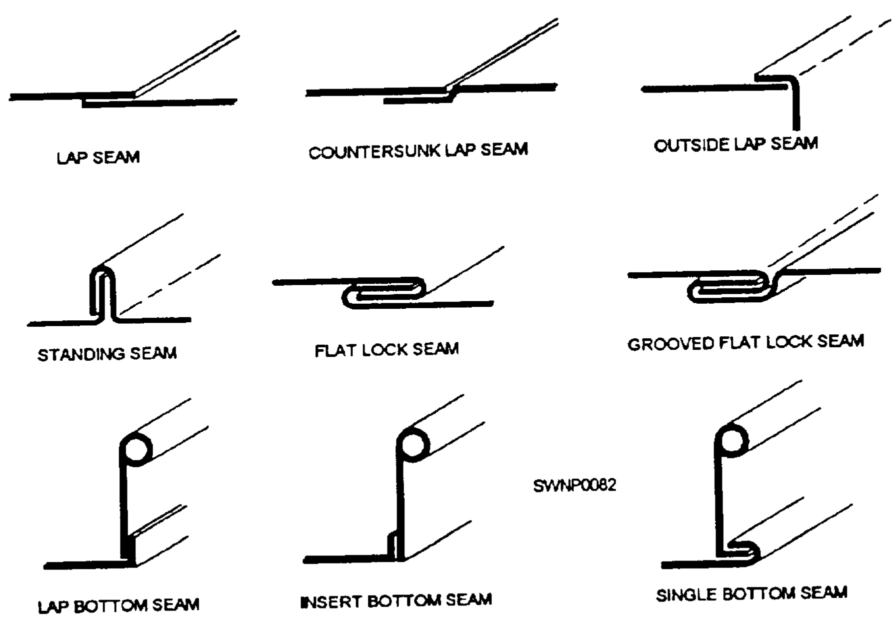

Figure 2-65.—Common sheet-metal seams.

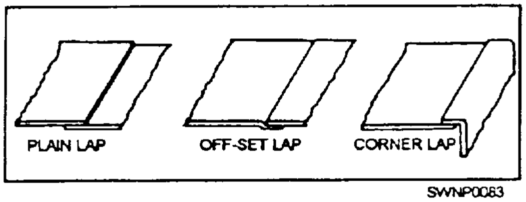

Figure 2-66.—Lap seams

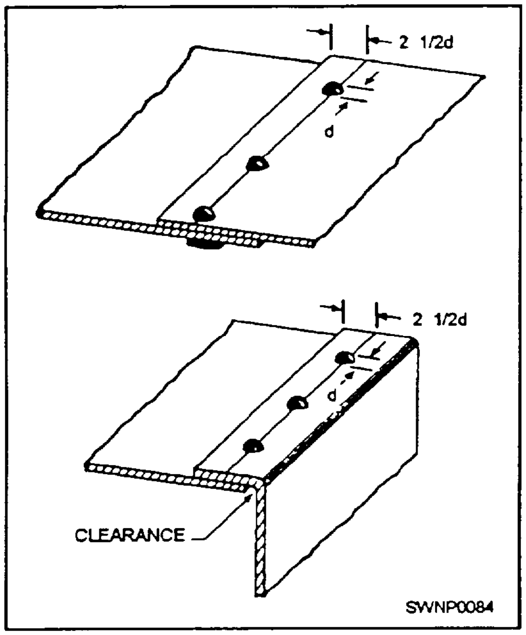

Figure 2-67.—Layout of lap seams for riveting.

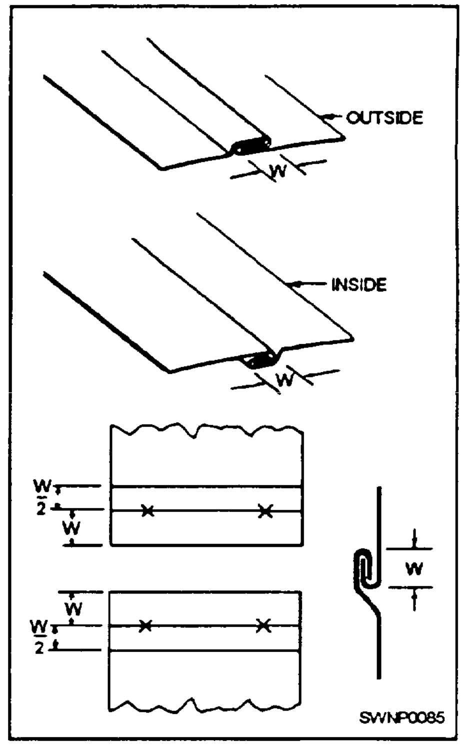

Figure 2-68.—Grooved seams

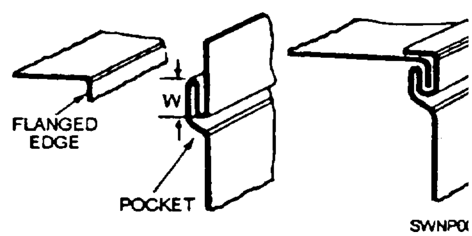

Figure 2-69.—Pittsburgh lock seam.

GROOVED SEAMS are useful in the fabrication of cylindrical shapes. There are two types of grooved seams-the outside grooved seam and the inside grooved seam (fig. 2-68). The allowance for a grooved seam is three times the width (W in fig. 2-68) of the lock, one half of this amount being added to each edge. For example, if you are to have a 1/4-inch grooved seam, 3 x 1/4 = 3/4 inch, or the total allowance; 1/2 of 3/4 inch = 3/8 inch, or the allowance that you are to add to each edge.

The PITTSBURGH LOCK SEAM (fig. 2-69) is a comer lock seam. Figure 2-69 shows a cross section of the two pieces of metal to be joined and a cross section of the finished seam. This seam is used as a lengthwise seam at comers of square and rectangular pipes and elbows as well as fittings and ducts. This seam can be made in a brake but it has proved to be so universal in use that special forming machines have been designed and are available. It appears to be quite complicated, but like lap and grooved seams, it consists of only two pieces. The two parts are the flanged, or single, edge and the pocket that forms the lock The pocket is formed when the flanged edge is inserted into the pocket, and the extended edge is turned over the inserted edge to complete the lock. The method of assembling and locking a Pittsburgh seam is shown in figures 2-70 and 2-71.

The allowance for the pocket is W + W + 3/16 inch. W is the width or depth of the pocket. The width of the flanged edge must be less than W. For example, if you are laying out a 1/4-inch Pittsburgh leek seam (fig. 2-72), your total allowance should be 1/4 + 1/4 + 3/16 inch, or 11/16 inch for the edge on which you are laying out the pocket and 3/16 inch on the flanged edge.

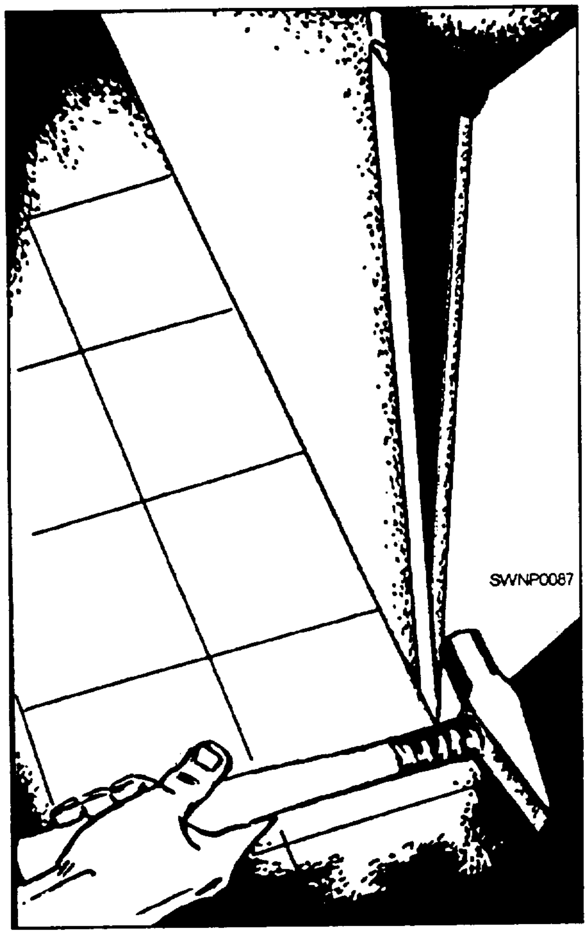

Figure 2-70.—Assembly of a Pittsburgh lock seam

STANDING SEAMS are used for joining metals where extra stiffness is needed, such as roofs, air housing, ducts, and so forth. Figure 2-73 is a cross section of the finished standing seam. Dimensions and rivet spacing will vary with application.

Standing seams used when stiffening is required are as follows: The SPREADER DRIVE CAP, the POCKET SLIP, and the GOVERNMENT LOCK (fig. 2-74) are seams frequently used in large duct construction where stiffeners are required.

The DOVETAIL SEAM is used mainly to join a round pipe/fitting to a flat sheet or duct. This seam can be made watertight by soldering. Figure 2-75 shows the pattern for forming a dovetail seam and an example of its use.

Notches

Notching is the last but not the least important step to be considered when you are getting ready to lay out

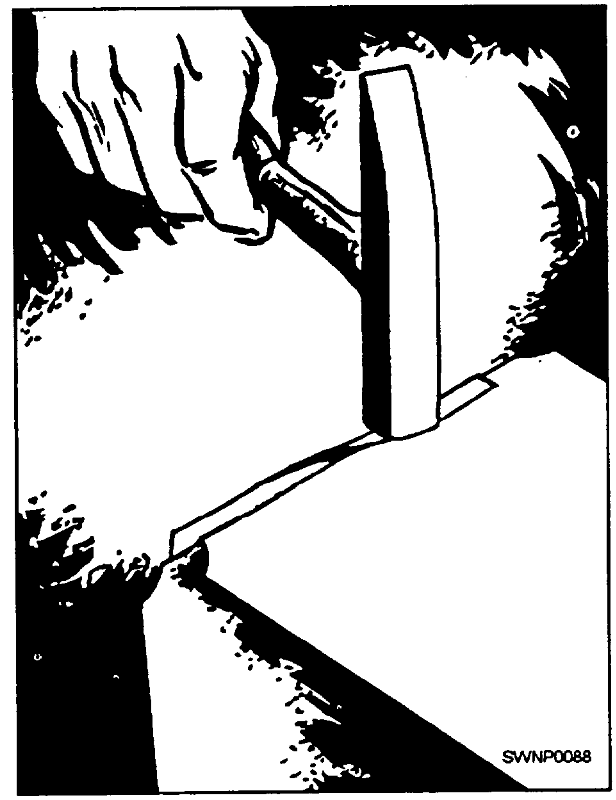

Figure 2-71.—Closing a Pittsburgh lock seam

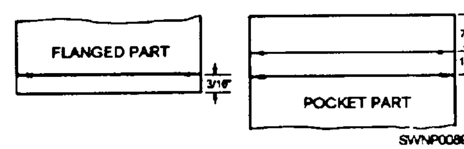

Figure 2-72.—Layout of a 1/4-inch Pittsburgh lock seam.

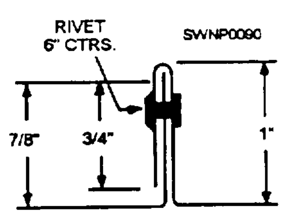

Figure 2-73.—Cross section of a standing seam.

a job. Before you can mark a notch, you will have to lay out the pattern and add the seams, the laps, or the stiffening edges. If the patterns are not properly notched, you will have trouble when you start forming, assembling, and finishing the job.

No definite rule for selecting a notch for a job can be given. But as soon as you can visualize the assembly of the job, you will not have any trouble determining the shape and size of the notch required

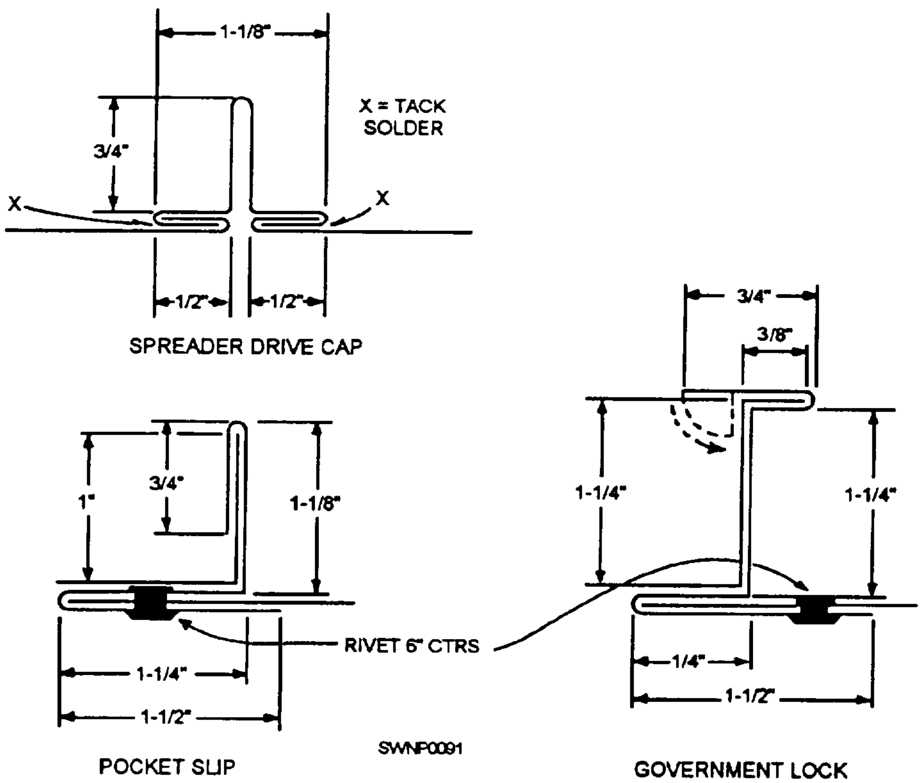

Figure 2-74.—Miscellaneous seam.

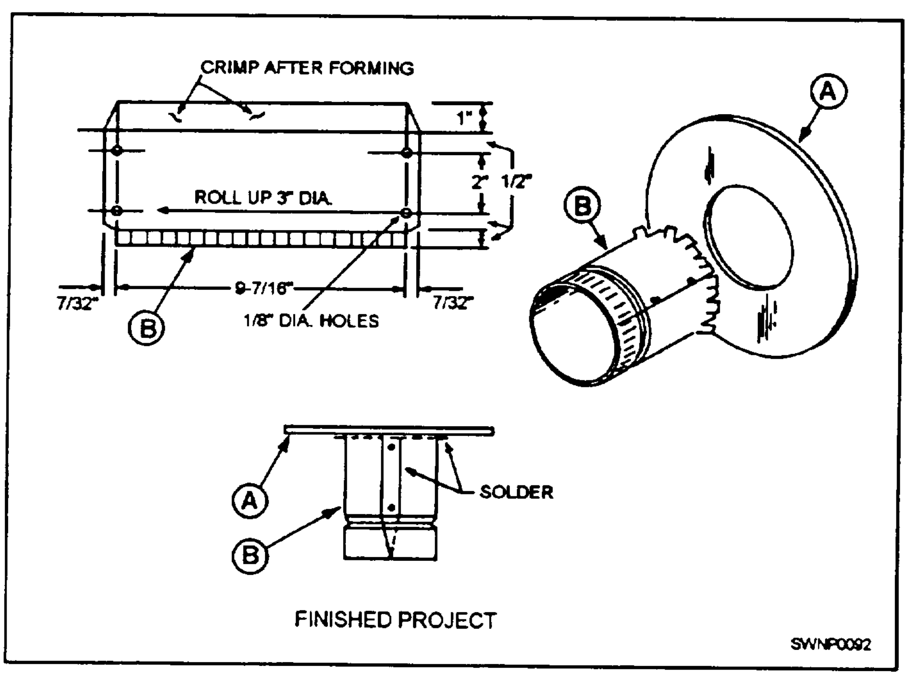

Figure 2-75.—Dovetail lock seam

for the job. If the notch is made too large, a hole will be left in the finished job. If the notch is too small or not the proper shape, the metal will overlap and bulge at the seam or edge. Do not concern yourself too much if your first notches do not come out as you expected—practice and experience will dictate size and shape.

A SQUARE NOTCH (fig. 2-76) is likely the first you will make. It is the kind you make in your layout of a box or drip pan and is used to eliminate surplus material This type of notch will result in butt comers. Take a look around the shop to see just how many different kinds of notches you can see in the sheet-metal shapes.

SLANT NOTCHES are cut at a 45-degree angle across the comer when a single hem is to meet at a 90-degree angle. Figure 2-77 shows the steps in forming a slant notch.

A V NOTCH is used for seaming ends of boxes. You will also use a full V notch when you have to construct a bracket with a toed-in flange or for similar construction. The full V is shown in figure 2-78.

When you are making an inside flange on an angle of less than 90 degrees, you will have to use a modification of the full V notch to get flush joints. The angle of the notch will depend upon the bend angle. A modified V notch is shown in figure 2-79.

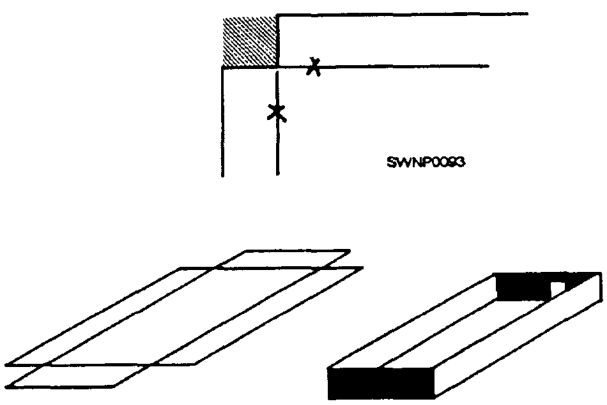

Figure 2-76.—Square notch.

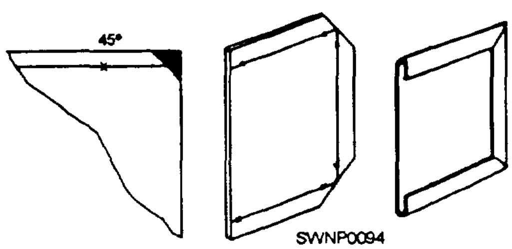

Figure 2-77.—Slant notch.

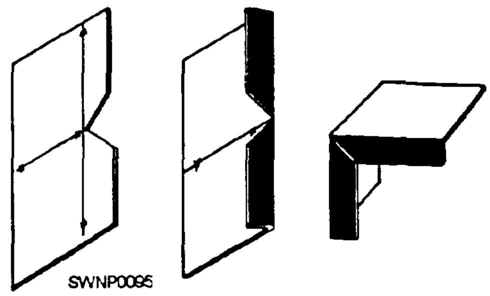

Figure 2-78.—V notch.

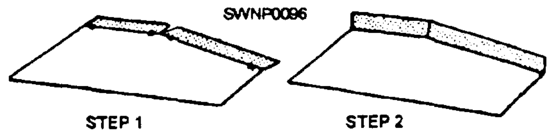

Figure 2-79.—Modified V notch.

A WIRE NOTCH is a notch used with a wire edge. Its depth from the edge of the pattern will be one wire diameter more than the depth of the allowance for the wire edge (2 1/2 d), or in other words, 3 1/2 times the diameter of the wire (3 1/2 d). Its width is equal to 1 1/2 times the width of the seam (1 1/2 w). That portion of the notch next to the wire edge will be straight. The shape of the notch on the seam will depend on the type of seam used, which, in figure 2-80, is 45 degrees for a grooved seam.

Most of your work will require more than one type of notch, as shown in figure 2-80, where a wire notch was used in the forming of a cylindrical shape joined by a grooved seam. In such a layout, you will have to notch for the wire edge and seam.

JOINING AND INSTALLING SHEET-METAL DUCT

After the sheet metal has been cut and formed, it has to be joined together. Most sheet-metal seams are locked or riveted but some will be joined by torch brazing or soldering. Lock seams are made primarily by the forming processes that have already been given.

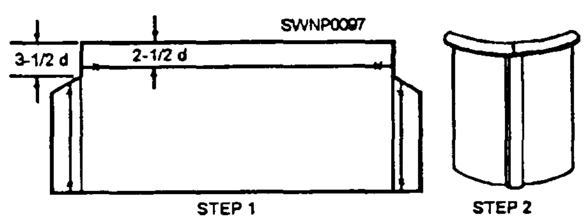

Figure 2-80.—Wire notch in a cylindrical layout.

Torch brazing and soldering are discussed in *Steelworker*, volume 1, chapter 6. This section deals only with joining sheet-metal seams by either metal screws or rivets.

METAL SCREWS

Different types of metal screws are available for sheet-metal work. The most common type in use is the MACHINE SCREW. Machine screws are normally made of brass or steel. They will have either a flathead or a roundhead and are identified by their number size, threads per inch, and length; for example, a 6 by 32 by 1 inch screw indicates a number 6 screw with 32 threads per inch and 1 inch in length.

SELF-TAPPING SHEET-METAL SCREWS are another common type of screw. Most screws of this type will be galvanized and are identified by their number size and length. These screws form a thread as they are driven (fig. 2-81), as the name implies.

THREAD-CUTTING SCREWS (fig. 2-82) are different from self-tapping screws in that they actually cut threads in the metal. They are hardened and are used to fasten nonferrous metals and join heavy gauge sheet metal.

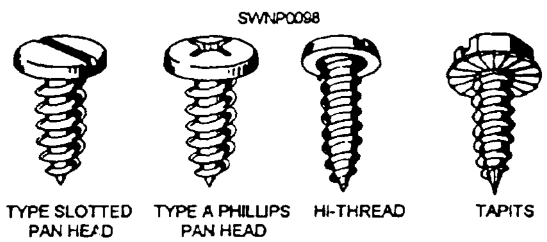

Figure 2-81.—Self-tapping sheet-metal screws

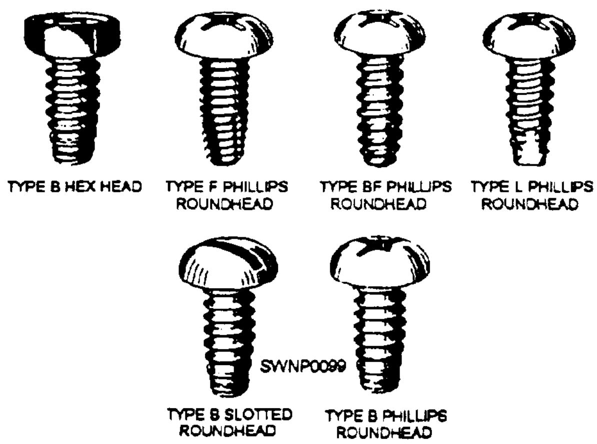

Figure 2-82.—Thread-cutttng screws.

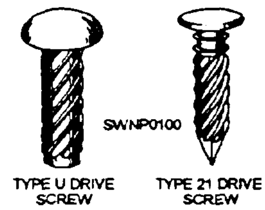

Figure 2-83.—Drive screws.

DRIVE SCREWS (fig. 2-83) are simply hammered into a drilled or punched hole of the proper size to make a permanent fastening.

RIVETS

Rivets are available in many different materials, sizes, and types. Rivets, made of steel, copper, brass, and aluminum, are widely used. Rivets should be the same material as the sheet metal that they join.

TINNERS' RIVETS of the kind shown in figure 2-84 are used in sheet-metal work more than any other type of rivet. Tinners' rivets vary in size from the 8-ounce rivet to the 16-pound rivet. This size designation signifies the weight of 1,000 rivets. If 1,000 rivets weigh 8 ounces, each rivet is called an 8-ounce rivet. As the weight per 1,000 rivets increases, the diameter and length of the rivets also increase. For example, the 8-ounce rivet has a diameter of 0.089 inch and a length of 5/32 inch, while the 12-pound rivet has a diameter of 0.259 inch and a length of 1/2 inch. For special jobs that require fastening several layers of metal together, special rivets with extra, long shanks are used. Table 2-1 is a guide for selecting rivets of the proper size for sheet-metal work.

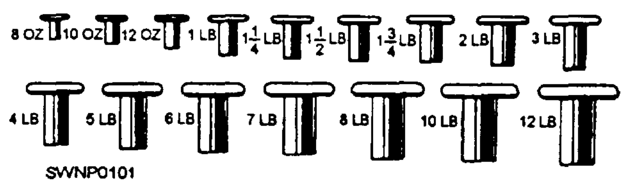

Figure 2-84.—Tinners' rivets.

Table 2-1.—Guide for Selecting Rivet Size for Sheet-Metal Work

Gauge of sheet metal	Rivet size (weight in pounds per 1,000 rivets)
26	1
24	2
22	2 1/2
20	3
18	3 1/2
16	4

When you are joining sheet metal that is greater than two thicknesses, remember that the shank of the rivet should extend 1 1/2 times the diameter of the rivet. This will give you adequate metal to form the head.

Rivet spacing is given on the blueprint or drawing you are working from. If the spacing is not given, space the rivets according to the service conditions the seam must withstand. For example, if the seam must be watertight, you will need more rivets per inch than is required for a seam that does not have to be watertight. No matter how far apart the rivets are, there must be a distance of 2 1/2 times the rivet diameter between the rivets and the edge of the sheet. This distance is measured from the center of the rivet holes to the edge of the sheet.

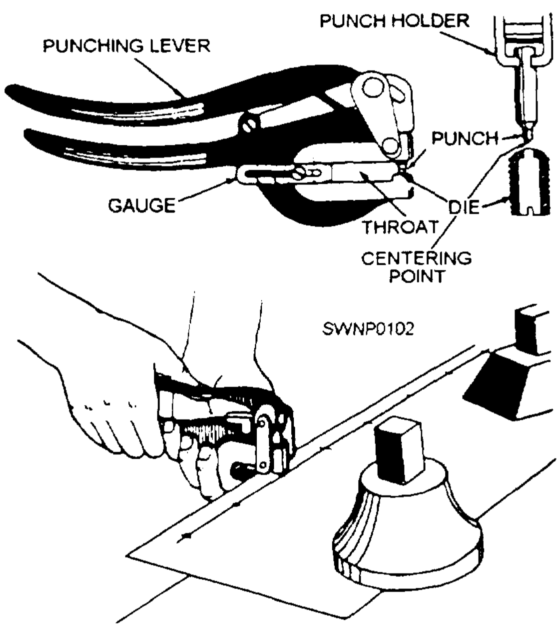

Figure 2-85.—Hand punch.

After you have determined the size and spacing of the rivets, mark the location of the centers of the rivet holes. Then make the holes by punching or by drilling. If the holes are located near the edge of the sheet, a hand punch, similar to the one shown in figure 2-85, can be used to punch the holes. If the holes are farther away from the edge, you can use a deep-threaded punch (either hand operated or power driven) or you can drill the holes. The hole must be slightly larger than the diameter of the rivet to provide a slight clearance.

Riveting involves three operations-drawing, upsetting, and heading (fig. 2-86). A rivet set and a riveting hammer are used to perform these operations. The method for riveting sheet metal follows:

1. Select a rivet set that has a hole slightly larger than the diameter of the rivet.

2. Insert the rivets in the holes and rest the sheets to be joined on a stake or on a solid bench top with the rivet heads against the stake or bench top.

3. Draw the sheets together by placing the deep hole of the rivet set over the rivet and striking the head of the set with a riveting hammer. Use a light hammer for small rivets, a heavier hammer for larger rivets.

4. When the sheets have been properly drawn together, remove the rivet set. Strike the end of the rivet LIGHTLY with the riveting hammer to upset the end of the rivet. Do not strike too hard a blow, as this would distort the metal around the rivet hole.

5. Place the heading die (dished part) of the rivet set over the upset end of the rivet and form the head. One or two hammer blows on the head of the rivet set will be enough to form the head on the rivet.

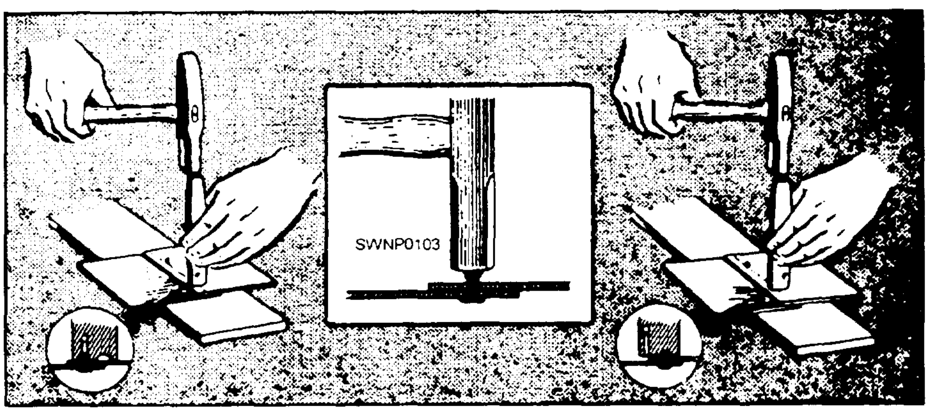

Figure 2-86.—Drawing, upsetting, and heading a rivet.

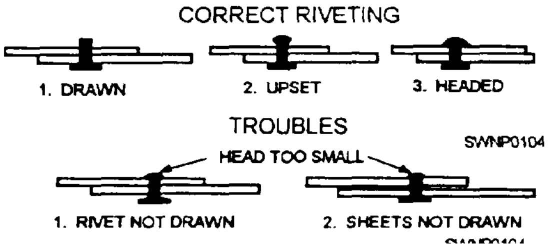

Figure 2-87.—Correct and incorrect riveting.

A correctly drawn, upset, and headed rivet is shown in the top part of figure 2-87. The lower part of this figure shows the results of incorrect riveting.

An addition to sheet-metal rivets are the pop rivets shown in figure 2-88. These pop rivets are high-strength, precision-made, hollow rivets assembled on a solid mandrel that forms an integral part of the rivet. They are especially useful for blind fastening-where there is limited or no access to the reverse side of the work.

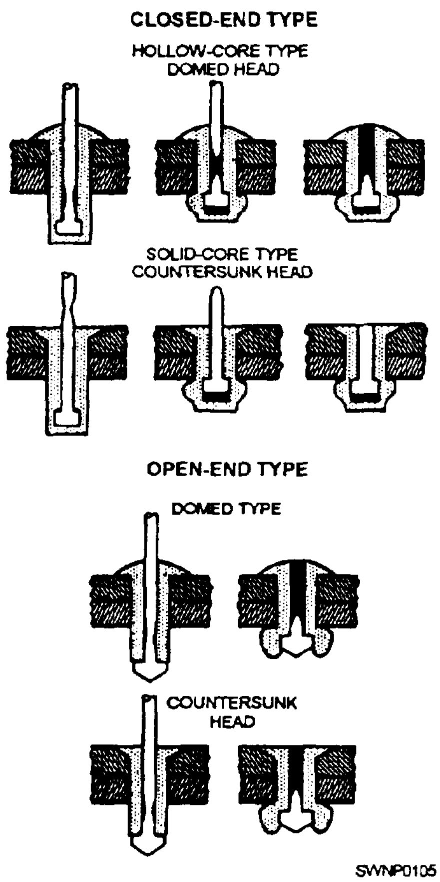

Figure 2-88.—Pop rivets.

Pop rivets provide simplicity and versatility. ‘hey are simple and easy to use in complicated installations. Expensive equipment or skilled operators are not required. Just drill a hole, insert, and set the pop rivet from the same side, and high riveting quality and strength are easily and quickly accomplished.

Two basic designs of pop rivets are used: closed end and open end. The closed-end type fills the need for blind rivets that seal as they are set. They are gastight and liquidtight, and like the open-end type, they are installed and set from the same side. As the rivet sets, a high degree of radial expansion is generated in the rivet body, providing effective hole-filing qualities.

The open-end type of pop rivet resembles a hollow rivet from the outside. Because the mandrel head stays in the rivet body, the mandrel stem seals to a certain degree, but it is not liquidtight.

Figure 2-89 shows two of the tools used for setting the pop rivets. These tools are lightweight and very easily used. For example, when using the small hand tool, you need only to insert the mandrel of the rivet in the nosepiece, squeeze the handle (usually three times), and the rivet is set. To operate the scissors-type tool, fully extend the lever linkage or gatelike mechanism and insert the rivet mandrel into the nosepiece of the tool. Insert the rivet into the piece being riveted. Apply firm pressure to the tool, ensuring that the nosepiece remains in close contact with the rivet head. Closing the lever linkage retracts the gripping mechanism, which withdraws the mandrel. The rivet is set when the mandrel head breaks.

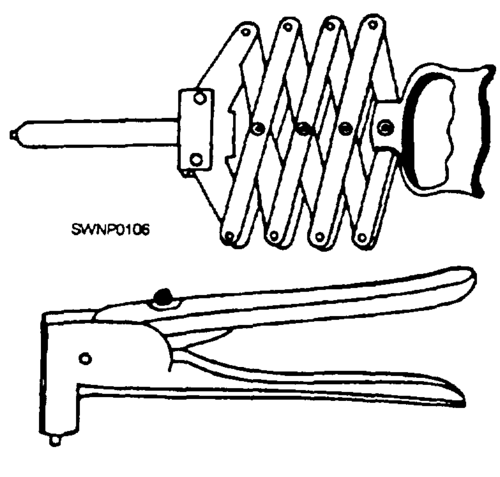

Figure 2-89.—Pop rivet toots.

Before inserting another rivet in the tool, be sure that the broken mandrel has been ejected from the tool. This can be done by fully extending the lever linkage and allowing the mandrel to fall clear.

The scissors or expandable type of tool is unique because it can reach hard-to-get-at areas and can set the rivets with ease. This tool is particular] y useful for installing ventilation ducting.

RIVETED SEAMS

Riveted seams are used for joining metals and have numerous applications.

Figure 2-90 shows the pattern of one of two pieces to be joined by lap and rivet. Note the cross section of the finished seam.

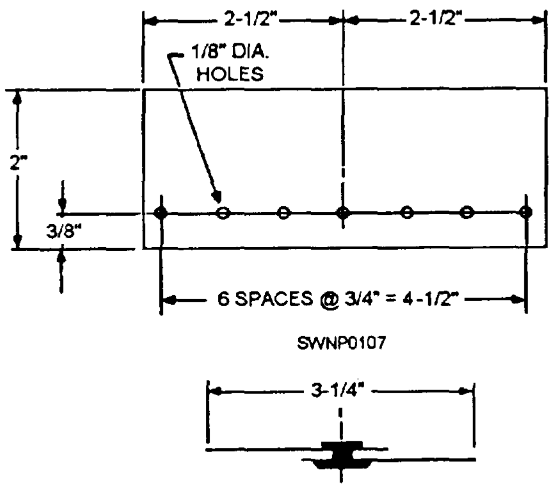

Figure 2-90.—Pattern for riveted lap seam.

Figure 2-91 shows the patterns for constructing a lapped and riveted comer seam. View A is the pattern for one piece and view B is the other. Note the cross section through the completed seam.

Frequent use is made of lapped and riveted seams in joining round pipe sections.

SHEET-METAL DUCT SYSTEMS

With the advent of high-tech equipment, such as computers and other specialized electronic equipment, air-conditioning systems are incorporated more than ever into many Naval Construction Force (NCF) construction projects. Many of the structures are designed for long-life usage instead of temporary buildings with a short time use. There are also some advanced base functional components (ABFC) which incorporate heating, ventilating, and air-conditioning systems (HVAC) within the facility design.

HVAC systems require close coordination between ratings. Air conditioning, air handling, and heating units are normally installed by an Utilitiesman, and the electrical connections are accomplished by a Construction Electrician. These items must be installed before the ductwork installation phase begins. The Steelworker must also coordinate with the Builder assigned to the project to ensure that all openings in walls and floors are sufficient to accommodate ducts, diffusers, and vents.

Sheet-metal HVAC systems require knowledgeable workers to fabricate and install the various ducts and

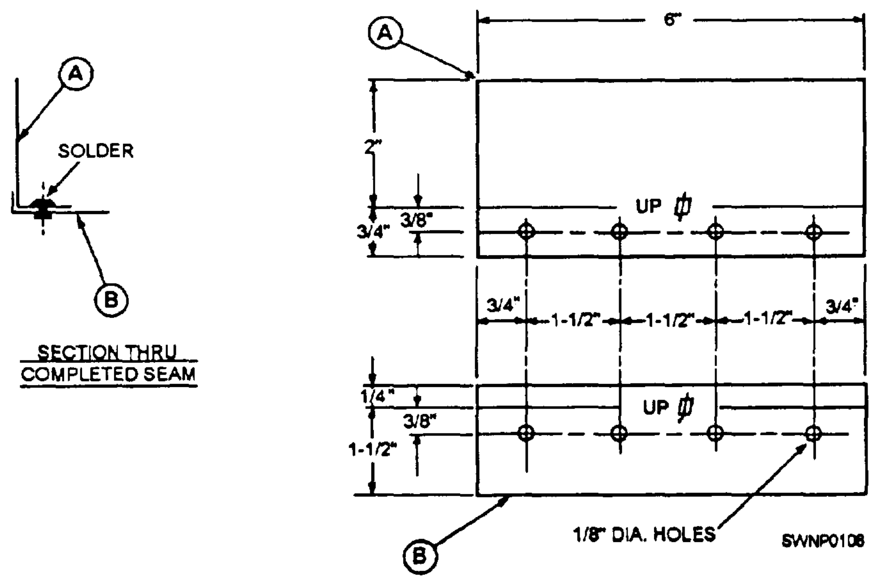

Figure 2-91.—Riveted seam for tapped and riveted corner seam.

fittings needed in a complete heating, ventilating, and air-conditioning system. The Steelworker must be very versatile because the most difficult part of sheet-metal work is the installation of a product that has been built in a shop and is installed on a site at a later time.

All of the variables and problems that occur during the installation process cannot be covered here; however, this section will cover some of the different hanging and connecting systems used by the sheet-metal worker. The type of connecting system used depends upon where the duct system is installed, its size, how many obstructions there are, and also, what type of structure the system is hanging from or connected to.

SHOP PROCEDURES

The small sheet metal shops in the NCF or in a Public Works Department are normally tasked with single fabrication jobs for an NCF project or small repair projects. These shops usually employ a small number of Steelworkers as part of a multi-shop environment. The senior Steelworker assigned to a shop is tasked with the plan development and estimating of materials. The layout Steelworker makes up most of the fittings in the shop and is responsible for stockpiling patterns and tracings on standard fittings used for sheet-metal duct systems.

NOTE: You should fabricate an entire job at the shop, rather than deliver an incomplete system to the jobsite.

SHOP DRAWINGS

A shop drawing is a plan view or an elevation view of a fitting, duct, or other object that is drawn either by the freehand sketch method or by using drafting instruments. It maybe useful to get assistance from an Engineering Aid for complex duct systems or fittings. One of the better methods is to draw a complete set of standard fittings and then add the required dimensions to fit the job.

The dimensions shown on the views of a shop drawing are finished dimensions. Once the finished dimensions have been determined, one-half inch must be added to each end to obtain the raw size of the pattern. This dimension produces a cut size dimension. The type of material, gauge number, and type of seam may be added to the shop drawing if desired. Usually these are specified on the drawings and on the pattern sheets.

DUCT MATERIAL

Metal sheets, wire, band iron, and angle iron are the most widely used materials in sheet-metal fabrication. The types of metal sheets are plain, flat sheets and ribbed sheets or corrugated sheets. The sheets are made of such materials as black iron, galvanized iron, tin plate, copper, aluminum, stainless steel, or Monel. Galvanized and black iron sheets are the most commonly used material in sheet-metal work.

The thickness of a sheet is designated by a series of numbers called gauges. Iron and steel sheets are designated by the U.S. standard gauge which is the accepted standard in the United States.

REINFORCEMENT AND SUPPORT

The recommended gauge thicknesses of sheet metal used in a standard ventilating and air-conditioning system with normal pressure and velocities are shown in table 2-2. Where special rigidity or stiffness is required, ducts should be constructed of metal two gauges heavier than those given in the table. All insulated ducts 18 inches or greater on any flat side should be cross broken, as shown in figure 2-92. Cross breaking maybe omitted if the duct is insulated with approved rigid type of insulation and sheet metal two gauges heavier is used.

The maximum length of any section of ductwork will not exceed 7 feet 10 inches; this measurement allows individual sections to be fabricated from an 8-foot sheet of metal with a 2-inch allowance for connection tabs. If lengths of 7 feet 10 inches are considered too long for a specific job, it is recommended that the duct system be constructed with sections of 3-foot 9-inch multiples.

Many duct systems run into unplanned obstructions, particularly in renovation work, such as electrical connections and wiring, structural members,

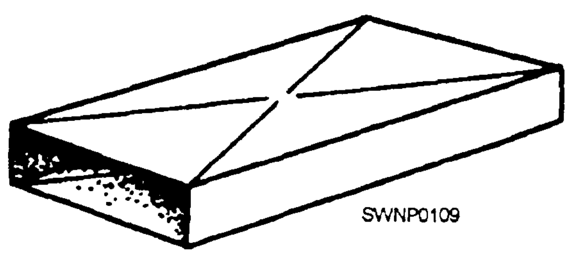

Figure 2-92.—Cross-broken flat surfaces

Table 2-2.—Recommended Gauges for Sheet-Metal Duct Construction

Aluminum B. & S. gauge	Steel U.S. std. gauge	Maximum side, inches	Type of transverse joint connections	Bracing
24	26	up to 12	S-drive, pocket or bar slips, on 7-ft. 10-in. centers	None.
		13 to 24	S-drive, pocket or bar slips, on 7-ft, 10-in. centers.	None.
22	24	25 to 30	S-drive, 1-in. pocket or 1-in. bar slips, on 7-ft. 10-in. centers.	1-× 1-× 1/8-in. angles 4 ft. from joint.
		31 to 40	Drive, 1-in. pocket or 1-in. bar slips, on 7-ft. 10-in. centers.	1-× 1-× 1/8-in. angles 4 ft. from joint.
20	22	41 to 60	1 1/2-in. angle connections, or 1 1/2-in. bar slips with 1 3/8-in. × 1/8-in. bar reinforcing on 7-ft. 10-in. centers.	1 1/2-× 1 1/2-× 1/8-in. angles 4 ft. from joint.
18	20	61 to 60	1 1/2-in. angle connections, or 1 1/2-in. bar slips 3-ft. 9-in. maximum centers with 1 3/8-× 1/8-in. bar reinforcing.	1 1/2-× 1 1/2-× 1/8-in. diagonal angles, or 1 1/2-× 1 1/2-× 1/8-in. angles 2 ft. from joint.
16	18	91 and up	2-in. angle connections or 1 1/2-in. bar slips 3-ft 9-in. maximum centers with 1 3/8- × 1/8-in. bar reinforcing.	1 1/2-× 1 1/2-× 1/8-in. diagonal angles, or 1 1/2-× 1 1/2-× 1/8-in. angles 2 ft. from joint.

and piping systems. These obstructions must be avoided by fabricating the duct system to go around the obstacles. Do NOT run obstructions through duct systems because it creates turbulence that reduces the efficiency of the system. When the obstruction is an electrical obstruction, you should ensure all power is off and safety checked. When running the duct through an obstruction is absolutely unavoidable, the turbulence can be reduced by enclosing the obstruction in a streamlined collar (fig. 2-93).

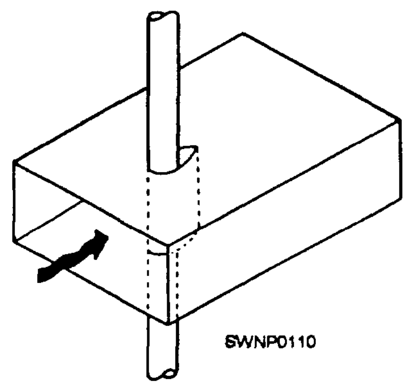

Figure 2-93.—Easement around an obstruction in ducts.

FLEXIBLE CONNECTIONS

Most duct systems are connected to either a heating or a cooling system. These systems are general] y electric motor driven to move air through the duct system. Therefore, all inlet and outlet duct connections to all fans or other equipment that may create vibration should be made with heavy canvas, as shown in figure 2-94.

The most common method of making connections between duct sections and fittings is the method of

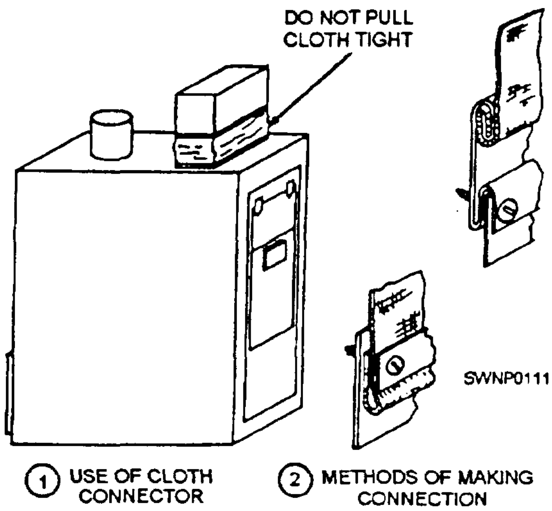

Figure 2-94.—Flexible duct connection.

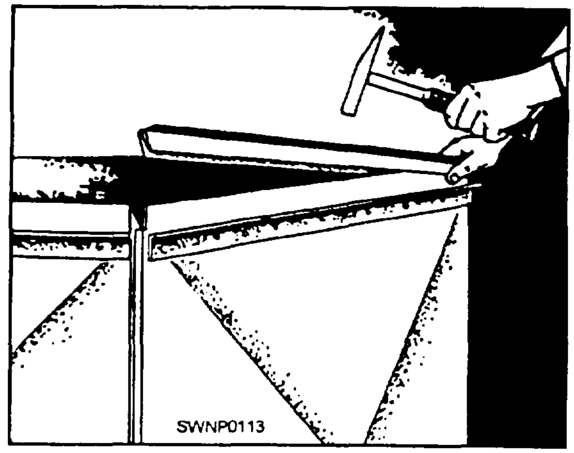

Figure 2-96.—Placing S slips for S-and-drive connection.

combining two S slips and two drive slips (fig. 2-95). S slips are first placed on two opposite edges of one of the sections or fittings to be joined. These S slips are applied to the widest dimension of the duct (fig. 2-96). The second section or fitting is then inserted into the slips, and the two sections are held together by inserting drive slips along the opposite sides [fig. 2-97). After the drive slips are driven home, they are locked in place by bending the ends of the drive slip over the comer of the S slips to close the comer and leek the drive slips in place (fig. 2-98), completing the joint shown in figure 2-99.

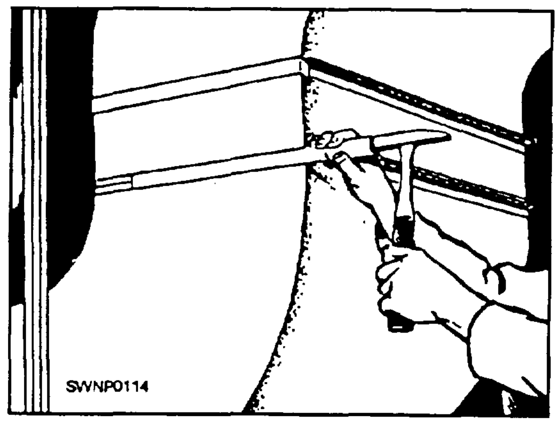

Figure 2-97.—Inserting drive slips.

HANGING DUCT FROM PURLINS OR BEAMS

Most of the ductwork Steelworkers install, modify, or repair are in pre-engineered buildings or repairs to more permanent type of ducting in buildings, such as barracks and base housing.

The most common installation method is hanging the duct from purlins or beams in the hidden area of a roof or below a ceiling. Figure 2-100 shows one such system when the duct is running parallel to the structural member. These systems require that angle be installed between the beams so that the hanger straps can be installed on both sides of the duct. Normally, 2-inch by 2-inch by 1/8-inch angle is

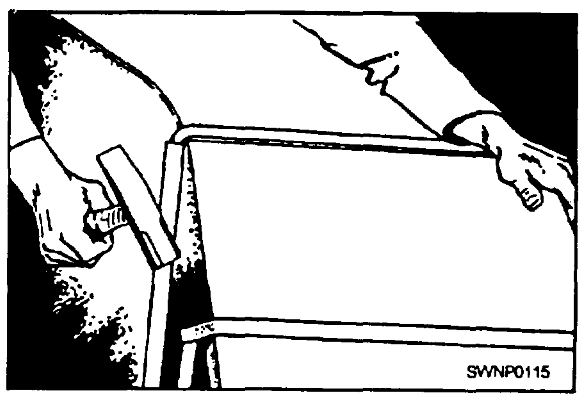

Figure 2-98.—Bending drive slips to complete the Joint.

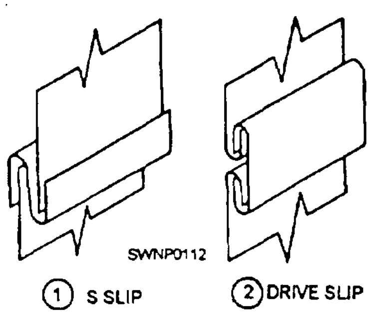

Figure 2-95.—Methods of connecting ducts,

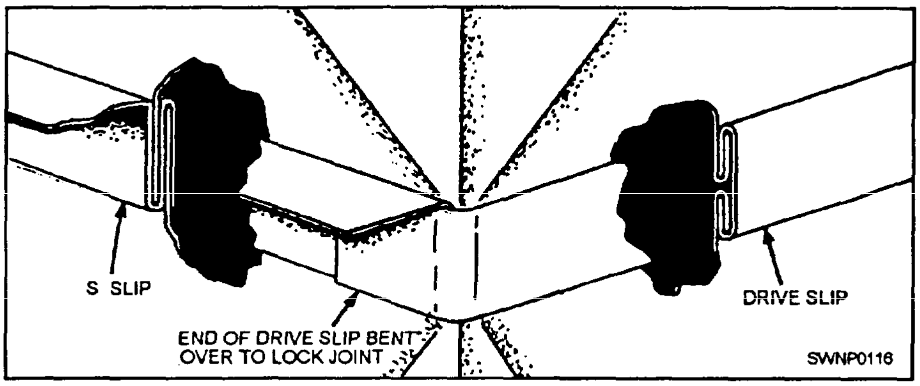

Figure 2-99.—Completed S-and-drive connection.

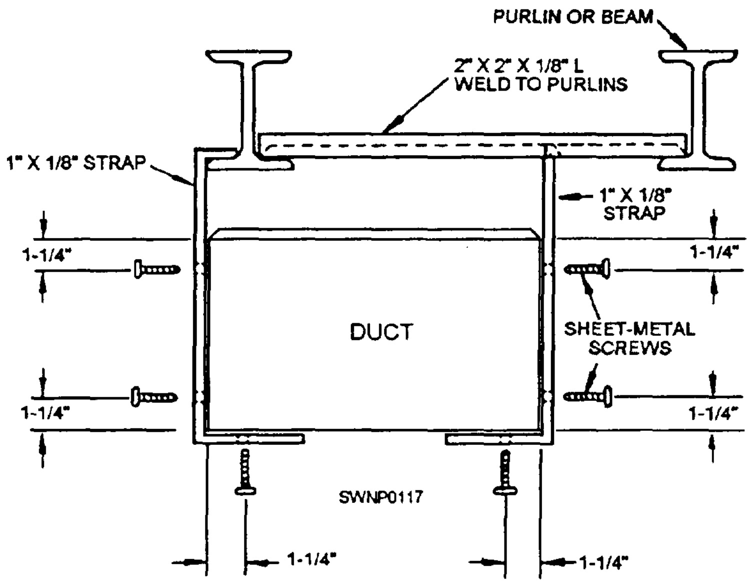

Figure 2-100.—Duct running parallel to purlins or beams.

sufficient. However, if the duct is of a very large size, a larger angle may be required.

The straps that are used as hangers may be fabricated from 1/8-inch plate. In a normal installation, a 1 inch by I/S-inch strap will suffice. All straps must be connected to the ductwork with sheet-metal screws. On all government work, it is required that the screws be placed 1 1/4 inches from all edges, as illustrated in the figure which shows that the duct system hanging from angle rails and that all angles be either bolted or tack-welded to purlins or beams.

Strap hangers may be hung directly on purlins or beams when the duct is running transverse] y or across the purlins or beams, as shown in figure 2-101. However, the strap hangers must be twisted to turn 90

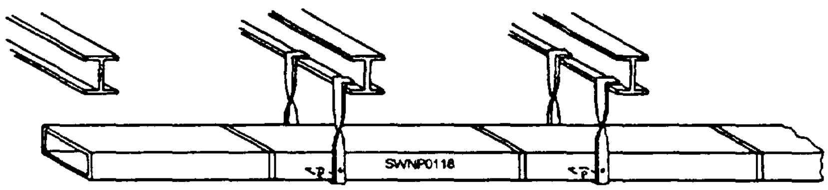

Figure 2-101.—Strap hangers from purlins.

degrees onto the flange of the beam or purlin. Again, the standard 7 feet 10 inches maximum span required between hangers applies. Also, the hanger screws standard will apply. The hanger span may be shortened to fit the job requirements.

For heavier or larger systems, an installation similar to that shown in figure 2-102 maybe required. This system is hung entirely on angle rails and the straps are fabricated into one-piece units. This system is by far the neatest looking and is normally used when the duct system is exposed.

Installing a duct system under a built-up steel roof (fig. 2-103) is accomplished by hanging the duct system with all-thread bolts and 2-inch by 2-inch by 1/8-inch angles. The all-thread bolt protrudes through the steel decking and is bolted from the top with a large washer and bolt, which extends down alongside the duct into the 2-inch by 2-inch angles which is also bolted from under the angle. This system allows for adjustment of height. Also notice that the all-the ad bolt extends into the top flat of the apex of the steel roof decking. This is required because connecting the all-thread bolt to the bottom valley of the steel deck will reduce the structural strength of the decking and may also cause water leaks.

FIBER-GLASS DUCT SYSTEMS

Throughout the Naval Construction Force (NCF) fiber-glass duct is becoming common on jobsites. It has the advantage of added insulating value, ease of fabrication and handling, as well as installation, and making it useful where traffic and handling/abuse are restricted.

DUCT CHARACTERISTICS

Fiber-glass ducts are manufactured of molded fiber-glass sheets covered with a thin film coating of aluminum, although thin vinyl or plastic coatings are sometimes used. In the NCF, we are primarily concerned with aluminum coated duct. Because it is fabricated of glass fibers, it is inherently insulated; therefore, it is used where insulation is a requirement.

Fiber-glass ducts can be molded into various shapes for special applications. The desired shapes can be ordered from the manufacturer's stock In the NCF, for all but special purposes, the duct is supplied in the flat form of a board that has V grooves cut into the inner surfaces to allow folding to fabricate rectangular sections (fig. 2-104, view A). The ends of the board is molded so when a rectangular/square duct is formed two sections of the same size will fit together in a shiplap joint (fig. 2-104, view C). This joint ensures a tight connection coupled with a positive alignment.

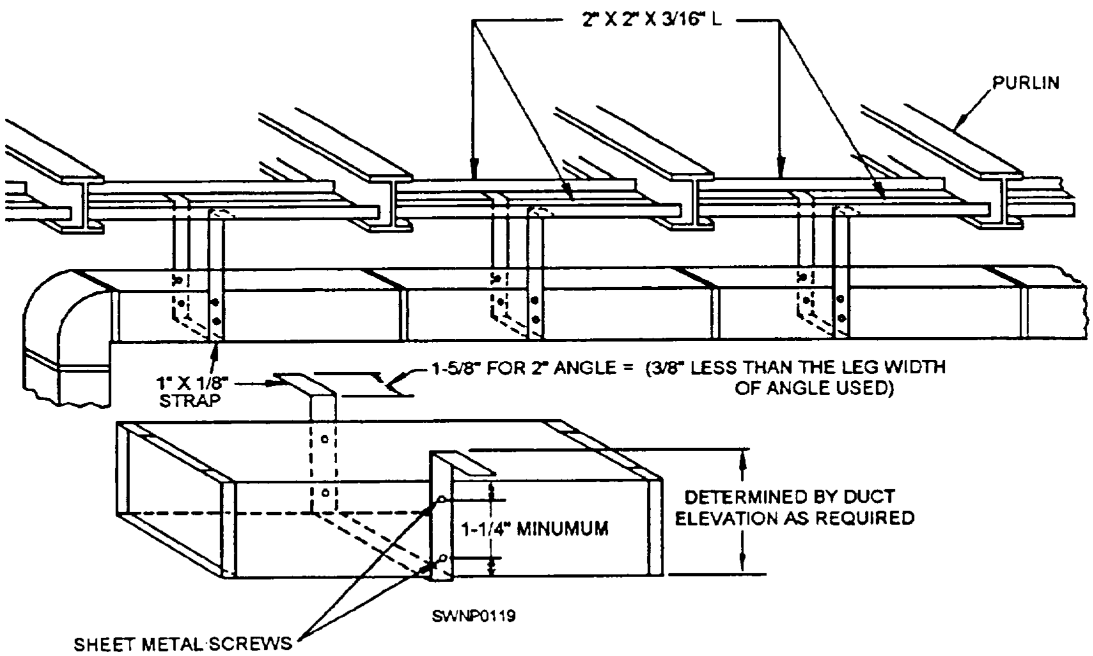

Figure 2-102.—Duct system with strap hangers from angle rails transverse to purlti

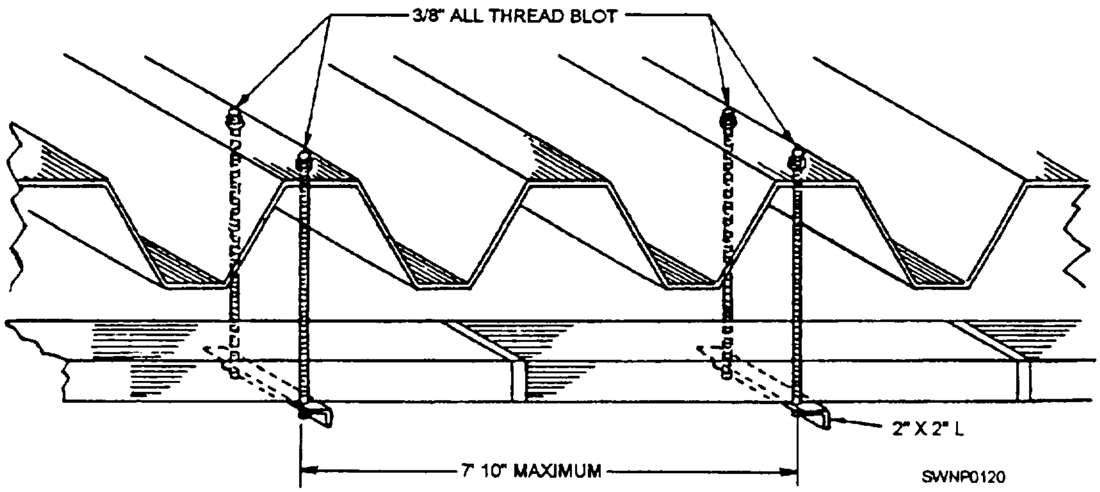

Figure 2-103.—Duct installed to a built-up steel roof.

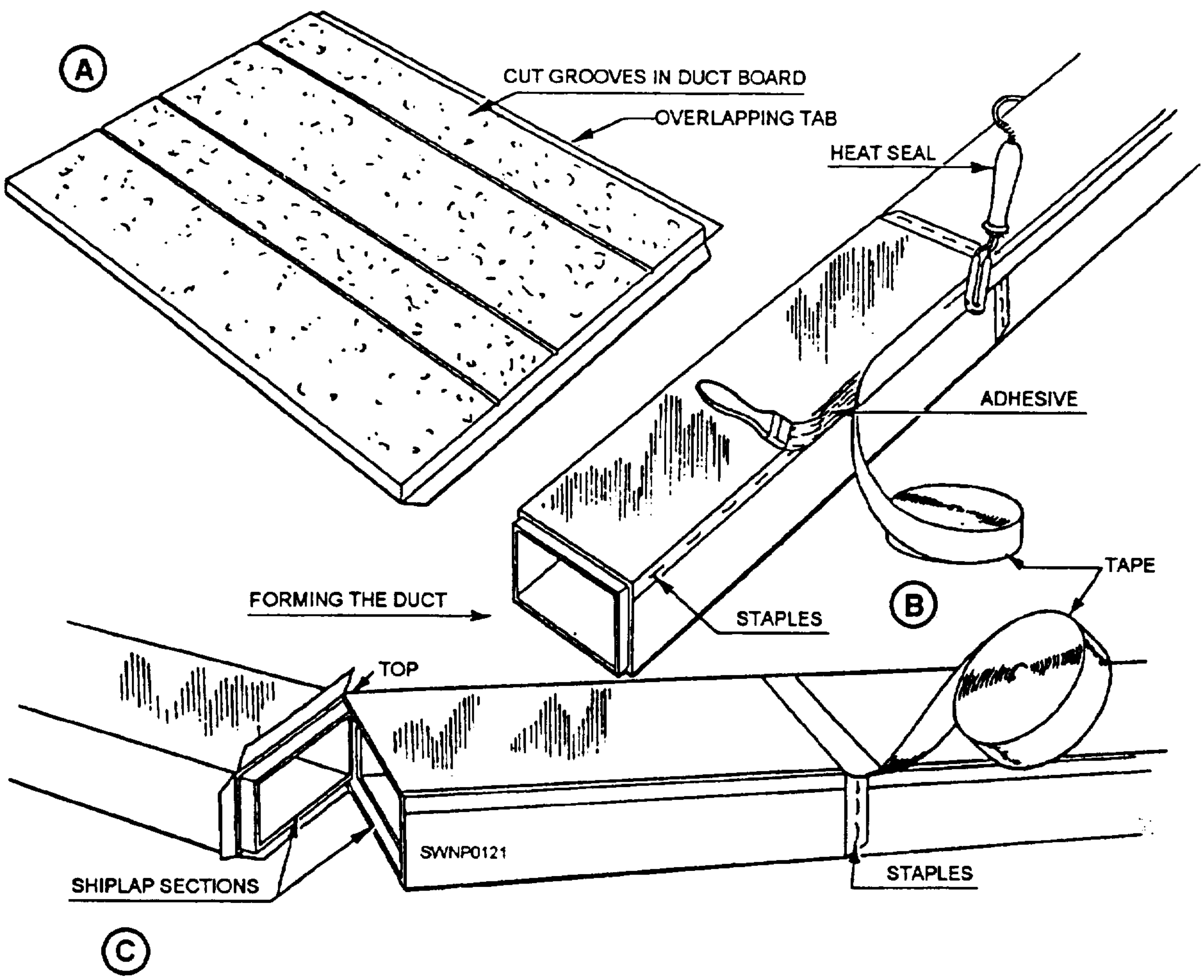

Figure 2-104.—Fabricating rectangular/square fiber-glass duct from duct board.

Of extreme importance is the selection of the proper board size to fabricate the duct before cutting and grooving. In all applications the inside diameter of the duct is the determining factor of the board size. Use table 2-3 to determine board size.

Table 2-3.—Duct Board Length Selection Chart

	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
6	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76
7	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78
8	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80
9	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82
10	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
11	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86
12	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
13	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90
14	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92
15	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94
16	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96
17	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98
18	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
19	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102
20	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104
21	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106
22	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108
23	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
24	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112
25	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114
26	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116
27	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118
28	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120
29	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	
30	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120		
31	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120			
32	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120				
33	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120					
34	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120						
35	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120							
36	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120								
37	94	96	98	100	102	104	106	108	110	112	114	116	118	120									
38	96	98	100	102	104	106	108	110	112	114	116	118	120										
39	98	100	102	104	106	108	110	112	114	116	118	120											
40	100	102	104	106	108	110	112	114	116	118	120												
41	102	104	106	108	110	112	114	116	118	120													
42	104	106	108	110	112	114	116	118	120														
43	106	108	110	112	114	116	118	120															
44	108	110	112	114	116	118	120																
45	110	112	114	116	118	120																	
46	112	114	116	118	120																		
47	114	116	118	120																			
48	116	118	120																				
49	118	120																					
50	120																						

*For 1 1/2-inch board—ADD 4 INCHES to these dimensions.

*For 2-inch board—ADD 8 INCHES to these dimensions.

NOTE: Within a heating system, the use of fiber-class duct is restricted by the adhesive used to affix the protective outer coating to the fiber glass. Check the specifications and ensure that it will not fail when exposed to heat over 250 degrees.

FABRICATION

To fabricate a rectangular/square duct, you must first measure the duct board accurately. Next, the grooves must be cut. Ensure they are at the proper locations and cut straight because this allows the board to be folded to create the desired rectangular/square shape. When cutting the board, you will need to leave an overlapping tab that is pulled tight and stapled (fig. 2-104, view A). Tape is then applied and the joint is heat-sealed (fig. 2-104, view B). Joints between sections are fabricated by pulling the shiplap end sections together and finished by stapling, taping, and heat sealing the joint (fig. 2-104, view C).

INSTALLATION

The very nature of fiber-glass duct requires that it be supported with 1-inch by 1/16-inch galvanized steel strap hangers. These must be supplied or fabricated to fit the duct precisely whether the duct be rectangular/square or round. Rectangular/square ducts up to 24 inches (span) can be supported on 8-foot centers. Ducts larger than 24 inches must be supported on 4-foot centers. For round ducts the supports must not be less than 6-foot centers.

SAFETY

Some of the safety precautions applicable to sheet-metal tools and equipment have been mentioned throughout this chapter. Here are a few additional precautions that should be carefully observed when you are working with sheet metal.

1. Sheet metal can cause serious cuts. Handle it with care. Wear steel reinforced gloves whenever feasible.

2. Treat every cut immediately, no matter how minor.

3. Remove all burrs from the metal sheet before attempting to work on it further.

4. Use a brush to clean the work area. NEVER brush metal with your hands.

5. Use tools that are sharp.

6. Keep your hands clear of the blade on all squaring shears.

7. A serious and painful foot injury will result if your foot is under the foot pedal of the squaring shears when a cut is made.

8. Do not run your hands over the surface of sheet metal that has just been cut or drilled. Painful cuts can be received from the burrs.

9. Get help when large pieces of sheet metal are being cut. Keep your helper well clear of the shears when you are making the cut.

10. Keep your hands and fingers clear of the rotating parts on forming machines.

11. Place scrap pieces of sheet metal in the scrap box.

12. Always remember to keep a clean shop. GOOD HOUSEKEEPING is the key to a safe shop.

13. Do not use tools that are not in first-class condition-hammer heads loose on the handle, chisels with mushroomed heads, power tools with guards removed, and so forth.

14. Wear goggles when in the shop.