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Essentials of Sheet Metal Work and Pattern Drafting

An Elementary and Advanced Course for Vocational and Trade School Students and Apprentices; also for Sheet Metal Workers, Contractors, and Instructors

By

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PREFACE

This book is written in answer to numerous requests for information regarding courses in sheet metal, suitable for grade and high schools, coming from school people who are introducing sheet metal work into the regular school curriculum. Realizing the need for a correlated course in practical sheet metal work and pattern drafting in text form, it is offered, therefore, to industrial teachers, students, apprentices, sheet metal workers and others interested in this subject.

The problems presented follow the lines of the best shop methods, derived from years of experience in teaching the subject and as a practical sheet metal worker. The course is outlined and the problems are presented in such sequence that the processes and machine operations are reviewed with each new problem.

It is not expected that the problems as given will be strictly copied, but rather that they will make clear the methods and processes that may be applied in the construction of similar problems. The proper sequence, so necessary for successful instruction in sheet metal pattern drafting, is an important feature of this course. Many of the problems are only partly solved, which prevents the student from copying from the text and compels him to develop his powers to think as well as to draw.

It is desired that the work shall be regarded as a collection of data presenting the essentials of sheet metal working, rather than an attempt to produce a series of models.

Pittsburgh, Pennsylvania. JAMES S. DAUGHERTY.

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ESSENTIALS OF SHEET METAL WORK AND PATTERN DRAFTING

CHAPTER I

TRANSFERRING PATTERNS TO METAL

When the student or workman is required to make articles simple in form, from sheet metal, the pattern can be made directly on the metal from given measurements. If he is required to make an article round in form with flaring sides, or an article having an irregular shape, it is highly important to make a full-sized drawing and to develop the patterns. This necessitates operations with the drafting board and drawing instruments, which will be taken up later in this course. After the pattern is developed on detail paper, it may be transferred to the sheet metal and the work of construction begun.

Methods of Transfer.—There are several methods of transfer in use, depending on the nature of the material and the shape of the pattern. For the more expensive materials, such as copper, brass, and German silver, the patterns and designs are transferred to the metal by means of carbon paper in the following manner:

The carbon paper is laid upon the face of the material with the face or glossy surface touching the metal; the pattern is carefully placed over the carbon paper and held in position by small weights; then with a hard pencil, stylus, or pointed tool firmly trace over the lines of the drawing. This will give a print of the pattern on the

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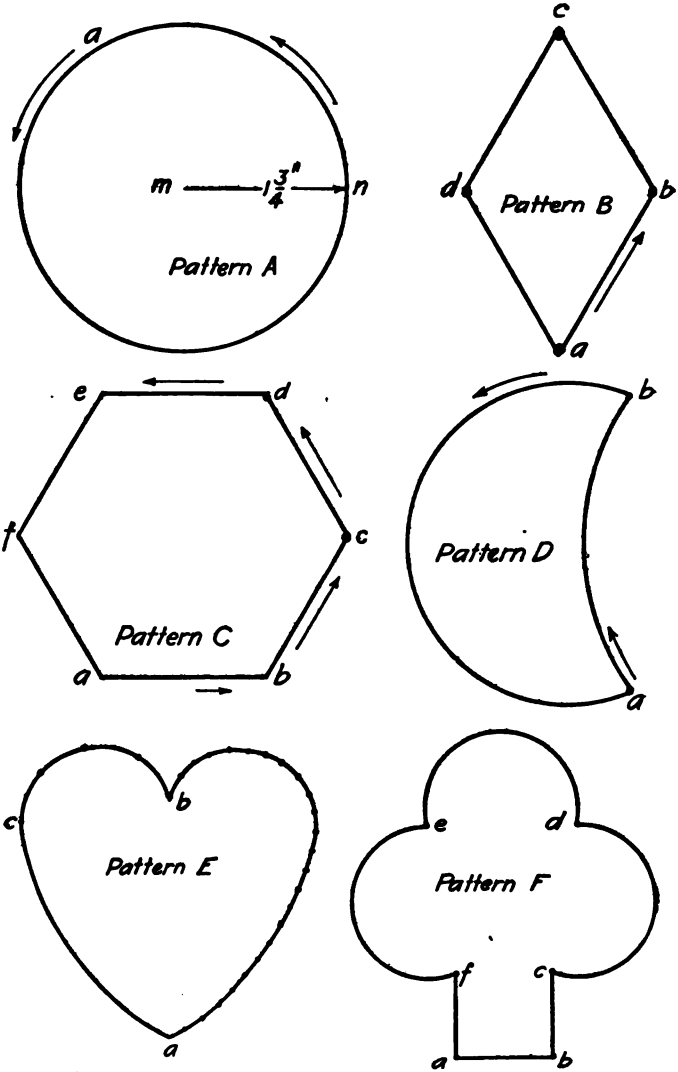

Figure 1.—Simple Patterns, or Templates. Arrows Show Proper Direction to Cut Metals with the Shears.

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bright metal. After obtaining a good impression, the carbon lines may be fixed on the metal by tracing over them with a steel scratch awl.

Another method of transfer is used for the cheaper materials, such as tin plate, zinc, black iron, and galvanized iron. The process is as follows: Place the drawing paper directly on the metal, then go over the outline of the pattern with a sharp tapering prick punch, tapping it lightly with a small hammer, making slight indentations on the metal at the principal points of the drawing. This method will be used throughout this course, and is in general use in the best commercial shops.

The prick punch used in this work should be about four inches long by $\frac{5}{16}$ inch in diameter, the end being forged tapering to a sharp point, as shown in Figure 2 (*J*). A mistake often made by the student is to strike the punch too heavily with the hammer, driving the point through the metal. This is bad practice and should be avoided.

Simple Patterns.—The first work of the student will be to draw to full size on paper, the set of simple patterns show one-half size in Figures 1 and 2, then to transfer them to metal, using IC bright tin, or light galvanized iron not heavier than No. 28 gauge. These patterns, or templates, are transferred to the metal in the following manner: To transfer pattern *A*, set the dividers 1¾″ equal to the radius *mn*, take a small piece of scrap metal and describe a circle. A mistake is often made by the beginner by pressing too heavily upon the wing divider, causing a deep depression in the center of the circle.

Patterns *B*, *C*, and similar forms, are transferred by pricking through the paper patterns to the metal. Place the pattern on the metal in a position to have as little waste of material as possible, placing a weight on the paper to keep it from moving; light prick marks are made on the metal at corners of the pattern as shown by

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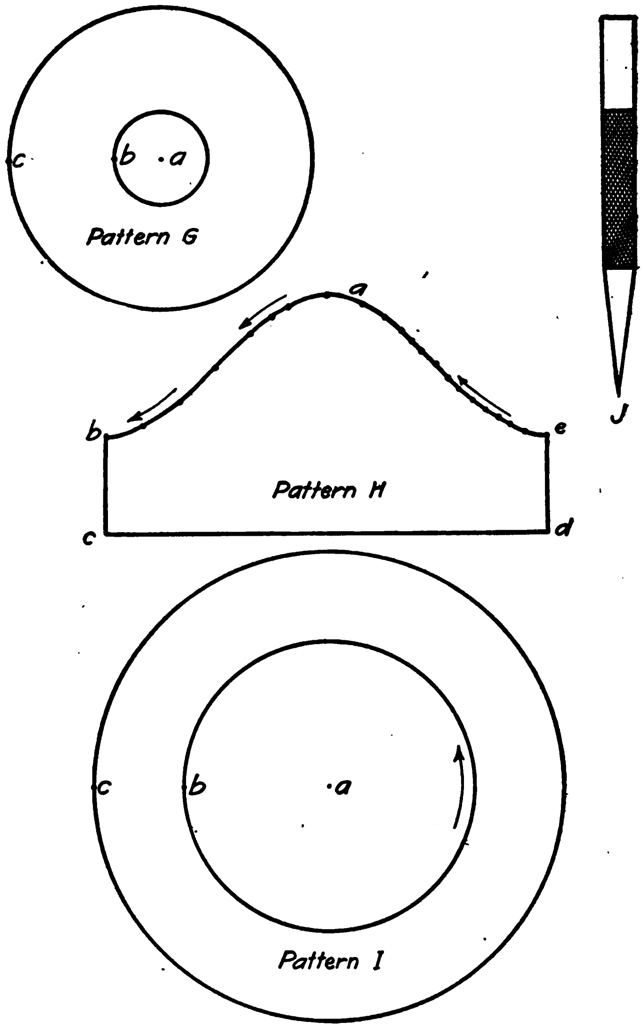

Figure 2.—Simple Patterns, Continued. *J*, a Prick Punch.

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heavy dots; remove the paper, and with a straightedge and scratch awl, complete the pattern by describing lines connecting the prick marks on the metal.

Patterns *D, E,* and *F,* are transferred to metal by pricking lightly the curved outline of the patterns. In pricking curved lines the prick marks should not be placed too far apart, but should be placed as shown from *a* to *b* in pattern *E.* After pricking the outline of patterns, a scratch awl, or lead pencil, is used to draw the curved line through the points on the metal. If the prick marks were placed too far apart as shown from *c* to *b,* pattern *E,* and *a* to *b,* pattern *H,* it would be impossible to draw the proper curve through the points, and the result would be a worthless pattern.

When transferring patterns *G* and *I,* it is not necessary to prick around the circles. Prick the points *a, b,* and *c,* upon the metal, then set the dividers with the radius *ab,* and *ac,* and describe the circles on the metal.

Use of Patterns.—If two or more pieces from a pattern are desired, do not prick through the paper pattern to obtain each piece. When one pattern is cut from metal, it should be used as a pattern whether two or a dozen pieces are required. Place the metal pattern upon the material, using a scratch awl, and scribe a line around the pattern. If the pattern is large, a weight should be placed upon it to keep it from moving, but if the pattern is small the weight is not necessary, as the pattern can be held in position with the fingers of the left hand while using the scratch awl with the right.

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CHAPTER II

CUTTING PATTERNS AND TEMPLATES

Hand Shears.—Sheet metal patterns are cut from metal by means of shears or snips of various shapes and sizes. The shears in general use for light work is known as the straight hand shears, or snip, having a left-hand cut, the length of the cut commonly being 3½ inches, an illustration of which is shown in Figure 3. This shears, when taken in the right hand, has the lower blade

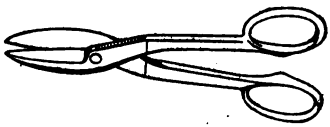

Figure 3.—1819 Original Straight Snip.

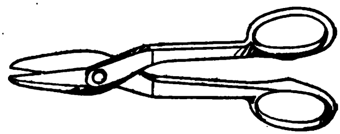

Figure 4.—Lyon Snip.

on the left side of the shears, and cuts at the left side of the upper jaw. The position of the jaws enables the sheet metal worker to follow the cutting line accurately, as it is always in full view.

Another straight shears, known as Lyon pattern snip, shown in Figure 4, is well adapted for regular work. The jaws are pointed and rounded, permitting the metal to pass freely when cutting curves, scrolls, and circles.

Circular snips, shown in Figure 5, are well adapted for cutting small circles and openings of various shapes in sheet metal. The popular size has a length of cut of 3 inches.

A bench shears, shown in Figure 6, is used for cutting heavy material. This tool is much larger than the

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ordinary hand shears. When in use it is fastened in the bench by inserting the prong in the bench plate, Figure 7, or a hole of the proper size cut in the bench for this purpose. This shears has a right-hand cut, with the lower blade on the right side of the shears. Note the difference

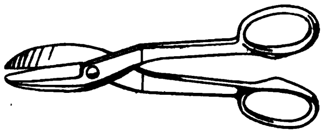

Figure 5.—1819 Original Circular Snip.

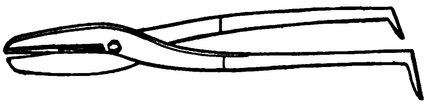

Figure 6.—Bench Shears.

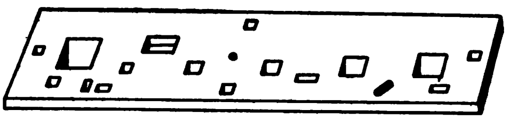

Figure 7.—Bench Plate for Holding Stakes.

in the position of the upper blades in the right hand shears in Figure 3, and the right hand bench shears in Figure 6.

The double cutting shears, shown in Figure 8, is adapted to cutting off round and square pipes, bottoms of pails, cans, etc. A hole is punched in the article to be cut, and the point of the lower blade inserted, after which the cutting is done in the regular manner, leaving the edges clean and smooth.

Squaring Shears.—Turning to cutting machinery, Figure 9 shows a modern squaring shears which is recommended for this course in cutting strips, squaring tin.

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and making long straight cuts across sheets of metal when shearing material for the construction of pipes and articles cylindrical in form.

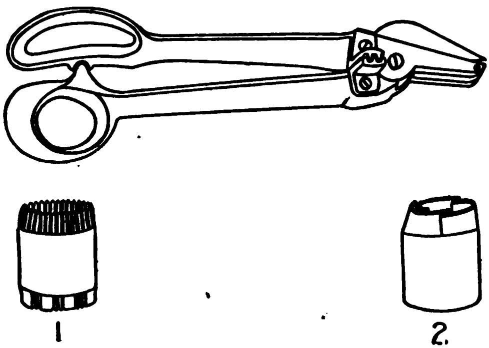

Figure 8.—Double Cutting Shears with Pipe Crimper. 1, Crimped with Attachment Fitted to Shears; 2, Old Method.

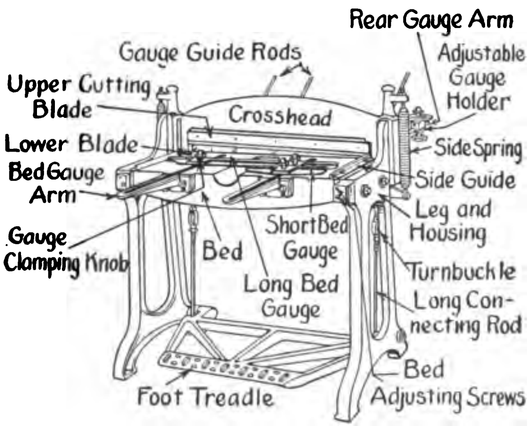

Figure 9.—Foot Power Squaring Shears.

If the shears do not respond in cutting material of heavier gauges within the rated capacities claimed by the manufacturer, the blades should be set farther apart. The lower blade must be set back from the upper, though not far enough to burr the edge of the material. This adjustment can be made by releasing slightly the bed bolts that hold the bed of the shears to the legs, and by loosening the two front bed screws. The bed can then be shifted on its seat towards or away from the upper cutting blade until the proper position is secured.

The blades can be easily removed for grinding, and

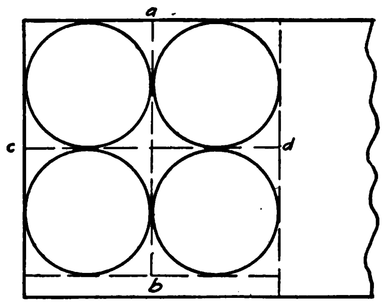

Figure 10.—How to Cut Circles to Avoid Waste of Metal.

when dull they should be returned to the factory for grinding. After being ground they are fastened securely to their frames and adjusted so that they will cut paper the entire length.

Cutting Circles and Curves.—When cutting circles from metal, as shown in Figure 1, pattern *A,* take the straight shears, Figure 3, in the right hand, start the cut at *n* on the scribed line, and make a continuous cut around the circle in the direction of the arrow shown in *na:* When several circles are to be cut from a large piece of metal, care should be taken to avoid waste of material by scribing the circles tangent to each other upon the metal, as shown in Fig. 10.

After the circles have been marked on the metal in this

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manner, cut the metal into squares by following the dotted lines *a* and *b*, after which the circles are cut in the usual manner; care being exercised in having each circle accurate and true.

When cutting curves, the cut should be continuous. Short cuts should never be made; stopping, and starting again at different points on the line, will result in an uneven pattern with rough edges containing slivers and projections that will cut the hands while working with the metal. When cutting patterns *B* and *C*, Figure 1, and similar forms, start to cut at the corner of the pattern, cutting in the direction of arrows *ab*, *bc*.

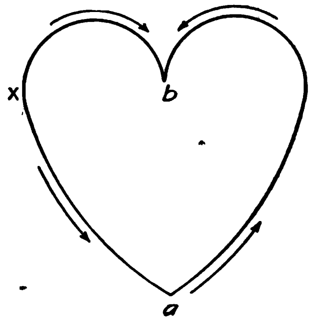

Figure 11.—Direction of Cut Shown by Arrows.

When cutting concave and convex curves, as shown in the outline of pattern *D*, Figure 1, use the straight shears, starting at *a*, and cut in the direction of arrows as shown in the drawing.

Pattern *E* is shown in Figure 11. Starting at *a*, make a continuous cut from *a* to *b*, then placing the shears at point *x* on the pattern, cut from *x* to *a*. Complete the pattern by cutting in the opposite direction from *x* to *b*.

When cutting pattern *F*, as shown in Figure 12, the cutting should begin at *a*, then to *b*, then to *c*, then start-

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ing at x the leaves should be cut in the direction of the arrows. A continuous cut could be made from x to x, but in turning the shears at points d and e, the metal is likely to be torn and the pattern ruined. The circular shears, as shown in Figure 5, can be used to advantage in cutting the small curves in patterns *E* and *F*.

The small circle in the center of pattern *G*, Figure 2, is cut out by using a hollow punch, as shown in Figure 13. The metal is placed upon a lead or wooden block. A

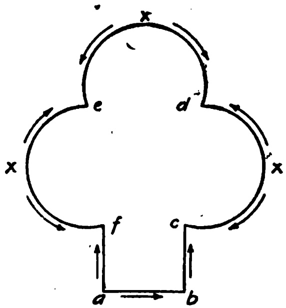

Figure 12.—Best Method of Cutting Indicated by Arrows.

Figure 13.—Hollow Punch.

punch of the required size is placed upon the circle and struck with a heavy mallet or hammer. If the piece of metal remains in the punch, it can be removed by striking the punch lightly with the hammer. Hollow punches are made in various sizes.

When an opening is to be cut in a piece of light metal as at *a* in pattern *I*, Figure 2, place the metal upon a block of lead; then by using a hollow punch or small thin chisel, cut a hole in the metal large enough to insert the point of the lower blade of the circular shears in the opening; then cut along the line in the direction of the arrow. The outer circle is cut in the usual manner, which completes the pattern.

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Cutting Elbow Patterns.—When cutting elbow patterns or similar forms, as shown in *H*, Figure 2, the straight cuts *b* to *c*, *c* to *d*, *d* to *e*, are made with the straight snips, or upon the square shears. The upper curve of the pattern is cut by using the straight shears, starting at *e* and making one continuous cut ending at *b*.

In using the hand shears, a mistake is often made by

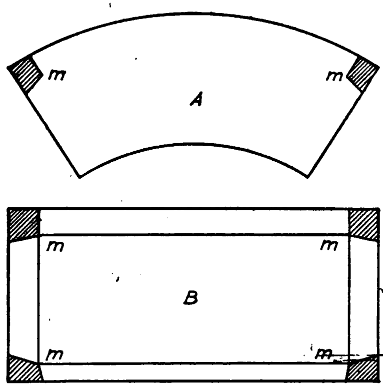

Figure 14.—Notched Patterns, the Shaded Portions Being the Notches.

the student in cutting beyond the stopping point shown on the pattern. This can be avoided by always completing the cut with the *point* of the shears. When cutting from *a* to *b*, Figure 11, the end of the shears should be directly upon point *b* when making the final cut. The point of the shears is also used in notching patterns, as shown in *A* and *B*, Figure 14. When cutting out the shaded portion of patterns, the end of the shears blade should never extend beyond the point *m* in the pattern.

Hints on the Care and Use of Hand Shears.—The following suggestions are offered on the use and care of the hand shears and should be followed carefully by the student or workman:

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When using the shears the blade should be held in a vertical position, making straight up and down cuts.

Never twist the shears sidewise when cutting, as this causes the bending of the edge of the metal, leaving a burred edge, which requires additional work in flattening it out with a mallet on a stake or level plate.

Keep the shears sharp, but do not grind too fine an edge.

The bolt and nut joint should be oiled frequently, and

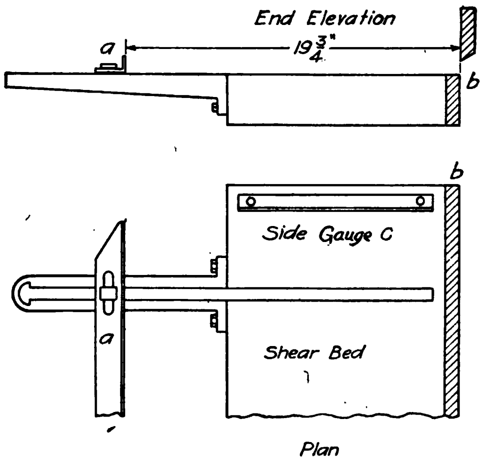

Figure 15.—Plan and End Elevation of Squaring Shears.

the nut adjusted so the shears will work easily at all times.

Never use the cutting edges of shears for cutting wire, but always use instead the cutting nippers which are made for this purpose.

Squaring Sheets of Metal.—In preparing sheets of tin for roofing purposes and constructing various sheet metal articles which require the sheets to be perfectly square

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and exactly the same size, with the edges true and straight, the sheets can be squared very rapidly and accurately on the squaring shears, Figure 1. A plan and end elevation of the squaring shears are shown in Figure 15, where *a* is the front gauge, *b* the lower cutting knife, and *c* the side gauge.

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CHAPTER III

FOLDING EDGES AND SEAMING

One of the most important processes in sheet metal working is that of seaming. Seams of various kinds are used, depending on the strain to be resisted and the equip-

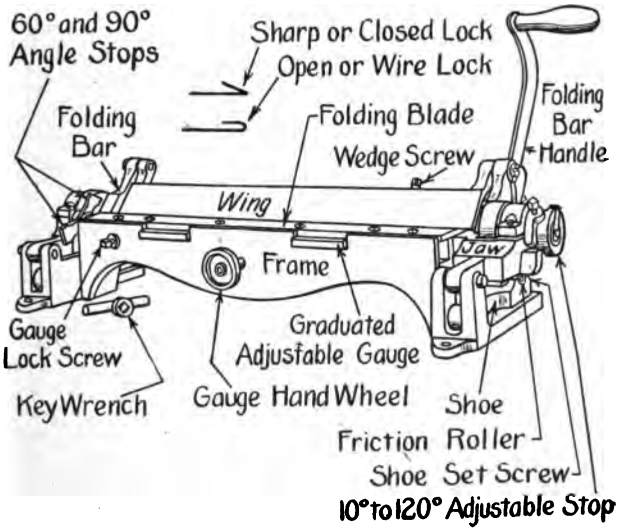

Figure 16.—Bar Folding Machine.

ment on hand for constructing them. The machine in general use for bending the edges of sheet metal for seaming is known as the adjustable bar folder, as shown in Figure 16. The following edges and seams are extensively used in light sheet metal work:

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Single Edge.—This edge, as shown in Figure 17, is used in constructing seams and hemming the edges of sheet metal. In forming this edge in the folder, set the gauge to the required width, then insert the metal in the machine, holding it firmly against the gauge with the left hand. Grasp the handle with the right hand and bring

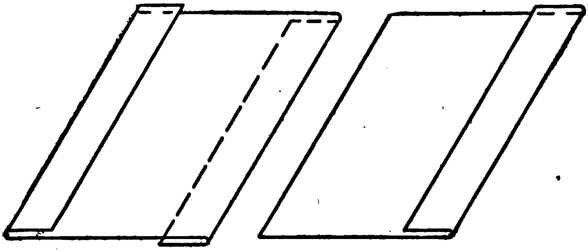

Figure 17.—Single Edges Formed on Sheet Metal.

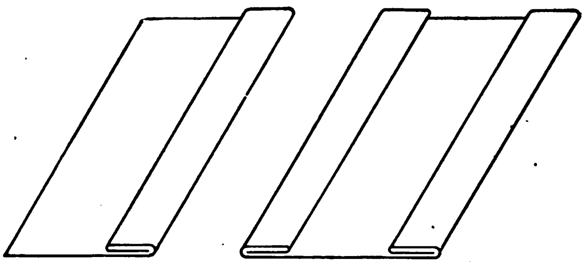

Figure 18.—Double Hemmed Edges.

the folding bar over until it rests on top of the machine. The handle of the machine is now brought to its former position and the metal removed from the machine, completing the operation.

Double Edge.—The double lock, shown in Figure 18, while used in certain work, is most commonly utilized to strengthen sheet metal forms. When used for this purpose it is known as a double hemmed edge. This edge is

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formed in the folder in the same manner as the single edge. After the latter is formed, the sheet is turned over, then the single edge is placed in the machine against the gauge and the operation is repeated.

Wire Edge.—It is often necessary to increase the strength of articles made from sheet metal by inclosing a wire in certain of their edges. The edges for this purpose must be rounded as shown in Figure 19. To form

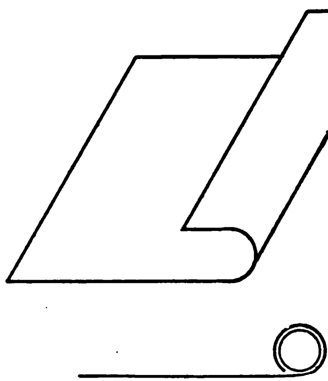

Figure 19.—Wire Edge, Open and Closed.

an open or round lock for wiring, set the gauge on the folder equal in width to two and one-half times the diameter of the wire to be used. Using the wrench, loosen the lock screw to the right on the back of the machine, and by moving this screw to the right or left in the slot the wing is raised or lowered. In adjusting the machine, lower the wing equal in width to the diameter of wire to be used, fasten the lock screws firmly, then turn the edge in the usual manner.

Lap Seam.—In Figure 20 is shown the ordinary lap seam, as used in the construction of small cylinders, square pipes, cornice miters, etc. This seam is usually

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soldered or riveted. When thin metal is used and the seam is to be soldered, allow from 1/8″ to 1/4″ for lapping.

Folded Seam.—In making this seam, a single edge is turned on the metal, and the edges are hooked together

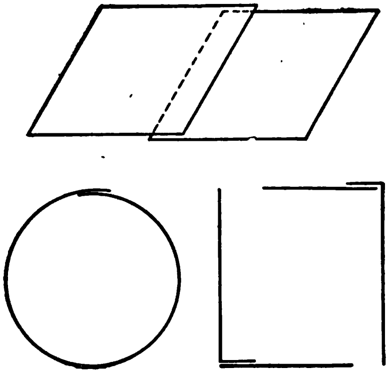

Figure 20.—Ordinary Lap Seams.

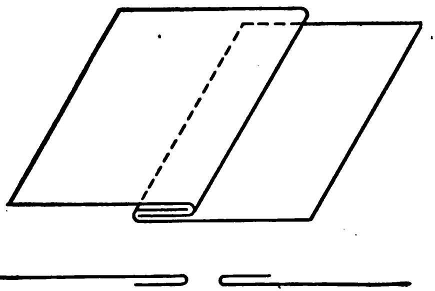

Figure 21.—Folded Seam, Consisting of Two Single Edges Hooked Together.

as shown in Figure 21, after which they are hammered down with a wooden mallet. Seams that are malleted down smooth are stronger and easier to solder than when uneven. Seams of this kind are used in laying flat seam tin and copper roofing.

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Grooved Seam.—With light material, the grooved seam is the universally used method of joining the edges of sheet metal. This seam is frequently used in joining two flat sheets of metal, making longitudinal seams in round and square pipes, and vertical side seams in sheet metal articles having a flaring or cylindrical surface. An illustration of this seam, showing the construction, is seen in Figure 22. When joining two flat pieces of metal by

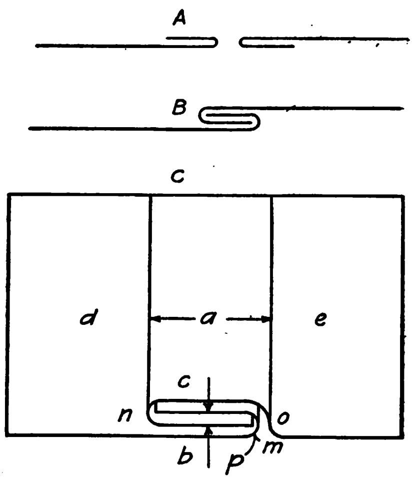

Figure 22.—Grooved Seam, Showing Construction.

this method, set the gauge on the folding machine to the width of the edge required, and turn a single edge on the sheets as shown at *A*. Hooking the edges together as shown at *B*, the seam is laid on the horn of the grooving machine (Figure 23). The rolls run over the seam lengthwise, completing the seam as shown at *C*. When the grooving wheel is run over the seam, an offset is made in the upper sheet *e* at *m*, which prevents the seam from coming apart. The seam is finished by placing it on a

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mandrel stake, pounding it with a wooden mallet, closing it down, and leaving the seam tight and smooth.

Allowance for Grooved Seam.—The amount of material to be added to the pattern for making a grooved seam from light sheet metal depends upon the width of the

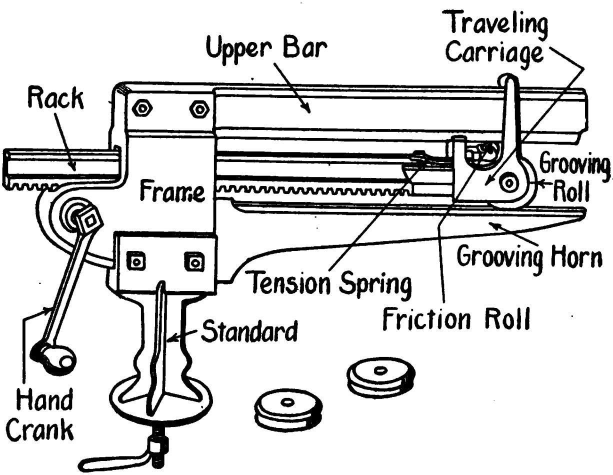

Figure 23.—Grooving Machine, Short Horn.

single edge turned on the folder, as shown in Figure 17. Three times the width of the single edge must be added to the pattern. The finished seam as shown at *C*, Figure 22, has four thicknesses of metal at *a*, the sheets *d* and *e* joining at *m*. The sheet *d* has a single edge *c*, while sheet *e* has a double edge, as shown at *a* and *b*. This shows the necessity of making an allowance equal to three times the dimension *a*, or width of the edge, for a grooved seam. When seaming tin plate and metal lighter than No. 24 gauge, no allowance is made for the stock taken up by the bends *n*, *o*, and *p*, in *C*, Figure 22.

Where heavier material is used and accuracy is

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required, the actual amount of material taken up by these bends must be added. The student can determine the amount by making a test seam in the following manner: Take a strip of metal six inches long. After cutting it into two parts, turn an edge on each piece. Groove the seam and close it down with a wooden mallet. Then measure the length of the strip accurately, and the difference between this dimension and the length of the piece before seaming will be the amount of material to be added for the seam.

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CHAPTER IV

FORMING, GROOVING, BEADING, AND CRIMPING

This chapter will treat of the various processes used in the construction of conductor pipes, stove pipe, furnace pipe, and air ducts. Although work of this kind is chiefly used in building construction and heating and ventilating systems, the following will apply as well to forming and seaming sheet metal articles cylindrical in form, where the longitudinal seam is made with the usual grooved seam.

When constructing pipes and cylinders the student must first find the circumference by multiplying the diameter by 3.1416, and to this dimension add the amount of material necessary for making the grooved seam, as shown in Figure 22. This will give the exact length to cut the material.

Constructing Sheet Metal Pipe.—When constructing pipes an allowance should be made for the thickness of metal used. This is necessary to permit the small end of the joint to fit snugly into the large end of the adjoining joint of pipe. The usual method is to cut the small end of the joint 1/8″ less in circumference than the large end when using tin plate and light iron up to No. 26 gauge, and 1/4″ for No. 24 to No. 20 gauge. The best practice is to make a difference of seven times the thickness of the metal between the large and small end of pipe.

When making pipe it is customary to place the sheets of metal on a bench behind the squaring shears (Figure 9). Then set the front gauge back from the cutting blade of the shears, having the left end of the gauge equal to the length of the large end of the pipe and the right

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end equal to the length of the small end. The sheet of metal is then passed between the shears blades. The student should extend his fingers and press down upon the middle of the sheet while holding it firmly against the gauge, and then cut the joint. Notch one corner of the small end. This notch will show which is the small end after the pipe is formed up.

After all the sheets have been cut, the joints are placed behind the folding machine (Figure 16) with the notched

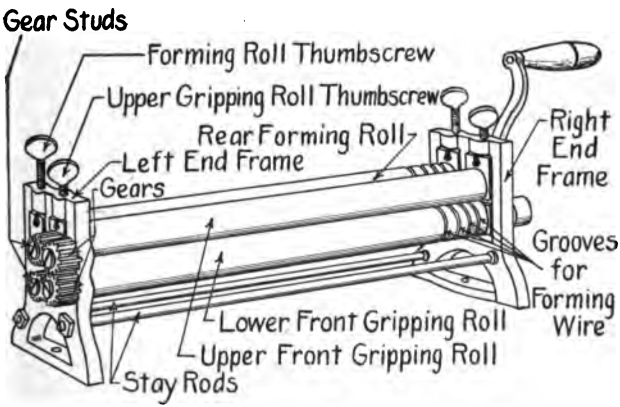

Figure 24.—Forming Machine with Solid Housings.

end to the right of the machine, and the single edges are turned as shown in Figure 17.

Forming Cylinders.—The next step in the construction of the pipe is to form it into shape on the forming machine (Figures 24, 25). This machine is easily adjusted by means of the adjusting screws on each end of the machine, and the rolls can be set for forming any desired size of cylinder. The upper front roll is slightly raised, to allow the folded edge of the sheet to pass between the rolls without closing the lock. The sheet with the folded

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edge on the under side is inserted in the machine just far enough to allow the front rolls to grip the edge, as shown in *a*, Figure 26. Then holding the handle of the machine

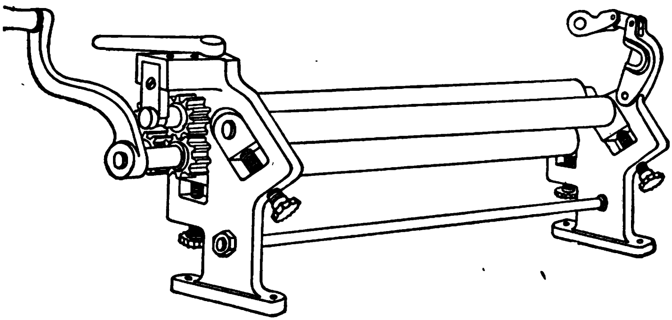

Figure 25.—Forming Machine, Slip Roll Pattern.

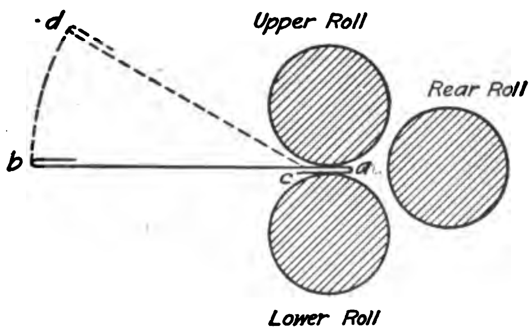

Figure 26.—Inserting the Sheet Between the Rolls of a Forming Machine, to Form a Cylinder.

firmly to keep the sheet in this position, raise the sheet to the dotted position *d*, making a slight bend at *c*. This bend enables the sheet to pass easily over the rear roll, giving it the required curve, as shown in Figure 27.

The adjustment is made by raising or lowering the rear

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roll until the required diameter is obtained. A cylinder having a grooved seam should be formed a trifle less than

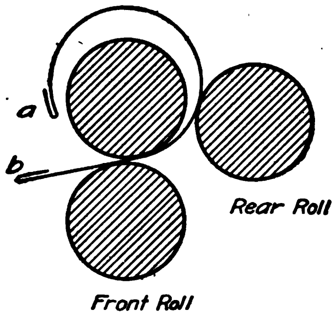

Figure 27.—Position of Sheet When Cylinder Is Nearly Formed.

its full diameter. This will allow the edges to hook tightly together while being grooved.

GROOVING SEAMS

Having formed the pipe properly, it is now ready for the grooving operation, which can be performed either by hand with the hand groover (Figure 28) and mallet

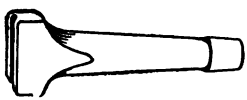

Figure 28.—Hand Groover.

over a mandrel stake (Figure 29) or upon the grooving machine (Figure 30).

Operating the Grooving Machine.—After the edges of the pipe have been hooked together as shown in *a*, Figure 31, the front latch of the machine is raised and the cylinder inserted over the grooving horn, the end of the cylinder resting against the lower adjustable stop, which

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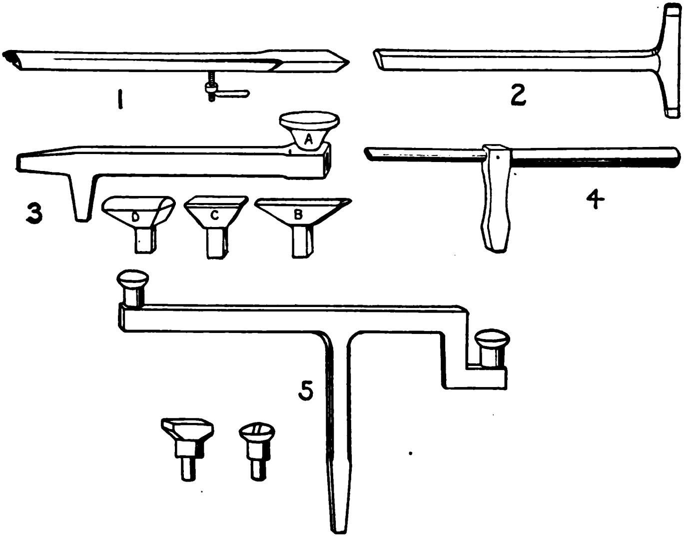

Figure 29.—Bench Stakes.

1, Hollow Mandrel Stake; 2, Mandrel Stake; 3, Double Seaming Stake, with Four Heads, A. B, C, D; 4, Conductor Stake; 5, Tea Kettle Stake with Four Heads. (See also Figures 53, 54.)

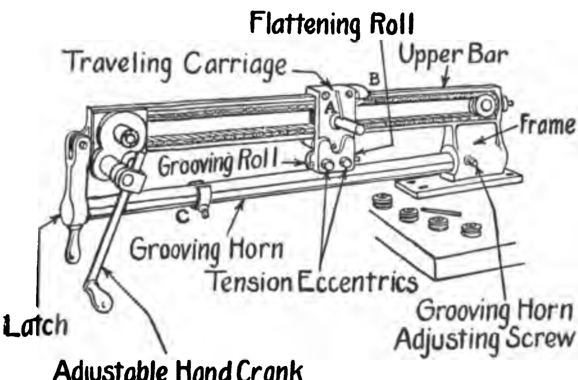

Figure 30.—Grooving Machine.

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prevents the work from slipping. The traveling carriage is then brought forward, allowing the grooving roll to run over the seam lengthwise, completing the seam as shown in *b*, Figure 31. The carriage is returned to the starting point by means of a handle. It has two rolls, one for grooving, and one for flattening the seam at the same operation.

Countersunk Grooved Seam.—This seam is used extensively in the construction of stove pipe, furnace pipe,

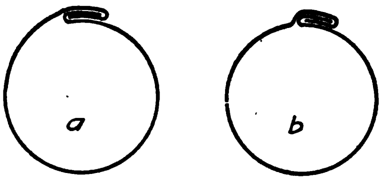

Figure 31.—Pipe Seam Hooked Together and Grooved.

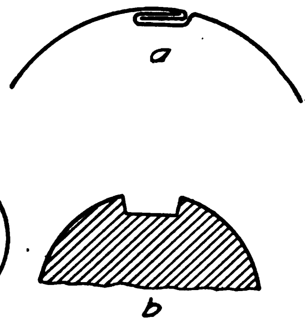

Figure 32.—*a*, Seam Grooved Inside Pipe; *b*, Groove in Horn of Grooving Machine.

and other sheet metal articles. This method of grooving places the seam on the inside, leaving an unbroken surface on the outside of the article, as shown in *a*, Figure 32.

When making this seam on the improved grooving machine (Figure 30), remove the grooving wheel from the traveling carriage, loosen the set screw, then turn the reversible grooving horn, bringing upward one of the grooves which is planed into the horn, as shown in *b*, Figure 32. The cylinder is placed on the grooving horn with the locked edges directly over the planed groove. The traveling carriage containing the flat roll is brought

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forward, which presses the seam into the groove and thus completes the operation.

Grooving Seams by Hand.—The ordinary small grooving machine shown in Figure 23, is used for seaming tinware, furnace pipes and articles made from light sheet metal, where a small seam can be employed to advantage. In sheet metal shops not equipped with a grooving machine, when it is required to seam articles made from black and galvanized iron by hand the article to be grooved is placed on the hollow mandrel (Figure 29), or the solid mandrel stake. The edges are hooked tightly together for their entire length. The hand grooving tool (Figure 28) is placed against the edge of the seam and struck with a wooden mallet (Figure 33). In this way

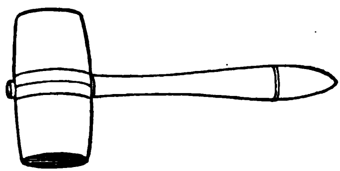

Figure 33.—Tinners' Hickory Mallet.

the seam is grooved at one end for several inches. The other end is then grooved in the same manner, after which the entire seam is grooved by striking the hand groover with the mallet while moving it along the seam. Care must be taken that the groover does not cut or mark the metal on either side of the seam. The seam is completed by flattening it down closely with the wooden mallet.

BEADING AND CRIMPING

In constructing articles cylindrical in form from light sheet metal, they are usually reinforced by being beaded or swaged upon the beading machine shown in Figures 34, 35. When making cylinders or pipe of large diame-

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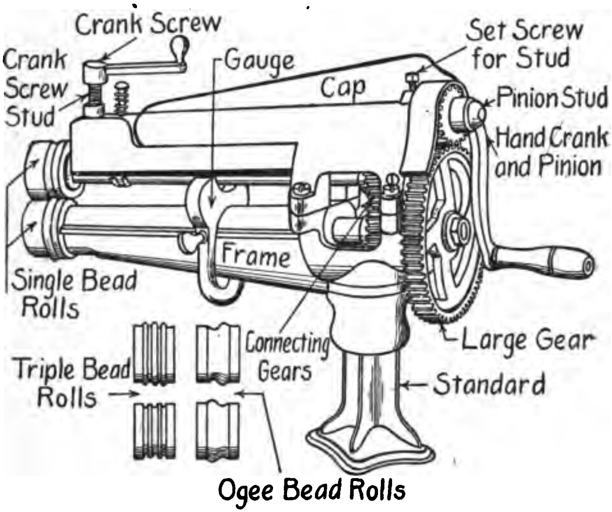

Figure 34.—Beading Machine.

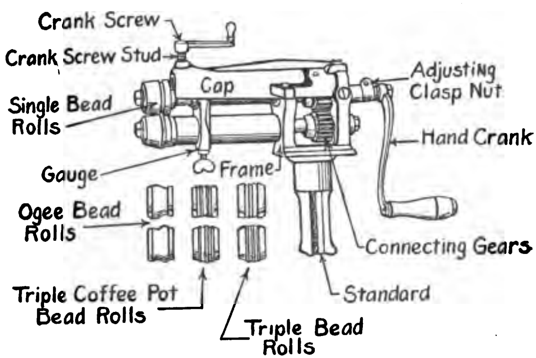

Figure 35.—Light Beading Machine.

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ter, several beads are usually placed close together near the ends of the cylinder. This tends to strengthen the body, keeping it round in form.

The beading machine is furnished with several sets of rolls, consisting of the single bead, ogee bead, triple bead, and the triple coffee pot bead rolls. The single and ogee bead rolls are generally used in beading the ends of pipe and large cylinders made from sheet iron. The triple bead and coffee pot bead rolls are used in swaging articles of tinware, both round and flaring in form. When mak-

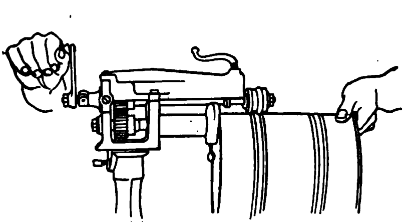

Figure 36.—Beading a Cylinder.

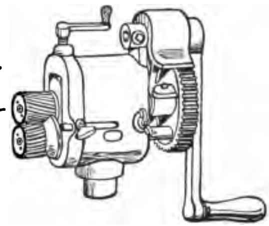

Figure 37.—Crimping Machine.

ing pipe of various sizes, a single or ogee bead is usually made on the small end of the pipe. This bead serves to stiffen the pipe and aids in keeping the pipe straight when riveting the joints together.

Operating the Beading Machine.—When beading pipe the gauge is moved back about $1\frac{1}{2}$ inch or 2 inches from the beading roll and fastened by means of the set screws. The small end of the pipe is then inserted between the rolls, with the end resting against the gauge. The rolls are now pressed together by means of the hand screw on top of the machine. The pipe is held in a horizontal position with the left hand while the machine is being turned with the right. The large end of the pipe should be allowed to pass easily through the fingers while being revolved in the machine, and care should be taken that

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the small end of the pipe is against the gauge at all times during the operation. A mistake often made by the student is to depress the upper roll too much. If this is done, there is great danger of cutting through the material. The beading process is clearly shown in Figure 36.

Crimping Pipe.—After the pipe has been beaded, the next step is to draw in the small end with the mallet on the mandrel stake, or crimp the edge about ½ inch in

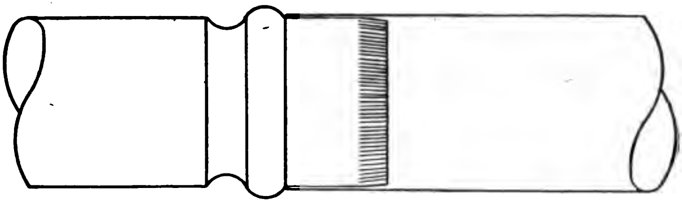

Figure 38.—Plain Lap Pipe Joint, Showing Crimped Edge.

width on the crimping machine shown in Figure 37. This operation contracts the edge of the pipe so that it will enter the next joint easily, as shown in Figure 38. The illustration shows a plain lap joint, having a lap of about 2 inches, and can be either riveted or soldered, or both as required.

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CHAPTER V

SOLDERING

The process of soldering consists of welding together pieces of metal by means of another metal of lower melting point. Soft soldering may be taken to mean the uniting of pieces of metal with fusible alloys of tin and lead.

In the operation of soldering, which is done by using soldering coppers for applying the heat, the solder must be fused to the pieces which are being joined. This is done by raising the temperature of the solder and the parts to be soldered to the fusing point. The solder is applied and sweated in by holding a hot soldering copper in contact with the seam until a correct fusing temperature has been attained, with the result that the metals fuse together into one homogeneous mass, making a perfect joint at every point.

The absolute necessity of heating the parts to be soldered and raising them to the correct fusing temperature can not be too strongly emphasized.

Fluxes.—When soldering two pieces of metal together, a perfect bond cannot be made unless oxide is kept out of the joint, and a flux must be used to prevent oxidation while the soldering operation is going on. The basis of all good fluxes is zinc chloride.

Many sheet metal workers prepare their own flux by "cutting" zinc in muriatic acid. This is done by putting pieces of zinc into a bottle of muriatic acid until the acid stops boiling and bubbles cease to rise. The acid eats away the zinc, liberating hydrogen during the process. This action continues until the acid is "cut" or "killed;"

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in other words, until all the hydrogen in the acid has been given all the zinc it will eat. What is left in the bottle is no longer muriatic acid, but is known as chloride of zinc.

Muriatic acid is the commercial name for hydrochloric acid, and is often used in its raw state as a flux for soldering galvanized iron and zinc.

Chloride of zinc, or "killed acid," is used as a flux when soldering clean galvanized iron, zinc, copper, and brass. When the material to be soldered is tin plate, bright copper, or lead, rosin is used as a flux, and when melting has a tendency to penetrate into the lock or seam. There are several kinds of soldering salts and noncorrosive fluxes on the market, that are being used with good results by the sheet metal trade. A too strong flux will do harm to the work and to the soldering tools. Whatever flux is employed should be diluted with water to the weakest condition for the work on hand.

Solder.—Practically all solders used by the sheet metal worker are combinations of tin and lead. The quality of the solder must not be overlooked. Solder should be purchased from a reliable dealer who will furnish a good article, having the correct proportions of lead and tin. The solder generally used is composed of half tin and half lead, commonly called half-and-half. It melts at about 370 degrees Fahrenheit. A better flowing solder, one having more resistance to stress, is composed of 60 per cent tin and 40 per cent lead. It melts at about 340 degrees F. The latter is the best possible combination, with the objection, however, that it is very costly.

Soldering Furnaces.—Furnaces for heating soldering coppers are made to burn gasoline, gas, oil, and charcoal. The fire pot shown in Figure 39 is well adapted for burning charcoal. Gas furnaces, as shown in Figures 40, 41, are most generally used; their greatest point of superiority being in the continuous supply of fuel.

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Figure 39.—Cast Iron Firepot.

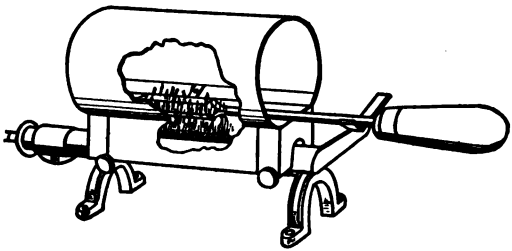

Figure 40.—Single Burner Gas Furnace.

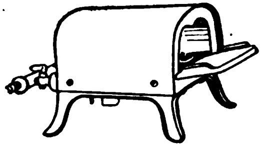

Figure 41.—Double Burner Gas Furnace.

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SOLDERING COPPERS

Soldering coppers of different sizes, suitable for different kinds of work (Figures 42-45) should be included in every shop equipment, and can be obtained in various weights.

A small copper should not be used on heavy work, as it cannot contain enough heat to allow the solder to flow

Figure 42.—Square Point Soldering Copper.

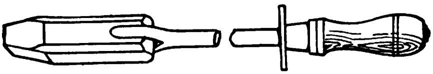

Figure 43.—Roofing Copper.

Figure 44.—Bottom Copper.

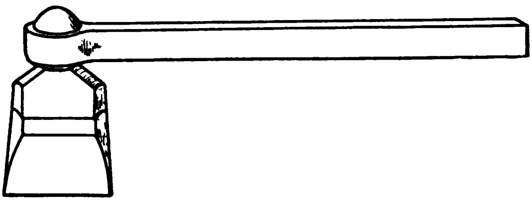

Figure 45.—Hatchet Copper.

and sweat into the joint as it should. When the small copper is applied to the metal, it becomes cool quickly, with the result that the workman wastes much time in trying to keep the coppers hot, or in soldering with relatively cold coppers, which means poor work. After selecting coppers of suitable weight for the work at hand, the next point to consider is the required shape.

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Forging and Tinning Coppers.—Soldering coppers are forged to any desired shape by placing the copper in the furnace and heating it to a dark cherry color. The dross and scale is removed by means of a coarse file; the copper is then forged to the required shape on an anvil or block

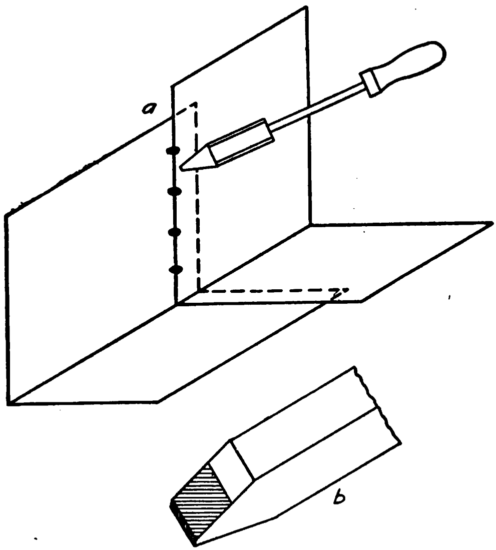

Figure 46.—*a*, Soldering Copper for Tinware, Applied to Vertical Seam; *b*, Bottom Copper.

of iron by means of a heavy hammer. Copper can be forged very easily if the metal is annealed or softened. The annealing operation for copper consists of heating the metal to a dull red heat. It can be allowed to cool out slowly in the air or by immersing in water.

The soldering copper shown in Figure 46 (*a*) is forged to a pointed shape. It is well adapted for soldering seams in tinware or any other bench work and generally weighs three or four pounds a pair. The bottom

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copper shown in Figure 46 (*b*) is wedge-shape in form and is used for soldering the bottom seams of sheet metal articles on the inside.

For soldering flat seams, coppers shaped as shown in Figure 43 are best adapted, being especially suitable for soldering flat-seam roofing, and should weigh from 6 to 10 pounds a pair.

Tinning Points of Coppers.—When tinning pointed coppers, they should be heated, then filed bright on four sides, not higher than about ¾ inch from the point. This gives a bright smooth surface, ready for tinning. The coppers are again placed in the furnace and heated sufficiently to melt solder. The point of the copper is then rubbed lightly on a small block of sal ammoniac, which cleans the surface. A small portion of solder is now melted upon the sal ammoniac and by lightly rubbing the copper back and forth upon the solder and sal ammoniac, it will become tinned and ready for use.

Soldering coppers can be tinned with rosin, instead of sal ammoniac. This is usually done by placing a piece of solder and some rosin upon a board or soft brick. The copper is filed in the usual manner, then heated just hot enough to melt solder. It is next taken and rubbed on the solder and rosin until the solder adheres to the copper. This method of tinning is generally used when soldering tin, and if rosin is being used as a flux.

Keeping the point of the copper bright and clean at all times is of vital importance. Never allow an oxide or scale to form on the points, for copper oxide is almost a non-conductor of heat and an oxidized soldering copper gives up its heat so poorly as to be practically useless. If a scale be allowed to form on the point, it flakes off and causes serious trouble in the soldering. A copper can never remain in good condition if it is overheated. When a copper is allowed to become red hot its usefulness is gone until it has been retinned.

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Dipping Solution.—When using charcoal, gasoline, or gas for heating, the point of the copper becomes discolored. Using an earthen fruit jar, mix a solution composed of ½ ounce of powdered sal ammoniac and one quart of water. After the sal ammoniac has been dissolved the solution is ready for use. The point of the heated copper, when taken from the furnace, is dipped quickly into this solution. This facilitates the soldering operation by making the tinned surface bright and clean.

METHODS OF SOLDERING

Soldering Flat Seams.—In Figure 47 is shown the method of soldering a flat seam having ½-inch to ¾-inch

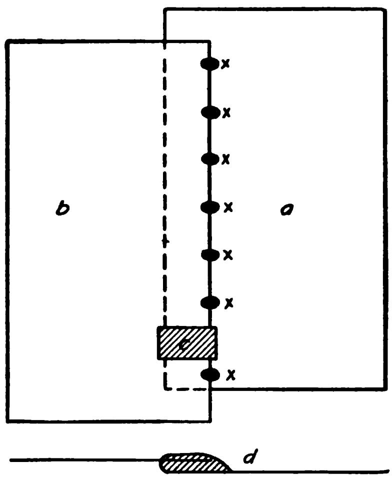

Figure 47.—Method of Soldering a Flat Seam.

lap. In this case two pieces of galvanized iron, about 2½ by 8 inches, are used as shown by *a* and *b*. Muriatic acid is employed as the flux and care must be taken that the flux is allowed to enter the seam the width of the lap, and

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not merely brushed over the edge of the seam without allowing the acid to penetrate. The seam is now tacked with solder as shown at *x*. The seam is then soldered its entire length by placing the copper directly upon the seam and soldering from tack to tack, being careful always to allow the solder to cool before soldering from one tack to another. In placing the copper directly upon the seam as shown at *c*, Figure 47, the solder is drawn into the seam its full width, soaking it thoroughly as shown at *d*.

Flat-locked seams are soldered in the same manner, by placing the copper directly upon the seam, as shown at

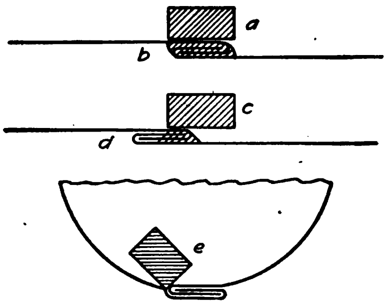

Figure 48.—Soldering Flat-Locked Seams; an Improper Method of Placing the Copper Is Shown at *e*.

a, Figure 48. Having applied the flux properly, the heated copper draws the solder into the seam, fusing the various metals and making a compact mass, as shown at *b*.

An improper way of placing the copper on the seam is shown at *c*; the soldering copper *c*, resting on the edge of the seam, allows but little solder to sweat into the joint as shown at *d*, resulting in a poorly soldered seam.

When soldering a grooved seam on the inside of sheet metal articles, a mistake is often made by workmen and students in placing the copper on the seam in the position shown at *e*, Figure 48. When placed in this position,

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the copper is held on the wrong side of the seam, drawing the solder away from, instead of into the seam. The copper should be held directly upon the seam, heating it thoroughly and drawing the solder into the joint.

Soldering Vertical Seams.—Upright seams in roof flashing, cornice gutters, and other work, whether lapped or locked, are more diffiicult to solder than flat seams. The ordinary lapped vertical seam is shown at *a*, Figure 46. When upright seams are to be soldered, no matter what metal is used, the soldering copper should be forged wedge-shape, being about ¾-inch wide and ¼-inch thick at the point when completed. The end and top side only are tinned as shown by the shaded portion in *b*, Figure 46.

When the end and upper face only are tinned, the solder can be easily controlled when applied to the seam. If the four sides of the copper were tinned, much of the solder would run to the under side and away from the seam, and result in a waste of time and material.

When soldering vertical seams, the handle must be held higher than the copper to allow the solder to flow forward until the required amount has been transferred to the seam and sweated into the joint. This is done by moving the copper to the right and left on the seam, heating it thoroughly and drawing the solder into the seam, as shown at *d*, Figure 47.

Repair Work.—When soldering old work and repairing sheet metal articles, the surface must be free from dirt or any substance which will prevent the solder from adhering to the metal. The parts to be soldered must be made perfectly bright by scraping or filing. Scraping is the best method and is usually done by means of a knife blade or tinner's scraper, shown in Figure 49. Regardless of what method is used, the surface must be cleaned and made perfectly bright or good soldering cannot be done. When soldering old tinware, after the metal has

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been scraped, use chloride of zinc or "killed acid" as a flux, instead of rosin.

Soldering Bench Work.—When soldering flat seams, ornaments on cornice work, bottom seams of tinware, and other small work at the bench, the work is often dis-

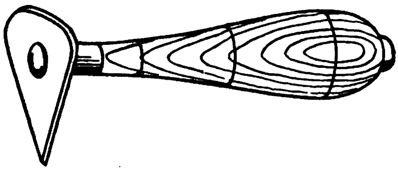

Figure 49.—Plumbers' Scraper.

colored by the hot copper burning the bench underneath and leaving a dark spot on the surface of the metal. This can be overcome by using a piece of black sheet iron, thick glass, or marble slab, upon which the work to be soldered can be placed. The glass or marble slab should be ½ to ¾-inch thick. It can be easily cleaned and also serves as a level plate while soldering.

EQUIPMENT

A good equipment for soldering is shown in Figure 50. This includes a gas furnace, acid cup, jar for dipping solution, small block of sal ammoniac, pointed soldering coppers, and a marble slab 14 inches square by ¾-inch thick. When soldering small articles, the solder should be applied to the copper, instead of directly to the work. A bar of solder is placed on the bench, one end being raised by resting it on the edge of the marble slab, or by placing some small tool under it. The end of the bar of solder is touched with the point of the copper, and if it has been properly tinned, a small portion of the solder will melt and adhere to the copper, which is then applied to the parts to be soldered.

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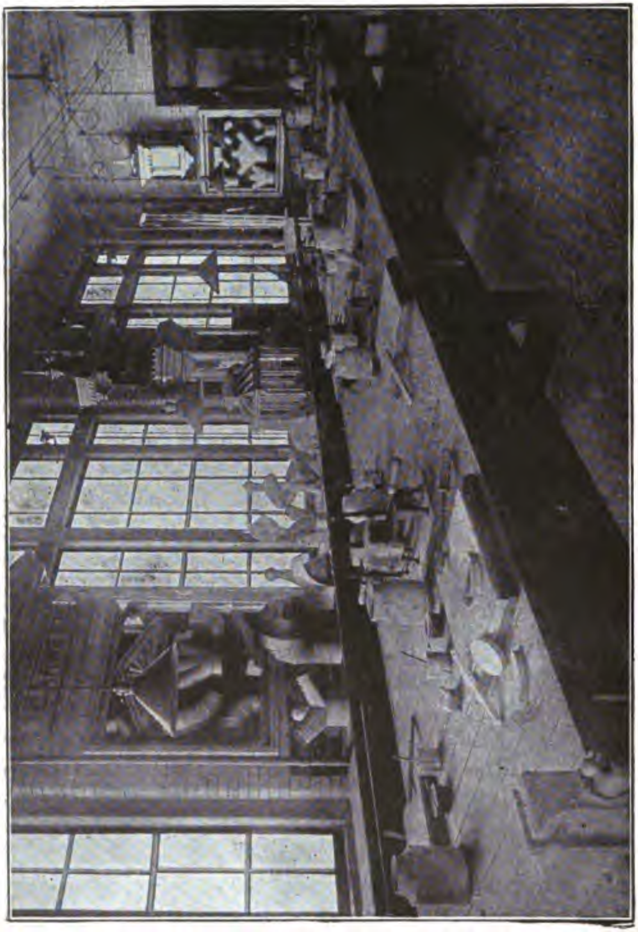

Figure 50.—Soldering Bench and Equipment.

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STRIPPING ORNAMENTS AND PATTERNS

When constructing dentils, brackets, letters, figures, and ornaments made from sheet metal, the parts are usually joined by the method of stripping. The next exercise in soldering will be to strip the pieces cut from patterns *A* and *I*, Figures 1, 2, in which the student obtains practice in soldering work of this kind. Using light galvanized iron as the material, set the gauge on the squaring shears (Figure 9) and cut strips ¾ inch in width and equal in length to the circumference of the circles, having them perfectly square on the end. The strips are now formed into a circle on the forming machine (Figures 24, 25) in the same manner as any pipe or cylinder. The pattern or face of the ornament is then placed on the marble slab. The circular strips are placed directly on top of the patterns, flush with the outer edge, and are soldered on the inside. A mistake often made by the student is to wrap the strip around the outer edge of the pattern. When this is done, the ornament when viewed from the front will show the edge of the strip.

When soldering work of this kind, hold the strip in position with the left hand; flux the joint with a little muriatic acid, then transfer a small drop of solder from the end of the bar to the seam with a pointed copper, tacking it about an inch apart its entire length; after which solder the seam between tacks, as described in the instructions for soldering flat seams.

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CHAPTER VI

DOUBLE HEMMED EDGE

In Figure 51 are shown several cake cutters of various forms, made of bright tin (see Figure 1). The upper edge of the body and edges of the handle are reinforced by a double hem. These simple articles can be made of scrap material. The strips for the body are cut 1½-inch wide and equal in length to the circumference

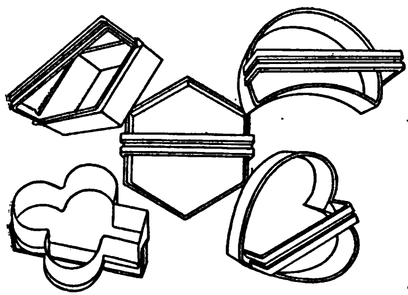

Figure 51.—Cake Cutters of Patterns Seen in Figure 1.

of the patterns *B, C, D, E, F,* Figure 1. To this length ⅛-inch is added for a lap seam where the ends are joined.

Hexagon-Shaped Cake Cutter.—In Figure 52 are shown a plan view, side view, and pattern of the hexagon-shaped cutter *C,* Figure 1. To find the length of material required, set the dividers equal to the length of one side as *1-2* in the plan. Starting at one end of the metal strip, mark the length of each side by spacing with the dividers, making a light impression on the metal at each point. Lines drawn through these points across the strip, as shown in *A, 1234561,* will mark the corners where

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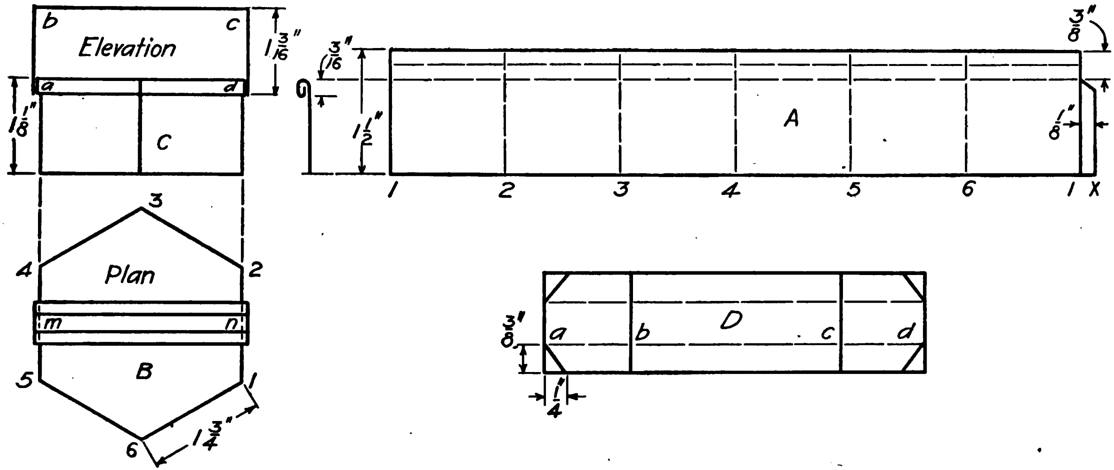

Figure 52.—Plan, Side View, and Pattern of Hexagon-Shaped Cake Cutter.

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the metal is bent when formed into shape; $\frac{1}{8}$-inch is added for a lap seam, as shown at *x*. The lap is notched $\frac{3}{8}$-inch on the upper corner. This is done to allow for a $\frac{3}{16}$-inch double hem, which will be turned on the upper

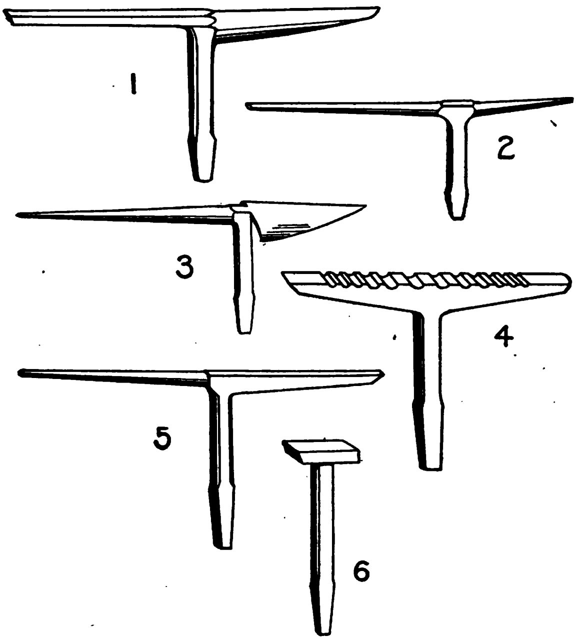

Figure 53.—Bench Stakes.

1, Beakhorn Stake; 2, Candle Mold Stake; 3, Blowhorn Stake; 4, Creasing Stake; 5, Needle Case Stake; 6, Square Stake.

edge of the strip. The pattern for the handle is cut $1\frac{3}{8}$ inch wide and equal in length to *abcd* in the elevation. Notch the corners of the handle, as shown at *D*. Then set the gauge on the folding machine (Figure 16) $\frac{3}{16}$-inch and turn a double edge on each side of the handle and the upper edge of the body.

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The next step will be to form the handle and body by hand on the needle case stake, shown in Figure 53. Place the metal strip with the bending line on the edge of the

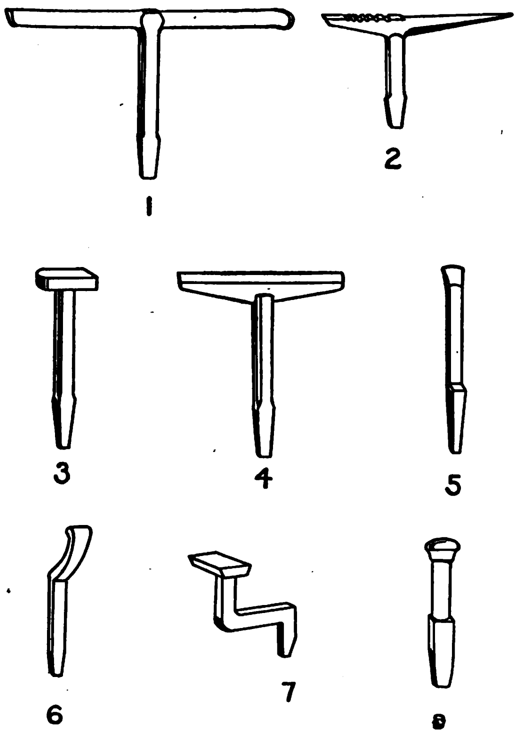

Figure 54.—Bench Stakes (Continued).
1, Double Seaming Stake; 2, Creasing Stake, with Horn; 3, Coppersmith's Square Stake; 4, Hatchet Stake; 5, Bottom Stake; 6, Bath Tub Stake; 7, Bevel Edge Square Stake; 8, Round Head Stake. (See also Figure 29.)

flat end of the stake, then bend the metal to the required angle, as shown by the template *B*. Each corner is bent in the same manner and should fit the template accurately

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when completed. The handle is formed by making a square bend on lines *b* and *c* in pattern *D*. The cutter is completed by soldering the seam at the corner and solder-

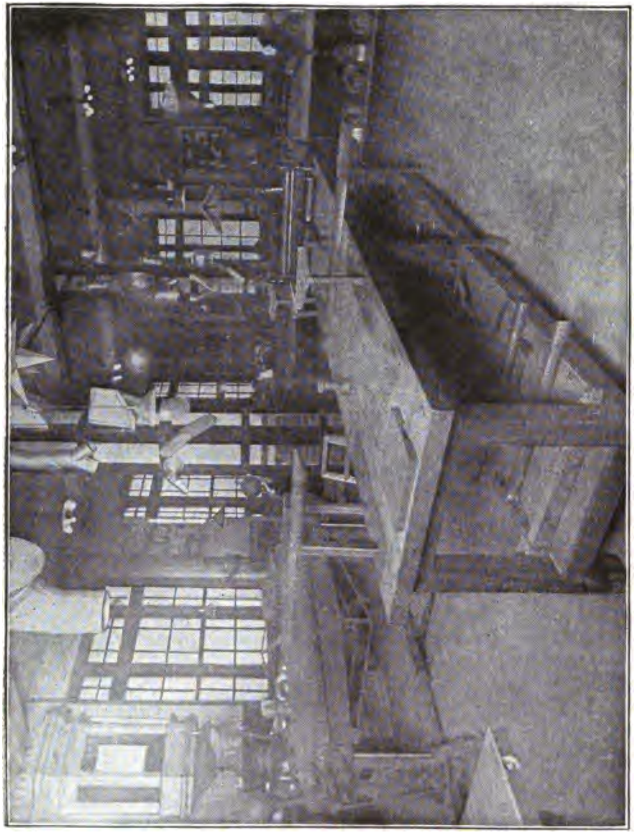

Figure 55.—Work Bench, with Stakes and Bench Plates.

ing the handle to the upper edge of the body in the position shown at *mn* in plan *B*.

The cutters *B, D, E, F*, Figure 1, are formed in a similar manner over the various stakes at hand. The following stakes are suitable for this purpose: Hatchet stake, conductor stake, blowhorn stake, candle mold stake, beakhorn stake. See Figures 29, 53, 54.

These stakes are used for various purposes and are fastened to the bench by inserting the square tapered shank into the proper size holes, cut in the bench for this purpose, or by having a cast-iron bench plate fastened to the bench, as shown in Figure 7. These bench plates can be obtained in different sizes and contain the proper size holes for holding stakes, bench shears, etc.

In Figure 55 is shown an illustration of a work bench with bench plates inserted in the top. The bench is 3x16 feet in size with a shelf underneath for holding stakes when not in use. This is a good arrangement for a school shop, as students can work on both sides of the bench at the same time.

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CHAPTER VII

WIRING PROCESS

In constructing work made of tin-plate and light gauge metal several methods are used to reinforce the top of the article, to keep its shape and to withstand rough usage. For very small articles this is done by turning a single or double hem on the edge of the metal, as pre-

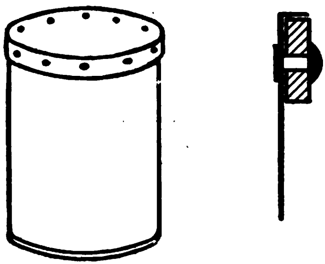

Figure 56.—Sheet Metal Can and Method of Riveting Band Iron to the Top Edge.

viously described. Large sheet metal articles are often stiffened by having band iron riveted to the top edge as shown in Figure 56.

The method most commonly used to increase the strength of flaring and straight articles is to inclose a wire or iron rod of suitable size in certain of their edges. The wire can be laid in by hand or by means of the wiring machine shown in Figure 57.

Allowance for Wiring.—It is important to know the exact amount to be added to the height of the pattern for the take-up of the wire. The amount usually added for this operation is equal in width to two and one-half times

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the diameter of the wire. Another method is to allow three-fourths of the circumference of the wire.

When using tin plate and light sheet metal, it is customary to make no allowance for the thickness of the metal, but in wiring heavy plate an allowance must be made for the thickness of the material used. The amount of material for covering the wire will vary according to

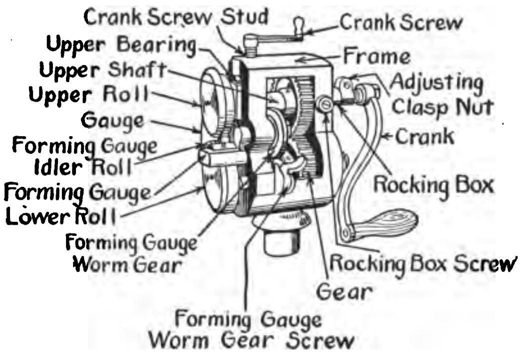

Figure 57.—Wiring Machine.

the thickness of the metal and the size of the wire to be inclosed and is found by the following rule:

Add twice the diameter of wire to four times the thickness of metal.

As an example, suppose in constructing a tank from sheet iron $\frac{1}{16}$-inch thick, the top is to be reinforced by inclosing a $\frac{1}{2}$-inch rod; then the amount to be added to the net height for wiring will be $\frac{1}{2} \times 2$ plus $\frac{1}{16} \times 4$, equals $1\frac{1}{4}$ inch.

The most accurate and practical method to determine the allowance for wiring is to take a narrow strip of metal and bend it closely around the wire with the pliers. This will give the exact amount of material required.

In wiring articles made from tin plate, Nos. 8, 10, 12,

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13, and 14, coppered or tinned iron wire is commonly used. The amount of material to allow for inclosing the above sizes of wire when using IC tin plate, and the width of edge to be turned on the folding machine, are given in the following table:

No. 14,	Wire	Allowance	$\frac{3}{16}''$	Set	Gauge	on	Folder	$\frac{5}{32}''$
No. 13,	"	"	$\frac{7}{32}''$	"	"	"	"	$\frac{3}{16}''$
No. 12,	"	"	$\frac{1}{4}''$	"	"	"	"	$\frac{7}{32}''$
No. 10,	"	"	$\frac{5}{16}''$	"	"	"	"	$\frac{1}{4}''$
No. 8,	"	"	$\frac{3}{8}''$	"	"	"	"	$\frac{5}{16}''$

Wiring Operation.—When wiring articles cylindrical in form having straight sides, such as cans, tanks, and

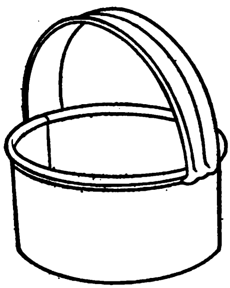

Figure 58.—Biscuit Cutter, Wired in Top Edge.

articles of tin-ware, the wire is inclosed in the edge of the metal while in the flat sheet before being formed into shape. The following problem is given to demonstrate the wiring operation and the method used in laying out patterns for work of this kind:

In Figure 58 is shown a biscuit cutter. This is a useful article made from IC bright tin, having a No. 14 iron wire inserted in the top edge. The seam in the body is lapped and soldered. The handle is double hemmed on the edges. The dimensions of the cutter and the patterns for the body and handle are shown in Figure 59. The

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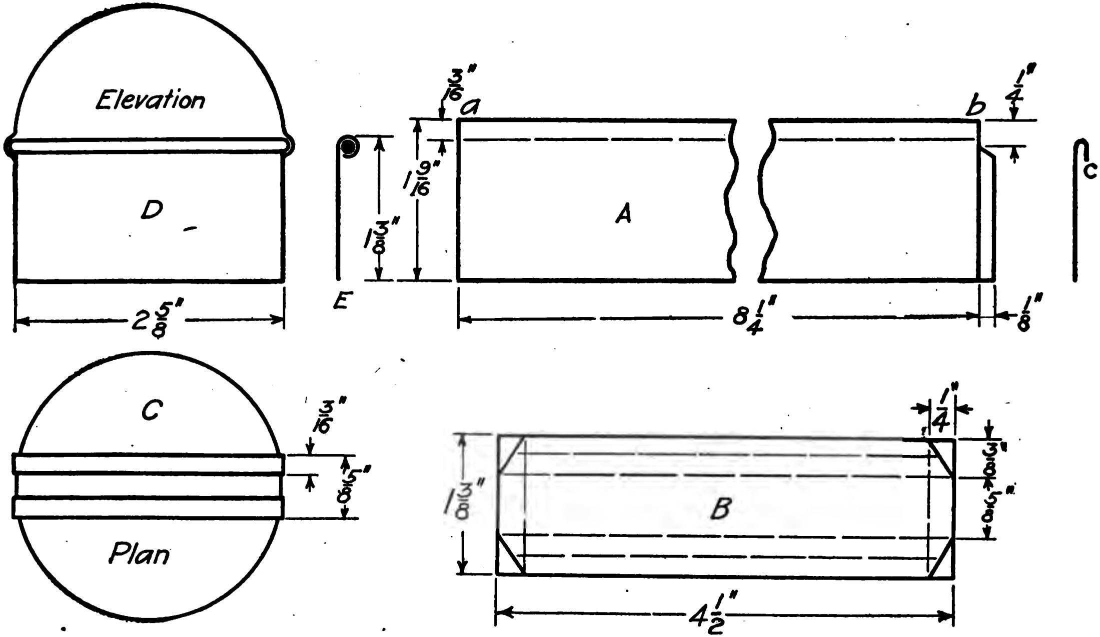

Figure 59.—Plan and Patterns for Biscuit Cutter.

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pattern *A* for the body is cut $8\frac{3}{8}$ inches long by $1\frac{3}{4}$ inches wide. To find the length of the pattern, multiply the diameter $2\frac{5}{8}$ inches by $3.1416 = 8\frac{1}{4}$ inches; to this amount add $\frac{1}{8}$-inch for the lap seam. The height of cutter is $1\frac{3}{8}$ inches when completed; to this dimension add $\frac{3}{16}$-inch, the allowance required for inclosing a No. 14 wire; then $1\frac{3}{8}+\frac{3}{16}=1\frac{9}{16}$ inches, is the width of pattern; the $\frac{1}{8}$-inch lap is notched $\frac{1}{4}$-inch at the upper corner to allow for turning the wire edge.

The open or round edge for the wire is now turned on

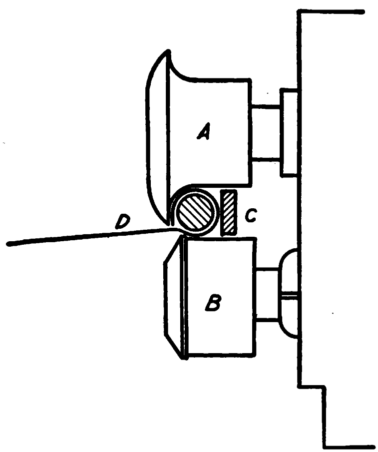

Figure 60.—Sectional View of Wiring Machine.

the folder as shown at *c*, a piece of wire equal in length to *a b* in pattern *A* is laid under the edge, and the metal closed over the wire for about one inch from the end. This is done with the hammer over the horn on the standard of the wiring machine.

Wiring Machine.—In Figure 60 is shown a sectional view of the wiring machine, used to complete the operation. Holding the work *D* in a horizontal position, place

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it on the lower roll *B* with the wire edge held firmly against the gauge *C*, bring down the upper roll *A*, and adjust the gauge, having the curved flange on the upper roll fit snugly over the wire. The work is then run through the rolls until the metal is fitted closely over the wire.

In Figure 61 the wiring operation is illustrated, giving a full view of the machine and the proper position of

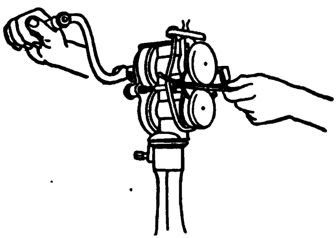

Figure 61.—Wiring Machine in Operation.

the hands. If the rolls should slip when wiring heavy metal, this is overcome by pulling the work lightly as it passes through the rolls.

The next step in the construction of the cutter is to form the body on the forming rolls (Figures 24, 25). The wired edge is placed in one of the grooves cut in the end of the rolls for this purpose, and the body is then formed the same as a cylinder. The wire should never be formed elsewhere than in these grooves.

Before inserting the work in the forming machine, place the work on the conductor stake (Figure 29) and slightly curve both ends of the wire by striking it lightly with a mallet. This enables the work to pass easily over the back roll of the forming machine.

Pattern *B* (Figure 59) for the handle is formed in the usual manner, after which the ends of the wire on the body are joined together, and the seam is soldered

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having the lap on the inside. The handle is soldered to the top in the position shown in *C* and *D*, Figure 59.

When forming cylinders in very small diameters, made from stiff or heavy metal, do not attempt to secure the correct diameter by passing the work once through the rolls, but form it gradually by passing through several times.

Wiring by Hand.—In wiring very heavy material, or when the sheet of metal is greater in length than the folding machine, making it impossible to turn the edge

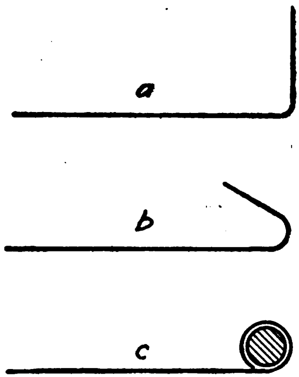

Figure 62.—Operations in Wiring an Edge by Hand.

for wire on the folder, the wiring operation is performed by hand as follows:

After marking the wire allowance on the metal by means of the dividers or scratch awl, lay the sheet with the scribed line directly over the edge of the bench or some other straight edge. Take the mallet and bend the metal to an angle of 90° as shown at *a*, Figure 62. Turn the sheet over on the bench and by means of the mallet bring the edge to the position shown at *b*. The wire is then laid under the edge and the metal is bent closely

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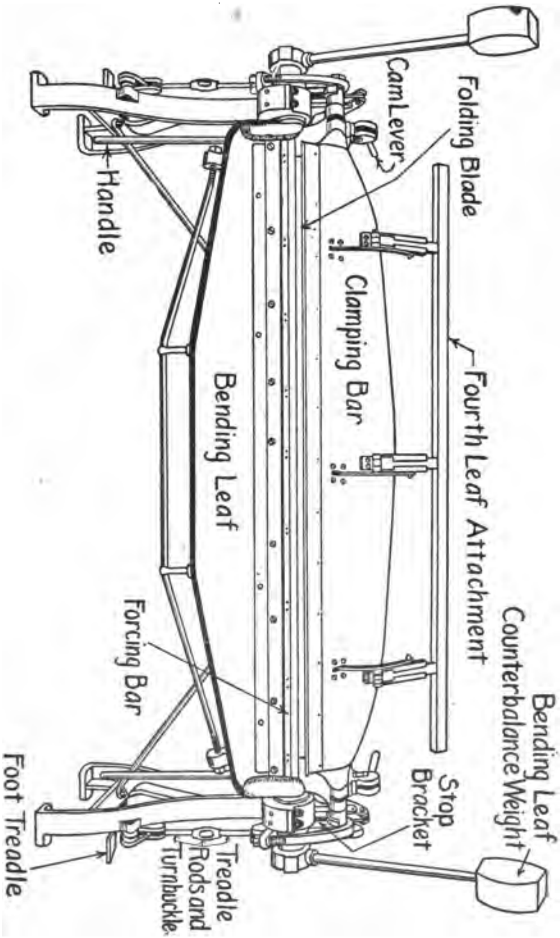

Figure 63.—Cornice Brake.

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over the wire as shown at *c*. The operation is completed by running the work through the wiring machine (Figure 57) in the usual manner. The right angle bend *a*, Figure

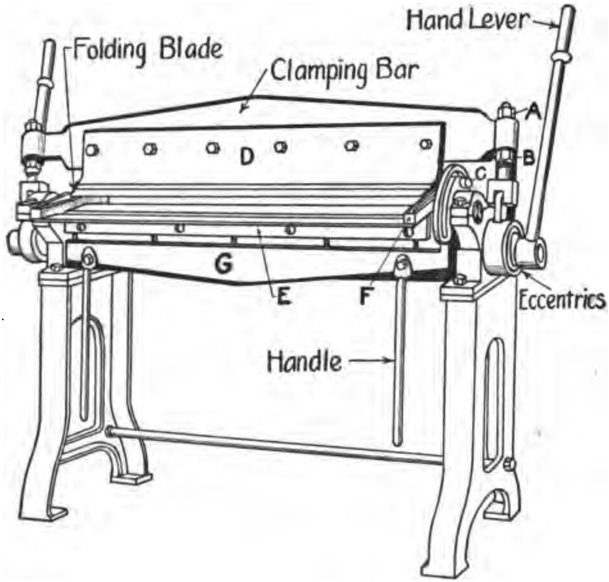

Figure 64.—Combination Brake and Folder.

62, can also be made on the cornice brake (Figures 63, 64, 65) and the wiring operation completed as described above.

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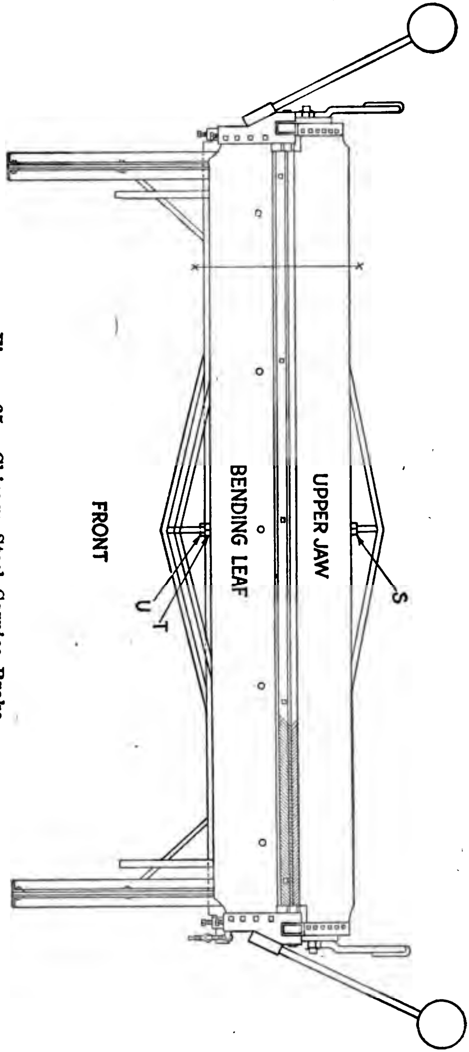

Figure 65.—Chicago Steel Cornice Brake.

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CHAPTER VIII

NOTCHING AND BURRING

Every experienced sheet metal worker understands the importance of notching patterns properly for wiring and seaming. Special attention should be given by the student to this part of the work, and great care should be taken that the corners are notched in such a manner that

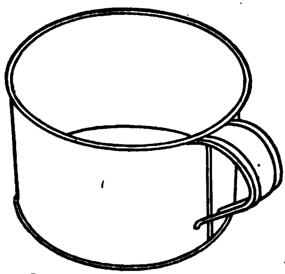

Figure 66.—Sheet Metal Cup, Notched and Burred.

when the work is formed up and seamed, the notched corners will fit snugly together without overlapping or leaving an opening exposing the wire at the end of the seam.

In constructing sheet metal articles in the form of a cylinder, having a wire inserted in the top edge, and the lower end inclosed with a bottom of the same material, if the side seam is grooved the corners of the pattern must be notched for wiring and seaming in such a manner that when finished the article will present a neat appearance.

We will take for a description of the notching and burring processes the making of a sheet metal cup, shown in Figure 66. This is the next problem given in the

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graded series that we are following. These cups are made up in different sizes and for various purposes.

The method of construction and patterns for the cup are shown in Figure 67, in which the sectional view at *E* shows the construction. A No. 12 wire is inclosed in the top edge at *kk*, the bottom with a single edge at *mm* is slipped over the body and soldered on the inside. The pattern *C* for the body is a rectangular piece of IC bright tin, equal in length to the circumference of the body shown at *A*. To this dimension is added an allowance for a 1/8-inch grooved seam. The width of pattern is equal to the height plus the 1/4-inch allowance for a No. 12 wire.

Notching Patterns.—Having cut the material the required size, the next step is to notch the pattern for wiring and seaming, as shown by the shaded corners in pattern *C*. The upper corners are notched for wiring as shown by *abcd*. The width of the notches *da* and *ef* is equal to one and one-half times the width of the 1/8-inch edge turned for the seam. When a 1/8-inch edge is turned, 3/8 inch is allowed for the seam, and one-half of this amount or 3/16 inch is notched from each corner. This will allow the notched corners *a* and *e* to fit snugly together. The grooved seam extends up to the wire as shown at *o*. The distance *ab* should be slightly greater than the allowance for covering the wire. A continuous cut is made from *a* to *b* to *c*, cutting *bc* on an angle of 45°. The lower corners are notched on an angle of about 45°, the width being one and one-half times the width of the edge to be turned. The corners *g* and *h* will then fit together, leaving only one thickness of metal on the lower edge after the grooved seam is completed.

After the pattern has been properly notched, set the gauge on the folder (Figure 16) 1/8 inch, then place one end of the pattern against the gauge, with the upper corners that have been notched for wire facing toward the right end of the machine. By placing the work in the

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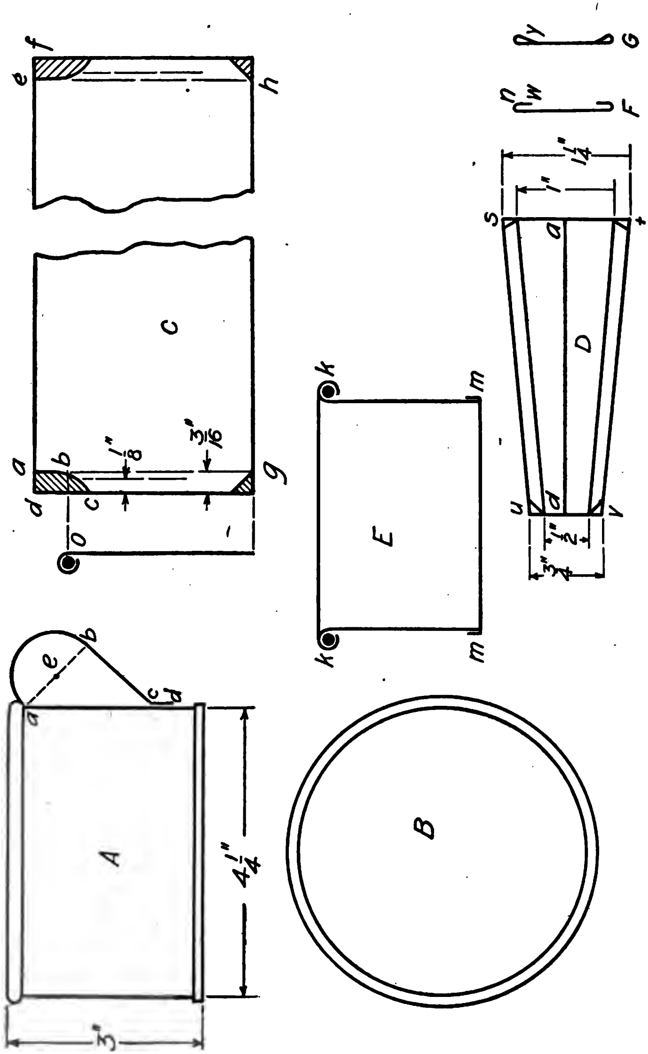

Figure 67.—Construction and Patterns for Sheet Metal Cup.

folder in this manner, the edges for the seam are turned in their proper position for wiring and seaming. The body is then wired, formed up on the rolls, and the seam grooved. These operations have been fully described in previous chapters.

The pattern *D* for the handle is laid out by drawing a center line, making *ad* equal in length to *abcd* in elevation *A*. Through points *a* and *d* at right angles to the center line draw *st* and *uv*, equal to the width of the top and bottom of the handle. Next draw lines *su* and *tv*. Then *sutv* will be the pattern for the handle, with the allowance added for a single hemmed edge. The corners are notched as shown in the drawing, and a 1/8-inch single edge turned on the sides. The handle is then formed by hand over the tapering end of the blowhorn stake (Figure 53).

The method of drawing the profile of the handle is shown in the elevation. At pleasure locate the point *c* where the lower end of the handle joins the cup. The upper end of the handle fits closely under the wire at point *a*. Using the 45° triangle, draw lines from points *c* and *a* intersecting at *b*. Bisect line *ab* at *e*; with *eb* as radius, and *e* as center, describe a half circle connecting *a* and *b*. The amount *cd* is added for a lap at the lower end. Then *abcd* will be the profile and stretch-out of the handle.

After the edges have been turned on the handle, as shown in *F*, Figure 67, set the gauge on the small burring machine (Figure 68) equal to the width of the edge *nw*. Then run the work through the machine, having the upper roll turn the inner edge *n* against the handle, as shown at *y* in *G*. This operation will make the handle rigid, giving it a finished appearance after being formed into shape.

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BURRING MACHINE

The burring machine shown in Figure 68 is used for various purposes and is well adapted for turning small edges on circular pieces of metal, edging hoops and rims of covers, and bodies of sheet metal articles for seaming. These machines are made in two sizes for general work. The small machine is used for turning edges on small curves, and will burr edges up to $\frac{3}{16}$ inch in width. For

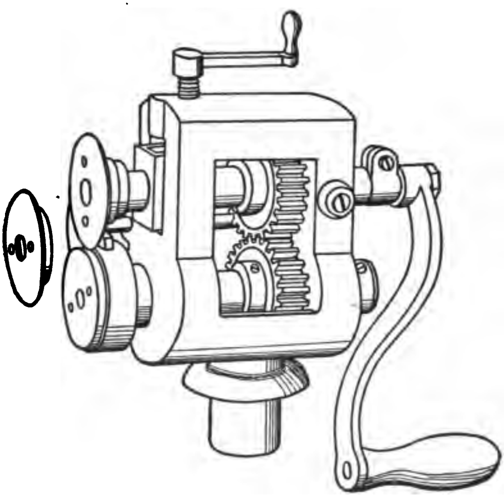

Figure 68.—Burring Machine.

large curves the large machine is preferable; an edge or flange up to ¼ inch wide can be turned on this machine.

When burring edges for seaming light sheet metal, the experienced workman will turn the edge as small as possible, as he fully understands that it is almost impossible to turn a wide edge evenly on thin metal without crimping the burr. A narrow edge for seaming is practically as strong as a wide edge. It can be turned easily, and the

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seam will have a more finished appearance when completed.

Burring Edges.—Turning edges on the burring machine is a difficult operation for the beginner. It requires careful work and practice to become proficient in burring an even edge on a circular piece of flat plate, without crimping the burr or warping the metal.

The pattern for the cup bottom with an allowance for a single edge is shown in *B*, Figure 67. The bottom is simply a circular piece of metal having an edge 1/8 inch wide turned at a right angle. To find the size of the bottom,

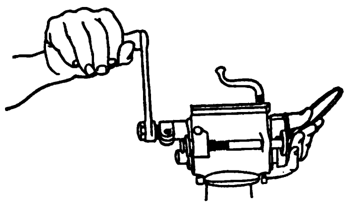

Figure 69.—Burring an Edge on Cup Bottom.

measure the diameter of the body, and to this dimension add twice the width of the burr to be turned by means of the small burring machine.

After the bottom is cut from metal, then proceed to burr the edge in the following manner: Having made an allowance for a 1/8-inch burr on the bottom, set the gauge on the machine a scant 1/8 inch from the edge of the upper roll. This will allow for the take-up of the material after the edge is turned. Then holding the bottom in a horizontal position, place the edge of the metal on the lower roll, touching the gauge. Next bring down the upper roll until the metal is held firmly between the rolls. Then with the palm of the left hand resting against the frame of the machine, grasp the bottom between the thumb and fingers, the ball of the thumb resting on the upper side near

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the center, with the fingers extended on the lower side. With the hand in this position, holding the edge of the bottom firmly against the gauge, allow the metal to pass between the thumb and fingers while revolving in the machine. After the first revolution and while the machine is turning, the bottom is gradually raised until the edge is turned to the required angle.

The correct position of the hand while burring edges on flat circular pieces of metal is shown in Figure 69. This method of holding the disc will keep the metal from warping out of shape while turning the edge. The bottom is then slipped over the body and the cup soldered on the inside, after which the handle is soldered in position, completing the problem.

BRAKING TIN

When constructing articles made from tin plate, sharp parallel kinks or wrinkles will often appear on the metal after being formed on the rolls. This can be avoided if the sheets are taken before wiring and passed through the forming rolls three or four times. With each pass they are reversed, then straightened out by being pulled over the rear roll while making the last pass through the machine. When formed up again the metal will not wrinkle. This process is known to the sheet metal worker as "braking tin" and is used constantly by the careful workman, for the parallel kinks are always evident if the metal is only rolled once.

SUPPLEMENTARY PROBLEMS

Before continuing with the next of the graded problems in this series, several supplementary problems are given, the construction being similar to the cup problem described in this chapter. These problems consist of small drinking cups and measuring cups for household use, and

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are usually made from IC or IX bright tin, having a No. 14 wire inclosed in the top. As these utensils hold a given quantity, unusual care must be observed by the workman when making the allowances for wiring and seaming.

Cup Dimensions.—The following table gives the diameter and height for different cups from $\frac{1}{2}$ pint to one quart in size:

Size	Diameter (Inches)	Height (Inches)
$\frac{1}{2}$ pint	$2\frac{9}{16}$	$2\frac{15}{16}$
$\frac{1}{2}$ pint	$2\frac{3}{4}$	$2\frac{3}{8}$
1 pint	3	$3\frac{7}{8}$
1 quart	$3\frac{9}{16}$	$5\frac{5}{8}$
Drinking cup	3	$2\frac{1}{2}$
Drinking cup	$3\frac{5}{8}$	$2\frac{3}{4}$

PATTERNS FOR A MEASURE LIP

Another adaption of the cup problem is the one quart lipped measure shown in Figure 70. The construction is the same, except that a circular flaring lip is attached

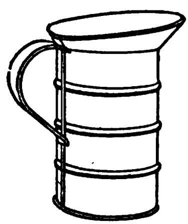

Figure 70.—One-Quart Measure with Flaring Lip.

to the top. The handle is double hemmed, and the body is graduated into four parts and marked on the metal by means of the beading machine. (Figure 35.)

The dimensions of the measure and method of obtaining the pattern for the lip are shown in Figure 71. First draw the elevation *A* to the required size. Then draw

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the side view of the lip *B* as shown by *abcd,* extending the lines until they intersect at *e.* With *f* as center describe the half section of the top of the measure as shown by *b5d;* divide this semicircle into equal parts as shown. The lip is an intersected frustum of a right cone, which can be developed by the radial method.

If the time is limited and only a few pieces are required, there are several short methods which can be applied to the same purpose. An approximate pattern developed by one of the short methods in common use is shown in *C,* Figure 71, and may be produced as follows: Draw a center line as *AB* and on it fix a convenient point *e.* With the compasses set to a radius equal to *ed* in the elevation *A,* scribe the arc *dbd;* starting from the point *b* space off a distance *dd* on each side equal to one-half the circumference of the top of the measure, as shown by the figures 1 to 9 in the half-section in the elevation. Draw a line from *e* extended through *d,* and place the width of the back of the lip as shown from *d* to *c.* Now take the distance of the front of the lip *ab* and place it as shown from *b* to *a.* Draw a line from *c* to *a* and bisect it to obtain the center point *m.* From *m* at right angles to *ca,* draw a line intersecting the center line *AB* at *n.* Then with *n* as center and *nc* as radius, describe the arc *cac,* which will complete the net pattern for the lip. Add an allowance for a lap seam on the end, and a 1/8-inch edge for a single hem on the top. After this edge has been turned in the burring machine (Figure 68) the lip is placed on a flat stake and the edge closed down by means of the mallet. Then the lip is formed on the blowhorn stake, placed in position on the top of the measure, and soldered on the inside. Lips for measures of large diameter are usually wired at the top edge, and the allowance for wire is made in the usual manner.

Another style of lip is shown by *abgh* in elevation, and incloses about three-fourths of the circumference of the

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measure. The top is cut off as shown by the dotted line *ag*. The method of laying out the pattern for a lip of this

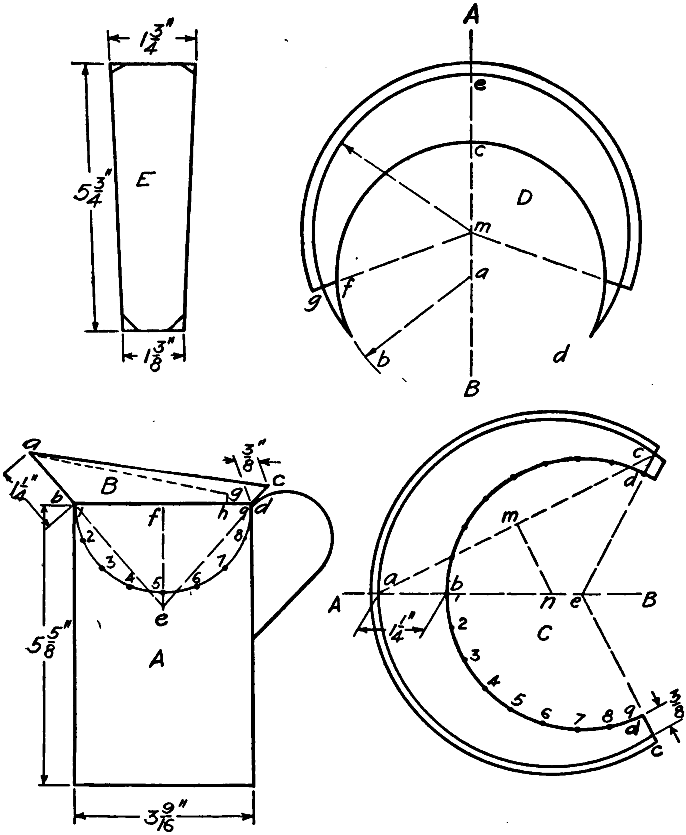

Figure 71.—Plan of Measure with Flaring Lip, and Patterns for Lip.

form is shown in *D*, and is obtained as follows: Draw center line *AB*. Set the compasses to a radius equal to three-quarters of the diameter of the top of measure.

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With *a* as center, describe the arc *bcd*. Next set off the width *ce*, and make the distance *cm* equal to one-half the diameter of the measure. With *m* as center and *me* as radius, describe an arc intersecting the arc *bd*. Cut off the end of the pattern as shown, making *fg* equal in width to *gh* in the elevation. Add allowances for wiring or hemming the top, thus completing the approximate pattern for the lip.

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CHAPTER IX

DOUBLE SEAMING, PEENING, AND RAISING

The next problem of this series is the covered pail shown in Figure 72, the construction of which involves the processes of cutting, notching, wiring, seaming, and

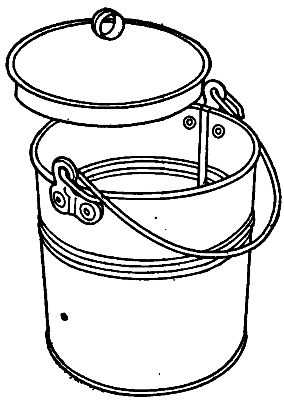

Figure 72.—One-Quart Covered Pail with Bottom Double Seamed.

burring, the same as the sheet metal cup described in the last chapter.

The construction of the body is practically the same, the only difference being that the bottom of the pail is double seamed to the body, instead of being slipped over the side as was done in constructing the cup. When the bottom of any sheet metal article is to be joined to the body, the diameter of which is 4 inches or larger, it is generally double seamed, either by hand or machine. The operations are fully described and shown in constructing the problem as follows:

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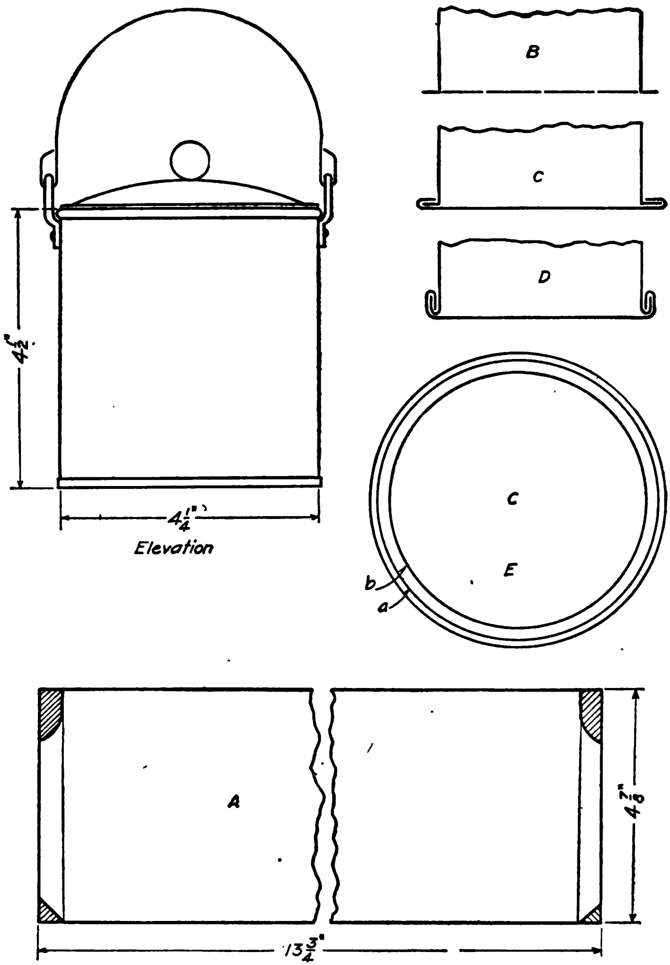

Figure 73.—Elevation and Patterns of One-Quart Covered Pail.

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In Figure 73 are shown the elevation, patterns, and dimensions of a one-quart covered pail. This is a regular stock size and will allow two bodies to be cut from a 10x14 sheet of tin without waste. The body has a No. 12 wire inclosed in the top, with a ⅛-inch grooved seam on the side. The cover is raised into shape from the flat metal, having a flaring hoop attached that fits on the inside of the pail. The wire bail or handle is fastened to the ears, which are made of malleable iron riveted to the body. The pattern *A* for the body is cut on the squaring shears (Figure 9) to the required size. The corners are notched and the edges turned for wiring and seaming. The body is then wired, formed, and the side seam grooved on the machine.

THE DOUBLE SEAMING PROCESS

After the body has been completed, we are ready for the bottom, which is joined to the body by the process of

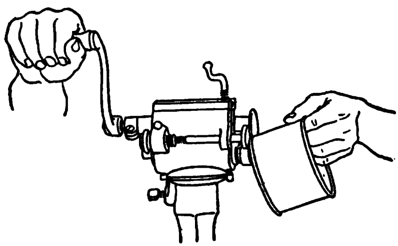

Figure 74.—Burring Edge on Bottom of Pail, Showing Correct Position of the Hands.

double seaming. The operations are clearly shown at *B, C, D,* Figure 73. The sectional detail at *B* shows an edge turned at a right angle to the body. The bottom is hooked over the edge on the body, as shown at *C*. The last operation and finished seam is shown at *D*.

Burring Edge on Body.—The first operation, burring the edge on the body, is shown in Figure 74. This edge

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is turned by means of the small burring machine (Figure 68) as follows: Set the gauge on the machine the required width for turning a 1/8-inch edge. Then hold the work in the left hand and place the edge against the gauge. Now, bring down the upper roll until the metal is held firmly between the rolls. The edge is then burred by allowing the work to revolve between the thumb and

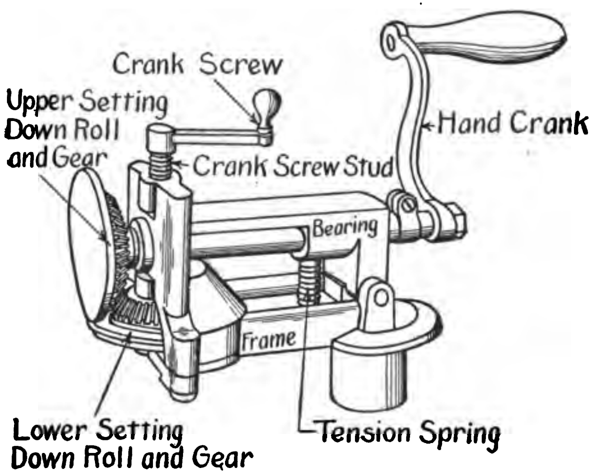

Figure 75.—Setting-Down Machine.

fingers while holding it against the gauge as it passes through the machine. The edge is brought to a right angle to the body by slightly raising the left hand while it is being burred. The correct position of the hands during this operation is shown in Figure 74.

Edge Allowance for Bottom.—The pattern for the bottom and the allowance for edges are shown at *E*, Figure 73. The diameter of the body is shown at *C*, and the allowance for a 1/8-inch edge on the body at *b;* a smaller edge turned on the bottom is shown at *a*.

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When making a double seam, an experienced workman will always turn the edge on the bottom smaller than the edge turned out on the body. This will allow the edge to be doubled over without binding against the side during the operation. Never turn wide edges for double seaming. A small edge is more easily seamed and will have a neater appearance when finished.

After the edge has been turned on the body of the article, the diameter of the bottom is usually found by measuring from edge to edge through the center; to this dimension add twice the width of the edge to be turned on the bottom. The bottom is now cut from metal and the edge burred on the small burring machine (Figure 68) while holding the bottom in the position shown in Figure 69. The bottom is then hooked over the edge on the body as shown at *C*, Figure 73. The edge is next closed down tightly by means of the setting hammer, or the setting down machine (Figure 75).

THE PEENING PROCESS

The term *peening* means to the sheet metal worker the process of closing or "setting down" edges by means of the setting hammer shown in Figure 76. These hammers

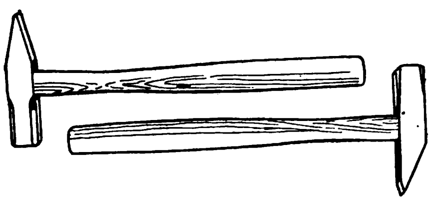

Figure 76.—Setting Hammer. Figure 77.—Riveting Hammer.

are made in different sizes, having a narrow beveled edge on one end, the face of the hammer being square in form. Figure 77 shows a riveting hammer used by sheet metal

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workers. This tool has a rounded edge on the tapered end, and is not suitable for peening purposes.

The bottom of the pail in our problem being ready for peening, the operation is simple and is clearly demonstrated in Figure 78. The illustration shows the bottom resting on the flat top of the square stake, also the position of the hands and hammer while closing down the edge. When peening the edge, care must be taken not to strike the sharp edge of the hammer against the body of

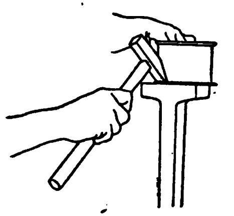

Figure 78.—Peening Edge of Bottom, Showing Position of Hands and Setting Hammer.

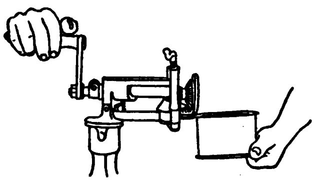

Figure 79.—Operating the Setting Down Machine.

the article, as that will make a disfiguring mark on the metal, showing careless work. This method of setting down the edge is universally used when seaming heavy material or large articles made from light metal.

Setting Down Machine.—When double seaming articles made from tin plate or light metal, if the edges have been turned true and even, the peening operation can be performed on the setting down machine (Figure 75). This operation is shown in Figure 79. The article is held

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bottom upward and the edge run between the two rolls, which will turn down and compress the edges, making a tight smooth joint ready for double seaming.

An improved setting down machine is shown in Figure 80. This machine is well adapted for setting down the

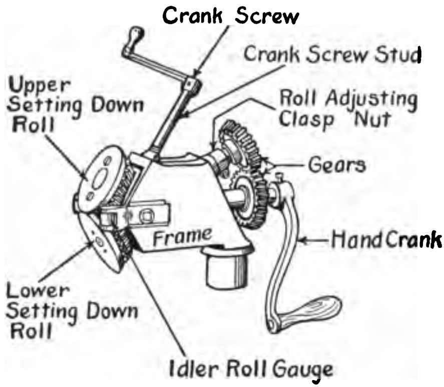

Figure 80.—Setting-Down Machine with Inclinable Rolls.

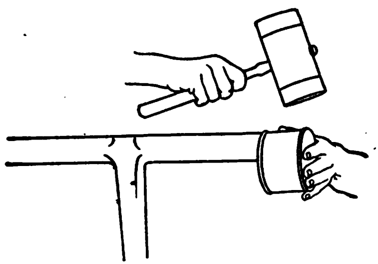

Figure 81.—Double Seaming on Stake.

edges on both straight and flaring articles. The inclined position of both rolls allows the work to be held with the bottom up or down, and the operator can start the seam inward while setting it down to facilitate double seaming.

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Double Seaming by Hand.—The final operation of the double seaming process is shown in Figure 81. The body of the article is slipped over the end of the double seaming stake and the edge bent over by means of the wooden mallet in the following manner: Hold the body firmly on top of the stake with the left hand in the position shown in the illustration; then turning the article slowly, strike an inward blow with the mallet, bending the edge at an angle of 45° while making one revolution of the bottom; complete the operation by hammering the seam down tight and smooth while holding the mallet in a vertical position.

When double seaming small articles, the double seaming stake shown in Figure 54 is well adapted for the work. For seaming large work or articles made from heavy material, the double seaming stake with four heads shown in Figure 29 will prove very suitable for a variety of work.

Double Seaming by Machine.—Double seaming machines are made in various styles, and if work is to be constructed in large quantities a machine for this purpose is indispensable. The machine shown in Figure 82 is adapted to many kinds of work, and many sheet metal workers prefer this type of seamer for general use.

Constructing Covers.—When constructing a cover made from light metal, it must be remembered that the first requirement is that it shall be rigid and strong enough to hold its shape without warping after the hoop has been attached to the rim. The hoop is made flaring in shape, so that it can be fitted snugly on the inside of the article. Covers of large diameter are generally constructed in the form of a flat cone, while the smaller sizes are either machine stamped or raised into shape from the flat metal by means of the raising hammer shown in Figure 83. Raising hammers can be obtained in different sizes and weights suitable for the work in hand.

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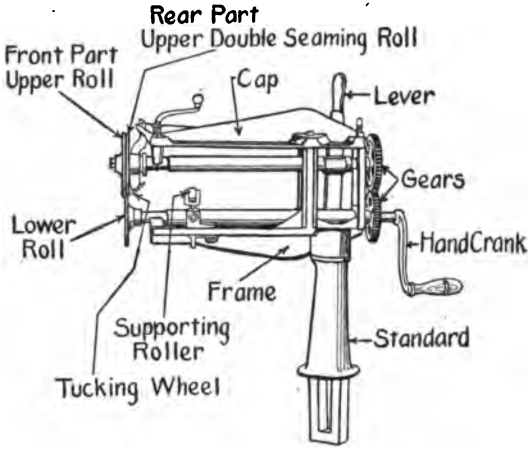

Figure 82.—Double Seaming Machine, Moore's Patent.

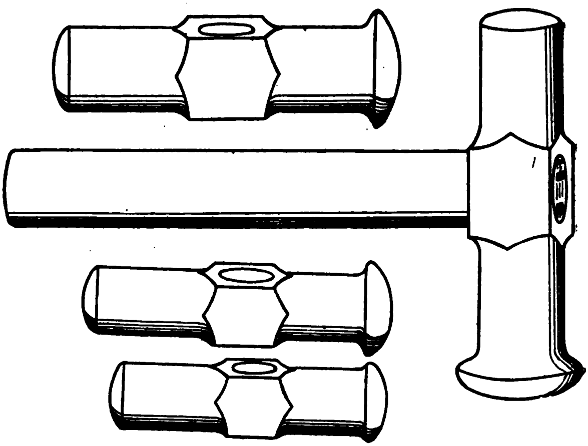

Figure 83.—Raising Hammers.

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Template for Hoop.—The method of laying out the patterns and the construction of the one-quart pail cover is shown in Figure 84. A detailed section showing the construction is given at *A*. The template, or pattern, for

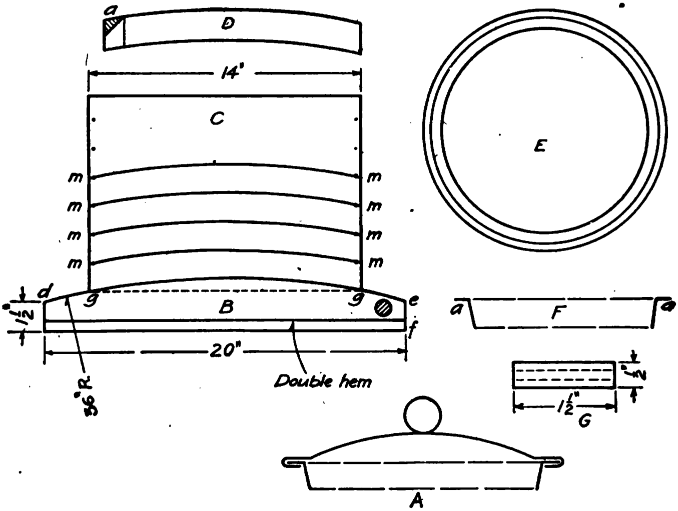

Figure 84.—Patterns and Construction of One-Quart Pail Cover.

scribing the arc of the flaring hoop is shown at *B*, and is made in the following manner:

Using a piece of heavy tin 20 inches long, turn a double hem on one side; locate points *d* and *e* 1½ inches from hemmed edge as shown by *ef;* then with the trammel points, using a 36-inch radius, scribe an arc from *d* to *e*. The metal is now cut on this line and a ½-inch hole punched near one end for hanging the template on the wall for future use. This template can be used for marking out hoops of any diameter. For large covers the hoop can be made in two or more pieces.

The hoop for the one-quart pail cover is made from one

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piece of metal, equal in length to the circumference of the body, and is laid out directly on the metal as shown at *C*. Whether one or a dozen pieces are required, set the points of the wing dividers equal to the width of the hoop. Then start at the lower edge of the sheet and mark the width of each hoop by making a light impression on the metal with the point of the dividers, as shown at *mm* on both ends of the sheet. The template *B* is now placed on the lower edge of the sheet with the rounded side touching the corners. Then using the scratch awl, scribe a line on the metal as shown from *g* to *g*. The template is moved upward on the sheet to the prick marks *mm*, and the arc is scribed across the sheet, completing the pattern for one hoop. This process can be repeated for any number required.

After the hoop has been cut from metal and formed upon the rolls, it is fitted to the pail by inserting it in the top, having it project about 1/8 inch above the wired edge. While in this position mark the end; then cut off the surplus length, allowing about 3/8 inch for lap, and notch the corner as shown at *a* in pattern *D*. After the lap is soldered, a 1/8-inch edge is burred on the upper edge, as shown in the drawing at *aa* in *F*. A pattern for the cover, shown at *E*, is simply a circular piece of metal, the diameter of which is found in the same manner as the pattern for the pail bottom shown at *E*, Figure 73. After the dimension has been ascertained by this method, cut the metal 1/8 inch larger in diameter, to allow for the take-up during the raising process.

THE RAISING PROCESS

The Raising Block.—In constructing sheet metal balls, ornaments for cornice work, curved moldings, and covers for various articles, the sheet metal worker is often required to raise, or bump, the work into form from the flat

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metal, by means of the raising hammer and raising block. The raising block is made from some substance giving resistance to the blows, and a hardwood or lead block is generally used for this purpose. The trunk of a hardwood tree, about 36 inches high and 12 inches in diameter, having several shallow circular depressions of varying

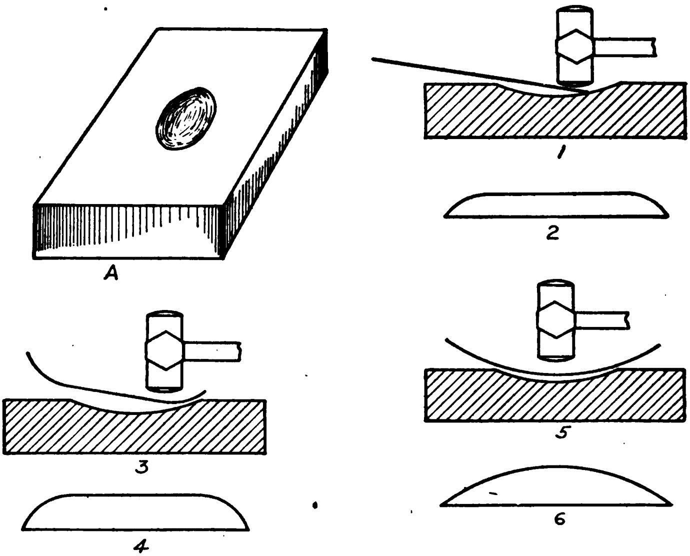

Figure 85.—The Raising Block (*a*) and Method of Raising a Circular Disc or Cover.

depth and diameter, cut in one end, is well adapted for this work.

When raising small forms, lead blocks are generally used, cast in a shape similar to that shown at *A*, Figure 85. These lead blocks are about 9x12 inches in size and about 4 inches high. The depression in the top is made by hammering with the round end of the raising hammer.

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When raising a circular disc or cover, always start at the outer edge, working inward in courses toward the center, gradually turning the disc as each blow is struck. A mistake often made by the student and workman is to strike too hard while raising the center, which results in the curve being of greater depth than required.

In bumping curved moldings and raising the sections of a sheet metal ball, the raised flare often shows marks and dents made by the hammer. To obtain a smooth, round surface, the work is placed on the round head stake shown in Figure 54, and dressed evenly by means of the wooden mallet.

Raising Pail Cover.—Having the pail cover *E*, Figure 84, cut from metal, we are now ready for the raising process. First, hammer a circular depression 3½ inches in diameter and ⅜ inch deep in the top of a lead block. Next, place the flat disc of metal over the depression in the block, in the position shown at *1*, Figure 85, and with the raising hammer strike blows all around the edge of the circle, hammering out any wrinkles that may form during the operation. This will raise the metal to the shape shown at *2*. Then, with the cover in the position shown in *3*, strike another course of blows around inside of the first course. Continue this process until the cover is brought to the shape shown at *4*. The center is then raised by striking light blows with the hammer while holding the cover in the position shown at *5*. This completes the operation, as shown at *6*. When raising covers made from light material, two or more of them can be placed together and raised at the same time.

Turning Machine.—Figure 86 shows a turning machine, better known to the sheet metal worker as the "thick edge." These machines are furnished with rolls of different thickness, suitable for a large variety of work, and are well adapted for turning edges on heavy material, preparing the edges of flaring articles for wiring, edging

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pieced elbows, and making a depression or bead on the metal when marking the width of a flange to be turned on a cylinder or cover.

Flanging the Cover.—After the cover has been hammered or raised into shape, it will be necessary to turn a wide edge or flange on the rim, to allow for joining the hoop and cover by means of a single seam shown at *A*, Figure 84. The first step in flanging is to set the gauge

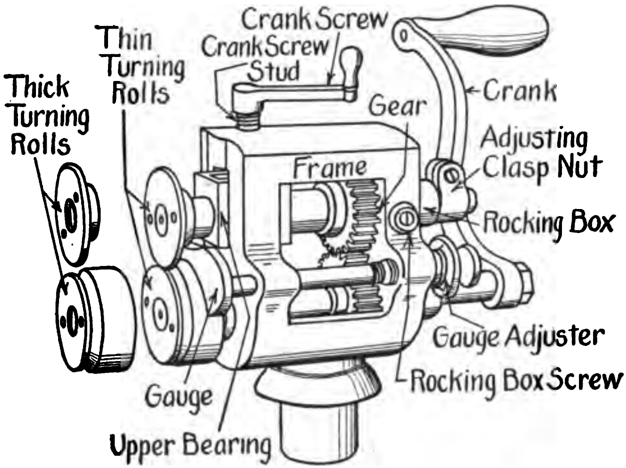

Figure 86.—Turning Machine.

on the turning machine (Figure 86) about 3/8 inch from the edge of the upper roll. Next, place the edge of the cover against the gauge, bring down the upper roll, and revolve the work in the machine, making a depression or bead as shown at number *1*, Figure 87. Then invert the cover and place the flange on top of the square stake, in the position shown at *2;* after which the edge is hammered down evenly by means of the wooden mallet. This completes the operation, leaving a flat surface 3/8 inch

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wide around the edge of the cover as shown at number *3*. By means of the small burring machine (Figure 68), a 1/8-inch edge is turned on the cover, as shown at number *4*. The cover is now hooked over the edge burred on the hoop, and the seam closed down by means of the setting hammer.

The ring for the cover is made from a piece of metal 1½ inches long and ½ inch in width, as shown at *G*,

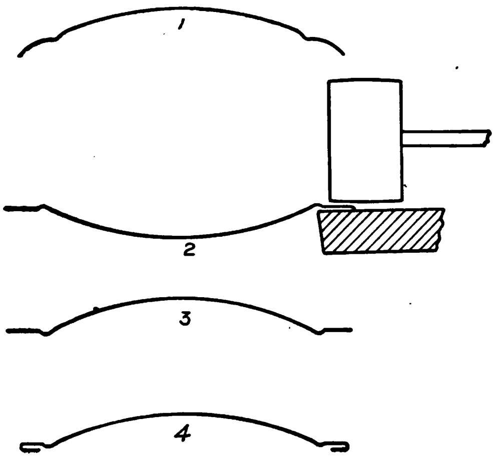

Figure 87.—Method of Flanging a Pail Cover.

Figure 84. A single edge is turned on both sides, and the metal strip is formed into shape over the round end of the needle-case stake (Figure 53). The ring is then soldered in position, which completes the construction of the cover.

Forming Wire Bails.—The small malleable ears that are riveted to the pail, and the progressive steps in forming the wire bail are shown in Figure 88. When making bails for articles having straight sides, cut the wire in length equal to two and one-half times the diameter of

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the top, and form into shape on the forming rolls (Figures 24, 25). Then place the wire in one of the grooves on the creasing stake (Figure 53), with the end extending about 1/4 inch over the edge of stake; bend the wire by means of the hammer to an angle of 45°, as shown at number *1*, Figure 88. Next, move the wire forward on the stake about 5/8 inch and bend to an angle of 90°, as

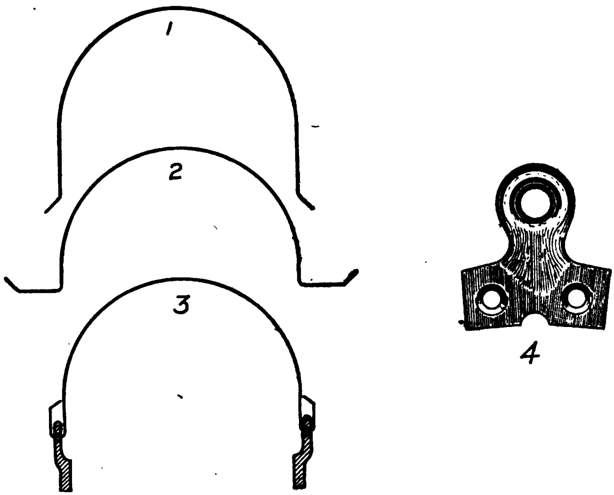

Figure 88.—*1*, *2*, *3*, Steps in Forming a Wire Bail; *4*, Malleable Ear to Receive Bail.

shown at number *2*. Both ends of the bail are now inserted into the opening in the ears and bent into shape on the creasing stake, as shown at number *3*.

An illustration showing this method of forming the hook on the end of a wire bail is seen in Figure 89. In Figure 54 is illustrated another type of creasing stake, having a tapering horn on one end, which is very useful in forming small flaring articles.

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Placing the Ears.—When riveting kettle ears on a sheet metal article, circular in form, one of the ears is placed directly over the seam where the two ends of the wire are joined together. The other is placed on the opposite side and the position located by measuring from the seam a distance equal to one-half the circumference of the

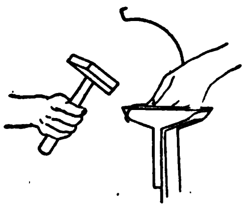

Figure 89.—Bending Hook on Wire Bail, Showing Use of Creasing Stake.

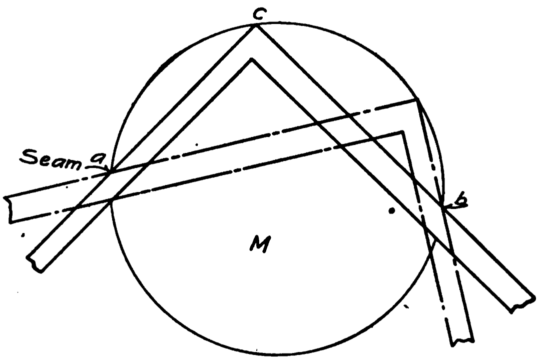

Figure 90.—Method of Finding Position for Ears with the Steel Square.

body. This point is usually marked on the metal before it is formed in the rolls.

If the position of the ear is not marked on the metal before being formed into shape, it can be found by the method shown in Figure 90. Let the circle *M* represent the top of the article. Place the steel square on the cir-

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cle in the position shown by the solid lines. With the outer edge of the blade on the seam at *a*, and the heel touching the circle at *c*, mark the metal where the outer edge of the blade intersects the circle at *b*. This gives the required point for riveting the ear. No measurements are necessary by this method. The square could be placed in the position shown by the dotted lines, obtaining the same result.

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CHAPTER X

RADIAL LINE DEVELOPMENTS

The problems in this chapter will teach in a simple, progressive manner the construction and method of developing the patterns for tapering forms that have for a base the circle, or any of the regular polygons in which lines drawn from the corners terminate in an apex over the center of the base.

Patterns for tapering forms are developed by the radial method, by means of radial lines converging to a common center. When developing such patterns, first draw an elevation showing the true length of the axis, and the true length of the radius with which to describe the stretch-out arc of the pattern. The stretch-out must be described with a radius equal to the length of the true edge of the solid, as shown by *AC*, Figure 91. Then a plan view must be drawn from which the length of the stretch-out can be obtained, as shown by *DEFG* in Figure 91.

The simplest forms of tapering article are the cone and pyramid, and these are applied in the construction of chimney caps, ventilator heads, pitched covers, etc.

The sheet metal worker is frequently required to construct an article in the form of a frustum, or plane section of a cone, and the method used in developing the pattern is simply to develop a pattern for the entire cone and then cut off the upper portion, leaving the desired frustum.

The bodies of well-known tapering articles, such as the furnace hood, funnel, dipper, coffee pot, strainer, bucket, pan, etc., are of this character, and when developing their

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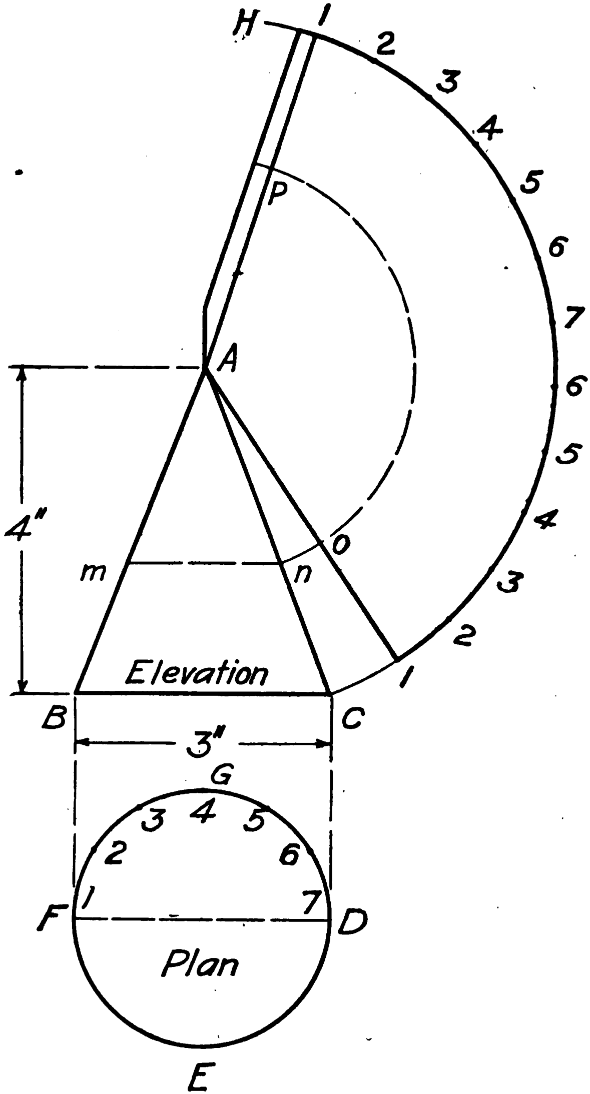

Figure 91.—Radial Method of Developing Pattern for a Right Cone.

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patterns they are treated as the frustums of cones, as referred to above.

Pattern for Cone and Frustum.—In Figure 91 is shown the method of developing the pattern for a right cone, which contains the principles applicable to all frustums of pyramids and cones.

Draw the elevation *ABC*. Then describe a circle to represent a plan view of the base as shown by *DEFG*. Divide one-half of the outline of the base in the plan into a number of equal parts as shown by the figures 1 to 7; from the apex *A* of the cone as center, with a radius equal to the true length of the slant height of the cone as shown by *AC*, describe the stretch-out arc *CH*. On any convenient point on the stretch-out locate point *1* and draw a line from *1* to *A*.

Then set dividers equal to the length of one of the spaces in the plan, and starting at point *1*, mark off spaces equal to twice the number of those on the plan as shown by *1-7-1*, which will make the stretch-out equal in length to the circumference of the base of the cone. From the end point thus located draw a line to the apex *A*, and then add an allowance for seaming. This completes the pattern for the right cone. When adding allowances for seaming flaring work, care should be taken that the added lines are drawn parallel to the edge lines of the net pattern.

When the frustum of a cone is desired as shown by *mnBC*, Figure 91, then the diameter of the small end of the frustum will be equal to *mn*, and the radius to describe the upper edge of the pattern will be equal to *An*. With *A* as center and *an* as radius, describe the arc *op* as shown by the dotted line. Then *op 1-7-1* will be the pattern for the frustum of the cone.

Pattern for a Square Pyramid.—This development is shown in Figure 92 and the same principles used in developing the pattern for a conical-shaped object are ap-

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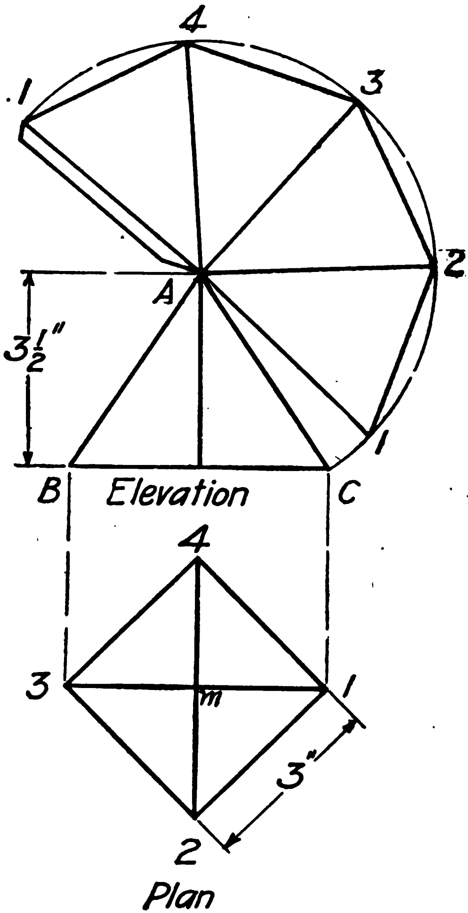

Figure 92.—Pattern for a Square Pyramid.

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plicable to the developments of pyramids having a base with any number of sides. In this case we have a square pyramid.

Draw the elevation as shown by *ABC* and the plan view as shown by *1-2-3-4*, according to the dimensions given in the figure. Next draw the two diagonal lines *1-3* and *2-4*, intersecting in the center at *m*. When the plan view is placed in the position as shown, the line *AC* in the elevation represents the true length of one of the corners of the pyramid. With *A* as center and *AC* as radius the stretch-out arc is described in the same manner as in the case of the cone in the preceding problem. After setting the dividers to the width of one side of the base, as *1-2* in the plan, starting at *1*, mark off on the stretch-out line spaces equal to *1-2-3-4-1* in plan; connect these points by straight lines as shown, and draw lines from each point to the apex *A*, completing the development.

Pattern for a Hexagonal Pyramid.—The development of this problem, as shown in Figure 93, does not differ from that of the preceding problem, except that the line *AD* in the elevation is not the correct radius with which to strike the stretch-out arc, and it is therefore necessary to draw a line that will represent the true length in the elevation. This is found as follows:

First draw the plan and elevation according to the dimensions given in the drawing. From the center *m* draw the line *m-n* at right angles to *6-1* in the plan. From *m* as center with the radius *m-6* describe an arc intersecting line *m-n* at *a*. From *a* erect the perpendicular line intersecting the base line *BD* of the elevation extended at *g*. From *g* draw a line to the apex *A*, which will be the true length of *m-6* in the plan, and is also the radius with which to describe the stretch-out arc. With this radius and the apex *A* as center, describe the stretch-out line.

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After setting the dividers to the width of one of the sides of the base which is shown in the plan, mark off six

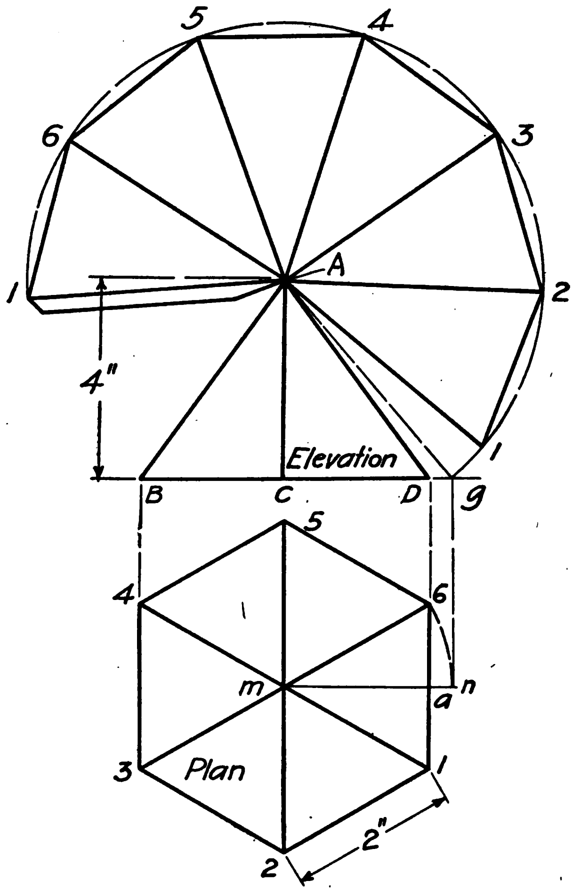

Figure 93.—Pattern for a Hexagonal Pyramid.

spaces on the stretch-out arc, and complete the pattern in the same manner as shown in the preceding problem.

Patterns for these problems should be developed, and models made from sheet metal, thus giving practice in construction. These models will at once show any error in the pattern which might otherwise be overlooked.

Rectangular Pitched Cover.—Sheet metal workers are frequently required to construct ornaments in cornice work, a hood, canopy, or a cover for an article square or rectangular in form. These articles are usually made in the form of a square or rectangular pyramid having a short height or rise to the apex.

Patterns for work of this kind are usually laid out directly on the metal by a short method in which no elevation is required, as the true length of the radius for describing the stretch-out arc is found in the plan. Figure 94 shows the development of a pattern for a rectangular pitched cover by this method.

The half elevation and section can be omitted. They were drawn in this case to show the construction and method of connecting the hoop *B* to the cover shown at *A*. The hoop is a strip of metal of the required width, having a single hem on the lower edge and an edge turned to a right angle on the upper side for seaming, as shown in the section.

The length, width and height of cover being known, first draw a plan to the required size, as shown by *1-2-3-4*. Next draw the diagonal lines intersecting in the center at *m*, which lines represent the hips of the pitched cover in plan. Bisect the line *1-2* and locate the point *x*, then draw a line from *x* to the center *m*, showing the position of the seam. Before describing the stretch-out arc for the pattern, find the true length of one of the hip lines in the plan and use that dimension as the radius for describing the stretch-out.

To find the radius, draw the line *m-o* at right angles to the hip line *m-3* in the plan. The height of the cover as shown by *ad* in the elevation is marked on the line *m-o* at

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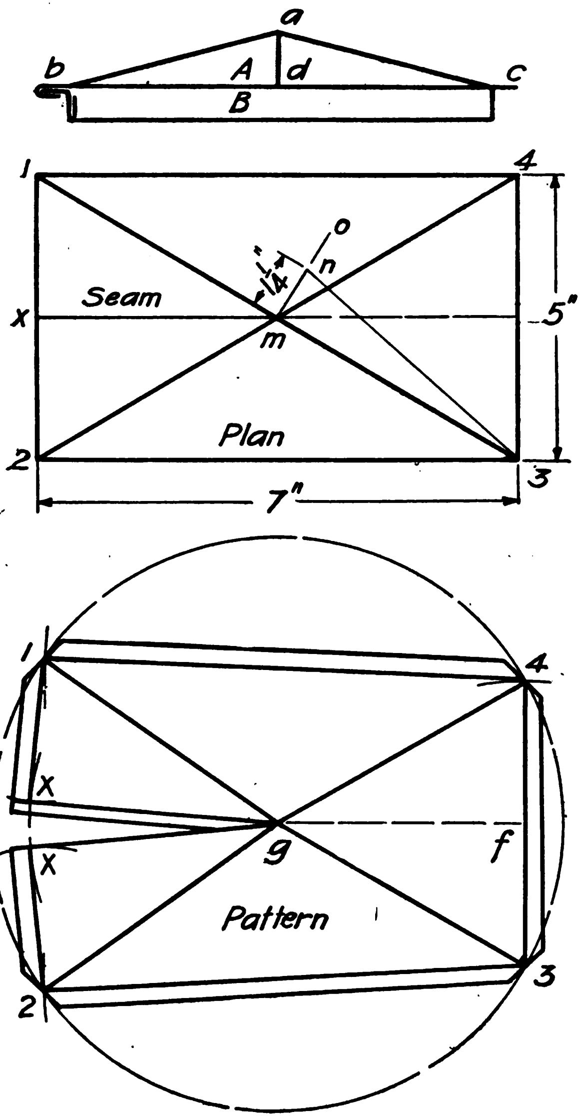

Figure 94.—Pattern for a Rectangular Pitched Cover.

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n. Now draw a line from *n* to *3*; then *n-3* is the true length of the line *m-3* in the plan and is the radius for describing the stretch-out.

After setting the dividers equal to *n-3* in plan, with *g* as center describe a circle on the metal. Starting at any convenient point on the circle, as point *3*, space off the length of the end and sides of the cover as shown by *1-2-3-4* in the pattern. From *1-2* as centers, with a radius equal to one-half the width of the cover as shown by *1-x* in the plan, describe short arcs on the pattern as shown. The true length of the seam line is shown by the dotted line *g-f* in the pattern. Then with *g-f* as radius and *g* as center describe arcs at *x*. Connect all points by straight lines and draw lines from them to the center *g*. This completes the net pattern, to which allowances for seaming are added as shown.

After the pattern has been cut from metal, notch the corners and turn edges on the folder. The pattern is formed by placing the metal on the hatchet stake and bending on the hip lines to the required angle. The lap seam is riveted or soldered, and the hoop is attached to the cover as shown at *b* in the elevation. The edge is then closed down by means of the setting hammer, completing the construction.

Construction of a Flaring Pan.—In Figure 95 is shown a perspective view of a flaring pan, the form of which is seen to be the part or frustum of a cone. It is to be made of IC bright tin, according to the following dimensions:

Diameter of top, 6¼ inches.
Diameter of bottom, 4¾ inches.
Height, 2⅝ inches.

A No. 12 wire is inclosed in the top edge and the bottom is double seamed to the body. The body is made in two pieces cut from a 10x14 sheet of tin. The number of

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pieces in which the body of an article in this form is made will depend upon its size and the material from which it is to be constructed.

In Figure 96 is shown a half elevation, also a half sectional view and the method of obtaining the pattern for a flaring pan made in two pieces. In developing the pattern, first draw the center line *GH*, upon which place the height of the pan, as shown by *AD*. Through these points draw lines at right angles to the center line. On

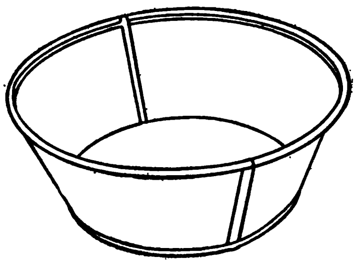

Figure 95.—Flaring Pan, Perspective View.

either side of the center line *GH*, from the points *AD*, place the half diameters *AB* of the top and *CD* of the bottom. Then *ABCD* shows the half elevation, while *AFDE* shows the half sectional view. Draw lines connecting *BC* and *EF* and extend them until they meet the center line at *K*, which is the center point with which to describe the pattern. With *CD* as radius and *D* as center, describe the quarter circle *CM*, and divide it into a number of equal spaces, as shown by the figures *1* to *7*. This quarter circle represents a one-quarter plan of the bottom of the pan.

The pattern is developed as follows: With *K* as center and the radii equal to *KB* and *KC*, draw the arcs *NO* and *RS* as shown. From *N* draw a line to the apex *K*, and starting from the point *R*, space off on the arc *RS*

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the stretch-out of twice the number of spaces contained in the quarter plan, as shown by the figures *1-7-1* on the arc *RS*. From *K* draw a line through *S*, extending it until it intersects the arc *NO* at *O*. Add laps for seaming and wiring, as shown by the dotted lines. This completes the half pattern for the pan.

A one-half elevation and a quarter plan of the top or bottom is all that is required to find the stretch-out and

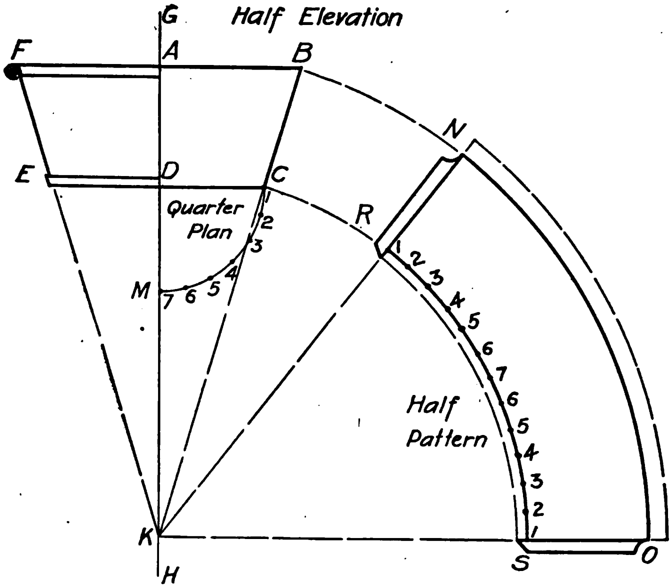

Figure 96.—Development of Pattern for a Flaring Pan.

radius for describing the pattern for the frustum of a cone. The allowances for seaming and wiring are made in the same manner as for the straight work described in previous chapters.

Wiring Flaring Articles.—Articles in the form of a frustum of a cone, such as a coffee pot or liquid measure,

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which have a wire inserted in the edge of the small end or top of the body, are wired while in the flat before being formed into shape; while flaring articles such as pails, pans, etc., having a wire inclosed in the large end, are wired after the body has been formed up and seamed together. A flaring article is to be wired always before seaming the bottom to the body.

Turning a Wire Edge.—Having completed the pattern for the one quart pan, Figure 96, transfer it to metal and cut two pieces from a sheet of 10x14″ bright tin. Notch the upper corners for wiring and the lower corners for seaming, as described in Chapter VIII. Place the two pieces together and form them into a semicircle on

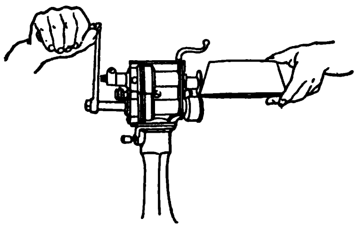

Figure 97.—Turning a Wire Edge on the Folding Machine.

the forming rolls (Figs. 24, 25). Next, turn the edge for the side seams on the folding machine (Figure 16), and then groove the seams and close them down by means of the mallet on the mandrel stake.

The next step will be to turn the edge for the wire. This is done on the small turning machine (Figure 86), in the following manner:

Having made an allowance of ¼ inch to the edge of the pattern for a No. 12 wire, set the gauge on the machine ¼ inch from the center of the depression in the lower roll. Then placing the upper edge of the pan against the gauge, bring down the upper roll and revolve the work in the machine, making a deep depression or bead on the metal.

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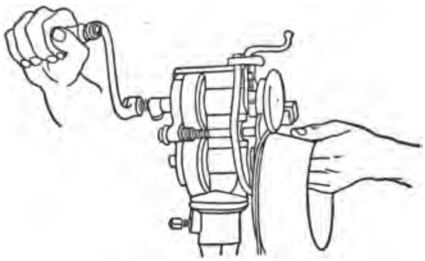
Run the work through the machine several times, gradually raising the work until the edge is turned to the required angle, which will bring the side of the pan to a vertical position, almost touching the upper roll.

When turning a wire edge on the turning machine, it is often a difficult matter to keep the work circular in form; this difficulty can be overcome by pulling the work and rounding it into shape as it passes through the machine.

The edging operation and the position of the workman while operating the machine is shown in Figure 97.



Figure, 98.—Wiring a Flaring Article, Showing Correct Position of the Hands.

Use of Wiring Machine.—After turning the edge for wire, we are ready for the wiring process, which is the same as that described in Chapter VII, except that the wire is formed in the rolls before being inclosed in the edge of the article. First cut a piece of wire about ½ inch longer than the circumference of the top of the pan and form it circular in shape on the forming rolls (Figures 24, 25). Then placing one end of the wire at the side of a vertical seam and under the wire edge, close the metal over the wire for a short distance from the end by means of the hammer and the horn on the standard of the machine, or some suitable stake.

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After setting the gauge on the wiring machine (Figure 57) to the required width, run the work through the rolls, wiring the top about three-fourths of its circumference. By stopping the operation at this point, the end of the wire can be held away from the edge of the metal and easily cut off to the required length by means of the wire cutters. The ends of the wire should fit close together. The work is then run through the rolls, completing the operation. In Figure 98 is shown a wiring machine and the correct position of the hands when wiring a flaring article.

The bottom is now double seamed to the body in the same manner as the bottom for the covered pail, and the process is fully described in Chapter IX. Using rosin as a flux, solder the bottom and the side seams on the inside of the pan, which completes the construction of the problem.

DIMENSIONS OF FLARING PANS

It is important that the student should know something of the standard sizes and dimensions of flaring pans that can be constructed with the least possible waste of material. For this purpose the following schedule of sizes and dimensions is presented:

Size	Diameter of Top	Diameter of Bottom	Height (Inches)
1 Pint	5¾	4	2⅜
1 Quart	6¼	4¾	2⅝
3 Pint	8⅛	6⅜	2½
2 Quart	8⅝	6⅛	3½
6 Quart	12¾	9	4
10 Quart	14¾	9⅜	4⅛

Making a Funnel.—A useful article in the form of a frustum of a cone is the common funnel shown in Figure 99. It is to be made from bright tin or No. 28 galvanized iron, having a No. 12 wire inclosed in the upper edge.

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The vertical height is 3½ inches. The diameter of the top is 5 inches, and the lower opening in the body measures one inch in diameter. The spout is 2 inches long, having a ½-inch outlet, the seam being lapped and soldered. The body is made in one piece, having a ⅛-inch grooved seam on the side.

The body and spout are merely two frustums of cones and the patterns are developed in a similar manner by the radial method as shown in Figure 100. In this figure, the full elevation is drawn, but in actual practice

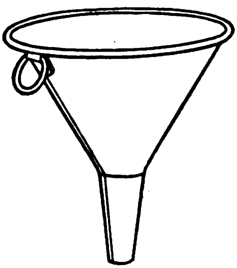

Figure 99.—Common Funnel, in Which Both Body and Spout Are Frustums of Cones.

much extra work can be avoided by drawing only one-half of the elevation, as shown, on one side of the center line *AB*. This is done to simplify the work and to avoid the drawing of unnecessary lines. To develop the patterns, extend the side lines of the body and spout until they intersect the center line at *M* and *G*. For the pattern for the body proceed as follows:

With *g* as center and radii equal to *GF* and *GE*, describe the arcs *ee* and *ff* of the pattern. On the arc *ee* step off four times the number of spaces contained in the quarter plan *C;* then draw lines to the center *g*. Add laps for seaming and wiring.

The pattern for the spout is developed in a similar

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manner, with a lap added to the upper edge and side for soldering.

After the pattern has been cut from metal, notch the corners, and turn the edge for the side seam on the folding machine. When the outline of the pattern is a semi-

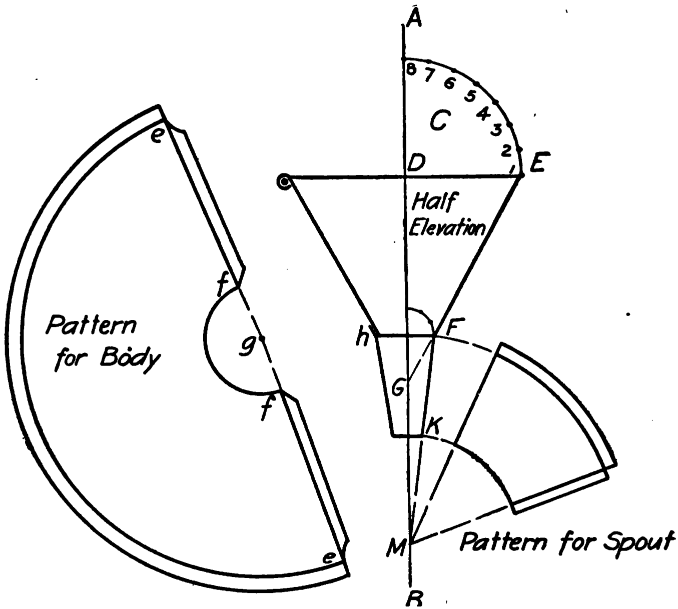

Figure 100.—Patterns for Funnel Body and Spout, Developed by the Radial Method.

circle or larger, place the work in the folder and bend the edge to a right angle, then finish the operation by means of the mallet on the hatchet stake. The patterns are now formed on the blowhorn stake, after which the side seam of the body is grooved and the upper edge is wired in the same manner as described in the preceding

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problem. The spout is slipped over the lower end of the funnel and soldered in position, as shown at *h*.

Flaring Liquid Measure.—Another application of the processes of wiring and seaming of flaring articles is the construction of flaring measures. These measures are usually made from bright tin, having a wire inclosed in the upper edge, and the bottom double seamed to the body.

When constructing measures of small size, the upper edge of the lip and side edges of the handle are usually hemmed, in the same manner as the one-quart lipped measure described in Chapter VIII. For the larger measures, greater strength is obtained by wiring these edges. As they must hold a given quantity when completed, the greatest accuracy is required in developing the patterns and in making the allowances for wiring and seaming.

DIMENSIONS OF FLARING MEASURES

While there are various proportions used by different workmen and for different purposes, the following schedule is one that is commonly used by sheet metal workers in commercial shops. The table presented gives the height, bottom and top diameters for flaring liquid measures from ¼ pint to 5 gallons.

Size	Top Diameter	Bottom Diameter	Height
¼ Pint	$2\frac{1}{16}$ in.	2¼ in.	2¼ in.
½ Pint	2¼ "	2½ "	2⅜ "
1 Pint	$2\frac{11}{16}$ "	3 "	$4\frac{9}{16}$ "
1 Quart	3¼ "	4 "	$5\frac{7}{16}$ "
½ Gallon	3½ "	$5\frac{3}{16}$ "	7¾ "
1 "	5 "	6½ "	8⅞ "
2 "	6¾ "	8¾ "	9¾ "
3 "	8 "	10½ "	10¼ "
4 "	8½ "	11 "	$12\frac{5}{16}$ "
5 "	9½ "	12½ "	$12\frac{1}{16}$ "

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One-Half Gallon Measure.—Assuming that a one-half gallon measure is to be made from IX bright tin, the pattern for the body is developed by the radial method, as

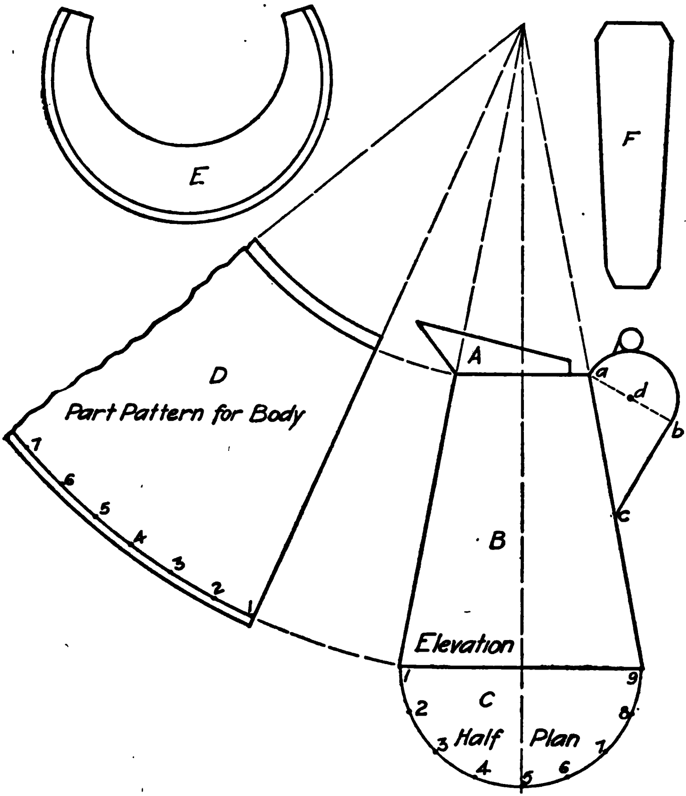

Figure 101.—Patterns for One-Half Gallon Measure, with Lip.

described in preceding problems. Using the dimensions given in the foregoing table, first draw the elevation and half plan as shown by *ABC* in Figure 101. Next lay out

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the pattern for the body in the usual manner and add allowances for wiring and seaming, as shown by the part pattern *D*. The pattern *E* for the lip is laid out by the short method shown in Figure 71, an allowance for a No. 14 wire being added to the upper edge. The pattern for the handle is shown at *F*. The length of this pattern is found by spacing the outline of the handle, as shown by *abc* in the elevation; to this dimension add laps at each end for soldering.

The handle is strengthened by inclosing a No. 13 wire in the side edges. After the patterns have been cut from metal, notch the corners, and turn edges on the folding machine (Figure 16) for wiring the handle and seaming the body. The edge for wire is now turned on the upper edge of the body and lip by means of the small turning machine (Figure 86), and wired in the usual manner on the wiring machine (Figure 57).

Next form the body, lip and handle in the forming rolls (Figures 24, 25), but do not place the wired edges in the grooves on one end of the rolls when passing the work through the machine. The bottom is double-seamed to the body, the lip and handle soldered in position, completing the problem.

Flaring articles in the form of a frustum of a cone, such as measures, pans, tapering pipes, etc., can be easily shaped on the forming rolls.

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CHAPTER XI

PITCHED COVERS AND FLARING ARTICLES

The problems in this chapter are some of the many articles made by the sheet metal worker in which the patterns are developed by the radial method described in Chapter X.

In Figure 102 is shown a sheet metal can, cylindrical in form, with a pitched cover inclosing the top. These cans

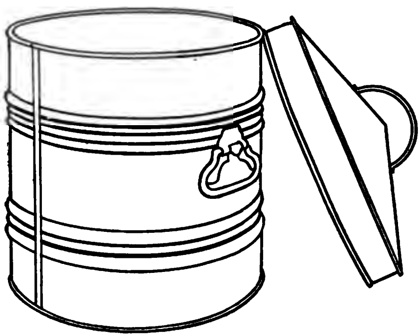

Figure 102.—Sheet Metal Waste Can with Pitched Cover.

are made from tin and galvanized iron, in a variety of sizes and for different purposes. The pitch of the cover can be varied at the pleasure of the workman.

The rim of the cover can also be made flaring in shape and fitted to the inside of the article in the same manner as the one-quart pail cover shown in Figure 84. As the sheet metal worker is often required to construct cans and tanks that will hold a given quantity, the following table

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is presented, giving the size, diameter, and height for cans from 1 to 200 gallons in capacity.

DIMENSIONS OF CANS AND TANKS

Gallon	Diameter	Height
1	6¾	6¾
2	8½	8¾
3	9	11½
5	10½	13¾
6	11½	13½
8	13½	13½
10	13½	16½
15	15½	19
20	17½	19½
20	16	23
25	18	23
30	18½	26½
35	18½	30½
40	18¾	34
45	19½	35
50	20½	35
55	21¼	36
60	22	37
65	22½	38
70	23	40
75	23½	40
80	24½	40
85	25	40
90	24½	45
95	25	45
100	26	45
125	27½	50
150	29	52½
175	30	57½
200	30¾	64

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The waste can, Figure 102, shows the pitched cover having a straight rim 1½ inches wide fitted over the outside of the body. This style of cover is generally used when constructing flour cans and receptacles for waste material of various kinds. The body of the can is 12 inches in diameter. The height is 14 inches. The ma-

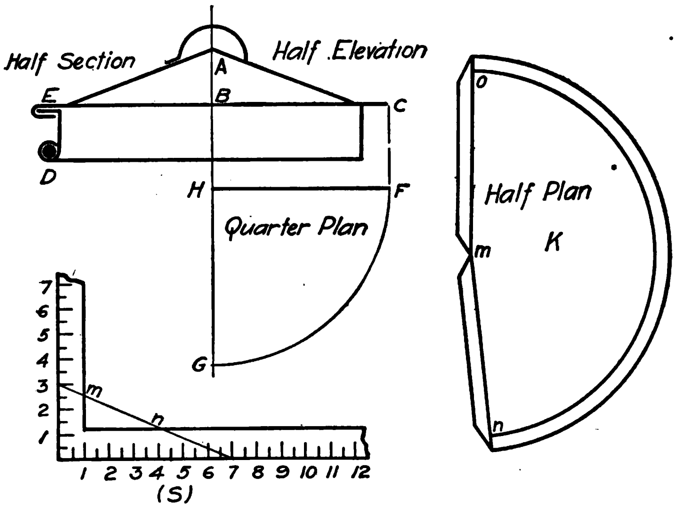

Figure 103.—Development of Pattern for Pitched Cover: *s*, Section of Steel Square and Method of Use in Laying Out Pattern.

terial used is No. 26 galvanized iron and a No. 8 wire is inclosed in its upper edge. An edge ¼ inch in width is used for the grooved side seam, and the bottom is attached to the body by a double seam in the usual way. The body is strengthened by several ogee beads. Tinned malleable iron handles are placed in position on the side as shown in the illustration.

Pattern for a Pitched Cover.—Figure 103 shows the method of obtaining the pattern for the pitched cover,

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which is in the form of a complete cone and is made in two pieces. First, draw the half elevation as shown by *ABC*. Make *AB* equal to the altitude and *BC* equal to one-half the diameter of the cover. With *BC* as radius and *H* as center, describe the arc *FG;* then *HFG* will represent a one-quarter plan view of the cover. With *m* as center and radius equal to *AC,* describe the arc *no* of the half pattern *K*. On this arc, step off twice the number of spaces contained in the one-quarter plan, then draw lines from *no* to *m,* and add laps for seaming, as shown.

After the edges have been turned on the bar folder, the two pieces are formed by hand and joined together with a grooved seam. The cover is now flanged and seamed to the rim, as shown at *E*. These operations are fully described in Chapter IX. The rim of the cover is simply a circular band of metal, having the lower edge wired and the upper edge burred, as shown at *D* and *E,* Figure 103.

Use of Steel Square.—Although the drawings for this problem are to be made on the drawing board, in actual practice many workmen lay out the pattern by means of the steel square and dividers directly upon the sheet metal, without the use of any drawing. This short method can be used for developing the patterns for cones and pitched covers of any diameter or height.

Assuming that a pitched cover 14 inches in diameter and 3 inches high is to be made in two pieces, to obtain the pattern by this method proceed as follows: At *S* in Figure 103 is shown the section of a steel square. Place one point of the dividers on the vertical arm of the square at *3*, which is the height of the cover, and the other point at *7*, which is one-half the diameter; the distance shown by the line *mn* will be the true radius with which to describe the stretch-out arc of the pattern. With a radius equal to *3-7*, and with any point, as *m* in

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the half pattern, as center, describe the arc *no*. To find the length of the stretch-out of the full pattern, multiply the diameter 14 by 3.1416, which will equal 44 inches. Set the points of the dividers 1 inch apart, and step off 22 spaces on the arc *no*. Draw lines from *n* to *m* and *o* to

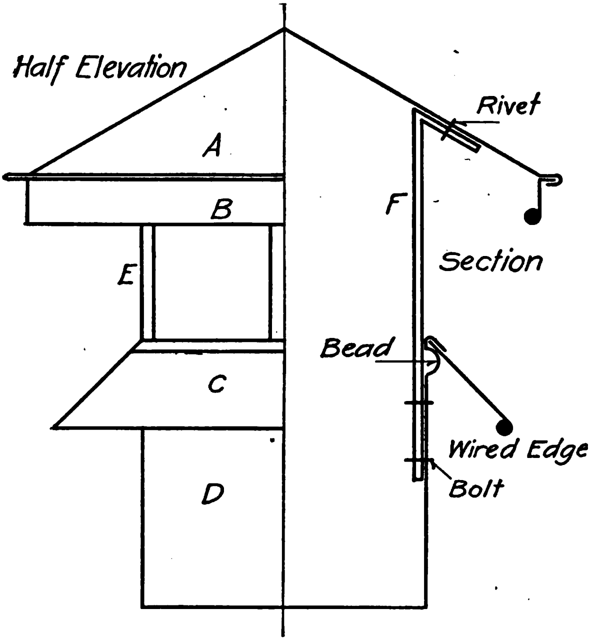

Figure 104.—Half Elevation and Details of Round Ventilator Head

m, and add laps for seaming, which will complete the one-half pattern for the cover.

Round Ventilator Head.—A ventilator head which is used for a variety of purposes, and with equal efficiency as the top for a smoke jack or a ventilator cap, is shown in Figure 104. The proportions are varied somewhat by

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different workmen. The rule usually employed is to make the upper hood *A* and the lower flange *C* twice the diameter of the pipe *D*. The supports *E* and *F* are generally made from band iron, riveted to the hood and pipe as shown in the drawing. The straight flange *B* is merely a band of metal, having the lower edge wired and the upper edge attached to the top in a similar manner as the rim of the pitched cover described in this chapter.

The drawing, Figure 104, is made to a scale of 3 inches to the foot, and represents a ventilator having a 6-inch

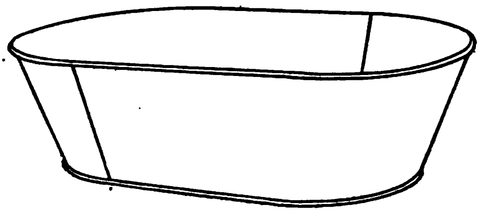

Figure 105.—Oblong Flaring Pan with Semicircular Ends.

opening. The half-section shows the construction and method of assembling the different parts.

To construct the ventilator, first draw the elevation full size, making it four times larger than the scaled drawing. The lower flange *B* has an inclination of 45° and the pitch of the upper hood *A* is at an angle of 30°. Since the upper hood is simply a flat cone, and the lower flange the frustum of a cone, the development of their patterns needs no explanation, as the method has been fully described in Chapter X.

Flaring Oblong Articles with Semicircular Ends.—Figure 105 shows a finished view of a flaring oblong pan with semicircular ends. The body is made in two pieces, having a wire inclosed in the top edge and the bottom double seamed in the usual manner. Articles of this form are made in various sizes and for different purposes.

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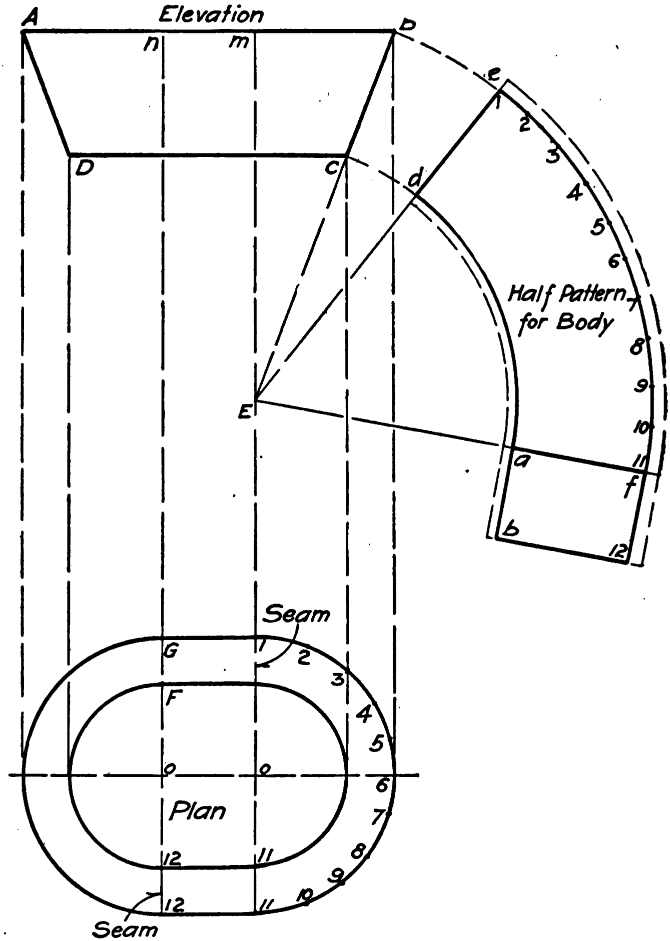

Figure 106.—Pattern for Oblong Flaring Pan with Semicircular Ends.

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The dimensions of the pan shown in the illustration are as follows: Top 11x15 inches, bottom 8x12 inches, vertical height $4\frac{1}{4}$ inches. The method of developing the pattern is shown in Figure 106.

Draw the elevation *ABCD* according to the given dimensions; next, draw the plan of the top and bottom, the semicircular ends being struck from the centers *o* and *o*, with the radii *oF* and *oG* equal to one-half the width of the top and bottom. Divide the outer arc into a convenient number of equal spaces, as shown from *1* to *11*. From *o* erect the perpendicular line *om*, then extend the

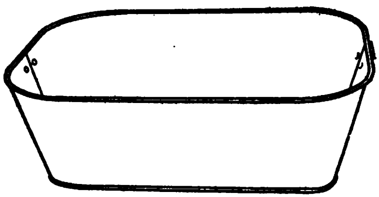

Figure 107.—Oblong Flaring Pan with Quarter-Circle Corners.

line *BC* in the elevation until it intersects the line *om* at *E*, which is the center with which to describe the arcs of the pattern. With *E* as center and radii equal to *EB* and *EC*, describe the arcs *da* and *ef*. Now, from any point on the outer arc, draw a line from *e* to the center *E*. Starting at point *1*, step off the stretch-out of the pattern, making it equal in length to the semicircle, as shown from *1* to *11* in the plan. From point *11*, draw a line to the center *E*, intersecting the lower arc at *a*. Then at right angles to the line *11a* draw the lines *11-12* and *ab*, making them equal to the straight side of the plan, as shown by the figures *11* and *12* in the plan.

This completes the pattern, with the exception of the allowances for seaming and wiring. Since these allowances differ in no way from those of preceding prob-

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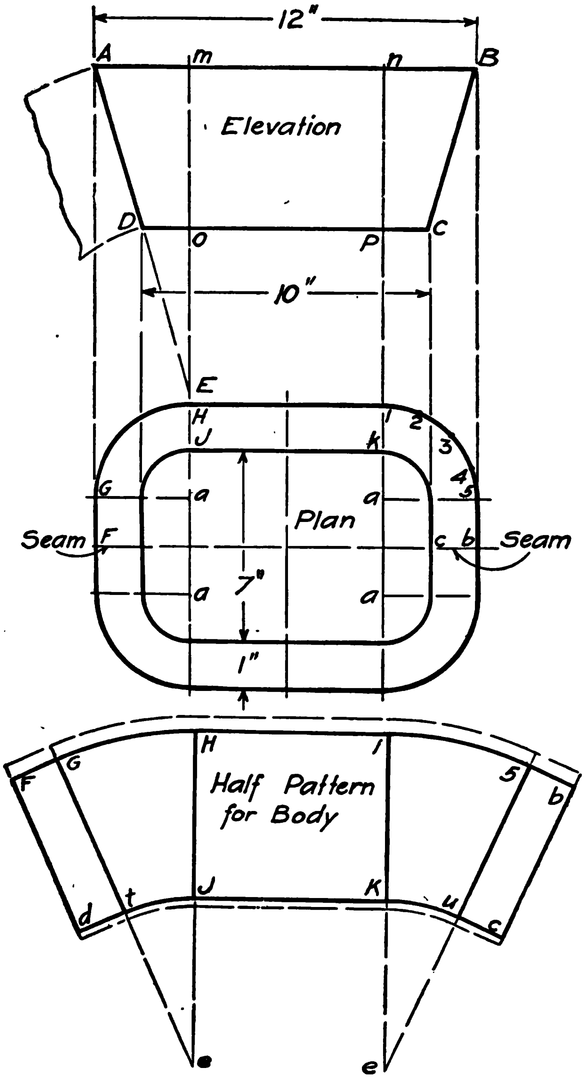

Figure 108.—Pattern for Oblong Flaring Pan with Quarter-Circle Corners.

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lems, they need no further explanation. The pattern for the bottom is laid out by merely adding an allowance for double seaming to the outline of the bottom shown in the plan view.

Oblong Article with Quarter-Circle Corners.—Another application of the processes of double seaming and wiring is the construction of a flaring article having straight sides and quarter-circle corners. Since problems of this form frequently occur in the sheet metal trades, the construction and method of developing the patterns should be thoroughly mastered by the student and workman. The common form of this article is shown in Figure 107. The body is made in two pieces; the top edge is wired and the bottom attached by a double seam. The method of obtaining the pattern is shown in Figure 108.

First draw the plan and elevation in accordance with the dimensions shown on the drawing. The quarter-circle corners of the top and bottom are struck from the four centers shown by *a* in the plan, the radius of the arcs for the corners of the bottom, as shown by *aj*, being 1½ inches. Draw the perpendicular lines *am* and *an*, then extend the side *AD* of the elevation until it intersects the line *am* in the point *E*, which gives the height of the cones, portions of whose frustums are to form the corners of the finished article. Next, by the line *Fb*, divide the plan into two equal parts, then divide one of the outer quarter-circles into a convenient number of equal parts, as shown by the figures *1* to *5*.

To lay out the half-pattern for the body, first draw the line *H1* equal in length to *H1* in the plan, and at right angles to this line draw the lines *He* and *1e*, equal in length to *AE* in the elevation. Make *HJ* and *1K* equal to the slant height of the side shown by *AD* in elevation. Then with *e* and *e* as centers and radii equal to *eK* and *e1*, describe the arcs *1-5* and *Ku*, also the arcs *HG* and *Jt*. Starting at points *H* and *1*, step off the stretch-out

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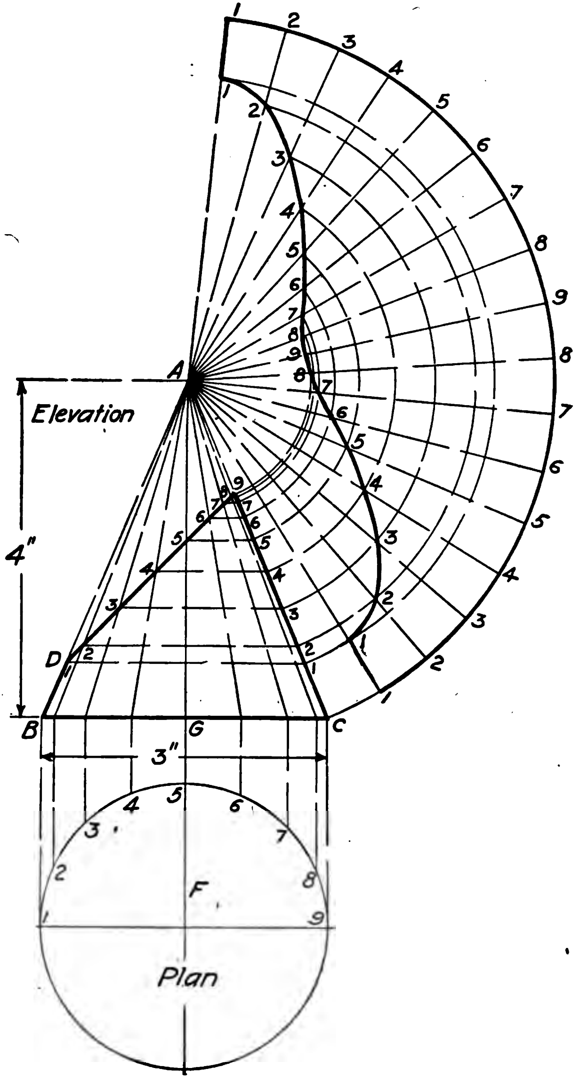

Figure 109.—Method of Obtaining Pattern for the Frustum of a Right Cone.

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of the arcs of the pattern, making *1-5* and *HG* equal in length to the quarter-circle shown in the plan by the figures *1* to *5*.

From points *5* and *G*, draw lines to the centers *e* and *a*, and at right angles to these lines, draw the lines *GF* and *td* on the left, and *5b* and *uc* on the right, equal in length to one-half the straight end of the pan, shown by *FG* in the plan. Connect these points and add laps for wiring and seaming. The pattern for the bottom is found by merely adding to the outline of the bottom shown in the plan, the allowance required for the double seam.

Pattern for Frustum of Right Cone.— The problems in radial developments up to this point have been what we might call articles in the form of a cone and the frustum of a cone having the upper and lower bases parallel or in the same plane. When constructing flaring roof collars, gutter outlets, and various articles in the form of a cone having the upper or lower end cut by a plane other than parallel to its base, the development is somewhat different.

Figure 109 shows the method of developing the pattern for the frustum of a right cone cut by the plane represented by the line *D9*. First draw the elevation of the cone *ABC*, and directly below it the plan view *F*. As both halves of the cone are symmetrical, it will be necessary to divide only one-half of the outline of the plan *F* into equal spaces, as shown by the figures *1* to *9*. Next represent the cutting plane *D9* by a line drawn at an angle of 45° with the base line *BC*, making the point *D* one inch from *B*. From the various points in the plan erect lines intersecting the base of the cone from *1* to *9*. From these points on the base line, draw radial lines to the apex *A*, intersecting the line *D9* as shown. From these points of intersection on the line *D9*, and at right angles to the axis line *AG*, draw lines as shown intersecting the side of the cone *AC*.

Then using *A* as center with *AC* as radius, describe

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the stretch-out arc. From *1*, draw a line to the apex *A*, and starting from point *1*, step off on the arc twice the number of spaces shown in the plan *F*, by the figures *1-9-1*. From these points draw radial lines to the apex *A*. Then, using *A* as center, with radii equal to the various points which are shown in their true length on the

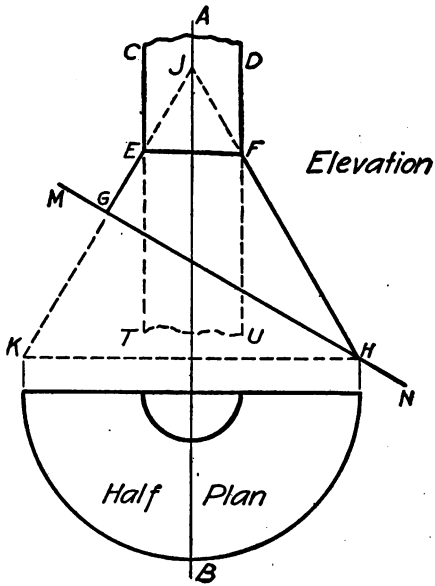

Figure 110.—Half Plan and Elevation of a Flaring Roof Collar.

line *AC*, draw arcs intersecting similar numbered radial lines in the pattern. The irregular curve is now traced through points thus obtained, which completes the desired development.

Flaring Roof Collar.—The principles used in developing the pattern for the intersected cone shown in Fig-

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ure 109 are applicable, no matter at what angle or point the bases of the cone are intersected. The workman will apply these principles in developing the pattern for a flaring roof collar shown by *EFGH* in Figure 110. A roof collar of this kind is commonly used by plumbers and sheet metal workers to secure a watertight joint when flashing around stacks and vent pipes that extend through the pitched roof of a building.

First, draw the center line *AB* and then draw the roof line *MN* at an angle of 30°. Next draw the outline of the vertical pipe shown by *CDTU*, and make the upper base of the collar *EF* at any convenient distance from the roof line. At a proper angle, draw the side lines of the collar through the points *EF* extended until they meet at the apex *J*. Next draw the horizontal line *HK*, and extend the side line *JG*, intersecting the line *HK* at *K*, as shown by the dotted lines. Then *JKH* will represent a right cone which is cut off on the lines *EF* and *GH*. The pattern is now developed in the same manner as the previous problem.

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CHAPTER XII

PARALLEL LINE DEVELOPMENT

Practical workshop problems, such as arise in every day practice, in which the patterns are developed by means of parallel lines, will now be presented. This method is used in laying out patterns for elbows, tee joints, roof gutters, skylights, cornices, etc. All of the problems should be carefully studied and the patterns drawn accurately. Unless the drawings are exact, they are of no value. There are certain fixed principles that apply to developments by this method, and the following rules should be carefully observed by the student and workman:

1. A plan and elevation must first be drawn, showing the article in a right position, in which the parallel lines of the solid are shown in their true length.
2. The pattern is always obtained from a right view of the article in which the line of joint or intersection is shown.
3. A stretch-out, or girth line, is always drawn at right angles to the parallel lines of the articles, upon which is placed each space contained in the section or plan view.
4. Measuring lines are always drawn at right angles to the stretch-out line of the pattern.
5. Lines drawn from the points of intersection on the miter line in the right view, intersecting similarly numbered lines on the stretch-out, will give the desired pattern.

Two-Pieced Elbow.—Figure 111 demonstrates the method of developing the patterns for a two-pieced 90° elbow.

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First draw the elevation *ABCDE7*. Then below the elevation describe a circle representing the profile or plan, shown at *F*. As each half of the pattern is symmetrical, draw a line through the plan *F*, and divide the upper half of the circle into a number of equal parts, as shown from *1* to *7*.

From these points perpendicular lines are drawn intersecting the miter line *C-7* as indicated. Then at right

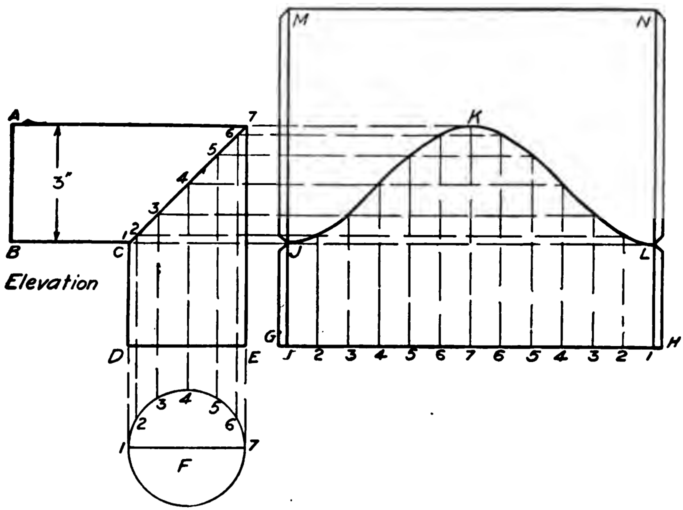

Figure 111.—Patterns for Two-Pieced 90° Elbow.

angles to the lower arm of the elbow *E-7*, draw the stretch-out line *GH*, and upon this line step off twice the number of spaces indicated in the plan, which will give the circumference of the elbow, as shown by the points *1-7-1* on the line *GH*. From these points and at a right angle to *GH*, measuring lines are erected and intersected by like numbered lines drawn at a right angle to the cylinder from similar numbered points of intersection on

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the miter line *C-7* in the elevation. A line traced through points thus obtained will be the pattern for the lower arm of the elbow, as shown by *GHLKJ*.

The manner of laying out the pattern for the upper arm of the elbow may need some explanation. The irregular curve traced through the points of the pattern is the only one required for both pieces of the elbow. The stretch-out of both pieces being of equal length, extend the outer lines of the pattern to *M* and *N* as pointed

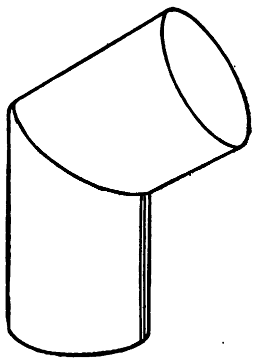

Figure 112.—Round Conductor Elbow.

out, and make *JM* and *LN* equal in length to the long side of the upper arm as shown by *A-7* in the elevation. Draw a line from *M* to *N;* then *JKLNM* will be the pattern for the upper arm of a two-pieced elbow. Allowances for seaming or riveting must be added as indicated. This method of development is applicable to any pieced elbow, no matter what angle is required.

Conductor Elbow.—An article often required to be made up from tin plate, sheet copper, and galvanized iron, is a round conductor elbow, shown in Figure 112. It is usually made at other than a right angle, to allow for drainage purposes.

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Figure 113 shows the elevation and plan view of a two-pieced conductor elbow, the circle representing the plan or profile being 3 inches in diameter. Draw the elevation and let *DEF* be the required angle. The miter line of a

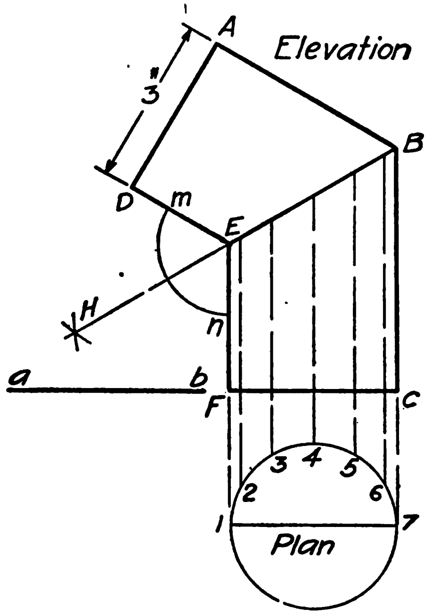

Figure 113.—Elevation and Plan of Two-Pieced Conductor Elbow.

two-pieced elbow is always found by bisecting the angle and is obtained as follows:

With *E* as center and any convenient radius describe the arc *mn*. With a slightly larger radius and *m* and *n* as centers, describe two arcs, intersecting at *H*. Then draw the line *HB*, which is the bisector of the angle *DEF*, and *EB* is the required miter line of the elbow.

The upper half of the plan is spaced into a number of equal parts, and from these points vertical lines are

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drawn, intersecting the miter line *EB* in the elevation. The stretch-out line as shown by the line *ab,* is now drawn at right angles to the lower arm of the elbow, and the patterns for both arms are laid out in the same manner as the 90° elbow. This development is shown fully in Figure 111 and the workman should have no trouble in completing the problem.

Pipe and Roof Flange.—A roof flange used by plumbers and sheet metal workers when flashing around vent

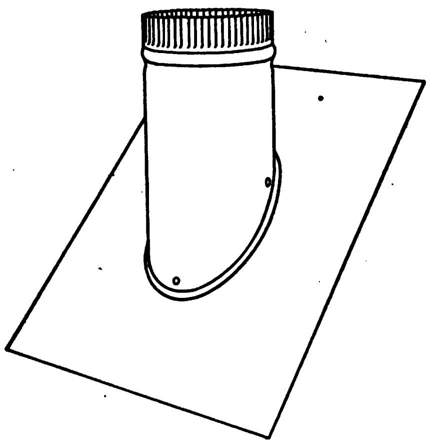

Figure 114.—Pipe and Roof Flange.

pipes and stacks that come through the slanting sides of a roof, is shown in Figure 114. As may be seen by the illustration, the roof flange is merely a flat plate of metal which is seamed to a cylinder or pipe having one end cut at an angle equal to the pitch of the roof.

Figure 115 shows the method of developing the pattern for the pipe and the opening in the roof plate. First draw the roof line *BC* at an angle of 45°, which will show the pitch of the roof. Then draw a side view of the

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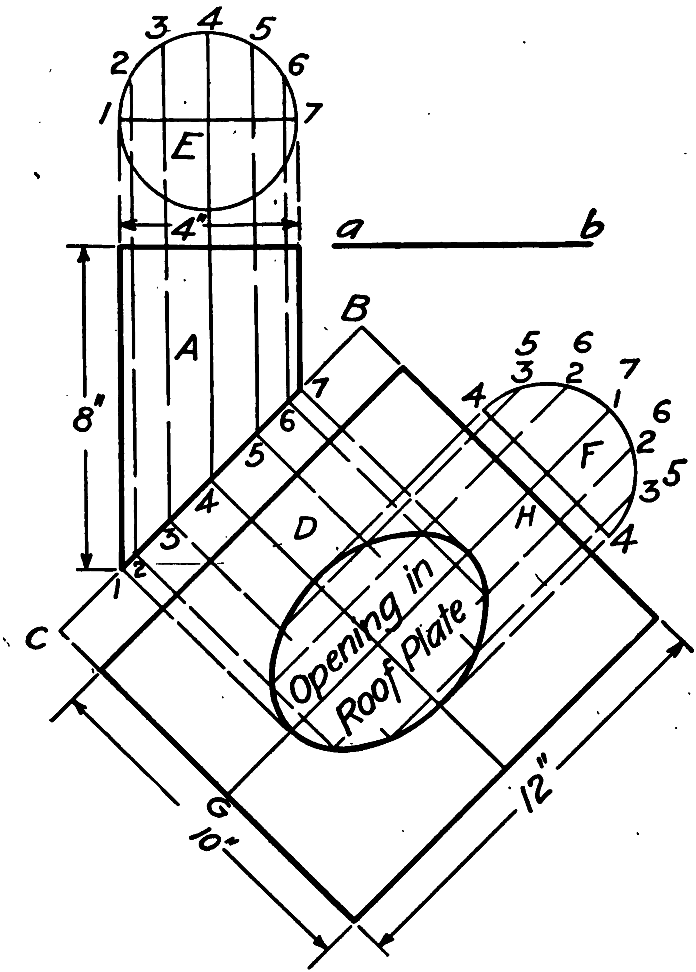

Figure 115.—Method of Obtaining Pattern for Pipe and Opening in Roof Plate.

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half of the circle is divided into a convenient number of pipe *A* and its section, indicated by the circle at *E*. One equal parts, and from these points parallel lines are drawn, intersecting the roof line *BC* as shown.

We are now ready to develop the pattern for the pipe *A*, which is a cylinder having one end cut at an angle of 45°. Draw the stretch-out line *ab* at right angles to the vertical side of the pipe, and obtain the pattern in a manner similar to the development of the lower arm of the two-pieced elbow shown in Figure 111.

The pattern for the opening in the roof plate is developed in the following manner:

First draw lines at right angles to the roof *BC* from the points *1* to *7*. Then at right angles to these lines

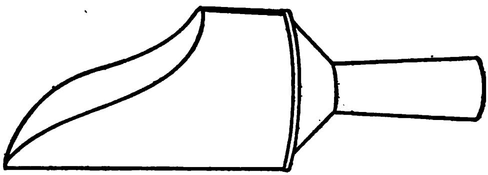

Figure 116.—Common Hand Scoop.

draw the line *GH* through the center of the roof plate *D*. On the line *GH* place half of section *E* as shown by *F*, and divide the half circle into the same number of equal spaces to correspond to the half-section *E*. From these points in *F* draw lines parallel to *GH*, intersecting similar numbered lines that have been drawn from the points on the line *BC*. A line traced through the points thus obtained will be the pattern for the opening in the roof plate.

Hand Scoop.—A typical hand scoop, commonly used, is represented in Figure 116. The illustration shows that the body is in the form of an intersected cylinder, and the handle and the brace are the frustums of two right

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cones. This problem, as presented, will require the development of patterns by both the parallel line and radial methods. In the construction of the patterns no prin-

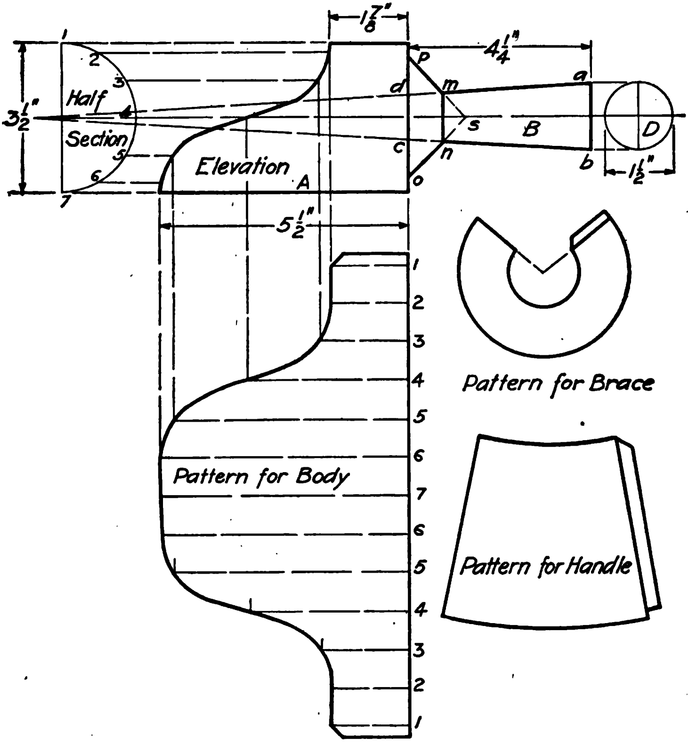

Figure 117.—Patterns for Body, Brace, and Handle of Hand Scoop.

ciples are employed other than those used in previous problems already given in this course.

To obtain the patterns, first draw the side elevation and half section to the dimensions shown in Figure 117. Divide the half section into a number of equal spaces, as

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shown from *1* to *7*, and from these points draw parallel lines intersecting the curved edge of the scoop as indicated. This curved edge can be drawn to any angle or shape at the pleasure of the workman.

To obtain the pattern for the body of the scoop, draw the stretch-out line *1-7-1*, upon which step off twice the number of spaces contained in the half section. From these points on the stretch-out line draw horizontal lines, which are intersected by vertical lines drawn from similar numbered points on the curved edge of the scoop, shown in the elevation. A line traced through these points will give the pattern for the body, to which laps are added for a 1/8-inch grooved seam. The scoop handle *B* is the frustum of a cone, shown by *abcd*, which is soldered to the center of the flat back of the scoop.

The conical brace is shown by *mnop*. The patterns for the brace and handle are shown in the drawing, and the method of development has been fully described in previous problems. The pattern for the back is simply a flat circular piece of metal, equal in diameter to the body of the scoop, to which allowances are added for seaming. The pattern for the end of the handle is a circular piece of metal, equal in diameter to the large end of the handle, shown at *D*. This disc is cut from the flat metal by means of a hollow punch of the required size. It is then placed in the opening and soldered in position.

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CHAPTER XIII

PIPE INTERSECTIONS AND TEE JOINTS

Pipes of the Same Diameter.—Figure 118 shows the method of developing the patterns for a T, or tee joint, or the intersection of two cylinders of the same diameter at right angles. Draw the half plan and elevation, making both pipes 3 inches in diameter. Make the height of the vertical pipe *A* 6 inches, and the short side of the horizontal pipe 1½ inches. Draw the half section of the horizontal pipe *B* and divide it into a number of equal parts, as shown in *1* to *7* in *D*. Then divide the half plan into the same number of spaces, placing the numbers in their proper positions, as shown.

In the half section *D* of the horizontal pipe the points *1* and *7* are on the top and bottom, while the point *4* is on the long side of the pipe, and when looking down upon the end of the vertical pipe, point *4* will intersect the vertical pipe on the side, as shown by point *4* in the half plan. Now draw horizontal lines from the points in section *D*, which are intersected by vertical lines drawn from similar numbered points in the half plan *C*. Lines traced through these points of intersection will give the miter line. The two pipes being of the same diameter, the miter is represented on the drawing by straight lines at an angle of 45°, shown by *abc*.

To obtain the pattern *E* for the horizontal pipe *B*, draw the stretch-out line *mn*, upon which step off twice the number of spaces contained in the half section *D*. From the various points on the stretch-out line of the pattern, draw horizontal measuring lines which intersect by vertical lines drawn from similar numbered points

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on the miter line *abc*. Trace a line through these intersections, shown by *defg,* and the desired pattern is secured.

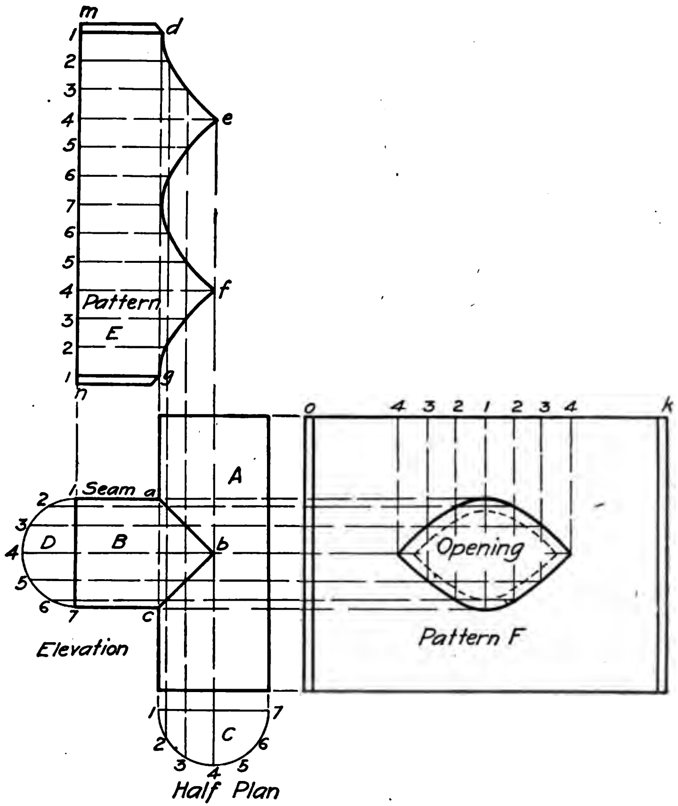

Figure 118.—Development of Patterns for a T or Tee Joint.

The pattern *F* for the vertical pipe *A* is simply a rectangular piece of metal, the width being equal to the height of the pipe and the length equal to its circum-

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ference. The pattern for the opening to be cut in pattern *F,* to receive the pipe *B,* is laid out in the following manner:

Upon the upper edge of the pattern, shown by the line *ok,* locate point *1,* which will be the center of the opening. On each side of point *1* step off the spaces shown from *1* to *4* in the half plan *C,* which will give the length of the opening. From these points on line *ok* draw vertical lines, which intersect by horizontal lines drawn from similar numbered points on the miter line *abc* in the elevation. A line traced through these

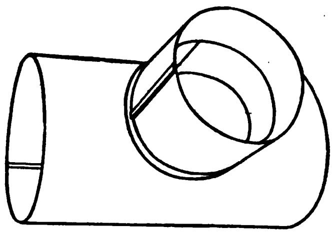

Figure 119.—T-Joint in Pipes of Different Diameters, Angle of 90°.

points of intersection will give the pattern for the opening. An allowance added for seaming is shown by the dotted line drawn parallel to the outline of the opening.

After the pattern for the vertical pipe has been transferred to metal, the opening is cut on the dotted line by means of the circular snips. Using the points of the straight snips, the lap is then notched, making the cuts about ½ inch apart around the entire opening.

The pipe is now formed up and seamed in the usual manner. Then using the flat pliers, bend the notched lap outward to fit inside the horizontal pipe, which is slipped over the flange thus made and can be soldered or riveted in position.

When constructed from black iron, the short stub is

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slipped over the flange and one or two rivets placed on each side at point *b* in the elevation. The flange is then closed tightly against the pipe on the inside by means of the hammer, making a tight, rigid joint between the two pipes.

Pipes of Different Diameters.—Figure 119 shows the finished view of a T-joint, the pipes being of different

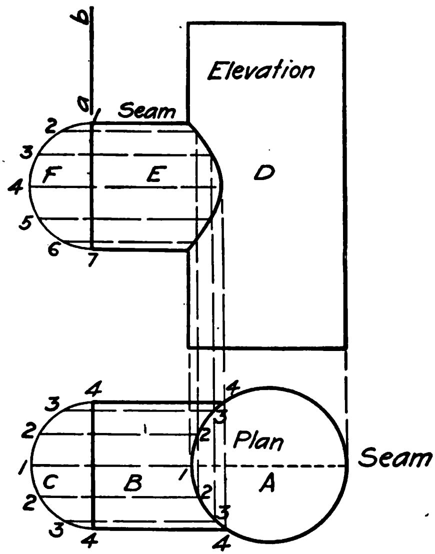

Figure 120.—Plan and Elevation for Right Angled Pipe Joint.

diameters, the horizontal pipe being placed in the center of the vertical pipe at an angle of 90°. Applying the method given in Figure 118, develop the patterns for the inclined pipe, also the opening in the vertical pipe.

First draw the plan and elevation shown in Figure 120; make the diameter of the large pipe *A* 4 inches and of the small pipe *B* 3 inches. The height of the vertical pipe *D* is 7 inches and the length of the shortest side of

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the horizontal pipe is 3 inches. After the outline of the small pipe *B* has been drawn in the plan-view, draw the half section *C* and divide it into a number of equal spaces. Then draw horizontal lines from these points, intersecting the large circle *A* as shown in the drawing. Next draw the half section *F* on the end of the small pipe in the elevation, which must be a duplicate of the half circle *C* in the plan, and is divided into the same number of spaces, the points being numbered in their proper position.

From these points in section *F* draw horizontal lines which are intersected by vertical lines drawn from similar numbered points on the large circle *A* in the plan. A curved line traced through these points of intersection will give the miter line between the two pipes.

To develop the pattern for the small pipe, draw the stretch-out line *ab* and proceed in the same manner as explained in the previous problem.

The pattern for the opening in the large pipe is obtained in the same manner as the opening in the vertical pipe shown in Figure 118. The stretch-out of the opening is shown by the figures *4-1-4* in the plan. The spaces being unequal in width, they must be transferred separately to the stretch-out line of the pattern.

Joining the Pipes.—The two pipes can be joined together by the method described in the previous problem, but if it is desired to make a more substantial connection, the method commonly used by the sheet metal worker when joining two pipes of unequal diameters is shown in Figure 119, and the joint is made in the following manner:

After the small pipe has been formed up and seamed, turn a flange about ¼ inch wide on the curved end, by means of the rounded end of the riveting hammer and square stake. A collar is now inserted in the end and riveted in several places about ½ inch above the flange.

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The collar is cut slightly smaller in length than the circumference of the stub, and should be wide enough to allow for riveting, and extend about 3/8 inch beyond the flanged end after it has been trimmed parallel to the outline of the end.

The projecting edge of the collar is notched and inserted into the opening of the large pipe; the notched edge of the collar is now bent over and fitted closely against the inside of the pipe by means of the hammer. By this

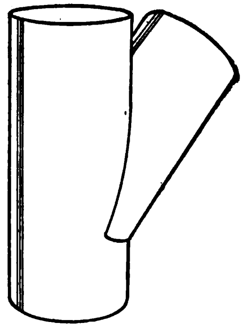

Figure 121.—T-Joint of 45° Angle.

method the large pipe is held firmly between the two flanges of the smaller pipe.

The principles used in the development of the patterns in this problem (Figure 120) are applicable, no matter what diameters the pipes are, or whether the small pipe is placed in the center or at one side of the vertical pipe. The pipes can also be placed at any angle, and differ in profile.

T-Joint at an Angle of 45°.—Figure 121 shows the finished view of a T-joint, both pipes having the same diameters, joined at an angle of 45°. The full development is shown in Figure 122. The principles in this problem do not differ from those given in Figure 118. The prob-

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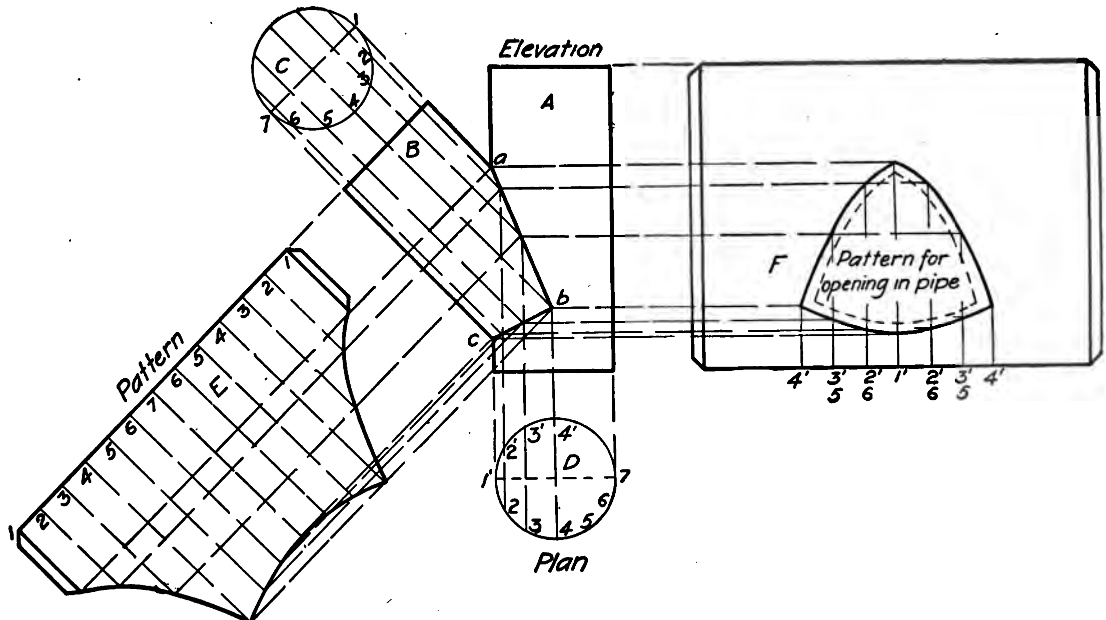

Figure 122.—Development of Patterns for 45° T-Joint.

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lems are the same, except in the position of the horizontal pipe *B*.

Draw the elevation and plan, making both pipes 3 inches in diameter, pipe *B* having an inclination of 45°. Space the plan *D*, and section *C* in the usual manner. Draw lines from these points intersecting in the elevation. A line traced through the intersections thus obtained will

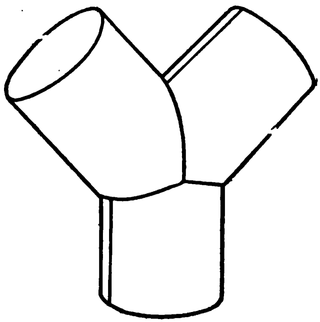

Figure 123.—Y-Joint in Pipes of Equal Diameters.

give the miter line between the two pipes, shown by *abc* in the elevation. Pattern *E* for the inclined pipe and pattern *F* for the vertical pipe are shown fully developed, and will require no further explanation, as the method has been described in the previous problems in this chapter.

Y-Joint.—Figure 123 is the illustration of a Y-joint, the diameter of each branch being the same. The sheet metal worker needs no introduction to this familiar form, as it is used for many different purposes in the trade. This problem is presented to give practice in developing patterns for intersected cylinders having the same diameter.

The elevation, partial development, and dimensions are shown in Figure 124. First draw the elevation ac

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cording to the dimensions shown on the drawing, making the arms *A* and *B* at an angle of 90°. The miter line *ab* is obtained by bisecting the angle *cad*, as shown.

The pipes being of the same diameter, a half section of the arm *A*, shown at *D*, is all that is required. Divide

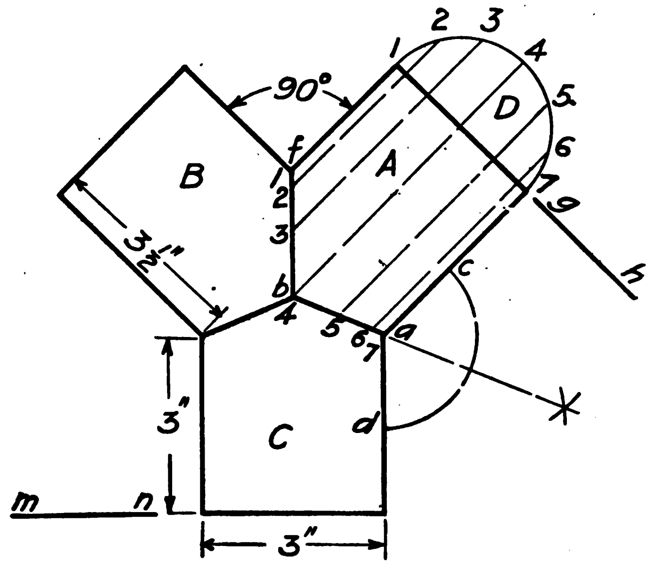

Figure 124.—Elevation and Partial Development of Pattern for Y-Joint.

the half section *D* into a number of equal parts, being careful to place a point on the quarter-circle, as shown by point *4*. Draw parallel lines from these points intersecting the miter lines *fb* and *ba* as shown. At right angles to the arms *A* and *C*, draw the stretch-out lines *gh* and *mn*, and complete the patterns as directed in the preceding problems.

Chimney Cap.—Figure 125 shows the elevation of a ventilator head, or chimney cap, the pipes being of the

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same diameter. This is presented as a test problem, as it involves the development of two problems described in this chapter. The arms *A* and *B* form a T-joint at a right angle, similar to Figure 118, while the arms *B* and *C* are joined at other than a right angle, similar to the problem shown in Figure 122.

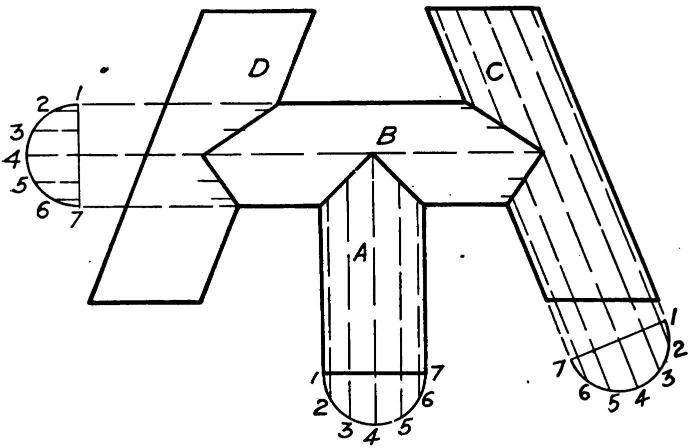

Figure 125.—Elevation of a Chimney Cap, or Ventilator Head.

Draw the elevation and half sections as shown in the drawing. Then develop the patterns for the arms *ABC*. The method of development has been fully explained in preceding cases, so that no further demonstration need be given.

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CHAPTER XIV

ELBOWS

An illustration of a four-piece 90° elbow, which is used universally in heating and ventilating work, is shown in Figure 126. Elbows of this form, having a small radius in the inner curve or throat, are commonly made use of in stovepipe work, furnace work, and in duct work where

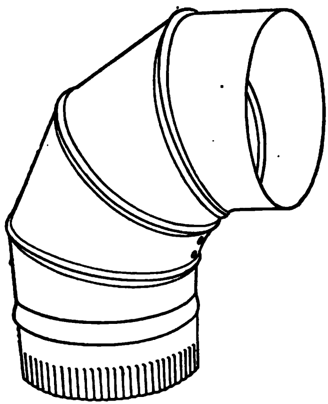

Figure 126.—Four-piece 90° Elbow.

a blast is not used. Elbows having a large radius in the throat are generally used for making turns in grain conveyers, exhaust and blow-piping work. In projects of this kind an elbow having a short radius should never be used if it can be avoided.

The drawings shown in Figure 127 contain all the necessary details for development of the patterns for elbows at any angle, having any number of pieces. The work-

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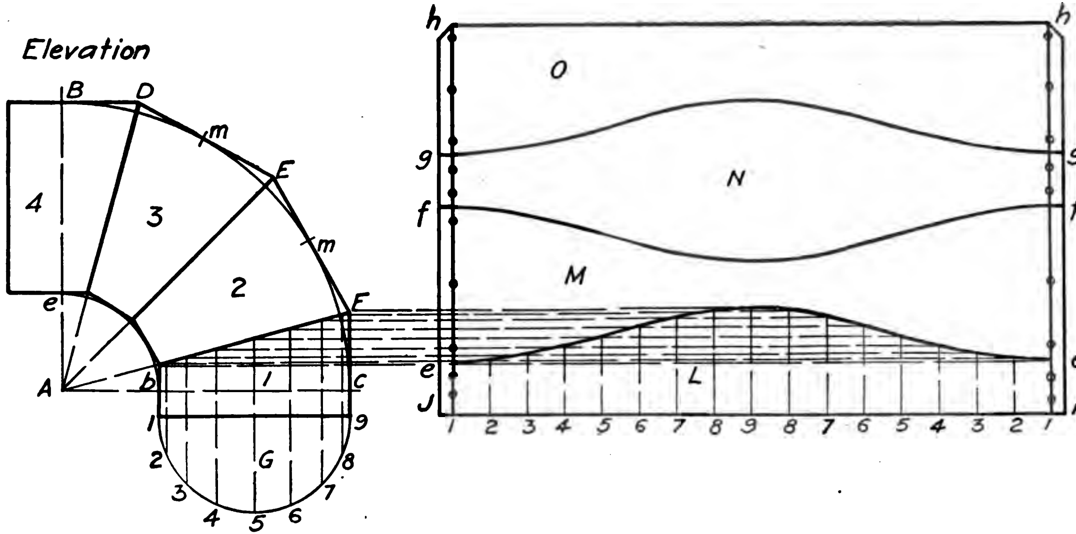

Figure 127.—Patterns for Four-piece 90° Elbow of 5 Inches Diameter.

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man should follow the instructions carefully, and memorize the construction of the problem.

Four-Piece 90° *Elbow.*—Figure 127 shows the method of obtaining the patterns for a four-piece 90° elbow having a diameter of 5 inches; the length of the radius for the inner curve of the elbow being 3 inches. First draw the right angle shown by the dotted line *BAC*. Next, on the line *AC* lay off a distance of 3 inches from *A* to *B*. With *A* as center and *Ab* as radius, describe the quarter circle *be*, which gives the required curve for the throat. Make *bC* equal 5 inches, the diameter of the elbow, and with *AC* as the radius and *A* as center describe the outer arc *BC*.

The joint lines of the elbow, shown by *DEF*, are found by dividing the outer arc *BC* into equal parts one less in number than the pieces required in the elbow; in this case into three spaces, shown by *Bm*, *mm*, and *mC*. Each of these spaces is bisected, and lines drawn from these points to the apex *A* will represent the joint or miter lines of the elbow. The outline of the different pieces of the elbow is now completed by drawing lines tangent to the arcs *eb* and *BC*, as shown in the drawing.

The above method can be used in obtaining the miter line for an elbow of any angle or of any desired number of pieces. After the elevation has been completed, draw the half section G, and divide it into a number of equal spaces, as shown by the figures *1* to *9*. From these points draw vertical lines intersecting the miter line *AF* in the elevation.

The pattern for the first section of the elbow is developed by drawing the horizontal line *JK*, upon which place the stretch-out of twice the number of spaces contained in the half section *G*. From these points on the stretch-out line draw vertical lines, which intersect lines drawn from similar numbered points on the miter line *AF* in the elevation. Through the points thus obtained, the irregu-

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lar curve of the pattern may be traced, as shown by *eLe*, which completes the pattern for piece No. 1 of the elbow. This irregular curve is the only one needed, and is used in laying out the patterns for the entire elbow.

The patterns for the sections numbered 2, 3 and 4 are

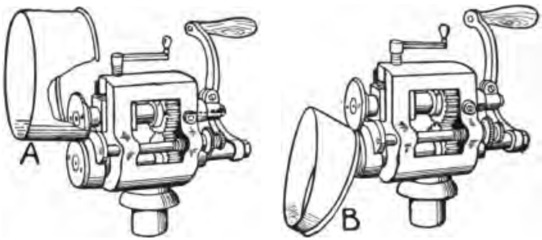

Figure 128.—Bench Elbow Edging Machine.

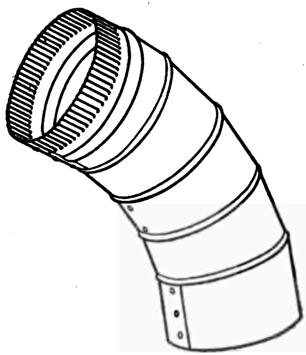

Figure 129.—Five-piece 60° Elbow.

usually laid out directly on the metal, in the following manner: A piece of metal equal in length to the stretch-out of the pattern is provided, and pattern *L* is transferred to the metal by the usual method of pricking, as described in Chapter I. Next, take the length of the wide side of section 2, as shown by *EF* in the elevation,

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and mark this dimension on each end of the metal, as shown by *ef*. Then take the throat width or short side of piece No. 3, and place it as shown by *fg*. The length of the long side or top of piece No. 4 is placed on the metal, as shown by *gh*.

Pattern *L* is now cut from the metal, after which the metal pattern is turned over and the curved edge placed on the points *ff*. The irregular curve of the pattern is scribed on the metal by means of the scratch awl, which completes the pattern for piece No. 2, shown at *M*.

The patterns for pieces Nos. 3 and 4 are completed by placing the curved edge of pattern *L* on the points *gg;* then scribe the irregular curve on the metal, and connect the points *hh* with a straight line, completing the patterns *N* and *O*.

This method of grouping the patterns places the seams opposite each other, and allows the patterns to be cut from a rectangular piece of metal without waste of material.

The patterns are now cut from the sheet, corners notched, rivet holes punched, formed in the forming machine (Figures 24, 25) and riveted on the mandrel stake; after which the edges for seaming the pieces together are turned on the elbow edging machine (Figure 128).

Five-Piece 60° *Elbow.*—Figure 129 shows a finished five-piece elbow with an angle of 60°, such as would be used in ventilating and blow-pipe work, where it is desired to reduce the friction to the lowest possible amount by constructing an elbow having a long length of throat.

In Figure 130 is shown the elevation of a 5-piece 60° elbow, the inner curve or throat being described with an 8-inch radius. This problem is introduced in order to give practice in developing the patterns for elbows at other than a right angle.

First, draw the required angle *BAC*. Next, on the line *AC*, measure off a distance of 8 inches from *A* to *D*, which

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is the required radius for the throat curve of the elbow. With *A* as center, describe the arc *DE*. Make *DC* equal 5 inches, and with *AC* as radius describe the outer arc *CB*,

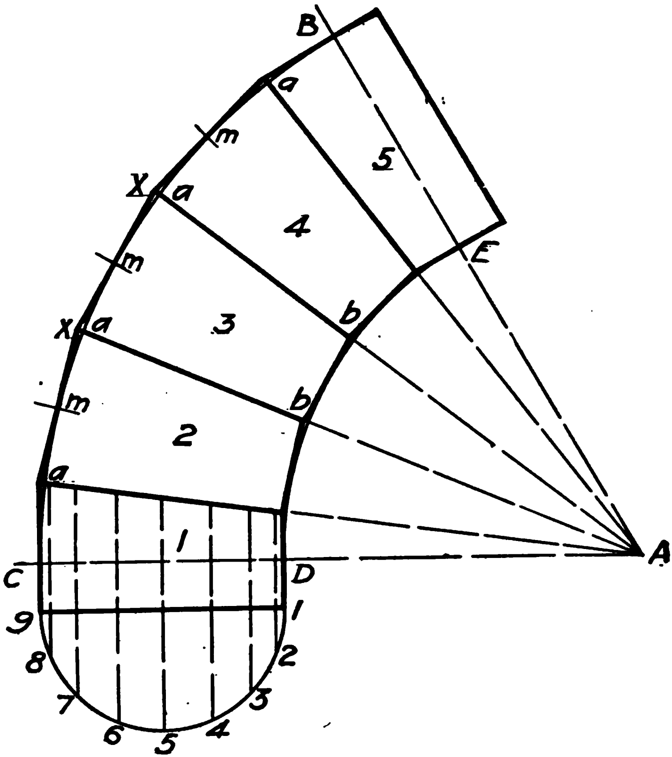

Figure 130.—Elevation of Five-piece 60° Elbow.

which is divided into four equal spaces, one less in number than the pieces in the elbow. These spaces are shown by *Bm, mm,* and *mc* in the drawing. Each of these spaces is bisected as shown at *a, a, a, a,* and lines drawn from these points to the apex *A* will give the required miter line for each section of the elbow.

Complete the elevation, and develop the pattern for piece No. 1. The development is not shown on the drawing, as the work would be simply a repetition of the operations described in laying out the patterns for the four-piece 90° elbow shown in Figure 127.

The end pieces, Nos. 1 and 5, may be made any length at the pleasure of the workman, but the length of the heel and throat of the middle sections 2, 3, and 4, should be taken from the elevation. These dimensions are shown by *xx* and *bb* in section No. 3, and cannot be changed when once the arc *DE*, representing the inner curve of the elbow, has been described on the drawing.

DUCT ELBOWS

Square or rectangular piping, or duct work, has become a very important part of the sheet metal trade, and is largely used in the installation of heating and ventilating systems. A curved elbow, of the style generally used in this class of work, is shown in Figure 131. These elbows

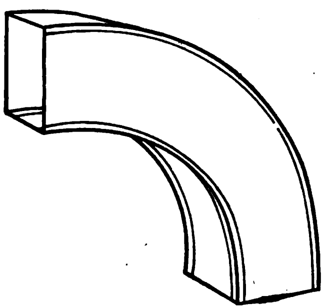

Figure 131.—Rectangular Duct 90° Elbow.

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are made in four pieces, consisting of the two sides, the heel, and the throat. The heel is the outer and the throat the inner curve.

When laying out the patterns for duct elbows of this kind, the radius for describing the inner curve or throat should be equal to the width of the duct. The pieces are usually joined together by riveting or double seaming the corners by means of the double-seaming stakes or "hand dollies."

This problem is presented to give practice in the construction of a duct elbow, and to describe an easy and quick method for seaming the corners of elbows and square or rectangular pipes by the method commonly known in the trade as "the Pittsburgh seam."

Rectangular Duct 90° *Elbow.*—In Figure 132 is shown the method of laying out the patterns for a 90° rectangular elbow, in which the turn is made on the short side of the pipe. Draw the elevation *A* and profile *B* according to the dimensions given on the drawing. First draw the right angle shown by *1-a-8*. With *a* as center and *a7* as radius, describe the quarter circle *1-7*, which represents the inner curve or throat of the elbow. Next make *7-8* equal the narrow side of the elbow, and with *a* as center and *a8* as radius describe the arc *1-8*. This is the outer curve, or the heel; the straight parts shown by *x1* and *y8* are added to the quadrant to make an easy connection with a straight duct. An allowance of ¼ inch, as shown by the dotted lines, is now added to the heel and throat for seaming; then the elevation *A* will also be a pattern for the two sides of the elbow.

The patterns for the heel and throat shown at *C* and *D*, are simply rectangular pieces of metal equal in length to the stretch-outs shown by *xY* in the elevation. The width is equal to the wide side of the elbow, to which 1 inch has been added on each side for seaming, as shown by *abc* in pattern D, making *ab* equal ⅜ inch and *bc* ⅝ inch.

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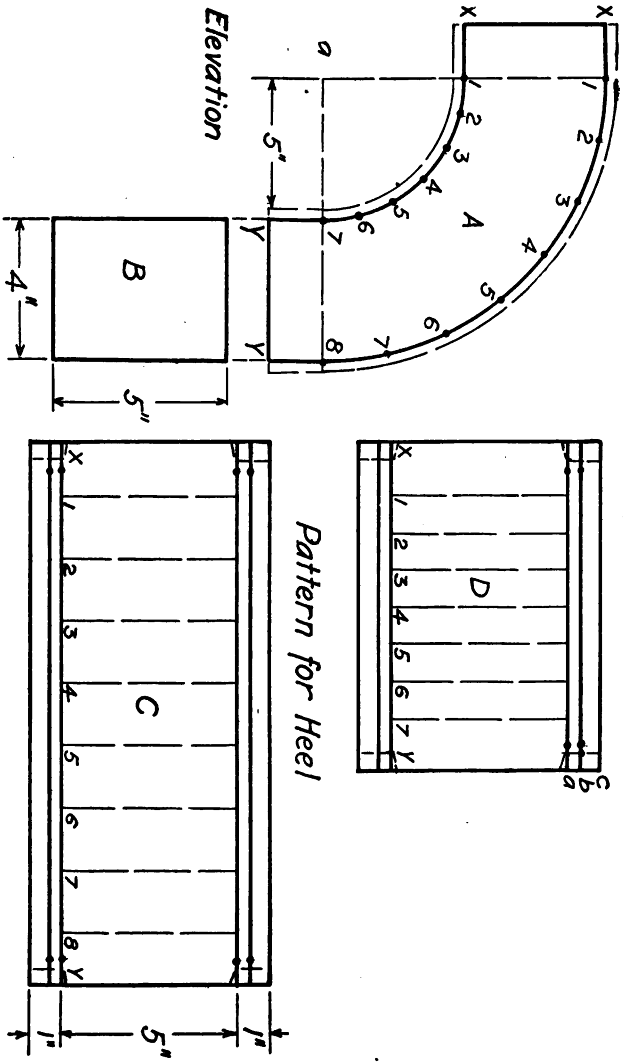

Figure 132.—Layout of Patterns for a 90° Rectangular Elbow.

Prick marks are made at these points for bending purposes, as shown by dots on each end of the patterns.

"The Pittsburgh Seam."—In Figure 133 is shown the method of bending the edges of the patterns for seaming. The operations are performed on the cornice brake and

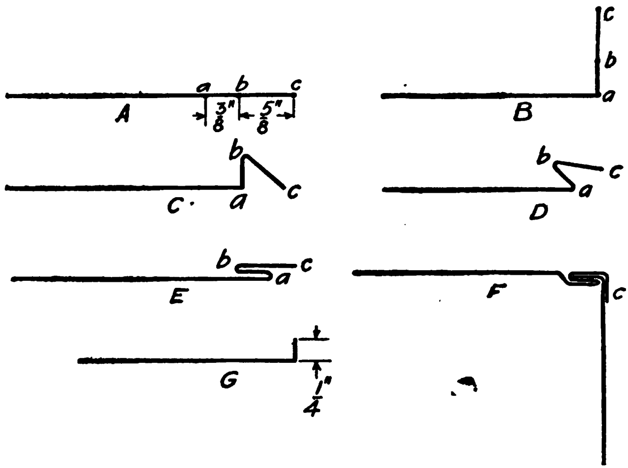

Figure 133.—Progressive Operations of Bending Edges to Form "the Pittsburgh Seam" on the Cornice Brake.

the various bends are shown by the letters *abc*, in the diagram at *A*.

The first operation is shown at *B*. Insert the sheet in the brake and bring down the upper clamp on the prick mark shown at *a*, then raise the lower bending leaf, bringing the metal up to a right angle, as shown at *B*. The sheet is now turned over, the edge placed in the brake, and the upper clamp closed down on the prick mark *b*; raise the bending leaf as far as it will go, which will bend the metal in the position shown at *C*. Now place the sheet in the brake once more on the point *a*, and bend it

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up as far as it will go, as shown at *D*. Place a strip of metal between *a* and *c*, and bring down the upper clamp, pressing the bends together closely. The strip of metal is removed and the edge of the sheet will appear as shown at *E*. The ¼-inch edges are now turned at a right angle on the sides of the elbow, as indicated at *G*.

The patterns for the heel and throat are given the required curve in the forming rolls, and during the operation a strip of metal is again placed between bends *a* and *c*, so that the pressure of the rolls will not close the opening between the bends. The parts are assembled by inserting the ¼-inch edge of the side pattern into the pocket edge of the throat and heel. The projecting edge *c* shown at *E*, is then hammered over, which completes the seam as shown at *F*. This seam, known as "the Pittsburgh seam," is used in the sheet metal trade to good advantage for various purposes. It is easily constructed and makes a tight, rigid joint.

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CHAPTER XV

RETURN AND FACE MITERS

This chapter treats of the method of obtaining patterns for miters between sheet metal moldings. The patterns are developed by the parallel method described in previous chapters. Any profile or shape may be used, and in order to illustrate the application of the principles underlying the development as applied to moldings, a number of practical problems are presented.

Square Return Miter.—In Figure 134 is shown the illustration of a square return miter, such as would be

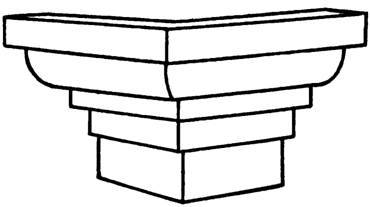

Figure 134.—Square Return Miter.

employed when a molding was made to return around the corner of a building. Figure 135 shows two methods of obtaining the pattern, known respectively as the long and the short method. The short method is the rule generally employed by the sheet metal worker, but can only be used when the miter is one of 90°; that is, a square miter. The long method can be used for obtaining the patterns for a miter between moldings, no matter what angle is required.

To develop the pattern by the long method, proceed as

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follows: First draw a full-size detail of the profile or section, the dimensions being taken from the section

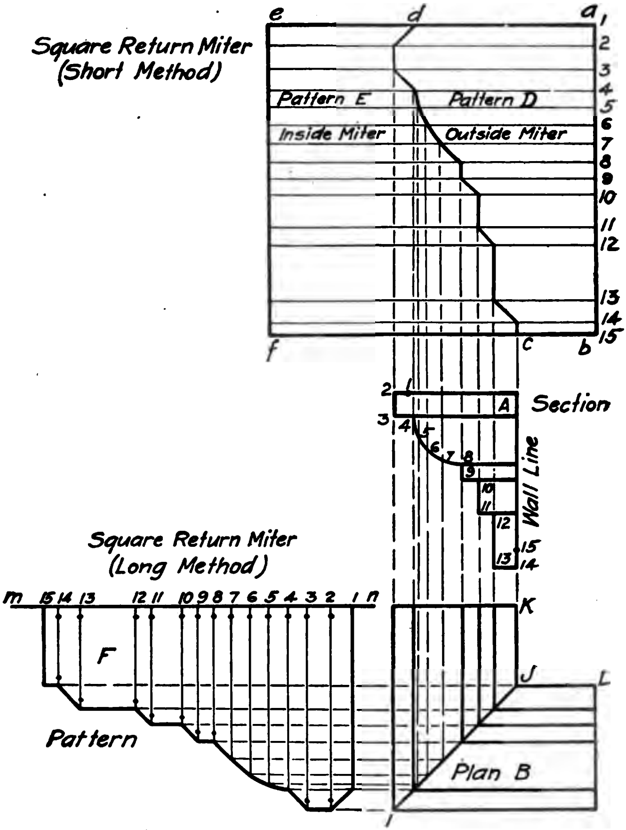

Figure 135.—Long and Short Methods of Obtaining Pattern for Square Return Miter.

shown at *A* in Figure 135, which is drawn to a 2-inch scale; but any other profile may be used if desired. Divide the curve into a number of equal spaces, placing a suffi-

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cient number of points on the curve, so that the outline of the pattern may be traced with accuracy. Number these points, also the corners of the molding, as shown by the figures *1* to *15*. Next, draw the plan *B* as shown, and bisect the angle *KJL* by the line *J1*, which will give the required miter line.

From the various points in section *A*, draw vertical lines intersecting the miter line in plan *B*. At right angles to *JK* draw the stretch-out line *mn;* upon this line place the stretch-out of the section, as shown by the

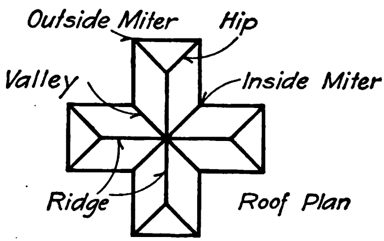

Figure 136.—Plan of Hipped Roof, Showing Outside and Inside Miters.

figures *1* to *15*. From these points on the stretch-out line draw vertical lines, which are intersected by horizontal lines drawn from similar numbered points of the miter line *J1* in the plan *B*. The outline of the pattern is then traced through the points thus obtained, and the lines upon which bends are to be made are marked by small circles or dots, as shown on the completed pattern at *F*.

The development of the pattern by the short method, in which no plan is required, is shown by pattern *D*. After the profile has been drawn in its proper position, as shown at *A*, the stretch-out line may conveniently be drawn either above or below the drawing of the profile. In this case it was drawn above, as shown by the vertical line *ab*. Upon this line place the stretch-out of the pro-

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file, and number the points in the usual manner, shown by the figures *1* to *15*. From these points at right angles to the stretch-out line, draw measuring lines, which intersect by vertical lines drawn from similar numbered points on the profile *A*. A line traced through the points thus located will complete the pattern, which is similar to pattern *F*, that was obtained from the plan and developed by the long method.

Outside and Inside Miters.—For the purpose of illustrating the difference between an outside miter and an inside miter, a sketch of a roof plan, representing a hipped roof, is shown in Figure 136. When constructing moldings and gutters, the workman is often required to develop patterns for miters returning around the outer and inner angles of a roof. Miters for the outer and inner angles are called outside and inside miters, and are placed as shown in the sketch. Pattern *D*, shown by *abcd* in Figure 135, is the pattern for an outside miter, while the opposite cut, shown by *defc*, is the pattern for an inside miter. It will be seen that both patterns are produced by a single miter cut, and it is important to know that this is also true when developing patterns for miters at any angle.

Octagon Return Miter.—Figure 137 shows the method of obtaining the pattern for an octagon return miter, and is also applicable for miters at any angle. The octagon miter is often employed in the construction of roof finials and cornices, and also frequently occurs in moldings and gutters passing around parts of a building octagonal in form.

The pattern for an octagonal return miter is developed from a plan view of the molding by the long method shown in Figure 137, which is drawn to a 2-inch scale. First draw a full size section of the molding shown at *A*, taking the dimensions from the scaled drawing. Next extend the wall line of the profile and draw the octagonal

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angle of 135°, shown by *mno*, which will represent the wall line in the plan *C*. Bisect the angle *mno* and draw the miter line *RN*. The curve in the profile is divided into a number of equal spaces and the points numbered as shown by the figures *1* to *15* in section *A*. From all

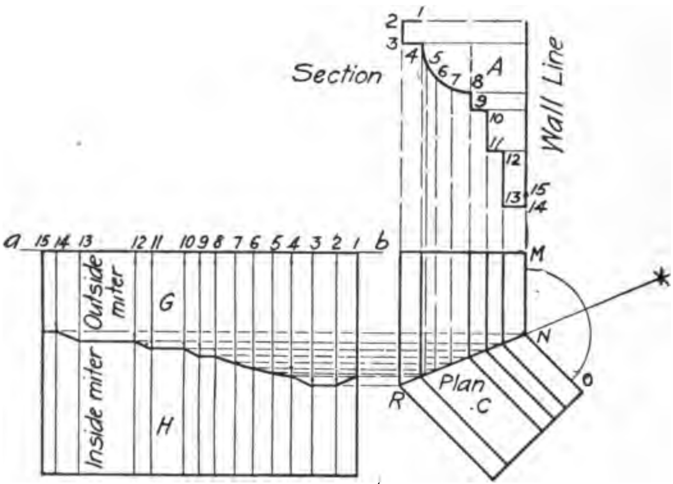

Figure 137.—Pattern for Octagon Return Miter.

points on the profile draw vertical lines intersecting the miter line *RN* in the plan.

The stretch-out of the molding is now placed upon the line *ab*, which is drawn at right angles to the wall line *MN* in the plan. Measuring lines are drawn from these points, which are intersected by horizontal lines drawn from similar numbered points on the miter line. A line traced through these intersections will complete the pattern, as shown at *G*. Should an inside miter be required, the opposite cut of pattern *G* is used, as shown by pattern *H*.

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Molded Gutter.—In Figure 138 is shown a finished view of a molded face gutter, or eave trough miter. This is simply a square return miter, and it is immaterial what

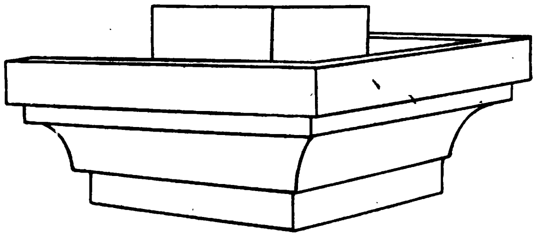

Figure 138.—Molded Face Gutter, or Eave Trough Miter.

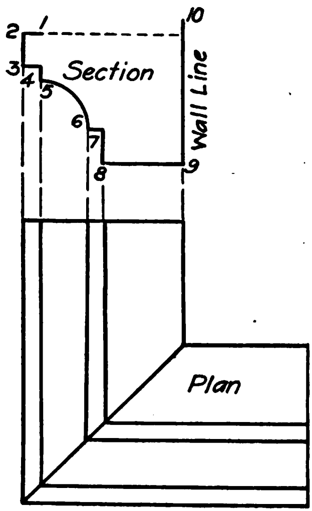

Figure 139.—Section and Plan of Molded Face Gutter.

profile or shape the gutter has,—the method of developing the pattern is the same.

In Figure 139 is shown a 2-inch scale drawing giving

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the section and plan view of a molded face gutter, for which a square outside miter pattern is to be developed by the short method shown in Figure 135. Place the stretch-out line either above or below the section, and omit the plan when making the full-size drawing.

Octagon Gutter Miter.—The next exercise for practice is the octagon gutter miter shown in Figure 140, which

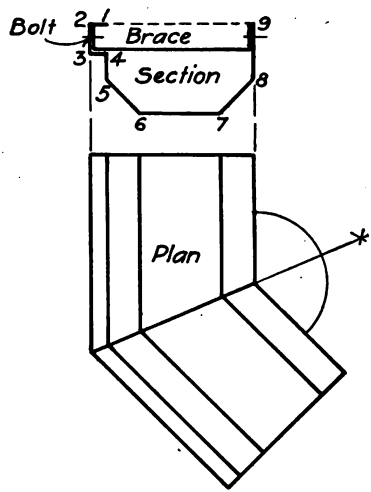

Figure 140.—Section and Plan of Octagon Gutter Miter.

is also drawn to a scale of 2 inches to the foot. In this drawing the section and plan are given of an octagon gutter forming a miter at an angle of 135° in the plan. Draw the section and plan as shown. Number the corners on the section and draw vertical lines intersecting the miter line in the plan. At right angles to the wall line draw the stretch-out line, and develop the pattern in the usual manner.

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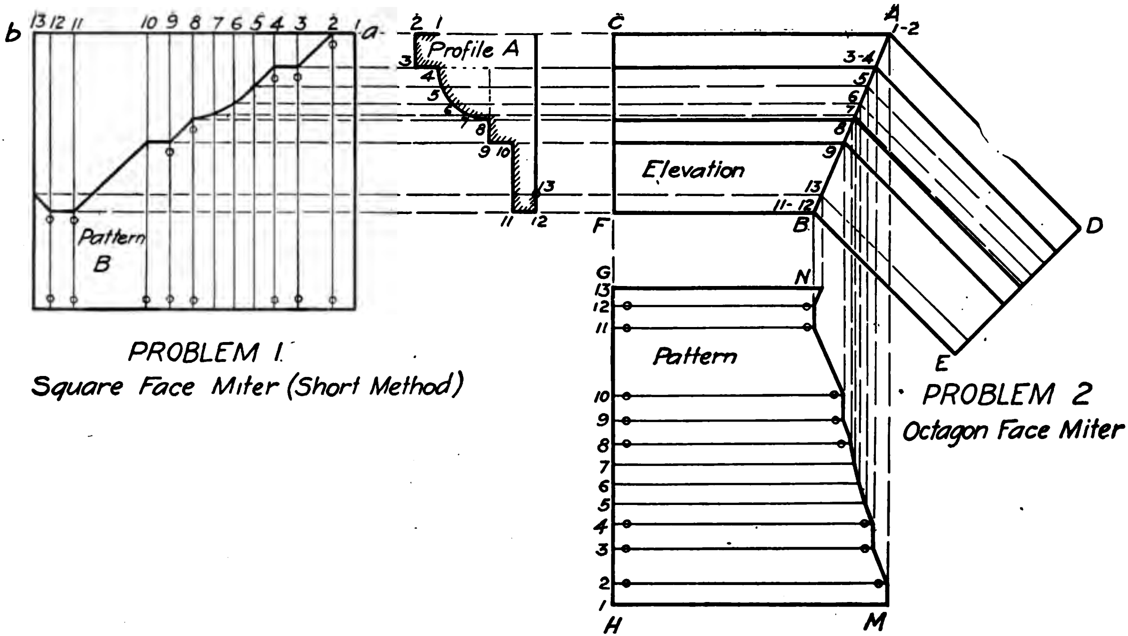

Figure 141.—Face Miter Problems: 1, Pattern for Square Face Miter; 2, Pattern for Octagon Face Miter.

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Face Miters.—The method of developing the pattern for a face miter is shown in Figure 141. This process is employed when developing the patterns for miters in panel moldings, picture frames, and gable moldings, also to obtain the miter cut when the return molding of a dormer window butts against a mansard roof or other inclined surface. As may be seen from the drawing, the method of development is similar to that described for the return miter, Figure 135. The only difference is in the position of the stretch-out line *ab* in the pattern for the square face miter shown at *B*. In this case the stretch-out line is placed in a horizontal position at the left of the profile, while the stretch-out for the square return miter, Figure 135, is placed in a vertical position above the profile.

When developing the patterns for moldings, the sheet metal worker must always be careful to place the stretch-out line in its proper position, or, instead of having a face miter as indicated in Figure 141, he will have a return miter, as shown in Figure 135.

In Figure 141 two problems in face miters are presented and the drawings are made to a scale of 3 inches to the foot. Problem 1 shows the method of obtaining the pattern for a *square face miter* by the short method. Draw the profile *A*, and place the stretch-out line *ab* to the left of the profile. The operations in the development of the pattern are the same as described in Figure 135, and need not be described further.

Problem 2, Figure 141, shows the development of an *octagonal face miter*. The patterns for face miters at other than a right angle are developed by the long method, and the miter line is found in the elevation. In problem 2 the elevation is shown at the right of the profile.

First draw the required angle *CAD*, which is bisected in the usual manner to obtain the miter line *AB*.

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Next, from the various points on the profile, draw horizontal lines intersecting the miter line as shown. At right angles to the line *BF* in the elevation, draw the stretch-out line *GH*. Upon this line place the stretch-out of the profile shown by the figures *1* to *13*. Measuring lines are now drawn from these points, which are intersected by lines drawn from similar numbered points on the miter line. Through the points thus obtained trace the pattern *GHMN*.

Molded Panel.—The development of the face miter described in previous problems leads naturally to the problem of the molded panel, shown in Figure 142.

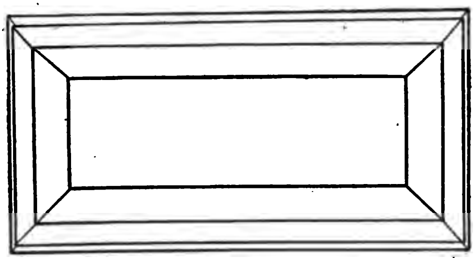

Figure 142.—Oblong Molded Panel.

The method of obtaining the pattern for an oblong panel is shown in Figure 143. First draw a section of the panel mold *A*, as indicated by the shaded portion of the drawing. Then divide the curve into a number of equal spaces and number each point on the section, as shown by the figures *1* to *8*. Through these points draw lines parallel to *EB*, intersecting the miter line *mB* as shown. From the points thus obtained on the miter line, draw lines parallel to *BC*, intersecting the miter line *nC*. At right angles to *BC* in the elevation, draw the stretch-out line *ab*, upon which place all of the divisions contained in the profile *A*. Through the points on the stretch-out line, draw horizontal measuring lines, which

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intersect by vertical lines drawn from similar numbered points on the miter lines *mB* and *nC* in the elevation. A line traced through the points of intersection will complete the pattern for the ends of the panel. This is the

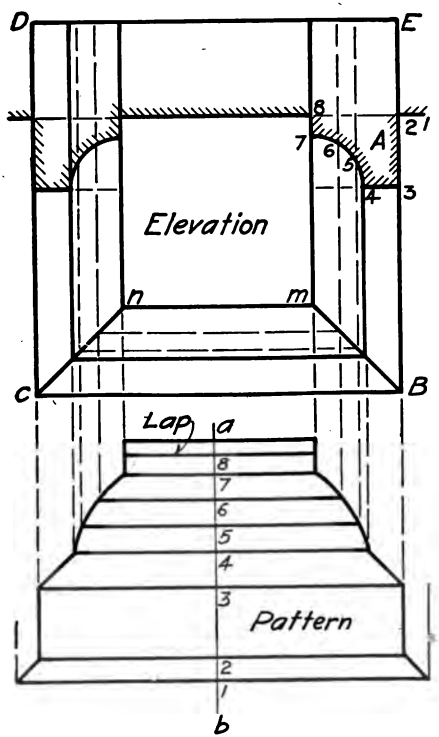

Figure 143.—Pattern for an Oblong Panel.

only pattern necessary for the construction of the problem, for the same miter cut is also used for the long side of the panel.

Roof Finial.—The sheet metal worker is often called upon to provide the apex of a hipped roof or tower with

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an ornamental finish made from galvanized iron or sheet copper. A plain fitting so used is shown in Figure 144 and is called a roof finial. The body, square in form, is made in four pieces, and is commonly used to provide a finish at the apex of a square tower, or as an ornament in cornice construction.

The method of laying out the pattern for a square finial is shown in Figure 145, which is drawn to a scale of 2 inches to the foot. The profile can be changed to

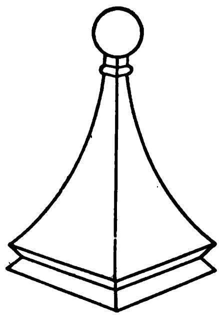

Figure 144.—Square Roof Finial.

any shape, but the development would be the same in every case.

First draw the center line *AB* and construct the elevation shown at *D,* the ball *C* being 3 inches in diameter. Divide the profile into a number of equal spaces and number the points, as shown by the figures *1* to *10.* The finial being square in form, the sides are joined together at an angle of 90°, and the miter on the corner is simply a square return miter, for which the pattern can be developed by the short method in the following manner:

Place the stretch-out of the profile *D* upon the center line *AB,* which is extended below the elevation. At right angles to *AB* draw the measuring lines, which are inter-

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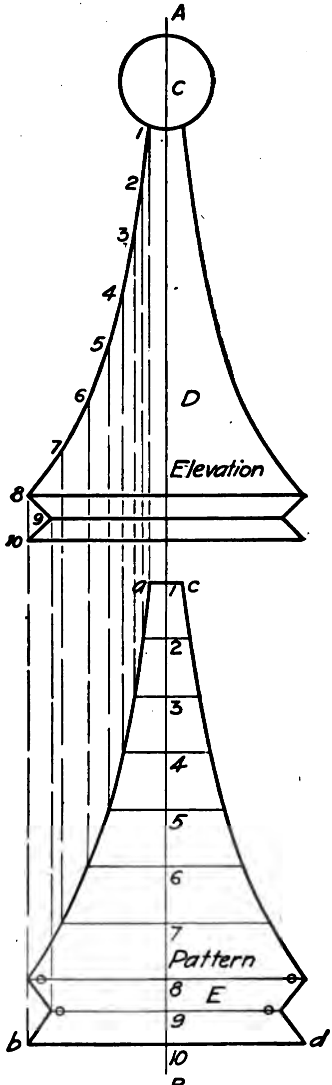

Figure 145.—Layout of Pattern for a Square Finial.

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sected by lines drawn from similar numbered points in the elevation. Now, measuring from the center line, transfer these points to the opposite side of the pattern

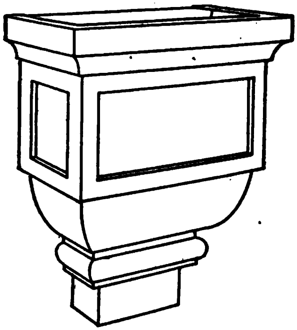

Figure 146.—Ornamental Conductor Head.

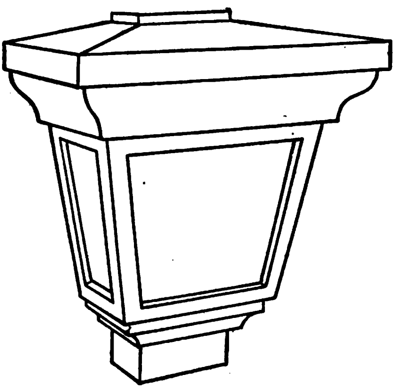

Figure 147.—Conductor Head with Inclosed Top.

by means of the dividers. Trace a line through the points thus obtained, completing the pattern for one side of the finial, shown by *abdc* at *E*.

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Conductor Heads.—When a conductor pipe is used to drain a roof where the outlet extends through a parapet wall, the connection should be made by means of a conductor head. The object in using a conductor head is that if the down spout should become obstructed in any manner, the water will overflow from the conductor head, leaving the roof outlet clear, which will prevent the water from backing up and flooding the roof.

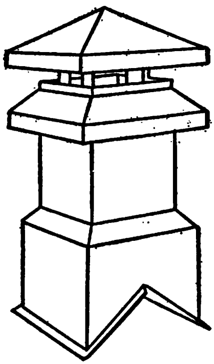

Figure 148.—Square Ventilator.

Figure 146 shows an ornamental conductor head having a flat back, the outer corners being mitered in the usual manner. Another form of head, having an inclosed top, is shown in Figure 147. There is no limit to the various designs that can be made at the pleasure of the workman.

The miters on the outer corners of the conductor heads shown in the illustrations are simply square return miters, and the patterns are developed by the short method described in the previous problem.

Square Ventilator.—The method of development used in obtaining the pattern for the roof finial, Figure 145, can also be applied in developing the patterns for the

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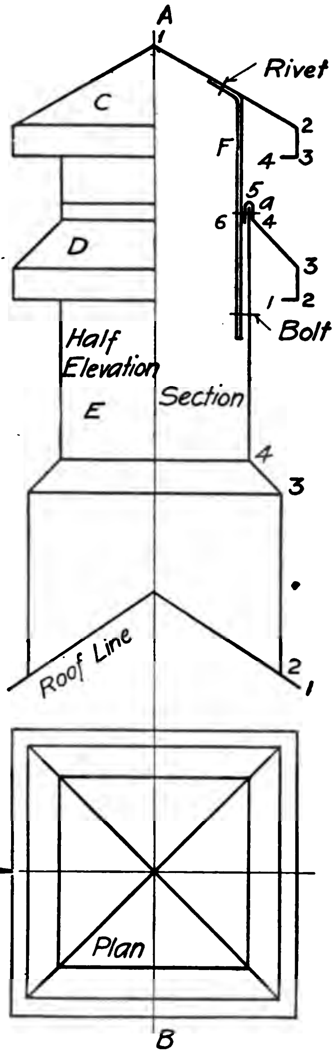

Figure 149.—Half Elevation, Section, and Plan of a Square Ventilator.

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square ventilator shown in Figure 148. These ventilators are usually made from sheet copper or galvanized iron, and are largely used in skylight construction and ventilating work.

In Figure 149 is shown the half elevation, also the half sectional and plan view of a square ventilator, which is drawn to a scale of 3 inches to the foot. As in the preceding problem (Figure 145), the first step is to construct the proper elevation, but in actual shop practice the half sectional view is all that is required for the development of the different patterns. Let *C* represent the hood of the ventilator and *D* the flange, which is joined to the square base shown at *E*.

The half sectional view shows the profile of the different sections, also the method used in joining the flange and base, which is shown at *a*. The position of the band-iron brace used in connecting the hood and base of the ventilator is shown at *F*. After the full-size elevation has been drawn, omit the plan view, and develop the patterns for the hood, flange, and base of the ventilator by the short method shown in Figure 145.

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