The Selvidge Series of Instruction Manuals

INSTRUCTION MANUAL

FOR

SHEET-METAL WORKERS

SELVIDGE AND CHRISTY

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For
SHEET-METAL WORKERS

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PREFACE

THIS manual is intended as a textbook for apprentices in the sheet-metal working industry and for pupils in trade schools, continuation schools and other schools wishing to give thoro and adequate instruction in sheet-metal work.

Employers and labor organizations will find it a most valuable guide in giving a definite outline of the instruction the apprentice should receive. This assures a more rapid progress of the apprentice and makes it possible to determine accurately whether or not he is receiving the instruction to which he is entitled.

In the preparation of the manual we have followed the plan outlined in **How to Teach a Trade.* The plan is a very simple one. It seems perfectly obvious that the first step in teaching a trade is to make a list of the things a man must *know* and must be able to *do* in order to be proficient in his trade. This gives us a list of the things we must teach him.

In making this analysis of the sheet-metal worker's trade we have endeavored to list the fundamental operations of the trade rather than the jobs of the trade. To list all of the jobs of the trade would be a great and useless task. To list the fundamental operations of the trade is a relatively simple task and adequately fulfills every requirement. If the jobs were listed it would be necessary to analyze each job into its fundamental operations in order to teach it. Since every conceivable *job* is made up of the *operations* of the trade, in various combinations, the simplest method of procedure is to analyze the trade for the operations involved and use these as the basis of analyzing the jobs of the trade. No job can be analyzed except in terms of the operations of the trade.

The list of operations constitute the alphabet of the trade. All jobs are made up of combinations of these operations just as words of our written language are made up of a combina-

* *How to Teach a Trade,* Selvidge, The Manual Arts Press, Peoria, Illinois.

tion of letters of the alphabet and with the same lack of consideration for the order in which they appear in the list.

The operations of the trade have been listed and definite directions given for performing each operation. These directions are followed by questions designed to make the learner think out the reasons why a thing is done in a certain way.

There is also a list of the topics of related trade information. These topics are treated in a brief and concise manner, in order to give the learner the necessary information in a readily available form.

Specific references are given in connection with the directions for each operation in order that the learner may get a more extended discussion of the subject if he desires to do so.

A number of valuable tables are given as well as problems in drafting, lay-out and construction together with methods of solving the problems.

The section on how to use the manual will prove of great value to teachers.

Acknowledgment is made to the Niagara Machine and Tool Works, Buffalo, N. Y.; and to the Peck, Stow and Wilcox Co., Southington, Conn., for furnishing illustrations of sheet metalworking machinery which appear in this book.

R. W. Selvidge.
E. W. Christy.

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HOW TO USE THE MANUAL

A CAREFUL examination of the teaching problem will reveal that there are several distinct phases of instruction in shop classes. This is true whether instruction is given in written or in oral form.

1. *There must be a clear and definite statement of the problem or job that the learner will know exactly what is required.*

This means that all drawings, specifications or instructions necessary for the completion of the job should be given the student. The student should then explain the instructions to the instructor until the instructor is sure that every detail is understood.

More failures result from a want of a thoro understanding of what is required than from all other causes combined. Be absolutely sure that every detail of the requirement is understood.

2. *The student should analyze the job for the operations involved.*

In order that the student may do this readily he should be given a list of the unit operations of the trade and on this he should check the operations involved in the particular job. This is a further verification of step one and assures the teacher that the student knows what is to be done. A few well directed questions will lead him to discover any errors in his analysis. He should also enter on the sheet his estimate of the time required for the job and at the completion of the job the actual time required should be entered.

3. *He should list the operations in the order in which they will be performed.*

Different orders of procedure often are equally good. The pupil should be questioned as to his method and if he can give good reasons for it he should be permitted to follow his plan, altho it may not be the usual order.

The teacher should never neglect this analysis and planning of the job. It is a matter of thought and reason and represents the highest type of development. The ability to do it is the thing that marks the distinction between the capable high grade mechanic, and the low grade journeyman who can do only the things he is told to do. It is quite different from acquiring information or developing manipulative skill, and to neglect it is to neglect one of the most important phases of the pupil's training.

4. *The instructor should give all necessary information and directions, and when necessary give a demonstration of any new process involved.*

The manual gives very definite directions for performing the operations. The pupil should be required to read these directions very carefully before starting on his task, and have them at hand for ready reference during the progress of the job. After a pupil has performed an operation a few times he will know how to do it and it will not be necessary for him to read the instructions unless he meets with some difficulty. *He will need practice, in order to acquire skill, long after he has learned how to perform the operation and no longer needs the instructions.*

The teacher should demonstrate any difficult manipulative operation not made perfectly clear by the printed instructions. The most effective way of doing this is to have the pupil read the instructions or directions while the teacher performs the operation step by step as directed. This helps the pupil to realize the real value of the printed instructions.

The teacher should be sure that the pupil is familiar with the topics of information that may affect the success of the work.

5. *The work should be done according to plan.*

Having a definite and clearly understood plan with complete directions, the pupil should proceed with speed and decision to the doing of the job. Loitering, indecision, or careless and slovenly habits should never be permitted. The teacher should observe the work carefully and render assistance only where it is actually needed. The necessary material having been placed in the hands of the pupil, he should solve his problem unaided unless there is danger of his falling into bad habits.

6. *The teacher should check results.*

The teacher should observe the work carefully in order to determine the effectiveness of the instruction and whether additional practice is necessary in order to attain the desired skill. This gives an opportunity to talk with the pupil concerning the virtues or defects of his plan.

7. *Students should report on the job.*

Students should report to the group when the job is finished. The report should cover the following items:

a) Time required to do the job.
b) Material used on the job.
c) Any special difficulties and how they were overcome.
d) Whether some other plan of procedure might have been better.

Such a report develops pride and a laudable ambition to excel in the matter of speed and workmanship. Also, some very valuable and helpful suggestions will be brought out in the discussion.

The teacher should be careful to assign a job that he believes to be within the capacity of the student and he should then hold him to a strict performance of the task. The teacher should never assign a job until he has first analyzed it. He can then readily determine whether the operations involved are too difficult for a given individual.

Some individual instruction will be necessary but care must be taken to develop self-reliance on the part of the student. It is well to remember that time is not wasted when it is spent in preliminary study and planning of the job.

The development of the ability to analyze and plan a job is so important that it is well to give considerable time to this, even when the jobs are not to be done by the students. A very keen interest is readily aroused in this work, and surprising results will be obtained in a short time.

One of the serious defects of the apprentice system is that the apprentice spends too much time on the low-skilled or semi-skilled operations of the trade. This prevents training on the more highly skilled operations and delays the completion of his training. With the trade analysis provided, it is an easy matter to keep track of his progress and put him on jobs involving new operations as soon as he is ready for them.

It should be remembered that the development of skill is one of the objects of this training and that skill is a thoroly established habit which can be developed only thru much practice. One should never be regarded as proficient in an operation until he can do it with speed and confidence.

No list of projects or jobs is given as there are already many lists of that character available. The purpose of this manual is to give a method and provide instruction for doing the jobs of any list. The jobs selected should be of such a character as to give sufficient practice in all of the operations it is desired to teach.

The following analysis sheets show how three jobs were analyzed and planned.

Trade Analysis

SHEET-METAL WORK

Name:	John Doe.	Estimated time, 40 min.
Date:	September 5, 1920.	Actual time, 1 hr.
Job:	Making a 6-inch Stove Pipe.	

Instructions:

First: Check at the left each unit operation involved in the job.

Second: Place in the column at the right the numbers checked in the order in which the unit operations should be performed.

Unit Operations	Order of Procedure
1. Making a dimensioned sketch	2
x 2. Developing patterns	3
x 3. Making a bill of material needed for a job	4
x 4. Cutting material	5
x 5. Folding edges	6
x 6. Forming cylinders with rolls	8
7. Forming with a brake	23
x 8. Grooving with a hand groover or grooving machine	17
x 9. Beading or swaging for reinforcing or making connections	9
x10. Crimping to shrink edges	10
11. Burring edges with a machine	
12. Peening, closing down or setting down seams	
13. Forming on stakes	
14. Double seaming on a stake or with a machine	
15. Turning edges with a machine	
16. Wiring edges	
x17. Riveting sheet-metal joints	
18. Tinning a soldering iron	
19. Soldering tin plate, zinc, and galvanized iron	
20. Brazing copper and brass	
21. Raising or bumping sheet-metal forms	
22. Flanging or stretching metal for riveted connections	
x23. Punching holes with a hollow or a solid punch	
24. Drilling holes	
25. Tinning copper, brass, and iron	
26. Cutting wire glass	
27. Building a charcoal fire in a fire pot	
28. Installing a warm air furnace	
29. Erecting a metal ceiling	
30. Sectioning and hanging or setting a cornice	
31. Hanging a gutter and down spout	
32. Flashing or making roof connections	
33. Laying a metal shingle roof	
34. Laying a tin roof	
35. Assembling, setting and glazing skylights	
36. Hanging and glazing hollow metal sash	
37. Setting and erecting stacks	
38. Laying a slate roof	

SHEET-METAL WORK

Name: John Doe. Estimated time, 4 hrs.

Date: September 5, 1920. Actual time, 5½ hrs.

Job: Making a Square to Round Connection for a Ventilating Pipe.

Instructions:

First: Check at the left each unit operation involved in the job.

Second: Place in the column at the right the numbers checked in the order in which the unit operations should be performed.

Unit Operations	Order of Procedure
x 1. Making a dimensioned sketch	1
x 2. Developing patterns	2
x 3. Making a bill of material needed for a job	3
x 4. Cutting material	4
5. Folding edges	23
6. Forming cylinders with rolls	7
x 7. Forming with a brake	17
8. Grooving with a hand groover or grooving machine	13
9. Beading or swaging for reinforcing or making connections	17
10. Crimping to shrink edges	22
11. Burring edges with a machine	23
12. Peening, closing down or setting down seams	17
x13. Forming on stakes	
14. Double seaming on a stake or with a machine	
15. Turning edges with a machine	
16. Wiring edges	
x17. Riveting sheet-metal joints	
18. Tinning a soldering iron	
19. Soldering tin plate, zinc, and galvanized iron	

UNIT OPERATIONS (*Continued*)	ORDER OF PROCEDURE
20. Brazing copper and brass........................	
21. Raising or bumping sheet-metal forms.............	
x22. Flanging or stretching metal for riveted connections.	
x23. Punching holes with a hollow or a solid punch......	
24. Drilling holes	
25. Tinning copper, brass, and iron..................	
26. Cutting wire glass	
27. Building a charcoal fire in a fire pot..............	
28. Installing a warm air furnace.....................	
29. Erecting a metal ceiling..........................	
30. Sectioning and hanging or setting a cornice........	
31. Hanging a gutter and down spout.................	
32. Flashing or making roof connections..............	
33. Laying a metal shingle roof	
34. Laying a tin roof	
35. Assembling, setting, and glazing skylights..........	
36. Hanging and glazing hollow metal sash............	
37. Setting and erecting stacks.......................	
38. Laying a slate roof.............................	

Trade Analysis

SHEET-METAL WORK

Name: John Doe. Estimated time, 6 hrs.

Date: September 5, 1920. Actual time, 5½ hrs.

Job: Making a Water Bucket.

Instructions:

First: Check at the left each unit operation involved in the job.

Second: Place in the column at the right the numbers checked in the order in which the unit operations should be performed.

Unit Operations	Order of Procedure
1. Making a dimensioned sketch	2
x 2. Developing patterns	3
x 3. Making a bill of material needed for a job	4
x 4. Cutting material	5
x 5. Folding edges	27
x 6. Forming cylinders with rolls	15
7. Forming with a brake	16
x 8. Grooving with a hand groover or grooving machine.	6
9. Beading or swaging for reinforcing or making connections	8 11
10. Crimping to shrink edges	12
x11. Burring edges with a machine	14
x12. Peening, closing down or setting down seams	13
x13. Forming on stakes	23
x14. Double seaming on a stake or with a machine	17
x15. Turning edges with a machine	18
x16. Wiring edges	19
x17. Riveting sheet-metal joints	
x18. Tinning a soldering iron	
x19. Soldering tin plate, zinc, and galvanized iron	
20. Brazing copper and brass	
21. Raising or bumping sheet-metal forms	
22. Flanging or stretching metal for riveted connections.	
23. Punching holes with a hollow or a solid punch	
24. Drilling holes	
25. Tinning copper, brass, and iron	
26. Cutting wire glass	
x27. Building a charcoal fire in a fire pot	
28. Installing a warm air furnace	
29. Erecting a metal ceiling	
30. Sectioning and hanging or setting a cornice	
31. Hanging a gutter and down spout	
32. Flashing or making roof connections	
33. Laying a metal shingle roof	
34. Laying a tin roof	
35. Assembling, setting and glazing skylights	
36. Hanging and glazing hollow metal sash	
37. Setting and erecting stacks	
38. Laying a slate roof	

OPERATION SHEET

Making a Dimensioned Sketch

Directions:

1. When making a pencil sketch of an object to be made of sheet metal, show the general shape, angles, offsets, reducers, branches, openings, and any other special features of the object. It is not necessary to make the lines of any definite length, but the nearer they are in proportion to the object itself, the better.

2. Use figures to indicate the diameter, length, height, width, number of degrees in angles, pitch of roof or any other dimensions which will be needed in making a detail drawing.

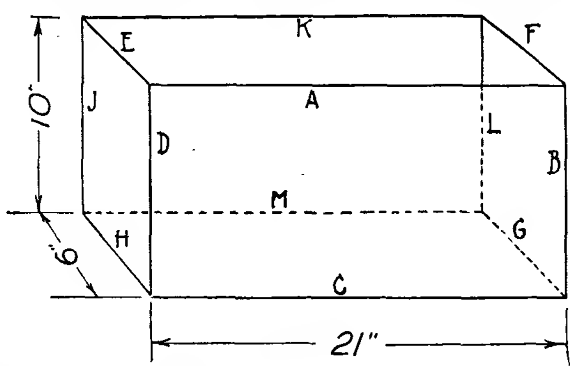


Fig. 1

Object with straight sides.

3. When the object to be sketched is similar in shape to an open sheet-metal box with right-angled corners, make a sketch of the front as it appears when looking directly at it.

Use vertical lines to represent its height and horizontal lines to represent its length as *A, B, C* and *D* in Fig. 1.

Draw oblique or slanting lines from the corners of this view to represent the corners of the ends of the box as *E, F, G* and *H*. These slanting lines should be parallel to each other. From these slanting lines draw vertical and horizontal lines to represent the back of the box as *J, K, L* and *M*.

Use broken or dotted lines to represent edges or corners which cannot be seen because of other surfaces in front of them.

Draw dimension lines parallel to the lines to which they refer and indicate by figures the dimension between any two points as 10″, 6″ and 21″.

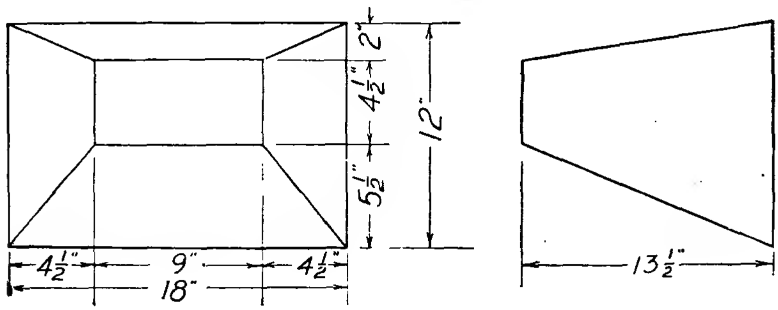


FIG. 2

4. It is sometimes necessary to make more than one sketch or view. Fig. 2. The first view in Fig. 2 shows the size and shape of the top and bottom but the second view is necessary to show the height of the object.

Cylinder.

5. Draw two parallel lines to represent the sides of a cylinder and represent the circular ends with ovals as in Fig. 3.

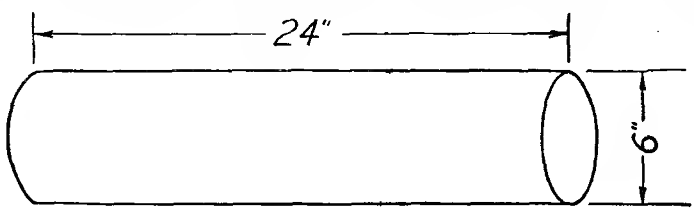


FIG. 3

Use dimension lines and figures to indicate the diameter and length.

6. When an object consists of two or more cylinders whose center lines or axes do not coincide, show in the sketch the amount of offset as *A* in Fig. 4. Show other dimensions parallel to the center lines as at *B*, not along the slanting lines.

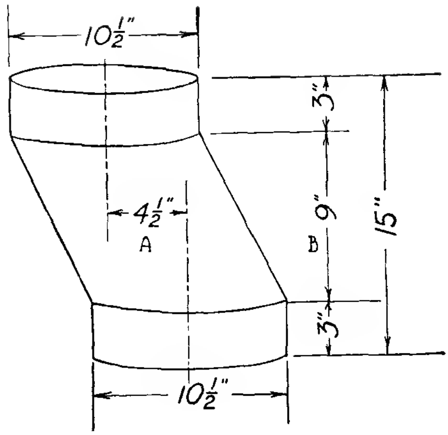


FIG. 4

Cone.

7. Make a sketch showing the diameters at the large and small ends and the true height measured along or parallel to the axis. If the taper of the sides is not the same all around. Show this by indicating the amount of offset between the centers of the top and bottom as in *B* and *C* of Fig. 5.

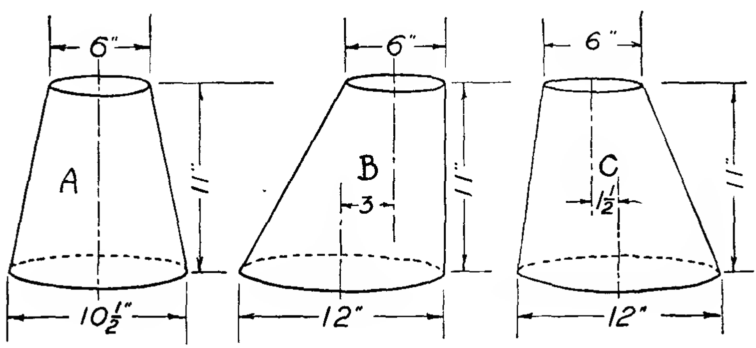


FIG. 5

References:

Longfield, *Sheet Metal Drafting.*

OPERATION SHEET

Developing Patterns

Directions:

1. Develop patterns for sheet-metal work on the metal; or on paper and transfer to the metal by punching thru the paper with a prick punch to locate the centers of arcs and the ends or intersections of lines. To transfer irregular curves, prick holes thru the paper pattern at close intervals along the line.
2. Use dividers to draw arcs and a straight-edge and scratch awl to draw straight lines on metal.
3. Make all measurements very accurately and make allowances on the pattern for laps and seams.
4. The three methods commonly used in developing sheet-metal patterns are by means of parallel lines, radial lines, and by triangulation.

Parallel Line Forms.

1. This method is used to develop patterns for cylinders, elbows, tee-joints, cornices, skylights, gutters and other objects in which the principal lines are parallel.

To Develop a Pattern for a Pipe cut at an Angle other than Square, Fig. 6.

2. Lay a metal sheet on a bench, and, if the edge is not perfectly straight, use a straight-edge and scratch awl to draw a horizontal straight base-line about ¼ inch from the bottom edge of the sheet.
3. Use a square to draw, perpendicular to the horizontal base line, two vertical lines with the distance between them equal to the diameter of the pipe; then measure off on one of the vertical lines the length of the long side of the pipe and draw a horizontal line from this point to the other vertical line. Measure off on the other vertical line the length of the short side of the pipe and connect the end of this side with the end of the long side with a straight line. This figure represents the side view or elevation of the pipe.

4. If the angle of the end is known, one may start from the end of one of the side lines and draw a straight line across the figure making an angle with the center line equal to the desired angle.

5. Directly above the elevation draw a half-circle or half-plan of the pipe.

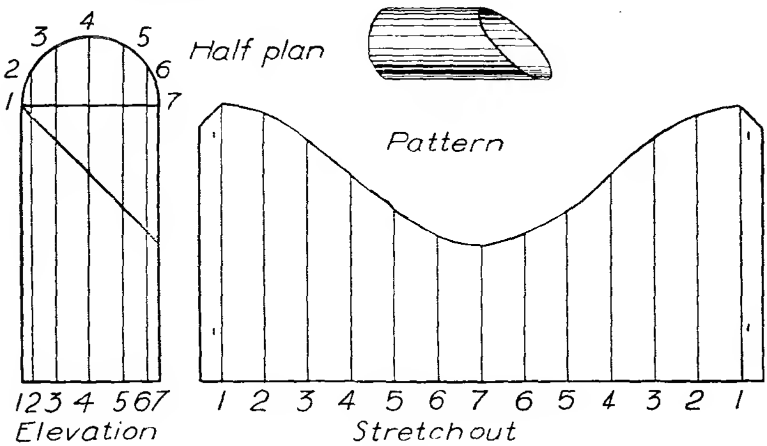


FIG. 6

6. With dividers step off the half circle into 6, 8, 12 or some other even number of equal spaces and number each point.

7. Hold a square against the horizontal base-line and draw vertical lines down from the numbered points to the horizontal base-line and number them to correspond with the numbers on the half-plan.

8. Compute the circumference of the cylinder and at one side of the elevation lay off this distance on the horizontal base-line. This line is called the stretch-out. Divide this stretch-out into twice as many equal spaces as are shown on the half-circle plan and at each point draw a perpendicular line.

9. Number the perpendicular line at the center of the stretch-out to correspond with the short side of the cylinder. Number the other lines to correspond with the other numbers in the half-plan. Since the stretch-out represents the full cir-

cumference, the numbers on the half-plan will be repeated on both sides of the center line.

10. Set dividers to the length of each line from the base-line to the slanting line on the elevation and mark off these lengths on the corresponding lines on the stretch-out.

11. Connect these points with a freehand curve to represent the edge of the metal which when rolled will form a pipe cut at the required angle.

12. At each end of the stretch-out allow 1½ times the desired width of a grooved seam. Measure back from the ends the width of the grooved seam and mark with a prick punch to indicate the amount to be folded. At an angle equal to the angle of the end of the pipe, cut the corners off at the upper end of the allowances for a seam.

Radial Line Form.

1. This method is used to develop patterns for conical shaped objects such as pitched covers, funnels, chimney tops, buckets, roof stacks and other objects the lines of which when extended meet in one point.

To Develop a Pattern for a Funnel. Fig. 7.

2. Draw a side view or elevation of the funnel and extend the side lines of both body and spout of funnel until they meet at *O* and *X*.

3. Directly above the top of funnel and the large end of spout draw half-circles or half-plans.

4. Divide the circumference of each of these half-plans into an even number of equal parts.

5. Set dividers equal to *OA* and on a blank space on the sheet strike an arc *ABA*. Set dividers equal to *OD* and strike arc *DCD*.

6. Set dividers equal to one of the equal parts of the circumference on the half-plan of funnel body and step off on arc ABA twice as many spaces as are shown on the half-plan. Draw lines from ends of *ABA* to center *O*. The figure *ABADCD* is the development of the surface of the funnel body.

7. Add 9/32-inch beyond the radial lines *ADO* for a seam and measure back from these lines 3/16 inch and mark with a

prick punch to indicate the amount to be folded. At an angle of 45 degrees cut the corners off the allowances for a seam. If the top edge is to be wired, mark on pattern outside of the arc *ABA* the regular allowance of 2½ times the diameter of the wire.

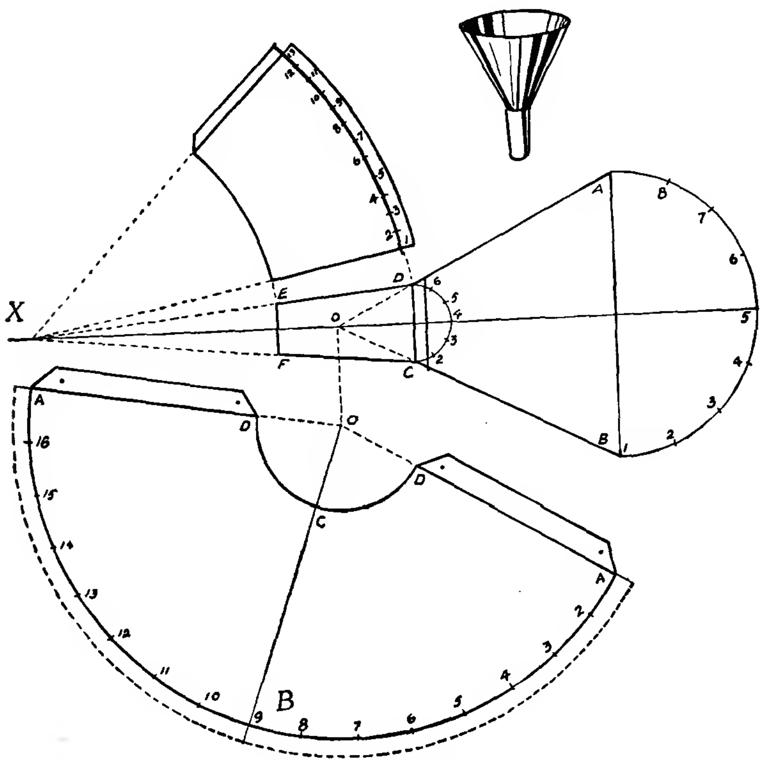


FIG. 7

8. With a radius equal to *XD* and one equal to *XE*, develop the surface of the spout. Add 3/16 inch beyond the radial line on one side for a lap joint and the same amount beyond the large arc for the lap around the body of funnel.

Irregular Forms.

1. In making sheet-metal work of irregular form, patterns are required which cannot be developed by either parallel or radial lines. Altho straight lines may be drawn on the

surface of such forms these lines will not be parallel nor will they meet in a common center. The method used for developing the surfaces of such objects is called triangulation. Often it is necessary to make only a half or quarter of pattern.

2. Make a plan and elevation of the object and in the plan view divide the lines representing the top and bottom into the same number of divisions and number them. Connect the ends of these divisions to form triangles covering the surface of the object. Use the lengths of the divisions in the plan as bases and the true length of the object as the altitude of right-angled triangles. Connect these lines to find the third side or true length of the lines on the surface of the object. These lines are used in developing a pattern of the surface of the object. The following example will illustrate the method which may be applied to any form. This figure is not developed by the radial line method previously described because the center of the top does not come directly over the center of the bottom and the angle of the side constantly changes.

To Develop a Pattern for a Reducing Pipe when the Center of the Top is not Directly above the Center of the Bottom. Fig. 8.

3. Draw an elevation and below the elevation draw a half-plan as it appears from the top.

4. Divide both half-circles of plan into the same number of parts and mark them with figures, using odd numbers on the line representing the plan of the top and even numbers on the line representing the plan of the bottom.

5. Connect the odd numbers to the next higher even number with full lines as *1-2, 3-4,* etc. Connect the even numbers with the next higher odd number with broken lines as *2-3, 4-5,* etc.

6. Draw a horizontal line and two vertical lines. Make the vertical lines equal to the true height of the object and letter them *AB* and *CD*.

7. Set the dividers to the length of full lines on the plan as *1-2* and space them off on horizontal line from point *A*. From these points draw lines to *B*. These lines represent

the true lengths of the full lines on the plan view. Number them according to the figures they connect as *1-2, 3-4,* etc.

8. Set the dividers to the length of broken lines on plan as *2-3* and space them off on horizontal line from point *C.*

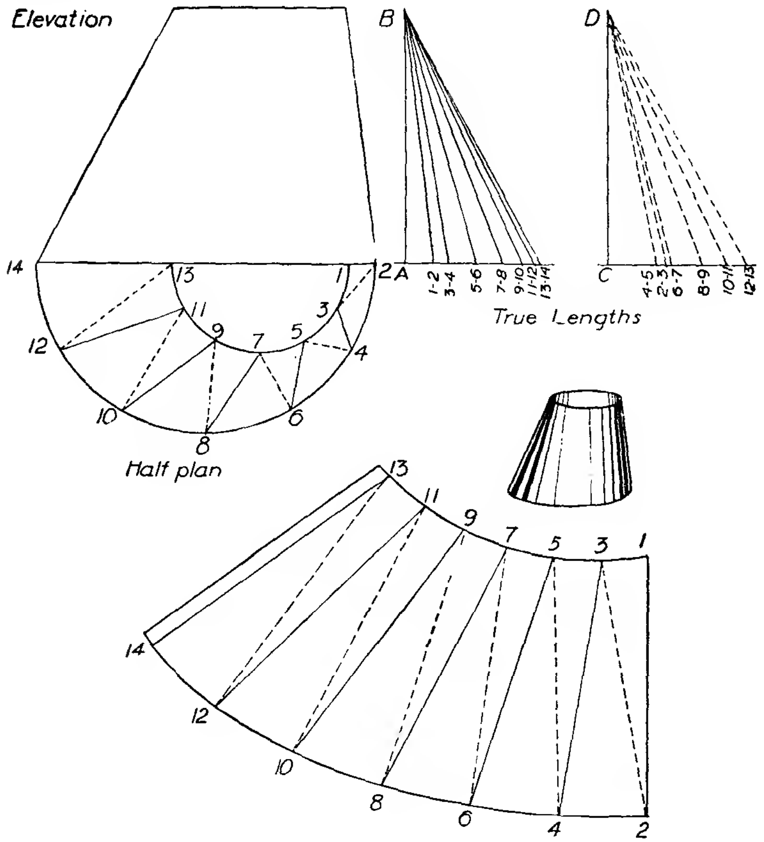


Fig. 8

From these points draw lines to *D.* These lines represent the true lengths of the broken lines on plan view. Number them according to the figures they connect as *2-3, 4-5,* etc.

9. To start the development of a half-pattern, draw a vertical line equal to the true length of *1-2* and number it the same.

10. With *2* on the development view as a center and the true length of *2-3* as a radius strike an arc. Set dividers to

1-3 on the plan and with *1* on the development view as a center strike an arc; and from the intersection of these two arcs draw the lines *2-3* and *1-3*.

11. With *3* on the development view as a center and the true length of *3-4* as a radius strike an arc. Set dividers to *2-4* on the plan and with *2* on the development view as a center strike an arc and from the intersection of these two arcs draw the lines *3-4* and *2-4*.

12. With *4* on the development view as a center and the true length of *4-5* as a radius strike an arc. Set dividers to *3-5* on the plan and with *3* on the development view as a center strike an arc and from the intersection of these two arcs draw the lines *4-5* and *3-5*.

Continue in this way to construct triangles until a half pattern is developed.

13. Allow ½ inch beyond the last line for a riveted seam.

To Develop a Pattern for a Rectangle to a Round Connection.

14. Draw a plan view *ABEF*, Fig. 8-a, and project above this for an elevation. Since the circle is in the center of the rectangle, only a half pattern is required.

15. Divide one-fourth of the circumference of the circle into four equal parts and draw lines *1-B*, *2-B*, *3-B*, *4-B* and *5-B*. These lines are the bases of triangles whose altitude is equal to the vertical height of the connection and whose hypotenuses lie in the surface of the connection to be developed.

16. Draw *OR* of indefinite length and from *O* draw a perpendicular line *OB* equal in length to the altitude of the connection.

17. With *O* as a center and *B1*, *B2*, *B3*, *B4* and *B5* of the plan view as radii, draw arcs cutting the line *OR* at *1*, *2*, *3*, *4* and *5*. Lines drawn from *B* to these points represent the true length of the corresponding lines in the plan view. With *O* as a center and *5D* as a radius lay off *OD*. The line *BD* then represents the true length of *5D* of the plan or the seam line in the pattern.

18. Lay off *AB* of the half pattern equal to *AB* of the plan view. With *A* and *B*, as centers and a radius equal to the true length of *B1*, draw arcs that intersect. Again with *A* and *B* as centers and radii equal to the true lengths of *B2*, *B3*, *B4*, and *B5*, draw arcs of indefinite length.

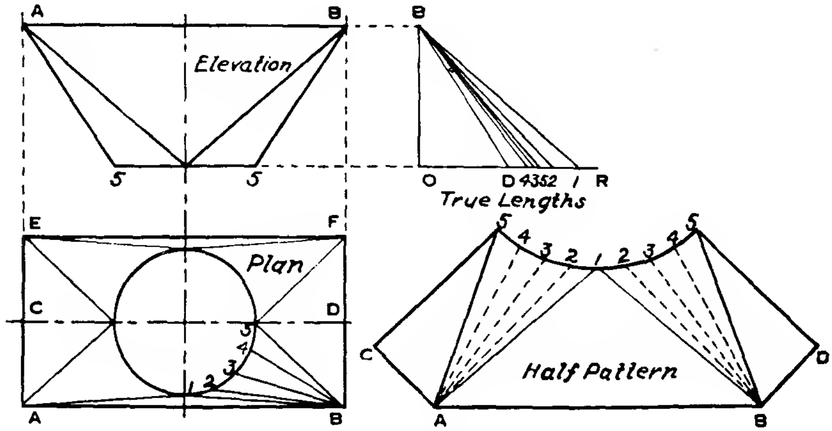


FIG. 8-a

19. With *1* as a center and a radius equal to *1-2* of the plan view draw an arc cutting the arcs *A2* and *B2* at *2*. With *2* as a center and the same radius draw arcs cutting the arcs *A3* and *B3* at *3*. Continue in this same way to locate points *4* and *5*. Thru *5-1-5* draw a curve. Connect *A5* and *A1* also *B5* and *B1*.

20. With *A* and *B* of the half pattern as centers and a radius equal to *BD* of the plan, draw arcs. With *5* and *5* of the half pattern as centers and a radius equal to *BD* of the true length lines draw arcs cutting at *C* and *D* the arcs previously drawn. Draw *AC* and *5C* also *BD* and *5D*. This completes the outline of a half pattern, *C5* and *D5* being the seam lines. Proper allowance must be added for seams or joints.

To Develop a Pattern for a Four Piece, 90 Degree Elbow.

Fig. 8-b.

21. With *O* as a center draw an elevation of the elbow. Divide the arc *BE9* into 3 equal parts *BD*, *DF* and *F9*, this being one less than the parts to be in the elbow. Bisect each

of these three arcs at C, E and G and draw lines from center O to each of these points. OC, OE and OG form the miter lines on which the seams are to be formed.

22. Draw BC, CE, EG and $G9$ tangent to the outside curve of the elbow at points B, D, F and 9. Draw similar tangents to the inside curve of the elbow.

23. Draw a half plan below the line *1-9* and divide its arc into an even number of equal parts. From these points on the arc of the plan draw vertical lines to the miter line OG.

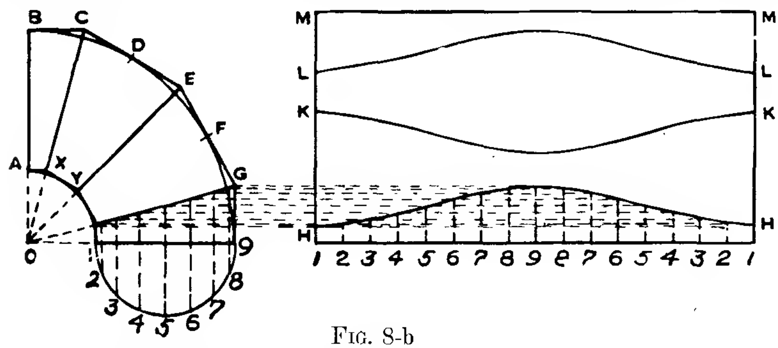


Fig. 8-b

24. Extend line $O9$ and lay off *1-9-1* equal to the circumference of the elbow on a miter line. Divide this stretch-out into twice as many equal spaces as the number of spaces in the half-plan and number them to correspond.

25. From each point on the miter line project across until the lines intersect lines of corresponding number drawn vertically from the stretch-out. Thru these points of intersection draw a curved line which represents the stretch-out of the miter line. All of the miter lines will conform to this shape.

26. To lay out a pattern for each of the sections, make HK equal to GE, KL equal to XY and LM equal to BC. Cut along the line HH and use this edge to mark the curves KK, and LL. When cutting the material, make allowance for joints.

References:

Daugherty, J. S., *Sheet-Metal Pattern Drafting and Shop Problems.*

Broemel, *Sheet Metal Workers Manual,* pp. 235-265.

Kidder, *Triangulation.*

OPERATION SHEET

Making a Bill of Material Needed for a Job

Directions:

Carefully read the drawings, details, specifications, and miscellaneous directions pertaining to the job. From these make a list of tools and the approximate amount of materials required such as:

1. Quantity, size and gage of galvanized iron.

2. Quantity, size and weight of copper by ounces to square foot or by gage.

3. Quantity and size of rivets. Indicate size of rivets by ounces and pounds to one thousand rivets and indicate whether tinned, black, or copper; flat, countersunk, or round head.

4. Quantity of solder and kind of flux.

5. Quantity of tin sheets for roofing, sixty-three sheets 14x20 for one hundred square feet.

6. Quantity of bright tin for tinware and cooking utensils.

7. Quantity, size and gage of sheet zinc.

8. Quantity, size and gage of black sheet iron or steel. Indicate thickness by U. S. Standard gauge.

9. Quantity of charcoal for fuel.

10. Quantity and size of angle and band iron.

11. Quantity and size of copper and galvanized wire.

12. Quantity and size of galvanized, copper, and wire nails.

13. Quantity and grade of roofing paper.

14. Quantity and grade of red mineral and oil.

15. Miscellaneous: Copper gauze, bolts, sheet-metal screws, rosin, muriatic acid and sal-ammoniac.

16 List all tools needed for the job, in addition to the regular tool kit, including bench machines and other special equipment when needed.

17. When making a bill of material from blue prints be careful to locate all places where sheet metal is required such as the following:

Roof	Chimney flashing
Gutters	Window flashing
Valleys	Porch flashing
Hips	Stove canopies
Ridge	Ventilating stacks
Cornice	Smoke stacks
Down spouts	Sky lights

Hot-air furnace and pipes

References:

Catalogues of Sheet-Metal Supply Houses.

Questions:

1. How do you indicate the thickness of sheet-iron or steel?
2. How is the thickness or weight of sheet copper indicated?
3. How many sheets of tin 14x20 will it take to cover fifty square feet?
4. Why is bright tin used in making cooking utensils?

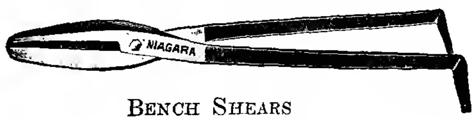
OPERATION SHEET

Cutting Material

Directions:

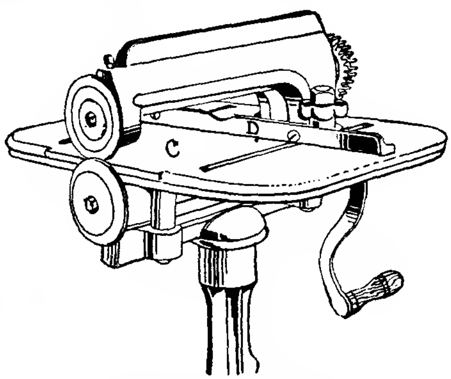
Hand Shears or Snips.

1. Use hand snips to cut metal 20 gage and lighter. Place the upper blade on the line to be followed, keep the blades perpendicular to the surface of the metal and make straight up and down cuts. Waste metal or the smaller piece should curl up on the upper side of the lower blade. Keep snips sharp, well oiled, and adjusted just tight enough to work freely. To cut an opening in a sheet of metal, first punch or cut a hole inside of the outline of the desired opening so that the blades of the snips will take hold. To cut an inside circular opening use circular or curved snips.



Bench Shears

Lever Shears



Rotary Slitting Shears

2. Use bench shears to cut metal from 22 gauge to 16 gage.

3. Use lever shears to cut metal heavier than 16 gage.

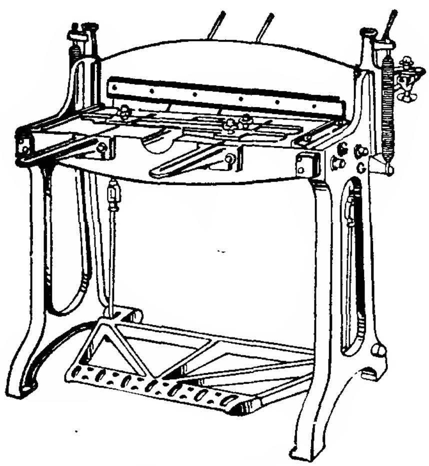
4. Use pliers to cut wire 8 gage and lighter and a cold chisel for heavier wire.

Rotary Slitting Shears.

5. Use a slitting machine to cut long strips. Hold the edge of the sheet against the gage, press the sheet against the cutting wheel and turn the handle until the full length of the strip has been cut.

Squaring Shears.

6. Foot power squaring shears are made to cut metal 22 gauge and lighter. (Power shears are made to cut heavier metal). Set the long or bed gage parallel to or at an angle

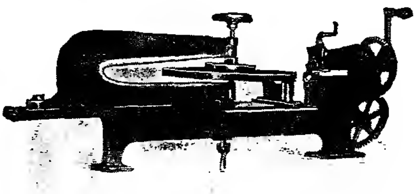


SQUARING SHEARS

with the blades according to the shape desired. Place the metal on the table of the machine and trim off from $\frac{1}{8}$ to $\frac{1}{4}$ inch to form a straight edge. Hold the trimmed edge against the gage and shear the sheets to size, one piece at a time. To square the corners of a piece of sheet metal, set the long gauge parallel to the blade at a distance equal to the width desired. Place the sheet between the blades and trim off $\frac{1}{8}$ to $\frac{1}{4}$ inch to form a straight edge. Turn the sheet over, hold trimmed edge firmly against the gage and shear to desired width. Set the long gage parallel to the blades at a distance equal to the length desired. Hold the edge of the sheet against the side gage and trim off from $\frac{1}{8}$ to $\frac{1}{4}$ inch to form the first square end. Turn the sheet over, hold squared end firmly against the long gage and one edge against the side gage then shear the second end square. Oil blade and bearings frequently.

Ring and Circle Shears.

7. To cut 22 gage or lighter metal to form true circular discs use a ring and circle shears. Cut metal to form squares about $\frac{1}{4}$ inch larger than the circle desired. Set swinging gage so that distance between gage and center of clamping discs equals $\frac{1}{2}$ the length of one side of the square. Set sliding circle arm so that the distance from the center of clamping discs to the cutting rolls equals $\frac{1}{2}$ of the diameter, (or the radius) of the desired circle. Some machines have on the side of the base a graduated scale for setting the sliding circle arm.



RING AND CIRCLE SHEARS

Place the square sheet between the discs with one edge against the swinging gage. Hold a second edge against the cutting rolls and turn the handle to draw the sheet between them enough to start the cut. Tighten the clamping discs and turn handle until complete circle is cut.

8. Use a hack-saw to cut angle iron and other heavy metal. Mark the length on the metal and clamp it in a vise. Have the blade tight in handle and cut with a forward stroke.

9. Use a miter box to cut metal trim. Set the saw guides to the desired angle, measure the molding length on inside edge, hold the molding firmly against the guides in the box and cut with a metal cutting saw sliding in the miter box guides.

References:

Broemel, *Sheet-Metal Manual*, pp. 39, 156, 161, 162.

Questions:

1. Why not use hand snips to cut metal heavier than 20 gauge?
2. Why should the blades of hand snips be held perpendicular to the surface of the metal being cut?
3. What advantage is gained by using a slitting machine to cut long metal strips?
4. Why use ring and circle shears to cut out circular pieces of metal?
5. Why should metal be cut into squares before it is cut into circles in a ring and circle shears?
6. Why is it important, before making accurate measurements on a sheet of metal, to trim one edge straight?
7. In squaring metal on a squaring shears why is it necessary to hold the metal firmly against the side gage?
8. Why use a hack-saw to cut angle iron?
9. Why is it good practice to use a miter box to cut metal trim?

OPERATION SHEET

Folding Edges

Directions:

Folding Edges for a Lock or a Grooved Seam. Fig. 9.

1. Loosen the lock screw in the front of the folder frame, turn the handwheel or lever to set the gage to the width of the

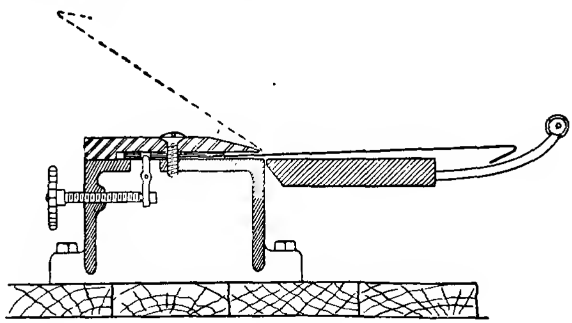
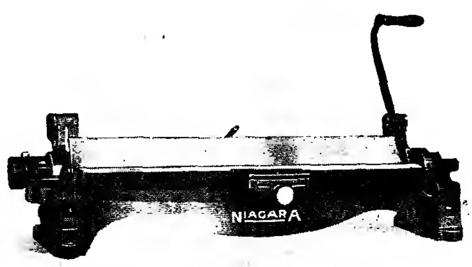


Fig. 9



Bar Folder

fold desired, then tighten the lock screw. The top of the bending leaf should be even with the top of the folder frame.

2. Hold the metal sheet in the folder firmly against the gage and with the handle at the right side of the machine, turn the bending leaf over as far as it will go. Hold the metal sheet in this position and return the bending leaf to the starting position.

3. Slide the sheet back and repeat the folding operation at the opposite end, being careful to have the second fold turn in the opposite direction to the first fold.

Folding Edges for a Hem. Fig. 10.

4. Fold the edge as for a seam, then lay the folded edge on the clamping bar and with the bending leaf, mash it flat. For a double hem, repeat the operations in the same direction.

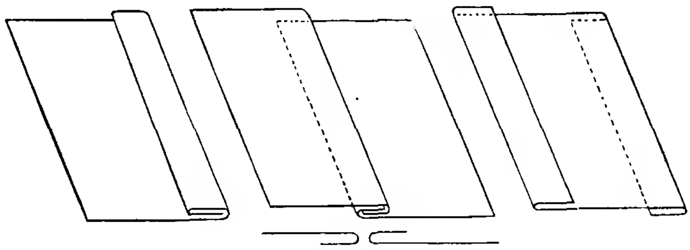


FIG. 10

Folding Edges for Wiring. Fig. 11.

5. Set the gage to 1½ times the diameter of the wire, then loosen the lock screw on the back of the machine and push this screw to the right or left to lower the bending leaf below the top of the folder frame a distance equal to the diameter of the wire. Fasten the lock screw, place the edge of the metal sheet against the gage and turn the bending leaf over as far as it will go.

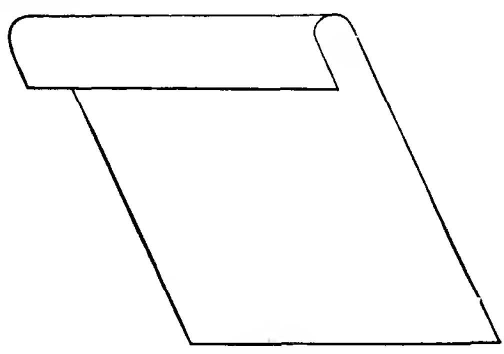


FIG. 11

6. Another method to fold for wiring is to set the gage to $2\frac{1}{2}$ times the diameter of the wire and fold the edge to a right angle, then set the gage to the diameter of the wire and again fold the edge to a right angle.

Folding Edges for Flat Lock Roofing. Fig 12.

7. Draw lines one-half inch from two adjoining edges of a square cornered metal sheet and note where they intersect. At an angle of 45 degrees cut the corner off on a line passing thru this point of intersection. Use this for a pattern to mark other sheets or to set gages on a squaring shears for duplicating this cut. Cut off the four corners of each sheet.

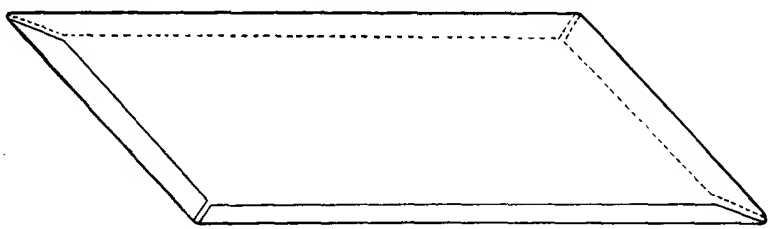


FIG. 12

8. Fold $\frac{1}{2}$ inch on four edges of the metal sheet with a common roofing folder, two adjoining edges to be folded to one side of the sheet and the other two edges to the other side of the sheet.

References:

Broemel, *Sheet Metal Workers Manual,* pp. 45, 164-165.
Neubecker, *Sheet Metal Work,* p. 167.

Questions:

1. Why should metal be held firmly against the gage when folding?
2. When metal sheets are to be joined by lock seams, why are two edges of each sheet folded, one to one side and the other to the opposite side of the sheet?
3. Why are hemmed edges mashed flat?
4. Why are all four edges of the metal sheets folded when making flat lock roofing?
5. In folding edges for wiring, why are some turned to $2\frac{1}{2}$ times the thickness of the wire and others $1\frac{1}{2}$ times the thickness of the wire?
6. What might occur if the lock screw were not tightened after the gage is set to the desired width?

OPERATION SHEET

Forming Cylinders with Rolls

Directions:

1. By means of the screws on top of the forming machine, bring both ends of the front rolls together until the metal sheet will just pass freely between them. If the edges have been folded, the rolls must be far enough apart to avoid mashing the folds.

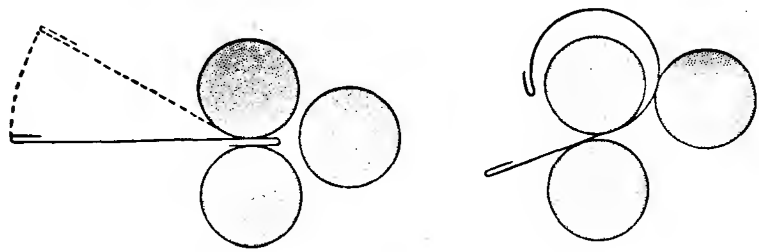


Fig. 13

2. Experiment to find the proper height of the rear roll to make a cylinder of the desired diameter. To make a larger cylinder, lower the rear roll; to make a smaller cylinder, raise the rear roll; to form a conical shape, have the rear roll higher at one end than at the other.

3. Hold the sheet in a horizontal position with the surface which is to form the outside of the cylinder, against the bottom roll. Start the sheet between the rolls, raise it as shown by the dotted line in Fig. 13, turn the handle until the cylinder is about half formed, then take hold of the first edge as it comes over the top of the upper roll and continue turning until the cylinder is completely formed.

4. When using a lock seam, make the cylinder larger than the final diameter and spring the seam together; for a lap seam, make the cylinder slightly smaller to help hold the lap in position while riveting or soldering. Fig. 14.

5. To remove a cylinder from a former with a solid housing, spring the edges of the sheet apart and draw the cylinder

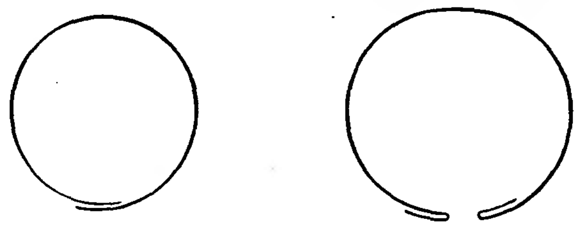
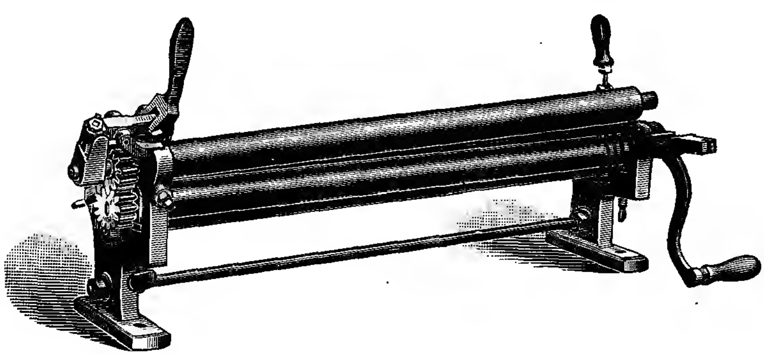


FIG. 14

over the roll; to remove a cylinder from a slip roll former, open the housing and slip the cylinder off at the end of the roll.



FORMING ROLLS

Forming a Cylinder with a Wired Edge.

6. Place the metal sheet between the rolls with the wired edge lying in the groove of the lower roll.

References:

Broemel, *Sheet Metal Workers Manual,* pp. 170, 171.

Questions:

1. Why should the rolls be adjusted at both ends?
2. Why should the end of the metal sheet be raised before passing it between the rolls?
3. In forming a conical shape, why should one end of the rear roll be higher than the other?

4. How does raising or lowering the rear roll change the diameter of the cylinder formed?

5. Why should caution be taken to avoid mashing folded edges when passing them between the rolls?

6. Why should a wired edge be placed in the groove of the lower roll?

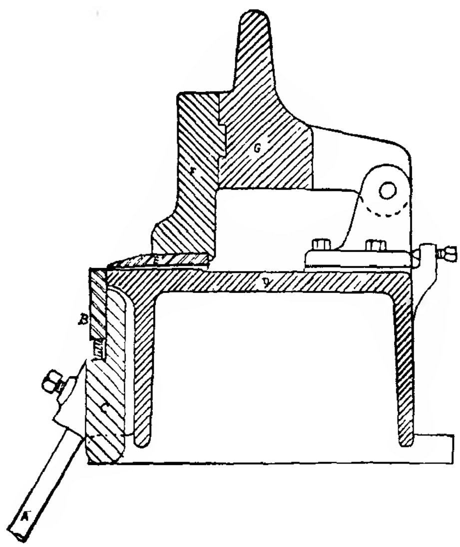
OPERATION SHEET

Forming With a Brake

Directions:

1. Lay off and mark bending lines on the sheet of metal.

2. Open the clamping bar by pushing the handle backwards and with the aid of a helper at the left side of the brake, place the sheet of metal on the brake table or bed. Bring the gage or prick-punch marks, indicating the line of the bend,



Cross Section of Brake

directly under the edge of the clamping bar, then bring the bar down to hold the metal firmly in place. The helper must stand clear of the bending leaf while the brake is being operated.

3. Set the stop at the right side of the brake to indicate the angle or the amount of the bend, raise the bending leaf until it strikes the stop, then return it to its former position.

4. Open the clamping bar and move the sheet so as to bring the next line of bend under the edge of the clamping bar. If the bend is to be turned in the opposite direction from the bend just made, the helper should step to the center of the brake, grasp the sheet near the center, swing it end for end and place it between the clamping bar and bed of brake, before placing it in position for bending. The helper should always assist in raising the bending leaf.

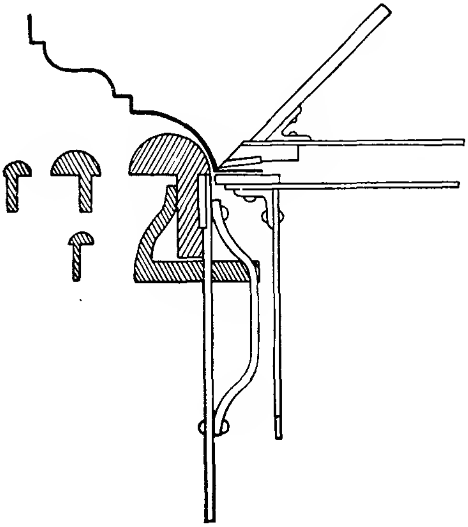


Fig. 15

Forming Molding. Fig. 15.

5. Bend the metal to a right angle.

6. Clamp a wooden mold of the desired radius on the bending leaf, open the clamping bar and place the metal on the bed of the brake. Draw the right angle bend against the wooden mold and hold the metal firmly in place with the clamping bar.

7. With hands held flat against the back of the metal, carefully bend it over the wooden mold until it retains the desired shape.

8. When bending metal heavier than 20 gage, move the clamping bar back on the bed the thickness of the metal and reinforce the bending leaf with an angle-iron.

References:

Broemel, *Sheet Metal Workers Manual,* pp. 55-69.

Questions:

1. Why are bending lines marked with a prick-punch before the metal is inserted in a brake?
2. Why should a brake be operated by the man on the right side?
3. Why is it necessary to reinforce the bending leaf when bending heavy metal?

OPERATION SHEET

Grooving with a Hand Groover or Grooving Machine

Directions:

Grooving Seams of Cylinders with a Hand Groover. Fig. 16.

1. Hook the folded edges of the seam together and place the cylinder over a mandrel stake. Fit a hand groover over the seam at one end and strike it with a hammer. Repeat this at the other end of the cylinder to keep the edges from coming apart, then continue the operation over the entire length of the seam. The width of the groover should be slightly greater than the width of the seam.

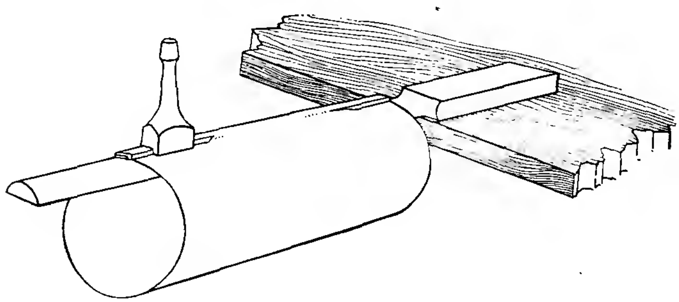


Fig. 16

2. Finish the seam by flattening it with a wooden or rawhide mallet while the cylinder is still on the mandrel stake.

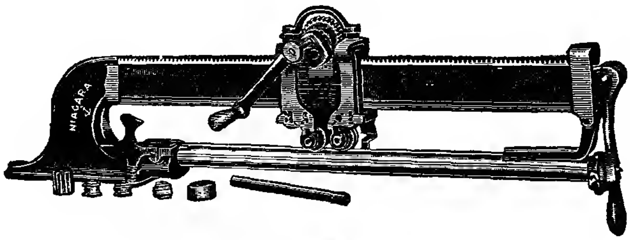
Grooving Seams of Flat Sheets.

3. Hook the edges of the seam together directly over a long and heavy flat piece of iron resting on a bench or table, then groove and flatten as directed above.

Grooving with a Machine. Fig. 17.

4. Place in the carriage of the machine a grooving wheel which fits the seam and run the wheel back to the frame of the machine.

5. Open the latch at the front of the grooving horn, hook the edges of the seam together to form a cylinder, place the seam directly over the center of the grooving horn and in line with the grooving wheel, then close the latch.



GROOVING MACHINE

6. Hold the cylinder firmly in place with the left hand, turn the crank with the right hand to run the grooving wheel over the seam, then return the grooving wheel to its former position, open the latch and remove the cylinder.

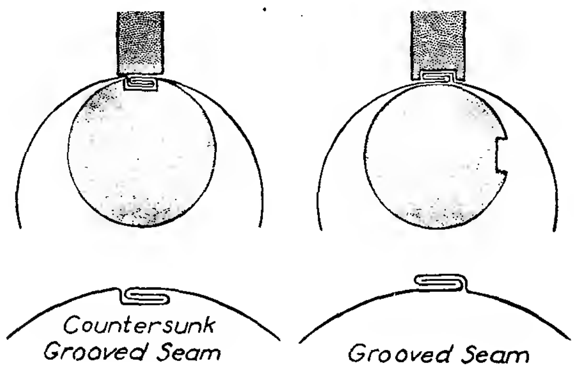


FIG. 17

7. If a countersunk grooved seam is desired, turn the grooving horn until the groove in it is directly under the grooving wheel and use a wheel which has a straight face.

8. Place the cylinder on a mandrel stake and flatten the seam with a wooden or rawhide mallet.

References:

Broemel, *Sheet Metal Workers Manual,* pp. 79, 172.

Questions:

1. Why are some grooved seams made wider than others?
2. Why should a grooved seam be flattened with a mallet?
3. Why should the latch at the end of the grooving horn be closed when the grooving wheel is passed over the seam?
4. Why should the groove in a hand groover or in a grooving wheel be slightly wider than the seam?

OPERATION SHEET

Beading or Swaging for Re-inforcing or Making Connections

Directions:

Re-inforcing Cylindrical or Conical Shaped Sheet Metal Objects. Fig. 18.

1. Use the ogee or triple beading rolls to re-inforce and strengthen sheet metal cylinders or conical shaped objects.

2. Set the gage on the lower arm of the machine so as to locate the bead the desired distance from the edge, then lock the gage with the thumb screw. Raise the upper beading roll by means of the crank screw located above it.

3. Place the metal article between the beading rolls with the edge firmly against the gauge. Turn the crank screw on the top of the machine until the metal is held quite firmly between the rolls.

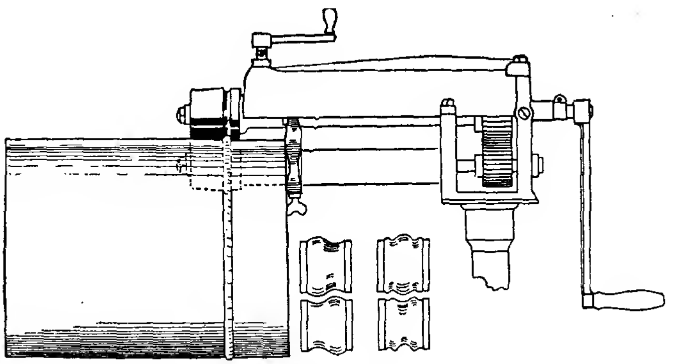


Fig. 18

4. Support the metal in a horizontal position with the left hand and turn the handle of the machine with right hand until the metal object makes a complete revolution. Then screw down on the top roll again and revolve the object. Repeat these operations until the desired depth of bead is

secured. Do not force the rolls against the metal tight enough to cut it.

5. Unscrew the crank on top of the machine and remove the object on which the bead has been formed. Do not pass a seam between the rolls.

Beading or Swaging for Connections.

6. Use a single bead roll when beading or swaging for connections.

References:

Broemel, *Sheet-Metal Workers Manual*, p. 174.

Williams, H. V., *New Tinsmith Helper and Pattern Book*, pp. 28-211.

Questions:

1. Why must a gage be used when turning a bead on a sheet-metal cylinder?
2. Why should the rolls be brought together gradually when using a beading machine?
3. Why are only ogee or triple bead rolls used for strengthening a cylinder on a beading machine?

OPERATION SHEET

Crimping to Shrink Edges

Directions:

1. Turn the crank at the top of the machine to raise the upper crimping roll.

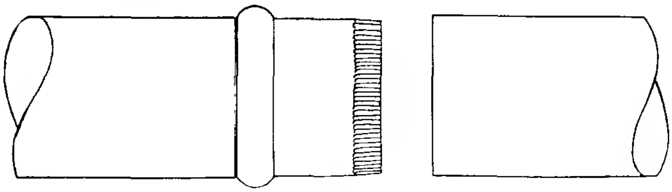
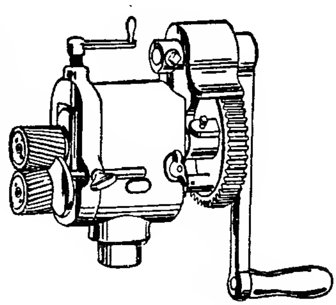


Fig. 19

2. Unscrew the set-screw and adjust the gage to the width of the crimp desired; then tighten the screw to keep the gage from moving.

3. Hold between the crimping rolls the edge to be crimped.

4. Turn the crank at the top of the machine to force the crimping rolls together so as to produce the depth of crimp desired.



Crimping Machine

5. Hold the metal loosely with one hand and with the other hand turn the handle of the machine to draw the metal between the crimping rolls. Do not pass a seam between the crimping rolls.

References:

Broemel, *Sheet-Metal Workers Manual,* p. 98.

Questions:

1. When the desired crimp is obtained, is it necessary to release the crimping rolls to remove the metal?
2. Why are the edges of sheet-metal sometimes crimped?
3. Why is it poor practice to pass a seam between crimping rolls?

OPERATION SHEET

Burring Edges with a Machine

Directions:

Forming a Small Right Angle Burr at the End of a Cylinder. Fig. 20.

1. Set the gage on the left side of the machine to the width of the burr to be formed. Hold the metal object in a horizontal position with its edge resting against the gage. Turn the crank at the top of the machine to set the upper burring

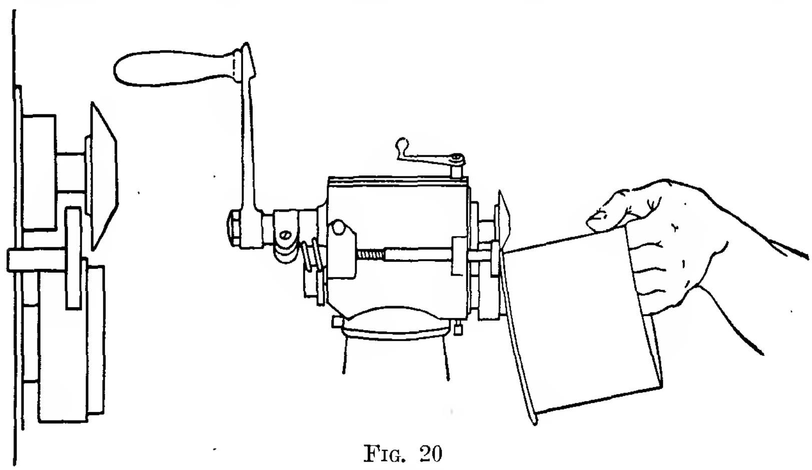


Fig. 20

wheel lightly on the metal. Turn the handle of the machine until a small depression is made in the metal all around the object. Continue to turn the handle and at the same time raise the object until a right angle burr is formed. Do not set the burring wheel down on the metal too tight or the edge will crimp and curl.

Burring a Circular Disc to Fit Over the End of a Cylinder. Fig. 21.

2. The metal disc should be large enough so that after the burr is formed on it, it will slip over the burred edge of the cylinder.

3. Fold crosswise a piece of metal 1½ inches wide and 3 inches long so that the angle will be about 30 degrees, and hold it in the crotch between the thumb and first finger of the left hand.

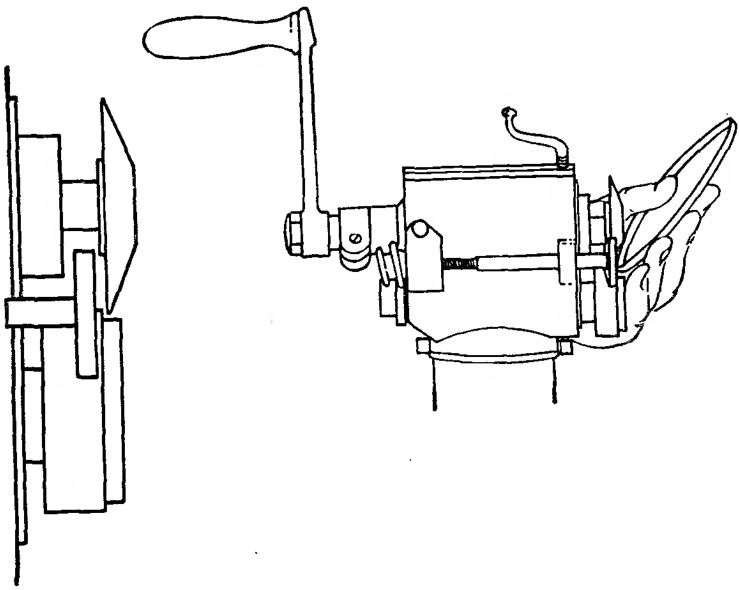


FIG. 21

4. With the metal disc resting in a horizontal position on the lower roll and its edge touching the gage, bring down the upper roll until the disc is held firmly between the two rolls. Allow the disc to rest on your finger tips and bear against its upper surface with your thumb. Rest the palm of your hand against the frame of the machine, turn the handle and allow the disc to pass freely thru your hand, being careful to keep the folded strip of metal between your hand and the edge of the revolving disc. While turning the machine, raise the disc gradually until a burr is turned on its edge, slightly beyond a right angle. Turn the machine rapidly to avoid buckling the metal.

References:

Broemel, *Sheet-Metal Workers Manual,* pp. 87, 201-202.

Questions:

1. Why should you raise the metal gradually when forming a right-angle burr?
2. Why can only a small edge be turned on a burring machine?
3. Why should you hold a piece of metal between your thumb and finger when burring the edges of a circular metal disc?
4. What may be the result if the burred edge is allowed to buckle?

OPERATION SHEET

Peening, Closing Down or Setting Down Seams

Directions:

Setting Down the Seam at the End of a Cylinder with a Hammer. Fig. 22.

1. Slip the burred edge of the cylinder bottom over the burred edge or flange formed on the end of the cylinder body. Rest the bottom on a flat stake and with the peen of a setting

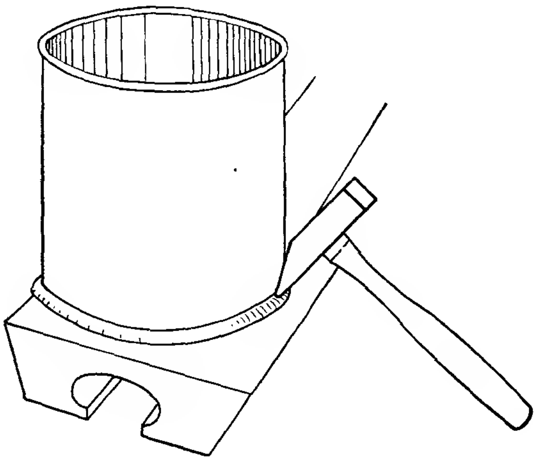


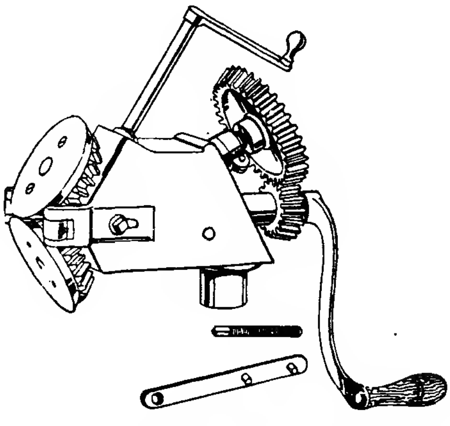
Fig. 22

hammer, bend or peen the edge of the cylinder bottom over the flange of the cylinder body, then with the flat face of the hammer, hammer the joint smooth.

Setting Down a Seam with a Machine.

2. Peen the seam with a hammer until the bottom is held securely in place. Set the roller gages on the machine to match the width of the seam. Place the seam over the lower roll and turn the crank on top of the machine to bring the

upper roll down and close the seam. Turn the handle of the machine to revolve the seam between the rolls. Some ma-



SETTING DOWN MACHINE

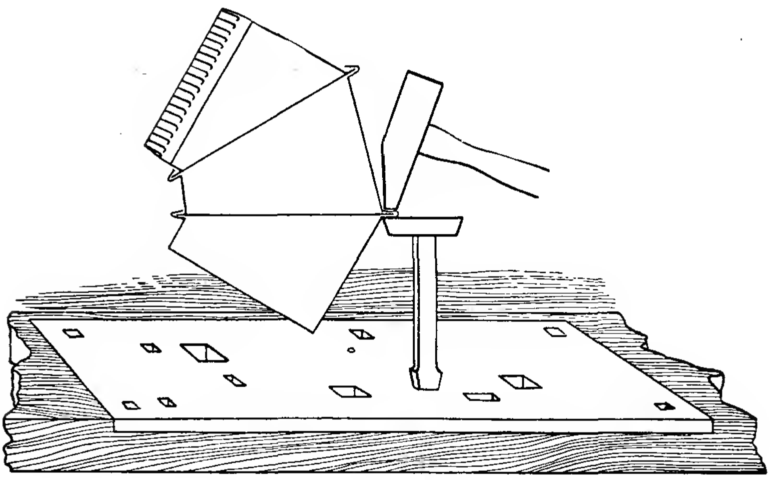


FIG. 23

chines require that the cylinder be held bottom side up while others may be used either way.

Peening Down the Seams on an Elbow. Fig. 23.

3. Slip the sections of the elbow together and rest a flange on top of a beak horn stake at its beveled edge. With the peen of a setting hammer peen the metal together and smooth the joint with flat face of the hammer.

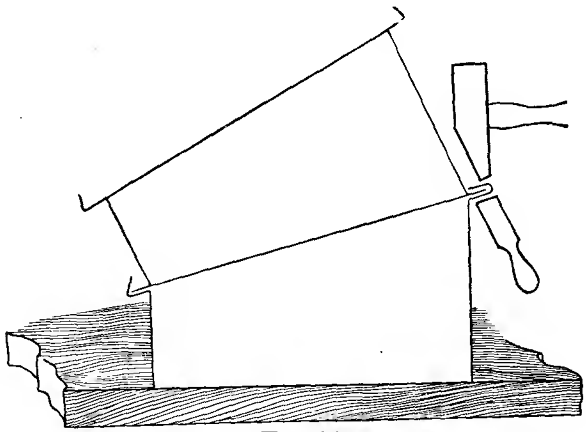


FIG. 24

4. When the elbow is too large or too heavy to hold on a stake, assemble the parts and hold a dolly, or a straight, heavy piece of iron under or back of the flange while peening. Fig. 24.

Peening Down Flat Lock Seams on a Metal Roof.

5. Slip the sheets together and peen the flanged edge of the upper sheet under the folded edge of the lower sheet, then flatten the seam with a mallet. Fig 25.

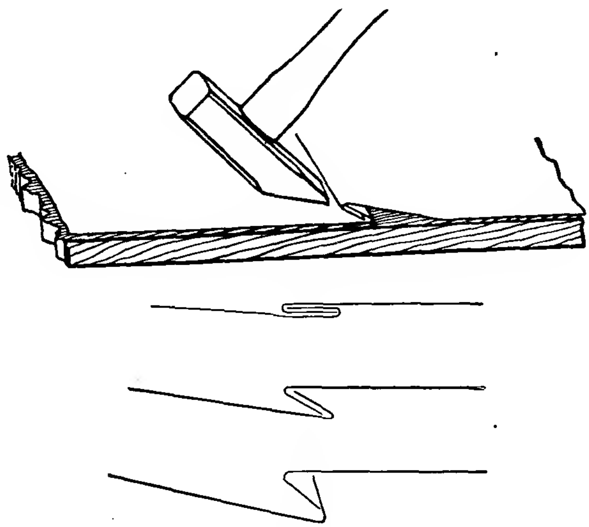


Fig. 25

References:

Broemel, *Sheet-Metal Workers Manual*, p. 211.

Williams, H. V., *New Tinsmith Helper and Pattern Book*, p. 199.

Questions:

1. Why do you use a peening hammer for setting down seams?
2. What precautions must be taken when setting down with hammer?
3. What other way can seams be set down?
4. Why are large elbows put together and finished in sections?
5. Why is it necessary to peen the upper edge under the lower edge when making flat seams?

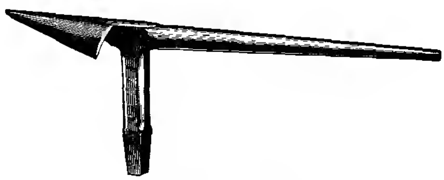
OPERATION SHEET

Forming on Stakes

Directions:

Forming on a Blowhorn Stake.

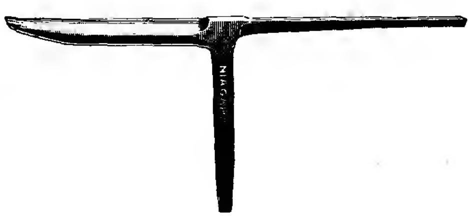
1. To form a cone shaped article, place one folded edge on the blowhorn stake a little beyond the top center line and bend the metal to start the circular shape. Repeat this operation at the other folded edge then continue the bending from one edge to the other. Hold a radial line of the sheet directly over the center line of the stake every time the metal is bent. As the shape of the stake is seldom the same as the cone desired, great care must be used to get the proper curve.



Blowhorn Stake

Forming on a Beakhorn Stake.

2. Hold the metal sheet on the flat part of a beakhorn stake so that the line on which the metal is to be bent is directly over the corner of the stake, then with the right hand,

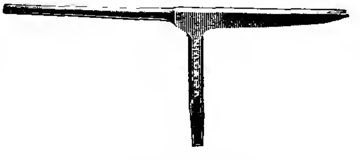


Beakhorn Stake

bend down the part extending beyond the stake to form the desired angle. Continue to hold the metal over the corner of the stake and strike on each side of the bend with a mallet until a sharp straight and smooth corner is formed.

Forming on a Needle Case Stake.

3. To form tubes and pipes, too small to be made on forming rolls, place the metal sheet over a needle case stake with one edge of the lap extending slightly beyond the top center line of the stake at a point where the diameter of the stake is slightly less than the diameter of the tube or pipe to be formed. Strike the metal with a mallet to start the bend and repeat the operation on the other edge, then hold the metal in both hands and gradually bend it over the stake until it is slightly larger than the finished diameter desired. When soldering the seam it may be pressed together by hand to the correct diameter.



Needle Case Stake

References:

Broemel, *Sheet-Metal Workers Manual*, pp. 128-131.

Questions:

1. Why is a blowhorn stake used in forming cone shaped articles?
2. Why are right-angle bends formed on a beakhorn stake?
3. In forming cylindrical shaped articles on stakes why must the edges be formed first?
4. What stakes are most often used in sheet-metal shops?

OPERATION SHEET

Double Seaming on a Stake or with a Machine

Note: After a sheet-metal object such as a cylinder with a closed end has been put together with a seam which has been finished with a hammer or a setting down machine, the seam is often bent over against the body of the cylinder. This joint is called a double seam and is made in several ways.

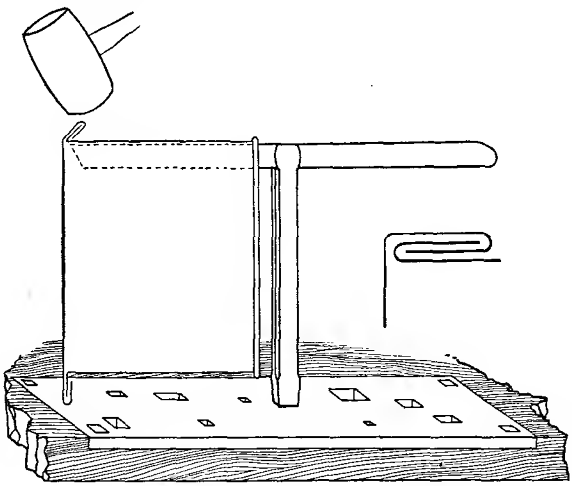


Fig. 26

Directions:

Double Seaming the End of a Cylinder on a Stake. Fig. 26.

1. With your left hand hold the cylinder over and firmly against the end of a double seaming stake. Strike inward blows with a mallet to bend the seam to an angle of about 45 degrees and continue all way around the seam. Complete the bending by hammering the seam down tight against the side of the cylinder and smooth it with a mallet.

2. Finish by holding the edge of the seam over a square head stake and with a mallet tap lightly on the bottom to square the corner. Fig. 27.

Double Seaming with a Machine. Fig 28.

3. Place the cylinder over the lower roll and move the upper roll over until the beveled edge is directly over the seam. Turn the crank screw until the beveled edge of the

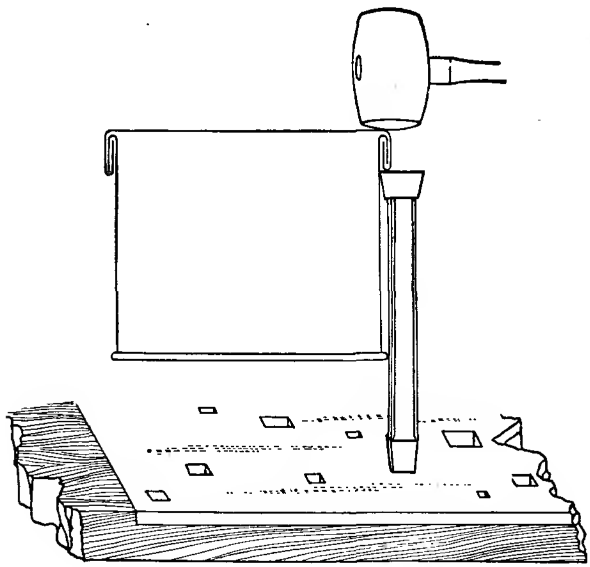


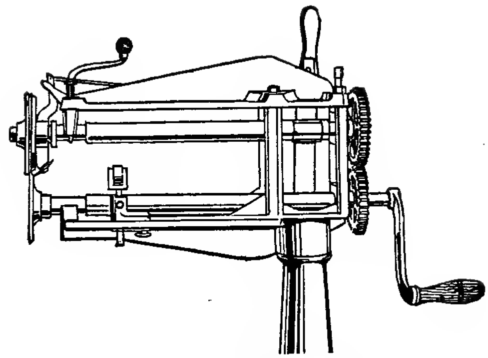
Fig. 27

wheel bends the seam over about 20 degrees, then turn the handle of the machine until the cylinder has made a complete revolution. Turn the crank screw until the seam is bent to an angle of 45 degrees and again revolve the cylinder.

4. Raise the upper roll and shift it over until the straight face is over the seam. Turn the crank screw to bring down the upper roll and in two operations press the seam flat against the side of the cylinder.

Double Seaming Corners on a Square Stake. Fig 29.

5. Hook the folded edge over the right-angle edge and place the object over a corner of a square stake. Close the seam with pliers, then bend it over and hammer it down smooth with a mallet.



DOUBLE SEAMING MACHINE

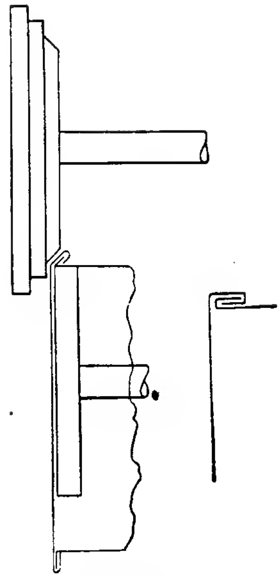


FIG. 28

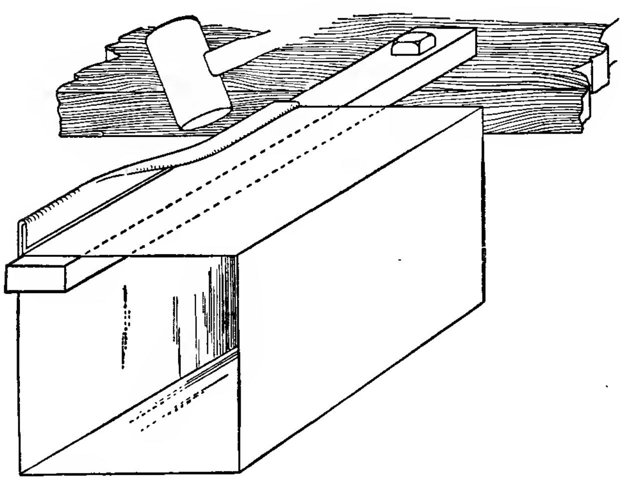


FIG. 29

Double Seaming a Flange on a Cylinder. Fig 30.

6. Hook the turned edges together and rest the sêam on a stake with a corner less than a right angle. Hammer the standing seam over gradually all around the joint and continue until it is closed down tight.

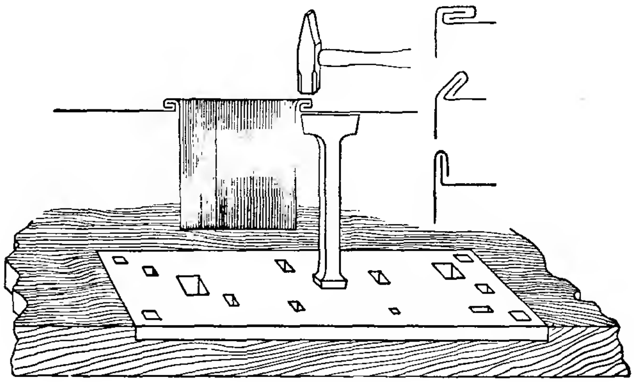


Fig. 30

References:

Broemel, *Sheet-Metal Workers Manual,* pp. 107, 212.

Questions:

1. Why must a seam be held firmly against a stake when double seaming?
2. Why use a mallet for turning edges over?
3. Why not turn edges completely over in the first operation?
4. What kind of metal is double seamed with a double seaming machine?
5. Why is it necessary to finish a hammer-made seam by placing the edge of the seam on a square stake and hammering the bottom of the vessel smooth?

OPERATION SHEET

Turning Edges with a Machine

Directions:

Turning Edges for Seaming Cylindrical Articles. Fig 31.

1. Set the gage to the width of the turned edge desired and lock it in place with a set-screw.

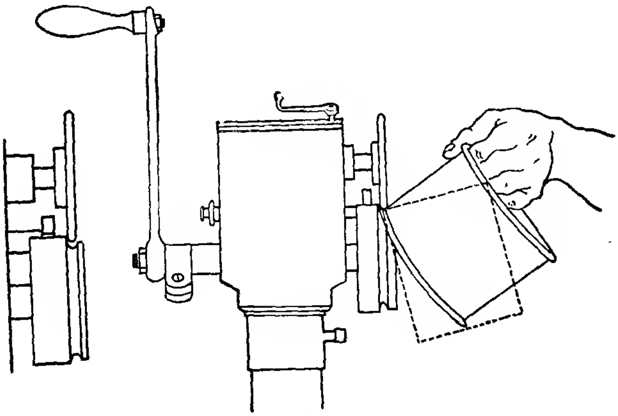


Fig. 31

2. Rest the cylinder in a horizontal position on the lower roll with its end pressed firmly against the gage. Turn the crank screw on top of the machine to lower the upper roll until it makes a slight depression in the metal. Turn the handle of the machine to revolve the cylinder between the rolls and at the same time raise the cylinder with the left hand until the edge is turned to a right angle.

Turning an Edge on a Circular Metal Disc. Fig 32.

3. Hold the metal disc in the palm of your hand, place it in the machine in a horizontal position firmly against the gage, bring down the upper roll and turn the edge as directed for a

cylinder. Turn the machine slowly and use care to keep the edge of the metal disc against the gage.

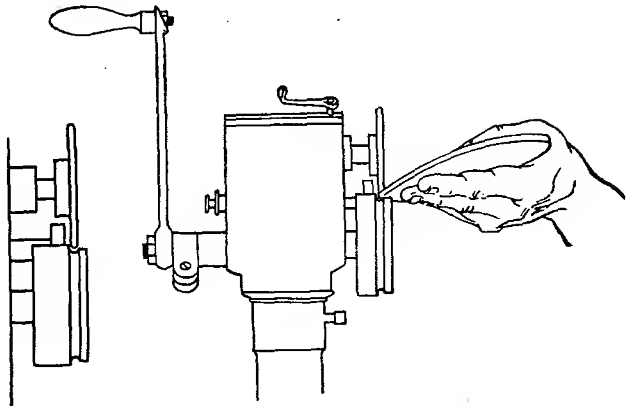


Fig. 32

Turning an Edge for Wiring.

4. Use turning rolls slightly thicker than the diameter of the wire to be used. Set the gage to $2\frac{1}{2}$ times the diameter of the wire from the inside edge of the upper turning roll. Place the metal between the rolls and turn an edge as directed for a cylinder, then lower the upper roll as far as it will go and continue the turning operation until the edge is turned well beyond a right angle.

5. When a turning machine is used to form a flange, finish the flange by holding it on a square stake and hammering it smooth.

Turning Elbow Edges.

6. Each seam requires the turning of a single and double edge. Set the gage to the width of the single edge and turn the edge of one piece until the flange which is formed will touch all around when laid on a flat surface. Set the gage to twice the width of single edge and turn the edge of the other piece the same as the single edge. Then set the gage to the width of the single edge and turn half of the wide

edge back until it forms a right angle with the part formed first.

Special Rolls for Elbow Edging.

7. Place the special elbow edging rolls on the turning machine and set the gage to the width of the edge desired. Hold the elbow sections between the rolls in a horizontal position. Bring down the upper roll until it touches the metal, then turn the handle of the machine; at the same time gradually lower the upper roll until the metal is pressed to fit the shape of the rolls.

References:

Broemel, *Sheet-Metal Workers Manual,* pp. 87, 110-113, 217.

Questions:

1. Why must the metal be held firmly against the gage while it is passing between the rolls of a turning machine?
2. Why must the object be gradually raised when its edge is being turned?
3. Why should the upper roll not be pressed down too tight on the metal?
4. When an edge which is being turned buckles, how may the buckle be removed?
5. What advantage is gained by using special rolls for turning elbow edges?

OPERATION SHEET

Wiring Edges

Directions:

1. Wired edges for cylindrical shaped objects should be completed while the metal sheet is flat.

2. Insert the wire in the edge prepared by the turning machine or the bar folder and secure the wire at several points by bending the metal over it with a hammer.

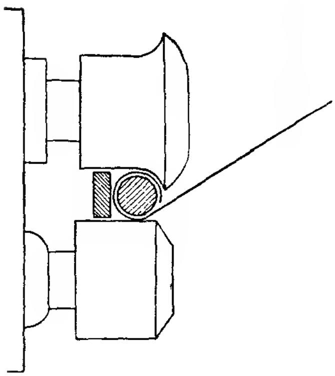
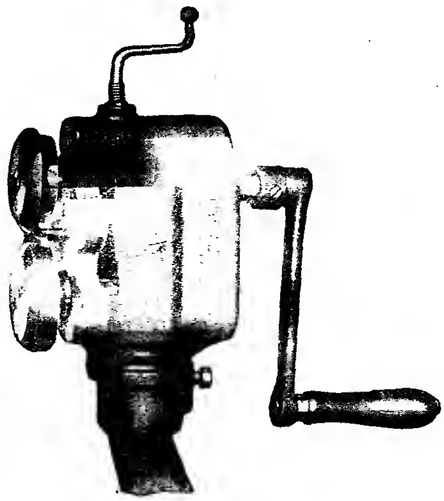


Fig. 33



Wiring Machine

3. Place over the lower roll of the wiring machine a section of the edge in which the metal has been bent around the wire and turn the crank screw on top of the machine to bring down the upper roll.

4. Set the gage so that the wired edge fits snugly between the gage and the edge of the upper roll, then turn the crank screw back about two turns to slightly raise the upper roll.

5. Turn the handle of the machine to draw the entire edge between the rolls. Lower the upper roll and pass the edge between the rolls again, until the metal is pressed firmly around

the wire; and at the same time, raise the object being wired, in order to bend the extreme edge of the metal under the wire. Fig. 33.

Wiring Edges of Objects with Straight Sides.

6. Fold the edges on a folder or brake while the metal sheet is flat.

7. Bend the sheet to the form or shape desired and secure the joints or seams.

8. Place the wire in the turned edge and proceed as before passing the rolls over the edge from one corner to the next and completing this section before moving the wiring machine to the next section. Since the rolls will not work into the corners the metal at these points must be bent over the wire with the peen of a hammer.

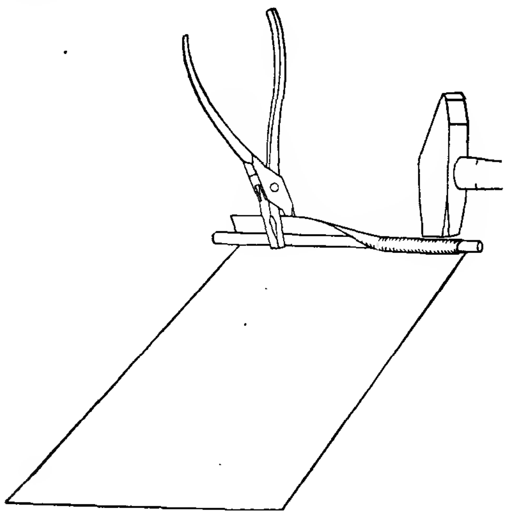


Fig. 34

Wiring Edges by Hand. Fig. 34.

9. Hold the object on a flat metal plate resting on a bench. Place the wire in the turned edge, hold it in position with pliers, and bend the metal over the wire with a mallet or hammer. Use the peen of a hammer to draw the metal close around the wire.

References:

Broemel, *Sheet-Metal Workers Manual,* p. 85.

Williams, H. V., *New Tinsmith Helper and Pattern Book,* p. 196.

Questions:

1. Why is the wire secured in the turned edge of a sheet of metal before it is run thru a wiring machine?
2. Why is it often necessary to pass a wired edge more than once thru the machine?
3. Why should care be taken not to set the rolls down too tight over a wired edge?
4. Why should the top roll be raised slightly after the gage is adjusted and before the edge is run thru the wiring machine the first time?

OPERATION SHEET

Riveting Sheet Metal Joints

Directions:

1. Holes for rivets having been previously punched by hand or machine, place a rivet thru matched holes in the joint by standing the rivet on its head on a stake and lowering the laps of joint over it. Fig. 35.

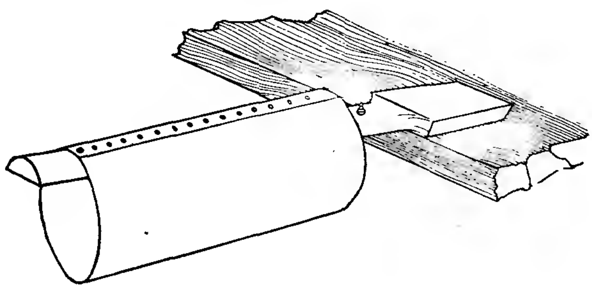


Fig. 35

2. Draw the laps together by placing a rivet set over the stem of the rivet and striking the set with a hammer. Remove the rivet set and strike the end of the rivet stem with a hammer to form a head, then use the cup-shaped die in the end of the rivet set to give the head the desired shape.

3. When a joint requires a number of rivets, place a rivet thru the metal at both ends but do not clinch it tight, then begin riveting at the middle of the joint and work toward the ends.

4. When the holes for rivets do not exactly match each other in location, use a drift pin to make a hole just large enough for the rivet to pass thru.

5. After rivets have been headed, place the joint over a stake and strike the lapped edges to bring them as close together as possible.

6. To draw rivets thru light metal without punching holes, place a rivet on a stake, hold the metal in position over the rivet and strike the metal lightly with a hammer directly over the stem of the rivet until a raised spot on the metal indicates its exact location. Place a set directly over the rivet and strike the set with a hammer to draw the rivet thru the metal.

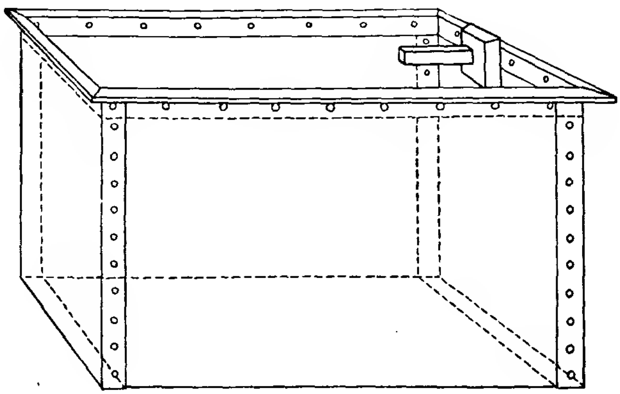


FIG. 36

7. When pieces are too large and heavy to place on a stake, assemble and bolt them together in some convenient position. Hold a dolly or some other heavy piece of metal against the head of the rivets to take the place of a stake while the stem of the rivet is being headed. Fig. 36.

Questions:

1. Why are the laps drawn together with a rivet set?
2. Why should riveting of long joints be started at the middle and worked toward the ends?
3. When rivets are placed in the end holes of a long joint to hold the sheets in position why should they not be clinched tight?
4. What is the purpose of using a cup-shaped die on a rivet head?

OPERATION SHEET

Tinning a Soldering Iron

Directions:

1. Heat the iron to a bright red.
2. Forge the iron to suit the job by striking with a hammer on an anvil or other heavy metal block.
3. Heat the iron again to a dark red.
4. Clamp the iron in a vise or hold it against a metal edge and file the surfaces of the point bright and smooth.
5. Heat the iron again until it will melt solder freely.
6. Rub the point of the iron on a lump of sal-ammoniac to clean it, then melt a few drops of solder on the sal-ammoniac and rub the iron over it until it is tinned. Fig. 37.

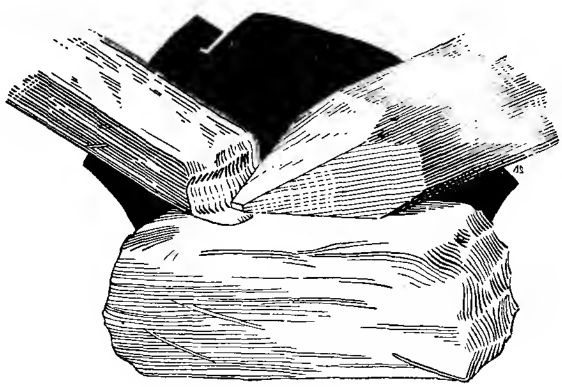


Fig. 37

7. Clean the soldering iron by dipping the point in a solution of sal-ammoniac and water. The solution should be made of one part of sal-ammoniac to forty parts of water. The solution should be kept in a glass or earthenware vessel.
8. If sal-ammoniac is not at hand, heat and clean the point of the soldering iron, place some powdered rosin on a board

or on a brick, rub the hot iron on the rosin, then drop solder on the rosin and rub the iron over the solder and rosin until it is well tinned. Fig. 38.

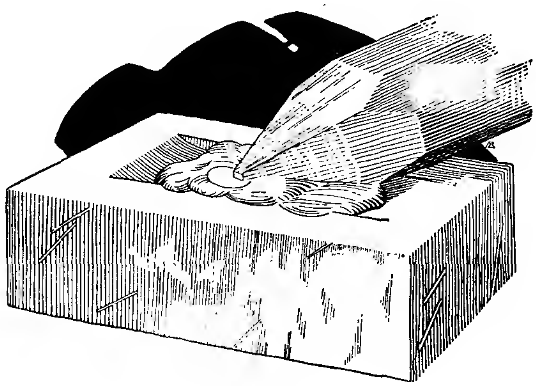


Fig. 38

Tinning a Soldering Iron for an Overhead Seam.

9. Tin the soldering iron on one side only; leave the other three sides rough.

References:

Broemel, *Sheet-Metal Workers Manual,* p. 179.

Williams, H. V., *New Tinsmith Helper and Pattern Book,* p. 236.

Questions:

1. Of what metal is a soldering iron made?
2. Why should a soldering iron be heated before forging and before tinning?
3. Why should a soldering iron be tinned?
4. Why is sal-ammoniac or rosin used in tinning a soldering iron?
5. What will be the effect if the iron gets too hot?
6. Why is a soldering iron for overhead soldering tinned on one side only?
7. What determines the angle to which a soldering iron should be dressed?
8. Why is a soldering iron rubbed with a cloth before using?

OPERATION SHEET

Soldering Tin Plate, Copper, Zinc, and Galvanized Iron

Directions:

1. Place pieces of metal in position ready for soldering.

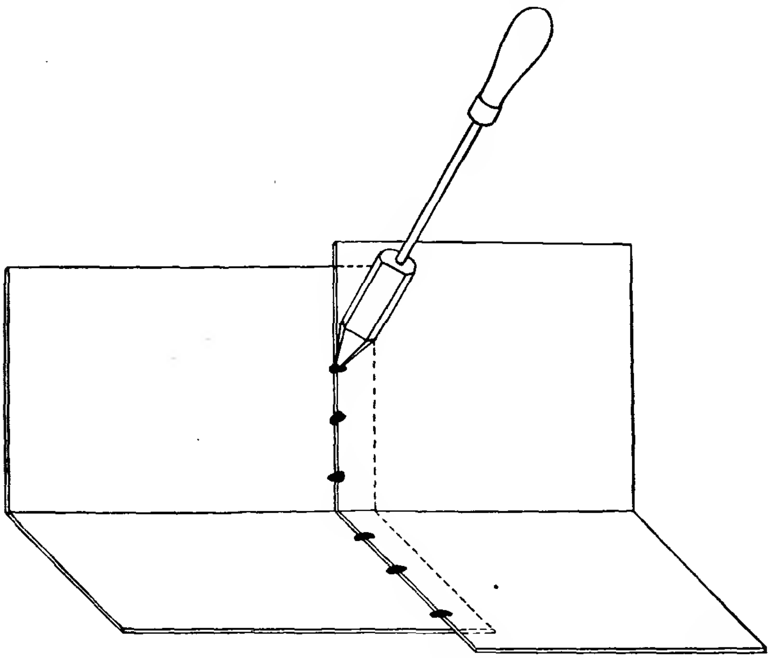


Fig. 39

2. Apply to the seam a flux suited to the work:
   (a) For galvanized iron, use raw muriatic acid.
   (b) For copper, brass, zinc, and iron, use "cut acid" (chloride of zinc) made by putting small pieces zinc in raw muriatic acid until it will dissolve no more.
   (c) For roofing and bright tin, use rosin.
   (d) Specially prepared fluxes may be used for purposes recommended by manufacturers.

3. Unless the edges are riveted or folded to hold them together, hold them in position with one hand and with the other take a soldering iron hot enough to melt solder freely, touch a bar of solder with it and with the drops of solder that adhere, tack the seam at a number of points to hold the sheets in position while soldering. Fig. 39.

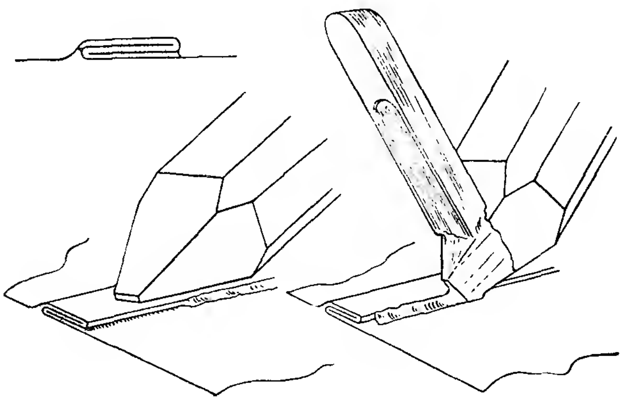


FIG. 40

4. Touch a bar of solder against a hot and well tinned soldering iron and draw the point of the iron along the edge of the seam. As the hot iron melts the solder, deposit a small quantity along the edge of the seam. Move the soldering iron back to the starting point, hold one of the beveled sides flat over the laps of the seam until the metal becomes as hot as the melted solder, then move the iron over the seam slowly enough to remelt the solder deposited along the edge and to draw or soak it between the laps of the seam. Make as long a stroke as possible before the iron becomes too cold. Fig. 40.

5. When the soldering iron has cooled until it no longer melts the solder freely, change it for a hot iron. Beginning at the point where soldering was stopped, hold the hot iron on the seam long enough to remelt the solder at that point, then move it along just fast enough to make a smooth seam.

Sweating. Fig. 41.

6. Sweating is a form of soldering. Tin both surfaces to be joined, hold the pieces together and heat with a soldering iron or torch until the solder melts and runs out. Keep the pieces in close contact until the solder cools and sets.

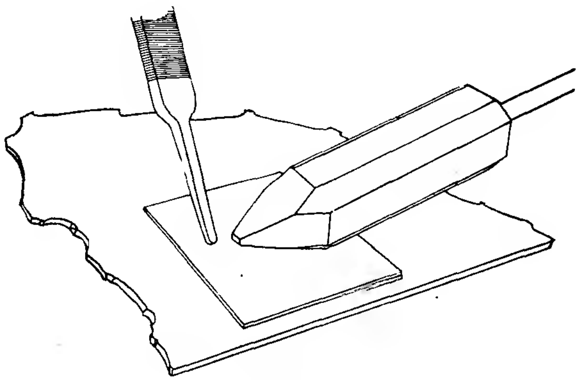


Fig. 41

References:

Broemel, *Sheet-Metal Workers Manual,* pp. 176-178
Hobart, *Soldering and Brazing,* pp. 65-79.

Questions:

1. Why not heat a soldering iron red hot after it has been tinned?
2. What is the purpose of a flux? How should it be applied?
3. Why should soldering irons be cleaned before soldering?
4. Why are soldering irons made of different sizes and shapes?
5. Why is a soldering iron drawn flat and slowly over a seam while soldering?
6. What makes the solder stick?
7. Why not melt the solder and pour it into the joint?
8. What is the objection to the use of acid for soldering tin?
9. Why should the flux be washed off after the soldering has been completed?

OPERATION SHEET

Brazing Copper and Brass

Directions:

1. Brighten with emery cloth or a file the parts to be brazed.

2. Where dovetail or lap seams are to brazed, rivet with small copper rivets to hold the seams in place. Fig. 42.

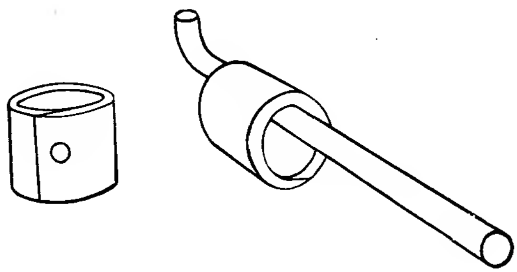


Fig. 42

3. Hold the object over a flame until the metal is heated to a dark red.

4. Apply powdered borax on the seam and hold it over a flame until the borax melts.

5. Remove the object from the flame and apply spelter over the seam, hold it over the flame again until the spelter starts to run thru the seam, then remove it and with a piece of metal scrape the surplus spelter from the surface while the spelter is still melted.

6. Dip the object in water, then smooth the seam with a file.

7. When brazing large vessels made of heavy copper or brass, heat the metal with a blow torch and always have the seam in a horizontal position so that it can be worked from the top or inside. Fig. 43.

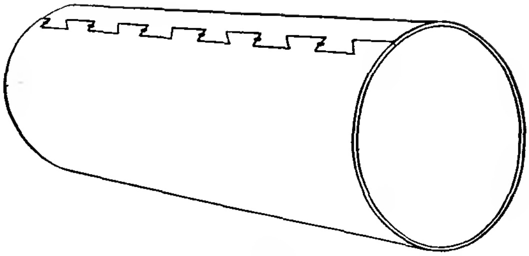


Fig. 43

References:

Broemel, *Sheet-Metal Workers Manual,* p. 430.
Hobart, *Brazing and Soldering,* pp. 150, 153, 159.

Questions:

1. Why is it necessary to brighten the parts to be brazed?
2. Why must metal be heated to a red heat before applying borax and spelter?
3. Why is borax used?
4. Why must spelter melt at a lower temperature than the metal being brazed?

OPERATION SHEET

Raising or Bumping Sheet-Metal Forms

Directions:

1. Carve a shallow circular depression in a wooden or lead block. Fig. 44.

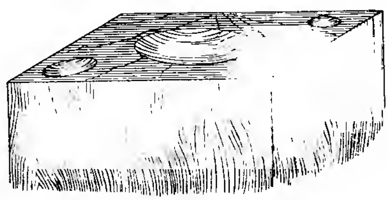


Fig. 44

2. Hold the sheet in your left hand, place the edge in the depression of the block and bump it with the small end of a raising hammer around the outline of the form to be raised. Fig. 45.

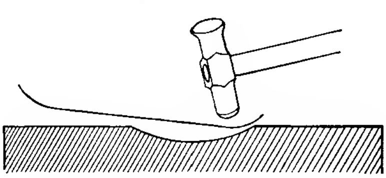


Fig. 45

3. Continue bumping the metal, gradually turn the sheet after each blow of the hammer and with each revolution work inward toward the center until the right shape is obtained.

4. Hold the raised form over a round-head stake and with a wooden mallet smooth out all dents that were made with the raising hammer. Fig. 46.

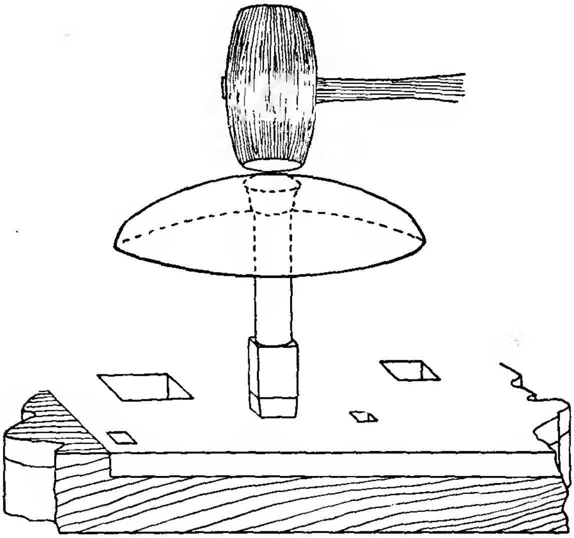


FIG. 46

5. Another method of making a raising form is to fill a vessel with sand and stretch a piece of canvas over it tight. This may be used in place of a block of wood or lead.

References:

Broemel, *Sheet-Metal Workers Manual*, pp. 215-216.

Questions:

1. Why is a shallow depression used for raising?
2. Why do you start to bump metal forms at the outer edge?
3. Why is a mallet used to smooth dents left in a raised form?

OPERATION SHEET

Flanging or Stretching Metal for Riveted Connections

Directions:

1. Mark with a gage the width of the edge to be flanged and rest the edge on a flat stake.

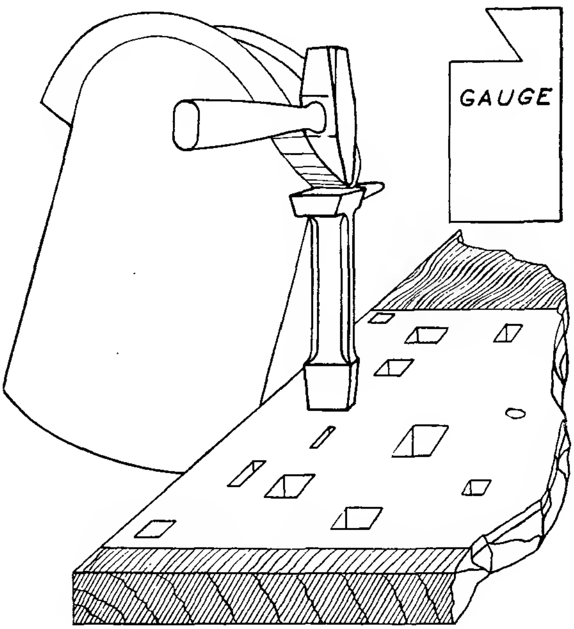


Fig. 47

2. With the cross peen of a riveting hammer strike the edge to be flanged. As the metal stretches, drop the main body of the metal until the desired angle of flange is produced. This angle varies according to the connections to be made. Fig. 47.

3. Hold the flange flat on the surface of a stake and smooth it with the flat face of a hammer.

4. To stretch a right-angle flange for circular work, hold the flange to be formed to a circle on the square head stake and strike the outer edge of the flange with the cross peen of a riveting hammer. As the metal stretches, move it forward and continue striking it until the desired circle is obtained. Fig. 48.

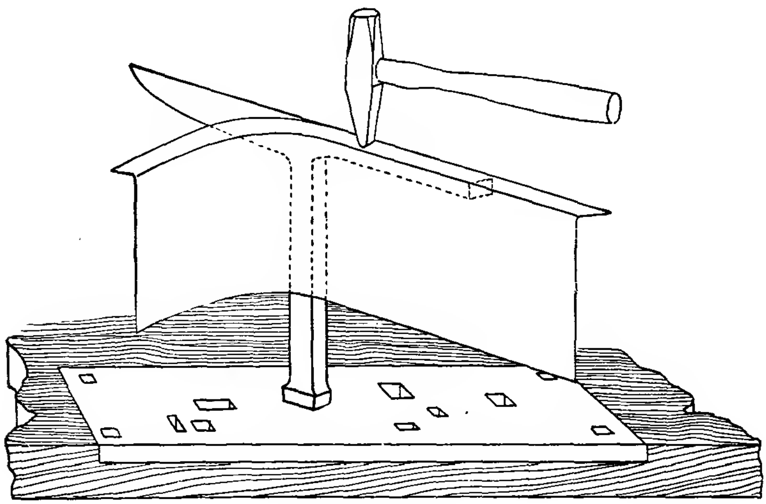


FIG. 48

Stretching Pipe.

5. When a joint of pipe is too small to slip over a connecting joint, slip it over a stake and strike the metal with the peen of a hammer. Gradually revolve the pipe over the stake as the metal stretches and strike light blows to avoid stretching the metal too much.

Turning a Flange Around an Opening in a Metal Sheet. Fig. 49.

6. Hold the edge of the metal at the opening over the square edge of a stake, lower the outside edge of the sheet slightly and with a cross peen hammer start to bend the flange all around the opening. Again lower the outside edge and bend the flange farther all around the opening. Continue to

lower the metal sheet and bend the flange until a right angle is formed.

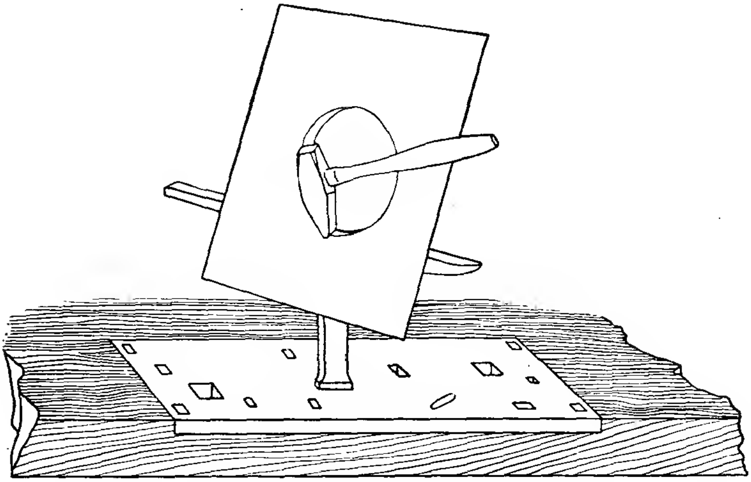


Fig. 49

Questions:

1. Why is it necessary to mark metal where it is to be flanged?
2. Why do you lower the body of metal when it is being stretched?
3. Why is it necessary to smooth a flange before connecting it to other fittings?
4. How do you determine when the desired circle is obtained?
5. When is it necessary to stretch pipe?

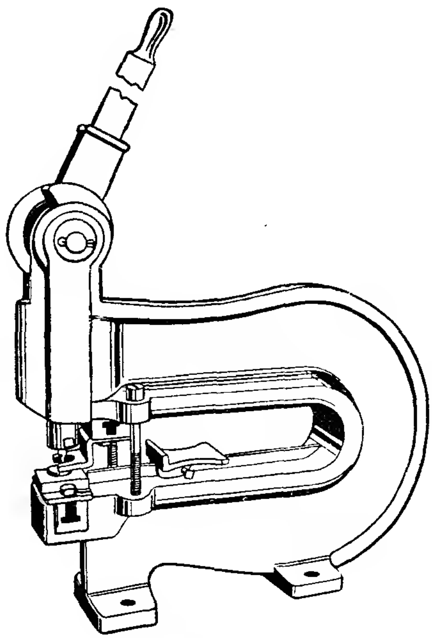
OPERATION SHEET

Punching Holes with a Solid or a Hollow Punch

Directions:

Punching Holes with a Hollow Punch.

1. Lay the metal on a block of lead or on the end grain of a wooden block.



Lever Punch

2. Place the punch on the circle indicating where the hole is to be punched and strike it with a large hammer until the metal is cut thru.

Punching Holes with a Solid Punch.

3. Locate the position of the holes with center punch marks. Lay the metal on a block of lead or on the end grain of a wooden block, place the punch on the center punch mark and strike it with a heavy hammer.

Punching Holes in Heavy Metal with a Lever Punch.

4. Insert the metal between the die and the punch so that center punch mark indicating the location of the hole is directly under the center of the punch. Then pull the lever down slowly until the punch is forced thru the metal.

5. When punching a number of holes an equal distance from the edge of a sheet, set, in the throat of the punch, the gage provided for that purpose. When punching metal sixteen gage and heavier, clamp the throat of the punch with stay bolts.

6. Keep the bearings of a lever punch well oiled and drop oil on the metal where the hole is to be punched.

References:

Broemel, *Sheet-Metal Workers Manual*, pp. 115, 135.

Questions:

1. Why should metal rest on a block of wood or lead when holes are being punched thru it?
2. Is it necessary to use a hollow punch when punching large circular holes?
3. Why is a lever punch used in punching holes in heavy metal?
4. Why should oil be used on the punch and on metal when punching by machine?
5. Why are stay bolts put in the throat of the punch when punching heavy metal?
6. Why are hand punches smaller at the cutting end than they are just back of the end?
7. Why are punches for a lever punch larger at the cutting end than they are just back of the end?

OPERATION SHEET

Drilling Holes

Directions:

1. Clamp the drill securely in a breast drill or a drilling machine.

2. With a center punch make a distinct mark to indicate the center of the hole.

3. Place the point of the drill in the center punch mark. When practicable have the metal resting on or against a wooden support.

4. Turn the drill to the right and at the same time force it against the metal. Relieve the pressure on the drill as it breaks thru the metal.

5. When drilling steel apply oil to the point of the drill. Do not use oil when drilling cast iron.

6. To countersink holes after they are drilled use a drill slightly larger than the head of the screw or bolt to be used in the hole.

7. A star drill may be used to drill holes in brick, stone and concrete. In using a star drill revolve it slightly after each hammer blow and keep the hole clean with a spoon-shaped tool.

Questions:

1. Why is a center punch mark made before starting to drill?
2. Why is oil used when drilling steel?
3. Why should the pressure on a drill be relieved when it breaks thru the metal?
4. Why should a star drill be continually revolved?

OPERATION SHEET

Tinning Copper, Brass and Iron

Directions:

1. Scrape and file the surfaces of the metal which are to be tinned, until they are bright.
2. Apply raw muriatic acid with a swab and wipe the surfaces with a clean cloth until all grease and dirt are removed.
3. Then apply cut acid with a swab, over the surfaces to be tinned,
4. Touch a hot soldering iron to a piece of solder and rub the solder which adheres, over the cleaned surfaces until they are covered with a thin layer of solder; this is called tinning.
5. With a cloth, wipe off the surplus solder while it is still melted.
6. The surface of iron must be filed quite smooth before it is tinned.

References:

Starbuck, *Standard Practical Plumbing,* pp. 36-49.
Hobart, *Soldering and Brazing,* p. 92.

Questions:

1. Why should metals be cleaned and brightened before tinning?
2. Why is raw muriatic acid used for this purpose?
3. Why is "cut acid" used as a flux for tinning?
4. Why must iron be filed quite smooth before tinning?

OPERATION SHEET

CUTTING WIRE GLASS

Directions:

Caution: Always carry glass in a vertical position.

1. Lay the glass flat on a solid flat table, measure the length to be cut and with the wheel of a glass cutter, mark this length near each edge.

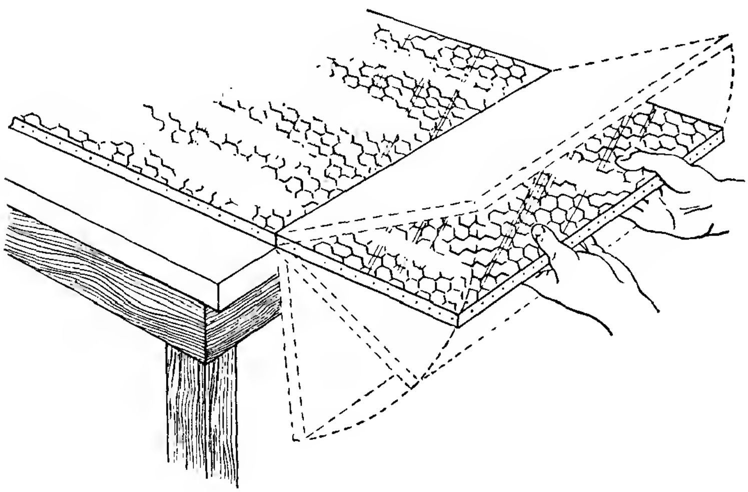


FIG. 50

2. Lay a straight-edge about one-eighth of an inch from these marks so that the glass cutter wheel will pass thru them.

3. Hold the glass cutter firmly against the straight edge and make only one continuous cut across the glass with the cutter held in a vertical position.

4. Grasp the end of the glass with both hands and pull it forward until the scratched line is even with the edge of the table. Lay a weight on the glass or have someone bear down on it, to hold it flat on the table, then give a quick jerk down-

ward for a short distance to break the glass. To break the wire, continue to bend down slowly until the piece is at a right angle, then bend it back until it breaks off. Fig. 50.

5. A second method is to let the scratched line on the glass extend beyond the edge of the table, tap lightly underneath the scratched line with the sharp end of a peening hammer until the crack extends thru the glass across the entire width, then lower and raise the end until the waste piece is broken off.

6. To cut narrow strips off a sheet of wire glass when no glass cutter is available, lay the glass on a table with the strip to be cut off extending over the edge. Use pliers to pinch off small pieces until the desired size is secured.

7. Always stack glass on edge.

References:

Ericson, *Glass and Glazing.*

Questions:

1. Why should glass be handled in a vertical position?
2. Why must a sheet of glass lay flat on a solid table when being marked and cut?
3. Why is it necessary to put a weight on the glass remaining on the table when the end is to be broken off?
4. Why should only one continuous stroke with a glass cutter be made across a sheet of glass?

OPERATION SHEET

Building a Charcoal Fire in a Fire Pot

Directions:

1. Put enough charcoal in the fire pot to cover the bottom about $1\frac{1}{2}$ inches deep.

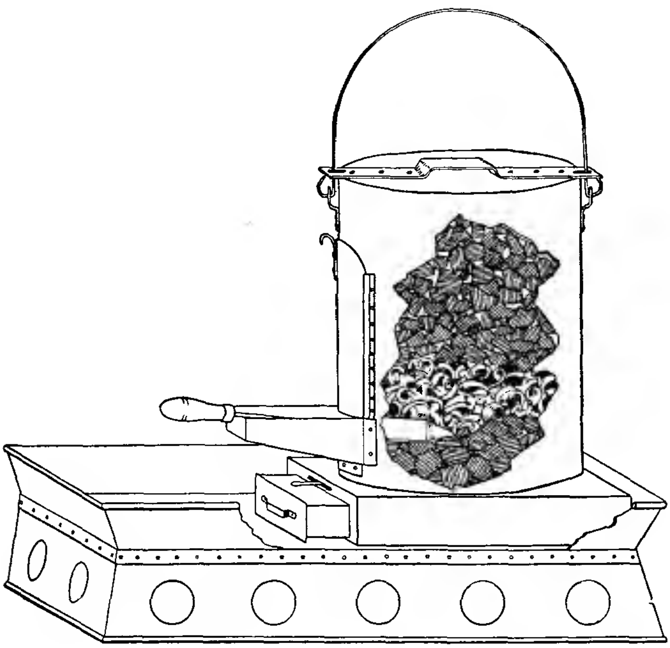


Fig. 51

2. Lay a handful of shavings or paper over the charcoal, then add more charcoal until the firepot is filled to the top.
3. Light the shavings or paper at the opening thru which soldering irons are placed in the fire for heating, then place the furnace in a draft.
4. After the charcoal is burning freely regulate the fire by gradually opening or closing the lid of the fire pot.

Questions:

1. Why should the bottom of a fire pot be covered with a layer of charcoal below the fire?
2. Why are shavings or paper required to start the fire?
3. Why should the fire pot be placed in a draft when starting a fire?
4. How does raising or lowering the lid regulate the fire?

OPERATION SHEET

Installing a Warm-Air Furnace

Directions:

1. When the building is being framed locate in the floor the openings for the first floor risers, the spaces between the studs for the second and third floor risers and also the proper place to set the furnace.

2. Place the risers in inside walls as near to the furnace as practicable. Never place a riser in an outside wall and do not run a pipe near a basement window if it can be avoided.

3. Make all of the risers, angles, boots, register boxes, and pipe in the shop and if they are to be concealed, cover them with asbestos paper before installing.

4. Place the register boxes in the walls or in the floors as called for in the architect's plans and specifications.

5. Anchor the risers to the floors and connect them with the register boxes and boots with slip joints.

6. Determine the size of the register boxes by referring to a catalogue of the register manufacturer.

7. Set the furnace on a level foundation north or northwest of the center of the basement but avoid long runs of pipe in the basement. Have the furnace facing south.

8. Set up the base, grate, fire pot, bowl and radiator, then close all of the joints tight with furnace cement.

9. Place the bottom section of the sheet-iron casing around the furnace and rest it on the cast-iron ring which extends around the base.

10. Before placing the second section of the casing in position, connect the cold air pipe at the bottom of the furnace in the rear and cut a hole in the casing to fit the door frame in the front of the furnace.

11. Place the joint ring over the first section of the casing, then set the second section and cut holes for the smoke pipe and the door frame and bolt the casing to the door frame.

12. Place the second joint ring in position and set the canopy over the top of the furnace.

13. Space the collars for the warm-air pipes as nearly equal as possible if all of the rooms require about an equal amount of heat otherwise leave a greater space on each side of the pipe requiring more heat. Use two pipes or pipes of larger diameter for large rooms. Connect the collars and keep their tops in line with the connecting boots.

14. Place the grate in the fire pot and also the brick lining if one is required.

15. Take the measurements of the warm-air pipes leading from the furnace to the boots, the cold air pipes leading from the outside and the inside of the building to the rear of the furnace, the smoke pipe leading from the furnace to the chimney, and all elbows, angles, and offsets and make them in the shop.

16. Connect the warm-air pipes from the furnace to the boots and place a damper in each one near to the collar to which it is attached. All pipes should have at least one inch rise to the foot. The greater the rise the better the results.

17. Cover all of the warm air pipes with asbestos paper. Provide thimbles in all walls where pipes enter or pass thru them.

18. When horizontal pipes are over eight feet long, support them from joists with number twelve wire.

19. Run the outside cold-air pipe from the south side of the building, or from the side opposite the prevailing winter winds, to the cold air connection in the rear of the furnace; this pipe must have a capacity equal to three-fourths of the combined areas of the warm-air pipes and should have a good damper.

20. Run the inside cold air pipe to the cold-air connection in the rear of the furnace. This pipe must have a capacity equal to one and a half times the combined areas of the warm air pipes. The combined areas of the openings in the register faces should equal the area of all of the warm-air pipes.

21. Provide a damper in the cold-air connection so that either the inside or the outside branch may be shut off.

References:

Hubbard, *Ventilation Hand Book,* pp. 181-211.
Any catalogue of Warm Air Furnaces and Fittings.

Questions:

1. Why should all warm-air pipes be covered with asbestos paper?
2. Why should risers be located close to the furnace and in inside walls?
3. Why is it necessary to make sketches for boots and register boxes?
4. How should you anchor wall pipes to the floor?
5. Why are register boxes much larger in area than risers?
6. Why is a furnace set closer to the north wall of the building than to other walls?
7. Why is it necessary to cement all joints when setting a furnace?
8. Why is a furnace set facing the south?
9. Why should the pipe from the furnace to the boots gradually rise?
10. Why are dampers placed in the pipe near the collars on the canopy top?
11. Why is cold air taken from the outside and also from the inside of buildings?

OPERATION SHEET

Erecting a Metal Ceiling

Directions:

1. Across the end of the room build a strong scaffold on trestles, allowing for a space of about 3 inches between the top of the workman's head and the ceiling.

2. Thru the center of the room strike a chalk line at right angles to the joists. On each side of this line strike other lines parallel to the first line, and as far apart as the distance between the nail holes in the opposite edges of the metal plates.

3. Nail furring strips across the joists with the center of the strips directly over the chalk lines. Strike chalk lines across the furring strips and nail cross strips between them to match the edges of the field plates. Around the edges of the ceiling fasten strips to support the brackets to which the cornice has previously been nailed.

4. Drive wedges between the furring strips and the joists to provide a level surface for the field plates.

5. Strike a chalk line along the center of the furring strip extending from the middle of the ceiling at one end of the room to the middle at other end.

6. Begin at the back of the room to nail to the furring strips the sheets which form the field. Put the sheets on in courses beginning with one edge on the center line and working toward each side of the room.

7. Nail the cornice to brackets and fill the space between the cornice and the field with filler sheets. Trim the filler sheets to fit the space, thus making adjustments for any slight variations in the width and length of the ceiling.

8. When joints do not lap tight, hold the end of a piece of metal about 1/4 inch by 3 inches, against the joint and strike it lightly with a hammer.

9. When necessary to fit metal ceiling around pipes, make careful measurements in order to secure a snug fit.

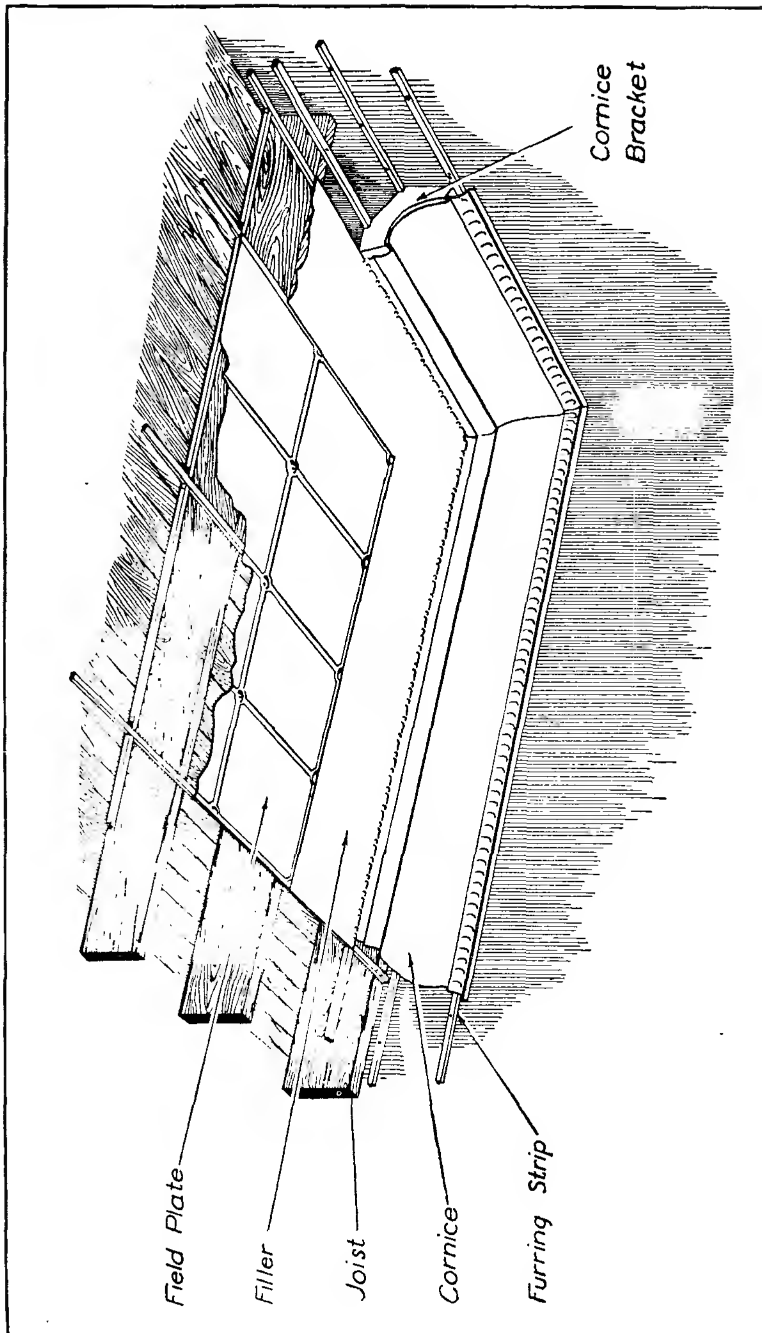

Cornice Bracket
Field Plate
Filler
Joist
Cornice
Furring Strip

Fig. 52

References:

Any catalogue of metal ceilings.

Questions:

1. Why should trestles be used for a scaffold?
2. Why should the center line of the room be located first?
3. Why is it necessary to strike a chalk line for locating strips?
4. Why must furring strips be level before applying metal ceiling?
5. Why must furring strips be spaced from the center line of the room?
6. Why should the installation of metal ceiling start at the back of the room?
7. Why is it important to close joints that are not tightly lapped?

OPERATION SHEET

Sectioning and Hanging or Setting a Cornice

Directions:

1. In constructing cornices, first draw a full size detail, then a profile, and from these a stretch-out and miter pattern. Use the pattern to mark the sheets while they are flat and cut the ends to shape before forming them on the brake.

2. To make a stay, place a piece of sheet metal under the profile drawing, mark thru with a prick punch and then cut it to shape. Use this stay to test each section as it is formed on the brake.

3. Use trestles and 2-inch boards to build a bench about 16 feet long.

4. Measure the wall at the bottom of the foot mould line to check the dimensions on the drawing used in the shop.

5. Place in position along the front edge of the bench two or more sections of the foot mould with the miter end of one section at the end of the bench. This is called sectioning. An allowance of about 1 inch must be made for joints between sections.

6. Line the sections carefully until when sighting along the several corners of the mould they appear straight, then tack the joints with solder at several points to keep them in position.

7. Rivet the joints in a number of places to give them strength, then solder the joints on the inside.

8. Mark each section with numbers or letters to indicate its position in the complete cornice and the side of the building to which it is to be attached.

9. Section the dentil, modillion, crown and other moulds in the same way as the foot mould, always using as a working measurement the length of the upper edge of the next lower section.

10. While the sections are lying on the bench, solder and rivet in position as shown by the architect's drawing all ornaments such as dentils, modillions and brackets.

Hanging a Cornice. Fig. 53.

11. Nail a line of 1-inch x 6-inch boards on top of, and even with the outside ends of the wooden lookouts to support the top edge of the crown mould. The outside edge of these boards must be straight and level from end to end, and the projection of this edge beyond the wall of the building must be the same as shown on the profile from which the cornice was developed.

12. To support a short scaffold make two wooden frames as shown in the illustration. This scaffold can be easily shifted from one position to another.

13. With a saw made of a piece of 1/16-inch metal about 10 inches long and 4 or 5 inches wide with teeth cut in one edge, cut the mortar out of the joint between bricks to receive the lower edge of the foot mould.

14. Place the mitered corner of the first section of the foot mould even with the corner of the building, with the lower edge slipped into the joint between the bricks, then nail the section to the lookouts.

15. Continue adding sections until the full length of the foot mould is in place, then sight along the edge, and if it is not straight, draw some of the nails and raise or lower the edge until it is perfectly straight, then nail securely and rivet the joints connecting the sections.

16. Erect the other courses in the same way, and when the whole cornice is in position line it true between the corners of the miters at the ends of the wall.

17. Nail the top of the crown mould even with the top edge of the roof sheathing, and at the line where the crown mould is connected with the frieze, mash the edges together, notch thru the three thicknesses of metal, bend them over and clinch them.

18. If the wash is to form a gutter, have it extend up on the wall not less than 2 inches higher than the top of the crown

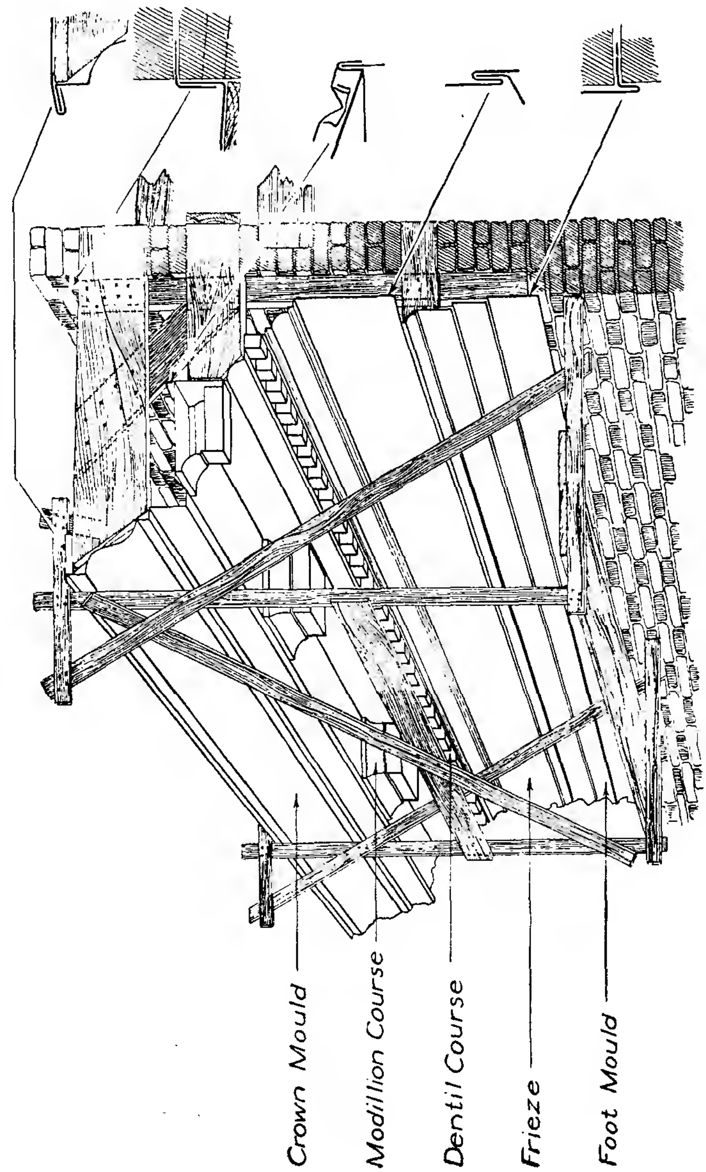

Crown Mould
Modillion Course
Dentil Course
Frieze
Foot Mould

FIG. 53

mould. Hook the outside folded edge of the wash over the upper edge of the crown mould, then lay the metal wash on top of the sheathing and have the back edge extend up on the brick wall about 3 inches.

19. One-half inch from the end of the metal wash, nail the metal to the sheathing, then with pliers or a small pair of tongs turn a ½-inch edge across the end of the wash to lock on the next sheet of the wash.

20. Provide an expansion joint every 50 feet. This joint is made by soldering to the ends of the 50-foot sections of the wash, right angle strips measuring 1 inch horizontally and vertically and slipping over these vertical strips a metal cap. A space of ½ inch must be allowed between the two ends for expansion and contraction.

21. Mash the edges of the wash which has been hooked over the edge of the crown mould and bend down slightly to form a drip.

22. Cut a hole in the metal and the wall at the back of the gutter, and solder a pipe to the gutter to carry the water thru the wall to the roof.

23. Saw the mortar out of the joint above the top edge of the wash extending up on the wall. Flash with a metal strip bent to a right angle, extending into the joint 1 inch and down over the wash 2 or 3 inches.

24. Hold the flashing in place by driving wedges, made of small rolls of scrap metal, between the bricks, then fill the joint with portland cement mortar.

Setting a Cornice. Fig. 54.

25. Hoist the cornice sections and lookouts to the top of the building.

26. Line the lookouts face side up, 3 feet apart, on the floor.

27. Begin with the foot mould and nail sections to the lookouts.

28. Secure all seams by soldering or by notching and clinching.

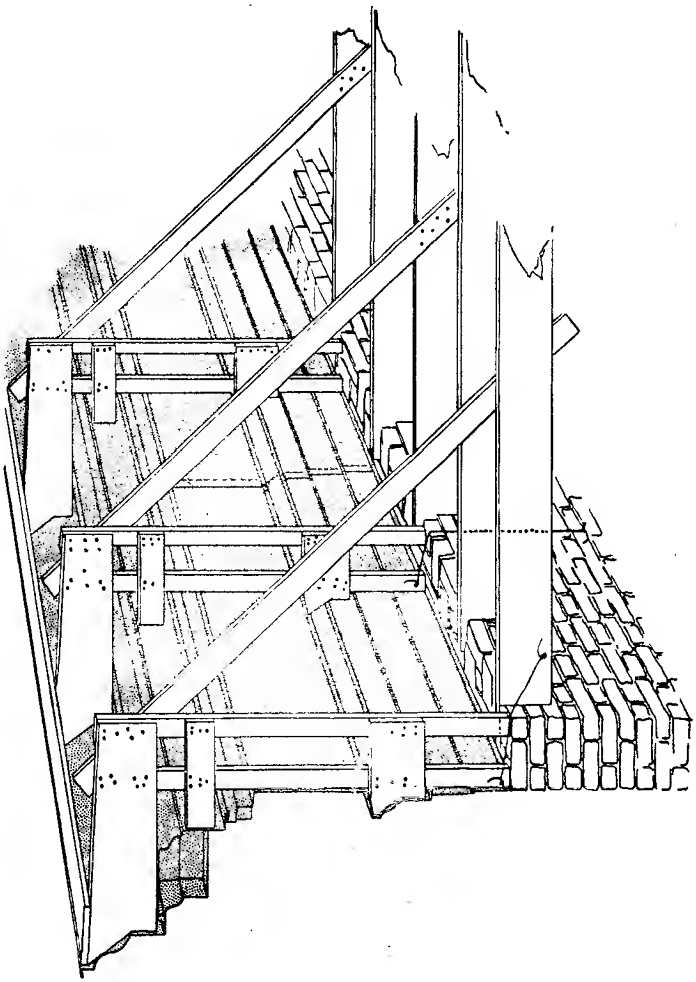


Fig. 54

29. Set full sections of the cornice on the wall plumb and level, and support them by nailing 2-inch by 4-inch braces from the upper part of lookouts to the floor joists.

30. In setting the different sections allow 1-inch lap at the joints for riveting.

31. Nail 1-inch x 6-inch boards even with the outside end of the lookouts. Hang a scaffold from these boards and rivet the joints connecting the sections.

32. After the brick mason builds the wall even with the top of the lookouts, place the wash in position as in hanging a cornice.

References:

Neubecker, *Sheet-Metal Work,* pp. 194-200.

Daugherty, J. S., *Sheet Metal Pattern Drafting and Shop Problems,* pp. 42-63.

Questions:

1. Why should a sketch be made of the wall when taking measurements to section a cornice?
2. Why should pieces of moulding be tacked together when they are lined straight?
3. Why is it necessary to first section the foot mould of a cornice?
4. Why is it necessary to lay a dentil mould flat on a board when soldering dentils in place?
5. Why must all joints be riveted?
6. Why is it necessary to drive nails thru a wash?
7. What is the object of putting an expansion joint in the wash of a cornice?
8. What is the advantage of setting a cornice instead of hanging it?
9. Why must a cornice be plumb and level when set?
10. Is it necessary to have a brace at every lookout when a cornice is being set?

OPERATION SHEET

Hanging a Gutter and Down Spout

Directions:

1. Use trestles and 2-inch boards to build a bench about 16 feet long.

2. Place in position on the bench two or more sections of the gutter with the bead of one section slipped inside the bead of the next section, and the joint lapped about 1 inch. This is called sectioning.

3. Sight along the bead from the end of the gutter and shift the sections until the beads are in a straight line, then tack each side and the bottom of the joint with solder. Then rivet the joint at three or four points and solder the whole joint.

4. Continue to add sections until the desired length of the gutter is made, then solder in the ends and the tube.

5. After the tube is soldered in place cut a hole in the gutter to match the tube.

Hanging Half-Round Gutter.

6. Fasten hangers around the gutter about 3 feet apart.

7. Carry a hammer and a few nails in your pocket.

8. Place a ladder against the building near the center of the space where the section is to be hung.

9. Balance the gutter in one hand, walk up the ladder and hold the gutter in position.

10. With other hand bend the straight wire of the hanger over on the roof and drive a nail thru the wire loop into the roof sheathing.

11. Move the ladder and after placing the gutter so that it has a fall of about ½ inch in 8 feet, fasten the wires at each end.

12. Raise or lower the gutter until the bead is straight and nail the balance of the wires to the roof sheathing.

Hanging an Ogee Gutter.

13. After the gutter is sectioned off, hold the tube on the gutter in the proper position and mark around it with a pencil, then lay the gutter on a solid board and cut around the line with a sharp chisel.

14. Drop the tube thru the hole from the inside of the gutter so that the burr on the tube will rest on the bottom of the gutter, then solder it securely in place.

15. Rivet the stays to the bead in the gutter every 3 feet and have the stays extend onto the roof 3 inches beyond the inside edge of the gutter.

16. Hang the gutter against the facier board and nail it to the roof sheathing, then line the head of the gutter straight and nail the stays to the roof sheathing.

Lining a Box Gutter.

17. Use metal wide enough to form the full stretch-out and extend 4 or 5 inches onto the roof.

18. At the low end of the gutter obtain the stretch-out by measuring from the drip line to the bottom of the gutter and mark on the metal, then measure the distance across the bottom of the gutter and mark again.

19. Obtain the same measurements at the opposite end of the sheet and strike a chalk line between the corresponding marks.

20. With valley tongs bend the metal along these lines to right angles, notch at the corners of the gutter and turn a ½-inch edge for a lock, whenever two sections of gutter are joined.

21. Lay the metal in the gutter and at each joint fasten the metal to the bottom of the gutter with cleats.

22. Hold a plank of wood firmly against the bottom and the side of the gutter and with a mallet bend the metal over the cap strip and then over the edge of the cap strip to form a drip.

23. With 2-penny nails fasten the drip of the gutter lining to the edge of the cap strip.

24. Bend the back of the gutter lining over on the roof sheathing and nail it at the upper edge every two feet.

25. Sweat the joints with solder.

Hanging Down Spouts.

26. Measure from the bottom of the gutter tube across to the point on the wall where the down spout is to be hung and mark this distance on a bench or on the floor.

27. Lay two 45-degree elbows in position on these lines and measure the distance between them to determine the proper length of straight pipe to connect them.

28. Solder the elbows and pipe together and place in position on the wall with the upper elbow slipped over the gutter tube.

29. Fasten the down spout to the wall with straps and nails and solder all the joints except the one between the upper elbow and the gutter tube.

References:

Daugherty, J. S., *Sheet Metal Pattern Drafting and Shop Problem,* pp. 42-63.

Questions:

1. Why is a work bench 16 feet long needed when sectioning gutter?
2. Why must gutter sections be straight before being tacked with solder?
3. Why should joints be tacked before being riveted?
4. In hanging a gutter why must the end with tube be lower than any other part of gutter?
5. What will happen to a gutter when hung so that all of the water does not run out?
6. Why are stays riveted in an ogee gutter?
7. Why must a gutter over 40 feet long be provided with an expansion joint?
8. Why should the down-spout offset from the gutter tube to the wall be run at an angle of 45 degrees?
9. Why must a gutter be higher in the back than at the bead?

OPERATION SHEET

Flashing or Making Roof Connections

Directions:

Flashing on Prepared Roofing.

1. Unroll on the roof along the wall where it is to be applied, a strip of metal which has been prepared for flashing.
2. With adjustable valley tongs bend the flashing to a trifle less than a right angle.
3. Place the angle of the flashing tight against the wall and nail the outer edge of the metal to the prepared roofing using 1-inch roofing nails 2 inches apart.
4. Lock all the lengths of flashing together and solder the seams.
5. After the flashing has been nailed in position around the entire wall begin to place the counter flashing.
6. Cut the mortar out of the joints of the wall above the flashing so that the top edge of the counter flashing may enter the wall one inch.
7. With metal wedges made of small rolls of scrap metal fasten the prepared counter flashing in place and fill the joint with Portland cement mortar.

Step-Flashing. Fig. 55.

8. Dig the mortar out of joints to form steps conforming to the pitch of the roof.
9. Start at the bottom of the roof and cut the metal for each step allowing 1 inch for a right-angle bend at the top edge.
10. Cut the lower edge at an angle to clear the roof about 1 inch.
11. Slip the upper edge between the layers of brick and hold it in place with metal wedges.
12. Cut and fit the next piece of flashing in the same manner, but overlap the first piece at least 2 inches. After all

of the flashing has been placed, fill the joints with portland cement mortar.

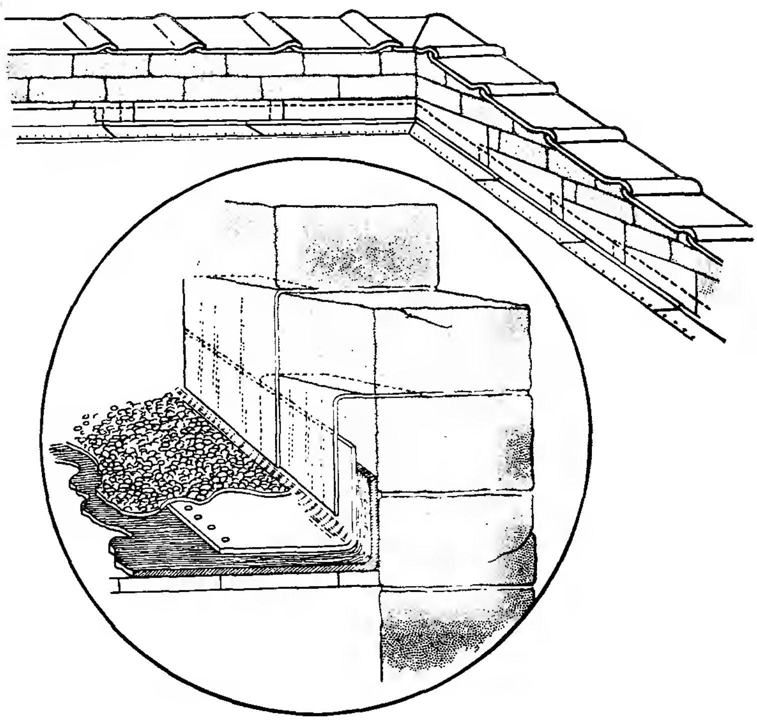


FIG. 55

References:

Williams, H. V., *New Tinsmith Helper and Pattern Book*, pp. 291.

Questions:

1. Why is the flashing unrolled on the roof?
2. Why is the flashing bent a trifle less than a right angle?
3. Why must counter flashing extend about one inch into the groove in the wall and then be fastened with wedges?
4. Why should each section of step-flashing overlap the next lower one about 2 inches?

OPERATION SHEET

Laying a Metal Shingle Roof

Directions:

1. Sheet-metal shingles require that the roof be covered solid with sheathing.

2. Erect a scaffold along the eaves of the building and rig up a rope and pulley to hoist material.

3. Lay enough roofing paper along the bottom edge of the roof to receive the first three courses of shingles and fasten the paper with ¾-inch roofing nails and tin washers.

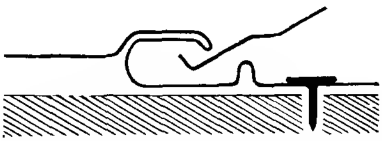


Fig. 56

4. Stretch a chalk line 1 inch beyond the edge of the eaves.

5. Lay the first shingle at the lower left-hand corner of the roof. Have the bottom edge even with the chalk line and the left side extending ½-inch beyond the end of the roof.

6. Drive nails thru the holes which have been punched in the shingles.

7. Slide the next shingle in the groove prepared for it, press it down flat and nail it to the sheathing. Continue to lay additional shingles until the full course is laid from the left side to the right side of the roof. Fig. 56.

8. Start another course of shingles on the left side and have the joints between the shingles of this course come at the middle of the shingles in the course below and lap over the corrugations at the top of the first layer. This is called breaking joints and makes it necessary to cut the first shingle in half.

9. After three courses are in place, lay another layer of paper with the lower edge overlapping the metal shingles

about one inch and continue these operations with paper and shingles until the roof is covered.

10. For scaffolds on the roof, nail 3-inch galvanized strips of metal about 15 inches long to 2-inch planks and nail the strips to the roof sheathing. Lay the shingles over the metal strips and when the roof is completed, cut the strips off near the bottom edge of the shingles to remove the scaffolds. Fig. 57.

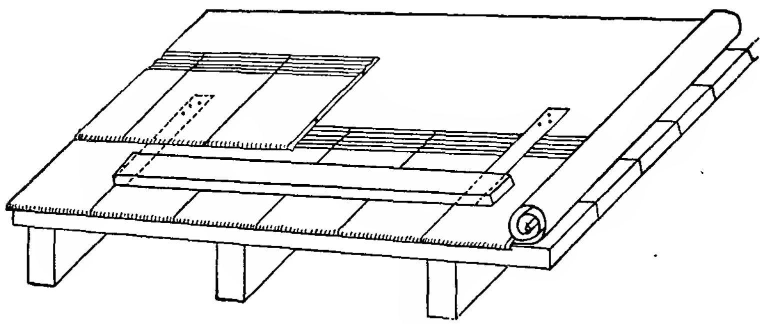


FIG. 57

Ridge and Hip Roll.

11. Special ridge and hip rolls are made so that shingles will slip into a groove. Nail the roll in position first then cut the mitered shingles to fit snug against the inside edge of the groove.

Valley.

12. Where two gables intersect in an ell-shape, start at the bottom and nail the metal valley in position with each section overlapping the next lower one at least 3 inches.

13. Form the valley to lay flat against the sheathing on each side of the roof.

14. Lay shingles on the valley in their proper position and mark the upper and lower edges of each shingle even with the turned edge of the valley, then draw a straight line across to connect these marks and allow ¾ inch beyond this line to form a lock, and draw a straight line thru these marks.

15. Cut the shingles along the last line and turn the edge to form a lock, then nail the shingles to the valley, and with a mallet hammer the locked edge flat.

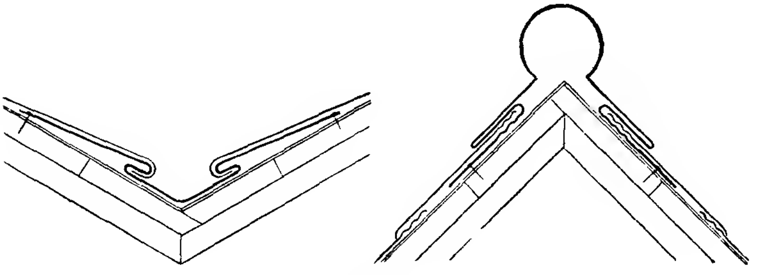


FIG. 58

References:

Neubecker, *Sheet Metal Work,* pp. 162-163.
Any catalogue of Metal Shingles.

Questions:

1. Why must roofing paper be laid under a metal shingle roof?
2. Why is it necessary to extend metal shingles one inch over the eaves of a roof?
3. Why is it necessary to start laying shingles at the left side of a roof?
4. Why is it necessary to lock shingles to a valley?

OPERATION SHEET

Laying a Tin Roof

Directions:

Laying Flat Lock Roofing.

1. Fold the edges of the tin sheets in the shop.
2. Paint the underside of the tin sheets and stand them on edge against a wall to dry.
3. Examine the roof to see that it is free of projecting nails and lay special roofing paper over the surface which is to be covered with tin.
4. Start to lay the tin sheets at the lower left-hand corner of the roof.
5. Have the long edge of each sheet parallel with the eaves and extend the sheet 1 inch beyond the sheathing at the end of the roof.
6. Hook cleats 8 inches apart over the folded top and right-hand edges of each sheet and nail the cleats to the sheathing close to the edge of the tin sheet.
7. Lay the tin with the upper and right edges turned up to receive the next sheet.
8. Hook another sheet over the right edge, fasten it with cleats and continue across the roof parallel to the eaves.
9. Cut a sheet in half by cutting from bottom to top and start laying a second course at the left side. Start the third course with a full sheet and continue in this way to break joints on every course.
10. When tin in rolls is used for flat-lock roofing, turn the edges with roofing tongs. Adjust the gage on each end of the tongs to ½ inch, place the tongs over the edge of the tin on the right side at one end, rest your left foot on the metal sheet, hold the gages firmly against the edge and squeeze the handles together so that the blades will clamp against the metal.
11. Raise the tongs to turn the edge to an angle of about 45 degrees, move the tongs forward and continue this operation

along the entire length of the edge, then work backwards and repeat the operation to turn the edge to a right angle, then work forward again and press the tongs over with your left foot to form a sharp angle ready for the lock seam.

12. Turn the sheet over and turn the other edge in the opposite direction to the first edge.

13. Lay the metal sheets parallel to the eaves and fasten them to the roof with cleats.

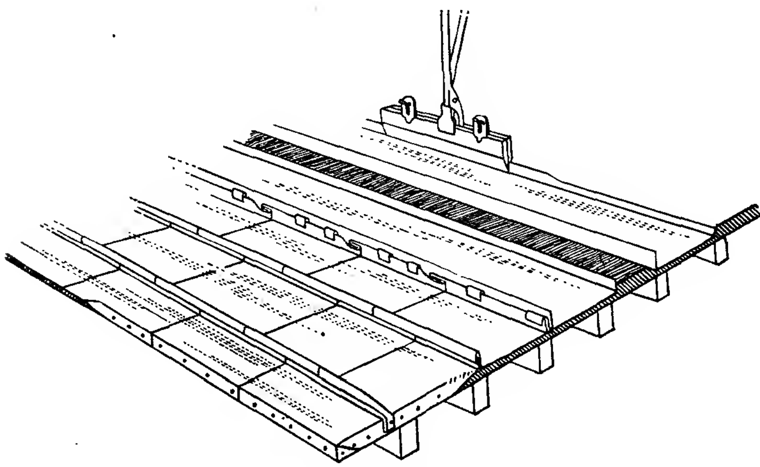


Fig. 59

14. Clean the tin with a broom and pound the seams down with a mallet.

15. Apply rosin as a flux and with a hot soldering iron soak solder thru the seams.

16. Paint the tin roof with a coat of red mineral and pure linseed oil.

Standing Seam Roofing. Fig. 59.

17. Notch and fold the narrow edges of the sheets.

18. Lock the sheets together in a long strip and soak the seams well with solder.

19. Paint the under side of the tin and lay the strips on racks to dry.

20. When the paint is dry, roll the strips into rolls and take them to the building.

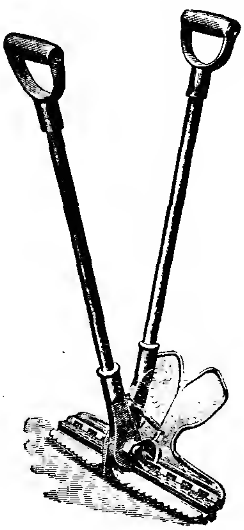
21. Lay special roofing paper over the surface to be covered with tin.

22. Unroll the tin and turn the edges of the long strips with roofing tongs. For a one-inch standing seam use one pair of tongs set for 1½ inches to turn one edge and another pair set for 1¼ inches to turn the other edge of each strip. Follow the operations as in paragraph II except that the edges should not be turned beyond a right angle.

23. Start at one end of the roof and lay the metal strips vertically. Turn the strips so that the open edges of the horizontal seams are at the bottom so that water will run over them without leaking thru. Extend the edges 1 inch beyond the edge of the sheathing.

24. Fasten the strips with cleats 12 inches apart.

Adjustable Roofing Tongs



Double Seamer

25. Lay each strip against the previous strip, fasten it to the sheathing with cleats and continue until the surface is covered.

26. Break horizontal seams, that is do not have them come opposite each other.

27. To double-seam the standing edge use gage seamers. Place the larger seamer over the edges with the square blade against the smaller edge. Press the handles together to bend the larger edge to a right angle over the smaller edge. Move the seamer forward and continue this operation over the entire seam. Reverse the seamer and place over the edge the blade which is supported by a spring and with the left foot press the blade down to turn the edge completely over.

28. Use a smaller seamer and repeat the operations as in paragraph 27 to form a double seam.

HAND DOUBLE SEAMER

29. To double-seam with a hand seamer, place the large side of the seamer against the smaller side of the standing edge and with a mallet pound the metal over on the seamer to a right angle. Move the seamer forward and continue the operation the full length of the seam. Hold the larger side of the seamer firmly against the opposite side of the standing edge and with a mallet mash the turned edge flat against the standing edge.

30. Hold the smaller side of the seamer against the turned edge again and bend the edge over to a right angle, then hold the seamer against the other side and mash the turned edge flat.

References:

Williams, H. V., *New Tinsmith Helper and Pattern Book,* p. 197.

Broemel, *Sheet-Metal Workers Manual,* pp. 119-121.

Questions:

1. Why are the edges on the square sheets turned in the shop?
2. Why is tin painted before being laid?
3. Why is paper laid underneath the tin?
4. Why is tin nailed to the sheathing with cleats?
5. What is the object of breaking joints?
6. Why must the tin roof be cleaned before being soldered?
7. Why are the long strips for standing seam roofing put together in the shop?
8. What kind of shoes should be worn when laying tin roofing? Why?

OPERATION SHEET

Assembling, Setting, and Glazing Skylights

Directions:

1. Set the curb of the skylight in position, then fit and solder the miter joints.

2. Square the curb, then fit and solder the hip and the ridge bars in position as indicated in the working drawing, Fig. 60.

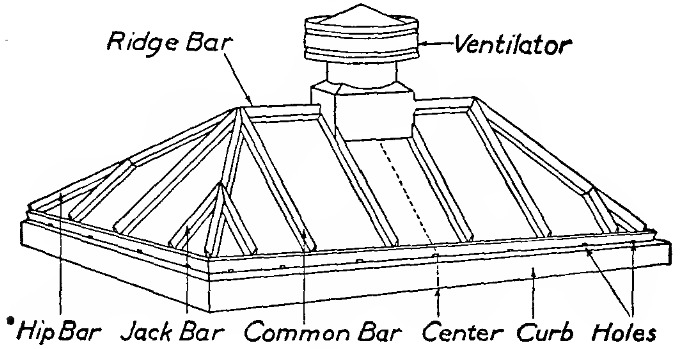


Fig. 60

3. Locate and mark the middle of each side of the curb and of the ridge bar, and space equally from these marks the bars to support the glass.

4. In spacing for bars allow $\frac{1}{4}$ inch more than the width of the glass.

5. Six inches from both ends of all bars solder copper lugs $\frac{1}{2}$ inch wide and $1\frac{1}{2}$ inches long to hold the caps in position.

6. Place common bars in position and solder them to the ridge, bars and curb, then place the jack bars in position and solder them to the hip bars and curb. If a ventilator is required, fit cross bars between the common bars to support the ventilator base.

7. Turn the skylight over and solder all the connecting joint.

8. With a small chisel cut holes thru the curb between each two bars to drain off the water which may collect from leaks or condensation.

9. Place the skylight over the frame in the roof and nail thru the curb.

10. Lay the glass on the bed of the bars.

11. Hold the skylight caps in position on the ridge, mark the location of lugs on the ridge; then with a chisel cut holes thru the caps large enough to slip over the lugs.

12. Miter the caps to fit each other at the joints.

13. Set the caps over the ridge bar until the lugs come thru the caps, cut off the ends of the lugs, press the caps against the glass, and bend the lugs down on each side of the caps.

14. Solder all the joints, but do not solder the lugs to the caps.

Bedding Glass in Putty.

15. With a putty knife, squeeze putty on the bed of the skylight bars and curb.

16. Lay the glass on the putty and press down on the glass with the flat part of your hand until the putty squeezes out around the edges.

17. With a putty knife cut off the putty which has squeezed out of the joints on to the under surface of the glass.

References:

Daugherty, J. S., *Sheet-Metal Pattern Drafting and Shop Problems*, pp. 136-148.

Questions:

1. Why are the common and jack bars spaced from the center of the skylight?
2. Why should bars be spaced ¼ inch more than the width of glass?
3. Why is it necessary to cut holes in the bottom of the curb?
4. Is it necessary to bed glass in putty? Why?
5. Why is it necessary to solder caps where they miter?

OPERATION SHEET

Hanging and Glazing Hollow Metal Sash

Directions:

1. Remove both sash and lay them on trestles.
2. Take out the screws and remove the muntin bars.
3. Slide the glass in position and screw the muntin bars back into place.
4. Squeeze putty in the groove between the metal and the glass then trim the putty straight and smooth with a putty knife.
5. Slip a wire over the sash pulley until it shows thru the opening in the side of the window frame. Hook one end of the sash chain on the wire and the other end on a sash weight. Pull the sash chain over the pulley and draw the sash weight to the top of the channel in the frame. To keep the weight at the top of the channel, slip a nail thru the chain close to the pulley. Repeat this operation on the other side of the frame.
6. Stand the upper sash in the window frame and rest it on the sill.
7. Drop the chains thru holes prepared on each side of the upper sash and slip a nail thru the chains below the holes.
8. Take out of the chains the nails that were holding the sash weights at upper end of the channel and raise the upper sash to the top of the frame.
9. Replace the jambs on each side of the frame, then fasten the chains to the lower sash in the same way.
10. Fasten the lower sash in the frame with enough play to slide freely.
11. Screw the hardware to the sash.

Questions:

1. Why is the sash taken out of frame to glaze?
2. Why are sash weights pulled up to the top of the channels in the frame before being hooked to the sash?
3. How much should sash weights weigh?
4. Are sash weights round or square?
5. What are sash weights made of?
6. What kind of glass is used in metal sash? Why?

OPERATION SHEET

Setting and Erecting Stacks

Directions:

1. Set the base of the stack in position over the opening in the roof and mark around the base with a nail or a prick punch.

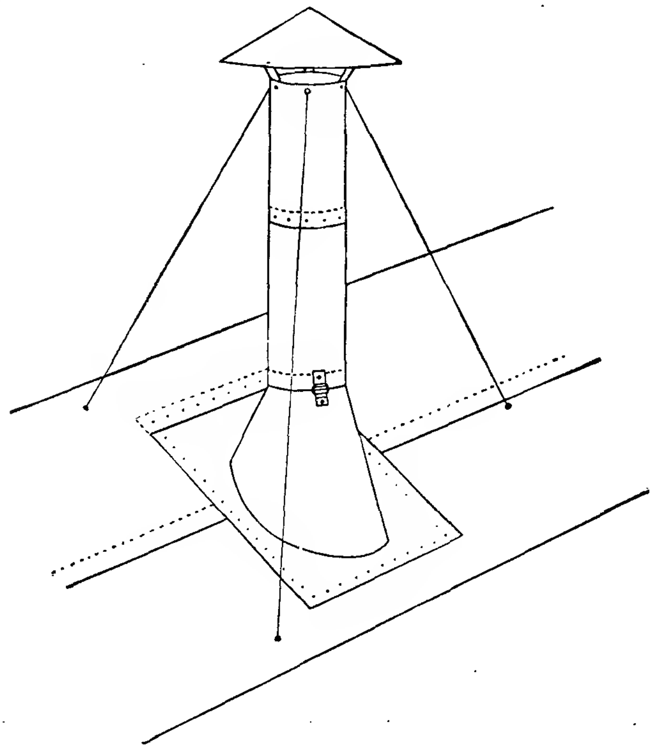


Fig. 61

2. Remove the base and 4 inches below the line of the top edge cut thru the roofing material the full width of the base.
3. Spread a band of pitch or roofing cement about 2 inches wide under the side edges and bottom edge of the base.
4. Slide the upper edge of the base flange under the roofing.

5. Spread pitch or cement between the flange and the roofing at the top edge of the base.

6. Nail the flange to the roof sheathing all around the outer edge every 3 inches, then spread pitch or roofing cement over the edges and nails.

7. Tie to the lugs prepared on the upper end of the stack three guy wires, one and a half times the length of the stack

8. Raise the stack and place it over the base.

9. Hold the stack plumb, loop the ends of the wires and nail them to the roof at three points equally spaced around the stack.

10. Tie the stack to the base with wire passing thru the holes in the lugs riveted to the stack and to the base for that purpose.

Questions:

1. Why is the flange of the base nailed over the top of the roofing?
2. Why is pitch or roofing cement spread under the flange before it is nailed?
3. Why should the flange be nailed all around the outer edge?
4. Why should three guy wires be tied to the upper end of the stack before it is erected?
5. Why should the stack be tied to the base?

OPERATION SHEET

Laying a Slate Roof

Directions:

1. Stack the slate on edge near some part of the building where it may be hoisted onto the roof.

2. Cover the entire surface of the roof with tar paper and hold it in position with wood lath nailed to the roof with 3-penny common nails.

3. Place all valleys before laying the paper and have the paper lap over on the valleys at least three inches.

4. Punch nail holes in the slate before hoisting it to the roof. The holes should be punched from the bottom side, two inches from the top edge and one inch from the sides, only two holes to the slate.

5. Where a large amount of slate is used the nail holes are usually punched with a special machine.

6. To punch nail holes by hand lay the face side of the slate on a slater's stake and punch the hole by striking on the slate near the stake with the sharp end of a slater's hammer.

7. Nail across the roof at the eaves a cant-strip $\frac{3}{8}$ inch thick.

8. Strike a chalk line across the roof to locate the position of the top edge of each course of slate.

9. Nail the first course with the long dimension of slate parallel with the eaves, using $1\frac{1}{4}$-inch galvanized nails. Do not drive nails too tight but the heads must be flush with the surface of the slate.

10. Nail the second course with the long dimension of slate at right angles with the eaves and the lower edge even with the lower edge of the first course.

11. Nail the following courses with the long dimension of the slate in the same direction as the second course, with the vertical joints of each course over the middle of each

slate in the next lower course. This is called breaking joints. Continue laying courses until the roof is covered.

12. To determine the amount of slate to be left uncovered (to the weather), subtract 3 inches from the length of the slate and divide the remainder by 2.

13. To cut slate to fit valleys and hips, lay the slate face side down with the line to be cut directly over a slater's stake. Punch holes close together along the line with the pointed end of a slater's hammer, break off the waste and cut the edge smooth with the knife edge of the hammer.

14. Nail the hip and the ridge moulding on with 6-penny galvanized nails.

Closed Valley or Hip.

15. Miter each course to fit closely the corresponding course on the adjoining portion of the roof. Under each course on the hip or valley lay a flashing bent to the shape of the valley or the hip and trim the lower edge of the flashing even with the lower edge of the course. The flashing should extend about 5 inches on each side of a valley or about 3 inches each side of a hip.

Bedding Slate in Elastic Cement.

16. When the specifications require that along valleys, gutters, drips, or ridges, the slate be laid in elastic cement, spread the cement on the roof for a distance of 2 feet from each valley, hip, gutter, or ridge and press the slate against the cement before nailing it.

Repairing a Slate Roof.

17. To remove a broken slate, slip a ripper under the broken slate and hook it over one of the nails holding it.

18. Push the ripper up about 3 inches and jerk downward to cut the nail. Cut the second nail in the same way.

19. Slide the new slate in position and mark for a nail in the joint between the two slates in the next course above. Then remove the slate and punch a hole from the under side.

20. Slide the new slate in position again, drive thru

it one nail until the head of the nail is flush with the surface of the slate then slip a piece of tin flashing about 6 inches long, under the upper slates and over the nail.

References:

Slate Manufacturers Catalogues.

Williams, H. V., *New Tinsmith Helper and Pattern Book,* p. 226.

Questions:

1. Why are slate stacked on edge?
2. Why are valleys placed before paper is laid?
3. Why are holes punched in slate by striking against the under side?
4. Why not drive nails tight against the slate?
5. Why is it necessary to nail a cant strip along the eaves before laying the first course of slate?
6. Why are galvanized nails used in nailing on slate?
7. Why is a slater's stake used in punching and cutting slate?
8. What is the object of laying slate in elastic cement?

INFORMATION TOPICS

INFORMATION TOPICS

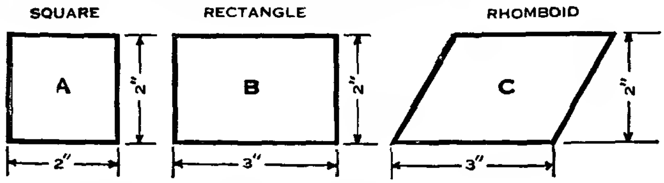
MENSURATION

Symbols and Abbreviations:

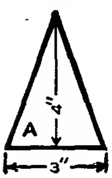
12 inches (12″) equal 1 foot (1′)
144 square inches (144 sq. in.) equal 1 square foot (1 sq. ft.)
1728 cubic inches (1728 cu. in.) equal 1 cubic foot (1 cu. ft.)
231 cubic inches (231 cu. in.) equal 1 gallon (1 gal.)
1 gallon (1 gal.) equals 4 quarts (4 qts.)
1 quart (1 qt.) equals 2 pints (2 pts.)
2150.42 cubic inches (2150.42 cu. in.) equal 1 bushel (1 bu.)

Areas of Surfaces and Volumes of Solids:

To find the *area* of any *parallelogram* multiply its length by its width or perpendicular height.

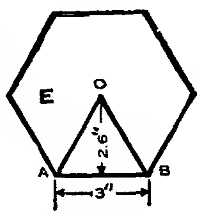


Example: Area of A equals $2\times2=4$ sq. in.
Area of B and C equals $3\times2=6$ sq. in.

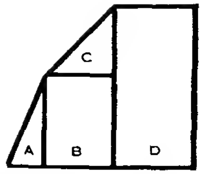


To find the *area* of a *triangle* multiply the length of its base by half of its height measured on a line drawn from the angle opposite the base perpendicular to the base.
Example: Area of A equals $3\times4/2$ or $3\times2=$ 6 sq. in.

To find the *area* of any *regular polygon* (a figure with any number of equal sides) draw lines from the ends of one side to the center, find the area of the *triangle* thus formed and multiply this area by the number of equal sides.

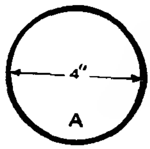


Example: Area of $AOB=3\times\frac{1}{2}$ of 2.6 or $3\times1.3=3.9$ sq. in.
Area of $E=6\times3.9=23.4$ sq. in.



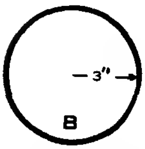
To find the *area* of any *polygon* draw lines so as to divide the surface into triangles or parallelograms, find the area of each division and add them together for the total area.

Example: Find the area of *A, B, C* and *D* and add these areas together to find the area of the whole surface.



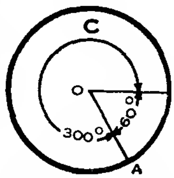
The *circumference* or distance around a *circle* equals the *diameter* multiplied by 3.1416.

Example: Circumference of Circle *A* equals 4×3.1416 equals 12.5664 in.



The *area* of a *circle* equals the *square* of the *radius* multiplied by 3.1416.

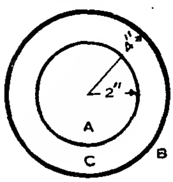
Example: Area of Circle *B* equals $3 \times 3 \times 3.1416$ or $9 \times 3.1416 = 28.2744$ sq. in.



A *circle* contains 360 *degrees.* An angle is measured by that portion of the *circumference* of a circle which connects its sides when the intersection of these sides is used as a center.

Example: Circle *C* contains 360 degrees (360°). Angle *AOB* contains 60/360 of the whole circle or 60°.

The area of the sector *AOB* is 60/360 or 1/6 of the area of circle *C*.



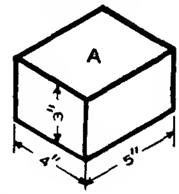
To find the *area* of a *circular ring,* find the area of both the inner and outer circles and subtract the smaller from the larger.

Example: Area of circle $A = 2 \times 2 \times 3.1416$ or $4 \times 3.1416 = 12.5664$.

Area of circle $B = 4 \times 4 \times 3.1416$ or $16 \times 3.1416 = 50.2656$.

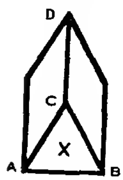
Area of ring $C = 50.2656 - 12.5664 = 37.6992$ sq. in.

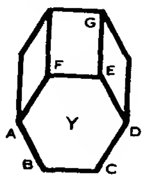
To find the cubic contents or volume of a *rectangular prism* multiply the area of its base by its height.



Example: Volume of *A* equals $5 \times 4 \times 3 = 60$ cu. in.

To find the *volume* of *any prism* multiply the area of its base by the height.

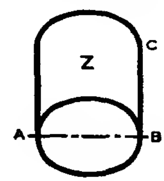




Example: Volume of triangular prism *X* equals the area of triangle *ABC* multiplied by height *CD*.

Volume of hexagonal prism *Y* equals the area of hexagon *ABCDEF* multiplied by its height *EG*.

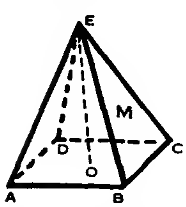
To find the *volume* of a *cylinder* multiply the area of its base by its height.



Example: Volume of cylinder *Z* equals area of circle *AB* multiplied by its height *BC*.

To find the *area* of the *curved surface* of a *cylinder* multiply the circumference of its base or its perimeter by its height.

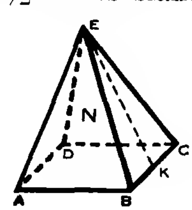
Example: Area of curved surface of cylinder *Z* equals the circumference or perimeter of *AB* multiplied by *BC*, the height of the cylinder.



To find the *volume* of a *pyramid* multiply the area of its base by 1/3 of its altitude.

Example: Volume of pyramid *M* equals area of base *ABCD* multiplied by 1/3 of its altitude *OE*.

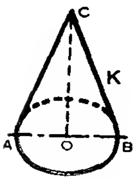
To find the *area* of the slanting sides of a *pyramid* with a regular polygon for its base, multiply the distance around its base or its perimeter by ½ of its slant height.



Example: Area of slanting sides of pyramid *N* equals the distance around its base or its perimeter multiplied by ½ of its slant height *EK*.

To find the *volume* of a *cone* multiply the area of its base by 1/3 of its altitude.

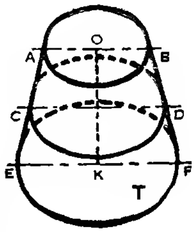
Example: Volume of cone *K* equals area of circle *AB* multiplied by 1/3 of altitude *OC*.



To find the *area* of the slanting surface of a *cone* multiply the distance around its base or its perimeter by ½ of its *slant height*.

Example: Area of slanting surface of cone *K* equals area of circle *AB* multiplied by ½ *BC*, its slant height.

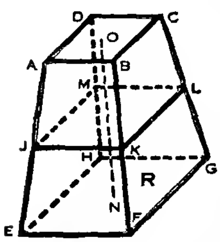
To find the *volume* of the frustum of a *cone* add the areas of the top and bottom to four times the area of the middle section and multiply this sum by 1/6 of the vertical height.



Example: Volume of frustum *T* equals area of *AB* plus area of *EF* plus 4 times area of *CD* and this sum multiplied by 1/6 of *OK*.

Note—To find diameter *CD*, add diameter *AB* to diameter *EF* and divide by 2.

To find the *volume* of the *frustrum* of a *pyramid* add the areas of the top and bottom to 4 times the area of the middle section and multiply this sum by 1/6 of the vertical height.



Example: Volume of frustum *R* equals area of *ABCD* plus area of *EFGH* plus 4 times area of *JKLM* times 1/6 of *ON*.

References:

Blinn, *Tin, Sheet-Iron and Copper-Plate Worker,* pp. 110-122.

Williams, *The New Tinsmith's Helper,* pp. 1-19.

Broemel, *Sheet-Metal Workers Manual,* pp. 484-496.

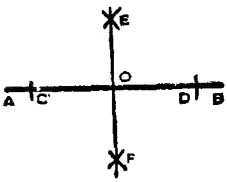
Neubecker, *Universal Sheet-Metal Pattern Cutter,* pp. 361-364.

INFORMATION TOPICS

Geometrical Problems

To erect a perpendicular at or near the center of a straight line.

Problem: Erect a perpendicular at point *O* on line *AB*.



With *O* as a center, and any radius, draw arcs cutting at *C* and *D*.

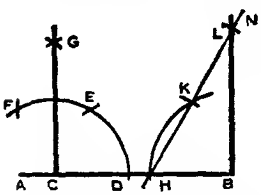
With *C* and *D* as centers, draw arcs cutting at *E* and *F*.

Draw line thru intersections *E* and *F* and it will be perpendicular to *AB* at *O*.

To erect a perpendicular at or near the end of a straight line.

First Method.

Problem: Erect a perpendicular at point *C* on line *AB*.



With *C* as a center, and any radius as *CD*, draw an arc.

With *D* as a center, and the same radius, step off *DE*.

With *E* as a center, and the same radius, step off *EF*.

With *E* and *F* as centers, draw arcs cutting at *G*.

Draw a line from *C* thru intersection at *G* and it will be perpendicular to *AB* at *C*.

Second Method.

Problem: Erect a perpendicular at point *B* on line *AB*.

With *B* as a center, and any radius, as *BH*, draw an arc.

With *H* as a center, and the same radius, draw an arc cutting at *K*.

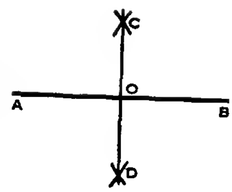
Thru *H* and *K*, draw line *HN*.

With *K* as a center, and with the same radius, *BH*, draw an arc cutting at *L*.

Draw a line from *B* thru the intersection at *L* and it will be perpendicular to *AB* at *B*.

To bisect a straight line.

Problem: Bisect line *AB*.

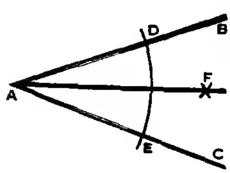


With *A* and *B* as centers, and any radius greater than ½ of *AB*, draw arcs cutting at *C* and *D*.

Draw a line thru the intersections *C* and *D* and it will bisect *AB* at *O*.

To bisect an angle.

Problem: Bisect angle *BAC*.



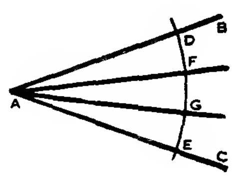
With *A* as a center, and any radius, draw arc *DE*.

With *D* and *E* as centers, draw arcs cutting at *F*.

From *A* draw a line thru intersection at *F* and it will bisect angle *BAC*.

To trisect an angle.

Problem: Trisect angle *BAC*.



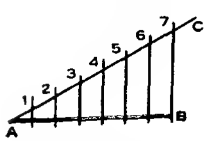
With *A* as a center, and any radius, draw arc *DE*.

With dividers step off three equal divisions on arc *DE* as at *F* and *G*.

From *A* draw lines thru *F* and *G* and they will trisect angle *BAC*.

To divide a straight line into any number of equal parts.

Problem: Divide *AB* into seven equal parts.



From *A* draw *AC* at any angle.

On *AC* step off seven equal divisions as at 1, 2, 3, 4, 5, 6 and 7.

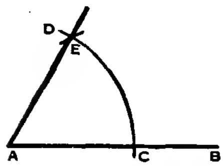
From 7 draw a line to *B*.

From each of the other numbers draw lines parallel to *7B* and they will divide *AB* into seven equal parts.

To construct an angle of 60 degrees.

Problem: Draw a line from A making an angle of 60° with the line AB.

With A as a center, and any radius, draw an arc CD.

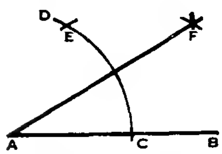


With C as a center, and the same radius, draw an arc cutting at E.

From A draw a line thru intersection E and it will form an angle of 60° with AB.

To construct an angle of 30 degrees.

Problem: Draw a line from A making an angle of 30° with the line AB.



With A as a center, and any radius, draw an arc CD.

With C as a center, and the same radius, draw an arc cutting at E.

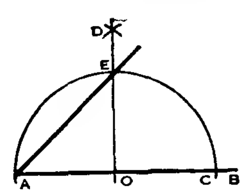
With C and E as centers, draw arcs cutting at F.

From A draw a line thru intersection F and it will form an angle of 30° with AB.

To construct an angle of 45 degrees.

Problem: Draw a line from A making an angle of 45° with the line AB.

Select any convenient point on AB as O.



With O as a center, and a radius equal to OA, draw the arc AEC.

With A and C as centers, draw arcs cutting at D.

From O draw a line thru intersection D cutting the arc AEC at E.

From A draw a line thru intersection E and it will form an angle of 45° with the line AB.

To construct an angle equal to another angle.

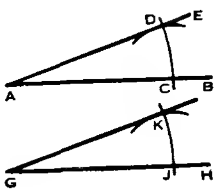
Problem: Construct an angle equal to angle *EAB.*

Draw line *GH.*

With *A* as a center, and any radius draw arc *CD.*

With *G* as a center, and the same radius, draw arc *JK.*

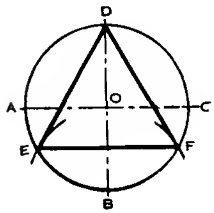
With *J* as a center, and radius equal to *CD,* draw an arc cutting at *K.*



From *G* draw a line thru intersection *K* and it will form an angle with *GH* equal to the angle *EAB.*

To construct an equilateral triangle in a circle.

Problem: Construct an equilateral triangle in the circle *ABCD.*



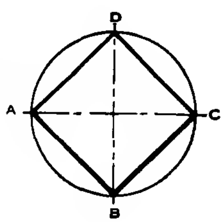
Draw horizontal and vertical center lines *AC* and *BD.*

With *B* as a center, and *BO* as a radius, draw arcs cutting at *E* and *F.*

Draw *EF, ED* and *FD* to form an equilateral triangle.

To construct a square in a circle.

Problem: Construct a square in the circle *ABCD.*



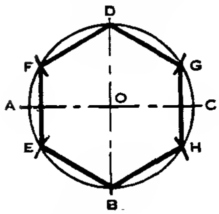
Draw horizontal and vertical center lines *AC* and *BD.*

Draw *AB, AD, CB* and *CD* to form a square.

To construct a regular hexagon in a circle.

Problem: Construct a regular hexagon in the circle *ABCD.*

Draw horizontal and vertical center lines *AC* and *BD.*



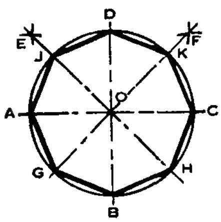
With *B* as a center, and *BO* as a radius, draw arcs cutting at *E* and *H.*

With *D* as a center, and the same radius, draw arcs cutting at *F* and *G.*

Draw lines *EF, FD, DG, GH, BH* and *EB* to form a regular hexagon.

To construct a regular octagon in a circle.

Problem: Construct a regular octagon in the circle *ABCD.*



Draw horizontal and vertical center lines *AC* and *BD.*

With *A* and *D* as centers, draw arcs cutting at *E.*

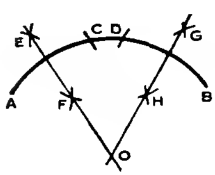
With *D* and *C* as centers, draw arcs cutting at *F.*

From *E* and *F* draw center lines thru center *O* cutting the circumference at *J, K, H* and *G.*

Draw *AJ, JD, DK, KC, CH, BH, GB* and *AG* to form a regular octagon.

To find the center of a circle when only an arc is given.

Problem: Find the center of circle of which *AB* is an arc.



With *A* and *B* as centers, draw arcs cutting at *C* and *D.*

With *A* and *C* as centers, draw arcs cutting at *E* and *F.*

With *B* and *D* as centers, draw arcs cutting at *G* and *H.*

Draw a line thru intersections *E* and *F.*

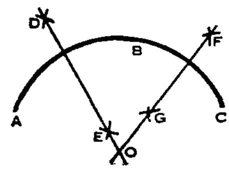
Draw a line thru intersections *G* and *H.*

The point of intersection of these two lines at *O* is the center of the circle.

To pass the circumference of a circle thru any three points.

Problem: Pass the circumference of a circle thru ABC.

With A and B as centers, draw arcs cutting at D and E.



With B and C as centers, draw arcs cutting at F and G.

Draw a line thru intersections D and E.

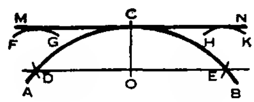
Draw a line thru intersections F and G.

With the point of intersection of these two lines at O as a center, and OA as a radius, draw the arc ABC.

To draw a tangent to a circle at a given point.

Problem: Draw a tangent to circle ABC at point C.

With C as a center, draw arcs cutting at D and E.



Draw the line DE.

Draw OC perpendicular to DE.

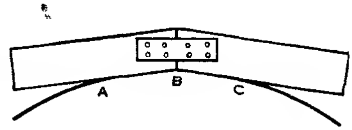
With D and E as centers, and OC as a radius, draw arcs FG and HK.

Draw MN touching arcs FG and HK and it will be tangent to circle ABC at C.

To describe an arc of large radius without locating its center when the rise of the arc is known.

Problem: Pass the arc of a circle thru AB and C without locating the center of the arc.

Join two straight edges so that the edge of one passes thru A and B and the edge of the other passes thru C and B.

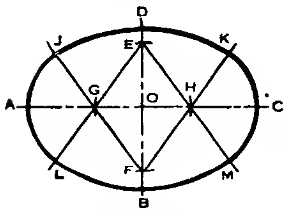


With the straight edges joined move them to either side and their intersection B will always fall in the circumference of the circle provided the edges themselves pass thru A and C.

Note: In practice it is customary to drive a wire nail at A and at C and slide the straight edges against them while drawing the arc with a pencil held at their intersection B.

To construct an ellipse.

Problem: Construct an ellipse with its major axis equal to AC and its minor axis equal to BD.



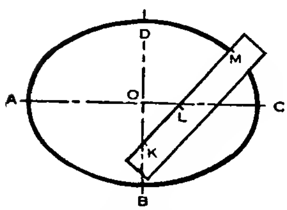
First Method (approximate.)

Lay off OE and OF each equal to the difference between AC and BD.

Lay off OG and OH each equal to ¾ of OE.

Draw lines EGL and EHM, FGJ and FHK.
With G as a center, and GA as a radius, draw arc LAJ.
With H as a center, and HC as a radius, draw arc MCK.
With F as a center, and FJ as a radius, draw arc JDK.
With E as a center, and EGL as a radius, draw arc LBM.

Second Method (with trammels.)



Draw major axis AC and minor axis BD.

On the edge of a strip of paper, lay off MK equal to ½ of the major axis and ML equal to ½ of the minor axis.

With K always on BD and L always on AC, rotate the strip of paper about the center O and mark the location of M at various points.

Thru these points draw a line to form the ellipse.

References:

Daugherty, J. S., *Sheet-Metal Pattern Drafting and Shop Problems,* pp. 12-23.

Broemel, *Sheet-Metal Workers Manual,* pp. 472-484.

Blinn, *Tin, Sheet-Iron and Copper-Plate Worker,* pp. 97-108.

INFORMATION TOPICS

Solders and Fluxes

Solders.

Most of the solder used by sheet-metal workers is what is known as half and half, that is, one-half lead and one-half tin. It melts at about 400 degrees Fahrenheit.

Plumbers use a finer solder consisting of two parts of tin to one part of lead. It melts at about 360 degrees Fahrenheit. Since much depends on the purity of the solder used it should be purchased from reliable dealers only.

Solder may be purchased in bars or in the form of wire.

Fluxes.

In order that two metal surfaces may be soldered, they must be chemically clean, that is they must be free from dirt, grease, and the oxidation which is caused by exposure to the air. To provide clean surfaces various fluxes are used previous to and during the process of soldering.

Cut Acid.

Cut acid is made by dropping into muriatic acid contained in an earthenware or glass jar, as much zinc as it will dissolve. The zinc will cause the acid to bubble and the resulting mixture is chloride of zinc. This cut acid is used as a flux on zinc, brass, copper, tin, iron and clean galvanized iron. Raw acid is used on old galvanized iron.

Rosin.

Rosin is used as a flux principally on tin plate and bright copper. The lumps of rosin are crushed into a powder and applied with a spoon or with one's fingers.

In order to prevent powdered rosin being blown away from a seam on a roof it may be dissolved in alcohol or gasoline, to the consistency of paste and then applied with a swab.

Tallow.

Tallow is used as a flux when soldering lead. It must be applied as soon as the surface of the lead is scraped bright.

Soldering Salts and Soldering Paste.

Soldering salts to be dissolved in water and soldering pastes are sold by various manufacturers to be used as fluxes. Some workers prefer these to the cut acid or rosin.

References:

Broemel, *Sheet-Metal Workers Manual,* p. 177.

Williams, H. V., *New Tinsmith Helper and Pattern Book,* pp. 229-243.

Questions:

1. Does solder melt at a lower temperature than either of the metals which compose it?
2. When may wire solder be used to advantage?
3. How do fluxes clean the surface of metal?
4. Is there danger of using too much zinc when making "cut acid"?
5. Why should "cut acid" be kept in a glass or earthenware vessel?

INFORMATION TOPICS

Materials

Tin.

Tin is a bright metal much resembling silver in appearance. It does not rust or corrode except at temperatures much higher than the atmosphere ordinarily reaches. It is malleable and flexible but not elastic. Its tensile strength is too low to form fine wire. It is a poor conductor of heat and electricity and melts at a temperature of about 460 degrees Fahrenheit.

It is sold in ingots or pigs as block tin and is known as, "Banca," "Malacca," "Australian," "Straits," etc., according to the place where it was mined. High-grade tin should be about 99.75% pure.

Tin is used for coating sheets of iron or steel and to coat copper, brass and iron wire, pipes and tubes. It is also an ingredient of solder.

The tin plate used by sheet-metal workers is not solid tin. It is used for many purposes such as for making cans to preserve fruits and vegetables, for kitchen utensils and for hot air furnace pipes. Tin plate on an open hearth steel base resists rust more than when a Bessemer steel base is used.

Terne plates are sheet steel coated with a mixture of tin and lead. They are used mostly for roofing and are very durable. They are not as bright as when coated with tin alone. All tin plate or terne plate used for roofing should be painted on both sides.

Tin plate comes in various sizes and thicknesses as shown in table No. 1 on page 152.

Black Iron.

Black iron or steel is the form in which sheets come from the rolling mills without any coating. In many cases articles are made of black iron and afterwards tinned or galvanized, painted or enameled.

Black iron sheets come in various sizes and thicknesses as shown in table 4, page 155.

Wood's Refined Smooth Black Sheets.

Wood's refined sheets are high grade black iron which has been given an extra smooth finish. They are used extensively for stove pipes because they require no lacquer or varnish to prevent rusting.

Galvanized Iron.

Galvanized iron is sheet-iron or steel covered with a thin coating of zinc. It is prepared in several ways but usually by cleaning the sheets with acid and then dipping them in a bath of molten zinc.

Because of its zinc coating galvanized iron is protected from corrosion by the weather and for that reason is extensively used for roofing, especially in the form of corrugated sheets. It is also used a great deal for heating and ventilating ducts.

Galvanized sheets come in various sizes and thicknesses as shown in table No. 3, page 152.

Lead.

Lead is a metal, blue-gray in color. Its surface tarnishes or oxidizes very quickly when exposed to the air. It is the softest and heaviest of the common metals.

It is malleable and ductile but not elastic.

Its tensile strength is too low to form fine wire.

It is a poor conductor of heat and electricity and melts at about 620 degrees Fahrenheit.

It is soft enough to be forced thru dies with a press to form rods or pipes.

The best grade should be about 99.5% pure.

Lead is used for lining tanks because it resists corrosion. It is also used to make lead pipe for plumbing because of its flexibility and the ease with which it can be soldered.

Lead is one of the ingredients of solder.

Copper.

Copper is a red metal which melts at about 1,200 degrees Fahrenheit.

It takes a high polish and is very malleable and ductile.

It does not deteriorate when exposed to the atmosphere and is therefore valuable for gutters, valleys and ridges of roofs, and for other parts of buildings exposed to the weather.

Hammering makes copper hard while heating to a red heat followed by cooling in the air or water softens it.

It is one of the best conductors of electricity and also is a good conductor of heat.

It is very difficult to make castings of pure copper.

Brass.

Brass is an alloy of copper and zinc.

Red brass contains about 10% zinc.

Yellow brass contains about 40% zinc.

Ordinary brass contains about 30% zinc.

The greater proportion of zinc makes yellow brass harder than red brass.

Brass may be melted and cast in molds. It is used in a great many different ways such as machine parts and pipe fittings. Altho it tarnishes quickly it does not corrode so that it is commonly used where a non-rusting metal is required.

It may be drawn into fine wire and rolled into sheets, rods and pipes. It takes a fine polish which may be preserved with a coat of transparent lacquer.

Zinc.

Zinc is a bluish-white metal which melts at about 415 degrees Fahrenheit.

It may be rolled into thin sheets in which form it is sometimes used for roofing.

Zinc is used extensively for coating iron and steel sheets called galvanized iron or steel.

It is also used in various alloys.

Paint.

Paint for metal is generally made of oxide of iron and red lead mixed with linseed oil. When applied to a clean metal surface, free from corrosion, it will prevent deterioration of the metal by reason of its exposure to the weather. When paint is required it should be applied to all of the surfaces of the metal which goes into building construction.

References:

Broemel, *Sheet-Metal Workers Manual,* pp. 14-17, 443-462.
Blinn, *Tin, Sheet-Iron and Copper-Plate Worker,* 159-166.
Neubecker, *Sheet-Metal Work,* pp. 161.

INFORMATION TOPICS

Roofing

Building Paper on Roofs.

All metal roofing should be laid over a layer of building paper which is free from acid. The sheathing of the roof should have tight joints, be free from loose knots and dry before the paper is laid. It should be examined to see that no nail heads extend above the surface.

Tin Roofing.

Some of the oldest roofs in existence are tin, a testimonial as to their durability when high grade materials are used. The tin plate used for roofing is called "Terne" plate, the sheet steel being coated with a mixture of tin and lead, this coating having proved most durable.

The bottom sides of sheets should be thoroly painted with good paint before being laid. Allow the tin roof to weather a few days and then paint all exposed surfaces. The durability of a tin roof depends largely on its being kept covered with paint and for that reason only good linseed oil paint should be used. A new coat should be applied before the old one wears thru.

Flat seam tin roofing is commonly used. It is the best type of seam for roofs having less than one third pitch. In laying flat seam roofing, nails should not be driven thru the sheets but thru cleats which are bent over to hold the sheets. 14x20 sheets require three cleats at the top and two at the side, 20x28 sheets require four cleats at the top and three at the side. The 14x20 sheets are most commonly used.

Standing seam tin roofing is used only when the roof has more than 1/3 pitch. The standing seams stiffen the roof and are especially valuable on large surfaces. The sheets should be painted on both sides the same as flat seam roofing. Standing seam roofing is usually made of 14x20 sheets, the 20-inch edges being joined by flat seams to form strips reaching from the eaves to the ridge. The long edges of these strips are then folded to form the standing seams.

Galvanized Iron Roofing.

Galvanized iron may be used for standing seam roofs.

"V" Crimp Roofing.

"V"-Crimp Roofing is made of galvanized or painted sheets of steel, the long edges of which have been crimped to form "V." In placing these sheets on a roof the V's are supported by triangular wooden strips. The crimp of one sheet is laid directly over the corresponding crimp of the previously laid sheet and all are held in place by driving wire nails thru both V's and the wooden strip into the roof sheathing.

The "V" crimps stiffen the sheets, and for this reason a third crimp is sometimes formed thru the middle of the sheet.

"V"-Crimp Roofing comes in 5 ft. to 10 ft. even foot lengths and covers 24 inches in width.

Corrugated Iron Roofing.

Corrugated iron roofing is used principally on steel frame work factory and warehouse buildings. The corrugations vary in size as 5 inch, 2½ inch, 1¼ inch and ¾ inch the measurement being from the center of one ridge to the center of the next ridge.

The depth of the grooves also varies as well as the gauge of the metal.

When corrugated iron is laid on wood sheathing galvanized iron nails and lead washers should be used. It should be securely fastened at the edge of the roof to prevent the wind from raising it. The side lap should be at least one corrugation and the end lap from 3 to 6 inches, the smaller figure on steep roofs.

Metal Shingles.

Metal shingles are so made that they may be nailed on the roof without soldering but should not be used on a roof with less than 1/3 pitch. They are made in various patterns and the edges are so shaped that one hooks under the other so securely as to make the roof water tight. Just as with a plain tin roof, they should be laid over a layer of building paper. Special hips, valleys, ridging, and ends for eaves are furnished with metal shingles.

Copper Roofing.

Copper roofing is sometimes used because of its great durability. When the surface is large, special provision must be made for expansion and contraction due to changes in temperature.

Slate Roofing and Tile Roofing.

Slate roofing and tile roofing are popular, but must be used only on steep roofs. Both are heavy and require a strong frame work under them. This is especially true of tile roofing.

Roofing slate comes in various sizes as large as 12x16, 12x18, 12x20, and 14x24. These sizes make fewer joints and require fewer nails. The most popular size however, is 9x18. Still smaller sizes look best on roofs which are cut up into small sections. Slate also comes in various thicknesses, such as $\frac{1}{4}$, $\frac{3}{16}$ and $\frac{1}{8}$ inches and in various colors, such as red, green, and dark gray, the dark gray being by far the most common. Slate is sold by the square, meaning sufficient to cover 100 sq. ft. of surface with three inches of lap over the upper end of the second course or layer below. On a slate 18 inches long this would leave $7\frac{1}{2}$ inches to the weather. For nailing slates 10x20 or larger, 4 penny copper, tinned, or galvanized nails should be used, for smaller slates 3 penny nails will do.

References:

Neubecker, *Sheet-Metal Work*, pp. 158-192.

Williams, *The New Tinsmith's Helper,* pp. 197-202, 214-215, 218, 223-228.

St Louis Technical Institute, *Studies in Sheet-Metal, Outside Jobbing.*

Questions:

1. Why should building paper be laid under metal roofing? Why should such paper be free from acid?
2. Why should no nail heads extend above the surface of sheathing?
3. Why is flat seam roofing best for flat roofs?
4. How does paint preserve a tin roof?
5. When nails are driven thru cleats to hold a metal roof why should the end of cleat be bent over the head of the nail driven thru it?
6. What are the advantages in using standing seam roofs on large surfaces? Why should they not be used on flat roofs?
7. When it is necessary to join copper and tin or copper and galvanized iron what precautions must be taken? Why?
8. How is corrugated iron fastened to the steel frame work of a roof?
9. How may corrugated iron be securely fastened at the edges of a roof?
10. Is galvanized iron used for flat seam roofing?
11. When should galvanized iron be painted? Why?
12. Why should a sheet-metal worker wear rubber shoes when working on a tin or slate roof?
13. Why permit the roof to weather a few days before painting?

INFORMATION TOPICS

Cornices

Information:

Cornices are used to add to the architectural beauty or design of buildings. Unless they do so there is no excuse for their being used. It is important therefore that their design be given very careful study. Cornices do not support any part of a building, in fact they must be supported by the building and provision for such support must be made while the building is being constructed.

Cornices are made of various materials, including terra cotta and cast-iron, but sheet-metal, because of its light weight and the ease with which it may be formed is most commonly used. Twenty-four gauge galvanized iron or 16 oz. copper are the weights preferred altho lighter galvanized iron is sometimes used. Only copper rivets and copper nails should be used in fastening copper cornices and galvanized nails and bolts and tinned rivets used for galvanized iron cornices.

The most serious objection to galvanized iron cornice is its liability to rust. This can best be overcome by using the better grades of material, by securely riveting and soldering all joints, thus covering exposed edges, and by protecting all points of support to prevent the accumulation of water at such places.

References:

St. Louis Technical Institute, *Studies in Sheet-Metal, Architectural.*

Neubecker, *Sheet-Metal Work,* pp. 193-262—Cornice work.

Daugherty, J. S., *Sheet-Metal Pattern Drafting and Shop Problems,* pp. 42-63.

Questions:

1. In what respects is a sheet-metal cornice superior to a terra cotta cornice?

2. In what respects is it inferior?

3. What practices by sheet-metal workers would tend to make sheet-metal cornices unpopular?

4. Why should copper rivets and nails be used on copper cornice and galvanized nails and bolts and tinned rivets on galvanized iron cornice? Why not use tinned rivets on copper or copper rivets on galvanized iron?

5. What precautions should be taken in the location of nails?

6. Why is copper a good material for cornices?

INFORMATION TOPICS

Hot-Air Furnaces

Information:

Hot-air furnaces are made either of cast-iron or sheet steel, both in heavy and light patterns. The heavy cast-iron furnace is conceded to be the best and the light cast-iron furnace is considered better than the light steel furnace.

The design of a hot-air furnace is based on the fact that when air is heated it expands, becomes lighter and rises. It is therefore necessary to provide in a furnace an inlet for cold air to take the place of the warm air as it rises up into the house. Formerly this cold air was always taken from the outside. It is now common practice to create a circulation of air within the house by means of registers in the floor thus permitting the cold air to return to the basement. In extremely cold weather the cold air for the furnace is drawn directly from the basement thus saving much fuel.

The size of furnace to install depends on the size of house and arrangement of the rooms. It is good practice to buy only from reputable manufacturers who will guarantee results after the measurements of building are considered. In the long run it is more economical to install an oversize furnace than one which is too small.

After locating all registers the furnace should be so placed that the various hot air pipes are as nearly equal in length as possible. It is best however, to place the furnace slightly nearer the side of the house against which the prevailing cold winds blow.

The modern pipeless furnace which is so extensively advertised avoids the use of wall stacks by delivering the full volume of warm air thru one register directly over the furnace. Its efficiency depends on establishing a complete circulation of air thruout the house. It is especially adapted to houses where all the rooms open into a central hallway.

References:

St. Louis Technical Institute, *Studies in Sheet-Metal, Furnace Work.*

Department of the Interior, Bureau of Mines, Technical Paper 208, *How to Improve the Hot-Air Furnace.*

Questions:

1. Why is a cast-iron furnace generally more satisfactory than a sheet-steel one?
2. What would be the effect if the cold-air duct of the furnace became closed? What part of the house would receive the most heat?
3. Why is an oversize furnace more economical than a small one?
4. Why should the furnace be located nearer the side of a house against which the prevailing cold winds blow?
5. When a pipeless furnace is used must all doors between hall and rooms be left open?
6. Which is the easier to heat, a brick or a frame house?
7. What effect does air space in brick walls have upon heating?
8. What effect do windows have on the ease with which a house may be heated?
9. What effect does an open fire place without a damper have on the heating of a room?

INFORMATION TOPICS

Blow-Pipe Work

Information:

Blow-Pipe Work.

Blow-pipe work has developed until it now is one of the important branches of sheet-metal work. The designing of blow-pipe systems is an engineering problem but the actual installation provides many problems for the sheet-metal worker.

Blow-pipe work includes the following:

Shavings-exhaust systems for removing shavings and dust from woodworking machines. These are often called dust collectors. Similar systems are used for removing dust from emery wheels or other machines from which dangerous or offensive dust is thrown off.

Exhaust systems for removing smoke and fumes from forges, furnaces or chemical apparatus.

Pressure blower systems for providing a blast to forges, furnaces or cupolas.

Ventilating systems for keeping pure the air in certain rooms or in whole buildings.

Blow-pipe heating systems for distributing warm air to the various parts of a building.

The sheet-metal worker must keep the inside of pipes and fittings as smooth as possible to avoid friction of the moving air which in some cases travels as much as 4,000 ft. per minute.

Seams and joints should be smooth and tight.

Elbows should be of large radius.

Branch pipes should enter main pipes at as slight an angle as possible.

As various branches join the main pipe the latter should be increased in size so that at all points its area equals the combined area of all branches feeding into it at that point.

Galvanized iron is most generally used for blow-pipe work.

Blow piping is made either round or rectangular in shape. Round pipes are best for high velocity systems because they will stand more pressure without collapsing, should the end of the pipe become closed. Large rectangular pipes are often reinforced by having small angle irons riveted on the outside.

Hoods should fit machines as closely as possible and should be so placed that material thrown off of the machine will enter the hood at a point where the velocity of the air is greatest.

After passing thru the power-driven fan the dust or shavings are discharged into a conical shaped metal receiver called a cyclone. It is in the cyclone that the dust and shavings are separated from the air. From the cyclone the dust may be conveyed to bins for final disposal.

Because of the danger of fire, exhaust systems for forges or furnaces must not come in contact with shaving exhaust systems.

The fittings for dust collector systems often provide intricate lay-out problems for sheet-metal workers. The purpose of the peculiar design of these fittings is to equalize suction and to avoid friction.

INFORMATION TOPICS

Tool Kit

Every sheet-metal worker should have his own tool box and a kit of tools in addition to those furnished by the employer. The following lists are suggested as meeting the ordinary needs; special jobs will often require more or special tools.

Roofing and General Outside Sheet-Metal Work.

The following tools are usually furnished by the sheet-metal worker:

- 1 Tool box made of sheet-metal —8" x 16" x 6" deep with a pitched top hinged to the box
- 1 Setting hammer
- 1 Straight shears
- 1 Circular shears
- 1 Scratch awl
- 1 Prick-punch
- 1 Pair of dividers
- 2 Solid punches, 3/16" and 3/8"
- 1 Screwdriver
- 1 Cold chisel
- 1 Rivet set
- 1 Buttons pliers
- 1 Rule, 2 ft. folding
- 1 Chalk line
- 1 Roofing scraper
- 1 Putty knife or small trowel.

The following tools are usually furnished by the employer:

- 1 Fire pot, charcoal or gasoline
- 1 Pair soldering coppers (to suit job)
- 1 Acid kit (cut and raw acid, rosin for new tin roof)
- 1 Small dolly or iron weight for bucking rivets
- 1 File
- 1 Mallet
- Roofing tongs and seamers
- Special tools as needed.

Furnace Work, or Heating and Ventilating.

The following tools are usually furnished by the sheet-metal worker:

- 1 Tool box made of sheet-metal —8"x16"x8" deep with a flat top hinged to the box
- 1 Setting hammer
- 1 Straight shears
- 1 Circular shears
- 1 Scratch awl
- 1 Prick-punch
- 1 Pair of dividers
- 2 Solid punches 3/16" and 3/8"
- 1 Screwdriver
- 1 Cold chisel
- 1 Rivet set
- 1 Buttons pliers
- 1 Rule, 2 ft. folding
- 1 Chalk line
- 1 Putty knife or small trowel.

The following tools are usually furnished by the employer:

1 Double cutting shears
1 Star drill
1 File
1 Mallet
1 Small dolly for seaming or for bucking rivets
1 Compass-saw
1 Hand-saw
1 Brace and several wood bits
1 Small level
Special tools as needed.

STANDARD TABLES

TABLE I

NET WEIGHT PER BOX OF TIN PLATES

BASIS, 10x14, 225 SHEETS; OR, 14x20, 112 SHEETS

Trade Term		80 lb.	85 lb.	90 lb.	95 lb.	100 lb.	1C	1XL	1X	1XX	1XXX	1XXXX
Approximate Wire Gage......		No. 33	32	31	31	30	30	28	28	27	26	25
Size of Sheets	Sheets per box	Weight, per Box, lbs.										
10 x14	225	80	85	90	95	100	107	128	135	155	175	195
14 x20	112	80	85	90	95	100	107	128	135	155	175	195
20 x28	112	160	170	180	190	200	214	256	270	310	350	390
10 x20	225	114	121	129	136	143	153	183	193	221	250	279
11 x22	225	138	147	156	164	172	184	222	234	268	302	337
11½x23	225	151	161	170	179	189	202	242	255	293	331	368
12 x24	112	82	87	93	98	103	110	132	139	159	180	201
13 x13	225	97	103	109	115	121	129	154	163	187	211	235
13 x26	112	97	103	109	115	121	129	154	163	187	211	235
14 x28	112	112	119	126	133	140	150	179	189	217	245	273
15 x15	225	129	137	145	153	161	172	206	217	249	281	313
16 x16	225	146	155	165	174	183	196	234	247	283	320	357
17 x17	225	165	175	186	196	206	221	264	279	320	361	403
18 x18	112	93	98	104	110	116	124	148	156	179	202	226
19 x19	112	103	110	116	122	129	138	165	174	200	226	251
20 x20	112	114	121	129	136	143	153	183	193	221	250	279
21 x21	112	126	134	142	150	158	169	202	213	244	276	307
22 x22	112	138	147	156	164	172	184	221	234	268	202	337
23 x23	112	151	161	170	179	189	202	242	255	295	333	370
24 x24	112	164	175	185	195	204	220	263	278	320	360	401
26 x26	112	193	205	217	229	241	258	309	326	374	422	471
13½x19½	112	75	80	85	89	94	100	...	...	...	...	...
14 x21	112	84	89	95	100	105	112	...	...	...	...	...
14 x22	112	88	94	99	105	110	118	...	...	...	...	...
16 x20	112	91	97	103	109	114	122	...	...	...	...	...
14 x31	112	124	132	140	147	155	166	...	...	...	...	...
15½x23	112	102	108	115	121	127	136	...	...	...	...	...

TABLE 2

STANDARD UNITED STATES GAGE OF SHEET IRON

ADOPTED BY THE ASSOCIATION OF IRON AND STEEL SHEET MANUFACTURERS

JULY 1, 1893

No. of Gauge	Weight per Square Foot in Pounds Avoirdupois	Weight per Square Foot in Ounces Avoirdupois	Approximate Thickness in Fractions of an Inch	Approximate Thickness in Decimal Parts of an Inch
0000000	20.00	320	1–2	.5
000000	18.75	300	15–32	.46875
00000	17.50	280	7–16	.4375
0000	16.25	260	13–32	.40625
000	15.	240	3–8	.375
00	13.75	220	11–32	.34375
0	12.50	200	5–16	.3125
1	11.25	180	9–32	.28125
2	10.625	170	17–64	.265625
3	10.	160	1–4	.25
4	9.375	150	15–64	.234375
5	8.75	140	7–32	.21875
6	8.125	130	13–64	.203125
7	7.5	120	3–16	.1875
8	6.875	110	11–64	.171875
9	6.25	100	5–32	.15625
10	5.625	90	9–64	.140625
11	5.	80	1–8	.125
12	4.375	70	7–64	.109375
13	3.75	60	3–32	.09375
14	3.125	50	5–64	.078125
15	2.8125	45	9–128	.0703125
16	2.5	40	1–16	.0625
17	2.25	36	9–160	.05625
18	2.	32	1–20	.05
19	1.75	28	7–160	.04375
20	1.50	24	3–80	.0375
21	1.375	22	11–320	.034375
22	1.25	20	1–32	.03125
23	1.125	18	9–320	.028125
24	1.	16	1–40	.025
25	.875	14	7–320	.021875
26	.75	12	3–160	.01875
27	.6875	11	11–640	.0171875
28	.625	10	1–64	.015625
29	.5625	9	9–640	.0140625
30	.5	8	1–80	.0125
31	.4375	7	7–640	.0109375
32	.40625	6½	13–1280	.01015625
33	.375	6	3–320	.009375
34	.34375	5½	11–1280	.00859375
35	.3125	5	5–640	.0078125
36	.28125	4½	9–1280	.00703125
37	.265625	4¼	17–2560	.006640625
38	.25	4	1–160	.00625

Note: This table gives gage numbers and approximate thickness in inches and weights per square foot of uncoated sheets. Galvanized sheets weigh 2½ ounces more per square foot than uncoated sheets of the same gage.

For the purpose of securing uniformity of gage thruout the United States, Congress, under date of March 3, 1893, adopted the above as the legal standard for determining the thickness of uncoated iron and steel sheets, allowing a variation of 2½ per cent either above or below for practical use and application.

TABLE 3

TABLE OF GALVANIZED SHEETS

WEIGHT OF SHEETS IN POUNDS

Gages	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Oz. per Sq. Ft.	42.5	38.5	34.5	30.5	26.5	24.5	22.5	20.5	18.5	16.5	14.5	13.5	12.5	11.5	10.5
Lbs. per Sq. Ft.	2.656	2.406	2.156	1.906	1.656	1.531	1.406	1.281	1.156	1.031	.9062	.8437	.7812	.7187	.6562
Sheets Size of	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet
24x72	31.87	28.87	25.87	22.87	19.87	18.37	16.87	15.37	13.87	12.37	10.87	10.12	9.37	8.62	7.87
26x72	34.53	31.28	28.03	24.78	21.53	19.91	18.28	16.66	15.03	13.41	11.78	10.97	10.16	9.34	8.53
28x72	37,19	33.69	30.19	26.69	23.19	21.44	19.69	17.94	16.19	14.44	12.69	11.81	10.94	10.06	9.19
30x72	39.84	36.09	32.34	28.59	24.84	22.97	21.09	19.22	17.34	15.47	13.59	12.66	11.72	10.78	9.84
36x72	47.81	43.31	38.81	34.31	29.81	27.56	25.31	23.06	20.81	18.56	16.31	15.19	14.06	12.94	11.81
24x84	37.19	33.69	30.19	26.69	23.19	21.44	19.69	17.94	16.19	14.44	12.69	11.81	10.94	10.06	9.19
26x84	40.27	36.48	32.69	28.90	25.11	23.21	21.32	19.42	17.53	15.63	13.74	12.79	11.84	10.90	9.95
28x84	43.38	39.29	35.21	31.13	27.05	25.01	22.96	20.92	18.88	16.84	14.80	13.78	12.76	11.74	10.72
30x84	46.48	42.11	37.73	33.36	28.98	26.80	24.61	22.42	20.23	18.05	15.86	14.77	13.67	12.58	11.48
36x84	55.78	50.53	45.28	40.03	34.78	32.16	29.53	26.91	24.28	21.66	19.03	17.72	16.41	15.09	13.78
24x96	42.50	38.50	34.50	30.50	26.50	24.50	22.50	20.50	18.50	16.50	14.50	13.50	12.50	11.50	10.50
26x96	46.03	41.70	37.37	33.04	28.70	26.54	24.37	22.20	20.04	17.87	15.71	14.62	13.04	12.46	11.37
28x96	49.57	44.90	40.24	35.57	30.91	28.57	26.24	23.91	21.58	19.24	16.91	15.74	14.58	13.41	12.25
30x96	53.12	48.12	43.12	38.12	33.12	30.62	28.12	25.62	23.12	20.62	18.12	16.87	15.62	14.37	13.12
36x96	63.75	57.75	51.75	45.75	39.75	36.75	33.75	30.75	27.75	24.75	21.75	20.25	18.75	17.25	15.75
24x120	53.12	48.12	43.12	38.12	33.12	30.62	28.12	25.62	23.12	20.62	18.12	16.87	15.62	14.37	13.12
26x120	57.53	52.12	46.70	41.29	35.87	33.17	30.46	27.75	25.04	22.34	19.63	18.28	16.92	15.57	14.21
28x120	61.97	56.14	50.31	44.47	38.64	35.72	32.81	29.89	26.98	24.06	21.14	19.68	18.23	16.77	15.31
30x120	66.41	60.16	53.91	47.66	41.41	38.28	35.16	32.03	28.91	25.78	22.66	21.09	19.53	17.97	16.41
36x120	79.69	72.19	64.69	57.19	49.69	45.94	42.19	38.44	34.69	30.94	27.19	25.31	23.44	21.56	16.69

TABLE 4—TABLE OF BLACK SHEETS

WEIGHT OF SHEETS IN POUNDS

Gauges	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Oz. per Sq. Ft.	40.	36.	32.	28.	22.	21.5	20.	18.	16.	14.	12.	11.04	10.	9.	8.
Lbs. per Sq. Ft.	2.5	2.25	2.	1.75	1.5	1.34	1.25	1.125	1.	.875	.75	.69	6.25	.5625	.5
Size of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet	Weight of Sheet
24x72	30.	27.	24.	21.	18.	16.5	15.	13.5	12.	10.5	9.	8.25	7.5	6.75	6.
26x72	32.5	29.25	26.	22.75	19.5	17.88	16.25	14.63	13.	11.38	9.75	8.94	8.13	7.31	6.5
28x72	35.	31.5	28.	24.5	21.	19.25	17.5	15.75	14.	12.25	10.5	9.63	8.75	7.88	7.
30x72	37.5	33.75	30.	26.25	22.5	20.63	18.75	16.88	15.	13.13	11.25	10.31	9.38	8.44	7.5
36x72	45.	40.5	36.	35.	27.	24.75	22.5	20.25	18.	15.75	13.5	12.38	11.25	10.13	9.
24x84	35.	31.5	28.	24.5	21.	19.25	17.5	15.75	14.	12.25	10.5	9.63	8.75	7.88	7.
26x84	37.92	34.13	30.33	26.54	22.75	20.85	18.96	17.06	15.15	13.27	11.38	10.43	9.48	8.53	7.58
28x84	40.83	36.75	32.67	28.58	24.5	22.46	20.42	18.37	16.33	14.29	12.25	11.23	10.21	9.19	8.17
30x84	43.75	39.38	35.	30.63	26.25	24.06	21.88	19.69	17.5	15.31	13.13	12.03	10.94	9.84	8.75
36x84	52.5	47.25	42.	36.75	31.5	28.88	26.25	23.63	21.	18.38	15.75	14.44	13.13	11.81	10.5
24x96	40.	36.	32.	28.	24.	22.	.20	18.	16.	14.	12.	11.	10.	9.	8.
26x96	43.33	39.	34.67	30.33	26.	23.83	21.67	19.5	17.33	15.17	13.	11.92	10.83	9.75	8.67
28x96	46.67	42.	37.33	32.67	28.	25.67	23.33	21.	18.67	16.33	14.	12.83	11.67	10.5	9.33
30x96	50.	45.	40.	35.	30.	27.5	25.	22.5	20.	17.5	15.	13.75	12.5	11.25	10.
36x96	60.	54.	48.	42.	36.	33.	30.	27.	24.	21.	18.	16.5	15.	13.5	12.
24x101	42.08	37.88	33.67	29.46	25.25	23.15	21.04	18.94	16.83	14.73	12.63	11.57	10.52	9.47	8.42
26x101	45.59	41.03	36.47	31.92	27.35	25.08	22.79	20.51	18.24	15.96	13.68	12.54	11.4	10.26	9.12
28x101	49.09	44.19	39.28	34.37	29.46	27.01	24.55	22.09	19.64	17.19	14.73	13.5	12.27	11.05	9.82
30x101	52.6	47.34	42.08	36.83	31.56	28.94	26.3	23.67	21.04	18.41	15.78	14.47	13.15	11.84	10.52
36x101	63.13	56.81	50.5	44.19	37.88	34.72	31.56	28.41	25.25	22.1	18.94	17.36	15.78	14.2	12.62
24x108	45.	40.5	36.	31.	27.	24.75	22.5	20.25	18.	15.75	13.5	12.38	11.25	10.13	9.
26x108	48.75	43.88	39.	34.	29.25	26.81	24.37	21.94	19.5	17.06	14.63	13.41	12.19	10.97	9.75
28x108	52.5	47.25	42.	36.75	51.5	28.87	26.25	23.62	21.	18.38	15.75	14.44	13.13	11.81	10.5
30x108	56.25	50.63	45.	39.38	33.75	30.94	28.12	25.31	22.5	19.69	16.88	15.47	14.06	12.66	11.25
36x108	67.5	60.75	54.	47.25	40.5	37.13	33.75	30.38	27.	23.63	20.25	18.56	16.88	15.19	13.5
24x120	50.	45.	40.	35.	30.	27.5	25.	22.5	20.	17.5	15.	13.75	12.5	11.25	10.
26x120	54.17	48.75	43.33	37.92	32.5	29.79	27.08	24.37	21.67	18.96	16.25	14.9	13.54	12.19	10.83
28x120	58.33	52.5	46.67	40.83	35.	32.08	29.17	26.25	23.33	20.42	17.5	16.04	14.58	13.13	11.67
30x120	62.5	56.25	50.	43.75	37.5	34.37	31.25	28.12	25.	21.88	18.75	17.19	15.63	14.06	12.5
36x120	75.	67.5	60.	52.5	45.	41.20	37.5	33.75	30.	26.25	22.5	20.63	18.75	16.88	15.

TABLE 5

WEIGHT OF RUSSIA SHEET IRON WITH APPROXIMATE U. S. GAGE NUMBERS

Russian Gage Number	U. S. Gage Number (Approximate)	Weight per Sheet (28"x56") Pounds
16	21	14½
15	22⅜	13½
14	23½	12½
13	23	12
12	24	11
11	25	10
10	26	9
9	27	8
8	28	7¼
7	29	6¼

Average net weight per bundle is about 225 pounds.

TABLE 6

CORRUGATED SHEET IRON

2½ INCH CORRUGATED SHEETS

The corrugations measure 2½ inches from center to center and are ⅝ inch deep for either black or galvanized.

Standard sheets are 26 inches wide after forming, having 10 corrugations to a sheet; and cover 24 inches, as 2 inches allowance is made for lap of one corrugation; and is used for siding.

Standard lengths: 5, 6, 7, 8, 9, and 10 feet. Maximum length: 12 feet.

Gauges No. 20 and lighter.

Special sizes will be rolled promptly.

WEIGHTS PER SQUARE IN POUNDS

Gauge	29	28	27	26	25	24	23	22	20
Black	60	68	76	83	96	110	123	136	163
Galvanized	77	85	91	98	111	124	138	151	178

2½ inch corrugated sheets 27½ inches wide after forming, having 10½ corrugations to a sheet, and cover 24 inches allowing for lap of one and one-half corrugations. This size is recommended for roofing.

1¼ INCH CORRUGATED SHEETS

The corrugations measure 1¼ inch from center to center and are ½ inch deep for either black or galvanized.

Standard sheets are 25 inches wide after forming, having 20 corrugations to a sheet and cover 24 inches, allowing for a lap of one corrugation, and is used for siding and ceilings.

Standard lengths: 5, 6, 7, 8, 9, and 10 feet. Maximum length: 12 feet.

Gauges No. 22 and lighter.

Special sizes will be rolled promptly.

WEIGHT OF CORRUGATED SHEETS PER SQUARE IN POUNDS

Gage	29	28	27	26	25	24	22
Black	64	72	79	86	100	114	141
Galvanized	79	87	94	101	115	129	157

1¼ inch corrugated sheets 26 inches wide after forming, covering width 24 inches, allowing a lap of 2 corrugations are also made. This size and lap are recommended for roofing as this secures the roof from leaks.

The selling width is full width after forming and no allowance is made for laps.

TABLE 7

WEIGHTS OF SHEET COPPER PER SQUARE FOOT, AND THICKNESS PER STUBBS' GAGE*

Stubbs' Wire Gage	Thickness in Decimal Parts of 1 Inch	Weight per Sq. Ft	Weight of Sheet 14x48 Inches	Weight of Sheet 24x48 Inches	Weight of Sheet 30x60 Inches	Weight of Sheet 36x72 Inches	Weight of Sheet 48x72 In.
		Oz.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
0	.340	253	.....	126½	198.	285.	380
1	.300	223	.....	111½	174.	251.	335
2	.284	211	.....	105½	165.	238.	317
3	.259	193	.....	96	151.	217.	289
4	.238	177	.....	88⅓	138.	199.	266
5	.220	164	.....	82	128.	184.	246
6	.203	151	.....	75½	118.	170.	227
7	.180	134	.....	67	105.	151.	201
8	.165	123	.....	61	96.	138.	184
9	.148	110	.....	55	86.	124.	165
10	.134	100	.....	50	78.	112.	150
11	.120	89	.....	44½	70.	100.	124
12	.109	81	.....	40½	63.	91.	122
13	.095	70	.....	35	55.	79.	105
14	.083	64	18.66	32	50.	72.	96
15	.072	56	16.33	28	43.75	63.	84
16	.065	48	14.	24	37.50	54.	72
18	.049	40	11.66	20	31.25	45.	60
19	.042	32	9.33	16	25.	36.	48
21	.032	24	7.	12	18.75	27.	36
22	.028	20	5.83	10	15.62	22.50	30
23	.025	18	5.25	9	14.06	20.25	27
24	.022	16	4.66	8	12.50	18.	24
26	.018	14	4.08	7	10.93	15.75	21
27	.016	12	3.50	6	9.37	13.50	18
29	.013	10	2.91	5	7.81	11.25	15
31	.010	8	2.33	4	6.25	9.	12
33	.008	6	1.75	3	4.68	6.75	9
35	.005	4	1.16	2	3.12	4.50	6

**Note:* Rolled copper has specific gravity of 8.93. One cubic foot weighs 558.125 pounds.

To ascertain the weight of copper:

Find the number of cubic inches in the piece, multiply by 0.3214, and the product will be the weight in pounds. Or, multiply the length and breadth (in feet), and that by the pounds per square foot.

WEIGHT OF SHEET COPPER PER SQUARE FOOT

$\frac{1}{16}$ inch thick weighs 3 pounds to the square foot.
$\frac{1}{8}$ inch thick weighs 6 pounds to the square foot.
$\frac{1}{4}$ inch thick weighs 12 pounds to the square foot.
$\frac{1}{2}$ inch thick weighs 24 pounds to the square foot.
1 inch thick weighs 46½ pounds to the square foot.

TABLE 8

Weights and Thickness of Sheet Lead

The thickness of sheet lead is commonly expressed in terms of its weight per square foot. A square foot $\frac{1}{16}$ of an inch thick weighs four pounds.

Weight	Thickness	Weight	Thickness
12 oz.	13–1000 inch	8 lbs.	1–8 inch
1 lbs.	1–64 "	10 "	5–32 "
1½ "	1–43 "	12 "	3–16 "
2 "	1–32 "	14 "	7–32 "
2½ "	1–24 "	16 "	1–4 "
3 "	3–64 "	20 "	5–16 "
4 "	1–16 "	24 "	3–8 "
5 "	5–64 "	32 "	1–2 "
6 "	3–32 "	60 "	1 "
7 "	7–64 "		

TABLE 9

Weight of Flat Bar Iron Per Lineal Foot in Pounds

Width in Inches	Thickness in Inches												
	1/16	3/32	⅛	3/16	¼	5/16	⅜	7/16	½	⅝	¾	⅞	1
½	.11	.16	.21	.32	.42	.53	.64	.75	.85	...	...	...	...
⅝	.13	.20	.26	.40	.53	.67	.79	.93	1.06	1.33	...	...	...
¾	.16	.24	.32	.48	.64	.80	.96	1.12	1.27	1.59	1.91	...	...
⅞	.19	.28	.37	.56	.74	.93	1.11	1.30	1.49	1.86	2.22	2.60	...
1	.21	.32	.42	.64	.85	1.06	1.28	1.49	1.70	2.13	2.55	2.98	3.40
1⅛	.24	.36	.47	.72	.96	1.20	1.44	1.67	1.91	2.39	2.88	3.35	3.83
1¼	.27	.40	.53	.80	1.06	1.33	1.59	1.86	2.12	2.66	3.19	3.72	4.25
1⅜	.29	.44	.58	.88	1.17	1.46	1.75	2.05	2.33	2.92	3.51	4.09	4.68
1½	.32	.48	.63	.96	1.28	1.59	1.92	2.23	2.55	3.19	3.83	4.47	5.10
1⅝	.35	.52	.68	1.04	1.38	1.73	2.08	2.42	2.76	3.45	4.15	4.84	5.53
1¾	.37	.56	.74	1.11	1.49	1.86	2.23	2.60	2.98	3.72	4.47	5.20	5.95
1⅞	.40	.60	.80	1.20	1.60	1.99	2.39	2.79	3.19	3.98	4.79	5.58	6.38
2	.43	.64	.85	1.28	1.70	2.12	2.55	2.98	3.40	4.25	5.10	5.95	6.80
2¼	.48	.72	.96	1.44	1.91	2.39	2.87	3.35	3.83	4.78	5.75	6.69	7.65
2½	.53	.80	1.06	1.59	2.12	2.65	3.19	3.72	4.25	5.31	6.38	7.44	8.50
2¾	.58	.88	1.17	1.75	2.34	2.92	3.51	4.09	4.67	5.84	7.02	8.18	9.35
3	.64	.96	1.28	1.91	2.55	3.19	3.83	4.46	5.10	6.38	7.65	8.93	10.20
3¼	.69	1.04	1.38	2.07	2.76	3.45	4.15	4.83	5.53	6.91	8.29	9.67	11.05
3½	.74	1.12	1.49	2.23	2.98	3.72	4.47	5.20	5.95	7.44	8.93	10.41	11.90
3¾	.80	1.20	1.59	2.39	3.19	3.99	4.78	5.58	6.38	7.97	9.57	11.16	12.75
4	.85	1.28	1.70	2.55	3.40	4.25	5.10	5.95	6.80	8.50	10.20	11.90	13.60

TABLE 10

Weight Per Foot of Square and Round Iron Bars

Iron Weighing 480 Pounds per Cubic Foot

Thickness or Diameter in Inches	Weight of Square Bar One Foot Long	Weight of Round Bar One Foot Long	Thickness or Diameter in Inches	Weight of Square Bar One Foot Long	Weight of Round Bar One Foot Long
1/16	.013	.010	1/16	3.763	2.955
⅛	.052	.041	⅛	4.219	3.313
3/16	.117	.092	3/16	4.701	3.692
¼	.208	.164	¼	5.208	4.091
5/16	.326	.256	5/16	5.742	4.510
⅜	.469	.368	⅜	6.302	4.950
7/16	.638	.501	7/16	6.888	5.410
½	.833	.654	½	7.500	5.890
9/16	1.055	.828	9/16	8.138	6.392
⅝	1.302	1.023	⅝	8.802	6.913
11/16	1.576	1.237	11/16	9.492	7.455
¾	1.875	1.473	¾	10.21	8.018
13/16	2.201	1.728	13/16	19.95	8.601
⅞	2.552	2.004	⅞	11.72	9.204
15/16	2.930	2.301	15/16	12.51	9.828
1	3.333	2.618	2	13.33	10.47

TABLE 11

Tinners' Rivets (Flat Heads)

Size (Weight per 1000)	Dimensions (Inches)	
	Diameter	Length
4 oz.	.070	⅛
6 "	.080	9/64
8 "	.090	5/32
10 "	.094	11/64
12 "	.101	3/16
14 "	.109	3/16
1 lbs.	.115	13/64
1¼ "	.120	7/32
1½ "	.125	15/64
1¾ "	.133	¼
2 "	.140	17/64
2½ "	.147	9/32
3 "	.160	5/16
3½ "	.163	21/64
4 "	.173	11/32
5 "	.185	⅜
6 "	.200	25/64
7 "	.215	13/32
8 "	.225	7/16
9 "	.230	29/64
10 "	.233	15/32
12 "	.253	½
14 "	.275	33/64
16 "	.293	17/32

TABLE 12

APPROXIMATE MELTING TEMPERATURES OF LEAD-TIN ALLOYS*

Proportion		Melting Temperature Degrees Fahrenheit	Proportion		Melting Temperature Degrees Fahrenheit
Tin	Lead		Tin	Lead	
	1	619	3	2	369
			Plumber's Solder		
1	9	577	2	1	356
1	4	532	7	3	365
3	7	491	4	1	388
2	3	446	9	1	419
(Half and Half)					
1	1	401	1		466

* *Note:* Certain alloys of lead and tin melt at lower temperatures than either of the metals themselves. By selecting alloys of the proper proportion they may be used to solder either tin or lead.

TABLE 13

Decimal Parts of an Inch					
1/64	.01563	11/32	.34375	43/64	.67188
1/32	.03125	23/64	.35938	11/16	.6875
3/64	.04688	3/8	.375		
1/16	.0625			45/64	.70313
		25/64	.39063	23/32	.71875
5/64	.07813	13/32	.40625	47/64	.73438
3/32	.09375	27/64	.42188	3/4	.75
7/64	.10938	7/16	.4375		
1/8	.125			49/64	.76563
		29/64	.45313	25/32	.78125
9/64	.14063	15/32	.46875	51/64	.79688
5/32	.15625	31/64	.48438	13/16	.8125
11/64	.17188	1/2	.5		
3/16	.1875			53/64	.82813
		33/64	.51563	27/32	.84375
13/64	.20313	17/32	.53125	55/64	.85938
7/32	.21875	35/64	.54688	7/8	.875
15/64	.23438	9/16	.5625		
1/4	.25			57/64	.89063
		37/64	.57813	29/32	.90625
17/64	.26563	19/32	.59375	59/64	.92188
9/32	.28125	39/64	.60938	15/16	.9375
19/64	.29688	5/8	.625		
5/16	.3125			61/64	.95313
		41/64	.64063	31/32	.96875
21/64	.32813	21/32	.65625	63/64	.97438

TABLE 14

DIAMETERS, AREAS AND CIRCUMFERENCES OF CIRCLES

Diam., In.	Circum., Ft.	Circum., In.	Area Sq. In.	Area Sq. Ft.	Diam., In.	Circum., Ft.	Circum., In.	Area Sq. In.	Area Sq. Ft.
¼		25/32	.0490	......	6½	1	8⅜	33.183	.2322
⅜		1 3/16	.1104	......	6⅝	1	8¾	34.471	.2412
½		1 9/16	.1963	......	6¾	1	9⅛	35.784	.2504
⅝		1 31/32	.3068	......	6⅞	1	9½	37.122	.2598
¾		2 11/32	.4417	......	7	1	10	38.484	.2603
⅞		2¾	.6013	......	7⅛	1	10⅜	39.871	.2791
1		3⅛	.7854	......	7¼	1	10¾	41.282	.2889
1⅛		3½	.9940	......	7⅜	1	11⅛	42.718	.2990
1¼		3⅞	1.227	......	7½	1	11½	44.178	.3002
1⅜		4¼	1.484	......	7⅝	1	11⅞	45.663	.3106
1½		4⅝	1.767	......	7¾	2	⅜	47.173	.3299
1⅝		5⅛	2.074	......	7⅞	2	¾	47.707	.3409
1¾		5½	2.405	......	8	2	1⅛	50.265	.3518
1⅞		5⅞	2.761	......	8⅛	2	1½	51.848	.3629
2		6¼	3.141	......	8¼	2	1⅞	53.456	.3741
2⅛		6⅝	3.546	......	8⅜	2	2¼	55.088	.3856
2¼		7	3.976	......	8½	2	2⅝	56.745	.3072
2⅜		7⅜	4.430	......	8⅝	2	3	58.426	.4089
2½		7¾	4.908	......	8¾	2	3⅜	60.132	.4209
2⅝		8¼	5.412	......	8⅞	2	3⅞	61.862	.4330
2¾		8⅝	5.939	......	9	2	4¼	63.617	.4453
2⅞		9	6.491	......	9⅛	2	4⅝	65.396	.4517
3		9⅜	7.068	......	9¼	2	5	67.200	.4704
3⅛		9¾	7.669	......	9⅜	2	5⅜	69.029	.4832
3¼		10¼	8.295	......	9½	2	5¾	70.882	.4961
3⅜		10⅝	8.946	......	9⅝	2	6¼	72.759	.5093
3½		11	9.621	......	9¾	2	6⅞	74.662	.5226
3⅝		11⅜	10.320	......	9⅞	2	7	76.588	.5361
3¾		11¾	11.044	......	10	2	7⅜	78.540	.5497
3⅞		12⅛	11.793	......	10⅛	2	7¾	80.515	.5636
4	1	½	12.566	.0879	10¼	2	8⅛	82.516	.5776
4⅛	1	⅞	13.364	.0035	10⅜	2	8½	84.540	.5917
4¼	1	1⅜	14.186	.0993	10½	2	8⅞	86.590	.6061
4⅜	1	1¾	15.033	.1052	10⅝	2	9⅜	88.664	.6206
4½	1	2⅛	15.904	.1113	10¾	2	9¾	90.762	.6353
4⅝	1	2½	16.800	.1176	10⅞	2	10⅛	92.855	.6499
4¾	1	2⅞	17.720	.1240	11	2	10½	95.033	.6652
4⅞	1	3¼	18.665	.1306	11⅛	2	10⅞	97.205	.6874
5	1	3⅝	19.685	.1374	11¼	2	11¼	99.402	.6958
5⅛	1	4⅛	20.629	.1444	11⅜	2	11¾	101.623	.7143
5¼	1	4½	21.647	.1515	11½	3	⅛	103.869	.7290
5⅜	1	4⅞	22.600	.1588	11⅝	3	½	106.139	.7429
5½	1	5¼	23.758	.1663	11¾	3	⅞	108.434	.7590
5⅝	1	5⅝	24.850	.1739	11⅞	3	1¼	110.753	.7752
5¾	1	6	25.967	.1817	12	3	1⅝	113.007	.7916
5⅞	1	6⅜	27.108	.1897	12⅛	3	2	115.466	.8082
6	1	6¾	28.274	.1979	12¼	3	2½	117.859	.8250
6⅛	1	7¼	29.464	.2062	12⅜	3	2⅞	120.276	.8419
6¼	1	7⅝	30.679	.2147	12½	3	3¼	122.718	.8590
6⅜	1	8	31.919	.2234	12⅝	3	3¾	125.185	.8762

Diameters, Areas and Circumferences of Circles (Cont.)

Diam., In.	Circum., Ft.	In.	Area Sq. In.	Area Sq. Ft.	Diam., In.	Circum., Ft.	In.	Area Sq. In.	Area Sq. In.
12¾	3	4	127.676	.8937	18½	4	10⅛	268.803	1.8816
12⅞	3	4⅜	130.192	.9113	18⅝	4	10½	272.447	1.9071
13	3	4¾	132.732	.9291	18¾	4	10⅞	276.117	1.9328
13⅛	3	5¼	135.297	.9470	18⅞	4	11¼	279.811	1.9586
13¼	3	5⅝	137.886	.9642	19	4	11⅝	283.529	1.9847
13⅜	3	6	140.500	.9835	19⅛	5		287.272	1.9941
13½	3	6⅜	143.139	1.0019	19¼	5	½	291.039	2.0371
13⅝	3	6¾	145.802	1.0206	19⅜	5	⅞	294.831	2.0637
13¾	3	7⅛	148.489	1.0294	19½	5	1¼	298.648	2.0904
13⅞	3	7½	151.201	1.0584	19⅝	5	1⅝	302.489	2.1172
14	3	7⅞	153.938	1.0775	19¾	5	2	306.355	2.1443
14⅛	3	8⅜	156.609	1.0968	19⅞	5	2⅜	310.245	2.1716
14¼	3	8¾	159.485	1.1193	20	5	2⅞	314.160	2.1990
14⅜	3	9⅛	162.295	1.1360	20⅛	5	3¼	318.099	2.2265
14½	3	9½	165.130	1.1569	20¼	5	3⅝	322.063	2.2543
14⅝	3	9⅞	167.989	1.1749	20⅜	5	4	326.051	2.2822
14¾	3	10¼	170.873	1.1061	20½	5	4⅜	330.064	2.3103
14⅞	3	10¾	173.782	1.2164	20⅝	5	4¾	334.101	2.3386
15	3	11⅛	176.715	1.2370	20¾	5	5⅛	338.163	2.3670
15⅛	3	11½	179.672	1.2577	20⅞	5	5½	342.250	2.3956
15¼	3	11⅞	182.654	1.2785	21	5	5⅞	346.361	2.4244
15⅜	4	¼	135.661	1.2096	21⅛	5	6⅜	350.497	2.4533
15½	4	⅝	188.602	1.3208	21¼	5	6¾	354.657	2.4824
15⅝	4	1	191.748	1.3422	21⅜	5	7⅛	358.841	2.5117
15¾	4	1½	194.828	1.3637	21½	5	7½	363.051	2.5412
15⅞	4	1⅞	197.933	1.3855	21⅝	5	7⅞	367.284	2.5708
16	4	2¼	201.062	1.4074	21¾	5	8¼	371.543	2.6007
16⅛	4	2⅝	204.216	1.4295	21⅞	5	8¾	375.826	2.6306
16¼	4	3	207.394	1.4517	22	5	9⅛	380.133	2.6608
16⅜	4	3⅜	210.597	1.4741	22⅛	5	9½	384.465	2.6691
16½	4	3¾	213.825	1.4967	22¼	5	9⅞	388.822	2.7016
16⅝	4	4¼	217.077	1.5195	22⅜	5	10¼	393.203	2.7224
16¾	4	4⅝	220.353	1.5424	22½	5	10⅝	397.608	2.7632
16⅞	4	5	223.654	1.5655	22⅝	5	11	402.038	2.7980
17	4	5⅜	226.980	1.5888	22¾	5	11½	406.493	2.8054
17⅛	4	5¾	230.330	1.6123	22⅞	5	11⅞	410.972	2.8658
17¼	4	6⅛	233.705	1.6359	23	6	¼	415.476	2.8903
17⅜	4	6½	237.104	1.6597	23¼	6	1	424.557	2.9518
17½	4	6⅞	240.528	1.6836	23⅛	6	⅝	420.004	2.9100
17⅝	4	7⅜	243.977	1.7078	23¼	6	1	424.557	2.9518
17¾	4	7¾	247.450	1.7321	23⅜	6	1⅜	429.135	2.9937
17⅞	4	8⅛	250.947	1.7566	23½	6	1¾	433.737	3.0129
18	4	8½	254.469	1.7812	23⅝	6	2¼	438.363	3.0261
18⅛	4	8⅞	258.016	1.8061	23¾	6	2⅝	443.014	3.0722
18¼	4	9¼	261.587	1.8311	23⅞	6	3	447.690	3.1081
18⅜	4	9¾	265.182	1.8562					

DIAMETERS, AREAS AND CIRCUMFERENCES OF CIRCLES (Cont.)

Diam., Ft.	In.	Circum., Ft.	In.	Area Sq. In.	Area Sq. Ft.	Diam., Ft.	In.	Circum., Ft.	In.	Area Sq. In.	Area Sq. Ft.
2		6	3⅜	452.290	3.1418	2	6¼	7	11	718.690	4.9901
2	¼	6	4⅛	461.864	3.2075	2	6½	7	11¾	730.618	5.0731
2	½	6	4⅞	471.436	3.2731	2	6¾	8	⅝	742.644	5.1573
2	¾	6	5¾	481.106	3.3410	2	7	8	1⅜	754.769	5.2278
2	1	6	6½	490.875	3.4081	2	7¼	8	2⅛	766.992	5.3264
2	1¼	6	7¼	500.741	3.4775	2	7½	8	2⅞	779.313	5.4112
2	1½	6	8⅛	510.706	3.5468	2	7¾	8	3¾	791.732	5.4982
2	1¾	6	8⅞	520.769	3.6101	2	8	8	4½	804.249	5.5850
2	2	6	9⅝	530.930	3.6870	2	8¼	8	5⅜	816.865	5.6729
2	2¼	6	10½	541.189	3.7583	2	8½	8	6⅛	829.578	5.7601
2	2½	6	11¼	551.547	3.8302	2	8¾	8	6⅞	842.390	5.8491
2	2¾	7		562.002	3.9042	2	9	8	7⅝	855.300	5.9398
2	3	7	¾	572.556	3.9761	2	9¼	8	8½	868.308	6.0291
2	3¼	7	1⅝	583.208	4.0500	2	9½	8	9¼	881.415	6.1201
2	3½	7	2⅜	593.958	4.1241	2	9¾	8	10	894.619	6.2129
2	3¾	7	3⅛	604.807	4.2000	2	10	8	10¾	907.922	6.3051
2	4	7	3⅞	615.753	4.2760	2	10¼	8	11½	921.323	6.3981
2	4¼	7	4¾	626.798	4.3521	2	10½	9	⅜	934.822	6.4911
2	4½	7	5½	637.941	4.4302	2	10¾	9	1⅛	948.419	6.5863
2	4¾	7	6¼	649.182	4.5083	2	11	9	1⅞	962.115	6.6815
2	5	7	7	660.521	4.5861	2	11¼	9	2¾	975.908	6.7772
2	5¼	7	7⅞	671.958	4.6665	2	11½	9	3½	989.800	6.8738
2	5½	7	8⅝	683.494	4.7467	2	11¾	9	4¼	1003.79	6.9701
2	5¾	7	9½	695.128	4.8274	3		9	5	1017.87	7.0688
2	6	7	10¼	706.860	4.9081						

TABLE 15

Sheet-Metal Workers' Circumference Table*

To Increase a Given Diameter

For 1/8 inch, add to its circumference, 3/8 and 1/64.
For 1/4 inch, add to its circumference, 3/4 and 1/32.
For 1/2 inch, add to its circumference, 1 1/2 and 1/16.
For 1 inch, add to its circumference, 3 1/8.

The following measures do not allow for seams.

Diam.	Circum.	Diam.	Circum.	Diam.	Circum.	Diam.	Circum.	Diam.	Circum.
1/2	1 9/16	6	18 7/8	12	37 3/4	18	56 5/8	24	75 7/16
5/8	1 15/16	6 1/4	19 3/4	12 1/4	38 5/8	18 1/4	57 3/8	24 1/2	77 1/4
3/4	2 11/32	6 1/2	20 1/2	12 1/2	39 1/2	18 1/2	58 1/4	25	78 13/16
7/8	2 3/4	6 3/4	21 1/4	12 3/4	40 1/4	18 3/4	59	25 1/2	80 7/16
1	3 1/8	7	22 1/16	13	41	19	59 7/8	26	82
1 1/4	3 7/8	7 1/4	22 13/16	13 1/4	41 3/4	19 1/4	60 5/8	26 1/2	83 9/16
1 1/2	4 11/16	7 1/2	23 5/8	13 1/2	42 9/16	19 1/2	61 3/8	27	85 1/8
1 3/4	5 7/16	7 3/4	24 3/8	13 3/4	43 5/16	19 3/4	62 1/4	27 1/2	86 11/16
2	6 5/16	8	25 3/16	14	44 1/8	20	63	28	88 1/4
2 1/4	7 1/8	8 1/4	26	14 1/4	44 7/8	20 1/4	63 3/4	28 1/2	89 13/16
2 1/2	7 15/16	8 1/2	26 3/4	14 1/2	45 3/4	20 1/2	64 9/16	29	91 3/8
2 3/4	8 11/16	8 3/4	27 9/16	14 3/4	46 1/2	20 3/4	65 5/16	29 1/2	92 15/16
3	9 3/8	9	28 5/16	15	47 1/4	21	66 1/8	30	94 1/2
3 1/4	10 1/4	9 1/4	29 1/8	15 1/4	48	21 1/4	66 7/8	30 1/2	96 1/16
3 1/2	11 1/16	9 1/2	29 7/8	15 1/2	48 13/16	21 1/2	67 3/4	31	97 5/8
3 3/4	11 13/16	9 3/4	30 11/16	15 3/4	49 9/16	21 3/4	68 1/2	31 1/2	98 3/16
4	12 5/8	10	31 7/16	16	50 3/8	22	69 1/4	32	100 3/4
4 1/4	13 3/8	10 1/4	32 1/4	16 1/4	51 1/8	22 1/4	70	32 1/2	101 5/16
4 1/2	14 3/16	10 1/2	33 1/16	16 1/2	51 15/16	22 1/2	70 13/16	33	103 7/8
4 3/4	14 15/16	10 3/4	33 13/16	16 3/4	52 11/16	22 3/4	71 9/16	33 1/2	104 7/16
5	15 3/4	11	34 5/8	17	53 1/2	23	72 3/8	34	107
5 1/4	16 1/2	11 1/4	35 3/8	17 1/4	54 1/4	23 1/4	73 1/8	34 1/2	108 9/16
5 1/2	17 5/16	11 1/2	36 3/16	17 1/2	55 1/16	23 1/2	73 15/16	35	109 1/4
5 3/4	18 1/16	11 3/4	36 15/16	17 3/4	55 13/16	23 3/4	74 3/4	35 1/2	110 13/16
								36	113 1/4

* For Common English Sheet Iron Nos. 25 and 26, the above table will apply as it is; but for every fourth number heavier; add 1/8 inch to the above measure. For Russia Sheet Iron, add 1/8 inch to every fourth number heavier than No. 10.

TABLE 16

STEAM, GAS AND WATER PIPE SIZES

Nominal Size	Threads per In.	Outside Diameter	Standard		Extra Strong		Double Extra Strong	
			Nominal Weight per Ft.	Inside Diameter	Nominal Weight per Ft.	Inside Diameter	Nominal Weight per Ft.	Inside Diameter
			lbs.		lbs.		lbs.	
1/8	27	.405	.24	.269	.29	.205		
1/4	18	.540	.42	.364	.54	.294		
3/8	18	.675	.56	.493	.74	.421		
1/2	14	.840	.84	.622	1.09	.542	1.7	.244
3/4	14	1.050	1.12	.824	1.39	.736	2.44	.422
1	11 1/2	1.315	1.67	1.047	2.17	.951	3.65	.587
1 1/4	11 1/2	1.660	2.24	1.380	3.00	1.272	5.20	.884
1 1/2	11 1/2	1.900	2.68	1.610	3.63	1.494	6.40	1.088
2	11 1/2	2.375	3.61	2.067	5.02	1.933	9.02	1.491