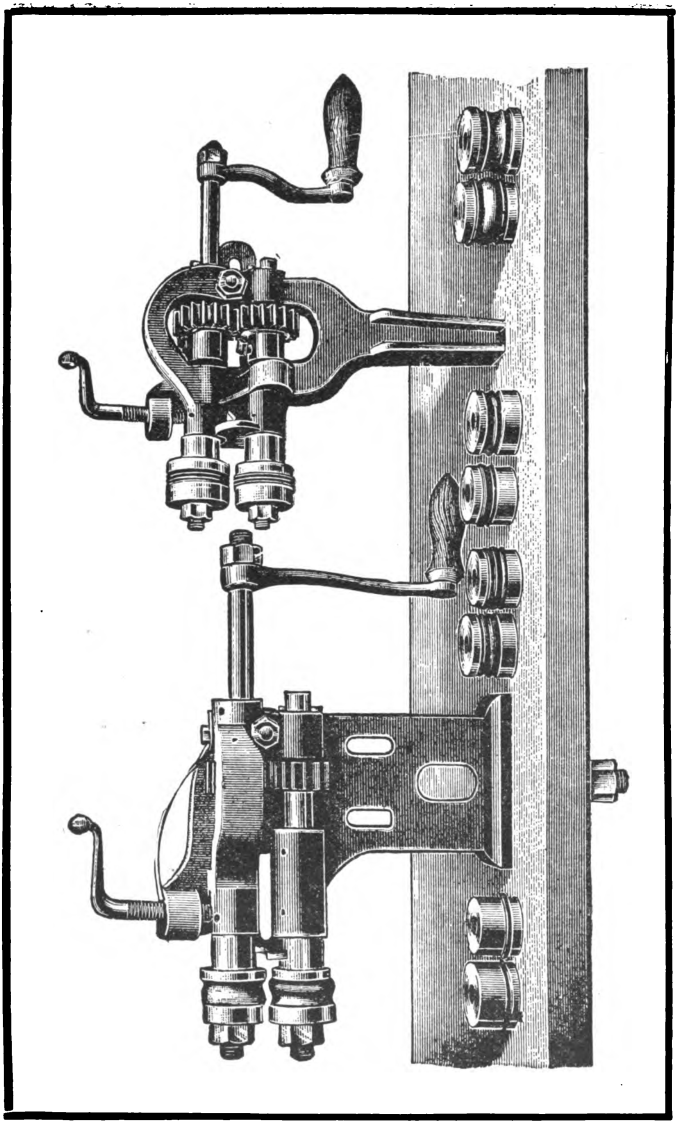

Modern Sheet-Metal Workers' Instructor

PRACTICAL GEOMETRY—MENSURATION—PROPERTIES OF METALS AND ALLOYS—SHEET-METAL WORKING MACHINERY—WORKING SHEET-METAL—SHEET-METAL WORKERS' TOOLS—SEAMS OR JOINTS—SOLDERING—SOLDERING FLUXES—PRACTICAL PROBLEMS IN SHEET-METAL AND CORNICE WORK—PIPE BENDING—COPPER AND TIN UTENSILS—HARDENING AND TEMPERING TOOLS—MICROMETER GAUGES—WORK DONE BY A DROP HAMMER—TECHNICAL DEFINITIONS—USEFUL INFORMATION—TABLES.

BY

JOSEPH H. ROSE

OVER 200 ILLUSTRATIONS

CHICAGO
FREDERICK J. DRAKE & CO., PUBLISHERS
1906

PREFACE

This book consists of useful information for Sheet-Metal Workers in all branches of the industry, and contains practical rules for describing patterns for Sheet-iron, Copper and Tin work. Practical Geometry and Mensuration. Properties of Metals. Tools and Machinery used in sheet-metal work. Seams or Joints. Soldering and Brazing. Manufacture of Tin Plate. Retinning and Galvanizing. Pipe Bending. Hardening and Tempering Tools. Micrometer Gauges. Technical Definitions. Useful Information and Tables, which will be found of untold value in connection with the subject matter in the book.

THE AUTHOR.

GEOMETRICAL DEFINITIONS OF PLANE FIGURES.

A **line** is length without breadth.

The **extremities of a line** are points.

A **straight line** is that which lies evenly between its extreme points.

A **plane surface** is that in which any two points, being taken, the straight line between them lies wholly in that surface.

The **extremities of a surface** are lines.

A **plane rectilineal angle** is the inclination of two straight lines to one another in a plane which meet together, but are not in the same straight line as in Fig. 1.

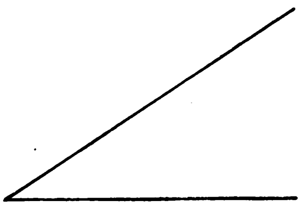

Fig. 1.

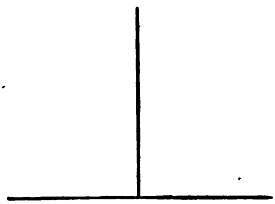

Fig. 2.

When a straight line, standing on another straight line, makes the adjacent angles equal to one another, each of the angles is called a **right angle** and the straight line which stands on the other is called a **perpendicular** to it as in Fig. 2.

GEOMETRICAL DEFINITIONS OF PLANE FIGURES.

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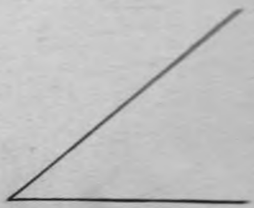

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When a straight line, standing on another straight line, makes the adjacent angles equal to one another, each of the angles is called a **right angle** and the straight line which stands on the other is called a **perpendicular** to it as in Fig. 2.

An **obtuse angle** is that which is greater than a right angle as in Fig. 3.

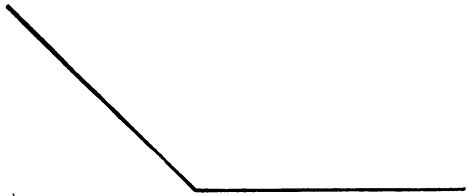


Fig. 3.

An **acute angle** is that which is less than a right angle as in Fig. 1.

A **term or boundary** is the extremity of anything.

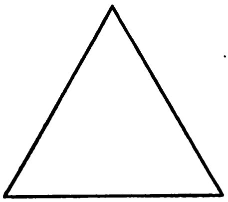


Fig. 4.

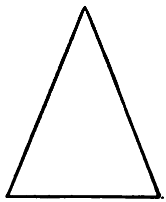


Fig. 5.

An **equilateral triangle** is that which has three equal sides as in Fig. 4.

An **isosccles triangle** is that which has two sides equal as in Fig. 5.

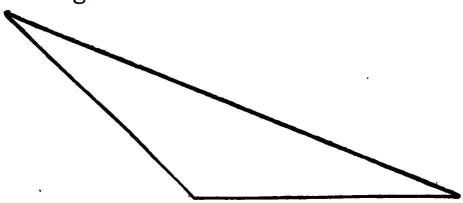


Fig. 6.

A **scalene triangle** is that which has three unequal sides as in Fig. 6.

A **right angled triangle** is that which has a right angle as in Fig. 7.

An **obtuse-angled triangle** is that which has an obtuse angle as in Fig. 6.

The **hypothenuse** in a right-angled triangle is the side opposite the right angle as in Fig. 7.

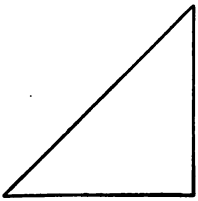


Fig. 7.

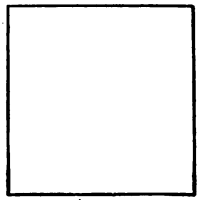


Fig. 8.

A **square** is that which has all its sides equal and all its angles right-angled as in Fig. 8.

A **rectangle** is that which has all its angles right angles, but only its opposite sides equal as in Fig. 9.

A **rhombus** is that which has all its sides equal, but its angles are not right angles as in Fig. 10.

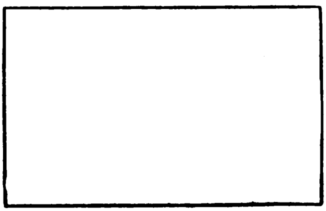


Fig. 9.

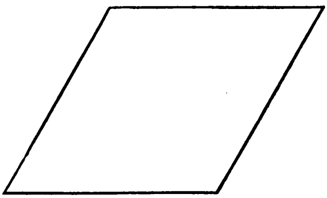


Fig. 10.

A **quadrilateral** figure which has its opposite sides parallel is called a parallelogram as in Figs. 8, 9 and 10.

A line joining two opposite angles of a quadrilateral is called a **diagonal.**

An **ellipse** is a plane figure bounded by one continuous curve described about two points, so that the sum

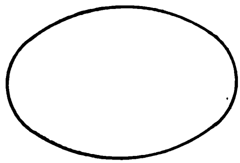


Fig. 11.

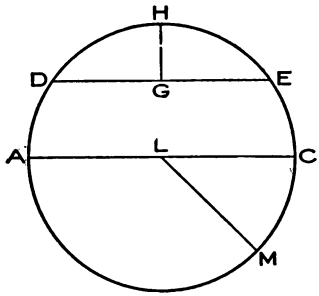


Fig. 12.

of the distances from every point in the curve to the two foci may be always the same—Fig. 11.

PROPERTIES OF THE CIRCLE.

A **circle** contains a greater area than any other plane figure bounded by the same length of circumference or outline.

A **circle** is a plane figure contained by one line and is such that all straight lines drawn from a point within the figure to the circumference are equal, and this point is called the center of the circle.

A **diameter** of a circle is a straight line drawn through the center and terminated both ways by the circumference, as AC in Fig 12.

A **radius** is a straight line drawn from the center to the circumference as LH in Fig. 12.

A **semicircle** is the figure contained by a diameter and that part of circumference cut off by a diameter as AHC in Fig. 12.

A **segment** of a circle is the figure contained by a straight line and the circumference which it cuts off as DHE in Fig. 12.

A **sector** of a circle is the figure contained by two straight lines down from the center and the circumference between them as LMC in Fig. 12.

A **chord** is a straight line, shorter than the diameter, lying within the circle, and terminated at both ends by the circumference as DE in Fig. 12.

An **arc** of a circle is any part of the circumference as DHE in Fig. 12.

The **versed sine** is a perpendicular joining the middle of the chord and circumference, as GH in Fig. 12.

Circumference. Multiply the diameter by 3.1416 the product is the circumference.

Diameter. Multiply the circumference by .31831, the product is the diameter, or multiply the square root of the area by 1.12837, the product is the diameter.

Area. Multiply the square of the diameter by .7854, the product is the area.

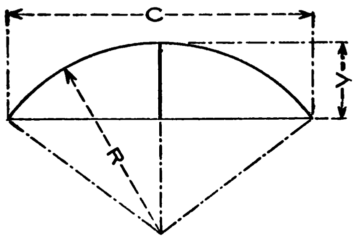


Fig. 13.

Side of the square. Multiply the diameter by .8862, the product is the side of a square of equal area.

Diameter of circle. Multiply the side of a square by

1.128, the product is the diameter of a circle of equal area.

To find the versed sine, chord of an arc or the radius when any two of the three factors are given.—Fig. 13.

$$R=\frac{C^2+4V^2}{8V} \qquad C=2\sqrt{V(2R-V)}$$

$$V=R-\sqrt{\frac{4R^2-C^2}{4}}$$

To find the length of any line perpendicular to the chord of an arc, when the distance of the line from the

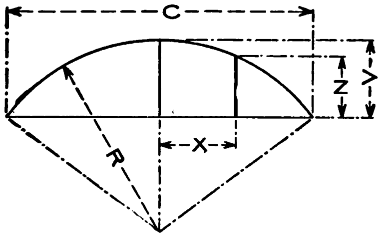


Fig. 14.

center of the chord, the radius of the arc and the length of the versed sine are given—Fig. 14.

$$N=\sqrt{(R^2-X^2)}-(R-H) \qquad R=\frac{C^2+4V^2}{8V}$$

$$C=2\sqrt{V(2R-V)} \qquad V=R-\sqrt{\frac{4R^2-C^2}{4}}$$

To find the diameter of a circle when the chord and versed sine of the arc are given.

$$AC=\frac{DG^2+GH^2}{GH}$$

To find the length of any arc of a circle, when the

chord of the whole arc and the chord of half the arc are given—Fig. 15.

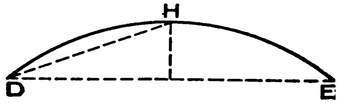


Fig. 15.

$$\text{Arc DHE} = \frac{8DH - DE}{3}$$

DEFINITION OF POLYGONS.

A **polygon,** if its sides are equal, is called a regular polygon, if unequal, an irregular polygon.

A **pentagon** is a five-sided figure.

A **hexagon** is a six-sided figure—Fig. 16.

A **heptagon** is a seven-sided figure.

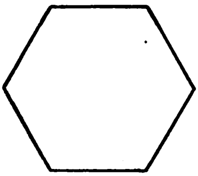


Fig. 16.

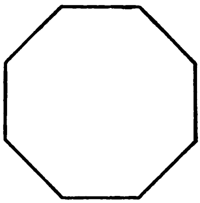


Fig. 17.

An **octagon** is an eight-sided figure—Fig. 17.

A **nonagon** is a nine-sided figure.

A **decagon** is a ten-sided figure.

A **unadecagon** is an eleven-sided figure.

A **duodecagon** is a twelve-sided figure.

GEOMETRICAL DEFINITION OF SOLID FIGURES.

A **solid** has length, breadth and thickness. The boundaries of a solid are surfaces.

A **solid angle** is that which is made by two or more plane angles, which are not in the same plane, meeting at one point.

A **cube** is a solid figure contained by six equal squares—Fig. 18.

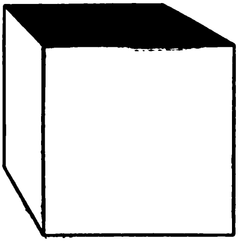


Fig. 18.

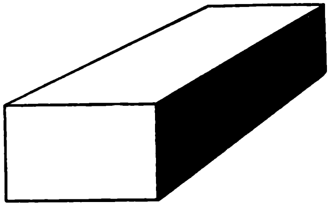


Fig. 19.

A **prism** is a solid figure contained by plane figures of which two that are opposite are equal, similar, and parallel to one another, the other sides are parallelograms—Fig. 19.

A **pyramid** is a solid figure contained by planes, one of which is the base, and the remainder are triangles, whose vertices meet a point about the base, called the vertex or apex of the pyramid—Fig. 20.

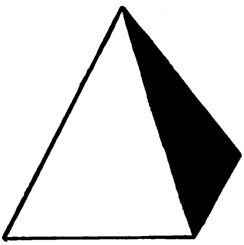


Fig. 20.

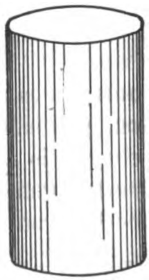


Fig. 21.

A **cylinder** is a solid figure described by the revolution of a rectangular or parallelogram about one of its sides—Fig. 21.

The **axis** of a cylinder is the fixed straight line about which the parallelogram revolves.

The **ends** of a cylinder are the circles described by the two revolving sides of the parallelogram.

A **sphere** is a solid figure described by the revolution of a semicircle about its diameter, which remains fixed—Fig. 22.

The **axis** of a sphere is the fixed straight line about which the semicircle revolves.

The **center** of a sphere is the same as that of the semicircle.

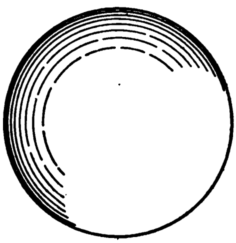


Fig. 22.

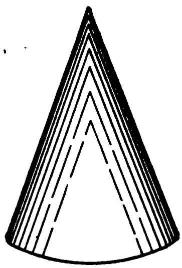


Fig. 23.

The **diameter** of a sphere is any straight line which passes through the center and is terminated both ways by the surface of the sphere.

A **cone** is a solid figure described by the revolution of a right-angled triangle about one of its sides containing the right angle, which side remains fixed—Fig. 23.

The **axis** of a cone is the circle described by that side of the triangle containing the right angle which revolves.

The **base** of the cone is the circle described by that side of the triangle containing the right-angle which revolves.

If a cone be cut obliquely so as to preserve the base entirely, the section is an **ellipse.**

When a cone is cut by a plane parallel to one of the sloping sides, the section is a **parabola,** if cut at right angles to its base, an **hyperbola.**

THE CONSTRUCTION OF ANGLES.

To bisect a given angle. Let DAC be the given angle. With center A and any radius AE describe an arc cutting AC and AD at E and G. With the same radius and centers E and G, describe arcs intersecting at H, and join AH. The angle DAC is bisected—Fig 24.

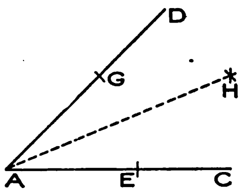


Fig. 24.

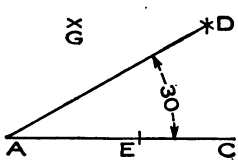


Fig. 25.

To construct an angle of 30°. With radius AE and with center A and E, describes arcs intersecting at G. With the same radius and with centers E and G, describe arcs intersecting at D, and join AD. The angle DAC contains 30°—Fig. 25.

To construct an angle of 60°. With radius AE, and with centers A and E, describe arcs intersecting at G, draw AD through G. The angle DAG contains 60°—Fig. 26.

To construct an angle of 45°. With radius AE and centers A and E, describe arcs intersecting at F, draw EG through F, and make FG equal to FE. Join GR, and with center R and radius AE make AH equal to

AE, with the same radius and with centers E and H describe arcs intersecting at L, draw AD through L. The angle DAC is 45°—Fig. 27.

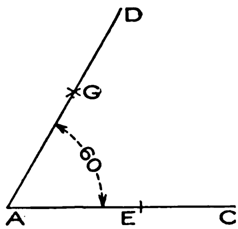


Fig. 26.

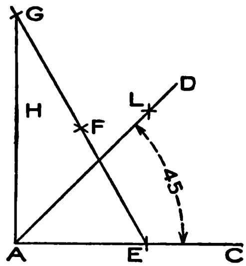


Fig. 27.

To construct an angle of 90°. With radius AE and centers A and E, describe arcs intersecting at F, with

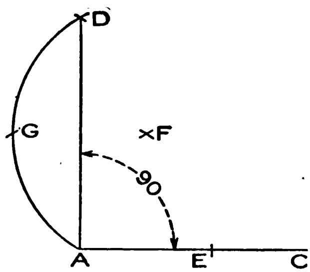


Fig. 28.

the same radius and center F describe the arc AGD, with radius AE, lay off AG and GD and join DA. The angle DAG is 90°—Fig. 28.

PRACTICAL GEOMETRY.

To bisect a straight line—Fig. 29. Let BC be the straight line to be bisected. With any convenient radius greater than AB or AC describe arcs cutting each other at D and E. A line drawn through D and E will bisect or divide the line BC into two equal parts.

To erect a perpendicular line at or near the end of a straight line—Fig. 30. With any convenient radius and at any distance from the line AC, describe an arc

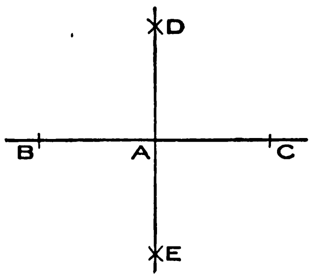


Fig. 29.

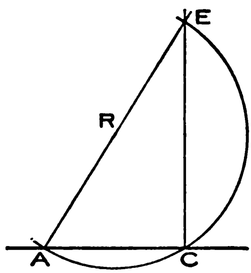


Fig. 30.

of a circle as ACE, cutting the line at A and C. Through the center R of the circle draw the line ARE, cutting the arc at point E. A line drawn from C to E will be the required perpendicular.

To divide a straight line into any number of equal parts—Fig. 31. Let AB be the straight line to be divided into a certain number of equal parts: From the points A and B, draw two parallel lines AD and BC, at any convenient angle with the line AB. Upon AD and BC set off one less than the number of equal parts required, as A-1, 1-2, 2-D, etc. Join C-1, 2-2, 1-D, the line AB will then be divided into the required number of equal parts.

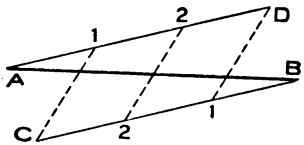


Fig. 31.

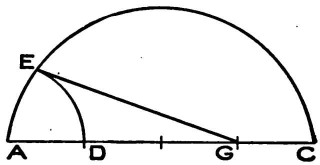


Fig. 32.

To find the length of an arc of a circle—Fig. 32. Divide the chord AC of the arc into four equal parts as shown. With the radius AD equal to one-fourth of the chord of the arc and with A as the center describe the arc DE. Draw the line EG and twice its length will be the length of the arc AEC.

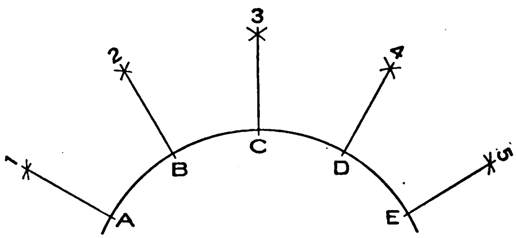


Fig. 33.

To draw radial lines from the circumference of a circle when the center is inaccessible—Fig. 33. Divide the circumference into any desired number of parts as

AB, BC, CD, DE. Then with a radius greater than the length of one part, describe arcs cutting each other as A-2, C-2, B-3, D-3, etc., also B-1, D-5. Describe the end arcs A-1, E-5 with a radius equal to B-2. Lines joining A-1, B-2, C-3, D-4 and E-5 will all be radial.

To inscribe any regular polygon in a circle—Fig. 34. Divide the diameter AB of the circle into as many equal parts as the polygon is to have sides. With the points A and B as centers and radius AB, describe arcs cutting each other at C. Draw the line CE through the second point of division of the diameter of AB, intersecting the circumference of the circle D. A line drawn from B to D is one of the sides of the polygon.

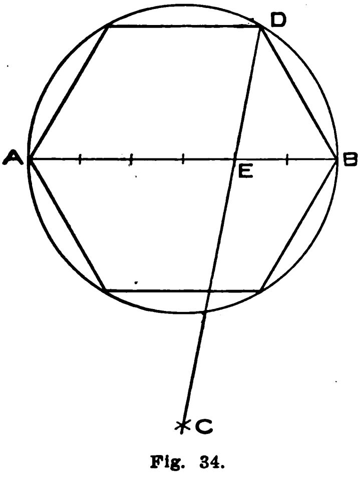


Fig. 34.

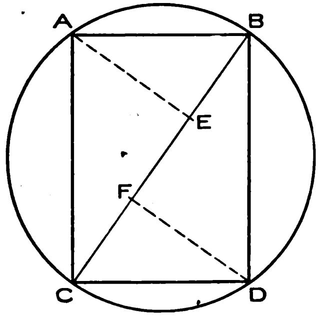


Fig. 35.

To cut a beam of the strongest shape from a circular section—Fig. 35. Divide any diameter CB of the circle into three equal parts as CF, FE and EB. At E and F erect perpendiculars EA and FD on opposite sides of the diameter CB. Join AB, BD, DC and CF. The erect angle ABCD will be the required shape of the beam.

To divide any triangle into two parts of equal area—Fig. 36. Let ABC be the given triangle: Bisect one of its sides AB at D and describe the semicircle AEB. At D erect the perpendicular DE and with center B and radius BE describe the arc EF which intersects the line AB at F. At F draw the line AG parallel at AC, this divides the triangle into two parts of equal area.

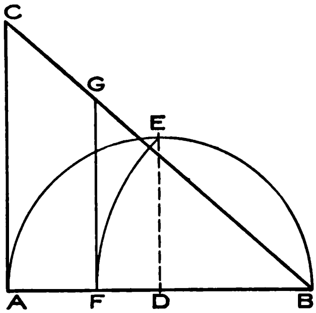


Fig. 36.

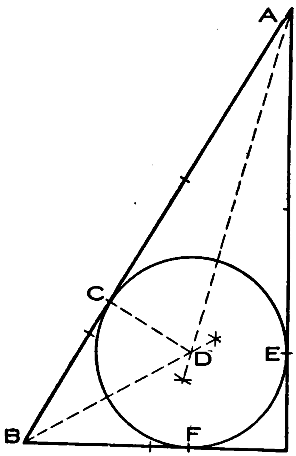


Fig. 37.

To inscribe a circle of the greatest possible diameter in a given triangle—Fig. 37. Bisect the angles A and B, and draw the lines, AD, BD which intersect each other at D. From D draw the line CD perpendicular to AB. Then CB will be the radius of the required circle CEF.

To construct a square equal in area to a given circle —Fig. 38. Let ACBD be the given circle: Draw the diameters AB and CD at right angles to each other, then bisect the half diameter or radius DB at E and draw the line FL, parallel to BA. At the points C and F erect the perpendiculars CH and FG, equal in length to CF. Join HG, then CFGH is the required square. The dotted line FL is equal to one-fourth the circle ACBD.

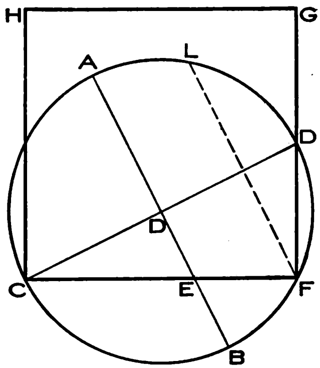


Fig. 38.

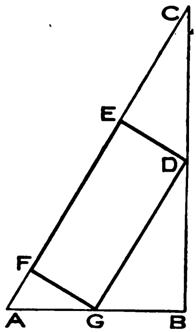


Fig. 39.

To construct a rectangle of the greatest possible area in a given triangle—Fig. 39. Let ABC be the given triangle: Bisect the sides AB and BC at G and F. Draw the line GD and from the points G and D, draw the lines GF and DE perpendicular to GD, then EFGD is the required rectangle.

To construct a rectangle equal in area to a given triangle—Fig. 40. Let ABC be the given triangle;

Bisect the base AB of the triangle at D and erect the perpendiculars DE and BF at D and B. Through C

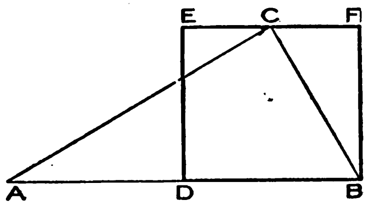


Fig. 40.

draw the line ECF intersecting the perpendiculars DE and B at E and F. Then BDEF is the required rectangle.

To construct a triangle equal in area to a given parallelogram—Fig 41. Let ABCD be the given parallelogram: Produce the line AB at B and make BE

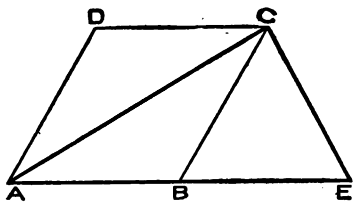


Fig. 41.

equal to AB. Joint the points A and C and ACE will be the triangle required.

To inscribe a square within a given circle—Fig. 42. Let ADBC be the given circle: Draw the diameters AB and CD at right angles to each other. Join AD, DB and CA, then ACBD is the inscribed square.

To describe a square without a given circle—Fig. 43. Draw the diameters AB and CD at right angles to each other. Through A and B draw the lines EF and GH,

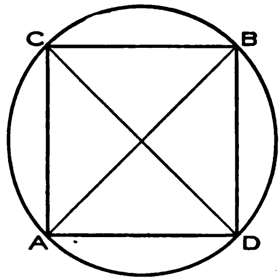


Fig. 42.

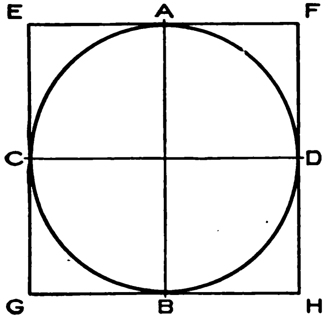


Fig. 43.

parallel to CD, also draw the lines EG and FH through the points C and D and parallel to AB, this completes the required square EFGH.

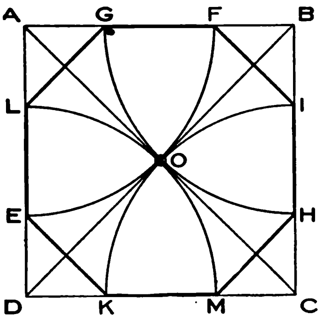


Fig. 44.

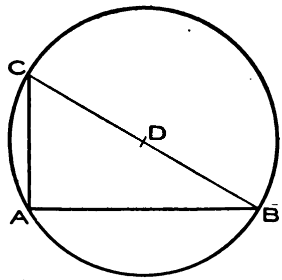


Fig. 45.

To construct an octagon in a given square—Fig. 44. Let ABCD be the given square: Draw the diagonal lines AC and BD, which intersect each other at the point O. With a radius equal to AO or OC, describe the arcs EF, GH, IK and LM. Connect the points EK, LG, FI and HM, then GFIHMKEL is the required octagon.

To construct a circle equal in area to two given circles—Fig. 45. Let AB and AC equal the diameters of the given circles: Erect AC at A and at right angles to AB. Connect B and C, then bisect the line BC at D and describe the circle ACB which is the circle required and is equal in area to the two given circles.

To describe an octagon about a given circle—Fig. 46. Let ACBD be the given circle: Draw the diameters AB and CD at right angles to each other. With

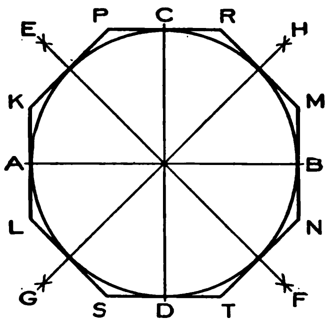


Fig. 46.

any convenient radius and centers A, C, B and D describe arcs intersecting each other at E, H, F and G. Join EF and GH which form two additional diameters. At the points AB and CD draw the lines KL, PR, MN and ST, parallel with the diameters CD and AB respectively. At the points of intersection of the circumference of the circle by the lines EF and GH, draw the lines KP, RM, NT and SL parallel with the lines EF and HG respectively, then PRMNTSLK is the required octagon.

To draw a straight line equal in length to a given portion of the circumference of a circle—Fig. 47. Let ACBD be the given circle: Draw the diameters AB and CD at right angles with each other. Divide the radius RB into four equal parts. Produce the diameter AB and B and make BE equal to three of the four parts of RB. At A draw the line AF parallel to CD

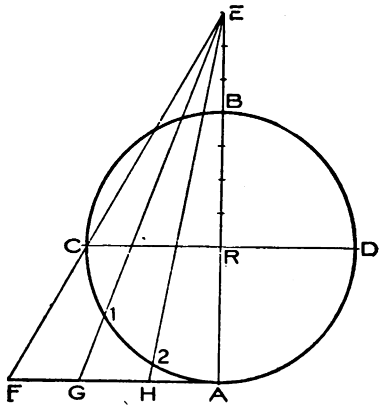


Fig. 47.

and then draw the line ECF which is to one-fourth of the circumference of the circle ACBD. If lines be drawn from E through points in the circumference of the circle as 1 and 2, meeting the line AF and G and H, then C-1, 1-2 and 2-A will equal FG, GH and HA respectively.

To construct a square equal in area to two given squares—Fig. 48. Let AC and AD be the length of the sides of the given squares: Make AD perpendicular to AC and connect DC, then DC is one of the sides of the square DCEG which is equal to the two given squares.

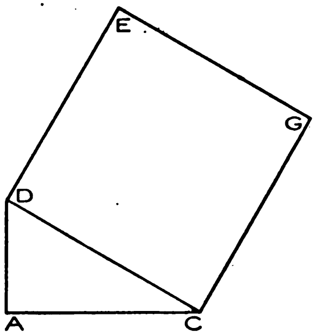


Fig. 48.

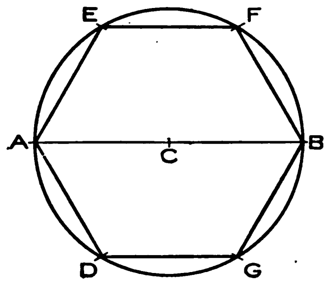


Fig. 49.

To inscribe a hexagon in a given circle—Fig. 49. Draw a diameter of the circle as AB: With centers A and B and radius AC or BG, describe arcs cutting the circumference of the circle at D, E, F and G. Join EF, FB, BG, GD, DA and AE, this gives the required hexagon.

To describe a cycloid, the diameter of the generating circle being given—Fig. 50. Let BD be the generating circle: Draw the line ABC equal in length to the circumference of the generating circle. Divide the circumference of the generating circle into 12 parts as shown. Draw lines from the points of division 1, 2, 3, etc., of the circumference of the generating circle parallel to the line ABC and on both sides of the circle. Lay off one division of the generating circle on the lines 5 and 7, two divisions on the lines 4 and 8, three

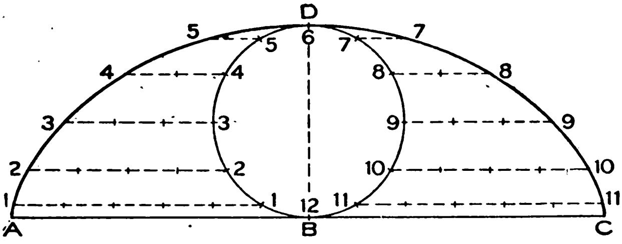


Fig. 50.

divisions on the lines 3 and 9, four divisions on the lines 2 and 10, and five divisions on the lines 1 and 11. A line traced through the points thus obtained will be the cycloid curve required.

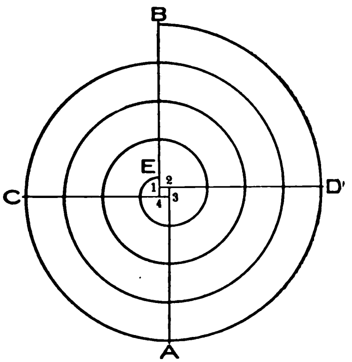


Fig. 51.

To develop a spiral with uniform spacing—Fig. 51. Divide the line BE into as many equal parts as there are required turns in the spiral. Then subdivide one of these spaces into four equal parts. Produce the line BE to 4, making the extension E-4 equal to two of the subdivisions. At 1 draw the line 1-D, lay off 1-2 equal to one of the subdivisions. At 2 draw 2-A perpendicular to 1-D and at 3 in 2-A draw 3-C, etc. With center 1 and radius 1-B describe the arc BD with center 2 and radius 2-D describe the arc DA, with center 3 and radius 3-A, etc. until the spiral is completed. If carefully laid out the spiral should terminate at E as shown in the drawing.

MENSURATION.

Mensuration is that branch of arithmetic which is used in ascertaining the extension and solidity or capacity of bodies capable of being measured.

DEFINITIONS OF ARITHMETICAL SIGNS.

$=$ Sign of Equality, as $4+8=12$.

$+$ Sign of Addition, as $6+6=12$, the Sum.

$-$ Sign of Subtraction, as $6-3=3$, the Remainder.

$\times$ Sign of Multiplication, as $8\times 4=32$, the Product.

$\div$ Sign of Division, as $24\div 6=4$ $\frac{24}{6}$ $24=4$.

$\sqrt{}$ Sign of Square Root, signifies Evolution or Extraction of Square Root.

^{2} Sign of to be Squared, thus $8^2=8\times 8=64$.

^{3} Sign of to be Cubed, thus $3^3=3\times 3\times 3=27$.

MENSURATION OF PLANE SURFACES.

To find the area of a circle—Fig. 52. Multiply the square of the diameter by .7854.

To find the circumference of a circle. Multiply the diameter by 3.1416.

Circle: Area $=.7854D^2$

Circ. $=3.1416D$

To find the area of a semi-circle.—Fig. 52. Multiply the square of the diameter by .3927.

To find the circumference of a semi-circle. Multiply the diameter by 2.5708.

Semi-circle: Area = $.3927D^2$
Circ. = $2.5708D$

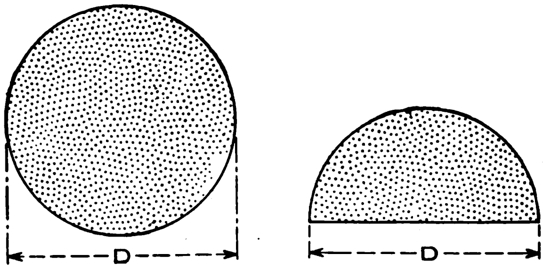


Fig. 52.

To find the area of an annular ring—Fig. 53. From the area of the outer circle subtract the area of the inner circle, the result will be the area of the annular ring.

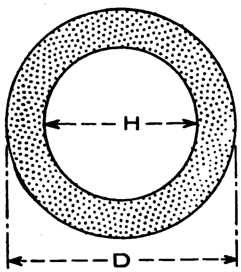


Fig. 53.

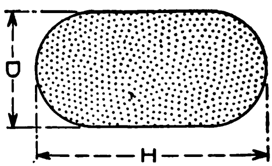


Fig. 54.

To find the outer circumference of an annular ring. Multiply the outer diameter by an 3.1416.

To find the inner circumference of an annular ring. Multiply the inner diameter by 3.1416.

Annular ring: Area $= .7854\ (D^2—H^2)$
Out. circ. $= 3.1416\ D$
Inn. circ. $= 3.1416\ H$

To find the area of a flat-oval—Fig. 54. Multiply the length by the width and subtract .214 times the square of the width from the result.

To find the circumference of a flat-oval. The circumference of a flat-oval is equal to twice its length plus 1.142 times its width.

Flat-oval: Area $= D\ (H—0.214D)$
Circ. $= 2\ (H \times 0.571D)$

To find the area of a parabola Fig. 55. Multiply the base by the height and by .667.

Parabola: Area $= .667\ (D \times H)$

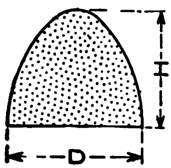


Fig. 55.

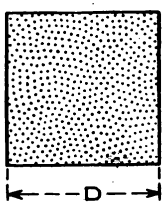


Fig. 56.

To find the area of a square—Fig. 56. Multiply the length by the width, or, in other words, the area is equal to square of the diameter.

To find the circumference of a square. The circumference of a square is equal to the sum of the lengths of the sides.

Square: Area $= D^2$
Circ. $= 4D$

To find the area of a rectangle—Fig. 57. Multiply the length by the width, the result is the area of the rectangle.

To find the circumference of a rectangle. The circumference of a rectangle is equal to twice the sum of the length and width.

Rectangle: Area $= D \times H$

Circ. $= 2\ (D \times H)$

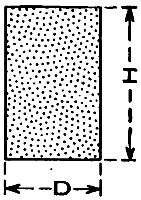


Fig. 57.

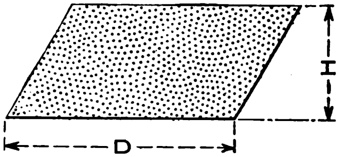


Fig. 58.

To find the area of a parallelogram Fig. 58. Multiply the base by the perpendicular height.

Parallelogram: Area $= D \times H$

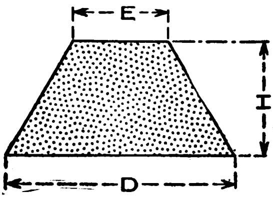


Fig. 59.

To find the area of a trapezoid—Fig. 59. Multiply half the sum of the two parallel sides by the perpendicular distance between the sides.

Trapezoid: Area $= \dfrac{(HE + D)}{2}$

To find the area of an equilateral triangle—Fig. 60. The area of an equilateral triangle is equal to the square of one side multiplied by .433.

To find the circumference of an equilateral triangle.

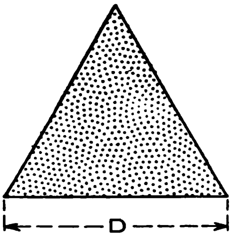


Fig. 60.

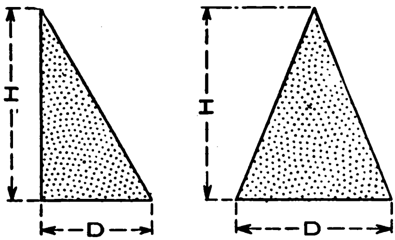


Fig. 61.

The circumference of an equilateral triangle is equal to the sum of the length of the sides.

Equilateral triangle: Area $= .433D^2$

Circ. $= 3D$

To find the area of a right-angle or an isosceles triangle—Fig. 61. Multiply the base by half the perpendicular height.

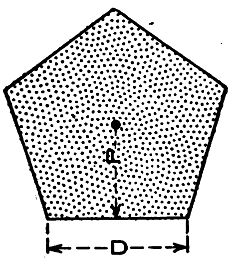


Fig. 62.

To find the circumference of any regular polygon—Fig. 62. The circumference of any polygon is equal to the sum of the length of the sides.

Polygon: $$\text{Area} = \frac{\text{No. of sides} \times D \times P}{2}$$

Circ. = No. of sides × D

D = Length of one side.

P = Perdendicular distance from the center to one side.

MENSURATION OF VOLUME AND SURFACE OF SOLIDS.

To find the cubic contents of a sphere—Fig. 63. Multiply the cubic of the diameter by .5236.

To find the superficial area of a sphere. Multiply the square of the diameter by 3.1416.

Sphere: Cubic contents = $.5236D^3$

Superficial area = $3.1416D^2$

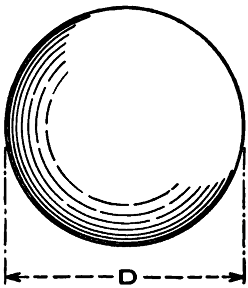


Fig. 63.

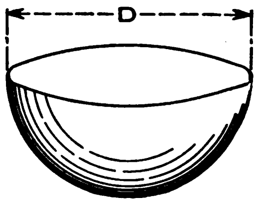


Fig. 64.

The area of the surface of a sphere is equal to the area of the surface of a cylinder, the diameter and the height of which are each equal to the diameter of the sphere. Also, the area of the surface of a sphere is equal to four times the area of its diameter.

The latter definition is easily remembered, and is useful in calculating the areas of the hemispheres, because the area of the sheet or disc of metal required for raising a hemisphere must be equal in area to the combined areas of two discs, each equal to the diameter of the hemisphere.

To find the cubic contents of a hemisphere—Fig. 64. Multiply the cube of the diameter by .2618.

To find the superficial area of a hemisphere.

Hemisphere: Cubic contents $= .2618D^2$

Superficial area $= 2.3562D^2$

To find the cubic contents of a cylindrical ring—Fig. 65. To the cross-sectional diameter of the ring add the inner diameter of the ring, multiply the sum by the

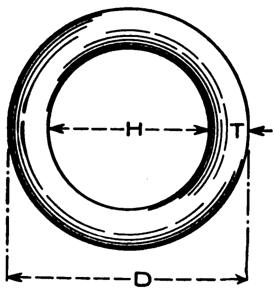


Fig. 65.

square of the cross-sectional diameter of the ring and by 2,4674. the product is the cubic contents.

To find the superficial area of a cylindrical ring. To the cross-sectional diameter of the ring add the inner diameter of the ring. Multiply the sum by the cross-sectional diameter of the ring and by 9.8696, the product is the superficial area.

Cylindrical ring: Cubic contents $= 2.4674T^2 (T + H)$
Superficial area $= 9.8696T (T + H)$
$D = (H + 2T)$

To find the cubic contents of a cylinder—Fig. 66. Multiply the area of one end by the length of the cylinder, the product will be the cubic contents of the cylinder.

To find the superficial area of a cylinder. Multiply the circumference of one end by the length of the cylinder and add to the product the area of both ends.

Cylinder: Cubic contents $= .7854 (D + H)$
Superficial area $= 1.5708D (2H + D)$

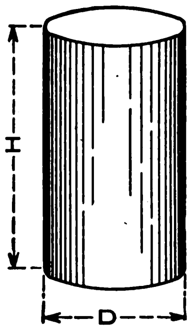


Fig. 66.

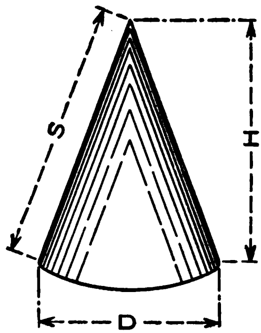


Fig. 67.

To find the cubic contents of a cone—Fig. 67. Multiply the square of the base by the perpendicular height and by .2618.

To find the superficial area of a cone. Multiply the circumference of the base by one-half the slant height and add to the product the area of the base.

Cone: Cubic contents $= .2618 (D^2 \times H)$
Superficial area $= .7854D (2S + D)$

To find the cubic contents of the frustum of a cone—Fig. 68. To the sum of the areas of the two ends of the frustum, add the square root of the product of the diameters of the two ends, this result multiplied by one-third of the perpendicular height of the frustum will give the cubic contents.

To find the superficial area of the surface of the frustum of a cone. Multiply the sum of the diameters of the ends by 3.1416 and by half the slant height. Add to the result the area of both ends and the sum of the two will be superficial area.

Frustum of cone:

$$\text{Cubic contents} = \frac{H(.2618\,(E^2+D^2)\sqrt{E\times D})}{3}$$

$$\text{Superficial area} = 3.1416S\left(\frac{D+E}{2}\right) + .7854(E^2+D^2)$$

$$S = \sqrt{\left(\frac{D-E}{2}\right)^2 + H^2}$$

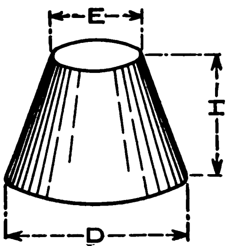


Fig. 68.

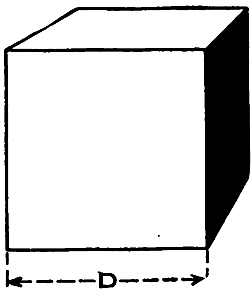


Fig. 69.

To find the contents of a cube—Fig. 69. The contents are equal to the cube of its diameter.

To find the superficial area of a cube. The superficial area of a cube is equal to six times the square of its diameter.

Cube: Cubic contents $= D^3$
Superficial area $= 6D^2$

To find the cubic contents of a rectangular solid—Fig. 70. Multiplying together the length, width and height will give the cubic contents of the rectangular solid.

To find the superficial area of a rectangular solid. Multiply the width by the sum of the height and length and add to it the product of the height multiplied by the length, twice this sum is the superficial area of the rectangular solid.

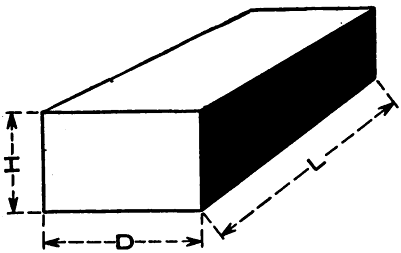


Fig. 70.

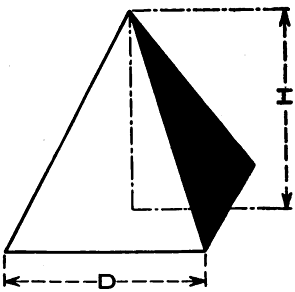


Fig. 71.

Rectangular solid:
Cubic contents $= D \times H \times L$
Superficial area $= 2\,(D\,(H + L) + HL)$

To find the cubic contents of a pyramid—Fig. 71. Multiply the area of the base by one-third the perpendicular height and the product will be the cubic contents of the pyramid.

To find the superficial area of a pyramid. Multiply the circumference of the base by half the slant height and to this add the area of the base, the sum will be the superficial area.

$$\text{Pyramid: Cubic contents} = \frac{D^2 \times H}{3}$$

$$\text{Superficial area} = \left(\frac{4D+S}{2} + 4D\right)$$

$$S = \sqrt{\frac{D^2}{4} + H^2}$$

MENSURATION OF TRIANGLES.

To find the base of a right-angle triangle when the perpendicular and the hypothenuse are given—Fig. 72.

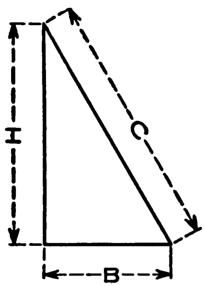


Fig. 72.

Subtract the square of the perpendicular from the square of the hypothenuse, the square root of the difference is equal to the length of the base.

$$\text{Base} = \sqrt{\text{Hypotenuse}^2 - \text{Perpendicular}^2} \text{ or } B = \sqrt{C^2 - H^2}$$

To find the perpendicular of a right-angle triangle

when the base and hypothenuse are given. Subtract the square of the base from the square of the hypothenuse, the square root of the difference is equal to the length of the perpendicular.

$$\text{Perpendicular}=\sqrt{\text{Hypotenuse}^2-\text{Base}^2} \text{ or } H=\sqrt{C^2-B^2}$$

To find the hypothenuse of a right-angle triangle when the base and the perpendicular are given. The square root of the sum of the squares of the base and the perpendicular is equal to the length of the hypothenuse.

$$\text{Hypotenuse}=\sqrt{\text{Base}^2+\text{Perpendicular}^2}$$

$$C=\sqrt{B^2+H^2}$$

To find the perpendicular height of any oblique angled triangle—Fig. 73. From half the sum of the three sides of the triangle, subtract each side severally. Multiply the half sum and the three remainders to-

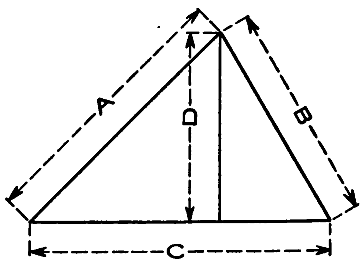


Fig. 73.

gether and twice the square root of the result divided by the base of the triangle will be the height of the perpendicular.

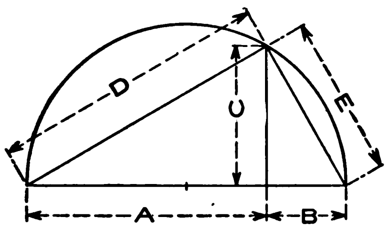
$$D=\frac{2\sqrt{S(S-A)\,(S-B)\,(S-C)}}{C}$$

$$S=\frac{\text{Sum of sides}}{2}$$

To find the area of any oblique angled triangle when only the three sides are given. From half the sum of the three sides, subtract each side severally. Multiply the half sum and the three remainders together and the square root of the product is equal to the area required.

$$\text{Area}=\sqrt{S(S-A)\,(S-B)\,(S-C)}$$

To find the height of the perpendicular and the two sides of any triangle inscribed in a semi-circle, when



Rig. 74.

the base of the triangle and the location of the perpendicular are given—Fig. 74.

$$A=\frac{C^2}{B} \qquad B=\frac{C^2}{A} \qquad C=\sqrt{A\times B}$$

$$D=\sqrt{A(A+B)} \qquad E=\sqrt{B(A+B)}$$

PROPERTIES OF METALS AND ALLOYS.

The properties of the common metals and alloys are well marked, and the different degrees in which these qualities are possessed by the different metals and alloys render each better adapted for certain purposes than the others. These properties are:

Metallic lustre, Tenacity, Ductility, Malleability, Conductivity, Fusibility, Specific gravity.

Each of these qualities is of special value in its place. The capacity for taking a polish in brightening, and planishing, and finishing copper and tinned goods. **Tenacity,** or the strength of a metal or alloy to resist stress, pressure, pulling, bending in vessels, bars, rods, wires. **Ductility,** or the capacity for drawing out, upon which properly the art of wire-drawing is based. Without **Malleability** it would be impossible to roll thin sheets, or to flatten or raise them into curved forms. The good **Conducting** power of metals for heat renders them suitable for warming and domestic purposes, while their power of conducting electricity is a property of equal value, as bearing on wires and plates. **Fusibility** lies at the basis of all casting, but though the sheet-metal worker is but slightly interested in this branch, a knowledge of the fusibility of alloys is essential to the practice of brazing and soldering. The **Specific gravities** or relative weights of the metals is an important property, even from the point of view of the worker in sheet metals, since all sheets of tin, lead, copper, and zinc are sold by pounds weight to the foot. A few remarks by way of explanation of these several qualities, possessed in common by metals and alloys, therefore, preface the descriptions of the metals and alloys to follow.

Metallic lustre. This is, in fact, nothing more than the power of reflecting light rays. If a surface absorbs light rays largely, the reflection is broken, and the appearance of the surface will not be bright, but dull. A broken or rough surface absorbs and scatters the light rays, a smooth surface, in the sense of being polished, reflects them. A porous substance cannot be polished. For a surface to be capable of taking a polish and becoming lustrous it must be dense, close, or hard. Thus no amount of polishing would make the natural surface of wood lustrous like that of iron, and no amount of polishing would make the surface of iron as lustrous as that of the harder steel. Metals not hard enough in themselves to take a high polish can be rendered harder and more lustrous by the admixture of another metal. Tin and copper in various proportions form speculum metal and bell metal, each extremely hard and lustrous, and so of alloys and of other metals.

Tenacity is equivalent to strength, or the resistance offered by a body to forces tending to pull its particles asunder. It is measured in pounds or tons per square inch. That is, if the ultimate tensile strength of a bar of iron is 40,000 pounds per square inch, that means that a load of 40,000 pounds suspended at the end of a bar 1 inch square, in cross section, would just suffice to tear the bar asunder. Tenacity, in this sense of breaking strength, is not of so much relative interest to the sheet-metal worker as it is to the engineer. Still, there are some matters cognate thereto which it is well to be aware of, such as the effect of the presence of impurities, the effect of temperature and the effect of drawing out. In brief, the presence of foreign matters varies, in some cases and in certain proportions tending to increase, in others to diminution of strength. The effect of increase of temperature is to lessen the tenacity of metals, the effect of excessive drawing out is to lessen the tenacity by overcoming the cohesive strength, and replacing the fibrous condition by the crystalline, on the other hand, the tenacity is raised by moderate drawing out. Steel and iron possess the highest tenacity, while zinc, tin and lead possess the least.

Ductility. In proportion to the ductility of metals and alloys they are adapted for the purpose of wire-drawing, hence, steel, wrought iron, and copper, being highly ductile, are used for this purpose. Gold, silver, and platinum stand highest in the range of ductility, but their cost precludes their use for any but some special purposes. Tenacity is closely related to ductility, inasmuch as a weak metal will break before it can be reduced to a fine wire. Zinc, tin, and lead, though soft, will not stand drawing down, because their tenacity is so low. Ductile metals become hardened and crystallized during the process of wire-drawing, until they reach the limit of the coherence of their particles. Then annealing becomes necessary. This is effected by heating the metal, and allowing it to cool slowly, the effect of heat being to produce a natural rearrangement of the molecular particles.

Malleability is not identical with ductility, though in some respects akin to it. The effect of hammering or rolling is to destroy the cohesion of the particles of metal, to restore which annealing is necessary. The softest metals are not the most malleable, neither are the most tenacious metals the most readily rolled and hammered. Lead and tin are soft, iron and steel are strong, or tenacious, but neither are malleable, as are gold, silver, and copper. Copper is the only really malleable substance used by sheet-metal workers, and that can be hammered into almost any form. Sheet-iron and steel can be bent and rolled, but cannot be raised under the hammer or in dies to anything like the same extent as copper. The malleability of thick metals is generally increased by heat, that of thin metals is not practically affected by it. The malleability of metal lies at the basis of the formation of work in sheet metal. There is an essential difference between the operations of the boilermaker and those of the sheet-metal worker. The materials are largely the same—steel, wrought iron, and copper—but the difference in thickness render the methods of working different. The first-named class of artisans do much of their work by the aid of heat, the second, in the cold. The difference is due to the relative thicknesses of the plates used by the first, and of the sheets used by the second. A thick plate cannot be bent to a quick curvature unless it is heated, a thin sheet can be bent, or hammered, or stamped, in the cold to almost any outline. The reason of this is readily apparent on a little consideration.

Take a plate of thick metal, a sheet of thin metal, and a sheet of rubber, and note the effect of bending in each case. The thick plate can only be bent by the application of much force, assisted, if the curvature be quick, by heat, the thin steel can be bent most readily to the same curvature, the rubber also with extreme ease. In each case the effect of bending is to extend the outer layers, and compress the inner layers. The layers in the center of the plate, or sheet, are neither extended nor compressed, and this central plane of bending is called the neutral axis. The difference in bending thick and thin metal plates is due to the fact that in the first the layers which are in compression and extension are at a considerable distance from the neutral axis, while in thin plates these layers are practically coincident therewith, so that in a thin plate there is no appreciable amount of compression or extension, hence the ease with which they can be bent.

But if the metal in the plates were highly elastic and mobile, like rubber, then, even though thick, extension and compression would take place in thick plates as in thin. The effect of heating thick plates is to cause the molecules to move over one another, and to become rearranged permanently, and this not necessarily in a state of high extension or compression, such as would result if the plates had been bent cold, but in a safe and natural way, provided the amount of bending does not exceed the limit which the nature of the material will permit it to sustain. The same kind of thing occurs in thin sheet-metals which are subjected to severe rolling, hammering, or stamping. Some movement and rearrangement of the particles of metal takes place, and the greater the amount of curvature or distortion of form produced, the more severe will be the stresses produced in the substance of the material. If a flat plate is raised by hammering, or if it is deeply beaded or dished, or set out, it will be brought into so high a state of tension that it will probably crack, unless heating is resorted to for the purpose of re-arranging the particles of metal. It is therefore obvious that the result of hammering, rolling, and stamping is to cause the particles of metal to glide over one another, extending some parts and compressing others, with the frequent coincidence also of thinning down some of the portions which have been subjected to the most severe treatment. If, therefore, the metals did not possess this property of malleability and of ductility, but were such that their particles could not be made to glide one over the other, no irregular metallic forms could be produced by hammering or stamping, but casting would be the only method available for obtaining these forms.

Conductivity of heat is a property which renders the metals so valuable for heating purposes. The conducting power of metals varies, but it so happens that copper, which is the best conductor among the metals in common use, is also the most malleable. Wrought iron is also an excellent conductor. The thinner the sheets, the more rapidly is heat transmitted through them. And, moreover, heat is transmitted so quickly through thin malleable sheets that there is no risk of fracture occurring, due to unequal contraction, as there is in many metallic substances.

Fusibility. The melting of steel, copper, and brass does not concern the worker in sheet metal, but the relative fusibilities of the numerous brass, lead, and tin solders are matters of much practical importance to him. These all melt at comparatively low temperatures, and it is essential to know at what temperatures certain solders melt, in order to employ on any given job a solder, the melting point of which is well below that of the material which has to be united. Coke or charcoal fires, jets of gas, and copper bits are used to fuse the various solders employed.

Specific Gravity. The specific gravity of a metal is estimated relatively to that of a given equal bulk of pure water at a temperature of 62 degrees Fahrenheit. Beyond the commercial classification of sheets by weight, the relative weights of metals do not concern the sheet-metal worker much.

The manner in which the physical properties of the alloys is affected by small variations in the proportions of their constituents is often remarkable. Malleability, ductility, fusing points, even appearances are often radically modified. Some metals are more readily influenced in this way than others. Among familiar examples may be noted the effect which very minute percentages of carbon, phosphorous, and silicon exercise on steel.

Taking very common examples, it is remarkable that the union of two soft and malleable metals, as copper and tin, results in alloys ranging from the tough yellow gun metal to the brittle bell and speculum metals of silvery whiteness. So, too, copper alloyed with the very brittle and crystalline zinc forms the soft, yellow brass, which is bent and cut with so much ease. Or, copper with lead forms an alloy so soft as to be hardly workable. Again, tin and lead alloyed together fuse at a temperature lower than that of either of the constituents—a fact which renders them valuable as solders. And by adopting different proportions, various fusing points higher and lower are obtained, suitable for soldering different qualities of metal or alloy.

Copper Alloys. Copper is not only highly valuable in the pure state, but its value is even perhaps greater when alloyed in various proportions with tin, lead, zinc, or other metals. It is only necessary to instance gun metal, brass, bell metal, and the solders. The subject of alloys is one of so great interest and value that volumes might be devoted to them. But, in strictness, the subject is of greater interest to the founder than to the sheet-metal worker. Still, there is very much of interest in it to the latter, since all brass sheets and wires are alloys. All tinning of copper vessels is effected by a union of the surfaces of dissimilar metals, the difference in qualities of sheets and wires depend mainly on the proportions in which certain elements occur. All solders, whether hard or soft, are alloys. So that for these and for other reasons a knowledge of the principles which underlie the union of dissimilar metals to form alloys is desirable.

Whether alloys are true chemical compounds has been doubted. At least, they are not recognized as such in science. The reason is, that there is no fixed and definite proportion in which, and in which alone, combination of the metallic elements occurs. In a true chemical compound such is the case. They invariably combine in definite proportions known as their combining weights, or in multiples of those combining weights. But true alloys are formed apart from any such definite combinations, so that one or other of the elements in one alloy shall be in excess by comparison with another alloy of the same metals. It seems, however, as though true chemical combination must take place, but that the compound is mechanically associated with an excess of one or more of the elements. The reason for assuming the existence of a true compound is, that an alloy usually possesses physical characteristics very different from those possessed by its separate elements—a feature in which it closely resembles most true chemical compounds. The strength, tenacity, hardness, and fusing points of alloys are generally higher than those of their constituent elements, in some cases very much higher—effects which do not seem possible by a mere mechanical mixture of elements.

Copper is alloyed with tin, lead, and zinc in various proportions. When alloyed with tin alone it forms the gun metals, bronzes, bell metals, and speculum metal. When alloyed with zinc only it forms various brasses and spelter solders. Alloyed with lead only, it forms the very common pot metals. Alloyed with tin, zinc, and lead, it forms various gun metals and bronzes.

Alloys of copper with zinc alone are used chiefly to form spelter solder and brass. Copper and zinc mix in all proportions, but exact proportions are difficult to determine, because zinc volatilizes readily. The fusibility of copper-zinc alloys increases with the proportion of zinc. The color ranges, with the successive additions of zinc, from the red of copper to silvery white, and the malleability decreases until a crystalline character prevails.

An alloy of about 1 part of zinc to 16 parts of copper is used for jewelry, one of 3 to 4 parts of zinc to 16 parts of copper for sundry alloys once known as pinchbeck, about 6 to 8 parts of zinc to 16 parts of copper form common brass, the latter being slightly more fusible than the former. Equal parts of zinc and copper form soft spelter solder, or 12 or 14 parts of zinc to 16 parts of copper would probably be the ultimate proportions after volatilization.

Copper and tin also mix in all proportions, successive additions of tin increase the fusibility of the alloy, the malleability diminishes, and the color gradually changes from red to white.

Copper-tin or gun metal alloys range from about 1 part of tin to 16 parts of copper in the softest, to 2 or 2½ parts of tin to 16 parts of copper in the hardest. Beyond the last proportion, up to 5 parts of tin to 16 parts of copper, range the bell metal alloys, from 7¼ to 8¼ parts of tin to 16 parts of copper form speculum metal.

The alloys of copper with lead alone are used in the cheap pot metals. The fusibility is increased with successive additions of lead, the malleability is soon lost, and the red color of copper gives place to a leaden hue. About 6 parts of lead to 16 parts of copper is the limit at which a true alloy can be formed, with an increase in the proportion of lead the latter separates in cooling.

Alloys of copper with zinc, tin, and lead are largely used under the names of brasses, bronzes, gun metals, and pot metal. There is practically no limit to the range of these alloys.

Generally, those alloys are not proportioned separately, but the copper is added to a brass alloy. In many mixtures lead is not used at all, but copper, tin, and zinc only. Antimony is also sometimes used. A little iron added to yellow brass hardens it. Lead, on the contrary, makes it more malleable. Zinc added to a pure mixture of copper and tin makes it mix better, and increases the malleability. Pot metal is improved by the addition of a little tin, and also of antimony.

Aluminum. This metal when of 98.5 per cent purity is bright white in color, somewhat resembling silver, though its appearance depends much on the temperature at which it has been worked. It is capable of taking a high polish. Its fusing point is about 1,050° Fahrenheit, but this may be increased to 1,832° Fahrenheit if impurities are present or if it is alloyed with another metal. Aluminium is only slightly elastic, it is, however, fairly malleable and ductile, but these latter properties are impaired by the presence of its chief two impurities, silicate and iron. If of more than 99 per cent purity, it can be rolled into leaves 1-40,000th part of an inch in thickness, in this respect being inferior only to gold. Aluminium has a tensile strength of 12,000 pounds to the square inch. When pure, it is non-corrosive and resists the oxidizing action of the atmosphere, but this advantage has to be partly sacrificed to obtain increased hardness and elasticity by adding small quantities of copper, nickel, or zinc. It dissolves in hydrochloric acid and in most solutions of the alkalies, but is only slightly affected by dilute sulphuric acid, and not at all by nitric acid. The rolled or forged metal breaks with a fine silky fracture. Aluminium is not found in a metallic state, but when in combination with oxygen, various alkalies, fluorine, silicon, and acids, it is the base of many clays and soils. Frequent compounds of aluminium are felspar, mica, gneiss, and trachyte, whilst other aluminium compounds, classed as precious stones, are the ruby, sapphire, garnet, turquoise, lazulite, topaz, etc. The ores from which aluminium is commercially reduced are bauxite, cryolite, and corundum. The chemical method of producing aluminium has been superseded by the cheaper and more satisfactory electrical process. There are three electrical methods, the first depending on the heating effect of the electric current and producing aluminium alloys only, whereas by the two latter methods aluminium salts are submitted to electrolytic action at a high temperature, pure metal being produced. The sheet-metal worker would do well to thoroughly acquaint himself with the many peculiarities of aluminium, which is replacing other metals for ornamental sheet metal work and in the formation of culinary and other utensils, for which purpose its indifference to the action of most acids and to atmospheric conditions renders it especially suitable. The great disadvantage of aluminium is the difficulty encountered in forming reliable soldered joints. This is caused by the formation of an oxide on the surface of the heated metal, the oxide preventing the soft solder from alloying with the aluminium and producing a good joint. With care the difficulty can be surmounted by employing soldering alloys of an easily fusible nature and by melting them with a special copper bit. Good solders for the purpose are given by authorities as follows: Tin 95 parts, and bismuth 5 parts. Tin 97, bismuth 3. Aluminum 2.5, zinc 25.25, phosphorus 25, tin 72. Aluminum 10, tin 90. Cadmium 50, zinc 20, tin 30. The copper bit should be wedge-shape and bent roundly to a quarter circle, its edge is then at right angles to the aluminium, and by lightly moving the bit backward and forward over the metal and the flowing solder the film of oxide can be removed. The coated surface can then be soldered with an ordinary copper bit.

Antimony. This is a bluish white metal, very crystalline and brittle, and so can easily be powdered. Its chief use is in the formation of serviceable alloys, such as white metal and pewter, to which it imparts brittleness. The melted metal rapidly oxidizes if exposed to the air, and if highly heated burns with a white flame, giving off fumes of antimony trioxide. Antimony is dissolved by hot hydrochloric acid, hot concentrated sulphuric acid, and aqua regis, and if treated with nitric acid forms a straw-colored powder known as antimonic acid. Commercial antimony contains impurities in the form of potassium, copper, iron, and lead. Antimony occurs native, but generally the metal is found in combination with others, the chief antimony ore is stibnite. The antimony is recovered from this ore by two distinct processes, by the first of these is separated the antimony sulphide, which is in its turn refined by the second process. In Germany, where much of the commercial antimony comes from, the ore is placed in covered pots having perforated bottoms, below which are receivers. Between the pots is the fire the heat of which fuses the sulphide, which runs through the holes into the receivers. Crucibles heated in circular wind-furnaces are employed to refine the sulphide. The charge is 40 pounds of sulphide and 20 pounds of scrap-iron, and the product is antimony and iron sulphide, which is again melted, this time with sulphate of soda and some slag, a product of the next process. The resultant metal is melted with pearlash and slag, and cast into ingots. Antimony can also be produced by electro-deposition.

Bismuth. This metal is reddish white in color, and has a bright lustre. It is very brittle and crystalline, volatilizes at a high temperature, and, burning, forms a crystalline scale—flowers of bismuth. The most important use of bismuth is in forming alloys, as its addition to any metal has the effect of considerably lowering the melting-point of that metal. Bismuth may be alloyed with antimony, lead, or tin. Bismuth solders may be formed of: Tin 4 parts, lead 4 parts, bismuth 1 part. Tin 3, lead 3, bismuth 1. Tin 2, lead 2, bismuth 1. Equal parts of tin, lead, and bismuth. Tin 2, lead 1, bismuth 2. Tin 3, lead 5, bismuth 3. Bismuth is found in the metallic state in the form of bismuth-glance (bismuth and sulphur), in combination with oxygen as an ochre, and in the ores of silver, lead, tin, copper, and cobalt. Furnaces for reducing bismuth each contain a number of inclined iron tubes, in which the ore is placed. A wood-fire is lighted, and the fused bismuth, together with some impurities, flows through apertures at the lower ends of the tubes into clay or iron pots heated by a fire underneath. The sulphur and arsenic contained in it are removed by again fusing the metal, this time accompanied by one tenth its weight of nitre.

Gold. This metal has a very limited application in the art of the sheet metal worker, but merely on account of its comparative scarcity to other metals, and hence its expensiveness. Were it not for this, its high malleability and ductility would cause it to be very extensively used in many of the industrial arts. So malleable is gold that it may be reduced to leaves only the 290,000th part of an inch in thickness. It is but very slightly affected by the atmosphere, and resists the action of all solvents with the exception of selenic, aqua regia, and aqueous chlorine. Gold is found in a metallic state in the form of grains in sand and it is then often in combination with silver, copper, platinum, or iron. Veins of gold quartz occur, and occasionally the metal is found native in lumps, termed nuggets. The ores of galena, copper pyrites, and iron, sometimes contain traces of gold.

Tin. This metal has nearly the lustrous whiteness of silver, is highly malleable, harder than lead, but is not very tenacious. It oxidizes only on being heated, when it forms stannic oxide. Tin can be decomposed by many acids, and, as has already been shown, easily alloys with most metals. Tin-plate as used by the sheet-metal worker is not solid tin, but steel-plate thinly coated with tin by a special process. Many of the more important alloys have tin as their principal constituent, some of these alloys are solders. Tin occurs in the form of sulphuret and oxide, but more generally in the form of ore, known as tin-stone. This is smelted either in blast or reverberatory furnaces. In the latter case the treatment is in two stages, one being the actual extraction of the metal and the other the refining. The roasted ore is washed to remove the sulphates, and is then placed in a furnace having an inclined bed and lined with about 8 inches of fireclay. Previous to placing in the furnace, the ore is mixed with anthracite coal and a small quantity of lime and fluor-spar. At the end of five hours more anthracite coal is thrown into the furnace, and in about an hour after that the molten metal can be run off. The remaining slag is an iron silicate which contains some oxides. To refine the pig-tin, it is placed in a reverberatory furnace and gradually heated to about 450° Fahrenheit, at this temperature the tin melts, and is drawn off into iron pots. The mass left in the furnace contains for the most part iron. On again melting the tin and stirring it with a pole of green wood, it is caused to boil by the escape of gases, and by this means the impurities, such as iron and arsenic, are brought to the surface, from which they are skimmed. Grain tin is made by allowing the molten metal to fall from a height on to a hard cold surface. To produce what is known as common tin, the metal passes at once to the moulds. Refined tin is the result of using better ores and lengthening the poling process. The purest metal in the mould is the upper portion, the middle portion is the common, and the bottom portion is too impure for use at all, and requires another fusing and poling. The ingots are known as block tin.

Iron and Steel. Iron in a state of purity is comparatively little known, the ores of it are various and abundant. In its commercial forms, as plate or sheet, bar, and cast iron, it is well known. As sheet it can be cut into patterns and bent into desired forms, as bar it can be made hot and wrought, that is, shaped by means of the hammer, and when molten it can be run or cast into all sorts of shapes. Cast iron is brittle, crystalline in fracture, and not workable by the hammer. In sheet and bar form, wrought iron is malleable, mostly fibrous in fracture, and capable of being welded. The presence of impurities in bar iron, that is, the presence of substances not wanted in it at the time being, seriously affects its malleability. Thus the presence of phosphorus, or tin, renders it brittle when cold, and the presence of sulphur makes it unworkable when hot. Iron quickly rusts if exposed to damp air, as in the case of iron exposed to all weathers, or to air and water, as with vessels in which barely sufficient water is left to cover the bottoms, the rusting being then much more rapid than when the vessels are kept full. Heated to redness and above, scale rapidly forms and interferes greatly with welding. It is impossible to enter here into any consideration of the processes by which iron is prepared from its ores.

The effects of the presence of foreign substances in iron as impurities has been alluded to, but the presence in it of carbon has not been spoken of. This is a substance which in its crystalline form is known as the diamond, and in its uncrystalline form as charcoal. The presence of carbon in iron destroys its malleability, but at the same time gives to it properties so remarkable and useful to mankind, that to say, as a defect, of a piece of iron with carbon in it, that it is not malleable, is simply equivalent to saying that a piece of brass is not a piece of copper. Quite the reverse of being matter in the wrong place, carbon in iron furnishes a compound so valuable on its own account that, if there were other substances not metals, the compounding of which with a metal gave products at all resembling those of iron and carbon, all such compounds would form a class of their own. The iron and carbon compound, however, stands inconveniently alone.

Iron is alloyed with carbon in proportions varying from say ½ to 5 per cent. When in the proportion of from 2 per cent upwards, the compound is cast iron, that is, iron suitable for casting purposes, in other proportions it is known as steel. In cast iron the metallic appearance is somewhat modified, in steel it is maintained. Originally steel was made by the addition of carbon to manufactured iron, and the word had then a fairly definite signification, meaning a material of a high tensile strength, that by being heated dull red and suddenly cooled could be made so hard that a file would not touch it, that is, would slide over it without marking it; and that could have that hardness modified or tempered by further application of heat. But with the introduction of the Bessemer process of steel making, and of the Siemens' process of making steel direct from the ores, processes by which any desired percentage of carbon can be given, the signification of the word has become enlarged, and now includes all alloys of iron and carbon between malleable iron and cast iron, except that the term mild steel is sometimes applied to those alloys that approach in qualities to malleable iron. Steel plates are now produced equal in toughness, and it is said even excelling the best charcoal plates, and as they are much cheaper, the old process is very generally giving way to the direct process. In practice, however, these plates are found to be more springy than good charcoal plates, and not so soft and easy to work.

As iron is very liable to rust, surface protection is given to it by a coating of tin, or of an alloy of lead and tin, or of zinc. Plates coated with tin are termed tin plates, with lead and tin have the name of terne plates, and if coated with zinc are said to be galvanized. Terne plates are used for lining packing-cases, also for work to be japanned.

Large iron sheets of various gauges coated with tin and having the same appearance as tin plate are called tinned iron. But the latter term is more generally applied to sheets of iron which are coated with lead and tin, and are dull like terne plates.

Iron coated with zinc is not so easily worked as when ungalvanized. In galvanizing, the zinc alloys with the surface of the iron, and this has a tendency to make the iron brittle. Galvanized iron is useful for water tanks and for roofing purposes, as the zinc coating prevents rust better than a tin coating. For roofing, however, terne plates are largely used, and, kept well painted, are found to be very durable. Owing to the ease with which zinc is attacked by acids, galvanized iron is not suitable for vessels exposed to acids or acid vapors.

Copper. This, the only red metal, is malleable, tenacious, soft, ductile, sonorous, and an excellent conductor of heat. For this reason, and because of its durability, it is largely made use of for cooking utensils. It is found in numerous states of combination with other constituents, as well as native. Its most important ore is copper pyrites. Copper melts at a dull white heat and becomes then covered with black crust. It burns when at a bright white heat with a greenish flame. No attempt at explanation of its manufacture will here be made, as any description not lengthy would be simply a bewilderment. For the production of sheet copper it is first cast in the forms of slabs, which are rolled, and then annealed and re-rolled, this annealing and re-rolling being repeated until the copper sheet is brought down to the desired thickness. In working ordinary sheet copper, it is hammered to stiffen it, and close the grain. Hard-rolled copper is, however, nowadays produced that does not require hammering.

In the course of the manufacture of copper it undergoes a process termed poling to get rid of impurities. We mention this because we shall find a similar process gone through in preparing solders. The poling of copper consists in plunging the end of a pole of green wood, preferably birch, beneath the surface of the molten metal, and stirring the mass with it. Violent ebullition takes place, large quantities of gases are liberated, and the copper is thoroughly agitated. It is doubtful if this poling process is fully understood, for, though it is quite obvious that there may be insufficient poling, it is not easy to explain overpoling. But overpoling, as a fact, is fully recognized in the manufacture of copper, and the metal is brittle, both if the poling is too long continued or not long enough. If duly poled, the cast slab when set displays a comparatively level surface, if underpoled a longitudinal furrow forms on the surface of the slab as it cools, if overpoled, instead of a furrow, the surface exhibits a longitudinal ridge. Copper, duly poled, is known as best selected.

Zinc. Of this metal, known also very commonly as spelter, calamine is a very abundant ore, another abundant ore is blende. The metal is extracted from its ores by a process of distillation, the metal volatilizing at a bright red heat, and the vapor, passing into tubes, condenses, and is collected from the tubes in powder and in solid condition. If required pure, further process is necessary. Zinc is hardened by rolling, and requires to be annealed at a low temperature to restore its malleability. Until the discovery of the malleability of zinc when a little hotter than boiling water, it was only used to alloy copper with, and sheet zinc was unknown. Zinc expands $\frac{1}{340}$th by heating from the freezing to the boiling point of water. The zinc of commerce dissolves readily in hydrochloric and in sulphuric acid, pure zinc only slowly. If zinc is exposed to the air, a film of dull grey oxide forms on the surface, it suffers afterwards little further change. Zinc alloys with copper and tin, but not with lead, it also alloys with iron, for which it is largely used as a coating, iron so coated being known as galvanized iron.

Lead. Another metal that is prepared in sheet is lead. This metal was known in the earliest ages of the world, it is soft, flexible, and has but little tenacity. One of its principal ores is galena. Being a soft metal, it is worked by the plumber into various shapes by means of special tools, which often saves the making of joints. As it is comparatively indestructible under ordinary conditions, it is largely used for roofing purposes and for water cisterns. It is also used for the lining of cisterns for strong acids, in which case the joints are not soldered in the ordinary way with plumber's solder, but made by a process termed autogenous soldering or lead burning. Lead prepared in sheet by casting is known as cast lead, but when prepared by the more modern method of casting a small slab of the metal and then rolling it to any desired thickness is called milled lead.

Alloys. An alloy is a compound of two or more metals. Alloys retain the metallic appearance, and whilst closely approximating in properties to the metals compounded, often possess in addition valuable properties which do not exist in either of the constituent metals forming the alloy. An alloy of copper and zinc has a metallic appearance and working properties somewhat similar to those of the individual metals it is made up of, and so with an alloy of gold, or silver, and a small percentage of copper. But the latter alloys have the further property of hardness, making them suitable for coinage, for which gold, or silver, unalloyed, is too soft. Like to this addition of copper to gold or silver is the addition of antimony to lead and to tin, by which alloys are obtained harder though more brittle than either lead or tin by itself. The alloy of lead and antimony is used for printer's type, for which lead alone is too soft.

SHEET-METAL WORKING MACHINERY

The machines used by sheet-metal workers are numerous, more than they were a few years ago, and they are constantly becoming more so. In view of the great importance of sheet-metal machinery, a book on sheet-metal working cannot be considered complete without a brief account of the principal types of machines employed, and their use, and it will serve as a source of information to those who are not acquainted with the nature of the work done in these machines. In the selection of machines for illustration, the requirements of the smaller workshops have been kept in mind rather than those of the larger manufacturers. Most of the machines illustrated are those which can be operated by hand or by foot power.

Adjustable Bar Folding Machine. The machine shown in Fig. 75 will turn locks from 1/8 to 1 5/8 inches in width.

These machines will form square joints or angles, turn narrow or wide locks, turn a round edge for wiring and form these locks on medium plate with ease. They will also form open or close locks. By open locks are meant such as are suitable for wiring straight work, and are formed by dropping the wing below the level of the griping jaw.

The adjustment of the folding bar for round or open locks is accomplished quickly and easily by a socket

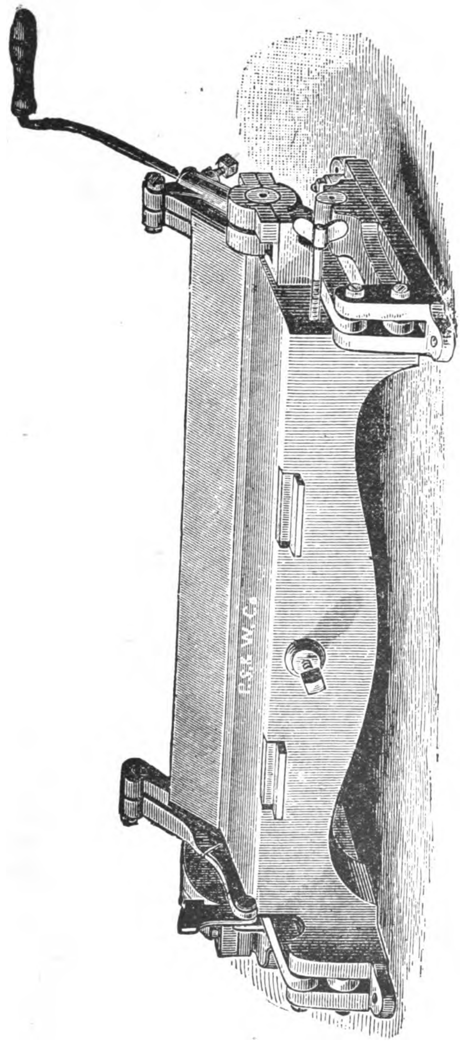


Fig. 75.

wrench not shown in the cut. This wrench raises and lowers the wing and the same wrench fastens the wedge securely in place by a screw. The gauge is adjusted by means of a screw at the end of the machine and the adjustment is in fractions of inches, indicated by the gauge shown on the front of the folder. The folder will bend any sheet metal of a thickness not greater than 22 gauge, but will not turn locks as narrow as 3-32 of an inch on metal as thick as XXX tin.

When sent from the factory these machines are adjusted properly for common and IX tin plate or other sheet metal of same thickness. If thicker stock is to be used, the machine must be adjusted according to the thickness by means of the screws at the rear end of the griping jaws.

The parts are interchangeable, that is, any part of one machine is exactly like the same part in another. All parts are lettered or numbered, and it is only necessary when ordering new parts to refer to the letter or number on the defective part, always giving the number and name of the machine for which the part is wanted.

Turning Machine. A machine to turn the flanges on the edges of dishpans, stewpans or saucepans is shown in Fig. 76.

Setting Down Machine. The machine shown in Fig. 77 closes the bottoms of articles after they have been edged up in the burring machine.

Wiring Machine. A machine for wiring the edges of pails, dishpans and washboilers is shown in Fig. 78.

Burring Machine. The machine illustrated in Fig. 79 is used to edge bottoms and bodies, to crease and edge covers and funnels. The creasing wheels are

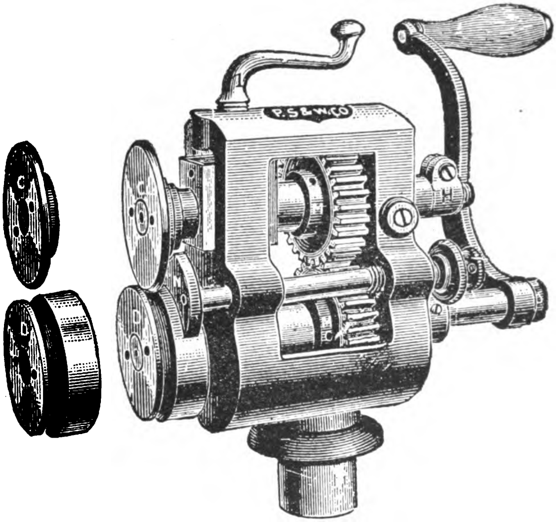


Fig. 76.

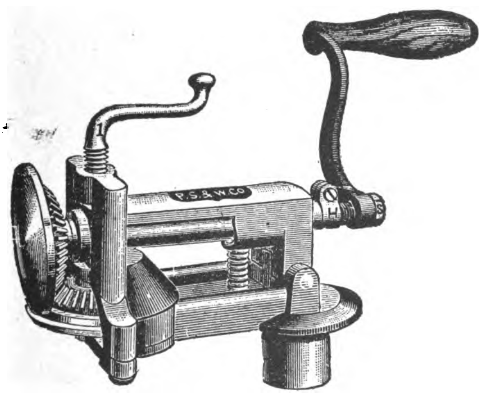


Fig. 77.

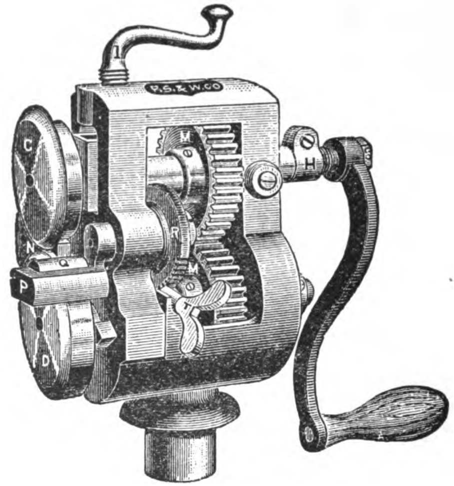


Fig. 78.

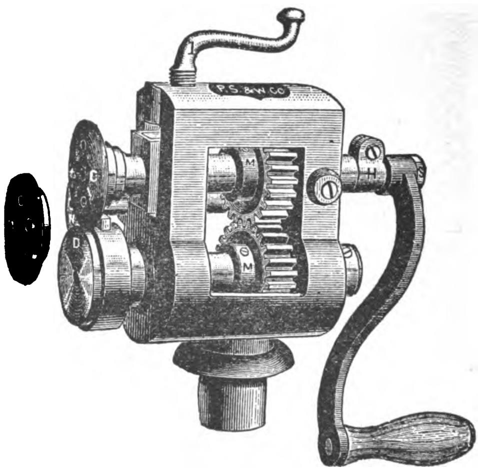


Fig. 79.

screwed onto the spindles and then pinned, thus allowing the work to be fed through the wheels, backwards or forwards, with danger of the wheels coming off.

Grooving Machine. In using the machine shown in Fig. 80 the operator can observe his work during the whole process of grooving. Seams can be formed on the inside or outside of the cylinder and it may be used on all vessels not less than two inches in diameter. Four rolls are put up with each machine, one each with

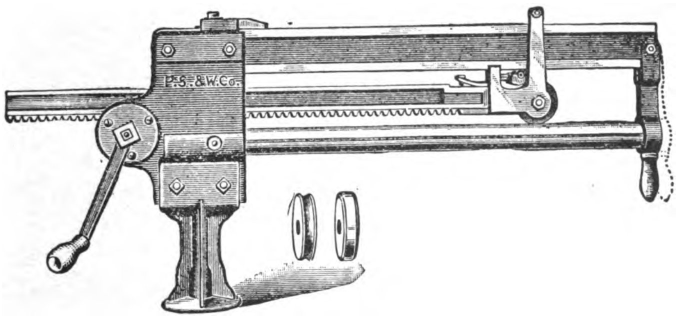


Fig. 80.

groove, and one flattening roll. When the rack is thrown back to the standard the grooving roll is lifted from the lower bar and can be easily released for the purpose of changing the rolls. These groovers are adapted to metal not heavier than No. 22 gauge.

The same machine is shown in Fig. 81, with a groove flattening attachment—this attachment enables the workman to groove and flatten the seam at one operation.

The grooving roll is placed in front of the attachment, and the flattening or following roll in the place occupied by the grooving roll. The grooving roll having passed along the lock and grooved it, the flattening roll follows and flattens it.

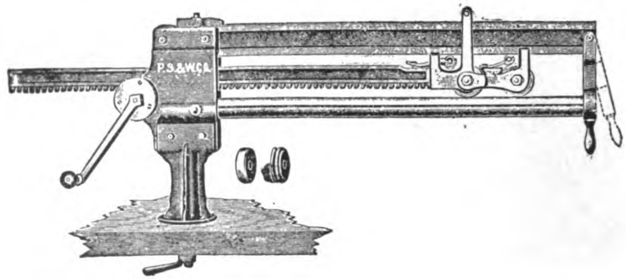


Fig. 81.

Stove Pipe Elbow Edger. The illustration in Fig. 82 shows the position of an elbow in turning the edge, also the form of crease made by the machine to enter the corresponding section in completing the elbow. And Fig. 83 shows the position of the pipe or elbow in forming the bead to receive the creased section, as shown in Fig. 82.

Power Wire Turning Machine. The machine shown in Fig. 84 is intended for use on very heavy work, and is suitable for brass kettles and other vessels made of sheet metal as heavy as No. 16 gauge. Wire as large as 3/8 inch in diameter may be used.

A turning machine is used in bending or curving the top of a vessel for the wire which is inserted to give it additional strength and finish.

A wiring machine is used to finish the operation by completely and compactly covering the wire.

The machine illustrated can be arranged to do a variety of work, such as wiring, turning, beading, etc.,

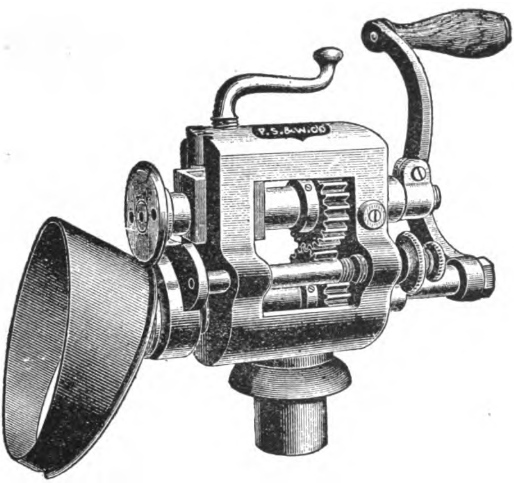


Fig. 82.

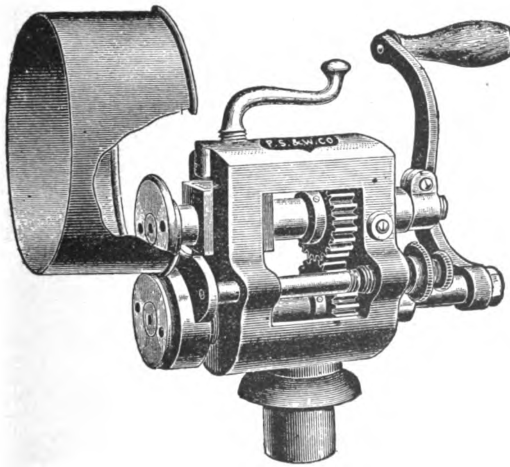


Fig. 83.

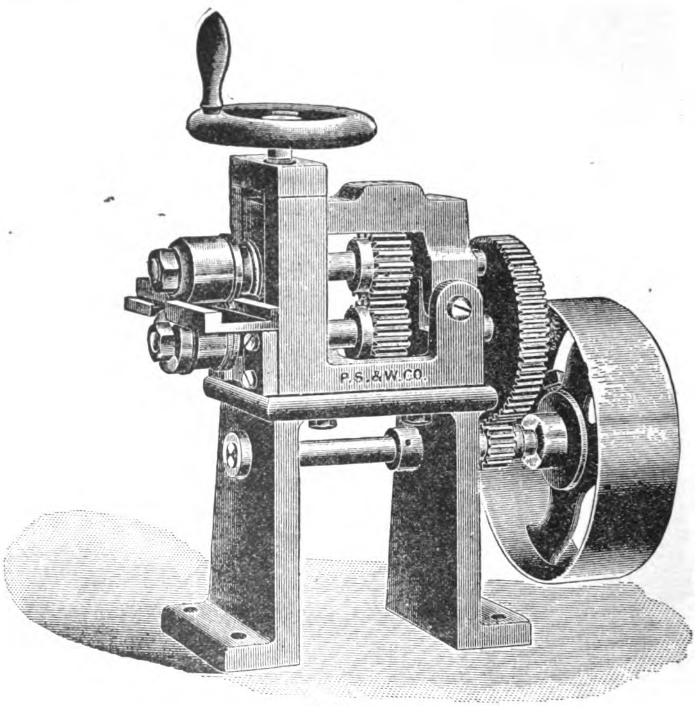


Fig. 84.

by making special rolls adapted to the work to be performed. The size of the pulley can be varied according to the work to be done. They are fitted with a pulley 12 inches in diameter, having a 3-inch face.

Combined Stove Pipe Crimper and Beader. These machines are designed to facilitate the making and putting together of metal pipe of different diameters. They crimp and contract the edges of stove and conductor pipe, so that the lengths are put together easily. Some are provided with beading rolls, which bead the pipe at the same time it is crimped. They have steel rolls. When crimping only is desired, the collar is substituted in place of the ogee rolls. They are adapted to material as thick as No. 22 gauge.

The machine shown in Fig. 85 can be regulated to crimp deep or shallow or of any uniform depths by means of the thumb screw near the handle, by lowering

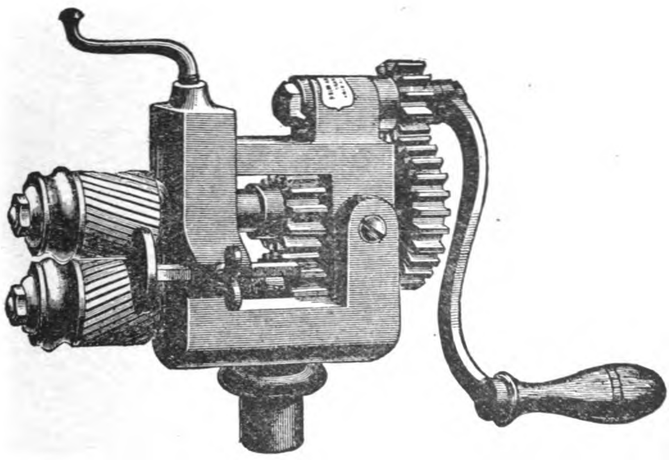


Fig. 85.

one or tightening the other—the upper shaft can be tipped either inward or from the handle as desired.

The machine shown in Fig. 86 is very similar to that illustrated in Fig. 85, except that it is arranged to be operated without the beader rolls. This allows the machine to crimp close up to a bend or angle. It will be found serviceable for cornice work.

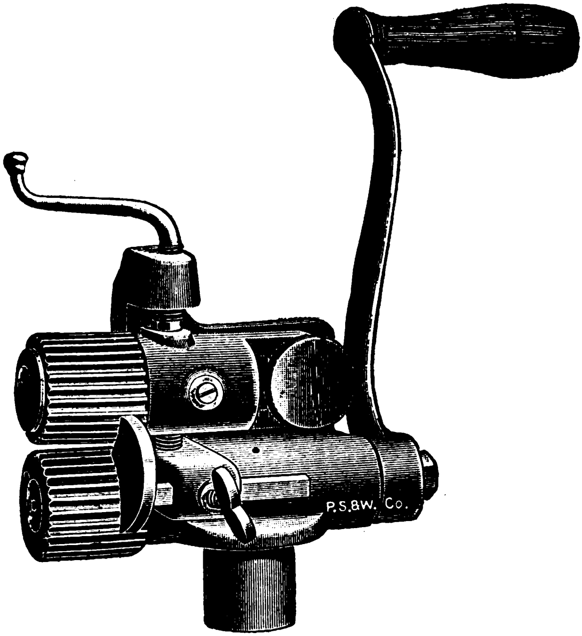


Fig. 86.

Rim Machine. The machine shown in Fig. 87, will form, flare and edge straight strips of tin or other metal at one operation, it contracts but does not corrugate the metal. It is adjustable so that rims of different widths can be formed. It is well adapted for general use in shops, as all strips of metal can be utilized.

Beading Machine. Fig. 88 represents an entirely new beader. It is most carefully made and is an excellent and desirable machine. The rod in front is designed as a guide rest, on which the cylinder or vessel

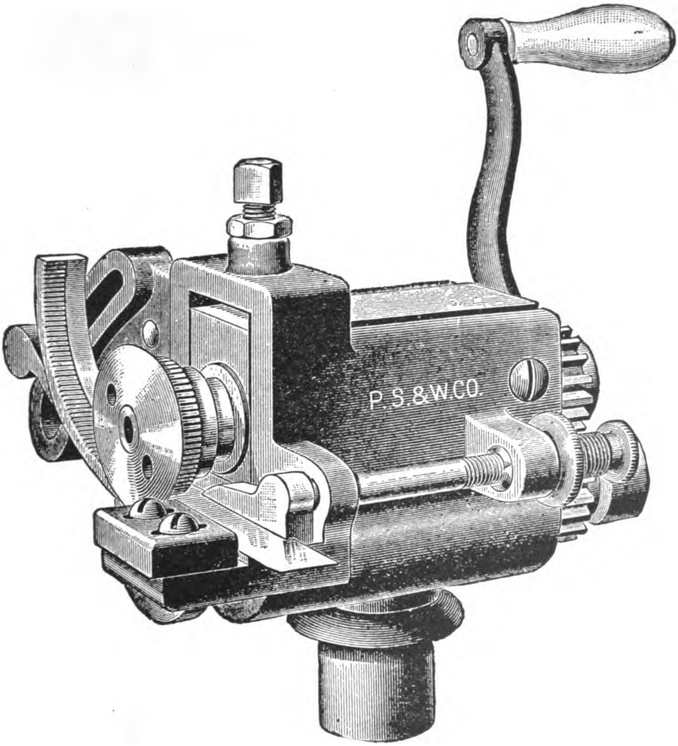


Fig. 87.

may rest while forming the bead, and revolves without guidance by the hand.

The machine is made with interchangeable parts, and is heavy enough to bead No. 20 iron. Crimping rolls can be furnished to fit these machines, and are with straight corrugations.

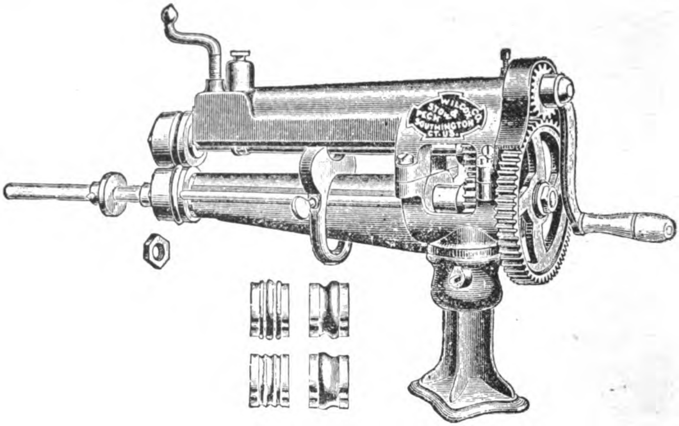


Fig. 88.

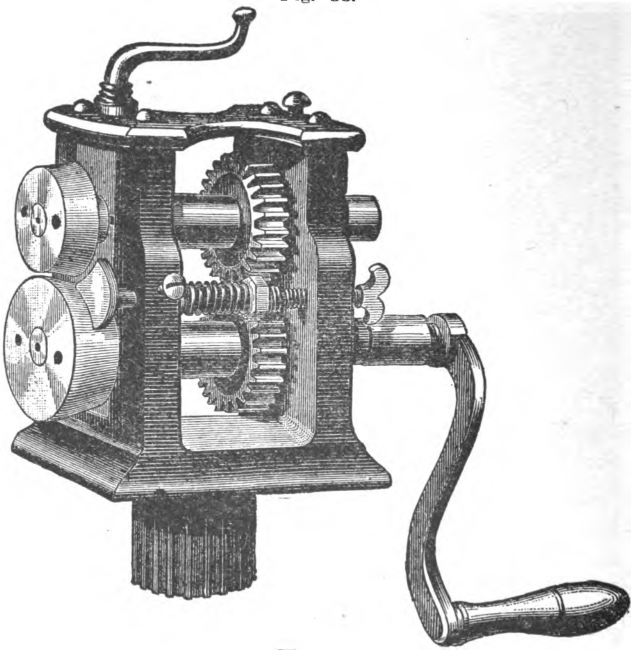


Fig. 89.

Tucking or Crimping Machine. The machine shown in Fig. 89 is used by manufacturers of canning boxes, and is intended for contracting inward or expanding outward the top or bottom edges of can bodies. It can be used on maerial not thicker than No. 27 gauge.

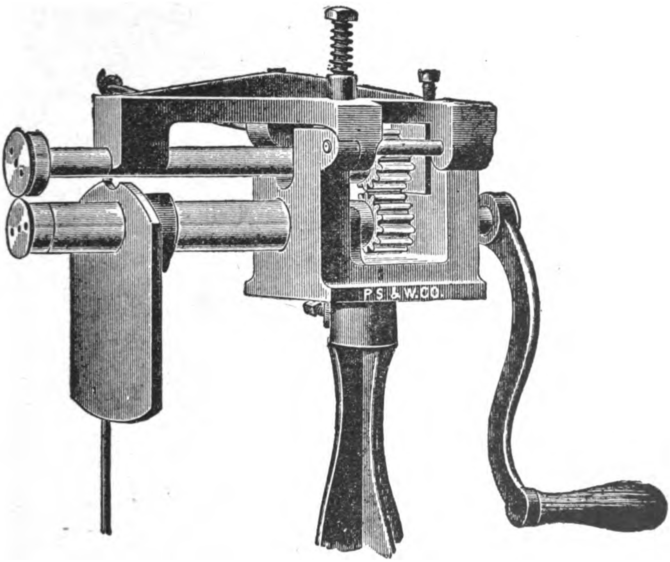


Fig. 90.

Crimping Machine. The machine shown in Fig. 90 will put bottoms on all cylinders of a diameter not less than 2½ inches, and in length not exceeding 7½ inches. The smaller size can be used for cylinders of a diameter not less than 1½ inches, and not longer than 6 inches. They can be used on metal not thicker than No. 27 gauge.

The gauges are so arranged as to be adjusted with ease and accuracy, and the top roller is adjusted by means of a foot treadle. These machines can be made to run by power.

Forming and Beading Machine. Fig. 91 represents a machine for forming and beading strips or narrow widths of metal, such as milk can bands, furnace bands

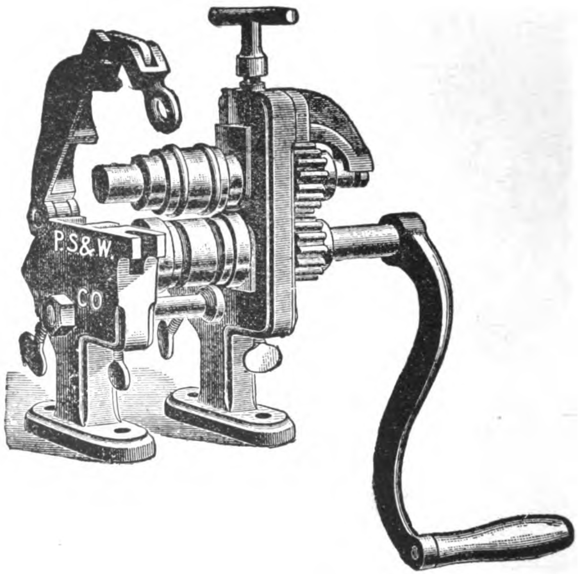


Fig. 91.

as wide as 6 inches. It can be made in different lengths from 6 to 16 inches between housings, and will form cylinders as small as 3 inches in diameter.

Power Beading Machine. The beading machine illustrated in Fig. 92 is designed to be run by power. They are furnished with pulleys 10 inches in diameter, having a 3-inch face, and have the same number and size of rolls as the regular beaders.

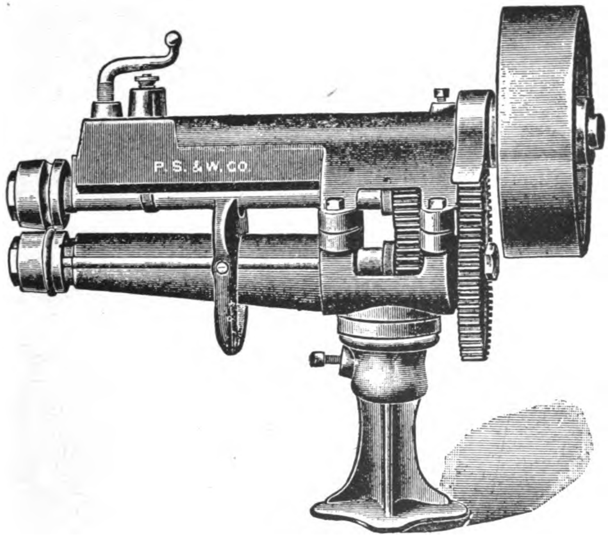


Fig. 92.

Double Seaming Machines. The seaming machine, illustrated in Fig. 93, will double seam vessels made of metal no heavier than No. 22 gauge, and of a diameter not less than 9¾ inches, and not deeper than 15½ inches.

The lower horn is encased in a heavy casting its entire length, giving great strength for the purpose of working very heavy material.

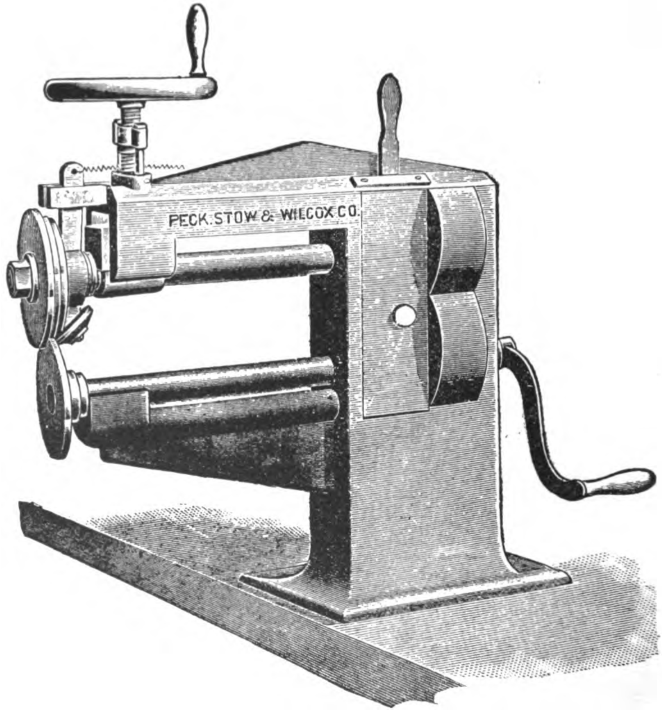


Fig. 93.

This machine is made to be run by hand or power.

A double seaming machine with setting-down attachment is shown in Fig. 94.

The setting down attachment to this machine will set down any work that can be double seamed on the machine. It works rapidly and accurately, and an inexperienced workman can use it without difficulty. It is also intended to be used on work that does not require to be double seamed, and to a large extent will take the place of the setting down in the set of machines. Eleven discs are furnished with each machine as follows: Flaring discs, $4\frac{1}{8}$, $4\frac{3}{8}$, $5\frac{3}{4}$, $6\frac{1}{4}$, $8\frac{5}{8}$ and $10\frac{7}{8}$ inches. Straight discs, 5, $5\frac{3}{4}$, 6, $6\frac{1}{2}$ and 8 inches. It is adapted to material as thick as No. 26 gauge.

Fig. 94.

The machine shown in Fig. 95 is more readily adjusted to double seam vessels of different sizes than any other manufactured. It is also the most expeditious in its operation. It acts more favorably in passing seams or locks, because the pressure to set down a double seam is obtained by means of a foot lever, which yields as the roll passes the seam. It is well adapted to wash basins, pans, etc., and will do any work that can be done on similar machines.

Fig. 95.

Elbow Seaming Machine. A plain elbow seaming machine is shown in Fig. 96, it is adapted for either hand or power.

Wire Straightener. Fig. 97 shows an eight-roll wire straightener, with central standard. This straightener

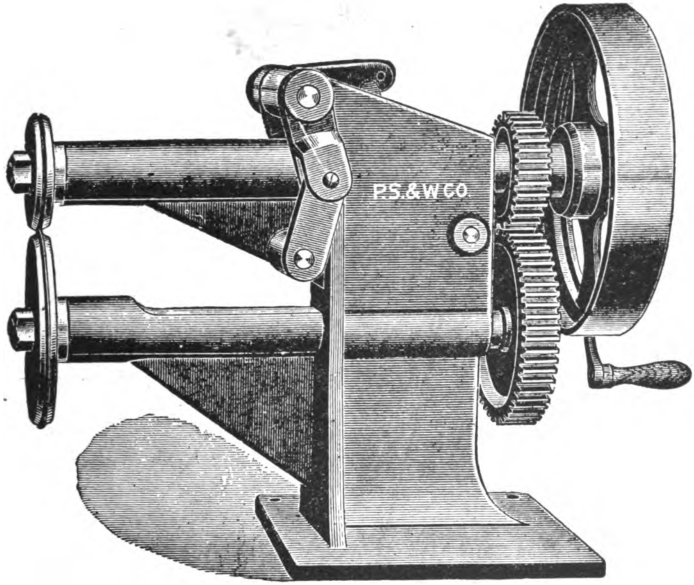


Fig. 96.

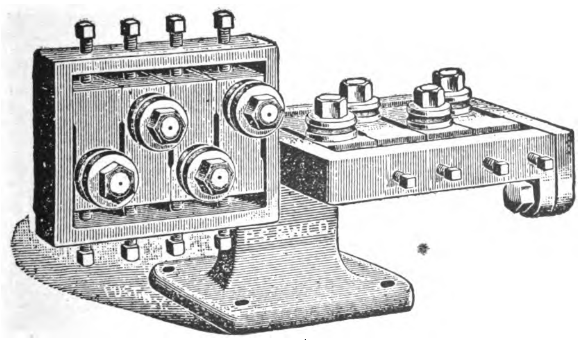


Fig. 97.

can be furnished with either a horizontal or a vertical stand.

When the straightener is used alone, the wire is pulled through by hand. It will straighten wire $\frac{1}{4}$-inch in diameter.

Wire Feed and Cutter. Fig. 98 represents a machine that can be used for various purposes. When fastened

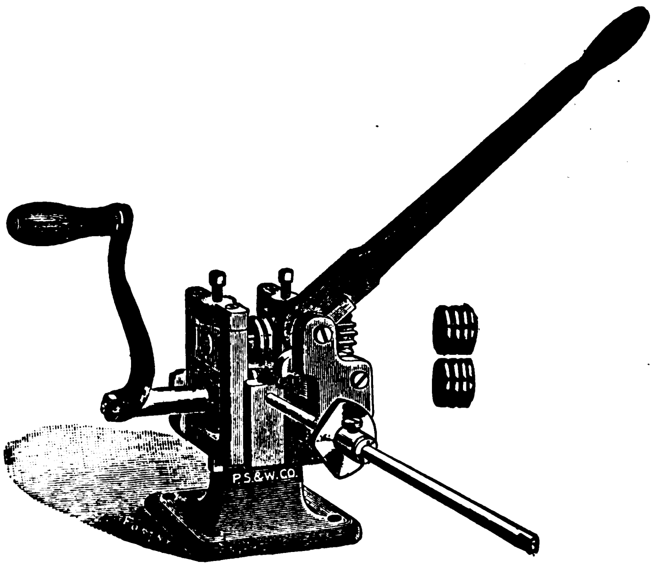


Fig. 98.

to the bench it can be used for drawing wire from the coil and cutting it to any desired length.

It can be used as a wire cutter only. By using this feed and cutter, wire can be drawn to cut any desired length with double the rapidity with which it can be cut in any other way.

The size represented is for cutting wire ¼-inch or less in diameter.

This machine can be used in connection with wire straighteners of any manufacture.

Slip Roll Forming Machine. In the machine shown

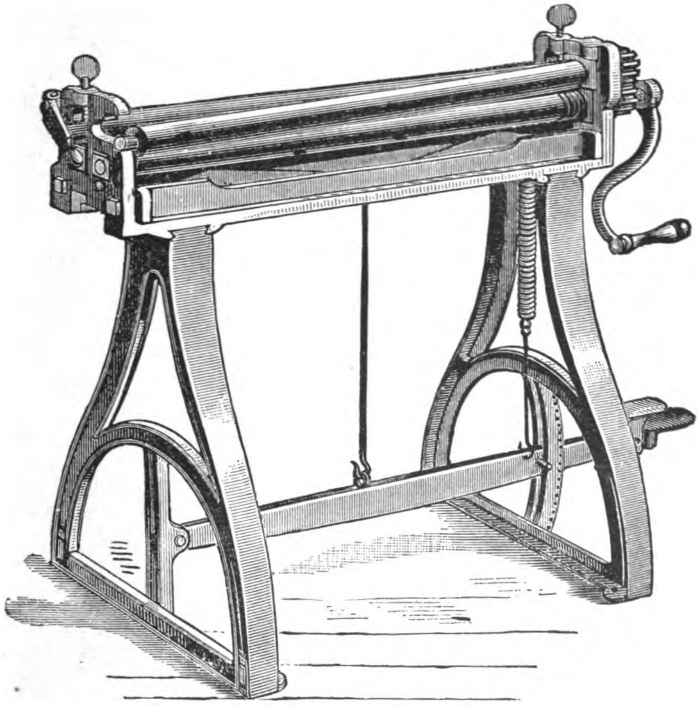


Fig. 99.

in Fig. 99, the roller around which the work is formed is easily and quickly released from its journal, so that the formed work can be taken from the end of the roller and not sprung over it. This arrangement enables the operator to make the pipe more nearly perfect, and to form even conductor pipe on a stove pipe forming machine. The machine is complete in itself, being set on standards or legs.

Slip Roll Former, with Compensating Gear. The machine shown in Fig. 100 is much more easily adjusted, and can be set for forming any desired size of cylinder in much less time than is required to set others. They are made with slip rolls, so that small work can be readily taken from the end after it has

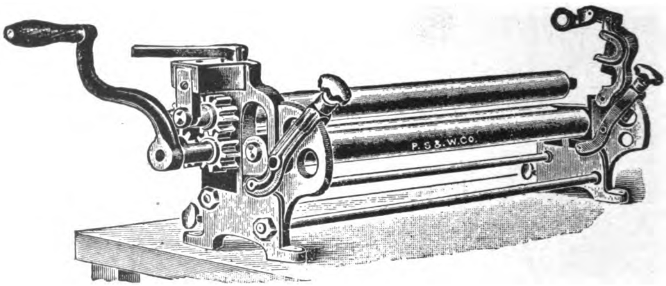


Fig. 100.

been formed. On the former, with 2-inch rolls, cylinders can be formed from D XXX tin, as small as 2½ inches in diameter, and from X tin as small as 2¼ inches. On the former with 1¾-inch rolls, pipe can be formed from D XXX tin as small as 2¼ inches in diameter, and from X tin 2 inches.

Heavy Formers on Legs. Fig. 101 represents a former on legs, arranged with pulley for power. They are adapted for the same work and the same diameter of cylinders and same thickness of metal as those previously described.

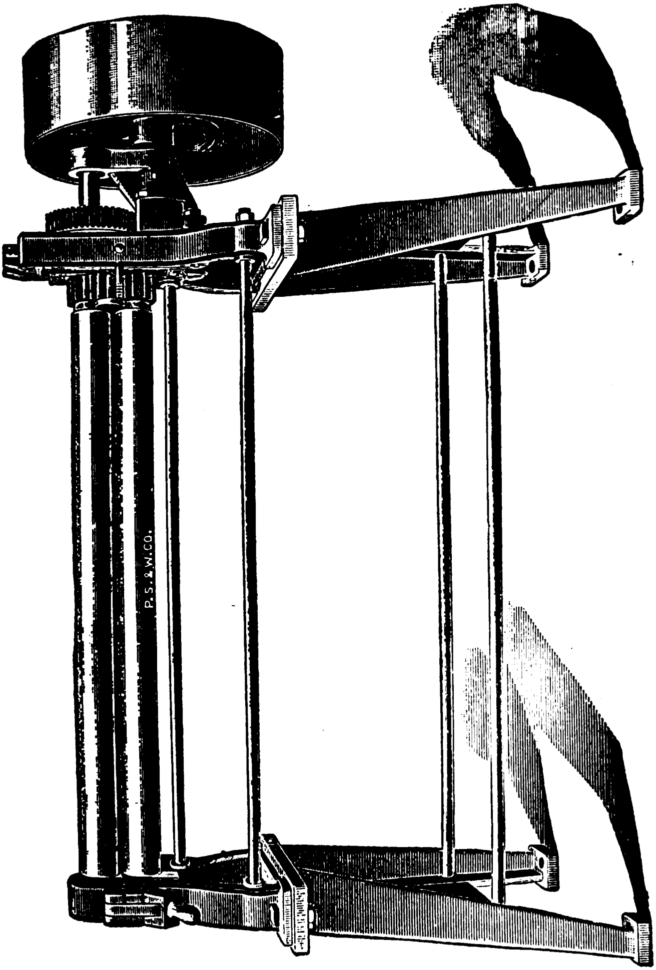


Fig. 101.

Former and Beader. Fig. 102 represents a machine for forming and shaping plastic material. The bead-

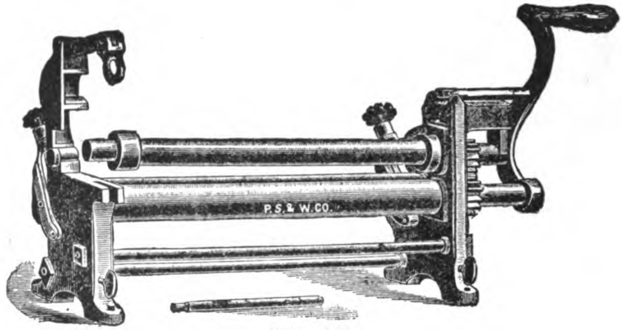


Fig. 102.

ing rolls are movable and can be used in different positions on the rolls.

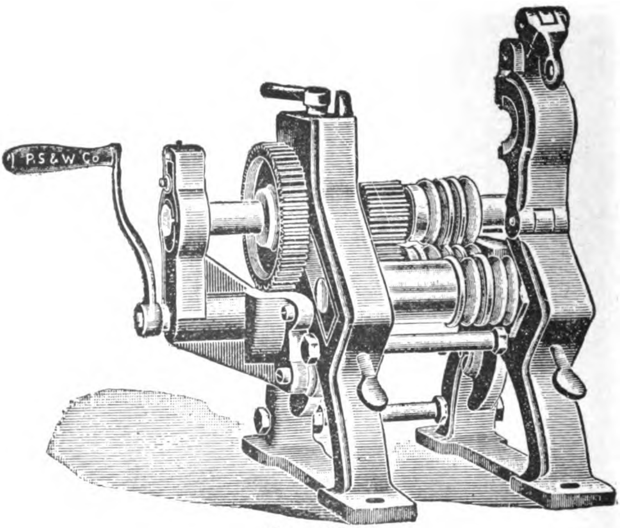


Fig. 103.

Forming and Beading Machine. Fig 103 illustrates a forming machine for special work. The rolls can be made of any length up to 15 inches between the housings. Beading rolls can be furnished of any style and shape required. It is adapted to metal as thick as No. 16 gauge.

Extra Heavy Former. The illustration in Fig. 104 represents an extra heavy three-roll former for special work. It is adapted to forming cylinders from 4

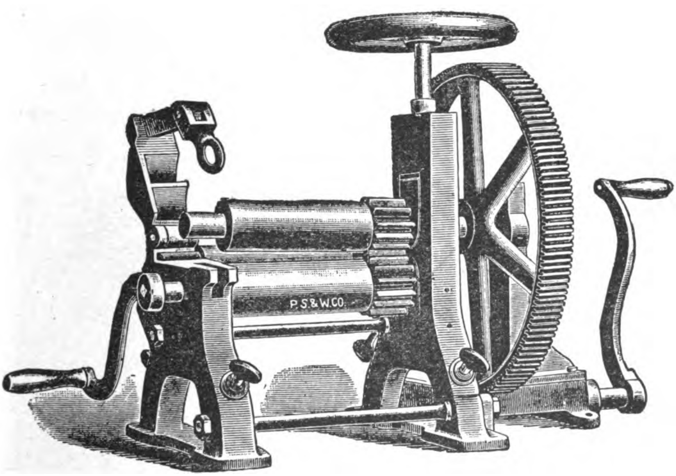


Fig. 104.

inches in diameter, upward, from stock as thick as ⅛-inch, and it will be found very desirable for such work.

They are made in different lengths to suit the requirements.

Power Crimping Machine. The cut in Fig. 105 represents a power corrugating machine, with 3-inch rolls 24 inches long. It was designed for special work and gives the best satisfaction. It is back-geared 8 to 1 and is adapted to corrugate material not heavier than IXXX tin.

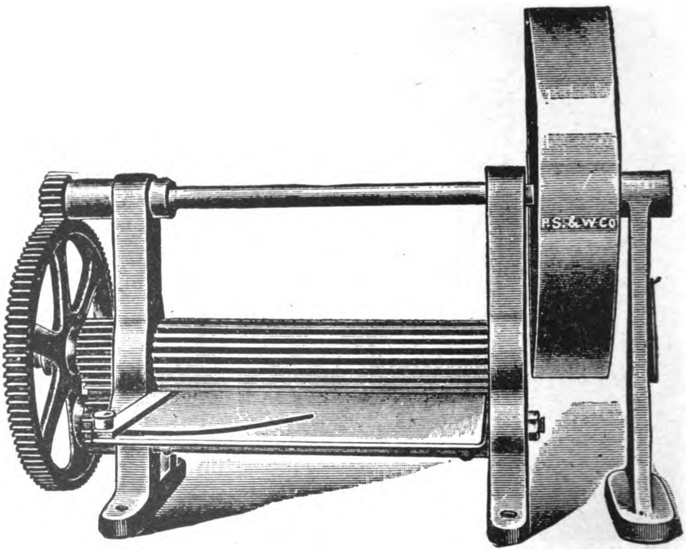


Fig. 105.

Other styles and sizes of these machines are made to work by hand or power as may be desired.

With each of the corrugating machines an attachment is furnished that straightens and leaves flat, sheets of metal after they are corrugated.

Corrugating and Crimping Machine. Fig. 106 represents an extra heavy power corrugating machine on legs with 8-inch steel rolls, 48 inches long. It has cut-

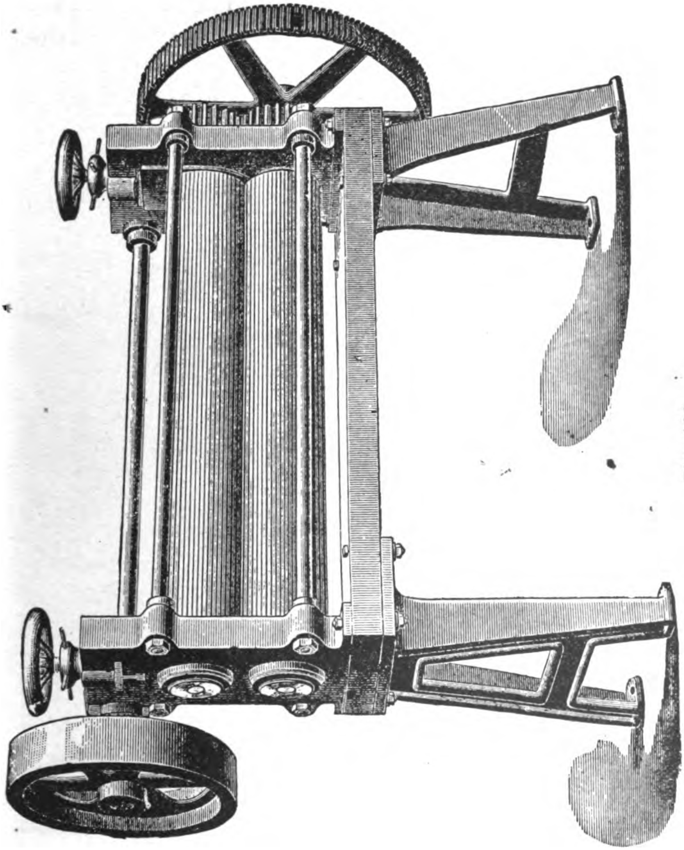


Fig. 106.

gear and will crimp No. 20 iron. They are made so that they can be arranged that either crank or pulley can be used.

These machines have the same special attachment for straightening and flattening the work after it has been corrugated as the machine illustrated in Fig. 106.

Lock Seam Tube Former. The machine shown in Fig. 107 is constructed for forming tubes which have lock seams. To do this it is necessary to first cut the blanks and turn the edges on a folder. On the mandril of the former there is a slot to receive the blank with the lock turned. When properly inserted the forming of the tube is completed by simply turning the mandril.

The back upright bar is so arranged at each end that it may be adjusted to admit of different sized

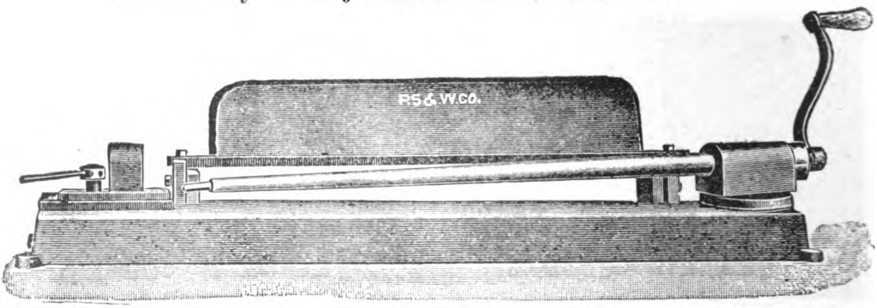


Fig. 107.

mandrils. The large end of the mandril to which the handle is attached fits into a socket in the journal box on the right of the machine. When in the correct position to form tubes the small end of the mandril fits into a socket on the left of the machine. The journal box is arranged to turn on a pivot, that the mandril when released from the socket at the small end may be turned at an angle and the work when completed easily removed. On this machine tubes from tin can be formed up to 32 inches in length,

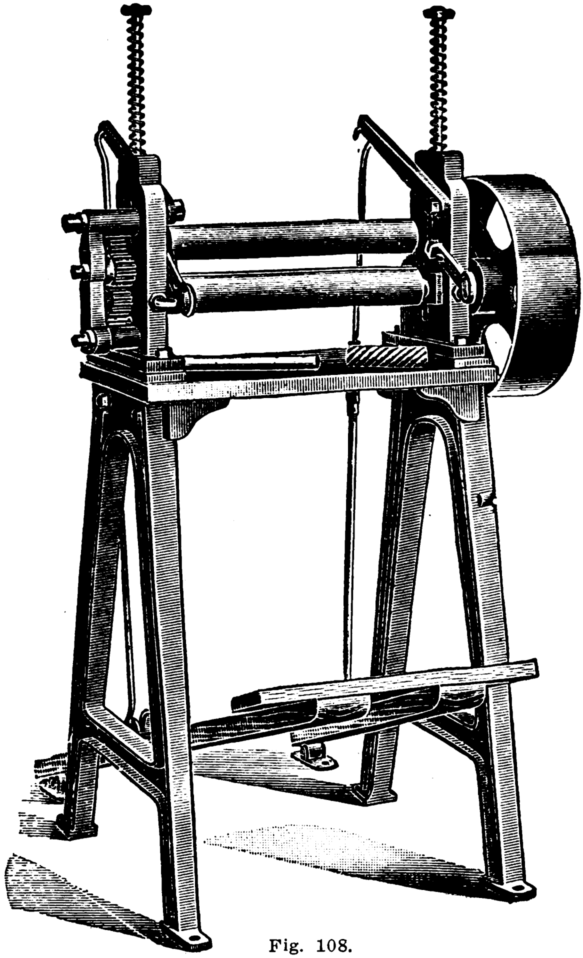


Fig. 108.

and in diameter from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches, and by the use of different mandrils straight or tapering tubes can be formed.

Tube Former. The machine represented in Fig. 108

can be used only with power, but can also be arranged to work by hand. It is so constructed that the same machine will form tubes or cylinders 24 inches long and of diameter ¾ to 1¾ inches, and any intermediate size. This machine is specially adapted for forming speaking tubes and is now constructed with an appliance to lift out the mandril after the tube is formed.

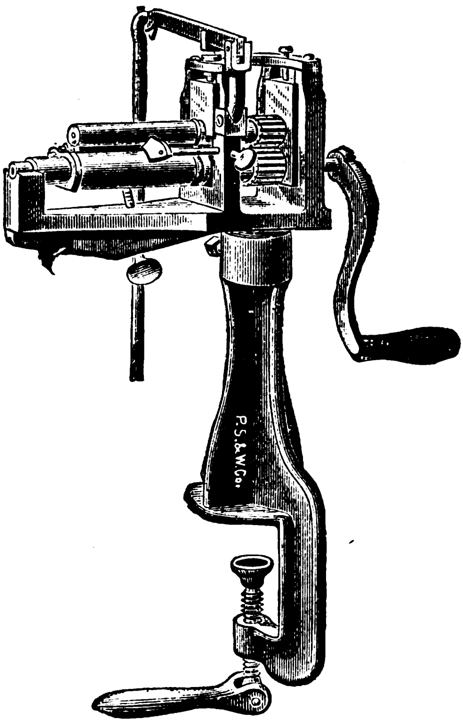


Fig. 109.

Candlestick Former and Beader. An illustration of a blacking, pepper or rattle box and candlestick former and beader, with steel rolls is shown in Fig. 109.

Wire Cutter and Bail Former. The machine shown in Fig. 110 is simple, cheap, durable and economical. It takes wire from the coil and gauges, and cuts it to the desired length. It cuts smoothly and easily one-quarter-inch wire, as well as all smaller sizes from 2

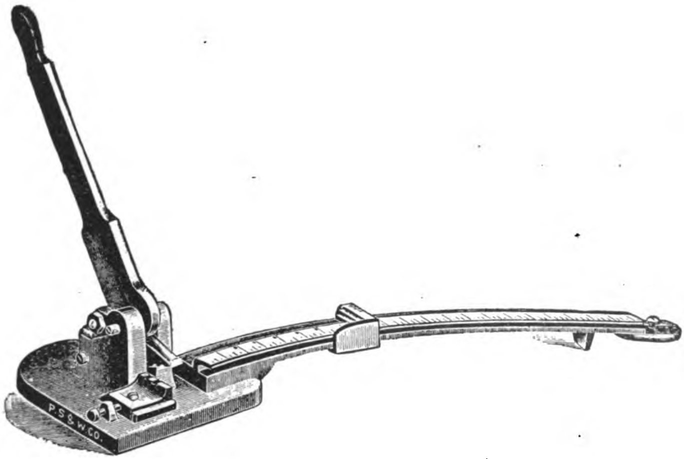


Fig. 110.

to 60 inches in length. It forms bucket pails with rapidity and accuracy. It saves the vexations experienced by every tinsmith in the frequent breaking of cutting nippers.

Power Squaring Shears. The shears shown in Fig. 111 are back-geared, therefore will not cut heavy metal. They are guaranteed, however, to cut No. 18 iron. They are arranged with gauges, which are 30 inches in length and admit of rapid adjustment. The machines are well made and all parts are nicely fitted.

Compound Lever Squaring Shears. The shears illustrated in Fig. 112 above are entirely new, are made extra heavy, both with and without hold-down attachment and with side extension tables. They are fitted

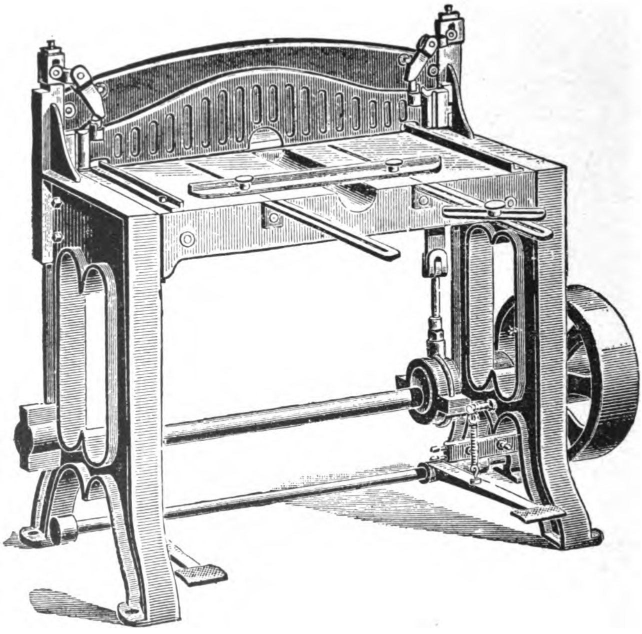


Fig. 111.

with a quick acting back gauge, which is operated quickly and set accurately. They have a compound lever treadle which enables the operator to cut thick stock more easily than with any similar shear on the market. Side springs are fitted with an adjusting screw for regulating the tension and compensating for wear. They will cut stock as thick as No. 14 gauge.

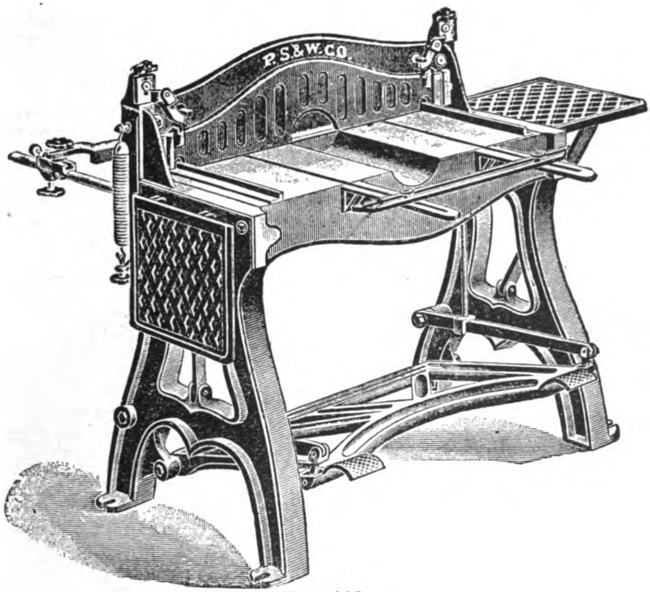


Fig. 112.

Continuous Cutting or Gap Shears. The shears shown in Fig. 113 are arranged with gauges for cutting sheet metal of any length into strips from ½ inch to 18 inches in width. Sheet metal 30 inches wide may be cross cut at any point desired.

To cut metal into strips longer than 30 inches, the gauges at the end of the shears should be removed. No other adjustment is necessary.

The hold-down attachment is operated by hand and slides on independent ways, so that when the blades are in motion the hold-down remains in a fixed position. It can be operated from either end of the shear by means of the small hand wheels. It is arranged with eccentrics, so that when the hold-down is brought against the plate it holds itself firmly in position.

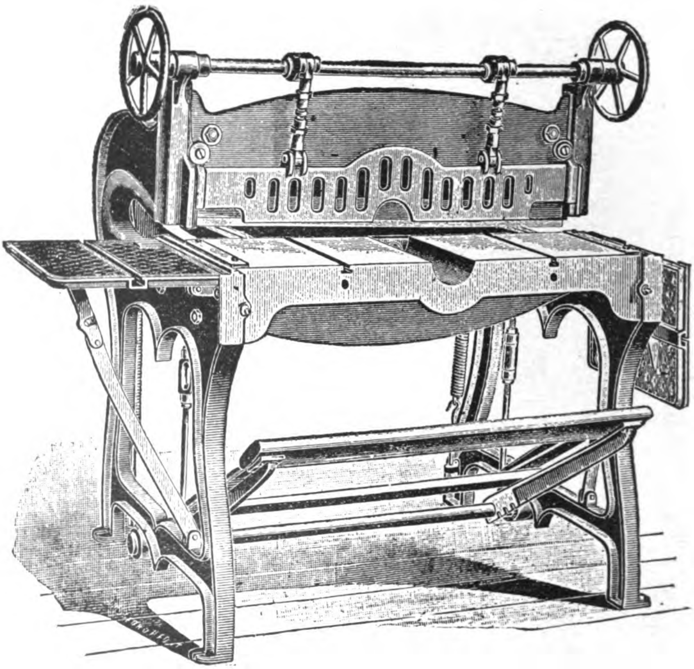


Fig. 113.

It is fitted with side extension tables for supporting long sheets of metal.

Distinct lines are planed in the bed plate parallel with the blades, to aid in adjusting the gauges.

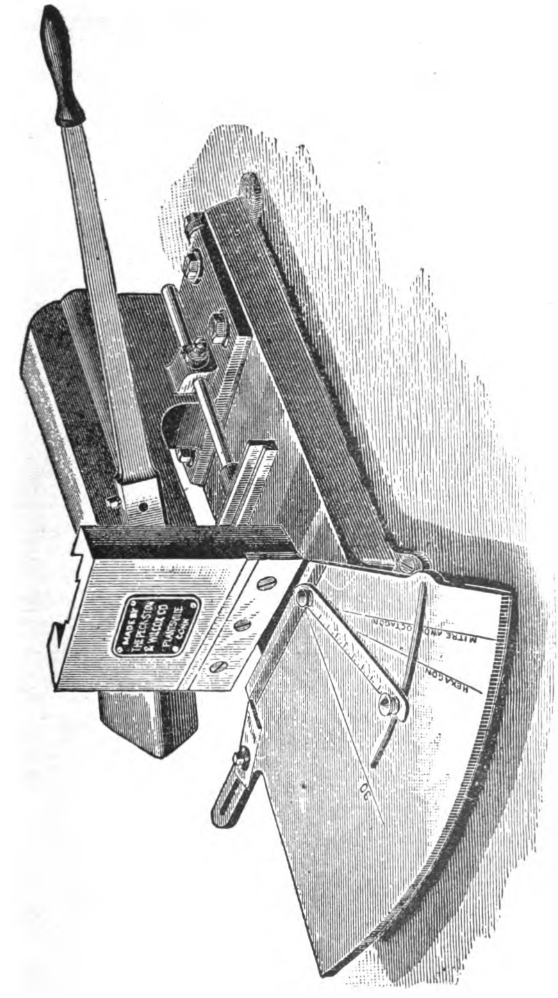


Fig. 114.

Adjustable gauges are provided for the side extension tables, to be used when cutting long sheets.

The treadle is arranged so that the connecting rod can be instantly changed to give increased leverage for cutting heavy metal. These shears are furnished with an extension treadle, as shown in the illustration. This extension will be found useful when cutting metal heavier than No. 18 gauge.

Combined Bench and Slitting Shears. The shears shown in Fig. 114 are constructed on entirely new principles. They surpass all other shears in the variety of work performed. Their superiority over other shears in sheet metal cutting is as follows:

They will do the work of ordinary bench shears, over which they have the following advantages: The length of cut is longer to the same movement of the hand, the same pressure of the hand will cut thicker stock, they cut with the same ease at all points of the cut, while ordinary bench shears cut harder near the point than near the bolt.

The lower blades of these shears are stationary, so that when cutting to line the mark may easily be followed with accuracy. The blades are so constructed that the line drawn is always exposed to the view of the operator.

The lift of the upper blade is adjusted to any desired height by a screw in the lever. When so adjusted as to permit the sheet to be passed through under the blades, the rear gauge may be so set as to cut slits, or square, octagonal, hexagonal, or any other shaped hole, with straight sides, in the center of a sheet of metal 20 inches square, or less, as illustrated in Fig. 115.

They will cut round or elliptical bottoms for vessels of any size having a radius of 2 inches or more.

The front table can be removed at pleasure, and should be removed when cutting to line. By placing this table in position, as seen in the cut, and fastening

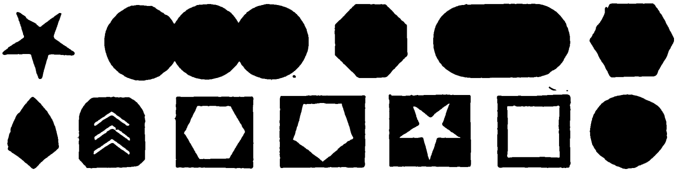


Fig. 115.

gauge in proper place, roofing plates can be cornered ready for turning the lock. This table is so graduated that at a glance the gauges can be set at any desired angle between 45 and 90 degrees.

The blades can be easily removed and ground. The shears are so constructed that they can readily be adjusted, and with proper care should last a lifetime. When used as ordinary bench shears the table should be removed.

Slitting Shears, with Gauge Table. The slitting shears shown in Fig. 116 are designed for cutting thin metal into strips from ½ to 9 inches in width. They are arranged with gauges and a supporting table, so that accuracy may be secured. They will cut material not thicker than No. 20 gauge.

Slitting Shears. The slitting shears shown in the illustration at Fig. 117 is an entirely new machine. The lower cutter is inserted in the bedplate and will

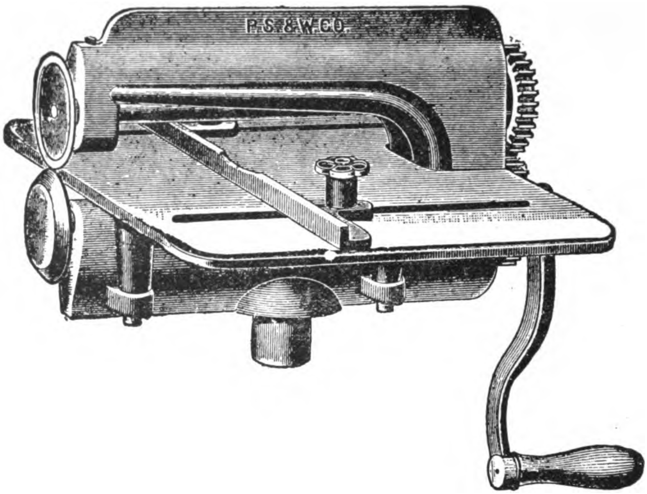


Fig. 116.

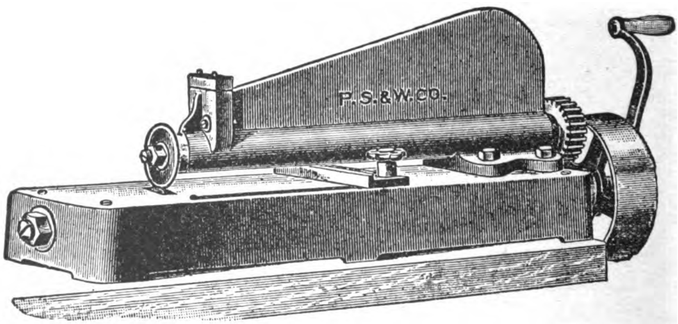


Fig. 117.

cut strips from ¼ to 15 inches in width, metal not thicker than No. 22 gauge. The bedplate forms a table 9 inches wide and 22 inches long. It is in every way a thoroughly reliable cutter. It may be operated by hand or power.

Continuous Rolling Cutter Shears. The shears shown in Fig. 118 are operated by a pinion lever engaging in a rack and cutting with the forward roll of the cutting disc.

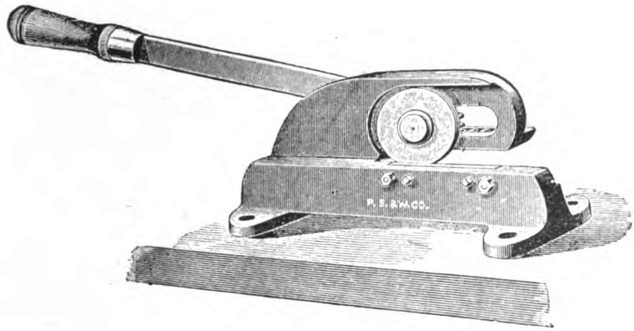


Fig. 118.

The advantage of this construction is that the power travels with the cutter. With ordinary shears as the cutting edge recedes from the fulcrum the resistance increases, not so with these shears, the resistance and power being the same all along the cut.

The motion of the circular cutting disc is about one-third of its circumference. The cutting disc is provided with three slots, which correspond with three pins on the cutting disc bolt, this enables the operator to change the cutting disc to six different positions; three on each side, the disc being reversible.

The lower or stationary straight cutter blade has two cutting edges, the ends of the cutter are beveled to match the heads of the bolts which draw the cutter blade in recess of shear stock. Two set screws which press this cutter blade in opposite directions are the means to adjust the lower cutter perfectly to the upper cutter disc.

The angle of contact of the two cutters remains the same during action, therefore, this shear is well adapted to cut pieces out of a sheet of metal without injuring the same by cross-cut marks, which is very difficult with other shears.

The circular cutter on the front of the vertical plate of shear stock, and the pinion lever on the back, whose surfaces are perfectly parallel, when drawn up reasonably well by the nut of the bolt or shaft, bear so well against the plate that the friction of the two cutters can be totally obliterated by proper adjustment with the set screws in combination with the bevel head bolts, thus securing long service before any sharpening is necessary. This is the most simple shearing device for cutting sheet metal. It is especially adapted to tin and sheet metal workers.

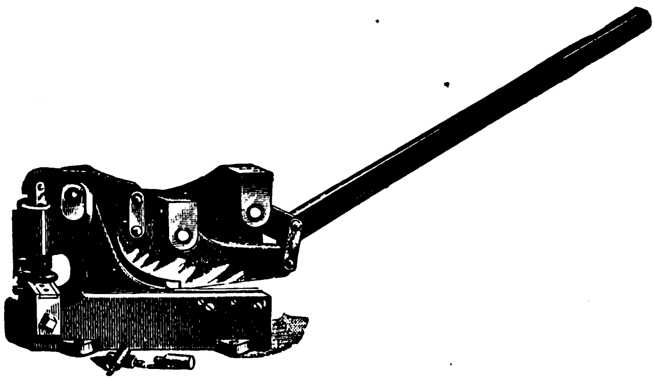


Fig. 119.

Combined Shear and Punch. The machine illustrated in Fig. 119 is suitable for both cutting and punching

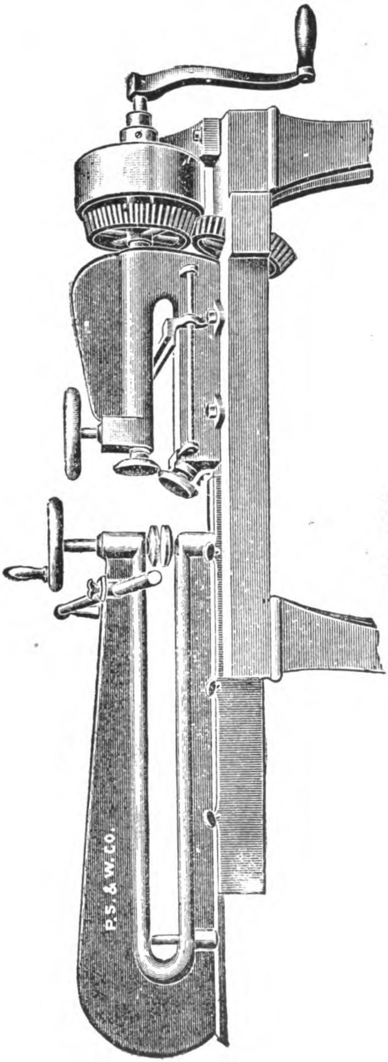


Fig. 120.

metal. It may be used for cutting 1/8-inch iron, and 3-16 and 1/4-inch narrow bars. The machine will punch the center of a circle 5 1/4 inches in diameter.

Shears for Cutting Circles or Rings. The machine shown in Fig. 120 is constructed so that it can be used either by hand or power. It is designed for cutting rings from a sheet of metal without cutting through the outer edge, that is, internal circles, it also can be used as a regular circular shears. It is made in one

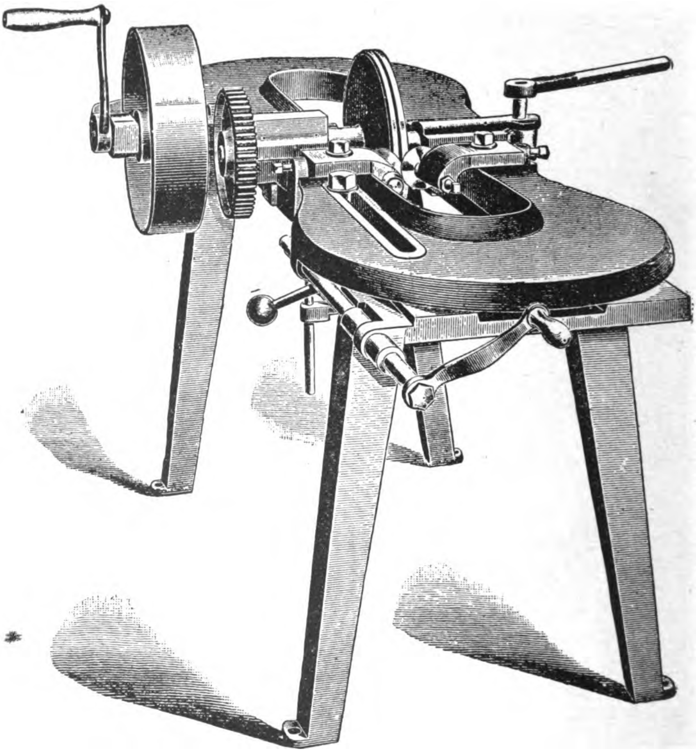


Fig. 121.

size only, and will cut circles from 3 to 40 inches in diameter, and internal rings from 3 to 39 inches in diameter. It can be used on sheet metal as heavy as No. 16 gauge. The machine as constructed is adapted to run at about 80 revolutions per minute and is fitted with a pulley 10x3 for power, and a crank for hand use.

Combination Circular or Rotary Shears. The shears represented in Fig. 121 are made so they can be used by hand or power, but are without burring attachment. They have an adjusting screw, and a scale on the bed, so that a very accurate adjustment can be made.

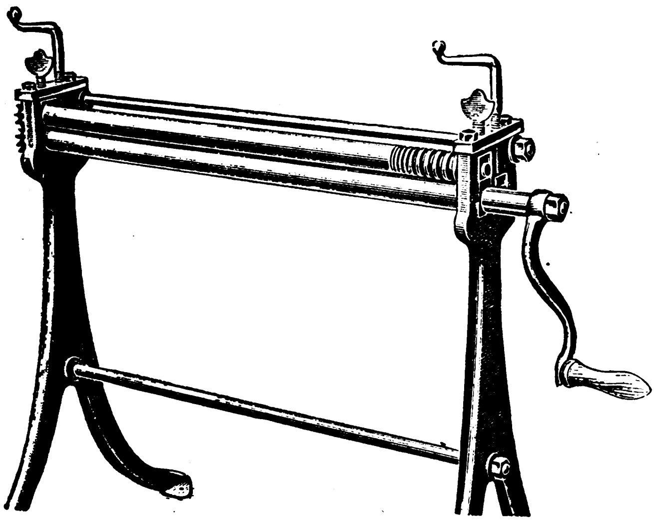


Fig. 122.

Light Bending Rolls. Bending rollers are used much by sheet-metal workers. They are light by comparison with those employed by boilermakers, or from one to two and a half inches in diameter, by from 12 to 36 inches long. They are operated by hand or by power. Fig. 122 shows light rollers which are also formed with grooves for bending wire of various gauges. Such machines are also fitted with spur gearing and fly-wheel in place of the winch-handle for heavy work.

Circle Cutting Machine. Fig. 123 shows a plain circle cutting machine. The sheet to be cut is held in the end of a long jaw, which can be moved along the

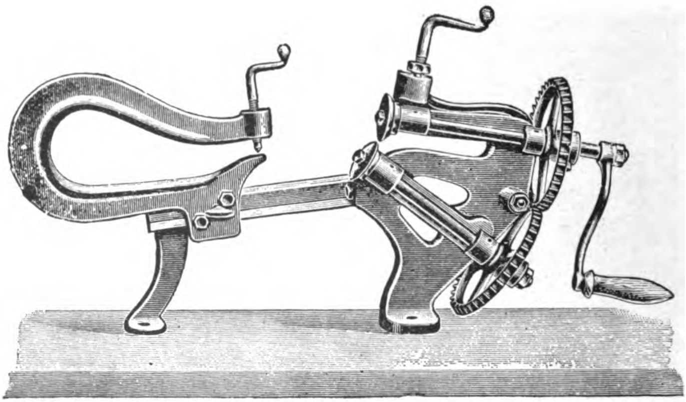


Fig. 123.

bed to give a radius of as much as nine inches from the cutters. The cutters are of hardened steel carried in a fixed head, and operated by gearing. In more powerful machines, sheets 48 inches in diameter by $\frac{1}{8}$-inch thick can be cut. Rings as well as discs can be cut. In one type of machine, the sheet to be cut has a small hole drilled in the center for fixing the sheet in the bow or arm.

Cornice Makers' Shears. As shown in the illustration at Fig. 124 these shears have an automatic hold-down attachment, gauges for squaring and cutting at angles, and a device for working the back gauge with arm and slide in place of bevel gears and screws as heretofore used. The lever is operated from the

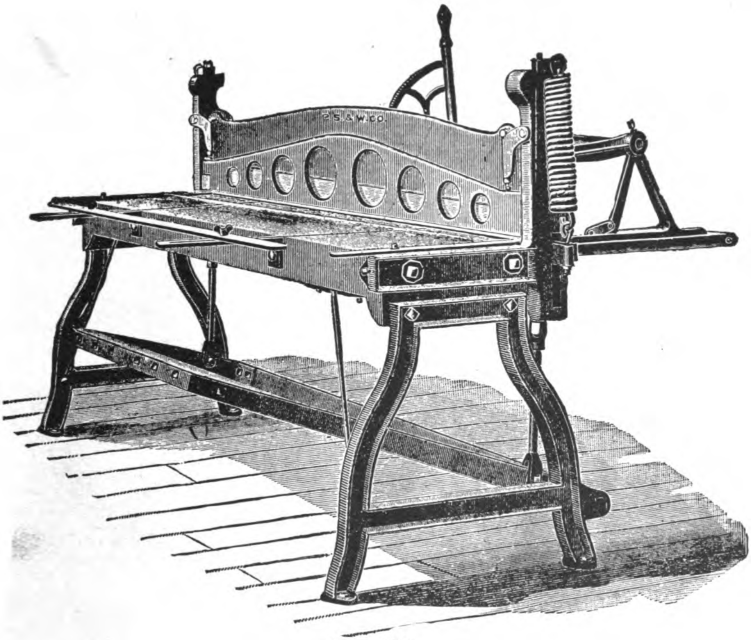


Fig. 124.

center of the shears on a graduated arc which indicates the position of the gauge, and from the front instead of the back of the shears. To cut sheets ¾ to 11 inches wide, simply move the lever to the corresponding measurement indicated on the arc. To cut from 11 to 20 inches in width, move the gauge to the second pocket in the slides and operate the lever in the same manner as in cutting narrow widths.

Cornice Makers' Brake. The machine shown in Fig. 125 is exceedingly well made and simple in construction, and of equal merit with any brake of its class.

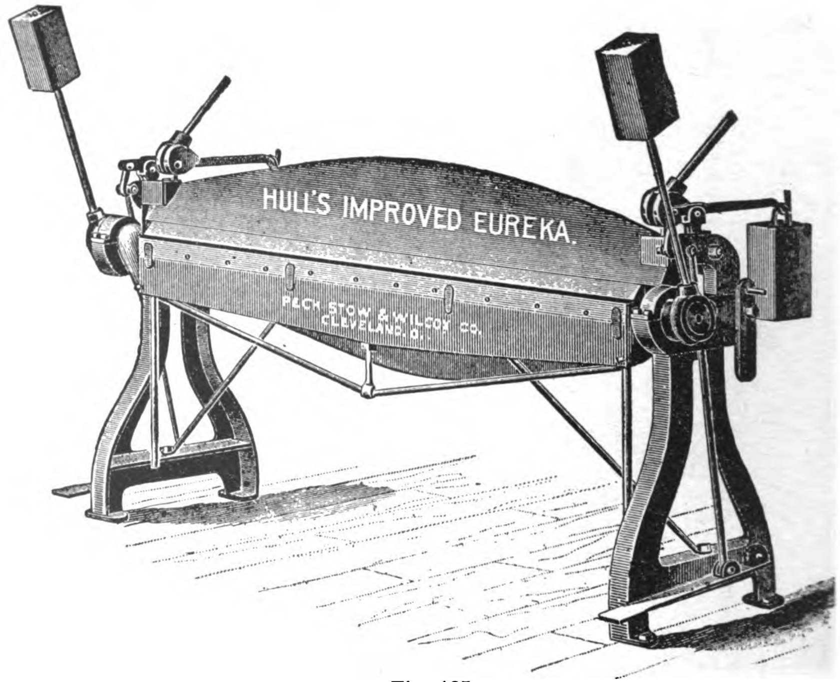


Fig. 125.

This brake is warranted to bend No. 20 iron perfectly straight its entire length without springing. It is easily and quickly operated. Seven formers are furnished with each machine for making circular bends.

Folding Machine. As now made, the machine shown in Fig. 126 will turn locks of different widths on any length of sheet. To turn an edge longer than the length of the machine, use the round rod, placing it so that the sheet will be put into the machine over it and

Fig. 126.

turn the folding bar against its round surface, making a slight bend the entire length of the sheet, and repeat this operation of bending until the lock is finished, or far enough to close it down in the ordinary way. In turning edges on long sheets it will be well to turn the edge slightly at first and repeat the process of bending until finished. To turn wider locks than the depth of the folding plate use the steel strips under the plate to increase the width, and operate the machine in the same manner as without them.

Sheet-iron Folding Machine. The machine shown in Fig. 127 has an improvement consisting of a round steel rod, against which the fold is completed, thereby preventing the edge of the frame from being worn off,

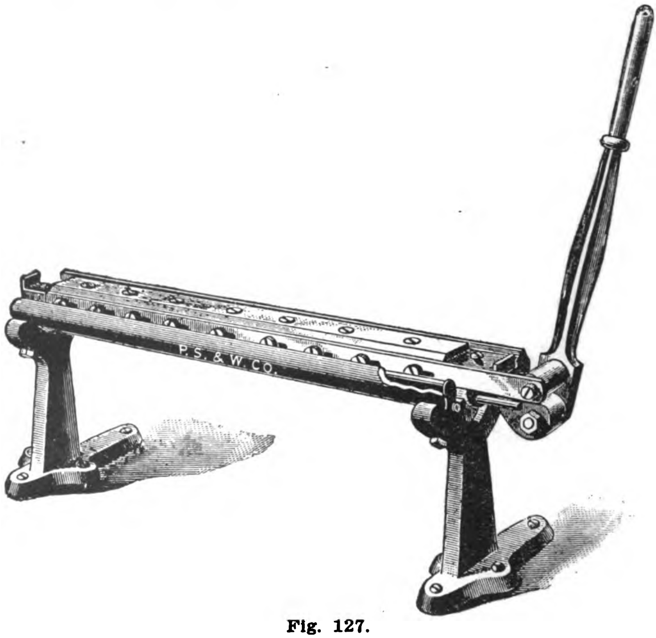


Fig. 127.

thus rendering the folding plate more durable and insuring a lock of uniform width of entire length, as variations in the hardness of the material will have no effect upon the uniformity of the lock.

This rod can be replaced at small expense.

WORKING SHEET METAL.

The operations of flattening, raising, spinning and bending sheet metal depend for their success upon the malleability of the metal so treated. There are few vessels the figure of which are so complicated and intricate that they cannot be worked into shape. A high degree of skill is required in this class of work, and the best work must necessarily be done by hand.

Flattening. The flattening of thin sheet metals is effected as in principle the other operations are performed, by causing certain parts of the metal to glide or spread over other parts immediately adjacent, so that parts which are tense by comparison with parts adjacent become loosened and extended to approximate to the condition of the parts adjacent, until all parts are in equal condition of tension. This is done by hammering the parts in tension, by means of what are termed solid blows, so spreading or extending the metal laterally, and allowing the bulged or loose parts room to expand or spread out. It would not do to hammer the loose or bulged portions, because that would increase the bulge by spreading or enlarging the area or curvature of the bulged portion. The metal there is bulged because it is prevented from expanding by reason of the tight parts adjacent, and the only way in which the bulge can be removed is by just giving it room to spread out, and this can only be effected by removing the excess of tension from the parts adjacent, so allowing them to spread out away from the bulge, leaving the latter free to expand into a true plane. A very minute amount of bulging is sufficient to cause buckle in a plate, the term buckle being commonly used to signify the condition of local tension and bulging, but however minute the degree of difference, nothing save the removal of the local tensions by hammering or by rolling will produce a true and level plate. The condition of buckle, even when slight, is easily recognized. When of considerable extent, it is recognized by the straightedge, or by casting the eye across the surface. Even when slight in extent, it can be recognized by the bending of the plate backwards and forwards, when if buckled there is a lack of elasticity evident to the practised hand and ear. There is the feeling that the continuity of the plate is broken, and a whip-like sound as of crackling or flapping.

The term solid, or opposed blows, signifies that the blows are delivered upon the plate between two hard, unyielding, and strictly opposed surfaces, as the face of the hammer and the face of the anvil. These blows invariably compress, and thin, and extend, or spread, and also harden the metal. The term is used in opposition to hollow blows, in which the metal is struck upon a yielding body, or with no body beneath it, the effect in this case being the reverse of the previous, the metal being bent, thrown up, or thickened. In much raised work the blows are of a dual character, partly solid, partly hollow, as when it is desired to produce curvatures without altering the thickness of the metal.

Raising. The formation of curved, dished, or hollow vessels by the process of raising depends for results upon the malleability of the metal. If a metal or alloy were rigid in the same sense of degree that a piece of cast-iron or tempered steel is rigid, then the formation of a curved surface by hammering would be impracticable. Cast iron and tempered steel are not malleable, from the practical point of view. In other words, the particles of which they are composed are so hard, rigid, and crystalline that they possess no faculty of relative movement over one another, no property of gliding, or viscosity. Therefore they do not yield under the hammer, but fracture only. The property of malleability possessed eminently by copper, and in a lesser degree by some other metals and alloys, is one to which there appears to be no limit in practice, to the alterations in form which are practicable by the simple process of hammering, provided due annealing is resorted to, sufficient in amount to counteract the brittleness induced by hammering, and restore the original ductility. In hammering, the metal is thinned and thickened alternately, now spread out, now thrown up again at the will of the workman, and almost as if by instinct. The first operation in raising a dish or a flaring rim, is the creation of a series of puckers or wrinkles. This is the result of trying to bring a larger circle into the circumference of a smaller one, the metal possesses a sufficient rigidity to resist, and becomes waved in consequence round the edges. But these wrinkles are obliterated by the subsequent process of raising, in which the projecting flutes are set down in detail, and made to glide into the adjoining depressions, with the result that a general curve, more or less regular, is formed.

In doing such work, the blows delivered partake of the solid or dead blow, and the hollow or elastic character, the result being that the metal is not permanently thinned or thickened in different localities, but its thickness is averaged about equal all over alike. It is difficult to describe the process clearly, as it is a matter of intelligent dexterity, which the workman is better able to perform than to describe. The principles, however, are those just laid down.

The details of raising hollow work are very numerous. In the case of a vessel with flared sides, it is usual to mark a circle to indicate where the dishing is to commence. The metal is first beaten roughly down, into a hollow most suitable to the form required, which wrinkles or flutes the edges, after which the razing down commences. In many cases the wrinkling is done over the edge of a suitable stake, the metal being bent with hammer or mallet. In all but the shallowest work, the bending is done in courses, or narrow circles, or curves, the metal being annealed after the formation of each course. Frequently in repetitive work several similar pieces are hollowed at once. The pieces are secured together by the outer sheets being prolonged to form clips for the temporary embracement of the inner sheets. The accuracy of the work is facilitated by turning the sheets round upon one another from time to time, in order to correct inequalities.

The raising is done in courses or circles, and the term "raising a course" is applied to each successive operation of this kind. The effect is the same as when metal is spun in the lathe, only that the hammer takes the place of the burnisher. In each case the metal is stretched, and thinned, or thrown up, and thickened, becoming accommodated to the new form imposed upon it by burnisher or hammer.

Obviously, therefore, in raised metal work, a rearrangement of the particles of metal must take place, the relative disposition of its molecules must be changed, notwithstanding that the total area remains the same, or nearly the same, and the thicknesses should also be practically the same all over. In all work of this character, therefore, the piece of metal required to produce a given form should be cut approximately the same area as that of the finished work, so that there shall be no excess and consequent waste or shortness of material, or inequality of thickness. In raising work in successive courses thus, the wrinkles or flutes which are outside in one course are made inside in the next course, in order that the hammer shall work equally on the inside and outside of the vessel. After a vessel has been raised, the marks left by the hammers are obliterated, either with a smooth-faced hammer or with a wooden mallet.

Spinning. In the art of metal spinning, the thin sheet of malleable metal or alloy, cut to the form of a flat disc at first, is bent into concentric curves by means of gentle and continuous pressure applied with a blunt but perfectly smooth burnisher held against the disc during its revolution in the lathe. The burnisher thins and spreads and thickens according as it is moved from center to circumference of the spinning sheet, or the reverse way, both movements being made to alternate, at will, according as the metal requires spreading, or thickening. The pressure is necessarily heavy. There are only three or four types of burnishers used, one, a plain round rod with a rounding end, another having its end shaped of a more or less globular form, another curved something like a machinist's curved burnisher, another flattened and rounded at the end. These are made of hardened steel and perfectly polished in order not to scratch the work. The lathe used for this work is of special construction. Wooden chucks or forms are turned of suitable shapes for the jobs in hand, and mounted on the face-plate of the headstock, and the thin sheet metal is gradually forced to take the outlines of the forms by continuous pressure exerted by the burnisher. Much of the work is done by a double-action of burnishers, and sticks or rubbers acting on opposite sides of the sheet, so bending it to double curvatures, and lessening the tendency of the work to chatter or wobble. The lathe-rest is fitted with pins, which afford fulcrums for the different positions of the burnisher and rubber, and the work is held by pressure on the center between the chuck and a holding-block, cupped holder, or other suitable means thrust against it by the tailstock. As the work is advanced the burnisher is moved along, taking its leverage from successive pins as suitable fulcrums, from which to operate the sweep of the burnisher forward and backward.

Stamping. In the work of spinning, the metal is stretched and bent as in bending rolls, the bending and stretching taking place, however, in concentric circles instead of in a cylindrical form. Very intricate shapes can be produced in this way, including the turning over and wiring of edges. It is, however, practicable only with very thin sheets. When comparatively thick sheets have to be operated on, then quick curvatures can only be imparted by hammering or by stamping. Spinning is frequently resorted to in order to finish work already stamped roughly to shape in dies. Thus the common hand-bowls used for washing are made by first stamping in a press, which brings them nearly into shape, but leaves a lot of pucker marks from the stamps. The bowls are then put in the spinning lathe, and the puckers all removed with steel burnishers. The concentric rings seen on these bowls when new are the marks left by the burnishing tool.

Spun work of awkward outlines, in which there are considerable differences in diameter, is usually made in two or more pieces, spun separately and soldered together. The easiest material to spin is white metal. The edges of round tins are squeezed over by means of rollers or discs. Among work so treated are tea cannisters, gunpowder cans, biscuit tins, gasoline cans, and tins and cans of any shape, rectangular, hexagonal, or oval. Square irregular tins have tops and bottoms crimped on by a squeezing machine with four jaws, which run up at the same time and fasten the tops or bottoms instantly at one blow.

There is a large class of machines employed for the formation of beads on traveling trunks and similar articles, and for folding or bending work, these operations being performed sometimes on separate machines, sometimes on a machine which combines both functions. By the setting down of the top rollers the required curvature lengthwise is imparted to the beading in course of formation. In some machines splitting cutters are added for dividing such beads down the center. Of kindred types are the cramp folding machines, and the guttering machines, used also for bending sheet metals into numerous forms. By means of dies and formers, pipes, ridge caps, and spouts, in diverse forms are readily bent. These machines are made to be operated both by hand wheel and gear, or by belt pulleys and gear. Other machines are made for bending tubes or pipes, their capacity ranging from about two and a half to ten inches bore, by from six feet to ten feet in length. The rolls are geared together and supported at several points to lessen the tendency to springing.

Small circular tins are formed and beaded on revolving rollers turned against a suitably grooved mandrel. Those other than circular are formed by pressure against blocks or forms of the shapes required.

SHEET-METAL WORKERS' TOOLS.

Blacksmiths' tools are heavy, those of sheet-metal workers are light, they are usually also longer and much more slender than those of the blacksmith. Instead of being set or fixed in an anvil, they are set in a bench, or block of wood or iron on the ground, or on the workbench.

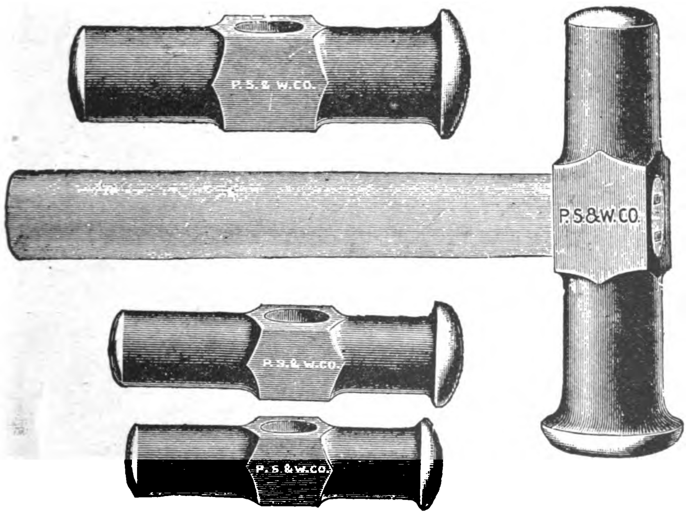


Fig. 128.

A detailed description of each tool will not be given, as by the reference to the illustrations, the uses of the tools may in most cases be inferred.

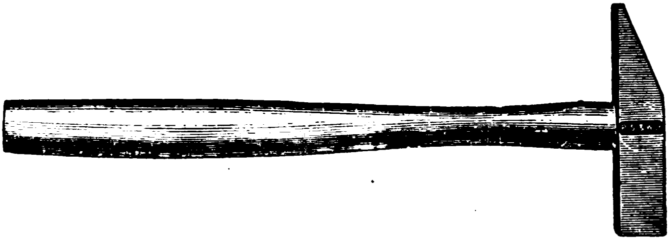


Fig. 129.

Raising hammers of various sizes are shown in Fig. 128, a setting hammer in Fig. 129, and a rivetting hammer in Fig. 130.

A set of solid punches are illustrated in Fig. 131, and a wooden mallet in Fig. 132.

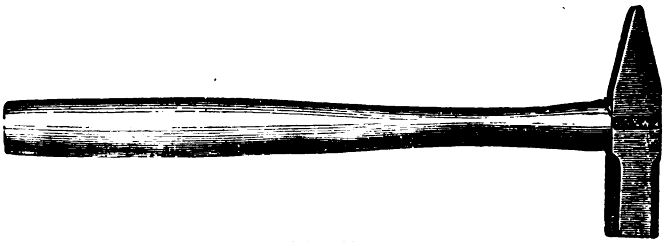


Fig. 130.

Sheet metal is shaped, principally, by being bent over anvils of peculiar forms, known as stakes. These fit into holes cut in the bench, and are of many kinds, as the following illustrations will show:

Figure 133 shows the beakhorn stake, the creasing stake which is used for making grooves for wire, the

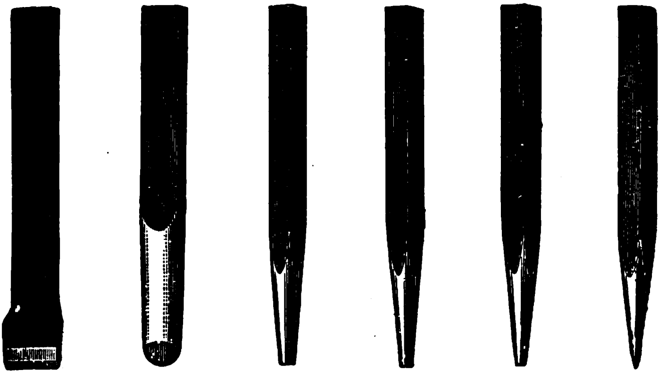


Fig. 131.

blowhorn stake, the needlecase stake, the candle-mould stake, and the square stake.

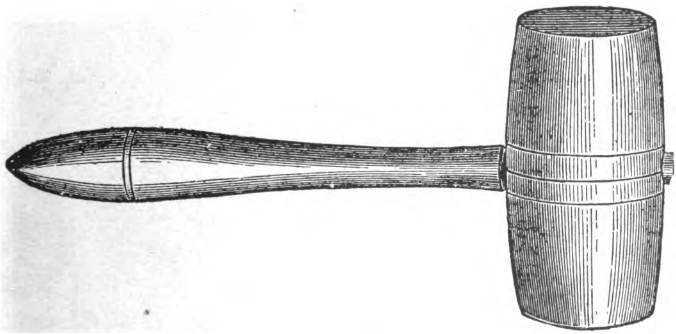
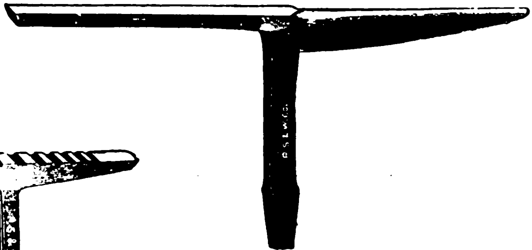
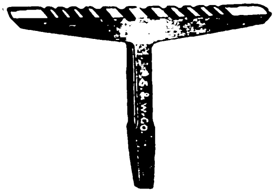


Fig. 132.

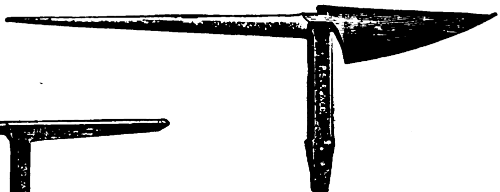
Figure 134 shows the double seaming stake, the creasing stake with horn, the coppersmith's square stake,



Beakhorn Stake.

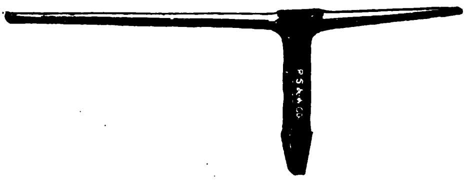


Creasing Stake.



Blowhorn Stake.

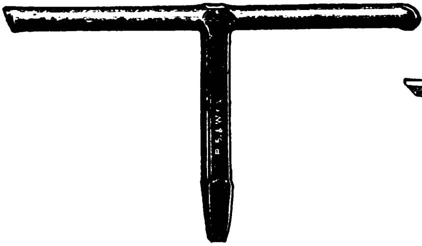
Needle Case Stake.



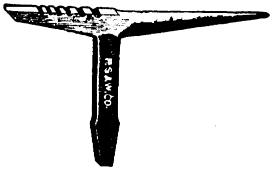
Candle Mould Stake.

Square Stake.

Fig. 133.

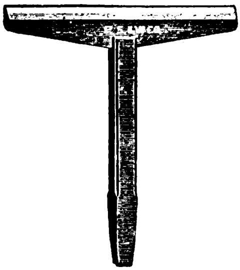


Double Seaming Stake.



Creasing Stake, with Horn.

Coppersmiths' Square Stake.



Hatchet Stake.

Bottom Stake.

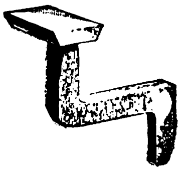
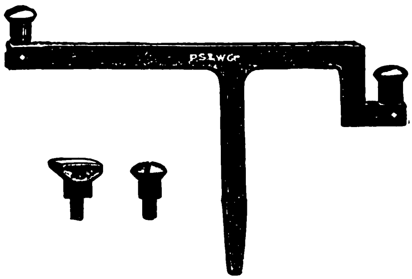


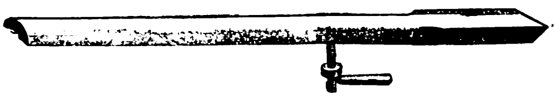
Fig. 134.

the hatchet stake, which is used for edging up tin plate, when there is no folding machines, the bottom stake and the bevel-edge square stake.

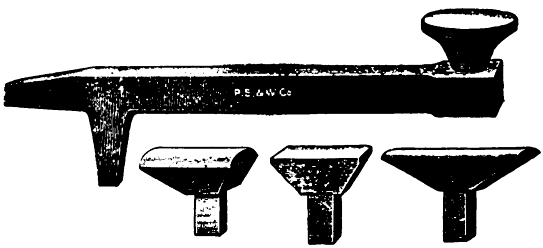
Figure 135 shows a tea-kettle stake with four steel heads, a hollow mandrel stake, and a double seaming stake with four heads.



Tea Kettle Stake, with Four Steel Heads.



Hollow Mandrel Stake.

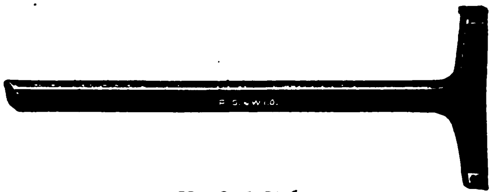


Double Seaming Stake, with Four Heads.

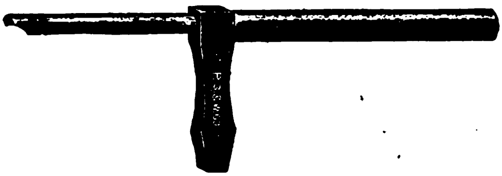
Fig. 135.

Figure 136 shows a plain mandrel stake, a conductor stake, a bath-tub stake, and a round-head stake.

Sheet metal is cut to the size of the pattern as required by means of shears. These come in a variety of shapes, but those that are really necessary are the bench shears as shown in Fig. 137, for cutting up stock in large quantities. Hand shears or snips as shown in Fig. 138.



Mandrel Stake.



Conductor Stake.

Bath Tub Stake.

Round Head Stake.

Fig. 136.

Confusion often arises as to the meaning of the terms right and left hand as applied to shears. A right-hand shears is one that when held in the right hand the lower blade is on the right side of the shears, and a left-hand is one where the lower blade is on the left side

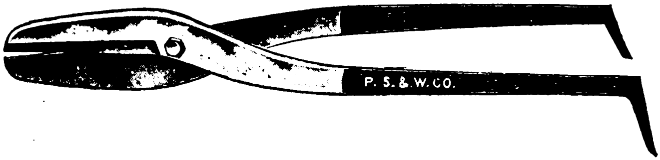


Fig. 137.

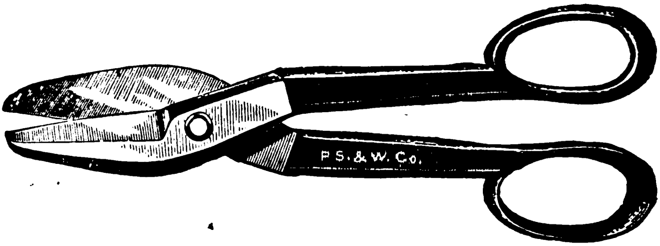


Fig. 138.

of the shears. Left-hand shears are more generally used, and are invariably sent unless right-hand are ordered.

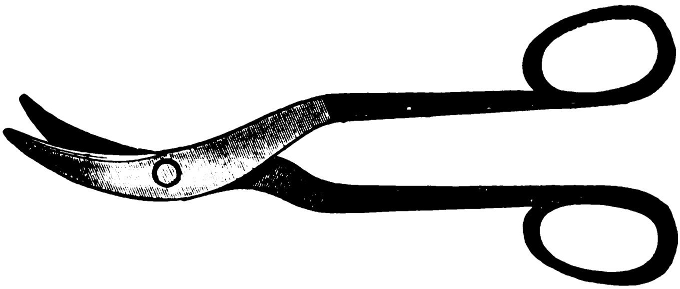


Fig. 139.

Curved shears, as shown in Fig. 139, are required for some kinds of work, it represents a curved shear of real worth and great merit. It is capable of cutting in sheet-metal openings of any kind and shape. Letters are easily cut out from sheet metal. They are especially adapted for cutting off the bottoms of metal vessels, and for cutting openings in pipes or cylinders of every description, for furnace jackets, thimbles, tee joints, etc. A bottom can be cut from a pint cup or a copper boiler with equal ease.

The double cutting shears, shown in Fig. 140, combined with a pipe crimper are well known. The blade is pointed and readily inserted in the metal at the point desired to begin the cutting. They are adapted to cutting off the bottom of pails, cans, etc., and suitable for cutting round or square work. The crimping attachment is designed for crimping any kind of sheet metal pipe, round or square. The parts are interchangeable, and the crimping jaws are of steel.

Fig. 140.

Tinners' Firepots. The firepot shown in Fig. 141 is a universal favorite with tinners. It is lined with fire brick and made in the most substantial manner. The draft door is in two sections, which economizes fuel.

The firepot shown in Fig. 142 is so constructed that the ashes fall into a pan beneath the coal, and the fire is kept clear and the draft is good. It is light and may easily be carried from place to place at the convenience of the workman.

Figure 143 represents a gas furnace for heating soldering coppers for plumbers' or tinners' use. It

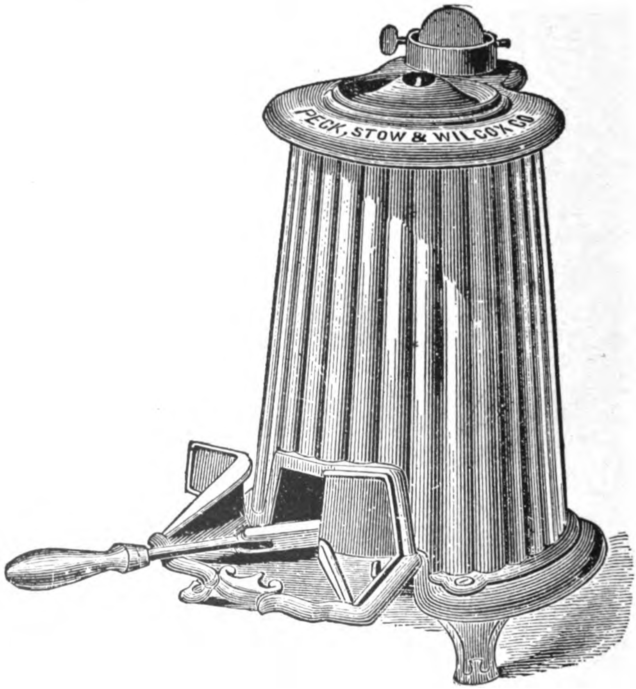


Fig. 141.

is light in weight and consumes but little gas. It economizes time, avoids dust and dirt. By regulating the aperture through which the air passes so that the flame has a blue appearance, the very hottest flame produced by gas can be secured.

Copper Soldering Bits. Soldering bits differ greatly in size and shape, according to the work to be done.

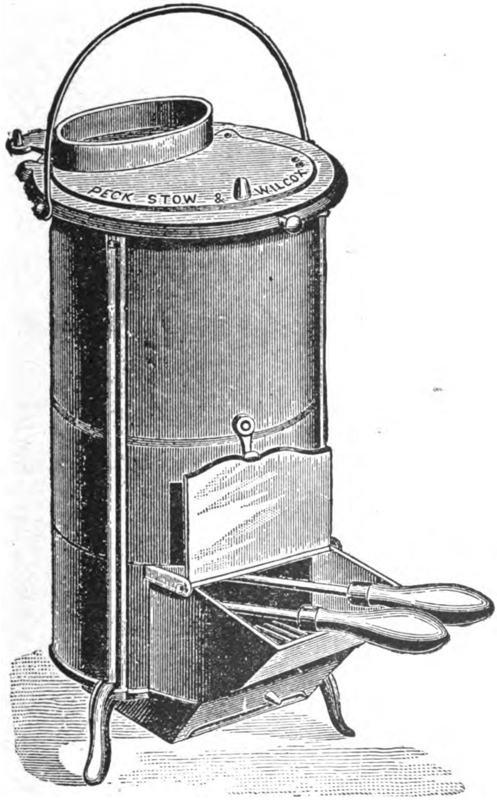


Fig. 142.

The upper view in Fig. 144 shows an ordinary pointed soldering bit such as is used for general work, the lower view shows a much lighter tool, having a bent point. A bottoming bit such as is shown in the upper view in Fig. 145 is used for soldering round the bot-

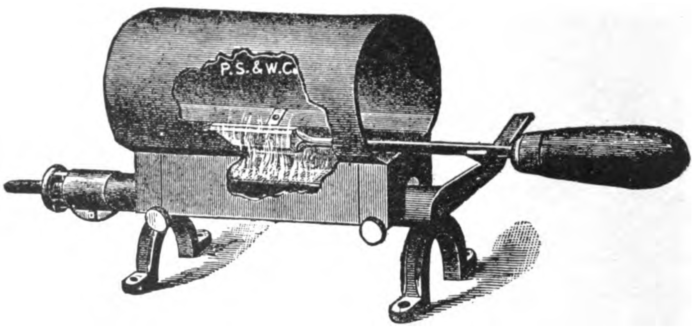


Fig. 143.

toms of saucepans and similar utensils. A hatchet bit is illustrated in the lower view in Fig. 145.

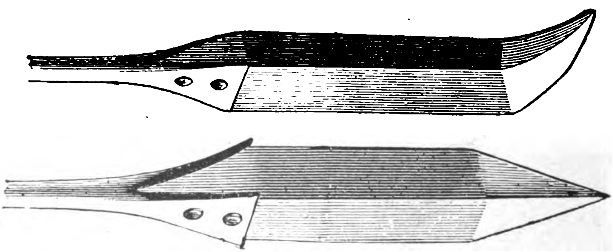


Fig. 144.

Soldering bits should have from 4 inches to 5 inches of copper, in addition to that which is riveted in the shank, as in constant usage the length soon diminishes by filing and drawing out. A copper bit that has a long shank tires the arm quickly, not only by the weight of the tool, but by the cramped position into which it throws the arm. For general use the soldering iron should be about 16 inches long from point to the ex-

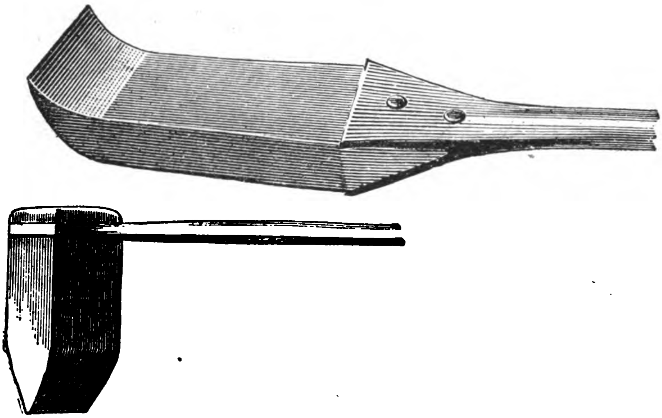


Fig. 145.

tremity of the handle. The latter should be made so as to afford a firm grasp and balance the copper bit.

THE MANUFACTURE OF TIN PLATE.

The first step in the manufacture is to cleanse the surface of the sheet steel from oxide, dust and grease. This is effected by dipping the sheets in a pickle of dilute sulphuric acid, 1 part of acid to 16 to 20 parts of water. The pickle is prepared by pouring the acid into the water, keeping the latter constantly agitated.

In small shops the pickling is done in lead-lined tanks by hand, but larger establishments employ machinery for the purpose of more rapidly exposing the surface to the acid, and then washing the acid away when the pickling is complete. The acid leaves the plate with a clean, dullish-gray metallic surface. Sometimes the action of the acid is assisted by scouring with sand and water. When no mechanical apparatus is used the plates are immersed in the acid bath for from fifteen to twenty minutes.

The cleaned plates, free from scale, are now ready for the first annealing process. The effect of the repeated rolling is to make the plates very stiff and brittle, and this has to be remedied by subjecting them to a long-continued heat and allowing them to cool slowly, this process is called annealing. The plates are piled one upon another on a cast-iron base plate, and covered over with a hood or cover to protect them from oxidation. The edges of the base plate stand higher than the rest, so that, when the cover is placed over the pile of plates, the space between the cover and the edge of the bottom plate may be luted with sand. The boxes are conveyed to the furnace by means of a low truck.

The annealing furnace has its bed on a level with the floor, several boxes being placed in it at one time. The fire-bridge is tolerably high, and the flame travels slowly over the boxes, gradually raising them to a cherry-red heat, at which temperature they are maintained for from twelve to twenty-four hours, the heat never being allowed to become so great as to cause the plates to become stuck together, or it will be impossible to separate them when the piles are removed from the boxes after cooling.

The plates are then cold-rolled between chilled rolls which have a highly polished surface and are very accurately adjusted, so that the plates may be perfectly flat and the surface finely polished. A second annealing is now necessary to remove the stiffening effect of the cold-rolling, but the temperature of the furnace is kept lower and the time is shortened to about six hours.

After having been annealed and cold-rolled, the plates are again found to be thinly coated with oxide, which must be entirely removed by a second pickling in acid, though the strength of the acid solution is very much weaker, being only 1 pound of acid to the hundredweight of plates. Scouring with sand and water is then resorted to, after which the plates are placed in troughs of clean running water. They now have a perfectly clean surface of a grayish metallic color, and can be kept in cold water without injury for some time. In all the stages so far any defective plates are carefully sorted out, but in spite of this it is sometimes found that during the process of tinning some of the plates are covered with small blisters, due to some defect in the steel.

Coating the plates with tin is the next and last operation. Cast-iron pots, some containing tin and some grease, are arranged in a row and surrounded by a flue from a fireplace. The black plates are taken up singly from the water, and placed in the first pot containing molten palm-oil until all moisture has been removed. They are then transferred to a pot containing molten tin covered with palm-oil.

After remaining a short time the plates are lifted out, and, to make the alloy of tin on the surface more perfect, they are dipped into the second tin pot containing pure molten tin. The excess of tin is brushed off each side of the sheet by means of a hempen brush, and the marks of the brush are obliterated by again dipping the sheets into pure tin in the third tin pot. The operation of tinning is completed by quickly passing each sheet from the third tin pot into the second grease pot, which contains an arrangement of rollers between which the tin-plates pass, first downwards, then upwards and out. The temperature of the second grease pot is carefully regulated, for its object is to allow the excess of tin to run off the surface of the plates, the speed of the rolls and the pressure regulate the quantity of tin left on the finishing plate. Coke plates take up about 2½ pounds of tin to the hundred pounds, being passed slowly through the rollers in the grease pot under considerable pressure, while charcoal plates have a thicker coating of about 6 pounds of tin per hundred pounds, as they are passed twice quickly through the rolls, which are adjusted to give less pressure.

To remove the grease left on the plates from the last stage of the tinning process, they are rubbed with coarse bran and then with finer bran, being finally polished with a duster made of the woolly side of a sheepskin.

Galvanizing. By galvanizing is meant merely the application of a coat of zinc which alloys with the surface of the metal to which it is applied. Thus the material known as galvanized iron is sheet steel, upon which has been deposited a film of zinc. Metal in sheet, galvanized before it is worked up, is treated generally by a method different from that adopted for vessels, utensils, etc., but there is no reason why the following process should not be suitable for galvanizing both metal in sheet and the articles into which it is formed. The success of the process, as in tinning metals, depends on the thoroughness with which the metal is cleansed previous to being passed through the molten zinc. The plates or vessels are first immersed in a warm bath of equal parts of sulphuric or muriatic acid and water, being afterwards scoured with emery or sand. They are now ready for the preparing bath, made by mixing together equal parts of saturated solutions of chloride of zinc and chloride of ammonium. The metallic bath through which they are next passed is a molten alloy of 640 parts by weight of zinc, 106 parts of mercury, and one-third part of sodium. Throw some sal-ammoniac on the top of the bath, previously skimming off any oxide that might have formed, and immerse the articles, bringing the temperature up to 680° Fahrenheit. Remove the articles directly this heat is attained, otherwise the zinc will dissolve a portion of the iron. Zinc has a great affinity for iron, and it is a good plan to partly satisfy this by allowing the molten zinc to previously act on a piece of scrap wrought-iron.

Small articles of solid iron or steel are galvanized preferably by the following method. The articles are cleansed in a revolving barrel or tumbling box containing sand, which chafes the iron and removes the scale. A solution is made by saturating with sheet zinc 10 parts of hydrochloric acid, and, when the evolution of gas has ceased, dissolving in it 1 part of muriate or sulphate of ammonia. The iron articles are heated and plunged in this solution for an instant, if of the right heat, they will dry at once on removal and be covered with crystals. Prepare a bath of molten zinc as before, removing all oxide and throwing in plenty of salammoniac to stop further oxidation. Heat the articles, dip them while quite dry into the zinc, shake off the superfluous metal, and cool in water. Small articles may be held in a wrought-iron basket when dipping into the zinc.

It may have been noticed that the process of galvanizing proper in both of these two methods is the same, the only difference being in the cleansing processes preceding the galvanizing. Two or three more methods of preparing the iron or steel for the galvanizing bath may now be noted. Immerse the iron articles for a few hours in muriatic acid diluted with twice its weight of water, and then wash thoroughly in hot water and scrub with brush and sand. The final preparation for the bath of molten zinc is immersion in a hot solution of 1 pound of salammoniac to 2 gallons of water. Dry before galvanizing. First remove all scale by passing through a bath of 1 part of muriatic acid and 4 parts of water. After brushing and scraping, pass through a fresh bath of 1 part of muriatic acid, 4 parts of water, and 1 ounce of salammoniac to every gallon of solution, and then dry in a hot oven. Scour with sand all scale and rust from the surface of the metal, and remove all grease and oil by boiling in a solution of caustic soda. Immerse in dilute muriatic acid, scrub with a metallic brush, and rinse in hot water, afterwards drying thoroughly. The molten metal is liable to spit if the article is passed into it wet. It is even possible for slight explosions to occur if moisture is left among the laps and rivets.

Perhaps the most general method of galvanizing sheet steel or iron is the one by which the metal first receives a preparatory coat of tin. The sheet metal is passed through baths of dilute muriatic acid, scoured with sand and otherwise made perfectly clean. A bath is prepared in a wooden vat by adding 1 part of a saturated solution of metallic tin in concentrated muriatic acid to 600 or 800 parts of water. The preparation of the tin solution occupies from two to three days. At the bottom of the vat is a thin layer of finely-granulated zinc, on top of this being a clean iron or steel plate, which in its turn is covered with granulated zinc, and so on until the bath is full. The zinc, iron, and solution form a weak galvanic battery, tin being deposited from the solution on the iron plates, a coat sufficiently thick for the purpose being obtained in about two hours. The plates are removed, and immediately carried by rollers through a bath of molten zinc covered with a thick layer of salammoniac mixed with earthy matter to lessen its volatilization. The speed with which the rollers revolve practically determines the thickness of the zinc coat on the plates.

Owing to the under coating of tin, galvanized plates prepared by this process have a crystalline appearance.

Not only steel and iron, but brass and copper utensils are often galvanized, there are two or three processes by which this can be done, though they are chemical rather than metallurgical. A simple method is to boil the brass or copper in a solution of chloride of zinc, adding at the same time a small quantity of zinc turnings to the solution. Another process is to cover granulated or powdered zinc, contained in a wooden vessel, with a concentrated solution of salammoniac. Heat to about the boiling point, and immerse the copper or brass articles, which should be chemically clean. A firm coating of zinc will be deposited in a few minutes.

SEAMS OR JOINTS.

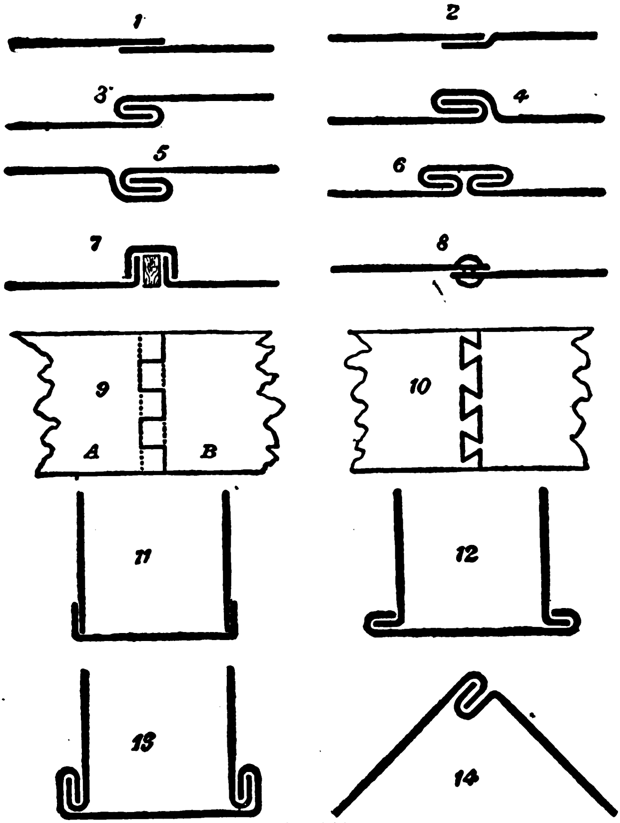


Fig. 146.

The more important seams or joints used in sheet-metal work are illustrated in Fig. 146.

Lap Seam. No. 1 shows how sheet-metal plates are arranged for a lap seam to be soldered.

Countersunk Lap Seam. This is shown in No. 2, it will be noticed that the edge of one of the plates is bent down, so that the edge of the other plate to be joined to it may lie in the shoulder formed by the part bent down.

Folded Seam. The method of preparing the edges of plates for a folded seam are shown in No. 3.

Grooved Seam. This is shown in No. 4. It may be seen that it is practically the same as No. 3, only one plate is countersunk.

Countersunk Grooved Seams. The seam shown in No. 5 is used when an unbroken surface is required on the outside of an article.

Double Folded Seam. This is shown in No. 6 and is used with thick plates, where these when joined are required to present an unbroken surface.

Zinc Roofing Joint. The joint shown in No. 7 admits of the expansion and contraction of the zinc sheets.

Rivetted Lap Seam. No. 8 shows a rivetted lap seam. The amount of lap should not be less than three times the diameter of the rivet.

Brazing Joints. A brazing joint for thin metal is shown in No. 9, the edge of plate A is cut to form laps and these laps are arranged alternately over and under the edge of plate B. A brazing joint for thick metal is shown in No. 10. It is practically the same thing as a carpenter's dovetail joint.

Circular Lap Seam. No. 11 shows how the edge of the bottom of a can is bent up previous to soldering.

Circular Folded Seams. A folded seam for a can or pail is sometimes made in the form of No. 12. Another form of circular folded seam is shown in No. 13.

Box Grooved Seam. The seam shown in No. 14 is used for joining sheets in square work, such as the ends or sides of a deed-box.

SOLDERING AND BRAZING.

To describe in detail the various operations of hard and soft soldering as adapted to various classes of work would demand much more space than could possibly be spared in this work. A clear idea of the general principles and practice involved therein will, however, be given. While there is much both in principle and practice which is common to both methods, for the sake of clearness it will be better to keep the treatment of the two distinct and separate.

Soldering in its generally understood sense signifies the close union of metallic surfaces by means of a thin film of molten metal or alloy run between the surfaces. There are two main classes of soldering, conveniently distinguished by the terms hard and soft, the first-named being known as brazing. Hard soldering is of the strongest character, requiring a high temperature, namely, a good red heat, visible in daylight, soft soldering is usually done at a temperature below that of melting lead. The hard solders are chiefly alloys of copper, and are known as spelter. Silver solders, used by the jewelers, also come under this class. The soft solders are mainly alloys of tin and lead. The proportion in which the metals are mixed to form soldering alloys are various, such variations being rendered necessary in order that a soldering alloy shall always have a lower melting point than that of the metal or alloy which it has to unite, and also in some cases to obtain as nearly as possible uniformity of color and strength between the two. Many a job has been spoiled by the use of an unsuitable solder, the work melting at the same time, or before the solder, and many a job strong in itself is rendered weak by the use of a solder too weak for it. In all cases the solder should be selected in order that it may melt at a temperature considerably below that of the materials which it has to unite, and the necessary knowledge may in some cases be obtained either directly from tables, or by experiment, in the manner to be noted presently. Moreover, the harder metals and alloys should always be united with hard solders, and the softer ones with soft solders, and then the seams will be of about equal strength with the other parts.

It is practicable to obtain a most extensive range of solders with melting points from below that of boiling water, up to those suited for copper and iron goods. The lowest melting points occur in what are termed the bismuth solders, the highest in the spelter and silver solders. An alloy of three of lead, five of tin, and three of bismuth, melts at 202 degrees Fahrenheit, one containing equal parts of lead, tin, and bismuth, at 254 degrees Fahrenheit, one containing four of lead, four of tin, and one of bismuth, at 320 degrees Fahrenheit. Such solders, and others with various melting points, are used chiefly for white metal work. Tin and lead mixed in various proportions form the most useful range of soft solders, their melting points ranging from about 380 degrees Fahrenheit to 558 degrees Fahrenheit. The commonest alloy is two of tin and one of lead, melting at 340 degrees Fahrenheit, one of tin and two of lead is plumber's solder, melting at 441 degrees Fahrenheit.

It is absolutely necessary to the intimate and perfect union of all soldered work, that metal shall unite to metal. That is, the presence of any dirt or oxide in the joint will effectually prevent a perfect union of the surfaces in contact. During the brief period of the raising of the temperature of the work to the melting point of the solder, some film of oxide will almost invariably form unless means be taken to prevent it. So that before a perfect joint can be made two precautions are necessary. One is to clean the surfaces first, the next is to keep them clean, until the solder is fused and run in. To effect the latter, a flux is used both to protect the cleaned surfaces from the action of the air, and also to dissolve any oxide which may form on the already cleaned surface. The selection of suitable fluxes is necessary to the making of a perfect joint.

The metals and alloys which are united by soft soldering are chiefly copper and its alloys, as brass, and gun metal, lead and tin, and alloys of the same, as the white metals and tinned iron and zinc. Copper, brass, and their alloys, are, however, more frequently united by hard soldering or brazing. When united with soft solder, the alloy used is about two parts of tin to one of lead, the ordinary tinsmith's solder. Tinned iron, or what is commonly called sheet tin, is united with the same solder, two of tin, one of lead, and chloride of zinc for a flux. Lead is united with a similar solder, or with others containing larger proportions of lead, but the flux used is tallow. White metal is united with solder containing two of tin and one of lead, and with chloride of zinc, or resin as flux, zinc with the same solder, and flux.

The bulk of soft soldering is done with the copper-bit, or by means of sweating on, or by wiping. The copper-bit, sometimes erroneously termed a soldering iron, is a convenient reservoir of heat for melting the solder while in contact with the work. Before using it is tinned, that is, heated to a low red, filed bright, and rubbed first with salammoniac, and then upon a piece of tin or of solder, to coat the surface, after which it is wiped with rag, or tow.

The edges to be soldered are scraped clean, and brought together, and protected with powdered resin, or with chloride of zinc, or other flux. Then the strip of solder being held in the left hand, and the copper-bit in the right, the two are brought into contact, and drawn along the edges of the work. The solder is thereby melted in small quantity, and is worked and spread and smoothed along the joint with the copper-bit. The bit must not be made too hot, or it will render the solder too fluid, and repel it.

The sweated joint is generally adopted for broad surfaces, and not for narrow edges. The surfaces are cleaned, and a thin layer of tin or of solder is spread over each, with the copper-bit. The two tinned surfaces are then brought together, and raised to a temperature sufficiently high to melt the films of metal, and cause them to unite.

The wiped joints are used for lead pipe. The melted solder is poured round the jointed pipes in quantity, and is smoothed to a rounding form with special irons, and with a well-greased pad of thick cloth.

The tinning of copper cooking utensils is akin to soldering, and is done to prevent the formation of oxide, which is poisonous. Stew pans, tea-kettles, and similar copper articles, are treated in this way. Previous to tinning, the inside of the vessel is washed with muriatic acid to remove all dirt. All trace of the acid is then removed by scouring with clean, sharp sand, and common salt, and washed in clean water. The inside is rubbed over with soldering fluid, or with salammoniac, and the outside is coated with a solution of whiting to protect the vessel from the fire, over which it is now heated. Melted block tin is poured in, and rubbed over the inside of the vessel with a wad of salammoniac. When all parts are coated the superfluous tin is poured off, and the inside wiped smoothly with a wisp of tow held in a gloved hand in the case of an open vessel, or wrapped round a wire if the vessel has a narrow mouth. Washing in clean water follows to remove any salammoniac remaining, and the article is dried in sawdust. Finally, the inside is polished with a rag and whiting, and the outside with a rag and crocus.

In hard soldering, or brazing, the parts to be united have to be raised to so high a temperature that the copper-bit is of no use, but the heat of a coke or charcoal fire, or in some cases of the air-blast, is employed. Moreover, since the work takes some time to execute, and because it is raised to so high a temperature, it is usual to secure the parts with soft iron wire, called binding wire. The flux used is borax, a compound which dissolves almost all oxides and earthy impurities that are likely to form on the joint. The hard or spelter solders mostly contain zinc, and the eye partly judges of the completion of the joint by the blue flame which accompanies the volatilization of the zinc. The spelter is granulated, and the borax is pounded fine. The two are mixed, and applied together, or separately, and sprinkled or spread along the joint. The heat is applied very gradually in order that the ebullition or boiling up of the borax, due to driving off of its water of crystallization by the heat, shall not displace the spelter from the joint. Afterwards the heat is increased, and at a low red the borax fuses, and at a bright red the solder fuses, and runs quickly into the joint. After covering or charging a joint with borax first and spelter afterwards, the water in the borax is slowly dried off, and if any borax has spread beyond the joint, this should be wiped off to prevent the spelter spreading farther than is necessary.

SOLDERING FLUXES.

Substances that aid the flow of metals when melting or melted are termed fluxes. The general subject of fluxes is outside the province of this work. But special interest is taken in soldering fluxes, those fluxes that facilitate the flow of the solders and of the metals of which they are composed.

This fluxing consists in the prevention of the formation of oxide to which metals are very prone when highly heated or melted. The black scale that forms on the surface of copper, for instance on copper-bits, when highly heated, is an oxide, also the scale that falls off red-hot iron when hammered, and the dross that forms on the surface of melted lead or melted solder.

Charcoal is used for the purpose of preventing the formation of dross in the preparation of solder. Sometimes a layer of it is spread over the surface of the melted metal to keep it from contact with the air, sometimes a layer of grease.

In aiding the flow of metals, fluxes are further applied to the surface of the metals to be soldered, which they clean, as well as aiding the flow of the melted solder when that is applied.

Spirits of salts, muriatic acid, when killed is a most useful flux for soft solders. The killing is done by dissolving zinc in the acid till gas is no longer given off, As the gas is most offensive, the dissolution of the zinc should be effected in the open air. This flux is not one to be used where rust would be serious, though there is very little danger of this, if, after soldering, the joint is wiped with a clean damp rag, and further cleaned with whiting.

Rosin or rosin and oil is a good flux for almost any kind of soft soldering. The surface to be soldered must, however, be well cleaned before applying the flux.

Killed spirits of chloride of zinc is specially useful for tin-plate soldering, because it assists in cleaning the edges to be joined, while if rosin, or rosin and oil, is used, the edges must, as stated, be cleaned previously.

Spirits of salts not killed is used for soldering zinc because it cleans the surface of the zinc, it acts as chloride of zinc, for this is what it becomes on the application to the zinc, in fact the cleaning is the result of this chemical action. The killed spirits, however, answers equally well as the strong acid if the zinc is bright and clean. The unkilled spirits of salts is improved, as a flux for soldering zinc, by adding a small piece of soda to it.

Powdered rosin, or rosin and oil, as a flux, possesses the great advantage over chloride of zinc, that there is no risk of rust afterwards. For this reason rosin, or rosin and oil, is much used in the manufacture of gas-meters. It is also used, or should be, for the bottoms and seams of oil cans. The rosin and oil flux can easily be wiped off joints immediately after soldering, it is for this reason better than dry rosin which has to be scraped off. Even this trouble, however, can be got over if the hot copper-bit is dipped in oil before application to the joint to be soldered.

In tinning a copper-bit, that is, coating its point with solder before using it in soldering, the best thing to use is a lump of salammoniac. In a small hollow made in the salammoniac, the point of the bit, after having been filed smooth and bright, should be well rubbed, while hot, along with some solder, the point of the bit will then become coated with solder. For tinning copper utensils, that is, coating them with tin, salammoniac both in powder and lump is largely used. Salammoniac water is also used for cleaning copper-bits, the hot copper-bits being dipped into it prior to being used for soldering. Killed spirits, however, acts better. Salammoniac and rosin, mixed, is used as a flux for soldering sights on gun-barrels.

As a flux for lead soldering, plumbers use tallow.

For hard soldering, the flux is borax. This flux is also made use of in steel welding.

TINNING AND RE-TINNING.

The object of covering the surface of a piece of sheet metal with tin is to protect the sheet from chemical action. In the case of iron, tinning prevents oxidation, in the case of copper cooking vessels, it protects the copper from the action of acids, which might prove injurious to health.

To insure the proper union of alloying of the tin with the iron or other surface to be covered, this surface must be made perfectly clean, and to assist the flow of the melted tin over it a suitable flux must be employed. According to the purpose for which the sheet metal under treatment is to be used, it has to be tinned on one or on both sides. If the sheet is to be tinned on one side only, the tin is placed, either in a melted or a solid state, on the cleaned surface, and heat, from a forge fire or a gas blowpipe, is applied to the under surface, so as to heat the sheet of metal to a temperature sufficient to keep the tin melted if already melted or to melt the tin if this is applied solid. Greater care is needed with the flux when the tinning is on one side only than when on both sides, because there is a tendency for fluxes such as chloride of zinc to dry and form a skin on the surface of the sheet before the tin has time to cover and unite with it. Hence fluxes such as salammoniac, rosin and tallow are the most suitable fluxes. Where a sheet has to be tinned on both sides the like care is not required, as it can be dipped bodily into molten tin. Care is required, however, that the sheet metal to be dipped is not wet or damp or even very cold, for if it is the tin will fly out, perhaps even to the serious injury of the operator. The sheet should be dipped gradually so that any dampness is steamed off and the sheet warmed before it is finally plunged and submerged in the melted tin.

Re-Tinning Copper. In the re-tinning of copper saucepans and other vessels that have been used for cooking, they should first be warmed and all grease, especially near rivets, carefully wiped off. They can be cleaned by scouring thoroughly until bright with either wet forge scale, or better still, silver sand which has been moistened with lemon juice, and which may be applied either with a cork to secure friction, or with a piece of rough moleskin, or with tow or similar material. It is sometimes necessary, when articles are very dirty and where there are rivets, to first clean them with warm killed spirits before scouring thoroughly bright. In the case of copper moulds, it is often difficult and inconvenient to thoroughly scour the inside crevices. It will be found very helpful in such cases to half fill the moulds with a solution of equal parts lemon juice and spirits of salts, and after a few minutes to rub with a strip of cork. This greatly assists in securing a perfectly bright surface. Better results are obtained with the mixture of lemon juice and raw spirits of salts than with either of these liquids separately. When the vessel to be re-tinned has been thoroughly cleansed, it should be well washed for about a minute with chloride of zinc, and then if it is to be tinned on both sides, it should be gradually and carefully dipped into a bath of melted tin. For re-tinning a vessel on one side only it is advisable to prepare the surface that is to go next the fire by coating it with a mixture of wet whiting and salt, as the untinned part can then be cleaned more readily afterwards. The vessel being placed on the fire, the tin is applied melted or solid. If melted or after melting, a little fresh mutton tallow or a little powdered rosin or powdered salammoniac may be dusted over the surface to prevent oxidation. Then the vessel should be moved about gently so that the melted tin passes over the whole of the surface that is to be covered. If there are any spots to which the tin does not readily adhere, it may be wiped over them by means of a piece of tow or by a piece of rod wire that has been previously prepared by being coiled up at one end and tinned. It is useful to have at hand a lump of salammoniac to make similar use of, wiping as it were with it the tin over the spots that do not readily cover. A large cork is also handy to rub the tin over the surface that does not willingly take it. The tin invariably clings about the edges of the vessel, and forms a list which must be shaken off. If it will not shake off, it must be wiped off gently and quickly with a piece of moleskin cloth, this is better than tow. When tinned either on one or both sides, the vessels should at once be washed with hot water, dried with bran, and polished bright, and it is important that this should be done immediately after the tinning if a bright surface is to be insured. Scouring and pickling liquids may be drained off and saved, and used over and over again, as well as the sand, which will settle at the bottom.

Re-Tinning Wrought Iron. Wrought iron is more difficult to tin than copper, and the surface requires longer time to prepare it to take a coating of tin, and the preparation is more troublesome. The article to be tinned should be heated to redness and afterwards placed in dilute sulphuric acid for about twelve hours and then immersed in killed spirits for about six hours, or, if the article cannot be annealed then it should be pickled in muriatic acid for twenty-four hours and afterwards immersed in chloride of zinc solution in which salammoniac has been dissolved. In either case, if there are patches on the surface which are difficult to clean or tin, it will be advantageous to well rub them with a piece of wet pumice stone. A wrought-iron stewpan which has been previously tinned and is in fair condition, may only require warming to clean off the grease, and judgment must be used as to the length of time required for the pickling, the article being examined at intervals to see whether the surface is clean and bright. The wrought-iron vessel thoroughly cleaned by either method, should now be gradually dipped in a bath of molten tin, and allowed to remain there for two or three minutes. If required to be tinned on one side only, the tinning may be done in the same way as already explained for copper.

Re-Tinning Cast Iron. Cast iron is most difficult to tin, and for this reason no attempt should be made to re-tin cast-iron cooking vessels, as it pays better to substitute new ones. If cast iron is to have anything like a good appearance when tinned, it must not be spongy, and its surface should be rendered smooth either by grinding, filing or machining, whichever it is most convenient to do. If possible the casting should be made red hot, and then pickled for twenty-four hours in slightly diluted muriatic acid, and immediately on being removed should again be completely immersed for about two hours in a solution of chloride of zinc. If the casting cannot be made red hot, it should be immersed for about ten minutes in dilute sulphuric acid and warmed to about 90 degrees Fahrenheit, then pickled in muriatic acid for two days, and afterwards allowed to soak for two hours in a mixture of chloride of zinc solution and salammoniac, about two ounces of the latter to a gallon of spirits.

The casting, by whichever method cleaned, is now ready to be dipped gradually into the tinning pot. Should it not be sufficiently tinned the first time, the surface should be well rubbed with a piece of cork directly the casting is withdrawn from the melted tin, and be again dipped in the chloride of zinc solution and then once more into the tinning pot. Sometimes it is required to tin a part of a casting and to use the copper-bit. When such is the case it is essential that the surface be cleaned and smoothed by scraping or otherwise, then soaked with raw spirits of salts, and then with chloride of zinc solution in which salammoniac has been dissolved. Then the tin should be applied by means of the copper-bit, and a piece of cork used to rub in the tin where there is a difficulty to get it to adhere. Tinning in this way, though not so strong as tinning in the way just described, is sufficiently effective for most purposes.

PRACTICAL PROBLEMS IN SHEET-METAL WORK.

To describe a pattern for a square tapering article. The plan and vertical height or elevation are shown in Fig. 147. Draw the diagonals and take the distance from the center **a** to **b**, and mark off the same from **g** to **d**. Take the distance from **a** to **l** or **k**, and mark off the same from **h** to **e**. Draw a line through the points **d**, **e**, to cut the perpendicular line at **f**. Then draw the perpendicular line **af**, Fig. 148, and take the radius **fd**, Fig. 147, and with it

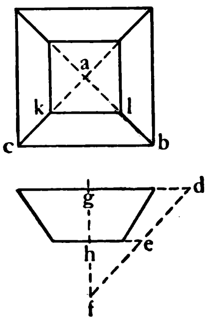


Fig. 147.

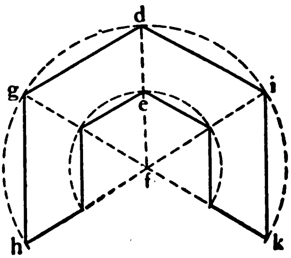
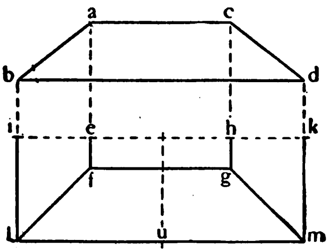


Fig. 148.

describe the arc of a circle **hdk**, Fig. 148. With the radius **fe** in Fig. 147, and with **f** in Fig. 148 as a center, draw the smaller arc **e**. Take the length of one side of the base from **c** to **b**, Fig. 147, and mark off the same four times on the circle **hdk** at **h, g, d, i, k.** Draw through these points to the center **f,** join these points **hg, gd, di,** and **ik.** Also join the points on the smaller circle in the same manner, which will complete the pattern.

To describe the pattern for a rectangular taper-sided tray. The vertical height and one-half the plan are shown in Fig. 149. Draw the horizontal line **bd** and the perpendicular line **op** as in Fig. 150. Draw the

Fig. 149.



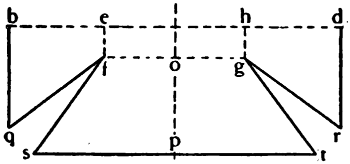


Fig. 150.

rectangle **efgh** the same size as **efgh** in Fig. 149. Take the length **ab** as in Fig. 149 and mark off a corresponding distance from **e** to **b**, **h** to **d**, and **o** to **p**, as in Fig. 150, and draw through the points **b, p,** and **d** the lines at right angles as **bq, st,** and **dr.** Transfer the length **il** to **bq** and to **dr,** also the length **ul** from **p** to **s,** and from **p** to **t.** Then draw the lines **qf, sf, tg,** and **rg,** which will complete one-half of the pattern.

To describe the pattern for a hexagon tray with tapering sides. The elevation and one-half the plan are shown in Fig. 151. To develop the pattern draw the perpendicular **bc**, Fig. 152, and draw the half-hexagon **efghi**, of the same size as **efghi** in Fig. 151. Divide the lines **hg** and **gf** into two equal parts and draw the lines **ak** and **am** through the points of bisection, then carry the length **ab**, Fig. 151, from **l** to **k** in Fig. 152. Draw through **k** the line **no** parallel to **hg**. Then take the **kl**, Fig. 151, and mark off the same from **k** to **n** and from **k** to **o**, and draw the lines **hn** and **go**. Proceed in the same manner to draw the remainder, which will complete one-half of the pattern.

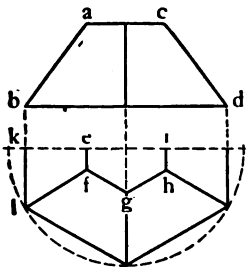


Fig. 151.

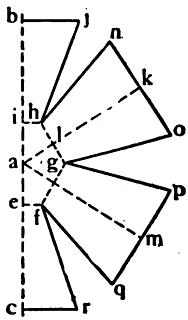


Fig. 152.

To describe the pattern for a diamond-shaped tapering body. The plan for the size and shape of top and bottom and the vertical height **fi** are shown in Fig. 153. Transfer the lengths **ac** and **ae** from **f** to **g** and **f** to **h** respectively, also the distances from **a** to **b** and **a** to **d**, to **il** and **ik**, and draw through **g** and **l** a line to cut the perpendicular at **m** and another line through **h** and

k to **m**. With the lengths **mg, mh, ml,** and **mk,** Fig. 153, as radii, describe the curves **g, h, l, k** from the center **m,** Fig. 154. Transfer the **ec,** Fig. 153, from **g** to **r** and from **g** to **n,** Fig. 154, also from **n** to **o** and **r** to **b,** and draw lines from **r, b, n,** and **o** to the center **m.** Connecting the points **br, rg, gn,** and **no,** also **ds, sl, lt,** and **tu** will complete the pattern.

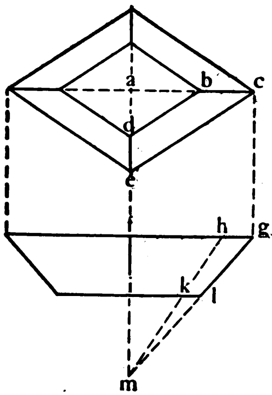


Fig. 153.

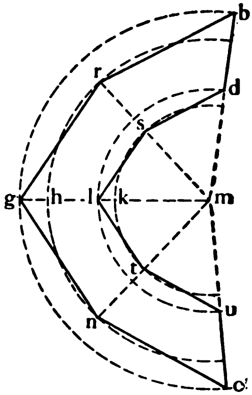


Fig. 154.

To describe the pattern for an oblique pyramid. The lengths of the sides are shown projected, **a′b** to **Cb′,** and **a′a** to **Cc′** giving for the true lengths **a′b′ and a′c′.** Take the length **a′c′** in Fig. 155, and with it strike the radius **a′c** in Fig. 156. With the length **a′b′** in Fig. 155, strike the radius **a′b** in Fig. 156. Take the length of one side as **ba** in Fig. 155, and set it off from **e** to **a,** and from **a** to **c,** from **c** to **b,** and from **b** to **e.** Connect the points of intersections of the arcs by means of straight lines as **ae, ac, cb,** and **be.** Also **a′** with **e** and **e,** and the outline will be described.

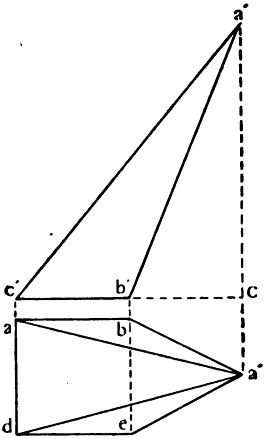


Fig. 155.

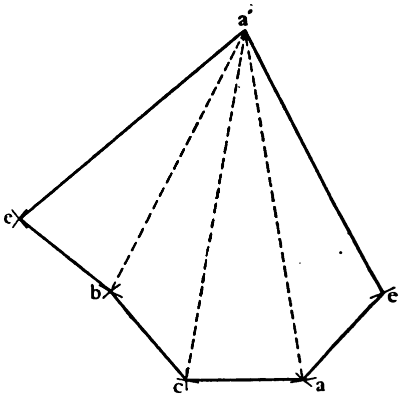


Fig. 156.

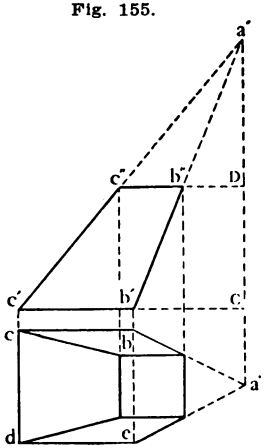


Fig. 157.

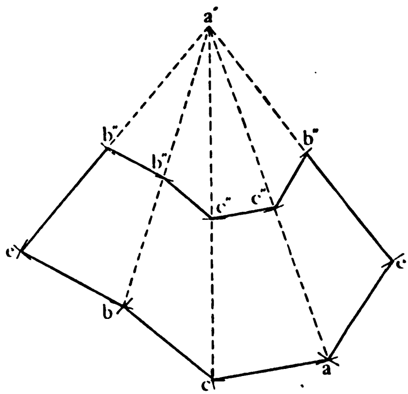


Fig. 158.

To describe the pattern for an oblique truncated pyramid. The correct lengths of the sides are shown projected in Fig. 157 as in the previous figure. The lengths **ab″, ac″** on the plane **D,** are also the correct lengths for the sides of the small end of the pyramid. In Fig. 158 the outline of the base is developed precisely the same as in the previous example. To develop the top edge, the lengths **c′c″** in Fig. 157 are transferred to **ac″, cc″** in Fig. 158, and the lengths **b′b″** in Fig. 157 to **b′b″, eb″** in Fig. 158. Connecting these points with straight lines gives the outline of the pattern.

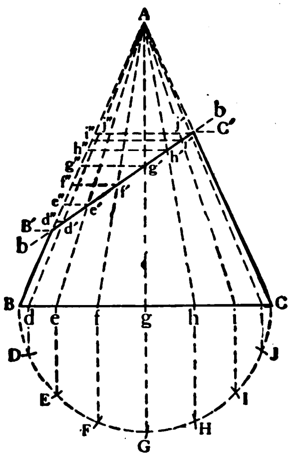


Fig. 159.

To describe the pattern for a cone cut in elliptical section. Fig. 159 shows the cone at **b-b,** the cut section forming or having the shape of an ellipse and Fig. 160 is the development of the lower part of the cone. Let **ABC,** Fig. 159, represent the outline of the cone. Strike a semicircle **BGC,** equal in radius to half the length of the base **BC,** and divide it into any number of equal parts as **B, D, E, F, G, H, I, J, C.** Carry perpendicular lines up to cut the line **BC** in **d, e, f, g, h, i, j,** and draw lines from these points to the apex at **A.** They will cut the diagonal **b-b** at **d′e′f′g′h′i′j′,** then carry horizontal lines from these points to meet the slant edge **B′A** in **d″, e″, f″, g″, h″, i″, j″.** Then the lengths **Bd″, Be″, Bf″, Bg″, Bh″, Bi″, Bj″,** will be the actual lengths of the lines **dd′, ee′, ff′, gg′,**

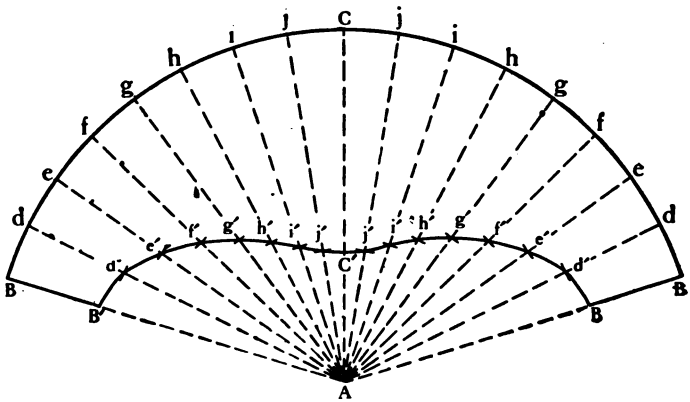


Fig. 160.

hh′, ii″, jj″ in Fig. 160. To describe the pattern take the length **AB** as a radius and strike an arc of a circle as **ABCD.** From the point **C** set off to the right and left the points **J, I, H, G, F, E, D, B,** using the lengths of the points of division in Fig. 159. Draw lines from the points of division to **A.** On these lines set off the projected lengths from Fig. 159 thus: Take the length **CC′** and set off from **C** to **C′** in Fig. 160. Take the length from **B** to **j′** and set it off from **j** to **j′** in Fig. 160. Take the length **B** to **i″** and set it off from **i** to **i′,** and so on. A curve drawn through the points **c′**, **j′**, **i′**, **h′**, **g′**, **f′**, **e′**, and **d′** to right and left will give the shape of the pattern.

To describe the pattern of a round elbow at right angles. Draw **ABCFED**, which is the size of the elbow required. On the line **CF**, Fig. 161, strike a semicircle of the same diameter as the pipe. Divide the semicircle into any number of equal parts as **a**, **b**, **c**,

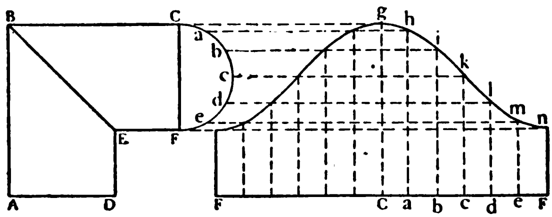


Fig. 161. **Fig. 162.**

d, **e**. Draw the line **FF** and make it equal to twice the length of the circumference of the semicircle in Fig. 161, by setting the parts **a**, **b**, **c**, **d**, **e** from **C** to **F** and **F** on each side, and draw the perpendicular lines **Fn**, **em**, **dl**, **ck**, **bi**, **ah**, **Cg**. Extend the line **BC** to cut the perpendicular **Cg**, and draw lines from the points **a**, **b**, **c**, **d**, and **e** in the semicircle to cut the perpendiculars at **h**, **i**, **k**, **l**, and **m**. Draw a curve through all the points of intersection, as **n**, **m**, **l**, **k**, **i**, **h**, and **g**. This will form the curve for half of the pattern.

To describe the patterns for two pipes which intersect at an angle. Let **DAEC** represent the larger pipe, and let **HFJG** be drawn to the required size of the pipe that is to be connected with it at any desired angle. Draw the line **FG**, Fig. 163, at right angles with **FH**, on **FG** describe a semicircle, and divide into any number of equal parts, as **1, 2, 3, 4, 5,** draw lines through these points at right angles with **FH.** Then describe a semicircle **ABC** representing the diameter of the larger

Fig. 163.

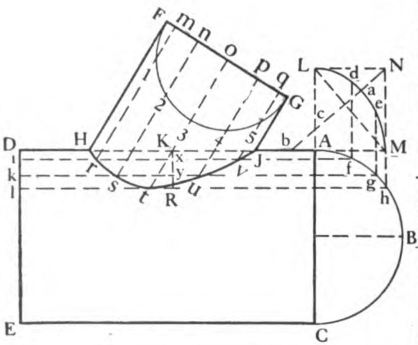
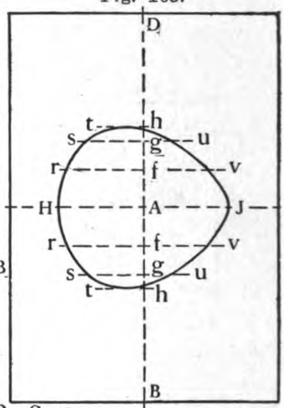


Fig. 165.



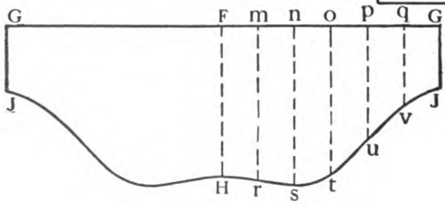
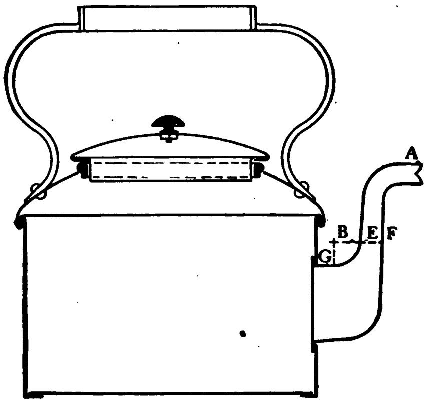


Fig. 164.

pipe, and extend the line **DA** to **M** and **CA** to **L,** take the radius **OF** of the smaller semicircle and from **A** mark off the same distance to **M,** then take the half length of the base of the smaller pipe as **K** to **H** or **H** to **J** and mark off a like distance from **A** to **L.** A quarter of an ellipse is required as shown from **L** to **M,** the radius of which may be obtained in the following manner: Draw a line from **M** to **N**, also one from **L** to **N** at right angles, and draw the diagonal line **LM**; draw a line from the point **N** to cut the diagonal **LM** at right angles, producing the points **c** and **b**. With **c** as a center and radius **cL** draw a curve from **L** to **a**. With **b** as a center and radius **ba**, draw the remainder of the curve from **a** to **M**. Divide the curve from **L** to **M** into three equal parts, and then draw perpendicular lines from these points to intersect the semicircle **ABC**, as **df, eg, Mh**. Draw lines parallel to **AD** from **f** to **i, g** to **k**, and **h** to **l**. The points where these lines are intersected by the lines drawn from the semicircle on the smaller cylinder will be the points through which to draw the curve **r, s, t, w, v**. Draw the line **GG**, Fig. 164, equal to the circumference of the smaller pipe, or to twice the number of divisions in the small semicircle. Divide one-half of **GG** into six equal parts, as **Fm, mn, no, op, pq**, and **qG**. Draw perpendicular lines from **F, m, n, o, p, q**, and **G**. Take the length of the lines in Fig. 163, as **FH, mr, ns, ot, pu, qv**, and **GJ**, and transfer their lengths to the perpendicular lines marked by corresponding letters. Draw a curve through the points thus obtained, as **H, r, s, t, w, v**, and **J**. This will give the half-pattern for the smaller pipe. To obtain the curve for the hole in the large pipe. Draw **DB** and **HJ**, Fig. 165, at right angles, take the distances in Fig. 163, from **A to f, g** and **h**, and mark off like distances on each side of **A** in Fig. 165, on the line **DB**, as **f, g**, and **h**, and draw lines from these points parallel to **HJ**. Draw a perpendicular line from the point **K** to **R** in Fig. 163, and transfer the lengths **KH** and **KJ**, from **A** to **H** and **A** to **J** in Fig. 165, also the distances **xr** and **xv** from **f** to **r** and **f** to **v** in Fig. 165, and the distances **y** to **s** and **y** to **u**, from **g** to **s** and **g** to **u**. Take the distance from **R** to **t** in Fig. 163 and mark off from **h** to **t** in Fig. 165. The curve drawn these

Fig. 166.



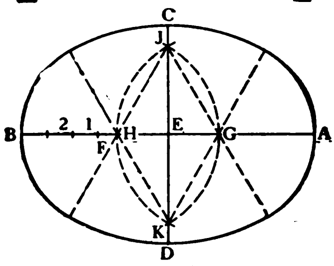


Fig. 167.

points will give the shape of the opening in the larger pipe.

To make a set of patterns for an oval tea-kettle. When getting out the patterns for an oval tea-kettle to hold 6 quarts, as shown in Fig. 166, first assume a suitable length and width for the bottom, then a height suitable to the capacity required can be readily ascertained. As 6 quarts contains 346½ cubic inches, divide this quantity by the number of square inches in the bottom of the kettle and the quotient will be the height required. If the bottom of the kettle be 10 inches long and 7 inches wide, then

$$\frac{346.5}{10 \times 7 \times .7854} = 6.30 \text{ inches,}$$

the required height for the body of the kettle. Next determine the circumference of the kettle by first finding the circumference of a circle whose diameter is equal to half the sum of the length and width of the oval, thus

$$\frac{10 + 7}{2} = 8.5 \times 3.1416 = 26.70 \text{ inches,}$$

the circumference of the body of the kettle.

The body pattern shown in Fig. 168 is a rectangle 26.7 inches long and 6.3 inches wide, one-half an inch extra depth is allowed for forming cramps to hold the bottom in position while brazing, also one-half inch along the side for the seam. To draw the oval for the bottom, draw the axes **AB** and **CD** as in Fig. 167, intersecting at **E**, and mark the length and width of the oval upon them. Then mark the width **CD** from **A** along **AB**, as at **F**, and divide the difference between the length and width into three equal parts, as **1, 2, B.** From **E** mark a distance equal to two of these divisions on each side of the center line to the points **G** and **H.** Using the distance **GH** as a radius and **G** and **H** as alternate centers, describe the arcs **JHK** and **JGK** intersecting at **J** and **K.** Draw lines through **JG** and

JH, and **KG** and **KH**. With centers **H** and **G** and **BH** or **GA** describe the end arcs. With centers **J** and **K**, and radius **JD** or **KC**, describe the side arcs to join with the end arcs. This completes the oval.

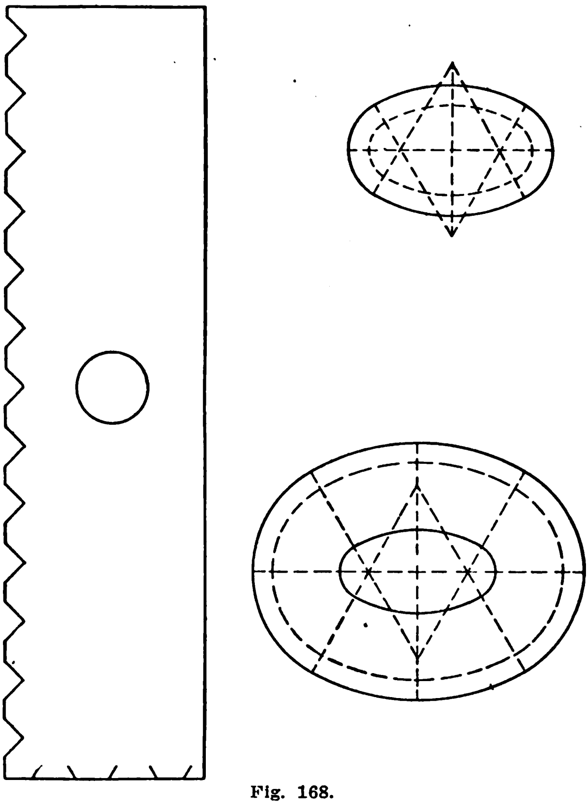


Fig. 168.

Lay out the pattern for the top shown in Fig. 168 in exactly the same manner, making due allowance for hollowing and edging, as indicated by the dotted lines.

Mark off the opening in the top for the cover, and using the same centers, describe the arcs required to form the cover opening. The pattern for the lid shown in Fig. 168 is also drawn in the same manner. The inner dotted lines are the same dimensions as the opening in the cover. Sufficient allowance should be made for the lap over the rim flange and also for hollowing.

To lay out the spout pattern approximately correct, draw a line as in Fig. 169, and set off **CD** equal in

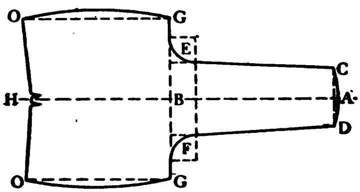


Fig. 169.

length to the circumference of the small end of the spout. From **A** to **B** mark a length equal to **AB** in Fig. 166, and through **B** draw a line at right angles. Make the length **EF** equal to the circumference **EF** in Fig. 166, and then draw the quarter circles at **E** and **F**, using the same radius as shown in Fig. 166. Draw **GC** equal to the straight length from the curve to the body on the inside of the spout at **G** in Fig. 166. From **GG** mark the lengths to **OO** equal to the circumference of the spout at the large end. Join these points to the center line at **H**, sloping them at the same angle as the base of the spout. Notch the center and cut a cramp at the top and bottom of the seam, as shown. The rim for the lid is a narrow strip of metal equal in length to the circumference of the hole, with a suitable allowance for lap at the seam.

To describe a pattern for a miter joint at right angles for a semicircular gutter. Let the semicircle **ACB,** Fig. 170, be the width and depth of the gutter. Draw the line **AB,** and draw the lines **AF** and **BE** at right angles to **AB.** Join **AF** and **BE** by the line **FE**

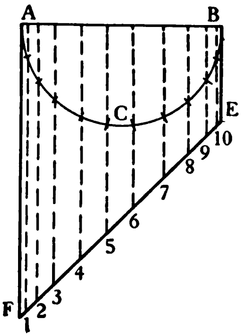


Fig. 170.

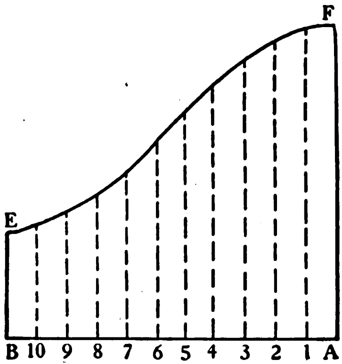


Fig. 171.

at an angle of 45 degrees. Divide the circumference of the semicircle **ACB** into any number of equal parts, and from these points draw lines parallel to **AF,** as **1, 2, 3, 4, 5, 6, 7, 8, 9,** and **10**; then lay off the line **AB** in Fig. 171, equal in length to the circumference of the semicircle **ACB.** Erect the lines **AF** and **BE** at right angles to **AB,** and lay off on the line **AB** the same number of equal spaces as on the circumference of the semicircle **ACB**, and from these points draw lines parallel to **AF**, as **1, 2, 3, 4, 5, 6, 7, 8, 9,** and **10.** Make **AF** equal in length to **AF** in Fig. 170 and **BE** equal to **BE** in the same figure; also each of the parallel lines bearing the numbers **1, 2, 3, 4, 5, 6, 7, 8, 9,** and **10.** A curve drawn through these points will give the shape of the pattern required.

To describe a pattern for a joint at any angle for a semicircular gutter. Let **ABC**, Fig. 172, be the width and depth of the gutter. Draw the line **AC** and the lines **EG** and **DH**, then draw the line **ED**, cutting the

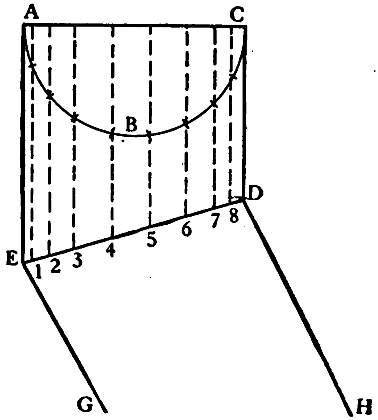


Fig. 172.

lines at the points **E** and **D.** Divide the circumference of the semicircle **ABC** into any number of equal parts, and from these points draw lines parallel to **AF**, as **1, 2, 3, 4, 5, 6, 7,** and **8.** Then lay off the line **AC**, Fig.

173, equal in length to the circumference of the semicircle **ABC**. Erect the lines **AE** and **CD** at right angles to **AC**, and then lay off on the line **AC** the same number of spaces as on the circumference of the semicircle **ABC**, and from these points draw lines parallel to **AE**, as **1, 2, 3, 4, 5, 6, 7,** and **8.** Make **AE** equal to **AE** in Fig. 172 and **CD** to **CD** in the same figure; also each of the parallel lines bearing the numbers **1, 2, 3, 4, 5, 6, 7,** and 8. A curve drawn through these points will give the shape of the pattern.

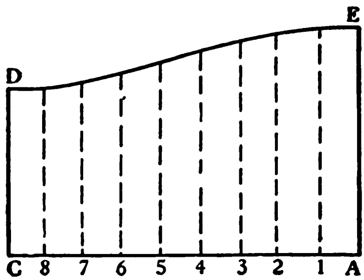


Fig. 173.

To describe a pattern for an O.G. gutter joint at right angles. Let **ABCD**, Fig. 174, be the given gutter. Divide the curved line **BC** into any number of equal parts and from these points draw lines parallel to **AD**, as **1, 2,** 3, **4,** 5, 6, 7, **8,** and **9**; then lay off the right angle **ABE** in Fig. 175 and make **BF** and **BA** equal to **AB** and **AD** in Fig. 174, and draw the line **CF** parallel to **AB.** Make **CF** equal in length to **AB,** and then draw the line **AC.** Make **FD** equal in length to the curved line **BC**, Fig. 174, and lay off on **FD** the same number of equal spaces as on the curved line **BC**, and from these points draw lines parallel to **CF**, as

Fig. 175.

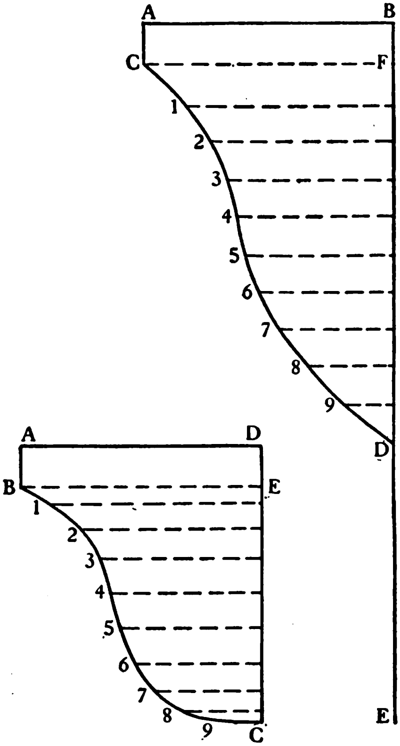


Fig. 174.

1, 2, 3, 4, 5, 6, 7, 8, and **9.** Make each of the parallel lines bearing the same figures as **1, 2, 3, 4, 5, 6, 7, 8,** and **9** equal. A curve drawn through these points will form the shape of the pattern.

To describe a pattern for a joint for an OG cornice at right angles. Draw the right angle **AFE** Fig. 176 and let **ABCDE** be the given cornice. Divide the curved line **BCH** into any number of equal parts as **1, 2, 3, 4, 5, 6, 7, 8 and 9,** and from these points draw lines parallel to **AF.** Lay out the right angle **ABCF** Fig. 177 and make **C1** equal to **AB** Fig. 176, then make **1G** equal in length to the curved line **BCH** and make **GE**

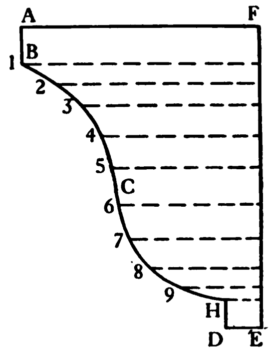


Fig. 176.

equal to **HD** and **EF** to **DE.** Lay off from **1** to **G** the same number of equal spaces as there are in the curved line **BCH.** Make **BC** and **11** equal to **AF,** and also each parallel line bearing the same number as **1, 2, 3, 4, 5, 6, 7, 8** and **9.** Make **KG** and **HE** equal to **DE** and a curve drawn through these points will give the shape of the pattern. When there is an offset or projection at right angles as **AB** in Fig. 177, make each of the dotted lines the same length as **AB,** and a curve traced through the points will give the pattern.

In place of using cornices and string-courses of stone in the fronts of brick houses, many prefer those of galvanized iron made in long lengths, and fixed to wooden blocks let into the brickwork, or to suitable rod-iron supports similarly fixed. Some of these cornices, when

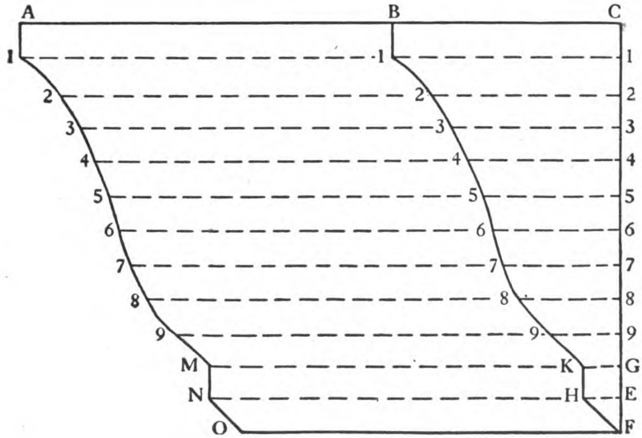


Fig. 177.

containing many members of mouldings, especially if they are circular in plan, need much skill. In general principle the metal is bent over the hatchet-stake with a mallet or a hammer, much as in making zinc guttering, assisting with swages where necessary.

"In making up circular mouldings, it is necessary to have the material sufficiently heavy to bear shrinking and stretching without breaking or becoming brittle. The best plan for bringing mouldings to the required shape is the following manner: Take a piece of hard wood 4 inches by 4 inches and 12 inches long, make a profile of the work intended, and on one end of this piece make a die of the desired shape, to this must be fitted a plunger, which allows the thickness of iron to intervene. The die is shown in the following figures: Fig. 178 is the top, Fig 179 is the sectional view

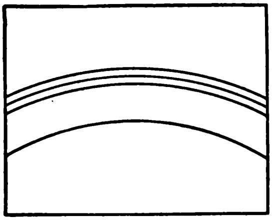


Fig. 178.

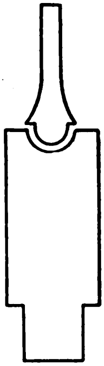


Fig. 179.

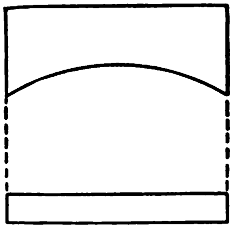


Fig. 180.

of the plunger and die for a half-round mould. Fig. 178 is to be made in the same circle as the work. Figs. 180 and 181 are the same, of a different moulding. Figs. 179 or 181 is to be placed in an oak block, as shown in Fig. 182. The right-hand portion should be of sufficient length to answer for a seat to the operator. Fig. 183 is a mallet about 12 inches long. To make these dies, imagine the cap to be stamped from one piece, and get out the die and plunger accordingly. The tools required will be a saw, brace, and ½-inch bit, a straight chisel, two or three sizes of gouges, a straight rasp, and a rasp curved at one end. When the iron is cut to the required pattern, it is raised in these dies, shifting the mould to and fro each time it is forced into the die with a blow on the plunger from the mallet, until it is brought to the required shape. A little practice will soon demonstrate the utility of this method, and also its superiority over the hammering process.

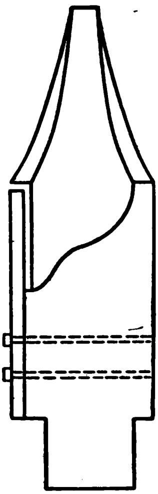


Fig. 181.

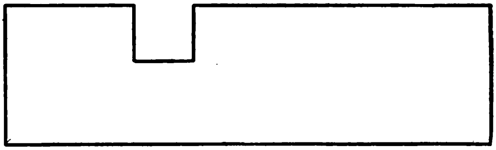


Fig. 182.

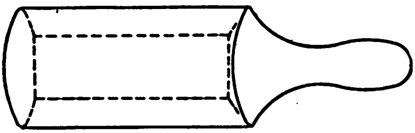


Fig. 183.

"When work is to be put together, never place two raw edges together. On one of the members turn 1/8 of an inch edge, and lap the member on this and soak the solder in well, so as to firmly unite the pieces, and on the top strip that is to be built in the wall turn a 1/2-inch edge to stiffen and answer the purpose of straps to hold the cap in position. An edge of the same kind should also be turned on the bottom strip, to extend over the frame, and if the cap is to have a drop or corbel, let the inside of the drop or corbel extend back past the frame at least one inch, to secure the corbel to the frame, and the other side of the corbel to have a ½-inch edge to fit against the wall."

Should the work be for a building already up, the strip should have an edge sufficient to nail through into mortar joints. Good judgment is required in putting up work of this character, to make it a success.

PIPE BENDING.

Before taking up the construction of bends from flat sheet-metal, it will not be out of place to devote some little space to a consideration of the methods to employ, and tools to use, in bending ordinary metal tubing, as this is a knowledge oftentimes wanted in the sheet-metal workshop, and is by no means common knowledge there. The workman who is unacquainted with these methods and tools finds great difficulty in giving to a straight piece of tubing a desired curvature, that is, so shaping it, that the completed bend shall be free from ridges, dents, or kinks, and not flattened in the throat, the perfection of a bend, of course, being when the internal diameter or bore of the tube is the same throughout.

What has to be done in the way of pipe bending in the ordinary workshop must be done with the appliances that are usually found there, or can easily be made there. The tools necessary for the production of bends, especially smooth and circular in section, such as those of wind musical instruments, cannot be made in the ordinary sheet-metal workshop, it will be well, however, to also give a brief description of the working of these bends.

The method of bending a pipe or tube varies with the metal, its diameter, and the curvature required. Ordinary gas pipe, of the smaller sizes, may readily be bent without any special preparation to curves, even of small radius. A piece of iron, preferably round iron, being gripped in a vice, horizontally or vertically as most convenient, and used as a fulcrum or bending post, the barrel may be shaped round it to the curve required. A slight curvature should first be given, then, changing the place of contact of pipe and fulcrum, a further curvature, and so on. A piece of wood, if of sufficiently large diameter to bear the strain it will be put to, may be similarly used. If the pipe is of so large diameter that its bending against a piece of iron in the manner described is beyond the workman's strength, it should be made red-hot where the bend is to come. Thus softened, the workman will find the bending comparatively easy. In bending iron pipe in this way there is always a slight flattening in the throat of the bend. In such work, however, as iron pipe is generally used for, this flattening is not of consequence, the thickness of the pipe and the toughness of the metal prevent any great amount of flattening.

The procedure necessary to bend tubes made of metals softer than iron, of copper, brass, zinc, tin or lead, is less simple, and to prevent buckling, puckering or flattening, in the throat of a bend, such pipe must be loaded. The materials used for loading are various, and the choice between them depends upon the metal of which the pipe to be bent is made, and greatly upon the finish and symmetry required in the particular work to be done. Lead, resin, pitch, and rosin and pitch in equal parts, are the substances most in favor. When set after being melted and run into tube, they are found to bend without breaking as the bending of a tube progresses, and to offer the needful resistance to change of section of it. A spiral spring not closely coiled, or a piece of cane or solid rubber, may often be advantageously used to load soft metal pipe with. Either of these loadings can be pulled through the made bend, and will serve again and again as loading. A tightly-rolled piece of paper will often serve, even for brass tubing, if used for brass tubing, it can be burnt out if need be. On an emergency, and if the ends of the piece of tube to be bent are tightly corked or otherwise sealed up, and the look of the finished work is not of particular importance, a pipe may be loaded with sand, or even with water. The reason why sand and water, as loading, are suitable only for an emergency, is that the plugging at one of the pipe ends often gives way in the course of the bending.

The melting-point of lead is 323° Centigrade, and as a loading substance for brazed brass tube, lead has this disadvantage, that when melting it out of a bent tube, there is danger lest any weak spot in the brazed seam should crack or open up, and special care needs to be taken to warm up the tube slowly and equally in melting out the lead because of this. When the lead has been run out of a bent tube, little particles of lead often remain in the tube adhering to the surface. To dislodge these, the tube should be again warmed up, to a temperature a little higher than that of the melting point of lead, and the open end struck smartly on the bench, or with a piece of wood, the tube being held with a pair of pliers, or otherwise as may be convenient. Rosin or pitch, as loading substances, leave behind a thin adherent film after being melted out of a pipe. This must not be forgotten when choice of a loading substance has to be made. If it is imperative that the inner surface of a bent pipe should be clean, then neither of these substances can be used with a tube of soft metal, as the film has to be burnt off, which would mean spoiling the tube. They may be used with copper or brass tubing, when, for the reason that the throat of the bend need not be perfectly circular in section, it is desired that the loading substance shall not offer any great resistance to bending.

Brass or copper drawn tubing should be annealed before being bent. In loading a piece of pipe with either lead, pitch, or rosin, two or three layers of brown paper should be wrapped round one end of it and securely tied. If lead is the loading material, the tube should be rigidly fixed vertically, with its closed end embedded in sand, so that molten lead may not run out to do mischief. The lead may be poured from an ordinary plumbers' ladle. And in loading with pitch and rosin the tube should rest and be secured with its closed end on some solid substance, to prevent leaking out of the hot pitch or rosin.

Small copper pipes, tubes, and spouts, are readily bent into curves without wrinkling, if they are first filled with lead. One end of the pipe is closed with thick brown paper, and the pipe laid in a box of damp sand, while the lead is being poured in. The lead must be soft. An iron rod is cast in with the lead, its end standing out at a distance of a few inches to afford the necessary leverage for bending the pipe. This, of course, is melted out after the bending is done. The bending is variously effected with a mallet, or with leverage, or with both in combination. Before running the lead out the outside of the work should be covered with a solution of whiting in water. Copper pipe may also be filled with rosin before bending. Lead is better for quick bends, rosin for long ones. Only the part to be bent and that immediately beyond need be filled, or wad of paper, or cotton waste being inserted at the locality beyond which the filling material is not required. The part which has to be bent must be annealed first to a cherry red, in daylight. Portions which have to be left straight must be left unannealed, or hard.

There are many methods and rigs adopted for bending copper pipes. Much depends on the size of the pipe. Up to about five inches diameter manual labor is sufficient, but above that hydraulic power is generally employed. The bending is always done by leverage or pressure, never by hammering. In all coppersmiths' shops there is a strong bending-block sunk in the floor for the purpose of pipe-bending. It is of cast-iron about twelve inches square, and standing up to about the ordinary height of a workbench. It is made to receive the various attachments required for pipe-bending. The top of the block is shouldered down to receive a strap which confines a bending-block. The latter is a stout plate of lead with a hole or holes in it for the insertion of pipes. The lead being soft does not bruise the pipe which is being bent. It is secured with the strap. On one side of the block a back plate is inserted with pins fitting into the holes cast in the block, which affords an essential point of leverage in the bending of pipes. Holes are cast in the top of the block to receive pins which also form suitable points of leverage.

Most work in sheet copper is planished at some stage or other. The object of planishing is to close and harden the grain of the metal, taking the limpness out of it, and to make it more elastic and rigid so that it will retain its shape. Often this operation is performed before any work is done upon the sheets, in order to make them stiff enough to work upon. Often it is done at a later stage. It consists in hammering over the whole surface in detail until every portion has been subjected to the hardening effect of the hammer blows. The hammering is done in straight lines, or in concentric curves, depending on the nature of the work. The planishing is done on a bottom stake, fixed in the floor-block, or on a level block of metal. Various hammers are used for different work. Copper goods are polished with a file first, followed by emery cloth applied on a stick, then by fine emery, rubbed on with hempen rope, wrapped round with a single hitch, and drawn to and fro, and finally with a metal burnisher and sweet oil.

COPPER AND TIN UTENSILS.

At the present time nearly all household utensils made of copper or tin are almost entirely machine made, about the only hand work on them being the assembling of the various parts such as tops, bottoms and bodies, for the purpose of brazing or soldering

Fig. 184.

them together. The tops, bottoms and covers, if any, being formed in punching presses by means of raising or drawing dies and the bodies being made in rolls which corrugate the sides and form the seams.

Various forms of copper household utensils are shown in the following illustrations: A copper tea kettle is shown in Fig. 184, the body is made from one piece of metal and tinned inside. The spout is double seamed solid to the body and beaded on the outside as shown in Fig. 185. The bail is made of heavy sheet brass

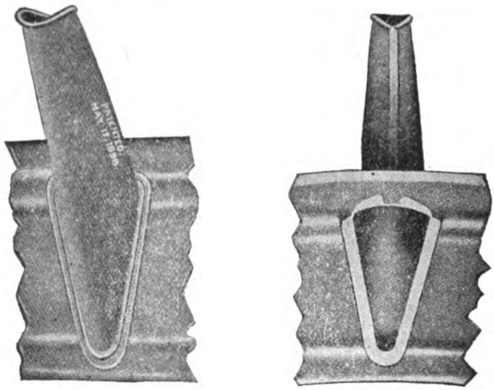


Fig. 185.

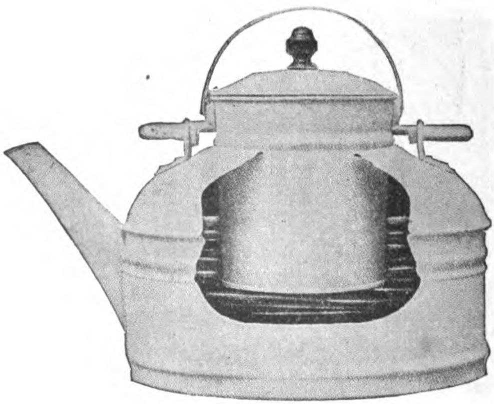


Fig. 186.

with wired edges and bossed centers, and securely fastened to the wooden handle by a solid steel rod running through it and riveted on both ends. It has heavy bail lugs with handle rests.

A tea kettle inset pail is shown in Fig. 186, this pail fits into the tea kettle, thus saving room on the stove,

Fig. 187.

the same cover can be used both for the tea kettle and the inset pail. It is especially adapted for boiling milk or cooking cereals.

Copper tea and coffee pots are illustrated in Figs. 187 and 188. They are tinned inside and have bright finish. The enamelled wood handle is fastened solidly to the body and will not get loose or melt off. The knob on the cover is securely riveted in place and there is neither solder or burr inside the cover.

A copper wash boiler is shown in Fig. 189, it has a flat double-seamed bottom, swaged body and hand made pitched tin cover with handle on top.

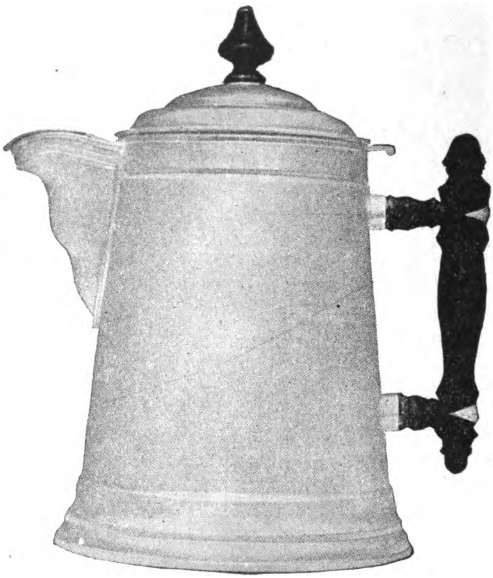


Fig. 188.

An all copper wash bowl is illustrated in Fig. 190, it has a flared rim and is made of one piece of metal.

Household utensils made of tin, or rather of sheet steel coated with tin, are shown in the accompanying illustrations:

A tin tea kettle is shown in Fig. 191, with a one piece body. The spout is double-seamed to the body and the

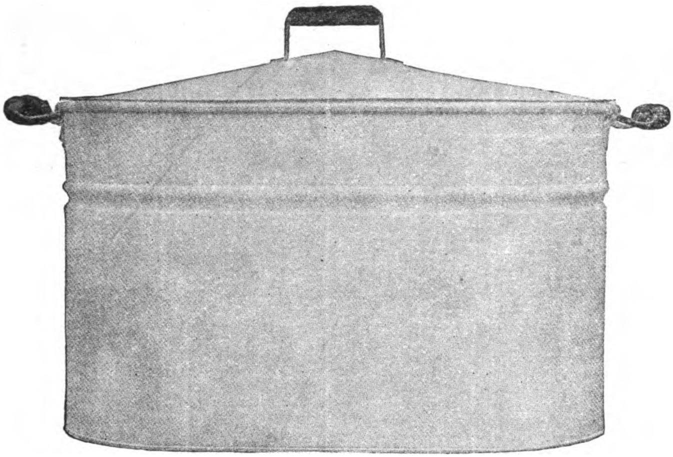


Fig. 189.

edges of the spout mouth curled, preventing denting or breaking.

Tin tea and coffee pots made of heavy material with

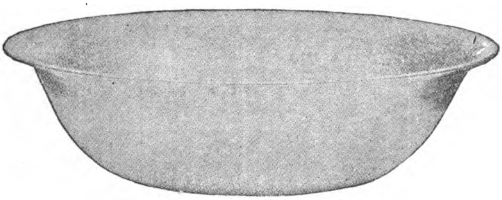


Fig. 190.

swaged bodies and top of bodies wired, and rimmed covers, are shown in Figs. 192 and 193.

Fig. 191.

Fig. 192.

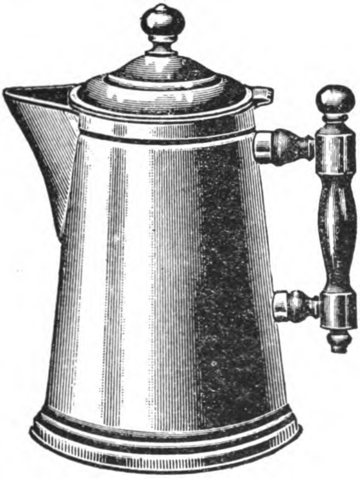


Fig. 193.

Fig. 194.

A tin wash boiler is shown in Fig. 194. It has a ribbed body and a pitched cover with handle on the top.

A tin wash bowl with flared rim and pit bottom is shown in Fig. 195.

A tin coffee boiler for hotel or restaurant use is illustrated in Fig. 196 and a lard pail in Fig. 197.

Fig. 195.

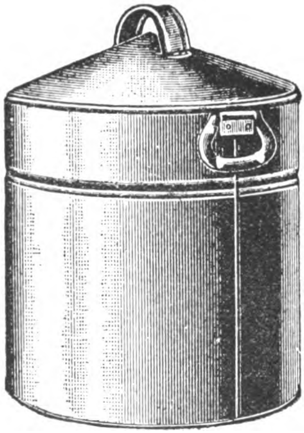


Fig. 197.

Fig. 196.

Repairing Copper Utensils. A very common repair with copper utensils is a hole worn on the edge of the bottom. This is done by brazing, the process being as follows. Hold the vessel over an open coke fire or gas blowpipe, and burn off all grease. Immerse in muriatic acid, and then scour with coke-dust or salt, to remove all traces of dirt. When this is done, if it is a small pan, dip it in and out of some nitric acid alternately using hot strong potash water. In about ten minutes, the tin inside the vessel will be eaten off, leaving the copper bare. The pan is now ready for brazing, which is done by using spelter, mixed wet with powdered borax, afterwards using some dry powdered borax to throw on as a flux whilst the spelter is melting. The hole to be brazed must be closed up so that the two edges that are worn away overlap one another. Melt the spelter over a sharp, quick fire of small coke, free from any particles of tin that might mix in the coke while burning off. As already mentioned, a gas blowpipe can be used instead of a fire if desired. When the pan is cold, trim the outside where brazed with a coarse file, and finish off with a few blows from the hammer to smooth it down. Where a pan is brazed as described above, the copper that is made red-hot naturally becomes softened, and if left without any further treatment would get bruised and knocked out of shape very quickly with wear. To strengthen the copper it is hammered on all those parts touched by the fire or blowpipe flame. The hammering hardens the copper again, and renders it better able to resist hard wear than if left without hammering. The burnt borax is removed by immersing the vessel in a solution of 1 part sulphuric acid and 10 parts water.

When the pan has remained in the dilute acid about half an hour it will be ready for scouring with equal parts of silver sand and common salt applied with a piece of tow, the borax is then easily removed. Time can be saved by dipping the article in nitric acid, this answering the same purpose as scouring with sand and salt. After rinsing the pan with chloride of zinc, it is ready to be retinned.

Vessels of thick copper often require to be re-bottomed, and in most cases the job is done by the raised-brazed method. The sides of saucepans and similar vessels, when of thick copper, will stand as many as three or four new bottoms, and each bottom lasts twice as long as the old style seamed bottoms. Raised-brazed bottoms enable a new brazed bottom to be put on an old pan without the depth being lessened, in fact, by the raised-brazed method a pan can be made deeper if required. By the old method depth was lost by cutting away the worn bottom and taking up more material for the new seaming edge. The new bottom is raised up similar in shape to an ordinary omelet pan, and the brazing seam is worked on the side instead of the bottom, hence the term raised-brazed.

In raised-brazing a new bottom to a copper saucepan, commence by taking off the handle. Set the pan on a surface plate with its bottom as level as possible, and with a pair of dividers describe a line round the side of the pan high enough up to clear the part that is worn thin. Cut the old bottom off at this line, afterwards heating the pan over a fire and wiping out as much of the old tin as possible with a piece of tow. To complete the removal of the tin, rinse repeatedly with, or immerse in, nitric acid, using hot potash water as before. Then draw down the fresh-cut edge with a thinning hammer, and if the edge in thinning becomes at all irregular, trim with a file. After rubbing over with wet salt, anneal the copper by bringing it to a red heat and allowing it to cool slowly, this softens it for further treatment. This process of salting and annealing is known as pickling off. Now cut the cramps regularly by means of a sharp chisel, they must not be too large, or the copper will be liable to draw in the brazing.

The cramps have the appearance of teeth, their size varying with the thickness of the pan. They are turned back nearly at right angles to the sides of the pan, so that the bottom, when ready,can fit on, being held in position with strong wire twisted round, the wire must be kept firm while the cramps are hammered down, and not taken off until after the brazing. The wet spelter should be laid on evenly all round the inside of the cramps by the aid of a spatula, and the whole pan should be gradually warmed to evaporate the water in the borax before any great heat is applied to melt the spelter. Just as the latter runs evenly, draw the pan a little way off the fire so as to allow the molten spelter to settle, the vessel must not be turned round to the full heat of the fire, or the spelter will run round also. This running of the spelter round the brazing seam must be guarded against. When the pan has been brazed quite soundly, it is finished off as before described.

Brazing is a simple art, but, for all that, neat and sound work can only be done as the result of considerable practice.

Repairing Tin Utensils. A few soldering examples will be given, and while these are connected with repairs, it must be remembered that the process of soldering in both new and old work is the same. The difference between the two is the fact that it is necessary to spend more time in preparing the surface of old work than the new.

It is required to repair a tin saucepan having a small hole in the body. If the hole is not visible, locate the leak by trying with water. Then scrape away the dirt for about 1 inch around it, as there may be other holes near. If one only is found, carefully scrape a bright patch about the size of a dime, using a file if necessary. Wet the bright part with the soldering solution, heat the copper bit, and melt off from the stick a knob of solder sufficient to cover the hole, and lay the solder on it. Then, with the point of the bit, melt the solder, which will flow over the clean part and adhere to it, remove the bit, and allow the solder to set. This method may be followed for all ordinary small repairs.

When a large hole has to be repaired, cut a patch of sheet tin to cover it, allowing a good margin. Trim off the sharp corners, and bend the patch to fit the body, then place it in position and mark round it. As before, carefully clean a patch about one-quarter of an inch beyond the mark, this will allow the solder to flow well under the patch. Brush some soldering solution on the under side and edges of the patch, hold it firmly in position, and solder. Much solder is not wanted on the outside of the patch, as it will be made quite sound by the solder flowing underneath.

Saucepans and similar tin utensils as a rule commence to leak at the junction of the bottom and the body, and a leak at this point is best repaired from the inside. Thoroughly clean the bruise or crack, as before described, but allow a fair proportion of solder to remain, so that the hole is well covered. Hold the article on its edge, and see that the solder is firmly set before moving. When the bottom is rusty inside, and cannot be reached to clean properly, the repair may be done on the outside. When very rusty, brush on a little raw acid after cleaning, allow it to remain for a short time, then wipe off with a wet rag. The solder will then adhere much more easily. A cracked bottom edge can be made sound with solder, first thoroughly clean the edges of the crack, then with the point of the bit draw the solder along the bright part, commencing at one end. In a repair of this kind the solder is liable to melt off in use when brought in direct contact with the fire or hot plate.

When a new bottom is required, it may be capped on, or peaned on, the first is usually soldered outside, the last inside. A vessel that needs no great strength, or that is not brought into direct contact with heat, such as an ordinary cheap oil-can, frequently has the bottom capped on. To re-bottom such a vessel, first scrape the body bright, about one-half an inch from the bottom all round, and thoroughly clean the seam. Then hold the can on the edge of the bench, and with a sharp chisel cut off the old bottom carefully, so that the body is not bruised. If drawn out of shape, the body may be rounded again with a mallet on an iron bar or mandrel. The bottom edge, if not true, must be trimmed with the shears. Cut a circle of tin, one-quarter inch larger in diameter than the body, and turn up the edge one-eighth inch all round at right angles to the bottom. When completed, this piece should exactly fit on the body, and may then be fixed by the solder being drawn neatly round the joint with the point of the copper bit.

To replace the bottom of a coffee-pot, which is usually peaned on, clean thoroughly, cut off the old bottom, take out the bruises, and trim the edge as in the last case. Then carefully turn the bottom edge of the body outwards, one-eighth inch all round at right angles to the body, making it perfectly level. Cut out a circle of tin for the bottom, allowing one-quarter inch for the edge. Turn up the edge of the bottom as before, fit it in position, and rap the edge inwards all round with a small hammer. Then with a pane hammer on a level surface fold the edge of the bottom over the bottom edge of the coffee-pot, and hammer it down close and tight. Solder it carefuly, the job is then complete.

To replace the knocked-up bottom of a saucepan, the old bottom should be cut off and the body trimmed and edgd as before described. As the soldering is done from the inside, it must be scraped thoroughly, using the file if necessary, and cleaning a depth of about one-quarter inch. Cut out, edge, and pean on the bottom. Place the saucepan on a mandrel, and with a mallet gradually fold the peaned edge over square with the body, going round several times if necessary, until the joint is close. The point of the mandrel must be kept well up in the lag, otherwise it may bruise the body, and the bottom will not be true when completed. Dress the bottom smooth with a square-faced hammer, then solder up inside, and the job is completed.

HARDENING AND TEMPERING TOOLS.

In the case of cutting, shearing, stamping, drawing, and similar tools that have to be hardened to enable them to deal with sheet metals, it is necessary to exercise special care in heating them to the required temperature before they are plunged into the water bath for cooling. The careful and uniform heating applies to all hardening, more or less, but it is of particular importance in the case of expensive dies or punches. The principal point is to watch that the tool be heated as gradually as possible, and too much stress cannot be placed upon the importance of care in hardening. It is not unusual to see a blacksmith or a toolmaker place a large die into a fire, heat one side red-hot, whilst the other side is nearly cold, he will next turn the die round and heat that side which was cold, whilst that which was red-hot will get nearly cold again. There are now special gas stoves that may be used, and properly constructed muffles may also be erected and fed by the application of fine slack, which will do useful work in heating tools for hardening. Where neither of these are handy it is possible to heat a tool properly in a breeze fire, providng that the fire is large enough for the purpose, but it is useless trying to heat tools uniformly in a small fire. First blow up a fairly large fire, then introduce the die, and, covering the die with red-hot breeze, blow the fire very gently until the die has a thorough gentle soaking. The greatest trouble with which the toolmaker has to contend in hardening his tools is the risk of their splitting, cracking, or warping. The cause of these troubles is generally the cooling and contraction of the various portions of the tool at different rates. To avoid this cracking and warping it is important that the tool be uniformly heated and as uniformly cooled as possible. In the case of dies, all screw, dowel, or gauge-pin holes in them should be filled with clay during the process of hardening. When quenching the tool plunge it straight down into the water, holding it stationary for a minute or so, then move it slowly about, keeping it perpendicular all the time. Do not use any of the so-called special hardening mixtures or fluids, as they are practically worthless for tools. Use a plentiful supply of fresh clean water and brine, or rain water and brine, then, when you meet with a brand or steel that cannot be hardened by heating to a cherry-red and quenching in cold clean water, treat it as useless for tools and at once dispense with it. Tools such as drawing or extending dies, where the hole is required to be perfectly hard for its whole depth or length, the cooling of the central portion of the die may be assisted by directing a powerful jet of water through the hole in the die. An ordinary cutting-out bed or die is usually quenched by being plunged into a tank filled with clean water and the die held under the water until it is quite cold, when it may be removed, have its face cleaned or ground bright. It may then be tempered by being placed upon a flat piece of red-hot iron.

Very large dies may be heated for tempering either in a muffle or over a breeze fire. In all cases the slower and more uniformly the change of color appears the more reliable will be the results from the tools. In tools for turning, planing, and shaping, chipping chisels, drills, and many varieties of cutting-out punches, where it is not necessary to have the tool hardened for the whole of its length, the hardening may be readily done at one heating. The following explanation of hardening and tempering a chipping chisel will serve to illustrate how this is accomplished:

The chisel, Fig. 198, being held by its head H in a pair of tongs, is placed into the fire for about one-third its length A B, and carefully heated to a cherry-red, care being taken that the extreme end E of the chisel

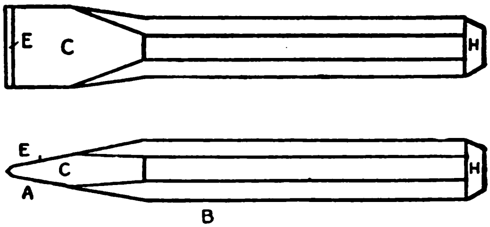


Fig. 198.

does not become overheated. If the chisel is very thin the end E should be cooled by dipping it into water once or twice during the time that the chisel is being heated. After it has been heated to the required temperature it is dipped into the water for a portion of its length, according to the size of the chisel this may vary from ¾ to 1½ inches, and held in the water until cold, then remove the chisel, and brighten the hardened portion C by rubbing with a piece of stone or emery cloth. The heat will now travel from the unquenched portion to the quenched portion. The change of color is watched as it travels along from B to A, until the required color appears at the cutting end E, when the chisel is again plunged into the water bath, this time the whole of it will be quenched. This method can be applied to any tools to be hardened at their ends only, but it must be understood that the nature of the work to be operated upon may necessitate the tool being brough down in temperature to a totally different color. For instance, turning tools, dark straw or yellow color, 450 degrees temperature, cutting-out punches for sheet steel, very dark straw or yellow, 490 degrees temperature; cold chisel for chipping cast iron, dark purple color, 550 degrees temperature.

It should be noted that when chisels, drills, or turning tools are being forged, it is advisable to hammer them until the steel has become quite cold, as this hammering gives toughness and fineness of texture, it may then be re-heated for the purpose of hardening. Taps and reamers are sometimes covered with a mixture of Castile soap and lampblack, to preserve their cutting edges, and to prevent them being burnt whilst being heated for hardening. This class of tools may also be heated in a wrought-iron pipe filled with charcoal dust, the ends being plugged with clay. This method generally results in the taps or reamers being heated uniformly, and they are afterwards dipped into water in a vertical position, and held there until cold.

Circular milling cutters may be covered with Castile soap and lampblack with advantage, and the hole of the cutter plugged up with clay, this preserves the center, which is not usually required to be hard. The tools are generally slightly warmed before the mixture of Castile soap and lampblack is applied, and a circular cutter should be plunged into the water bath edgeways. The tempering of a tap or reamer is usually done by introducing it into a cast-iron or wrought-iron collar, which has been made red-hot, the tool is held in a pair of tongs, and passed along the center of the hole. At the same time it assists matters if the tool is rotated whilst being moved along, as the continual change of position prevents one portion becoming hotter than another, and results in a more even temper. Taps, reamers, milling cutters, and similar tools are generally tempered to a light brown color, and quenched in oil.

Small punches from 1/16 to ½ inch diameter, and dies from ¼ to 1 inch diameter, are best heated in a wrought-iron pipe about 12 inches long and 2 inches in diameter, with one end closed. This may be done by welding a wrought-iron plug in one end of the pipe. The small punches or dies are placed in the pipe, which is, in turn, thrust into the breeze fire. This method gives much better results than can be obtained when the flame of a fire is allowed to come in contact with such small tools. When the punches or beds, as the case may be, are sufficiently heated the pipe is removed from the fire, and the tools tipped into a bucket of clean water containing a handful of common salt. Tools hardened in this manner will be found to be quite clean, and ready for tempering. This may be readily done by placing the tools upon a wrought-iron plate, say 12 inches square by ⅛ inch thick, heated over a gas stove, the small round punches should be rolled over the hot plate until the required color appears, while small dies are best placed endways on the plate.

ANNEALING DIES AND TOOLS.

When dealing with cutting-dies, punches, stamping-dies, or any piece of steel which has to be worked or shaped by the action of cutting tools when in the cold state, previous to the tool being hardened, it is desirable that the steel be carefully annealed. Particularly is this necessary when stamp-dies of some peculiar and difficult shape have to be worked and finished in a first-class manner. When a die or punch, after having been forged, is thrown down upon the floor of a smith's shop to cool, thereby being exposed to cold air, especially in winter time, it frequently results in the steel being in an unequally hardened condition, which may also be partly caused by the hammering process. Annealing will generally remedy this defect, as the process of annealing reduces the steel to its softest and most uniform condition. The ease with which steel may be worked by the various cutting tools in a lathe, planing, milling, or drilling machines more than repays the little trouble that is necessary for anealing. Small articles, for instance, as delicate tools, cutters, reamers, punches, and dies, may be placed in an iron box, surrounded or buried in powdered charcoal, the charcoal prevents the steel from losing its carbon and assists the uniform heating of these small tools, at the same time preserving their shape and preventing any damage being done to their cutting edges. After being heated the box is placed somewhere to gradually get cool before the small tools are removed. The larger tools can be successfully annealed by moderately and uniformly heating them in a muffle, then allowing them to cool slowly. This is sometimes done by burying them in ashes to retard the cooling.

The anealing is usually done before the forgings leave the blacksmith's shop, a good method being to carefully re-heat them after forging to a dull red and place them into an iron box containing slaked lime, where they should remain until cold, which frequently takes a whole day. They are then taken out of the lime, and will be found to be more easily worked into shape, and are not so likely to leave their shape when undergoing the hardening process. There are instances when dies and punches are annealed, roughed-out, and annealed a second time before being finally shaped to their finished outline with beneficial results. But this is not advisable if the tool can be readily worked fairly easy after one annealing, since too much heating may removed the nature from the steel.

MICROMETER GAUGES.

Brown and Sharpe micrometer gauges form convenient and accurate tools for external measurements. They are made in various sizes and styles to measure up to 24 inches and are graduated to read to thousandths and ten-thousandths of an inch, they are also made to read to hundredths of a millimetre. The decimal equivalents stamped on the frame are convenient for the immediate expression of readings in eighths, sixteenths, thirty-seconds, and sixty-fourths of an inch.

The chief mechanical principle embodied in the construction is that of a screw free to move in a fixed nut, an opening to receive the work to be measured is afforded by the backward movement of the screw, and the size of the opening is indicated by the graduations.

Referring to Fig. 199, the pitch of the screw C is forty to the inch, the graduations on the barrel A, in a line parallel to the axis of the screw, are forty to the inch, and figured 0, 1, 2 etc., every fourth division. As these graduations conform to the pitch of the screw, each division equals the longitudinal distance traversed by the screw in one complete revolution, and shows that the gauge has been opened one-fortieth or twenty-five-thousandths of an inch. This opening (between B and C) in Fig. 198, is three divisions exactly, and is therefore = 3 × 1-40th of an inch, or seventy-five-thousandths.

The bevelled edge of the thimble D is graduated into twenty-five equal parts, figured every fifth division, 0, 5, 10, 15, 20, each divison, and when coincident with the line of graduations on the barrel A, indicates that the gauge screw has made one-twenty-fifth of a revolution, and the opening of the gauge increased one-twenty-fifth of twenty-five-thousandth = one-thousandth of an inch.

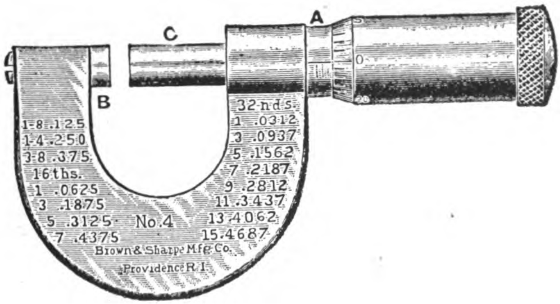


Fig. 199.

Hence to read the gauge, multiply the number of divisions visible on the scale of the barrel A by 25, and add the number of divisions on the scale of the thimble D, from zero to the line coincident with the line of graduations on the hub.

A micrometer gauge, which has recently been introduced for the use of sheet metal workers, is shown by Fig. 200, and it is well adapted for this class of work. The gauge screw is encased and protected from dirt or injury, and means of adjustment are provided to compensate for wear. The opening in the frame is about 6 inches deep, this is a very important feature,

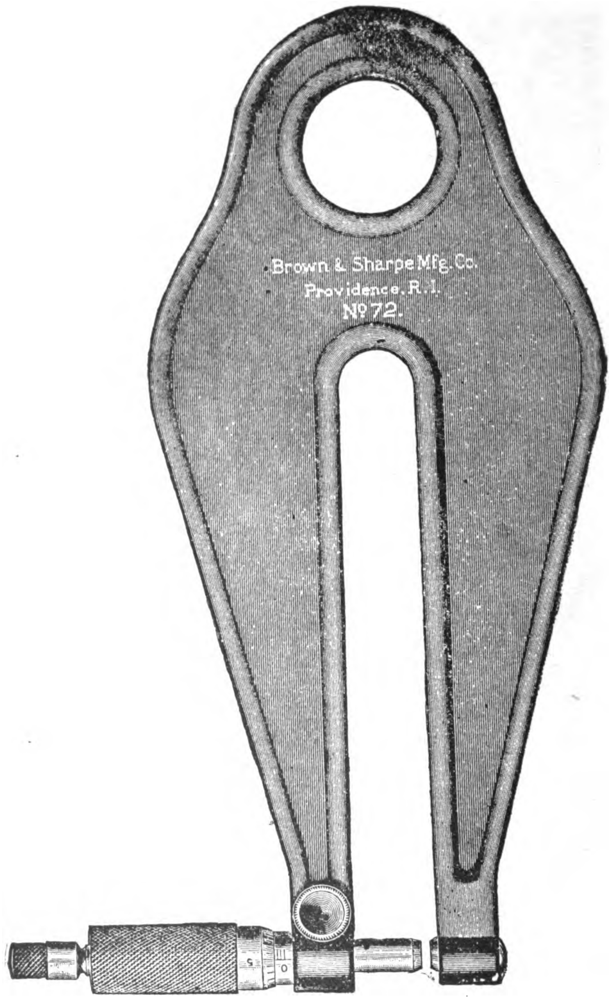


Fig. 200.

as it enables sheet metal to be more accurately measured than would be possible with an ordinary micrometer. This great depth in the frame makes it possible to measure or gauge the metal at various points in the width of the sheet, which could not be reached with the ordinary pattern of micrometer gauge.

WORK DONE BY A DROP HAMMER.

The great value of the drop hammer is its simplicity and cheapness as a means of storing energy, which can be given out again in doing the work of raising, stamping, and forging.

The drop hammer is an example of the useful application of the principle of the falling weight. In finding the work accumulated in any moving body, such, for instance, as energy stored up in a flywheel, the work of a locomotive when ascending an incline, the work of a cannon ball, and similar questions, it is necessary to introduce the force of gravity into the calculation, since the law of gravitation necessarily has an effect upon such bodies as are dealt with in these calculations. It is therefore perhaps necessary to briefly review the action of gravity on falling bodies to enable the practical mechanic to understand what the gravity constant means.

If a body be raised 16 1/12 feet, then allowed to fall freely, it will fall through this space of 16 1/12 feet in one second, and at the end of that second it will have attained a velocity of 32 1/6 feet per second. This velocity of 32 1/6 feet per second, which is simply due to the force of gravity, is denoted by **g** and the velocity **v** attained at the end of **t** seconds will be $t \times 32\ 1/6$, or $v = t \times 32\ 1/6$. Therefore the velocity of a body which has fallen for four seconds will be at the end of that time travelling at a velocity $= 4 \times 32\ 1/6 = 128\ 2/3$ feet per second.

The mean velocity—that is, the velocity in the middle of that time—will be $2 \times 32\ 1/6 = 64\ 1/3$ feet per second, and the space described will be $4^2 \times 16\ 1/12 = 257\ 1/3$ feet.

Formula for Falling Bodies when Falling from Rest.

h = height of fall in feet.
v = velocity in feet per second.
g = force of gravity = 32.2.
t = time of fall in seconds.

$$h = \frac{g\,t^2}{2} = \tfrac{1}{2}\,g\,t^2 = \frac{v^2}{2g}$$

$$v = g\,t = \frac{2\,h}{t} = \sqrt{2\,g\,h}$$

$$t = \frac{v}{g} = \frac{2\,h}{v} = \sqrt{\frac{2\,h}{g}}$$

If the drop hammer be raised to a definite height, the work expended in raising it will be $W \times i$, and in doing so the force of gravity will have to be overcome. If the hammer be now supported, there will be potential energy stored up in it, and when allowed to fall it will attain a certain velocity depending upon the distance fallen. When the hammer reaches the end of its fall, the accumulated work in the hammer will be

$$\frac{W\,v^2}{2\,g} = W\,h$$

Example. Suppose a drop hammer of 500 pound weight be raised through a height of 579 feet. The work expended in raising this hammer will be

$W \times h = 500 \times 579 = 289500$ foot-pounds.

If the hammer be now supported at this height, the potential energy which exists in, or is stored up, will be = 289,500 foot-pounds. When allowed to fall the accumulated work will be equal to

$$\frac{W v^2}{2 g}$$

First find v:

$$v = \sqrt{2 g h} = \sqrt{2 \times 32\tfrac{1}{6} \times 579} = 193 \text{ feet per second,}$$

when the hammer reaches the end of its fall it will have attained a velocity equal to 193 feet per second, therefore

$$\frac{W v^2}{2 g} = \frac{500 \times 193 \times 193}{2 \times 32\tfrac{1}{6}} = 289500 \text{ foot-pounds,}$$

and this is the same result as $W \times h$.

A certain amount of energy is passed into the drop hammer in raising it up, and when it falls the energy is given out again. There is neither gain nor loss of power. It may be that a great pressure is exerted through a small space, or a less pressure through a greater space, and in both instances the work may be the same.

If a resistance is offered to a 560-pound hammer, falling from a height of 16 feet, during the last one foot of its fall the average pressure acting against the resistance will be 8,960 pounds, the pressure being much greater at the commencement, and reducing as it reaches the last inch, the accumulated energy gradually decreasing to simply that of the weight of the hammer itself as it reaches the end of its fall.

But should the hammer be brought to rest in a fraction of 1 foot, then the resistance offered must be proportionally greater.

A stamp hammer 200 pounds in weight falls 10 feet, and in stamping a piece of metal the hammer is brought to rest in the space of the last ½ inch of its fall. What resistance has been offered by the metal article?

$$W \times h = 200 \times 10 = 2000 \text{ foot-pounds,}$$

$$\tfrac{1}{2} \text{ inch} = \tfrac{1}{2} \text{ of } \tfrac{1}{12} = \tfrac{1}{24} \text{ of 1 foot,}$$

$$\text{and since } 2000 = \frac{R \times 1}{24}$$

$$\text{therefore } R = \frac{2000 \times 24}{1} = 48000 \text{ pounds.}$$

Work done by a hand hammer. The conditions under which the hand hammer is used make it necessary that the law of gravitation shall be introduced into the calculation. Take the case of a machinist striking a blow upon the head of a chisel, or driving a nail into a piece of wood, with a 2-pound hand hammer.

As another example, consider the case of a machinist driving a key into the boss of a flywheel with a 4-pound hammer. In the first case there are two forces acting upon the hammer, namely, force of gravity and the man's muscular force. The workman raises the hammer, he then drives it home, delivering a blow upon the head of the chisel. The first portion of the distance through which the hammer moves is traversed by a movement of the whole arm from the shoulder.

This is followed up by the workman straightening his arm at the elbow, then, just as he is about to reach the head of the chisel with the hammer to strike the blow, he straightens his wrist, thereby adding impetus to the hammer, which is already rapidly falling, and in this manner a very great velocity is given, probably at the exact moment of impact the actual velocity may be 50 feet per second.

In the second example, where a blow is delivered upon the head of a steel key by a hammer, and the hammer is driven in a horizontal line, the machinist will swing the hammer through a comparatively long distance, and will probably put the weight of the upper half of his body into the blow, thereby considerably increasing the velocity of the hammer, which may be 50 feet per second, as before. In both these cases of hand hammers the accumulated work or energy stored up in the hammer will be the same as though the hammer had fallen from a sufficient height to attain that velocity which the hammer has at the moment of impact. But here the only information we have to assist us in solving the problem is the weight of the hammer and the assumed velocity at which it is moving, say 50 feet per second. Since having no particulars as to the height from which a body must fall to attain this velocity, it is necessary to introduce the law of gravitation into the calculation to enable reliable results to be obtained.

We have for the 2-pound hammer accumulated work

$$\frac{W v^2}{2 g} = \frac{2 \times 50 \times 50}{2 \times 32} = 78 \text{ foot-pounds.}$$

If the face of the hammer moves the head of the chisel 1/16 inch, then

$$\tfrac{1}{16} \times \tfrac{1}{12} = \tfrac{1}{192} \text{ of 1 foot,}$$

$$\text{and } R = \frac{78 \times 192}{1} = 14976 \text{ pounds.}$$

If a nail had been driven $\frac{1}{4}$ inch,

$$\tfrac{1}{4} \times \tfrac{1}{12} = \tfrac{1}{48} \text{ of 1 foot,}$$

$$\text{and } R = \frac{78 \times 48}{1} = 3744 \text{ pounds.}$$

In the case of the 4-pound hammer we have accumulated work

$$\frac{W\,v^2}{2\,g} = \frac{4 \times 50 \times 50}{2 \times 32} = 156 \text{ foot-pounds.}$$

If the key is driven $\frac{1}{8}$ inch by the blow,

$$\tfrac{1}{8} \times \tfrac{1}{12} = \tfrac{1}{96} \text{ of 1 foot.}$$

$$\text{and } R = \frac{156 \times 96}{1} = 14976 \text{ pounds resistance.}$$

The work done by the jack hammer, namely, 14,976 pounds, is approximately the same that would be obtained by a dead load of 14,976 pounds giving a direct pressure.

TECHNICAL DEFINITIONS.

The unit of work is the work done in lifting one pound through a height of one foot, or work done when a resistance of one pound is overcome through a space of one foot, and is called the foot-pound.

The number of units of work performed = P × S where P equals the force applied, or the resistance overcome in pounds, and S equals the space moved over in feet.

Force is any action which can be expressed simply by weight, and which can be realized only by an equal amount of reaction, and is the first element in dynamics. All bodies in nature possess the incessant virtue of attracting one another by gravitation, which action is recognized as force.

Velocity is speed or rate of motion, and is the second element in dynamics.

Time implies a continuous perception recognized as duration, or that measured by a clock, and is the third element in dynamics.

Power is the product of force and velocity, that is to say, a force multiplied by the velocity with which it is acting is the power in operation. Power is the differential of work, or any action that produces work, whether mental or physical. Power multiplied by the time of action is work, work divided by time is power.

Work is the product obtained by multiplying together the three simple elements, force, velocity, and time.

The energy of a body is its capacity for performing work.

The potential energy, or the energy stored in a body, is the product of the effort and the distance through which it is capable of acting.

Kinetic energy, or accumulated work of a moving body, is the product of the mass and half the square of its velocity, or the weight of the body multiplied by the height from which it must fall to gain its velocity.

Gravity is the mutual tendency which all bodies of nature have to approach each other, or the tendency of any falling body to approach the centre of the earth.

The mass of a body is its weight divided by 32.2.

The acceleration of motion is the rate of change in the velocity of a moving body, which is increased at different intervals of time.

The unit of acceleration is that which imparts unit change of velocity to a moving body in unit time, or an acceleration of one foot per second in one second.

The acceleration due to gravity varies at different places on the earth's surface. It is reckoned at 32.2 feet per second in this country, and is generally indicated by the letter **g**.

Retarded motion. The motion of a body, instead of being accelerated, may be retarded, that is, its velocity may decrease at different intervals of time.

Varied motion is usually understood to refer to a moving body, when the change varies in either accelerated or retarded motion, at different intervals of time.

Inertia is that quality inherent in matter whereby it is absolutely passive or indifferent to a state of motion.

A couple consists of two parallel forces which are equal, and act in opposite directions.

The weight of a body is the pressure which the mutual attraction of the earth and the body causes that body to exert on another with which it is in contact= mass multiplied by 32.2.

Linear Velocity is the rate of motion in a straight line, and is measured in feet per second, or per minute, or in miles per hour.

PROPERTIES OF WATER.

Water expands about one-tenth its bulk by freezing solid.

Water is at its greatest density and occupies the least space at 39 degrees Fahrenheit.

Water is the best known absorbent of heat, consequently a good vehicle for conveying and transmitting heat.

A U. S. gallon of water contains 231 cubic inches and weighs 8 1/3 pounds.

A column of water 27.67 inches high has a pressure of 1 pound to the square inch at the bottom.

Doubling the diameter of a pipe increases its capacity four times.

To find the lateral pressure of water upon the side of a tank, multiply in inches, the area of the submerged side, by the pressure due to one-half the depth.

Example—Suppose a tank to be 12 feet long and 12 feet deep. Find the pressure on the side of the tank.

144 × 144=20,736 square inches area of side.

12 × .43=5.16, pressure at bottom of tank. Pressure at the top of tank is 0. Average pressure will then be 2.6. Therefore 20,736 × 2.6=53,914 pounds pressure on side of tank.

To find the number of gallons in a foot of pipe of any given diameter, multiply the square of diameter of the pipe in inches, by .0408

To find the diameter of pipe to discharge a given volume of water per minute in cubic feet, multiply the square of the quantity in cubic feet per minute by 96. This will give the diameter in inches.

To find the number of gallons in a cylindrical tank, multiply the diameter in inches by itself, this by the height in inches, and the result by .34. To find the number of gallons in a rectangular tank, multiply together the length, breadth and height in feet, and this result by 7.4. If the dimensions are in inches, multiply the product by .004329. To find the pressure in pounds per square inch, of a column of water, multiply the height of the column in feet by .434.

To find the head in feet, the pressure being known, multiply the pressure per square inch by 2.31.

Salt water boils at a higher temperature than fresh, owing to its greater density, and because the boiling-point of water is increased by any substance that enters into chemical combination with it. The density of water decreases as the temperature increases, since heat destroys cohesion and expands the particles, causing them to occupy greater space. The power of water to hold chemical substances, such as the salts of lime, in solution, decreases as the temperature increases.

The law of expansion by heat and contraction by cold is true as relating to water, with this exception, that as hot water cools down from the boiling-point it contracts until 45 degrees Fahrenheit is reached, but if cooled down from this point, it expands again.

With the barometer at 30 degrees Fahrenheit water boils in the open air, at sea-level at 212 degrees Fahrenheit, and in vacuum at 88 degrees Fahrenheit. The less the pressure of the atmosphere, the lower is the temperature at which water will boil. The pressure of the atmosphere at sea-level is 14.7 pounds per square inch, pressing equally and in all directions. A cubic foot of water evaporated under a pressure of one atmosphere, or 14.7 pounds per square inch, occupies a space of 1,700 cubic feet.

One cubic inch of water evaporated at atmospheric pressure makes 1 cubic foot of steam.

A heat unit known as a British Thermal Unit raises the temperature of 1 pound of water 1 degree Fahrenheit.

Water boils in a vacuum at 98 degrees Fahrenheit.

A cubic foot of water weighs 62½ pounds, it contains 1,728 cubic inches or 7½ gallons. Water expands in boiling about one-twentieth of its bulk.

In turning into steam water expands 1,700 its bulk, approximately 1 cubic inch of water will produce 1 cubic foot of steam.

At atmospheric pressure 966 heat units are required to evaporate one pound of water into steam.

To produce one horsepower requires the evaporation of 2.66 pounds of water.

Heated air and water rise because their particles are more expanded, and therefore lighter than the colder particles.

A vacuum is a portion of space from which the air has been entirely exhausted.

Evaporation is the slow passage of a liquid into the form of vapor.

Increase of temperature, increased exposure of surface, and the passage of air currents over the surface, cause increased evaporation.

Condensation is the passage of a vapor into the liquid state, and is the reverse of evaporation.

Pressure exerted upon a liquid is transmitted undiminished in all directions, and acts with the same force on all surfaces, and at right angles to those surfaces.

The pressure at each level of a liquid is proportional to its depth.

With different liquids and the same depth, pressure is proportional to the density of the liquid.

The pressure is the same at all points on any given level of a liquid.

The pressure of the upper layers of a body of liquid on the lower layers causes the latter to exert an equal reactive upward force. This force is called buoyancy.

Friction does not depend in the least on the pressure of the liquid upon the surface over which it is flowing.

Friction is proportional to the area of the surface.

At a low velocity friction increases with the velocity of the liquid.

Friction increases with the roughness of the surface.

Friction increases with the density of the liquid.

Friction is greater comparatively, in small pipes, for a greater proportion of the water comes in contact with the sides of the pipe than in the case of the large pipe. For this reason mains on heating apparatus should be generous in size.

Air is extremely compressible, while water is almost incompressible.

Water is composed of two parts of hydrogen, and one part of oxygen.

Water will absorb gases, and to the greatest extent when the pressure of the gas upon the water is greatest, and when the temperature is the lowest, for the elastic force of gas is then less.

To find the area of a required pipe, when the volume and velocity of the water are given, multiply the number of cubic feet of water by 144 and divide this amount by the velocity in feet per minute.

Water boils in an open vessel (atmospheric pressure at sea level) at 212 degrees Fahrenheit.

Water expands in heating from 39 to 212 degrees Fahrenheit, about 4 per cent.

When a substance solidifies or freezes, there is always a change of volume, which usually is contraction, but, in the case of water, an expansion takes place. The expansion of water at the freezing-point is by no means gradual, but takes place almost instantaneously, and the amount of force exerted at the time is enormous. It has been demonstrated by actual experiments, that in freezing, water exerts a pressure of about 30, 000 pounds per square inch.

The specific gravity of all waters is not the same. Sea water varies from 1.0269 to 1.0285, the mean being 1.0277, thus requiring 34.9741 cubic feet of sea water to make one ton, and about 35 cubic feet of fresh water.

Water has the greatest specific heat of all known liquids except hydrogen, and is therefore taken as the standard for all solids and fluids. The latent heat of water is 143 degrees Fahrenheit and that of ice 140 degrees Fahrenheit, as it absorbs that amount of heat in changing from a solid to a liquid state.

When water in a vessel is subjected to the action of fire it readily imbibes the heat and sooner or later, according to the intensity of the heat, attains a temperature of 212 degrees Fahrenheit. If, at this point of temperature, the water be not inclosed, but exposed to atmospheric pressure, ebullition will take place, and steam or vapor will ascend through the water, carrying with it the superabundant heat, or that which the water cannot, under such circumstances of pressure, absorb, to be retained, and to indicate a higher temperature.

Water in attaining the aëriform state, is thus uniformly confined to the same laws, under every degree of pressure, but, as the pressure is augmented, so is the indicated temperature proportionately elevated. Hence the various densities of steam, and corresponding degrees of elastic force.

USEFUL INFORMATION.

Marine Glue. Dissolve 4 parts of India rubber in 34 parts of coal tar naphtha—aiding the solution with heat and agitation; add to it 64 parts of powdered shellac, which must be heated in the mixture, till the whole is dissolved. While the mixture is hot it is poured upon metal plates in sheets like leather. When required for use, it is heated in a pot, till soft, and then applied with a brush to the surfaces to be joined. Two pieces of wood joined with this glue can scarcely be sundered.

Dextrine. Dry potato-starch heated from 300 to 600 degrees Fahrenheit until it becomes brown, soluble in cold water, and ceases to turn blue with iodine. Used by calico printers and others, instead of gum arabic.

A Liquid Glue that Keeps for Years. Dissolve 2 pounds good glue in 2 and one-ninth pints hot water, add gradually 7 ounces nitric acid, and mix well.

An excellent liquid glue is also made by dissolving glue in nitric ether, this fluid will only dissolve a certain amount of glue, consequently the solution cannot be made too thick. The glue solution obtained has about the consistency of syrup.

Prepared Liquid Glue. Take of best white glue 16 ounces, white lead, dry, 4 ounces, rain water 2 pints, alcohol 4 ounces. With constant stirring dissolve the glue and lead in the water by means of a water-bath.

Add the alcohol, and continue the heat for a few minutes. Lastly pour into bottles while it is hot.

Liquid Glues. Dissolve 33 parts of best glue on the steam bath in a porcelain vessel, in 36 parts of water. Then add gradually, stirring constantly, 3 parts of aqua fortis, or as much as is sufficient to prevent the glue from hardening when cool. Or dissolve one part of powdered alum in 120 of water, add 120 parts of glue, 10 of acetic acid and 40 of alcohol, and digest.

Aluminum Solder. This consists of 28 pounds of block tin, three and one-half pounds of lead, seven pounds of spelter, and 14 pounds of phosphor-tin. The phosphor-tin should contain 10 per cent of phosphorus. Clean off all the dirt and grease from the surface of the metal with benzine, apply the solder with a copper bit, and when the molten solder covers the metal, scratch through the solder with a wire scratch brush.

Sweating Aluminum to Other Metals. First coat the aluminum surface to be soldered with a layer of zinc. On top of the zinc is melted a layer of an alloy of one part aluminum to two and one-half parts of zinc. The surfaces are placed together and heated until the alloy between them is liquefied.

Soldering Fluid. Take of scrap zinc or pure spelter about $\frac{1}{4}$ pound, and immerse in a half-pint of muriatic acid. If the scraps completely dissolve add more until the acid ceases to bubble and a small piece of metal remains. Let this stand for a day and then carefully pour off the clear liquid, or filter it through a cone of blotting paper. Add a teaspoonful of sal-ammoniac, and when thoroughly dissolved, the solution is ready for use. Depending on the materials to be soldered, the quantity of sal-ammoniac can be reduced. Its presence makes soldering very easy, but, unless the parts are well heated so as to evaporate the salt, the joints may rust.

Mixture for Silvering. Dissolve 2 ounces of silver with 3 grains of corrosive sublimate, add tartaric acid 4 pounds, salt 8 quarts.

To Separate Silver from Copper. Mix sulphuric acid 1 part, nitric acid 1 part, water 1 part, boil the metal in the mixture till it is dissolved, and throw in a little salt to cause the silver to precipate.

Solvent for Gold. Mix equal quantities of nitric and muriatic acids.

Composition used in Welding Cast Steel. Borax 10, sal ammoniac 1 part. Grind or pound them roughly together, then fuse in a metal pot over a clear fire, taking care to continue the heat until all scum has disappeared from the surface. When the liquid appears clear, the composition is ready to be poured out to cool and concrete, afterwards, being ground to a fine powder, it is ready for use. To use this composition, the steel to be welded is raised to a heat which may be expressed as a bright-yellow. It is then dipped among the welding powder, and again placed in the fire until it attains the same degree of heat as before. It is then ready to be placed under the hammer.

Cast Iron Cement. Clean borings, or turnings, of cast iron 16, sal ammoniac 2, flour of sulphur 1 part. Mix them well together in a mortar and keep them dry. When required for use, take of the mixture 1, clean borings 20 parts. Mix thoroughly and add a sufficient quantity of water. A little grindstone dust added improves the cement.

Durable Bronze for Tin and Tin Alloys. After carefully cleansing the article from dirt and grease, coat it lightly with a solution of 1 part of sulphate of copper (blue vitriol), and 1 part of copperas, in 20 parts of water, and after drying, with a solution of 1 part of verdigris in 4 of vinegar. After again drying, impart lustre to the article by rubbing with a soft brush dipped at first into jewelers' rouge, and frequently breathing upon it. The places in relief are then rubbed with a piece of soft leather moistened with solution of wax in turpentine, and finally rubbed with a dry leather.

Etching on Iron or Steel. Take one-half ounce of nitric acid and one ounce of muriatic acid. Mix, shake well together, and it is ready for use. Cover the place you wish to mark with melted beeswax, when cold write the inscription plainly in the wax clear to the metal with a sharp instrument, then apply the mixed acids with a feather, carefully filling each letter. Let it remain from one to ten minutes, according to the appearance desired. Then throw on water, which stops the etching process and removes the wax.

Soldering Solution. An excellent method of preparing resin for soldering bright tin is given as follows: Take one and one-half pounds of olive oil and one and one-half pounds of tallow and 12 ounces of pulverized resin. Mix these ingredients and let them boil up. When this mixture has become cool, add one and three-eighths pints of water saturated with pulverized sal ammoniac, stirring constantly.

Softening Cast Iron. To soften iron for drilling, heat to a cherry-red, having it lie level in the fire. Then with tongs, put on a piece of brimstone, a little less in size than the hole is to be. This softens the iron entirely through. Let it lie in the fire until cooled, when it is ready to drill.

To Tin Copper and Brass. Boil 3 pounds of cream of tartar, 4 pounds of granulated tin or tin shavings, and 2 gallons of water. After boiling for a sufficient time, place the articles to be tinned in the mixture, and the boiling being continued, the tin is precipitated in its metallic form.

To Tin Iron Sauce-pans. If the sauce-pan is an old one, it must be put on the fire and allowed to get nearly red hot, which will get rid of all the grease. Then make a pickle of the following proportions: Sulphuric acid one-quarter pound, muriatic acid 2 ounces, water 1 pint. If the sauce-pan can be filled, so much the better, if not, keep the pickle flowing over it for five minutes, then rinse off with water, scour well with sand or coke dust, and rinse thoroughly with water. If the pan is clean, it will be of a uniform gray color, but if there are any red or black spots, it must be pickled and scoured again until thoroughly clean. Have ready chloride of zinc, or muriatic acid, in which sheet zinc has been dissolved, some powdered sal ammoniac, about 18 inches of iron rod about one-quarter or three-eighths inch thick, one end flattened out and bent up a little, and filed clean, and some bar tin. Dip a wisp of tow in the chloride of zinc, then into the powdered sal ammoniac, taking up a good quantity, and rub well all over the inside. This must be done directly after the scouring, for, if allowed to stand, it will oxidize. Now put the pan over the fire until it is hot enough to melt tin, and then brush the end of a bar of tin over the heated part until melted. Rub the tin well over the surface with the flattened end of the iron rod. Care should be had not to heat too large a surface at once, nor to let it get too hot, which may be known by the tin getting discolored, when some dry sal ammoniac must be thrown in. Having gone all over it, wipe lightly with a wisp of tow, made just warm enough to prevent the tin from sticking to it. When cold, scour well with sand and tow, rinsing with plenty of water.

Cold Tinning. Block tin dissolved in muriatic acid with a little mercury forms a very good amalgam for cold tinning, or 1 part of tin, 2 of zinc, and 6 of mercury. Mix the tin and mercury together until they form a soft paste. Clean the metal to be tinned, taking care to free it from greasiness. Then rub it with a piece of cloth moistened with muriatic acid and immediately apply a little of the amalgam to the surface, rubbing it with the same rag. The amalgam will adhere to the surface and thoroughly tin it. Cast-iron, wrought-iron, steel and copper may be tinned in this manner. Those who find it difficult to make soft solder adhere to iron with sal ammoniac, will find no difficulty if they first tin the surfaces in this manner, and then proceed as with ordinary tin plate.

To Tin Small Articles. Place them in warm water, with a little sulphuric acid added to it, which will clean them. Then powder some sal ammoniac, and mix it in the water, stirring vigorously until all is dissolved. After washing the articles in clean water, place them in the solution for a few minutes and then place them near the fire to dry. Procure a pan resembling a frying pan in shape, the bottom of which must be full of small holes. The pot for melting the tin must be large enough to admit the pan for holding the articles. Cover the bottom of the pan with the articles to be tinned, and after sprinkling a little powdered sal ammoniac over the surface of the molten tin to clear it from dross, dip the pan containing the articles into it, after all smoke has disappeared, lift it out and shake well over the pot, sprinkling a little sal ammoniac over the goods to prevent them from having too thick a coat, and then cool them quickly in cold water to keep them bright.

Galvanizing Brass and Copper. Copper and brass may be coated with metallic zinc in the following way: Finely divided zinc, in a non-metallic vessel, is covered with a concentrated solution of sal ammoniac, this is heated to boiling, and the articles of copper or brass, properly cleansed, are introduced. A few minutes then suffice to produce a firm and brilliant coating. The requisite fineness of the zinc is produced by pouring the melted metal into a mortar and triturating it until it solidifies.

Cheap and Quick Method of Coloring Metals. Metals may be colored quickly and cheaply by forming on their surface a coating of a thin film of a sulphide. In 5 minutes brass articles may be coated with any color varying from gold to copper red, then to carmine, dark red, and from light aniline blue to a blue white, like sulphide of lead, and at last a reddish white according to the thickness of the coat, which depends on the length of time the metal remains in the solution used. The colors possess a very good lustre, and if the articles to be colored have been previously thoroughly cleansed by means of acid and alkalies, they adhere so firmly that they may be operated upon by the polishing steel.

To prepare the solution dissolve 1½ ounces of hyposulphite of soda in 1 pint of water, and add 1½ ounces of acetate of lead, dissolved in half a pint of water. When this clear solution is heated to from 190 to 210 degrees Fahrenheit, it decomposes slowly and precipitates sulphide of lead in brown flakes. If metal be now present, a part of the sulphide of lead is deposited thereon, and according to the thickness of the deposited sulphide of lead, the above-mentioned colors are produced. To produce an even coloring, the articles must be evenly heated. Iron treated with this solution takes a steel-blue color, zinc a brown color, in the case of copper objects, the first gold color does not appear.

If, instead of the acetate of lead, an equal weight of sulphuric acid is added to the hyposulphite of soda, and the process carried on as before, the brass is covered with a very beautiful red, which is followed by a green, and changes finally to a splendid brown with green and red iris glitter. This last is a very durable coating. Very beautiful marble designs can be produced by using a lead solution, thickened with gum tragacanth, on brass which has been heated to 210 degrees Fahrenheit, and is afterwards treated by the usual solution of sulphide of lead. The solution may be used several times.

Cleaning Tinware. Ordinary tinware is made of sheet-iron, coated with tin. Acids should never be employed to clean such articles, because they attack the metal and remove it from the iron. Rub the articles to be cleaned first with rotten stone and sweet oil, then finish with whiting and a piece of soft leather. Articles made of solid tin should be cleaned in the same manner. In a dry atmosphere planished tin will remain bright for a long period, but it soon becomes tarnished in moist air.

Suggestions how to Solder. Clean the parts thoroughly from all rust, grease or scale, then wet with prepared acid. Hold the soldering copper on each part until the article is well tinned and the solder has flowed to all parts.

Watch-Makers' Oil that Will Never Corrode or Thicken. Take a bottle about half full of good olive oil and put in thin strips of sheet lead, expose it to the sun for a month, then pour off the clear oil. The above is a very cheap way of making a first-class oil for any light machinery.

Varnish for Copper. To protect copper from oxidation a varnish may be employed which is composed of carbon disulphide 1 part, benzine 1 part, turpentine oil 1 part, wood alcohol 2 parts and hard copal 1 part. It is well to apply several coats of it to the copper.

Glue for Iron. Put an equal amount by weight of finely powdered rosin in glue and it will adhere firmly to iron or other metal surfaces.

Soldering or Tinning Acid. Muriatic acid 1 pound, put into it all the zinc it will dissolve and 1 ounce of sal ammoniac, add as much clear water as you have acid, it is then ready for use.

Plaster of Paris. Common plaster that farmers use to put on land and plaster of Paris are the same thing, except plaster of Paris is common plaster calcined. Many times it is difficult to get calcined plaster, and when it is procured it is badly adulterated with lime and unfit for many uses. To calcine plaster, or in other words, to make common plaster so it will harden, you have but to take the plaster and put it in an iron kettle and place it over a slow fire, put no water in it. In a few moments it will begin to boil and will continue to do so until every particle of moisture is evaporated out of it. When it has stopped boiling take it off, and when cold it is ready for use. Plaster treated in this way will harden much quicker and harder than any which can be bought ready prepared.

Hardening Small Articles. To harden small tools or articles that are apt to warp in hardening, heat very carefully, and insert in a raw potato, then draw the temper as usual.

Bluing Brass. Dissolve one ounce of antimony chloride in twenty ounces of water and add three ounces of pure hydrochloric acid. Place the warmed brass article into this solution until it has turned blue. Then wash it and dry in saw-dust.

Drilling Glass. Take an old three-cornered file, one that is worn out will do, break it off and sharpen to a point like a drill and place in a carpenter's brace. Have the glass fastened on a good solid table so there will be no danger of its breaking. Wet the glass at the point where the hole is to made with the following solution:

Ammonia	6½ drachms
Ether	3½ drachms
Turpentine	1 ounce

Keep the drill wet with the above solution and bore the hole part way from each side of the glass.

Another solution is to dissolve a piece of gum camphor the size of a walnut in one ounce of turpentine.

Another method is to use a steel drill hardened, but not drawn. Saturate spirits of turpentine with camphor and wet the drill. The drill should be ground with a long point and plenty of clearance. Run the drill fast and with a light feed. In this manner glass can be drilled with small holes, up to 3-16 inch in diameter nearly as rapidly as cast steel.

Cement for Pipe Joints. Mix 10 parts iron filings and 3 parts chloride of lime to a paste by means of water. Apply to the joint and clamp up. It will be solid in 12 hours.

Removing Stains. To remove Ink Stains, wash with pure fresh water, and apply oxalic acid. If this changes the stain to a red color, apply ammonia. To remove Iron Rust from White Fabrics, saturate the spots with lemon juice and salt and expose to the sun.

Resharpening Files. Well-worn files are first carefully cleaned with hot water and soda, they are then placed in connection with the positive pole of a battery, in a bath composed of 40 parts of sulphuric acid and 1,000 of water. The negative is formed of a copper spiral surrounding the files, but not touching them, the coil terminates in a wire which rises towards the surface. When the files have been in the bath 10 minutes, they are taken out, washed and dried, when the whole of the hollows will be found to have been attacked in a very sensible manner, but should the effect not be sufficient, they are replaced in the bath for the same period as before. Sometimes two operations are necessary, but seldom more. The files thus treated are to all appearances like new ones, and are said to be good for 60 hours' work. Twelve medium Bunsen cells are used for the battery.

To Repair Broken Belting. Broken belting can be reunited by the use of chrome glue. With a lap of 4 or 5 inches, the reunited part is apparently as firm as any part of the band, though it is well to take the precaution to tack down the ends of the lapped pieces with a few stitches of stout thread. The chrome glue is prepared as follows: Take 100 parts glue, soaked 12 hours in water, then pour off the remaining water, melt the glue, add 2 per cent of glycerine and 3 per cent of red chromate of potash, melting them with the glue. This mixture, thinned by warming, is applied to the lapped ends after having been roughened with a rasp, and then placed between two hard wood strips in a vice and well pressed. Leave the lapped ends for 24 hours in the vice to become thoroughly dried.

Weight of Castings. If you have a pattern made of soft pine, put together without nails, an iron casting made from it will weigh sixteen pounds to every pound of the pattern. If the casting is of brass, it will weigh eighteen pounds to every pound of the pattern.

Ordering Taps and Dies. In ordering Taps and Dies, be sure and give the kind, exact size and thread wanted. Always remember you are writing to a person who knows nothing of what is wanted, therefore make the order plain and explicit. Never order a special Tap or Die if it can be avoided, as such will cost at least double that of regular sizes and threads.

Tapping Nuts. Always use good lard oil in cutting threads with a die or tapping out nuts. Poor cheap oil will soon ruin both die and tap.

Grindstones. Grindstones to grind tools should be run at a speed of about 800 feet per minute at its periphery, a 30-inch stone should be run about 100 revolutions per minute. When used to grind carpenters' tools a speed of 600 feet at its periphery, a 30-inch stone should therefore be run at 75 revolutions per minute.

White Metal for Bearings. White metal for bearings consists of 48 pounds of tin, 4 pounds of copper, and 1 pound of antimony. The copper and tin are melted first, and then the antimony is added.

Marine Glue. One part of pure india rubber dissolved in naphtha. When melted add two parts of shellac. Melt until thoroughly mixed.

To Soften Cast Iron. Heat the whole piece to a bright glow and gradually cool under a covering of fine coal dust. Small objects should be packed in quantities, in a crucible in a furnace or open fire, under materials which when heated to a glow give out carbon to the iron. They should be heated gradually, and kept at a bright heat for an hour and allowed to cool slowly. The substances recommended to be added are cast-iron turnings, sodium carbonate or raw sugar. If only raw sugar is used, the quantity should not be too small. By this process it is said that cast-iron may be made so soft that it can almost be cut with a pocket-knife.

To Harden Files. To harden files dip the file in red-hot lead, handle up. This gives a uniform heat and prevents warping. Run the file endwise back and forth in a pan of salt water. Set the file in a vise and straighten it while still warm.

Leather Belts. A leather belt is more economical in the end than a rubber one. When buying a leather belt it should be tested by doubling it up with the hair side out. If it should crack, reject it as it cannot realize the whole amount of power it should transmit. If it shows a spongy appearance it should be condemned at once, for it must be pliable as well as firm. The grain or hair side should be free from wrinkles and the belt should be of uniform thickness throughout its length. It should be tested for quality by immersing a small strip in strong vinegar. If the leather has been properly tanned and is of good quality, it will remain in vinegar for weeks without alteration, excepting it will grow darker in color. If the leather has not been properly tanned the fiber will swell and the leather will become softened, turning it into a jelly-like mass.

To Cement Rubber to Leather. Roughen both surfaces with a sharp piece of glass, apply on both a diluted solution of gutta percha in carbon bisulphide, and let the solution soak into the material. Then press upon each surface a skin of gutta percha about one-hundredth of an inch in thickness, between a pair of rolls. Unite the two surfaces in a press that should be warm but not hot. In case a press cannot be used, dissolve 30 parts of rubber in 140 parts of carbon bisulphide, the vessel being placed on a water bath of a temperature of 86 degrees Fahrenheit. Melt ten parts of rubber with fifteen parts of rosin and add 35 parts of oil of turpentine. When the rubber has been completely dissolved, the two liquids may be mixed. The resulting cement must be kept well corked.

Drilling Holes in Glass. Holes of any size desired may be drilled in glass by the following method: Get a small 3-cornered file and grind the points from one corner and the bias from the other and set the file in a brace, such as is used in boring wood. Lay the glass in which the holes are to be bored on a smooth surface covered with a blanket and begin to bore a hole. When a slight impression is made on the glass, place a disk of putty around it and fill with turpentine to prevent too great heating by friction. Continue boring the hole, which will be as smooth as one drilled in wood with an auger. Do not press too hard on the brace while drilling.

To Polish Brass. Smooth the brass with a fine file and run it with smooth fine grain stone, or with charcoal and water. When quite smooth and free from scratches, polish with pumice stone and oil, spirits of turpentine, or alcohol.

How to Make a Soft Alloy. A soft alloy which will adhere tenaciously to metal, glass or porcelain, and can also be used as a solder for articles which cannot bear a high degree of heat, is made as follows:

Obtain copper-dust by precipitating copper from the sulphate by means of metallic zinc. Place from 20 to 36 parts of the copper-dust, according to the hardness desired, in a porcelain-lined mortar, and mix well with some sulphuric acid of a specific gravity of 1.85. Add to this paste 70 parts of mercury, stirring constantly, and when thoroughly mixed, rinse the amalgam in warm water to remove the acid. Let cool from 10 to 12 hours, after which time it will be hard enough to scratch tin.

When ready to use it, heat to 707 degrees Fahrenheit and knead in an iron mortar till plastic. It can then be spread on any surface, and when it has cooled and hardened will adhere most tenaciously.

Paint for Iron. Dissolve ½ pound of asphaltum and ½ pound of pounded resin in 2 pounds of tar oil.

Mix hot in an iron kettle, but do not allow it to come in contact with the fire. It may be used as soon as cold, and is good both for outdoor wood and iron-work.

Recipe for Heat-Proof Paint. A good cylinder and exhaust pipe paint is made as follows:

Two pounds of black oxide of manganese, 3 pounds of graphite and 9 pounds of Fuller's earth, thoroughly mixed. Add a compound of 10 parts of sodium silicate, 1 part of glucose and 4 parts of water, until the consistency is such that it can be applied with a brush.

Rust Joint Composition. This is a cement made of sal ammoniac 1 pound; sulphur ½ pound, cast-iron turnings 100 pounds. The whole should be thoroughly mixed and moistened with a little water. If the joint is required to set very quick, add ¼ pound more sal ammoniac. Care should be taken not to use too much sal ammoniac, or the mixture will become rotten.

Removing Rust from Iron. Iron may be quickly and easily cleaned by dipping in or washing with nitric acid one part, muriatic acid one part and water twelve parts. After using wash with clean water.

Making Pipe Joints. Never screw pipe together for either steam, water or gas without putting white or red lead on the joints.

Many times in taking pipe apart the joints are stuck so hard that it is impossible to unscrew the pipe; heat the coupling (not the pipe) by holding a hot iron on it, or hammer the coupling with a light hammer, either one will expand the coupling and break the joint so it can be easily unscrewed.

Annealing Cast Iron. To anneal cast iron, heat it in a slow charcoal fire to a dull red heat; then cover it over about two inches with fine charcoal, then cover all with ashes. Let it lay until cold. Hard cast iron can be softened enough in this way to be filed or drilled. This process will be exceedingly useful to iron founders, as by this means there will be a great saving of expense in making new patterns.

To make a casting of precisely the same size of a broken casting without the original patterns: Put the pieces of broken casting together and mould them, and cast from this mould. Then anneal it as above described, it will expand to the original size of the pattern, and there remain in that expanded state.

Preventing Iron or Steel from Rusting. The best treatment for polished iron or steel, which has a habit of growing gray and lustreless, is to wash it very clean with a stiff brush and ammonia soapsuds, rinse well and dry by heat if possible, then oil plentifully with sweet oil and dust thickly with powdered quick lime. Let the lime stay on two days, then brush it off with a clean stiff brush. Polish with a softer brush, and rub with cloths until the lustre comes out. By leaving the lime on, iron and steel may be kept from rust almost indefinitely.

Loosening Rusted Screws. One of the simplest and readiest ways of loosening a rusted screw is to apply heat to the head of the screw. A small bar or rod of iron, flat at the end, if reddened in the fire and applied for two or three minutes to the head of a rusty screw, will, as soon as it heats the screw, render its withdrawal as easy with the screwdriver as if it were only a recently inserted screw. This is not particularly novel, but it is worth knowing.

MEDICAL AID.

Things to Do in Case of Sprains or Dislocations. The most important thing is to secure rest until the arrival of the surgeon. If the sprain is in the ankle or foot, place a folded towel around the part and cover with a bandage. Apply moist heat. The foot should be immersed in a bucket of hot water and more hot water added from time to time, so that it can be kept as hot as can be borne for fifteen or twenty minutes, after which a firm bandage should be applied, by a surgeon, if possible, and the foot elevated.

In sprains of the wrist, a straight piece of wood should be used as a splint, cover with cotton or wool to make it soft, and lightly bandage, and carry the arm in a sling. In all cases of sprains the results may be serious, and a surgeon should be obtained as soon as possible. After the acute symptoms of pain and swelling have subsided, it is still necessary that the joint should have complete rest by the use of a splint and bandage and such applications as the surgeon may direct.

Simple dislocation of the fingers can be put in place by strong pulling, aided by a little pressure on the part of the bones nearest the joint.

The best that can be done in most cases is to put the part in the position easiest to the sufferer, and to apply cold wet cloths, while awaiting the arrival of a surgeon.

To Remove Foreign Substances from the Eye. Take hold of the upper lid and turn it up so that the inside of the upper lid may be seen. Have the patient make several movements with the eye, first up, then down, to the right side and to the left. Then take a toothpick with a little piece of absorbent cotton wound around the end and moistened in cold water, and swab it out. The foreign substance will adhere to the swab and the object will be removed from the eye without any trouble.

In Case of Cuts. The chief points to be attended to are: Arrest the bleeding. Remove from the wound all foreign substances as soon as possible. Bring the wounded parts opposite to each other and keep them so. This is best done by means of strips of surgeon's plaster, first applied to one side of the wound and then secured to the other. These strips should not be too broad, and space must be left between the strips to allow any matter to escape. Wounds too extensive to be held together by plaster must be stitched by a surgeon, who should always be sent for in severe cases.

Broken Limbs. To get at a broken limb or rib, the clothing must be removed, and it is essential that this should be done without injury to the patient. The simplest plan is to rip up the seams of such garments as are in the way. Shoes must always be cut off. It is not imperatively necessary to do anything to a broken limb before the arrival of a doctor, except to keep it perfectly at rest.

Wounds. If a wound be discovered in a part covered by the clothing, cut the clothing at the seams. Remove only sufficient clothing to uncover and inspect the wound.

All wounds should be covered and dressed as quickly as possible. If a severe bleeding should occur, see that this is stopped, if possible, before the wound is dressed.

Treatment of Burns. In treating burns of a serious nature, the first thing to be done after the fire is extinguished should be to remove the clothing. The greatest care must be exercised, as anything like pulling will bring the skin away. If the clothing is not thoroughly wet, be sure to saturate it with water or oil before attempting to remove it.

If portions of the clothing will not drop off, allow them to remain. Then make a thick solution of common baking soda and water, and dip soft cloths in it and lay them over the injured parts, and bandage them lightly to keep them in position. Have the solution near by, and the instant any part of a cloth shows signs of dryness, squeeze some of the solution on that part. Do not remove the cloth, as total exclusion of the air is necessary, and little, if any, pain, will be felt as long as the cloths are kept saturated. This may be kept up for several days, after which soft cloths dipped in oil may be applied, and covered with cotton batting. If the feet are cold, apply heat and give hot water to drink, and if the burns are very serious send for a doctor as soon as possible. The presence of pain is a good sign, showing that vitality is present.

Bleeding. In case of bleeding, the person may become weak and faint, unless the blood is flowing actively. This is not a serious sign, and the quiet condition of the faint often assists nature in stopping the bleeding, by allowing the blood to clot and so block up any wound in a blood vessel.

Unless the faint is prolonged or the patient is losing much blood, it is better not to relieve the faint condition. When in this state excitement should be avoided, and external warmth should be applied, the person covered with blankets, and bottles of hot water or hot bricks applied to the feet and arm-pits.

Watch carefully if unconscious.

If vomiting occurs, turn the patient's body on one side, with the head low, so that the matters vomited may not go into the lungs.

Bleeding is of three kinds: From the arteries which lead from the heart. That which comes from the veins which take the blood back to the heart. That from the small veins which carry the blood to the surface of the body. In the first, the blood is bright scarlet and escapes as though it were being pumped. In the second, the blood is dark red and flows away in an uninterrupted stream. In the third, the blood oozes out. In some wounds all three kinds of bleeding occur at the same time.

Carrying an Injured Person. In case of an injury where walking is impossible, and lying down is not absolutely necessary, the injured person may be seated in a chair, and carried, or he may sit upon a board, the ends of which are carried by two men, around whose necks they should place his arms so as to steady himself.

Where an injured person can walk he will get much help by putting his arms over the shoulders and round the necks of two others.

TABLES OF DIFFERENT WIRE GAUGES.

Number of Wire Gauge.	Stubs Wire Gauge.	Whitworth or English Wire Gauge.	Metric Equivalent in Millimeters	Birmingham Wire Gauge, for Sheet Iron.	Fractions of an Inch for B. W. Gauge.	American, or Brown and Sharpe,
0/4	.454	......	10.16	....	....	.46
0/3	.425	......	9.449	....	....	.40964
0/2	.38	......	8.839	....	....	.3648
0	.34	......	8.229	....	....	.32486
1	.3	.001	7.62	.3125	5/16	.2893
2	.284	.002	7.01	.28125	....	.25763
3	.259	.003	6.401	.25	1/4	.22942
4	.238	.004	5.893	.234375	....	.20431
5	.22	.005	5.385	.21875	....	.18194
6	.203	.006	4.877	.203125	....	.16202
7	.18	.007	4.47	.1875	3/16	.14428
8	.165	.008	4.064	.171875	....	.12849
9	.148	.009	3.658	.15625	....	.11443
10	.134	.010	3.251	.140625	....	.10189
11	.12	.011	2.946	.12518	....	.090742
12	.109	.012	2.642	.1125	....	.080808
13	.095	.013	2.337	.10	1/10	.071961
14	.083	.014	2.032	.0875	....	.064084
15	.072	.015	1.829	.075	....	.057068
16	.065	.016	1.626	.0625	1/16	.05082
17	.058	.017	1.422	.05625	....	.045257
18	.049	.018	1.219	.05	1/20	.040303

TABLES OF DIFFERENT WIRE GAUGES.—CONTINUED.

Number of Wire Gauge.	Stubs Wire Gauge.	Whitworth or English Wire Gauge.	Metric Equivalent in Millimeters	Birmingham Wire Gauge, for Sheet Iron.	Fractions of an Inch for B. W. Gauge.	American, or Brown and Sharpe.
19	.042	.019	1.0116	.04375	....	.03589
20	.035	.02	.914	.0375	....	.031961
21	.032	......	.813	.034375	....	.028462
22	.028	.022	.711	.03125	$\frac{1}{32}$	.025347
23	.025	......	.61	.028125	....	.022571
24	.022	.024	.559	.025	$\frac{1}{40}$	.0201
25	.02	......	.508	.02344	....	.0179
26	.018	.026	.457	.021875	....	.01594
27	.016	......	.4166	.020312	....	.014195
28	.014	.028	.3759	.01875	....	.012641
29	.013	......	.3454	.01719	....	.011257
30	.012	.03	.315	.015625	....	.010025
31	.01	......	.2946	.01406	....	.008928
32	.009	.032	.2743	.0125	$\frac{1}{80}$	.00795
33	.008	......	.254	....	....	.00708
34	.007	.034	.2337	....	....	.006304
35	.005	......	.2134	....	....	.005614
36	.094	.036	.193	....	....	.005
37	......	......	.1727	....	....	.004453
38	......	.038	.1524	....	....	.003965
39	......	......	.1321	....	....	.003531
40	......	.04	.1219	....	....	.003144

Decimal Equivalents of a Foot in Inches.

Inches.	Equivalents.	Inches.	Equivalent.	Inches.	Equivalent.
1/16	.0052083	2 1/2	.2083	5 3/4	.47916
1/8	.010416	2 5/8	.21875	5 7/8	.489583
3/16	.015625	2 3/4	.22916	6	.5
1/4	.02083	2 7/8	.239583	6 1/4	.52083
5/16	.0260416	3	.25	6 1/2	.5416
3/8	.03125	3 1/8	.260416	6 3/4	.5625
7/16	.0364583	3 1/4	.27083	7	.583
1/2	.0416	3 3/8	.28125	7 1/4	.60416
9/16	.046875	3 1/2	.2916	7 1/2	.625
5/8	.052083	3 5/8	.302083	7 3/4	.64583
11/16	.0572916	3 3/4	.3125	8	.6666
3/4	.0625	3 7/8	.322916	8 1/4	.6875
13/16	.0677083	4	.3333	8 1/2	.7083
7/8	.072916	4 1/8	.34375	8 3/4	.72916
15/16	.078125	4 1/4	.35416	9	.75
1	.083	4 3/8	.364583	9 1/4	.77083
1 1/8	.09375	4 1/2	.375	9 1/2	.7916
1 1/4	.10416	4 5/8	.385416	9 3/4	.8125
1 3/8	.114583	4 3/4	.39583	10	.8333
1 1/2	.125	4 7/8	.40625	10 1/4	.85416
1 5/8	.135416	5	.416	10 1/2	.875
1 3/4	.14583	5 1/8	.427083	10 3/4	.89583
1 7/8	.15625	5 1/4	.4375	11	.916
2	.1666	5 3/8	.447916	11 1/4	.9375
2 1/8	.177083	5 1/2	.4583	11 1/2	.9583
2 1/4	.1875	5 5/8	.46875	11 3/4	.97916
2 3/8	.197916			12	1.

Decimal Equivalents of an Inch.

1/32	.03125	3/8	.375	11/16	.6875
1/16	.0625	13/32	.40625	23/32	.71875
3/32	.09375	7/16	.4375	3/4	.75
1/8	.125	15/32	.46875	25/32	.78125
5/32	.15625	1/2	.5	13/16	.8125
3/16	.1875	17/32	.53125	27/32	.84375
7/32	.21875	9/16	.5625	7/8	.875
1/4	.25	19/32	.59375	29/32	.90625
9/32	.28125	5/8	.625	15/16	.9375
5/16	.3125	21/32	.65625	31/32	.96875
11/32	.34375			1	1.

Weight of Square Iron, from ¼ Inch to 12 Inches, and 1 Foot in Length.

Size in Inches.	Weight in Pounds.	Size in Inches.	Weight in Pounds.
¼	.2	4¾	76.3
⅜	.5	4⅞	80.3
½	.8	5	84.5
⅝	1.3	5⅛	88.8
¾	1.9	5¼	93.2
⅞	2.6	5⅜	97.7
1	3.4	5½	102.2
1⅛	4.3	5⅝	107.
1¼	5.3	5¾	111.8
1⅜	6.4	5⅞	116.7
1½	7.6	6	121.7
1⅝	8.9	6¼	132.
1¾	10.4	6½	142.8
1⅞	11.9	6¾	154.
2	13.5	7	165.6
2⅛	15.3	7¼	177.7
2¼	17.1	7½	190.1
2⅜	19.1	7¾	203.
2½	21.1	8	216.3
2⅝	23.3	8¼	230.1
2¾	25.6	8½	244.2
2⅞	27.9	8¾	258.8
3	30.4	9	273.8
3⅛	33.	9¼	289.2
3¼	35.7	9½	305.1
3⅜	38.5	9¾	321.3
3½	41.4	10	337.9
3⅝	44.4	10¼	355.1
3¾	47.5	10½	372.7
3⅞	50.8	10¾	390.6
4	54.1	11	409.
4⅛	57.5	11¼	427.8
4¼	61.1	11½	447.
4⅜	64.7	11¾	466.7
4½	68.4	12	486.7
4⅝	72.3		

Weight of Flat Iron, from $\frac{1}{8}$ by $\frac{1}{2}$ Inch to 1 by 6 Inches in Width.

Thick.	Width.	Weight in Lbs.	Thick.	Width.	Weight in Lbs.	Thick.	Width.	Weight in Lbs.
1-8	1-2	.211	3-8	4	5.1	5-8	3 1-4	6.9
1-8	5-8	.264	3-8	4 1-4	5.4	5-8	3 1-2	7.4
1-8	3-4	.316	3-8	4 1-2	5.7	5-8	3 3-4	7.9
1-8	7-8	.369	3-8	4 3-4	6.	5-8	4	8.4
1-8	1	.422	3-8	5	6.3	5-8	4 1-4	9.
1-8	1 1-8	.475	3-8	5 1-4	6.7	5-8	4 1-2	9.5
1-4	1	.8	3-8	5 1-2	7.	5-8	4 3-4	10.
1-4	1 1-4	1.1	3-8	5 3-4	7.3	5-8	5	10.6
1-4	1 1-2	1.3	3-8	6	7.6	8-8	5 1-4	11.1
1-4	1 3-4	1.5	1-2	1	1.7	5-8	5 1-2	11.6
1-4	2	1.7	1-2	1 1-4	2.1	5-8	5 3-4	12.1
1-4	2 1-4	1.9	1-2	1 1-2	2.5	5-8	6	12.7
1-4	2 1-2	2.1	1-2	1 3-4	3.	3-4	1	2.5
1-4	2 3-4	2.3	1-2	2	3.4	3-4	1 1-4	3.2
1-4	3	2.5	1-2	2 1-4	3.8	3-4	1 1-2	3.8
1-4	3 1-4	2.7	1-2	2 1-2	4.2	3-4	1 3-4	4.4
1-4	3 1-2	3.	1-2	2 3-4	4.6	3-4	2	5.1
1-4	3 3-4	3.2	1-2	3	5.1	3-4	2 1-4	5.7
1-4	4	3.4	1-2	3 1-4	5.5	3-4	2 1-2	6.3
1-4	4 1-4	3.6	1-2	3 1-2	5.9	3-4	2 3-4	7.
1-4	4 1-2	3.8	1-2	3 3-4	6.3	3-4	3	7.6
1-4	4 3-4	4.	1-2	4	6.8	3-4	3 1-4	8.2
1-4	5	4.2	1-2	4 1-4	7.2	3-4	3 1-2	8.9
1-4	5 1-4	4.4	1-2	4 1-2	7.6	3-4	3 3-4	9.5
1-4	5 1-2	4.6	1-2	4 3-4	8.	3-4	4	10.1
1-4	5 3-4	4.9	1-2	5	8.4	3-4	4 1-4	10.8
1-4	6	5.1	1-2	5 1-4	8.9	3-4	4 1-2	11.4
3-8	1	1.3	1-2	5 1-2	9.3	3-4	4 3-4	12.
3-8	1 1-4	1.6	1-2	5 3-4	9.7	3-4	5	12.7
3-8	1 1-2	1.9	1-2	6	10.1	3-4	5 1-4	13.3
3-8	1 3-4	2.2	5-8	1	2.1	3-4	5 1-2	13.9
3-8	2	2.5	5-8	1 1-4	2.6	3-4	5 3-4	14.6
3-8	2 1-4	2.9	5-8	1 1-2	3.2	3-4	6	15.2
3-8	2 1-2	3.2	5-8	1 3-4	3.7	1	1 1-2	5.1
3-8	2 3-4	3.5	5-8	2	4.2	1	2	6.8
3-8	3	3.8	5-8	2 1-4	4.8	1	3	10.1
3-8	3 1-4	4.1	5-8	2 1-2	5.3	1	4	13.5
3-8	3 1-2	4.4	5-8	2 3-4	5.8	1	5	16.9
3-8	3 3-4	4.8	5-8	3	6.3	1	6	20.3

Weight of Round Iron, from ¼ Inch to 12 Inches in Diameter, and one Foot in Length.

Diameter.	Weight in Pounds.	Diameter.	Weight in Pounds.
1-4	.2	4 3-4	60.
3-8	.4	4 7-8	63.1
1-2	.7	5	66.8
5-8	1.	5 1-8	69.7
3-4	1.5	5 1-4	73.2
7-8	2.	5 3-8	76.7
1	2.7	5 1-2	80.3
1 1-8	3.4	5 5-8	84.
1 1-4	4.2	5 3-4	87.8
1 3-8	5.	5 7-8	91.6
1 1-2	6.	6	95.6
1 5-8	7.	6 1-4	103.7
1 3-4	8.1	6 1-2	112.2
1 7-8	9.3	6 3-4	121.
2	10.6	7	130.
2 1-8	12.	7 1-4	139.5
2 1-4	13.5	7 1-2	149.3
2 3-8	15.	7 3-4	159.5
2 1-2	16.7	8	169.9
2 5-8	18.8	8 1-4	180.7
2 3-4	20.1	8 1-2	191.8
2 7-8	21.9	8 3-4	203.3
3	23.9	9	215.
3 1-8	25.9	9 1-4	227.2
3 1-4	28.	9 1-2	239.6
3 3-8	30.2	9 3-4	252.4
3 1-2	32.5	10	266.3
3 5-8	34.9	10 1-4	278.9
3 3-4	37.3	10 1-2	292.7
3 7-8	39.9	10 3-4	306.8
4	42.5	11	321.2
4 1-8	45.2	11 1-4	336.
4 1-4	48.	11 1-2	351.1
4 3-8	50.8	11 3-4	366.5
4 1-2	53.8	12	382.2
4 5-8	56.8		

WEIGHT OF A SQUARE FOOT OF WROUGHT IRON, COPPER AND LEAD, FROM $\frac{1}{16}$ TO 2 INCHES THICK.

	Wrought Iron.	Copper.	Lead.
1-16	2.517	2.89	3.691
1-8	5.035	5.741	7.382
3-16	7.552	8.672	11.074
1-4	10.07	11.562	14.765
5-16	12.589	14.453	18.456
3-8	15.106	17.344	22.148
7-16	17.623	20.234	25.839
1-2	20.141	23.125	29.530
9-16	22.659	26.106	33.222
5-8	25.176	28.906	36.913
11-16	27.694	31.797	40.604
3-4	30.211	34.688	44.296
13-16	32.729	37.578	47.987
7-8	35.247	40.469	51.678
15-16	37.764	43.359	55.370
1	40.282	46.25	59.061
1 1-8	45.317	52.03	66.444
1 1-4	50.352	57.813	73.826
1 3-8	55.387	63.594	81.21
1 1-2	60.422	69.375	88.592
1 5-8	65.458	75.156	95.975
1 3-4	70.493	80.938	103.358
1 7-8	75.528	86.719	110.74
2	80.563	92.5	118.128

Weight of Copper Bolts, from ¼ to 4 Inches in Diameter, and 1 Foot in Length.

Diameter	Pounds	Diameter	Pounds	Diameter	Pounds
¼	.1892	1⅛	3.8312	2⅜	17.075
5/16	.2956	1 3/16	4.2688	2½	18.9161
⅜	.4256	1¼	4.7298	2⅝	20.8562
7/16	.5794	1 5/16	5.214	2¾	22.8913
½	.7567	1⅜	5.7228	2⅞	25.0188
9/16	.9578	1 7/16	6.2547	3	27.2435
⅝	1.1824	1½	6.8109	3⅛	29.5594
11/16	1.4307	1 9/16	7.3898	3¼	33.9722
¾	1.7027	1⅝	7.9931	3⅜	34.4815
13/16	1.9982	1¾	9.2702	3½	37.0808
⅞	2.3176	1⅞	10.642	3⅝	39.7774
15/16	2.6605	2	12.1082	3¾	42.5680
1	3.027	2⅛	13.6677	3⅞	45.455
1 1/16	3.417	2¼	15.3251	4	48.433

Weight of a Square Foot of Sheet-Iron, Copper, and Brass.

B. W. Gauge	Iron	Copper	Brass	B. W. Gauge	Iron	Galv. Iron	Copper	Brass
1	12.5	14.5	13.75	16	2.62	3.	2.9	2.75
2	12.	13.9	13.2	17	2.2	2.69	2.52	2.4
3	11.	12.75	12.1	18	1.92	2.31	2.15	2.04
4	10.5	11.6	11.	19	1.75	2.07	1.97	1.87
5	9.	10.1	9.61	20	1.54	1.75	1.78	1.69
6	8.34	9.4	8.93	21	1.4	1.5	1.62	1.54
7	7.5	8.7	8.25	22	1.25	1.32	1.45	1.37
8	6.86	7.9	7.54	23	1.13	1.19	1.3	1.23
9	6.29	7.2	6.86	24	1.02	1.06	1.16	1.1
10	5.62	6.5	6.18	25	.9	1.	1.04	.99
11	5.	5.8	5.5	26	.8	.96	.92	.88
12	4.5	5.08	4.81	27	.75	.88	.83	.79
13	4.	4.34	4.12	28	.65	.75	.74	.7
14	3.23	3.6	3.43	29	.58	.69	.64	.61
15	2.97	3.27	3.1					

Weight of a Square Foot of Plates of Different Metals in Pounds.

Thickness in Inches.	Iron.	Brass.	Copper.	Lead.	Zinc.	Thickness. Inches.	Birm. Wr. Gauge.
1/16	2.5	2.7	2.9	3.7	2.3	.0625 =	16
1/8	5.	5.5	5.8	7.4	4.7	.125 =	11
3/16	7.5	8.2	8.7	11.1	7.	.1875 =	7
1/4	10.	11.	11.6	14.8	9.4	.25 =	4
5/16	12.5	13.7	14.5	18.5	11.7	.3125 =	1
3/8	15.	16.4	17.2	22.2	14.	.375	
7/16	17.5	19.2	20.	25.9	16.4	.4375	
1/2	20.	21.9	22.9	29.5	18.7	.5	
9/16	22.5	24.6	25.7	33.2	21.1	.5625	
5/8	25.	27.4	28.6	36.9	23.4	.625	
11/16	27.5	30.1	31.4	40.6	25.7	.6875	
3/4	30.	32.9	34.3	44.3	28.1	.75	
13/16	32.5	35.6	37.2	48.	30.4	.8125	
7/8	35.	38.3	40.	51.7	32.8	.875	
15/16	37.5	41.2	42.9	55.4	35.1	.9375	
1	40.	43.9	45.8	59.1	37.5	1.	

Weights of Various Substances.

Name.	Cubic Foot in Pounds.	Cubic Inch in Pounds.
Cast iron	450.55	.2607
Wrought iron	486.65	.2816
Steel	489.8	.2834
Copper	555.	.32118
Lead	708.85	.4101
Brass	537.75	.3112
Tin	456.	.263
White pine	29.56	.0171
Salt water (sea)	64.3	.03721
Fresh water	62.5	.03616
Air	.07529	
Steam	.03689	

Heat. One of the remarkable effects of the application of heat to matter is, that the same amount will affect equal weights of dissimilar kinds in different degrees. Thus the amount of heat that will raise 1 pound of water from 100 degrees Fahrenheit to 200 degrees Fahrenheit, will raise 30 pounds of mercury through the same range. The amount that will raise 1 pound of water 1 degree, will raise 14 pounds of air 1 degree Fahrenheit.

The capacity of a body for heat is termed its specific heat, and may be defined as the number of units of heat necessary to raise the temperature of 1 pound of that body 1 degree Fahrenheit.

The thermal unit, or unit of heat, is the quantity of heat that will raise 1 pound of pure water 1 degree Fahrenheit, or from 39 degrees to 40 degrees Fahrenheit.

Latent heat is the quantity of heat which has disappeared from a body owing to an increase of temperature. The sensible heat is that which is sensible to the touch or measurable by the thermometer.

SPECIFIC HEAT OF DIFFERENT SUBSTANCES.

SOLIDS.			
Copper	.0951	Alumina	.1970
Gold	.0324	Stones, bricks, &c. about	.2200
Iron	.1138	LIQUIDS.	
Lead	.0314	Water	1.
Platinum	.0324	Lead, melted	.0402
Silver	.0570	Sulphur, melted	.2340
Tin	.0562	Bismuth, melted	.0363
Zinc	.0955	Tin, melted	.0637
Brass	.0939	Mercury	.0332
Glass	.1977	Alcohol	.6150
Ice	.5040	Fusel oil	.5640
Sulphur	.2020	Benzine	.4500
Charcoal	.2410	Ether	.5034

Latent Heat of Various Substances.

Substance.	Deg. Fah.	Substance.	Deg. Fah.
Alcohol	442	Lead	162
Ammonia	860	Sulphur	144
Beeswax	176	Steam	990
Ether	301	Vinegar	875
Ice	140	Zinc	493

Fusing Points of the Principal Metals and other Elements Employed in Alloys.

Substance.	Deg. Fah.	Substance.	Deg. Fah.
Aluminum	1292	Lead	626
Antimony	797	Mercury	40
Arsenic	773	Nickel	2732 to 2912
Bismuth	504	Phosphorus	111
Cadmium	608	Platinum	4712
Copper	1922	Silver	1832
Gold	2282	Sulphur	239
Iron, cast	1922 to 2192	Tellurium	716
Iron, steel	2372 to 2552	Tin	455
Iron, wrought	2732 to 2912	Zinc	773

Relative Heat-Conducting Power of Bodies.

Substance.	Relative Conducting Power	Substance.	Relative Conducting Power
Gold	1.000	Zinc	.363
Platinum	.981	Tin	.304
Silver	.973	Lead	.108
Copper	.892	Marble	.024
Brass	.749	Porcelain	.012
Cast Iron	.562	Terra-Cotta	.011
Wrought Iron	.374		

Effects of Heat upon Bodies.

Substance.	Degrees Fahrenheit.
Cast iron melts at	2754
Fine gold melts at	1983
Fine silver melts at	1850
Copper melts at	2160
Brass melts at	1900
Zinc melts at	740
Lead melts at	594
Bismuth melts at	476
Tin melts at	421
Tin and bismuth (equal parts) melt at	283
Tin 3 parts, bismuth 5, and lead 2, melt at	212
Mercury boils at	630
Linseed oil boils at	600
Alcohol boils at	174
Ether boils at	98
Mercury melts at	39

Expansion of Metals by Heat.

In raising the temperature of bars of various metals from 32° Fahrenheit to 212° Fahrenheit, they are found to expand nearly as follows:

Metal.	Parts.	Metal.	Parts.
Platinum	1 in 1097	Copper	1 in 557
Palladium	" 1000	Gunmetal (cop. 8 tin 1)	" 550
Antimony	" 923	Brass	" 524
Cast iron	" 901	Speculum metal	" 517
Steel	" 824	Silver	" 499
Wrought iron	" 801	Tin	" 424
Bismuth	" 718	Lead	" 350
Gold	" 667	Zinc	" 336

PROPERTIES OF METALS.

	Melting Point. Degrees Fahrenheit.	Weight in Lbs. per Cubic Foot.	Weight in Lbs. per Cubic Inch.	Tensile Strength in Pounds per Square Inch.
Aluminum	1140	166.5	.0963	15000-30000
Antimony	810-1000	421.6	.2439	1050
Brass (average)	1500-1700	523.2	.3027	30000-45000
Copper	1930	552.	.3195	30000-40000
Gold (pure)	2100	1200.9	.6949	20380
Iron, cast	1900-2200	450.	.2604	20000-35000
Iron, wrought	2700-2830	480.	.2779	35000-60000
Lead	618	709.7	.4106	1000-3000
Mercury	39	846.8	.4900	
Nickel	2800	548.7	.3175	
Silver (pure)	1800	655.1	.3791	40000
Steel	2370-2685	489.6	.2834	50000-120000
Tin	475	458.3	.2652	5000
Zinc	780	436.5	.2526	3500

NOTE.—The wide variations in the tensile strength are due to the different forms and qualities of the metal tested. In the case of lead, the lowest strength is for lead cast in a mould, the highest for wire drawn after numerous workings of the metal. With steel it varies with the percentage of carbon used, which is varied according to the grade of steel required. Mercury becomes solid at 39 degrees below zero.

PROPERTIES OF METALS.

Name of Metal.	Specific Gravity.	Melting Point. Degrees. Fah.	Melting Point. Degrees. Cent.	Relative Ductility.	Relative Malle-ability.	Relative Tenacity.
Aluminum	2.56	1050	565.5	6	5	9
Antimony	6.7	810	432.2	—	—	—
Bismuth	9.9	500	260.	—	—	—
Copper	8.9	2000	1093.3	5	3	2
Gold	19.5	2016	1102.2	1	1	5
Iron	7.8	2700	1482.2	4	9	1
Lead	11.4	612	322.2	9	7	8
Nickel	8.82	2700	1482.2	10	10	—
Platinum	21.5	3080	1693.3	3	6	3
Silver	10.5	1873	1022.7	2	2	4
Tin	7.3	442	227.7	8	4	7
Zinc	7.	773	411.6	7	8	6

SPECIFIC GRAVITIES AND MELTING-POINTS OF METALS.

Metals.	Specific Gravities.	Melting-points. (Centigrade.)
Antimony	6.7	432
Bismuth	9.8	268.3
Copper (cast)	8.6	1054
" (wrought)	8.8	1054
Steel	7.8	1300 to 1400
Cadmium	8.6	320.7
Iron (wrought)	7.8	1500 to 1600
Lead	11.36	326.2
Tin	7.29	232.7
Zinc	7.19	433.3
Aluminum	2.67	1045
Nickel	8.3	1450
Platinum	21.25	1775

MELTING, BOILING AND FREEZING POINTS IN DEGREES FAHRENHEIT OF VARIOUS SUBSTANCES.

Substance.	Melts at Degrees	Substance.	Melts at Degrees
Platinum	3080	Antimony	810
Wrought-Iron	2830	Zinc	780
Nickel	2800	Lead	618
Steel	2600	Bismuth	476
Cast-Iron	2200	Tin	475
Gold (pure)	2100	Cadmium	442
Copper	1930	Sulphur	226
Gun Metal	1960	Bees-Wax	151
Brass	1900	Spermaceti	142
Silver (pure)	1800	Tallow	72
Aluminum	1140	Mercury	39

Substance.	Boils at Degrees	Substance.	Freezes at Degrees
Mercury	660	Olive Oil	36
Linseed Oil	600	Fresh Water	32
Sulphuric Acid	590	Vinegar	28
Oil of Turpentine	560	Sea Water	27½
Nitric Acid	242	Turpentine	14
Sea Water	213	Sulphuric Acid	1
Fresh Water	212		

Malleability, Ductility and Tenacity of Metals.

Malleability.	Ductility.	Tenacity
Gold	Gold	Steel
Silver	Silver	Iron
Copper	Platinum	Copper
Tin	Iron	Platinum
Platinum	Copper	Silver
Lead	Aluminum	Gold
Zinc	Zinc	Zinc
Iron	Tin	Tin
Nickel	Lead	Lead

Composition and Melting Points of Soft Solders.

Solder.	Tin.	Lead.	Bismuth.	Melting point Deg. Fahr.
Bismuth solder	3	5	3	202
“ “	2	2	1	229
“ “	1	1	1	254
“ “	4	4	1	320
Tinsmith's coarse solder	3	2		334
“ fine solder	2	1		340
Plumber's fine solder	1	2		441
“ coarse solder	1	3		482
Solder for soldering lead	1	1½		
“ “ “ tin	1	2		
“ “ “ pewter	2	1		

Hard Solders or Brazing Mixtures.

Solder.	Copper	Tin.	Zinc.	Brass	Silv r
Hard solder for copper and brass	1		1		
“ “ “ “ “ “			1	5	
Harder “ “ “ “ “	2		1		
“ “ “ “ “ “	3		1		
Silver Solder	8		8		1
“ “				1	1
“ “				1	2

TABLE OF STANDARD TIN PLATES.

Size and Kind of Plates, Number and Weight of Sheets in a Box, and Wire Gauge Thickness.

Size.	Grade.	Sheets in Box.	Pounds in Box.	B. W. Gauge.
10 x 10	IC	225	80	29
"	IX	225	100	27
"	IXX	225	115	26
"	IXXX	225	130	25
"	IXXXX	225	145	24½
10 x 14	IC	225	112	29
"	IX	225	140	27
"	IXX	225	161	26
"	IXXX	225	182	25
"	IXXXX	225	203	24½
"	IXXXXX	225	224	24
"	IXXXXXX	225	245	23½
10 x 20	IC	225	160	29
"	IX	225	200	27
11 x 11	IC	225	95	29
"	IX	225	121	27
"	IXX	225	139	26
"	IXXX	225	157	25
"	IXXXX	225	175	24½
11 x 15	SDC	200	168	26
"	SDX	200	189	25
"	SDXX	200	210	24½
11 x 15	SDXXX	200	230	24
12 x 12	IC	225	112	29
"	IX	225	140	27
"	IXX	225	161	20
"	IXXX	225	182	25
"	IXXXX	225	203	24½
"	IXXXXX	225	224	24
"	IXXXXXX	225	245	23½

TABLE OF STANDARD TIN PLATES.—CONTINUED.

Size.	Grade.	Sheets in Box.	Pounds in Box.	B. W. Gauge.
12½ x 17	DC	100	98	28
"	DX	100	126	26
"	DXX	100	147	24
"	DXXX	100	168	23
"	DXXXX	100	189	22
"	DXXXXX	100	210	21
13 x 13	IC	225	135	29
"	IX	225	169	27
"	IXX	225	194	26
"	IXXX	225	220	25
"	IXXXX	225	245	24½
13 x 17	IXX	225	254	26
13 x 18	IX	225	234	27
"	IXX	225	269	26
14 x 14	IC	225	157	29
"	IX	225	196	27
"	IXX	225	225	26
"	IXXX	225	255	25
"	IXXXX	225	284	24½
14 x 17	IX	225	238	27
14 x 20	IC	112	113	29
"	IX	112	143	27
"	IXX	112	162	26
"	IXXX	112	183	25
"	IXXXX	112	202	24½
15 x 15	IX	225	225	27
"	IXX	225	259	26
"	IXXX	225	293	25
"	IXXXX	225	326	24½
15 x 21	IX	112	158	27
"	DXX	100	218	24
"	DXXX	100	249	23
"	DXXXX	100	280	22
15 x 22	IXX	112	190	26
"	SDXX	100	210	24½

TABLE OF STANDARD TIN PLATES.—CONTINUED.

Size.	Grade.	Sheets in Box.	Pounds. in Box.	B. W. Gauge.
15 x 22	SDXXX	100	230	24
16 x 16	IC	225	205	29
"	IX	225	256	27
"	IXX	225	294	26
"	IXXX	225	333	25
"	IXXXX	225	371	24½
17 x 17	IC	225	231	29
17 x 17	IX	225	289	27
"	IXX	112	166	26
"	IXXX	112	188	25
"	IXXXX	112	210	24½
17 x 25	DC	100	196	28
"	DX	100	252	26
"	DXX	50	146	24
"	DXXX	50	168	23
"	DXXXX	50	189	22
"	IX	112	213	27
"	IXX	112	244	26
18 x 18	IX	112	162	27
"	IXX	112	186	26
"	IXXX	112	211	25
"	IXXXX	112	235	24½
19 x 19	IC	112	144	29
"	IX	112	180	27
"	IXX	112	207	26
"	IXXX	112	234	25
"	IXXXX	112	262	24½
20 x 20	IC	112	160	29
"	IX	112	200	27
"	IXX	112	230	26
"	IXXX	112	260	25
"	IXXXX	112	290	24½
20 x 28	IC	112	224	29
"	IX	112	280	27
"	IXX	112	322	26

AREA OF CIRCLES.

Diam.	Area.	Diam.	Area.	Diam.	Area.	Diam.	Area.
⅛	0.0123	10	78.54	30	706.86	65	3318.3
¼	0.0491	10½	86.59	31	754.76	66	3421.2
⅜	0.1104	11	95.03	32	804.24	67	3525.6
½	0.1963	11½	103.86	33	855.30	68	3631.6
⅝	0.3068	12	113.09	34	907.92	69	3739.2
¾	0.4418	12½	122.71	35	962.11	70	3848.4
⅞	0.6013	13	132.73	36	1017.8	71	3959.2
1	0.7854	13½	143.13	37	1075.2	72	4071.5
1⅛	0.9940	14	153.93	38	1134.1	73	4185.4
1¼	1.227	14½	165.13	39	1194.5	74	4300.8
1⅜	1.484	15	176.71	40	1256.6	75	4417.8
1½	1.767	15½	188.69	41	1320.2	76	4536.4
1⅝	2.073	16	201.06	42	1385.4	77	4656.6
1¾	2.405	16½	213.82	43	1452.2	78	4778.3
1⅞	2.761	17	226.98	44	1520.5	79	4901.6
2	3.141	17½	240.52	45	1590.4	80	5026.5
2¼	3.976	18	254.46	46	1661.9	81	5153.0
2½	4.908	18½	268.80	47	1734.9	82	5281.0
2¾	5.939	19	283.52	48	1809.5	83	5410.6
3	7.068	19½	298.64	49	1885.7	84	5541.7
3¼	8.295	20	314.16	50	1963.5	85	5674.5
3½	9.621	20½	330.06	51	2042.8	86	5808.8
3¾	11.044	21	346.36	52	2123.7	87	5944.6
4	12.566	21½	363.05	53	2206.1	88	6082.1
4½	15.904	22	380.13	54	2290.2	89	6221.1
5	19.635	22½	397.60	55	2375.8	90	6361.7
5½	23.758	23	415.47	56	2463.0	91	6503.9
6	28.274	23½	433.73	57	2551.7	92	6647.6
6½	33.183	24	452.39	58	2642.0	93	6792.9
7	38 484	24½	471.43	59	2733.9	94	6939.8
7½	44.178	25	490.87	60	2827.4	95	7088.2
8	50.265	26	530.93	61	2922.4	96	7238.2
8½	56.745	27	572.55	62	3019.0	97	7389.8
9	63.617	28	615.75	63	3117.2	98	7542.9
9½	70.882	29	660.52	64	3216.9	99	7697.7

To compute the area of a diameter greater than any in the above table:

RULE.—Divide the dimension by 2, 3, 4, etc., if practicable, until it is reduced to a quotient to be found in the table, then multiply the tabular area of the quotient by the square of the factor. The product will be the area required.

EXAMPLE.—What is area of diameter of 150? 150÷5=30. Tabular area of 30=706.86 which × 25=17,671.5 area required.

CIRCUMFERENCE OF CIRCLES.

Diam.	Circum.	Diam.	Circum.	Diam.	Circum.	Diam.	Circum.
1/8	.3927	10	31.41	30	94.24	65	204.2
1/4	.7854	10 1/2	32.98	31	97.38	66	207.3
3/8	1.178	11	34.55	32	100.5	67	210.4
1/2	1.570	11 1/2	36.12	33	103.6	68	213.6
5/8	1.963	12	37.69	34	106.8	69	216.7
3/4	2.356	12 1/2	39.27	35	109.9	70	219.9
7/8	2.748	13	40.84	36	113.0	71	223.0
1	3.141	13 1/2	42.41	37	116.2	72	226.1
1 1/8	3.534	14	43.98	38	119.3	73	229.3
1 1/4	3.927	14 1/2	45.55	39	122.5	74	232.4
1 3/8	4.319	15	47.12	40	125.6	75	235.6
1 1/2	4.712	15 1/2	48.69	41	128.8	76	238.7
1 5/8	5.105	16	50.26	42	131.9	77	241.9
1 3/4	5.497	16 1/2	51.83	43	135.0	78	245.0
1 7/8	5.890	17	53.40	44	138.2	79	248.1
2	6.283	17 1/2	54.97	45	141.3	80	251.3
2 1/4	7.068	18	56.54	46	144.5	81	254.4
2 1/2	7.854	18 1/2	58.11	47	147.6	82	257.6
2 3/4	8.639	19	59.69	48	150.7	83	260.7
3	9.424	19 1/2	61.26	49	153.9	84	263.8
3 1/4	10.21	20	62.83	50	157.0	85	267.0
3 1/2	10.99	20 1/2	64.40	51	160.2	86	270.1
3 3/4	11.78	21	65.97	52	163.3	87	273.3
4	12.56	21 1/2	67.54	53	166.5	88	276.4
4 1/2	14.13	22	69.11	54	169.6	89	279.6
5	15.70	22 1/2	70.68	55	172.7	90	282.7
5 1/2	17.27	23	72.25	56	175.9	91	285.8
6	18.84	23 1/2	73.82	57	179.0	92	289.0
6 1/2	20.42	24	75.39	58	182.2	93	292.1
7	21.99	24 1/2	76.96	59	185.3	94	295.3
7 1/2	23.56	25	78.54	60	188.4	95	298.4
8	25 13	26	81.68	61	191.6	96	301.5
8 1/2	26.70	27	84.82	62	194.7	97	304.7
9	28.27	28	87.96	63	197.9	98	307.8
9 1/2	29.84	29	91.10	64	201.0	99	311.0

To compute the circumference of a diameter greater than any in the above table:

RULE.—Divide the dimension by 2, 3, 4, etc., if practicable, until it is reduced to a diameter to be found in table. Take the tabular circumference of this diameter, multiply it by 2, 3, 4, etc., according as it was divided, and the product will be the circumference required.

EXAMPLE.—What is the circumference of a diameter of 125? 125 ÷ 5 = 25. Tabular circumference of 25 = 78.54, 78.54 × 5 = 392.7, circumference required.

Capacity of Cylinders in Gallons.

Depth in Inch's	Diameter in Inches.					
	4	5	6	7	8	9
1	.0544	.0850	.1224	.1666	.2176	.2754
2	.1088	.1700	.2448	.3332	.4352	.5508
3	.1632	.2550	.3672	.4998	.6528	.8262
4	.2176	.3400	.4896	.6664	.8704	1.1016
5	.2720	.4250	.6120	.8330	1.0880	1.3770
6	.3264	.5100	.7344	.9996	1.3056	1.6524
7	.3808	.5950	.8568	1.1662	1.5232	1.9278
8	.4352	.6800	.9792	1.3328	1.7408	2.2032
9	.4896	.7650	1.1016	1.4994	1.9584	2.4786
10	.5440	.8500	1.2240	1.6660	2.1760	2.7540
11	.5984	.9350	1.3464	1.8326	2.3936	3.0294
12	.6528	1.0200	1.4688	1.9992	2.6112	3.3048
13	.7072	1.1050	1.5912	2.1658	2.8288	3.5802
14	.7616	1.1900	1.7136	2.3324	3.0464	3.8556
15	.8160	1.2750	1.8360	2.4990	3.2640	4.1310
16	.8704	1.3600	1.9584	2.6656	3.4816	4.4064
17	.9248	1.4450	2.0808	2.8322	3.6992	4.6818
18	.9792	1.5300	2.2032	2.9988	3.9168	4.9572
19	1.0336	1.6150	2.3256	3.1654	4.1344	5.2326
20	1.0880	1.7000	2.4480	3.3320	4.3520	5.5080
21	1.1424	1.7850	2.5704	3.4986	4.5696	5.7834
22	1.1968	1.8700	2.6928	3.6652	4.7872	6.0588
23	1.2512	1.9550	2.8152	3.8318	5.0048	6.3342
24	1.3056	2.0400	2.9376	3.9984	5.2224	6.6096
25	1.3600	2.1250	3.0600	4.1650	5.4400	6.8850
26	1.4144	2.2100	3.1824	4.3316	5.6576	7.1604
27	1.4688	2.2950	3.3048	4.4982	5.8752	7.4358
28	1.5232	2.3800	3.4272	4.6648	6.0928	7.7112
29	1.5776	2.4650	3.5496	4.8314	6.3104	7.9866
30	1.6320	2.5500	3.6720	4.9980	6.5289	8.2620
31	1.6864	2.6350	3.7944	5.1646	6.7456	8.5324
32	1.7408	2.7200	3.9168	5.3312	6.9632	8.8128
33	1.7952	2.8050	4.0392	5.4978	7.1808	9.0882
34	1.8496	2.8900	4.1616	5.6644	7.3984	9.3636
35	1.9040	2.9750	4.2840	5.8310	7.6160	9.6390
36	1.9584	3.0600	4.4064	5.9976	7.8336	9.9144
40	2.1760	3.4000	4.8960	6.6640	8.7040	11.0160
44	2.3936	3.7400	5.3856	7.3304	9.5744	12.1176
48	2.6112	4.0800	5.8752	7.9968	10.4448	13.2192
54	2.9376	4.5900	6.6096	8.9964	11.7504	14.8716
60	3.2640	5.1000	7.3440	9.9960	13.0560	16.5240
72	3.9168	6.1200	8.8128	11.9952	15.6672	19.8288

Capacity of Cylinders—Continued.

Depth in Inch's	Diameter in Inches. 10	11	12	13	14	15
1	.3400	.4114	.4896	.5746	.6664	.7650
2	.6800	.8228	.9792	1.1492	1.3328	1.5300
3	1.0200	1.2342	1.4688	1.7238	1.9992	2.2950
4	1.3600	1.6456	1.9584	2.2984	2.6656	3.0600
5	1.7000	2.0570	2.4480	2.8730	3.3320	3.8250
6	2.0400	2.4684	2.9376	3.4476	3.9984	4.5900
7	2.3800	2.8798	3.4272	4.0222	4.6648	5.3550
8	2.7200	3.2912	3.9168	4.5968	5.3312	6.1200
9	3.0600	3.7026	4.4064	5.1714	5.9976	6.8850
10	3.4000	4.1140	4.8960	5.7460	6.6640	7.6500
11	3.7400	4.5254	5.3856	6.3206	7.3304	8.4150
12	4.0800	4.9368	5.8752	6.8952	7.9968	9.1800
13	4.4200	5.3482	6.3648	7.4698	8.6632	9.9450
14	4.7600	5.7596	6.8544	8.0444	9.3296	10.7100
15	5.1000	6.1710	7.3440	8.6190	9.9960	11.4750
16	5.4400	6.5824	7.8336	9.1936	10.6624	12.2400
17	5.7800	6.9938	8.3232	9.7682	11.3288	13.0050
18	6.1200	7.4052	8.8128	10.3428	11.9952	13.7700
19	6.4600	7.8166	9.3024	10.9174	12.6616	14.5350
20	6.8000	8.2280	9.7920	11.4920	13.3280	15.3000
21	7.1400	8.6394	10.2816	12.0666	13.9944	16.0650
22	7 4800	9.0508	10.7712	12.6412	14.6608	16.8300
23	7.8200	9.4622	11.2608	13.2158	15.3272	17.5950
24	8.1600	9.8736	11.7504	13.7904	15.9936	18.3600
25	8.5000	10.2850	12.2400	14.3650	16.6600	19.1250
26	8.8400	10.6964	12.7296	14.9396	17.3264	19.8900
27	9.1800	11.1078	13.2192	15.5142	17.9928	20.6550
28	9.5200	11.5192	13.7088	16.0888	18.6592	21.4200
29	9.8600	11.9306	14.1984	16.6634	19.3256	22.1850
30	10.2000	12.3420	14.6880	17.2380	19.9920	22.9500
31	10.5400	12.7534	15.1776	17.8126	20.6584	23.7150
32	10.8800	13.1648	15.6672	18.3872	21.3248	24.4800
33	11.2200	13.5762	16.1568	18.9618	21.9912	25.2450
34	11.5600	13.9876	16.6464	19.5364	22.6576	26.0100
35	11.9000	14.3990	17.1360	20.1110	23.3240	26.7750
36	12.2400	14.8104	17.6256	20.6856	23.9904	27.5400
40	13.6000	16.4560	19.5840	22.9840	26.6560	30.6000
44	14.9600	18.1060	21.5424	25.2824	29.3216	33.6600
48	16.3200	19.7472	23.5008	27.5808	31.9872	36.7200
54	18.3600	22.2156	26.4384	31.0284	35.9856	41.3100
60	20.4000	24.6840	29.3760	34.4760	39.9840	45.9000
72	24.4800	29.6208	35.2512	41.3712	47.9808	55.0800

Capacity of Cylinders—Continued.

Depth in Inch's	Diameter in Inches.					
	16	17	18	19	20	21
1	.8704	.9826	1.1016	1.2274	1.3600	1.4994
2	1.7408	1.9652	2.2032	2.4548	2.7200	2.9988
3	2.6112	2.9478	3.3048	3.6822	4.0800	4.4982
4	3.4816	3.9304	4.4064	4.9096	5.4400	5.9976
5	4.3520	4.9130	5.5080	6.1370	6.8000	7.4970
6	5.2224	5.8956	6.6096	7.3644	8.1600	8.9964
7	6.0928	6.8782	7.7112	8.5918	9.5200	10.4958
8	6.9632	7.8608	8.8128	9.8192	10.8800	11.9952
9	7.8336	8.8434	9.9144	11.0466	12.2400	13.4946
10	8.7040	9.8260	11.0160	12.2740	13.6000	14.9940
11	9.5744	10.8086	12.1176	13.5014	14.9600	16.4934
12	10.4448	11.7912	13.2192	14.7288	16.3200	17.9928
13	11.3152	12.7738	14.3208	15.9562	17.6800	19.4922
14	12.1856	13.7504	15.4224	17.1836	19.0400	20.9916
15	13.0560	14.7390	16.5240	18.4110	20.4000	22.4910
16	13.9264	15.7216	17.6256	19.6384	21.7600	23.9904
17	14.7968	16.7042	18.7272	20.8658	23.1200	25.4898
18	15.6672	17.6868	19.8288	22.0932	24.4800	26.9892
19	16.5376	18.6694	20.9304	23.3206	25.8400	28.4886
20	17.4080	19.6520	22.0320	24.5480	27.2000	29.9880
21	18.2784	20.6346	23.1336	25.7754	28.5600	31.4874
22	19.1488	21.6172	24.2352	27.0028	29.9200	32.9868
23	20.0192	22.5998	25.3368	28.2302	31.2800	34.4882
24	20.8896	23.5824	26.4384	29.4576	32.6400	35.9856
25	21.7600	24.5650	27.5400	30.6850	34.0000	37.4850
26	22.6304	25.5476	28.6416	31.9124	35.3600	38.9844
27	23.5008	26.5302	29.7432	33.1398	36.7200	40.4838
28	24.3712	27.5128	30.8448	34.3672	38.0800	41.9832
29	25.2416	28.4954	31.9464	35.5946	39.4400	43.4826
30	26.1120	29.4780	33.0480	36.8220	40.8000	44.9820
31	26.9824	30.4606	34.1496	38.0494	42.1600	46.4814
32	27.8528	31.4432	35.2512	39.2768	43.5200	47.9808
33	28.7232	32.4258	36.3528	40.5042	44.8800	49.4802
34	29.5936	33.4084	37.4544	41.7316	46.2400	50.9796
35	30.4640	34.3910	38.5560	42.9590	47.6000	52.4790
36	31.3344	35.3736	39.6576	44.1864	48.9600	53.9784
40	34.8160	39.3040	44.0640	49.0960	54.4000	59.9760
44	38.2976	43.2344	48.4704	54.0056	59.8400	65.9736
48	41.7792	47.1648	52.8768	58.9152	65.2800	71.9712
54	47.0016	53.0604	59.4864	66.2706	73.4400	80.9676
60	52.2240	58.9560	66.0960	73.6440	81.6000	89.9640
72	62.6688	70.7472	79.3152	88.3728	97.9200	107.9570

CAPACITY OF CYLINDERS—CONTINUED.

Depth in Inches.	Diameter in Inches.				
	22	23	24	26	28
1	1.6456	1.7986	1.9584	2.2984	2.6656
2	3.2912	3.5972	3.9168	4.5968	5.3312
3	4.9368	5.3958	5.8752	6.8952	7.9968
4	6.5824	7.1944	7.8336	9.1930	10.6624
5	8.2280	8.9930	9.7920	11.4920	13.3280
6	9.8736	10.7916	11.7504	13.7904	15.9936
7	11.5192	12.5902	13.7088	16.0888	18.6592
8	13.1648	14.3888	15.6672	18.3872	21.3248
9	14.8104	16.1874	17.6256	20.6856	23.9904
10	16.4560	17.9860	19.5840	22.9840	26.6560
11	18.1016	19.7846	21.5424	25.2824	29.3216
12	19.7472	21.5832	23.5008	27.5808	31.9872
13	21.3928	23.3818	25.4592	29.8792	34.6528
14	23.0384	25.1804	27.4176	32.1776	37.3184
15	24.6840	26.9790	29.3760	34.4760	39.9840
16	26.3296	28.7776	31.3334	36.7744	42.6496
17	27.9752	30.5762	33.2928	39.0728	45.3152
18	29.6208	32.3748	35.2512	41.3712	47.9808
19	31.2664	34.1734	37.2096	43.6696	50.6464
20	32.9120	35.9720	39.1680	45.9680	53.3120
21	34.5576	37.7706	41.1264	48.2664	55.9796
22	36.2032	39.5692	43.0848	50.5648	58.6432
23	37.8488	41.3678	45.0432	52.8632	61.3088
24	39.4944	43.1664	47.0016	55.1616	63.9744
25	41.1400	44.9650	48.9600	57.4600	66.6400
26	42.7856	46.7636	50.9184	59.7584	69.3056
27	44.4312	48.5622	52.8768	62.0568	71.9712
28	46.0768	50.3608	54.8352	64.3552	74.6368
29	47.7224	52.1594	56.7936	66.6536	77.3024
30	49.3680	53.9580	58.7520	68.9520	79.9680
31	51.0136	55.7566	60.7104	71.2504	82.6336
32	52.6592	57.5552	62.6688	73.5488	85.2992
33	54.3048	59.3538	64.6272	75.8472	87.9648
34	55.9504	61.1524	66.5856	78.1456	90.6304
35	57.5960	62.9510	68.5440	80.4440	93.2960
36	59.2416	64.7496	70.5024	82.7424	95.9616
40	65.8240	71.9440	78.3360	91.9360	106.6240
44	72.4064	79.1384	86.1696	101.1300	117.2860
48	78.9888	86.3328	94.0032	110.3230	127.9490
54	88.8624	97.1244	105.7540	124.1140	143.9420
60	98.7360	107.9160	117.5040	137.9040	159.9360
72	118.4830	129.4990	141.0050	165.4850	191.9230

Capacity of Cylinders—Continued.

Depth in Inches.	Diameter in Inches, 30	32	34	36	40
1	3.06	3.4816	3.9304	4.4064	5.44
2	6.12	6.9632	7.8608	8.8128	10.88
3	9.18	10.4448	11.7912	13.2192	16.32
4	12.24	13.9264	15.7216	17.6256	21.76
5	15.30	17.4080	19.6520	22.0320	27.20
6	18.36	20.8896	23.5824	26.4384	32.64
7	21.42	24.3712	27.5128	30.8448	38.08
8	24.48	27.8528	31.4422	35.2512	43.52
9	27.54	31.3344	35.3736	39.6576	48.96
10	30.60	34.8160	39.3740	44.0640	54.40
11	33.66	38.2976	43.2344	48.4704	59.84
12	36.72	41.7792	47.1648	52.8768	65.28
13	39.78	45.2608	51.0952	57.2832	70.72
14	42.84	48.7424	55.0256	61.6896	76.16
15	45.90	52.2240	58.9560	66.0960	81.60
16	48.96	55.7056	62.8864	70.5024	87.04
17	52.02	59.1872	66.8168	74.9088	92.48
18	55.08	62.6688	70.7472	79.3152	97.92
19	58.14	66.1504	74.6776	83.7216	103.36
20	61.20	69.6320	78.6080	88.1280	108.80
21	64.26	73.1136	82.5384	92.5344	114.24
22	67.32	76.5952	86.4688	96.9408	119.68
23	70.38	80.0768	90.3992	101.3470	125.12
24	73.44	83.5584	94.3296	105.7540	130.56
25	76.50	87.0400	98.2600	110.1600	136.00
26	79.56	90.5216	102.1900	114.5660	141.44
27	82.62	94.0032	106.1210	118.9730	146.88
28	85.68	97.4848	110.0510	123.3790	152.32
29	88.74	100.9660	113.9820	127.7860	157.76
30	91.80	104.4480	117.9120	132.1920	163.20
31	94.86	107.9300	121.8420	136.5980	168.64
32	97.92	111.4110	125.7730	141.0050	174.08
33	100.98	114.8930	129.7030	145.4110	179.52
34	104.04	118.3740	133.6340	149.8180	184.96
35	107.10	121.8560	137.5640	154.2240	190.40
36	110.16	125.3380	141.4940	158.6300	195.84
40	122.40	139.2640	157.2160	176.2560	217.60
44	134.64	153.1900	172.9380	103.8820	239.36
48	146.88	167.1170	188.6590	211.5070	261.12
54	165.24	188.0060	212.2420	237.9460	293.76
60	183.60	208.8960	235.8240	264.3840	326.40
72	220.32	250.6750	282.9890	317.2610	391.68

Capacity of Cylinders—Continued.

Depth in Inches.	Diameter in Inches.				
	44	48	54	60	72
1	6.5824	7.8336	9.9144	12.24	17.6256
2	13.1648	15.6672	19.8288	24.48	35.2512
3	19.7472	23.5008	29.7432	36.72	52.8768
4	26.3296	31.3344	39.6576	48.96	70.5024
5	32.9120	39.1680	49.5720	61.20	88.1280
6	39.4944	47.0016	59.4864	73.44	105.7540
7	46.0768	54.8352	69.4008	85.68	123.3790
8	52.6592	62.6688	79.3152	97.92	141.0050
9	59.2416	70.5024	89.2296	110.16	158.6300
10	65.8240	78.3360	99.1440	122.40	176.2560
11	72.4064	86.1696	109.0580	134.64	193.8820
12	78.9888	94.0032	118.9730	146.88	211.5070
13	85.5712	101.8370	128.8870	159.12	229.1330
14	92.1536	109.6700	138.8020	171.36	246.7580
15	98 7360	117.5040	148.7160	183.60	264.3840
16	105.3180	125.3380	158.6300	195.84	282.0100
17	111.9010	133.1710	168.5450	208.08	299.6350
18	118.4830	141.0050	178.4590	220.32	317.2610
19	125.0660	148.8380	188.3740	232.56	334.8860
20	131.6480	156.6720	198.2880	244.80	352.5120
21	138.2300	164.5060	208.2020	257.04	370.1380
22	144.8130	172.3390	218.1170	269.28	387.7630
23	151.3950	180.1730	228.0310	281.52	405.3890
24	157.9780	188.0060	237.9460	293.76	423.0140
25	164.5600	195.8400	247.8600	306.00	440.6400
26	171.1420	203.6740	257.7740	318.24	458.2660
27	177.7250	211.5070	267.6890	330.48	475.8910
28	184.3070	219.3410	277.6030	342.72	493.5170
29	190.8900	227.1740	287.5180	354.96	511.1420
30	197.4720	235.0080	297.4320	367.20	528.7680
31	204.0540	242.8420	307.3460	379.44	546.3940
32	210.6370	250.6750	317.2610	391.68	564.0190
33	217.2190	258.5090	327.1750	403.92	581.6450
34	223.8020	266.3420	337.0900	416.16	599.2710
35	230.3840	274.1760	347.0040	428.40	616.8960
36	236.9660	282.0100	356.9180	440.64	634.5220
40	263.2960	313.3440	396.5760	489.60	705.0240
44	289.6260	344.6780	436.2340	538.56	775.5260
48	315.9550	376.0130	475.8910	587.52	846.0290
54	355.4500	423.0140	535.3780	660.96	951.7820
60	394.9440	470.0160	594.8640	734.40	1057.5400
72	473.9330	564.0190	713.8370	881.21	1269.0400

The Decimal Equivalents of the Fractional Parts of a Gallon.

Decimal Part of a Gallon.	Equal to	Decimal Part of a Gallon.	Equal to
0.03125	1 gill	0.53125	17 gills
0.06250	½ pint	0.56250	4½ pints
0.09375	3 gills	0.59375	19 gills
0.12500	1 pint	0.62500	5 pints
0.15625	5 gills	0.65625	21 gills
0.18750	1½ pint	0.68750	5½ pints
0.21875	7 gills	0.71875	23 gills
0.25000	1 quart	0.75000	3 quarts
0.28125	9 gills	0.78125	25 gills
0.31250	2½ pints	0.81259	6½ pints
0.34375	11 gills	0.84375	27 gills
0.37500	3 pints	0.87500	7 pints
0.40625	13 gills	0.90625	29 gills
0.43750	3½ pints	0.93750	7½ pints
0.46875	15 gills	0.96875	31 gills
0.50000	½ gallon	1.00000	1 gallon

A very few words are needed to explain the foregoing tables and the simplest method is to apply it to a practical case. Suppose, for instance, it is desired to find the dimensions of a cylinder holding 27 gallons. On going down the column headed 19, the number 27.0028 is found and following the line across the number 22, hence a cylinder 19 inches in diameter and 22 inches deep will hold 27 gallons and .0028 gallon. Turning to the supplementary table we find a gill is equal to .03125 gallon, so the capacity of the cylinder in question is about $\frac{1}{10}$ of a gill more than 27 gallons.

Again, if it is desired to find the depth of a 15-inch cylinder that shall hold 27 gallons, run down the column headed 15 until the number 27.54 is reached and following the line across the depth is 36 inches. The decimal .54, on consulting the supplementary table, is equivalent to between 1 and 2 pints, therefore a 15-inch cylinder 36 inches deep will hold between 1 and 2 pints more than 27 gallons. Similarly, to find the diameter of a cylinder 15 inches deep that shall hold 27 gallons, run across the line opposite 15 until the number 26.976 is reached under the column headed 23. The decimal part according to the small table is equivalent to between 31 gills and 1 gallon, so the capacity of a cylinder 15 inches deep and 23 inches in diameter is about ½ gill less than 27 gallons. Where it is desired to find the capacity of a cylinder, both dimensions of which are given, it is only necessary to run down the column headed with the diameter until the line across from the given depth is reached, where the number found will be the capacity of the cylinder in gallons. To illustrate: What is the capacity of a cylinder 29 inches deep and 32 inches in diameter? Consulting the table, the number is 100.966, the decimal part of which according to the second table is about 31 gills, or 3 quarts, 1 pint, 3 gills, the given cylinder, therefore, holding 100 gallons, 3 quarts, 1 pint, 3 gills.

Proportionate Weight of Castings to Weight of Wood Patterns.

A Pattern Weighing One Pound Made of (*Less Weight of Core Prints*)	Cast Iron.	Brass.	Copper.	Bronze.	Bell Metal.	White Metal.
Pine or Fir	16	15.8	16.7	16.3	17.1	13.5
Oak	9	10.1	10.4	10.3	10.9	8.6
Beech	9.7	10.9	11.4	11.3	11.9	9.1
Linden	13.4	15.1	16.7	15.5	16.3	12.9
Pear	10.2	11.5	11.9	11.8	12,4	9.8
Birch	10.6	11.9	12.3	12.2	12.9	10.2
Alder	12.8	14.3	14.9	14.7	15.5	12.2
Mahogany	11.7	13.2	13.7	13.5	14.2	11.2
Brass	0.85	0.95	0.99	0.98	1.0	0.81

To ascertain the approximate weight of a casting from the weight of the pattern:

Multiply the weight of the pattern (less the weight of the core prints) by the number in the table corresponding to the material of which the pattern is made and the metal which is to be used for the casting. The result will be the approximate weight of the casting in pounds.

Letter Sizes of Drills.

Diameter Inches.	Decimals of 1 Inch.	Diameter Inches.	Decimals of 1 Inch.
A 15/64	.234	N	.302
B	.238	O 5/16	.316
C	.242	P 21/64	.323
D	.246	Q	.332
E 1/4	.250	R 11/32	.339
F	.257	S	.348
G	.261	T 23/64	.358
H 17/64	.266	U	.368
I	.272	V 3/8	.377
J	.277	W 25/64	.386
K 9/32	.281	X	.397
L	.290	Y 13/32	.404
M 19/64	.295	Z	.413

Sizes of Tap Drills.

Tap Diameter.	Threads per Inch.	Drill for V Thread.	Drill for U. S. Standard.	Drill for Whitworth.
1/4	16, 18, 20	5/32 5/32 11/64	3-16	3-16
9/32	16, 18, 20	3/16 13/64 13/64		
5/16	16, 18	7/32 15/64	1-4	15-64
11/32	16, 18	1/4 17/64		
3/8	14, 16, 18	1/4 9/32 9/32	9-32	9-32
13/32	14, 16, 18	19/64 21/64 21/64		
7/16	14, 16	21/64 11/32	11-32	11-32
15/32	14, 16	23/64 3/8		
1/2	12, 13, 14	3/8 25/64 25/64	13-32	3-8
9/16	12, 14	7/16 29/64	7-16	
5/8	10, 11, 12	15/32 1/2 1/2	1-2	1-2
11/16	11, 12	9/16 9/16		
3/4	10, 11, 12	19/32 5/8 5/8	5-8	5-8
13/16	10	21/32		
7/8	9, 10	45/64 23/32	23-32	23-32
15/16	9	49/64		
1	8	13/16	27-32	27-32

WEIGHT OF SHEET IRON AND STEEL PER SQUARE FOOT.

Thickness by Birmingham Gauge.				Thickness by American (Brown & Sharpe's) Gauge.			
No. of Gauge.	Thickness in Inches.	Weight in Pounds. Iron.	Weight in Pounds. Steel.	No. of Gauge.	Thickness in Inches.	Weight in Pounds. Iron	Weight in Pounds. Steel.
0000	.454	18.16	18.52	0000	.46	18.40	18.77
000	.425	17.00	17.34	000	.4096	16.38	16.71
00	.38	15.20	15.30	00	.3648	14.59	14.88
0	.34	13.60	13.87	0	.3249	13.00	13.26
1	.3	12.00	12.24	1	.2893	11.57	11.80
2	.284	11.36	11.59	2	.2576	10.30	10.51
3	.259	10.36	10.57	3	.2294	9.18	9.36
4	.238	9.52	9.71	4	2043	8.17	8.34
5	.22	8.80	8.98	5	.1819	7.28	7.42
6	.203	8.12	8.28	6	.1620	6.48	6.61
7	.18	7.20	7.34	7	.1443	5.77	5.89
8	.165	6.60	6.73	8	.1285	5.14	5.24
9	.148	5.92	6.04	9	.1144	4.58	4.67
10	.134	5.36	5.47	10	.1019	4.08	4.16
11	.12	4.80	4.90	11	.0907	3.63	3.70
12	.109	4.36	4.45	12	.0808	3.23	3.30
13	.095	3.80	3.88	13	.0720	2.88	2.94
14	.083	3.32	3.39	14	.0641	2.56	2.62
15	.072	2.88	2.94	15	.0571	2.28	2.33
16	.065	2.60	2.65	16	.0508	2.03	2.07
17	.058	2.32	2.37	17	.0453	1.81	1.85
18	.049	1.96	2.00	18	.0403	1.61	1.64
19	.042	1.68	1.71	19	.0359	1.44	1.46
20	.035	1.40	1.43	20	.0320	1.28	1.31

CONTINUED—WEIGHT OF SHEET IRON AND STEEL PER SQUARE FOOT.

Thickness by Birmingham Gauge.				Thickness by American (Brown and Sharpe's) Gauge.			
No. of Gauge.	Thickness in Inches.	Weight in Pounds.		No. of Gauge.	Thickness in Inches.	Weight in Pounds.	
		Iron.	Steel.			Iron.	Steel.
21	.032	1.28	1.31	21	.0285	1.14	1.16
22	.028	1.12	1.14	22	.0253	1.01	1.03
23	.025	1.00	1.02	23	.0226	.904	.922
24	.022	.88	.898	24	.0201	.804	.820
25	.02	.80	.816	25	.0179	.716	.730
26	.018	.72	.734	26	.0159	.636	.649
27	.016	.64	.653	27	.0142	.568	.579
28	.014	.56	.571	28	.0126	.504	.514
29	.013	.52	.530	29	.0113	.452	.461
30	.012	.48	.490	30	.0100	.400	.408
31	.01	.40	.408	31	.0089	.356	.363
32	.009	.36	.367	32	.0080	.320	.326
33	.008	.32	.326	33	.0071	.284	.290
34	.007	.28	.286	34	.0063	.252	.257
35	.005	.20	.204	35	.0056	.224	.228

	IRON.	STEEL.
Specific gravity.	7.7	7.854
Weight per cubic foot,	480	489.6
Weight per cubic inch,	.2778	.2833

As there are many gauges in use differing from each other orders for sheets should always state the weight per square foot, or the thickness in thousands of an inch.

Wire Gauges in use in the United States.

Number of Wire Gauge.	American or Brown & Sharpe.	Birmingham or Stubs' Wire.	Washburn & Moen Mfg. Co., Worcester, Mass.	Imperial Wire Gauge.	Stubs' Steel Wire.	U. S. Standard for Plate.	Number of Wire Gauge.
000000				.464		.46875	000000
00000				.432		.4375	00000
0000	.46	.454	.3938	.400		.40625	0000
000	.40964	.425	.3625	.372		.375	000
00	.3648	.38	.3310	.348		.34375	00
0	.32486	.34	.3065	.324		.3125	0
1	.2893	.3	.2830	.300	.227	.28125	1
2	.25763	.284	.2625	.276	.219	.265625	2
3	.22942	.259	.2437	.252	.212	.25	3
4	.20431	.238	.2253	.232	.207	.234375	4
5	.18194	.22	.2070	.212	.204	.21875	5
6	.16202	.203	.1920	.192	.201	.203125	6
7	.14428	.18	.1770	.176	.199	.1875	7
8	.12849	.165	.1620	.160	.197	.171875	8
9	.11443	.148	.1483	.144	.194	.15625	9
10	.10189	.134	.1350	.128	.191	.140625	10
11	.090742	.12	.1205	.116	.188	.125	11
12	.080808	.109	.1055	.104	.185	.109375	12
13	.071961	.095	.0915	.092	.182	.09375	13
14	.064084	.083	.0800	.080	.180	.078125	14
15	.057068	.072	.0720	.072	.178	.0703125	15
16	.05082	.065	.0625	.064	.175	.0625	16
17	.045257	.058	.0540	.056	.172	.05625	17

WIRE GAUGES IN USE IN THE UNITED STATES. (CONT.)

Number of Wire Gauge.	American or Brown & Sharpe.	Birmingham or Stubs' Wire.	Washburn & Moen Mfg. Co., Worcester, Mass.	Imperial Wire Gauge.	Stubs' Steel Wire.	U. S. Standard for Plate.	Number of Wire Gauge.
18	.040303	.049	.0475	.048	.168	.05	18
19	.03589	.042	.0410	.040	.164	.04375	19
20	.031961	.035	.0348	.036	.161	.0375	20
21	.028462	.032	.03175	.032	.157	.034375	21
22	.025347	.028	.0286	.028	.155	.03125	22
23	.022571	.025	.0258	.024	.153	.028125	23
24	.0201	.022	.0230	.022	.151	.025	24
25	.0179	.02	.0204	.020	.148	.021875	25
26	.01594	.018	.0181	.018	.146	.01875	26
27	.014195	.016	.0173	.0164	.143	.0171875	27
28	.012641	.014	.0162	.0149	.139	.015625	28
29	.011257	.013	.0150	.0136	.134	.0140625	29
30	.010025	.012	.0140	.0124	.127	.0125	30
31	.008928	.01	.0132	.0116	.120	.0109375	31
32	.00795	.009	.0128	.0108	.115	.01015625	32
33	.00708	.008	.0118	.0100	.112	.009375	33
34	.006304	.007	.0104	.0092	.110	.00859375	34
35	.005614	.005	.0095	.0084	.108	.0078125	35
36	.005	.004	.0090	.0076	.106	.00703125	36
37	.004453			.0068	.103	.006640625	37
38	.003965			.0060	.101	.00625	38
39	.003531			.0052	.099		39
40	.003144			.0048	.097		40

Weight per Foot of Flat Bar Steel.
Steel weighing 490 pounds per square foot.

Thickness in Inches	1	1 1-4	1 1-2	1 3-4	2	2 1-4	2 1-2	3	3 1-2	4
	Width in Inches.									
3-16	.638	.797	.957	1.11	1.28	1.44	1.59	1.91	2.23	2.55
1-4	.850	1.06	1.28	1.49	1.70	1.91	2.12	2.55	2.98	3.40
5-16	1.06	1.33	1.59	1.86	2.12	2.39	2.65	3.19	3.72	4.25
3-8	1.28	1.59	1.92	2.23	2.55	2.87	3.19	3.83	4.47	5.10
7-16	1.49	1.86	2.23	2.60	2.98	3.35	3.73	4.46	5.20	5.95
1-2	1.70	2.12	2.55	2.98	3.40	3.83	4.25	5.10	5.95	6.80
9-16	1.92	2.39	2.87	3.35	3.83	4.30	4.78	5.74	6.70	7.65
5-8	2.12	2.65	3.19	3.72	4.25	4.78	5.31	6.38	7.44	8.50
11-16	2.34	2.92	3.51	4.09	4.67	5.26	5.84	7.02	8.18	9.35
3-4	2.55	3.19	3.83	4.47	5.10	5.75	6.38	7.65	8.93	10.20
13-16	2.76	3.45	4.14	4.84	5.53	6.21	6.90	8.29	9.67	11.05
7-8	2.98	3.72	4.47	5.20	5.95	6.69	7.44	8.93	10.41	11.90
15-16	3.19	3.99	4.78	5.58	6.38	7.18	7.97	9.57	11.16	12.75
1	3.40	4.25	5.10	5.95	6.80	7.65	8.50	10.20	11.90	13.60
1 1-16	3.61	4.52	5.42	6.32	7.22	8.13	9.03	10.84	12.15	14.45
1 1-8	3.83	4.78	5.74	6.70	7.65	8.61	9.57	11.48	13.39	15.30
1 3-16	4.04	5.05	6.06	7.07	8.08	9.09	10.10	12.12	14.13	16.15
1 1-4	4.25	5.31	6.38	7.44	8.50	9.57	10.63	12.75	14.87	17.00
1 5-16	4.46	5.58	6.69	7.81	8.93	10.04	11.16	13.39	15.62	17.85
1 3-8	4.67	5.84	7.02	8.18	9.35	10.52	11.69	14.03	16.36	18.70
1 7-16	4.89	6.11	7.34	8.56	9.78	11.00	12.22	14.66	17.10	19.55
1 1-2	5.10	6.38	7.65	8.93	10.20	11.48	12.75	15.30	17.85	20.40
1 9-16	5.32	6.64	7.97	9.30	10.63	11.65	13.28	15.94	18.60	21.25
1 5-8	5.52	6.90	8.29	9.67	11.05	12.43	13.81	16.58	19.34	22.10
1 11-16	5.74	7.17	8.61	10.04	11.47	12.91	14.34	17.22	20.08	22.95
1 3-4	5.95	7.44	8.93	10.42	11.90	13.40	14.88	17.85	20.83	23.80
1 13-16	6.16	7.70	9.24	10.79	12.33	13.86	15.40	18.49	21.57	24.65
1 7-8	6.38	7.97	9.57	11.15	12.75	14.34	15.94	19.13	22.31	25.50
1 15-16	6.59	8.24	9.88	11.53	13.18	14.83	16.47	19.77	23.06	26.35
2	6.80	8.50	10.20	11.90	13.60	15.30	17.00	20.40	23.80	27.20

WEIGHT PER FOOT OF FLAT BAR IRON.

Thickness.	WIDTH IN INCHES. 1	1¼	1½	1¾	2	2¼	2½	3	3½	4
⅛	.42	.53	.63	.74	.84	.95	1.05	1.26	1.47	1.68
¼	.84	1.05	1.26	1.47	1.68	1.90	2.11	2.53	2.95	3.37
⅜	1.26	1.58	1.90	2.21	2.53	2.84	3.16	3.79	4.42	5.05
½	1.68	2.11	2.53	2.95	3.37	3.79	4.21	5.05	5.89	6.74
⅝	2.11	2.63	3.16	3.68	4.21	4.74	5.26	6.32	7.37	8.42
¾	2.53	3.16	3.79	4.42	5.05	5.68	6.32	7.58	8.84	10.10
⅞	2.95	3.68	4.42	5.16	5.89	6.83	7.37	8.84	10.32	11.79
1	3.37	4.21	5.05	5.89	6.74	7.58	8.42	10.10	11.79	13.47

Plate iron weighs 40 pounds per square foot, 1 inch thick. Hence, a square foot weighs 10 pounds if ½ inch thick, 5 pounds if ⅛ inch thick, etc.

To find the weight of round iron, per square foot in length: Square the diameter, expressed in quarter inches and divide by 6.

Thus, a 1¼ inch rod weighs $5 \times 5 = 25$, $25 \div 6 = 4\frac{1}{6}$ pounds per foot.

To find the weight of square or flat iron, per yard in length: Multiply the area of the cross section by 10.

Thus, a bar 2 by ⅜ has an area of ¾ of a square inch, and consequently weighs $\frac{3}{4} \times 10 = 7\frac{1}{2}$ pounds per yard.

To find the tensile strength of round iron: Square the diameter, expressed in quarters of an inch, the result will be its approximate strength in tons.

Thus, a rod 1 quarter inch in diameter will sustain 1 ton; 2 quarters, 4 tons; 3 quarters 9 tons; 4 quarters, or 1 inch, 16 tons.

If the rod is square, and of the same diameter as the round bar, it will carry about 25 per cent more, hence, a bar 1 inch square will sustain about 20 tons.

Size and Weight of Hot Pressed Hexagon Nuts

United States Standard Sizes.

Weights and sizes are for unfinished Nuts.

Width over Flats.	Thickness in Inches.	Size of Hole.		Size of Bolt.	Weight of 100 Nuts.	Number of Nuts in 100 Lbs.
1-2	1-4	0.185	$\frac{3}{16}$ scant.	$\frac{1}{4}$	1.3	7615
19-32	5-16	0.240	$\frac{1}{4}$ "	$\frac{5}{16}$	1.9	5200
11-16	3-8	0.294	$\frac{19}{64}$ "	$\frac{3}{8}$	3.3	3000
25-32	7-16	0.344	$\frac{11}{32}$	$\frac{7}{16}$	5.0	2000
7-8	1-2	0.400	$\frac{13}{32}$ scant.	$\frac{1}{2}$	7.0	1430
31-32	9-16	0.454	$\frac{29}{64}$	$\frac{9}{16}$	9.1	1100
1 1-16	5-8	0.507	$\frac{1}{2}$ full.	$\frac{5}{8}$	13.5	740
1 1-4	3-4	0.620	$\frac{5}{8}$ scant.	$\frac{3}{4}$	22.2	450
1 7-16	7-8	0.731	$\frac{47}{64}$ scant.	$\frac{7}{8}$	32.4	309
1 5-8	1	0.837	$\frac{27}{32}$ "	1	46.3	216
1 13-16	1 1-8	0.940	$\frac{15}{16}$ full.	$1\frac{1}{8}$	67.6	148
2	1 1-4	1.065	$1\frac{1}{16}$ "	$1\frac{1}{4}$	90.1	111
2 3-16	1 3-8	1.160	$1\frac{5}{32}$ full.	$1\frac{3}{8}$	117.5	85
2 3-8	1 1-2	1.284	$1\frac{9}{32}$ "	$1\frac{1}{2}$	147.1	68
2 9-16	1 5-8	1.389	$1\frac{25}{64}$ scant.	$1\frac{5}{8}$	178.6	56
2 3-4	1 3-4	1.491	$1\frac{1}{2}$ "	$1\frac{3}{4}$	250.0	40
2 15-16	1 7-8	1.616	$1\frac{5}{8}$ scant.	$1\frac{7}{8}$	285.7	35
3 1-8	2	1.712	$1\frac{23}{32}$ "	2	344.8	29
3 5-16	2 1-8	1.836	$1\frac{27}{32}$ "	$2\frac{1}{8}$	384.6	26
3 1-2	2 1-4	1.962	$1\frac{31}{32}$ "	$2\frac{1}{4}$	434.8	23

SIZE AND WEIGHT OF HOT PRESSED SQUARE NUTS

UNITED STATES STANDARD SIZES.

Weights and sizes are for unfinished Nuts.

Width.	Thickness in Inches,	Size of Hole.		Size of Bolt.	Weight of 100 Nuts.	Number of Nuts in 100 Lbs,
1-2	1-4	0.185	3/16 scant.	1/4	1.4	7270
19-32	5-16	0.240	1/4 "	5/16	2.2	4700
11-16	3-8	0.294	19/64 "	3/8	4.3	2330
25-32	7-16	0.344	11/32	7/16	6.1	1630
7-8	1-2	0.400	13/32 scant.	1/2	9.0	1120
31-32	9-16	0.454	29/64	9/16	11.2	890
1 1-16	5-8	0.507	1/2 full.	5/8	15.6	640
1 1-4	3-4	0.620	5/8 scant.	3/4	26.3	380
1 7-16	7-8	0.731	47/64 scant.	7/8	35.7	280
1 5-8	1	0.837	27/32 "	1	58.8	170
1 13-16	1 1-8	0.940	15/16 full.	1 1/8	76.9	130
2	1 1-4	1.065	1 1/16 "	1 1/4	104.2	96
2 3-16	1 3-8	1.160	1 5/32 full.	1 3/8	142.8	70
2 3-8	1 1-2	1.284	1 9/32 "	1 1/2	172.4	58
2 9-16	1 5-8	1.389	1 25/64 scant.	1 5/8	227.3	44
2 3-4	1 3-4	1.491	1 1/2 "	1 3/4	294.1	34
2 15-16	1 7-8	1.616	1 5/8 scant.	1 7/8	370.4	27
3 1-8	2	1.712	1 23/32 "	2	416.7	24
3 5-16	2 1-8	1.836	1 27/32 "	2 1/8	500.0	20
3 1-2	2 1-4	1.962	1 31/32 "	2 1/4	588.2	17

Weight and Area of Square and Round Steel, and the Circumference of Round Bars.

Steel weighing 490 pounds per cubic foot.

Thickness or Diameter in Inches.	Weight of Square Bar 1 ft. long.	Weight of Round Bar 1 ft. long.	Area of Square Bar in Square Inches.	Area of Round Bar in Square Inches.	Circumference of Round Bar in Inches.
3-16	.120	.094	.0352	.0276	.5890
1-4	.213	.167	.0625	.0491	.7854
5-16	.332	.261	.0977	.0767	.9817
3-8	.478	.375	.1406	.1104	1.1781
7-16	.651	.511	.1914	.1503	1.3744
1-2	.851	.668	.2500	.1963	1.5708
9-16	1.076	.845	.3164	.2485	1.7671
5-8	1.329	1.044	.3906	.3068	1.9635
11-16	1.608	1.263	.4727	.3712	2.1598
3-4	1.914	1.503	.5625	.4418	2.3562
13-16	2.246	1.764	.6602	.5185	2.5525
7-8	2.605	2.046	.7656	.6013	2.7489
15-16	2.990	2.348	.8789	.6903	2.9452
1	3.402	2.672	1.0000	.7854	3.1416
1-16	3.841	3.017	1.1289	.8866	3.3379
1-8	4.306	3.382	1.2656	.9940	3.5343
3-16	4.798	3.768	1.4102	1.1075	3.7306
1-4	5.316	4.175	1.5625	1.2272	3.9270
5-16	5.861	4.603	1.7227	1.3530	4.1233
3-8	6.433	5.052	1.8906	1.4849	4.3197
7-16	7.030	5.521	2.0664	1.6230	4.5160
1-2	7.655	6.012	2.2500	1.7671	4.7124
9-16	8.306	6.524	2.4414	1.9175	4.9087
5-8	8.984	7.056	2.6406	2.0739	5.1051
11-16	9.688	7.609	2.8477	2.2365	5.3014
3-4	10.419	8.183	3.0625	2.4053	5.4978
13-16	11.177	8.778	3.2852	2.5802	5.6941
7-8	11.961	9.394	3.5156	2.7612	5.8905
15-16	12.772	10.031	3.7539	2.9483	6.0868

WEIGHT AND AREA OF SQUARE AND ROUND STEEL, AND THE CIRCUMFERENCE OF ROUND BARS.

Steel weighing 490 pounds per cubic foot.

Thickness or Diameter in Inches.	Weight of Square Bar 1 ft. long.	Weight of Round Bar 1 ft. long.	Area of Square Bar in Square Inches.	Area of Round Bar in Square Inches.	Circumference of Round Bar in Inches.
2	13.61	10.69	4.0000	3.1416	6.2832
1-16	14.47	11.36	4.2539	3.3410	6.4795
1-8	15.36	12.06	4.5136	3.5466	6.6759
3-16	16.28	12.79	4.7852	3.7583	6.8722
1-4	17.22	13.52	5.0625	3.9651	7.0686
5-16	18.19	14.02	5.3477	4.2000	7.2649
3-8	19.19	15.07	5.6406	4.4301	7.4613
7-16	20.21	15.87	5.9414	4.6664	7.6576
1-2	21.26	16.70	6.2500	4.9087	7.8540
9-16	22.34	17.55	6.5664	5.1572	8.0503
5-8	23.44	18.41	6.8906	5.4119	8.2467
11-16	24.57	19.30	7.2227	5.6727	8.4430
3-4	25.73	20.21	7.5625	5.9396	8.6394
13-16	26.91	21.14	7.9102	6.2126	8.8357
7-8	28.12	22.09	8.2656	6.4918	9.0321
15-16	29.36	23.06	8.6289	6.7771	9.2284
3	30.62	24.05	9.0000	7.0686	9.4248
1-16	31.91	25.06	9.3789	7.3662	9.6211
1-8	33.23	26.10	9.7656	7.6699	9.8175
3-16	34.57	27.15	10.160	7.9798	10.014
1-4	35.94	28.23	10.563	8.2958	10.210
5-16	37.33	29.32	10.973	8.6179	10.407
3-8	38.75	30.43	11.391	8.9462	10.603
7-16	40.20	31.57	11.816	9.2806	10.799
1-2	41.68	32.74	12.250	9.6211	10.996
9-16	43.17	33.91	12.691	9.9678	11.192
5-8	44.71	35.12	13.141	10.321	11.388
11-16	46.26	36.33	13.598	10.680	11.585
3-4	47.84	37.57	14.063	11.045	11.781
13-16	49.45	38.84	14.535	11.416	11.977
7-8	51.09	40.13	15.016	11.793	12.174
15-16	52.75	41.43	15.504	12.177	12.370
4	54.45	42.77	16.00	12.566	12.566

Wrought Iron and Steel Steam, Gas and Water Pipe.

Table of Standard Dimensions.

Diameter.			Nominal Thickness.	Circumference.		Transverse Areas.			Length of Pipe per Square Foot of		Length of Pipe Containing One Cubic Foot.	Nominal Weight per Foot.	Number of Threads per Inch of Screw
Nominal Internal.	Actual External.	Approximate Internal Diameter.		External.	Internal.	External.	Internal.	Metal.	External Surface.	Internal Surface.			
Inch.	Inches.	Inches.	Inch.	Inches.	Inches.	Sq. In.	Sq. In.	Sq. In.	Feet.	Feet.	Feet.	Pounds	
1/8	.405	.27	.068	1.272	.848	.129	.0573	.0717	9.44	14.15	2513.	.241	27
1/4	.54	.364	.088	1.696	1.144	.229	.1041	.1249	7.075	10.49	1383.3	.42	18
3/8	.675	.494	.091	2.121	1.552	.358	.1917	.1663	5.657	7.73	751.2	.559	18
1/2	.84	.623	.109	2.639	1.957	.554	.3048	.2492	4.547	6.13	472.4	.837	14
3/4	1.05	.824	.113	3.299	2.589	.866	.5333	.3327	3.637	4.635	270.	1.115	14
1	1.315	1.048	.134	4.131	3.292	1.358	.8626	.4954	2.904	3.645	166.9	1.668	11½
1¼	1.66	1.38	.14	5.215	4.335	2.164	1.496	.668	2.301	2.768	96.25	2.244	11½
1½	1.9	1.611	.145	5.969	5.061	2.835	2.038	.797	2.01	2.371	70.66	2.678	11½
2	2.375	2.067	.154	7.461	6.494	4.43	3.356	1.074	1.608	1.848	42.91	3.609	11½
2½	2.875	2.468	.204	9.032	7.753	6.492	4.784	1.708	1.328	1.547	30.1	5.739	8
3	3.5	3.067	.217	10.996	9.936	9.621	7.388	2.243	1.091	1.245	19.5	7.536	8

WROUGHT IRON AND STEEL STEAM, GAS AND WATER PIPE.—(CONTINUED.)

Table of Standard Dimensions.

Diameter.			Nominal Thickness.	Circumference.		Transverse Areas.			Length of Pipe per Square Foot of		Length of Pipe Containing One Cubic Foot.	Nominal Weight per Foot.	Number of Threads per Inch of Screw.
Nominal Internal.	Actual External.	Approximate Internal Diameter.		External.	Internal.	External.	Internal.	Metal.	External Surface.	Internal Surface.			
Inch.	Inches.	Inches.	Inch.	Inches.	Inches.	Sq. In.	Sq. In.	Sq. In.	Feet.	Feet.	Feet.	Pounds	
3½	4.	3.548	.226	12.566	11.146	12.566	9.887	2.679	.955	1.077	14.57	9.001	8
4	4.5	4.026	.237	14.137	12.648	15.904	12.73	3.174	.849	.949	11.31	10.665	8
4½	5.	4.508	.246	15.708	14.162	19.635	15.961	3.674	.764	.848	9.02	12.49	8
5	5.563	5.045	.259	17.477	15.849	24.306	19.99	4.316	.687	.757	7.2	14.502	8
6	6.625	6.065	.28	20.813	19.054	34.472	28.888	5.584	.577	.63	4.98	18.762	8
7	7.625	7.023	.301	23.955	22.063	45.664	38.738	6.926	.501	.544	3.72	23.271	8
8	8.625	7.982	.322	27.096	25.076	58.426	50.04	8.386	.443	.478	2.88	28.177	8
9	9.625	8.937	.344	30.238	28.076	72.76	62.73	10.03	.397	.427	2.29	33.701	8
10	10.75	10.019	.366	33.772	31.477	90.763	78.839	11.924	.355	.382	1.82	40.065	8
11	11,75	11.		36.914	34.558	108.434	95.033	13.401	.325	.347	1.51	45.028	8
12	12.75	12.		40.055	37.7	127.677	113.098	14.579	.299	.319	1.27	48.985	8

WROUGHT IRON AND STEEL EXTRA STRONG PIPE.

Table of Standard Dimensions.

Diameter.			Nominal Thickness.	Nearest Wire Gauge.	Circumference.		Transverse Areas.			Length of Pipe per Square Foot of		Nominal Weight Per Foot.
Nominal Internal.	Actual External.	Approximate Internal Diameter.			External.	Internal.	External.	Internal.	Metal.	External Surface.	Internal Surface.	
Inch.	Inches.	Inches.	Inches.	No.	Inches.	Inches.	Sq. In.	Sq. In.	Sq. In.	Feet.	Feet.	Pounds
1/8	.405	.205	.1	12½	1.272	.644	.129	.033	.086	9.433	18.632	.29
1/4	.54	.294	.123	11	1.696	.924	.229	.068	.161	7.075	12.986	.54
3/8	.675	.421	.127	10½	2.121	1.323	.358	.139	.219	5.657	9.07	.74
1/2	.84	.542	.149	9	2.639	1.703	.554	.231	.323	4.547	7.046	1.09
3/4	1.05	.736	.157	8½	3.299	2.312	.866	.452	.414	3.637	5.109	1.39
1	1.315	.951	.182	7	4.131	2.988	1.358	.71	.648	2.904	4.016	2.17
1¼	1.66	1.272	.194	6½	5.215	3.996	2.164	1.271	.893	2.301	3.003	3.
1½	1.9	1.494	.203	6	5.969	4.694	2.835	1.753	1.082	2.01	2.556	3.63
2	2.375	1.933	.221	5	7.461	6.073	4.43	2.935	1.495	1.608	1.975	5.02
2½	2.875	2.315	.28	2	9.032	7.273	6.492	4.209	2.283	1.328	1.649	7.67
3	3.5	2.892	.304	1	10.096	9.085	9.621	6.569	3.052	1.091	1.328	10.25
3½	4.	3.358	.321	0	12.566	10.549	12.566	8.856	3.71	.955	1.137	12.47
4	4.5	3.818	.341	0	14.137	11.995	15.904	11.449	4.455	.849	1.	14.97
5	5.563	4.813	.375	00	17.477	15.120	24.306	18.193	6.12	.687	.793	20.54
6	6.625	5.75	.437	000	20.813	18.064	34.472	25.967	8.505	.577	.664	28.58

WEIGHT AND THICKNESS OF SHEET LEAD.

Weight in Lbs. per Sup. Foot.	Thickness in Inches.	Weight in Lbs. per Sup. Foot.	Thickness in Inches.
1	0.017	7	0.118
2	0.034	8	0.135
3	0.051	9	0.152
4	0.068	10	0.169
5	0.085	11	0.186
6	.0101	12	0.203

Table Showing Pressure of Water at Different Elevations.

Feet Head.	Equals Pressure per Square Inch.	Feet Head.	Equals Pressure per Square Inch.	Feet Head.	Equals Pressure per Square Inch.
1	.43	130	56.31	255	110.46
5	2.16	135	58.48	260	112.62
10	4.33	140	60.64	265	114.79
15	6.49	145	62.81	270	116.96
20	8.66	150	64.97	275	119.12
25	10.82	155	67.14	280	121.29
30	12.99	160	69.31	285	123.45
35	15.16	165	71.47	290	125.62
40	17.32	170	73.64	295	127.78
45	19.49	175	75.80	300	129.95
50	21.65	180	77.97	310	134.28
55	23.82	185	80.14	320	138.62
60	25.99	190	82.30	330	142.95
65	28.15	195	84.47	340	147.28
70	30.32	200	86.63	350	151.61
75	32.48	205	88.80	360	155.94
80	34.65	210	90.96	370	160.27
85	36.82	215	93.14	380	164.61
90	38.98	220	95.30	390	168.94
95	41.15	225	97.49	400	173.27
100	43.31	230	99.63	500	216.58
105	45.48	235	101.79	600	259.90
110	47.64	240	103.96	700	303.22
115	49.81	245	106.13	800	346.54
120	51.98	250	108.29	900	389.86
125	54.15			1000	433.81

Weight of Pipe per Foot for a Given Head or Fall of Water.

Head, or Number of Feet Fall.	Pressure per Square Inch.	Diameter and Weight per Foot of Lead Pipe Required.													
		3-8 Inch.		1-2 Inch.		5-8 Inch.		3-4 Inch.		1 Inch.		1 1-4 Inch.		1 1-2 Inch.	
	Pounds.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.
30	15	0	8	0	12	1 1	4 8	1 1	4 8	1 2	12 0	2	8	3	8
40	20	0 0	10 12	0 1	14 0	1	12	1 2	12 0	2	8	3	0	4	0
50	25	0	12	1	4	1 2	12 0	2 2	4 8	3	0	4	0	4 5	8 0
75	38	1	0	1 1	8 12	2 2	4 8	3 3	0 8	4	0	4 5	8 0	6	0
100	50	1	4	2	0	2 3	12 0	4	0	5	0	7	0	10	0
150	75	1 1	4 8	2	8	3 3	4 8	4	8	6	0	9	0	12	0
200	100	1	8	3	0	4	0	5	0	7	0	12	0	15	0

Table of Quantity of Water Delivered by Service Pipes of Various Sizes Under Various Pressures.

Proportion of Head of Water (H) to Length of Pipe (L).

Gallons Per Minute.

Diameter of Pipe Inches.	H = 10 L.	H = 9 L.	H = 8 L.	H = 7 L.	H = 6 L.	H = 5 L.	H = 4 L.	H = 3 L.
½	19.8	18.7	17.7	16.5	15.3	14.0	12.5	10.8
⅝	34.5	32.7	30.1	28.9	26.5	24.4	21.5	18.9
¾	54.4	51.7	48.7	45.6	42.2	38.5	34.4	29.8
1	111.8	106.0	100.0	93.5	86.6	79.0	70.7	61.2
1¼	195.2	185.2	174.6	163.3	151.2	138.0	123.4	106.9
1½	308.0	292.1	275.4	257.6	238.5	217.7	194.8	168.7
2	632.2	599.7	566.4	538.9	488.1	447.0	399.8	346.3
2½	1104.0	1048 0	987.8	924.0	855.4	780.9	698.5	604.9
3	1745.0	1651.0	1560.0	1460.0	1351.0	1234.0	1103.0	955.5
4	3581.0	3397.0	3203.0	2996.0	2774.0	2532.0	2265.0	1962.0
5	6247.0	5928.0	5588.0	5227.0	4839.0	4417.0	3951.0	3406 0
6	9855 0	9349.0	8814.0	8245.0	7633.0	6968.0	6233.0	5391.0
Diameter of Pipe Inches.	**H = 2 L.**	**H = 1¾ L.**	**H = 1½ L.**	**H = 1¼ L.**	**H = 1 L.**	**H = ¾ L.**	**H = ½ L.**	**H = ¼ L.**
½	8.8	8.3	7.7	7.0	6.3	5.4	4.4	3.1
⅝	15.4	14.4	13.4	12.2	10.9	9.5	7.7	5.5
¾	24.3	22.8	21.1	19.3	17.2	14.9	12.2	8.6
1	50.0	46.8	43.2	39.5	35.3	30.6	25.0	17.7
1¼	87.3	81.6	75.6	69.0	61.7	53.5	43.7	30.9
1½	137.7	128.8	119.3	108.9	97.4	84.3	68.7	48.7
2	282.7	264.4	248.8	223.5	199.9	173.1	141.4	100.0
2½	493.9	482.0	427.7	390.4	349.2	302.4	246.9	174.6
3	780.2	728.8	674.8	615.9	555.5	477.1	390.1	275.8
4	1602.0	1496.0	1385.0	1264.0	1133.0	979.3	800.8	566.2
5	2791.0	2613.0	2420.0	2209.0	1976.0	1711.0	1394.0	987.7
6	4407.0	4122.0	3817.0	3484.0	3116.0	2693.0	2204.0	1558.0

Capacity of Drain Pipe Under Different Amounts of Fall.

Gallons per Minute.

Size of Pipe.	1-2 inch fall per 100 feet.	3 inch fall per 100 feet.	6 inch fall per 100 feet,	9 inch fall per 100 feet.
3 In.	21	30	42	52
4 "	36	52	76	92
6 "	84	120	169	206
9 "	232	330	470	570
12 "	470	680	960	1160
15 "	830	1180	1680	2040
18 "	1300	1850	2630	3200
20 "	1760	2450	3450	4180

Size of Pipe.	12 inch fall per 100 feet.	18 inch fall per 100 feet.	24 inch fall per 100 feet.	36 inch fall per 100 feet.
3 In.	60	74	85	104
4 "	108	132	148	184
6 "	240	294	338	414
9 "	660	810	930	1140
12 "	1360	1670	1920	2350
15 "	2370	2920	3340	4100
18 "	3740	4600	5270	6470
20 "	4860	5980	6850	8410

DIMENSIONS OF WROUGHT-IRON PIPE.

Nominal Inside Diameter.	Actual Outside Diameter in Inches.	Actual Inside Diameter in Inches.	Thickness of Metal in Inches.	Threads per Inch.	Length of Full Thread in Inches.
1/8	.405	.270	.068	27	.19
1/4	.540	.364	.085	18	.29
3/8	.675	.493	.091	18	.30
1/2	.840	.622	.109	14	.39
3/4	1.050	.824	.113	14	.40
1	1.315	1.048	.134	11 1/2	.51
1 1/4	1.660	1.380	.140	11 1/2	.54
1 1/2	1.900	1.610	.145	11 1/2	.55
2	2.375	2.067	.154	11 1/2	.58
2 1/2	2.875	2.468	.204	8	.89
3	3.500	3.067	.217	8	.95
3 1/2	4.000	3.548	.226	8	1.00
4	4.500	4.026	.237	8	1.05
4 1/2	5.000	4.508	.246	8	1.10
5	5.563	5.045	.259	8	1.16
6	6.625	6.065	.280	8	1.26
7	7.625	7.023	.301	8	1.36
8	8.625	7.981	.322	8	1.46
9	9.625	8.937	.344	8	1.57
10	10.750	10.018	.366	8	1.68
11	11.75	11.000	.375	8	1.78
12	12.75	12.000	.375	8	1.88
13	14.	13.25	.375	8	2.09
14	15.	14.25	.375	8	2.10
15	16.	15.25	.375	8	2.20

Taper of the thread is 3/4 inch to one foot.

Pipe from 1/8 inch to 1 inch inclusive is butt welded and tested to 300 pounds per square inch.

Pipe 1 1/4 inch and larger is lap welded and tested to 500 pounds per square inch.

WEIGHT OF TWELVE INCHES SQUARE OF VARIOUS METALS.

Thickness.	Wrought Iron.	Cast Iron.	Steel.	Gun Metal.	Brass.	Copper.	Tin.	Zinc.	Lead.
1/16	2.50	2.34	2.56	2.75	2.69	2.87	2.37	2.25	3.68
1/8	5.00	4.69	5.12	5.50	5.38	5.75	4.75	4.50	7.37
3/16	7.50	7.03	7.68	8.25	8.07	8.62	7.12	6.75	11.05
1/4	10.00	9.38	10.25	11.00	10.75	11.50	9.50	9.00	14.75
5/16	12.50	11.72	12.81	13.75	13.45	14.37	11.87	11.25	18.42
3/8	15.00	14.06	15.36	16.50	16.14	17.24	14.24	13.50	22.10
7/16	17.50	16.41	17.93	19.25	18.82	20.12	16.17	15.75	25.80
1/2	20.90	18.75	20.50	22.00	21.50	23.00	19.00	18.00	29.50
9/16	22.50	21.10	23.06	24.75	24.20	25.87	21.37	20.25	33.17
5/8	25.00	23.44	25.62	27.50	26.90	28.74	23.74	22.50	36.84
11/16	27.50	25.79	28.18	30.25	29.58	31.62	26.12	24.75	40.54
3/4	30.00	28.12	30.72	33.00	32.28	34.48	28.48	27.00	44.20
13/16	32.50	30.48	33.28	35.75	34.95	37.37	30.87	29.25	47.92
7/8	35.00	32.82	35.86	38.50	37.64	40.24	32.34	31.50	51.60
15/16	37.50	35.16	38.43	41.25	40.32	43.12	35.61	33.75	55.36
1	40.00	37.50	41.00	44.00	43.00	46.00	38.00	36.00	59.00

WEIGHT OF METALS. TO FIND WEIGHT IN POUNDS.

Aluminium	cubic	inches	× 0.094
Brass	"	"	× 0.31
Copper	"	"	× 0.32
Cast-Iron	"	"	× 0.26
Wrought-Iron	"	"	× 0.28
Lead	"	"	× 0.41
Mercury	"	"	× 0.49
Nickel	"	"	× 0.31
Tin	"	"	× 0.26
Zinc	"	"	× 0.26

Weight of Copper Pipes per Foot.

Bore in Inches.	Thickness of Metal in Parts of an Inch.					
	1/16	1/8	3/16	1/4	5/16	3/8
	pounds.	pounds.	pounds.	pounds.	pounds.	pounds.
1/2	0.426	0.946	1.561	2.270	3.075	3.973
5/8	0.520	1.185	1.845	2.649	3.547	4.540
3/4	0.615	1.324	2.129	3.027	4.020	5.108
7/8	0.709	1.514	2.412	3.425	4.493	5.676
1	0.804	1.703	2.696	3.784	4.966	6.243
1 1/4	0.993	2.081	3.263	4.540	5.712	7.378
1 1/2	1.182	2.459	3.831	5.297	6.857	8.514
1 3/4	1.372	2.838	4.388	6.055	7.805	9.646
2	1.560	3.217	4.967	6.808	8.748	10.783
2 1/4	1.750	3.591	5.531	7.566	9.694	11.918
2 1/2	1.940	3.975	6.103	8.327	10.643	13.066
2 3/4	2.128	4.352	6.668	9.081	11.590	14.190
3	2.316	4.729	7.238	9.737	12.534	15.325

Weight of Brass Pipes per Foot.

Bore in Inches.	Thickness in Parts of an Inch.						
	1/16	1/8	3/16	1/4	5/16	3/8	7/16
	pounds	pounds	pounds.	pounds.	pounds.	pounds.	pounds.
1/4	0.22	0.53	0.94	1.43	2.01	2.68	3.44
1/2	0.40	0.89	1.47	2.15	2.91	3.75	4.70
3/4	0.58	1.25	2.01	2.86	3.80	4.83	5.95
1	0.76	1.61	2.55	3.58	4.70	5.92	7.25
1 1/4	0.94	1.96	3.09	4.31	5.64	6.98	9.46
1 1/2	1.12	2.34	3.67	5.01	6.49	8.05	9.71
1 3/4	1.33	2.66	4.14	5.70	7.36	9.11	10.94
2	1.48	3.04	4.69	6.44	8.27	10.20	12.21
2 1/4	1.65	3.40	5.23	7.16	9.17	11.27	13.46
2 1/2	1.83	3.75	5.77	7.87	10.06	12.35	14.72
2 3/4	2.01	4.11	6.31	8.59	10.96	13.42	15.97
3	2.19	4.47	6.84	9.31	11.85	14.69	17.42

Diameters, Circumferences, Areas, Squares, and Cubes.

Diameter in Inches.	Circumference in Inches.	Area in Square Inches.	Area in Square Feet.	Square, in Inches.	Cube, in Inches.
1/8	.3927	.0122	....	.0156	.00195
1/4	.7854	.0490	....	.0625	.01563
3/8	1.1781	.1104	....	.1406	.05273
1/2	1.5708	.1963	....	.25	.125
5/8	1.9635	.3068	....	.3906	.24414
3/4	2.3562	.4417	....	.5625	.42138
7/8	2.7489	.6013	....	.7656	.66992
1	3.1416	.7854	....	1.	1.
1 1/8	3.5343	.9940	.0069	1.2656	1.42383
1 1/4	3.9270	1.2271	.0084	1.5625	1.95313
1 3/8	4.3197	1.4848	.0102	1.8906	2.59961
1 1/2	4.7124	1.7671	.0122	2.25	3.375
1 5/8	5.1051	2.0739	.0143	2.6406	4.291
1 3/4	5.4978	2.4052	.0166	3.0265	5.3593
1 7/8	5.8905	2.7611	.0191	3.5156	6.5918
2	6.2832	3.1416	.0225	4.	8.
2 1/8	6.6759	3.5465	.0245	4.5156	9.5957
2 1/4	7.0686	3.9760	.0275	5.0625	11.3906
2 3/8	7.4613	4.4302	.0307	5.6406	13.3965
2 1/2	7.8540	4.9087	0340	6.25	15.625
2 5/8	8.2467	4.4119	.0375	6.8906	18.0879
2 3/4	3.6394	5.9395	.0411	7.5625	20.7969
2 7/8	9.0321	6.4918	.0450	8.2656	23.7637
3	9.4248	7.0686	.0490	9.	27.
3 1/8	9.8175	7.6699	.0531	9.7656	30.5176
3 1/4	10.210	8.2957	.0575	10.5525	34.3281
3 3/8	10.602	8.9462	.0620	11.3906	38.4434
3 1/2	10.995	9.6211	.0668	12.25	42.875
3 5/8	11.388	10.320	.0730	13.1406	47.634
3 3/4	11.781	11.044	.0767	14.0625	52.734
3 7/8	12.173	11.793	.0818	15.0156	58.185
4	12.566	12.566	.0879	16.	64.

Diameters, Circumferences, Areas, Squares, and Cubes.

Diameter in Inches.	Circumference in Inches.	Area in Square Inches.	Area in Square Feet.	Square in Inches.	Cube in Inches.
4⅛	12.959	13.364	.0935	17.0156	70.1895
4¼	13.351	14.186	.0993	18.0625	76.7656
4⅜	13.744	15.033	.1052	19.1406	83.7402
4½	14.137	15.904	.1113	20.25	91.125
4⅝	14.529	16.800	.1176	21.3906	98.9316
4¾	14.922	17.720	.1240	22.5625	107.1719
4⅞	15.315	18.665	.1306	23.7656	115.8574
5	15.708	19.635	.1374	25.	125.
5⅛	16.100	20.629	.1444	26.2656	134.6113
5¼	16.493	21.647	.1515	27.5625	144.7031
5⅜	16.886	22.690	.1588	28.8906	155.2871
5½	17.278	23.758	.1663	30.25	166.375
5⅝	17.671	24.850	.1739	31.6406	177.9785
5¾	18.064	25.967	.1817	33.0625	190.1094
5⅞	18.457	27.108	.1897	34.5186	202.7793
6	18.849	28.274	.1979	36.	216.
6⅛	19.243	29.464	.2062	37.5156	229.7832
6¼	19.635	30.679	.2147	36.0625	244.1406
6⅜	20.027	31.919	.2234	40.6406	259 084
6½	20.420	33.183	.2322	42.25	274.625
6⅝	20.813	34.471	.2412	43.8906	290.7754
6¾	21.205	35.784	.2504	45.5625	307.5469
6⅞	21.598	37.122	.2598	47.2656	324.9512
7	21.991	38.484	.2693	49.	343.
7⅛	22.383	39.871	.2791	50.7656	361.7051
7¼	22.776	41.282	.2889	52.5625	381.0781
7⅜	23.169	42.718	.2990	54.3906	410.1309
7½	23.562	44.178	.3092	56.25	421.876
7⅝	23.954	45.663	.3196	58.1406	443.3223
7¾	24.347	47.173	.3299	60.0625	465.4844
7⅞	24.740	48.707	.3409	62.0156	488.3730
8	25.132	50.265	.3518	64.	512.

Diameters, Circumferences, Areas, Squares, and Cubes.

Diameter in Inches.	Circumference in Inches.	Area in Square Inches.	Area in Square Feet.	Square in Inches.	Cube in Inches.
8⅛	25.515	51.848	.3629	66.0156	536.3770
8¼	25.918	53.456	.3741	68.0625	561.5156
8⅜	26.310	55.088	.3856	70.1406	587.4277
8½	26.703	56.745	.3972	72.25	614.125
8⅝	27.096	58.426	.4089	74.3906	641.6191
8¾	27.489	60.132	.4209	76.5625	669.9219
8⅞	27.881	61.862	.4330	78.7656	699.0449
9	28.274	63.617	.4453	81.	729.
9⅛	28.667	65.396	.4577	83.2656	759.7988
9¼	29.059	67.200	.4704	85.5625	791.4531
9⅜	29.452	69.029	.4832	87.8906	828.9746
9½	29.845	70.882	.4961	90.25	857.375
9⅝	30.237	72.759	.5093	92.6406	891.666
9¾	30.630	74.662	.5226	95.0625	926.8594
9⅞	31.025	76.588	.5361	97.5156	962.0968
10	31.416	78.540	.5497	100.	1000.
10⅛	31.808	80.515	.5636	102.5156	1037.9707
10¼	32.201	82.516	.5776	105.0625	1076.8906
10⅜	32.594	84.540	.5917	107.6406	1116.7715
10½	32.986	86.590	.6061	110.25	1157.625
10⅝	33.379	88.664	.6206	112.8906	1199.4629
10¾	33.772	90.762	.6353	115.5625	1242.2969
10⅞	34.164	92.885	.6499	118.2656	1286.1387
11	34.557	95.033	.6652	121.	1331.
11⅛	34.950	97.205	.6804	123.7656	1376.8926
11¼	35.343	99.402	.6958	126.5625	1423.8281
11⅜	35.735	101.623	.7143	129.3906	1471.8184
11½	36.128	103.869	.7270	132.25	1520.875
11⅝	36.521	106.139	.7429	135.1406	1571.0098
11¾	36.913	108.434	.7590	138.0625	1622.234
11⅞	37.306	110.753	.7752	141.0155	1674.5605
12	37.699	113.097	.7916	144.	1728.

Tensile Strength of Bolts.

Diameter of Bolt in Inches.	Area at Bottom of Thread.	At 7,000 lbs. per square inch.	At 10,000 lbs. per square inch.	At 12,000 lbs. per square inch.	At 15,000 lbs, per square inch.	At 20,000 lbs. per square inch.
½	.125	875	1,250	1,500	1,875	2,500
⅝	.196	1,372	1,960	2,350	2,940	8,920
¾	.3	2,100	3,000	3,600	4,500	6,000
⅞	.42	2,940	4,200	5,040	6,300	8,400
1	.55	3,850	5,500	6,600	8,250	11,000
1⅛	.69	4,830	6,900	8,280	10,350	13,800
1¼	.78	5,460	7,800	9,300	11,700	15,600
1⅜	1.06	7,420	10,600	12,720	15,900	21,200
1½	1.28	8,960	12,800	15,360	19,200	25,600
1⅝	1.53	10,710	15,300	18,360	22,950	30,600
1¾	1.76	12,320	17,600	21,120	26,400	35,200
1⅞	2.03	14,210	20,300	24,360	30,450	40,600
2	2.3	16,100	23,000	27,600	34,500	46,000
2¼	3.12	21,840	31,200	37,440	46,800	62,400
2½	3.7	25,900	37,000	44,400	55,500	74,000

The breaking strength of good American bolt iron is usually taken at 50,000 pounds per square inch, with an elongation of 15 per cent before breaking. It should not set under a strain of less than 25,000 pounds. The proof strain is 20,000 pounds per square inch, and beyond this amount iron should never be strained in practice.

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