BREWING COPPERS OR KETTLES.

Large brewing coppers are made in several different ways; the accompanying illustrations give three of the styles most in use, and will, I think, be sufficient for our purpose.

Fig. 444 is an open copper with a light course; that is, an addition to the copper proper, to enlarge its capacity and lessen the cost, the light course being made of lighter material than the copper proper, and yet of sufficient strength, as it is usually supported by brick work built around the course nearly or up to the brim. Let us build one of these large coppers with a light course, and let it hold, say, 50 barrels in each course; that is, the copper proper to hold 50 and the light course to hold 50 barrels also. The coppers may be made in any proportions to suit the place they are to occupy; that is, they can be tall or squat, as the room can be spared, because the copper, in consequence of its bulk, together with the brick work necessary for the furnace, takes up considerable room, and therefore is usually placed in some convenient position, as much out of the way as possible.

In an early chapter it was shown that the usual proportion for a copper to hold 106 gallons is, top 38, bottom 33½ and depth 28, so we will make our proposed 50-barrel kettle in the same proportion, and then add the light course to it. Now, all vessels of capacity are in the triplicate ratio; that is, comprise length, breadth and thickness, or their capacity is found by multiplying these three dimensions together.

Therefore we will take the diameter at the top as the basis by which to obtain the dimensions required for the sides and bottom. Then the top diameter of a 106-gallon kettle measures 38 inches, and $\overline{38}^{\,3} = 54,872$ inches, and as a barrel (English) contains 36 gallons, therefore 50 barrels contain 1800 gallons, and $1800 \div 106 = 16.981$, or the number of times 106 gallons is contained in 50 barrels. We now multiply the cube of 38, or 54,872, by 16.981, the number of times 1800 gallons contain 106 gallons, which gives us 930,781.432, and then extracting the cube root of this last result we get 97.63, or the top diameter of a copper to hold 50 barrels, which, in practice, we should call 8 feet 2 inches. Here then we

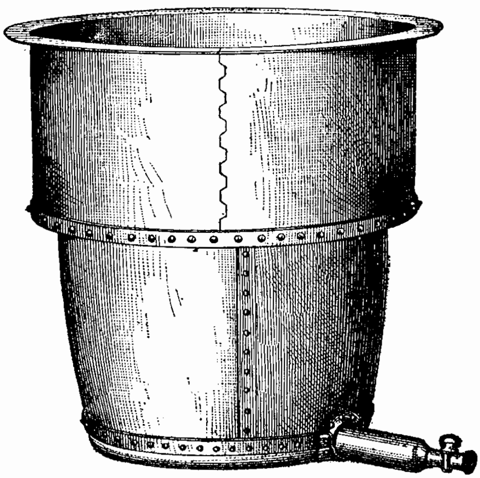

Fig. 444.—*Open Copper, with Light Course.*

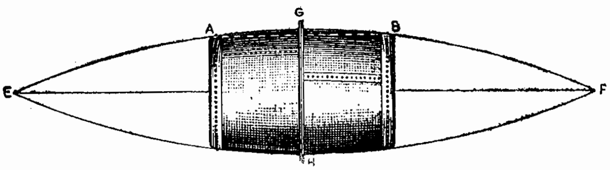

Fig. 445.—*Sketch Illustrating Shape of Coppers.*

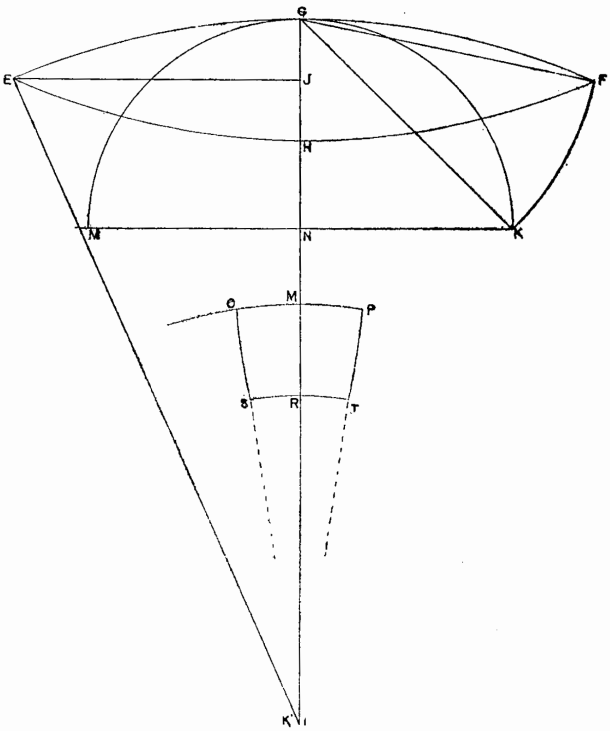

Fig. 446.—*Diagram Used in Calculating Patterns.*

have the first dimension of our proposed copper, 8 feet 2 inches. We will now proceed to obtain the other two dimensions by proportion, thus: Taking the dimensions of our 106-gallon vessel, as stated, top 38, bottom 33 5, and depth 28 inches; then 38 : 33.5 :: 97.63 : 86. Again, 38 : 28 :: 97.63 : 71.938 From this, then, we find the three dimensions of a 50-barrel copper to be: Top, 97.63; bottom, 86.068, and depth, 71.938, which we should call 8 feet 2 inches top, 7 feet 2 inches bottom and 6 feet deep. We must now have the pattern for the sides, which we will proceed to get. By referring to Fig. 445, it will be seen that a copper is a part of the middle zone of a circular spindle; that is to say, the body of which it is a part is generated by the revolution of the segment of a circle, and the versed sine of the segment is one half the diameter of the copper at the brim. Without a knowledge of the properties of the circular spindle, we can at best only make a good guess at what the pattern should be.

The illustration here given shows two coppers with their brims placed together, and then the outline of the spindle completed. This when carefully and intelligently performed gives the key for cutting the sides of all bellied vessels which are built up of a number of pieces, as in the case of large coppers. Then as stated: The depth of the copper is one-half the chord of the arc A B, and is 71.938 inches, and the versed sine of the arc A B is one-half the difference between the diameter of the top and bottom, which is $\frac{11.57}{2}$ or 5.785.

$\frac{\frac{\overline{71.938}^2}{5.785} + 5.785}{2} = 450.176$, the radius E I, Fig. 446, of the circle of which the curve of the spindle (that is, the sides of the coppers from top to bottom, or from A to B) E A B F is a part. The diameter G H at the center of the spindle is 97.63; then one-half G H, or $\frac{97.63}{2} = 48.815$, or the versed sine G J of the arc E G F, Fig. 446, and $450.176 \times 2 - 48.815 = 851.538$; then $\sqrt[2]{851.538 \times 48.815} = 203.611$, or E J, which is one-half the length of the spindle, and $\sqrt[2]{851.538 \times 48.815 + \overline{48.815}^2}$ $= 209.586$, or G F.

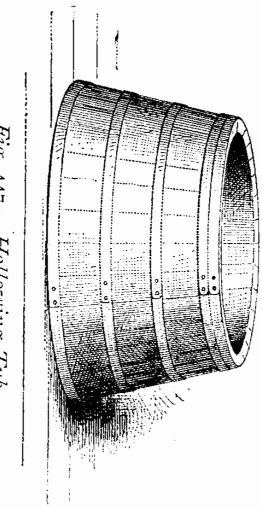

Fig. 447.—Hollowing Tub.

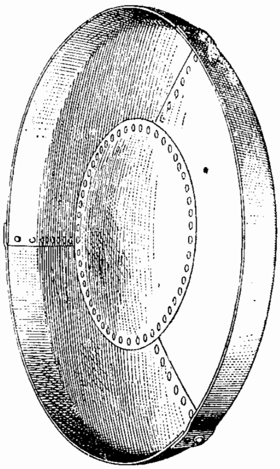

Fig. 448.—Four-Piece Bottom.

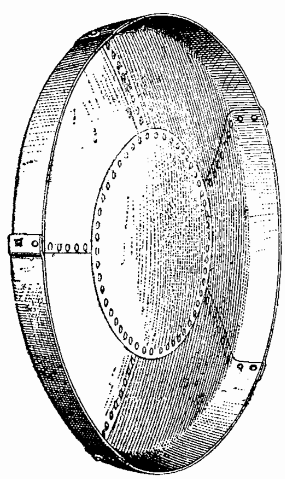

Fig. 449.—Six-Piece Bottom.

Fig. 450.—Sectional View of the Bottom Crown, Shaped Ready for Sides.

But G F = G K, therefore $\sqrt{\frac{851.538 \times 48.815 + \overline{48.815}^2}{2}} = 144.91$, or K N, the radius of the circle M G K; whence K M is 144.91 × 2, or 289.82; that is, 24.15 feet is the radius of the curve at the brim edge of the pattern, and 289.82 – 71.93 = 217.89, or 18.157 feet, is the radius for the arc S T at the bottom edge. Again: $\frac{97.63 \times 3.1416}{6} = 51.1424$, or the versed sine of the arc of the circle of which curve the side edges must be cut before hollowing in the hollowing tub, Fig. 447, ready for placing in position for riveting—that is, when the sides are in three pieces. Then $\frac{\overline{203.611}^2}{51.1424} + 51.1424 = 812.78$, or the diameter in inches of the circle of which the curve of the two edges are a part or must be cut before hollowing.

Therefore $\frac{812.78}{2} = 406.39$, or 33.8658 feet, for the radius of the two side edges of the pattern. Here, then, we have three pieces or sides in the small sketch, Fig. 446, 102.2383 from O to P, 71.93 from M′ to R, and 90.059 from S to T, with a radius of 33.8658 feet for the curve of the side seam edges, and a radius of 24.15 feet for the curve at brim, and 18.157 the radius of the curve at the bottom.

These dimensions are, of course, all bare—that is, nothing allowed for the seams or the brim, which must be left on to suit the rivets which are to be used in the side seams and the width of the brim required for the light course, a part of which would be taken from the depth, as the side would not reach the lag of the bottom by some 2 or 3 inches, for which allowance must also be made We now come to the bottom. To-day they may be had already milled up in one piece of any size or strength up to 15 feet in diameter. But when I was a boy there was no machinery then in existence of such capacity; hence it was necessary to make large bottoms by hand in four, five and sometimes more pieces, Figs. 448 and 449. But we will suppose that we have the bottom supplied to use in one piece, and let it be 7 inches deep. Now, the first thing is to put the bottom in shape for planishing—that is, form the crown, as shown in Fig. 450, by hollowing in the hollowing tub. This hollowing tub, Fig. 447, as we call it, is a

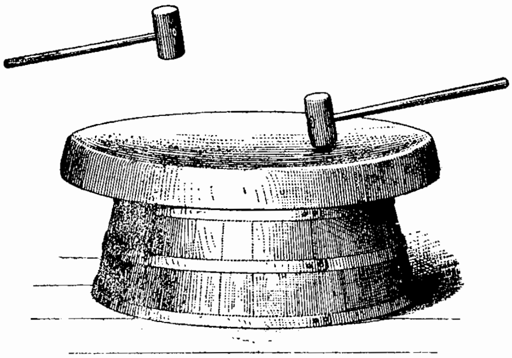

Fig. 451.—*Crowning Bottom in Hollowing Tub.*

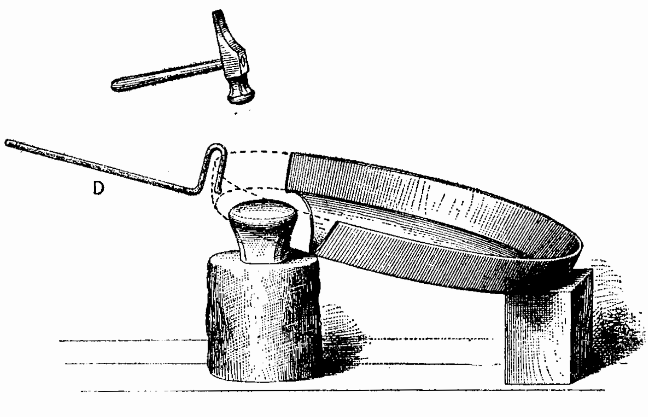

Fig. 452.—*Planishing Bottom.*

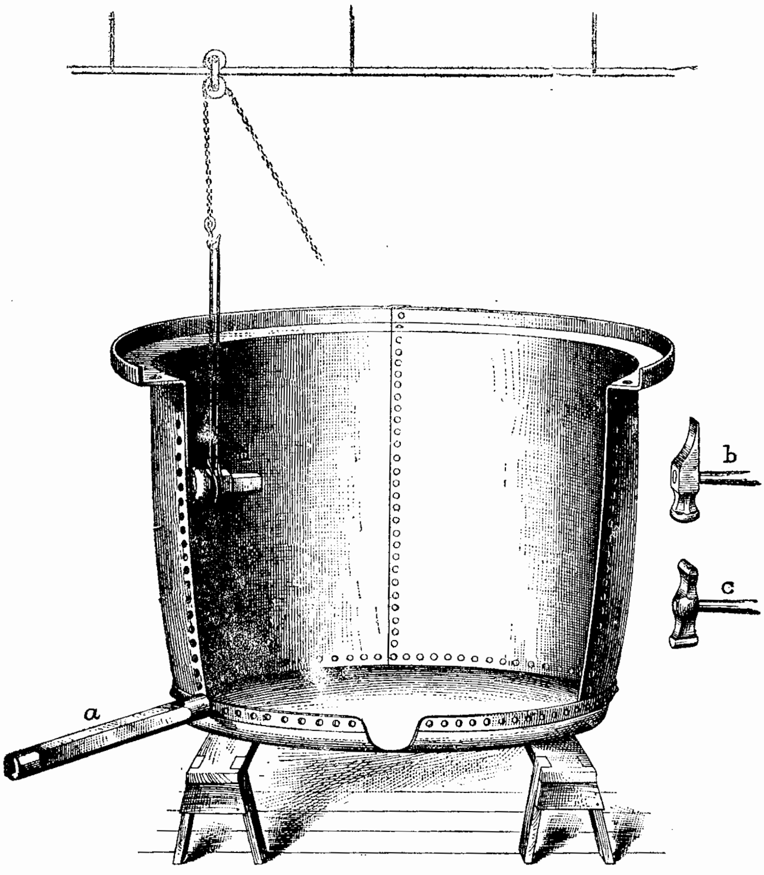

Fig. 453.—*Copper on Trestles, Ready for Working.*

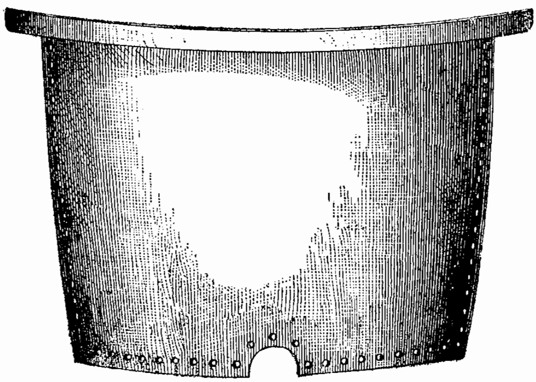

Fig. 454.—*Side Ready for Riveting*.

wooden ring like a washtub without a bottom, made of oak staves about $2\frac{1}{2}$ inches thick, about 2 feet high and from 3 to 4 feet in diameter, taper, and supported by three stout hoops, which are bolted to their places after the wood has shrunk sufficiently. The bottom is laid over the tub bottom side up, Fig. 451, and two men with large mauls or hammers sink the bottom in the tub, while another man guides the bottom on the tub with the iron dog D, shown in Fig. 452. When the bottom fits the template it is turned the right side up and the planishing is begun, which is done as shown in Fig. 452. A suitable large head is placed in a block and the bottom is then smeared all over on the outside with wet plumbago, also the surface of the block on which the bottom rests, so that the bottom will slide about with ease while the planishing is going on. The inside is rubbed all over with either wet or dry Spanish brown, so that the blows may be plainly seen. When the planishing has been completed, the bottom is placed on two or more suitable trestles, Fig. 453, and after marking the holes the proper distance apart, the rivet holes are punched in the bottom with a punch placed in a chisel rod and the hammer *b*, while a man holds a bolster, *a*, on the outside (the bolster *a* explains itself). Then all three sides, which have been previously prepared—that is. bellied or hollowed and planished, Fig. 454—are placed in position and secured with bolts. Then the head is taken out of the block and put into a sling, *d*, Fig. 453, and one man holds the head in position inside while two others, opposite each other outside, work in the rivets, first with long-handled cross-peined hammers, *c*, and finishing with hammer *b*. The light course is now prepared, the sides of which may be brazed or riveted together, as desired, when, after planishing, the holes are punched in the bottom edge, and then the course is set in its place on the copper brim and the rivet holes punched through the riveting edge into a small bolster and the rivets worked in with short-handle hand hammers. The pipe or outlet is next worked in and all finished up complete.

The same methods which are here described may be used for building a vessel of any number of pieces in the side or of any shape. In Fig. 455 is shown a large open copper, with a light course, completed ready for use, and about to be set in its future resting place. This vessel was built in 1891 by Messrs. Shears & Co. of Bank-side, London, and is said to be the largest copper ever built in England. It has a capacity of 36,000 English gallons. This large vessel was built

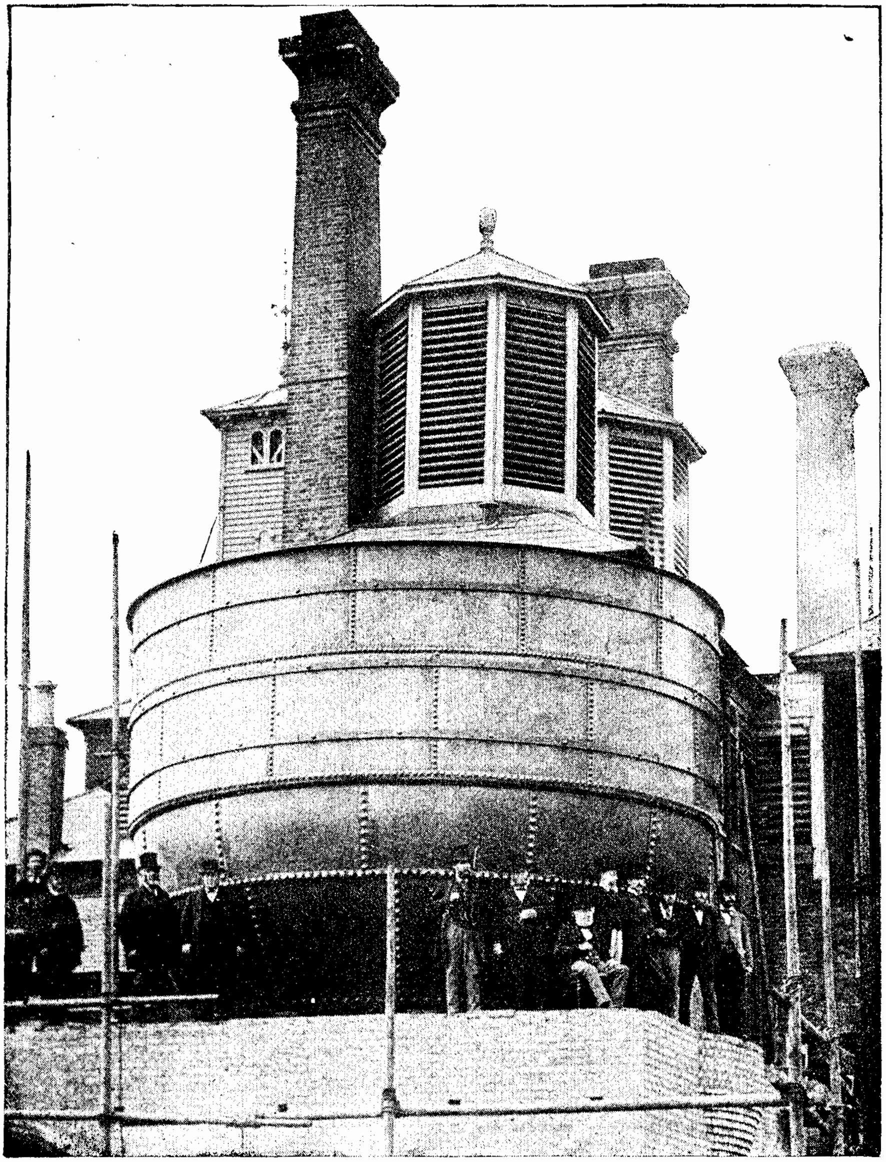

Fig. 455.—*Large Open Copper with Light Course.*

for Ind, Coope & Co. The reader can get an excellent idea of its construction, as well as its immense size. The size of the rivets should be noticed, the proportion of the copper proper to the light course, and then the three iron bands placed around the light course to strengthen it; also that the wall at the end of the building has been taken down to let it into its place. This is a very interesting and instructive illustration for these engaged in this kind of work.

DOME COPPERS.

Dome coppers, as will be seen, Fig 456, are made similar to open ones, the dome being substituted for the light course. Let us suppose we have a copper ready for a dome, and it is required to make a dome and work it on to the copper. As I have said before, a dome may now be had in one piece, but were this not the case, as in years gone by, then it must be made in pieces, and these must conform to the size of the sheets at hand. Now, let the size at the brim be as in the last example, namely: 97.63 inches in diameter, and the brim or dome seat $3\frac{1}{2}$ inches wide, with a riveting edge turned up 2 inches deep, and the dome a half sphere, made in four pieces. To obtain the pattern for this we proceed as follows: The diameter inside the turned-up dome seat or riveting edge A B, Fig. 457, will be $97.63 + 3.5 \times 2$ or 104.63. Then $\frac{104.63}{2} = 52.31$, and $\sqrt[2]{\overline{52.31}^2 \times 2} = 73.97$ or C B; that is to say, it equals the side of the inscribed square of a circle A B, whose diameter is 104.63 inches, or the diameter inside the riveting edge, representing the circle D C A N B. Now $\frac{73.97}{2} = 36.98$ or one-half the cord C B of the arc C D B, or F B, and one-half the diameter D E — F E = D F; that is to say, $51.31 - 36.98 = 15.33$, and $\overline{FB}^2 + \overline{DF}^2 = \overline{DB}^2$, or $\overline{36.98}^2 + \overline{15.33}^2 = 40.30$; that is, it equals the cord D B of half the arc C D B; but D G equals D B and $\overline{DB}^2$ — one-half of $\overline{DF}^2$ (that is, D H) equals $\overline{HG}^2$, or $\overline{DG}^2 - \overline{DH}^2 = \overline{HG}^2$, which is $\overline{40.30}^2 - \overline{7.66}^2 = 39.29$. Then $\frac{\overline{HG}^2}{DH} + DH = DN \times 2$, or $\frac{\overline{39.29}^2}{7.66} + 7.66 = 209.20$, or the diameter of a circle of which the curve of each side of the pattern is a part. Now construct the triangle on K G (that is, on O P, Fig. 458, which is equal to K G), and with D N or 104.60 or $\frac{209.20}{2}$ (that is, the diameter of the dome seat) as a radius

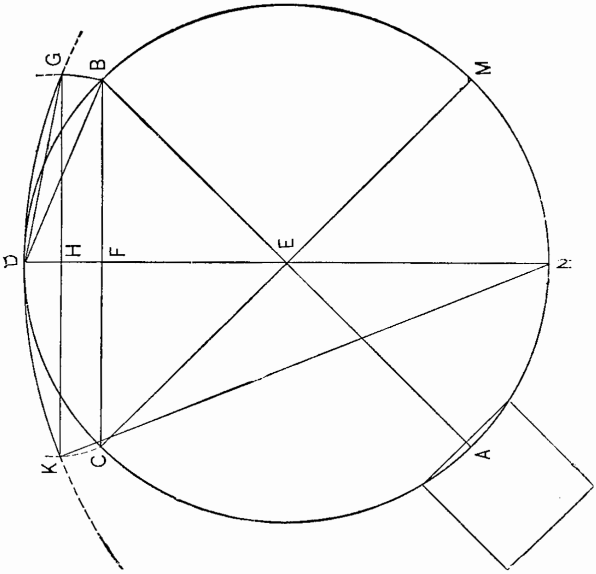

Fig. 457.—*Method of Obtaining Pattern of Dome.*

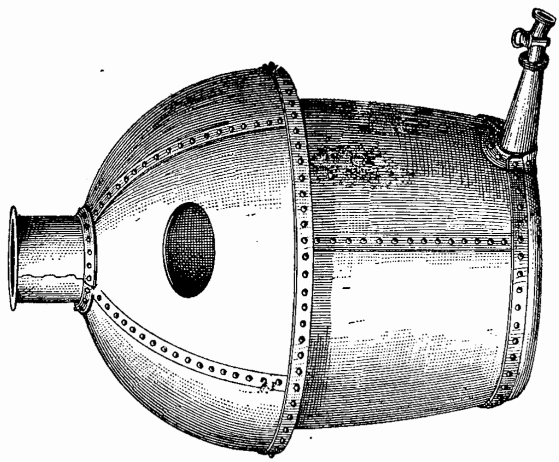

Fig. 456.—*Dome Copper.*

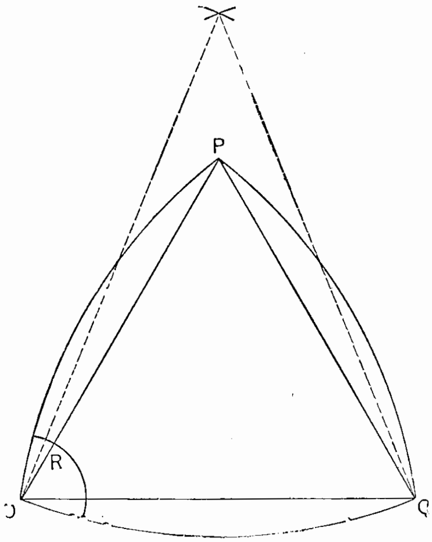

Fig. 458.—*Pattern for Quarter of Dome.*

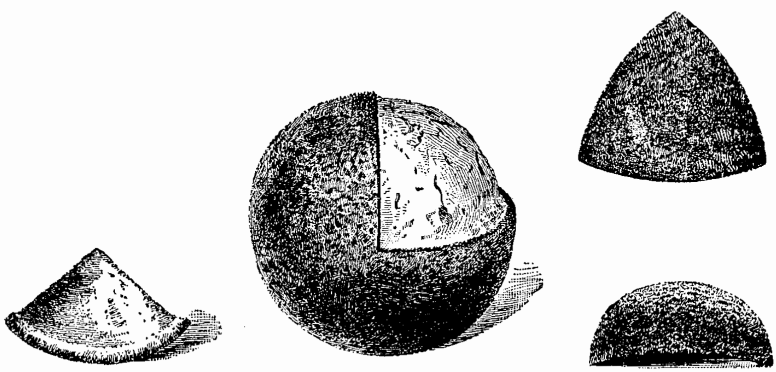

Fig. 459.—*Illustrated Lesson by an Orange.*

describe the arcs about the triangle O P Q, as shown in Fig. 458. Then at one corner, O, of the pattern, with a radius, O R, equal to one-half the diameter of the crown pipe, mark out the hole for it, making the hole so that when complete it will be about 20 inches in diameter, which will then complete the pattern required of one of the four sections of the dome. Now, having the pattern and the four pieces cut out by it, bend an iron template to the curve of a radius of 48.81 inches, and take the sections to the hollowing tub and hollow them until they fit the template every way, after which planish them in a promiscuous way on a suitable head placed in a solid block. Then punch them and place them in position in the seat, remembering to have the crown pipe also in position before the last quarter of the dome is put finally into its place. Next bolt them together in succession. The manhole may be prepared and fixed to the last quarter before placing, or it may be worked on after, at the discretion of the workman or employer. Put three or four temporary rivets in each seam of the dome and in the seat at each seam, and one or two between. We are now ready to work in the rivets, which may be done in a similar manner to that described and illustrated for an open copper with a light course.

I wish here to make a suggestion for the benefit of the boy who may have occasion to peruse these pages in the hope of finding the assistance he is in search of, because I think this is one of the most appropriate places which has suggested itself, where we can take a practical lesson from nature. Fig. 459 is the picture of an orange with the rind peeled off from three-fourths of the upper half of it, one-fourth being left on to illustrate a part of our lesson. Lying apart from the orange are the three-fourths of the rind which have been taken off. One piece is lying with the concave or flesh side of the skin upward and one with the concave side down and one lying perfectly flat. Now let us carefully consider these three pieces of rind in relation to the lesson under consideration. Let the upper half of the rind of this orange represent the dome of the copper in the next example, and let the dome be made in four pieces, as before. It will be readily seen that the four pieces of orange rind, after being removed from the orange, show in miniature: 1, the exact shape of the pattern; 2, the exact shape it should be when hollowed and planished, and, 3, the position of the first piece when it is placed in the riveting edge on the copper brim. Now, if we conceive the edges for riveting to have been left on at two sides of the pattern, then the rivet holes of the seam would come down the line of division where the rind of the orange has been cut. With a little study this should be plainly understood. We will now proceed to find the shape and size of this pattern, as suggested to us by the orange rind. Let the diameter C M of a spherical dome or an orange, Fig. 457, be 88 inches in the present example. Describe the circle A C B M to some easy scale that would represent a large-sized orange, say ¾ inch to a foot, and divide its circumference into four equal parts, A C, C B, B M and M A; then the diameter of the circle C M is $\frac{88}{16}$ inch, or 5½ inches. Now draw the diameters A B and C M, and join C B; then the arc C D B represents the bend of either side of the section when hollowed to fit the surface of the orange. Draw D B, which represents the chord of half the arc C D B. Now divide D F in two equal parts at H, and through H draw K H G, parallel to C F B; then with D B as radius and D as center describe the arcs B G and C K, cutting K H G in K and G; then K G represents the true length of the side of a triangle, O P, Fig. 460; that is, from point to point, when the section is lying flat the same as the orange rind in the picture, the line D B having remained the same as it was before the section was flattened and made a plane by being pressed down level. Here, then, we have the length K G of one side of a triangle lying within the pattern O P, Fig. 460, and we find by actual measurement that the line K G is full 4⅛ inches, which, being multiplied by 16, is 66 inches (or more correctly, 66.1). Now bisect P Q in S, and through S draw O S and continue it to T, making S T equal to D H, Fig. 457, or one-half of D F; and draw the lines, or chords, T P and T Q; and bisect these chords perpendicularly with lines meeting in U. Then from the point of intersection of these lines at U, with the distance U Q, U T or U P (which is 5.5 inches, and this multiplied by 16 gives 88; the first, the diameter of the orange, and the second, that of the dome), describe the arcs O P, P Q, Q O. Now, with O R as radius, describe the arc W V for the crown pipe hole, and W P Q V is the pattern of one section of the dome, as before, but without riveting edge, which must be left on the two sides W P and Q V.

There are very many useful lessons that may be learned in a similar way to that suggested here by the rind of an orange, if the student is apt and is of an inquiring turn of mind.

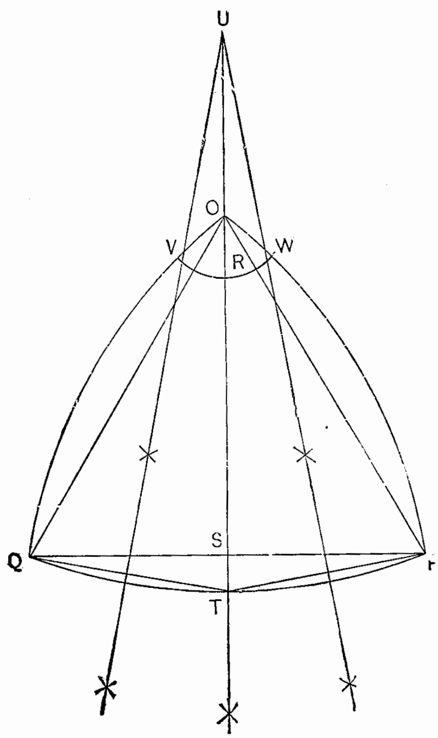

Fig. 460.—*Second Method of Obtaining Pattern.*

DOME AND PAN COPPERS.

Dome and pan coppers are a combination of the other two coppers we have been treating of, combined in one apparatus, with some few additions, such as the valves at the top of the chimney and the two side pipes to convey the overflow into the pan should the liquor in the copper tend to boil over; also to convey the steam generated in the copper into the liquor which may have been placed in the pan to be heated. It will be seen that the pan bottom is made separate, and when formed ready the inner edge is fitted to the sides, with the edge of the dome crown (except when the dome is in one piece, when the pan would be worked on the dome, as shown in Fig. 461), and then all three are riveted secure, and the rivets scrubbed up so that the heads are all smooth and even with the inner side. The inlet pipes are made of a suitable size, as in N, and connected by flanges with the pan bottom and the side of the copper. At the upper end of the inlet pipes and on the inside of the pan bottom is bolted a screw valve, Fig. 462, which is secured to its place by the same bolts that hold the pipe flange to the pan bottom. When the pan bottom and crown (if the dome is made in pieces) have been worked in the manhole H, Fig. 461, and the inlet pipes also completed, then the sides of the pan may be put up into position and the rivets worked in. The screw valves are now applied with a rod and T-handle with which to open and close them, the rod being held in position by a bracket, B, bolted to the side of the pan. Any good workman who has made a large open or d me copper should be competent, after studying the preceding pages and the accompanying illustrations, to build a dome and pan successfully. I shall therefore let the directions given for the building of the other two styles suffice for that of a dome and pan, and thus avoid repetition as much as possible.

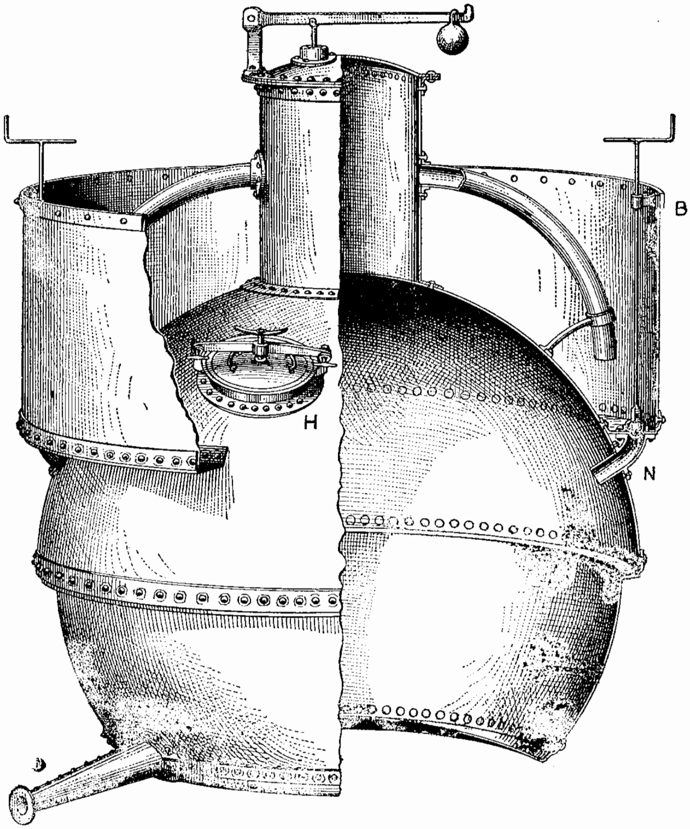

Fig. 461.—*Dome and Pan Copper.*

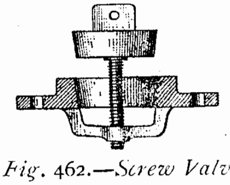

Fig. 462.—*Screw Valve.*

TALLOW COPPERS.

In Fig. 463 is shown a tallow copper. These vessels were made for and used by tallow chandlers, whose principal use for them at one time was in manufacturing tallow candles. Tallow coppers are an extra good job, because of the greater care necessary to make them sound—that is to say, perfectly tight and not liable to leak. These coppers were at one time in great demand, when all England burned candles much more so than now. But there is yet an occasional demand for one, because tallow is still used for many other purposes besides that of making candles, and the shape of this copper is better adapted for the use of rendering out tallow than any other, as the curve or spherical shape of the sides tends to throw the fat that boils up the sides toward the center, which partially accounts for its peculiar shape, as compared with coppers for some other purposes. This copper has a wide brim, so that any slopping or drainings may be conveyed back into the copper

NOTE.—In this connection some piece work prices for coppersmith's work paid in London will be of interest :

Brewing coppers, 3½ cents per pound for men ; one-half the price for boys.
Tieches for planishing general, 2 cents for men ; one-half the price for boys.
Four-inch worms, 4 cents per pound for man and boy.
Retorts, 6 cents per pound for man and boy.
Stills, 3½ cents per pound, metal as well.
Middle pieces, 4 cents per pound for brazed seams.
Four-inch tee-pieces, $1 each for men ; 50 cents for boys.
Three-inch tee-pieces, 75 cents each for men ; 37½ cents for boys.
Four-inch bend complete, 83 cents each for men ; 41½ cents for boys.
Three and one-half-inch bend complete, 64 cents each for men ; 32 cents for boys.
Three-inch bend complete, 50 cents each for men, 25 cents for boys.
Two-inch bend complete, 37½ cents each for men ; 18 cents for boys.
Worms, when two men work at them, 8 cents ; when a man and boy work at them, 6 cents.

The time usually consumed putting up sides into bottom of a 300-barrel copper by two men inside and three outside, two and one-half days. Punching holes, in bout, three men inside and two outside, one and one-half days each.

Setting-to 105 holes, two men one day. Setting-to 20 holes in seam and working in 20 No. 2 nails, with one man inside and two outside, three hours.

Working one seam of 20 nails, three men, one day. Working one bout of 15 nails, No. 1, three men, one day.

Time consumed taking off old bottom from a dyer's copper and putting on new one, the new bottom weighing 140 pounds, 38 inches in diameter and 9 inches deep. Cutting out old bottom and annealing sides and planishing, ten hours. Planishing new bottom, seven hours. Putting up block, punching holes, bolting together and working in 40 No. 4 nails, nine hours. Scrubbing up new bottom, eight hours. Total time for job, three days four hours.

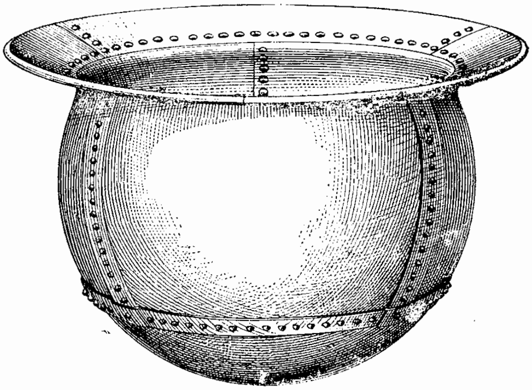

Fig. 463.—*Broad-Brim Tallow Copper.*

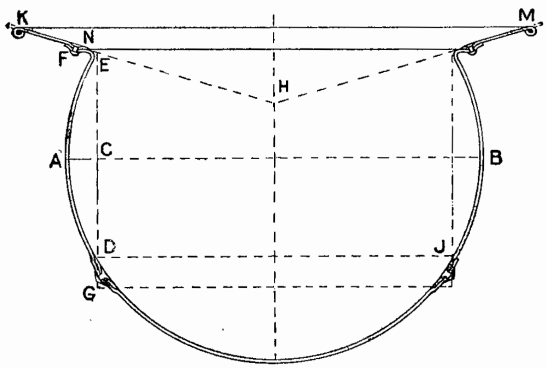

Fig. 464.—*Section Through Broad-Brim Tallow Copper.*

by it. They are made sometimes with narrow brims, in which case the broad brim is substituted by one made of lead, covering the whole of the brick work on its top surface about the brim, and turning down over it on the inside of the copper from 2 to 3 inches, which, in some cases, is preferable, because, then, none of the tallow can penetrate the brick work from the top.

Let us make one of these broad-brimmed tallow coppers, and let the sides be made from a sheet of, say, 35-pound plate, or about 1-16 inch in thickness, to hold 200 gallons, and let its sides be in three pieces and the bottom in one. It will be noticed that this vessel, Fig. 463, is spherical in form, the body being made up of the middle zone and the bottom segment, the other or top segment being absent to form the brim or copper mouth. Now, the first thing we must do is to find the size of a vessel of this shape that will hold 200 gallons, which we will now proceed to do as follows: It is well known that a spherical inch is represented by 0.5236, but the copper is a sphere with a segment cut off equal in hight to one quarter of the diameter of the sphere (see Fig. 464), and the value of this segment cut off is 0.08181; therefore, $0.5236 - 0.08181 = 0.4417$. Now, there are 277.274 inches in a gallon (English measure), therefore, $277.274 \times 200 = 55,454.80$ cubic inches, and $\frac{55,454.80}{0.4417} = 125,548$; when, extracting the cube root of 125,548, we get 50 inches as the diameter A B of the middle zone of the copper when ready for the bottom. If Fig. 464 be drawn to a scale of ¾ inch to a foot, it will be found that from C to B is 47 inches, from D to E is 25, from F to E is 4 inches, and from D to G 3 inches. Adding these last three dimensions together, we have $25 + 4 + 3 = 32$ inches for the depth of the sides before working, and the diameter C B 47 inches, when $47 \times 3.1416 = 147.6552$, and 147.6552 divided by 3, the number of sides to be used, we have 49.2184, or 49¼ inches. To this we add 2 inches to each piece for seams, when we get 51¼ inches for the length of each side, including edges, and 32 inches deep, including brim and lap for the bottom seam. Now we find the size the disk should be for the bottom before hollowing, as follows: It was stated in a former chapter that the surface of a sphere is equal to its circumscribed cylinder, and therefore the surface of any segment of a sphere is equal to the diameter of the sphere multiplied by the hight of the segment, multiplied by 3.1416; or the surface of a sphere is equal to four disks whose diameter is equal to the diameter of the sphere. From which we get $50 \times 12.5 \times 4 = 2500$, and extracting the square root we get 50 inches for the diameter of the disk to form the bottom before hollowing, or $\sqrt{50 \times 12.5 \times 4}$. Now we have the sides and bottom, and require the broad brim, which is obtained as follows: The brim when completed with a ¾-inch wire in the outer edge should measure 10 inches or thereabouts from E to K, Fig. 464. Now the wiring edge at K will take 1½ inches, and will reach and lap at N 2 inches, which will make the brim before working 10½ inches wide. Then the diameter of the brim from K to M when complete before wiring is 66 inches, and forms a frustum of a cone, the slant hight of which is H M, or 34.5; that is, *x y*, Fig. 465. With the radius *y x* from *y* as center describe the circle *x w v u s*, making the distance around it from *x* to *s* equal to the circumference of a circle whose diameter is K M, or 66 inches. Now $66 \times 3.1416 = 207.345$ and $69 \times 3.1416 = 216.77$ and $216.77 - 207.345 = 9.42$, or 9½ inches nearly; that is to say, the segment *s y x* from *s* to *x*, which would be taken out, is equal to 9½ inches nearly. The brim may be put on in any number of pieces. In this case let there be four; then *s u a b* is one section of the brim bare. Adding 2 inches on for riveting edge, the pattern is complete and will measure from *u* to *d* 53.83, and from *a* to *c* 38.06, and from *c* to *d* 10.5 inches. Here we have all the patterns and will now begin to put them in shape: First, the bottom, by taking it to a hollowing tub, and with suitable mauls sink it in the tub until it is hollowed enough; that is, until it measures across it 46 inches. Then mark the rivet holes for about No. 1 or No. 2 wrought copper rivets, and space the holes so that the edges of the rivet heads are about ½ inch apart. The sides are next in order. These will be put together with No. 3 or No. 4 rivets, and the heads about ⅜ inch apart and reaching to within ¼ inch of the lap edge. When the sides have been punched bend them into shape and put in a few temporary rivets; take a racer and divide the depth into three spaces and proceed to raze in both ends; the bottom end right out to the end, the top end to within 4 inches, making the lower end fit into the bottom about 3½ inches, and drawing the top end out until it measures 43 inches at 4 inches from the end, when the brim is thrown back for the additional wide brim. While the two ends are being worked in the sides are put on the tub at the end of each course, and hollowed out to complete the spherical curve of the body. Now we form the brim by putting the four pieces together and wiring the edges with a ¾-inch

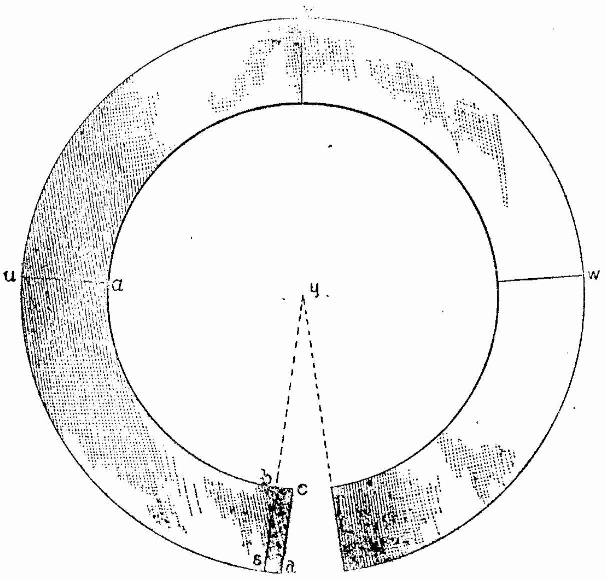

Fig. 465.—*Pattern of Brim.*

iron ring. The workmen may now select which is more convenient to him, and first put on the brim or the bottom. If the brim is first put on, carefully scrub the rivets and make the surface smooth about the rivet heads, and work the seam edge carefully down close, then the same with the bottom. It is usual to rub the seam well with white lead and oil on the inside after the job is finished

DYERS' COPPERS.

Dyers' coppers, as compared with some others, are not a difficult job, which will be readily seen by referring to Fig. 466. A dyers' copper is made with a cylindrical body and a segment of a sphere for a bottom. The sides are usually made in two pieces, and the bottom in one. These coppers may be made with a broad or narrow brim, similar to that of a tallow copper; or they may be supplied with a lead apron to catch and convey the drip and slopping, which is always a contingent circumstance in the dyers' art. Let us make a dyers' copper to hold 150 gallons American standard. Now, we have learned by experience that the easiest way to build this vessel is to make the bottom one-fourth the depth and the sides three-fourths, without the brim, although this, like all others, may be made any style or shape to suit the taste or convenience of the purchaser. But we will suppose the sides needed are three-fourths the depth and the bottom one-fourth. An American gallon equals 231 cubic inches, and $231 \times 150 = 34{,}650$, or the number of inches in 150 gallons, and we have 0.7854, which represents a cylindrical inch; then $\frac{0.7854}{4} \times 3 = 0.58905$, or ¾ cylindrical inch. The value of a segment of a sphere whose hight is one-fourth its diameter is 0.08181, and adding this to the value of ¾ cylindric inch we have $0.58905 + 0.08181 = 0.67086$, the value of the figure which represents a dyers' copper. Then $34.650 \div 0.67068 = 51.663.982$, and extracting the cube root of this last result we have 37.2 as the diameter, or $\sqrt[3]{\frac{34.650}{0.67068}} = 37.2$; that is to say, $37\frac{2}{10}$ inches is the diameter of the sides, and $\frac{37.2}{4} \times 3 = 27.9$, or 28 inches nearly, is the depth, without seams, and $\frac{37.2 \times 3.1416}{2} = 58.4337$, the length of one side. Add to each side about 2½ for seams and we have the full length represented by $58.4337 + 2.5$, or 60.9337, which we should call in practice 61 inches. Now we must add 3 inches for the brim, and we have $27.9 + 3 = 30.9$,

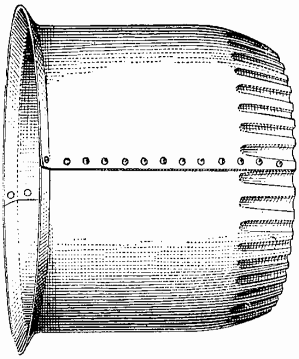

Fig. 469.—*Drawing in the Sides to Fit Bottom.*

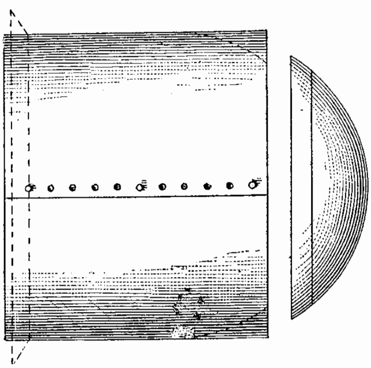

Fig. 468.—*Preparing to Turn the Brim.*

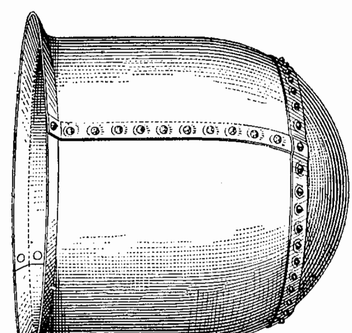

Fig. 466.—*Dyers' Copper.*

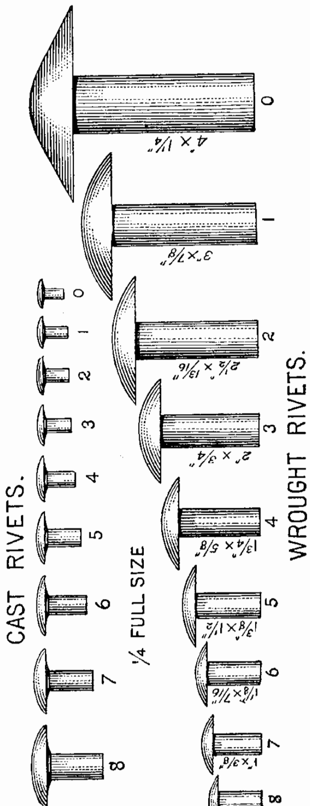

Fig. 467.—*Size and Shape of Copper Rivets, One-Quarter Size.*

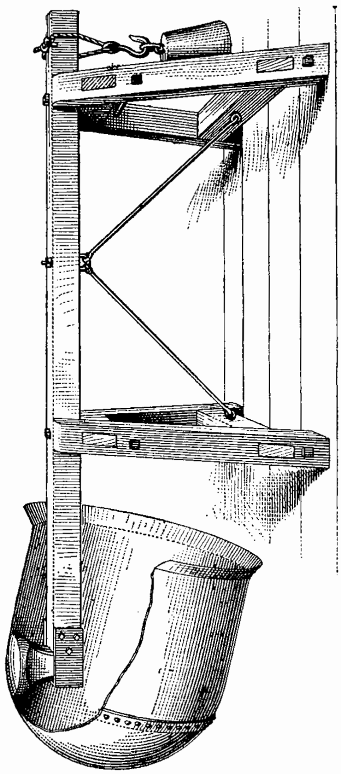

Fig. 470.—Planishing Dyers' Copper.

or 31 inches nearly. Let the sides be 60 inches long and 31 inches deep. The bottom is obtained as follows: $\sqrt[2]{6.975 + 3 \times 4 \times 37.2} = 38.52$; that is to say, one-fourth of the hight of the copper, or 6.975, with 3 inches added for bottom seam, making 9.975, multiplied by 4, and then by 37.2, the diameter of the copper, and the square root of this last result is 38.52, or 38½ inches, which is the diameter of the bottom before hollowing.

We are now ready to hollow the bottom, mark and punch it, also to prepare the sides for putting together in the same way. In the building of this copper we may use cast or wrought rivets; let us use cast. I should here state that the sizes of cast rivets are designated the opposite way to that of wrought—that is, No. 0 is the largest size in wrought rivets, which run from 0 to 8, while 8 is the largest cast rivet, which run from 8 to 0. Fig. 467 shows the shape and sizes of both wrought and cast. (We usually call the wrought ones nails to distinguish them from cast rivets.) Take the bottom and wrinkle it regularly around the edge; then sink it in the hollowing tub, and work out the wrinkles carefully until the diameter is the size required; smooth up and planish. Now work and punch the sides and bend them to shape, and put three temporary rivets into each seam; then with a racer mark off the depth of the brim and run around it with a hammer, Fig. 468, to harden it at the turn, and then lay off the brim. Draw in the other end at the sides to fit the bottom, Fig. 469, and planish the sides on the horse as shown in Fig. 470, and work in the seam rivets. Scrub and finish the seam, making the surface of the seam inside smooth. Mark and punch the holes for the bottom seam, after which set the sides into the bottom evenly all round, and mark the holes in the bottom by the sides, and punch the bottom. Put the sides back in the same place, and put into the bottom seam a few temporary rivets. Now work them in all round the bottom seam, performing the work on the horse. When they are all in, scrub them up tight until the inside is smooth, after which head up the rivets outside and finish.

TIECHES.

Sugar tieches were made the same as a tallow copper, excepting that heavier material was used, and the brim usually made narrow, as shown in Fig. 471. They can now be made in one piece, but where this is not possible the same rules and directions given for tallow coppers may be used, and will be found as useful for tieches and all other vessels of this shape as for tallow coppers, due allowance always being made for seams, as suggested in the directions given.

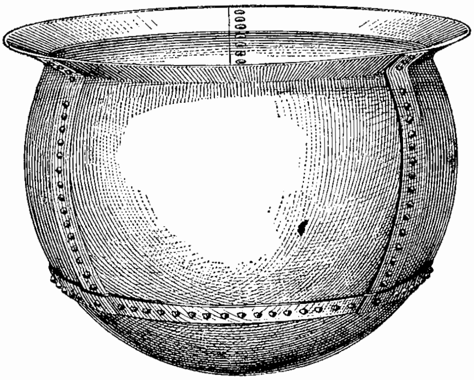

Fig. 471.—*Sugar Tiech.*

STILLS.

Copper stills are and have been in continual demand for many years and are likly to be, seeing that there are so many uses to which they may be put in the manufacture of the many commercial commodities which depend upon the process of distillation. Stills are made from 1000 to 5000 gallons capacity, according to the uses for which they are required. The largest, however, are used for the purpose of distilling spirits, such as gin, rum and brandy. These large stills will occupy our attention. In Fig. 472 is shown a squat or fire still with head and worm. This apparatus is usually made in three sections—that is to say, the still boiler, the head, and then the worm, which together complete the still proper. But they are often supplemented with retorts of various designs, the most common of which is shown in Fig. 472. These retorts are used for rectifying purposes, and there are sometimes several interposed between the still and the worm, according to the degree of rectification required. As all large stills are made nearly the same pattern, we will make one as an example or guide for ascertaining the dimensions and pattern of those most in use and then consider their construction. Let our example be required to hold 500 gallons. It will be seen by reference to Fig. 472 that the outline or design of the body of the still boiler is that of an oblate spheroid—that is, down to the lag of the bottom, when the bottom is reversed or pressed upward to form the bottom crown, in the same way as that of a brewing copper. Here, in the case of a still, as in a brewing copper, the quantity displaced by the crown of the bottom is quite an item in the capacity and must, therefore, be taken into account, although it was ignored in the case of large brewing coppers. Our body, then (that is, the boiler), is to hold 500 English gallons. Now, we find the solid contents of a spheroid by multiplying the square of the revolving axis by the fixed axis and this product by 0.5236. Here, then, we have the key to the solution of the various problems involved in the sizes or dimensions we should make the still boiler, and we will proceed to find the diameter and hight of a still boiler to hold 500 gallons (English meas-

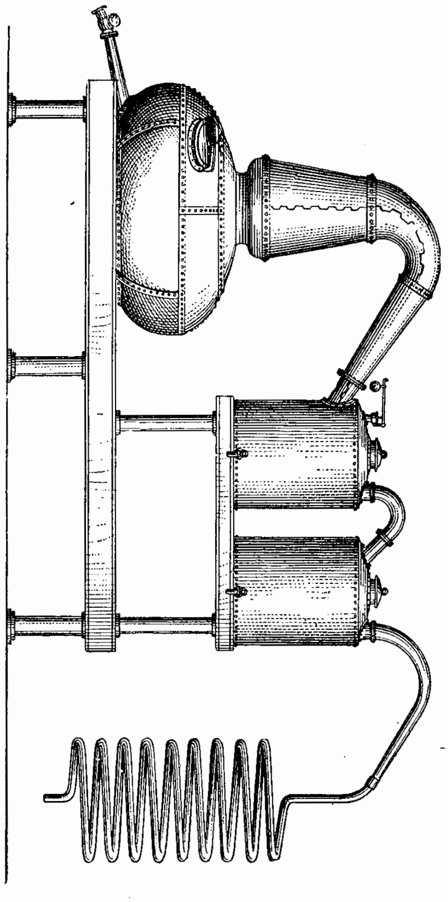

Fig. 472.—Fire Still with Head and Worm.

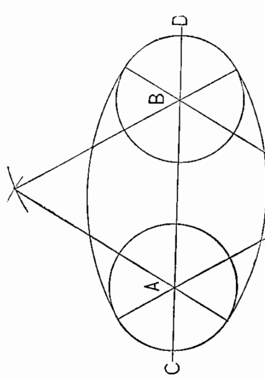

Fig. 473.—*Method of Drawing Oblate Spheroid.*

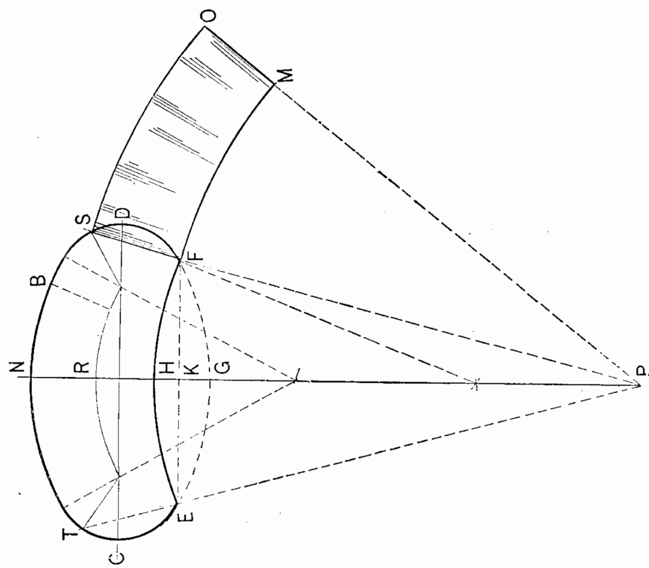

Fig. 474.—*Pattern for Sides of Boiler.*

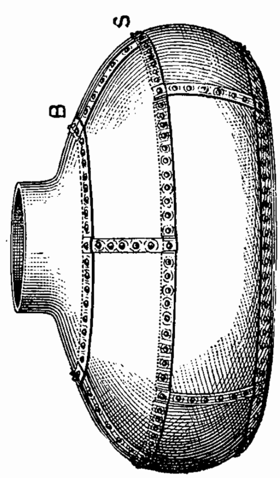

Fig. 475.—*Elevation of Boiler.*

ure), to be used as a rule to find any or all others. An English gallon contains 277.274 cubic inches, therefore 500 × 277.274 = 138,637. Again, in an oblate spheroid whose dimensions are fixed in the proportions shown in Fig. 473—namely, two and a half diameters of the focal circles A and B as the measure of the transverse axis of the ellipse which forms the outline for or boundaries of the spheroid, and whose axis is C D, or is 1—the value of its solidity is found by the rule given to be 0.29362. The spheroid, however, is made concave on the under side to form the lag and crown of the boiler bottom, therefore this value must be reduced by the value of the spherical segment E G F, Fig. 474, which vanishes, together with the segment E H F, which forms the bottom crown. Now, $\overline{EK}^2 \times 3 + \overline{GK}^2 \times GK \times 0.5236 = 9.02758$, the solid content of the segment H E F, and $\overline{EK}^2 \times 3 + \overline{HK}^2 \times HK \times 0.5236 = 0.02128$, the solid content of the segement E H F, or the segment which forms the crown of the boiler bottom; then subtracting the value of these two segments from the whole spheroid we have 0.29362 − (0.02758 + 0.02128) = 0.24476, or the value of solid figures whose dimensions are similar to or like that of a still boiler. To proceed: the solid content of 500 English gallons is shown to be 138.637 cubic inches; then 138.637 ÷ 0.24476 = 566,420.168 boiler inches, and extracting the cube root of this last result we have 82.73 as the diameter C D of a still boiler to hold 500 gallons. Now, we want the depth, H N, Fig. 474, which we find by multiplying the transverse axis C D, or 82.73, the diameter of the boiler, by 0.3701; that is to say, C D by H N, or 82.73 × 0.3701 = 30.618. We thus have the diameter of the boiler 82.73 inches, or 6 feet 10⅝ inches, and the depth from the bottom crown to the head collar 30.618 inches, or 2 feet 6⅝ inches nearly. For the pattern proceed as follows: Through S F and T E, Fig. 474, draw the lines S P and T P, and with P F as radius describe the arc F M, and with P S as radius describe the arc S O, making the distance from F to S equal to 26.028; that is, 82.85 multiplied by one-fourth of the circumference of the focal circle. The length of each one of the sides from F to M may be any convenient length, according to the size of the sheet; but for the symmetry and beauty of the work the sides should be all alike; that is to say, either three, or four, or any other suitable number, so long as they are all alike or can be got out of the sheets at hand without waste. Now take sides enough so that when they are put together they will measure 83 inches in diameter at the points C and D after the top and bottom have been tucked in to form the bulge or curves of the sides, and let the sides, when ready for the bottom, go into the raise of the bottom within about 2½ inches of the bottom lag The first section of the crown from S to B, Fig. 475, may be made in the same number of pieces as the sides if it cannot be supplied in one piece with the bottom, but the crown pieces are usually supplied. Having then the sides, bottom and crown, the workman may proceed to put them together in a similar manner to that described for the building of large brewing coppers. I should here say, it is sometimes better to cover the trestles with boards of a suitable thickness (if at hand), which will add firmness to the trestles and make the stage more complete. The illustration, Fig. 472, fully explains itself as to the construction of the still head and worm, while the processes or methods used to make them have been explained in a former chapter and need not be repeated.