THE SHEET-METAL WORKERS' INSTRUCTOR

BY

R. H. WARN.

THE

SHEET METAL WORKER'S INSTRUCTOR,

FOR

ZINC, SHEET IRON, COPPER, AND TIN PLATE WORKERS, &c.;

CONTAINING A

SELECTION OF GEOMETRICAL PROBLEMS,

ALSO

PRACTICAL AND SIMPLE RULES FOR DESCRIBING THE VARIOUS PATTERNS REQUIRED IN THE DIFFERENT BRANCHES OF THE ABOVE TRADES.

BY

REUBEN HENRY WARN,
PRACTICAL TIN PLATE WORKER.

Price 10*s.*; *post free*, 10*s.* 6*d.*

PUBLISHED BY THE AUTHOR,
54, MARQUIS ROAD, CAMDEN SQUARE, N.W.

1869.

[ENTERED AT STATIONERS' HALL.]

KNOTT, PRINTER, GREVILLE STREET, HOLBORN.

PREFACE.

Mr. Warn has asked me to write a few lines as an Introduction to this Work, because he thinks that it would afford a good opportunity for saying a few words as to the importance of "Technical Education." I wish he had chosen some one more competent to do this, for the object is one which requires the best efforts of our best men.

There are a few considerations in reference to this matter which cannot be too often repeated, and they are these. While some nations feed their people by producing and selling their surplus agricultural produce, and some by trading and carrying, others, like England, greatly rely upon manufacturing. A large part of our people therefore has become dependent for their daily bread upon that kind of production, and it has now to be carried on under very different conditions from what was formerly the case. Once we had hardly any competitors; now we have rivals everywhere, because of a long European peace, of the creation of the means of traffic throughout Europe by railways, of the immense growth of capital, and, above all, *of the increase of scientific knowledge.* We have now, therefore, a tremendous competition; and the great question with each nation is, how to get the largest market by selling cheapest. Cheapness of production depends, of course, on several things, but on nothing so much as on the application of scientific and artistic knowledge to that production—on the constant resort to the great Forces of Nature, such as those we call by the names of Chemistry, Electricity, Mechanics, Dynamics, &c.

That nation, therefore, will do best in this great race of competition whose producers, among all grades, know most about the Forces of Nature, or Laws of Science, and how to apply them—the nation which has the greatest number of clear-headed, well-instructed, well-trained, and industrious men. What, then, is it but national suicide for a manufacturing nation like ours to neglect any means of giving the very best and widest instruction to all classes of its people?

In reference to this question, it must be borne in mind how much depends, in our country, upon *individual effort*; and that, with us, the Government seldom originates any national action, but rather supplements the work of individuals and societies. This throws a great responsibility on all of us individually. Honour to those men who, like Mr. Warn, recognise that responsibility, and do what they can, in one way or another, to promote the industrial knowledge of the country. The greater honour is due when the individual who does this good work is not a man of leisure and pecuniary independence, but one who has to earn his daily bread by constant toil. May such an example as Mr. Warn has afforded in producing this book, be largely followed by men of all classes and qualifications! There is need for every man's help in this work.

Industrial knowledge may be described as theoretical and practical,—dealing with the scientific and artistic principles which form the foundation of all work, or dealing with the application of those principles to production. This book deals with the latter, and until the nation builds up a perfect system of instruction for all grades and ages, we must, to a great extent, be content with teaching men the practical details of their work, without showing them the *principles.* These latter require more instruction and time than our schools have yet made provision for. It is always something to help men to become skilful in their profession, and to prevent the waste of time, labour, and material which everywhere arises from want of knowledge and skill.

In papers read before the Society of Arts, statements have been made which show that, in numerous trades, it often happens that when an object has to be made in a form different from what has hitherto been required, neither master, foreman, or workman, knows how to set about it. The desired result is obtained by "trial"—that is, at a cost of time, labour, and material, which would have been saved if there had been the requisite knowledge of *principles*.

Mr. Warn has meritoriously endeavoured for a long time past to help his younger fellow-workmen, by teaching them, in the evenings, how "to strike" the various patterns required in metal work; and this led to the idea of putting the requisite diagrams in a permanent shape, so that the information he had laboriously collected might be of permanent and extended service to all engaged in the trade. In doing this, he has deserved the gratitude, not only of his fellow-workmen, but of the masters engaged in the trade, who will thereby be saved from loss of time and material.

Long convinced of the importance of every such effort in the promotion of industrial, professional, or technical instruction, I have made inquiries, when travelling on the Continent, as to the efforts made by our foreign competitors for the promotion of this kind of teaching. What has been done by foreign Governments in the schools and colleges for children, apprentices, foremen or manufacturers, is well known from the Reports which Parliament has published. It is not so well known that in every foreign town may be found, at trifling cost, admirable hand-books, treatises, drawing models, designs and patterns, for the use of workmen in every branch of industry. I have collected a few of these books, in the hope of their being translated and adapted for the use of English workmen. In the case of the very branch of industry to which this work of Mr. Warn belongs, I was able to place in his hands an admirable collection of designs and patterns, which is sold for seven shillings at Darmstadt, where the Government of that little State, combining with an association of manufacturers, has for many years past been producing a vast library of similar works for the various trades.

It is a serious thing that England should be so deficient in all such means and appliances of industrial instruction. To put the matter on the lowest ground, as some would term it, this is a matter of daily bread to thousands. All *waste* is national loss, and terribly so to that part of the nation which has to work for the mere necessaries of existence. Ignorance and unskilfulness are the unceasing causes of such waste.

There is, too, another fact which has recently been brought into prominent notice by an official report based on careful and extensive inquiry, viz., that the need for employment which so presses upon us is mainly felt among the masses of unskilled labourers, and that as we ascend in the scale of industrial knowledge, the pressure is less and less. It must be so. The pressure of competition for work will ever be greatest amongst those who have nothing with which to earn their bread but mere bodily toil. Labour which involves mind and skill and taste will always fetch a price proportionate to the degree in which those higher qualities are possessed. The whole history of modern industry is that of a constantly increasing demand for labour involving those qualities, as compared with labour which is purely one of bone and muscle.

In conclusion, I would ask all working men who have children, to bear in mind how greatly the future welfare of their children depends upon their giving them as much of preparation as possible for the position of skilled workmen; how a few pence a week saved by taking them early from school and putting them to work, will, perhaps, cause a loss to them of many shillings a week later in life. To secure that more remunerative employment, good night schools are necessary for the apprentices; but the great difficulty in teaching apprentices the principles of their work, is that their school education has been so short and imperfect. Let it never be forgotten, too, that the extensive employment of children must as surely diminish the wages of grown-up workmen, as that two and two make four.

HODGSON PRATT.

8, Lancaster Terrace, Regent's Park,
October, 1869.

CONTENTS.

INTRODUCTION.

This Work is intended as a book for private study for artizans in the various branches of the Sheet Metal Trades.

The first four plates contain a selection of Problems on Practical Geometry, which embrace principles in the above trades, and which it is hoped will serve as an introduction to the accompanying diagrams, enabling the student more readily to work out the several figures. Indeed, Geometry is of great service to working mechanics, both when called upon to work from drawn plans, and when required (as is frequently the case) either to alter some device, or to form an original pattern; nor is it less serviceable when instructing apprentices in their respective arts.

In selecting the subjects contained in the plates, the aim has been to place them in such easy stages of advancement, that the figures may be easily worked, and so that the earlier diagrams may assist the student both in comprehending and in working out those which follow.

The student is recommended not merely to read the letterpress, but to take a pair of compasses, with shifting leg for pencil, a T and set squares, a square board, and some paper, and work out every figure in the book, for it is only in this way that he can hope to obtain a proper knowledge of the various diagrams herein contained. By working out carefully each figure, the mind will embrace the principles contained therein, and the figures themselves will be thereby better fastened on the memory; and further, the student by this means will derive increasing pleasure as he proceeds from figure to figure. Some students will find it beneficial to work the figures through in this manner several times.

If any reader should think the description of the diagrams too diffuse, or even commonplace, the answer must be that the Author desires the work to be useful, not only to the most cultured of his fellow-workmen, but also to apprentices, and to such adults as may have had only a very limited education: and further, as the words used in one trade are often almost unintelligible to others, such language has been used throughout as will, perhaps, be on the whole most readily understood.

While the Author disclaims entire originality for the whole of this course of instruction, yet there are many portions thereof which he has never seen elsewhere, and believes to be original.

And as, in the few years the Author has turned his attention to the subject, he has found considerable pleasure and benefit therefrom, he hopes that his fellow-workmen who may use this book will derive equal or even greater pleasure and benefit from its study; and if so he will feel great satisfaction in the effort herein bestowed.

R. H. WARN.

ERRATA.

Page 39, at end of first paragraph—For "from in BCD," read "from BCB, in fig. 4."

" Second paragraph, 10th line—For "*v* to *n*," read "*u* to *n*."

Plate. 1.

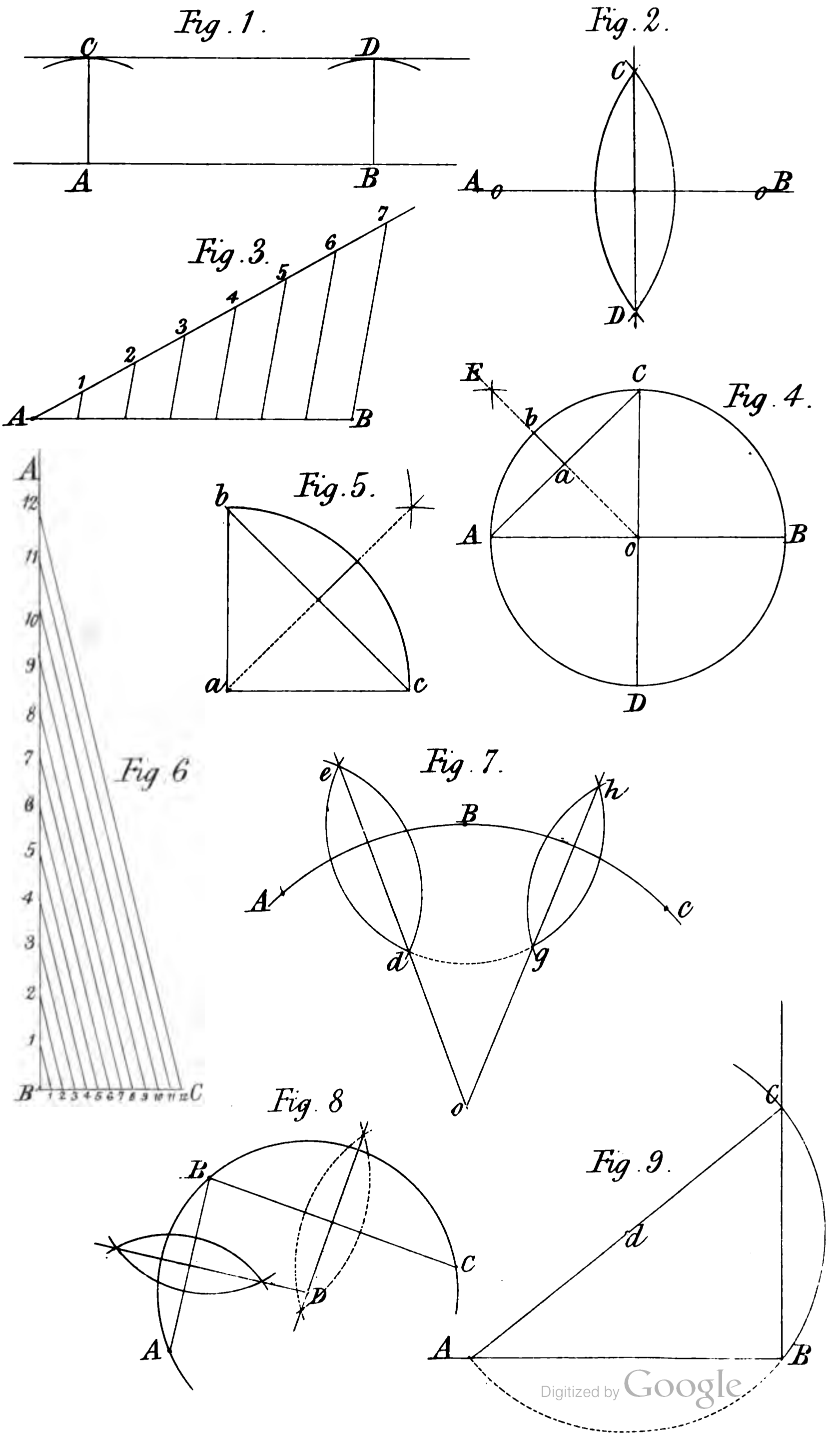


Fig. 1.
C D A B
Fig. 2.
C D A B o o
Fig. 3.
A B 1 2 3 4 5 6 7
Fig. 4.
E C b a A B o D
Fig. 5.
b a c
Fig 6
A B C 1 2 3 4 5 6 7 8 9 10 11 12
Fig. 7.
e h B A C d g o
Fig. 8
B C D A
Fig. 9.
C d A B

THE

SHEET METAL WORKER'S INSTRUCTOR.

PLATE I.

FIG. 1.—To draw a straight line parallel[1] to a given line, and at a given distance from it.

Let AB be the given straight line, and the line AC to represent the distance between the parallels.

Then with A as a centre, with the radius AC describe the arcs[2] (or curves) C and D. Draw the line CD so as to touch these curves, and CD will be parallel to AB as required.

FIG. 2.—To bisect a given straight line; that is, to divide it into two equal parts at right angles.

Let AB be the given line. From any part, say *o o*, with radius[3] greater than half the length *o o*, describe curves cutting each other in CD. Then a straight line drawn through the points of intersection[4] will bisect the line AB.

FIG. 3.—To divide a given line into any number of equal parts (in this case seven).

Let AB be the given line which is to be divided into seven equal parts. From the point A draw another line (not being particular as to what angle with AB), and with any convenient opening of the compasses set off seven equal parts, as 1, 2, 3, 4, 5, 6, 7. Join the points 7 and B, and draw parallel lines from 6, 5, 4, 3, 2, 1, to cut the line AB, which will be divided into seven equal parts as required.

FIG. 4.—To draw a straight line equal to the circumference of a given circle.

Let ADBC be the given circle. Draw the diameter AB, and from its centre *o* draw the perpendicular CD. Draw a diagonal line AC; set the compasses in C, and with a radius at any distance beyond its centre *a* describe the arc E; now with the compass in A draw another arc intersecting at *e*, and draw the line *o* E, then three times the diameter, with the distance *a b* added, will be a close approximation to the length of the circumference.

FIG. 5 is the same, but showing only the section required.

Fig. 6.—To construct a plain scale, for drawing a small plan proportionate to a larger one.

Draw a line AB, say 12 inches long, and mark off the inches as from 1 to 12; then draw BC, say 2 inches long. Draw a line from 12 to C, and draw parallel lines from the points 11, 10, 9, 8, etc., to cut the line BC. By using the distances on the line BC, as 1, 2, 3, 4, etc., as inches, you would get a scale of 2 inches to the foot.

Fig. 7.—To find the centre of a circle or the radius of a curve.

From the point B as a centre, with radius greater than half the distance to the other points, draw a portion of a circle, as *e d g h*, and from A and C as centres, with the same radii, draw curves to intersect or cut the part of a circle first drawn at *e d* and *g h*. From these points of intersection draw lines *e d* and *g h* until they meet at *o*, which will be the centre of the curve required.

Fig. 8.—To draw a circle through any three given points (provided they are not in a direct line).

Let ABC be the three given points; join AB and BC; bisect AB and BC, and produce the bisecting lines until they cut each other in the point D, then D will be equi-distant from each of the three points, and the centre of the circle required.

Fig. 9.—From the point B on the line AB to erect a perpendicular.[5]

Above the given line AB take any point *d*, and with the radius *d* B draw a portion of a circle ABC. Draw a line from points A *d* to meet the circle in C. Draw the line BC, which will be perpendicular to AB.

Notes.

[1] A parallel line is one that runs in the same direction as another line, but always keeps at the same distance from it.

[2] Arc is part of a circle. The word "curve" will be used frequently in the commencement instead of arc; but it should be remembered that a curve is not always part of a circle.

[3] A circle is a figure bounded by a curve equally distant in every part from its centre. A straight line across the figure through the centre is called its diameter, half this line is the radius, it being the length from the centre of a circle to its outer line or circumference.

[4] Where one line or curve crosses or cuts through another, is called the point of intersection.

[5] Perpendicular means square with another line. To say that a line is perpendicular does not necessarily mean that it is upright, but at right angles or perpendicular to the line on which it is drawn. When two lines are perpendicular to each other they form a right angle. A line formed by a cord having a weight at its end is really an upright line or a vertical line.

Plate 2.

Fig. 1.

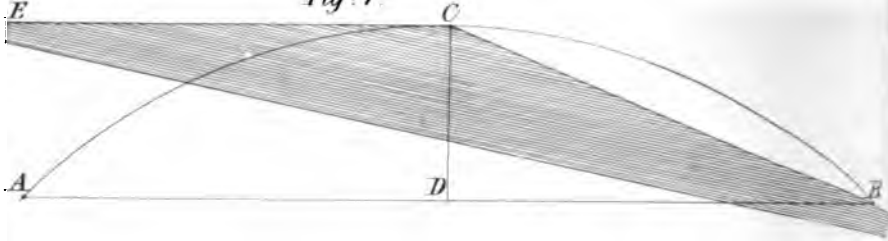


Fig. 2.

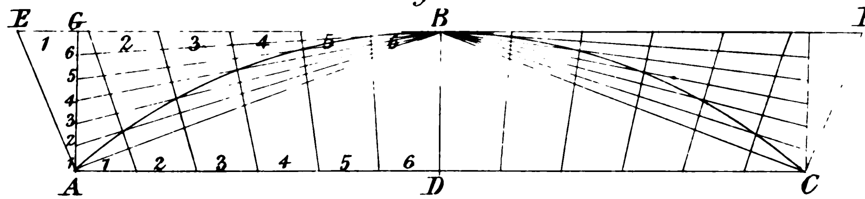
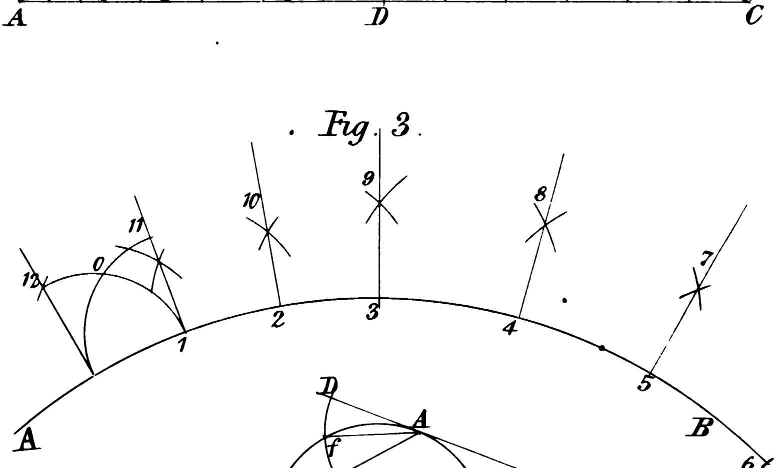


Fig. 3.



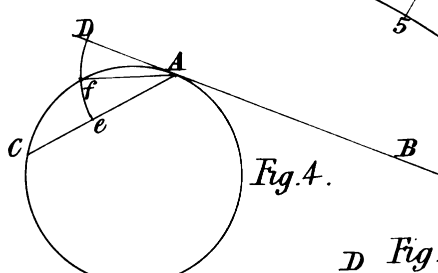


Fig. 4.

Fig. 5.

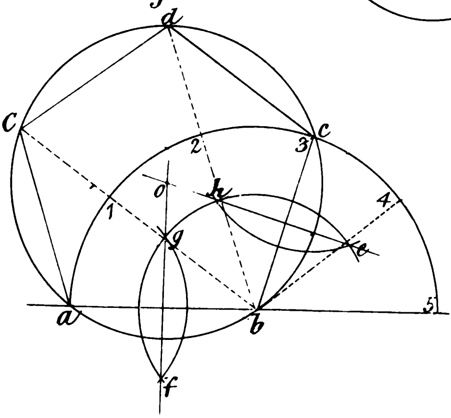


Fig. 6.

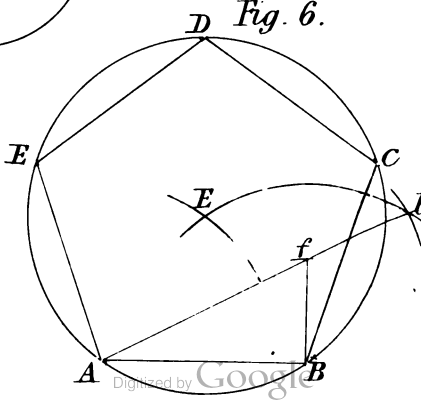


PLATE II.

Fig. 1.—To strike a segment (or part of a circle) by a triangular guide, the chord[1] and height being given.

Let AB be the chord of the segment and DC the height (or versed sine), join BC and cut CE parallel to AB, and make it equal BC, fix a pin in B and another in C, and with the triangle ECB describe the curve CB, then remove the pin B to A, and by guiding the sides of the triangle against AC, strike the other part of the curve ACB.

Fig. 2.—The chord and height of a segment of a circle of large radius being given, to find the curve without having recourse to the centre, which is supposed to be unattainable.

Let AC be the chord line and DB the height, through B draw EF parallel to AC, join AB and BC, draw AE at right angles to AB, and CF at right angles to BC, divide AD and EB into any number of equal parts (say 6) join the corresponding numbers 1 1, 2 2, 3 3, &c. Also divide AG into the same number of equal parts, and from each division draw lines to B, and the points of intersection will be points in the curves.

Fig. 3.—Having an arc of a circle given, to raise perpendiculars from any point or points without finding the centre.

Let AB be the given curve or arc, and A 1 2 3 4 5 the points from which perpendiculars are to be erected, in the space 5B make the point 6 equal to 4 5, from 4 and 6 as centres, with a radii greater than half the distance between them describe arcs intersecting each other at 7, a line drawn at the point of intersection at 7 to 5 gives one of the perpendiculars required, the other points as far as 11 will be found in the same manner. If a perpendicular is to be raised at A, the extremity of the curve, a method somewhat different must be employed; suppose the perpendicular 1 11 to be erected, from 1 with the radius 1 A describe the curve A 11, and from A with the same distance describe 12 1, make *o* 12 equal *o* 11 and join A 12, will give the perpendicular wanted.

Note.—The A should be exactly under the line 12, it has been drawn too far in error.

Fig. 4.—To draw a tangent[2] to a circle or portion of a circle without having recourse to the centre.

Let A be the point from which the tangent is to be drawn, take any other point in the circle AC, join AC and bisect the curve AC at *f*, then from A as centre with o radius A*f*, the chord of half the curve, describe the curve *efD*, making *f*D equal *ef*, then through the points AD draw the line DAB, which will be the tangent required.

Fig. 5.—Upon a given straight line to describe any regular polygon (in this case a pentagon).

Produce *ab* indefinitely,[3] from *b* as centre with a radius *ba*, describe the semicircle *ao*5, which divide into as many equal parts as there are to be sides in the polygon, which in the present example is five, through the second division from 5 draw the line *bc*, which will form another side, bisect these sides as shown at *fg he*, the point of intersection at *o* is the centre of the circle of which *abc* are points in the circumference, then by producing the dotted lines *b* 1 to *c*, and *b* 2 to *d*, will divide the circle into the number of parts required.

Fig. 6.—Upon a given side to draw a regular pentagon.

Let AB be the given side, from its extremity B erect a perpendicular B*f* equal to half AB, join A*f* and produce it till *fb* be equal to B*f*, from A and B as centres with a radius equal to B*b*, draw arcs intersecting at E, which will be the centre of a circle containing five divisions equal to AB.

Notes.

[1] Chord, a line cutting off any part of a circle. The part of a circle thus cut off or divided by a chord is called a segment.

[2] Tangent, a line perpendicular to a radius, that is to say, a line required to be drawn from a curve or a circle without any perceptible point where it joins the curve; the line should be at right angles with the centre that the curve was struck by, the line will then be tangent.

[3] To produce a line, or draw a line indefinitely is to carry it further or make longer in the same direction, its required length is sometimes not known until intersected by another line.

Plate 3.

Fig. 1.

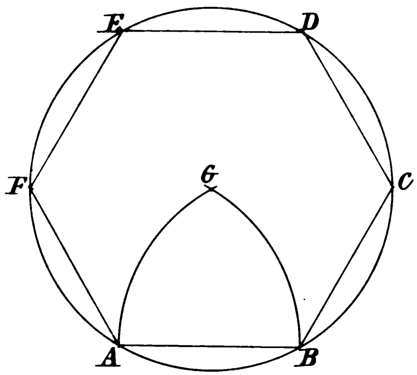


Fig. 2.

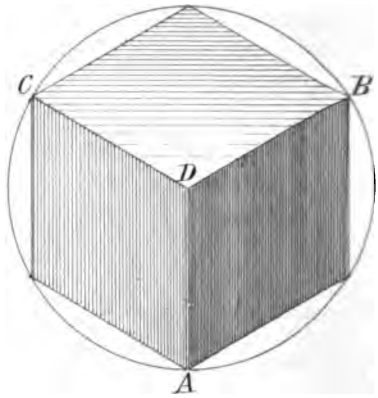


Fig. 3.

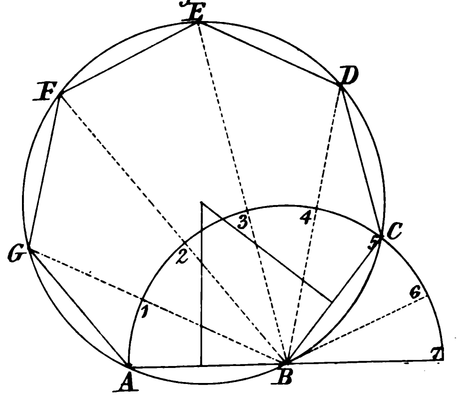


Fig. 4.

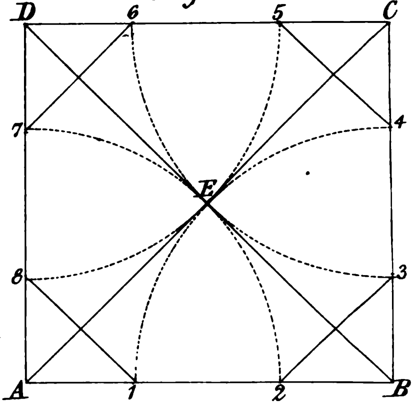


Fig. 5.

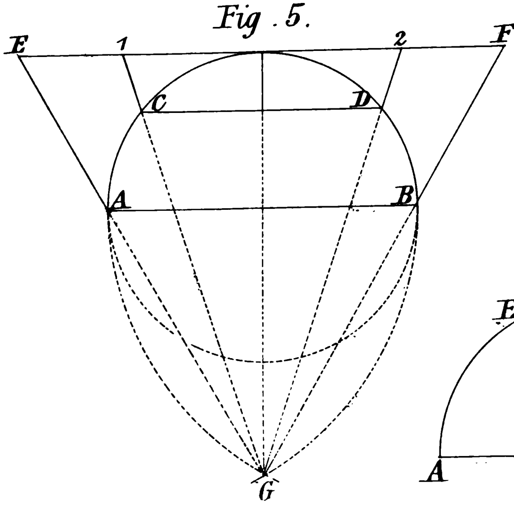


Fig. 6.

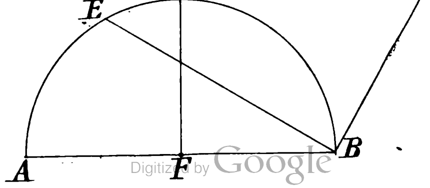


PLATE III.

Fig. 1.—Upon a given side to draw a hexagon.

Suppose AB to be the given side, from the extremities A and B draw curves intersecting at G; from G with a radius GA describe the circle ABCDEF, which will contain six divisions equal to AB.

Fig. 2 is drawn precisely the same.

By drawing the lines ABC to the centre D, the vertical and horizontal projections of a cube are given, with the plan and elevation in one view.

Fig. 3 is a heptagon, drawn on the same principle as the pentagon, Fig. 5, Plate II., and which will give a sufficient explanation how this or any other polygon having a given number of equal sides is drawn.

Fig. 4 shows how to describe an octagon in a given square.

Let ABCD be the given square. Draw the diagonals ACDB, then from the angular points ABC and D, with a radius equal to AE, describe curves cutting the sides of the square in 1 2 3 4 5 6 7 8, then by joining these points the polygon will be complete.

Fig. 5.—To draw a straight line equal to any given part of a circle.

Let AB or CD be the given arcs. From A with radius AB, and vice versa, describe arcs intersecting at *g*. Draw EF parallel to AB, then from E draw lines through A and B cutting at E and F, then EF in the length of the curve from A to B.

Again, draw lines from E, through C and D, cutting at 1 and 2 will give the stretch-out from C to D. On the same principle the stretch-out may be found from any other point in the semi-circle.

Fig. 6.—To find the stretch-out of a semi-circle by another method.

Let ACB be the semi-circle. Make AC equal AF, and draw EB, then draw BD at right angles to EB, and draw CD parallel to AB; CD is the length of the quadrant CB, and twice CD the length of the semi-circle ACB.

Definition of Polygons.

All figures having more than four sides are called polygons, and are distinguished by names denoting the number of their sides, thus:—

A Polygon of	five	sides is called a	Pentagon.
"	six	"	Hexagon.
"	seven	"	Heptagon.
"	eight	"	Octagon.
"	nine	"	Nonagon.
"	ten	"	Decagon.
"	eleven	"	Undecagon.
"	twelve	"	Duodecagon.

When all the sides of a polygon are equal and all its angles equal, it is called "regular." When they are not equal, the polygon is called "irregular."

Definition of Four-sided figures, or Parallelograms.

A parallelogram is a four-sided figure whose opposite sides are parallel to each other. When the four sides are equal and the four angles are right angles the figure is called a square, as shown by Fig. 4 (Plate III) ABCD.

Diagonals are lines crossing to opposite angles, as AC and DB.

When one pair of sides is of a different length to the other, but the sides remain parallel to each other in opposite pairs, the angles being right-angles, the figure is called a rectangle or parallelogram, such as the four right lines within which an oval is described, (Fig. 2, Plate IV.) When the four sides are equal and the opposite sides parallel to each other, but the angles not right angles, the figure is called a rhombus or lozenge, a figure frequently known as a diamond shape (see Fig. 7, Plate II.)

An angle is an opening formed by any two lines meeting at a point. If this opening be greater than that formed by a line meeting perpendicularly it is called an obtuse angle. If the opening be less than one formed by a perpendicular line it is called an acute angle.

TRIANGLES.—In a right-angle triangle, one of the angles is a right-angle or square, as in Fig. 9, Plate I. A triangle having all three sides and angles alike, is called an equilateral triangle.

Fig. 1.

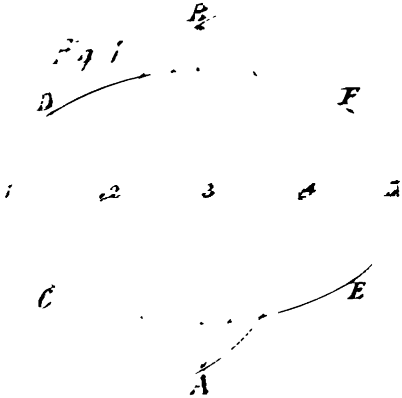


Fig. 2.

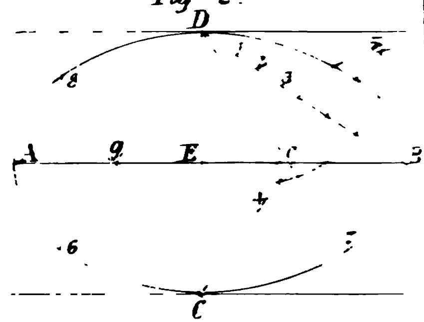


Fig. 3.

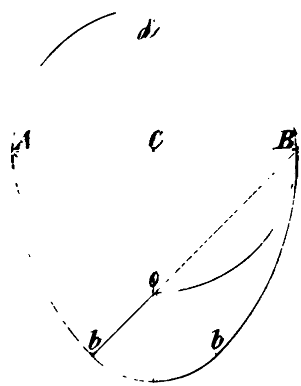
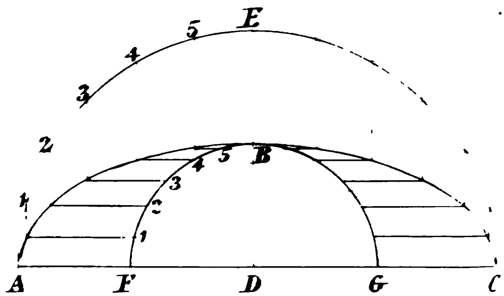


Fig. 4.



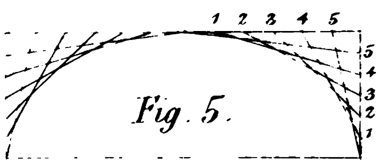


Fig. 5.

Fig. 6.

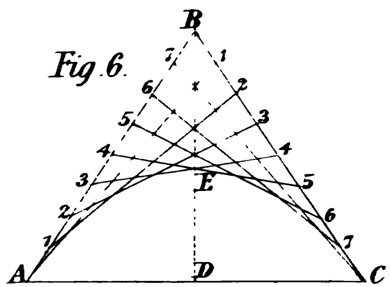


Fig. 7.

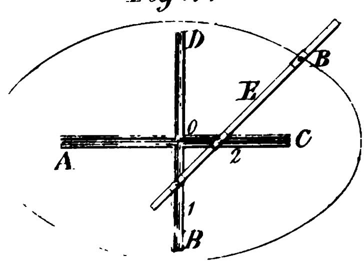


Fig. 8.

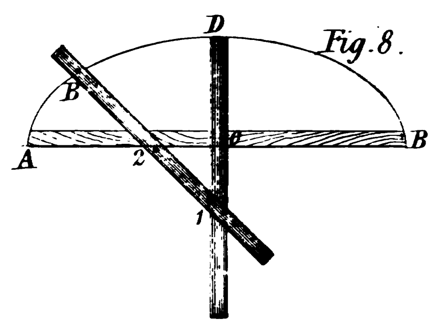


PLATE IV.

FIG. 1.—To strike an ellipse (or oval) with the compasses, the length or major axis being given.

Divide the given length 1 5 into five equal parts, then with 2 as the centre and a radius 2 4, and vice versa, describe curves intersecting at A and B; then from the points A and B draw lines through 2 and 4 indefinitely, with 2 as centre and radius 2 1, describe the curve CD, and from 4 the curve EF; now with centre A and radius AD, describe the curve DF, and from B the curve CE, which completes the ellipse.

FIG. 2.—To describe an ellipse within a given square, or when the major and minor axes are given.

Draw the major axis AB, and minor axis CD, make the diagonal BD, take the distance AE on the major axis, and transfer from B to 1 on the diagonal BD, also the distance ED to the point 3; take half 1 3 in the point 2 as centre, and any distance towards B greater than its half, and vice versa; from B describe arcs intersecting at 4 and 5, through these points draw a line until it cuts the minor axis at C, make E*g* equal E*o*, and ED equal EC, from C and D draw lines through *o* and *g* indefinitely, then with centre *g* and radius *g*A, describe the curve 6A8, and from centre *o*, 5B7; then from centre C and radius CD, draw the curve 8D5, and centre D the curve 6C7, which will complete the ellipse.

FIG. 3 shows a method of drawing an egg-shaped oval.

Draw the line AB, and bisect it in C, with centre C draw circle A *o* B *d*, and draw the diagonals A *o b* and B *o b*, then with A as centre, and radius AB, draw the curve B *b*, and with centre B the curve A *b*; now with *o* for centre, and radius *o b*, describe the curve *b b*, which makes the oval required.

FIG. 4.—If two semi-circles are described as shown in this figure, and both semi-circles divided into the same number of equal parts, and if through the points of division of the larger semi-circle lines are drawn perpendicular to AC, and through the corresponding points in the smaller one parallel to AC, the points of intersection will be points in the elliptic curve, giving a graphic illustration of what an ellipse really is.

FIG. 5 is another method of drawing an ellipse by intersecting lines, so simple in construction as to need no further explanation.

FIG. 6.—To draw a parabola by the intersection of lines, its axis, height, and base or ordinate, being given.

Let AC be the base, and DE the axis, and E its vertex, produce the axis to B and make EB equal DE, join AB, CB, and divide them into the same number of equal parts, join the divisions by the lines 1 1, 2 2, &c., and their intersections will produce the curve required.

Fig. 7.—To draw an ellipse with the trammel.

The trammel is an instrument consisting of a right-angled cross ABCD grooved on one side, and a tracer E with three moveable studs 1,2,B, two of which slide in the grooves just mentioned, the other at B is provided with a pencil to trace the curve of the ellipse. For the application suppose AC to be the major axis, and BD the minor, lay the cross of the trammel on these lines; then adjust the sliders of the tracer so that 1B may be equal to *o* C, and EB equal *o* D; then by sliding the tracer in the grooves of the cross, the pencil at B will describe the ellipse.

Fig. 8.—This is precisely the same principle of drawing the ellipse as Fig. 7, and is inserted because the trammel (which is perhaps preferable to any other method of drawing this curve) is not always at hand; and this is a trammel easily constructed and answers every purpose.

Take A to *o* as the major axis, and D to *o* as the minor, on which another straight-edge is to be fastened and extended as shown, put a bradawl or nail through at 1 and 2, and apply the pencil at B, then by sliding the tracer round, keeping the bradawls against the axes of the ellipse, one quarter of the curve will be described; now move the tracer to another quarter, and describe it in the same manner, and continue in like manner until the ellipse is completed.

Notes.

Fig. 3 (Plate IV.) represents an oval, which is egg-like (from *ova*, an egg); but according to the custom of many trades Figs. 1 and 2, and Fig. 8 in Plate V. are commonly accepted as ovals, although strictly they are ellipses, or methods of describing an ellipse with the compasses by means of arcs of circles, practically good and useful.

Figs. 4, 5, 7, 8 show various methods employed to obtain perfect ellipses under the following definitions. An ellipse is a figure bounded by a curve having no centre but two foci, from which it is generated. It owes its form to the section of a right cone oblique to its axis. In Plate VIII. is shown elliptical fig. described by a piece of string and pencil, which forms no part of a circle.

The words major and minor axes are terms used to describe the length and width of the ellipse or the diameters, they are also described sometimes as the transverse and conjugate axes.

Plate 5.

Fig. 2.

Fig. 1.

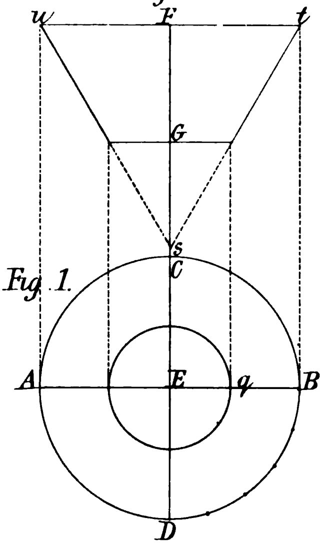


Fig. 3.

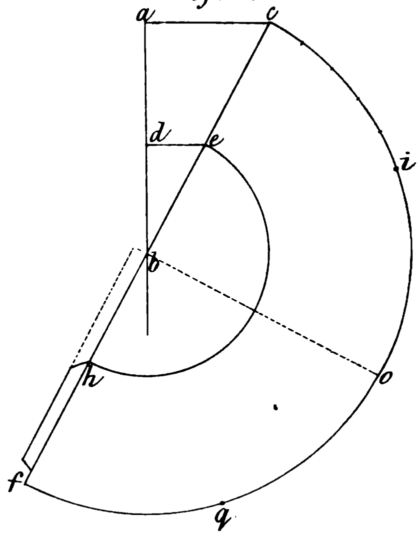


Fig. 5

Fig. 4.

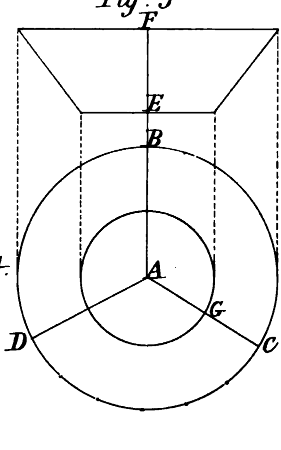


Fig. 6

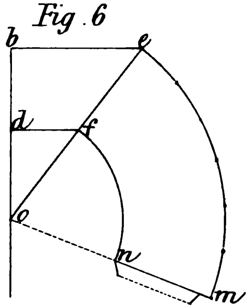


Fig. 7.

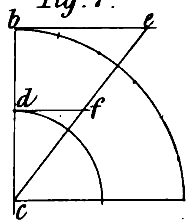


Fig. 8.

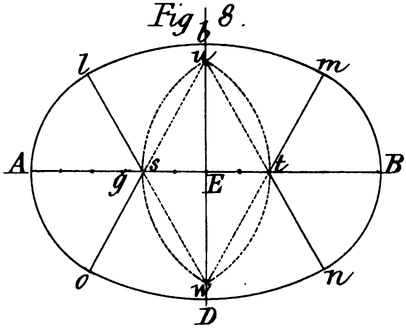


Fig. 9.

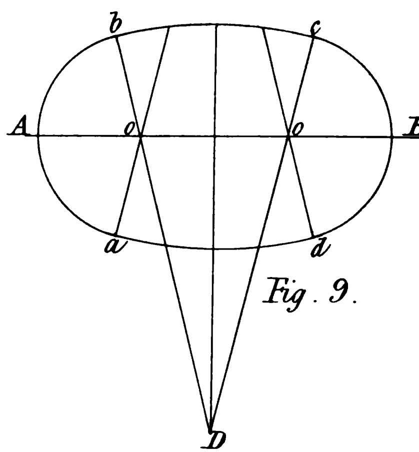


PLATE V.

To strike a pattern for a Round Tapering or Flue Article (or a Frustrum of a Cone.)

Fig. 1 represents the diameter of both top and bottom, and Fig. 2 from G to F the upright height. Divide the circle with lines, as AB and CD, at right angles, then draw a line as *a b* in Fig. 3, and take upright depth required, as from F to G, mark off from *a* to *d*, and draw the lines *a c* and *d e* at right angles with *a b*, take the radius of the larger circle EB with the compasses, and mark off the distance from *a* to *c*, take also the radius of the small circle E to *g*, and mark it off from *d* to *e*, then draw a line from the points *c e* to cut the line *a d b*, with *b* as centre and radius *b e*, strike the curve *e h*, open the compass to *c*, still using *b* as centre, and strike the curve *c i o q f*. The circle Fig. 1 is divided into quarters, take one of them and divide it into any convenient number of equal parts as D to B, from *c* (Fig. 3) measure off a corresponding number of distances to *i*, the curve *c* to *i* shows one quarter of the pattern required, by adding on a like distance, as from *i* to *o*, represents half the pattern, and the distance *c i o q f* the whole pattern required in one piece, draw a line from *f* to the centre *b*, and the required lap to be added on as shown.

To describe the plan of a Round Flue body to be cut in Three Pieces.

Fig. 4 represents the top and bottom of the body, this is to be divided into three parts, which is done in a very simple manner. The radius by which a circle is struck will measure six times the distance on the circumference, as shown in Plate III, Figs. 1 and 2, so that by drawing a line from every alternate point to the centre will divide the circle into three, as BCD. The pattern for this body is shown by Fig. 6, draw *o b e* at right angles; take the perpendicular height FE (Fig. 5), and mark it off from *b* to *d* (Fig. 6). Draw line *d f* at right angles with *b o*. Take the radius of the outer circle at AB, and mark it off from *b* to *e*, and the radius AG to be marked off from *d* to *f*. Draw a line from the points *e f* to cut the line *b o*. Take *o* as centre, radius *o f*, to strike the curve *f n*. Open the compass to *e*, still using *o* as centre, and strike the curve *e m* (Fig. 6). Divide the part of circle DB into any convenient number of equal parts, and measure off a corresponding quantity of equal parts in Fig. 6 from *e* to *m*. Draw a line from *m* to the centre *o*, which gives the pattern of one third of the body required, the perpendicular height of which will be equal to EF.

Fig. 7 gives the flue or slanting height of the same articles; the only difference between this and Fig. 6 is, that the radius is taken from *d* and *b*, instead of *f* and *e*.

Fig. 8 represents an oval (this is recommended for general practical use.)

Let AB be the given length, and *b*D the width.

From B set off *g* equal to *b*D the given width.

Divide *g* A into three equal parts. Set off two of these parts on each side of E, as *s* and *t*.

From *s* and *t*, as centres, with radius *s t*, describe curves or arcs, cutting each other in *u w*. From *u* and *w* draw lines through *s* and *f*, and produce them as *o n l m*. Take *s* as centre, *s*A as radius; draw the curve *o* A *l* and *t* as centre; draw the curve *m* B *n*. Then with *u* and *w* as centres, radius *w l*, strike the curves *l b m* and *o* D *n*, which will complete the oval required.

Fig. 9 shows a kind of oval very frequently used in the manufacture of various articles; a method of getting this shape is required so as to cut a flue or tapering body (which will be shown in a future example.)

Take AB the given length, set the compass to nearly half the required width. From A and B mark off the points *o o*, and strike semicircles *a* A *b* and *c* B *d*.

Take any distance on this curve, as from A to *b*, or further if required, and mark off a corresponding distance from B to *c* and *d*.

Produce lines from *b o* and *c o* until they meet as at D. Then with radius D *b* strike the remainder of the curves *b c* and *a d*, which will give the oval required.

Cone and Frustrum of a Cone.

[1] **A cone is a solid the base of which is a circle, but which tapers to a point from the base upwards. If a cone be cut horizontally, that is, parallel to the base, all such sections will be circles.**

Fig. 2. (Plate V.)—Take *t* F *u* for the base, *u s* and *t s* form a cone: the point *s* being cut off by the line G, the Fig. from F to G only being required, is called a section or frustrum of a cone, the point or apex being cut off.

Plate. 6.

Fig. 2

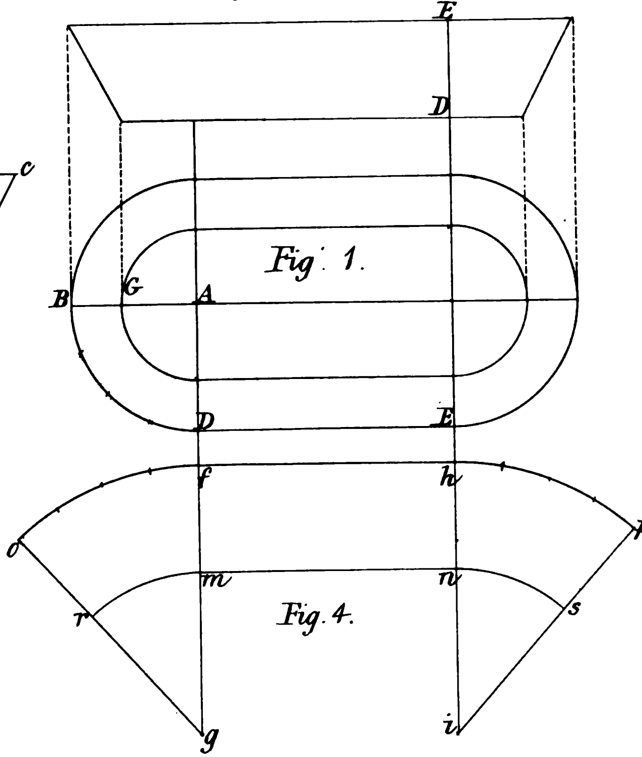


Fig. 1.

Fig. 4.

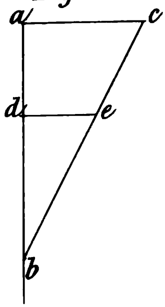


Fig. 3.

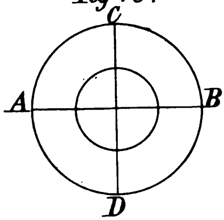


Fig. 8.

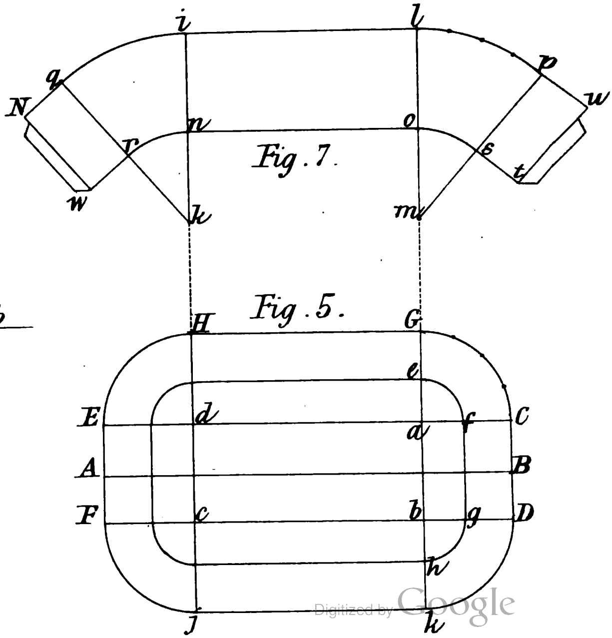


Fig. 7.

Fig. 5.

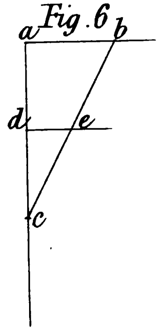


Fig. 6

PLATE VI.

To strike the pattern of an article where the Sides are Straight and the Ends Semi-circular.

Fig. 1 shows the size and shape of the required article at top and bottom. Fig. 2 is the upright height. Having drawn figs. 1 and 2, showing the plan and elevation, proceed with fig. 3; draw *a b* and *a c* at right angles, take the depth ED (fig. 2), and mark it off from *a* to *d*, draw *d e* parallel to *a c*, take the radius AB, and mark off the distance on the line *a c*, and the radius AG, marking off the point from *d* to *e*, then draw a line from the points *c* and *e* to cut the line *a b*, which will give the slanting height and the radius. This pattern is to be made in halves joined at each end as at B. To strike the pattern shown in fig. 4, make the straight part for the side *f h* equal DE (fig. 1). Extend the lines *f m* and *h n* indefinitely, take the distance from *c* to *b* (fig. 3), and mark off the points from *f* to *g* and *h* to *i*, then with radius *b c* taking *g* and *i* as centres, strike the curves *f o* and *h p*, with radius *b e* (fig. 3), still using *g* and *i* as centres, strike the curves *m r* and *n s*. Divide the curve from D to B (fig. 1) into any convenient number of parts with the compasses, and mark a similar number of parts on the curve *f o* (fig. 4) make *h p* equal *f o*, and draw lines from *p* to *i* and *o* to *g* the centres, which will give one half the pattern required.

To strike the pattern of an Oblong Tapering Pan in two parts or sections.

Fig. 5.—Draw lines EC and FD, the distance apart required for the straight part of the ends. Draw HJ and G *k*, the distance apart required for the straight part of the sides. Take the points *a b c d* for centres, and then draw curves, or the corners, as at GC and *e f*, &c. at each of the corners, then draw straight lines to meet the curves as at HG and CD, and *f g*, and so on, which will give the size of the article both top and bottom, the line AB shows where the two halves meet for jointing together in fig. 6. Draw *a b* and *a c* at right angles, take the required depth from *a* to *d*, draw *d e* parallel to *ab*, then take the radius from *a* to G, mark off the point from *a* to *c*, also the radius of the small curve from *a* to *e*, mark off from *d* to *e* (fig. 6), draw the line from *c* to *e* to cut the line *a b*; from *c* to *e* will give the slanting depth.

Fig. 7 is the development of the pattern. Make the straight part from *i* to *l* equal GH, the depth from *i n* and *l o* to equal *b e* (fig. 6), take the distance *b c* (fig. 6), and mark off from *i* to *k* and *l* to *m* (fig. 7), take *k* and *m* as centres, with radius *e b* strike the curves *i q* and *l p*, divide the length of the curve from C to G, and dot off the same distance from *l* to *p*, make *i q* equal *l p*, draw the lines *p m* and *q k*; with radius *c e*, still using *m* and *k* as centres, strike the curves *o s* and *n r*. Draw lines *p u* and *s t* at right angles with *p m*, making *p u* equal to CB (fig. 5), draw *u t* parallel to *p s*, finish the opposite end in like manner, adding the lap in both instances as required. Where wiring or edging is required, add on accordingly.

Fig. 8 shows two circles divided into four equal parts, ACBD, equal to the four corners of fig. 5, with a little calculation the pattern may be obtained without going through the process of again constructing fig. 5. To illustrate this, take an article, say 10 inches from A to B (fig. 5), and 7 inches from H to *j*, the corner EH to be the section of a 4 inch circle, as from A to C (fig 8.) The diameter AB being 4 inches, subtract 4 inches from 7 inches, would leave 3 inches straight at end, as from F to E.

Again, subtracting the 4 inch circle from 10 inches the given length, will leave 6 inches straight in the sides, as from H to G, then drawing lines *n o* and *i l*, the required depth as previously described, draw the *l o* and *i n*, the perpendiculars 7 inches apart; then drawing the corners as previously described, adding on an inch and a half, as form *p* to *u* and *q* to *n*, at right angles with *p m* and *q k*, will give the required pattern.

Plate. 7.

Fig. 2.

Fig. 3.

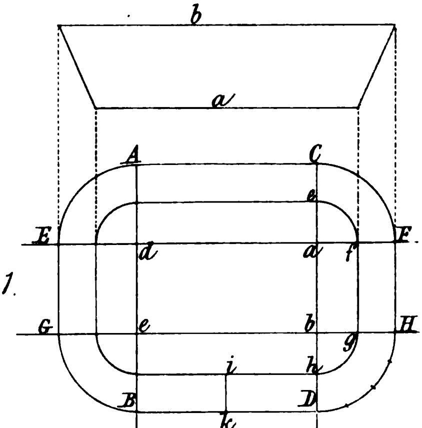
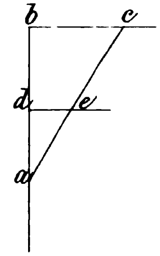


Fig. 1.



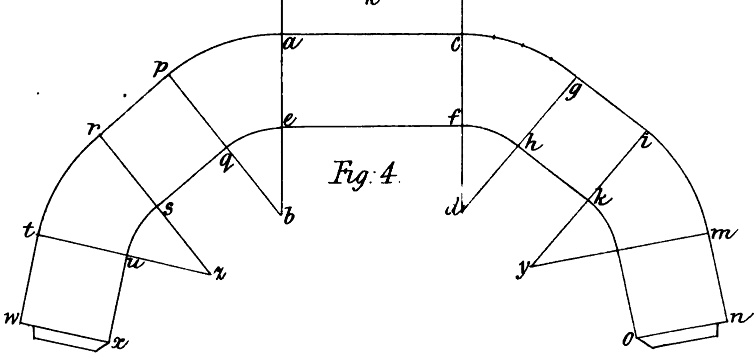


Fig. 4.

Fig. 6

Fig. 5.

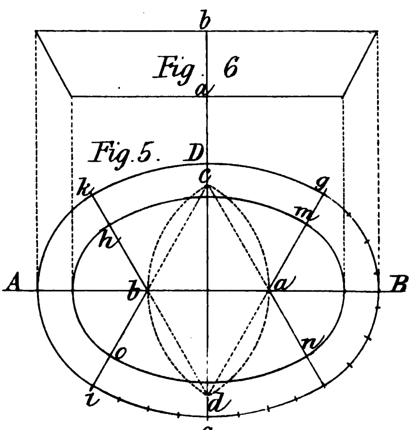


Fig. 7

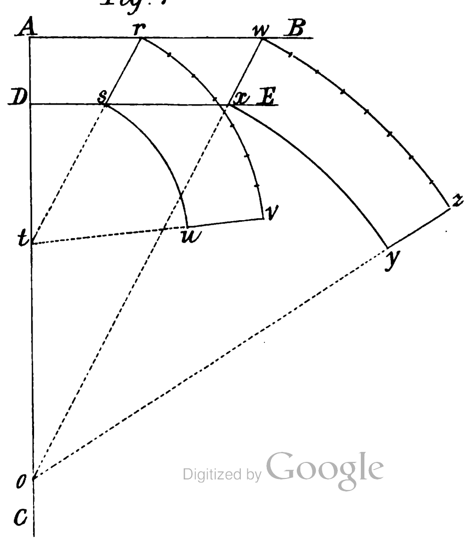


PLATE VII.

To strike the pattern for a Tapering Oblong article in one piece, such as a flue oblong candlestick.

Fig. 1 is the size, top and bottom, and fig. 2 upright height. Take the perpendicular height *a b* (fig. 2), and mark it off from *b* to *d* (fig. 3). Take the radius for the corners *a* C (fig. 1), and mark it off from *b* to *c* (fig. 3), also the radius *a e*, mark off from *d* to *e*, drawing a line from *c e* to cut the line *b a*, which gives the slanting height and the radii required for striking the corners. Draw the lines *e f* and *a c* (fig. 4) the same distance apart as *e* to *c* in fig. 3. Draw the perpendiculars *a e* and *c f* (fig. 4) equal to A C (fig. 1), making the straight part of the side required. With radius *a c* (fig. 3), using *b* and *d* (fig. 4) as centres, strike the curves *a p* and *c g*, and with radius *a e* (fig. 3), still using the same centres in fig. 4, strike the curves *e q* and *f h*. Take the length of the curve DH (fig. 1), and dot off the same distance from *c* to *g* (fig. 4), make *a p* equal to *c g*, draw lines from *p* and *g* to the centres *b* and *d*, draw *p r* and *q s* at right angles with *p b*. Take the distance from E to G (fig. 1), and make the same distance from *p* to *r* and *q* to *s* (fig. 4). Draw *r s* parallel with *p b*, from *r* mark off point *z*, the same length as *p* to *b*, then using *z* as centre strike the curves *r t* and *s u*, making the curve *r t* equal *p a*, draw line from *t* to centre *z*, draw *t w* and *u x* at right angles to *t z*, taking the distance from B to *k* (fig. 1), mark off the same distance from *t* to *w* and *u* to *x*, draw *w x* parallel with *t u*, and proceed in the same manner with the other end; adding on the lap, as shown, will make the pattern complete in one piece, being joined together at *k i*.

To strike the pattern for a Tapering Oval article in Four pieces or sections.

Fig. 5.—Draw the smaller oval (as explained in fig. 8, Plate V.) first the size required for the bottom, then from the same centre, which in this instance is *a b c d*, describe the outer oval as much larger as required for the top of the article, drawing the diameters AB and CD at right angles.

Fig. 6 shows the perpendicular height. Draw AB and DE (fig. 7) parallel, the same distance apart as *a b* (fig. 6), being the upright depth, make AC at right angles with AB and DE, take the radius which the end section of the oval is struck by, and mark it off on fig. 7, *i.e.*, take the distance *a* B or *a g* (fig. 5), and set it off from A to *r* (fig. 7), and the radius *a m* or *a n*, and mark off the same distance from D to *s*. Draw a line from *r s* to cut the perpendicular AC at *t*, then with *t* for centre and *t s* as radius, strike the curve *s u*; open the compasses from *t* to *r* as radius, and draw the curve *r v*. Take the length of the curve from *k* to *i* (fig. 5), marking off a convenient number of parts, then taking a like distance with a corresponding number of parts, as from *r* to *v* (fig. 7); now draw the line from *v* to the centre *t*, which will give the pattern of the end section.

For the pattern of the side take the radius *d k* or *d g* (fig. 5), mark off an equal distance from A *w* (fig. 7), and the radius *d h* (fig. 5), mark off from D *x* (fig. 7); draw a line from points *w x* to cut the perpendicular at *o*; with *o* as centre, radius *o x*, strike the curve *x y*, open the compass from *o* to *w*, strike the curve *w z*, take the length of the curve *k g* (fig. 5), and take a corresponding length of curve from *w* to *z* (fig. 7), then draw a line from *z* to centre *o*, which by adding the usual laps will complete the side.

Plate 8.

Fig. 3.

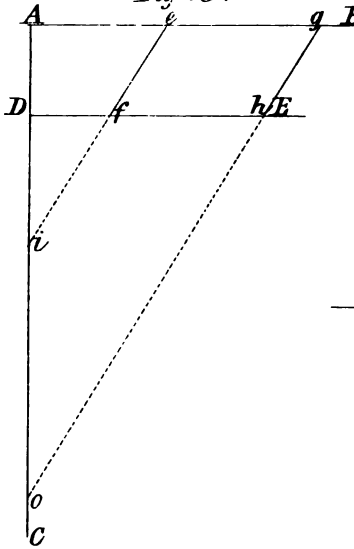


Fig. 2.

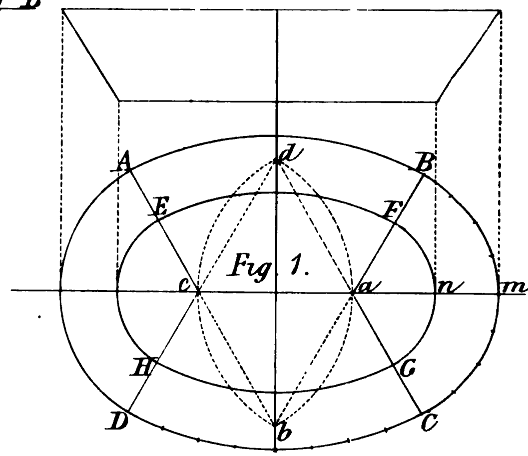
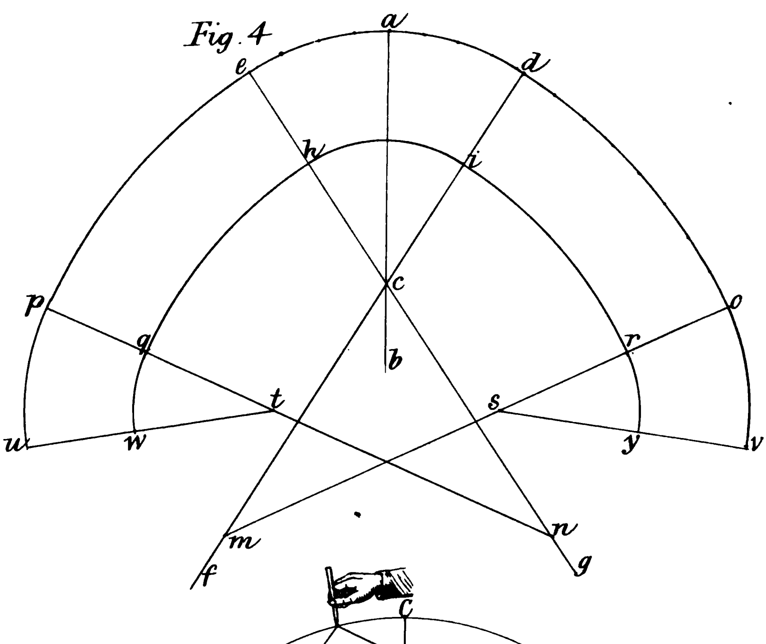


Fig. 4



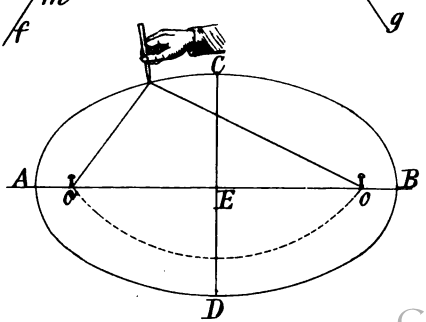


PLATE VIII.

To describe a Tapering Oval body in one piece.

Draw the two ovals (fig 1) as previously explained, and proceed with fig. 3 (as in Plate VII. fig. 7.) Draw AB and AC at right angles, and the required depth from A to D; draw DE parallel to AB; from centre *a* (fig. 1) take the radius *a m*, that the curve BC is struck by, and mark off the distance on fig. 3 from A to *e*, also the radius of the smaller curve as *a m*; mark off from D to *f* (fig. 3); draw *e f* to cut the perpendicular line AC at *i*. Take the radius of the curve of the side from *b* to A or *b* to B, mark off the distance from A to *g* (fig. 3), then take the radius from *b* to E (fig. 1), being the radius by which the curve EF is struck, and mark it off on the line DE to *h* (fig. 3), draw a line from the points *g h*, to cut the perpendicular line AC at *o*, and this will give the radii for describing the pattern, the development of which will be found in fig. 4.

To commence fig. 4, draw the line *a b*, set the compasses from *i* to *e* (fig .3), and on the line *ab* (fig. 4), taking *c* for centre, strike the curve *e a d*, make the length of the curve *e a d* the same as B *m* C (fig. 1). Draw lines from *d* and *e* through the centre *c*, and extend them indefinitely as *f* and *g*. Take the distance *i f* (fig. 3) for radius, still using *c* (fig. 4) as centre, strike the curve *h i*. Now take the distance *o* to *g* (fig 3), with the compasses, and from *e* (fig. 4) mark off the point *n* on the line *e g*, likewise mark off a like distance *d* to *m* on the line *d f*, using *n* and *m* as centres, strike the curves *d o* and *e p*, with radius equal to *o h* (fig 3), still using *m* and *n* as centres, strike the curves *i r*, and *h g*.

Divide off the length of the curve C to D (fig. 1), and take the same distance from *d* to *o* (fig. 4), draw line from *o* to the centre *m*, make the distance from *e* to *p* the same as from *d* to *o*, draw line from *p* to centre *n*, mark off the points *t* and *s*, on the lines *p n* and *o m*, equal to the distance from *a* to *c*, using *t* and *s* as centres, radius *t p*, strike the curves *p u* and *o v*, then with radius *t q* strike the curves *q w* and *r y*, take the length of the curve from *a* to *d*, mark off like distances from *o* to *v*, and *p* to *u*, draw lines from *u* to centre *t* and from *v* to *s*, which will complete the pattern.

A method of drawing an Ellipse or Oval with a string and pencil.

Make the given diameters AB and CD at right angles to each other at their centre E. Take the distance from E to A, then using C as centre, draw an arc to cut the diameter AB in *o o* (these two points *o o*, are called the *foci* of the ellipse.) Place a pin at each point where the curve cuts the line AB, as at *o o*, and another at C, pass a string round the three pins, and tie it securely, thus forming a triangle with the string, as *o o* C. Take out the pin at C and substitute the point of a pencil, which may be drawn along moving with the string, and the point will thus trace a perfect ellipse.

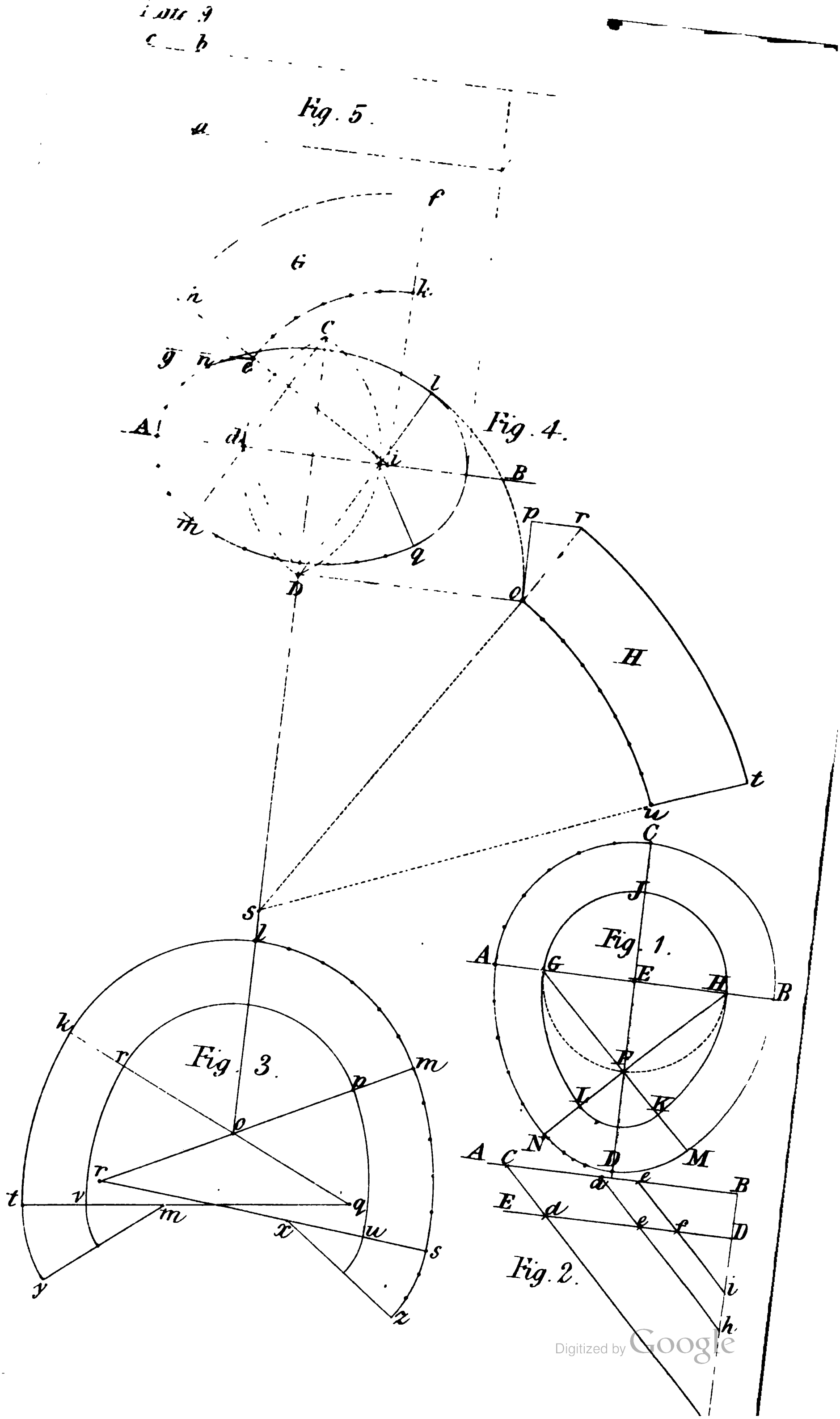


Fig. 5.
Fig. 4.
Fig. 3.
Fig. 1.
Fig. 2.

PLATE IX.

To describe the pattern of an Egg-shaped Oval Tapering body.

Fig. 1. Draw AB and CD at right angles, and from E, with radius EH, draw a circle cutting the line CD at F; from G and H draw lines through F, and produce them indefinitely, and GH and F will be the centres to strike the remainder of the figure (as shown in Plate IV. fig. 3), then from the same centres draw the larger oval as much larger as the flue requires.

Fig. 2. Draw AB and ED the required depth, and BC at right angles, mark off B *a* and D *e* equal to EC and EJ (fig. 1). Draw line from *a e* to cut the perpendicular line at *h*. Take HA, and mark off from B to C on the line BA. Take HG and mark off from D to *d* on the line DE, and draw C *d* to *g*. Take the radii FM and FK and mark off from B to *e* and D to *f*, and draw *e f* to *i*.

Fig. 3. Draw line *l o* with radii *h a* and *h e* (fig. 2); using *o* (fig. 3) as centre, strike the curves *k l m* and *r p*. Take the length of curve from A to C (fig. 1), and dot off a like distance from *l* to *m* and *l* to *k* (fig. 3). Draw lines from *m* and *k* through the centre *o*, and produce them indefinitely, take radius *g* to C (fig. 2), and from *k* mark off *q*, and from *m* mark off *r*, take *q* and *r* as centres, radius *r m*, and draw curves *m s* and *k t*; make *m s* and *k t* the same length as AN and BM, draw lines from *t* to centre *q*; and from *s* to *r*, with radius *g d*, draw curves *p u* and *r v*. Take the radius *i e*, and from *t* and *s* mark off *m* and *x* for centres, and strike the curves *t y* and *s z*: make *s z* same length as ND, and draw lines from *z* to the centre *x*; and from *y* to *m*, with radius *i f*, describe the curves from *u* and *v*, which will complete the pattern.

These figures heretofore described are recommended to be well studied before reading the ensuing ones.

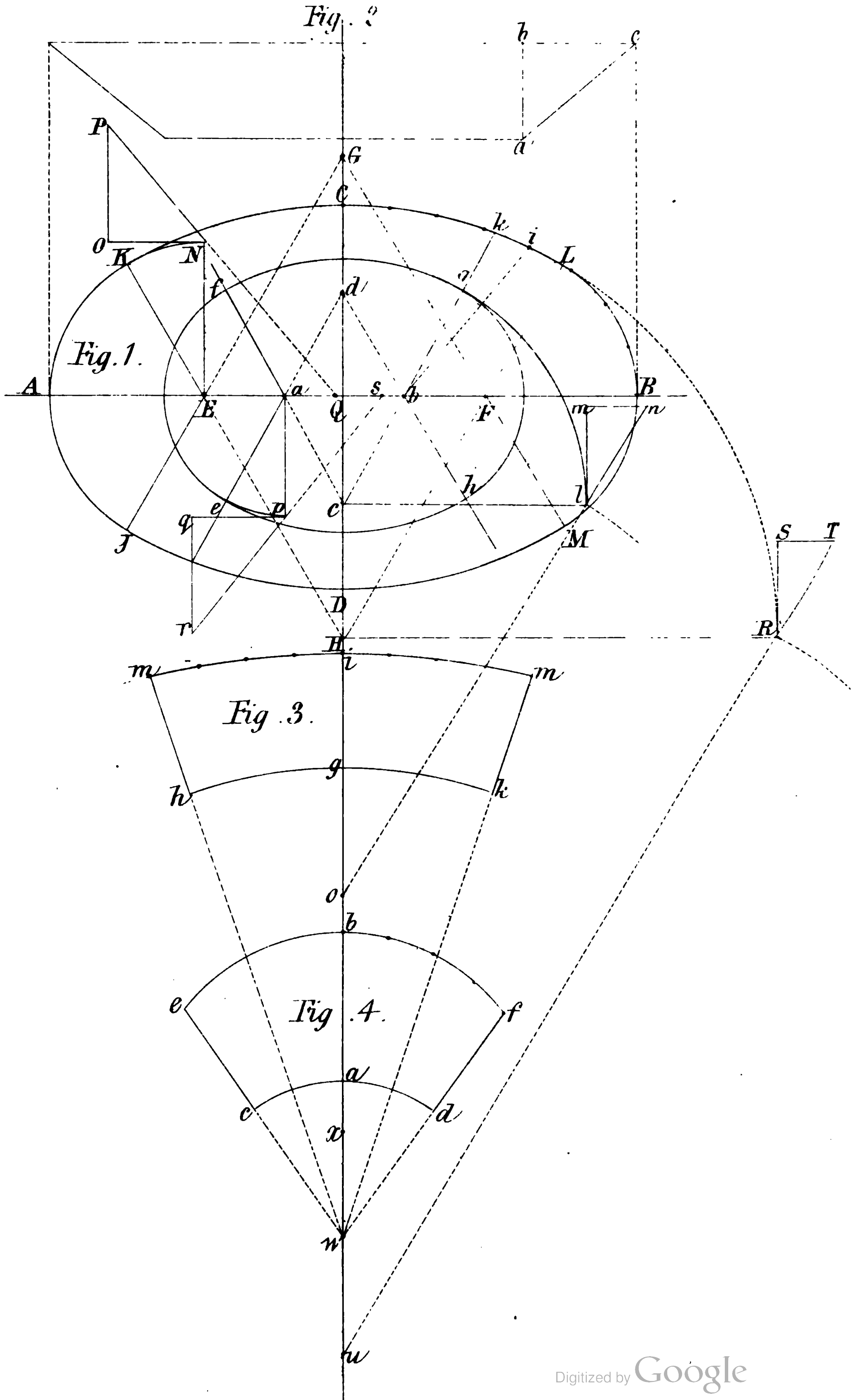
Another method of describing an Oval Tapering body.

Fig. 4. shows the oval the size required for the bottom. Draw the diameters AB and CD at right angles, and describe the oval as already explained.

Fig. 5. shows the upright height and flue required. To strike the pattern G, which is the end section, *d* being the centre from which the curve *m n* is struck, draw a line *d e* at right angles with AB. Produce or extend the curve *m n* to cut the line *d e* at *e*, draw the line *e g* at right angles with *d e*, make *e g* the upright height as *a b* in fig. 5. Draw *g h* at right angles with *g e*; *c b* in fig. 5 showing the flue required, mark off a like distance from *g* to *h*. Draw line from points *h e* to cut the line AB at *i*, taking *i* for centre on the line AB, with the radius *i h* draw the curve *h f*, and with

radius *i e* draw the curve *e k*. Measure off the length of curve *m n* from *e* to *k*, and draw line from *i k* to *f*.

Proceed with the side section H in the same manner. Extend the line CD indefinitely, D being the centre by which the curve *n l* is struck, draw a line D *o* at right angles with CD; extend the curve *n l* as dotted, until it cuts the line D *o*; draw line *o p* at right angles with D *o*, make *o p* the upright height as from *a* to *b* (fig. 5). Draw *p r* at right angles with *p o*, make *p r* the required flue as *b c* (fig. 5), draw line from *r o* to cut the extended line CD at *s*; with *s* for centre, and radius *s r*, draw the curve *r t*, and with radius *s o* strike the curve *o u*. Measure the length from *m* to *q*, taking a like distance from *o* to *u*; now draw line from *s u* to *t*, which comples the pattern. This pattern will, after being well studied, be found an excellent introduction to Plate X.; it is a different method from that described at Plate VII. figs. 5 to 7, and in other diagrams, but the result will on practice be found precisely the same. In these and the foregoing figures, the tapering must be equal on all sides.



h 8 Red Lion Sq^re W.C

PLATE X.

To describe a Tapering Oval body, where the tapering is not equal on all sides

(In this case more tapering at the ends than at the sides).

Fig. 1 shows the diameters of two distinct ovals, each one being described by a separate set of centres. To proceed with the larger or outer oval, which (as well as the smaller or inner one) is constructed in the same manner as described in fig. 8, Plate V., take the required diameters, as AB and CD, the centres being EF and GH. The smaller oval will have to be constructed in the centre of the larger one, according to the given length and width required for the bottom of the article, the centres by which this oval is struck being *a b* and *c d*: fig. 2, from *a* to *b*, shows the upright height.

Fig. 3 shows a pattern of the side, which is obtained in the following manner. H being the centre by which the curve KL (fig. 1) is struck, draw line HR at right angles with the perpendicular line GH, and extend the curve KL as dotted, to meet the line HR. Draw the line RS perpendicular with the line HR, mark off the depth from R to S, equal to the upright height, as *a b* (fig. 2). Draw ST at right angles with RS, take the distance at D between the two ovals on the line CD (the width between them being the flue of the sides), mark off the same distance from S to T, draw a line from the points TR, and extend it as shown by the dotted line to cut the extended perpendicular line CD at *u*; with radius *u* R, taking for the centre any part of the perpendicular line (there not being space enough on the plate to show the centre), and strike the curve *m i m*: *c* being the centre by which the curve *f g* (the side of the smaller oval) is struck, draw line *c l* at right angles with the perpendicular line CD, extending the curve *f g* with the same radius to meet the line *c l*. Draw line *l m* at right angles with *c l*, again taking the distance *a b* (fig. 2) from *l* to *m* (fig. 1). Draw a line *m n* at right angles with *l m*. Take the distance again between the two ovals at the side C, and mark off the distance on the line *m n*, draw a line from the points *n* and *l* to cut the perpendicular line CD as at *o*. Take the distance from *l* to *n*, or from R to T, and measure off a like distance from *i* to *g* (fig. 3), being the slanting height of the body at the centre of the side. Take the distance from *o* to *l*, and from *g* mark off the point *w*; with *w* as centre, radius *o l*, strike the curve *h g k*. Extend the line *c b g* (fig. 1), which shows the division of the smaller oval, to *k* on the curve of the larger one, the point L being the right sectional line of the larger oval, while the extended line *c b* to *k*, would be the sectional line of the inner one; let the distance be equally divided as at *i*, draw line from *i* to *b*, being the centre by which the end of the smaller oval is struck, take the length of the curve from *i* to C, measuring off a like distance from *i* to *m* on each side of the perpendicular line, and draw lines from *m* to the point *w*, being the centre by which the bottom curve *g h k* is struck; this being done, will complete the pattern for the side.

Fig. 4 shows a pattern of the end, which is obtained as follows: E (fig. 1) being the centre by which the end of the large oval JAK is struck, draw line from E to N at right angles with the diameter AB, extend the curve JAK, to cut the line EN at N. Draw line from N to O at right angles with NE, make NO equal to *a b* (fig. 2) the upright height. Draw OP at right angles with ON, take the distance between the two ovals at the end on the line AB, being the flue of the end, and mark off a corresponding distance from O to P. Draw line from PN to cut the diameter AB at Q. With radius QN, and *x* (fig. 4) as centre, describe the curve *e b f*. Take *a* (being the centre by which the end of the smaller oval, as *f e*, is struck) and draw *a p* at right angles with the centre AB, extending the curve *f e* to cut the line *a p* at *p*, draw *p q* at right angles with *a p*, again taking the upright height as at *a b* (fig. 2), and mark off a like distance from *p* to *q*. Draw *q r* at right angles with *q p*, take the distance from A to the end of the smaller oval, and mark off the same from *q* to *r*. Draw a line from the points *r p* to cut the centre line at *s*, take the distance from *r* to *p*, or from P to N, which will give the slanting depth of the centre of the end, mark off the distance from *b* to *a* (fig. 4), take radius from *s* to *p* (fig. 1), and from *a* (fig. 4) mark off the point *w*. With *w* as centre, radius *s p*, strike the curve *c a d*, take the length of the curve from B to *i* (fig. 1) and mark off a corresponding distance on fig. 4 from *b* to *f*, and *b* to *e*, draw lines from *f* and *e* to the centre *w*, being the centre by which the curve of the bottom is struck, which will complete the pattern for the end.

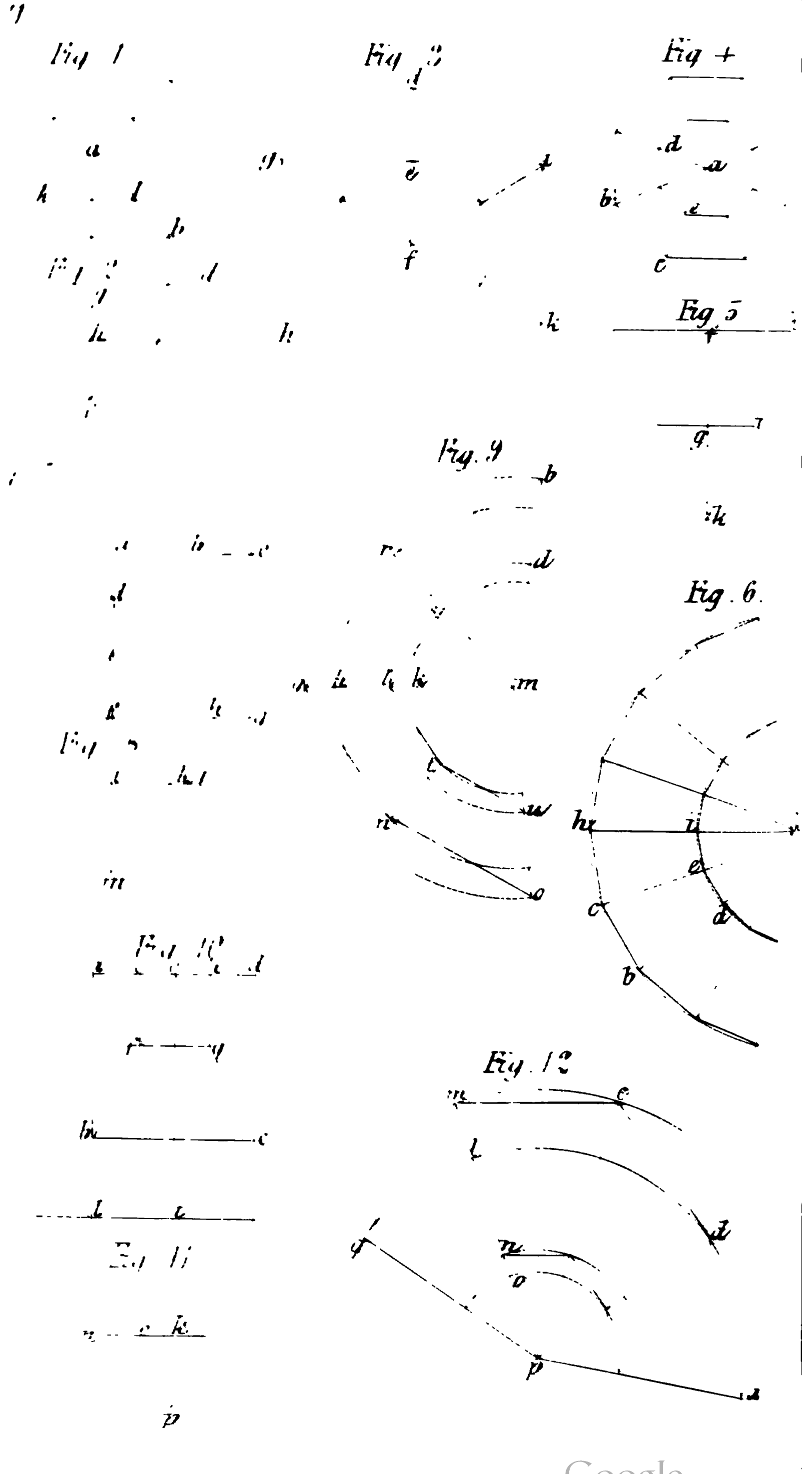


Fig. 1
Fig. 3
Fig. 4
Fig. 5
Fig. 6.
Fig. 9
Fig. 12

PLATE XI.

To strike the pattern for a Square Tapering article (or Pyramid).

Fig. 1 represents the size or projection, and fig. 2 the upright height or elevation. Draw the diagonals, and take distance from the centre *a* to *b* (fig. 1), and mark off the same in fig. 2 from *g* to *d*. Also take the distance (in fig. 1) from *a* to *l* or *k*, and mark off in fig. 2 from *h* to *e*. Draw a line from points *d e* to cut the perpendicular line at *f*. Then draw (in fig. 3) the perpendicular line *d f*, and take the radius *f d* (in fig. 2), and in fig. 3 describe the circle *h d k*, and with radius *f e* in fig. 2, still using *f* as centre in fig. 3, draw the smaller circle *e*, take the length of one side from *c* to *b* (fig. 1), and mark off the same four times on the larger circle (fig. 3), as *h g d i k*. Draw lines from these points to the centre *f*; join these points by lines as *h g*, *g d*, &c., and from the points on the smaller circle in the same manner, which will complete the pattern.

To strike the pattern for a Tapering Octagon body, in one piece

Fig. 4 represents the size of top and bottom (the method of striking this figure is given in Plate III. fig. 3 and 4), fig. 5 from *g* to *f*, being the upright height required, take the distance from the centre *a* to one of the extreme points as *c* (fig. 4), and from *f* mark off the same distance at *h* (fig. 5), and the distance *a* to *e*, mark off from *g* to *i*, draw the line *h i* to cut the perpendicular line *f g* at *k*. With radius *k h* (fig. 5) draw portion of circle as *h c b* (fig. 6), and with radius, *k i*, still using *k* as centre strike the curve *i e d* (fig. 6). Take the distance *b c* (fig. 4), and mark off eight times the same distance on the larger curve (fig. 6), as *b c h*, &c. Draw lines from all these points to the centre *k*. Draw straight lines from these points as from *h* to *c*, and *c* to *b*, and likewise from the intersecting points of the smaller curve, which will complete the pattern.

To strike the pattern for a Diamond-shaped Tapering body, in one piece.

Fig. 7 shows the size and shape required. Fig. 8 from *i* to *f*, the upright height. Carry the length of *a c* and *a e* (fig. 7), on fig. 8, from *f* to *g* and from *f* to *h*, also the distance from *a* to *b* and *a* to *d*, from *i* to *l* and *i* to *k*, and draw through *g* and *l* a line to cut the perpendicular at *m*, also through *h* and *k*. Draw a line which will cut the perpendicular at the same point *m*. With the length of *m g*, *m h*, *m l*, and *m k* (fig. 8) as radii, describe the curves *g*, *h*, *l*, *k*, in fig. 9, from the centre *m*, and draw the line *g m*, carry the length *e e* (fig. 7), from *g* to *r* and *s* (fig. 9), also from *s* to *e* and from *r* to *b*, and draw lines from *r* and *b* to the centre *m*, likewise from *s* and *e*. Connecting these points by straight lines *b r*, *r g*, *d s*, *s l*, &c., will complete the pattern.

To describe the pattern of a Square Funnel, where one side is straight or upright.

Fig. 10, *a b c d* shows the projection for the top, *e f g h* the hole or bottom of the funnel. Fig. 11, from *i* to *k*, shows the elevation (or upright height). Draw lines from the points *b f* and *c g* to cut each other on the centre line as at *o*. Carry the distance *o b* and *o a* (fig. 10) to fig. 11 from *i* to *m* and *i* to *l*, also the length *o f* and *o e*, from *k* to *n* and *k* to *o*. Draw the line *m n* to cut the perpendicular line at *p*. Also the line through the points *l* and *o*, which will cut the perpendicular line at the same point *p*, if the distances are taken correctly. Take the distances from *p m*, *p l*, *p n*, and *p o* in fig. 11 as radii, and describe the curves *m l n o* from the centre *p* (fig. 12). Take the length from *b* to *c* (fig. 10), and mark off the same from *m* to *c* (fig. 12), and draw the lines from *m* and *c* to the centre *p*, also take the distance *b* to *a*, and mark off the same from *m* to *g* and from *c* to *d*, and the distance *a* to *d* (fig. 10) mark off from *d* to *a* (fig. 12). Draw lines from these points to the centre *p*, and connect these points with straight lines, as *a d* and *d e*, &c., and also from the corresponding points on the smaller curves *n* and *o*, will complete the pattern required.

Note.—This will be found a very useful method for striking a square or rectangular tapering top or sides. Whether the tapering be proportionate or not, by drawing lines as *b f* and *c g* from the angles (which show the position of the top and bottom of the article required) to cut the centre line wherever the point *o* may come, by taking it as a working centre, one half or a section of the pattern may be developed.

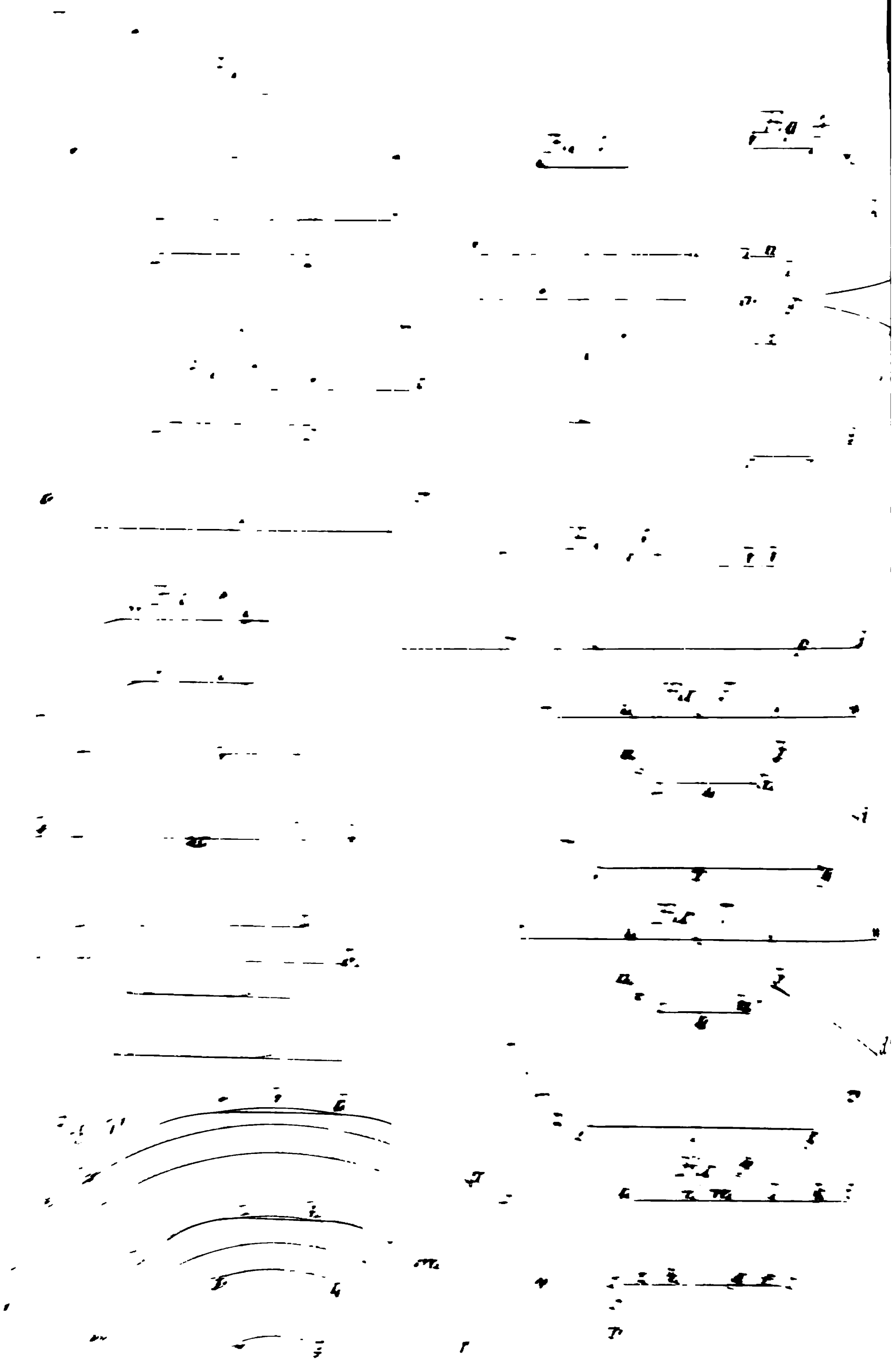


PLATE XII.

To describe the pattern for a Square or Rectangular Tapering Top or Tray, with sides and bottom, in one piece.

Fig. 1 shows the upright height and one half of the plan. Draw in fig. 2 the horizontal line *b d* and the perpendicular line *o p*. Draw the rectangle *e f g h*, the same size as *e f g h* in fig. 1.

Take the length *a b* (fig. 1), and mark off corresponding distances from *e* to *b*, *h* to *d*, and *o* to *p* (fig. 2), and draw through the points *b p* and *d* the lines (at right angles) *b q*, *s t*, and *d r*; and carry the length *i l* to *b q* and to *d r*; also the length of *u l* from *p s* and *t*. Then draw the lines *q f*, *s f*, *t g*, and *r g*, which will complete one half of the pattern.

To describe the pattern for a Hexagon Mould or Tray, having the bottom and sides in one piece.

Fig. 3 shows the elevation and half an hexagon for the plan. To obtain a development of the pattern, draw (in fig. 4) the perpendicular *b c*, and draw the half hexagon *e f g h i*, the same size as *e f g h i* (fig. 3).

Divide the lines *h g* and *g f* into equal parts, and draw the lines *a k* and *a m*; then carry the length of *a b* (fig. 3) from *l* to *k* (fig. 4). Draw through *k* the line *n o* parallel with *h g*. Take the length *k l* (fig. 3), and mark off the same from *k* to *n* and *o*, and draw the lines *h n g o*: *h g n o* is the sixth part of the pattern. Proceed in the same manner to draw the remainder, one half of the pattern (as well as the plan) only being shown here.

To describe the pattern of an Irregular Octagon Pan or Tray, with the sides or bottom in one piece.

Figs. 5 and 6 show the required projection and elevation, having drawn which, proceed with the development of the pattern in fig. 7. Draw the half octagon *u a f h b* and *v* to the same dimensions as the corresponding letters in fig. 5. Draw the horizontal line *t w* and the perpendicular line *o c*. Divide the sides *a f* and *h b* into equal parts, and draw the lines *o r* and *o p*, then carry the length of the line *a c* (fig. 6)—being the slanting height of the larger sides—from *q* to *c*, from *u* to *t*, and from *v* to *w* (fig. 7). Draw from *t* and *w* lines perpendicular, and through the point *c* draw the line *e g* parallel with *t w*.

Take the distance from *t* to *c* (fig. 5), mark off the same in fig. 7 from *t* to *c*, *w* to *d*, *c* to *e*, and *c* to *g*, and draw the lines *c a*, *e f*, *g h*, and *d b*.

Then in fig. 6 draw the perpendicular line *x r*, and from fig. 5 take the projection of the small side the distance *s r*, and carry the same from *r* to *s* (fig. 6), and draw line *s x*, the length of which should now be transferred from *s* to *r* (fig. 7). Draw *y z* parallel to *a f*.

Take the distance *r s* (fig. 5), and mark off the same from *r* to *y* and *s* in fig. 7, draw lines *y a* and *z f*. For the other side *p* proceed in like manner, which on being done will complete half the pattern.

To strike the pattern of an Oblong Pan, with Round Corners, but struck from different centres, and tapering more at the ends than the sides.

To construct the plan fig. 8, first draw the larger rectangle and the diameter lines, also the diagonals, and from the diagonals draw the four lines showing the width and length for the bottom. Draw the quadrants (or quarter circles) for the corners, as *g f*, from the centre *c* any size required, and from the points *g* and *f* draw lines to the centre *a*, which will give a proportionate size for the corner of the bottom, as shown in the curve *d e*, struck from *b* as centre.

Having drawn the plan, proceed now with fig. 9. To obtain the radii required draw *a b* and *a d* at right angles, from *a* to *c*, take the upright depth required, and draw *c e* parallel with *a d*, then carry the lengths of *a g*, *a f*, and *a k* (fig. 8), to *a d*, *a k*, and *a l* (fig. 9), also the distances *a d*, *a e*, and *a l* (fig. 8), to *c e*, *c f*, and *c g* (fig. 9), and draw lines from the points *d e*, *k f*, and *l g*, to cut the perpendicular *a b* at *b* (all cutting at one point), then take the lengths from *c* to *g* and *b* to *d*, (being the radii of the corners) and carry them from *a* to *m*, and *a* to *n*, and draw the lines *m p* and *n o* parallel with *k f*.

To proceed with the pattern drawn in fig. 10, the perpendicular line *a b*, take the lengths of *b d*, *b k*, and *b l* in fig. 9 as radii, and describe from point *a* as centre the curves *c d*, *e f*, and *g w* (fig. 10), also take the radii *b e* and *b g*, and from the same centre *a* (fig. 10) strike the curves *i k* and *u o*. Then carry the length *m g* (fig. 8) on the curve *c d* (fig. 10), and draw the lines *c a*, *d a*, and *c d*. From the points *c*, *d*, *i*, and *k*, draw perpendicular lines as *c p*, *d q*, *i r*, and *k s*. Take the length *p m* (fig. 9) and carry the same from *c* to *p* and *d* to *q* (fig. 10); take also the length *o n*, and mark off the same from *i* to *r* and *k* to *s*. From *p* and *q* as centres, radius *p m*, strike the curves *c t* and *d x* to meet the curve *e f*, draw the lines *t p* and *x q*, also the lines *t a* and *x a*; then from *r* and *s* as centres, radius *o n*, describe the curves *i l* and *k m*. Now take the distance from *f* to *k* (fig. 8), and mark off the same distance from *t* to *v* on the curve *g*, also the same distance from *x* to *w*, and draw lines from *v* to *a* and from *w* to *a*. Draw the lines from *t* to *v* and from *x* to *w*, also *l u* and *m o*, which developes one half of the pattern.

Plate 13

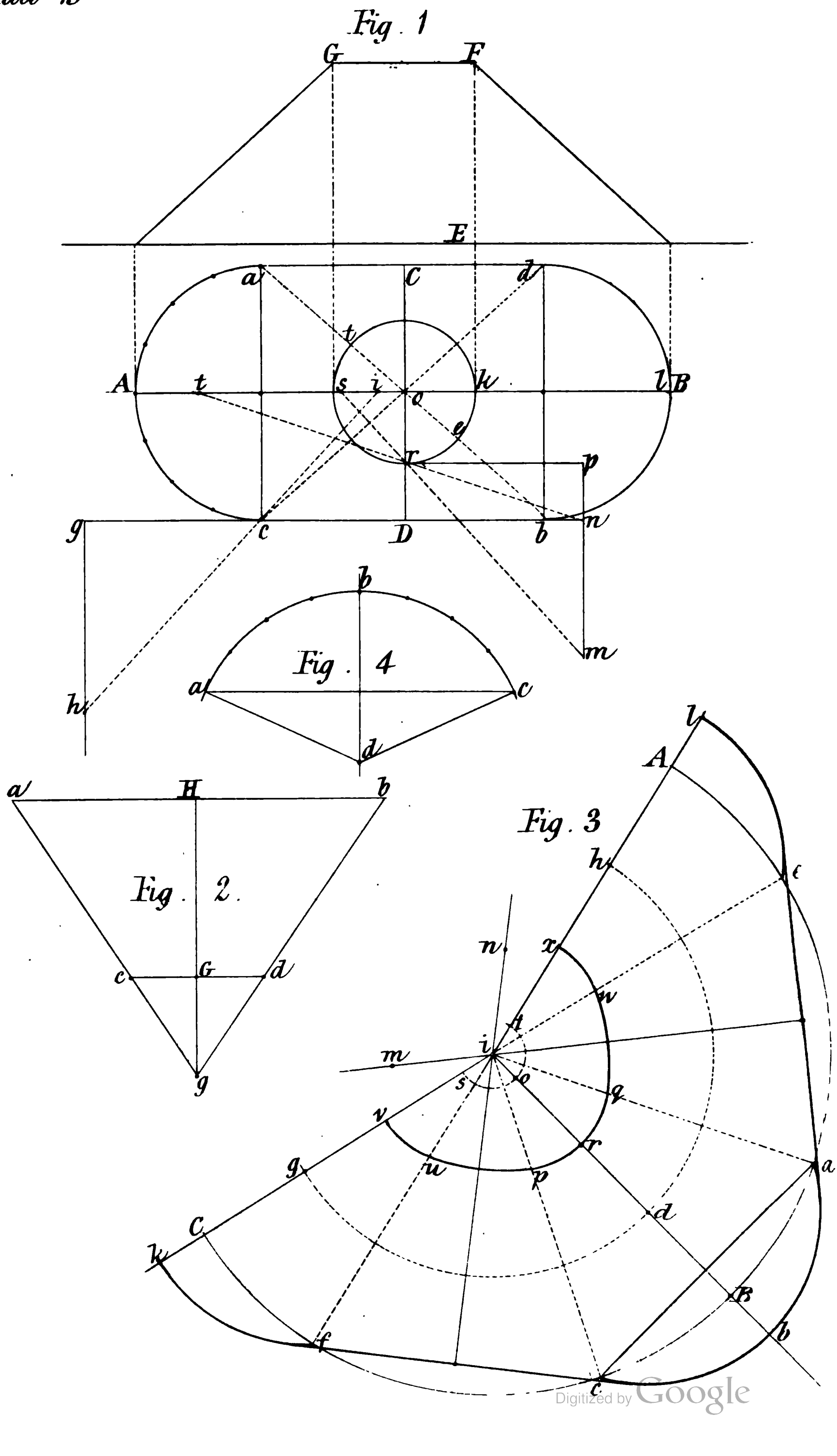


Fig. 1
G
F
E
A
B
C
D
a
d
t
s
i
k
l
o
e
r
p
c
b
n
g
h
m
Fig. 4
b
a
c
d
Fig. 2
a
H
b
c
G
d
g
Fig. 3
l
A
h
x
w
n
m
i
s
o
q
r
v
g
u
p
d
C
k
f
c
a
B
b

PLATE XIII.

To describe a Pattern for a Tapering Top, the base being straight at the sides, and with circular ends, the hole in the top to be circular, and parallel with the base,

(Similar to a Tea Bottle Top.)

Fig. 1 shows the plan and elevation required. Draw the lines *a d* and *c b*, the required width of the top, and draw *a c* and *d b* at right angles with them, and through the centres by which the circular ends are struck. Then draw the diagonal lines *a b* and *c d*, which will give the centre *o*, and draw the diameters AB and CD at right angles through the centre *o*. Take the distance from E to F, being the upright height, and mark off a like distance on the line H to G (fig. 2), draw the lines *a b* and *c d* at right angles with the line HG. Take the length of the diagonal line *a b* (fig. 1), and make it equal to *a* H *b* (fig. 2), take the distances from the centre *o* to *t*, and *o* to *e* (being the diameter of the circle), and mark off corresponding distances on fig. 2 from G to *c* and G to *d*. Draw lines from points *b d* and *a c* to cut each other at *g*, with radius *g a* or *g b*, with *i* (fig. 3) as centre, strike the curve ABC (which will give a boundary line to describe the pattern on).

The curve of the end (fig. 1) being a semi-circle, extend the line *b c* to *g*, which will be at right angles with *a c*, take the distance EF (being the upright height) and mark off a like distance from *c* to *g*, draw *g h* at right-angles with *c g*, take the distance from *k* to *l*, being the taper of the end, and mark off a like distance from *g* to the point *h*, draw line from *h c* to cut the line AB at *i*; with radius *i c*, taking *d* as centre, strike the curve *a b c* (fig. 4), now take the length of the curve *a* A *c* (fig. 1), and mark off a corresponding distance from *a b* to *c* (fig. 4), draw the chord from *a* to *c* (fig. 4). In fig. 3 draw a line from the centre *i* to B on the curve ABC, and take the length of the chord *a c* in fig. 4, marking off an equal distance from *a* to *c* (fig. 3) on the curve ABC. Take the distance from *a* to *d* (fig. 4), and from *a* (fig. 3) mark off the point *d* on the line *i* B; with *d* as centre (with the same radius as the curve *a b c* is struck by) strike the curve *a b c* (fig. 3), take the distance *c b* (fig. 1), which is the straight part of the side, and mark off on fig. 3 from *a* to *e* and *c* to *f* on the circle ABC, draw lines from *e a c* and *f* to the centre *i*, take the distances from B to *c* or B to *a*, marking off the same distance from *e* to A and *f* to C, draw lines from the centre *i* to A and *i* to C, and produce them as at *k* and *l*: with radius *i d* draw the circle as dotted *g d h*, take *g* and *h* as centres with radius *d b*, and strike the curves from *f* to *k* and *e* to *l*, draw lines *a e* and *c f* from the highest part of the curves, which will make them tangent, and the base of the pattern will be finished.

To get the curve for the hole in the top, bisect the lines *a e* and *c f* (fig. 3) through the centre *i*, and produce them indefinitely as *n* and *m*, from *r* on the circle (fig. 1) draw a line *r p* at right angles with CD, take the upright depth as EF, and mark a like distance from *r* to *p*. Draw *p m* at right angles with *r p*, take the distance from *k l* (which shows the slant of the end), and mark off a corresponding distance from *p* to *m*, take the distance from *r* to D (being the slant of the side) and mark off a corresponding distance from *p* to *n* on the line *p m*, draw line from points *m r* to cut the centre line A B at *s*, also draw line from points *n r* to cut the centre line at *t*, take the distances from *m* to *r* or *h* to *o*, and mark off like distances from *b* to *r*, *l* to *x*, and *k* to *v* (fig. 3), being the slanting depth of the end of the pattern. Take the distance from *s* to *r* (fig. 1), and from *r* (fig. 3) mark off the point *o*, and from *v* the point *s*, and from *x* the point *t*; using *t o* and *s* as centres strike the curves *s w*, *v u*, and *p r q*, with the radius *s r* (fig. 1). Now take radius *t r* (fig. 1), using *m* and *n* as centres, strike the curves *w q* and *p u*, which will complete the pattern required.

Plate 14.

Fig. 1.

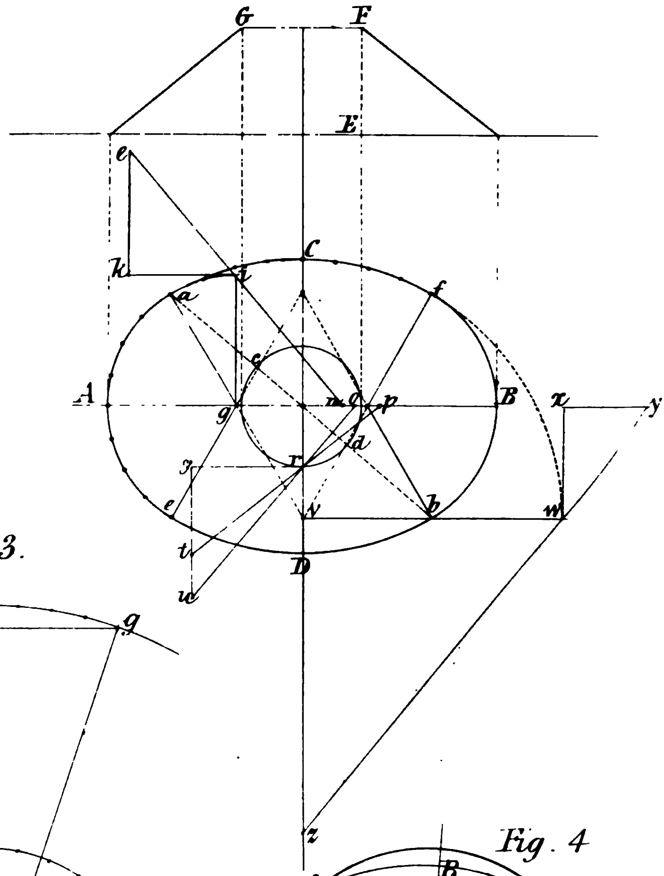
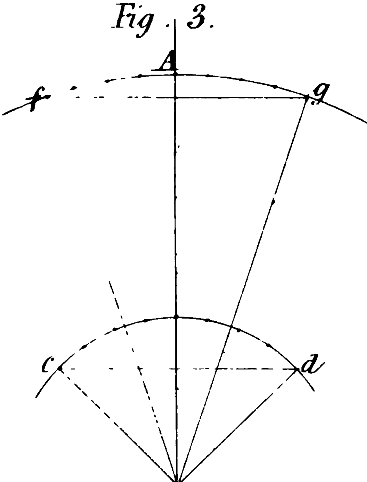


Fig. 3.



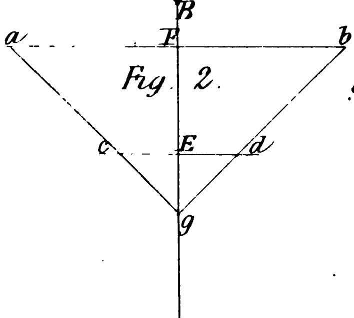


Fig. 2.

Fig. 4

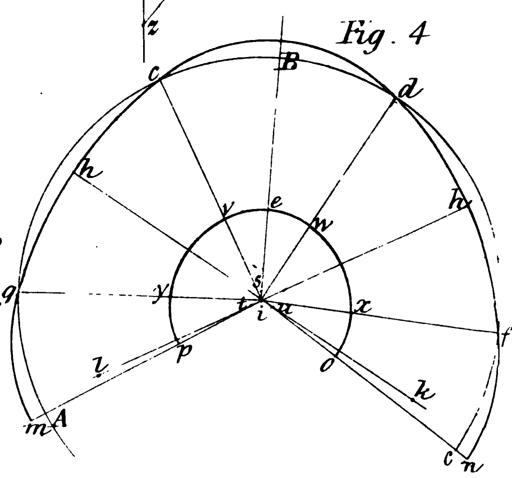


PLATE XIV.

To describe the pattern for a Tapering article, oval at the base and round at the top,

(Such as an oval Canister Top, having a round hole for the neck & cover).

Fig. 1 represents the plan and elevation of the top required. Take AB and CD, being the given diameters. Draw a diagonal line from the points *a* and *b*, being the sectional points of the curves; make the line *a b* (fig. 2) equal to *a b* (fig. 1). Now take the distance from F to E (fig. 1), and mark off a like distance from F to E (fig. 2), draw *c d* parallel to *a b*, make *c d* (fig. 2), equal in length to the diameter of the circle from *c* to *d* (fig. 1). Draw *b d* and *a c* to cut the perpendicular line at *g*, with radius *g b* from centre *i* strike the circle AB*c* (fig. 4), or boundary line; *v* being the centre from which the curve ACF is struck, draw line *v w* at right angles with CD, and extend the curve ACF as dotted to cut the line *v w*. Draw *w x* at right angles with *v w*, take the upright height EF and mark off from *w* to *x*, draw *x y* at right angles with *w x*, take the distance from D to *r*, being the flue of the side, and mark off a like distance from *x* to *y*, draw line from *y* and *w* to cut the perpendicular CD at *z*. Draw a perpendicular line as AB (fig. 3); taking B as centre, with radius *z w* (fig. 1) strike the curve *f* A *g* (fig. 3). Take the length of the curve from C to *f* (fig. 1), and like distances from A to *g* and A to *f* (fig. 3). Draw lines from *f* and *g* to the centre B, and draw line *f g*, which will give one section of the base of the pattern.

The curve of the end of the base being struck from *g* (fig. 1) as centre, draw line from *g* at right angles with AB, and extend the curve *e a* to cut the line produced from *g* to *i*. Draw line *i k* at right-angles with *i g*, making *i k* equal the upright height, as EF. Draw *k e* at right-angles with *i k*, make *k* to *e* equal the flue of the end, as from A to *g*, or the distance from the curve of the oval to the circle on the line AB.

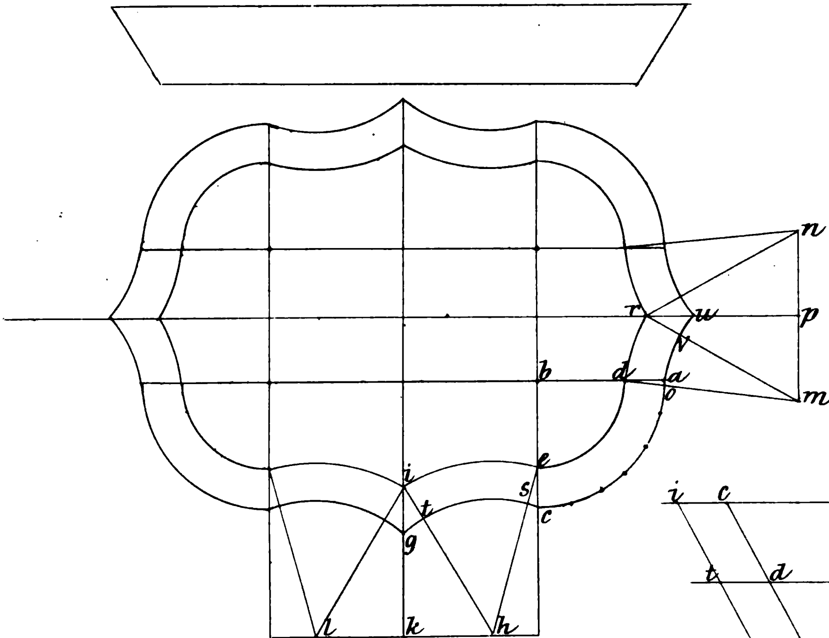
Draw line from points *e* and *i* to cut the centre line AB at *n*, now with radius *n i* from B (fig. 3) as centre, strike the curve *c d*, take the length of the end curve from *e* to *a* (fig. 1), and mark off a like distance as from *c* to *d* (fig. 3), draw chord line *c d*, which will give the end section of the base.

Take the distance from *c* to *d* (fig. 3), and mark off an equal distance on the circle ABC (fig. 4) as from *c* to *d*, and draw lines from the points *c* and *d* to the centre *i*, bisect these lines by the perpendicular B *i*, take the distance from either B to *d* (fig. 3) or *n* to *i* (fig. 1) as radius, and from *c* or *d* (fig. 4) mark off point *e* on the line B *i*, with *e* as centre, strike the curve *c d*. Take the distance from *f* to *g* (fig. 3), and mark off a like distance on the circle or boundary line from *c* to *g* (fig. 4), and *d* to *f*. Draw lines from *g* to the centre *i*, and from *f* to *i* bisect the distances from *g* to *c* as at *h*, and from *d* to *f* at *h*, extend these lines as *k* and *l*. Take the distance from *s* to *w* as radius (fig. 1), and from *d* (fig. 4) mark the point *l* on the line *h l*, and from *g* mark off the point *k*. Using *l* and *k* alternately as centres, strike the curves *d f* and *c g*. Take the distance from *d* to B, and mark off from *g* to A and *f* to *c*, and draw lines from the centre *i* to A and C. Again using *n i* (fig. 1) as radius, strike the curves *f n* from a centre on the line *n i*, also from a centre on the line *m i* strike the curve *g m*, which will complete the curve for the base.

Now to describe the curve for the circular hole in the top;—the line CD being drawn through the centre by which the circle is struck, from point *r* draw *r y* at right angles with the diameter line CD, take the distance EF, being the upright height required, and mark off the same distance from *r* to *y*, draw the line *y* to *u* at right angles with *r y*, take the distance from D to *r*, and mark off from *y* to *t*, being the slant of the side. Draw line from points *t r* to cut the diameter line AB at *p*, then take the distance from the oval to the circle, as from A to *g*, being the slant of the end, and mark off a like distance from *y* to *u*, draw line from *u* and *r* to *o* on the line AB, take the distance from *u* to *r* or from *e* to *i*, which should be the same, being the slanting depth of the end, and mark off like distances from *n* to *o* (fig. 4), from *m* to *p*, and from B to *e* (the outer curve). Take the distance *o r* (fig. 1) as radius, making *s* (fig. 4) as centre on the line B *e*, and strike the curve *v e w* through the point *e*: with the same radius strike the curve *o x*, with *u* as centre on the line *c i*; also with *t* as centre on the line *m i*, strike the curve *p y*; with radius *p r* (fig. 1) strike the curves *y v* (fig. 4) and *w x*, with centres found on the lines *h k* and *h l*, which will complete the pattern required.

Plate 15

Fig. 1.



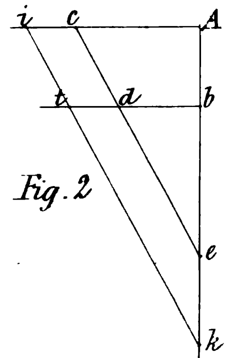


Fig. 2

Fig. 3.

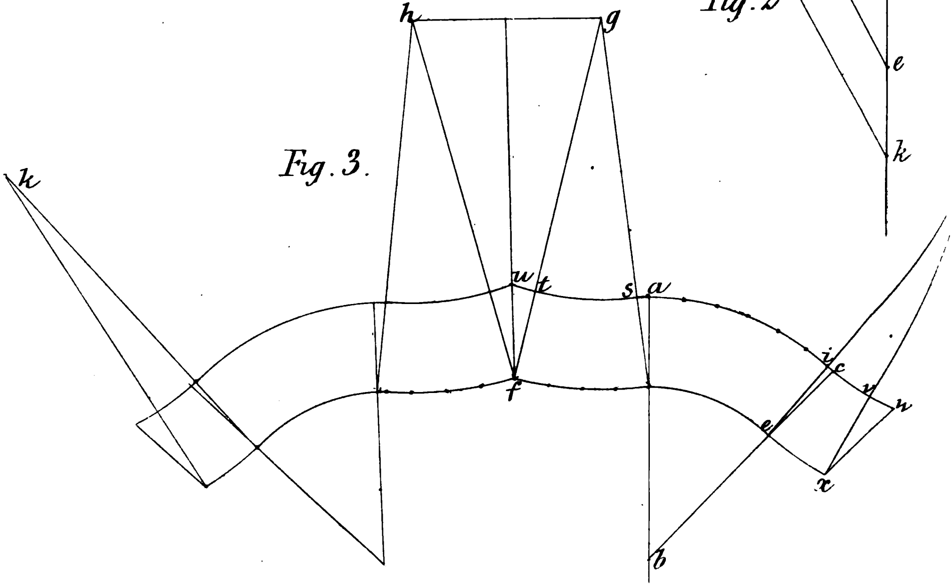


PLATE XV.

To strike a pattern for the Tapering Sides of a Tray having various curves.

Fig. 1 shows the plan and elevation of the article, for which a pattern for the tapering sides is required. Having drawn the plan, it is required to show the points or centres from which the various curves are struck, as shown here by *n m*, *b h*, and *l*. The tapering being equal on all sides, the curves for the bottom and top are struck from the same centre, that is, the curves *i e* and *g c* are both struck from one centre, viz., *h*.

To prepare for the development of the pattern construct fig. 2, making the distance from A to *b* the required upright height, (fig. 1), and take the radius by which the curves *a c* and *d e* are struck, that is the distance from *b* to *a* and *b* to *d*, and mark off the same on fig. 2 from A to *c* and from *b* to *d*; draw the line from points *c* and *d* to cut the perpendicular at *e*, also the distance *h e* or *h i*, and mark off the same from A to *i* (fig. 2), and the distance from *h* to *t* mark off from *b* to *t* (fig. 2). Draw a line from points *i* and *t* to *k*. (The radius *m r*, and *m v*, in this case, being the same as from *h* to *i* and *h* to *t*, do not require to be transferred to fig. 2.)

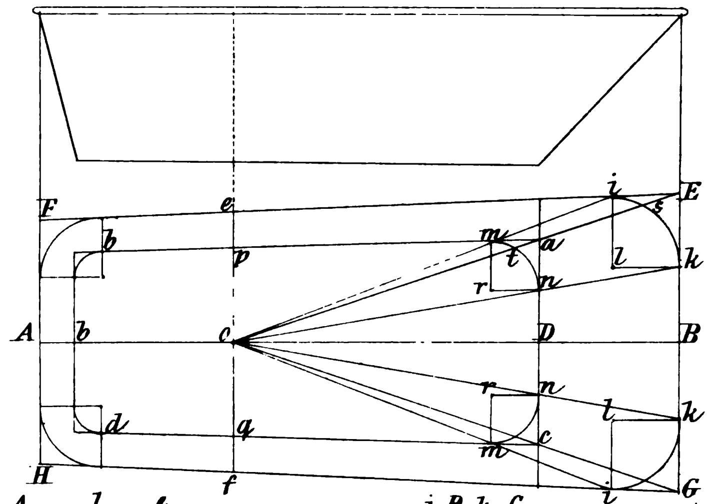
To commence describing the pattern take *e c* (fig. 2) as radius, and from *b* as centre describe the curve *a c* (fig. 3), and take the length of the curve from *a* to *c* (fig. 1) and mark off a corresponding distance from *a* to *c* (fig. 3), and draw lines from *a* and *c* to the centre *b*. Now take the radius from *e* to *d* (fig. 2), and again using *b* as centre (fig. 3) strike the curve from *e* as far as the line *a b*. Take the distance from *a* to *o* in fig. 1, and mark off the same from *c* to *i* (fig. 3), likewise the distance from *c* to *s* (fig. 1); and take a like distance from *a* to *s* (fig. 3), and draw lines through the points thus received from the points where the curve *e* intersects the lines *a b* and *c b*, and produce them indefinitely as *s g* and *i k*.

NOTE.—In further describing the pattern the letter *d* will be used, it ought to have been placed on the line *a b*, as *e* on the line *c b*.

Take the radius *k i* (fig. 2), and from the curve *e* (fig. 3) mark off the point *k* on the line *e i*, also from *d* the point *g* on the line *d s*; using *k* as centre strike the curve *e x*, and from *g* as centre strike the curve *d f*. Again from *k* and *g* as centres, and radius *k t* (fig. 2), strike the curves *a u* and *i w*, take the length of curve from *d* to *r* (fig. 1) and mark off a corresponding distance from *e* to *x* (fig. 3) and draw the line *x k*; the distance *v u* in fig. 1 will show what is required to be added on the curve from *v* to *w* in fig. 3; and draw the line *x w*, which will give one end of the pattern to meet for joining at *r u* (fig. 1). Now take the length of the curve from *e* to *i* (fig. 1) and mark off a corresponding distance from *d* to *f* (fig. 3). Draw line from *f* to the point *g*, mark off the distance from *t* to *u* equal to *t* to *g* (fig. 1) and draw line from points *f* and *u* (fig. 3) and produce it indefinitely as far as *g*. Draw line from *g* to *h* at right angles with the line from *f* and *u*, make the distance from centre line to *h* equal it at *g*, which will be the centre for the next curve, and proceed in like manner to complete the pattern.

Plate 16

Fig. 1.



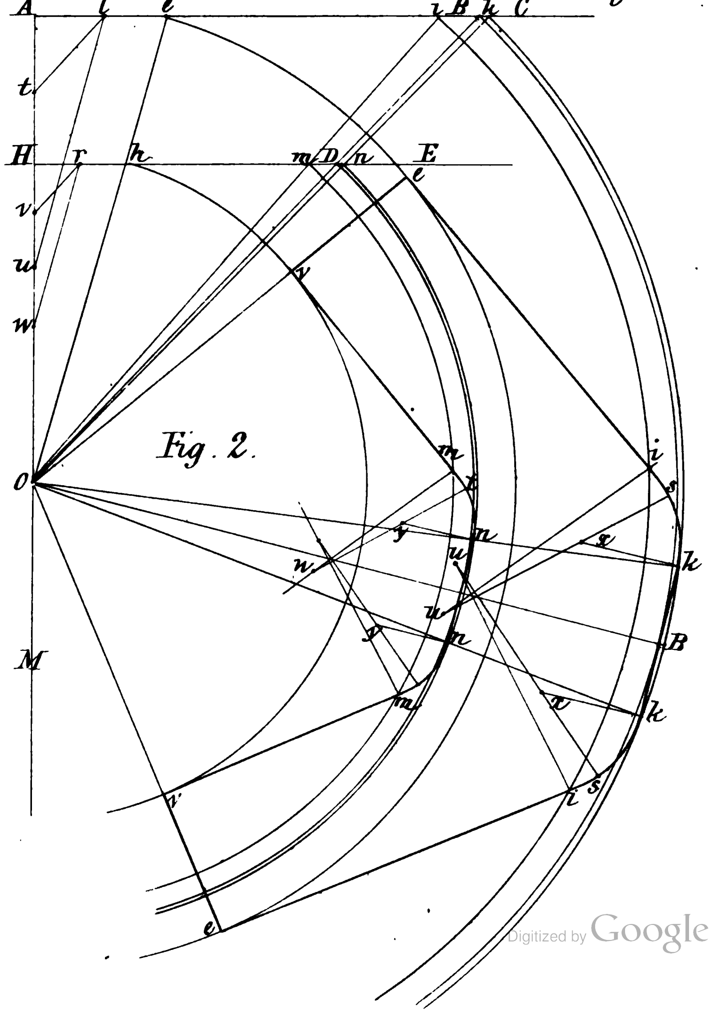


Fig. 2.

PLATE XVI.

To strike the pattern for an Oblong Tapering Bath.

Fig. 1 represents the elevation and plan for the bottom and top, showing a much greater slant or fall at the head than at any other part. Having drawn the lines FE, HG, FH, and EG, which represents the size of the article at the top, draw also four similar lines, which represents the size and the position required for the bottom. Draw the diameter line AB, and draw lines from the angles in the top and bottom as from E and *a*, G and *c*, and produce them to meet the centre line AB, as at *o*. Draw the corners as *i k*, and draw lines from *i* and *k* to the centre *o*; where they cut on the lines *a b* and *a c* will show proportionate corners for the bottom (these corners being quarter-circles, are struck from *r* and *l* as centres). Draw a line *e f* through the point *o* at right angles with AB.

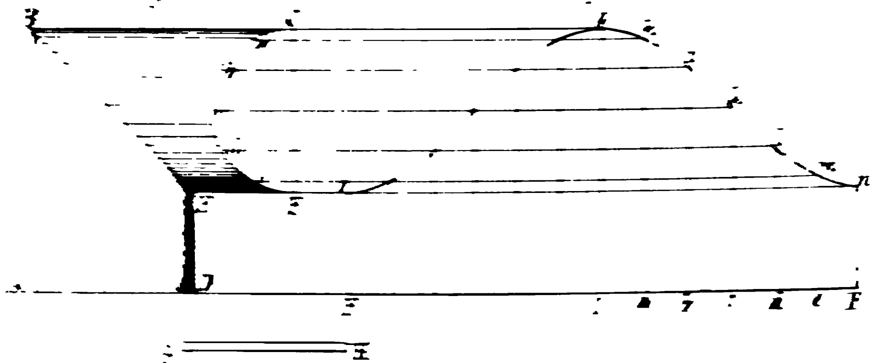
To proceed with fig. 2 where the pattern has to be developed. Draw the perpendicular AM, take the upright height from A to H, aud draw AC and HE at right angles with AM. Take the length of the lines from O to B, O to *k*, O to *i*, and O to *e* (fig. 1), and from A (fig. 2) mark off the points B *k i* and *e*. Again in fig. 1 take the distances OD, O *n*, O *m*, and O *p*, and from H (fig. 2) mark off corresponding distances at D, *n*, *m*, and *h*. Draw the lines from points B and D to cut the perpendicular line at O, also the lines from *k* and *n*, *i* and *m*, *e* and *h*, which will also cut the perpendicular at O.

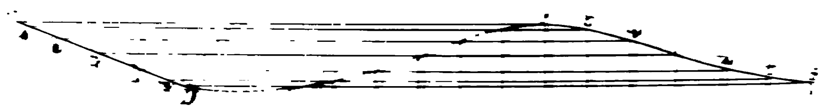
Take the radius of the large corner, as *l i* (fig. 1), and mark off the same from A to *l* (fig. 2), also the radius of the small corner *r n*, and mark off the same from H to *r*. Draw the lines from *l* to *t* and *r* to *v* parallel with the line B D O, also the lines from *l* to *u* and *r* to *w* parallel with the line *e h*.

With O as centre draw curves from the points on the line A C, that is from *k* B *i* and *e*, also on the line H E from points *n* D *m* and *h*. Draw the line B O (fig. 2), and from B mark off to *k k* the same distance as the corresponding letters in fig. 1, draw lines from *k* to O, also a line from *k* to *k*. Now from where the lines *k* O intersect the curve *n*, draw line as from *n* to *n*, and draw perpendicular lines from points *n* to *y*, likewise from *k* to *x* take the length of the line *t l*, and from *k* mark off the point *x*; from *x* as centre, radius *t l*, strike the curve *k s* on each side, taking the length of the curve from *k* to *s* (fig. 1) mark off the same distance from *k* to *s* (fig. 2), draw line from *s* through the point *x* indefinitely, take the length of the line *u* to *l*, and from *s* mark off the point *u*; using *u* as centre with radius *u l* strike the remainder of the curve from *s* to *i*.

Taking the distance from *i* to *e* (fig. 1), mark off a like distance from *i* to *e* (on the curve *e* fig. 2), draw lines from *i* to *e*, also from *e* to the centre O. With radius *v r*, from *n* mark off the point *y* for a centre, and strike the curve *n t*, making it the same length as *n t* (fig. 1): draw line from *t* through the centre *y*, and produce it as to *w*, taking the distance from *w* to *r* as radius, and from *t* mark off the point *w* for a centre, and strike the remainder of the curve from *t* to *m* to meet the curve drawn from *m* on the line HE. Draw line from *m* to cut the line *e o* as at *v* on the curve *h*: this will complete the pattern of the head, and the part of the body shown at the line *e f*. The remaining portion (or toe) being about equal tapering, can be obtained in the same manner as an ordinary oblong article which is fully described in Plate VII.

NOTE.—The tapering at the end being so much more than that of the sides, it becomes necessary to strike the corners in the pattern in two sections as divided by the line E *a* O, the end section being struck in proportion to the slant of the end, and the remainder in proportion to the slant of the side.





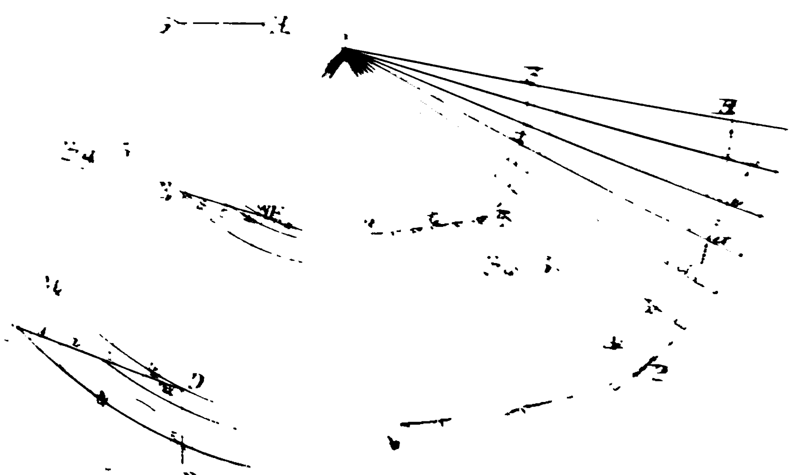


PLATE XVII.

To strike the pattern of an Elbow at right angles, in a Round Pipe.

Draw ABCDE and F (fig. 1), which shows the size of the elbow required. Take the centre on the line CF, and strike a semi-circle the size of the cylinder. Divide the semi-circle into any convenient number of equal parts, as *a b c d e* and F, extend the line AD indefinitely, and take twice the number of parts as there are on the semi-circle (fig. 1) as shown from C to F (fig. 2), on each side of the centre C, and draw perpendicular lines from F *n*, *e m*, *d l*, *c k*, *b i*, *a h*, C *g*, &c. Extend the line BC to cut the perpendicular C *g*, and draw lines from the points in the semi-circle *a b c*, &c., to cut the perpendiculars as at *h i k*, &c.

Draw a curve line from all the points of intersection, as *m n l*, &c. to *o*, which forms the curve required for the pattern. This curve should, from *n* to *m*, commence somewhat at right angles with the perpendicular *n* F, also at *h* to *g*, to give a curve, and not to show a point at *g*.

To strike the pattern of an Elbow in a Round Pipe at any angle required, (in this case, an obtuse angle).

Draw ACEG and BDEH according to the angle required in the pipe. Draw the section line CD from the two points of the angle, showing where the joint is required. Extend the line AB indefinitely. Draw the semi-circle the size of the cylinder, divide it into a convenient number of parts, as *b c d e f* B, and take a corresponding number of points from B to A, and from A to B, as *b c d e f.* Draw the perpendiculars B *s*, *f t*, *e u*, &c. Now through the points *b c d*, &c. on the semi-circle, draw the perpendiculars *g r*, *h g*, *i p*, *l o*, and *n m*. Either take the length of the lines as AC, *r g*, and *g h*, &c., and mark off the same lengths from A to *y*, *b* to *x*, *c* to *w*, etc.; or draw lines parallel to AB from the points on the section line, as *g h i*, etc., to intersect the perpendiculars, as at *y x w*, and draw a curve from these points of intersection, as *s t u v*, &c., which will give the pattern required.

To strike the pattern of a Tapering piece of Pipe to join Two Upright Cylinders, to form a Double Elbow.

Draw A C, E G and B D, F H (fig. 5) according to the plan required: produce the lines C E and D F until they meet at the point O. Draw the semi-circle and divide into equal parts as *b c d e f*, and draw the perpendiculars through these points to cut the section line CD as at *g h i k n*, from these points draw lines all leading to the point O. With O as centre, radius O *i*, draw the curve NA, (fig. 6), and extend it indefinitely; with the same compass set as divided the semi-circle into six parts on the curve N, mark off twelve points from N to B, and draw lines from these points to the centre O. With radius OC strike the curve CP, and with radius OD strike the curve DB.

If curves were drawn with O as centre from the points *g h k* and *n*, which are not shown here, the points of intersection would give the exact direction of the curve BPN, and curves drawn from the same centre from the points of intersection on the line EF (fig 5), the points of intersection (fig. 6) will give the direction of the curve F *t* E *t* F which will give the pattern for the tapering part of the angular pipe. The other parts can be drawn as previously described.

NOTE.—The curves mentioned which give the pattern should be drawn from the various points with free hand. As there are many curves in geometry and in mechanical drawing which are drawn better by hand from given points than by instruments, the student is recommended to practice free-hand drawing at the same period that he studies other portions of mechanical art.

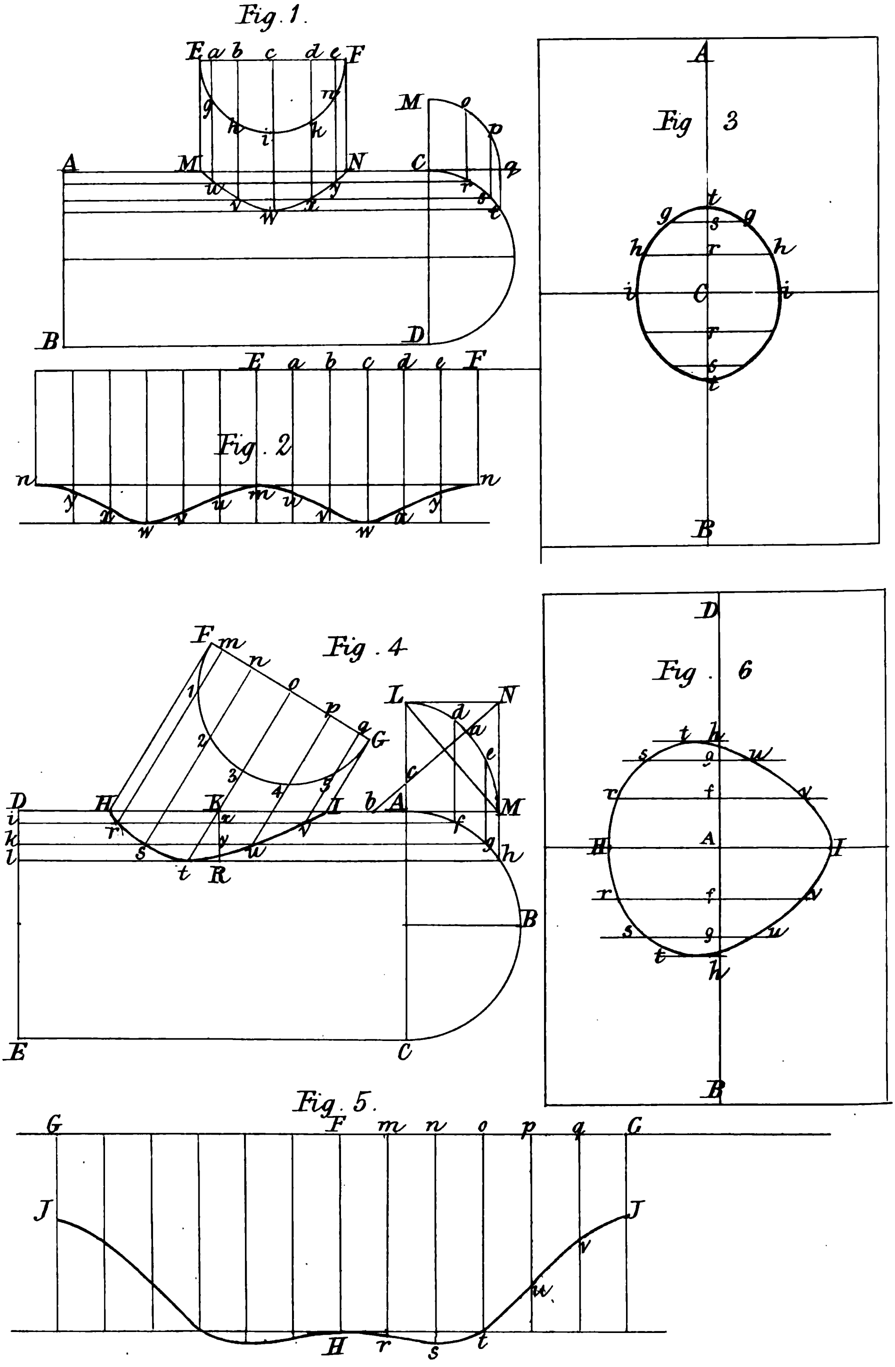


Fig. 1.
Fig 3
Fig. 2
Fig. 4
Fig. 6
Fig. 5.

PLATE XVIII.

To strike the pattern for a T-piece, or to join two cylinders at right angles.

Strike a semi-circle the size of the smaller cylinder (fig. 1) from E to F, also extend the lines DC and AC as shown at M and *q*, and describe a quadrant with the same radius as the semi-circle is struck by. Now divide the semi-circle into a convenient number of parts, in this case six, as *g h i k n* and F, divide the quadrant into three equal parts, as *o p q*, also strike a semi-circle from C to D the size of the larger cylinder, and draw perpendiculars from *o p* and *q* to cut the curve in the larger cylinder, as at *r s* and *t*. Now draw lines from the points *r s t* parallel to CA, and draw also perpendiculars from points *g h i k n* to intersect the horizontal lines *r s t*; those points of intersection, as *u v w x y* N, will show the course of the curve generated by the smaller cylinder being fitted against the larger one at right angles.

Now draw twelve perpendiculars as shown in fig. 2, as F *e d* &c., and take the lengths in fig. 1 from FN, *e y*, *d x*, *c w*, *b v*, *a u*, EM, and transfer the same to the corresponding letters in fig. 2, and draw a curve from these points, which will give the pattern for the smaller cylinder.

Next, to obtain the hole to receive the smaller cylinder, proceed in fig. 3 to draw the line AB, and bisect it at C, take the distances from C to *r*, C *s*, and C *t* (fig. 1), and mark off on each side of C (fig. 3) like distances shown by the corresponding letters, and through these points draw lines *h h* and *g y*, &c., at right angles with AB. Take the distance from *o* to *i* (fig. 1) and mark off a corresponding distance on each side of C to *i* (fig. 3); also the lengths *b h* and *a g* (fig. 1), and transfer the same to fig. 3, on each side of *r* to *h*, and each side of *s* to *g*: a curve drawn from these points will give the required aperture to receive the smaller cylinder.

To strike the pattern of Two Cylinders for joining at an Oblique Angle (or slanting direction).

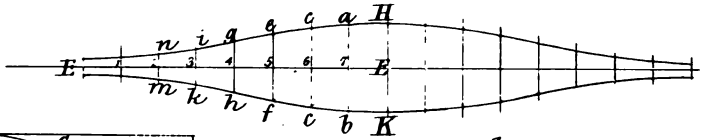
DA and EC (fig. 4) represent the larger cylinder, and let HF and IG be drawn the required size of the cylinder that has to be connected to it at any angle or position required. Draw line FG at right angles with HF, and describe the semi-circle from F to G, and divide it into six equal parts, as 1, 2, 3, &c., draw lines through these points at right angles with FG, now strike the semi-circle ABC representing the size of the larger cylinder, and extend the lines DA to M, and CA to L, take the radius of the semi-circle, as *o* F or *o* G, and from A mark off the same distance to M, now take half the length of the base of the cylinder, as from K to H or K to

I, and mark off a like distance from A to L. Now, instead of drawing a quarter-circle as required in fig. 1, where the cylinders meet at right angles, here 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 line from M to N, also from L to N at right angles, and draw the diagonal line LM, draw a line from the point N to cut through the diagonal LM at right angles, producing the points *c* and *b*: with *c* as centre, radius *c* L, draw the curve from L to *a*; with *b* as centre, radius *b a*, draw the remainder of the curve from *a* to M. Divide the curve from L to M into three equal parts, and draw perpendiculars from these points to meet the curve AB, as *d f*, *e g*, M *h*, draw also lines parallel to AD from *f* to *i*, *g* to *k*, and *h* to *l*: where those lines are intersected by the lines drawn through the smaller cylinder, will be the points from which to trace the curve, as *r s t u*, &c. Draw twelve perpendicular lines in fig. 5, as F *m n o*, &c., the same distances apart as the divisions in the semi-circle (fig. 4), and take the length of the lines in fig. 4, as FH, *m r*, *n s*, &c., and transfer the same to the perpendiculars in fig. 5 marked by the corresponding letters. Draw a curve from the points thus obtained, as from J *v u*, etc., which will give the pattern for the smaller cylinder.

To obtain the curve for the hole in the larger cylinder. Draw DB and HI (fig. 6) at right angles, take the distances from A to *f* *g* and *h* (fig. 4) and mark off like distances on each side of A on the line DB, as *f g h*, and draw lines from these points parallel to HI. Draw a perpendicular from point K to R (fig. 4) and carry the length of KH and KI (fig. 4) from A to H and A to I (fig. 6), also the distances *x r* and *x v* (fig, 4) from *f* to *r* and *f* to *v* (fig. 6) from *y* to *s* and *y* to *u* (fig. 4). Transfer to fig. 6 from *g* to *s* and *g* to *u*, take the distance from R to *t* (fig. 4) and mark off the same from *h* to *t* (fig. 6), the curve drawn from the points thus obtained will give the aperture required to receive the smaller cylinder.

Plate 19

Fig. 2.



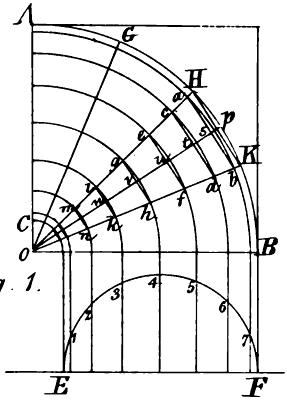
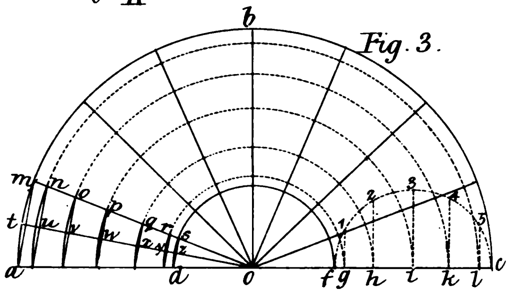


Fig. 1.

Fig. 3.



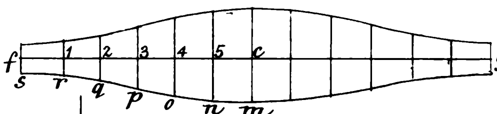


Fig. 4.

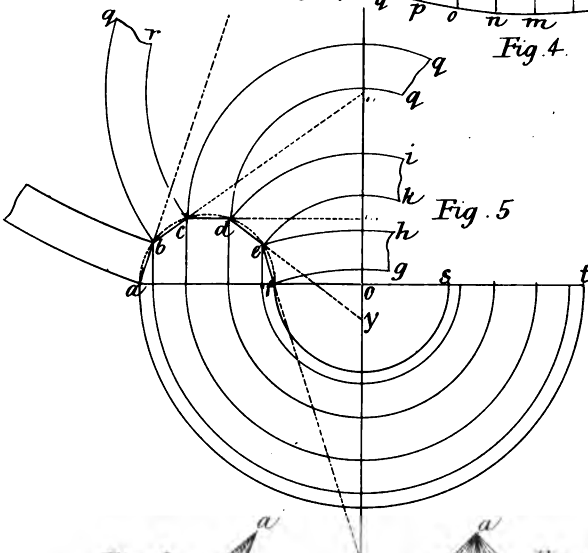


Fig. 5

Fig. 6

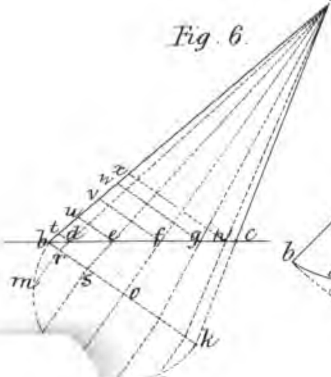


Fig. 7

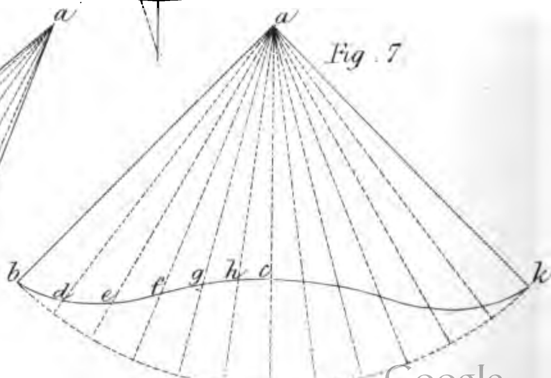


PLATE XIX.

To strike the pattern for a Lobster-back Cowl.

Describe the semi-circle from E to F (fig. 1) any given size, and divide it into a convenient number of parts, as 1, 2, 3, etc., through those points draw perpendiculars to meet the line OB, taking O as centre describe the curve BHA, also let curves be drawn from all the perpendiculars, as 1, 2, 3, etc. Divide the curve from B to A into as many parts as sections required, in this case four, as shown at KHGA, draw a line from O to *p* through the centre of one of these sections, and draw straight lines from the points on the curve where intersected by the lines HO and KO, as *a b*, *c d*, *e f*, *g h*, etc. Mark off twice the number of points as are contained on the semi-circle and the same distance apart, on the line E (fig. 2) as 1, 2, 3, 4, etc., from *p* to H and K (fig. 1) mark off the same distance from E to H and K (fig. 2), from *s* to *a* and *b* (fig. 1) mark off the same distance from 7 to *a* and *b* (fig. 2), also the distance from *t* to *c* and *d* (fig. 1) mark off a like distance from 6 to *c* and *c* (fig. 2), and so on with the remaining distances in fig. 1, which are marked with corresponding letters in fig. 2. A curve drawn from the points thus obtained will give the development of one section, which, as the four sections are alike, will render further explanation unnecessary.

To strike the pattern for a Round Pipe, to form a Semi-circle for connection to other pipes.

Draw the semi-circle from *f* to *c* (fig. 3) which represents the size of the pipe, divide it into a convenient number of equal parts, as 1, 2, 3, 4, 5 *c*, and draw perpendiculars from these points, as from 1 to *g*, 2 to *h*, 3 to *i*, etc., and from *g h i k* and *l* draw the semi-circles, now divide the curve *a b c* into a convenient number of parts, showing the number of sections the pipe will be composed of, take one of those sections as from *a* to *m*, and bisect it at *t*, draw a line from *t* to the centre *o*, and draw straight lines from where the curves intersect the lines *m o*, and *a o*, to connect those points shown from *m* to *a*.

Draw the horizontal line (fig. 4) as *f g*, and on this line take twice the number of distances as there are on the semi-circle (fig. 3) 1, 2, 3, 4, 5, *c*, and take the distances from *t m*, *u n*, *v o*, etc. (fig. 3), and carry the same on each side of the centre line *f g* (fig. 4) from *c* to *m*, 5 to *n*, 4 to *o*, etc. A curve drawn through the points thus obtained will give the pattern for one section.

Fig. 5 also shows a semi-circular pipe, but the joints of the various pieces of which it is composed will run in an opposite direction.

Draw the semi-circle from *a* to *f*, showing the size of the pipe, and divide it into a convenient number of equal parts, as *a b c d e f* and draw a line perpendicular to the base of the semi-circle *a t*, and from the points *a b*, *b c*, *c d*, etc., draw lines to cut the perpendicular drawn through the centre, these points used as centres, and the corresponding points on the semi-circle from which they are produced, will give the radii for the various curves of which the pipe is required to be made.

Fig. 6. To develope the pattern of a cone cut oblique to its base: *b a* and *b k* represent a right cone, the line *b c* represents the oblique direction of the base required, draw the lines *a b* and *a c* to *k*, and from *o*, the centre, strike a semicircle *b l k*, divide it into six equal parts as *m n l p q*, and draw perpendicular lines from these points to cut the line *b k*, as at *r s o*, etc., from the points thus received on the line *bk*, draw lines to the apex *a*, where they are intersected by the line *b c*, draw lines parallel with *k b*, from *d* to *t*, *e* to *u*, *f* to *v*, etc. Now take the distance from *a* to *b* as radius, and in fig. 7, using *a* as centre, strike the curve *b o k*, with the same distances as the semicircle is divided by fig. 6, take twice the number of points in fig. 7 from *b* to *k*, and draw lines from those points to the centre *a*, as *b d e f*, etc. Now take the distance in fig. 6 from the centre *a*, to *t u v w* and *x*, and mark off the same from the centre *a* in fig. 7 to *d e f g* and *h*; also on the other side of *c*; now a curve drawn from these points will give the pattern required.

Plate 20.

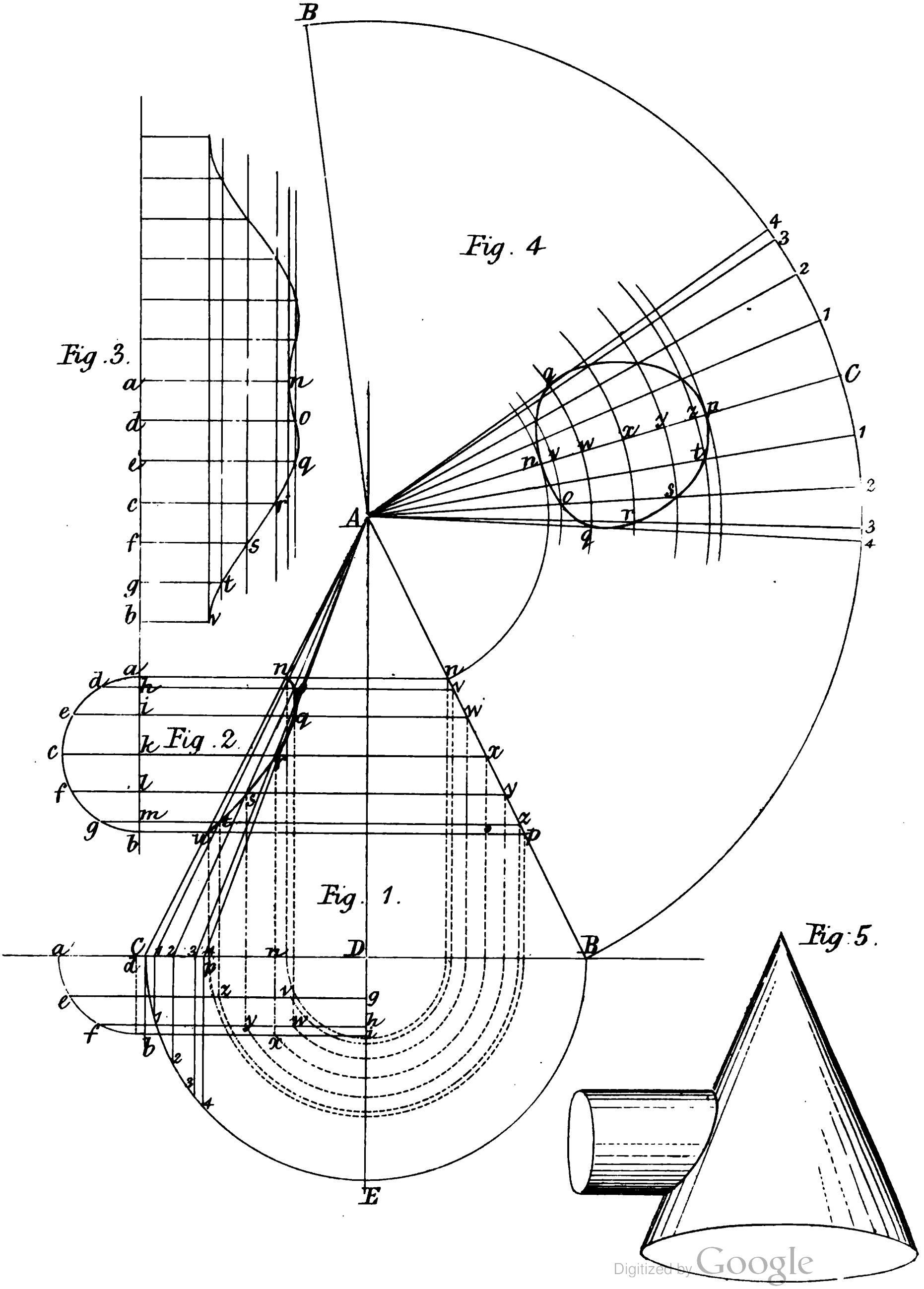


PLATE XX.

To describe the pattern for a Cone and Cylinder, to intersect or meet at right angles with their axes.

Fig. 5 is a (small) representation of the cone having a cylinder joined to it at right angles with its axis. The patterns which are required to describe, being first, the development of the cone, secondly, the curve of the cylinder, to fit when placed against the cone, and thirdly, the shape required for the hole or aperture in the cone to receive the cylinder (or to meet edge to edge for joining). Fig. 1. CB shows the base, and DA the elevation of the cone. Draw the lines AC and AB, from centre D strike the semicircle CEB. Now to develope the pattern of the cone, take A as centre, radius AB, and strike the curve BCB (fig. 4), find the length of the curve BEC (fig. 1), and take twice that length from in BCD fig. 4.

The next problem is to find the curve which will be generated by the intersection of a cylinder (which is a round body of equal diameter) with the cone (which is a round body of ever decreasing diameter). The lines *a n* and *b u* (fig. 2) represent the size of the cylinder, draw the semi-circle and divide it into equal parts, as *d e o f g b*, and from these points draw lines parallel to *a n* to cut the line AB, and from these points *n v w x y z p*, draw perpendicular lines as dotted to cut the base line BC. Next from C draw the perpendicular line C *b*, and take half the length of the line from *v* to *n* (fig. 2), which will be where it is intersected by the line *o x*, and carry the same from C to *a* (fig. 1) and take the radius of the semi-circle *k* to *o*, and mark off the same from C to *b*, and describe the curve *a b*. Divide it into half as many parts as the semi-circle has been divided into (but the distances will not be the same) and from these points draw the lines *e g*, *f h*, and *b i* parallel to CD. Now using D as centre strike the curves from the dotted lines drawn from the points *p z y*, etc., to meet the horizontal lines just drawn in rotation as follows, join the perpendicular drawn from *p* on the line AB with a curve, and extend it to *p* on the line *a* CD and raise a perpendicular from *p* to *u*. Next from the perpendicular brought down from *z*, draw a curve to meet the line *e g* at *z*, and raise a perpendicular from *z* to *t* cutting the line *g z*, and from the line brought down from *y* strike the curve to meet the line *f h* at *y*, and raise a perpendicular to cut the line *f y* as at *s*, and from the line *x* strike the curve *x* to meet the line *b i*, and raise the perpendicular to meet the line *o x* as shown at *r*. The other curves *w v* and *n* follow back in the same manner on the lines *f h*, *e g*, and CD, producing the points *q o* and *n* (fig. 2). The points *u t s r q o n* will show the course of the curve sought.

By drawing the horizontal lines *b g f o e d a* (fig. 3) the same distance apart as the corresponding letters on the semi-circle (fig. 2), and by producing the perpendiculars from *n o q r s t u* to intersect the horizontal lines drawn in fig. 3, the points of intersection will show the course of the curve for the pattern of the cylinder.

Now to find the shape of the aperture in the pattern of the cone. First draw the line AC (fig. 4), and taking A as centre, with radii A *n*, A *v*, A *w*, etc., (fig. 1), describe the arcs as *n v w x*, etc., (fig. 4). Now from A draw lines through the points *t s r q o*, to cut the line CD at 1 2 3 4, and from these points draw perpendiculars to cut the curve CE at 1 2 3 4. Take the distance C 1, C 2, C 3, and 4, on the curve CE, and from C (fig. 4) mark off the same as shown by corresponding figures. Draw lines from these figures to A, the points of intersection will give the course of the curve. The line drawn from A through *o*, also cuts through point *s*, being line 2; so, observe in fig. 4 the points *o* and *s* are the required points for the curve on the same line 2.

NOTE.—The distance from *a* to *d* being the same as from C to *b*, the distance between the lines *d* and *b* shows that the required curve from *a* to *b* is more than a quarter-circle, therefore it should be a quarter of an ellipse, as in fig. 4, Plate XVIII.

Fig. 1

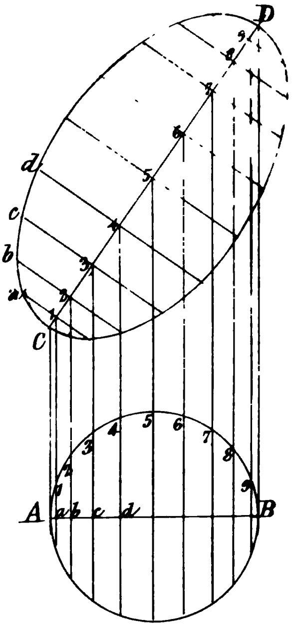


Fig. 2.

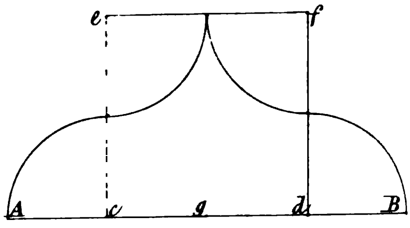


Fig. 3.

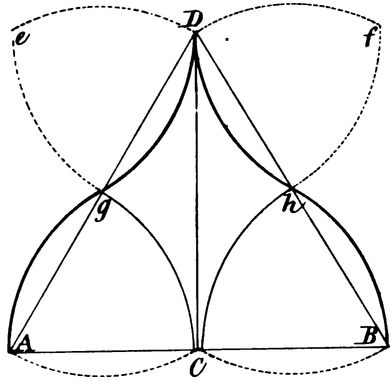


Fig. 4.

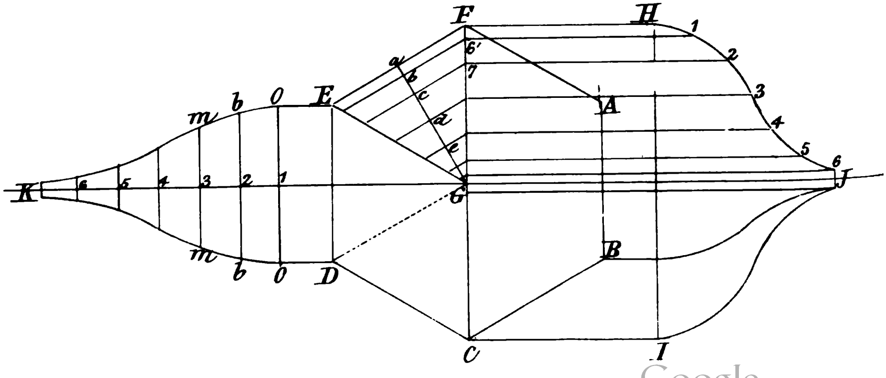


PLATE XXI.

To describe a Cylindric Section through any given angle.

Let AB (fig. 1) be a section of a right cylinder, and CD the line of the required section. Draw the circle at AB, and on the arc take any number of points, as 1 2 3 4, etc., from which draw lines perpendicular to AB, produced to cut the line CD in 1 2 3 4, etc. From those points draw the lines 1 *a*, 2 *b*, 3 *c*, 4 *d*, etc., perpendicular to CD, and make these ordinates respectively equal their corresponding points on its base, that is to say, let *d* 4, *c* 3, etc., on its base equal 4 *d*, 3 *c*, etc. on the line of its required section; continue this process throughout, and through the points found in this way will be the required section.*

To draw an Ogee Arch.

Fig. 2.—Divide the width AB into four equal parts, A *c g d* B, and on *c d* erect the square *c e d f*: the points *e d e f* are the centres of the four quadrants composing the arch.

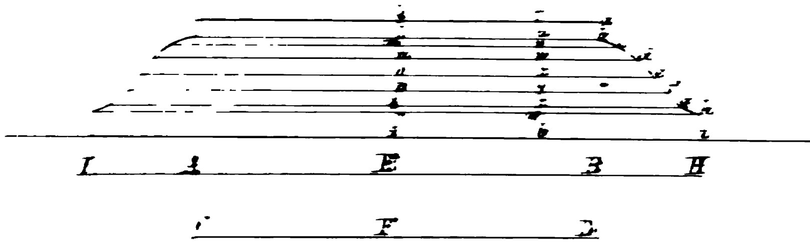
Another Method.

Fig. 3.—Let AB be the width and CD the height of the arch, join ADBD and bisect them in *g* and *h*; then from the centres A *g* D *h* B describe arcs intersecting at *e f* C, which are the centres of the four arcs composing the arch.

To find the covering of an Ogee Dome, the plan of which is Hexagonal.

Fig. 4.—Let ABCDEF be the plan, and HIJ the elevation. Divide HJ into any number of equal parts, as 1 2 3 4 5 6, and through these points draw perpendiculars to FG; through the points in FG draw lines parallel to FE (the side of the hexagon) to EG, bisect EF in *a*, and draw *a* G, which is the seat of one side of the dome. Now to find the development of one section, set off the lines 1 2 3 4 5 6 K the same distance apart as 1 2 3 4 5 6 on the elevation from H to J. Then take *a* E or *a* F on the plan, and transfer it to 1 *o* each side of 1 on the pattern; now take *b* 6 on the plan, and transfer it from 2 to *b* on each side; then *c* 7 on the plan transfer to 3 *m*, and so on to K, and through the points *o b m*, etc., trace the curve as shown, and it will form the covering for one side of the dome. All the sides being equal, of course, the pattern of one side is all that is required.

* Note.—This problem will also show that a round cylinder being cut oblique to its base, the surface so cut becomes an ellipse, hence the reason for requiring a quarter of an ellipse to be placed on the larger cylinder in fig. 4, Plate 18, to be divided, and produce lines to meet corresponding lines coming from a cylinder placed in an oblique direction.



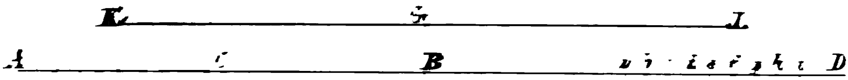
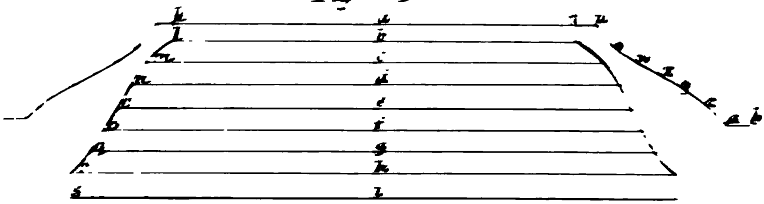
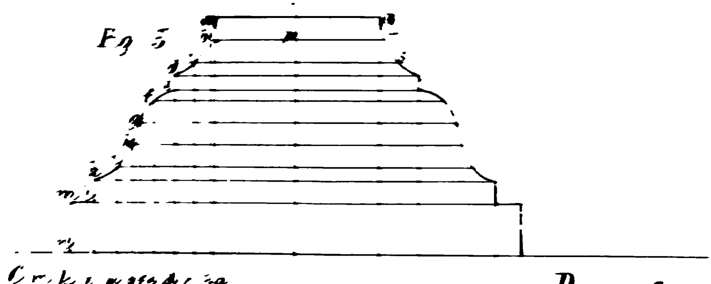


Fig. 3





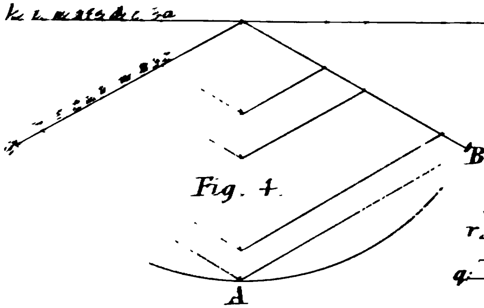


Fig. 4.

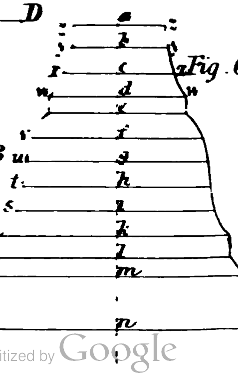


Fig. 6

PLATE XXII.

To describe the pattern for a Rectangular Base and Bottom in one piece, where the flue or curve is equal on all sides.

Such as may be used as a base for either an Aquarium or a Fern-case.

Draw fig. 1, which represents half the projection; fig. 2 shows the elevation and profile of the base. Next, in fig. 3, draw the rectangle C *k t a*, same size as ACDB in fig. 1. Take the upright distance from *a* to *b*, and divide the curve into any number of equal parts, as *c d e f*, etc., and mark off corresponding distances on the perpendicular line from *a* to *i*, also from *a* to *i* on the line BD, likewise from C to A, and draw parallel lines from these points, and the distances from K to *a*, *m* to *c*, and *n* to *d* etc., will show the required distances, as from *b* to *l*, *c* to *m*, and *d* to *n*, to be taken on each side of the centre line, fig. 3. Then by taking the distance from B to D in fig. 1, and marking off the same from *a* to *t*, fig. 2, and drawing the perpendicular *t b*, the required length of the lines will be obtained, as from *b* to *u*, *c v*, *d w*, *e x*, etc., in fig. 3. A curve drawn from the points thus obtained will give one half the required pattern.

To describe the pattern for a Hexagon Base.

Draw fig. 4, the half hexagon so placed that half of a side, as *q k*, will be perpendicular and at right angles with the base. Draw a perpendicular line, *o* A, and lines from B and *q* to the centre. Now in fig. 5 (the elevation) divide the curve into a convenient number of parts, and draw the horizontal lines, and also the perpendiculars, and extend them to cut the line drawn from *q* to the centre at *q r s t*, &c. Now draw the perpendicular *a n* in fig. 6, and carry on this line all the distances of the straight lines and angles, likewise the points of division on the curve of the elevation (fig. 5), as *n m l k i*, &c., to the points marked by corresponding letters in fig. 6, and through the points thus received draw parallel lines at right angles with the perpendicular *a n*, and on each side mark off the points *a z*, *b y*, *c x*, and *d w*, the same distance as the corresponding letters in fig. 4. By connecting these points by curves and right lines (according to the plan in fig. 5) the required pattern will be obtained.

Plate 23

Fig. 1.

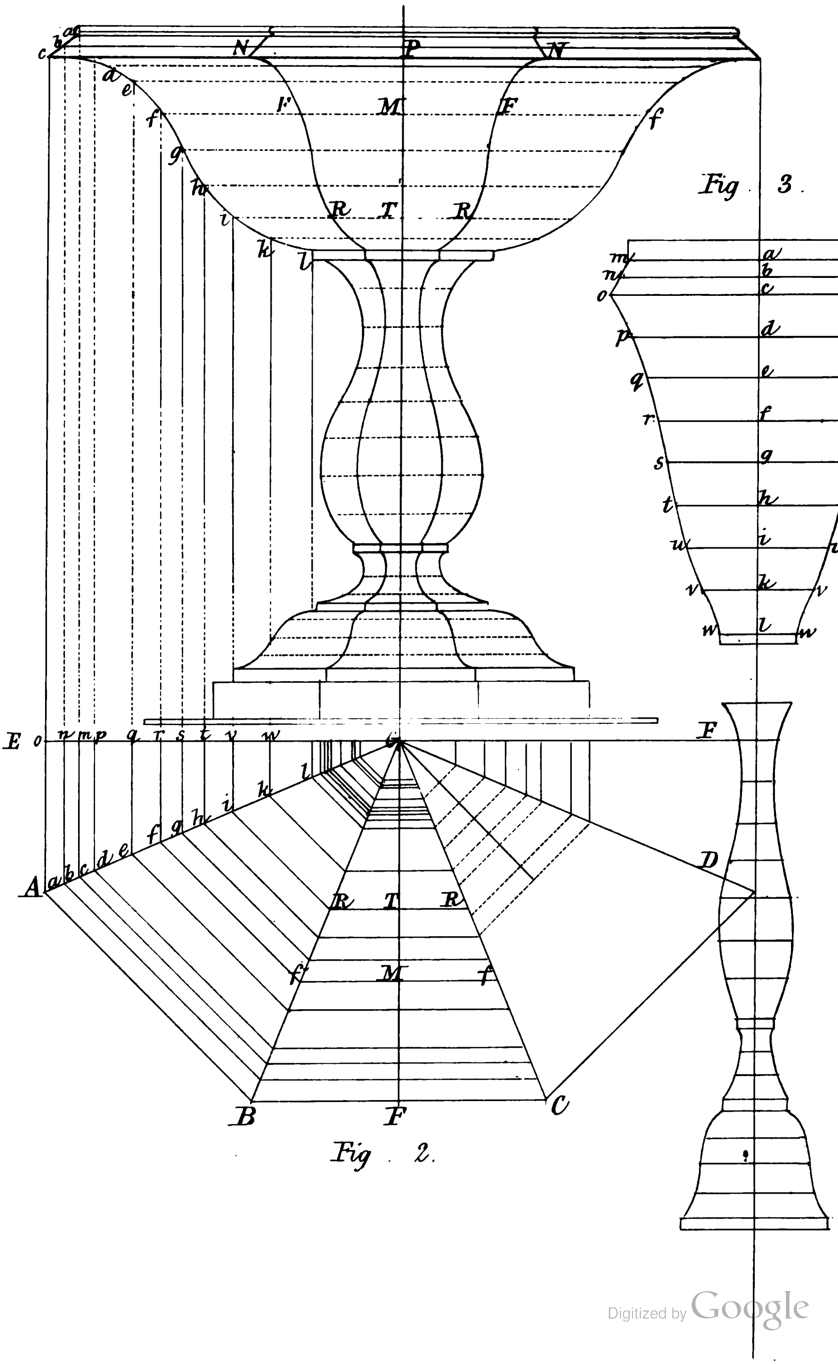


Fig. 2.

Fig. 3.

PLATE XXIII.

To describe the pattern for a Vase, Octagon Shape.

Draw the profile (fig. 1) the required design, and the half octagon (fig. 2) the size corresponding with the extreme points in fig. 1 (as described in fig. 4, Plate 3) and to be placed so that one half of the side, as from A to E, may be perpendicular with the base, and draw section lines from points A, B, C, and D, to the centre G, now divide the curve in the plan into any convenient number of parts, as *a b c d*, &c., and from these points draw horizontal lines across the plan, also draw perpendiculars and extend them to cut the line AG. Now mark off the same distances as shown by corresponding letters in fig. 3, and from these points draw parallel lines *m m*, *n n*, *o o*, etc., take the length of the line (produced from *a*) from *c* to *m* (fig. 2) and mark off the same from *a* to *m* on each side of the perpendicular line in fig. 3, also the distance from *b* to *n* (being the line produced from *b*, fig. 1), and mark off the same from *b* to *n* (fig. 3), also let the distance from A to *o* (fig. 2) be carried from *c* to *o* (fig. 3). Now take the distance from *d* to *p* (fig. 1) and carry the same from *d* to *p* (fig. 3), and so on; tracing all the distances between the lines EG and AG, until all the points in the development of the pattern are obtained, and draw a curve from these points, which will complete the pattern.

To make the pattern look more complete, and to give a prospective view of the article, the course of the curves N, F, R, may be obtained in the following manner (although not necessary for the development of the pattern). From the points *a b c d e f*, etc., on the line AG (fig. 2) draw lines parallel to AB, to cut the section line BG, and again produce them to cut the line CG parallel with BC. Now if a vertical line was raised from B and C in the projection (fig. 2) it would cut the horizontal line *c* in the elevation at N and N; also by following the line from *f* in the elevation to *f* M *f* in the projection, and raising perpendiculars as before, they will give the points FF in the elevation; likewise by following the perpendicular from *i*, produced at RR in fig. 2, perpendiculars raised from these points will give the points RR in fig. 1. By tracing all the points in like manner the course of the curves NFR, etc., will be found. And it will be observed that these curves will show the same width as the pattern (fig. 3) all the way through, while the length of the pattern will correspond with the length of the curve of the side, as at *a b c d e f*, etc.

Plate 24

Fig. 1

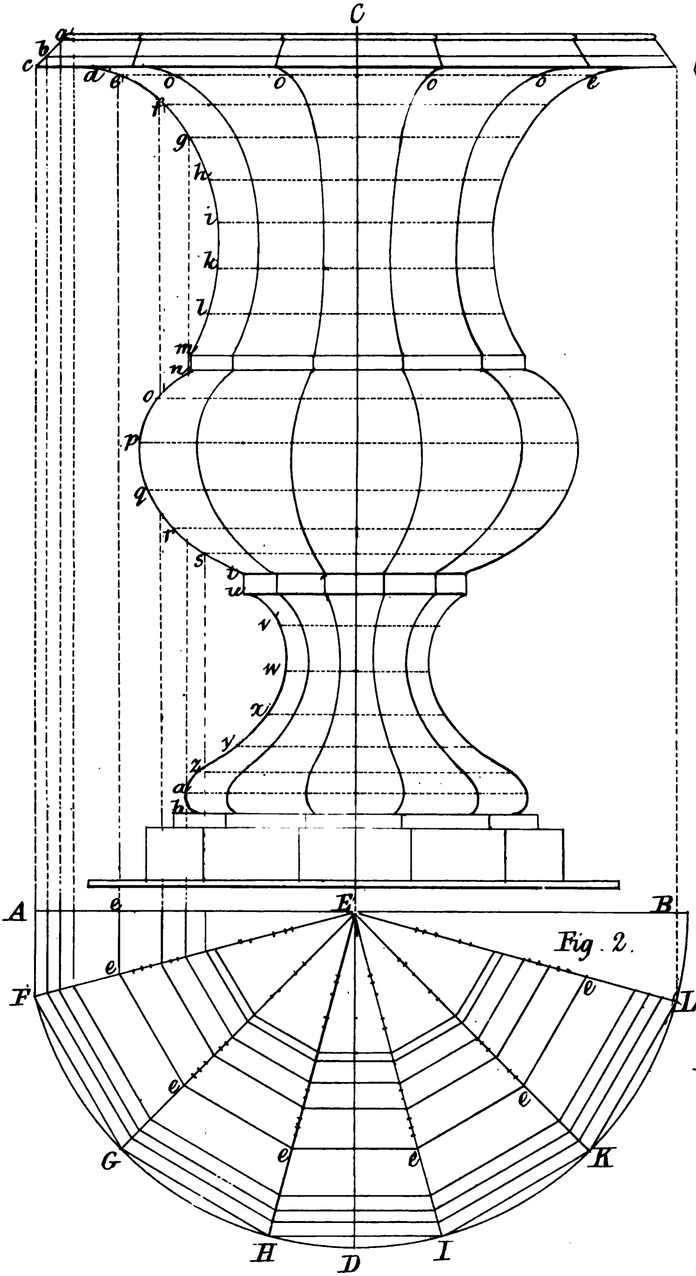


Fig. 2

Fig. 3

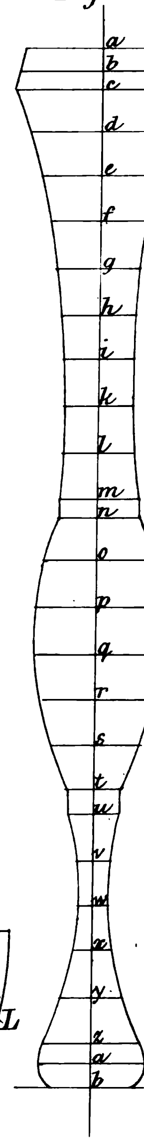


PLATE XXIV.

To describe the pattern for a Vase having twelve sides (Duodecagon).

Draw the profile fig. 1 (the two outer curves only), also draw the perpendicular line CD through the centre, and draw the horizontal line AB (fig. 2), on which construct half the plan of the projection as in Plate XXIII., and draw the sectional lines from points FGHIK and L, to the centre E, having half of a side from F to A perpendicular, and at right angles with the base. Now divide the outer curve in the plan into any convenient number of parts, as *a*, *b*, *c*, *d*, *e*, *f*, &c., and from these points draw horizontal lines across the plan, also draw perpendiculars, and extend them to cut the line FE, obseving the points from which they are produced, take the distances between the lines AE and FE, and transfer them to the lines marked by corresponding letters in fig. 3. Now connect the points FG, GH, and HI, etc. (fig. 2), and draw lines parallel from all the points produced on the line FE; observing that where there are straight parts in the elevation, as from *m* to *n*, and from *t* to *u*, the same distance be taken, as marked by the corresponding letters in the development of the pattern (fig. 3), and the two lines as *t* and *u* will be connected by lines at right angles (as they are both the same length).

Now carry parallel lines from all the points on the line FE to all the other sectional lines in the projection, as from F to G, G to H, and H to I, etc., and by raising perpendiculars from these points, or by marking off points perpendicular to them on the corresponding horizontal lines in fig. 1, the course of all the curves may be obtained, showing all the joints aud angles, or giving a prospective view of the Vase. For example, by following the perpendicnlar line drawn from *e* (fig. 1), to *e* on the line FE (fig. 2), and all the other sectional lines marked by *e*, perpendiculars raised from these points, on the lines GHI and K, will give the direction of the various curves on the horizontal line *e e* (fig. 1), as *o o o o*.

Plate 25

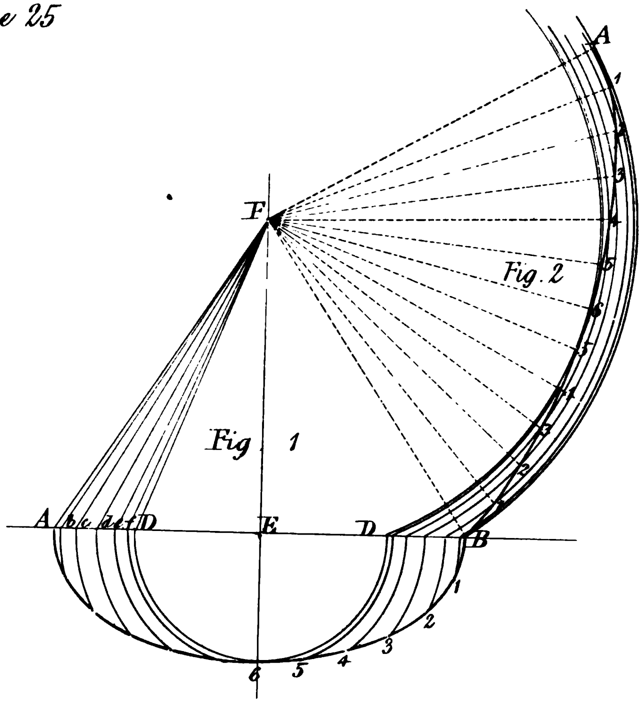


Fig. 1

Fig. 2

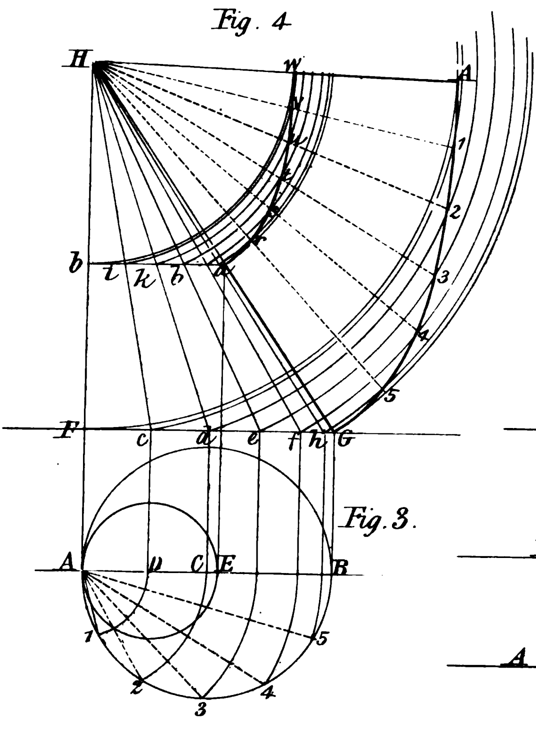


Fig. 4

Fig. 3.

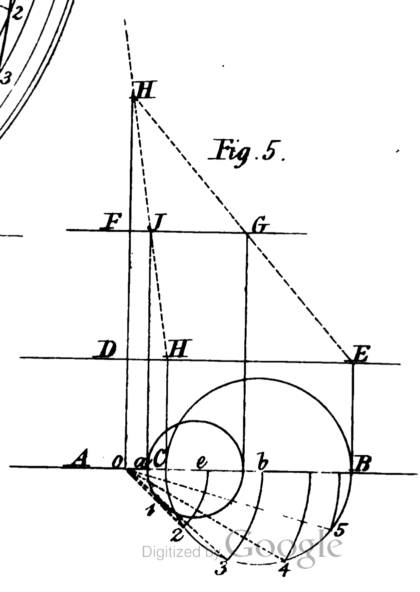


Fig. 5.

PLATE XXV.

To describe the pattern for a Cone with an Elliptic Base.

In fig. 1, let AB represent the major diameter, and DD the minor, and E (the centre of the base) to F (the apex) represent the vertical height. Now draw half of the ellipse, as from A to B, and divide it into a convenient number of equal parts, as 1, 2, 3, 4, 5, 6; and from these points, using E as centre, describe arcs to cut the base line AB. Now taking F for centre, radius FB, draw the curve BA in fig. 2, and so from all the points from B to D, describe the curves in fig. 2 to A. With the same compass set as the divisions 1 2 3 4 5 6 in fig. 1 were obtained by, take twice that number in fig. 2, but in measuring off the distances with the compasses in fig. 2, commencing on the outer curve, from each point step into the next one, as 1 2 3 4 5 6, and then retreating back in like manner to A; lines drawn from those points to the centre F, and a curve drawn from the points so obtained, will complete the pattern; the length of the lines drawn from FA, F1, F2, F3, &c. (fig. 2) will be equal to the length FA, F *b*, F *c*, F *d*, &c. (fig. 1).

To describe the pattern of an Oblique Cone, or the Frustrum of a Cone cut parallel with the Base.

The vertical position of the two diameters is shown by the two circles in fig. 3. Now take the upright height from F to *b*, and draw FG and *b a* parallel to AB, the diameter line (being drawn across the two centres by which the circles are struck), and draw AH perpendicular to AB; also draw perpendiculars from E to *a* and from B to G, and draw a line from points G and *a* to cut the line AH. Now FH represents the vertical height of the cone, and FG the base, and the line *b a* shows the frustrum or section required, the apex or point being cut off parallel with the base.

Divide half the plan into equal parts, as 1, 2, 3, 4, 5, and draw lines from these points to A. Now using A as centre, draw arcs from these points, as 1 D, 2 C, etc., to cut the diameter AB, and draw perpendiculars from these points to the base line FG. Next using the point H as centre (fig. 4), describe arcs from G *h f e d c* and F to A, also from *b i k*, etc. Now with the same compass set as the plan is divided by, as 1 2 3 4 5 B, mark off the same distances in fig. 4 from G to 5 4 3 2 1 and A, stepping from the outer curve into the second and third, and so on, and draw lines from these points to the centre H. By drawing curves from these points of intersection as A 1 2 3 4 5 G, and also from *w v u t s r* and *a*, one half of the development will be obtained.

Fig. 5 is a further illustration of the same principle. The two circles struck from centres on the line AB, show the vertical position of the section of the cone required, and from D to F the elevation. Draw perpendicular lines from C to H and from B to E, being the diameter of the base, also carry perpendiculars showing the diameter of the top of the cone to J and G, join HJ and EG, and produce them to meet at the point H, and draw a perpendicular line from H to cut the line AB at *o*, which will be used as a working centre, as the point A is in fig. 3; likewise the development will be obtained in the same manner.

Plate . 26

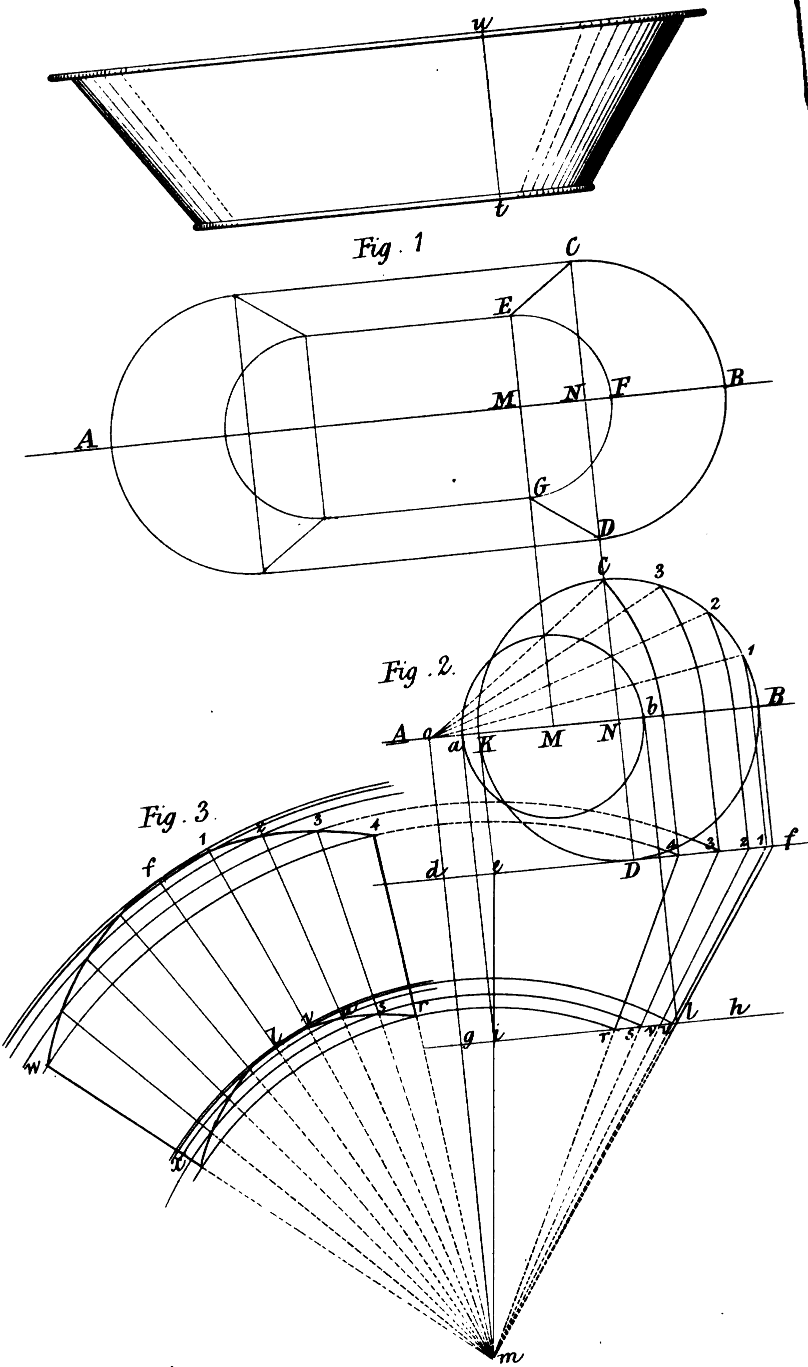

w
t
Fig . 1
C
E
A
M
N
F
B
G
D
Fig . 2.
C
3
2
1
A
o
a
K
M
N
b
B
Fig . 3.
1
2
3
4
f
d
e
D
4
3
2
1
f
w
v
u
s
r
l
h
g
i
r
s
v
u
x
m

PLATE XXVI.

To describe the pattern for a Round-end Bath, tapering more at the ends than at the sides.

It will readily be seen that the pattern required for the end of this bath is a section of the oblique cone in the last plate. The semi-circles CBD and EFG being struck from N and M as centres, extend these lines to N and M on the line AB (fig. 2), and draw two circles corresponding with the semicircles in fig. 1; one quarter of the circumference is all that is required to be divided here, as from B to C; the lines *d f* and *g h* being drawn the same distance apart as from *t* to *u*, the upright height. The vertical line from *m* to *o* will be obtained as explained in Plate 25, figs. 4 and 5. It will be observed that lines drawn from 1 2 3 and C to *o*, the working centre, will also divide the same section of the smaller circle into a like number of equal parts (a line drawn from C to *o* being perpendicular with the centre N, also cuts the perpendicular from M, the centre of the smaller circle.) Now using *o* as centre describe the arcs from C 3 2 1 to cut the diameter AB, and draw the perpendiculars to meet the line *d f*, as at 4 3 2 1 *f*; from the points thus obtained strike the various curves in fig. 3, as previously explained in Plate 25, figs. 2 and 4; and from the point *m* draw line *l f*, and with the same compass set as the section BC (fig. 2) is divided by, mark off the same distances from *f* to 1 2 3 4 (fig. 3) from the outer to the inner curve, also from *f* to *w*. Now draw lines from these points to the centre *m*, and draw a curve from the points of intersection, as from 4 3 2 1 *f*, etc., also from the points *r s u v*, etc., which will give the development of the pattern for the end, so far as shown by the semi-circles in the plan CBD and EFG.

Plate 27

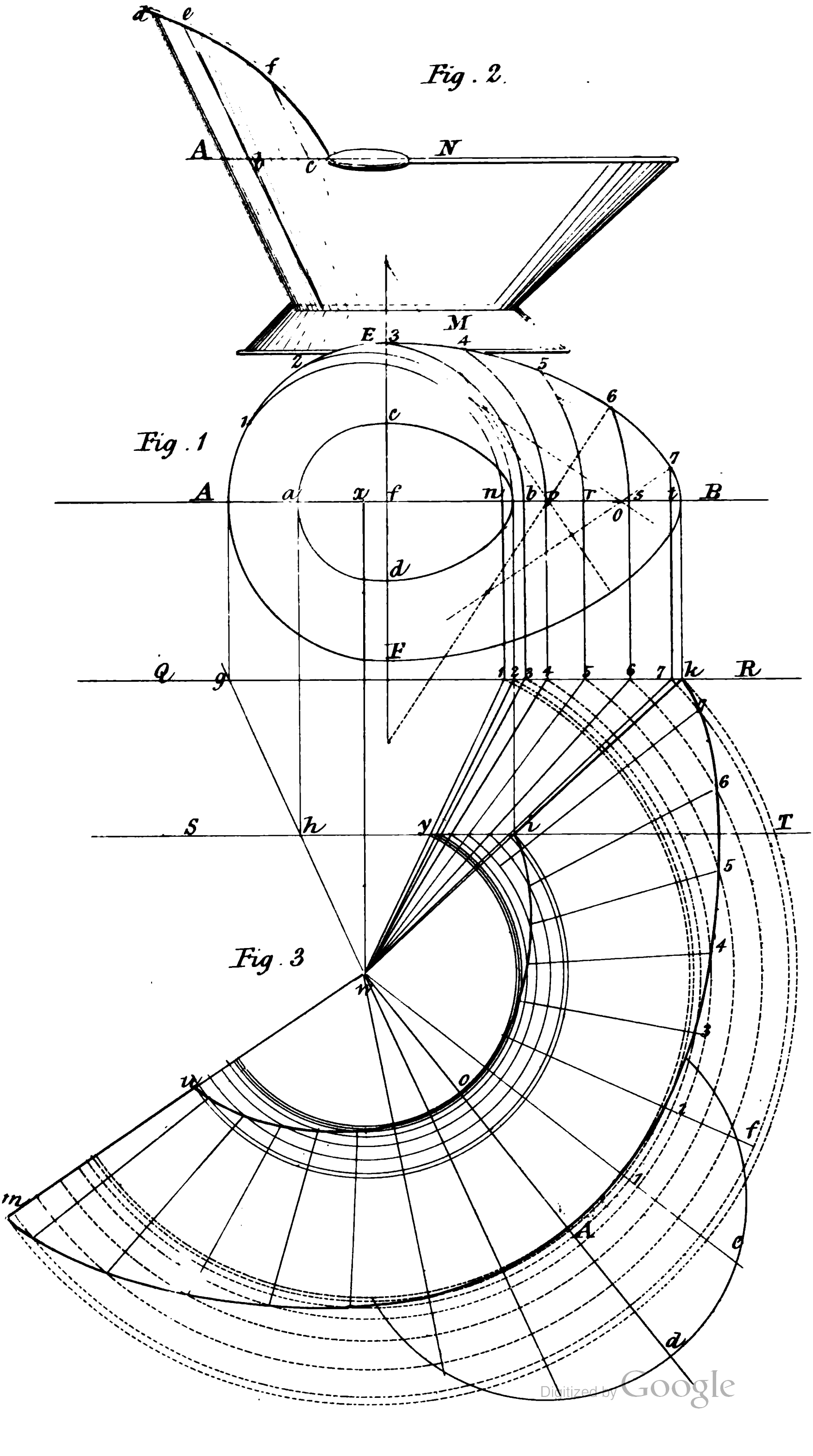


PLATE XXVII.

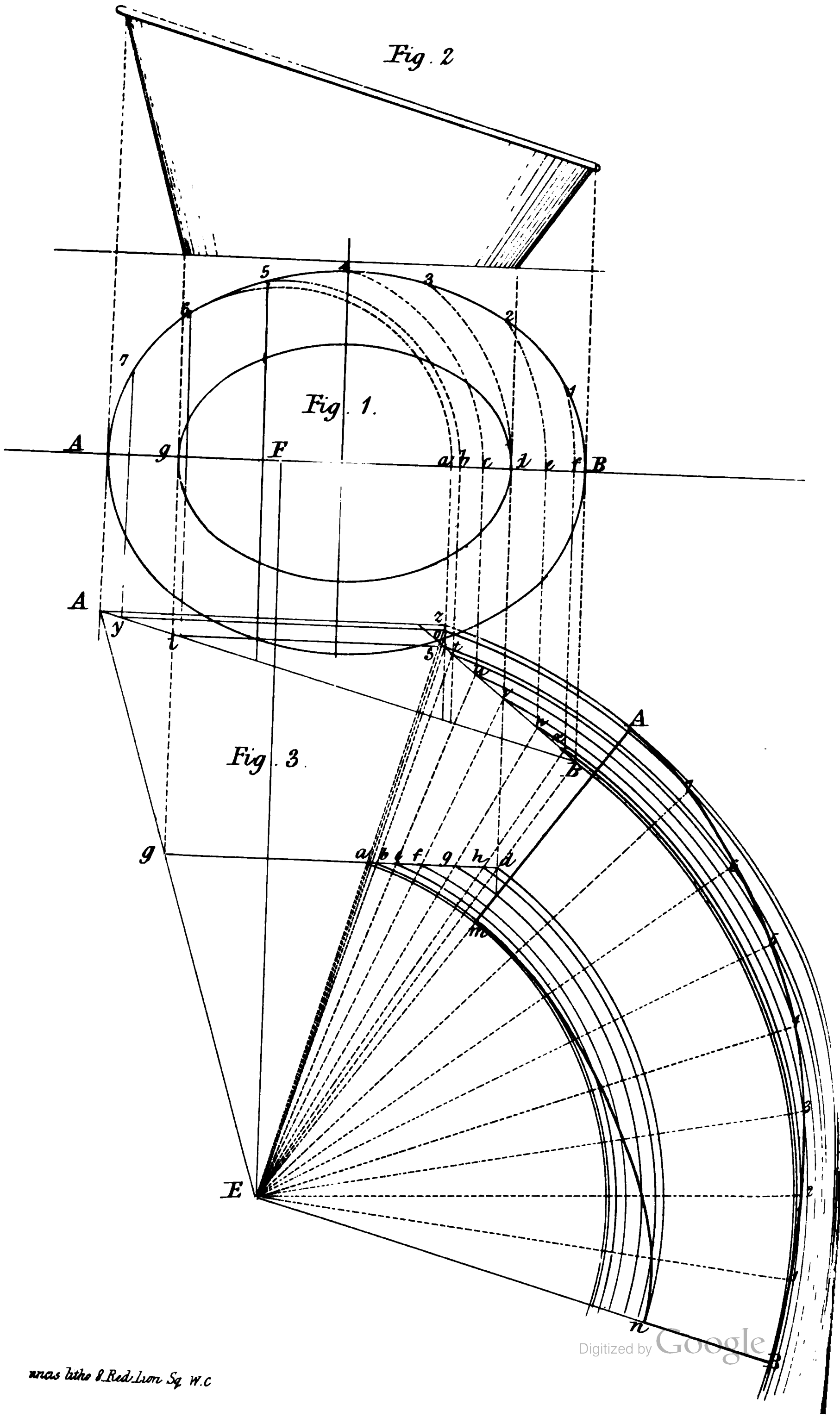
To describe the Pattern for a Hip Bath.

Fig. 1 shows the plan, also the position of the bottom, which may be drawn to any given dimensions. Let the lines QR and ST represent the perpendicular height, as from M to N (fig. 2), both drawn parallel to the diameter line AB (fig. 1).

Draw perpendicular lines from the extreme points B and A in the plan to *k* and *g* on the line QR, which will represent the top of the Bath; also perpendiculars from *a* to *h*, and from *n* to *i*, on the line ST, showing the position and length of the bottom. The smaller oval need not necessarily be drawn, only the points *a* and *n* marked off, showing the position of the bottom or the required slant of the toe and back, as the shape of the bottom will be found in the development to come in proportion.

Draw lines from the points *g h* and *k i*, and produce them to meet at *w* (fig. 3); now from *w* draw a perpendicular line to cut the diameter AB at *x* in the plan, which is to be used as a working centre; next let one-half the plan from A to B be divided into any number of parts as 1, 2, 3, 4, 5, 6, 7, and from these points, using *x* as centre, describe arcs cutting the diameter line AB, as at *t s r*, etc., and draw perpendiculars to cut the line QR, as marked by figures corresponding with those on the curve. Now, by using *w* as centre, and describing the various portions of circles, as shown, from 1, 2, 3, 4, 5, 6, 7 and *k*, likewise from the points from *y* to *i*, and taking the same distances from *k* to A and from A to *m* (on the arcs *k*, 7, 6, 5, etc.) as the divisions in the plan from B to A (in fig. 1); and by drawing lines from 7, 6, 5, 4, etc., leading towards the centre *w*, all the points of intersection will be obtained, from which the curves may be drawn (by free hand) to give the development of the pattern in one piece.

To obtain the shape of the back, draw the curve *d e f*, in fig, 2, as required, and mark off points *b* and *c*, perpendicular to 1 and 2 in fig. 1, and draw *b e* and *c f* parallel with A *d*; now transfer the lengths of A *d*, *b e*, and *c f*, from A to *d*, 1 to *e*, and 2 to *f*, in fig. 3, which will give the course of the curve of the back to correspond with the plan of the same in fig. 2.



...nnas litho 8 Red Lion Sq W.C

PLATE XXVIII.

To describe the Pattern for a Travelling Sitz Bath.

Fig. 1 represents the plan of the top and bottom required, and fig. 2 the elevation. (It will be seen that the tapering is as much in the front as at the back, but the back being much higher than the front, the tapering is not equal in proportion to the depth; this, however, may be governed according to dimensions required.) Let the horizontal line *g d* (fig. 3) be drawn to represent the required length of the bottom, as shown by the dotted lines brought down from the plan (fig. 2), and let the line AB represent the slanting length of the top, as shown by its meeting the perpendiculars drawn from the top of the plan (fig. 2); now draw lines A *g* and B *d*, and produce them to meet at the apex E, and draw a vertical line from E to cut the line AB (fig. 1) at F, which will be used as a working centre.

Let one-half the ellipse be divided into any number of parts, as 1, 2, 3, 4, 5, 6, 7, A, and using F as centre, describe the arcs cutting the diameter line AB, as at *f*, *e*, *d*, *c*, *b*, *a*; and from these points draw perpendiculars, as shown by the dotted lines. It will now be observed that the radius from F to A and from F to 7 will be (in this case) the same as from F to 6, by which the arc from 6 to *a* is drawn, which will prevent separate arcs being described from points 7 and A, as shown from all the other points; therefore a perpendicular from point 6 must be drawn to cut the line AB (fig. 3) as at *i*, and from this point draw a line to *s*, parallel with *g d* (to cut the perpendicular from *a*), and from point *s* draw a line to B, which will give the various heights (where intersected by the perpendiculars drawn from *b c d e f*) of the Bath from B to the point 6 (fig. 1). Now, from point 7, draw a perpendicular to cut the line AB (fig. 3) at *y*, and a perpendicular from A (fig. 1) to A (fig. 3); now, from *y* and A draw lines parallel to *g d*, to cut the perpendicular dotted line from *a* (fig. 1), as at *o* and *z*, which will give the two remaining points which were deficient while in the process of describing the arcs; and from all the points, as *z*, *o*, *s*, *t*, *u*, *v*, *w*, etc., describe arcs indefinitely; now draw lines from all these points to the apex E, and where the line *g d* is cut, as at *d*, *h*, *g*, *f*, etc., will be the points from which another set of arcs are required to be drawn. Take the same compass set as half of the plan (fig. 1) is divided by, and measure off the same number of distances from B 1 2 3, etc., in the development (fig. 3), stepping from the first arc into the second, third, and so on; and draw lines from all those points to the apex E, which will give the points of intersection on the smaller set of arcs. Now by drawing the curves from these points of intersection from *m* to *n*, and from the points 'A to 7 6 5, etc. to B, will give one half of the pattern required.

Plate 29.

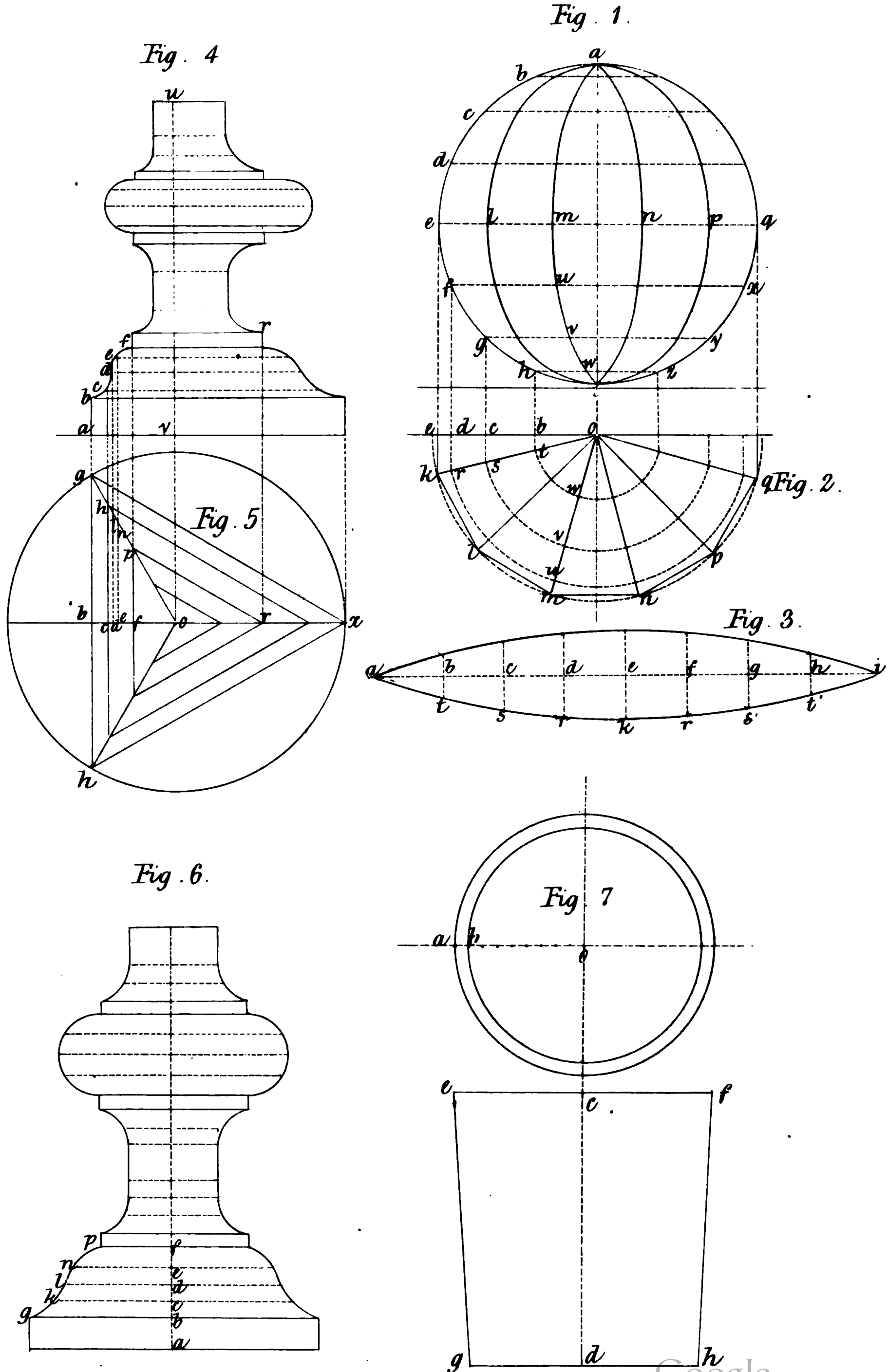


Fig. 1.
a b c d e l m n p q f u x g v y h w z
Fig. 2.
e d c b o t k r s q w v l p u m n
Fig. 3.
a b c d e f g h i
t s r k r s' t'
Fig. 4
u r f e d c b a v
Fig. 5
g h t n p b c d e f o r x h
Fig. 6.
p f n e l d k c g b a
Fig. 7
a b o e c f g d h

PLATE XXIX.

To describe the pattern for a Globe, formed of twelve pieces joined together.

In fig. 1 describe a circle the required size, and draw the perpendicular *a w*, now divide the half circle into any number of parts, as *a b c d*, etc., and draw the horizontals, as *e q*, *f x*, *g y*, etc.; next draw in fig. 2 half a circle, and divide it into six equal parts, having half a side from *e* to *k* perpendicular with the base; now in fig. 3 draw line *a i*, and mark off the points *a b c d e*, etc. the same distance apart as the corresponding letters in fig. 1, also draw perpendiculars in fig. 1, from points *h g f e*, etc. to cut the line *k o* (fig. 2), and let the distances from *b* to *t*, *c* to *s*, *d* to *r*, and so on, be transferred to corresponding points in fig. 3, which will give the course of the curve to complete the pattern.

To describe the pattern for a Triangular Pedestal or Pyramid, with all three sides alike (an equilateral triangle).

To draw the projection for this figure, let the point *x*, and the centre point *o*, come in a horizontal line, also at right angles with the line *u o*, which represents the real centre of the article, not the centre of either of the sides. Now in order that the curves may be equal on all sides, divide the circle into three equal parts, from *x* to *g* and *h*, and draw lines to the centre *o*. Now draw the required shape for the side in fig. 4, from *a b c d e f*, etc., and let this side be divided into any number of parts, and draw horizontal lines across the profile, likewise perpendiculars to intersect the lines *g o* and *h o* in fig. 5, and from these points draw lines parallel to *h x* and *g x*. Now by raising perpendiculars from all the points on the line *o x*, as shown from *x* and *r*, the direction of the curve will be obtained, showing the point or angle of the article, which at first may appear to have more curve, but by referring to the plan (fig. 5) it will be seen that the one gives a view of the side, and the other that of a point or angle. Now to develope the pattern (fig. 6) will require but little further explanation; the distances between the lines *a b c d*, etc., are transferred from the corresponding letters in fig. 4, and the lengths from *b* to *g*, *c* to *k*, etc. are equal to those similarly marked in fig. 5, which will give the course of the curves to complete the pattern.

To obtain the radius required for striking the pattern of a slightly Tapering article, without the necessity of producing lines to meet.

Let the two circles in fig. 7 represent the diameters at the top and bottom, as *e f* and *g h*, then the distance from *a* to *b* will show the flue on all sides. Take the distance from *a* to *b* with the compasses, and measure off or find how many times that distance there is between *a* and the centre *o* on the diameter line: in this case 9. Now let the upright depth, as from *c* to *d*, be multiplied by 9, and the result will be the radius required, or the length of string or wire to strike the curve with.

To show an example. Suppose the diameter of the larger circle is 18 inches, and that of the smaller one 16 inches, the distance from *a* to *b* would be 1 inch, and from *a* to *o* would be 9 times as much as from *a* to *b*. Now suppose the upright depth from *d* to *c* be 2 feet. Therefore, 9 times 2 being 18, a radius of 18 feet would strike the required curve for the pattern.

Plate 30

Fig. 1.

Fig. 2.

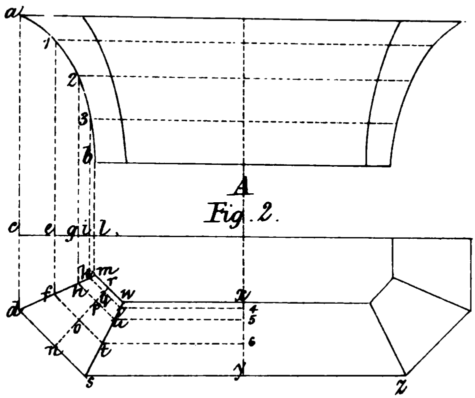


Fig. 3

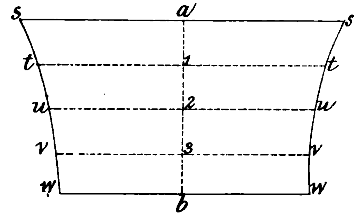


Fig. 4

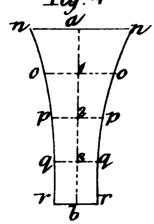


Fig. 5

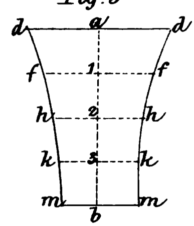


Fig. 6

Fig. 7

Fig. 8

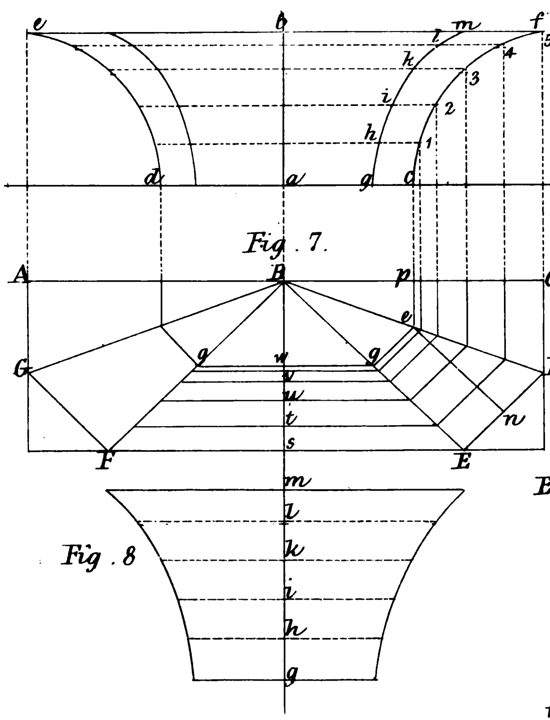
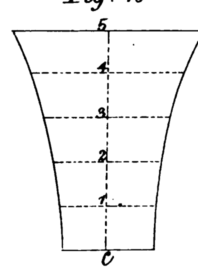


Fig. 10



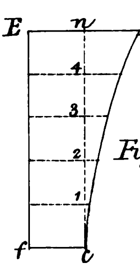


Fig. 9.

PLATE XXX.

To describe the patterns for the sides of an Irregular Octagon Pan.

Figs. 1 and 2 show the plan and elevation of the article required, having the flue or curve equal on all sides, as shown by the distance from *c* to *l* and from *y* to *x*, these being alike; therefore all that is needed to be described is to divide the curve (fig. 1) into equal parts, as *a*, 1, 2, 3, *b*, and take the same from *a*, 1, 2, 3, *b* on the perpendicular lines in figs. 3, 4, and 5; and the widths of these patterns will be obtained from the plan (fig. 2), as previously described in Plates XXII. and XXIII.

Figs. 6 and 7 show also the plan and elevation of an irregular octagon article, where the curve will not be alike on all sides, but proportionate, and its angles or section lines all leading to the centre.

Draw the elevation (fig. 6); also draw half the projection (fig. 7) AGFEDC, as required, and draw the sectional lines, from G, F, and E, D, to the centre B. Divide the curve from *o* to *f* into equal parts, as 1, 2, 3, 4, 5, and draw horizontal lines across the plan from these points; also perpendiculars to cut the line DB, and carry the lines from D *e* to E *g* and F *g* parallel with DE and EF.

Now, to obtain the pattern for the end, draw the perpendicular (fig. 10), and mark off the same distances as 1, 2, 3, 4, 5 (fig. 6), and take the distances from CD to *p e* on each side, which will give the widths of the pattern.

Next draw the line *e n* (fig. 7) at right angles with *g e*; and as this line *e n* is the same length as from *p* to C, draw the perpendicular *c n* (fig. 9), and draw the parallel lines 1, 2, 3, 4, *n*, the same distance apart as in fig. 10. Now mark off the distance from *n* to E and D, the same as from *n* to E and D (fig. 7); likewise transfer all the distances on each side of the line *n e* in the same order on fig. 9, as shown; and lines drawn from the points thus obtained will give the pattern for the small side.

Now the projection of the side from *w* to *s* being much less than that of the end from *p* to C, proceed as follows:—take the distances (fig. 7) from B, the centre, to *w*, *v*, *u*, *t*, and *s*, and mark off the same (fig. 6) from the perpendicular *a b*, to *g*, *h*, *i*, *k*, *l*, and *m*, and draw a curve from these points, which shows the fall of the side before mentioned; now draw the perpendicular (fig. 8), and draw the parallel lines *g*, *h*, *i*, *k*, *l*, *m*, the same distance apart as the corresponding letters in the elevation (these will not be equal distances apart, as in figs. 9 and 10), and make them the same length as the lines *s*, *t*, *u*, *v*, *w* (fig. 7); this being done, will give the course of the curve required to complete the pattern.

[The few points of variation between this and the plates heretofore referred to are recommended to be well studied; they will be found of great assistance in studying Plate XXXI.]

Fig. 1.

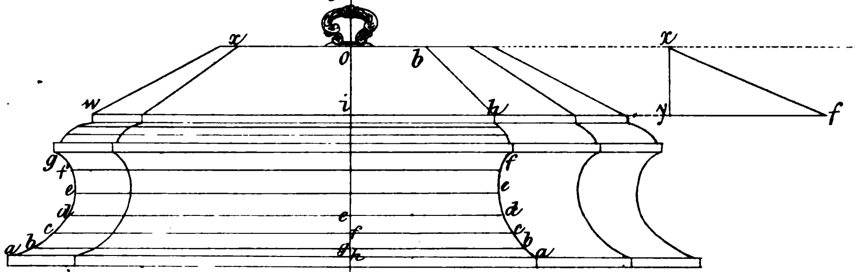


Fig 2

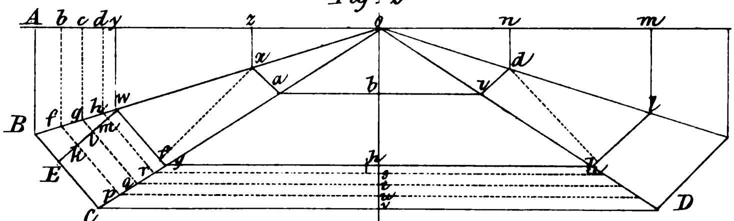


Fig 3

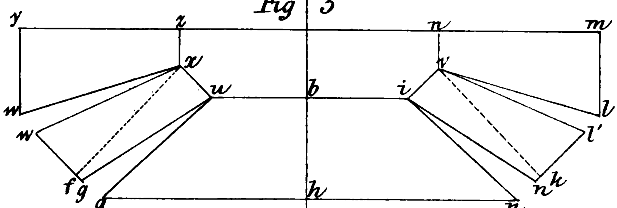


Fig 4

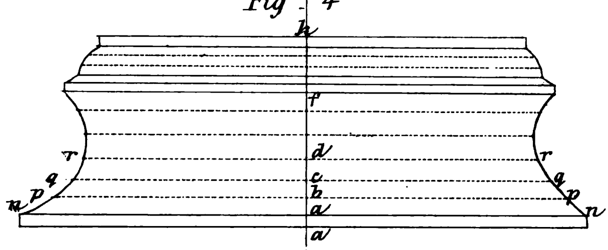


Fig. 5.

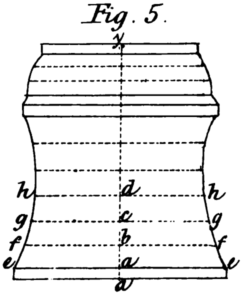


Fig. 6.

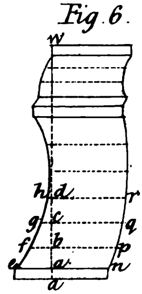


PLATE XXXI.

To describe the pattern for a Cover and Neck of an Irregular Octagon Article, such as a Tureen.

Fig. 1 represents the elevation and the required curves, and fig. 2 shows one half the plan.

To obtain the pattern for the cover, first draw the half octagon *s x u b i v n* (fig. 3) the same size as *s x a b i d n* (fig. 2), and draw through the centre the perpendicular line *b h*.

Draw the line from *x* to *f* at right angles to *x u*; also from *v* draw the line *v k*, at right angles with *v i*; then take the length of the line *x w* (fig. 1), and carry the same from *s* to *y* and *n* to *m* (fig. 3), and draw the perpendiculars *y w* and *m l*; then take the length of *y w* (fig. 2), and mark off the same from *y* to *w* and *m* to *l* (fig. 3), and draw the lines *w x* and *l v*. Now, in the projection (fig. 2), draw a line *x f* from *x*, at right angles with *x a*, and carry the length of *x f* from *y* to *f* (fig. 1), and raise the perpendicular *y x*, and draw line from *x* to *f*. Now take the length of *x f*, and mark off the same from *x* to *f* and *v* to *k* (fig. 3), and draw the line *w g* through the point *f*, parallel to *x u*; take the distances from *f* to *g* and *f* to *w* (fig. 2), and mark off the same from *f* to *g* and *w* (fig. 3), and draw lines as *w x* and *g u*.

Now take the distances from *o* to *b* and *o* to *h*, in the projection, and mark off the same from *o* to *b* and *i* to *h*, in the elevation, and draw the line *b h*. Now take the length of *b h* (fig. 1), and mark off the same from *b* to *h* (fig. 3), and through the point *h* draw *g n* parallel to *u i*; take the length of *h g* (fig. 2), and mark off the same from *h* to *g* and *n* (fig. 3), and draw lines *g u* and *n i*, which completes half the pattern for the top.

Now to describe the patterns for the sides or neck. The octagon being irregular, and the angles leading towards the centre, the several sides will take different curves; therefore each section will have a little variation.

To obtain a pattern for the end, of which BA represents one half, the process is simply to divide the curve from *a*, *b*, *c*, etc. to *g* and *w* (fig. 1), and draw the horizontal lines from these points, and also draw perpendiculars from the same points, and extend them to cut the lines AO and BO, in the projection (fig. 2). On the perpendicular line (fig. 5) take a corresponding number of distances, and draw the horizontal lines, as *a*, *b*, *c*, *d*, etc., and on each side of these points mark off the points *e e*, *f f*, *g g*, etc., the same length as AB, *b f*, *c g*, *d h*, etc. (fig. 2). A curve drawn from the points so obtained will give the pattern for the end.

Note.—The lines in fig. 2, as AB, *b f*, *c g*, etc., are not all that would be obtained from the points in the curve (fig. 1), but they will sufficiently illustrate the principle.

Now, to obtain the pattern for the side from B to C, draw the lines from *f* to *p*, from *g* to *q*, and from *h* to *r*, etc., parallel to BC, and draw a line from *w* to E, at right angles with *w f* or BC, precisely the same as the line *x f* was drawn at right angles with *x a*. Now draw the perpendicular line (fig. 6), also the horizontals, as from *a*, *b*, *c*, *d*, etc., the same distance apart as in fig. 5; and take the distances from E to B and C, and mark off the same from *a* to *e* and *n* (fig. 6), also the distances from *k* to *f* and *p*, and mark off from *b* to *f* and *p*, and so on until all the points are obtained, which will give the direction for the curve to be drawn to give the pattern for the small side.

Now draw lines from *p*, *q*, *r*, etc., parallel to CD (fig. 2), and take the distances from *o v*, *o u*, *o t*, *o s*, and *o h*, and transfer the same from *h* to *a*, *g* to *b*, *f* to *c*, and *e* to *d*, and so on, to *i h*; and from the points thus obtained draw the curve from *h* and *f* to *a*. Take the distances between the horizontals (previously drawn from the curve at the extreme end), and on the perpendicular (fig. 4) mark off corresponding distances, and draw the horizontal lines, and take the distances from *v* to C, *u* to *p*, *t* to *q*, and *s* to *r*, etc. (fig. 2), and transfer the same on each side of the perpendicular line (fig. 4), from *a* to *n*, *b* to *p*, *c* to *q*, etc. A curve drawn from these points will complete the necessary patterns.

Plate 32.

Fig. 5

Fig. 1.

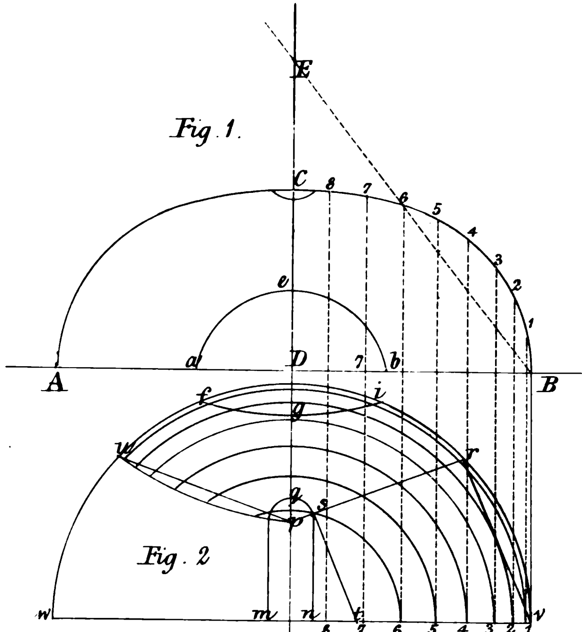


Fig. 2

Fig. 4.

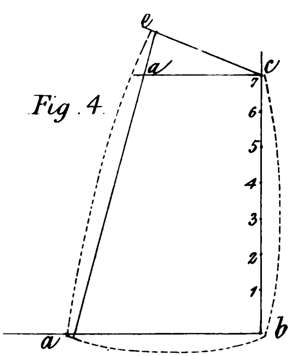


Fig. 3.

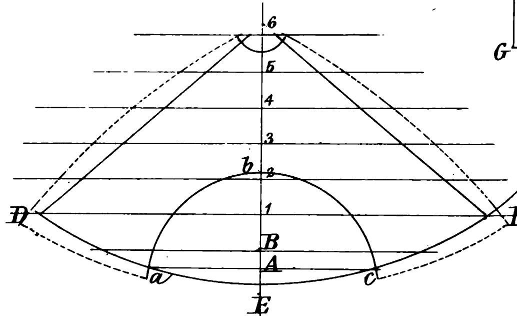


PLATE XXXII.

To describe the pattern for the Top of a Jack Screen.

[It will be seen that, in striking this pattern, sufficient allowance must be made for hollowing, in addition to the leading points obtained. This must be left to the judgment of the workman, as there are no known rules to describe it.]

Fig. 5 represents the article of which the development of the top is required.

Fig. 1 shows the elevation or the shape of the front of the screen, and fig. 2 gives the shape of the top or projection, the top being intended to be made in three pieces.

Draw in the projection the shape of the hole for the jack to work through, as shown by *m q n*, and draw lines from *u* and *r* to the centre *p*, from any part of the outer curve that will make the back and side-pieces look proportionate or convenient for material. Now divide one side of the elevation into any number of equal parts, and draw perpendiculars to cut the line *w v* in the projection, as marked by corresponding figures; and from these points describe arcs cutting the lines *r p* and *u p*.

Now the height of the top, as far as the back piece, will come, is shown by the arc drawn from 6 intersecting it at *s*; therefore, from B (fig. 3) mark off 1, 2, 3, 4, 5, 6, the same distance apart as the same figures in fig. 1, and draw the horizontal lines from B to 6. Now the curve *a e b* in fig. 1 represents the opening in the top for the doorway, and the curve *f g i* (fig. 2) gives its course in the projection, shown by the point *g* coming between the second and third arc, as the point *b* (fig. 1) comes between the second and third perpendicular; draw FGH at right angles, and take the distance from D to *e* (fig. 1), and mark off the same from G to F, also the distance from *g* to the outer curve in the projection, and mark off from G to H, drawing the line FH; now let difference between the distances from FG to FH be added on from B to A (fig. 3), and draw the line *a c*; draw the curve *a b c* about one-fourth wider than *a b* in fig. 1, as it will draw in much closer by hollowing. Draw line from B to 6 (being the height of the back piece as previously stated) and extend it to cut the perpendicular at E; now with radius EB describe the curve for the bottom of the pattern from points *a* and *c*, and take the distance from *f* to *u* (fig. 2) and an allowance for the seam, and mark off from *a* to D, and *c* to F, and draw lines from points so obtained to 6; now draw the dotted curves for the hollowing as shown, according to judgment.

To obtain the pattern for the side, draw the line *r v* at right angles with *r s*, and also the line *s t* in the same manner, now draw *o b a* (fig. 4) at right angles, and by taking the distance from *r* to *s* in fig. 2, and by measuring off the same distance on the line AB (fig. 1) from B it will just reach the perpendicular 7; now take the distance from B to 7 on the curve, and mark off the same from *b* to 7 on the perpendicular in fig. 4, and draw *c a* at right angles with *c b*. Take the distance from *s* to *t* (fig. 2) and mark off the same from *c* to *a* (fig. 4) also take the distance from *r* to *v* (fig. 2) and mark off the same from *b* to *a* (at the base, fig. 4) and draw line from points *a a* and extend it; now take the distance *n* to *t* (fig. 2) and let the same be added on from *a* to *e* (fig. 4) and draw line *c e*, this will give the main points and size required for the pattern of the side; curves for hollowing and wiring to be added on as shown by dotted lines.