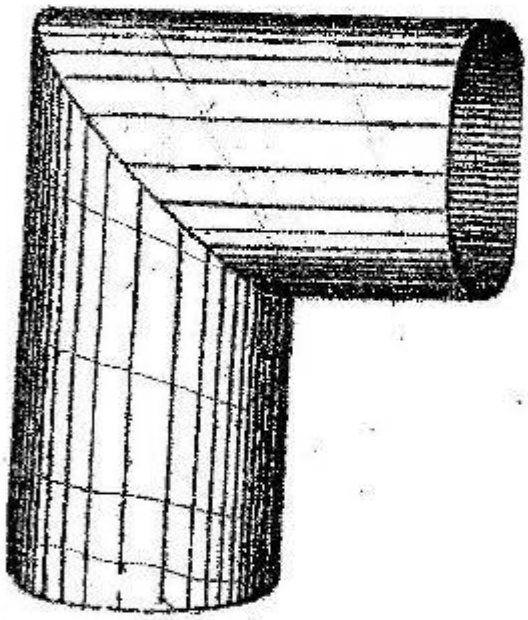
Reading Material
On
Fabrication of Pipe Bends



HUMAN RESOURCE DEVELOPMENT CENTRE
ROURKELA STEEL PLANT
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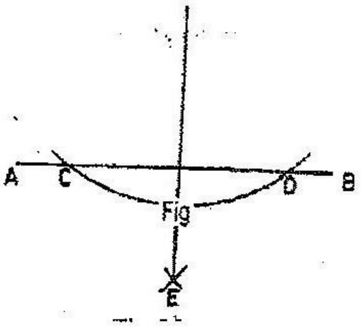
Exercise: *To draw a perpendicular on a line through a point not on the line.*

Solution: Consider a line *AB* and a point *0* outside the line. Assuming *0* as centre and taking any radius draw an arc cutting the line *AB* at *C* and *D*. Now with the same radius and *C* and *D* as centres draw arcs which intersect at *E*. Join *OE*. This *OE* will be the required perpendicular.



Exercise: *To bisect a given angle.*

Solution. Let *ABC* be the given angle. With *B* as centre and any radius *BE* draw an arc *DE*. With same radius and centres *E* and *D* draw arcs which intersect at *P*. Join *PB*. Angle *ABP* =Angle *CBP* thus bisecting the angle *ABC*,

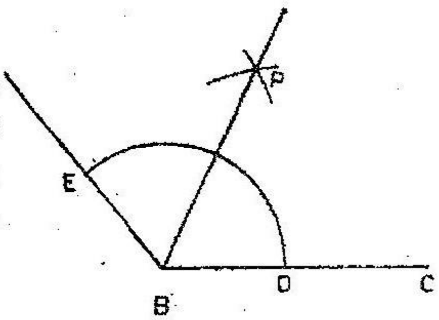
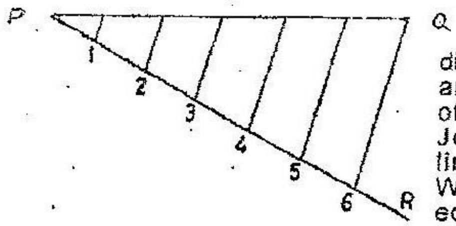


Fig.

To divide a given line into a number of equal parts.



Solution: Let *PQ* is a line and it is to be divided into six equal parts. Draw a line PR at any angle to *PQ* but not exceeding 45° With the help of a divider cut six equal parts on the line *PR*. Join the last point 6 with *Q*. Now draw parallel lines to *Q6* through different points on *PR*. Where these lines intersect *PQ* will give the six equal parts of *PQ*.

Fig.

Exercise: *To find the centre of a given circle.*

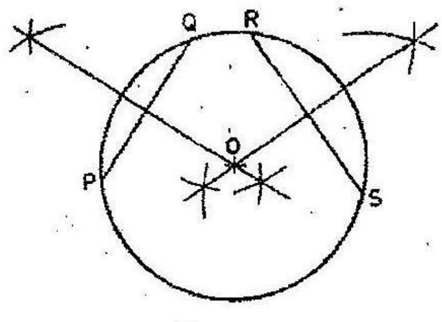


Fig.

Solution: Draw any two chords *PQ* and *RS* of the circle. Draw the bisectors of these chords which intersect at *0*. *0* will be the centre of the circle .

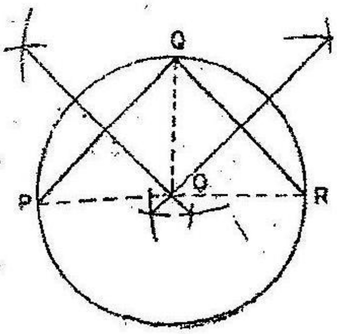


Fig.

Exercise : *To describe a circle through three given points P, Q and R.*

Solution. Join *PQ* and *QR* (Fig. 3'G), Draw the bisecting lines of *PQ* and *QR* at right angles. The right angle bisectors will meet at *0*, which is the required centre with radius *OP*, *OQ* or *OR*.

Exercise: *To draw a tangent to a given circle from a given point outside the circle.*

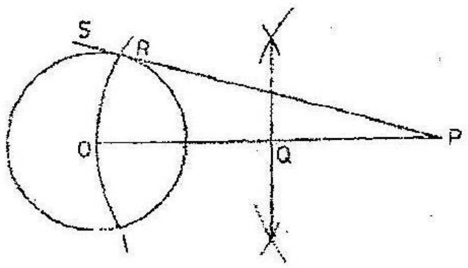
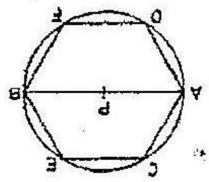


Fig.

Solution. The given circle has *0* as centre. It is required to draw a tangent to the circle from point P. Join *OP*. Now draw bisector of line *OP*. Which will cut *OP* at *Q*. With *Q* as centre and *OQ* as radius draw an arc which will cut the circle at *R*. Join *PR*. *PRS* is the required tangent on the circle.

Exercise : *To inscribe a hexagon in a circle.*



Solution. Consider a circle with centre *P* Draw the diameter *AB*. Now with *A* as centre and *PA* as radius (radius of circle) draw arcs cutting the circle at *C* and *D*. Again with *B* as centre and radius equal to radius of circle draw arcs cutting the circle at *E* and *F*. Join *ACEBFD*. This will give required hexagon.

Exercise: *To construct a regular pentagon on a given base.*

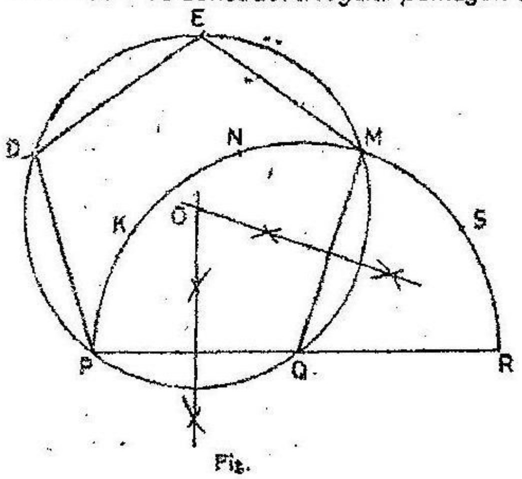


Fig.

Solution. *PQ* is the given base on which the regular pentagon is to be constructed. Produce *PQ* so that

PQ=QR

Now with *Q* as centre and *PQ* as radius draw a semicircle and divide it into five equal divisions. *(BS=SM=MN=NK =KP)*. Join *QM*.

Bisect *PQ* and *QM* so that bisectors intersect at *0*.

Now *0* as centre and radius equal to *OP* draw a circle and mark off on the circle points *E* and *D* so that

ME=ED

=DP=PQ

PQMED is the required regular pentagon.

ISOMETRIC PROJECTION

Generally orthographic projection i e. Elevation, plan and end view of an object are drawn to define its shape, and size. But sometimes to have clear concept of the object it becomes essential to supply the pictorial drawing of the object. In pictorial drawing the object is viewed in such a position that several faces appear in a single view. Pictorial drawings in single plane are classified as follows:

(i) Axonometric projection,
(ii) Oblique projection,
(iii) Perspective projection.

Axonometric Projection

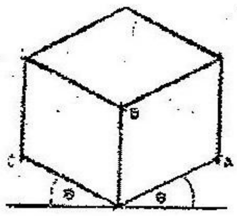
In axonometric projection the projector lines from the object to the picture plane are orthographic *i.e.* they are perpendicular to the plane and are thus parallel to each other.

Axonometric projection is of three types:

(a) Isometric projection.
(b) Dimetric projection.
(c) Trimetric projection.

Isometric projection. In isometric projection the three faces of the object make equal angles with the plane of projection. Line of sight is perpendicular to the plane of projection. Isometric drawing is based on equal measurements and three lines called isometric axes are required to draw the isometric view of the object. In the isometric view of an object the horizontal lines in the original object are rotated through angle of 33° to the horizontal and all vertical lines in the original object remain vertical in isometric view. When drawing isometric views only one scale is used. As shown in Fig. *OA*, *OB* and *OC* all are drawn to the same scale and angle θ=30°.

Dimetric Projection: In dimetric projection the object is set at an angle to the picture plane so that any two of its three dimensions are equally foreshortened on the pictorial view the third dimension is shortened to a different amount. As shown in Fig. *OA*, and *0C* are drawn to the same scale and *OB* is drawn to a different scale. Angle θ is any convenient angle.



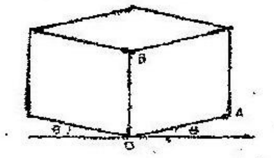


Fig. 3.3 Dimetric projection.

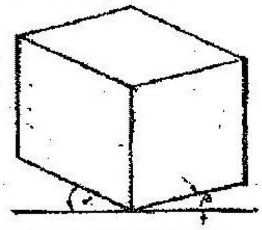


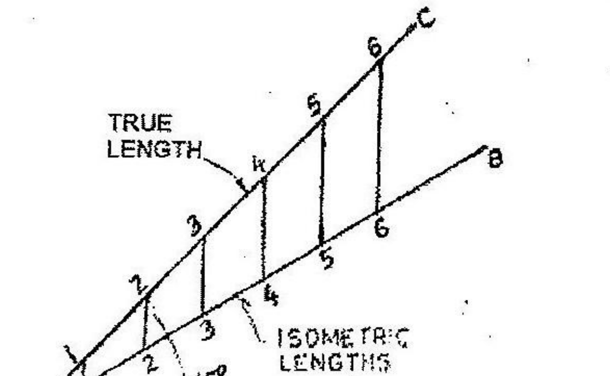
Fig. 3.4. Trimetric projection.

horizontal. Draw vertical lines to OA

Trimetric projection. In trimetric projection the object is set at such an angle to the picture plane so that all its three dimensions (length width and height) are foreshortened on the projected view to a different amount. As shown in Fig., *OA,OB* and *OC* are all drawn to different scales and angles α and β are different angles. In all axonometric projections edges which are parallel on the projected view.

Isometric Scale

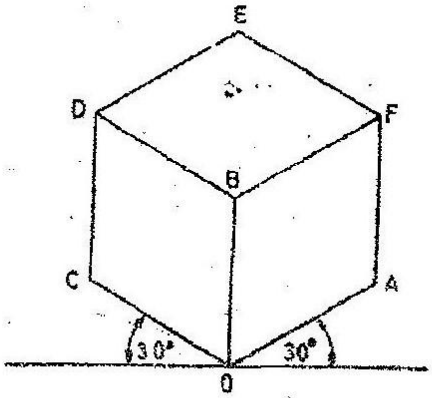
In isometric projection isometric scale should be used. But in usual practice the actual measurements are used in isometric, drawing. The construction of isometric scale is illustrated in Fig. Draw a horizontal line *OA*. The true lengths are taken on a line *OC* inclined at 45° to the horizontal. Then a line *OB* is drawn at 30° to the horizontal. Draw vertical lines to *OA* from different points of true lengths on *OG*. The corresponding points on the 30° line *OB* give the isometric lengths.



scale.

Fig. Isometric scale

Example: *Draw the isometric view cube each of side 2 cm.*



Solution. Draw three axes *OA*, *OB*, *OC*. *OB* is vertical and *OA* and *OC* being inclined at angle 30° to the horizontal.
Measure *OA* = *OB* = *OC* =2 cm.
From *C*, and *A* draw vertical lines. From *B* draw a line *BD* parallel to axis *OG* to locate *D*. Again from *B* draw *BF* parallel to axis *OA* to locate *F*.

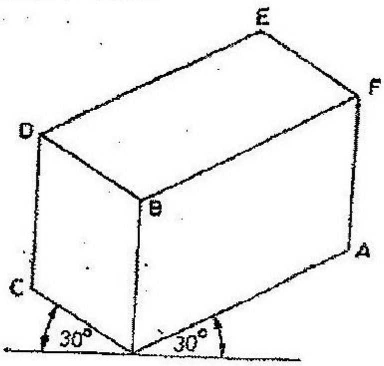
Now from *D* draw *DE* parallel to *OA* and from *F* draw *FE* parallel to *OC* and where they will intersect it will give point *E*.

Example: *Draw the isometric view of a rectangular block 20X80X 60 mm.*

Solution. Draw *OA* and *OC* at an angle 30° to the horizontal. Set out

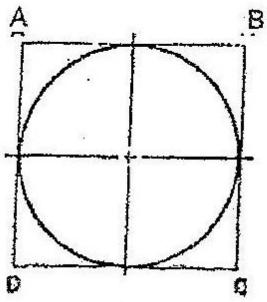
OA = 80
and OC = 20mm

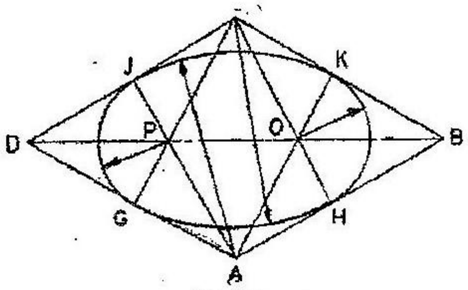
Draw *OB* vertical and cut *OB*=60 mm. From *C* draw *CD* vertical and from *A* draw *AF* vertical, Now draw *BD* parallel to *OC* and *BF* parallel to *OA*.
Then draw *DE* parallel to *OA* and *FE* parallel to *OC*,
DE=*80* mm
and *FE*=*20* mm.



Circle in Isometric Drawing

Circle in isometric drawing appears as ellipse. The four centre method of drawing ellipse is illustrated as follows.
(i) Draw the circle of given diameter and enclose the circle in a square *ABCD*.



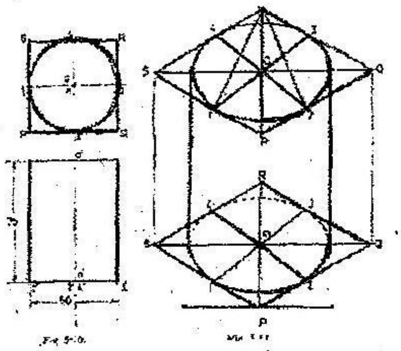


(ii) Construct an isometric squire the side of it being equal to the diameter of the circle. Draw the bisectors *CG and OH* from *C* and *AJ* and *AK* from *A* and then draw an arc with radius *AJ* and centre *A*

Repeat the same with *C* as centre. Join these arcs by smaller arcs drawn with P and Q as centres and radius *PJ.*

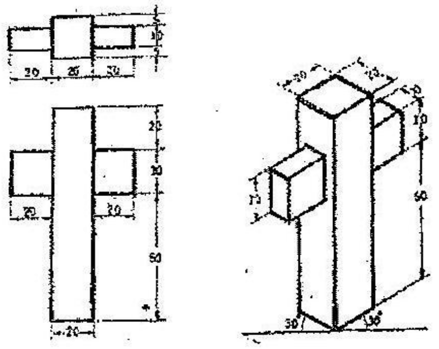
Example: *Draw the isometric view of a cylinder base 50mm dia and 70mm long.*

Solution. Draw the elevation and plan of cylinder shown in Fig. Enclose the cylinder in a square box. Draw the isometric view of the box. Then draw the isometric view of circles to complete the isometric view.



Example: *Fig. Shows the plan and elevation of a cross. Draw its isometric view.*

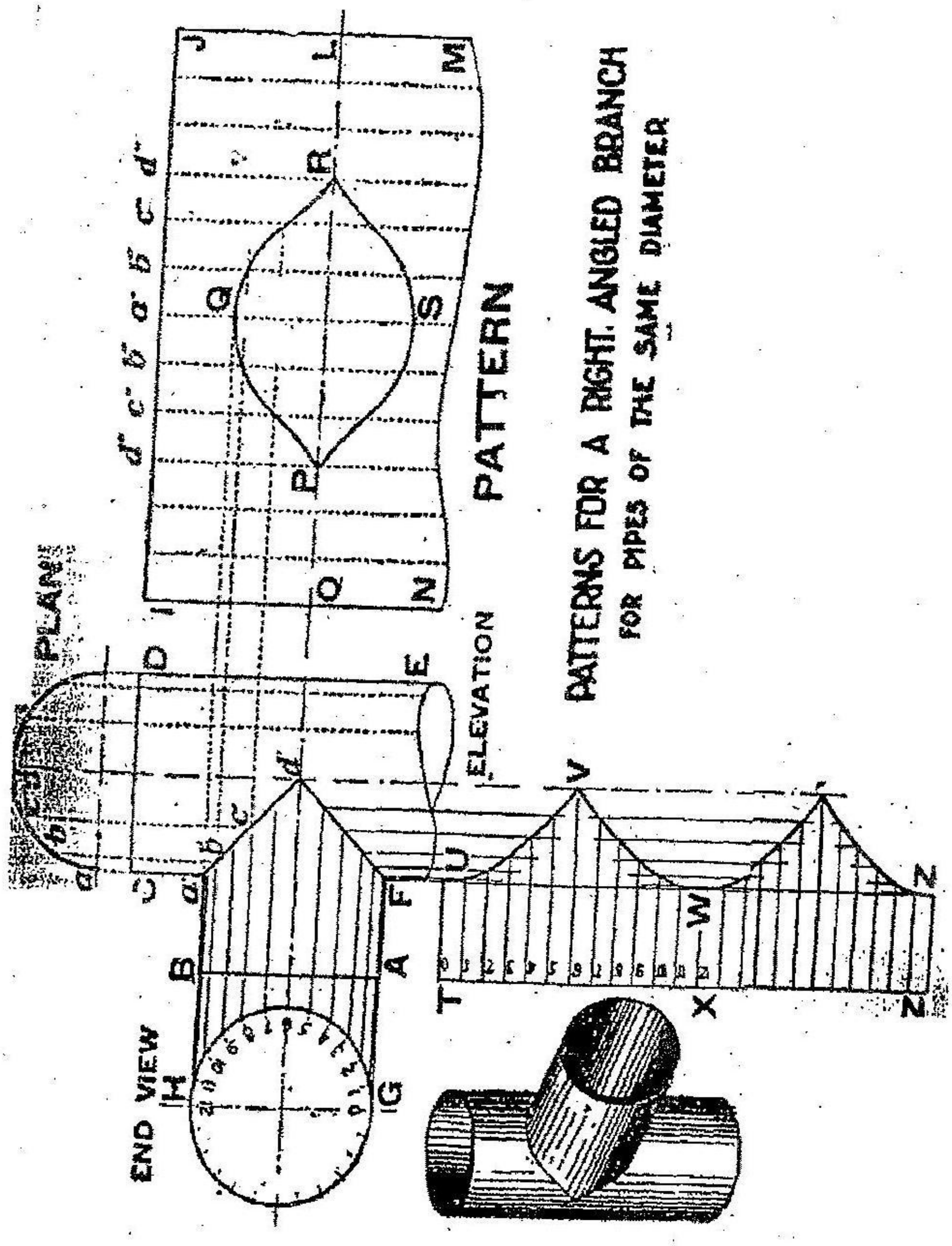
Solution: The isometric view of cross is shown fig.



PATTERNS FOR A TEE PIPE.

The problem involves the development of two intersecting cylinders, of equal diameters. The solution here given is the more important because it applies to a large class of elbows and other objects composed of intersecting cylinders. The method here used, may also be used where the intersecting cylinders are not of the same diameter. A hole must be cut in the vertical or *run* pipe to provide an opening of suitable shape for the *branch* pipe and the end of the branch pipe must be shaped to fit the opening in the run.

NIJM, shows the development of the run pipe. The length IJ, is that of the circumference of the pipe, half of which is shown in the plan. The equally measured divisions on this circumference are put together to make up the line IJ. At right angles to this line, the lengthwise edges of the development of the run pipe are shown by the lines IN, and JM. Only a part of the length of this pipe is developed, the part around the required opening PQRS.



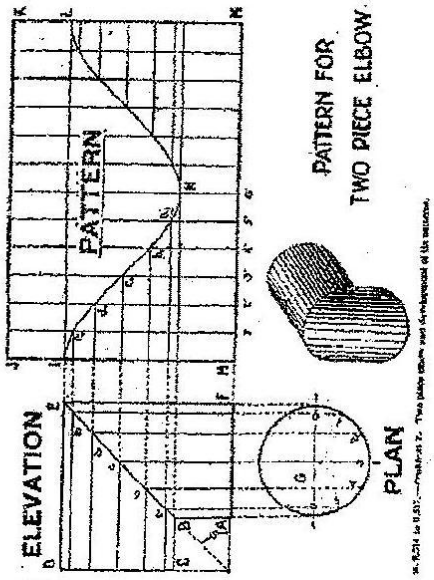
Tee pipe with run and branch of same diameter, and development of it pattern.

From the points of division in the plan, the longitudinally drawn projecting lines furnish on the joint line a'd', the points a', b', c', d'. From these, another series of projecting lines is drawn to the development, intersecting the longitudinal lines on the development which start from the points d", c", b", a', b", c', d", thus giving points defining the outline of the opening PQRS as clearly shown.

In a like manner the other pattern, Z,T,U,Z is obtained from *A.B.a'.b'.c', d'*. The circumference of the branch pipe GH, is divided at the points 0,1,2,3, etc., into equal parts. All these divisions are laid down, together, on the line ZT, so that the length ZT, is equal to the entire circumference of the branch pipe.

The procedure for the tracing of the outline Z'YWVU is the same as for the opening PQRS, It is clearly shown by the lines.

The patterns do not show any laps for joints.



PATTERNS FOR A TWO-PIECE ELBOW

A two piece elbow for round pipes may be imagined to have been made up of two adjoining parts of one pipe that was cut at a miter of 45°. Hence, the patterns for the two halves of the elbow may be obtained first by developing the whole pipe of which the elbow parts are to be derived, and secondly, by dividing this development into two portions, in a suitable manner.

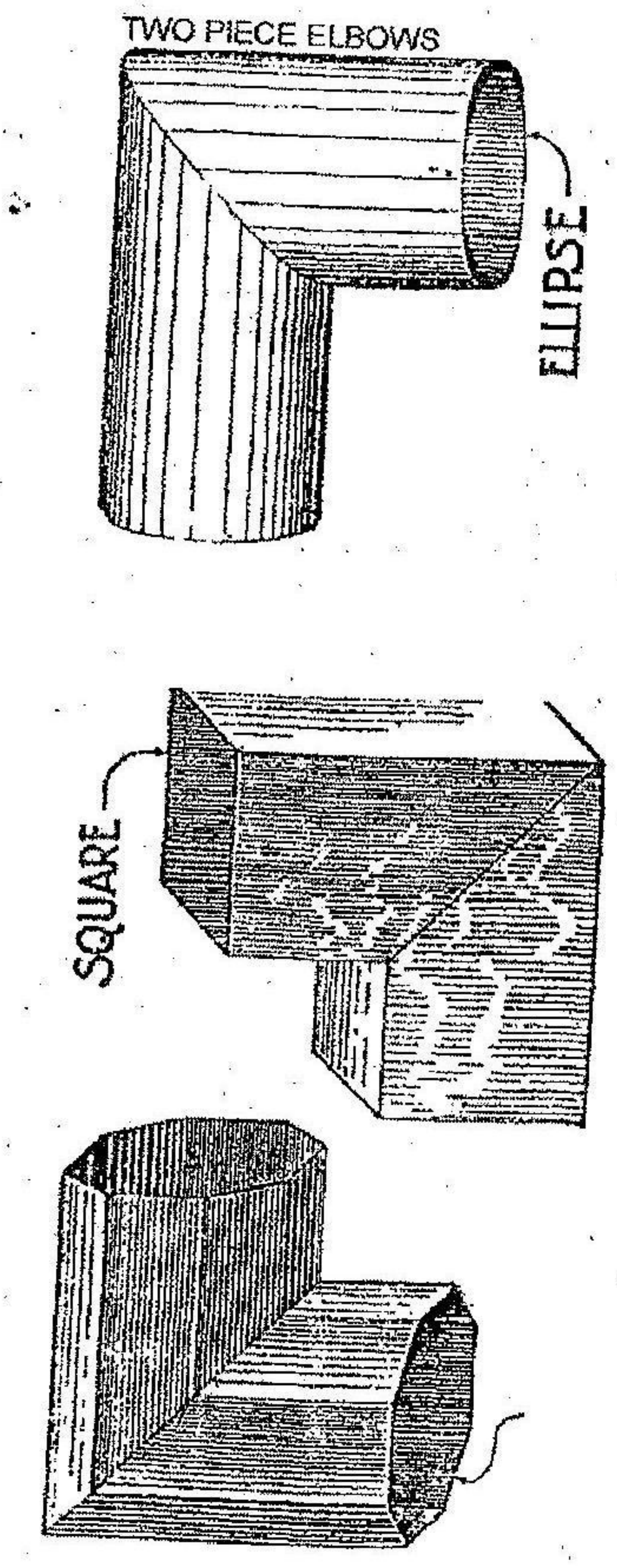
In the elevation, ABEF, is one part of the elbow and the other part BCDE, is identical to the first part.

In the plan is shown the circumference of the elbow with a convenient number of equal divisions.

In the pattern development, HJ, is taken equal to AB + FE (in elevation). HJ, then represents the length of the single pipe that is to furnish the two component parts of the elbow. Hence develop the cylinder, whose length is HJ, in the rectangle HJKM, wherein the divisions upon HM, are reproductions of the divisions on the circumference shown in plan, so that HM, is equal to the stretched out circumference.

Vertical or elementary lines (1'2'3' etc.) are drawn from the points just obtained. Project point 1,2,3, etc., in plan to cut the miter line EB (in elevation) in points B,a,b,c, etc., whence, in turn, horizontal projecting lines are drawn to intersect the elementary lines upon the development in the points N, a,*b*, etc., thus giving the curve lN, as well as its counterpart NL. This curve divides the development into the two halves of which the elbow is to be made up.

The pattern does not show which laps should b<i provided for the joint. For method of making this provision see Problem 3.



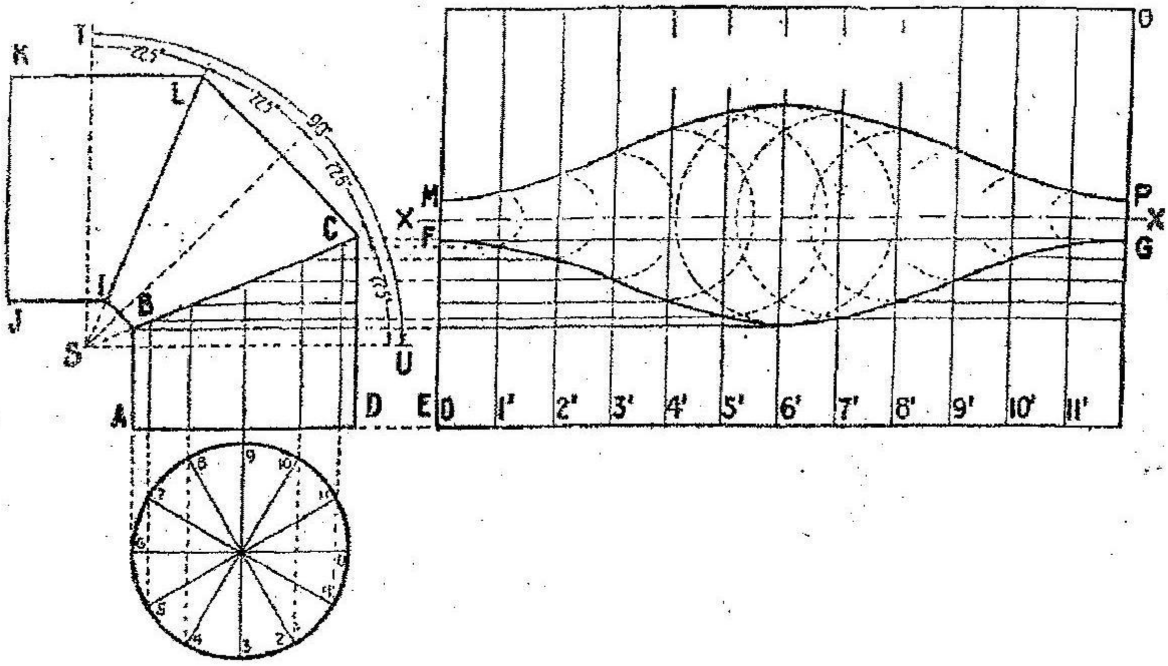
OCTAGON

Two piece elbows. A. Elliptical, B. Square; C. octagonal.

PATTERNS FOR THREE PIECE ELBOW

Three piece elbow and development of its patterns.

Problem: Patterns for a three-piece elbow. The general shape of the elbow is shown in the elevation. The imaginary cylinder from which the three parts of the desired elbow are to be had will be equal to the combined lengths CD, IB, and KL, in elevation. This combined length is shown as EN, in the development wherein EF, is equal to DC;



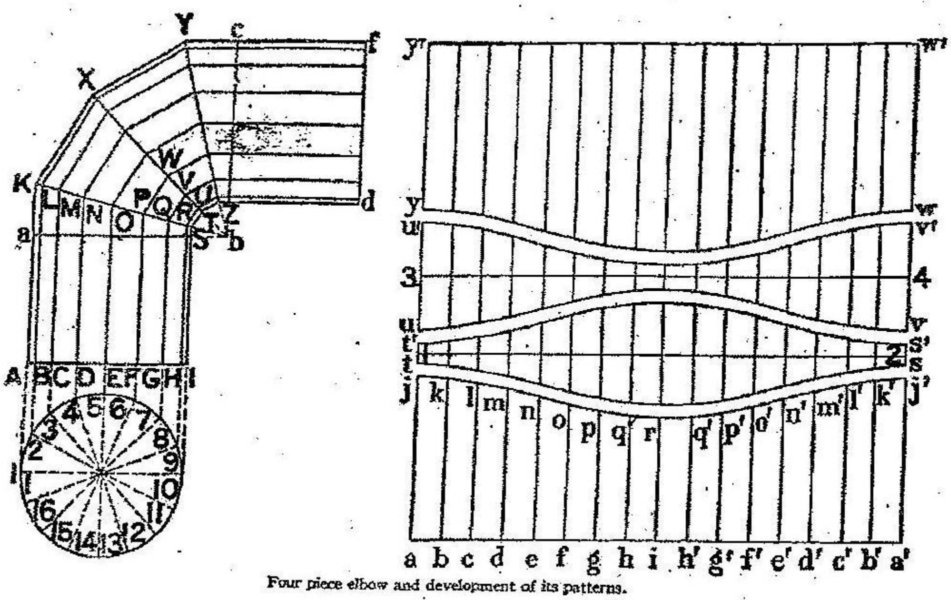
FM, equal to BI; MN, equal to KL. The development of the imaginary cylinder is shown as the rectangle ENOH, EH being equal to the length of the circumference of the pipe shown in plan. The development of the pattern is by elementary lines through points 0, 1', 2', 3', etc., parallel to EN. and spaced equal to the arc distance, between similar points 0,1,2,3, etc., in plan.

By projecting points 1,2,3,in plan up to miter line BC, in elevation, thence, over to pattern, the intersections with corresponding elementary lines 0,1', 2',3', etc., will give points defining the curve FG.

To obtain the curve MP, draw the center line XX' so as to bisect the distances MF and PG. Then, set off upon each of the elementary lines 0,1', 2',3', etc., above XX', the amount which the curve FG, deviates from XX', thus obtaining similar points which define curve MP.

PATTERNS FOR A FOUR PIECE ELBOW

In the elevation, the four pieces forming the elbow are AKSI, KXTS, XYZT, and Y/tfZ. Of these four parts, the two larger parts, AKSI and Y/rfZ. are equal, The same is true of the two remaining



Four piece elbow and development of its patterns.

Smaller parts KXTS and XYZT.

To lay out these parts in the elevation a right angle *abc*, is drawn, the sides of which intersect at right angles, the two largest branches of the joint. It is evident that the point *b*, must be equidistant from both pipes.

The right angle *abc*, is divided first into three equal parts and then each one of these parts is divided in turn into two equal parts; the right angle is thus divided into six equal parts, of which *Kba*, is one part, *KbX*, equals two parts, XbY equals two parts and *Ybc* one part. It will be noticed that this construction does not depend on the diameter of the pipe.

The problem of developing the four part elbow resolves itself into developing two only of its parts, one large branch and one smaller part of the elbow, the remaining parts being correspondingly equal to these.

The circumference of the pipe, as seen in plan, is divided into sixteen equal parts by the points 1,2,3,4,5, etc.

Through these points are drawn lines parallel to the center line of the pipe which is to be developed.
In the development, the vertical branch of the elbow, (AKSI, of the elevation), will be taken up for the purpose. The parallels upon the surface of this branch are AK, BL, CM, DN, EO, FP, GQ, HR, and IS. Through the points K,L,M,N,O,P,Q,R, and S, draw parallels for the part KXTS, which will be next developed; some of these parallels are ST, RU, QV, PW.

To develop the vertical branch of the four piece elbow set off, upon a straight line *aa'*, sixteen equal parts, which altogether are equal to the circumference of the cylinder, which is to be developed.

Let the division points *a,b,c,d,e,f,* etc. correspond to the division points, 1,2,3,4, etc., upon the circle in plan. Through the points, *a,b,c,d,e,* etc., draw vertical lines equal to the parallel lines drawn upon the surface of the vertical branch of the joint; thus *aj,* is made equal to AK, *bk,* equal to BL; *cl,* equal to CM and so on until *ri* is made equal to SI.

The part laid out so far is *ojklmnopqri.* This is one-half of the development; the other half, *irj'a'* being exactly the same as the first one, may be laid out in the same way.

The part *tt' ss'* is the development of the small part of the elbow. It is evident that its length, *ts,* must be equal to the circumference of the pipe in the elbow. The lines in the pattern, *tt' ss'* drawn at right angles to the center line of it, and bisected by it, are made equal to the parallel lines, ST, RU, QV, PW, etc., drawn upon the surface of the part, KXTS, in the development.

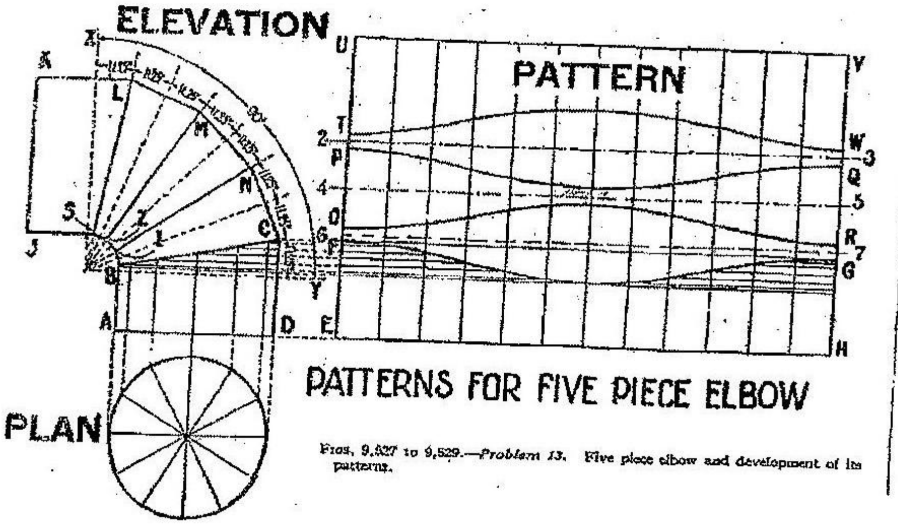
It is plain that the part, *uu' vv'* is equal to the part *tt'ss',* with the difference that the small parallels in it are laid out above the large parallels in the other part; in the same manner, the part *yy' ww'* is equal to the part *aja'j'.*

Laying out the pattern in this manner makes it possible to cut out the complete elbow from the square piece of metal, *ay'w'a'.* The spaces between the patterns are left for laps, which are necessary for joining all parts.

PATTERNS FOR FIVE PIECE ELBOW

Problem Patterns for a five-piece elbow.

The five parts of the elbow may be thought of as so many parts of one long pipe, cut to the miter angle at proper distances. The length of that ' cylinder, this time, will be made up of the sum of the alternately consecutive outlines of the five parts of the elevation of the required elbow. Thus, in the development of the whole cylinder shown at EUVH, the vertical edge EU, is equal to the combined lengths of DC, BI, MN, ZS and KL, laid off on the development as the lengths EF, FO, OP, PT and TU.



Figs. 9,527 to 9,529.—*Problem 13.* Five piece elbow and development of its patterns.

Along the horizontal edge of the development, on EH, lay off all the equal parts into which the circumference of the elbow pipe is divided and, from the points of division on the edge EH, draw vertical elementary lines across the development.

From the division points on the circumference, projecting lines are drawn upward to the miter line BC, cutting it in a number of points from which, in turn, horizontal projecting lines are drawn meeting the vertical elementary lines on the development in points forming the curve FG. The miter line, as is seen in the elevation, has an angle of $11^1/_4$°.

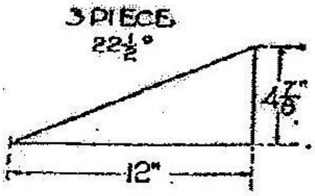
The curve OP, is plotted so as to be an exact counterpart of the first curve, at the other side of the center line 6,7, which bisects OF, and RG; that is, curve OR, is the curve that would be obtained by revolving curve FG, 180° on 67°, as an axis.

Having obtained the second curve OR, a second center line 45, is drawn bisecting OP and RQ, and, above this center line, the curve PQ, is plotted so as to deviate from the center line, along each vertical elementary line exactly as much as the curve OR deviates from the center line.

In a like manner, with the aid of the third center line, 23, the curve TW, is laid out opposite and equal to the curve PQ, the center line 23, bisects PT and QW. For simplicity in explaining the development no laps are provided for joints. The method of making this provision is explained earlier.

Problem: Miter angles for round pipe elbows.

In all elbows, the miter upon the end piece depends upon the number of pieces of which the elbow is to be made up.



For 2 piece elbow the miter angle is 45°.
For 3 piece elbow the miter angle is $22^1/_2$°.
For 4 piece elbow the miter angle is 15°.
For 5 piece elbow the miter angle is $11^1/_4$°.
For 6 piece elbow the miter angle is 9°.