See fig. 16.1. Note that the prism and cylinder roll out into rectangular stretch-outs called **parallel-line development.** The pyramid and cone roll out into isosceles triangles and sectors of a circle respectively, called **radial-line development.**

(iii) **Triangulation method** is used for developing transition pieces.

(iv) **Approximate method** is employed for double curved surfaces like spheres, as they are theoritically undevelopable.

NOTE : *Usually the lateral surfaces of solids are developed and the ends or bases are omitted from the developments. They can easily be added whenever required.*

PARALLEL LINE DEVELOPMENT METHOD

Problem 1 : *(Fig. 16.2) Draw the development of the lateral surface of a right square prism of edge of base 30 mm and axis 50 mm long.*

1. Draw the top and front views of the prism and name the corners.

To draw the development of the lateral surface of the prism :

2. It consists of four equal rectangles of size 50 mm x 30 mm in contact and in sequence. Hence draw a rectangle $A_1 A_1 AA$ such that $A_1 A_1$ = perimeter of the base of the prism and AA_1 = its height.

3. On the line $A_1 A_1$, mark four equal divisions $A_1 B_1$, $B_1 C_1$, etc. each equal to the side of base 30 mm.

4. Erect perpendiculars at B_1, C_1 and D_1. Darken the four rectangles which give the development of the lateral surface of the prism.

NOTE : *In the development of the lateral surface, the starting and closing edges should be the same (viz. AA_1) to obtain the closed object.*

Problem 2 : *(Fig. 16.3) Draw the development of the outside case and tray of a match-box of size 45 mm x 33 mm x 16 mm.*

1. **Development of the outside case :** The outside case has four sides ABFE, BCGF, etc. the development of which is shown in fig. (i).

2. **Development of the tray :** The tray has five sides and the sixth side is open. Fig. (ii) shows the development of the tray.

Problem 3 : *(Fig. 16.4) Draw the development of the complete surface of a G.I. cylindrical drum with lid. Diameter is 30 cm and the height is 1.6 times the diameter. Take a suitable scale.*

Since the drum has the bottom base and lid, the complete development is as shown in fig. 16.4.

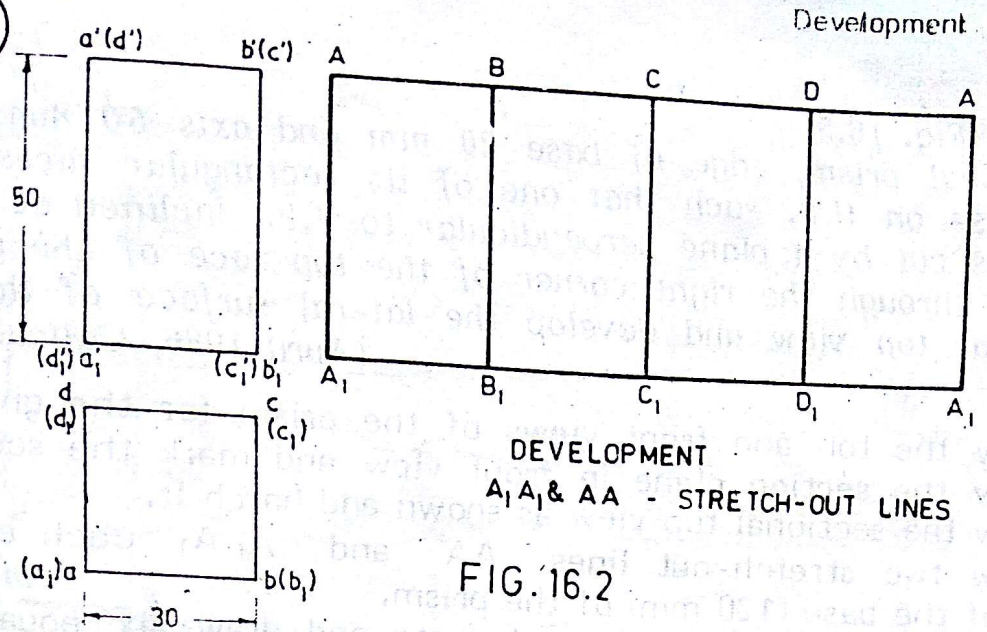
NOTE : *It is advisable to draw the top and bottom circles at the extreme end as shown, to facilitate economical way of cutting the sheet metal.*

Problem 4 : *(Exercise) Develop the complete surface of a cube of 35 mm side.*

Problem 5 : *(Exercise) Develop the lateral surface of a pentagonal prism of side of base 25 mm and height 50 mm.*

Problem 6 : *(Exercise) Draw the development of the complete surface of a steel cup-board of size 75 cm x 40 cm x 100 cm with two shelves.*

1



DEVELOPMENT

A_1A_1 & AA - STRETCH-OUT LINES

FIG. 16.2

2

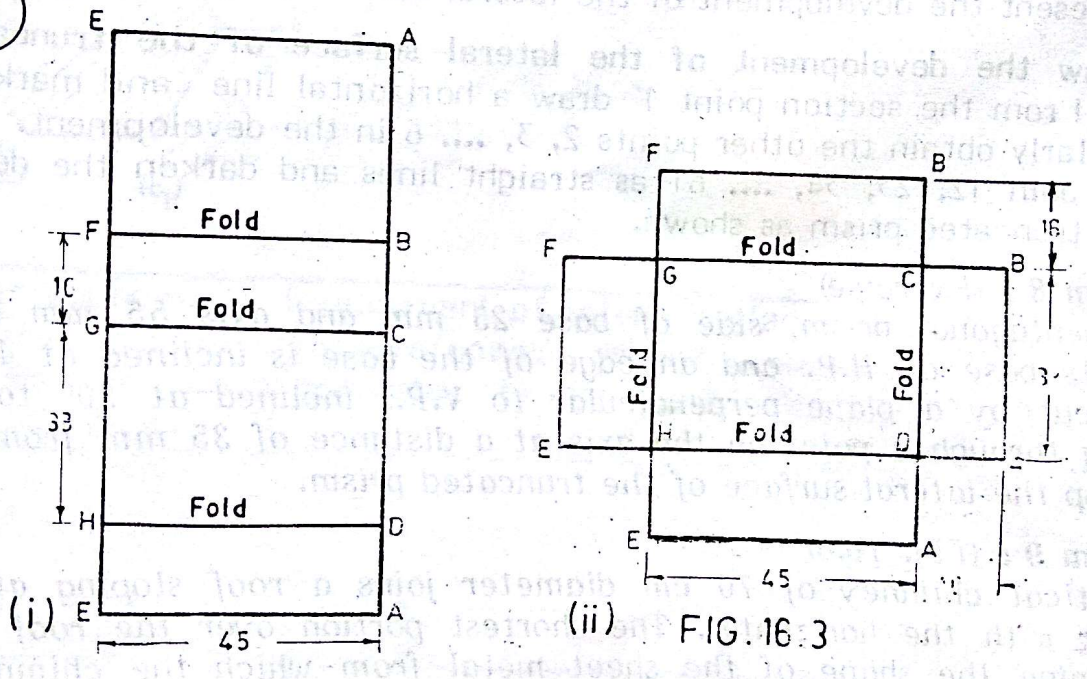


FIG. 16.3

3

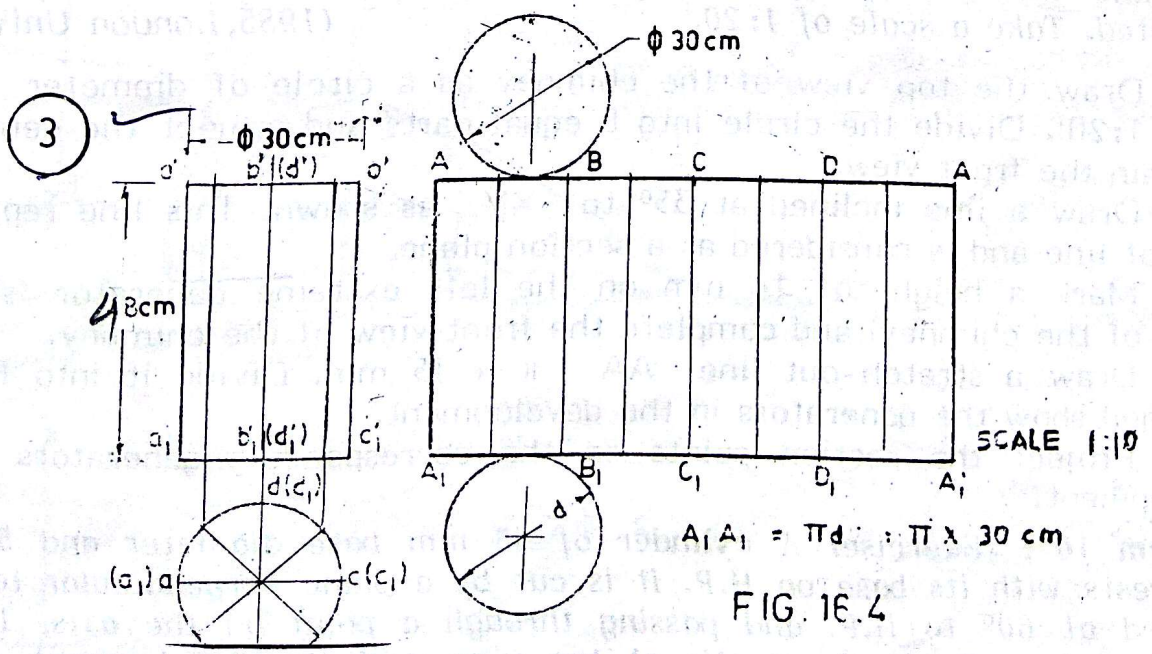


FIG. 16.4

Problem 7 : *(Fig. 16.5)*

A hexagonal prism, edge of base 20 mm and axis 50 mm long, rests with its base on H.P. such that one of its rectangular faces is parallel to V.P. It is cut by a plane perpendicular to V.P., inclined at 45° to H.P. and passing through the right corner of the top face of the prism. Draw the sectional top view and develop the lateral surface of the truncated prism. *(April 1986, Calicut University)*

1. Draw the top and front views of the prism for the given position.
2. Draw the section plane in front view and mark the section points.
3. Draw the sectional top view as shown and hatch it.
4. Draw two stretch-out lines AA and A_1A_1 each equal to the perimeter of the base (120 mm) of the prism.
5. Divide A_1A_1 into six equal parts and draw six equal rectangles to represent the development of the lateral surface of the prism.

To draw the development of the lateral surface of the truncated prism:

6. From the section point 1 draw a horizontal line and mark 1 on AA_1 Similarly obtain the other points 2, 3, ... 6 in the development.
7. Join 12, 23, 34, ... 61 as straight lines and darken the development of the truncated prism as shown.

Problem 8 : *(Exercise)*

A pentagonal prism, side of base 25 mm and axis 55 mm long, rests with its base on H.P. and an edge of the base is inclined at 45° to V.P. It is cut by a plane perpendicular to V.P., inclined at 30° to H.P. and passing through a point on the axis at a distance of 35 mm from the base. Develop the lateral surface of the truncated prism.

Problem 9 : *(Fig. 16.6)*

A vertical chimney of 70 cm diameter joins a roof sloping at an angle of 35° with the horizontal. The shortest portion over the roof is 32 cm. Determine the shape of the sheet metal from which the chimney can be fabricated. Take a scale of 1:20. *(1985, London University)*

1. Draw the top view of the chimney as a circle of diameter 35 mm (Scale 1:20). Divide the circle into 8 equal parts and project the generators to obtain the front view.
2. Draw a line inclined at 35° to XY as shown. This line represents the roof line and is considered as a section plane.
3. Mark a height of 16 mm on the left extreme generator (shortest height of the chimney) and complete the front view of the chimney.
4. Draw a stretch-out line AA = $\pi \times 35$ mm. Divide it into 8 equal parts and show the generators in the development.
5. Project the section points on the corresponding generators in the development.

Problem 10 : *(Exercise) A cylinder of 45 mm base diameter and 55 mm long rests with its base on H.P. It is cut by a plane perpendicular to V.P., inclined at 60° to H.P. and passing through a point on the axis, 12 mm from its top. Draw the sectional top view and the development of the lateral surface of the truncated cylinder.*

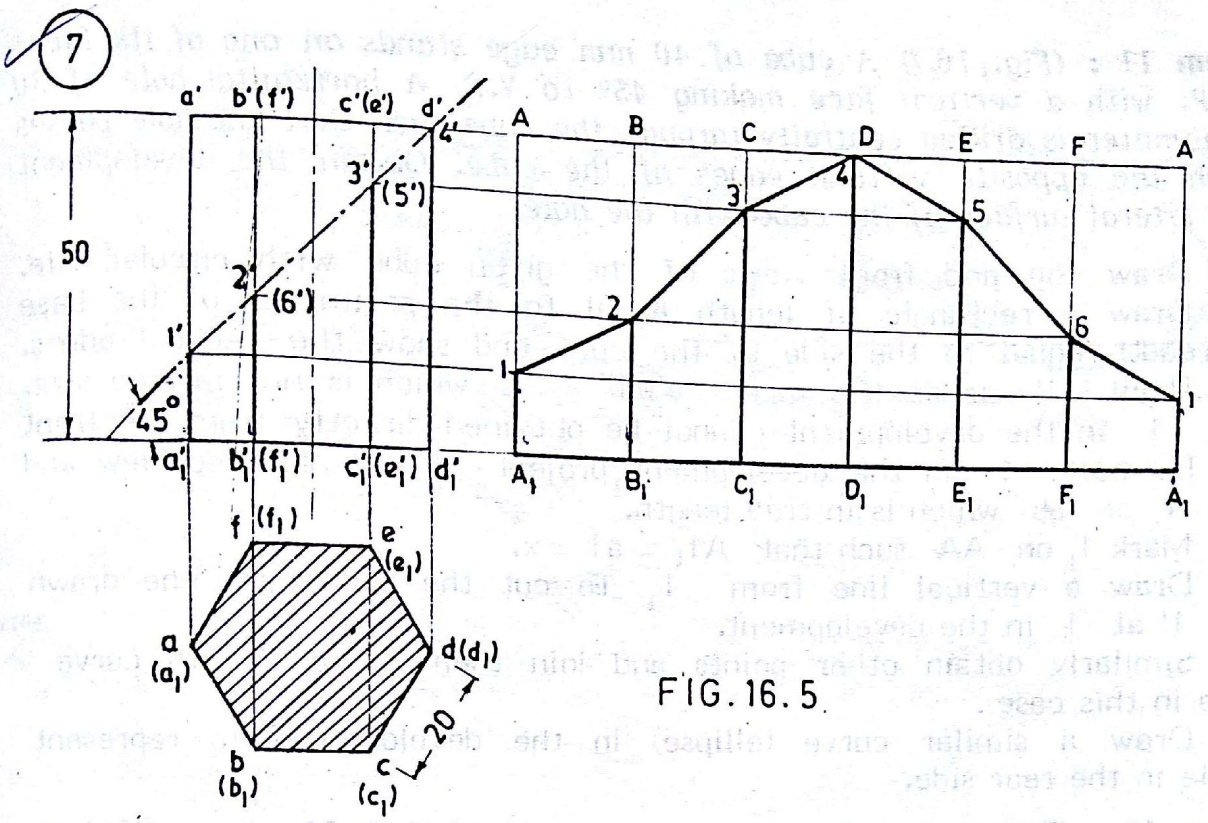


FIG. 16.5

RULE : For economical development of lateral surfaces of the truncated solids (prisms/pyramids/cylinders/cones), draw the development starting with the shortest edge/generator to facilitate minimum welding or riveting at the joint.

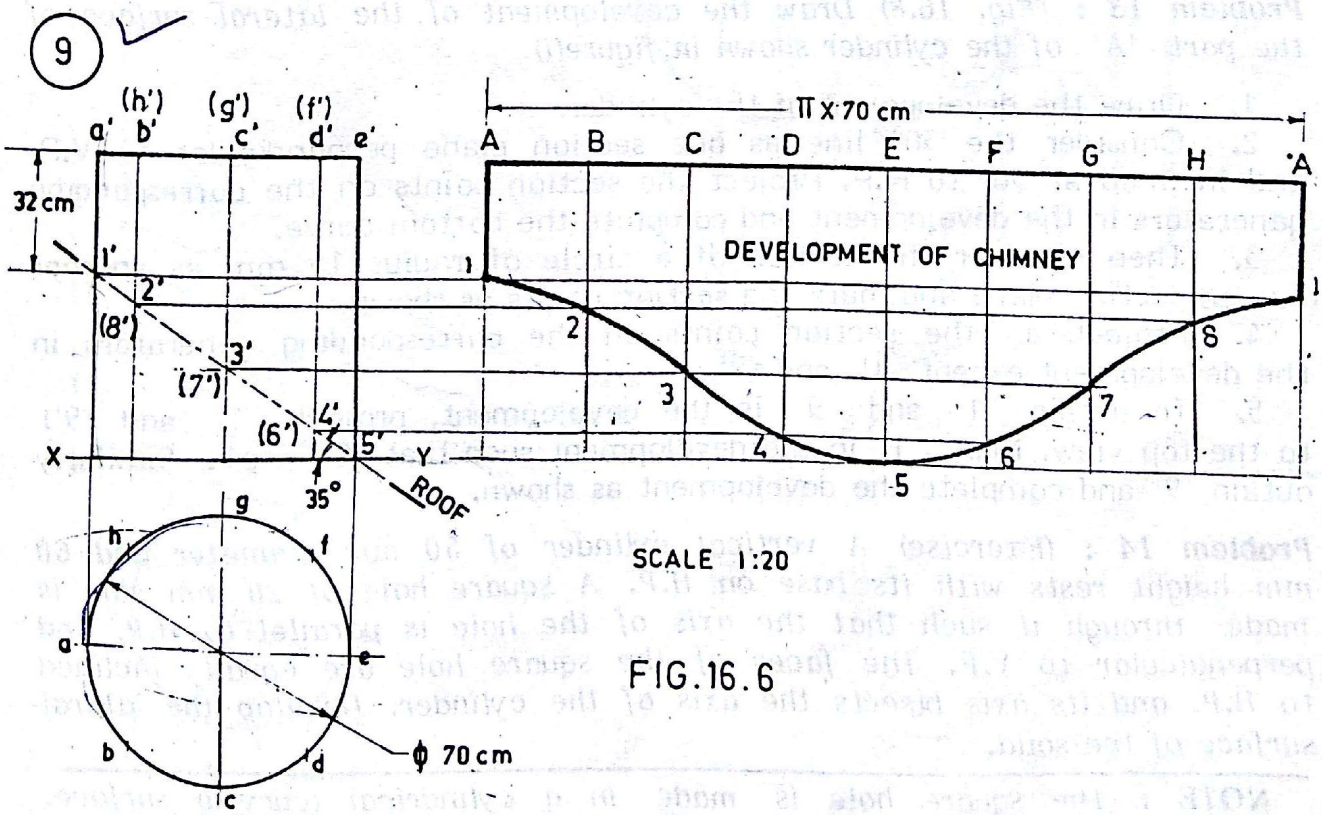


FIG. 16.6

RADIAL LINE DEVELOPMENT METHOD

Problem 18 : *Fig. (16.11) Draw the development of the lateral surface of a square pyramid, side of base 25 mm and height 50 mm, resting with its base on H.P. and an edge of the base parallel to V.P.*

1. Draw the top and front views of the pyramid for the given position.
2. To draw its development, true length of the slant edge is required.

RULE : *If the top view of a slant edge of a pyramid is parallel to XY, then the front view of that edge will give its true length and vice-versa.*

Here, in both the views, the projections of none of the slant edges is parallel to XY. Hence its true length cannot be measured directly either from the top or front view. Therefore to obtain the true length of a slant edge (say OA) make oa parallel to XY, i.e., with o as centre and oa as radius draw an arc to cut the horizontal drawn from o at a_1. Now $o'a'_1$ will be the true length of the slant edge OA.

3. With O as centre and $o'a'_1$ as radius draw an arc. On this arc, mark 4 equal divisions, i.e., chord AB = BC = CD = DA = 25 mm.
4. Complete the triangles OAB, OBC, OCD and ODA by thick lines which will give the development of the lateral surface of the pyramid.

Fig. (iii) shows the uneconomical method of development of the pyramid.

Problem 19 : *(Exercise) Draw the development of a hexagonal pyramid of side of base 25 mm and altitude 50 mm.*

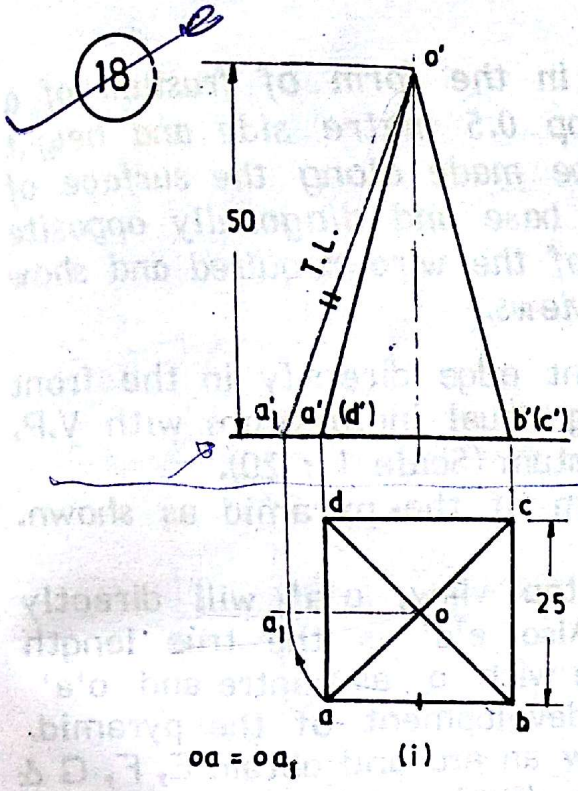
Problem 20 : *(Fig. 16.12) A pentagonal pyramid, side of base 30 mm and height 52 mm, stands with its base on H.P. and an edge of the base is parallel to V.P. It is cut by a plane perpendicular to V.P., inclined at 40° to H.P. and passing through a point on the axis, 32 mm above the base. Draw the sectional top view and develop the lateral surface of the truncated pyramid.* *(April 1987, University of Madras)*

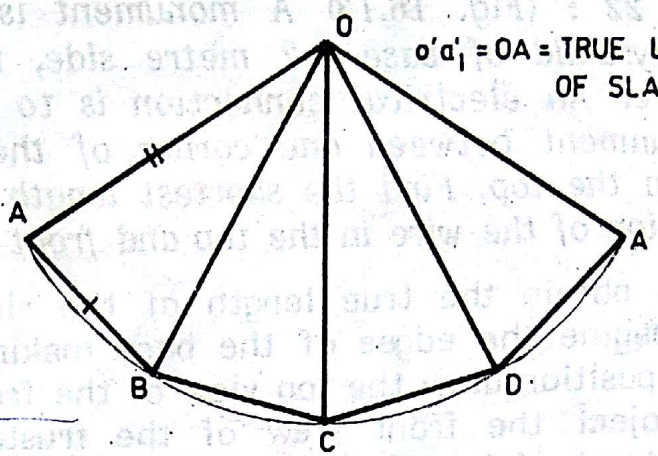
1. Draw the top and front views of the given pyramid.
2. Find the true length of the slant edge and draw the development of the lateral surface of the pyramid as shown.

To develop the lateral surface of the truncated pyramid :

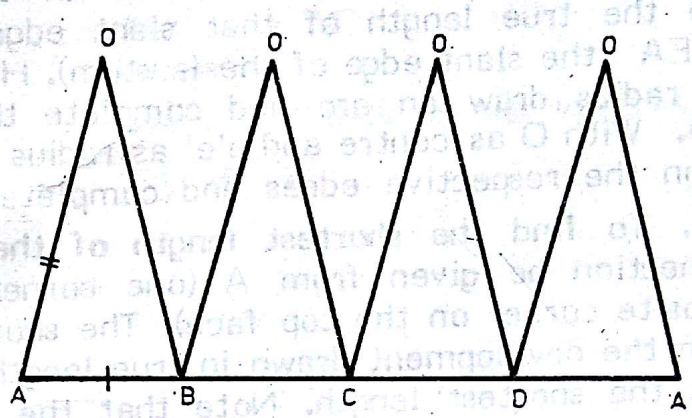
3. Draw the section plane in front view and mark the section points.
4. Draw the sectional top view and hatch the cut surface.
5. To find the true length of the remaining portion of the slant edges, draw horizontal lines through the section points 1', 2', 3' etc to cut $o'a'_1$ (true length of the slant edge OA) at $1'_1$, $2'_1$, $3'_1$ etc.
6. With O as centre and $o'1'_1$ as radius draw an arc to cut OA at 1.
7. Similarly obtain the points 2,3,4 & 5 and complete the development of the truncated pyramid.

Problem 21 : *(Exercise) A triangular pyramid, side of base 35 mm and height 60 mm, stands with its base on H.P. It is cut by a plane perpendicular to V.P., inclined at 30° to H.P. and passing through a point on the axis, 25 mm from the base. Draw the sectional top view and develop the lateral surface of the truncated pyramid.*



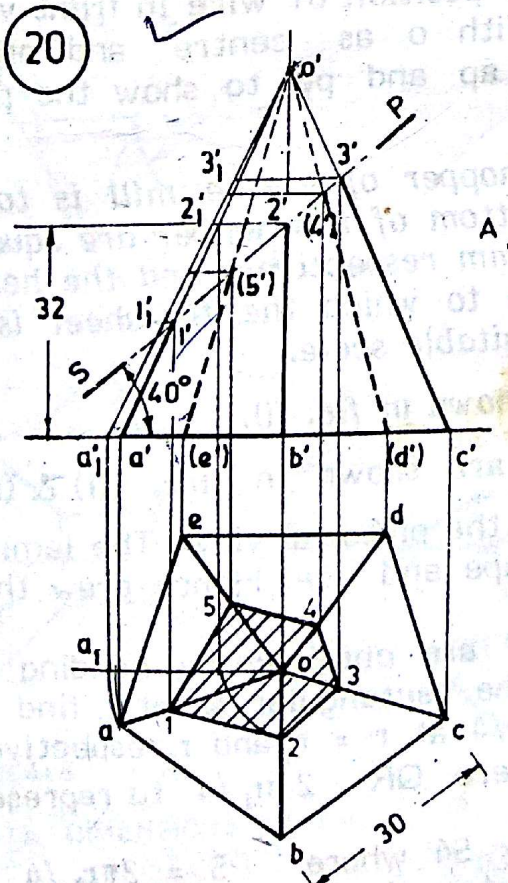


(ii) DEVELOPMENT (ECONOMICAL)



(iii) UNECONOMICAL DEVELOPMENT

FIG. 16.11



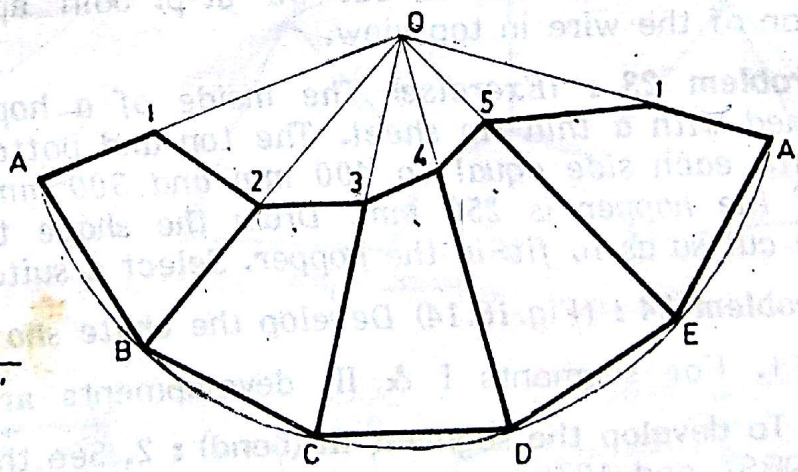


FIG. 16.12

Problem 25 : *(Fig. 16.15) A cone of base 50 mm diameter and height 65 mm rests with its base on H.P. A section plane perpendicular to V.P. and inclined at 30° to H.P. bisects the axis of the cone. Draw the development of the lateral surface of the truncated cone.*

1. Draw the top and front views of the cone. Divide the base circle into 8 or 12 equal parts and show the generators in both the views.

Development of the lateral surface of the cone : In the top view oa is parallel to XY. Hence o'a' is equal to the true length L of the generator.

2. Development of the cone is a sector of a circle of radius equal to the true length L of the generator (slant height). Length of the arc of the sector is equal to the circumference of the base circle ($2\pi r$) and the angle subtended by the arc at the centre is θ.

Then $L\theta = 2\pi r$, $= 360° \times r$. Hence $\theta = 360° \times r/L$.

3. O as centre and L as radius draw an arc subtending angle θ at O.

4. Since the base circle is divided into 8 or 12 equal parts, divide θ also into the same 8 or 12 equal parts as the case may be. Draw the radial lines OA, OB, OC etc and complete the development of the cone.

Development of the truncated cone : 5. Draw the section plane at 30° to XY, bisecting the axis in front view. Mark the section points 1',2',3' etc.

6. Mark 1 on OA in the development such that 01 = o'1'.

7. To mark points 2,3 etc in the development, draw horizontal lines from 2',3' etc to meet end generator o'a' at $2_1'$, $3_1'$ etc. Transfer the distances $o'2_1'$, $o'3_1'$ etc on the respective generators in the development.

8. Draw a smooth curve passing through the points 1,2,3 etc and complete the development of the truncated cone as shown.

Problem 26 : *(Exercise) The inside of the hopper of a flour mill is lined with tin sheet. Top and bottom of the hopper are circles of 50 cm and 30 cm diameters respectively. Height of the hopper is 48 cm. Draw the shape of the sheet to which it is to be cut to fit-in the hopper.*

NOTE : *All the generators of the frustum of a cone have equal length.*

Problem 27 : *(Fig. 16.16) A lamp shade is formed by cutting a cone of base 144 mm diameter and 174 mm height by a horizontal plane at a distance of 72 mm from the apex and another plane inclined at 30° to H.P., passing through one extremity of the base. Draw the development of the shade.*

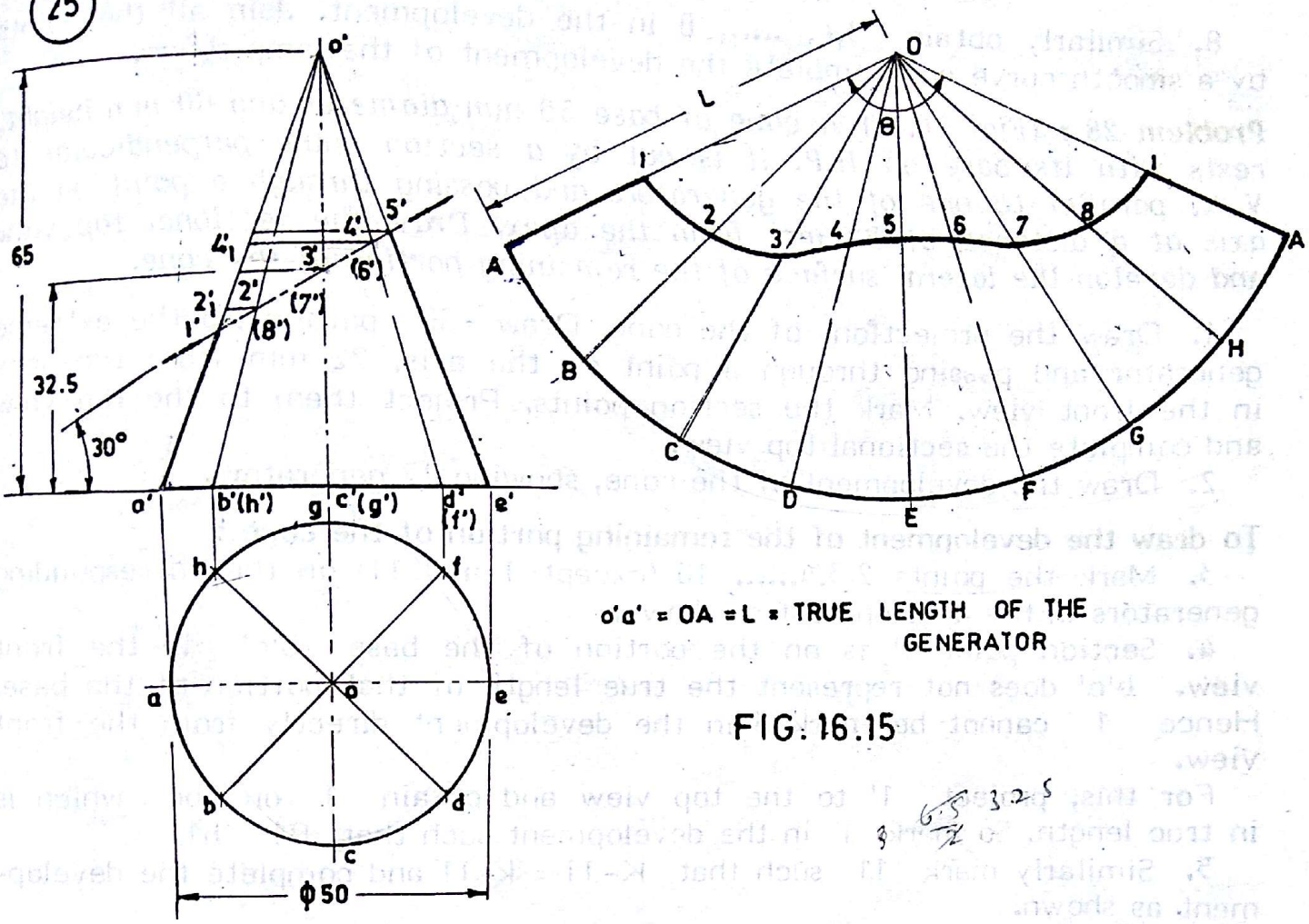
1. Draw the projections of the cone and mark 8 or 12 generators.
2. Draw the two given section planes and name the section points.
3. Draw the development of the cone, as a sector of a circle with (true length of the generator) as radius and angle θ at the centre O.
4. Divide this sector into the same 8 or 12 equal parts as shown.

To develop the lamp shade : 5. The horizontal section plane gives frustum of the cone. To develop this, with O as centre and o'p' as radius, draw an arc cutting OA at P.

6. Consider the inclined section plane separately. In the development mark 1 on OA such that 01 = o'1'.

7. o'2' does not represent the true length. So draw a horizontal line from 2' to cut o'a' at $2_1'$. Now mark 2 on OB such that $02 = o'2_1'$.

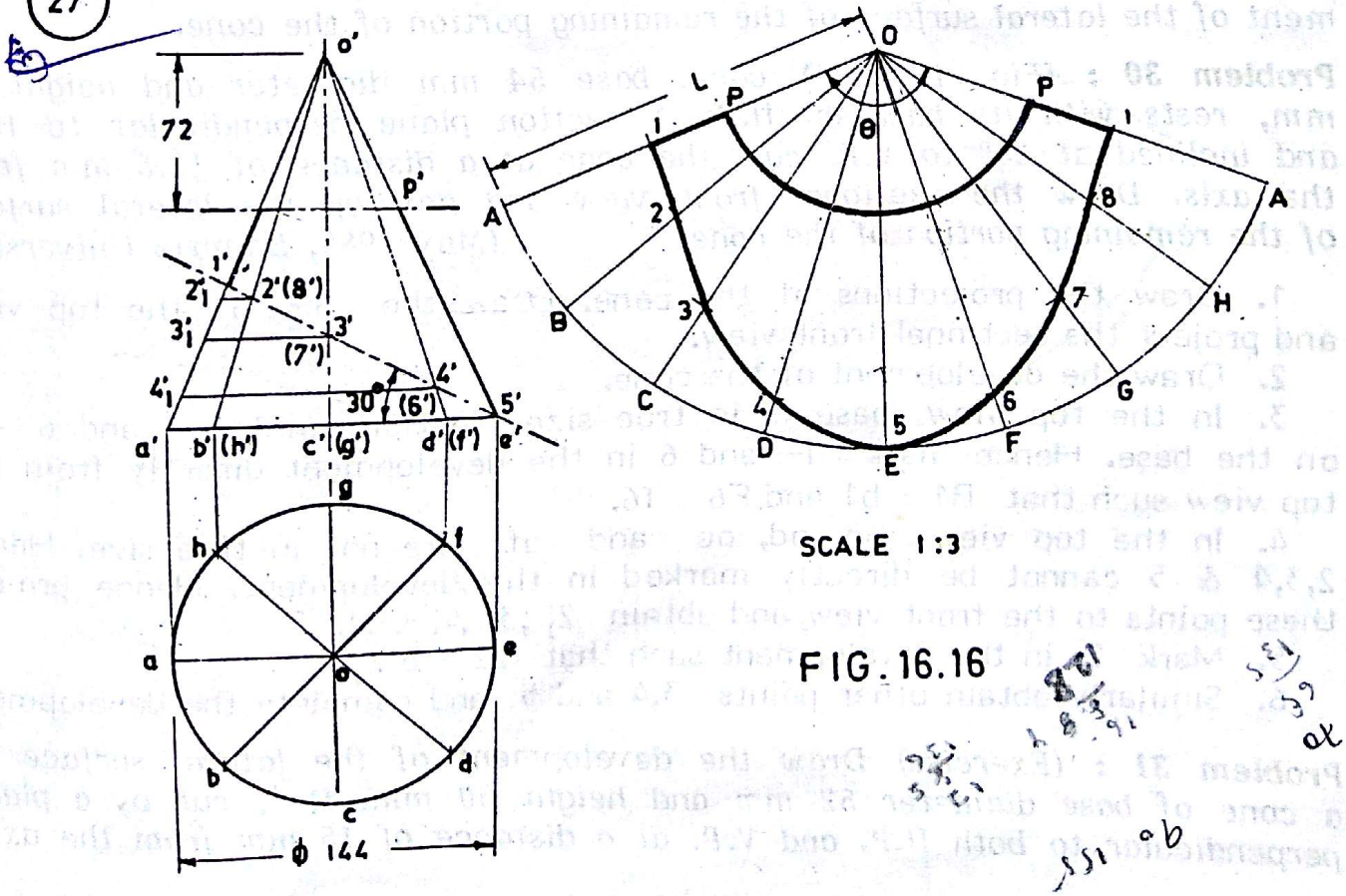
25



o'a' = OA = L = TRUE LENGTH OF THE GENERATOR

FIG. 16.15

27



SCALE 1:3

FIG. 16.16