SECTIONS OF SOLIDS

12.1 INTRODUCTION

The conventional orthographic views, if selected and drawn properly, may reveal sufficient information about the shape and size of the object. However, the conventional views may consist of too many hidden lines for complicated objects, which make the interpretation difficult. To overcome this, it is customary to imagine the object, cut by a section plane. The portion of the object between the observer and the section plane is assumed to be removed. The projection of the remaining solid is known as a sectional view. The actual sectioned portion of the view is shown by cross-hatched lines.

12.2 POSITION OF SECTION PLANES

The shape of the section obtained or revealed will depend upon the orientation of the solid and the section plane, with respect to the principal planes of projection. The following are some of the positions of the section planes:

1. Section plane parallel to H.P
2. Section plane parallel to V.P
3. Section plane inclined to H.P and perpendicular to V.P
4. Section plane inclined to V.P and perpendicular to H.P
5. Section plane perpendicular to both H.P and V.P
6. Section plane inclined to both H.P and V.P

Section planes are usually represented by their traces. The types of solids that are dealt with here are: (i) Polyhedra and (ii) solids of revolution.

12.2.1 True shape of a section

The projection of the section on a plane parallel to the section plane, will appear in its true shape of the section. Thus, when the section plane is parallel to H.P, the true shape of the section will be seen in the sectional top view. When it is parallel to V.P, the true shape of the section will appear in the sectional front view.

12.3.1 Section plane parallel to H.P

When a section plane parallel to H.P, passes through any polyhedron resting on H.P, the sectioned portion will appear in its true shape in the top view. In the front view, it will appear as a straight line, parallel to xy and coincides with V.T of the section plane. When a section plane parallel to H.P, passes through any solid of revolution, resting on a base on H.P, the section is a circle and it also represents the true shape of the section.

NOTE When a cone or pyramid is cut by a section plane, parallel to the base; the retained portion of the solid is called the frustum.

Problem 1 *A cube of 40 edge, is resting on H.P on one of its edges, with a face parallel to V.P. One of the faces containing the resting edge is inclined at 30° to H.P. The solid is cut by a section plane, parallel to H.P and 10 above the axis. Draw the projections of the remaining solid.*

HINT As the section plane is parallel to H.P, it is perpendicular to V.P. Hence, the section plane is represented by its trace (V.T) in the front view.

Construction (Fig. 12.2)

1. Draw the projections of the cube, satisfying the given conditions.
2. Draw the V.T of the section plane in the front view, at a height of 10 above o′.
3. Locate the intersection points 1′, 2′, 3′ and 4′, between the V.T and edges of the cube.
4. Project and locate these points, on the corresponding edges in the top view.
5. Join the points in the order by straight lines and complete the sectional top view, by cross-hatching the sectioned portion.

NOTE
1. The points 1′, 2′, 3′ and 4′ are on the edges a′ d′, d′ c′, r′ s′ and q′ p′ respectively.
2. The shape and size of the sectioned portion will depend upon the position of the section plane.
3. The section also represents the true shape.

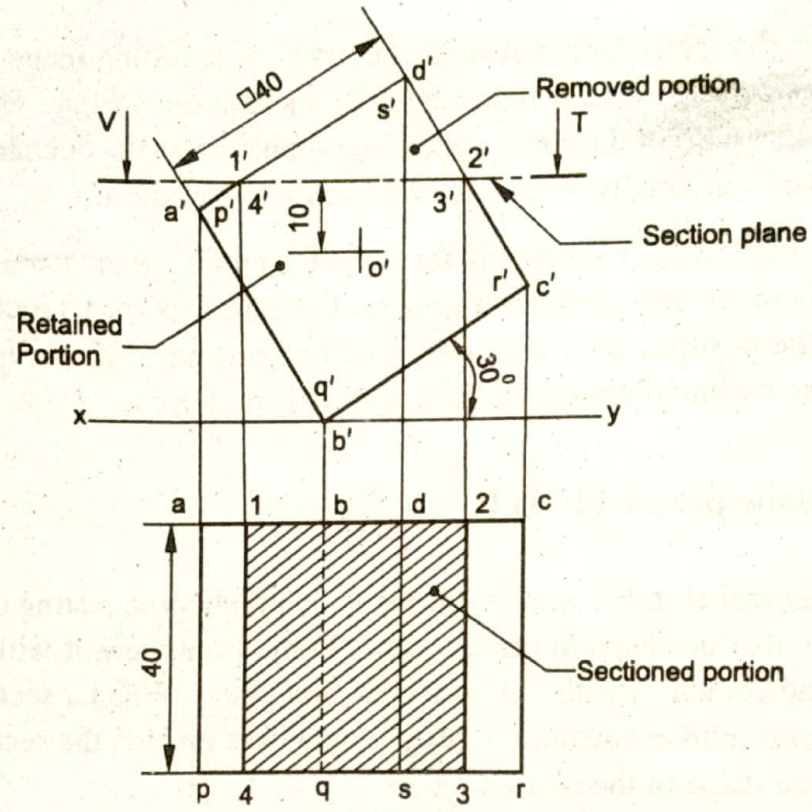

Fig. 12.2

Problem 2 *A pentagonal pyramid with side of base 30 and axis 60 long, is resting with its base on H.P and one of the edges of its base is perpendicular to V.P. It is cut by a section plane, parallel to H.P and passing through the axis at a point 35 above the base. Draw the projections of the remaining solid.*

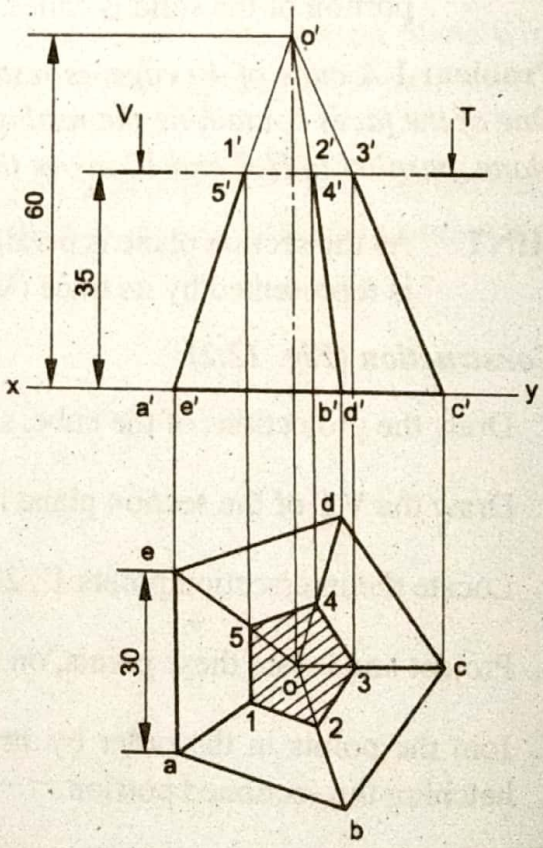

Fig. 12.3

Construction (Fig. 12.3)

1. Draw the projections of the pyramid, keeping one edge of the base perpendicular to V.P.
2. Draw the V.T of section plane, at a height of 35 above xy.
3. Locate the intersection points 1′, 2′, etc., between the trace and slant edges of the pyramid.
4. Project and locate the corresponding points in the top view, on the respective slant edges.
5. Join these points in the order by straight lines and complete the sectional top view, by cross-hatching the sectioned portion.

NOTE As the section plane is parallel to the base of the pyramid, the sectioned portion will appear in its true shape as a pentagon, the size of which depends upon the location of the cutting plane.

Problem 3 *A triangular prism of base 30 side and axis 50 long, is lying on H.P on one of its rectangular faces, with its axis inclined at 30° to V.P. It is cut by a section plane, parallel to H.P and at a distance of 12 above H.P. Draw the front and sectional top view.*

Construction (Fig. 12.4)

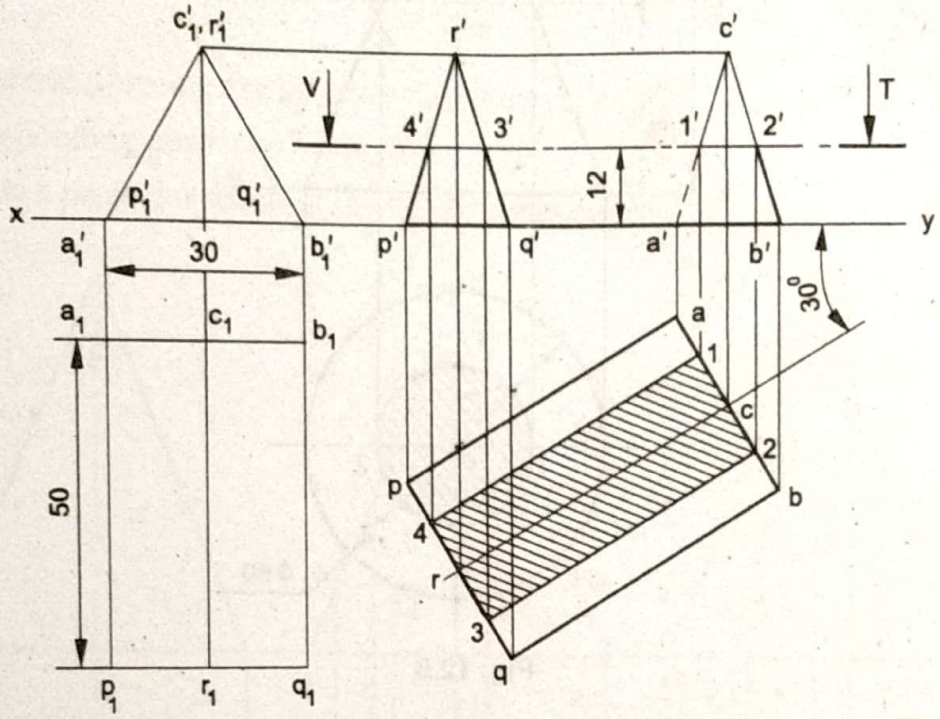

Fig. 12.4

1. Draw the projections of the prism, satisfying the given conditions.
2. Locate the V.T of section plane, at a height of 12 from xy.
3. Locate the intersection points 1′, 2′, 3′ and 4′, between the V.T and edges of the solid, a′ c′, c′ b′, q′ r′ and r′ p′ respectively.
4. Project and locate these points on the corresponding edges in the top view.
5. Join these points in the order by straight lines and complete the sectional top view by cross-hatching the sectioned portion.

Problem 4 *A cone with base 60 diameter and axis 75 long, is resting on its base on H.P. It is cut by a section plane parallel to H.P and passing through the mid-point of the axis. Draw the projections of the cut solid*

Construction (Fig. 12.5)

1. Draw the projections of the cone.
2. Draw the V.T of section plane, passing through the mid-point m′ of the axis.
3. Locate the intersection points 1′and 2′, between the V.T and extreme generators of the cone.
4. With centre o and diameter 1′ -2′, draw a circle in the top view and cross-hatch it; completing the sectional top view.

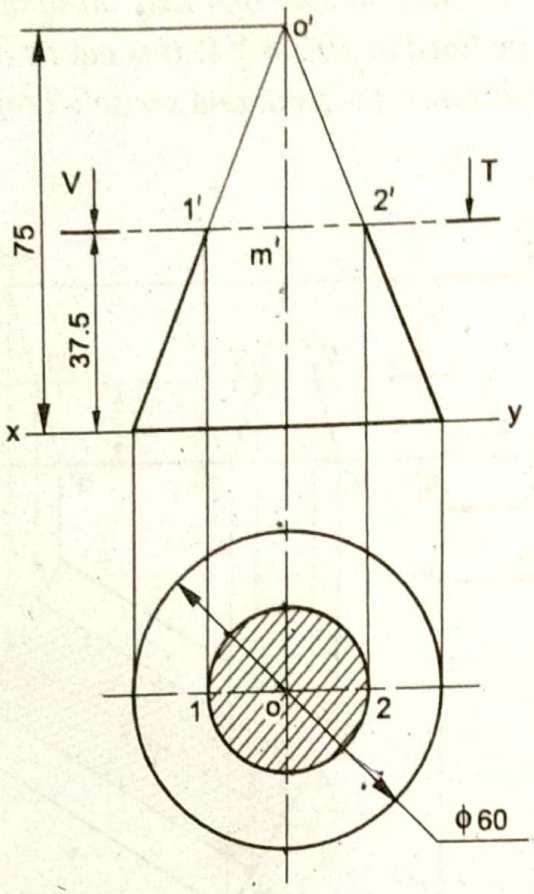

Fig. 12.5

Problem 5 *Figure 12.6a shows the projections of a cone, with the front view p′ of a point P and top view q of a point Q. Locate the top view of the point P and front view of the point Q.*

Construction (Fig. 12.6b and c)

To locate the top view of P

Method I

1. Through p′, draw a line 1′ -1′, parallel to the base.
2. With centre o and diameter equal to 1′ -1′, draw a circle in the top view.
3. Through p′, draw a projector intersecting the circle at p and p_1.

   p is the top view of the visible point of p′ and p_1 is the top view of another point, lying on the rear side of the cone and coinciding with p′ in the front view.

Method II

1. Through p′, draw a generator.
2. Project and obtain the corresponding division lines in the top view.
3. Through p′, draw a projector; meeting the above lines at p_1 and p.

To locate the front view of Q

12.3.2 Section plane parallel to V.P

When a section plane passing through a solid is parallel to V.P, the sectioned portion will appear in its true shape in the front view. In the top view, it will appear as a straight line, parallel to xy and coincides with its H.T. When the section plane passes through a solid of revolution, the section produced depends upon the type of solid. In the case of a cylinder, the section is a rectangle; in the case of a cone, when the section plane passes through the apex, it is a triangle; otherwise, it is a hyperbola and in the case of a sphere, it is a circle.

Problem 6 *A cylinder of 40 diameter and axis 55 long, stands vertically with its base on H.P. It is cut by a section plane, parallel to V.P and passes at a distance of 10 from the axis. Draw the projections of the retained solid.*

Construction (Fig. 12.7)

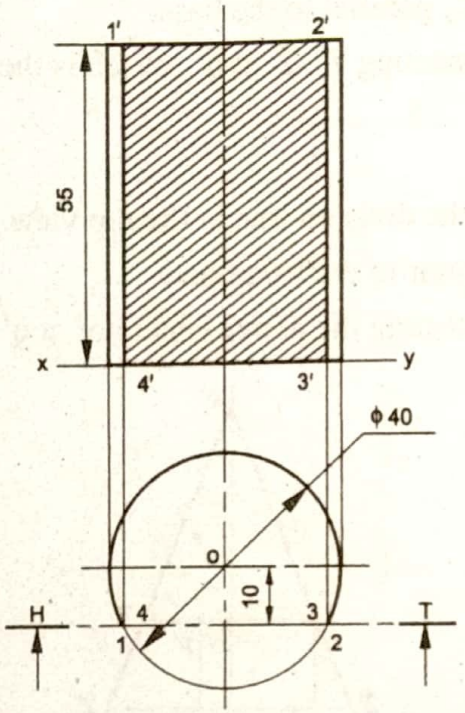

Fig. 12.7

1. Draw the projections of the cylinder.
2. Draw the H.T of section plane, which lies at a distance of 10 from the axis.
3. Locate the points of intersection 1, 2, 3 and 4, between the H.T and bases of the cylinder (points 1 and 2 lie on the top base and 3 and 4 on the bottom base).
4. Project and locate the points $1'$, $2'$, $3'$ and $4'$, on the corresponding bases in the front view.
5. Join these points in the order by straight lines and complete the sectional front view, by cross-hatching the sectioned portion.

NOTE When a cylinder is cut by a section plane, parallel to its axis, the sectioned portion is a rectangle, the length being equal to the length of the axis but the width depends upon the position of the cutting plane from the axis.

Problem 7 *A tetrahedron of side 50, is resting on H.P on one of its faces, with an edge of it parallel to V.P and away from it. It is cut by a section plane parallel to V.P and at a distance of 10 from the apex. Draw the projections of the retained solid.*

Construction (Fig. 12.8)

1. Draw the projections of the tetrahedron.
2. Draw the H.T of section plane, at a distance of 10 from o.
3. Locate the points of intersection 1, 2, 3, 4, between the H.T and edges of the solid in a sequence.

For the given position of the solid, points 1 and 4 are on the edges of the base AC and BC respectively and the points 2 and 3 are on the slant edges OA and OB respectively.

4. Project and locate these points on the corresponding edges in the front view.
5. Join the points in the order by straight lines and complete the sectional front view, by cross-hatching the sectioned portion.

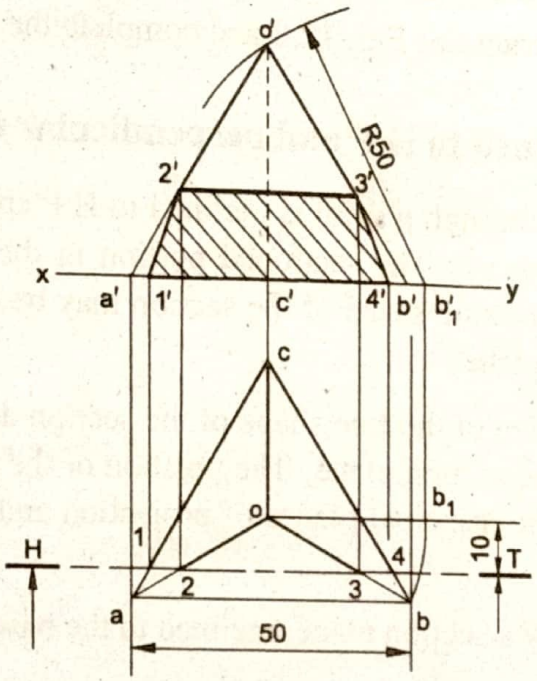

Fig. 12.8

Problem 8 *A pentagonal pyramid of side of base 35 and axis 60 long, stands with its base on H.P such that, one of the base edges is perpendicular to V.P. A section plane parallel to V.P, cuts the solid at a distance of 15 from the corner of the base which is nearer to the observer. Draw the top and sectional front views of the cut solid.*

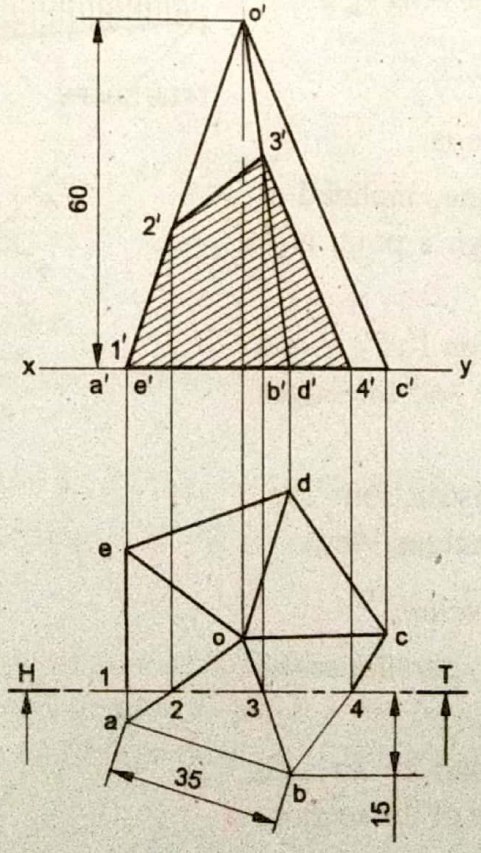

Fig. 12.9

Construction (Fig. 12.9)

1. Draw the projections of the pyramid.
2. Draw the H.T of section plane, at a distance of 15 from b.
3. Repeat steps 3 to 5 of Construction: Fig. 12.8 and complete the sectional front view.

12.3.3 Section plane inclined to H.P and perpendicular to V.P

When a section plane passing through a solid is inclined to H.P and perpendicular to V.P, its V.T is inclined to the reference line xy. The sectioned portion in the top view does not reveal the true shape. In all such cases, the true shape of the section may be obtained on an auxiliary plane (A.I.P), parallel to the section plane.

In general, the shape and size of the true shape of the section depends upon the orientation of the solid and the position of the section plane. The position of the section plane will be specified by the inclination of it, with the principal planes of projection and the point in the solid through which it passes.

NOTE When a solid is cut by a section plane, inclined to the base, the retained portion is called the truncated solid.

Problem 9 *A cube of side 40, is resting on H.P on one of its faces, with a vertical face inclined at 45° to H.P and passing through the axis at 8 from the top surface. Draw the projections of the solid and also show the true shape of the section.*

Construction (Fig. 12.10)

1. Draw the projections of the cube.
2. Draw the V.T of section plane, inclined at 45° to xy and passing through a point at 8 from the top end of the axis.
3. Locate the points of intersection 1′, 2′, 3′ and 4′, between the vertical trace and the edges of the cube.
4. Repeat steps 4 and 5 of Construction: Fig. 12.2 and complete the sectional top view.

To obtain the true shape of the section:

(i) Draw the reference line x_1y_1, parallel to the V.T of section plane.

(ii) Project the points 1′, 2′, 3′ and 4′, through x_1y_1 and obtain the true shape of the section.

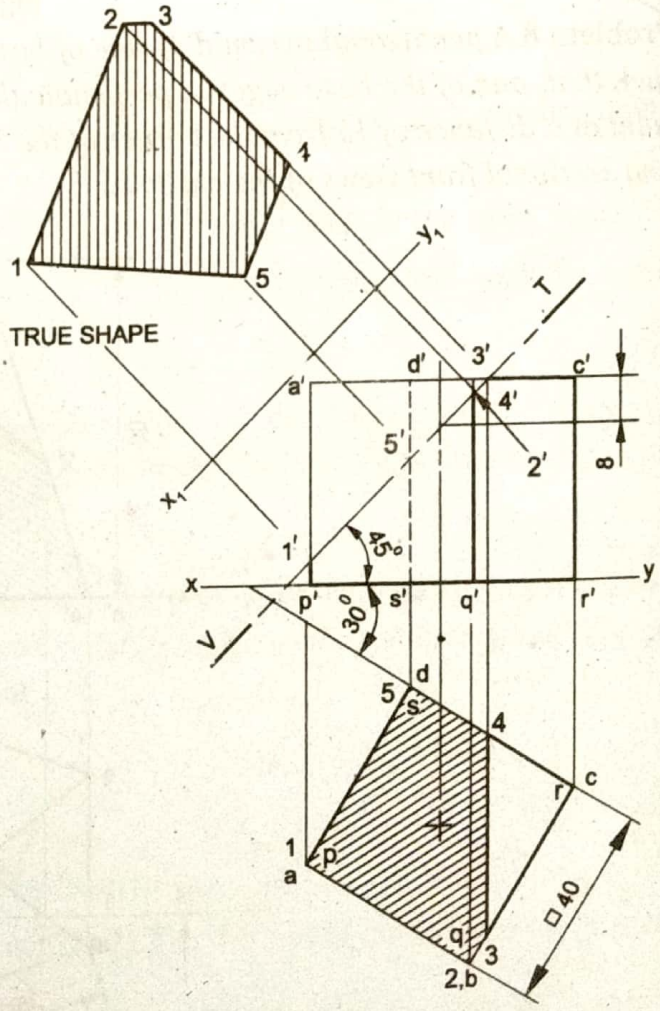

Fig. 12.10

Problem 11 *A hexagonal pyramid of side of base 30 and axis 60 long, is resting on its base on H.P, with an edge of the base perpendicular to V.P. It is cut by a section plane, inclined at 30° to H.P and passing through the axis at 20 from the base. Draw the three views of the solid and obtain the true shape of the section*

Construction (Fig. 12.12)

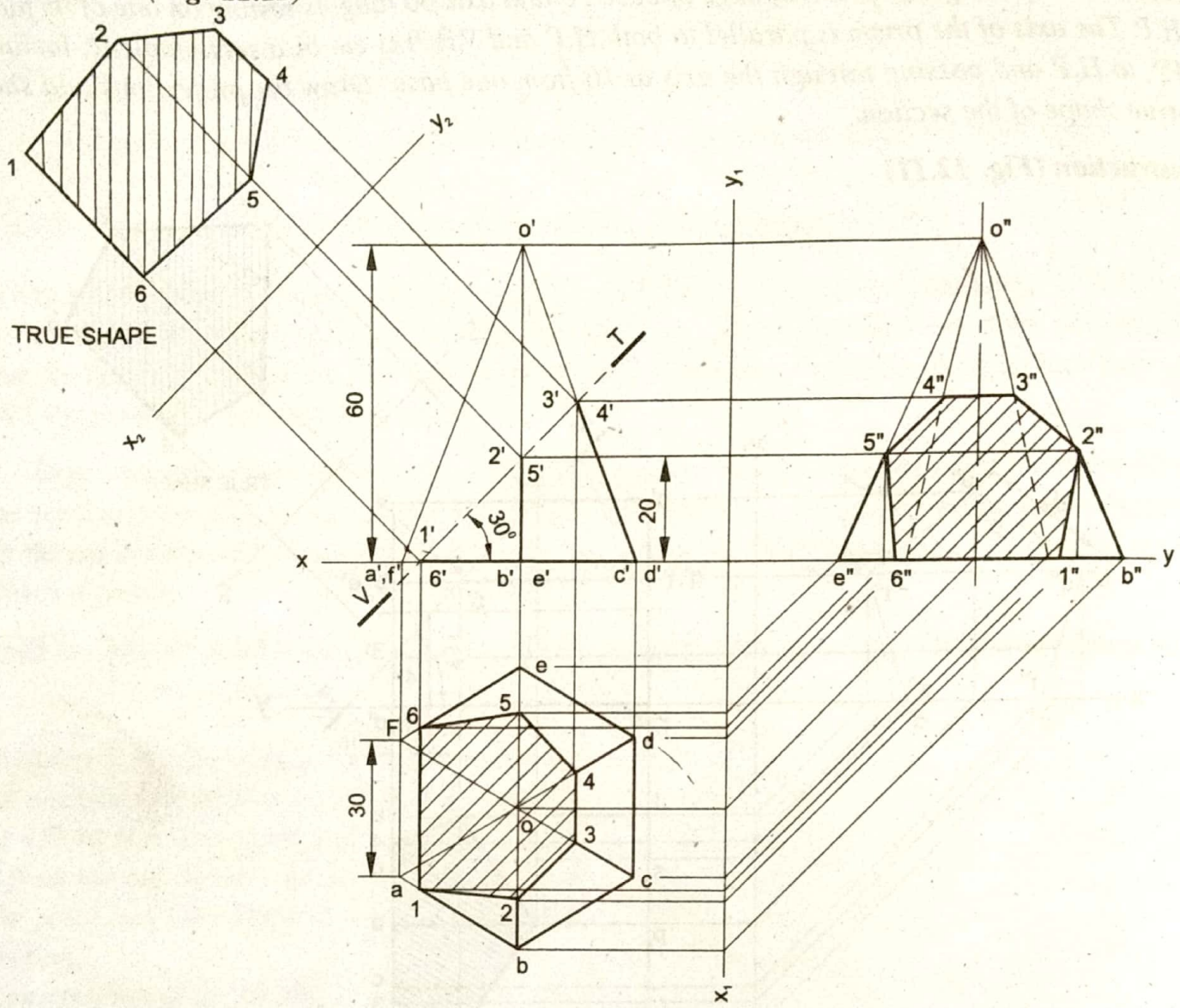

Fig. 12.12

1. Draw the projections of the pyramid.
2. Draw the V.T of section plane, inclined at 30° to xy and passing through a point on the axis at 20 from the base.
3. Locate the points of intersection 1′, 2′, etc., between the V.T and edges of the pyramid.

It may be noted that the points 1′ and 6′ lie on the edges of the base, whereas the remaining points lie on the slant edges of the solid.

4. Project the points 1′ and 6′ on to the top view and other points on to the side view.
5. Transfer the points 2″, 3″, etc., to the top view by projection and complete the sectional top view.
6. Transfer the points 1 and 6 to the side view by projection and complete the sectional side view.

Problem 12 *A cylinder of 45 diameter and 70 long, is resting on one of its bases on H.P. It is cut by a section plane, inclined at 60° with H.P and passing through a point on the axis at 15 from one end. Draw the three views of the solid and also obtain the true shape of the section.*

Construction (Fig. 12.13)

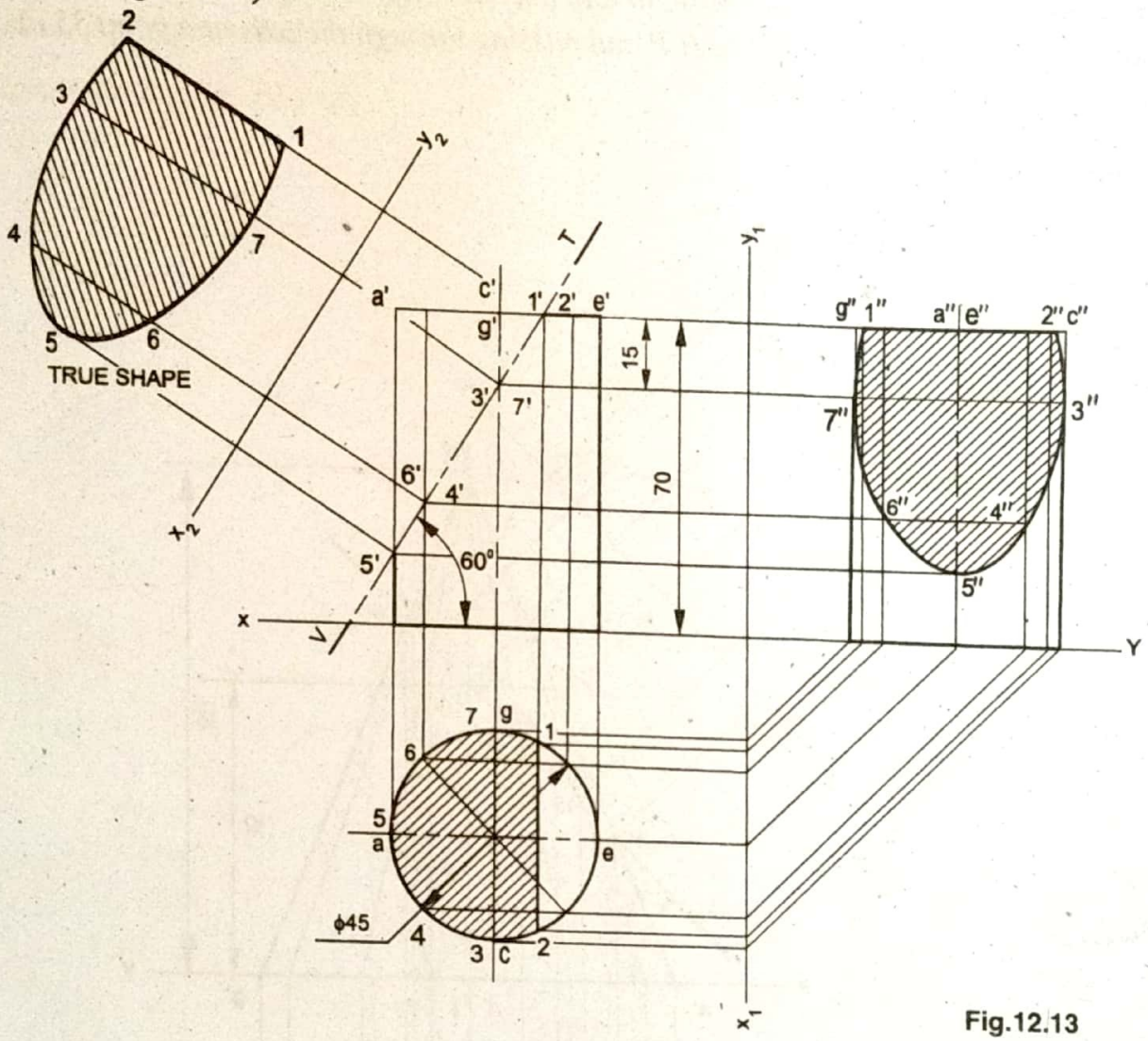

Fig.12.13

1. Draw the projections of the cylinder.
2. Divide the base (top view) into a number of equal parts, say 8 and draw the corresponding generators in the front view.
3. Draw the V.T of section plane, inclined at 60° to xy and passing through a point on the axis at 15 from its top end.
4. Locate the points of intersection 1′, 2′, etc., between the V.T and base and generators of the cylinder.
5. Project and locate the corresponding points 1, 2, etc., in the top view.
6. Join the points in the order and complete the sectional top view and cross-hatch the sectioned portion.
7. Obtain the true shape of the section and sectional left side view, by suitably following the principle of Construction: Fig. 12.12.

NOTE (i) The boundary of the intersection is a straight line, when the section plane passes through the base.

(ii) The remaining part of the boundary, corresponding to the plane, passing through the curved surface of the solid is a curve

Problem 13 *A cone with diameter of base 50 and axis 60 long, is resting on its base on H.P. It is cut by a section plane inclined at 45° to H.P and passing through the axis at a point 35 above H.I Draw the projections of the cut solid.*

Construction (Fig. 12.14)

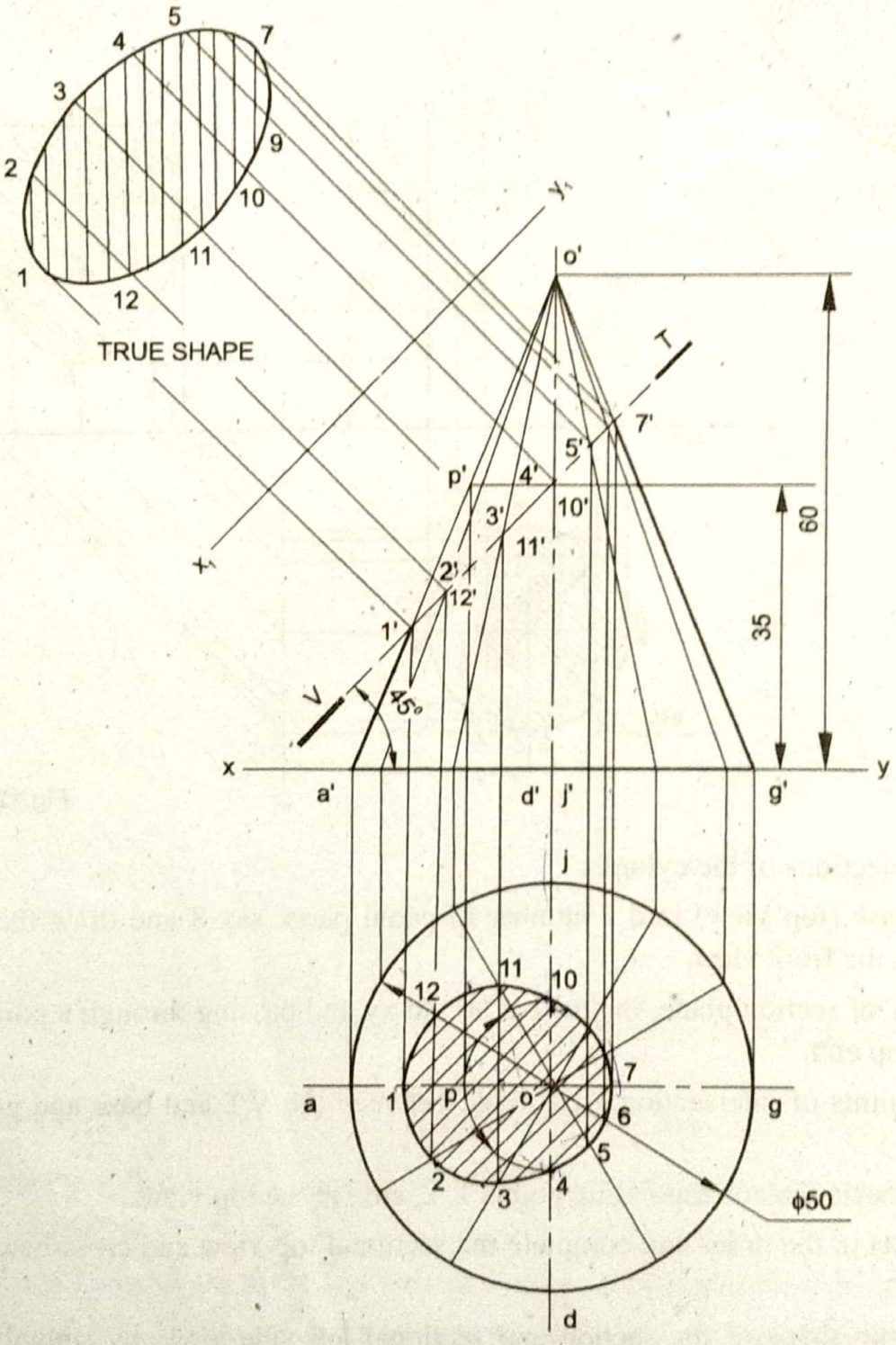

Fig. 12.14a

1. Draw the projections of the cone.
2. Draw the V.T of section plane, inclined at 45° to xy and passing through a point on the axis at 35 from the base.

12.3.4 Section plane inclined to V.P and perpendicular to H.P

When a section plane passing through the solid is inclined to V.P and perpendicular to H.P, its H.T is inclined to xy. The true shape of the section may be obtained on an A.V.P, parallel to the given section plane.

Problem 14 *A hexagonal prism of side of base 25 and axis 60 long, is resting on its base on H.P such that, an edge of the base is parallel to V.P. It is cut by a section plane, inclined at 45° to V.P and 10 away from the axis. Draw the projections of the solid. Also obtain an auxiliary front view, showing the true shape of the section.*

Construction (Fig. 12.15)

1. Draw the projections of the prism.
2. Draw the H.T of the section plane, inclined at 45° to xy and 10 away from axis.
3. Locate the points of intersection 1, 2, 3 and 4 between the H.T and edges of the base.
4. Project and locate the corresponding points $1'$, $2'$, $3'$ and $4'$ in the front view.
5. Join the points in the order by straight lines and obtain the section.
6. Draw the reference line x_1y_1, parallel to the H.T of section plane and obtain the auxiliary front view for the retained portion of the solid, which also shows the true shape of the section.

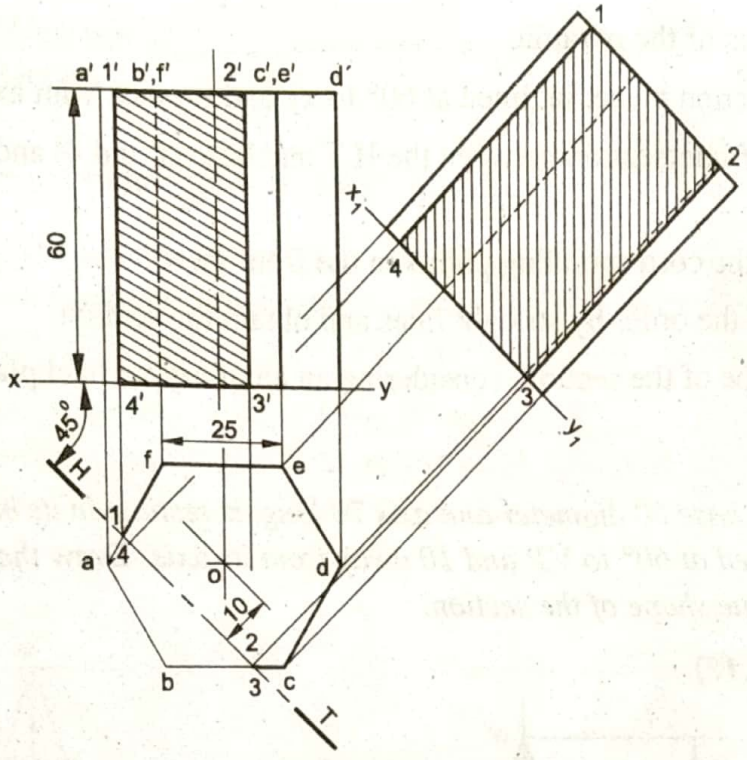

Fig. 12.15

Problem 15 *A pentagonal pyramid with edge of base 25 and axis 65 long, is resting on H.P on its base with an edge nearer to the observer, parallel to V.P. It is cut by a section plane, inclined at 60° to V.P and at a distance of 6 from the axis. Draw the projections and obtain the true shape of the section.*

Construction (Fig. 12.16)

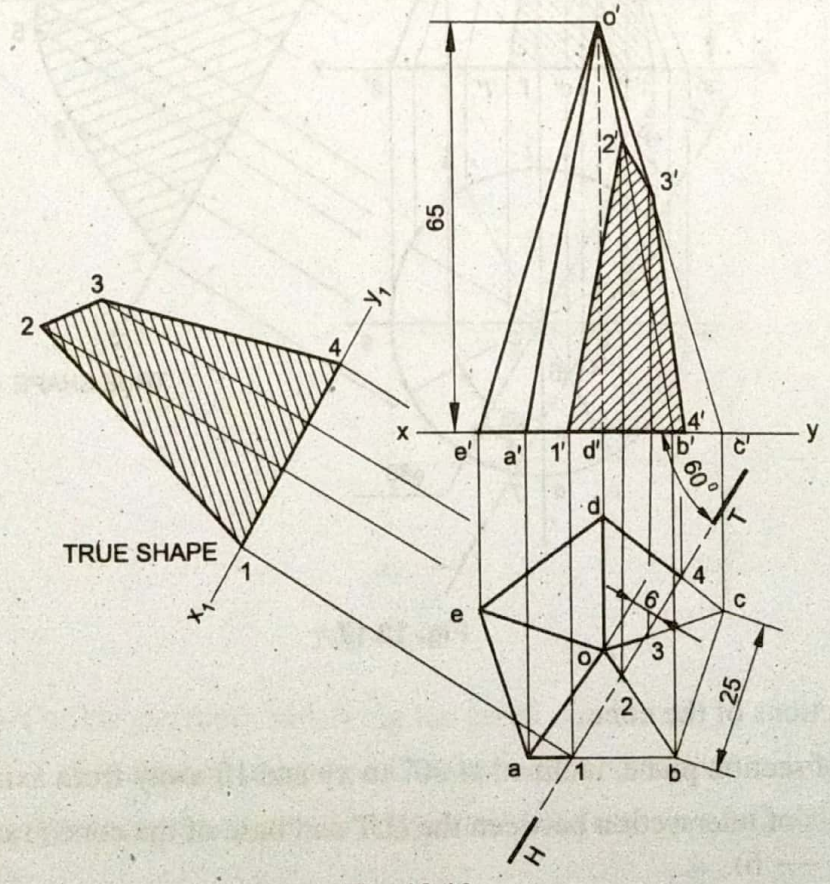

Fig. 12.16

1. Draw the projections of the pyramid.
2. Draw the H.T of section plane, inclined at 60° to xy and 6 away from axis.
3. Locate the points of intersection between the H.T and base (1 and 4) and the slant edges (2 and 3) of the pyramid.
4. Project and obtain the corresponding points in the front view.
5. Join these points in the order by straight lines and obtain the section.
6. Obtain the true shape of the section, considering an auxiliary vertical plane, parallel to the H.T of section plane.

Problem 16 *A cone of base 60 diameter and axis 70 long, is resting on its base on H.P. It is cut by a section plane, inclined at 60° to V.P and 10 away from its axis. Draw the projections of the cut solid and obtain the true shape of the section.*

Construction (Fig. 12.17)

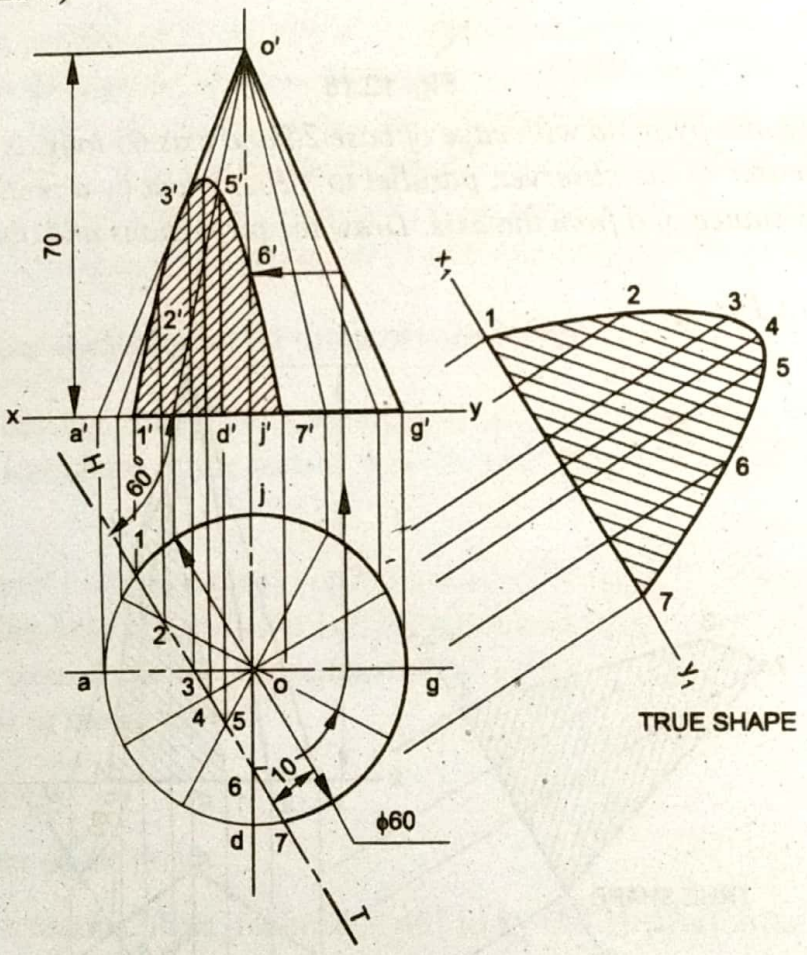

Fig. 12.17

1. Draw the projections of the cone.
2. Draw the H.T of section plane, inclined at 60° to xy and 10 away from axis.
3. Locate the points of intersection between the H.T and base of the cone (1and 7) and the generators (2, 3,– – –– 6).

6. Cross-hatch the sectioned portion in the top view and complete the sectional top view.
7. Draw the reference line x_1y_1, parallel to the V.T of section plane and obtain the true shape of the section, by projection.

Problem 20 *A cube of 50 edge, rests on one face on H.P, with its vertical faces equally inclined to V.P. It is cut by a section plane, perpendicular to V.P, producing a large rhombus. Draw the projections, true shape of the section and determine the inclination of the section plane with H.P.*

Construction (Fig. 12.21)

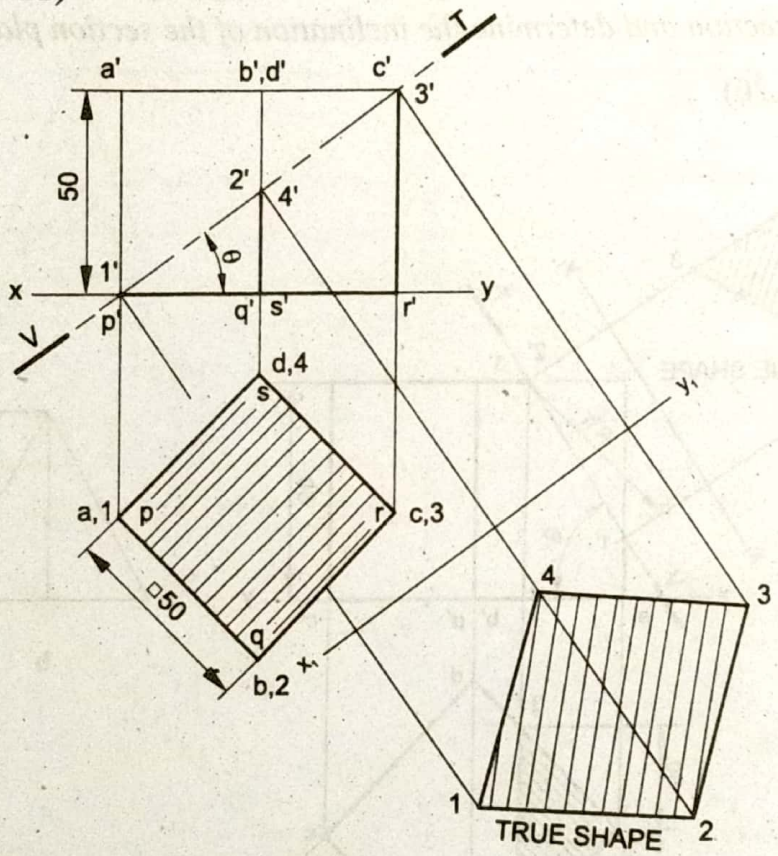

Fig. 12.21

1. Draw the projections of the cube, satisfying the given conditions.

NOTE When the V.T of a section plane is inclined to xy and passes through the extreme vertical edges of the front view, the true shape produced is a rhombus. So, to produce a largest possible rhombus, the section plane should pass through the diagonally opposite corners of the front view.

2. Draw the V.T of section plane such that, it passes through the diagonally opposite corners, p' and c' in the front view.
3. Locate the points of intersection $1'$, $2'$, $3'$ and $4'$ between the V.T and edges of the cube.
4. Cross-hatch the complete top view, as the entire area comes under sectioned zone.
5. Measure the angle θ which is the inclination of the section plane with H.P.
6. Draw the reference line x_1y_1, parallel to the V.T of section plane and obtain the true shape of the section, by projection.

Problem 21 *A hexagonal prism of side of base 30 and length of axis 75, is resting on a corner of its base on H.P, with the longer edge containing that corner, inclined to H.P at 30°. It is cut by a section plane parallel to H.P and passing through the mid-point of the axis. Draw the front and sectional top views of the solid.*

Construction (Fig. 12. 22)

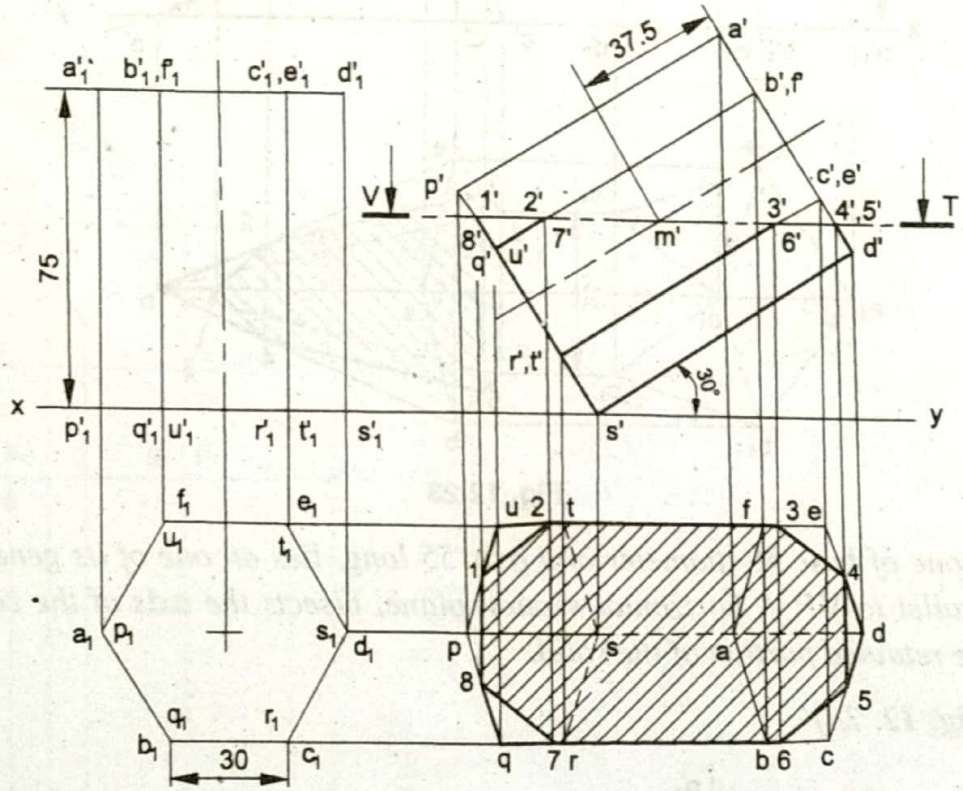

Fig. 12.22

1. Draw the projections of the prism, satisfying the given conditions.
2. Draw the V.T of section plane, parallel to xy and passing through the mid-point m′ of the axis.
3. Repeat steps 3 to 5 of Construction: Fig. 12.4 suitably and obtain the sectional top view.

Problem 22 *A pentagonal pyramid of side of base 25 and 50 height, rests on a triangular face on H.P, with its axis parallel to V.P. It is cut by a horizontal section plane, bisecting the axis. Draw the projections of the retained solid.*

Construction (Fig. 12. 23)

1. Draw the projections of the pyramid, satisfying the given conditions.
2. Repeat steps 2 to 5 of Construction: Fig. 12.4 suitably and obtain the sectional top view.

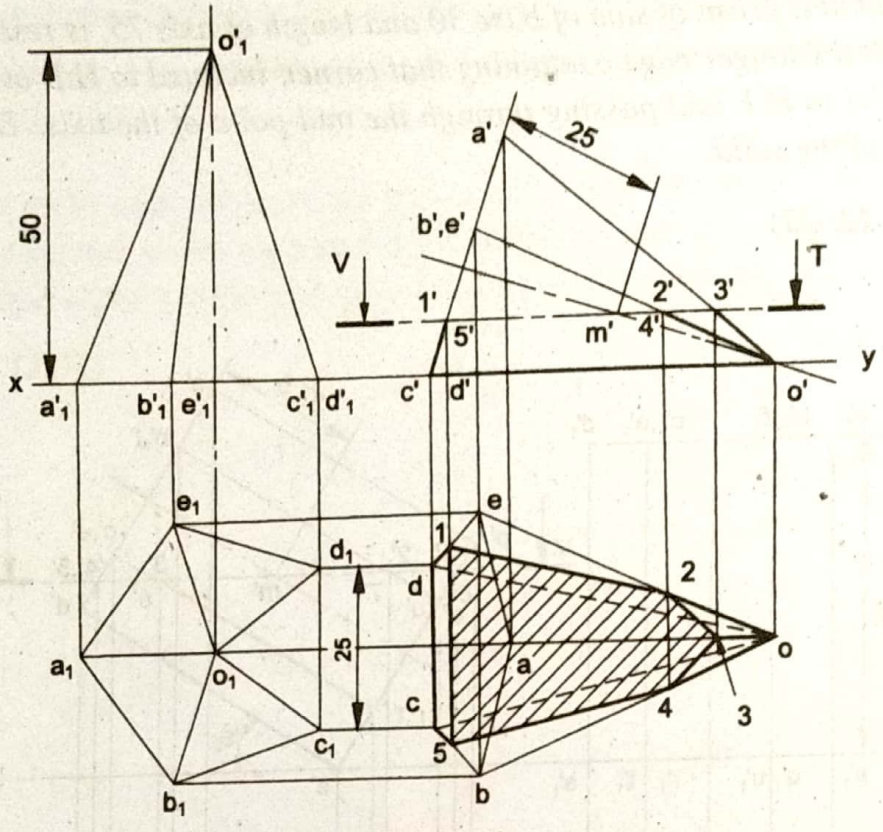

Fig. 12.23

Problem 23 *A cone of base 40 diameter and axis 55 long, lies on one of its generators on H.P with its axis parallel to V.P. A horizontal section plane, bisects the axis of the cone. Draw the projections of the retained portion of the solid.*

Construction (Fig. 12. 24)

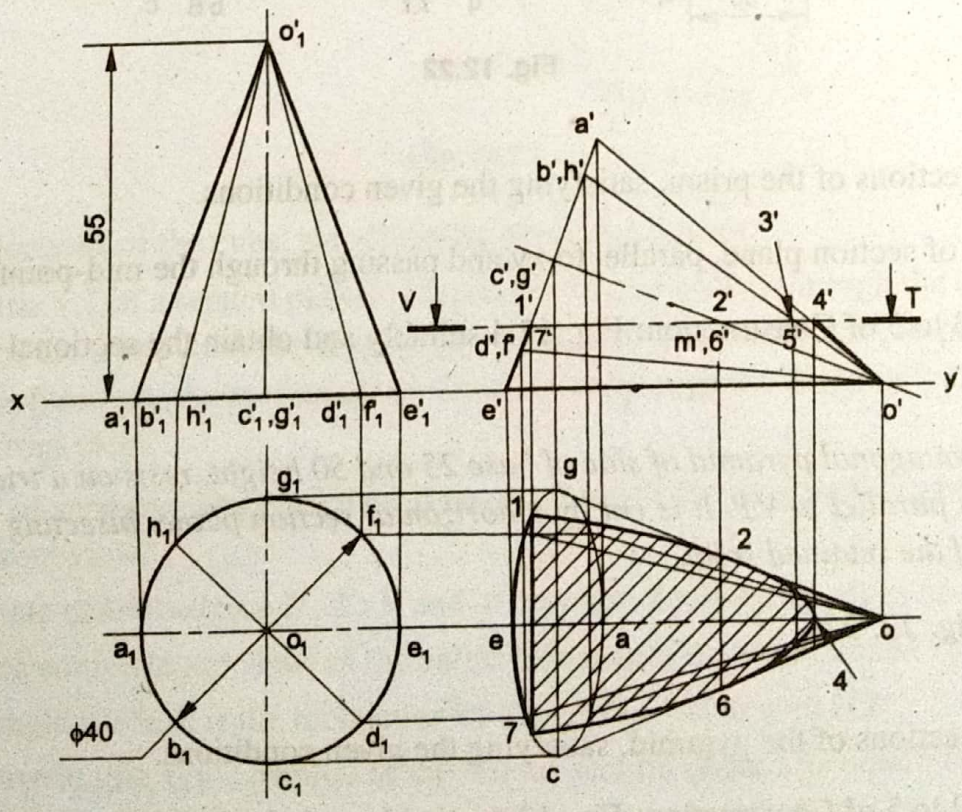

Fig. 12.24

1. Draw the projections of the cone, satisfying the given conditions.
2. Repeat steps 2 to 5 of Construction: Fig. 12.14a suitably and obtain the sectional top view.

Problem 24 *A cylinder of 50 diameter and axis 70 long, lies on H.P on one of its generators such that, the axis is inclined at 45° to V.P. A section plane parallel to V.P, passes through the farthest point of the visible base. Draw the projections of the cut solid.*

Construction (Fig. 12. 25)

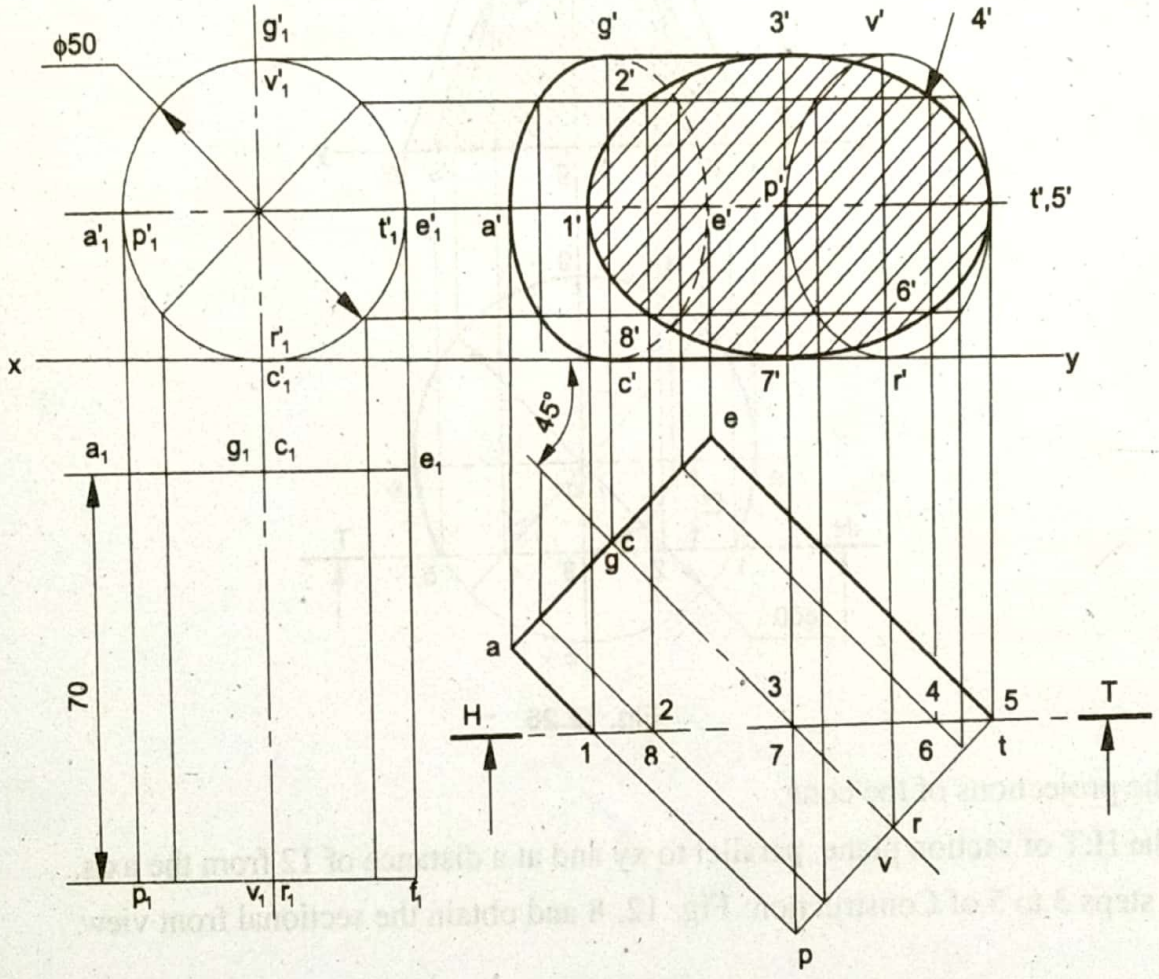

Fig. 12.25

1. Draw the projections of the cylinder, satisfying the given conditions.
2. Draw the H.T of section plane, parallel to xy and passing through the farthest point of the visible base.
3. Locate the points of intersection 1, 2, etc., between the H.T and generators.
4. Transfer the above points to the front view and obtain the sectional front view by joining them with a smooth curve.

NOTE The sectioned portion obtained in the front view is in its true shape and it is an ellipse.

Problem 25 *A cone of base 50 diameter and axis 60 long, stands with its base on H.P. A section plane parallel to V.P, cuts the solid at 12 from the axis. Draw the projections of the sectioned solid.*

Construction (Fig. 12.26)

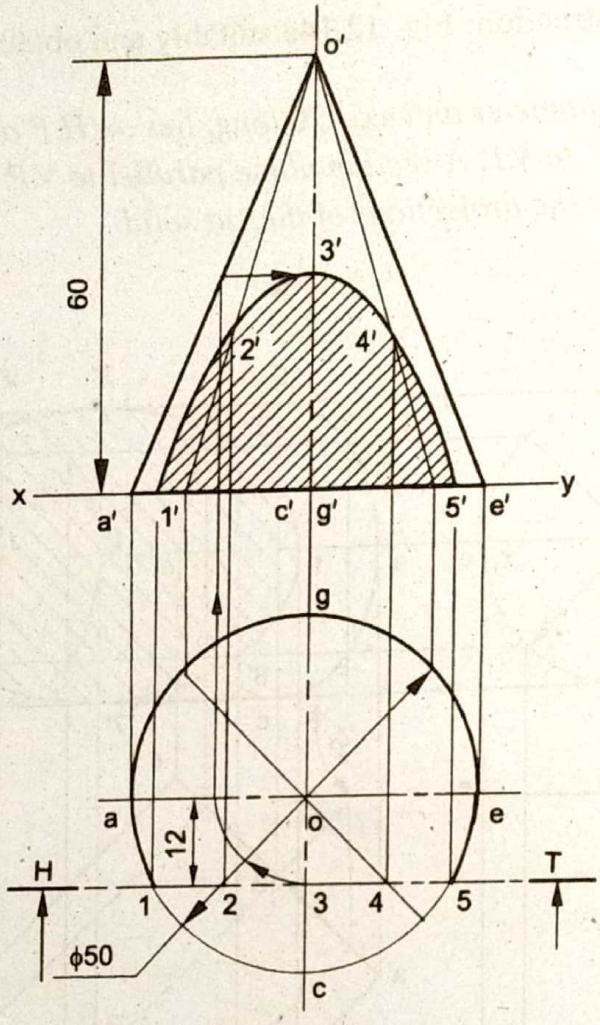

Fig. 12.26

1. Draw the projections of the cone.
2. Draw the H.T of section plane, parallel to xy and at a distance of 12 from the axis.
3. Repeat steps 3 to 5 of Construction: Fig. 12. 8 and obtain the sectional front view.

NOTE The sectioned portion obtained in the front view is in its true shape and the name of the curve is hyperbola.

Problem 26 *A square pyramid of base side 25 and height 40 rests on H.P with its base edges equally inclined to V.P. It is cut by a plane perpendicular to V.P and inclined at 30° to H.P, meeting the axis at 21 from the base. Draw the sectional top view and true shape of the section.*

Construction (Fig. 12. 27)

1. Draw the projections of the pyramid.
2. Draw the V.T of the section plane, inclined at 30° to xy and passing through a point on the axis at 21 from the base.
3. Locate the points of intersection 1′, 2′, 3′, etc., between the V.T and edges of the pyramid.
4. Project and locate these points, on the corresponding edges in the top view.

5. Join the points in the order by straight lines and complete the sectional top view, by cross-hatching the sectioned portion.
6. Consider a reference line x_1y_1, parallel to the V.T of the section plane and obtain the true shape of the section, by projection.

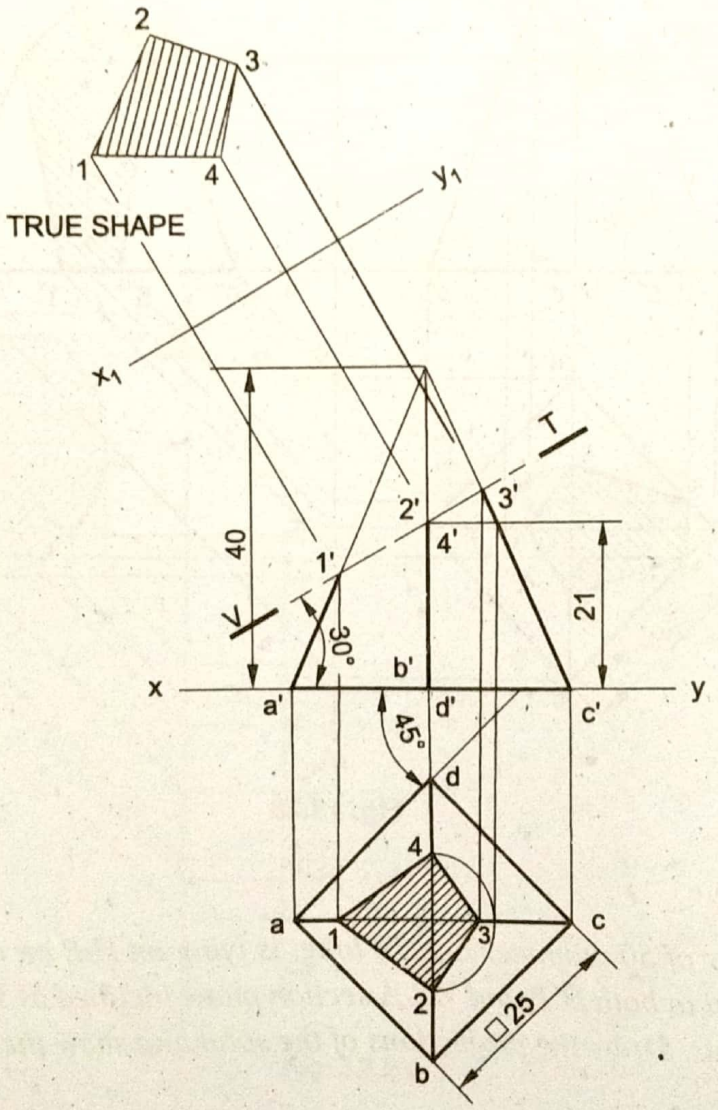

Fig. 12.27

Problem 29 *A cone of base 50 diameter and 60 height, is resting on its base on H.P. It is cut by a section plane such that, the true shape produced is a parabola of base 40. Locate the V.T of the section plane and draw the projections of the solid.*

HINT When a cone is cut by a section plane, parallel to an extreme generator, the section produced is a parabola, the size of which depends upon the position of the section plane.

Construction (Fig. 12.30)

1. Draw the projections of the cone.
2. In the top view, locate the chord 1-11 of length 40 and perpendicular to xy.
3. Through 1 (11), draw a projector, meeting xy at 1′ (11′).

4. Through 1′, draw the V.T, parallel to the extreme generator.

5. Repeat steps 3 to 6 of Construction: Fig. 12.14a suitably and obtain sectional top view and the true shape of the section.

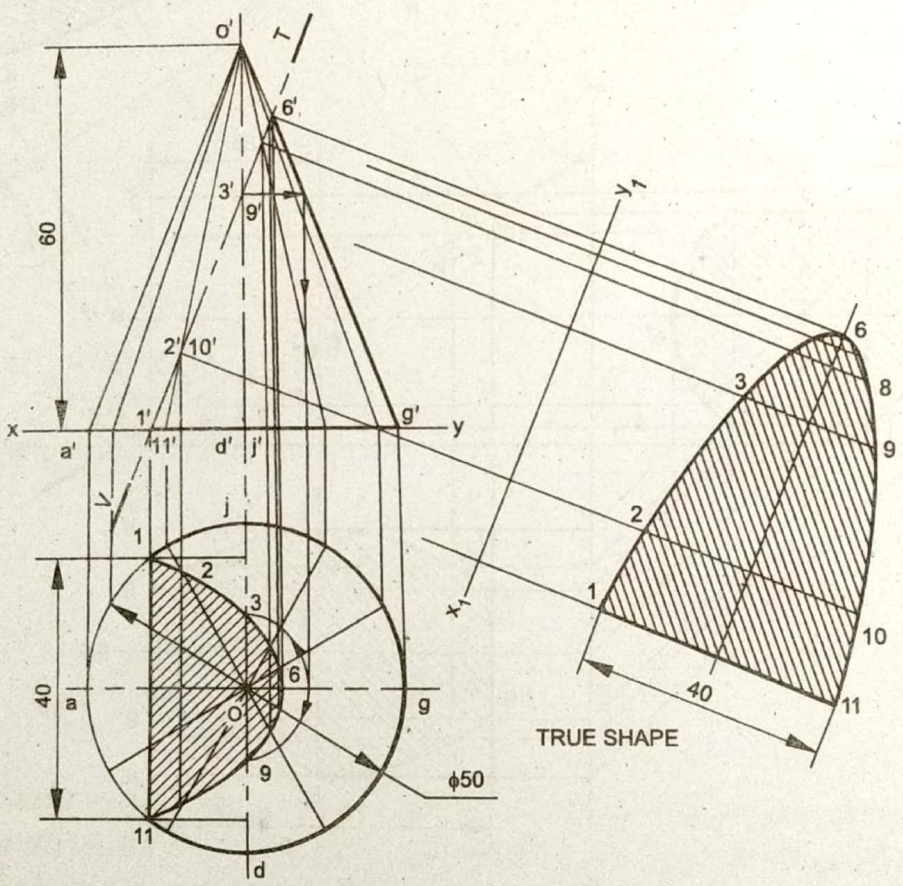

Fig. 12.30

Problem 35 *A square prism of base 50 side and axis 100 long, stands with its base on H.P such that, all the faces are equally inclined to V.P. It is cut by a section plane, perpendicular to V.P such that, the true shape of the section is a rhombus of longer diagonal 90. Find the inclination of the section plane with H.P. Draw the projections of the solid.*

Construction (Fig. 12.36)

1. Draw the projections of the prism.

   HINT For the true shape of the section to be a rhombus, the section plane should pass through the extreme lateral edges in the front view

2. Locate the V.T of section plane such that, it passes through the extreme lateral edges of the prism in the front view and the length of the intercept is equal to 90. The angle θ is the inclination of the section plane with H.P.

3. Consider a reference line x_1y_1, parallel to the V.T of section plane and obtain the true shape of the section, by projection.

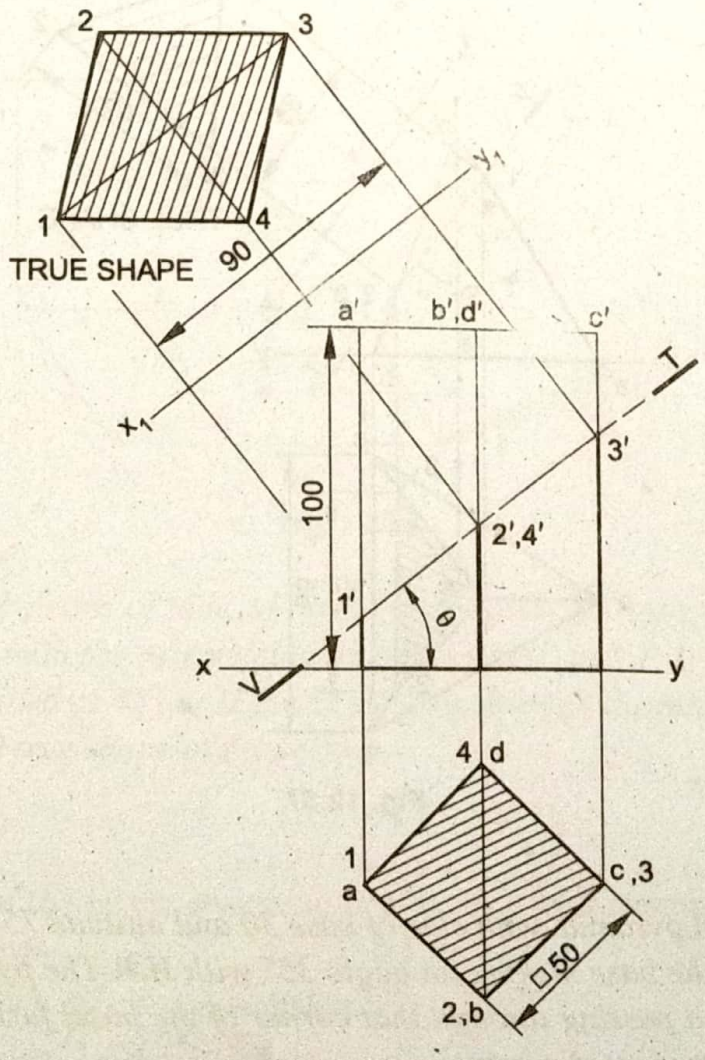

Fig. 12.36