Chapter 14

SECTIONS OF SOLIDS

14-0. INTRODUCTION

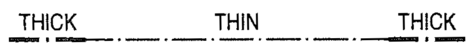
Invisible features of an object are shown by dotted lines in their projected views. But when such features are too many, these lines make the views more complicated and difficult to interpret. In such cases, it is customary to imagine the object as being cut through or *sectioned* by planes. The part of the object between the cutting plane and the observer is assumed to be removed and the view is then shown *in section*.

The imaginary plane is called a section *plane* or a *cutting plane*. The surface produced by cutting the object by the section plane is called the *section*. It is indicated by thin section lines uniformly spaced and inclined at 45°.

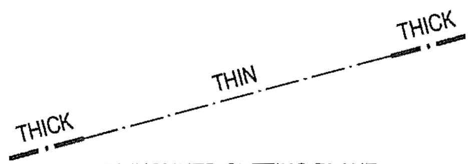
The projection of the section along with the remaining portion of the object is called a *sectional view*. Sometimes, only the word section is also used to denote a sectional view.

(1) Section planes: Section planes are generally perpendicular planes. They may be perpendicular to one of the reference planes and either perpendicular, parallel or inclined to the other plane. They are usually described by their traces. It is important to remember that the projection of a section plane, on the plane to which it is perpendicular, is a straight line. This line will be parallel, perpendicular or inclined to *xy*, depending upon the section plane being parallel, per-pendicular or inclined respectively to the other reference plane.

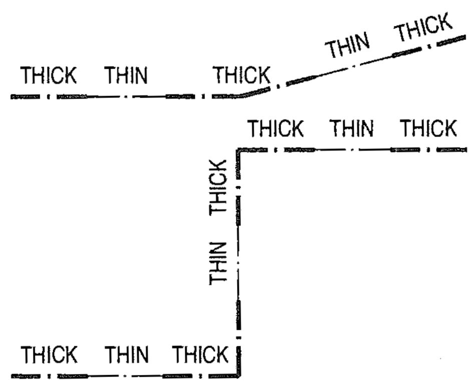
As per latest B.I.S. convention (SP: 46-2003), the cutting-plane line should be drawn as shown in fig. 3-2 which is reproduced here in fig. 14-1 for ready reference.



(a) PARALLEL CUTTING PLANE



(b) INCLINED CUTTING PLANE



(c) CUTTING PLANE AT CHANGING POSITION

FIG. 14-1

(2) Sections: The projection of the section on the reference plane to which the section plane is perpendicular, will be a straight line coinciding with the trace of the section plane on it. Its projection on the other plane to which it is inclined is called *apparent section*. This is obtained by

(i) projecting on the other plane, the points at which the trace of the section plane intersects the edges of the solid and

(ii) drawing lines joining these points in proper sequence.

(3) True shape of a section: The projection of the section on a plane parallel to the section plane will show the true shape of the section. Thus, when the section plane is parallel to the H.P. or the ground, the true shape of the section will be seen in *sectional top view*. When it is parallel to the V.P., the true shape will be visible in the *sectional front view*.

But when the section plane is inclined, the section has to be projected on an auxiliary plane parallel to the section plane, to obtain its true shape. When the section plane is perpendicular to both the reference planes, the sectional side view will show the true shape of the section. In this chapter sections of different solids are explained in stages by means of typical problems as follows:

1. Sections of prisms
2. Sections of pyramids
3. Sections of cylinders
4. Sections of cones
5. Sections of spheres.

14-1. SECTIONS OF PRISMS

These are illustrated according to the position of the section plane with reference to the principal planes as follows:

(1) Section plane parallel to the V.P.

(2) Section plane parallel to the H.P.

(3) Section plane perpendicular to the H.P. and inclined to the V.P.

(4) Section plane perpendicular to the V.P. and inclined to the H.P.

(1) Section plane parallel to the V.P.

Problem 14-1. (fig. 14-2): *A cube of 35 mm long edges is resting on the H.P. on one of its faces with a vertical face inclined at 30° to the V.P. It is cut by a section plane parallel to the V.P. and 9 mm away from the axis and further away from the V.P. Draw its sectional front view and the top view.*

In fig. 14-2(i), the section plane is assumed to be transparent and the cube is shown with the cut-portion removed. It can be seen that four edges of the cube are cut and hence, the section is a figure having four sides.

Draw the projections of the whole cube in the required position [fig. 14-2(ii)].

As the section plane is parallel to the V.P., it is perpendicular to the H.P.; hence, the section will be seen as a line in the top view coinciding with the H.T. of the section plane.

(i) Draw a line H.T. in the top view (to represent the section plane) parallel to *xy* and 9 mm from *o*.

(ii) Name the points at which the edges are cut, viz. *ab* at 1, *bc* at 2, *gf* at 3 and *fe* at 4.

(iii) Project these points on the corresponding edges in the front view and join them in proper order.

As the section plane is parallel to the V.P., figure 1' 2' 3' 4' in the front view, shows the true shape of the section.

Show the views by dark but thin lines, leaving the lines for the cut-portion fainter.

(iv) Draw section lines in the rectangle for the section.

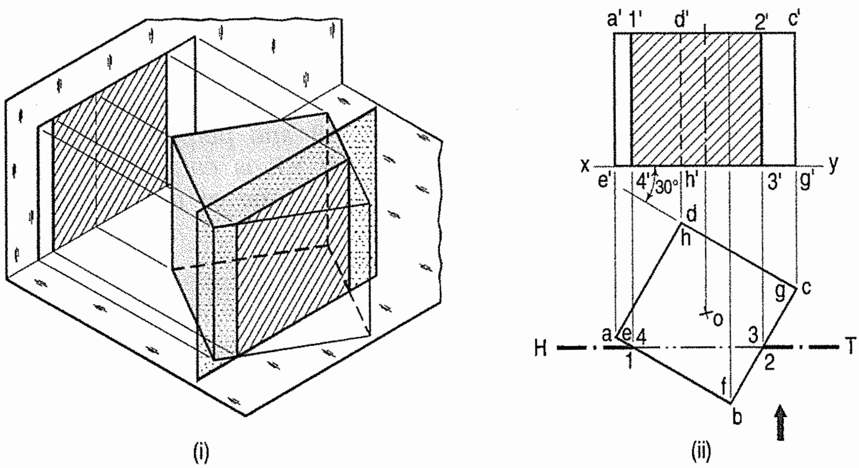


FIG. 14-2

(2) Section plane parallel to the H.P.

Problem 14-2. (fig. 14-3): *A triangular prism, base 30 mm side and axis 50 mm long, is lying on the H.P. on one of its rectangular faces with its axis inclined at 30° to the V.P. It is cut by a horizontal section plane, at a distance of 12 mm above the ground. Draw its front view and sectional top view.*

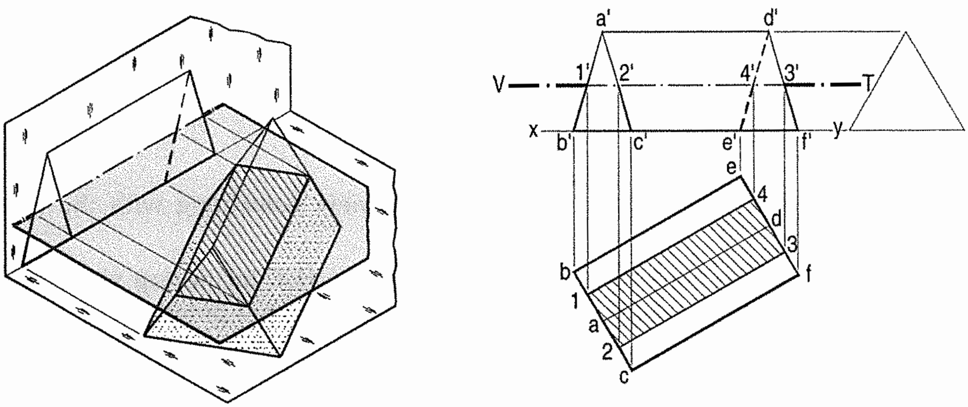


FIG. 14-3

Draw the projections of the prism in the required position.

As the section plane is horizontal, i.e. parallel to the H.P., it is perpendicular to the V.P. Hence, the section will be seen as a line in the front view, coinciding with the V.T. of the section plane.

(i) Therefore, draw a line V.T. in the front view to represent the section plane, parallel to *xy* and 12 mm above it.

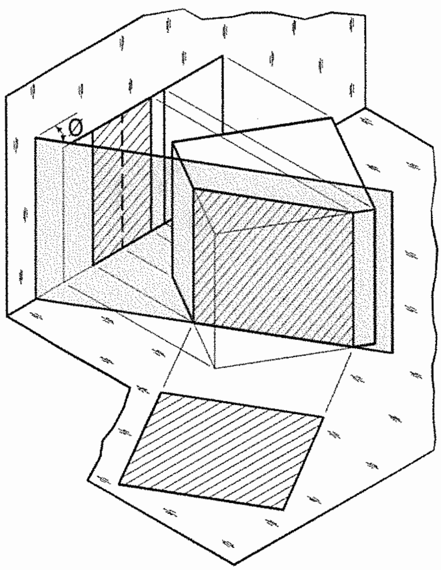
(ii) Name in correct sequence, points at which the edges are cut viz. *a'b'* at 1', *a'c'* at 2', *d'f'* at 3' and *d'e'* at 4'.

(iii) Project these points on the corresponding lines in the top view and complete the sectional top view by joining them in proper order.

As the section plane is parallel to the H.P., the figure 1 2 3 4 (in the top view) is the true shape of the section.

(3) Section plane perpendicular to the H.P. and inclined to the V.P.

Problem 14-3. (fig. 14-4): *A cube in the same position as in problem 14-1, is cut by a section plane, inclined at 60° to the V.P. and perpendicular to the H.P., so that the face which makes 60° angle with the V.P. is cut in two equal halves. Draw the sectional front view, top view and true shape of the section.*



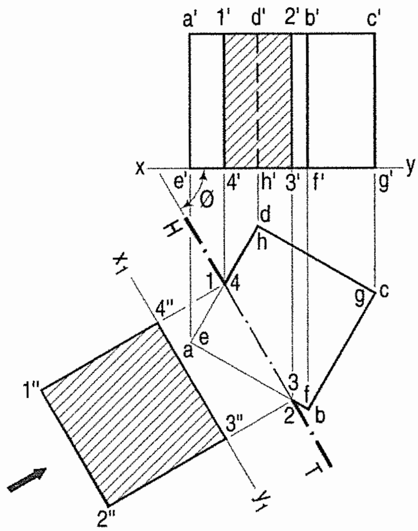


FIG. 14-4

The section will be seen as a line in the top view coinciding with the H.T. of the section plane.

(i) Draw the projections of the cube. Draw a line H.T. in the top view inclined at 60° to *xy* and cutting the line *ad* (or *bc*) at its mid-point.

(ii) Name the corners at which the four edges are cut and project them in the front view. As the section plane is inclined to the V.P., the front view of the section viz. 1' 2' 3' 4' does not reveal its true shape. Only the vertical lines show true lengths, while the true lengths of the horizontal lines are seen in the top view.

The true shape of the section will be seen when it is projected on an auxiliary vertical plane, parallel to the section plane.

(iii) Therefore, draw a new reference line x_1y_1 parallel to the H.T. and project the section on it. The distances of the points from x_1y_1 should be taken equal to their corresponding distances from *xy* in the front view. Thus 4" and 3" will be on x_1y_1. 1" 4" and 2" 3" will be equal to 1' 4' and 2' 3' respectively. Complete the rectangle 1" 2" 3" 4" which is the true shape of the section and draw section lines in it.

(4) **Section plane perpendicular to the V.P. and inclined to the H.P.**

Problem 14-4. (fig. 14-5): *A cube in the same position as in problem 14-1 is cut by a section plane, perpendicular to the V.P., inclined at 45° to the H.P. and passing through the top end of the axis. (i) Draw its front view, sectional top view and true shape of the section. (ii) Project another top view on an auxiliary plane, parallel to the section plane.*

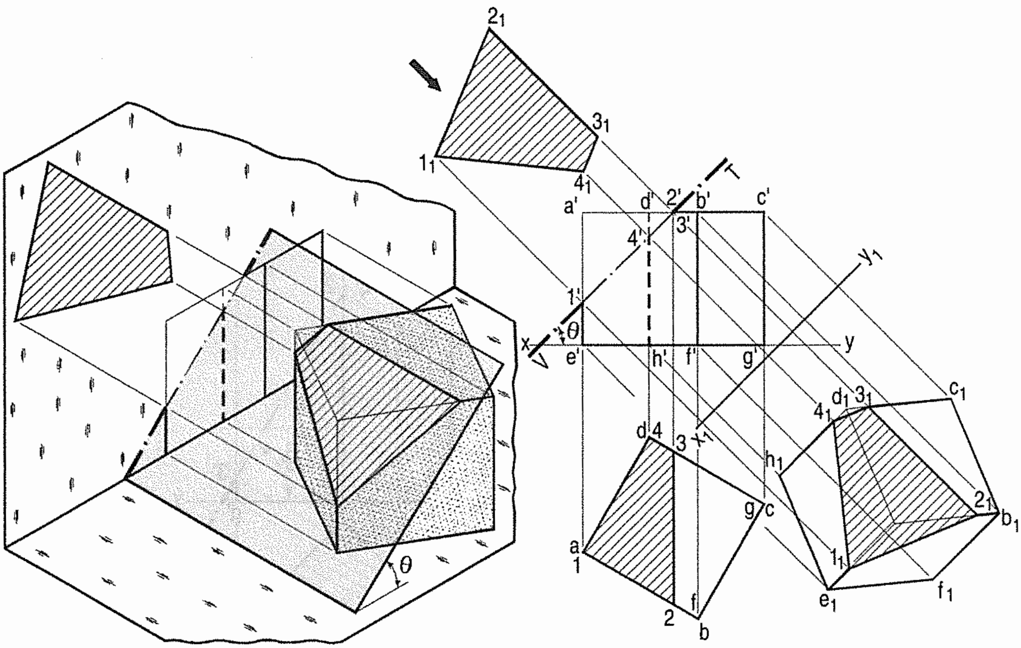


FIG. 14-5

The section will be seen as a line in the front view.

(i) Draw a line V.T. in the front view, inclined at 45° to *xy* and passing through the top end of the axis. It cuts four edges, viz. *a' e'* at 1', *a' b'* at 2', *c'd'* at 3' and *d'h'* at 4'.

(ii) Project the top view of the section, viz. the figure 1 2 3 4. It does not show the true shape of the section, as the section plane is inclined to the H.P.

To determine the true shape, an auxiliary top view of the section should be projected on an A.I.P. parallel to the section plane.

(iii) Assuming the new reference line for the A.I.P. to coincide with the V.T., project the true shape of the section as shown by quadrilateral 1_1 2_1 3_1 4_1.

The distances of all the points from the V.T. should be taken equal to their corresponding distances from xy in the top view, e.g. $1_1 1' = e'1$, $4_1 4' = h'4$ etc.

(iv) To project an auxiliary sectional top view of the cube, draw a new reference line $x_1 y_1$, parallel to the V.T. The whole cube may first be projected and the points for the section may then be projected on the corresponding lines for the edges. Join these points in correct sequence and obtain the required top view.

(v) Draw section lines in the cut-surface, in the views where it is seen. Keep the lines for the removed edges thin and fainter.

Additional problems on sections of prisms:

Problem 14-5. (fig. 14-6): *A square prism, base 40 mm side, axis 80 mm long, has its base on the H.P. and its faces equally inclined to the V.P. It is cut by a plane, perpendicular to the V.P., inclined at 60° to the H.P. and passing through a point on the axis, 55 mm above the H.P. Draw its front view, sectional top view and another top view on an A.I.P. parallel to the section plane.*

The problem is similar to problem 14-4 and needs no further explanation. The true shape of the section is seen in the auxiliary top view.

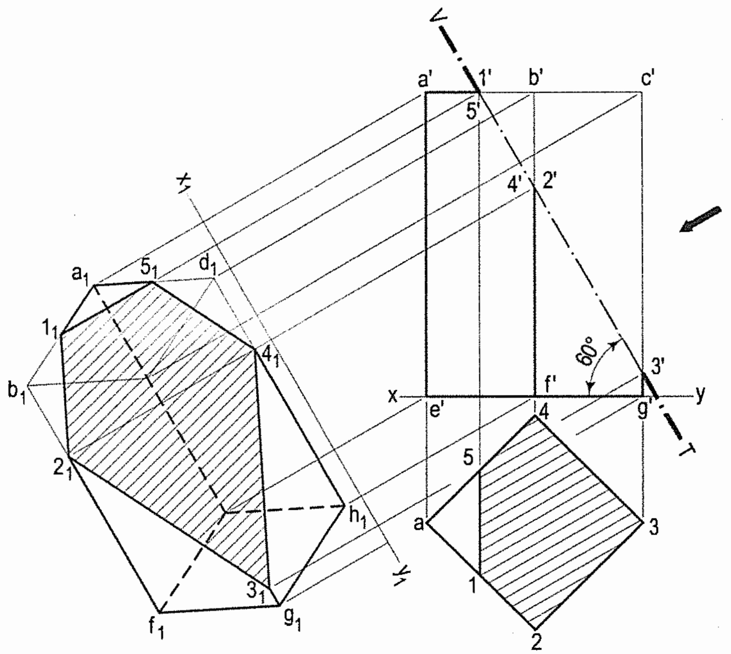


FIG. 14-6

Problem 14-6. (fig. 14-7): *A hexagonal prism, has a face on the H.P. and the axis parallel to the V.P. It is cut by a vertical section plane, the H.T. of which makes an angle of 45° with xy and which cuts the axis at a point 20 mm from one of its ends. Draw its sectional front view and the true shape of the section. Side of base 25 mm long; height 65 mm.*

(i) Draw the front view and the top view of the prism and show the H.T. of the section plane in the top view. Name in proper sequence, the points at which the lines are cut.

(ii) Project them on the corresponding lines in the front view. The positions of points 4 and 5 cannot be located directly. Hence, project them on the first top view to 4_1 on *ef* and 5_1 on *ed*. From this top view, obtain their positions $4'_1$ and $5'_1$ on the corresponding lines in the first front view. As the two front views are identical, these points can now be transferred to the second front view by making e'4' equal to $e'4'_1$ and e'5' equal to $e'5'_1$. 4' and 5' are the projections of points 4 and 5 respectively. Complete the sectional front view as shown.

(iii) Obtain the true shape of the section on x_1y_1 as explained in problem 14-3, making o"1" equal to o'1', etc.

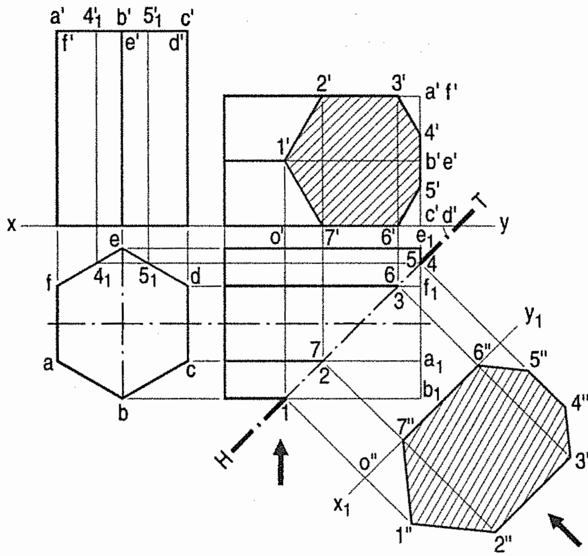


FIG. 14-7

Problem 14-7. (fig. 14-8): *A pentagonal prism, base 28 mm side and height 65 mm has an edge of its base on the H.P. and the axis parallel to the V.P. and inclined at 60° to the H.P. A section plane, having its H.T. perpendicular to xy, and the V.T. inclined at 60° to xy and passing through the highest corner, cuts the prism. Draw the sectional top view and true shape of the section.*

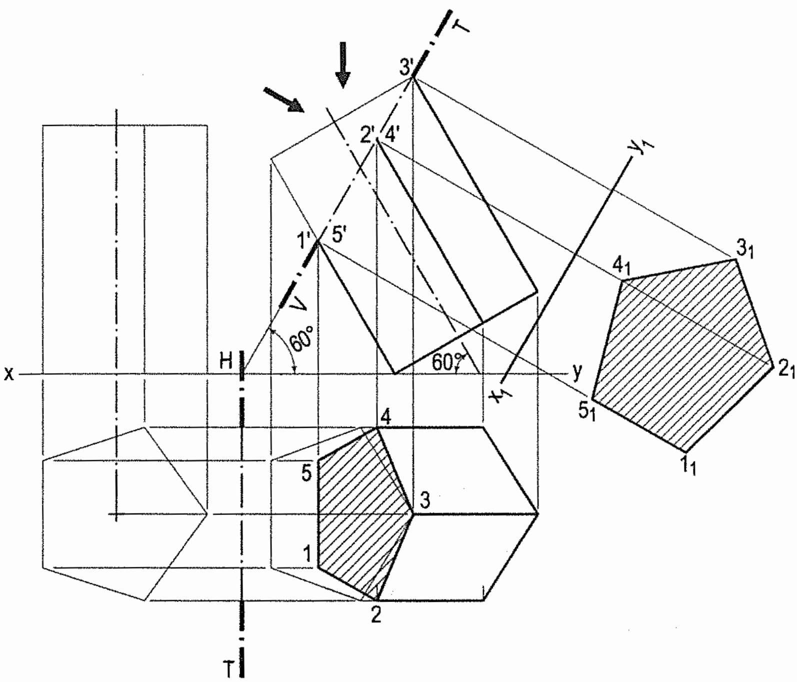


FIG. 14-8

(i) Draw the projections of the prism in the required position.

(ii) Draw the line V.T. passing through the highest corner 3' and inclined at 60° to *xy*. A perpendicular to *xy* through *V* will be the H.T. of the section plane.

(iii) Project the sectional top view and the true shape of the section, as shown in the figure.

Problem 14-8. (fig. 14-9): *A hollow square prism, base 40 mm side (outside), height 65 mm and thickness 8 mm is resting on its base on the H.P. with a vertical face inclined at 30° to the V.P. A section plane, inclined at 30° to the H.P., perpendicular to the V.P. and passing through the axis at a point 12 mm from its top end, cuts the prism. Draw its sectional top view, sectional side view and true shape of the section.*

(i) Draw the projections of the prism in the given position, showing the hidden edges by dashed lines.

(ii) Draw a line V.T. for the cutting plane and mark points at which the inside and outside edges are cut.

(iii) Project the sectional top view, true shape of the section and the sectional side view as shown.

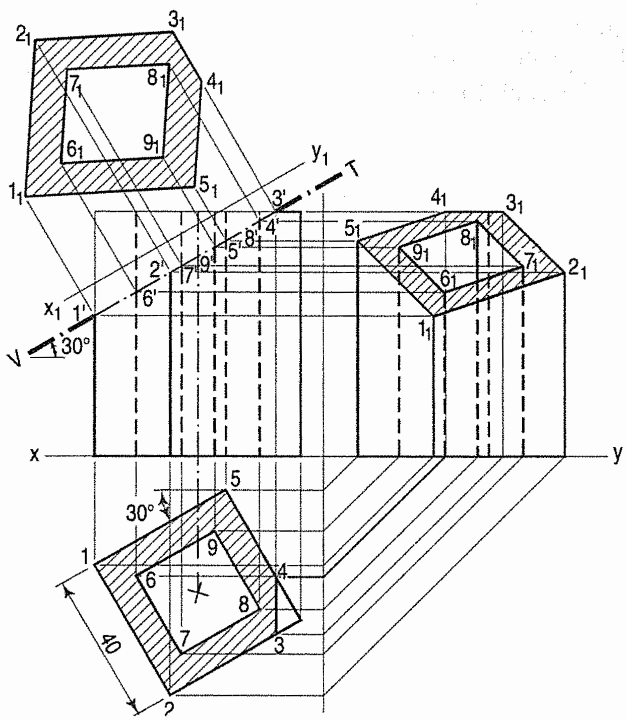


FIG. 14-9

14-2. SECTIONS OF PYRAMIDS

The following cases are discussed in details.

(1) Section plane parallel to the base of the pyramid.

(2) Section plane parallel to the V.P.

(3) Section plane perpendicular to the V.P. and inclined to the H.P.

(4) Section plane perpendicular to the H.P. and inclined to the V.P.

(1) Section plane parallel to the base of the pyramid.

Problem 14-9. (fig. 14-10): *A pentagonal pyramid, base 30 mm side and axis 65 mm long, has its base horizontal and an edge of the base parallel to the V.P. A horizontal section plane cuts it at a distance of 25 mm above the base. Draw its front view and sectional top view.*

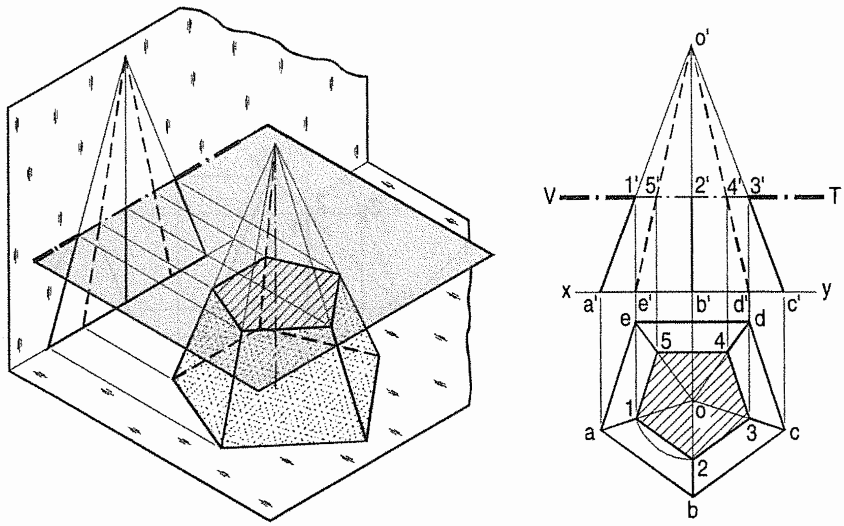


FIG. 14-10

(i) Draw the projections of the pyramid in the required position and show a line V.T. for the section plane, parallel to and 25 mm above the base.

All the five slant edges are cut.

(ii) Project the points at which they are cut, on the corresponding edges in the top view. The point 2' cannot be projected directly as the line *ob* is perpendicular to *xy*. But it is quite evident from the projections of other points that the lines of the section in the top view, viz. 3-4, 4-5 and 5-1 are parallel to the edges of the base in their respective faces and that the points 1, 3, 4 and 5 are equidistant from o.

(iii) Hence, line 1-2 also will be parallel to *ab* and o2 will be equal to o1, o3 etc. Therefore, with *o* as centre and radius o1, draw an arc cutting *ob* at a point 2 which will be the projection of 2'. Complete the sectional top view in which the true shape of the section, viz. the pentagon 1, 2, 3, 4 and 5 is also seen.

(iv) Hence, when a pyramid is cut by a plane parallel to its base, the true shape of the section will be a figure, similar to the base; the sides of the section will be parallel to the edges of the base in the respective faces and the corners of the section will be equidistant from the axis.

(2) Section plane parallel to the V.P.

Problem 14-10. (fig. 14-11): *A triangular pyramid, having base 40 mm side and axis 50 mm long, is lying on the H.P. on one of its faces, with the axis parallel to the V.P. A section plane, parallel to the V.P. cuts the pyramid at a distance of 6 mm from the axis. Draw its sectional front view and the top view.*

(i) Draw the projections of the pyramid in the required position and show a line H.T. (for the cutting plane) in the top view parallel to *xy* and 6 mm from the axis.

(ii) Project points 1, 2 and 3 (at which the edges are cut) on corresponding edges in the front view and join them. Figure 1' 2' 3' shows the true shape of the section.

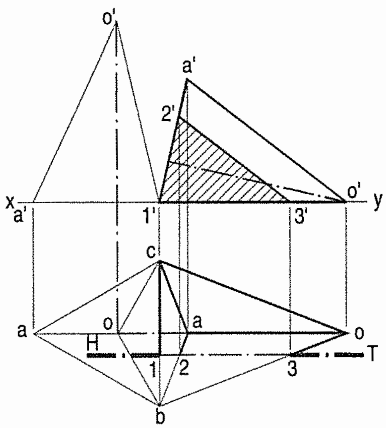


FIG. 14-11

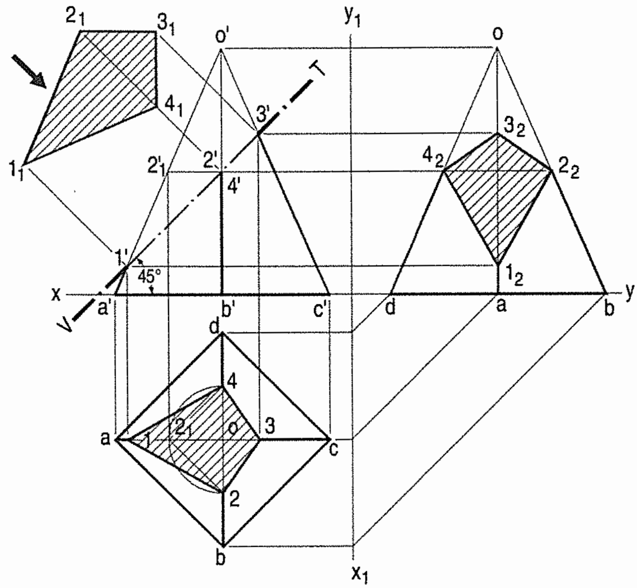


FIG. 14-12

(3) Section plane perpendicular to the V.P. and inclined to the H.P.

Problem 14-11. (fig. 14-12): *A square pyramid, base 40 mm side and axis 65 mm long, has its base on the H.P. and all the edges of the base equally inclined to the V.P. It is cut by a section plane, perpendicular to the V.P., inclined at 45° to the H.P. and bisecting the axis. Draw its sectional top view, sectional side view and true shape of the section.*

(i) Draw the projections of the pyramid in the required position. The section plane will be seen as a line in the front view. Hence, draw a line V.T. through the mid-point of the axis and inclined at 45° to *xy*. Name in correct sequence the points at which the four edges are cut and project them in the top view. Here also, points 2' and 4' cannot be projected directly.

Hence, assume a horizontal section through 2' and draw a line parallel to the base, cutting *o' a'* at $2'_1$. Project $2'_1$ to 2_1 on *oa* in the top view. From 2_1 draw a line parallel to *ab* and cutting *ob* at a point 2. Or, with *o* as centre and radius o 2_1, draw an arc cutting *ob* at 2 and *ob* at 4. Complete the section 1 2 3 4 by joining the points and draw section lines in it.

(ii) Assuming the V.T. to be the new reference line, draw the true shape of the section. Project the side view from the two views. The removed portion of the pyramid may be shown by thin and faint lines.

(4) Section plane perpendicular to the H.P. and inclined to the V.P.

Problem 14-12. (fig. 14-13): *A pentagonal pyramid has its base on the H.P. and the edge of the base nearer the V.P., parallel to it. A vertical section plane, inclined at 45° to the V.P., cuts the pyramid at a distance of 6 mm from the axis. Draw the top view, sectional front view and the auxiliary front view on an A.V.P. parallel to the section plane. Base of the pyramid 30 mm side; axis 50 mm long.*

The section plane will be seen as a line in the top view. It is to be at a distance of 6 mm from the axis.

(i) Hence, draw a circle with o as centre and radius equal to 6 mm.

(ii) Draw a line H.T., tangent to this circle and inclined at 45° to xy. It can be drawn in four different positions, of which any one may be selected.

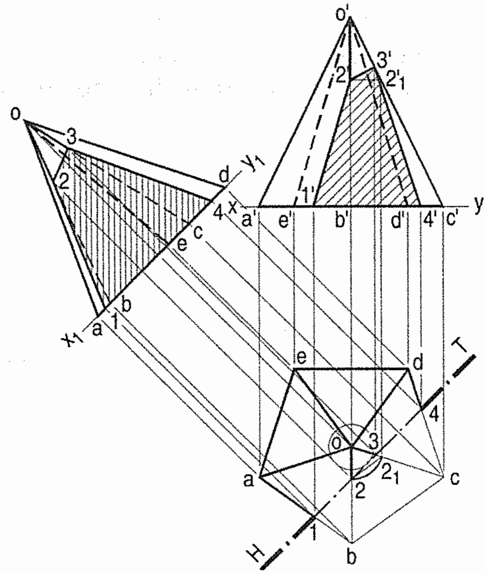


FIG. 14-13

(iii) Project points 1, 2 etc. from the top view to the corresponding edges in the front view. Here again, point 2 cannot be projected directly. The process shown in problem 14-11 must be reversed. With centre o and radius $o2$ draw an arc cutting any one of the slant edges, say oc at 2_1. Project 2_1 to $2'_1$ on $o'c'$.

(iv) Through $2'_1$, draw a line parallel to the base, cutting $o'b'$ at 2'. Then 2' is the required point. Complete the view. It will show the apparent section.

(v) Draw a reference line x_1y_1 parallel to the H.T. and project an auxiliary sectional front view which will show the true shape of the section also.

Additional problems on sections of pyramids:

Problem 14-13. (fig. 14-14): *A hexagonal pyramid, base 30 mm side and axis 65 mm long, is resting on its base on the H.P. with two edges parallel to the V.P. It is cut by a section plane, perpendicular to the V.P. inclined at 45° to the H.P. and intersecting the axis at a point 25 mm above the base. Draw the front view, sectional top view, sectional side view and true shape of the section.*

This problem is similar to problem 14-11. In this case, the base is also cut and hence, the section is a heptagon. Care must be taken to name the points in proper sequence.

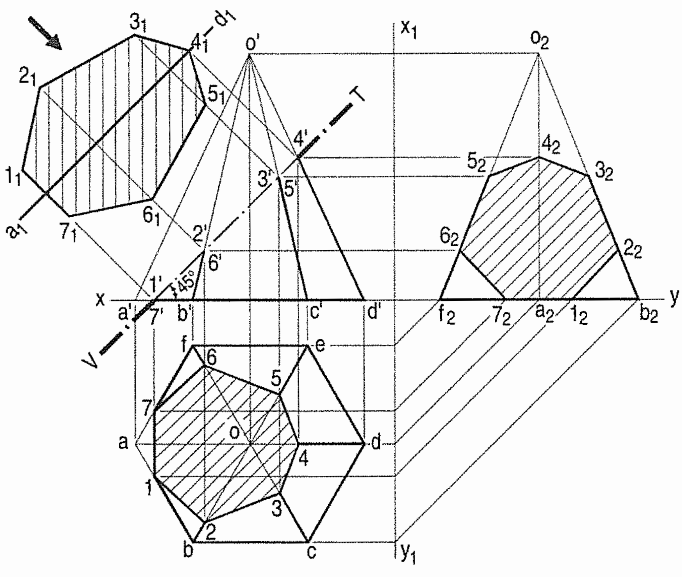


FIG. 14-14

The true shape may be drawn on the V.T. as a new reference line or around the centre line a_1d_1, drawn parallel to the V.T. as shown.

The distances of the points 1_1, 2_1 etc. from $a_1\ d_1$ are taken equal to the distances of points 1, 2 etc. from the line *ad* (which is parallel to *xy*).

Problem 14-14. (fig. 14-15): *A pentagonal pyramid, base 30 mm side and axis 60 mm long, is lying on one of its triangular faces on the H.P. with the axis parallel to the V.P. A vertical section plane, whose H.T. bisects the top view of the axis and makes an angle of 30° with the reference line, cuts the pyramid, removing its top part. Draw the top view, sectional front view, true shape of the section and development of the surface of the remaining portion of the pyramid.*

(i) Draw the H.T. of the section plane and name the points at which the edges are cut, in correct sequence, i.e. mark the visible edges first and then the hidden edges.

(ii) Project the sectional front view which will show the apparent section.

(iii) Obtain the true shape of the section on x_1y_1 as a new reference line drawn parallel to the H.T.

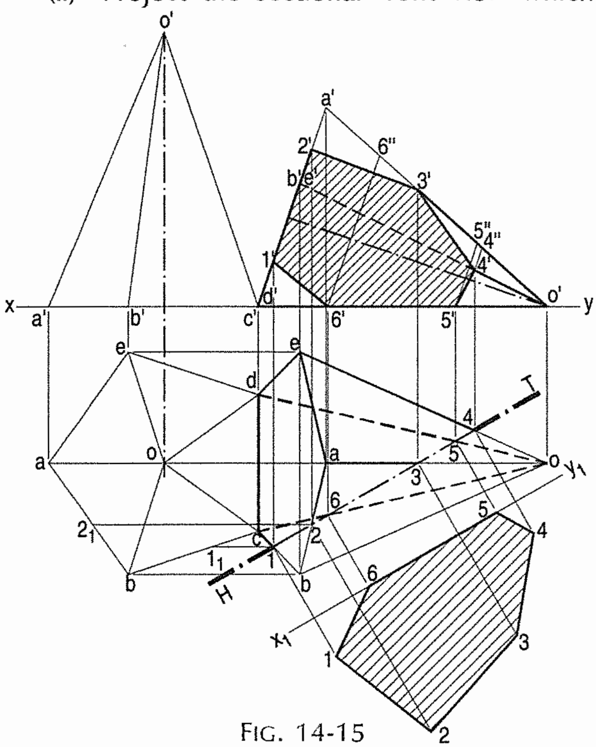


FIG. 14-15

Development (fig. 14-16): The line *o'a'* shows the true length of the slant edge.

(i) With any point *O* as centre and radius *o'a'*, draw an arc and construct the development of the whole pyramid. Mark points on it, taking the positions of 1 and 2 from the first top view and those of other points by projecting them on the true-length-line *o'a'*.

(ii) Draw lines joining these points and complete the development as shown in the figure.

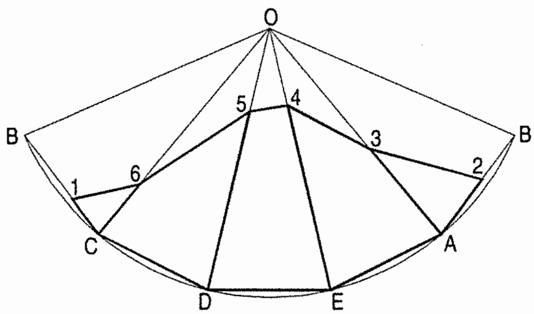


FIG. 14-16

Problem 14-15. (fig. 14-17): *A hexagonal pyramid, base 30 mm side and axis 60 mm long, has a triangular face on the H.P. and the axis parallel to the V.P. It is cut by a horizontal section plane which bisects the axis. Draw the front view and sectional top view and develop the surface of the cut-pyramid.*

The V.T. cuts six edges. The sectional top view shows the true shape of the section also.

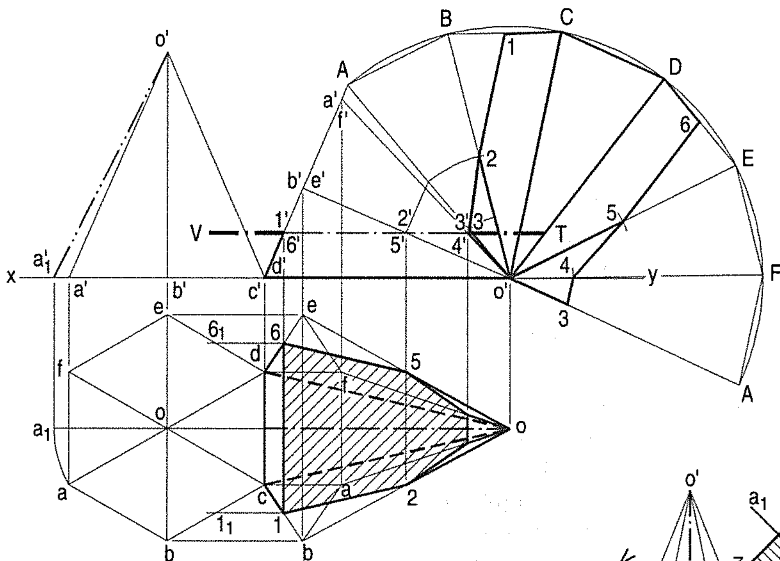


FIG. 14-17

Development: None of the edges shows the true length of the slant edge.

(i) Hence, determine the true length $o'a'_1$ and draw the development of the whole pyramid.

(ii) Locate positions of the points 1 and 6 by projecting them on the first top view and positions of other points by drawing lines through them, parallel to the base and upto the true length line *o'A*.

(iii) Mark these points on the development and complete it as shown.

Problem 14-16. (fig. 14-18): *A hexagonal pyramid, base 30 mm side and axis 75 mm long, resting on its base on the H.P. with two of its edges parallel to the V.P. is cut by two section planes, both perpendicular to the V.P. The horizontal section plane cuts the axis at a point 35 mm from the apex. The other plane which makes an angle of 45° with the H.P., also intersects the axis at the same point. Draw the front view, sectional top view, true shape of the section and development of the surface of the remaining part of the pyramid.*

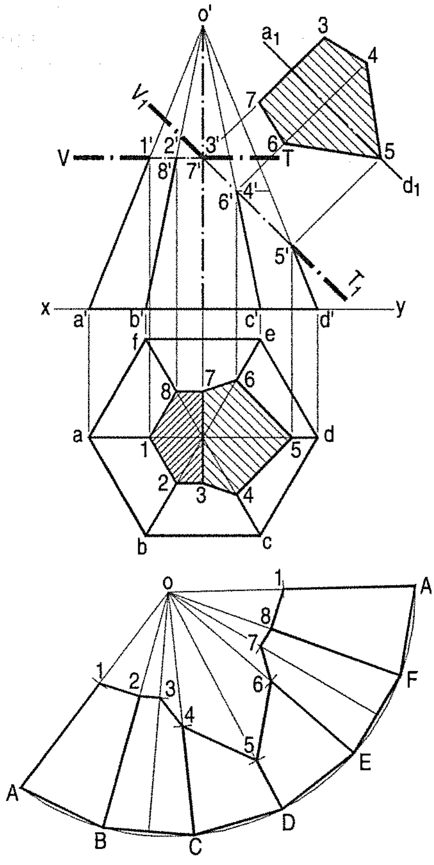


FIG. 14-18

(i) Draw lines V.T. and V_1T_1 for the two section planes. The top view will show the true shape of the horizontal section, the sides of which are parallel to the respective sides of the base. The true shape of the other section may be obtained on V_1T_1 as the reference line or around a_1d_1.

(ii) Draw the development with *o' a'* or *o' d'* as radius and locate the points on it, as shown in the figure.

14-3. SECTIONS OF CYLINDERS

We shall now learn the following three cases. They are

(1) Section plane parallel to the base
(2) Section plane parallel to the axis
(3) Section plane inclined to the base.

(1) Section plane parallel to the base: When a cylinder is cut by a section plane parallel to the base, the true shape of the section is a circle of the same diameter.

(2) Section plane parallel to the axis: When a cylinder is cut by a section plane parallel to the axis, the true shape of the section is a rectangle, the sides of which are respectively equal to the length of the axis and the length of the section plane within the cylinder (fig. 14-19). When the section plane contains the axis, the rectangle will be of the maximum size.

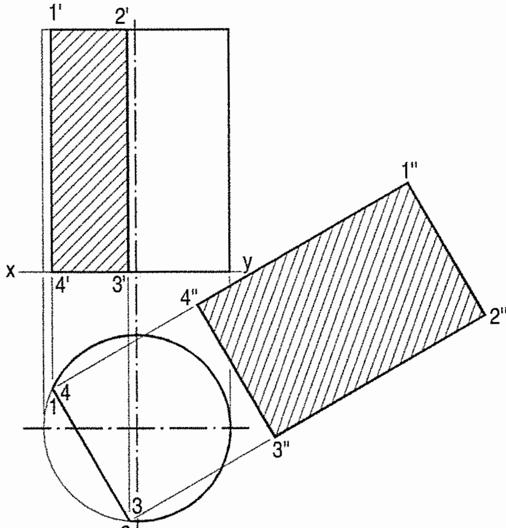


FIG. 14-19

(3) Section plane inclined to the base:

CHAROTAR COGNIFRONT

This book is accompanied by a computer CD, which contains an audiovisual animation presented for better visualization and understanding of the subject. Readers are requested to refer Presentation module 31 for the following problem.

Problem 14-17. (fig. 14-20): *A cylinder of 40 mm diameter, 60 mm height and having its axis vertical, is cut by a section plane, perpendicular to the V.P., inclined at 45° to the H.P. and intersecting the axis 32 mm above the base. Draw its front view, sectional top view, sectional side view and true shape of the section.*

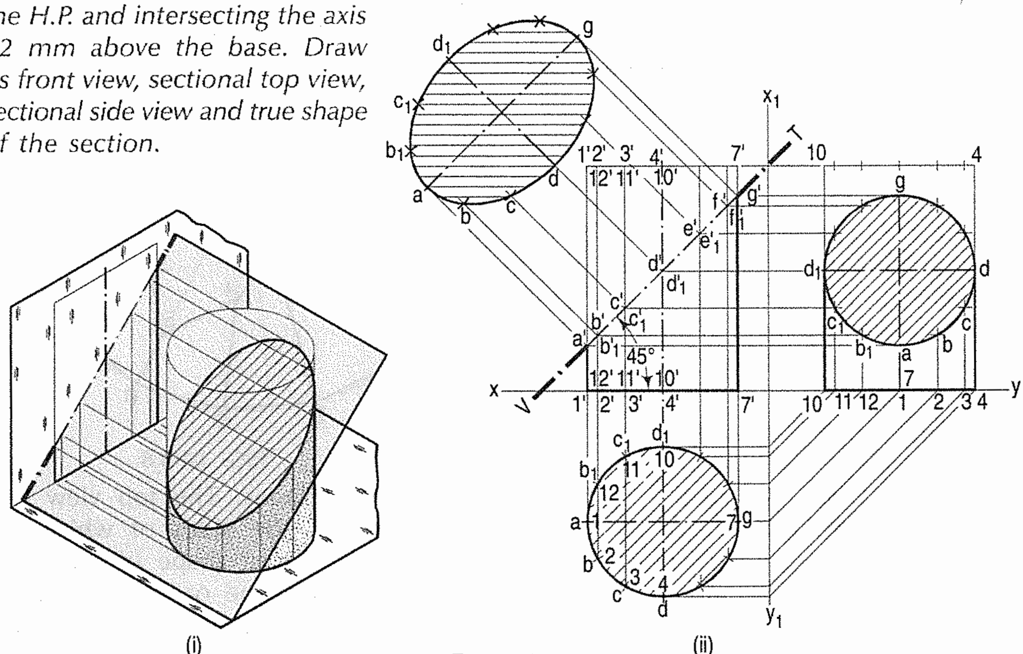


FIG. 14-20

As the cylinder has no edges, a number of lines representing the generators may be assumed on its curved surface by dividing the base-circle into, say 12 equal parts.

(i) Name the points at which these lines are cut by the V.T. In the top view, these points lie on the circle and hence, the same circle is the top view of the section. The width of the section at any point, say c', will be equal to the length of the chord cc_1 in the top view.

(ii) The true shape of the section may be drawn around the centre line *ag* drawn parallel to V.T. as shown. It is an ellipse the major axis of which is equal to the length of the section plane viz. *a'g'*, and the minor axis equal to the diameter of the cylinder viz. dd_1.

(iii) Project the sectional side view as shown. The section will be seen as a circle because the section plane makes 45° angle with *xy*.

Additional problems on sections of cylinders:

Problem 14-18. (fig. 14-21): *A cylinder 50 mm diameter and 60 mm long, is resting on its base on the ground. It is cut by a section plane perpendicular to the V.P., the V.T. of which cuts the axis at a point 40 mm from the base and makes an angle of 45° with the H.P. Draw its front view, sectional top view and another sectional top view on an A.I.P. parallel to the section plane.*

In this case, the top end of the cylinder is also cut. Hence, the true shape of the section is a part of an ellipse as shown in the auxiliary top view.

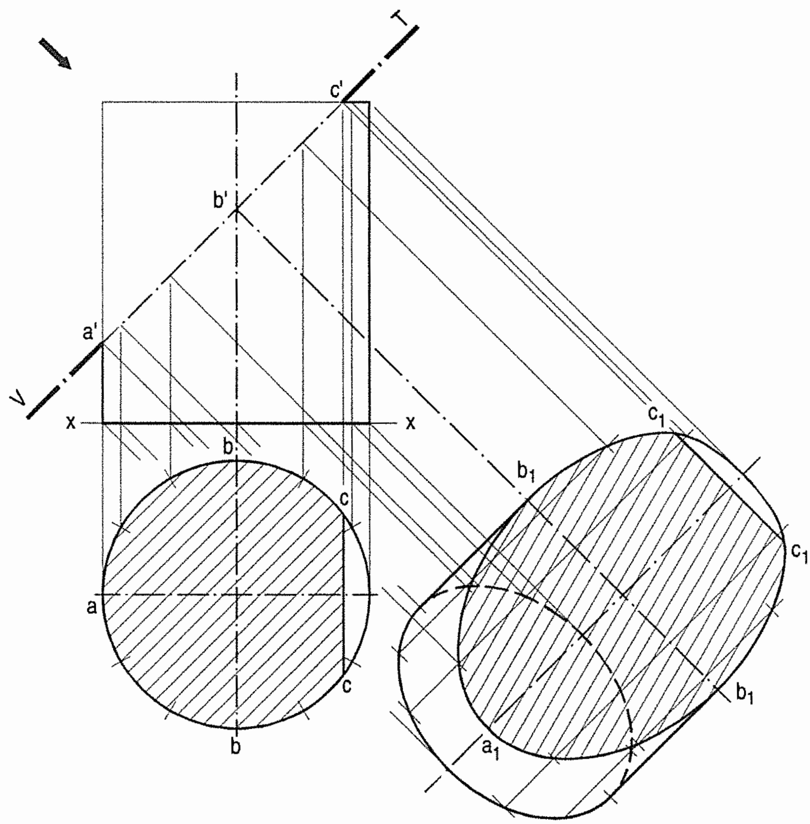


FIG. 14-21

Problem 14-19. (fig. 14-22): *A cylinder, 55 mm diameter and 65 mm long, has its axis parallel to both the H.P. and the V.P. It is cut by a vertical section plane inclined at 30° to the V.P., so that the axis is cut at a point 30 mm from one of its ends and both the bases of the cylinder are partly cut. Draw its sectional front view and true shape of the section.*

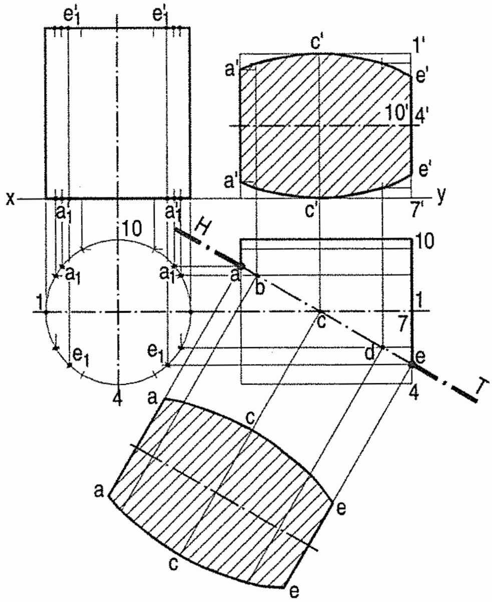


FIG. 14-22

Draw the projections of the cylinder and a line H.T. for the section plane. Project the points at which the bases and the lines are cut. The points on the bases cannot be projected directly. Therefore, project them

(i) To the first top view i.e. a to a_1 and e to e_1.

(ii) Then to the first front view, i.e. a_1 to a'_1 and e_1 to e'_1.

(iii) Finally, transfer them to the second front view to a' and e' each, at two places as shown.

(iv) Draw the true shape of the section either on a new reference line or symmetrically around the centre line and making *aa* equal to *a'a'*, *cc* equal to *c'c'* etc.

Problem 14-20. (fig. 14-23): *A hollow cylinder, 50 mm outside diameter, axis 70 mm long and thickness 8 mm has its axis parallel to the V.P. and inclined at 30° to the vertical. It is cut in two equal halves by a horizontal section plane. Draw its sectional top view.*

The figure is self-explanatory. Note that a part of the ellipse for the inside bottom will also be visible.

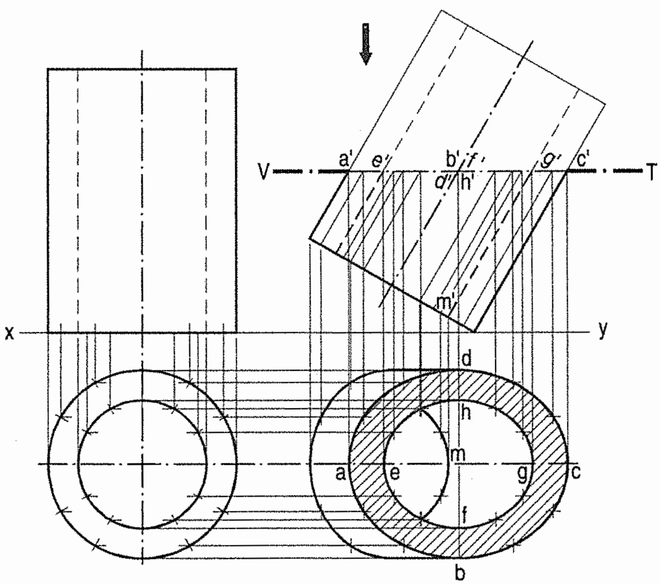


FIG. 14-23

14-4. SECTIONS OF CONES

This is discussed in details as follows:

(1) Section plane parallel to the base of the cone.

(2) Section plane passing through the apex of the cone.

(3) Section plane inclined to the base of the cone at an angle smaller than the angle of inclination of the generators with the base.

(4) Section plane parallel to a generator of the cone.

(5) Section plane inclined to the base of the cone at an angle greater than the angle of inclination of the generators with the base.

(1) Section plane parallel to the base of the cone:

The cone resting on the H.P. on its base [fig. 14-24(i)] is cut by a section plane parallel to the base. The true shape of the section is shown by the circle in the top view, whose diameter is equal to the length of the section viz. a'a'. The width of the section at any point, say *b'*, is equal to the length of the chord bb_1.

Problem 14-21. [fig. 14-24(ii)]: *To locate the position in the top view of any given point p' in the front view of the above cone.*

Method I:

(i) Through *p'*, draw a line *r'r'* parallel to the base.

(ii) With *o* as centre and diameter equal to *r'r'*, draw a circle in the top view.

(iii) Project *p'* to points *p* and p_1 on this circle. *p* is the top view of *p'*. p_1 is the top view of another point p'_1 on the back side of the cone and coinciding with *p'*. The chord pp_1 shows the width of the horizontal section of the cone at the point *p'*. This method may be called the *circle method*.

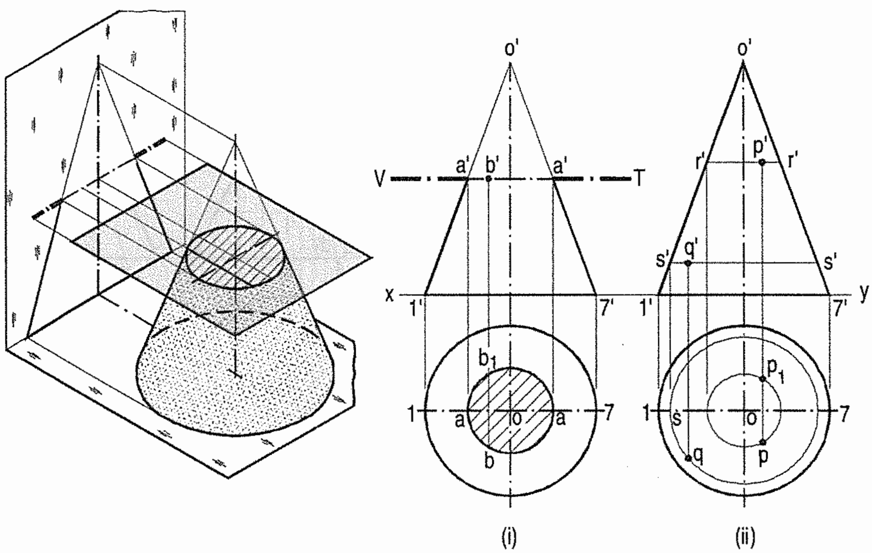


FIG. 14-24

Method II:

When the position of a point in the top view say q is given, its front view q' can be determined by reversing the above process.

(i) With centre o and radius oq, draw a circle cutting the horizontal centre line at s.

(ii) Through s, draw a projector cutting the slant side $o'1'$ at s'.

(iii) Draw the line $s's'$ parallel to the base, intersecting a projector through q at the required point q'.

(2) Section plane passing through the apex of the cone:

Problem 14-22. [fig. 14-25(i)]: *A cone, diameter of base 50 mm and axis 50 mm long is resting on its base on the H.P. It is cut by a section plane perpendicular to the V.P., inclined at 75° to the H.P. and passing through the apex. Draw its front view, sectional top view and true shape of the section.*

Draw the projections of the cone and on it, show the line V.T. for the section plane.

Mark a number of points a', b' etc. on the V.T. and project them to points a, b etc. in the top view by the circle method. It will be found that these points lie on a straight line through o.

Thus, od is the top view of the line or generator $o'd'$ and triangle odd_1 is the top view of the section. The width of the section at any point b' on the section is the line bb_1, obtained by projecting b' on this triangle. This method is called the generator method.

Project the true shape of the section. It is an isosceles triangle, the base of which is equal to the length of the chord on the base-circle and the altitude is equal to the length of the section plane within the cone.

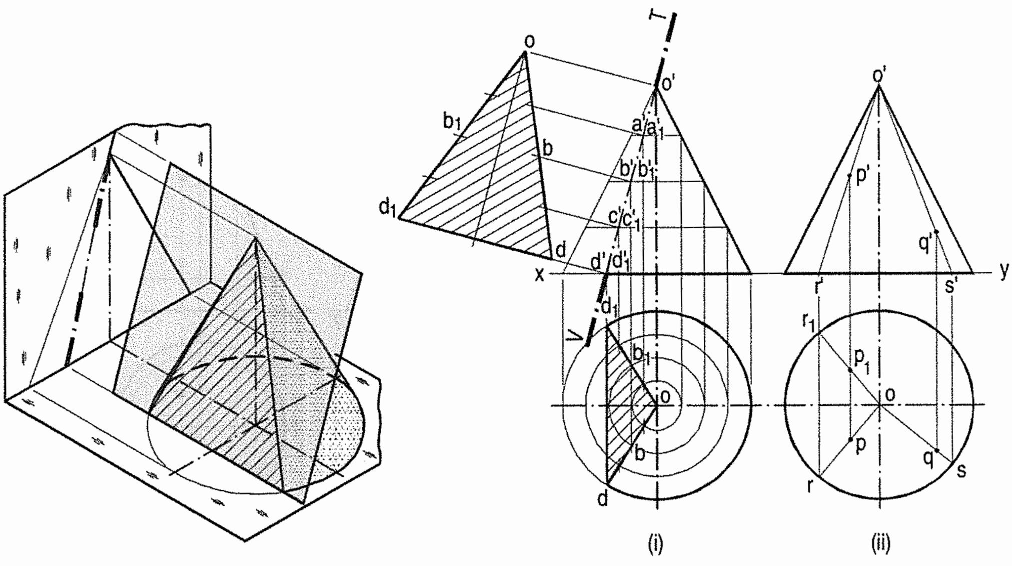


FIG. 14-25

Problem 14-23. [fig. 14-25(ii)]: *To determine by generator method, the position in the top view of a given point p' in the front view of the above cone.*

Draw the line $o'p'$ and produce it to cut the base at r'. Project r' to points r and r_1 on the base-circle in the top view. Draw lines or and or_1. Thus, or is the top view of the generator $o'r'$, and or_1 that of the generator (at the back) which coincides with $o'r'$. Project p' to p and p_1 on or and or_1 respectively. Thus, p is the top view of p', and p_1 is the top view of another point on the other side of the cone and coinciding with p'. The line pp_1 is the width of the horizon-section of the cone at p'.

The position in the front view of any point in the top view, say q, may be determined by reversing the process. Draw the line oq and produce it to cut the base-circle at s. Project s to s' on the base in the front view. Join o' with s'. Through, q, draw a projector to cut $o's'$ at the required point q'.

Sectional views of cones may be obtained by applying any one of the above two methods for locating the positions of points. The generator method is more suitable particularly when the cone is in inclined positions.

(3) Section plane inclined to the base of the cone at an angle smaller than the angle of inclination of the generators with the base:

Problem 14-24. *A cone, base 75 mm diameter and axis 80 mm long is resting on its base on the H.P. It is cut by a section plane perpendicular to the V.P., inclined at 45° to the H.P. and cutting the axis at a point 35 mm from the apex. Draw its front view, sectional top view, sectional side view and true shape of the section.*

Draw a line V.T. in the required position in the front view of the cone. The positions of points on this line and the width of section at each point can be determined by one of the methods explained in problem 14-21 and problem 14-23 and as described below.

(i) ***Generator method*** [fig. 14-26(i) and fig. 14-26(ii)]:

(a) Divide the base-circle into a number of equal parts, say 12. Draw lines (i.e. generators) joining these points with o. Project these points on the line representing the base in the front view.

(b) Draw lines o' 2', o' 3' etc. cutting the line for the section at points b', c' etc. Project these points on the corresponding lines in the top view. For example, point b' on o' 2', also represents point b'_1 on o'-12' which coincides with o'-12'. Therefore, project b' to b on o 2 and to b_1 on o'-12'. b and b_1 are the points on the section (in the top view).

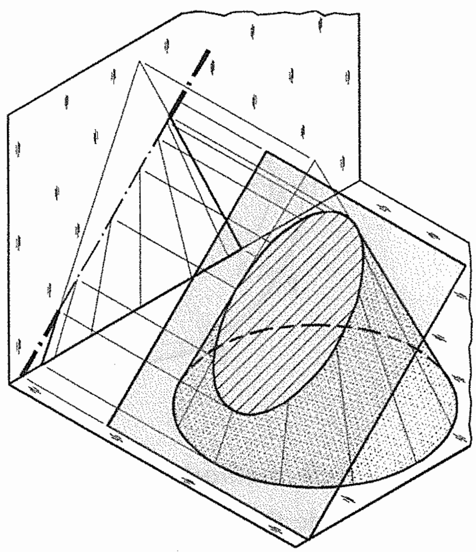


FIG. 14-26(i)

(c) Similarly, obtain other points. Point d' cannot be projected directly. Hence, the same method as in case of pyramids should be employed to determine the positions d and d_1, as shown. In addition to these, two more points for the maximum width of the section at its centre should also be obtained. Mark *m'*, the mid-point of the section and obtain the points *m* and m_1. Draw a smooth curve through these points.

(d) The true shape of the section may be obtained on the V.T. as a new reference line or symmetrically around the centre line *ag*, drawn parallel to the V.T. as shown. It is an ellipse whose major axis is equal to the length of the section and minor axis equal to the width of the section at its centre.

Draw the sectional side view by projecting the points on corresponding generators, as shown.

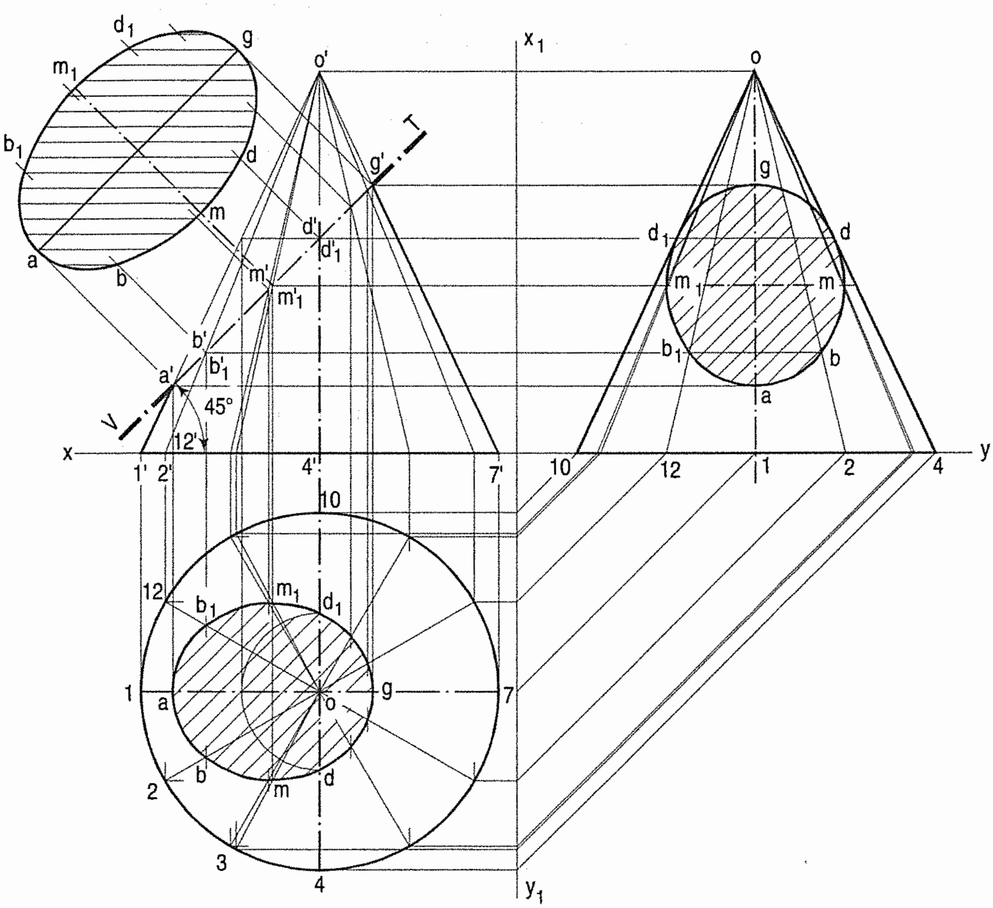


FIG. 14-26(ii)

(ii) *Circle method* (fig. 14-27):

(a) Divide the line of section into a number of equal parts. Determine the width of section at, and the position of each division-point in the top view by the circle method. For example, through *c'*, draw a line *c"c"* parallel to the base.

(b) With *o* as centre and radius equal to half of *c"c"*, draw an arc. Project *c'* to *c* and c_1 on this arc. Then *c* and c_1 are the required points. The straight line joining *c* and c_1 will be the width of the section at *c'*.

(c) Similarly, obtain all other points and draw a smooth curve through them. This curve will show the apparent section. The maximum width of the section will be at the mid-point e'. It is shown in the top view by the length of the chord joining e and e_1.

(d) Draw a reference line $x_1 y_1$ parallel to the V.T. and project the true shape of the section. In the figure, the auxiliary sectional top view of the truncated cone is shown. It shows the true shape of the section.

The sectional side view (not shown in the figure) may be obtained by projecting all the division-points horizontally and then marking the width of the section at each point, symmetrically around the axis of the cone.

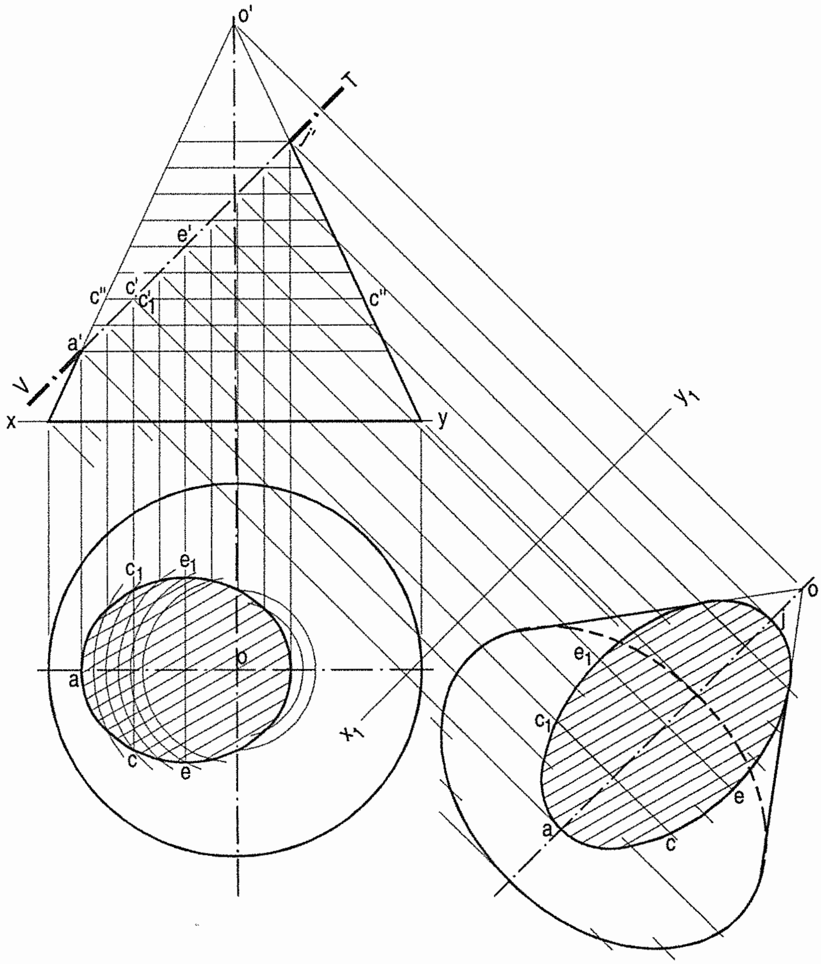


FIG. 14-27

(4) Section plane parallel to a generator of the cone:

Problem 14-25. (fig. 14-28): *The cone in same position as in problem 14-24, is cut by a section plane perpendicular to the V.P. and parallel to and 12 mm away from one of its end generators. Draw its front view, sectional top view and true shape of the section.*

(i) Draw a line V.T. (for the section plane) parallel to and 12 mm away from the generator $o'1'$.

(ii) Draw the twelve generators in the top view and project them to the front view. All the generators except $o'1'$, $o'2'$ and o'-$12'$ are cut by the section plane. Project the points at which they are cut, to the corresponding generators in the top view. The width of the section at the point where the base is cut will be the chord aa_1. Draw a curve through $a...f...a_1$. The figure enclosed between aa_1 and the curve is the apparent section.

(iii) Obtain the true shape of the section as explained in the previous problem. It will be a parabola.

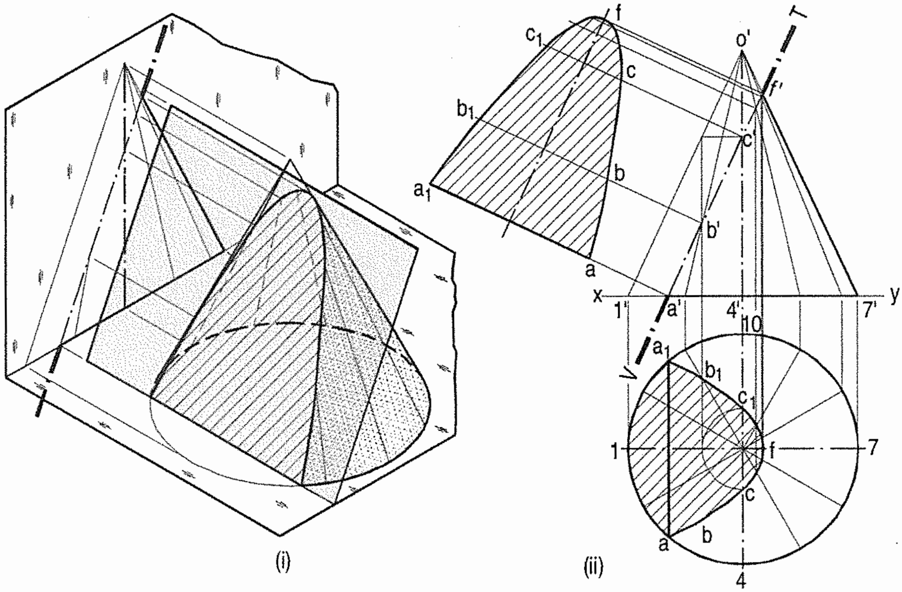


FIG. 14-28

(5) Section plane inclined to the base of the cone at an angle greater than the angle of inclination of the generators with the base:

This book is accompanied by a computer CD, which contains an audiovisual animation presented for better visualization and understanding of the subject. Readers are requested to refer Presentation module 32 for the following problem.

Problem 14-26. [fig. 14-29(i) and fig. 14-29(ii)]: *A cone, base 45 mm diameter and axis 55 mm long is resting on the H.P. on its base. It is cut by a section plane, perpendicular to both the H.P. and the V.P. and 6 mm away from the axis. Draw its front view, top view and sectional side view.*

The section will be seen as a line, perpendicular to xy, in both the front view and the top view. The side view will show the true shape of the section. The width of the section at any point, say c', will be equal to cc_1 obtained by the circle method [fig. 14-29(i)].

(i) Draw the side view of the cone.

(ii) Project the points (on the section) in the side view taking the widths from the top view. For example, through c' draw a horizontal line. Mark on it points c'' and c''_1 equidistant from and on both sides of the axis so that $c''\ c''_1 = cc_1$.

(iii) Draw a curve through the points thus obtained. It will be a hyperbola.

Fig. 14-29(ii) shows the views obtained by the generator method.

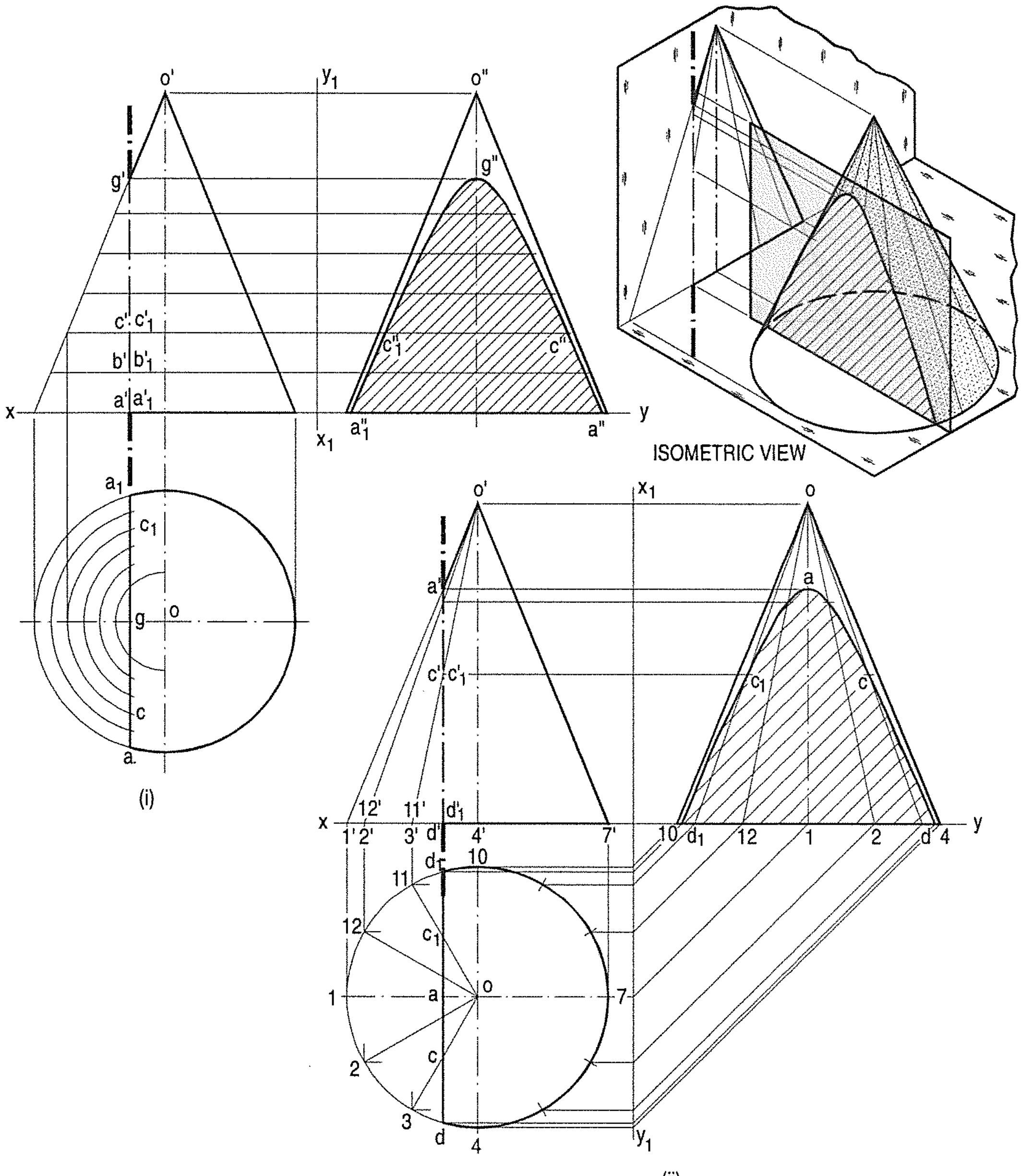


FIG. 14-29

Additional problems on sections of cones:

Problem 14-27. (fig. 14-30): *A cone, diameter of base 50 mm and axis 65 mm long, is lying on the H.P. on one of its generators with the axis parallel to the V.P. It is cut by a horizontal section plane 12 mm above the ground. Draw its front view, sectional top view, and development of its surface.*

Use the generator method and project the points in the top view. The curve will show the true shape of the section viz. a parabola.

For development, the true lengths of the cut-generators are obtained by drawing lines parallel to the base. Positions of points a and a_1 are determined by projecting them on the base-circle in the first top view.

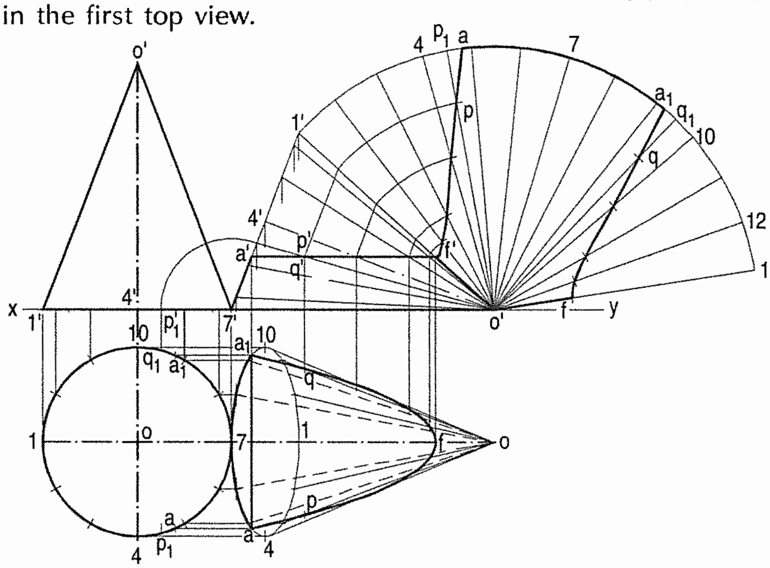


FIG. 14-30

Problem 14-28. (fig. 14-31): *A cone, base 70 mm diameter, axis 75 mm long and resting on its base on the H.P., is cut by a vertical section plane, the H.T. of which makes an angle of 60° with the reference line and is 12 mm away from the top view of the axis. (i) Draw the sectional front view and the true shape of the section. (ii) Also draw the sectional front view and the top view when the same section plane is parallel to the V.P.*

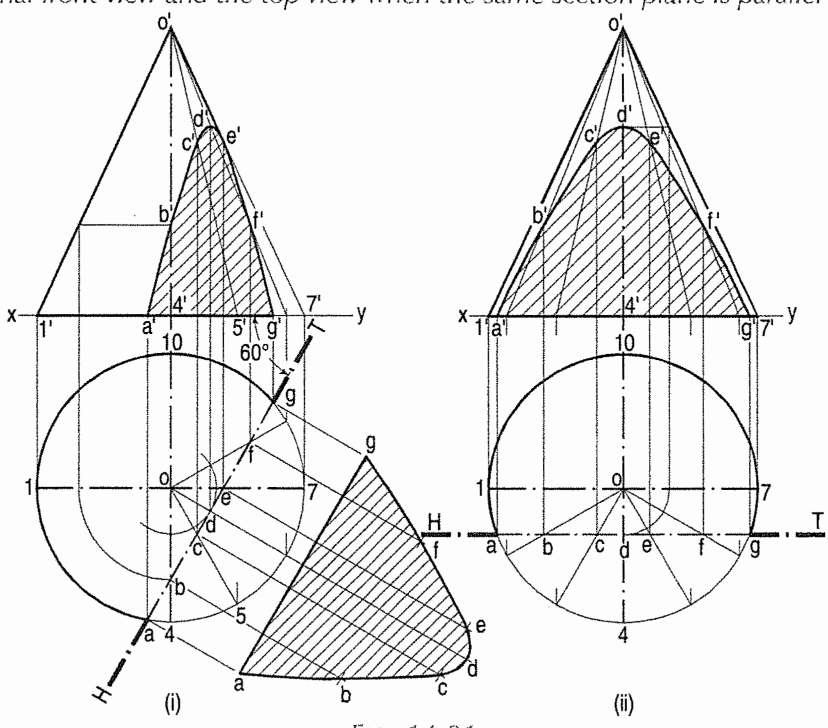


FIG. 14-31

(i) Draw a circle with centre o and radius equal to 12 mm.

(ii) Draw a line for the section plane, tangent to this circle and inclined at 60° to xy [fig. 14-31(i)].

(iii) Project the front view by the generator method as shown. Note how the point f' is obtained.

Fig. 14-31(ii) shows the two views when the section plane is parallel to the V.P.

Problem 14-29. (fig. 14-32): *A cone, base 60 mm diameter and axis 60 mm long is lying on the H.P. on one of its generators with the axis parallel to the V.P. A vertical section plane parallel to the generator which is tangent to the ellipse (for the base) in the top view, cuts the cone bisecting the axis and removing a portion containing the apex. Draw its sectional front view and true shape of the section.*

(i) Name in correct sequence the points at which the base and the generators are cut and project them in the front view.

(ii) Project the true shape of the section on the new reference line $x_1 y_1$ drawn parallel to the H.T.

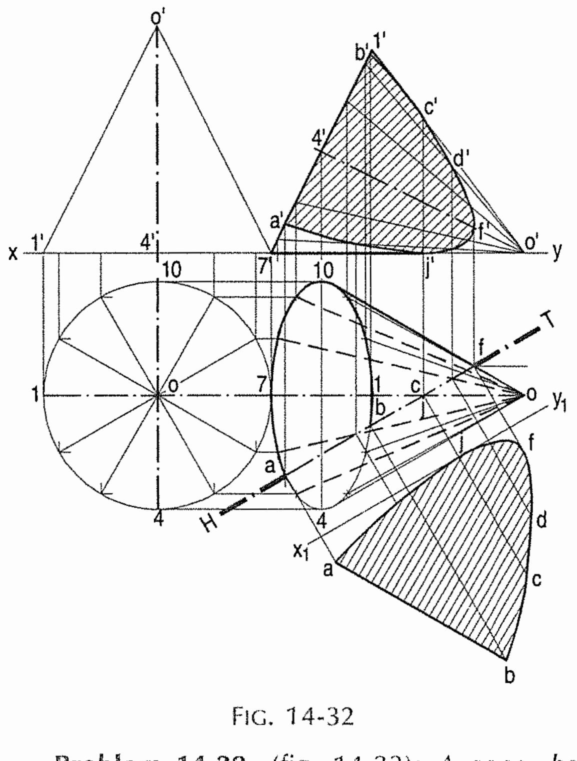


FIG. 14-32

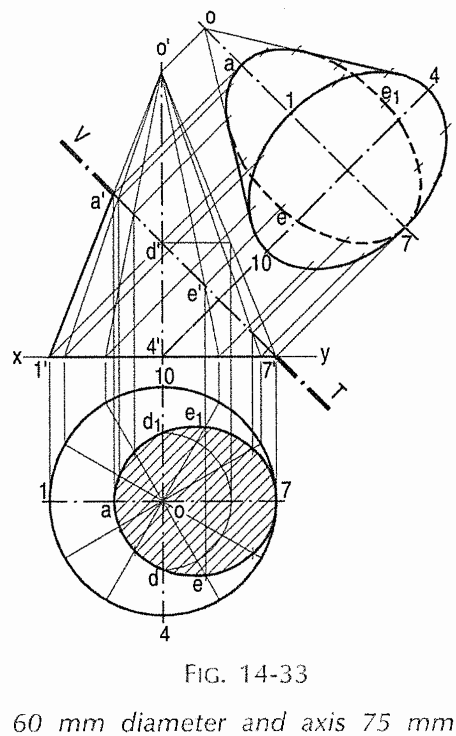


FIG. 14-33

Problem 14-30. (fig. 14-33): *A cone, base 60 mm diameter and axis 75 mm long, is resting on the H.P. on its base. It is cut by a section plane, perpendicular to the V.P., inclined at 45° to the H.P. and intersecting the axis 30 mm above the base. Draw its front view and sectional top view. Also draw its top view when it is lying on the ground on its cut-surface with the axis parallel to the V.P.*

See the figure which is self-explanatory. Note that, when the cone is tilted so as to lie on the cut-surface, its base is fully visible, while the section is hidden in the top view.

14-5. SECTIONS OF SPHERES

These are discussed in details as under.

(1) Section plane parallel to the H.P.

(2) Section plane parallel to the V.P.

(3) Section plane perpendicular to the V.P. and inclined to the H.P.

(4) Section plane perpendicular to the H.P. and inclined to the V.P.

(1) Section plane parallel to the H.P.: When a sphere is cut by a plane, the true shape of the section is always a circle.

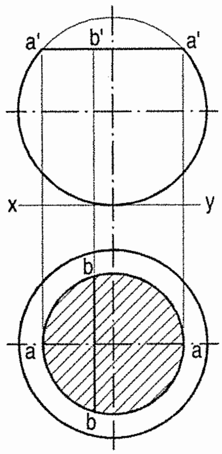


FIG. 14-34

The sphere in fig. 14-34 is cut by a horizontal section plane. The true shape of the section (seen in the top view) is a circle of diameter *a'a'*. The width of the section at any point say *b'*, is equal to the length of the chord *bb*.

(2) Section plane parallel to the V.P.: When the sphere is cut by a section plane parallel to the V.P. (fig. 14-35), the true shape of the section, seen in the front view, is a circle of diameter *cc*. The width of section at any point *d* is equal to the length of the chord *d'd'*.

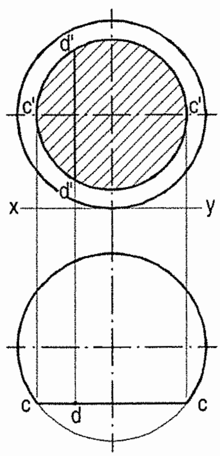


FIG. 14-35

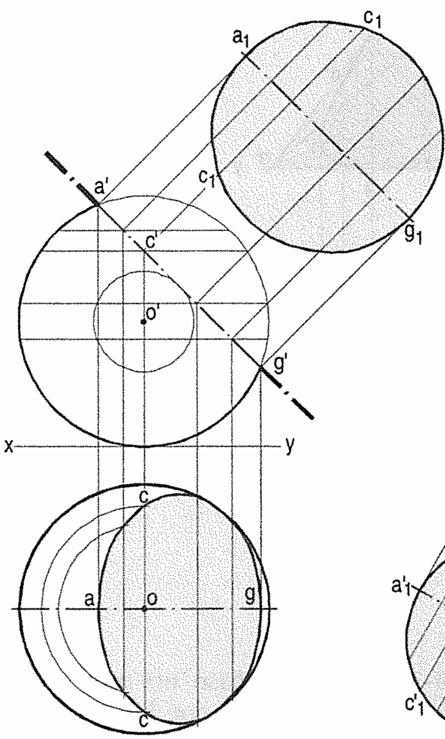


FIG. 14-36

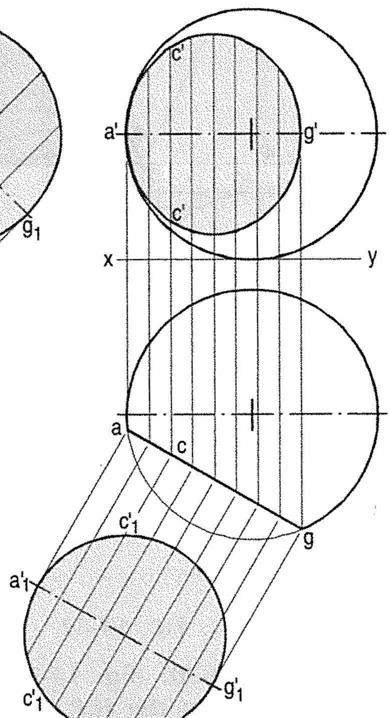


FIG. 14-37

(3) Section plane perpendicular to the V.P. and inclined to the H.P.:

Problem 14-31. (fig. 14-36): *A sphere of 50 mm diameter is cut by a section plane perpendicular to the V.P., inclined at 45° to the H.P. and at a distance of 10 mm from its centre. Draw the sectional top view and true shape of the section.*

Draw a line (for the section plane) inclined at 45° to *xy* and tangent to the circle of 10 mm radius drawn with *o'* as centre. Mark a number of points on this line.

Method I:

(i) Find the width of section at each point in the top view as shown in fig. 14-34. For example, the chord *cc* is the width of section at the point *c'*.

(ii) Draw a curve through the points thus obtained. It will be an ellipse. The true shape of the section will be a circle of diameter *a'g'*.

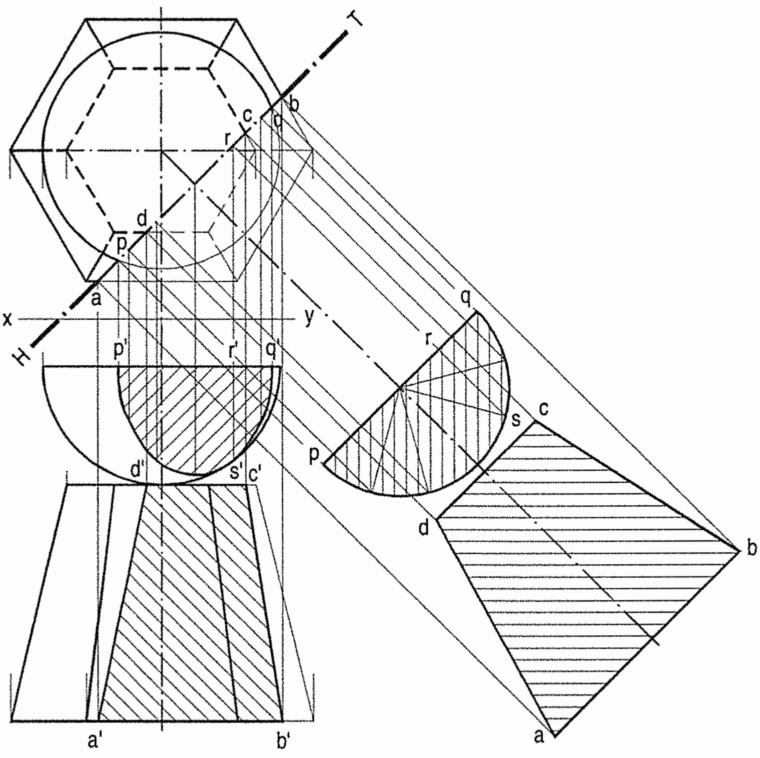
Method II:

It is known that the true shape of the section is a circle of diameter equal to *a'g'*. The width of section at any point say *c'* is equal to the chord c_1c_1 on this circle. Therefore, project *c'* to points *c* in the top view so that $cc = c_1c_1$. Similarly, obtain other points and draw the ellipse through them.

Fig. 14-37 shows the sectional front view and true shape of the section when the section plane is vertical and inclined to the V.P.

(4) Section plane perpendicular to the H.P. and inclined to the V.P.:

Problem 14-32. (fig. 14-38): *The projections of a hemisphere 50 mm diameter, placed centrally on the top of a frustum of a hexagonal pyramid, base 32 mm side, top 20 mm side and axis 50 mm long are given. Draw the sectional front view when the vertical section plane H.T. inclined at 45° to the V.P. and 10 mm from the axis, cuts them. Also draw the true shapes of the sections of both the solids.*



(Third-angle projection)

FIG. 14-38

The widths of the section of the sphere at various points are obtained from the semi-circle drawn in the top view.

14-6. TYPICAL PROBLEMS OF SECTIONS OF SOLIDS

Problem 14-33. *A solid composed of a half-cone and a half-hexagonal pyramid is shown in fig. 14-39. It is cut by a section plane, which makes an angle of 30° with the base, is perpendicular to the V.P. and contains an edge of the base of the pyramid. Draw its sectional top view, true shape of the section and development of the surface of the remaining portion. Base of cone 60 mm diameter; axis 70 mm long.*

(i) Draw a line V.T. inclined at 30° to the base and passing through a'.

(ii) Project the sectional top view. Note how points b and b_1 are obtained. The true shape of the section will be partly elliptical.

(iii) Draw the development of the half-cone and half-pyramid and show the lines for the section in it.

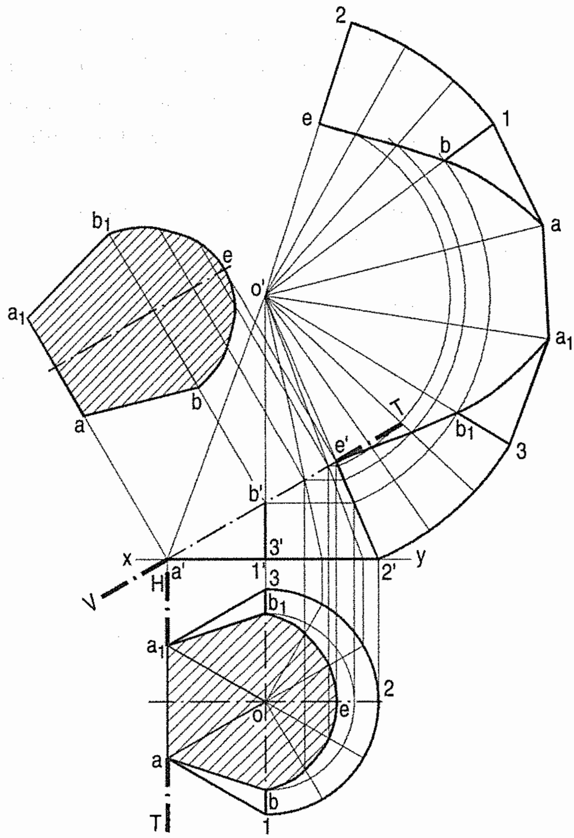


FIG. 14-39

Problem 14-34. (fig. 14-40): *A cylinder, base 50 mm diameter and axis 75 mm long, has a square hole of 25 mm side cut through it so that the axis of the hole coincides with that of the cylinder. The cylinder is lying on the H.P. with the axis perpendicular to the V.P. and the faces of the hole equally inclined to the H.P.*

A vertical section plane, inclined at 60° to the V.P. cuts the cylinder in two equal halves. Project the front view of the cylinder on an A.V.P. parallel to the section plane.

(i) Assuming the cylinder to be whole, draw its auxiliary front view.

(ii) Project the points at which the generators of the cylinder and the edges of the hole are cut. The section of the cylinder will be a part of an ellipse. Join the points at which the edges of the hole are cut. The back edges

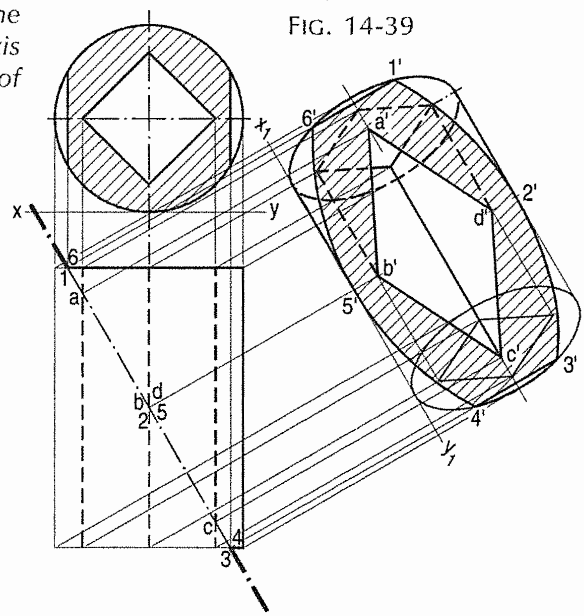


FIG. 14-40

of the hole will be visible within the section and hence, must be shown as full lines.

(iii) Complete the view by showing the section and the remaining portion of the cylinder with dark lines.

Problem 14-35. (fig. 14-41): *A square prism axis 110 mm long is resting on its base in the H.P. The edges of the base are equally inclined to V.P.*

The prism is cut by an A.I.P. passing through the mid-point of the axis in such a way that the true shape of the section is rhombus having diagonals of 100 mm and 50 mm. Draw the projections and determine the inclination of A.I.P. with the H.P.

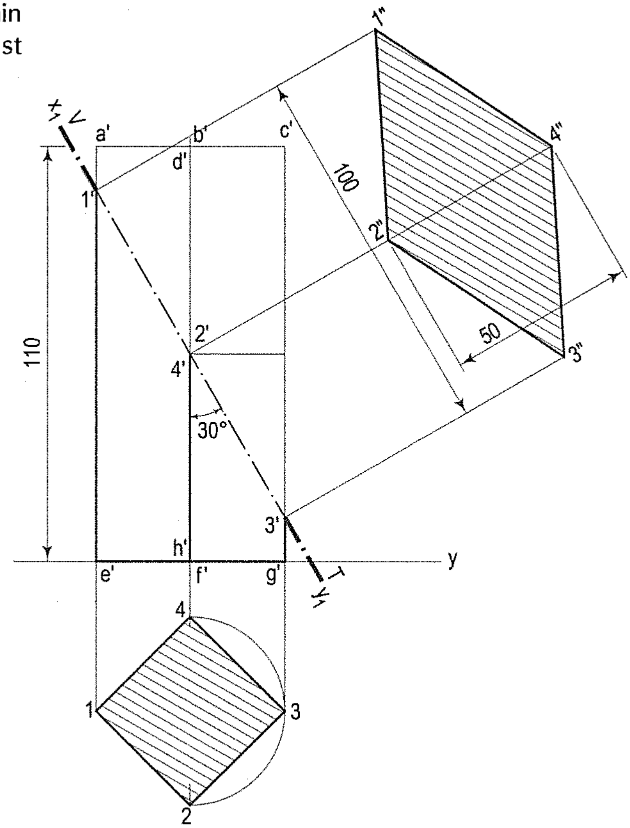


FIG. 14-41

(i) Draw the top view and the front view as shown.

(ii) Mark the mid-point of the axis in the front view.

(iii) With the mid-point of the axis as centre and radius equal to 50 mm (half of the longer diagonal i.e. 100 mm), draw an arc cutting the two opposite vertical sides of the prism. Project the points and complete the true shape as shown.

Problem 14-36. (fig. 14-42): *A vertical cylinder 50 mm diameter is cut by an A.V.P. making 30° to the V.P. in such a way that the true shape of the section is a rectangle of 40 mm × 80 mm sides. Draw the projections and the true shape of the section.*

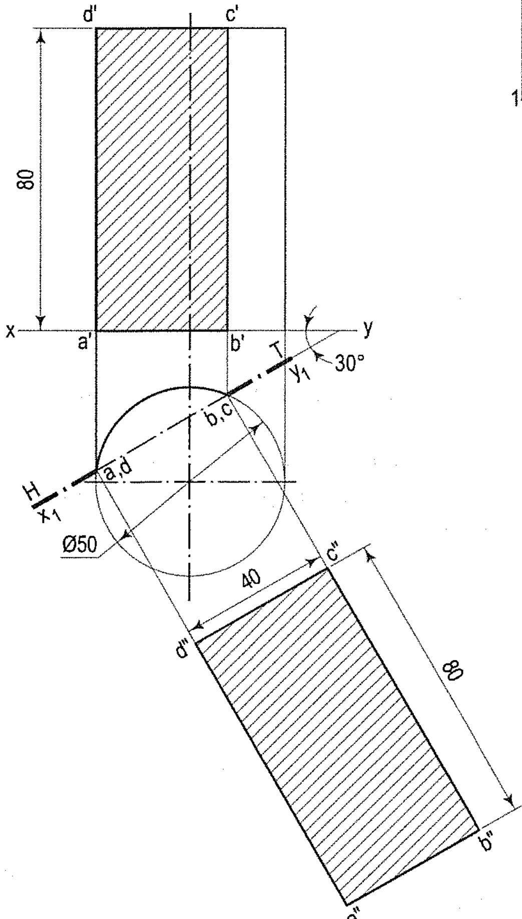


FIG. 14-42

(i) Draw a top view and an front view of the cylinder.

(ii) Draw x_1y_1 at 30° to xy in such a way that the chord length in the top view is 40 mm. Project points 1, 2, 3 and 4 and draw the rectangle of 40 mm × 80 mm as shown.

Problem 14-37. (fig. 14-43): *A hexagonal pyramid, base 30 mm side and axis 70 mm long is resting on its slant edge of the face on the horizontal plane.*

A section plane, perpendicular to the V.P., inclined to the H.P. passes through the highest corner of the base and intersecting the axis at 25 mm from the base. Draw the projections of the solid and determine the inclination of the section plane with the H.P.

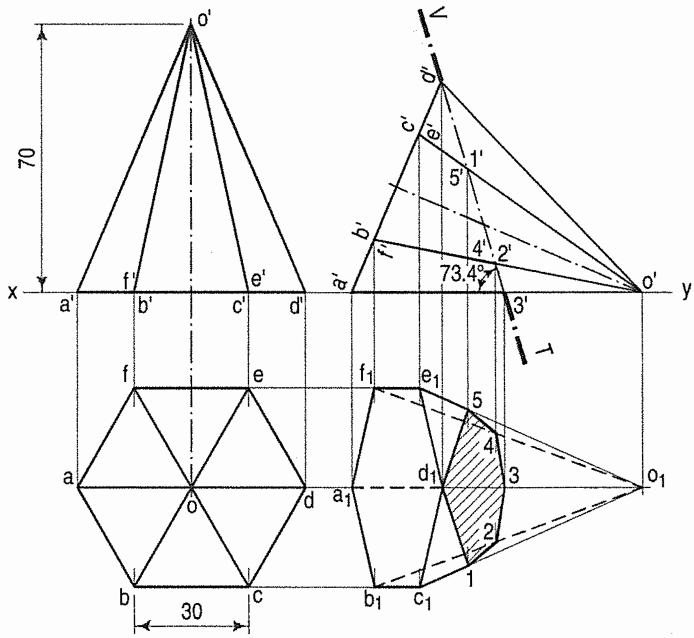


FIG. 14-43

(i) Draw the top view and the front view keeping one of the sides of the base parallel to xy.

(ii) With a' and o', as centres and radii equal to $a'd'$ and $o'd'$ draw arcs intersecting each other at point d'. Draw a section plane passing through d' and point 25 mm away from the base along the axis as shown.

(iii) Measure the angle by V.T. with xy.

Problem 14-38. (fig. 14-44): *A pentagonal pyramid, base side 30 mm, length of axis 80 mm is resting on a base edge on the H.P. with a triangular face containing that edge being perpendicular to the V.P. and inclined to the H.P. at 60°. It is cut by a horizontal section plane whose V.T. passes through the mid-point of the axis. Draw the front view, sectional top view and add a profile view.*

(i) Draw the top view and the front view keeping one of the sides of the base perpendicular to xy.

(ii) Tilt the front view on the points c', d' as shown.

(iii) Draw a line parallel to xy and passing through the mid-point of the axis representing V.T. of the section plane.

(iv) Complete the projection as shown.

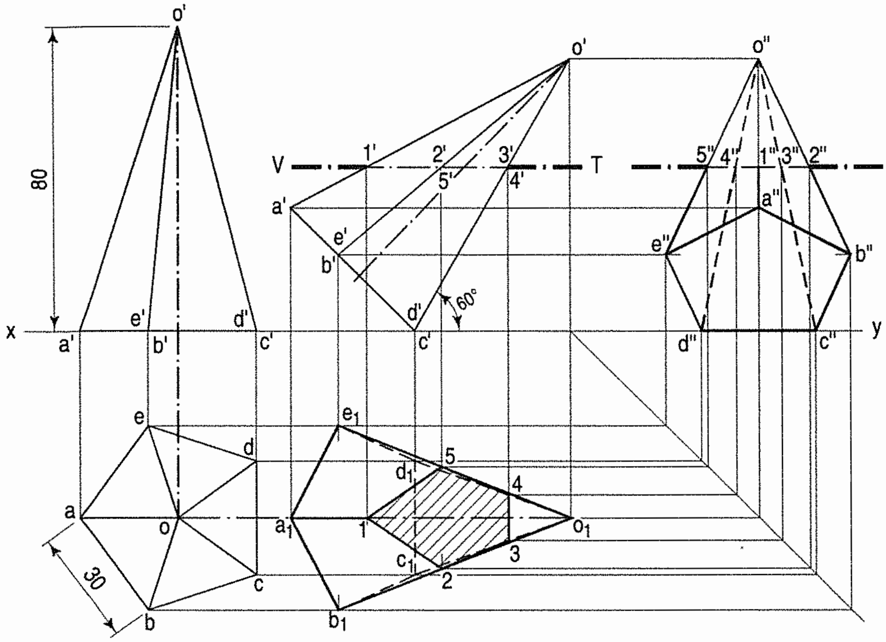


FIG. 14-44

Problem 14-39. (fig. 14-45): *A cone, diameter of the base 60 mm and axis 70 mm long is resting on its base on the H.P. It is cut by an A.I.P. so that the true shape of the section is an isosceles triangle having 50 mm base. Draw the top view, the front view and the true shape of the section.*

When a section plane passes through an apex of a cone and cuts the base of the cone, the true-shape of section is a triangle.

(i) Draw a top view and an front view as shown.

(ii) Mark chord *ab* of 50 mm (the base of triangle) in the top view. Project points *a* and *b* in the front view intersecting base at *a*' or *b*'. Join points *a*' and *o*'.

This represents V.T. of the section plane.

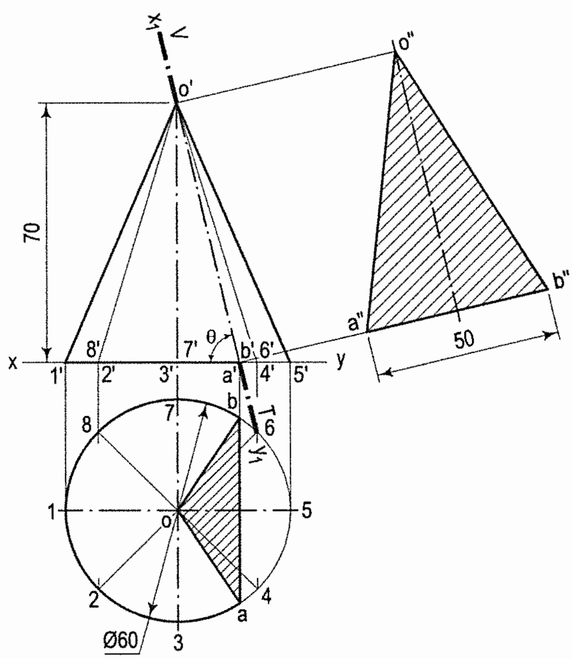


FIG. 14-45

(iii) Considering line V.T. as new line $x_1 y_1$, draw the projectors from *o*', *a*' and *b*'.

(iv) Construct the true shape of triangle as shown.

Problem 14-40. (fig. 14-46): *A square pyramid of 60 mm side of base and 70 mm length of axis is resting on its base on the H.P., having a side of base perpendicular to the V.P. It is cut by two cutting planes. One is parallel to its extreme right face and 10 mm away from it. While the other is parallel to the extreme left face.*

Both the cutting planes intersect each other on the axis of the pyramid. Draw the sectional top view, front view and the left hand side view.

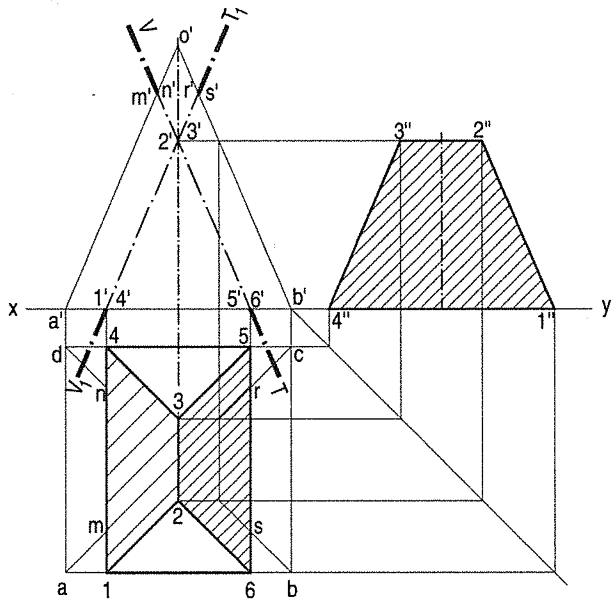


FIG. 14-46

(i) Draw the top view and the front view as shown.

(ii) Draw lines V.T. and V_1T_1 representing section planes in the front view intersecting at 2' and 3'.

(iii) Complete the projections. Note that the intersection points 2' and 3' are transferred on the slant edge *o'b'* and then projected in the top view.

Problem 14-41. (fig. 14-47): *A cylinder of diameter 50 mm and axial height 90 mm having 34 mm square hole centrally along the axis, rests on a point on the circular edge of the base remaining on the H.P. The axis of the cylinder is parallel to the V.P. and inclined at 30° to the H.P. and the rectangular faces of the square hole remain equally inclined to the V.P. A section plane perpendicular to the V.P. and inclined to the horizontal plane passing through the mid-point of the axis, such that the apparent section in the top view is a circle of 50 mm diameter cuts the cylinder. Draw the front view, section plane, true shape of the section and find the inclination of the section plane with H.P.*

Fig. 14-47 shows the projections of the solid. Note that the generators 4 and 6 cut the apparent section at the points *s*, *q*, s_1 and q_1. These points are transferred in the front view as shown. The required section plane must pass through the midpoint of the axis, and *s*, *q* (s_1 and q_1).

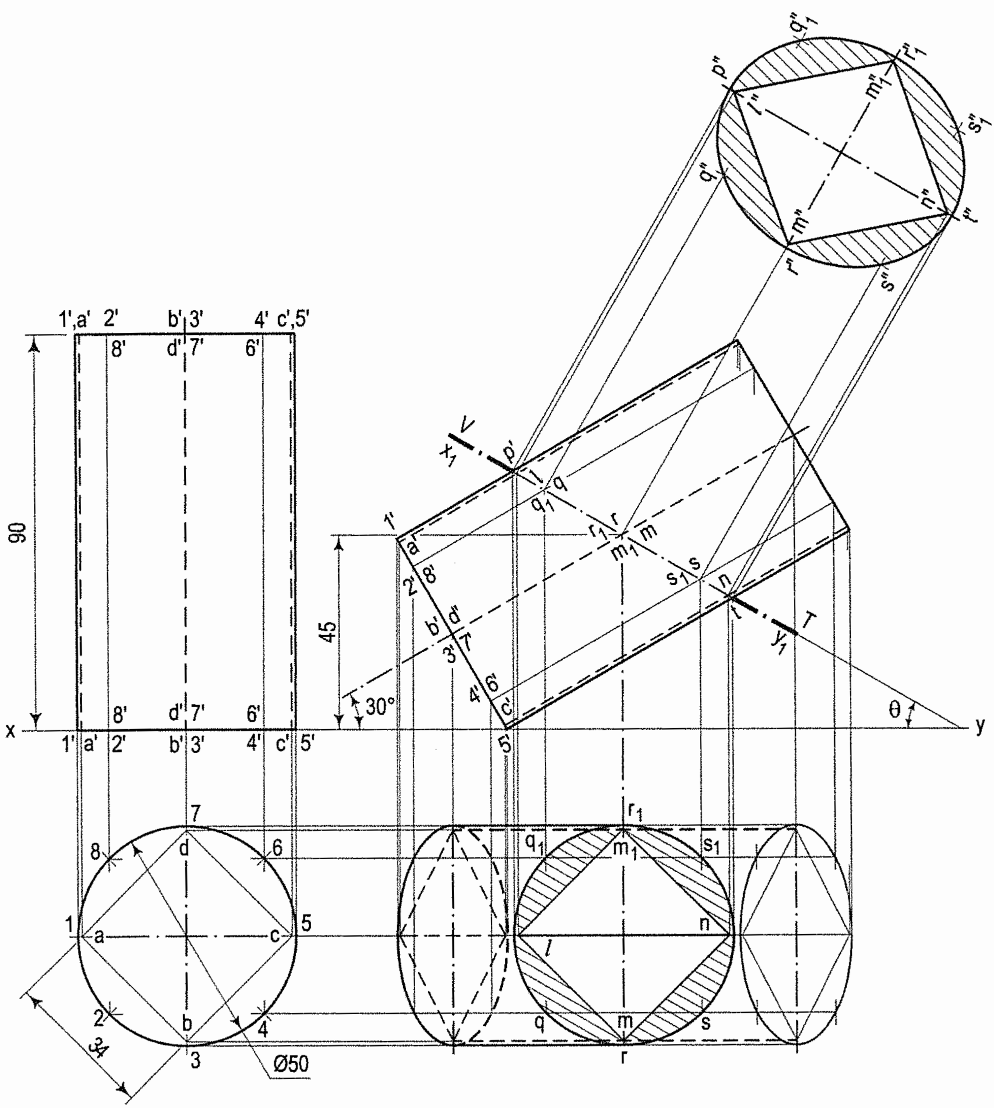


FIG. 14-47

Problem 14-42. (fig. 14-48): *A cylindrical disc of 46 mm diameter is resting on the H.P. and has height of 20 mm. A hexagonal prism of side 23 mm and height of 30 mm is resting on the disc such that their axes are in one line and its faces are equally inclined with the V.P.. It is cut by the auxiliary plane, offset 10 mm infront of the centre of the disc and is inclined at 40° with xy. Draw the projection of combined solids and obtain true shape of the section.*

(i) Draw the projections of the combined solids with given positions.

(ii) Draw an offset circle of 10 mm radius and mark a cutting plane inclined at 40°, touching this circle.

(iii) Project various points in the front view as shown.

(iv) Draw x_1y_1 parallel to the cutting plane.

(v) Obtain true shape as shown.

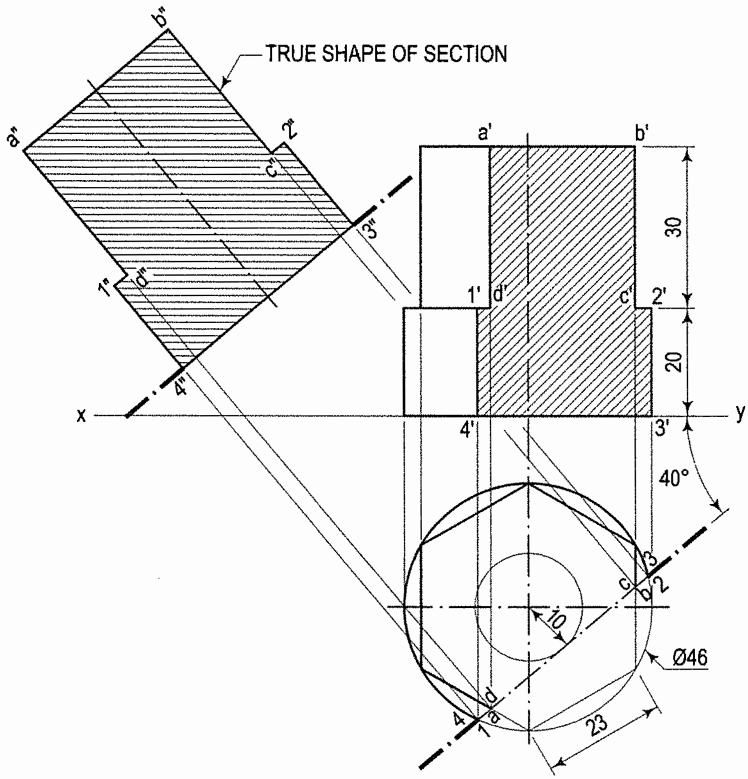


FIG. 14-48

Problem 14-43. (fig. 14-49): *A square prism of 40 mm side is resting on H.P. and has height of 30 mm. Its faces are equally inclined with the V.P. A frustum of cone having base diameter 40 mm and top 30 mm diameter with height 30 mm is kept on the prism such that axes of the both solids are coinciding. A sectional plane cuts the combined axes and inclined at 55° with H.P. passes through left corners of the prism. Draw the front view and section top view. Draw also true-shape of the section.*

(i) Draw the top view and front view of combined solid as shown.

(ii) In front view, draw a section plane at angle of 55° with *xy* passing through the corner of square prism. Mark points 1', 2', 3', 4', 5' and 6' as shown.

(iii) Project these points in the top view and draw section line as shown in fig. 14-49.

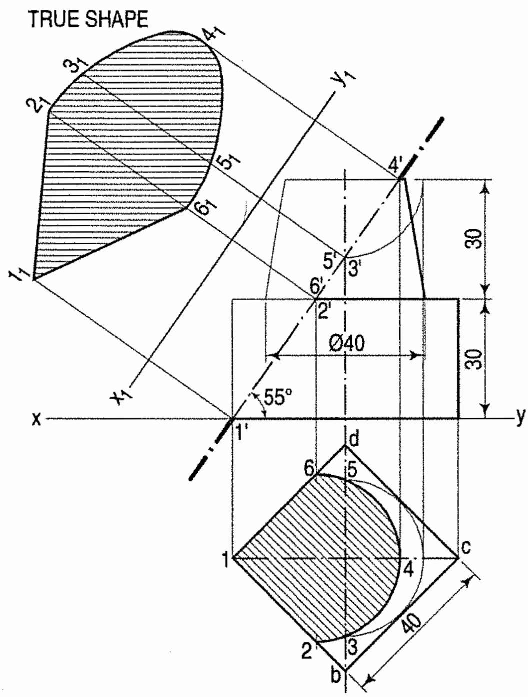


FIG. 14-49

(iv) Draw a new reference line x_1y_1 parallel to the section plane and project the section on it.

(v) The distances of the points from x_1y_1 should be taken equal to their corresponding distances from xy in the top view of combined solids.

Problem 14-44. (fig. 14-50): *A horizontal frustum of square pyramid having front square of 20 mm side and back square of 30 mm at length of 60 mm has axis perpendicular to the V.P. and the side of square is inclined to 45° with H.P. It is cut by section plane making 40° with V.P. and passing through a point on axis 30 mm from the surface of large square side. Draw projections of the frustum.*

(i) Mark point b' and construct the square a' b' c' d' with sides equally inclined to the xy. This is a front view of the frustum of square pyramid.

(ii) Project the top view such that the axis remains perpendicular to xy as shown in fig. 14-50.

(iii) Draw a section plane at distance of 20 mm along axis from large square at angle of 40° with xy.

(iv) Mark the points p, q, r, s and project them in the front view. Draw section lines in the front view for the section and complete the view.

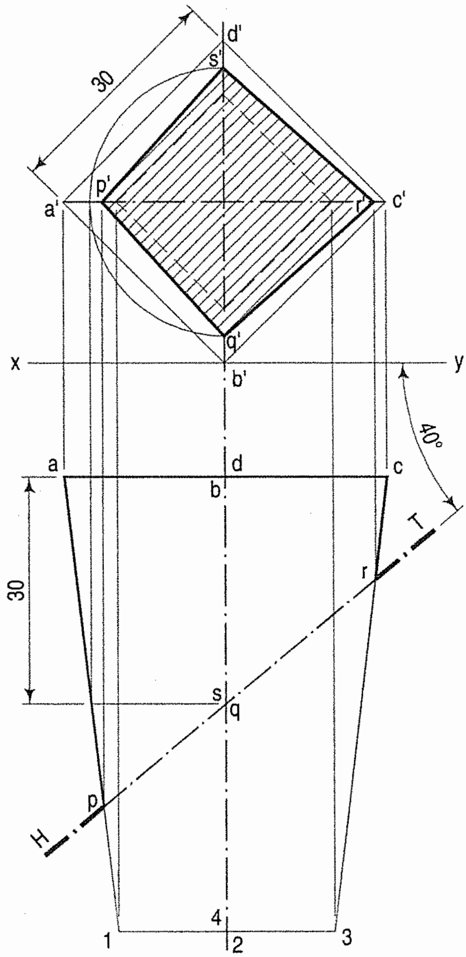


FIG. 14-50

EXERCISES 14

1. A cube of 50 mm long edges is resting on the H.P. with a vertical face inclined at 30° to the V.P. It is cut by a section plane, perpendicular to the V.P., inclined at 30° to the H.P. and passing through a point on the axis, 38 mm above the H.P. Draw the sectional top view, true shape of the section and development of the surface of the remaining portion of the cube.

2. A hexagonal prism, side of base 35 mm and height 75 mm is resting on one of its corners on the H.P. with a longer edge containing that corner inclined at 60° to the H.P. and a rectangular face parallel to the V.P. A horizontal section plane cuts the prism in two equal halves.
   (i) Draw the front view and sectional top view of the cut prism.
   (ii) Draw another top view on an auxiliary inclined plane which makes an angle of 45° with the H.P.

3. A pentagonal prism, side of base 50 mm and length 100 mm has a rectangular face on the H.P. and the axis parallel to the V.P. It is cut by a vertical section

plane, the H.T. of which makes an angle of 30° with *xy* and bisects the axis. Draw the sectional front view, top view and true shape of the section. Develop the surface of the remaining half of the prism.

4. A hollow square prism, base 50 mm side (outside), length 75 mm and thickness 9 mm is lying on the H.P. on one of its rectangular faces, with the axis inclined at 30° to the V.P. A section plane, parallel to the V.P. cuts the prism, intersecting the axis at a point 25 mm from one of its ends. Draw the top view and sectional front view of the prism.
5. A cylinder, 65 mm diameter and 90 mm long, has its axis parallel to the H.P. and inclined at 30° to the V.P. It is cut by a vertical section plane in such a way that the true shape of the section is an ellipse having the major axis 75 mm long. Draw its sectional front view and true shape of the section.
6. A cube of 65 mm long edges has its vertical faces equally inclined to the V.P. It is cut by a section plane, perpendicular to the V.P., so that the true shape of the section is a regular hexagon. Determine the inclination of the cutting plane with the H.P. and draw the sectional top view and true shape of the section.
7. A vertical hollow cylinder, outside diameter 60 mm, length 85 mm and thickness 9 mm is cut by two section planes which are normal to the V.P. and which intersect each other at the top end of the axis. The planes cut the cylinder on opposite sides of the axis and are inclined at 30° and 45° respectively to it. Draw the front view, sectional top view and auxiliary sectional top views on planes parallel to the respective section planes.
8. A square pyramid, base 50 mm side and axis 75 mm long, is resting on the H.P. on one of its triangular faces, the top view of the axis making an angle of 30° with the V.P. It is cut by a horizontal section plane, the V.T. of which intersects the axis at a point 6 mm from the base. Draw the front view, sectional top view and the development of the sectioned pyramid.
9. A pentagonal pyramid, base 30 mm side and axis 75 mm long, has its base horizontal and an edge of the base parallel to the V.P. It is cut by a section plane, perpendicular to the V.P., inclined at 60° to the H.P. and bisecting the axis. Draw the front view and the top view when the pyramid is tilted so that it lies on its cut-face on the ground with the axis parallel to the V.P. Show the shape of the section by dotted lines. Develop the surface of the truncated pyramid.
10. A tetrahedron of 65 mm long edges is lying on the H.P. on one of its faces, with an edge perpendicular to the V.P. It is cut by a section plane which is perpendicular to the V.P. so that the true shape of the section is an isosceles triangle of base 50 mm long and altitude 40 mm. Find the inclination of the section plane with the H.P. and draw the front view, sectional top view and the true shape of the section.
11. A hexagonal pyramid, base 50 mm side and axis 100 mm long, is lying on the H.P. on one of its triangular faces with the axis parallel to the V.P. A vertical section plane the H.T. of which makes an angle of 30° with the reference line, passes through the centre of the base and cuts the pyramid, the apex being retained. Draw the top view, sectional front view, true shape of the section and the development of the surface of the cut-pyramid.
12. A cone, base 75 mm diameter and axis 75 mm long, has its axis parallel to the V.P. and inclined at 45° to the H.P. A horizontal section plane cuts the

cone through the mid-point of the axis. Draw the front view, sectional top view and an auxiliary top view on a plane parallel to the axis.

13. A cone, base 65 mm diameter and axis 75 mm long, is lying on the H.P. on one of its generators with the axis parallel to the V.P. A section plane which is parallel to the V.P. cuts the cone 6 mm away from the axis. Draw the sectional front view and development of the surface of the remaining portion of the cone.
14. The cone in above problem 13 is cut by a horizontal section plane passing through the centre of the base. Draw the sectional top view and another top view on an auxiliary plane parallel to the axis of the cone.
15. A hemisphere of 65 mm diameter, lying on the H.P. on its flat face, is cut by a vertical section plane inclined to the V.P. so that the semi-ellipse seen in the front view has its minor axis 45 mm long and half major axis 25 mm long. Draw the top view, sectional front view and true shape of the section.
16. The top view of a cylinder 75 mm diameter, 125 mm long, placed on top of the frustum of a cone, base 100 mm diameter, top 50 mm diameter and axis 125 mm long is shown in fig. 14-51. Both the solids are cut by a vertical section plane, the H.T. of which is 12 mm from the axis of the frustum and makes 30° angle with *xy*. Draw the sectional front view and true shape of the sections.

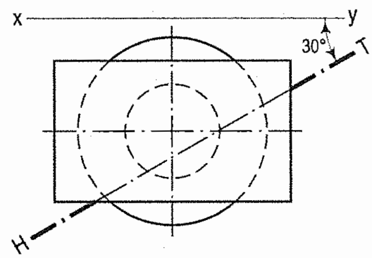


FIG. 14-51

17. A sphere of 75 mm diameter is cut by a section plane, perpendicular to the V.P. and inclined at 30° to the H.P. in such a way that the true shape of the section is a circle of 50 mm diameter. Draw its front view, sectional top view and sectional side view.
18. A frustum of a cone, base 75 mm diameter, top 50 mm diameter and axis 75 mm long, has a hole of 30 mm diameter drilled centrally through its flat faces. It is resting on its base on the H.P. and is cut by a section plane, the V.T. of which makes an angle of 60° with *xy* and bisects the axis. Draw its sectional top view and an auxiliary top view on a reference line parallel to the V.T., showing clearly the shape of the section.
19. A hexagonal prism, side of the base 25 mm long and axis 65 mm long is resting on an edge of the base on the H.P., its axis being inclined at 60° to the H.P. and parallel to the V.P. A section plane, inclined at 45° to the V.P. and normal to the H.P., cuts the prism and passes through a point on the axis at a distance of 20 mm from the top end of the axis. Draw its sectional front view and true shape of the section.
20. A pentagonal pyramid, edge of base 25 mm long and height 50 mm is resting on the H.P. on a corner of its base in such a way that the slant edge containing that corner makes an angle of 60° with the H.P. and is parallel to the V.P. It is cut by a section plane making an angle of 30° with the V.P., perpendicular to the H.P. and passing through a point on the axis at a distance of 6 mm from its base. Draw its sectional front view and true shape of the section.
21. The distance between the opposite parallel faces of a 50 mm thick hexagonal block is 75 mm. The block has one of its rectangular faces parallel to the H.P. and its axis makes an angle of 30° with the V.P. It is cut by a section plane making

an angle of 30° with the H.P., normal to the V.P. and bisecting the axis. Draw its sectional top view and another top view on a plane parallel to the section.

22. *PQR* is an isosceles triangle having base *PR* horizontal and 50 mm long, and altitude 50 mm. A point *A* is taken on *PR* at a distance of 15 mm from *P* and a straight line *AB* is drawn parallel to *PQ* cutting *QR* at *B*. If *AB* is regarded as the V.T. of an inclined plane perpendicular to the V.P., cutting a cone of which *PQR* is the front view, draw the sectional top view, sectional side view and true shape of the section.
23. A cone of 55 mm diameter and 75 mm height is resting on the H.P. on one of its generators in such a way that, the generator is parallel to the V.P. It is cut by a plane parallel to the V.P. and inclined at 90° to the H.P. and passing through a point 15 mm in front of its axis. Draw the sectional front view and the top view of the cone.
24. The true section of a vertical square prism cut by an inclined plane is a rectangle of 75 mm × 40 mm. The plane cuts one of the side faces at a height of 40 mm from the base. Draw three views of the cut prism when it rests on the cut face on the H.P. with its axis remaining parallel to the V.P.
25. An equilateral triangular prism, base 50 mm side and height 100 mm is standing on the H.P. on its triangular face with one of the sides of that face inclined at 90° to the V.P. It is cut by an inclined plane in such a way that the true shape of the section is a trapezium of 50 mm and 12 mm parallel sides. Draw the projections and true shape of the section and find the angle which the cutting plane makes with the H.P.
26. A horizontal cylinder, 30 mm diameter and length 60 mm, is placed centrally on the top of a frustum of a cone, diameter of the base 45 mm, diameter of the top 25 mm and height 45 mm. Draw a sectional front view of the two solids on a vertical plane, distance 12 mm from the axis of the cone and making an angle of 60° with the axis of the cylinder.
27. A cone, base 75 mm diameter and axis 100 mm long, has its base on the H.P. A section plane, parallel to one of the end generators and perpendicular to the V.P., cuts the cone intersecting the axis at a point 75 mm from the base. Draw the sectional top view and project another top view on a plane parallel to the section plane, showing the shape of the section clearly.
28. A solid is made up of a cylinder, 30 mm diameter and 75 mm long, which joins another cylinder, 75 mm diameter and 25 mm long, by a fillet of 20 mm radius, the axes of the two cylinders being in a straight line. Draw the top view of a horizontal section of the solid made by a plane parallel to and 15 mm above the axis.
29. A cone frustum, base 75 mm diameter, top 35 mm diameter and height 65 mm has a hole of 30 mm diameter drilled through it so that the axis of the hole coincides with that of the cone. It is resting on its base on the H.P. and is cut by a section plane perpendicular to the V.P., parallel to an end generator and passing through the top end of the axis. Draw sectional top view and sectional side view of the frustum.
30. A cube of 25 mm edge rests on one of its corners on the H.P. so that a solid diagonal is vertical and two of its faces are perpendicular to the V.P. A vertical section plane parallel to the V.P. cuts the cube at a distance of 8 mm from the solid diagonal and nearer to the V.P. Draw its sectional front view.