Revolutions

Learning Objectives

After studying this chapter, you will be able to:

- Explain and apply the principles of revolution.
- Create revolved views using manual and CAD procedures.
- Revolve a line to determine its true length.
- Revolve a line to determine the true angle between the line and a principal plane.
- Revolve a plane to determine its true size.
- Determine the true angle between planes using the revolution method.

Technical Terms

Path of revolution
Primary revolution
Revolution
Successive revolutions

Revolution is a method in which spatial relationships are defined by rotating or revolving parts. Creating revolved views is similar to creating auxiliary views. As the principles of revolution are learned and applied, the similarities between this method and the auxiliary view method become apparent. Each method tends to enhance one's understanding of the other.

To obtain an auxiliary view of a surface or object, the observer moves to a point where the line of sight is perpendicular to the inclined surface, **Figure 13-1A**. In a revolution of an object, the observer is assumed to remain in the original position while the object is revolved, **Figure 13-1B**. The auxiliary view of a surface appears exactly the same as a revolution of the surface.

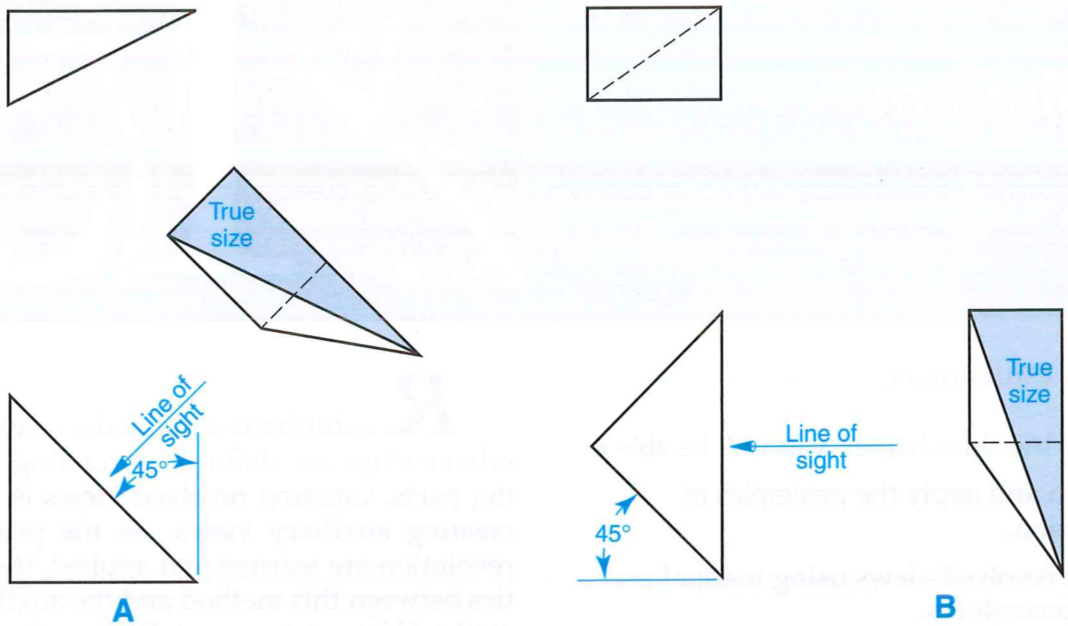

Figure 13-1. Revolved views are similar to auxiliary views. A—In an auxiliary view, the observer "moves" so that the line of sight is perpendicular to the inclined surface. B—In a revolution, the observer "remains still" and the object is "moved" so that the line of sight is perpendicular to the inclined surface.

The method of revolution may be visualized by revolving an imaginary plane section of a cone. When the section is inclined to the observer, it appears foreshortened and not in its true size, **Figure 13-2A**. If the cone is imagined as being "revolved" so that the plane AB′C′ is perpendicular to the line of sight, the plane appears true size, **Figure 13-2B**. Line AC is not shown true length because it is not on a plane that is perpendicular to the line of sight. However, Line AC′ is a true length line since it lies on a plane that is perpendicular to the line of sight.

Revolution Procedures

The revolution method is used to define spatial relationships of points, lines, and planes. Revolution procedures used in manual and CAD drafting are discussed in the following sections.

Manual projection techniques are used to create revolved views in manual drafting. The methods used are similar to those used for creating auxiliary views.

In CAD drafting, revolved views of inclined surfaces are most typically generated by creating three-dimensional (3D) views of models. When working in 3D, special viewing commands such as the **Orbit** command are used to orient the viewing direction at any angle in space. Another way to revolve 3D models in space is to use the **Rotate 3D** command. This command allows you to revolve an object about an axis, such as the X, Y, or Z axis, or an axis defined by two points picked on screen.

For 2D CAD drawings, the **Rotate** command can be used to revolve geometry to define spatial relationships. As is the case with auxiliary views, the **Xline** command and other drawing commands can be used to project lines in revolved views.

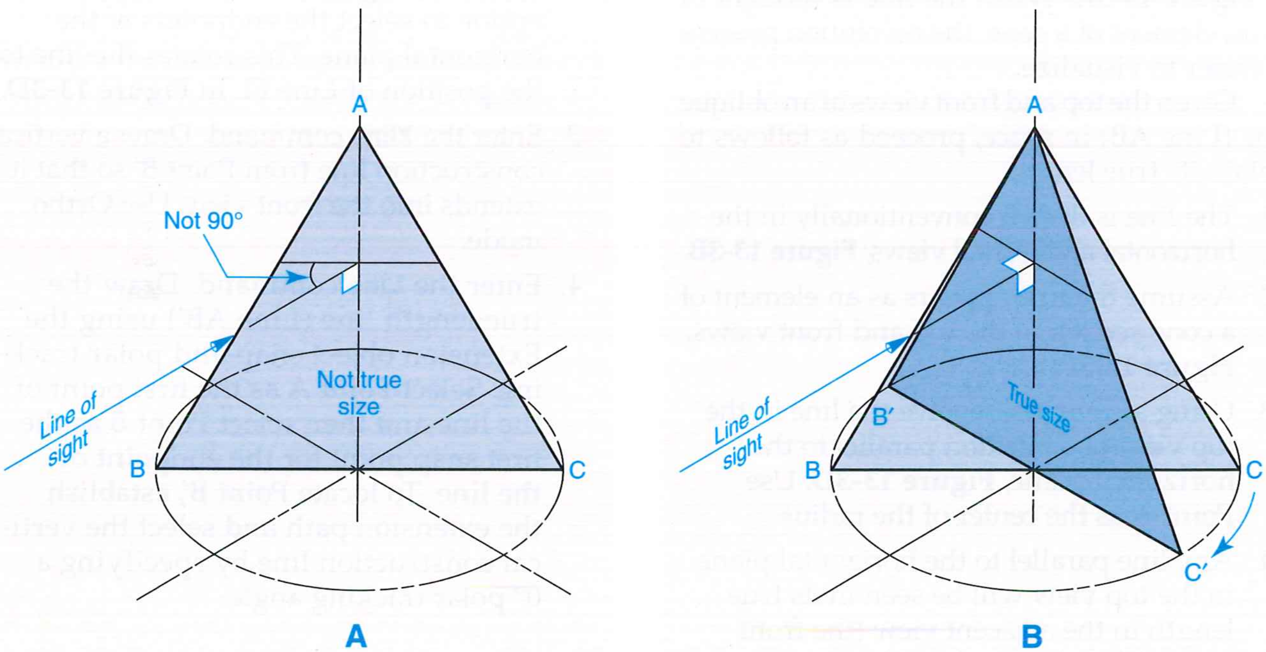

Figure 13-2. Revolving the plane section of a cone helps clarify the principles of revolution. A—When a section of a cone is viewed at an angle other than 90°, the surface is not seen in its true size or shape. B—If the surface is "revolved" so that the line of sight is 90°, the surface will be seen in its true size and shape.

Revolve a Line to Find Its True Length

Using Instruments (Manual Procedure)

The revolution method may be used to find the true length of a line in space. A frontal line that is revolved to find its true length is shown in **Figure 13-3A**. When the line is thought of as an element of a cone, the revolution process is easier to visualize.

Given the top and front views of an oblique line (Line AB) in space, proceed as follows to obtain its true length.

1. The line is drawn conventionally in the horizontal and frontal views, **Figure 13-3B**.
2. Assume the line appears as an element of a cone section in the top and front views, **Figure 13-3C**.
3. Using a compass, revolve the line in the top view to a position parallel to the horizontal plane, **Figure 13-3D**. Use Point A as the center of the radius.
4. Any line parallel to the horizontal plane in the top view will be seen in its true length in the adjacent view (the front view). Therefore, Line AB′ is shown true length in the front view, **Figure 13-3D**.

Using the Rotate Command (CAD Procedure)

1. The top and front views of the line are given. Refer to **Figure 13-3B**.
2. Enter the **Rotate** command. Select the line in the top view and then select Point A_H as the base point. Enter the **Reference** option to rotate the line so that it is parallel to the horizontal plane. Select the endpoints of the line to define the reference angle and then use the **Points** option to select the endpoints of the horizontal plane. This rotates the line to the position of Line FL in **Figure 13-3D**.
3. Enter the **Xline** command. Draw a vertical construction line from Point B′ so that it extends into the front view. Use Ortho mode.
4. Enter the **Line** command. Draw the true length line (Line AB′) using the Extension object snap and polar tracking. Select Point A as the first point of the line and then select Point B as the first snap point for the endpoint of the line. To locate Point B′, establish the extension path and select the vertical construction line by specifying a 0° polar tracking angle.

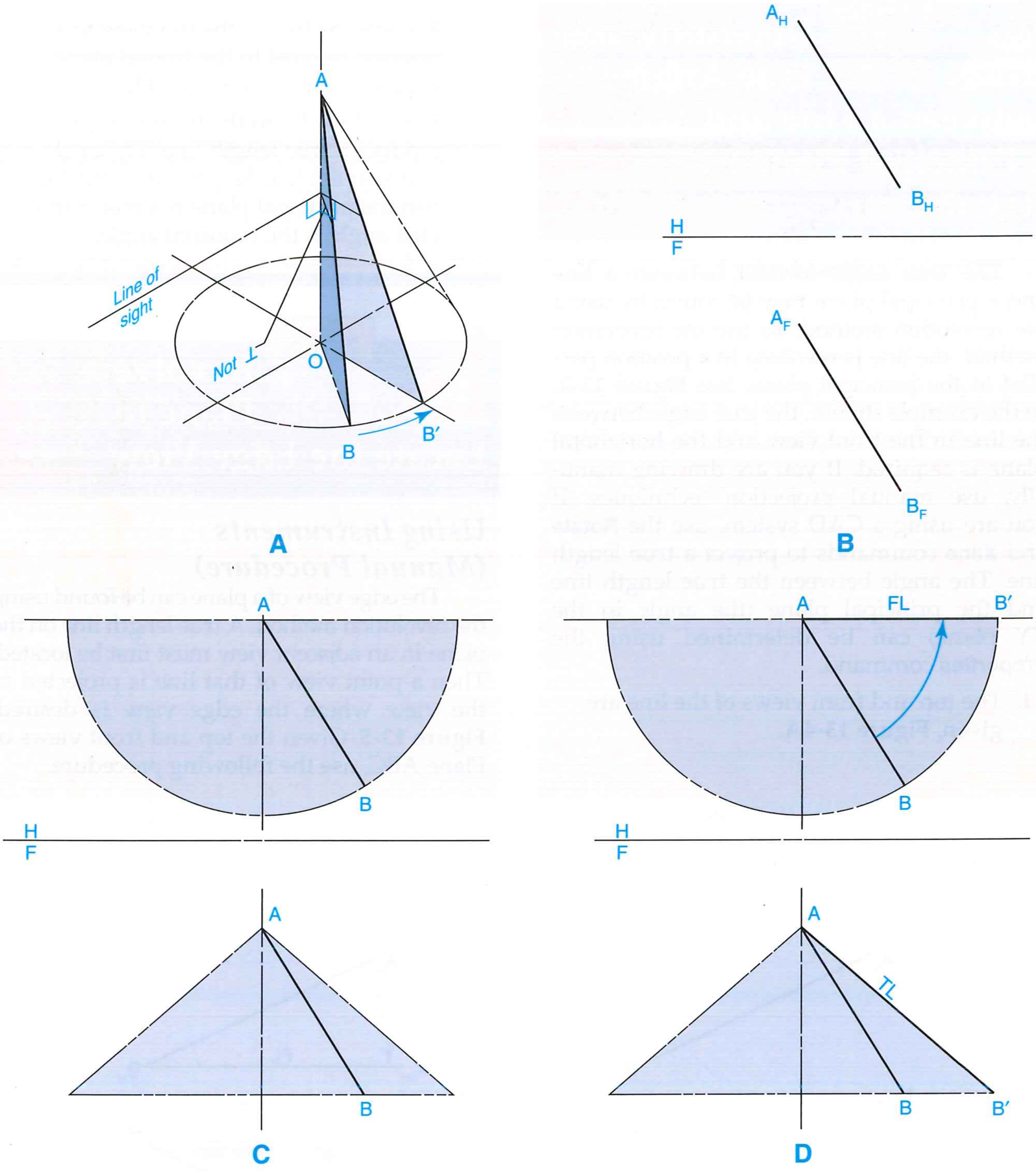

Figure 13-3. Revolving a line to determine its true length.

Determine the True Angle between a Line and a Principal Plane by Revolution

The true angle formed between a line and a principal plane may be found by using the revolution method. To use the revolution method, the line is revolved to a position parallel to the principal plane. See **Figure 13-4**. In the example shown, the true angle between the line in the front view and the horizontal plane is required. If you are drawing manually, use manual projection techniques. If you are using a CAD system, use the **Rotate** and **Xline** commands to project a true length line. The angle between the true length line and the principal plane (the angle in the XY plane) can be determined using the **Properties** command.

1. The top and front views of the line are given, **Figure 13-4A**.
2. Revolve the line in the top view to a position parallel to the frontal plane, **Figure 13-4B**. This is Line FL.
3. Project Line FL to the front view to produce a true length line. The angle between the true length line, Line TL, and the principal plane is a true angle. This angle is the required angle.

Revolve a Plane to Locate the Edge View

Using Instruments (Manual Procedure)

The edge view of a plane can be found using the revolution method. A true length line on the plane in an adjacent view must first be located. Then a point view of that line is projected to the view where the edge view is desired, **Figure 13-5**. Given the top and front views of Plane ABC, use the following procedure.

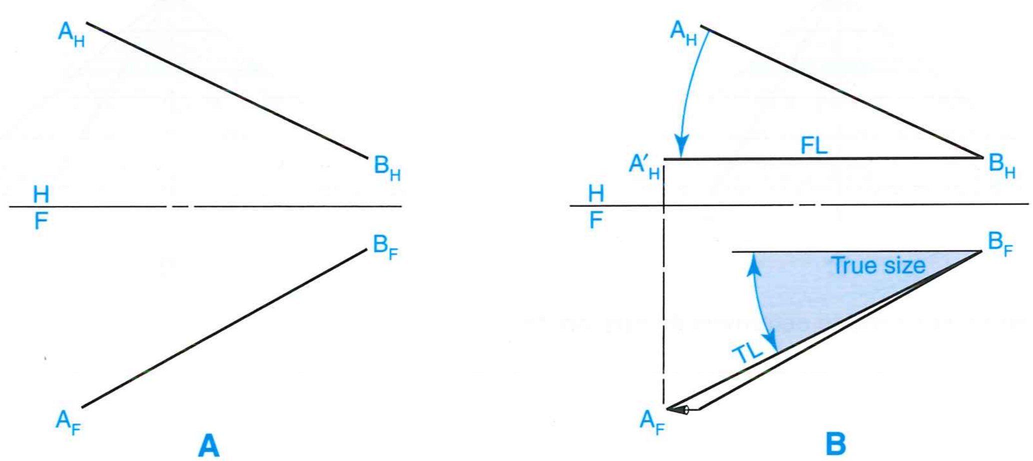

Figure 13-4. Revolving a line to determine the true angle between the line and a principal plane. A—The top and front views of the line. B—The line is first revolved in the top view to a position parallel to the frontal plane. The true length line (Line FL) is then projected to the front view. The angle between the projected true length line and a principal plane is true size.

1. Draw the frontal line (FL) in the top view parallel to the plane of projection H-F, **Figure 13-5A**. This is Line AD. Project this line to the front view to establish the true length line (TL) on Plane ABC.
2. Using a compass, revolve the true length line (Line AD) to the vertical position AD′, using Point A as the radius center. Then, using a compass and dividers, transfer Plane ABC to its corresponding position around Line AD′, **Figure 13-5B**.
3. Project Points A, B′, and C′ to the top view perpendicularly to intersect with their corresponding projectors, **Figure 13-5C**.
4. Join these points to form an edge view of Plane ABC. Points A, B′, and C′ will lie in a straight line if the projections and measurements have been made accurately.

Using the Rotate Command (CAD Procedure)

1. The top and front views of Plane ABC are given. Refer to **Figure 13-5**.
2. Enter the **Line** command and draw the frontal line (FL) in the top view. Refer to **Figure 13-5A**.
3. Enter the **Xline** command. Draw vertical construction lines to project the frontal line (Line AD) to the front view to establish the true length line (TL). Enter the **Line** command and draw the true length line.
4. Enter the **Rotate** command. Select the lines making up Plane ABC and the true length line. Specify Point A as the base point and rotate the plane so that the true length line rotates to the vertical position AD′. Use the **Reference** option to identify the angle of the true length line and use a polar tracking angle of 90° to specify the new angle. Refer to **Figure 13-5B**.
5. Enter the **Xline** command. Draw vertical construction lines to project Points A, B′, and C′ to the top view. Enter the **Xline** command and draw horizontal projectors from the corresponding points in the top view. Refer to **Figure 13-5C**.
6. Enter the **Line** command and join Points A, B′, and C′ to form the edge view.

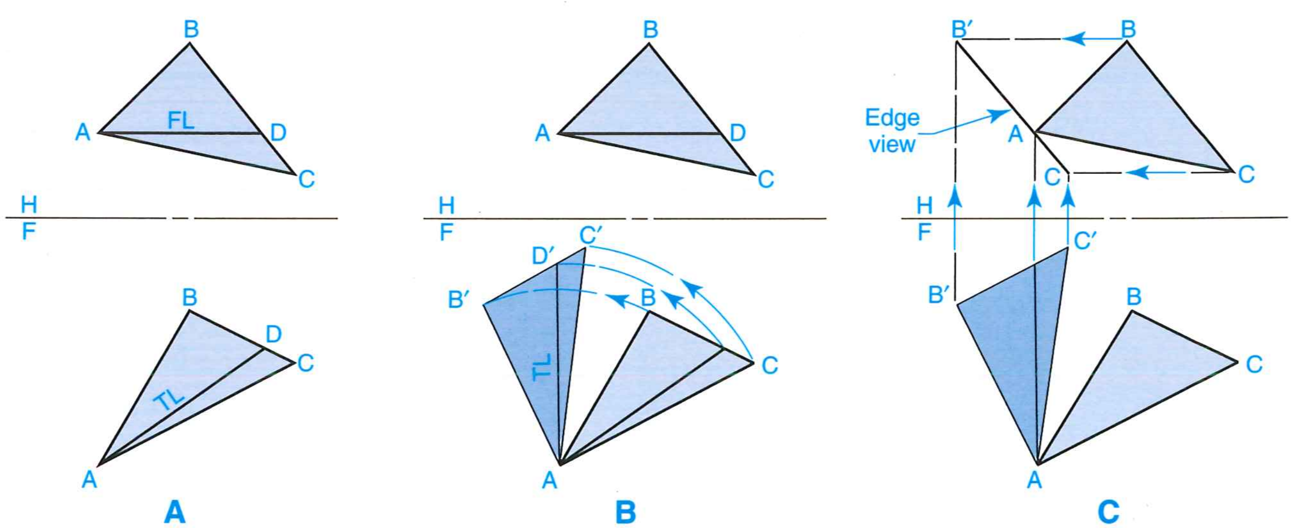

Figure 13-5. Revolving a plane to locate the edge view.

Revolve a Plane to Determine Its True Size

Using Instruments (Manual Procedure)

To determine the true size of a plane, an edge view of the plane must first be constructed in a primary auxiliary view. The construction is completed by revolving the edge, then projecting it back to the principal view.

Given the top and front views of Plane ABC, use the following procedure. See **Figure 13-6**.

1. Locate a point view of the plane by first drawing a horizontal line (Line HL) in the front view, **Figure 13-6A**. This will locate the true length line (Line TL) in the top view. From Line TL, a point view primary auxiliary is projected. Plane ABC appears as an edge view in this auxiliary.
2. Using a compass and Point B as the radius center, revolve the edge view of Plane ABC to a position parallel to Plane H-1, **Figure 13-6B**.
3. Project Points B, C′, and A′ to the top view. These points will intersect corresponding projectors that are drawn parallel to Plane H-1, **Figure 13-6C**.
4. Connect these points of intersection to produce the true size plane (Plane A′BC′).

A true size plane could have been found in the front view in a similar manner.

Using the Rotate Command (CAD Procedure)

1. The top and front views of Plane ABC are given. Refer to **Figure 13-6**.
2. Enter the **Line** command and draw Line HL in the front view. Refer to **Figure 13-6A**. Enter the **Xline** command and draw vertical construction lines to locate the endpoints of the true length line (Line TL) in the top view. Enter the **Line** command and draw Line TL.
3. Create a primary auxiliary view. Enter the **Xline** command and use the Perpendicular object snap to draw the reference plane H-1. Enter the **Offset** command and offset the reference plane to locate points in the auxiliary. Using the Endpoint and Perpendicular object snaps, draw construction lines from the top view through the offset lines. Enter the **Line** command and draw the edge view.

4. Enter the **Rotate** command. Rotate the edge view to a position parallel to Plane H-1. Refer to **Figure 13-6B**. Specify Point B as the base point. Use the **Reference** option to identify the angle of the edge view. Use the **Points** option and select two points on the reference plane where the construction lines from the top view intersect to specify the new angle.
5. Enter the **Xline** command. Draw construction lines from Points A, B, and C in the top view. Use the Parallel object snap to draw the lines parallel to the reference plane H-1. Then, draw construction lines from Points B, C′, and A′ to the top view. Use the Perpendicular object snap to draw the lines perpendicular to the reference plane H-1. Refer to **Figure 13-6C**.
6. Enter the **Line** command and connect the points of intersection in the top view to draw the true size plane (Plane A′BC′).

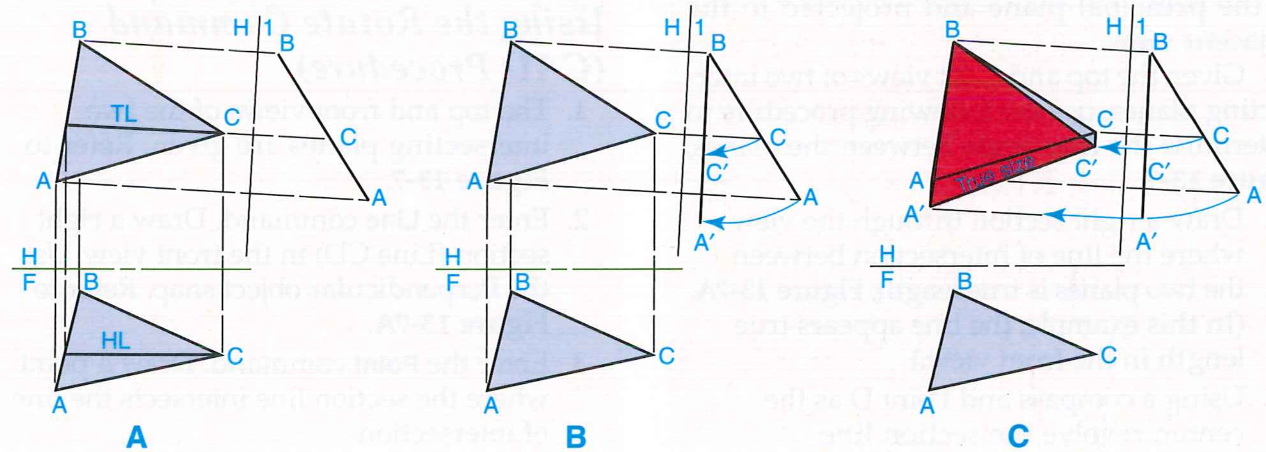

Figure 13-6. Revolving a plane to determine its true size.

Determine the True Angle between Two Intersecting Planes by Revolution

Using Instruments (Manual Procedure)

If the line of intersection between two planes appears true length in a principal view, the angle between the two planes can be found using the revolution method. A right section is first drawn through the two planes. This section is then revolved to the principal plane and projected to the adjacent view.

Given the top and front views of two intersecting planes, use the following procedure to determine the true angle between the planes, **Figure 13-7**.

1. Draw a right section through the view where the line of intersection between the two planes is true length, **Figure 13-7A**. (In this example, the line appears true length in the front view.)
2. Using a compass and Point D as the center, revolve the section line (Line CD) to a position parallel to Plane H-F, **Figure 13-7B**. The revolved line is Line C′D. Revolve the point where the line of intersection crosses the right section line, Point E.
3. Project Points C′, E′, and D to their corresponding points of intersection in the top view. Note that the horizontal line in the front view (Line C′D) projects true length in the top view.
4. Connect the points of intersection in the top view to form the true size angle (Angle C′E′D), **Figure 13-7C**. This angle is the required angle between the two intersecting planes.

Using the Rotate Command (CAD Procedure)

1. The top and front views of the two intersecting planes are given. Refer to **Figure 13-7**.
2. Enter the **Line** command. Draw a right section (Line CD) in the front view. Use the Perpendicular object snap. Refer to **Figure 13-7A**.
3. Enter the **Point** command. Draw a point where the section line intersects the line of intersection.

4. Enter the **Rotate** command and rotate Line CD to a position parallel to Plane H-F. Specify Point D as the base point. Use the **Reference** option to identify the angle of Line CD and use the **Points** option to select two points on the reference plane to specify the new angle. Refer to **Figure 13-7B**.
5. Enter the **Xline** command. Draw construction lines from Points C′, E′, and D to the top view.
6. Enter the **Line** command and draw lines to connect the points of intersection in the top view. Refer to **Figure 13-7C**. The angle between Lines C′E′ and DE′ can be determined using the **Properties** command.

CAD Determine the True Angle between Two Intersecting Oblique Planes

The true size of angles between intersecting planes oblique to the principal planes of projection can be found by revolution. First construct a primary auxiliary view where the line of intersection between the two planes appears in its true length. Then use the preceding procedure discussed for determining the true angle between intersecting planes.

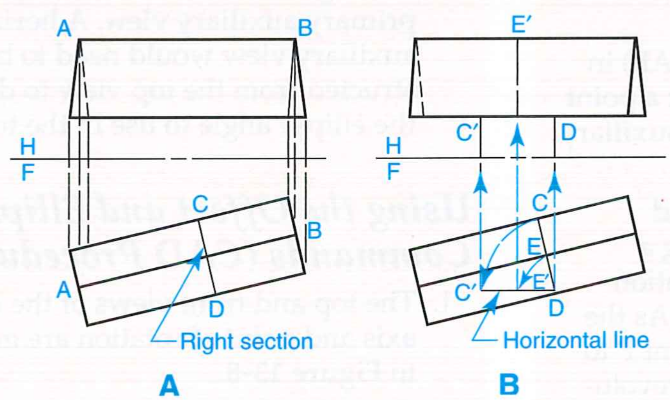

Figure 13-7. Using the revolution method to determine the true angle between two intersecting planes.

Revolve a Point About an Oblique Axis to Determine Its Path

Using Instruments (Manual Procedure)

Machine designs occasionally include parts that meet the machine surface at an oblique angle. For example, hand cranks frequently meet the machine surface at an oblique angle. The ***path of revolution*** of such a machine part may be determined by the revolution of a point with successive auxiliary views.

Given the top and front views of an oblique axis and a point of rotation, use the following procedure, **Figure 13-8**.

1. Develop a true length line (Line AB) in a primary auxiliary view. Project a point view of Line AB in a secondary auxiliary view, **Figure 13-8A**.
2. Project Point P to the primary and secondary auxiliary views. Using a compass, draw the path of revolution in the secondary auxiliary view. As the radius, use the distance from Point P to the axis of Line AB. The path of revolution appears as an edge in the primary auxiliary. This "edge" is perpendicular to Line AB and passes through Point P.
3. Next, locate the highest point on the path of Point P. Draw a true length vertical line (Line AC) to Plane HF to locate Point C in the front view, **Figure 13-8B**. Then project Line AC as a point in the top view. Project this point through the primary and secondary auxiliary views. The point where the directional arrow crosses the circular path in the secondary auxiliary, Point P′, is the highest point on the path of Point P.
4. Project Point P′ back through successive views to the top view where it lies on Line AB, verifying it as the highest point, **Figure 13-8C**. The position of Point P′ in the views should be established by careful measurements from the appropriate reference planes, as shown in **Figure 13-8C**. Any other position could have been established, such as the lowest or forward position on the path of rotation. This would be done by drawing a line in the required direction in the appropriate principal view and then projecting it into all views.
5. To draw the elliptical path of revolution of the point in the principal views, use an ellipse template to draw an ellipse of the appropriate major diameter and angle. The major diameter is the diameter of the circular path. The ellipse angle used in the front view is the angle formed by the line of sight from the front view with the edge view of the circular path in the primary auxiliary view. A horizontal auxiliary view would need to be constructed from the top view to determine the ellipse angle to use in the top view.

Using the Offset and Ellipse Commands (CAD Procedure)

1. The top and front views of the oblique axis and point of rotation are given. Refer to **Figure 13-8**.
2. Using the **Offset** command, construct a true length line (Line AB) in a primary auxiliary view. Use the **Distance Between Two Points** calculator function to calculate the offset distances for Points A and B in the top view. In a similar manner, use the **Offset** command to develop a point view of Line AB in a secondary auxiliary view. To create the reference plane, use the **Xline** command and the Perpendicular object snap.
3. Using the **Offset** command and the **Distance Between Two Points** calculator function, project Point P to the primary and secondary auxiliary views.
4. Enter the **Circle** command. Use the **Two Points** option to draw the path of revolution in the secondary auxiliary view.

Select the axis of Line AB as the center point and select Point P as the second point.

5. Enter the **Xline** command. Using the Parallel object snap, draw a construction line parallel to the reference plane 1-2 through the center of the circular path. Draw construction lines from the intersection points parallel to Line AB in the primary auxiliary view. Then, enter the **Line** command and draw the edge view of the circular path through Point P. Use the Perpendicular object snap to draw the line perpendicular to the construction lines.
6. Enter the **Line** command. Using object snaps, draw Line AC in the front view. Refer to **Figure 13-8B**. Enter the **Point** command and draw Point C in the top view. Using the **Offset** and **Xline** commands, project Point C through the primary and secondary auxiliary views. Use the **Distance Between Two Points** calculator function to calculate the offset distance in the primary auxiliary view. Draw a construction line to locate Point P′ on the circular path.
7. Using the **Offset** and **Xline** commands, project Point P′ to the front and top views. Refer to **Figure 13-8C**. Use the **Distance Between Two Points** calculator function with object snaps to calculate each offset distance. Offset the appropriate reference planes and draw construction lines to locate the points.
8. To draw the path of revolution in each principal view, draw an ellipse using the **Ellipse** command. First, use the **Point** command to locate the ellipse center points. Locate the centers by projecting the center point of the circular path from the edge view and secondary auxiliary view. Use the **Offset** command and offset the appropriate reference planes using calculated offset distances. After locating each center point, enter the **Ellipse** command. Use the **Center** and **Rotation** options to draw the ellipse in the front view. Select Point P′ as an axis endpoint. Then, enter the **Rotation** option and specify the appropriate ellipse angle. To draw the ellipse in the top view, first locate one of the major axis endpoints by projecting a point from the primary and secondary auxiliary views. Then, enter the **Ellipse** command and use the **Center** and **Rotation** options to draw the ellipse at the appropriate angle.

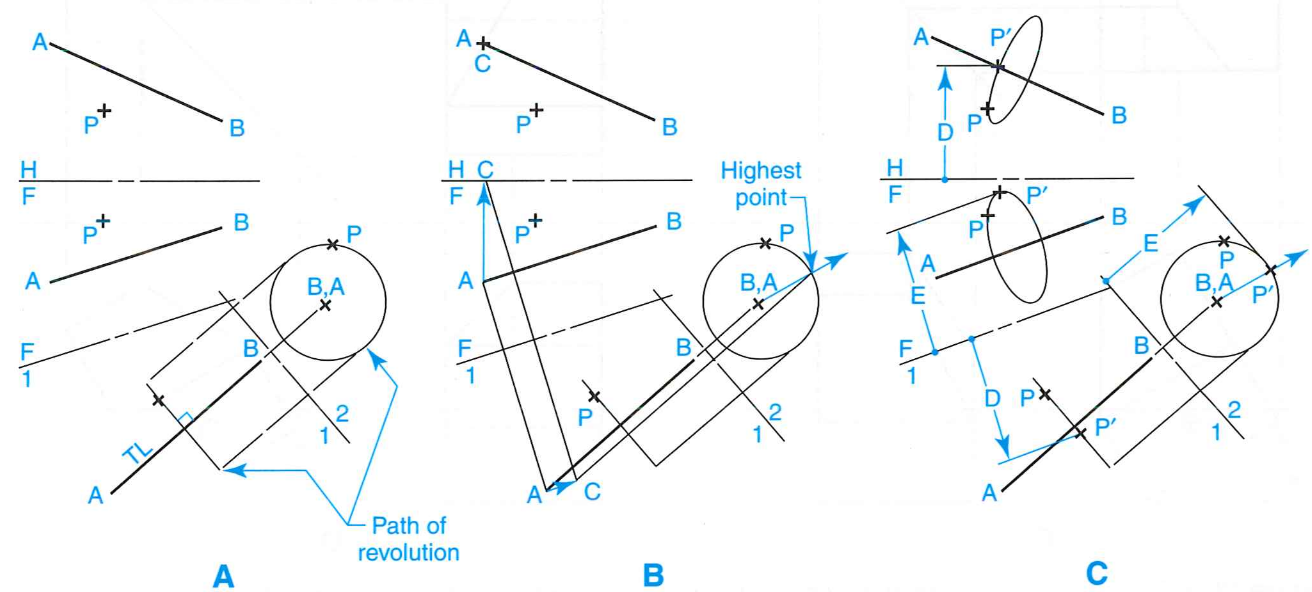

Figure 13-8. Revolving a point about an oblique axis to locate its path and highest point.

Primary Revolutions of Objects About Axes Perpendicular to Principal Planes

Revolutions are made to obtain one or more of three constructions to clarify drawings: a clear view of an object, the true length of a line, or the true size of a surface. A ***primary revolution*** is drawn perpendicular to one of the principal planes of projection. An object is shown in its normal position in **Figure 13-9A**. It is revolved in the horizontal plane in **Figure 13-9B**. The object is revolved in the frontal plane in **Figure 13-9C**. It is revolved in the profile plane in **Figure 13-9D**. Regular orthographic principles are used in projecting primary revolutions.

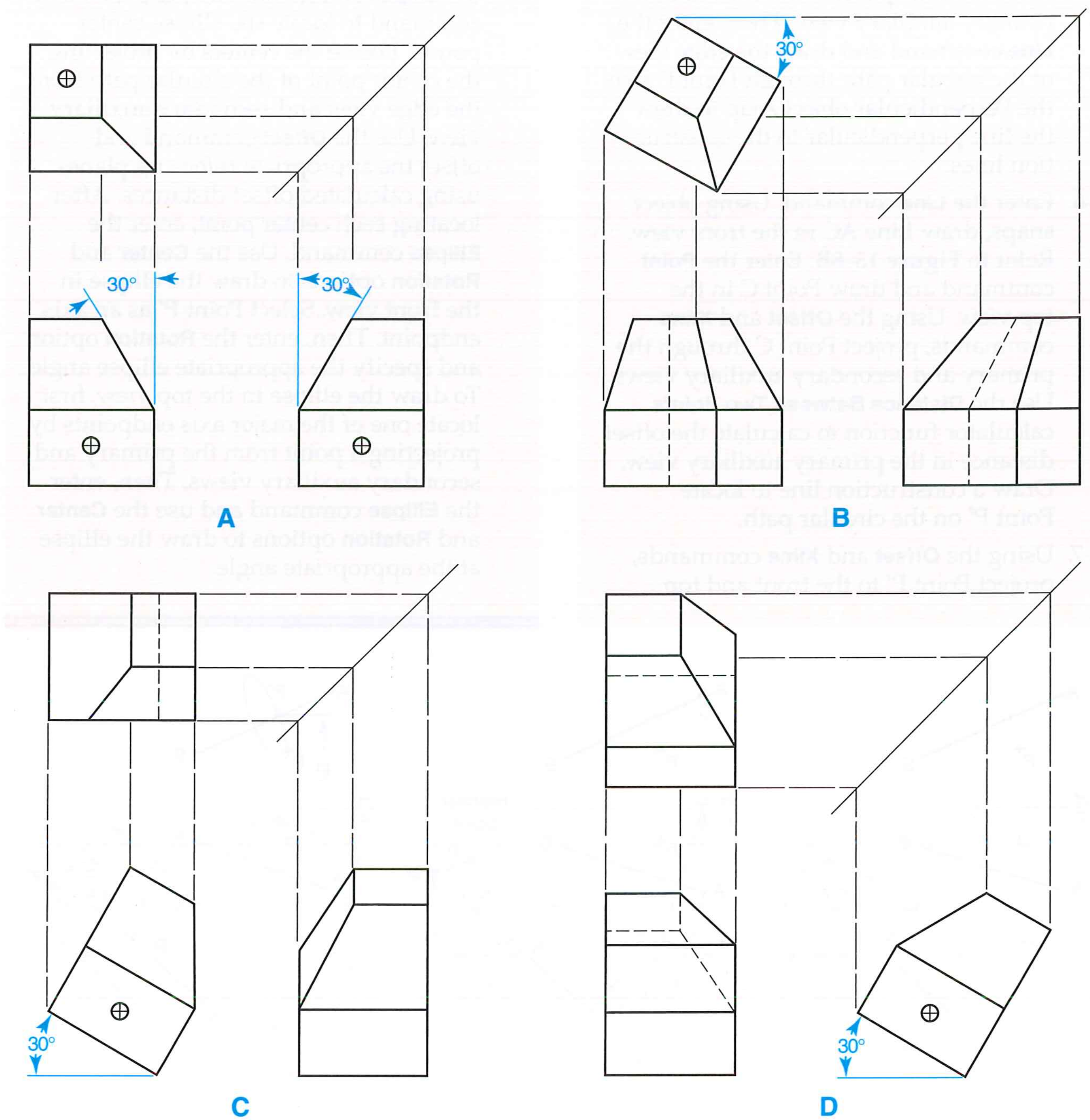

Figure 13-9. Primary revolutions of an object are projected perpendicular to one of the principal planes of projection.

Successive Revolutions of an Object With an Oblique Surface

The true size of an oblique surface may be determined by ***successive revolutions***, **Figure 13-10**. This method is similar to finding the true size of an oblique surface through successive auxiliary views.

A pictorial view of an object with an oblique surface is shown in **Figure 13-10A**. The object is shown in its normal orthographic position in **Figure 13-10B**, with an indication of the revolution to be made in the first of two successive revolutions. The first revolution of the object is performed in **Figure 13-10C**, while the second revolution (in **Figure 13-10D**) produces the true size view of the oblique surface.

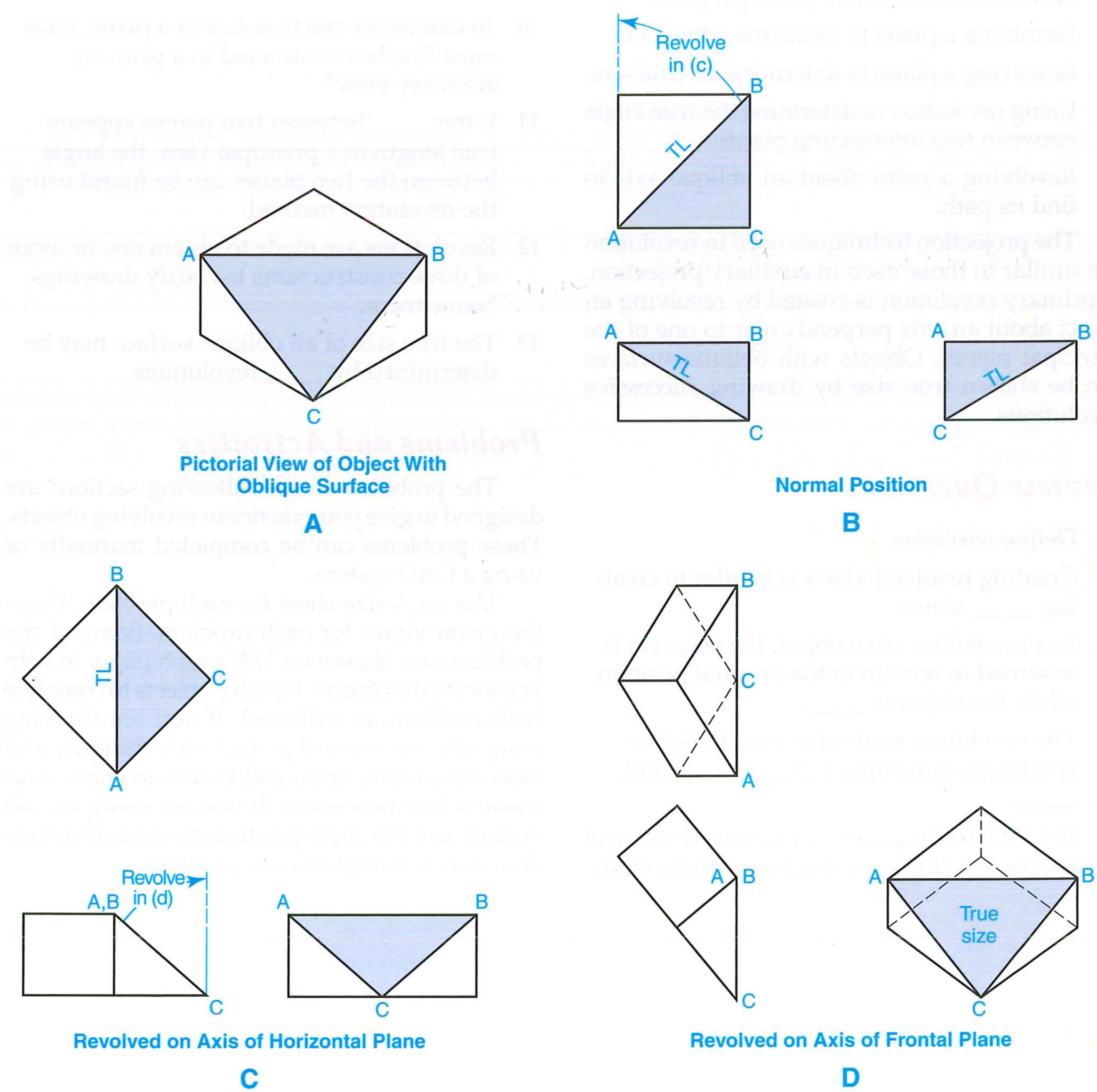

Figure 13-10. Successive revolutions can be used to determine the true size of an oblique surface.

Chapter Summary

In revolved views, objects are "moved" and the viewer "remains" in one place. The revolution method produces results similar to those produced by the auxiliary view method.

The revolution method is used to define spatial relationships. Revolution procedures include the following:

- Revolving a line to find its true length.
- Revolving a line to find the true angle between the line and a principal plane.
- Revolving a plane to locate the edge view.
- Revolving a plane to determine its true size.
- Using revolution to determine the true angle between two intersecting planes.
- Revolving a point about an oblique axis to find its path.

The projection techniques used in revolution are similar to those used in auxiliary projection. A primary revolution is created by revolving an object about an axis perpendicular to one of the principal planes. Objects with oblique surfaces can be shown true size by drawing successive revolutions.

Review Questions

1. Define *revolution.*
2. Creating revolved views is similar to creating _____ views.
3. In a revolution of an object, the observer is assumed to remain in the original position while the object is _____.
4. The revolution method is used to define spatial relationships of _____, _____, and _____.
5. In CAD drafting, how are revolved views of inclined surfaces most typically generated?
6. When drawing with CAD, which commands are used to orient the viewing direction at any angle in space?
7. For 2D CAD drawings, which command can be used to revolve geometry to define spatial relationships?
8. The revolution method may be used to find the true _____ of a line in space.
9. The _____ angle formed between a line and a principal plane may be found by using the revolution method.
10. To determine the true size of a plane, what must first be constructed in a primary auxiliary view?
11. If the _____ between two planes appears true length in a principal view, the angle between the two planes can be found using the revolution method.
12. Revolutions are made to obtain one or more of three constructions to clarify drawings. Name them.
13. The true size of an oblique surface may be determined by _____ revolutions.

Problems and Activities

The problems in the following sections are designed to give you practice in revolving objects. These problems can be completed manually or using a CAD system.

Use an A-size sheet for each problem. Draw the given views for each problem. Some of the problems are shown on 1/4" graph paper to help you locate the objects. Revolve objects to complete each problem as indicated. If you are drawing manually, use manual projection techniques and label the points, lines, and planes to show your construction procedure. If you are using a CAD system, use the appropriate drawing commands and tools to complete each problem.