Auxiliary Views

Learning Objectives

After studying this chapter, you will be able to:

- List the basic types of auxiliary views and explain the purpose of each type.
- Describe the common applications of auxiliary views.
- Explain the projection procedures for creating auxiliary views.
- Draw primary and secondary auxiliary views using manual and CAD methods.

Technical Terms

Auxiliary projections	Secondary auxiliary view
Auxiliary view	Slope
Dihedral angle	Successive auxiliary view
Primary auxiliary view	

The principal views of multiview drawings (the top, front, and side views) are normally adequate for describing the shape and size of most objects. However, objects having features inclined to the principal projection planes require special projection procedures, **Figure 12-1**. These projection procedures are possible through auxiliary views. An ***auxiliary view*** is a supplementary view used to provide a true size and shape description of an object surface (typically an inclined surface).

Auxiliary views are often used in the sheet metal and packaging industries. In many cases, patterns must be developed for surfaces of various shapes that are at an angle with other surfaces. The projection of these features in normal views always results in foreshortened and distorted views. These surfaces are not true shape and size. ***Auxiliary projections*** are necessary to sufficiently analyze and describe these features for production purposes.

Auxiliary views provide the following basic information for features appearing on surfaces other than the principal surfaces:

- The true length of a line.
- The point view of a line.
- The edge view of a plane.
- The true size of a plane.
- The true angle between planes.

Two basic types of auxiliary views are used in describing and refining the design of industrial products: primary auxiliary views and secondary auxiliary views. A ***primary auxiliary view*** is projected from an orthographic view (the horizontal, frontal, or profile view). A ***secondary auxiliary view*** is projected from a primary auxiliary view and a principal view. A view projected after a secondary auxiliary is known as a ***successive auxiliary view***.

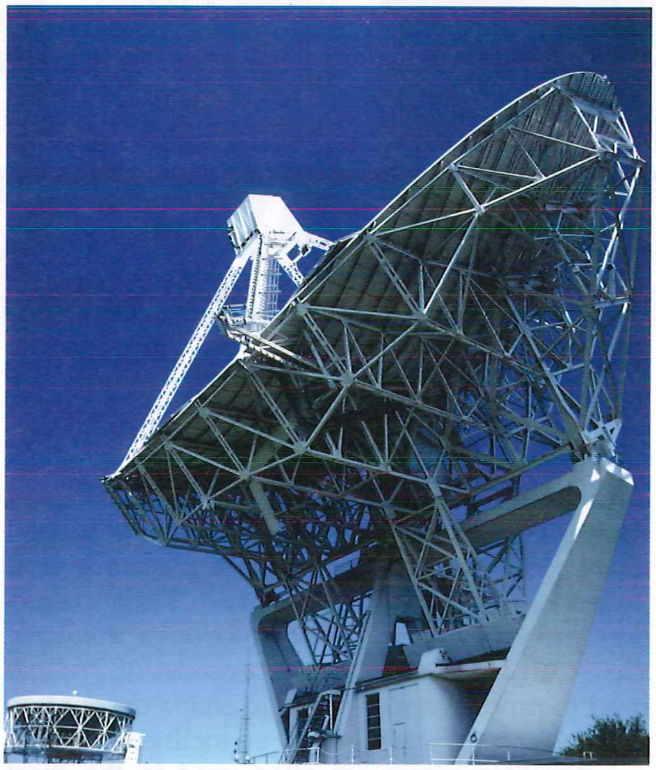

Figure 12-1. Assemblies with inclined surfaces such as satellite dishes require auxiliary views in their design.

Primary Auxiliary Views

A primary auxiliary view is a first, or direct, projection of an inclined surface. It is projected perpendicular to one of the principal orthographic views (the horizontal, frontal, or profile view), **Figure 12-2**. A primary auxiliary view is perpendicular to only one of the principal views. (A view that is perpendicular to two of the principal views is a normal orthographic view and not an auxiliary view.)

Determining True Size and Shape of Inclined Surfaces

The primary auxiliary view is useful in determining the true size and shape of a surface that is inclined. This view is not useful in finding true size in any of the principal views of projection. The auxiliary view is projected from the principal view where the inclined surface appears as an "edge." The example in **Figure 12-3** shows the auxiliary view as an edge in the frontal plane. Therefore, the auxiliary projection is called a frontal projection.

Primary auxiliary planes of projection are always numbered "1" and preceded by the letter indicating a frontal, horizontal, or profile plane. In **Figure 12-3B**, the reference plane F-1 is drawn at any convenient location and parallel to the line in the front view that represents the edge of the inclined surface.

Note in **Figure 12-3** that the primary auxiliary plane of projection is perpendicular to the frontal plane. Also, the line of sight is perpendicular to the auxiliary plane. This is how any of the normal projection planes are viewed as well. Distances along the plane of projection are projected perpendicularly in their true length, **Figure 12-3B**. In manual drafting, true length measurements of depth are transferred with a scale or dividers from the top or side view to the auxiliary view. In CAD drafting, depth features can be constructed in the auxiliary view by using the **Line** and **Copy** commands with polar tracking to locate the features based on true length measurements in the top or side view.

The object in **Figure 12-3** could be arranged so that the inclined surface appears as an edge in the top view, **Figure 12-4**. The inclined surface

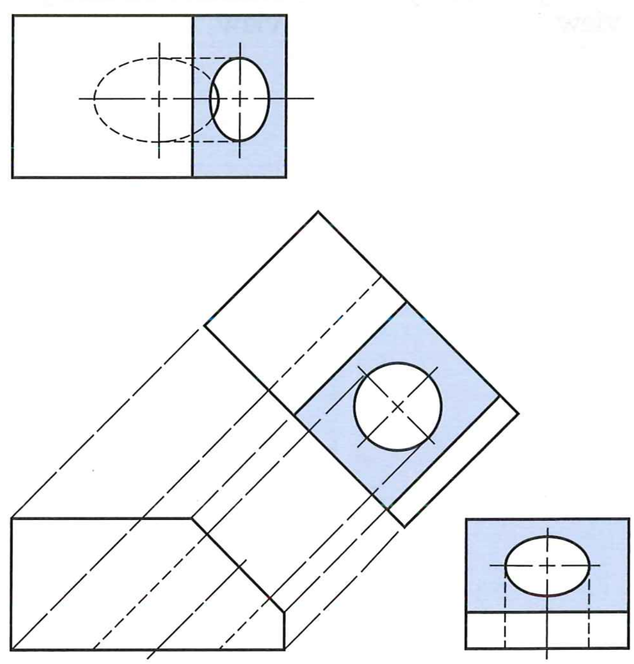

Figure 12-2. A primary auxiliary view is a first, or direct, projection of an inclined surface.

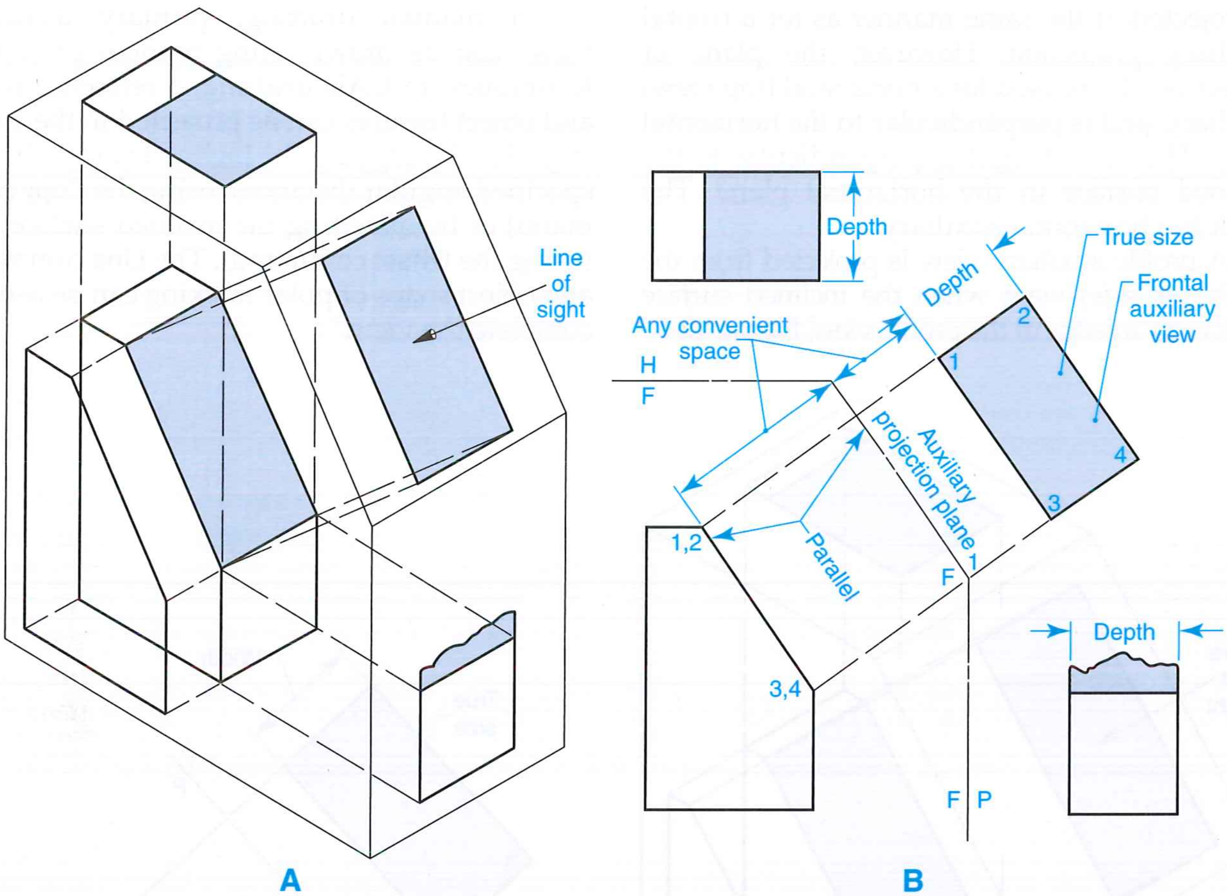

Figure 12-3. In a frontal auxiliary projection, the auxiliary view is projected from an inclined surface that appears as an edge in the front view. The reference plane is drawn parallel to the line in the front view that represents the inclined surface.

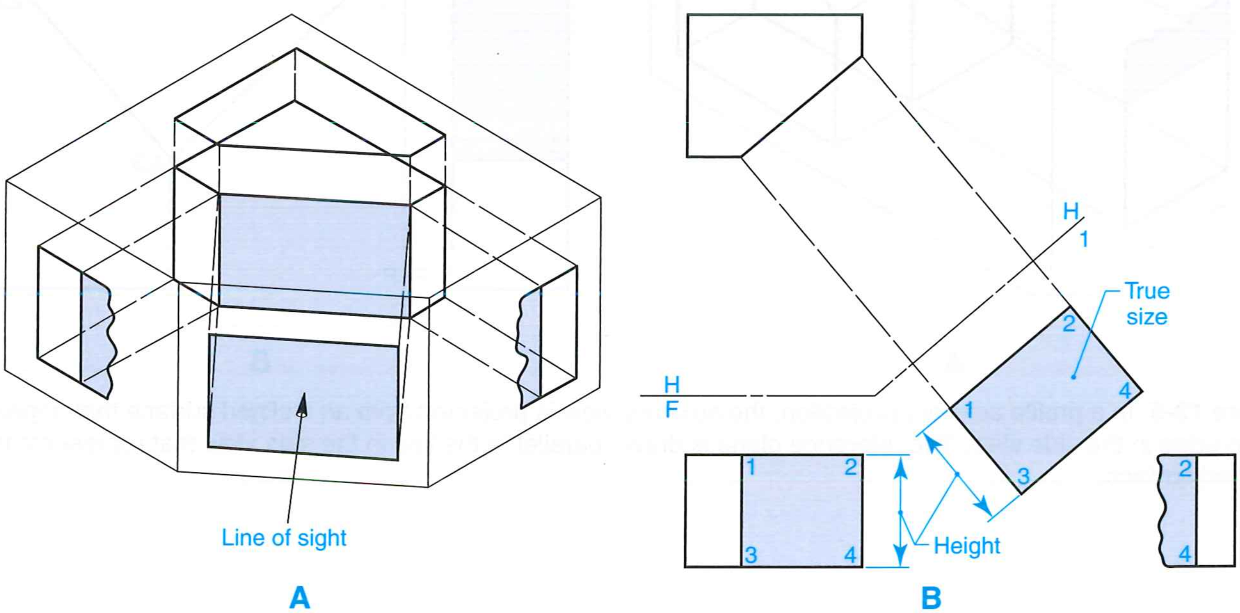

Figure 12-4. In a horizontal auxiliary projection, the auxiliary view is projected from an inclined surface that appears as an edge in the top view. The reference plane is drawn parallel to the line in the top view that represents the inclined surface.

is projected in the same manner as for a frontal auxiliary projection. However, the plane of projection H-1 is used for a horizontal (top view) auxiliary, and is perpendicular to the horizontal plane. The line of sight is perpendicular to the inclined surface in the horizontal plane. The result is a horizontal auxiliary.

A profile auxiliary view is projected from the profile (or side) view, when the inclined surface appears as an edge in the profile view, **Figure 12-5**.

In manual drafting, primary auxiliary views can be drawn using manual projection techniques. In CAD drafting, a reference plane and object features can be projected to the auxiliary view by copying the inclined surface line at specified angular distances (using the **Copy** command) or by offsetting the inclined surface line (using the **Offset** command). The **Line** command and object snaps or polar tracking can be used to complete the view.

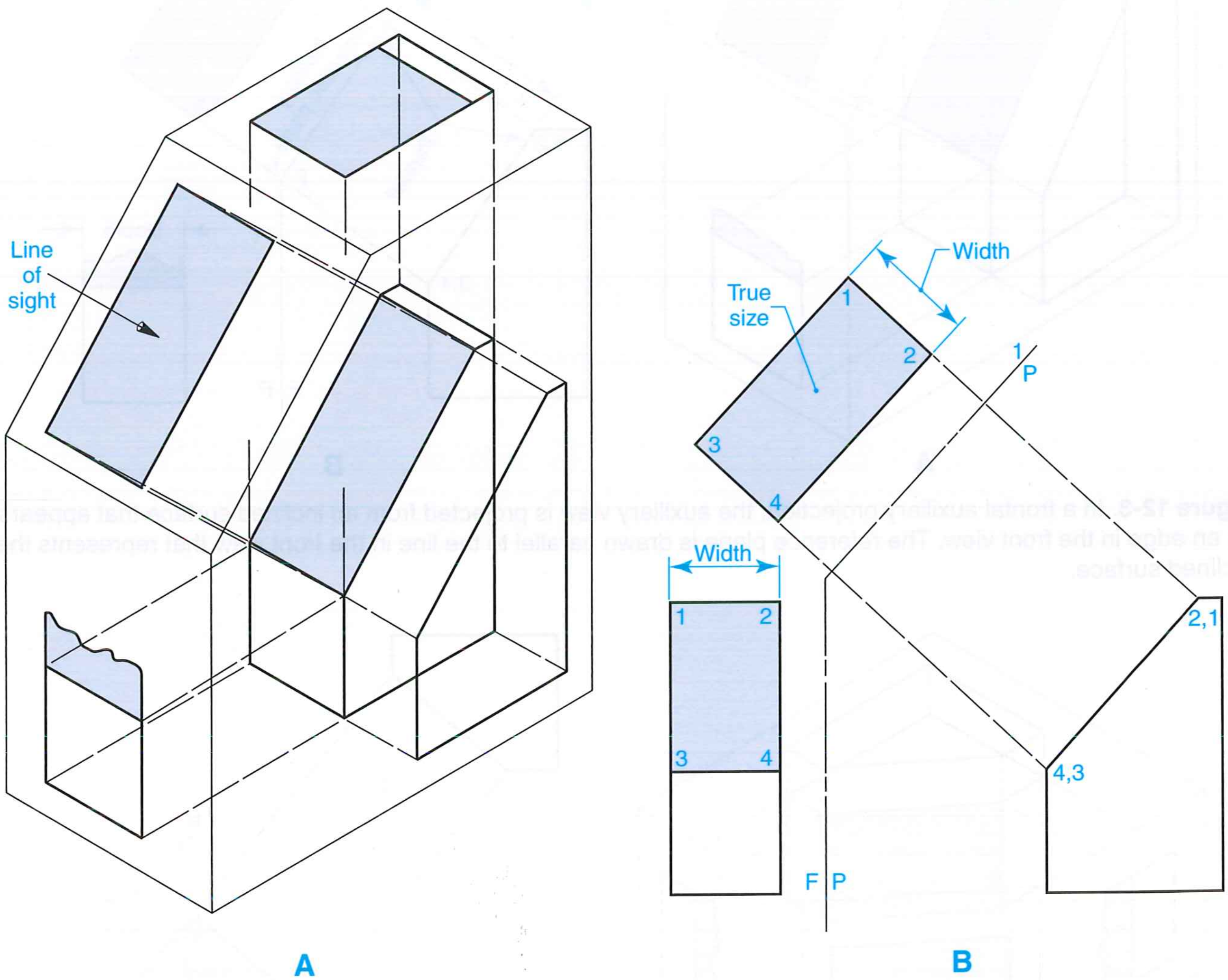

Figure 12-5. In a profile auxiliary projection, the auxiliary view is projected from an inclined surface that appears as an edge in the side view. The reference plane is drawn parallel to the line in the side view that represents the inclined surface.

Locating a Point in an Auxiliary View

The location of points in an auxiliary view is the first important step in understanding the projection and development of auxiliary views, **Figure 12-6**. In **Figure 12-6A**, Point A is shown in the "glass box." This point has been projected to the frontal, horizontal, and auxiliary planes. Since the inclined surface is perpendicular to the frontal plane, a frontal auxiliary is projected. Point A is located in the auxiliary view by projecting it perpendicularly to the plane of projection and setting off the depth from the top view, **Figure 12-6B**.

Locating a True Length Line in an Auxiliary View

The auxiliary view method is useful in determining the location and true length of a line that is inclined to the principal views in orthographic projection. Location and determination of the line's true length consists of locating its two endpoints in the auxiliary view and connecting these points to form the required line.

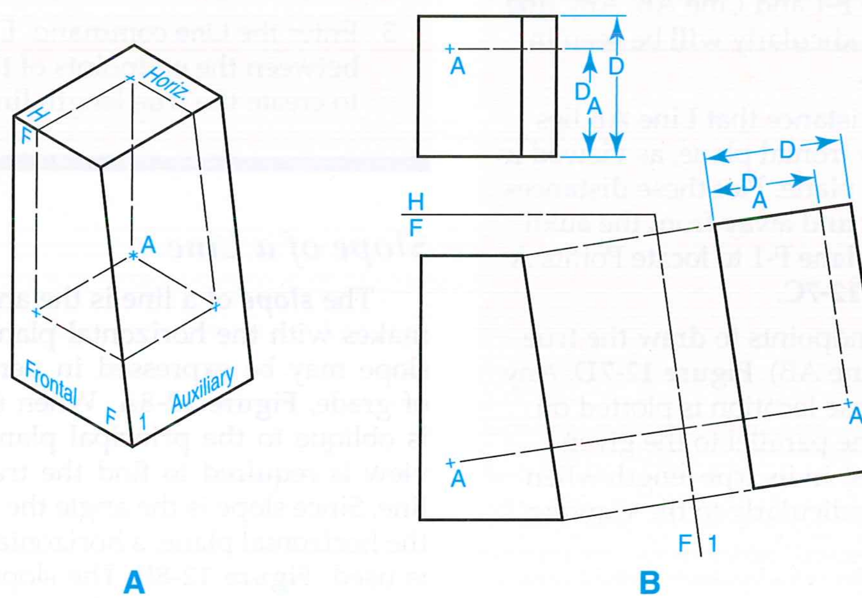

Figure 12-6. Locating a point in an auxiliary view. This is the first important step in understanding auxiliary projection.

Construct a True Length Line in an Auxiliary View

Using Instruments (Manual Procedure)

Given the top and front views, the procedure for locating a true length line in an auxiliary view is as follows. See **Figure 12-7**.

1. Draw the auxiliary viewing plane F-1 parallel to Line AB in the front view, **Figure 12-7B**. (The viewing plane can also be established for the top view.)
2. The line of sight is perpendicular to the viewing plane F-1 and Line AB. Any line viewed perpendicularly will be seen in its true length.
3. Measure the distance that Line AB lies away from the frontal plane, as viewed in the horizontal plane. Plot these distances perpendicular and away from the auxiliary viewing plane F-1 to locate Points A and B, **Figure 12-7C**.
4. Connect the endpoints to draw the true length line (Line AB), **Figure 12-7D**. Any given line whose location is plotted on a viewing plane parallel to the given line will appear in its true length when viewed perpendicularly to the viewing plane.

Using the Offset and Line Commands (CAD Procedure)

The top and front views are given. Refer to **Figure 12-7**.

1. To create the auxiliary viewing plane F-1, enter the **Offset** command. Enter a suitable offset distance and offset Line AB in the front view. This line is parallel to Line AB. Refer to **Figure 12-7B**.
2. To locate the endpoints of the true length line, enter the **Offset** command and offset the viewing plane line. To specify the first offset distance (Distance D_A), access the system calculator and use the **Distance Between Two Points** calculator function. Select Point A in the top view using the Endpoint object snap and then select the projection plane H-F using the Perpendicular object snap. Offset the line at the calculated distance. To specify the second offset distance (Distance D_B), use the **Distance Between Two Points** calculator function. Select Point B in the top view using the Endpoint object snap and then select the projection plane H-F using the Perpendicular object snap. Offset the line at the calculated distance.
3. Enter the **Line** command. Draw a line between the endpoints of the offset lines to create the true length line.

Slope of a Line

The ***slope*** of a line is the angle that the line makes with the horizontal plane. The extent of slope may be expressed in percent or degrees of grade, **Figure 12-8A**. When the line of slope is oblique to the principal planes, an auxiliary view is required to find the true length of the line. Since slope is the angle the line makes with the horizontal plane, a horizontal auxiliary view is used, **Figure 12-8B**. The slope line (Line AB) will appear true length. The angle it makes with the horizontal viewing plane is the required angle. The slope of a line may be designated as positive or negative. If positive, the slope is upward from the designated point. If negative, the slope is downward.

Slope has many applications in industry. Gravity-feed delivery systems require the slope of a line to be determined. Ramps designed for wheelchairs have very specific slope requirements, **Figure 12-9**. The roads that you drive on every day make use of slope as well.

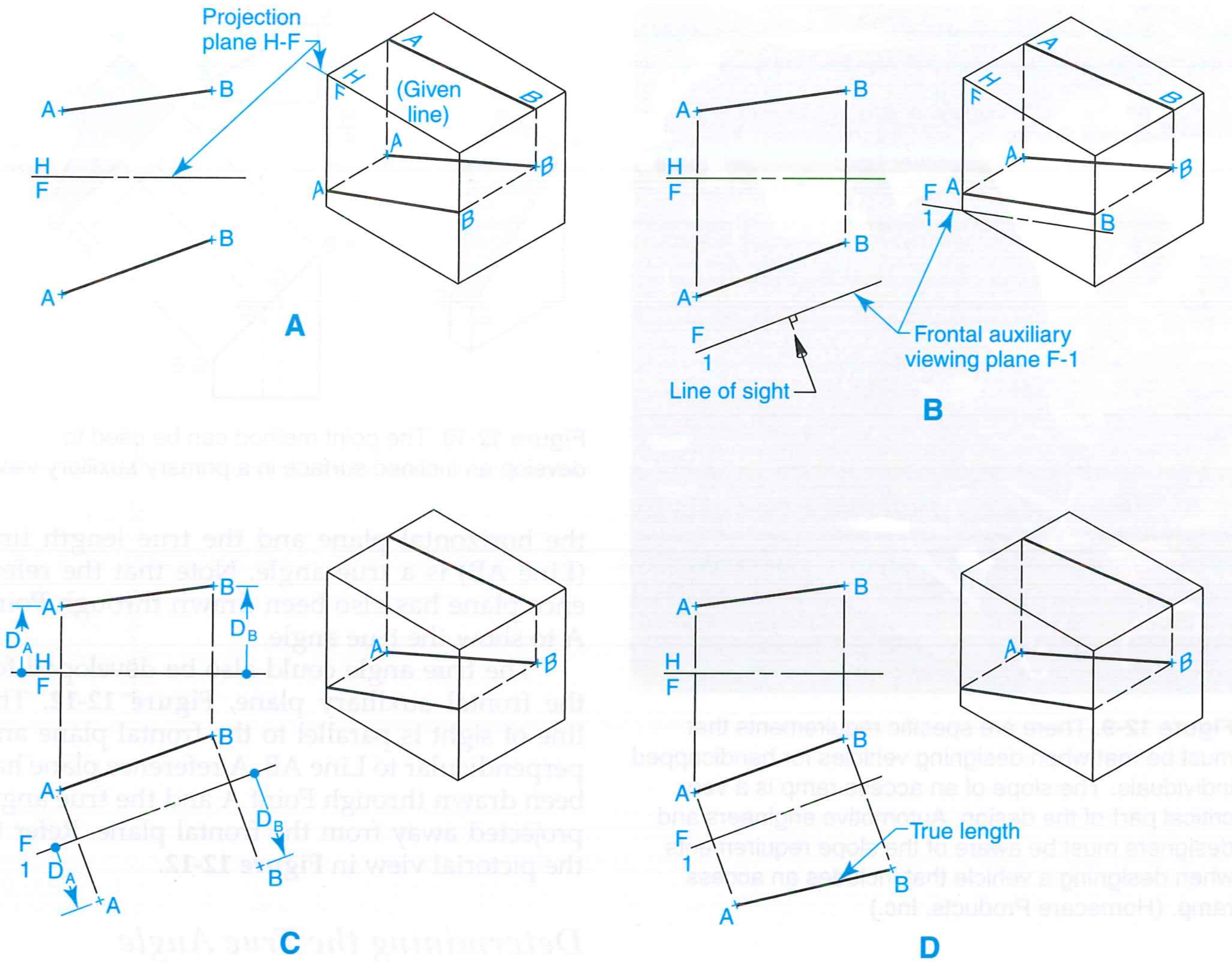

Figure 12-7. The auxiliary view projection method can be used to determine the true length of a line.

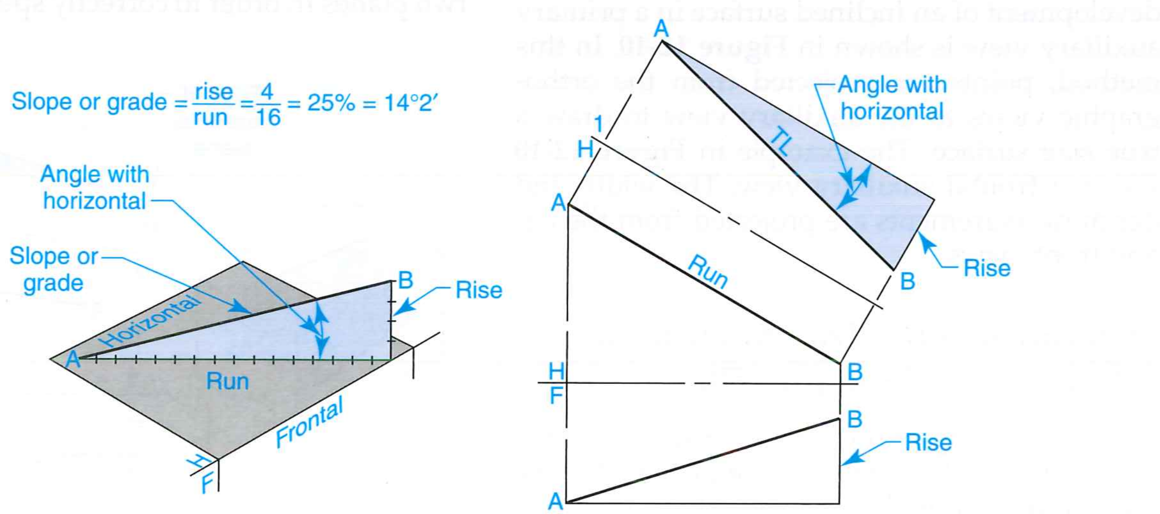

Figure 12-8. The slope of a line is the angle that the line makes with the horizontal plane. When a slope line is oblique to the principal planes, an auxiliary view is needed to find the true length.

Figure 12-9. There are specific requirements that must be met when designing vehicles for handicapped individuals. The slope of an access ramp is a very critical part of the design. Automotive engineers and designers must be aware of the slope requirements when designing a vehicle that includes an access ramp. (Homecare Products, Inc.)

Using the Point Method to Develop an Inclined Surface

The application of the point method to the development of an inclined surface in a primary auxiliary view is shown in **Figure 12-10**. In this method, points are projected from the orthographic views to the auxiliary view to draw a true size surface. The example in **Figure 12-10** shows a frontal auxiliary view. The width and depth measurements are projected from the top and front views.

Determining the True Angle between a Line and a Principal Plane

The true angle (θ) formed between a line in a primary auxiliary view and a principal plane may be determined in a view where the principal plane appears as an edge and the line is true length. In **Figure 12-11**, the angle between

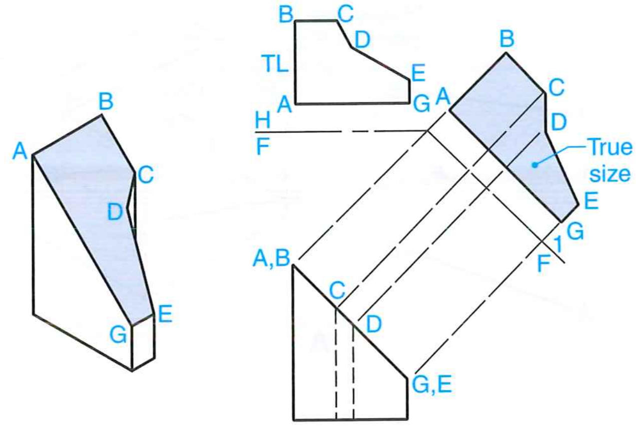

Figure 12-10. The point method can be used to develop an inclined surface in a primary auxiliary view.

the horizontal plane and the true length line (Line AB) is a true angle. Note that the reference plane has also been drawn through Point A to show the true angle.

The true angle could also be developed for the frontal auxiliary plane, **Figure 12-12**. The line of sight is parallel to the frontal plane and perpendicular to Line AB. A reference plane has been drawn through Point A and the true angle projected away from the frontal plane. Refer to the pictorial view in **Figure 12-12**.

Determining the True Angle between Two Planes

In the design and manufacture of parts, it is often necessary to determine the angle between two planes in order to correctly specify a design,

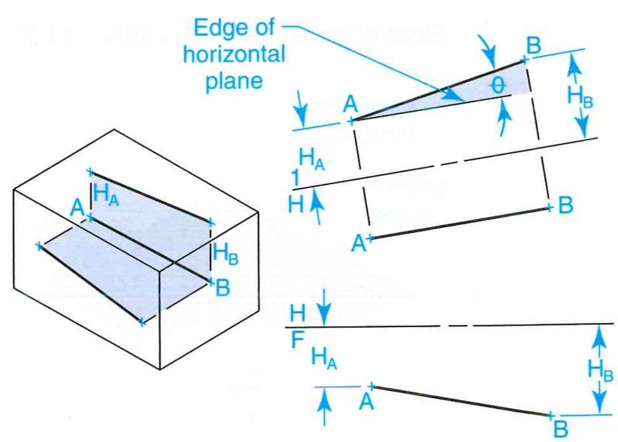

Figure 12-11. Determining the true angle between a line in a primary auxiliary view and a principal plane.

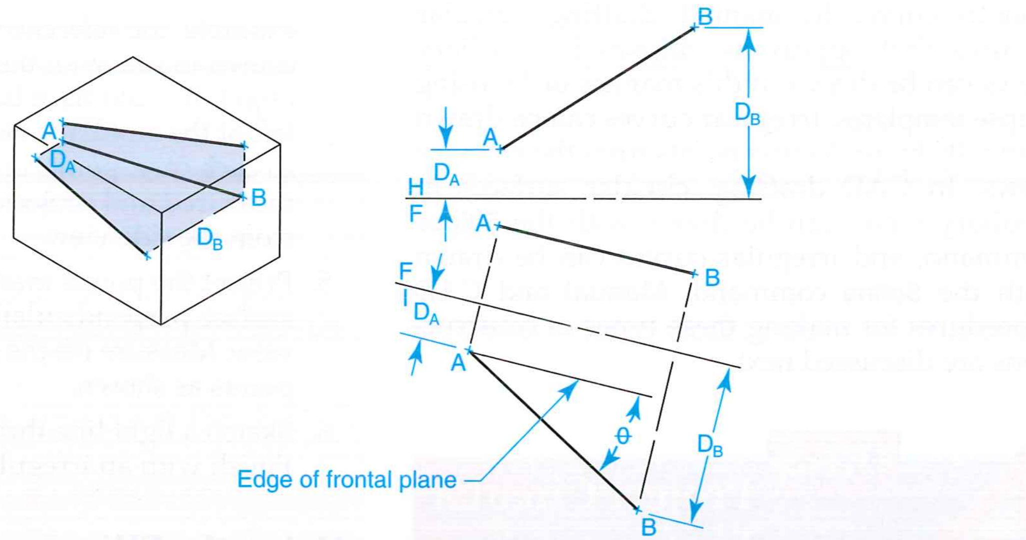

Figure 12-12. Determining the true angle between a line in a frontal auxiliary view and the frontal plane.

Figure 12-13. The true angle between two planes is called the ***dihedral angle***. A dihedral angle can be found in a primary auxiliary view. This occurs when the line of intersection is true length in one of the principal views and it appears as a point in the auxiliary view.

In **Figure 12-14**, the line of intersection (Line AB) is seen in its true length in the top view since it is parallel to the horizontal plane. A horizontal auxiliary is drawn perpendicular to Line AB, providing a point view of Line AB. The angle between the two planes in the auxiliary view is a true angle.

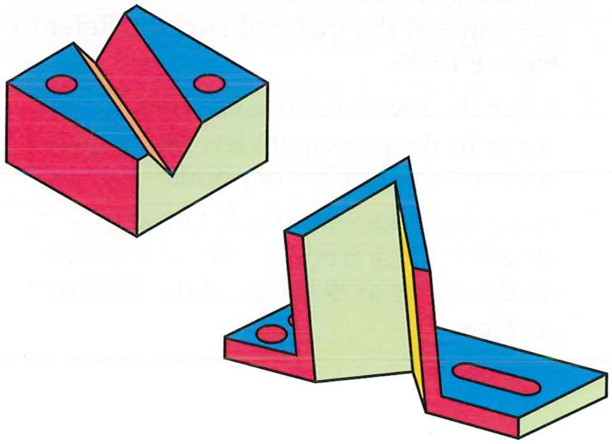

Figure 12-13. Some manufactured parts require that angles between different planes be defined before the parts can actually be manufactured. Auxiliary views are used to define these angles.

Drawing Circular Features and Irregular Curves in Auxiliary Views

Circular surfaces and irregularly curved lines may be projected in auxiliary views by identifying a sufficient number of points in the primary views. These points are then projected to the auxiliary view and plotted to provide a

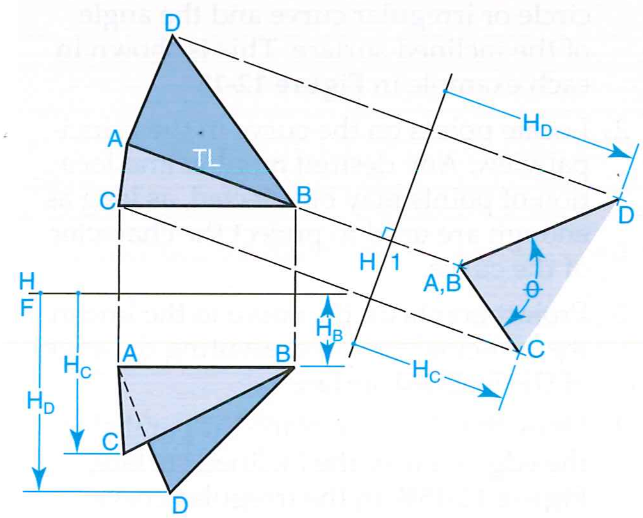

Figure 12-14. Determining the true angle between two planes. Line AB (the line of intersection) is parallel to the horizontal plane, and therefore seen as true length in the top view. A horizontal auxiliary drawn perpendicular to Line AB will provide a point view of Line AB. The angle formed between the two planes in the auxiliary view is a true angle.

smooth curve. In manual drafting, circular features that appear as ellipses in auxiliary views can be drawn in this manner or by using ellipse templates. Irregular curves can be drawn manually by projecting points from the primary views. In CAD drafting, circular surfaces in auxiliary views can be drawn with the **Ellipse** command, and irregular curves can be drawn with the **Spline** command. Manual and CAD procedures for making these types of constructions are discussed next.

Project Circular Features and Irregular Curves in Auxiliary Views

Using Instruments (Manual Procedure)

The steps involved in the projection of circles and irregularly curved lines in a primary auxiliary view are as follows. See **Figure 12-15**.

1. Draw two principal views showing the circle or irregular curve and the angle of the inclined surface. This is shown in each example in **Figure 12-15**.
2. Locate points on the curve in the principal view. Any desired number and location of points may be selected, as long as enough are used to project the character of the curve.
3. Project points on the curve to the line in the principal view representing the edge of the inclined surface.
4. Draw the reference plane F-1 parallel to the edge view of the inclined surface, **Figure 12-15B**. In the irregular curve example, the reference plane has been drawn in line with the far side of the object. It could have been drawn to the left of the auxiliary view, or in the center. In each case, points and distances are measured and projected accordingly from the side view.
5. Project the points marked on the inclined surface perpendicularly to the auxiliary view. Measure off the location of the points as shown.
6. Sketch a light line through these points. Finish with an irregular curve.

Using the Ellipse and Spline Commands (CAD Procedure)

The following procedure is used in two-dimensional (2D) drafting applications. For 3D applications, certain programs provide special commands for generating auxiliary views from solid models. This saves considerable drafting time. The procedure is similar to creating section views from solid models. When creating an auxiliary view from a 3D model, a line defining the inclined surface is selected and the view is generated automatically. The view is placed correctly in relation to the orthographic view and circular features are shown in the correct orientation.

1. Using the appropriate drawing commands, draw two principal views showing the circle or irregular curve and the angle of the inclined surface. Refer to **Figure 12-15**.
2. Enter the **Divide** command. Divide the curve in the principal view using an appropriate number of points.
3. Enter the **Xline** command. Draw construction lines from the division points on the curve to the edge of the inclined surface.

4. Enter the **Offset** command. Offset the inclined line to create the centerline in the auxiliary view (in **Figure 12-15A**) or the reference plane F-1 (in **Figure 12-15B**). For the example shown in **Figure 12-15A**, offset two more construction lines defining the minor axis of the ellipse using measurements from the top view. For the example shown in **Figure 12-15B**, offset the reference plane line to define the opposite edge of the auxiliary view. Use measurements from the side view.
5. Enter the **Xline** command. Draw construction lines from the line intersections on the inclined surface to the auxiliary view. For the elliptical surface example, draw construction lines from the top and bottom corners and the midpoint of the inclined surface. The intersections with the centerline in the auxiliary view will locate the major axis of the ellipse. For the irregular curve example, draw construction lines from each of the line intersections in the front view to establish point locations for the curve in the auxiliary view.
6. To complete the elliptical surface, enter the **Ellipse** command. Enter the **Center** option and pick the center point intersection in the auxiliary view. Then, select one endpoint of each ellipse axis. Use object snaps as needed. To complete the irregular curve, enter the **Spline** command. Draw a spline through the points of intersection in the auxiliary view. Use object snaps as needed.

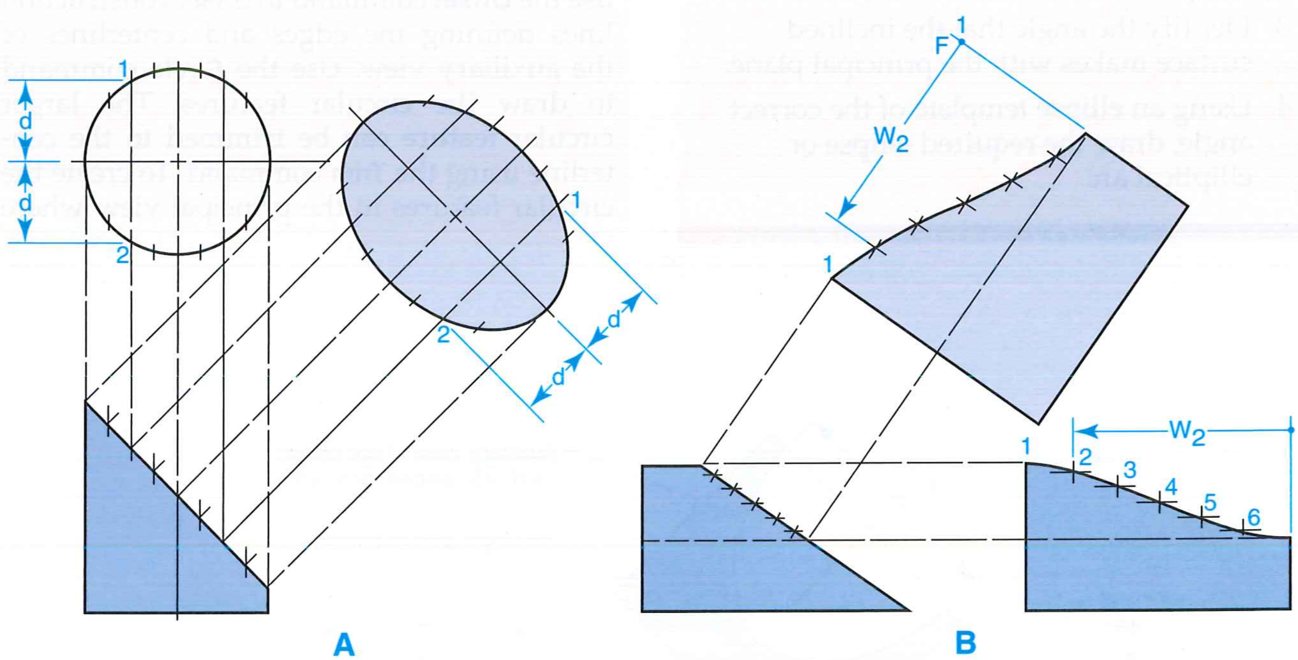

Figure 12-15. Circular features and irregular curves can be projected in auxiliary views by identifying points and projecting the points.

Draw Circles and Arcs in Auxiliary Views Using Ellipse Templates

Circular shapes may be drawn in auxiliary views by projection methods. However, in manual drafting, ellipse templates speed up the process and produce much better results. Use the following procedure to draw regular circular features appearing as ellipses in auxiliary views.

1. Locate the reference plane for the auxiliary view (in the center of the view), **Figure 12-16.**
2. Project to the auxiliary view points and lines that locate the centerline, the major axis, and the minor axis of the circular feature.
3. Identify the angle that the inclined surface makes with the principal plane.
4. Using an ellipse template of the correct angle, draw the required ellipse or elliptical arc.

Construct a Principal View with the Aid of an Auxiliary View

Sometimes, the true size and shape of a feature exists on an inclined surface of a part. For example, the part may include a true size circular curve or hole on an inclined surface. When this occurs, it is necessary to construct an auxiliary view, and then reverse the projection procedure by constructing the principal view where the feature is shown foreshortened, **Figure 12-17.**

The following procedure is used to construct a principal view from an auxiliary view. If you are drawing manually, plot points to project the circular features as discussed previously. If you are using a CAD system, use the **Offset** command to offset construction lines defining the edges and centerlines of the auxiliary view. Use the **Circle** command to draw the circular features. The larger circular feature can be trimmed to the centerline using the **Trim** command. To create the circular features in the principal view where

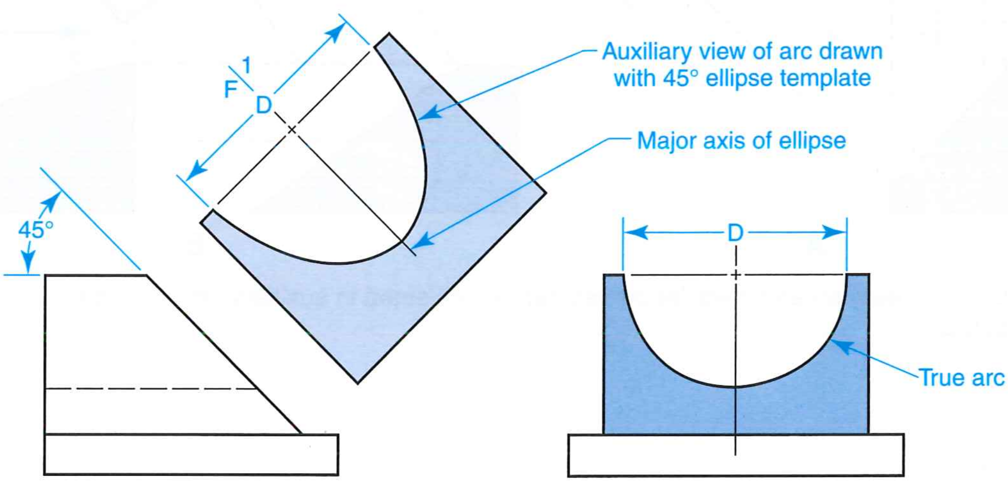

Figure 12-16. Ellipse templates speed the drawing process in manual drafting. In order to use an ellipse template, the major and minor axes must first be located.

they appear foreshortened, draw construction lines using the **Xline** command to locate the axis endpoints of the elliptical features. Then, draw the ellipses using the **Ellipse** command.

1. Construct the view where the inclined surface appears as an edge. This is the profile view in **Figure 12-17**. It may be helpful to partially complete the view until the features involved have been drawn in the auxiliary view.
2. Construct the auxiliary view perpendicular to a reference plane that is parallel to the inclined surface. This is Line P-1 in **Figure 12-17**. This line is located in the center of the feature.
3. Locate a sufficient number of points on the outline of the feature to assure an accurate representation.
4. Project the points from the auxiliary view to its principal view. Then project these points to the other principal view where the feature appears in a foreshortened plane. Measurements are taken from the reference plane in the auxiliary view (Line P-1) and transferred to the principal view.
5. Complete the view by joining the points.

Note

The auxiliary view in **Figure 12-17** is a complete auxiliary view, rather than a partial auxiliary view, since the entire part is shown, not just the inclined surface. Also, as shown in this example, hidden lines are normally omitted in auxiliary views unless required for clarity.

Secondary Auxiliary Views

Oblique surfaces are not parallel or perpendicular to any of the principal planes of projection. Therefore, a secondary auxiliary view is required to describe their true size and shape.

In structures having many oblique surfaces, a number of auxiliary views are required. All auxiliary views beyond the secondary auxiliary view are called successive auxiliary views. Successive auxiliary views are projected from secondary or prior successive auxiliary views.

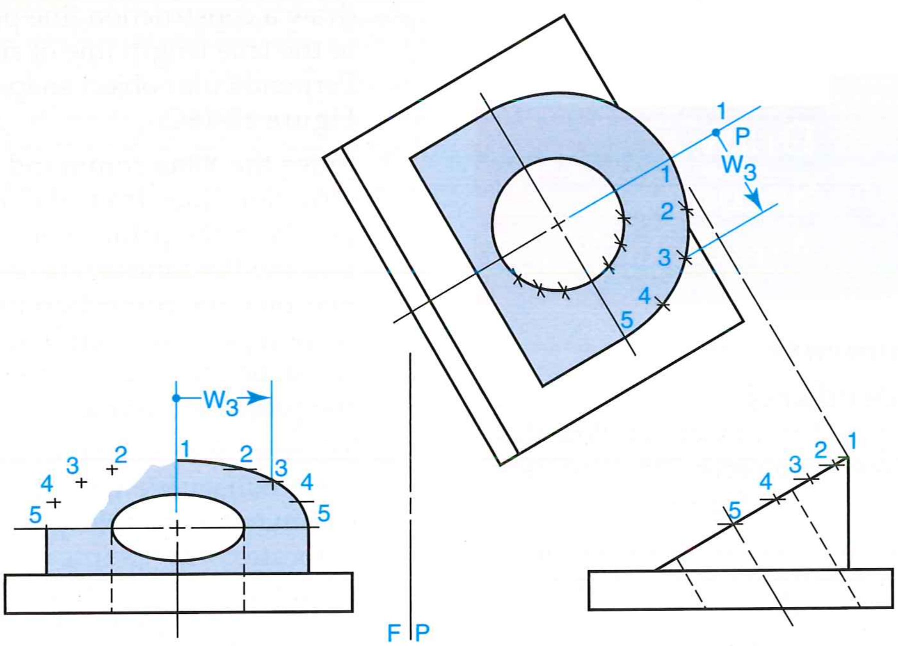

Figure 12-17. Using an auxiliary view to construct a principal view.

Constructing Secondary Auxiliary Views

Primary auxiliary views require two principal views for their projection. Secondary auxiliary views are projected from a primary auxiliary view and one of the principal views, **Figure 12-18.**

The line of sight that the object is viewed from is indicated in the top and front views, **Figure 12-18A**. The line of sight is shown in its true length in the primary auxiliary view, **Figure 12-18B.**

An auxiliary must be oriented so that it is viewed in the direction of its line of sight. To do this, the secondary auxiliary viewing plane 1-2 is constructed at right angles to the true length line of sight. This gives a point view of the line of sight, **Figure 12-18C**.

Two plane surfaces are projected to the secondary auxiliary and given letters to aid in identifying the formation of the object. In the secondary view, the object is completed, showing visible surfaces and lines, plus edges that are hidden from view, **Figure 12-18D.**

The steps in the construction of a secondary auxiliary view are shown in **Figure 12-18**. No oblique surfaces were involved in the projection of this object. Projecting point views of lines, true sizes, and true shapes of oblique surfaces will be covered later in this chapter.

Draw a Secondary Auxiliary View

Using Instruments (Manual Procedure)

Given the top and front views, follow this procedure for drawing a secondary auxiliary view of an object. Refer to **Figure 12-18.**

1. Project a primary auxiliary view of the object from a principal view so that it is perpendicular to the chosen line of sight. Refer to **Figure 12-18B.**
2. Construct the true length line of sight.
3. Draw the secondary auxiliary projection plane 1-2 perpendicular to the true length line of sight in the primary auxiliary. Refer to **Figure 12-18C**. Projection of this line will give a point view in the secondary auxiliary.
4. Project two planes by locating their points of intersections and dimensions from Plane H-1.
5. Locate the remaining points and draw connecting lines to complete the object. Refer to **Figure 12-18D**. The line of sight will indicate the surfaces and edges that are visible and the ones that are hidden.

Using the Xline and Offset Commands (CAD Procedure)

The top and front views are given. Refer to **Figure 12-18A.**

1. Draw a primary auxiliary view using the **Copy** or **Offset** command as discussed earlier in this chapter. Create a true length line for the line of sight using the **Offset** command as discussed earlier in this chapter. Refer to **Figure 12-18B.**
2. To create the secondary auxiliary projection plane, enter the **Xline** command and draw a construction line perpendicular to the true length line of sight. Use the Perpendicular object snap. Refer to **Figure 12-18C.**
3. Enter the **Xline** command. Draw construction lines from the intersection points in the primary auxiliary view. Use the Perpendicular object snap and pick the projection plane as the second point of each line. The resulting construction lines are perpendicular to the projection plane.
4. To create the two planes in the secondary auxiliary view, enter the **Offset** command. Offset the projection plane to locate corner points using offset distances taken from the top view. Use the **Distance Between Two Points**

calculator function to calculate the offset distances. For example, to locate Point F in the secondary auxiliary, specify the offset distance by selecting Point F in the top view (using the Endpoint object snap) and then Plane H-1 (using the Perpendicular object snap). Offset the projection plane at the calculated distance. The intersection of the offset line and the corresponding construction line extending from the primary auxiliary locates Point F. Locate the other corner points in the secondary auxiliary in a similar fashion.

5. Enter the **Line** command and draw connecting lines to complete the secondary auxiliary. Refer to **Figure 12-18D**.

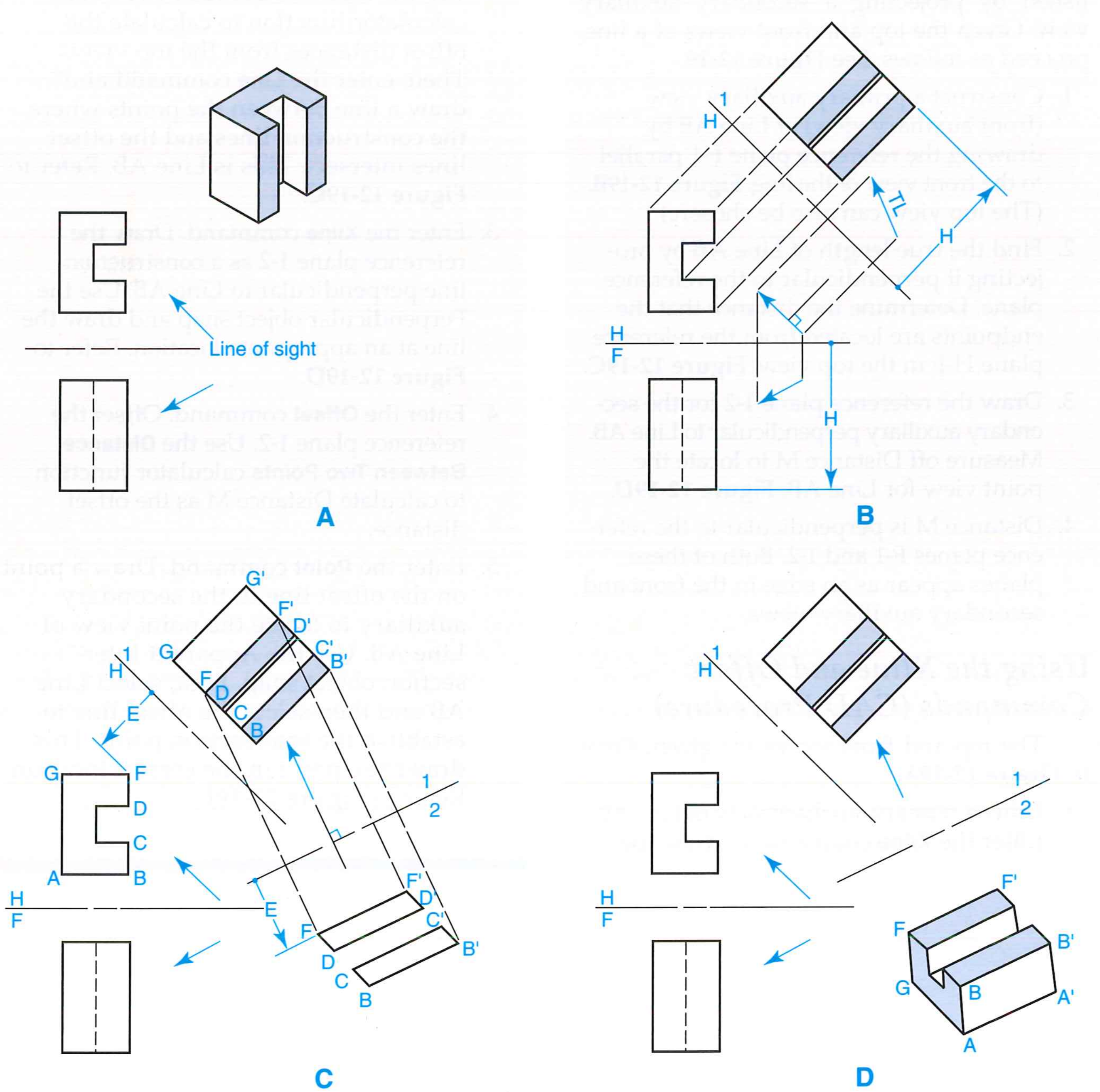

Figure 12-18. Projecting a secondary auxiliary view of an object.

Draw a Point View of a Line in a Secondary Auxiliary View

Using Instruments (Manual Procedure)

The point view of a line can be established by projecting a secondary auxiliary view. Given the top and front views of a line, proceed as follows. See **Figure 12-19**.

1. Construct a primary auxiliary view (front auxiliary view) of Line AB by drawing the reference plane F-1 parallel to the front view of the line, **Figure 12-19B**. (The top view can also be chosen.)
2. Find the true length of Line AB by projecting it perpendicular to the reference plane. Determine the distance that the endpoints are located from the reference plane H-F in the top view, **Figure 12-19C**.
3. Draw the reference plane 1-2 for the secondary auxiliary perpendicular to Line AB. Measure off Distance M to locate the point view for Line AB, **Figure 12-19D**.
4. Distance M is perpendicular to the reference planes F-1 and 1-2. Both of these planes appear as an edge in the front and secondary auxiliary views.

Using the Xline and Offset Commands (CAD Procedure)

The top and front views are given. Refer to **Figure 12-19A**.

1. Draw a primary auxiliary view of Line AB. Enter the **Xline** command to draw the reference plane F-1 parallel to the front view of the line. Use the Parallel object snap. Refer to **Figure 12-19B**.
2. To draw the true length line (Line AB), enter the **Xline** command. Draw construction lines from Points A and B in the front view perpendicular to the reference plane. Use the Perpendicular object snap. Enter the **Offset** command and offset the reference plane twice. Use the **Distance Between Two Points** calculator function to calculate the offset distances from the top view. Then, enter the **Line** command and draw a line between the points where the construction lines and the offset lines intersect. This is Line AB. Refer to **Figure 12-19C**.
3. Enter the **Xline** command. Draw the reference plane 1-2 as a construction line perpendicular to Line AB. Use the Perpendicular object snap and draw the line at an appropriate location. Refer to **Figure 12-19D**.
4. Enter the **Offset** command. Offset the reference plane 1-2. Use the **Distance Between Two Points** calculator function to calculate Distance M as the offset distance.
5. Enter the **Point** command. Draw a point on the offset line in the secondary auxiliary to locate the point view of Line AB. Use the Apparent Intersection object snap. First, select Line AB and then select the offset line to establish the intersection point. This draws the point in the correct location. Refer to **Figure 12-19D**.

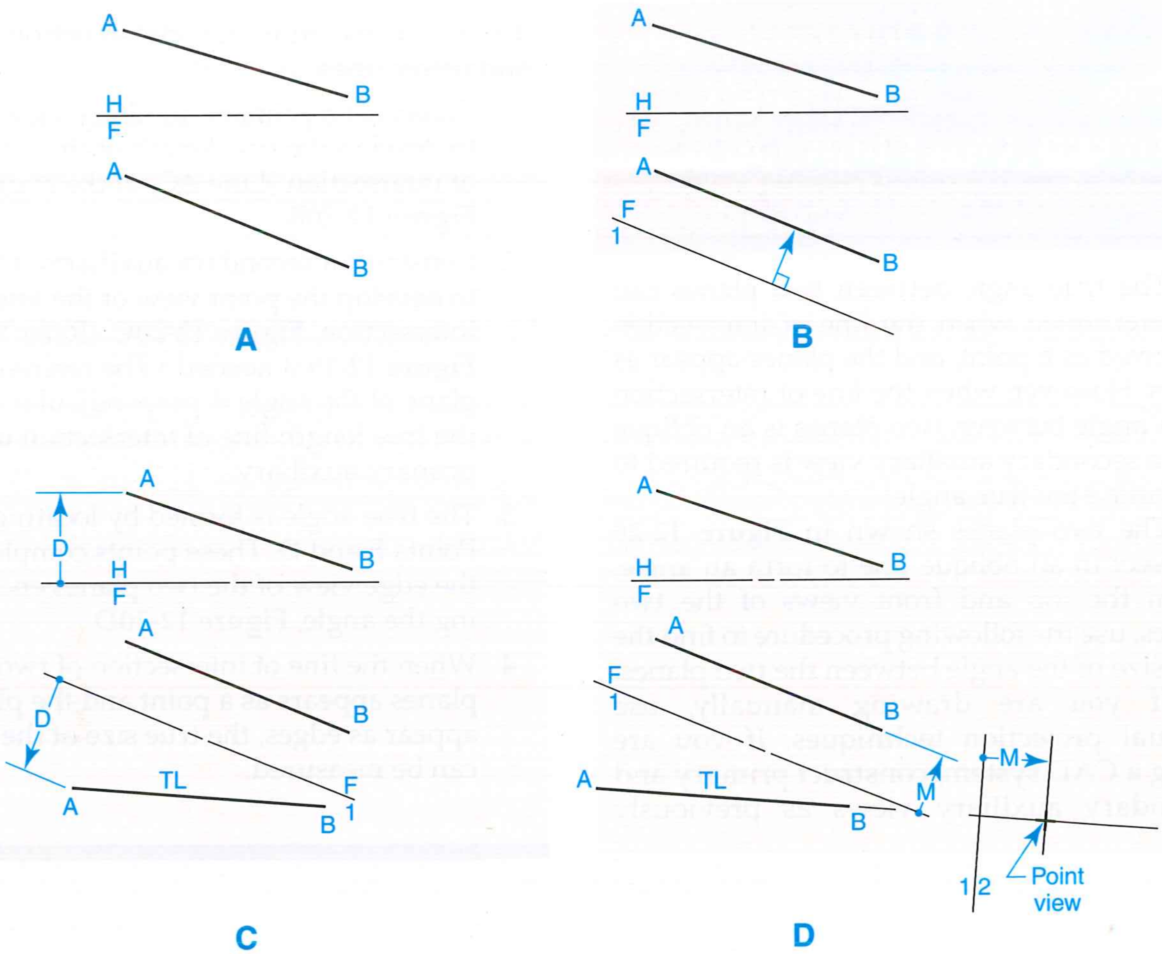

Figure 12-19. Drawing a point view of a line in a secondary auxiliary view.

Determine the True Angle between Two Planes in a Secondary Auxiliary View

The true angle between two planes can be determined when the line of intersection is viewed as a point, and the planes appear as edges. However, when the line of intersection of an angle between two planes is an oblique line, a secondary auxiliary view is required to determine the true angle.

The two planes shown in **Figure 12-20** intersect in an oblique line to form an angle. Given the top and front views of the two planes, use the following procedure to find the true size of the angle between the two planes.

If you are drawing manually, use manual projection techniques. If you are using a CAD system, construct primary and secondary auxiliary views as previously discussed by drawing construction lines and offset lines.

1. Construct a primary auxiliary view to develop the true length of the line of intersection (Line AC) of the angle, **Figure 12-20B**.
2. Construct a secondary auxiliary view to develop the point view of the line of intersection, **Figure 12-20C**. (Refer to **Figure 12-19** if needed.) The reference plane of the angle is perpendicular to the true length line of intersection in the primary auxiliary.
3. The true angle is formed by locating Points B and D. These points complete the edge view of the two planes enclosing the angle, **Figure 12-20D**.
4. When the line of intersection of two planes appears as a point and the planes appear as edges, the true size of the angle can be measured.

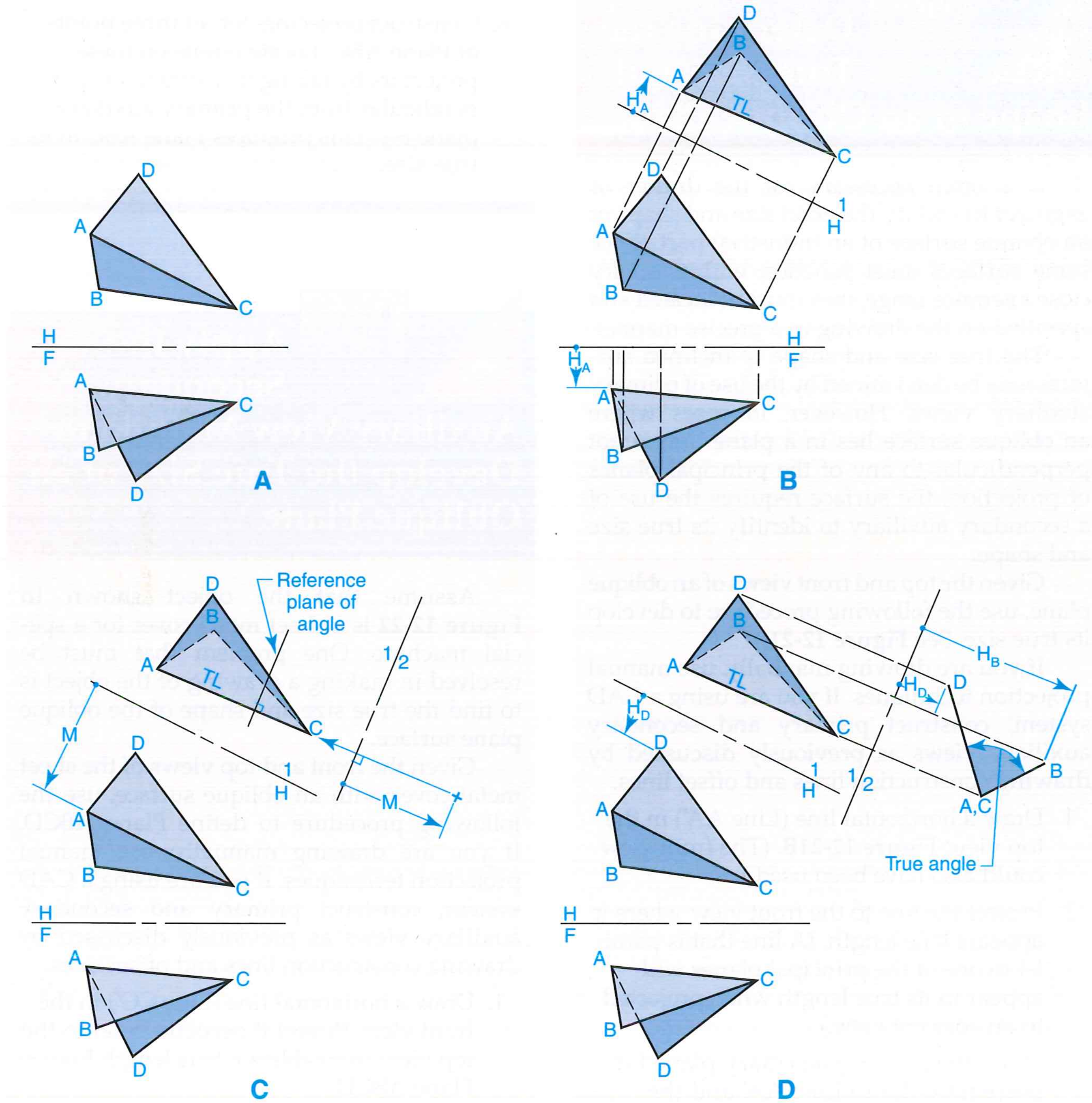

Figure 12-20. When the line of intersection of an angle between two planes is an oblique line, a second auxiliary is required to find the true angle between the planes.

Determine the True Size and Shape of an Oblique Plane

It is often necessary for the drafter or engineer to specify the exact size and shape of an oblique surface of an industrial part. Since some surfaces must function within a very close tolerance range, they must be located and specified on the drawing in a precise manner.

The true size and shape of inclined surfaces may be determined by the use of primary auxiliary views. However, in cases where an oblique surface lies in a plane that is not perpendicular to any of the principal planes of projection, the surface requires the use of a secondary auxiliary to identify its true size and shape.

Given the top and front views of an oblique plane, use the following procedure to develop its true size. See **Figure 12-21**.

If you are drawing manually, use manual projection techniques. If you are using a CAD system, construct primary and secondary auxiliary views as previously discussed by drawing construction lines and offset lines.

1. Draw a horizontal line (Line AA′) in the top view, **Figure 12-21B**. (The front view could also have been used.)
2. Project the line to the front view where it appears true length. (A line that is parallel to one of the principal planes will appear in its true length when projected to an adjacent view.)
3. Draw the primary auxiliary plane F-1 perpendicular to Line AA′ and the line of sight. Project a point view of Line AA′ in the primary auxiliary view, **Figure 12-21C**.
4. Project Points B and C to this view where the plane will appear as an edge.
5. Draw the secondary auxiliary plane 1-2 parallel to the edge view of Plane ABC, **Figure 12-21D**.
6. Construct projectors for all three points of Plane ABC. Locate points on these projectors by taking measurements perpendicular from the primary auxiliary plane F-1. This produces Plane ABC in its true size.

Apply the Secondary Auxiliary View Method to Develop the True Size of an Oblique Plane

Assume that the object shown in **Figure 12-22** is a sheet metal cover for a special machine. One problem that must be resolved in making a drawing of the object is to find the true size and shape of the oblique plane surface.

Given the front and top views of the sheet metal cover with an oblique surface, use the following procedure to define Plane ABCD. If you are drawing manually, use manual projection techniques. If you are using a CAD system, construct primary and secondary auxiliary views as previously discussed by drawing construction lines and offset lines.

1. Draw a horizontal line (Line CC′) in the front view. Project it perpendicular to the top view to establish a true length line on Plane ABCD.
2. Draw the reference plane H-1 perpendicular to the line of sight. This will produce a point view of Line CC′ in the primary auxiliary view.
3. Project Points A, B, and D and measure their location from the reference plane H-F in the front view to form an edge view of Plane ABCD.

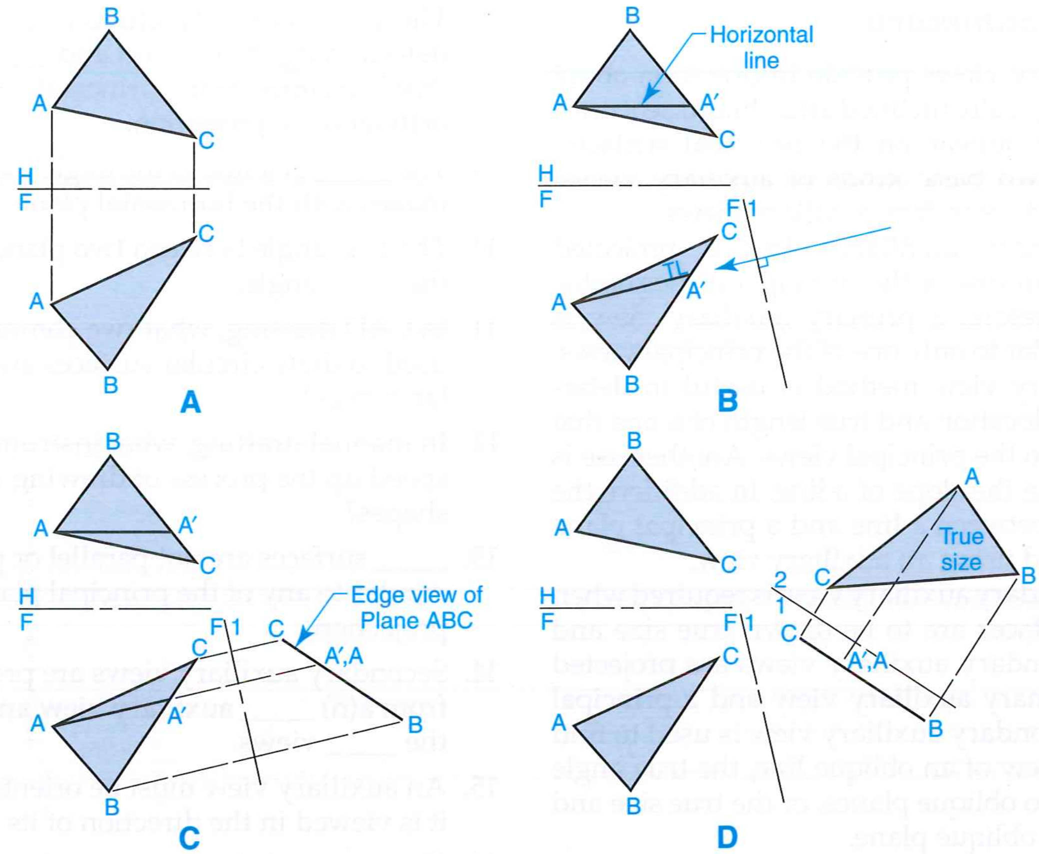

Figure 12-21. A secondary auxiliary view is used to find the true size and shape of an oblique plane.

4. Draw the reference plane 1-2 perpendicular to the line of sight for the edge view of Plane ABCD.
5. Project Points A, B, C, and D and measure their location from the reference plane H-1 in the top view.
6. Connect the points to complete Plane ABCD in its true size.

Note

The secondary auxiliary view shown in **Figure 12-22** is a partial auxiliary view. It only shows the oblique surface. The remainder of the object can be projected, but it is not needed in this view and would be out of true size and shape.

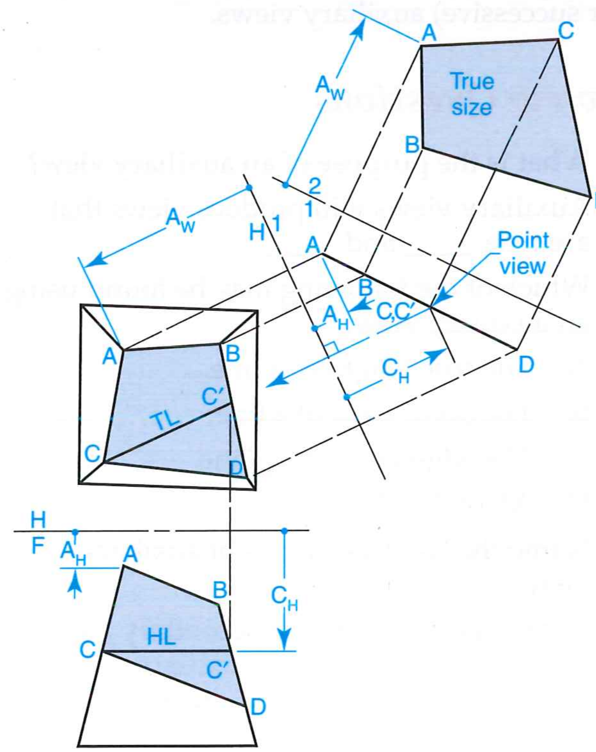

Figure 12-22. Using the secondary auxiliary view method to develop the true size and shape of an oblique plane.

Chapter Summary

Auxiliary views provide information about features (typically inclined and oblique features) that do not appear on the principal surfaces. There are two basic kinds of auxiliary views: primary and secondary auxiliary views.

A primary auxiliary view is projected directly from one of the principal orthographic views. Therefore, a primary auxiliary view is perpendicular to only one of the principal views. The auxiliary view method is useful in determining the location and true length of a line that is inclined to the principal views. Another use is to determine the slope of a line. In addition, the true angle between a line and a principal plane can be found using an auxiliary view.

A secondary auxiliary view is required when oblique surfaces are to be drawn true size and shape. Secondary auxiliary views are projected from a primary auxiliary view and a principal view. A secondary auxiliary view is used to find the point view of an oblique line, the true angle between two oblique planes, or the true size and shape of an oblique plane.

Successive auxiliary views are also used in drafting. They are projected from secondary (or later successive) auxiliary views.

Review Questions

1. What is the purpose of an auxiliary view?
2. Auxiliary views will produce views that are true _____ and _____.
3. Which of the following may be found using an auxiliary view?
   A. The true length of a line.
   B. The point view of a line.
   C. The edge view of a plane.
   D. All of the above.
4. Name the two basic types of auxiliary views.
5. A view projected after a secondary auxiliary is known as a _____ auxiliary view.
6. What is a *primary auxiliary view*?
7. The primary auxiliary view is useful in determining the true size and shape of a surface that is _____.
8. The auxiliary view method is useful in determining the location and _____ of a line that is inclined to the principal views in orthographic projection.
9. The _____ of a line is the angle that the line makes with the horizontal plane.
10. The true angle between two planes is called the _____ angle.
11. In CAD drafting, what two commands are used to draw circular surfaces and irregular curves?
12. In manual drafting, what instruments speed up the process of drawing circular shapes?
13. _____ surfaces are not parallel or perpendicular to any of the principal planes of projection.
14. Secondary auxiliary views are projected from a(n) _____ auxiliary view and one of the _____ views.
15. An auxiliary view must be oriented so that it is viewed in the direction of its _____.
16. The true angle between two planes can be determined when the line of intersection is viewed as a _____, and the planes appear as _____.
17. When the line of intersection of an angle between two planes is a(n) _____ line, a secondary auxiliary view is required to determine the true angle.

Problems and Activities

Multiview problems are given in the following sections to provide you with experience in auxiliary projection techniques. 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. The problems are shown on 1/4″ graph paper to help you locate the objects. Develop auxiliary views 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.