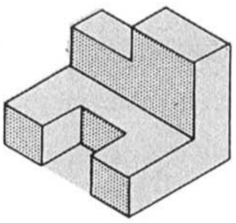
CHAPTER 3 Theory of Shape Description



UNIT 3-1 Theory of Shape Description

Chapter 2 illustrated many simple parts that required only one view to completely describe them. However, in industry, the majority of parts that have to be drawn are more complicated than the ones previously described. More than one view of the object is required to show all the construction features.

Pictorial (three-dimensional) drawings of objects are sometimes used, but the majority of drawings used in mechanical drafting for completely describing an object are multiview drawings as shown in Fig. 3-1-1.

Pictorial projections, such as axonometric, oblique, and perspective projection, are useful for illustrative purposes and are frequently employed in installation and maintenance drawings and design sketches.

As a result of new drawing techniques and equipment, pictorial drawings are becoming a popular form of communication, especially with people not trained to read engineering drawings. Practically all drawings of do-it-yourself projects for the general public or of assembly-line instructions for nontechnical personnel are done in pictorial form.

SHAPE DESCRIPTION BY VIEWS

When looking at objects, we normally see them as three-dimensional, having *width*, *depth*, and *height*, or *length*, *width*, and *height*. The choice of terms used depends on the shape and proportions of the object.

Spherical shapes, such as a basketball, are described as having a certain *diameter* (one term).

Cylindrical shapes, such as a baseball bat, have *diameter* and *length*. However, a hockey puck would have *diameter* and *thickness* (two terms).

Objects which are not spherical or cylindrical require three terms to describe their overall shape. The terms used for a car would probably be length, width, and height; for a filing cabinet, width, height, and depth; for a sheet of drawing paper, length, width, and thickness. These terms are used interchangeably according to the *proportions* of the object being described, and the *position* it is in when being viewed. For example, a telephone pole lying on the ground would be described as having diameter and length, but when placed in a vertical position, its dimensions would be diameter and height.

In general, distances from left to right are referred to as width or length, distances from front to back as depth or width, and vertical distances (except when very small in proportion to the others) as height. On drawings, the multidimensional shape is represented by a view or views on the flat surface of the drawing paper.

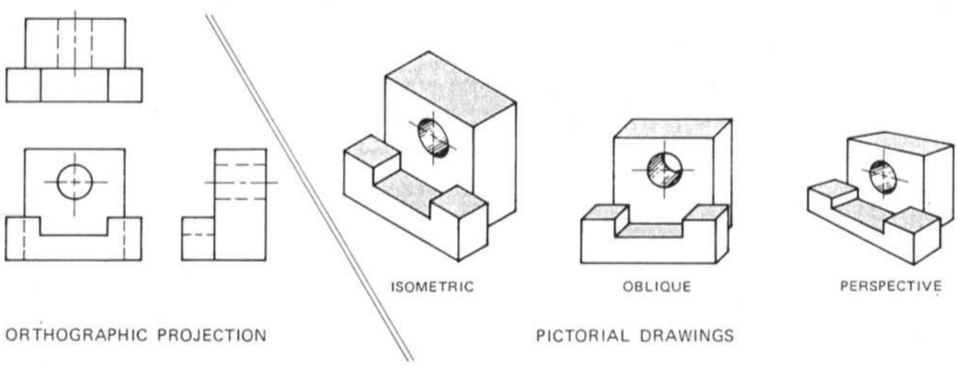


Fig. 3-1-1 Types of projection used in drafting.

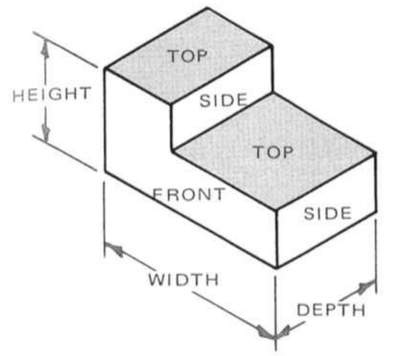
PICTORIAL VIEWS

Pictorial drawings represent the shape with just one view, and are frequently used for illustrative purposes, for installation and maintenance drawings, and do-it-yourself projects for the general public. However, the majority of parts manufactured in industry are too complicated in shape and detail to be described successfully by a pictorial view.

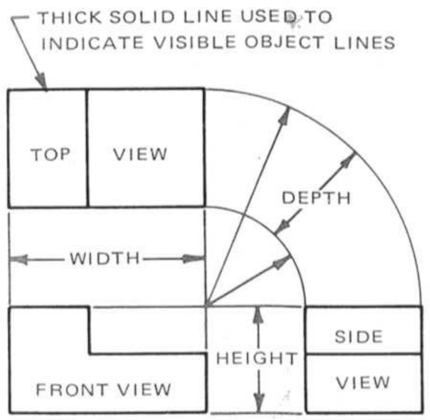
ORTHOGRAPHIC PROJECTION

The drafter must represent the part which appears as three-dimensional (width, height, depth) to the eye on the flat plane of the drawing paper. Different views of the object—front, side, and top views—are systematically arranged on the drawing paper to convey the necessary information to the reader (Fig. 3-1-2B and 3-1-3). Features are projected from one view to another. This type of drawing is called an *orthographic projection*. The word *orthographic* is derived from two Greek words: *orthos*, meaning straight, correct, at right angles to; and *graphikos*, meaning to write or describe by drawing lines.

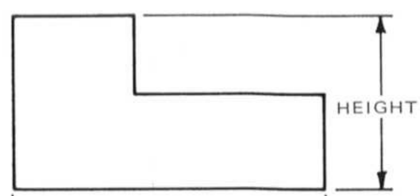
An orthographic view is what you would see looking directly at one side or "face" of the object. When looking directly at the front face, you would see width and height (two dimensions) but not the third dimension, depth. Each orthographic view gives two of the three major dimensions.



(A) PICTORIAL DRAWING (ISOMETRIC)



(B) ORTHOGRAPHIC PROJECTION DRAWING (THIRD ANGLE)



(C) ORTHOGRAPHIC VIEW

Fig. 3-1-2 A simple object shown in pictorial and orthographic projection.

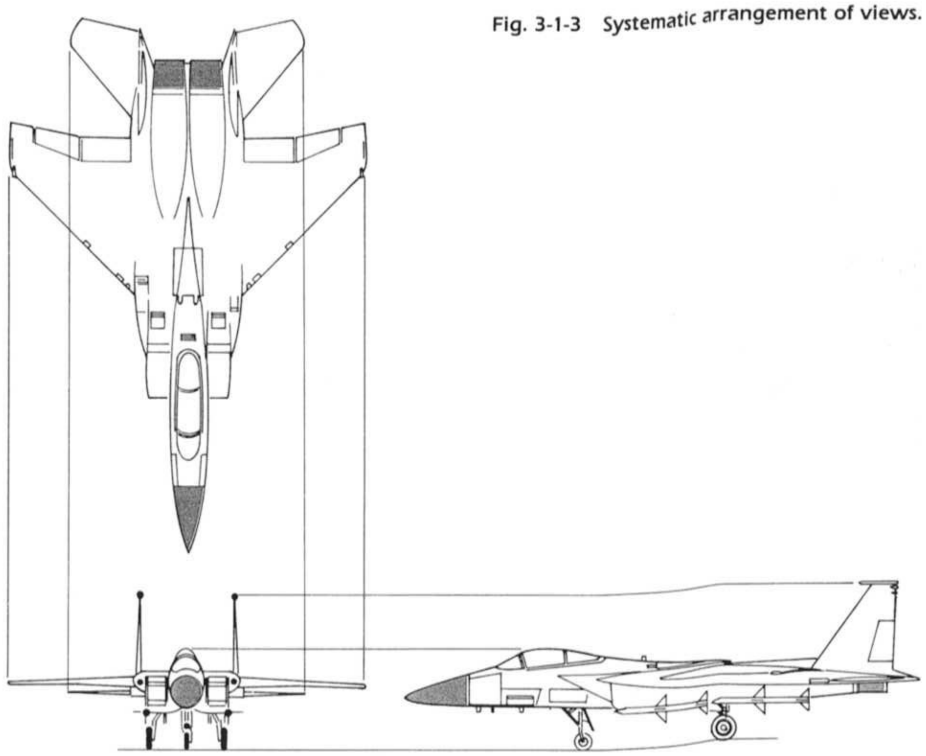


Fig. 3-1-3 Systematic arrangement of views.

Orthographic Systems

The principles of orthographic projection can be applied in four different "angles" or systems: first-, second-, third-, and fourth-angle projection (Fig. 3-1-4).

However, only two systems—first- and third-angle projection—are used. Third-angle projection is used in the United States, Canada, and many other countries throughout the world. First-angle projection, which will be described in detail in Unit 3-7, is used mainly in many European and Asiatic countries. As world trade has brought about the exchange of engineering drawings as well as the end products, drafters are now called upon to communicate in, as well as understand, both types of orthographic projection.

ISO Projection Symbol

With two types of projection being used on engineering drawings, a method of identifying the type of projection is necessary. The International

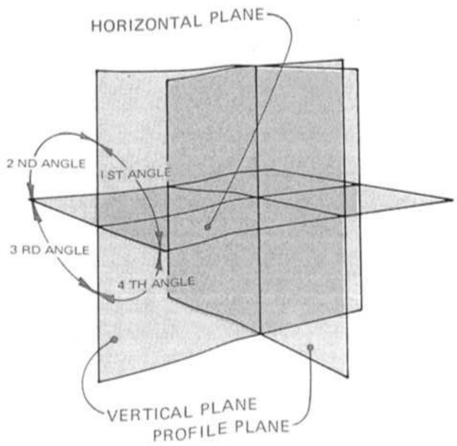


Fig. 3-1-4 The three planes used in orthographic projection.

Standards Organization, known as ISO, has recommended that the symbol shown in Fig. 3-1-5 be shown on all drawings and located preferably in the lower right-hand corner of the drawing, adjacent to the title block (Fig. 3-1-6). To aid the reader in learning the language of industry, many objects throughout this text have been drawn in first- as well as third-angle projection. The ISO symbol will indicate the type of projection used.

Third-Angle Projection

In third-angle projection, the object is positioned in the third-angle quadrant, as shown in Fig. 3-1-7. The person viewing the object does so from six different positions, namely, from the

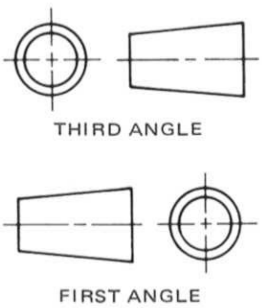


Fig. 3-1-5 ISO projection symbol.

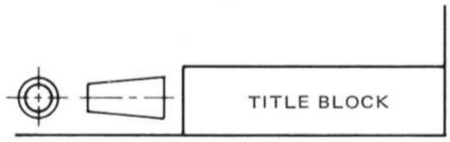


Fig. 3-1-6 Locating ISO symbol on drawing paper.

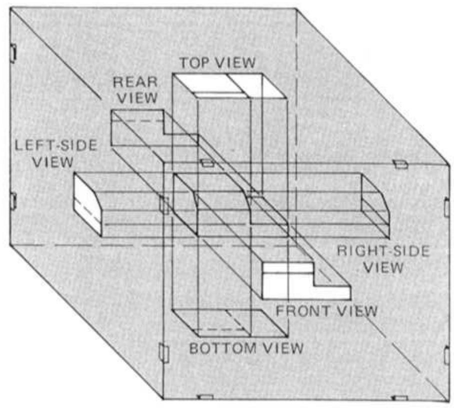


Fig. 3-1-7 Relationship of object with viewing planes in third-angle projection.

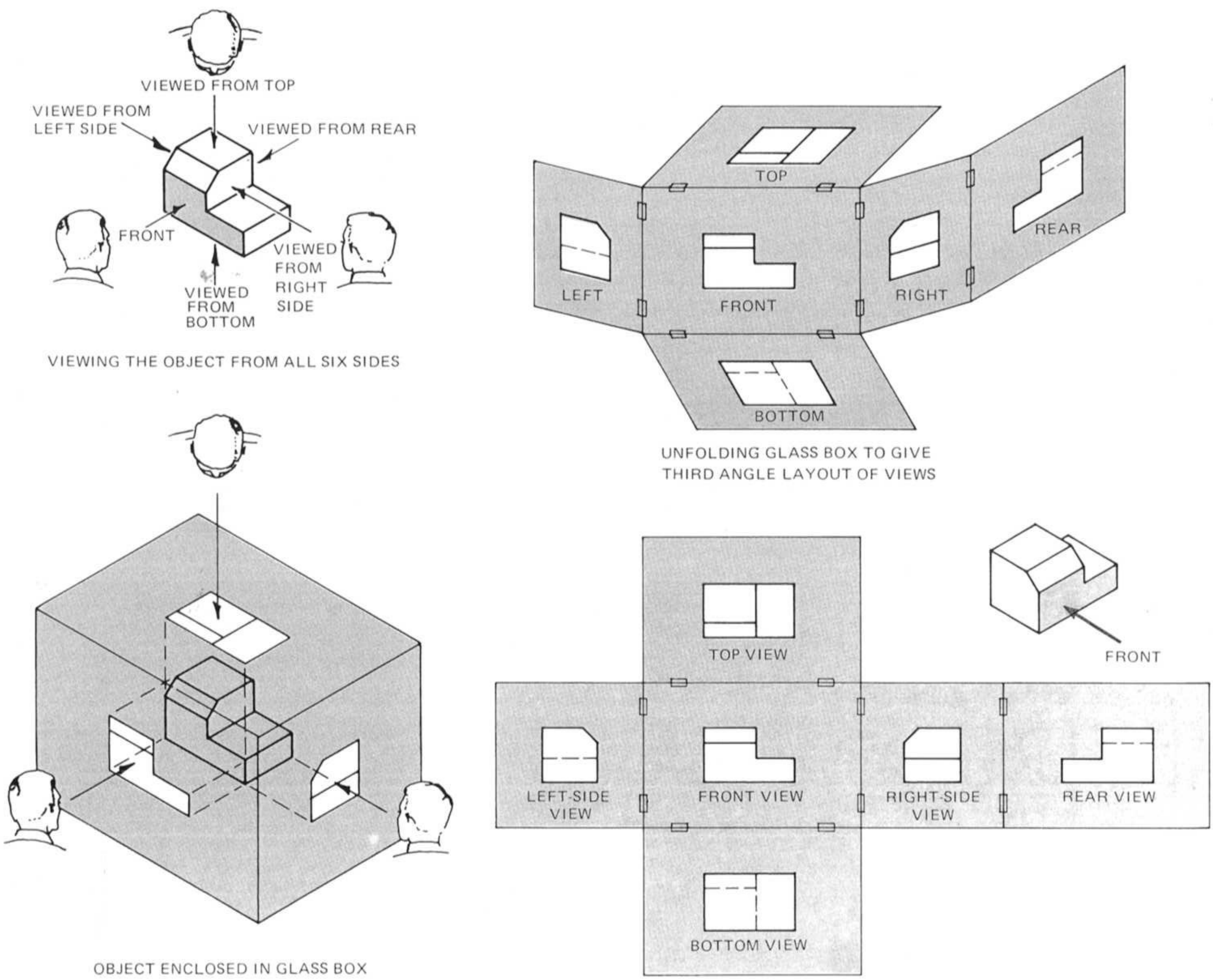


Fig. 3-1-8 Systematic arrangement of views.

top, front, right side, left side, rear, and bottom. The views or pictures seen from these positions are then recorded or drawn on the plane located between the viewer and the object. These six viewing planes are then rotated or positioned so that they lie in a single plane, as shown in Fig. 3-1-8. Rarely are all six views used. Only the views which are necessary to fully describe the object are drawn. Simple objects, such as a gasket, can be described sufficiently by one view alone. However, in mechanical drafting two- or three-view drawings of objects are more common, the rear, bottom, and one of the two side views being rarely used. Figure 3-1-9 shows simple objects drawn in orthographic and pictorial form.

To fully appreciate the shape and detail of views drawn in third-angle orthographic projection, the units for this chapter have been designed according to the types of surfaces generally found on objects. These surfaces can be divided into flat surfaces parallel to the viewing planes with and without hidden features; flat surfaces which appear inclined in one plane and parallel to the other two principal reference planes (called *inclined* surfaces); flat surfaces which are inclined in all three reference planes (called *oblique* surfaces); and surfaces which have diameters or radii. These drawings are so designed that only the top, front, and right side views are required.

All Surfaces Parallel to the Viewing Planes and All Edges and Lines Visible When a surface is parallel to the viewing planes, that surface will show as a surface on one view and a line on the other views. The lengths of these lines are the same as the lines shown on the surface view. The drawing has been made showing each side to represent the exact shape and size of the object and the relationship of the three views to one another.

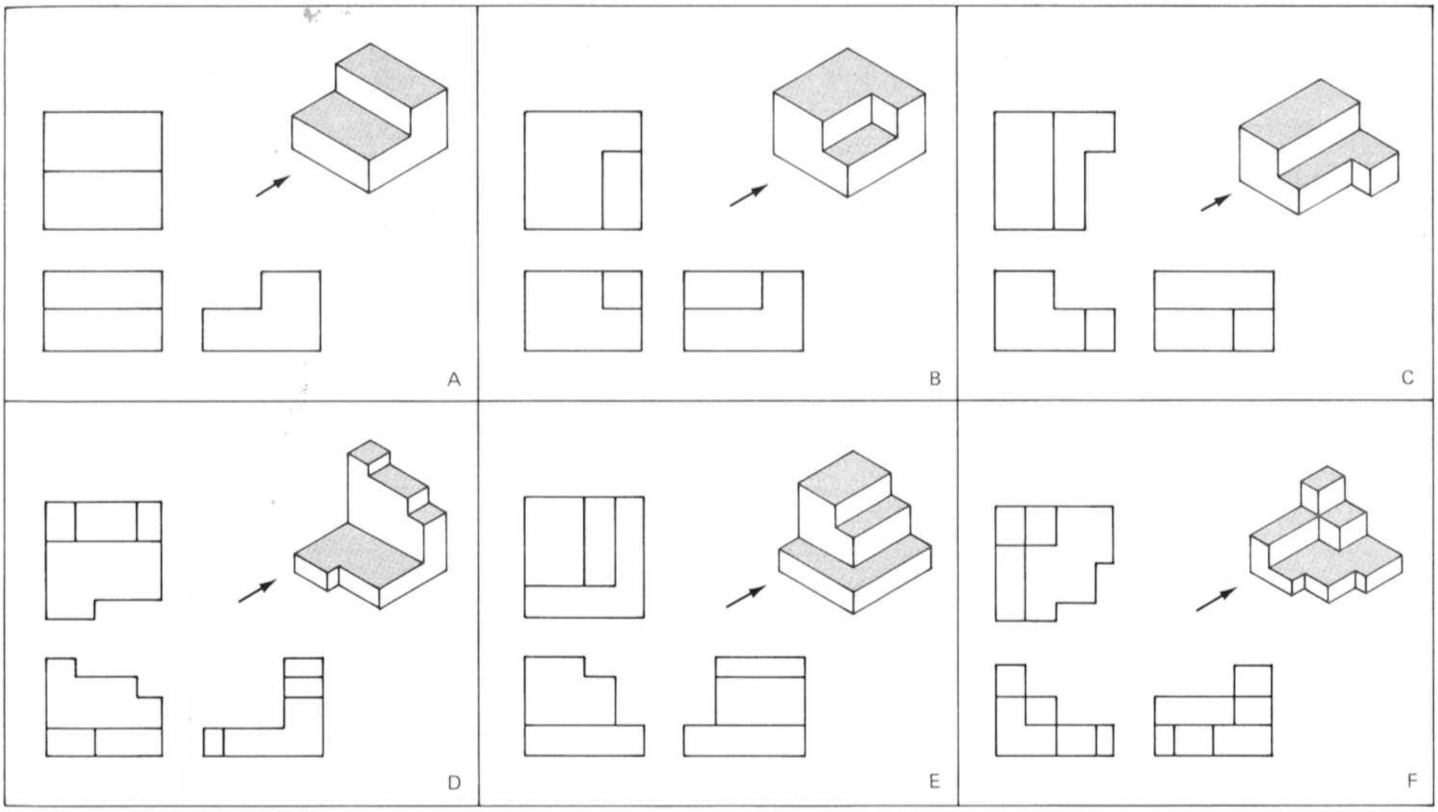
ASSIGNMENTS

See Assignments 1 and 2 for Unit 3-1 on page 56.

UNIT 3-2
Spacing of Views and Miter Lines

SPACING THE VIEWS

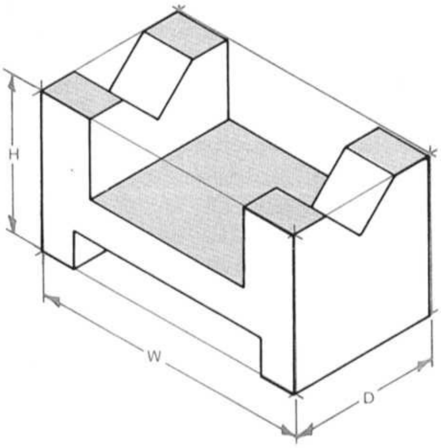
It is important for clarity and good appearance that the views be well balanced on the drawing paper, whether the drawing shows one view, two views, three views, or more. The drafter must anticipate the approximate space required. This is determined from the size of the object to be drawn, the number of views, the scale used, and the space between views. Ample space should be provided between views to permit placement of dimensions on the drawing without crowding. Space should also be allotted so that notes can be added without crowding. However, space between views should not be excessive. Once the size of paper, scale, and number of views are established, the balancing of the three views is relatively simple. A



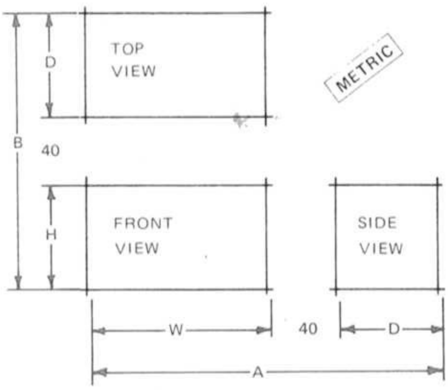
NOTE: ARROWS INDICATE DIRECTION OF SIGHT WHEN LOOKING AT THE FRONT VIEW.

Fig. 3-1-9 Illustrations of objects drawn in third-angle orthographic projection.

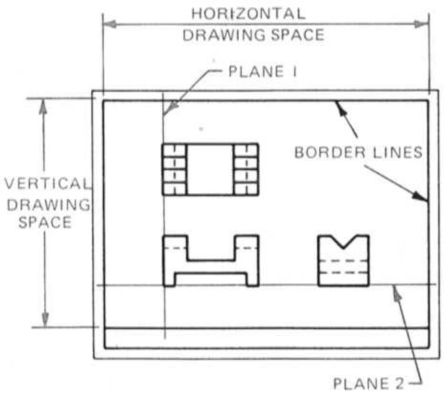
simple method of positioning the views on the drawing paper is shown in Fig. 3-2-1. In this example, a distance of 40 mm (1.50 in.) is left between views. For the beginning drafter, between 30 and 40 mm (1.20 to 1.50 in.) is recommended for the distance between views.



(A) DECIDING THE VIEWS TO BE DRAWN AND THE SCALE TO BE USED



(B) CALCULATING DISTANCES A AND B



(C) ESTABLISHING LOCATION OF PLANES 1 AND 2

Fig. 3-2-1 Balancing the drawing on the drawing paper.

USE OF A MITER LINE

The use of a miter line provides a fast and accurate method of constructing the third view once two views are established (Fig. 3-2-2).

Using a Miter Line to Construct the Right Side View

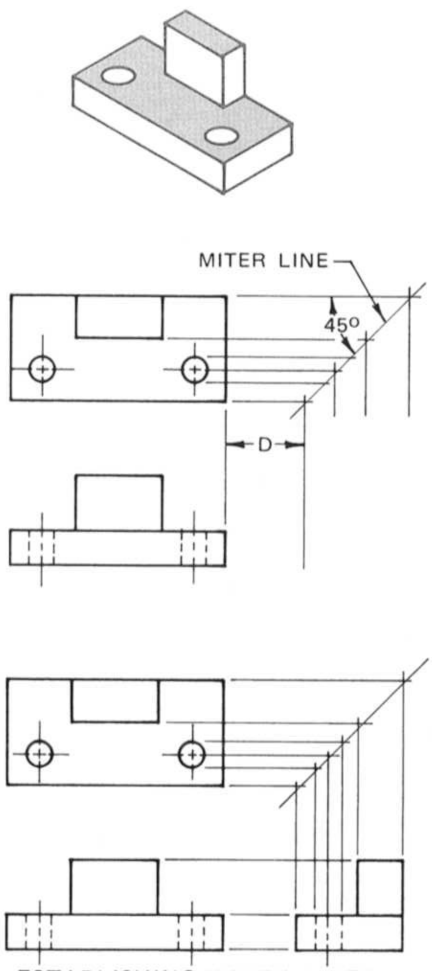
1. Given the top and front views, project lines to the right of the top view.
2. Establish how far from the front view the side view is to be drawn (distance *D*).
3. Construct the miter line at 45° to the horizon.
4. Where the horizontal projection lines of the top view intersect the miter line, drop vertical projection lines.
5. Project horizontal lines to the right of the front view and complete the side view.

Using a Miter Line to Construct the Top View

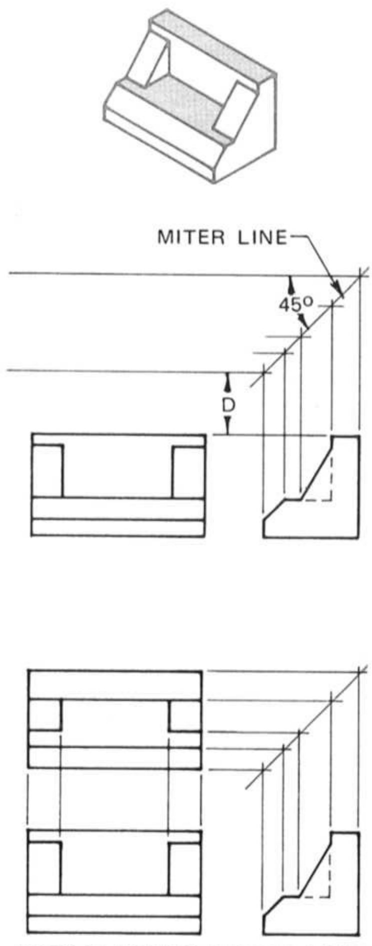
1. Given the front and side views, project vertical lines up from the side view.
2. Establish how far away from the front view the top view is to be drawn (distance *D*).
3. Construct the miter line at 45° to the horizon.
4. Where the vertical projection lines of the side view intersect the miter line, project horizontal lines to the left.
5. Project vertical lines up from the front view and complete the top view.

ASSIGNMENTS

See Assignments 3 through 6 for Unit 3-2 on page 56.



ESTABLISHING WIDTH LINES ON SIDE VIEW



ESTABLISHING WIDTH LINES ON TOP VIEW

Fig. 3-2-2 Use of miter line.

UNIT 3-3
All Surfaces Parallel to the Viewing Planes with Some Edges and Surfaces Hidden

Most objects drawn in engineering offices are more complicated than the ones shown in Fig. 3-3-1. Many features (lines, holes, etc.) cannot be seen when viewed from outside the piece. These hidden edges are shown with *hidden lines* and are normally required on the drawing to show the true shape of the object. Figure 3-3-2 shows additional examples of objects requiring hidden lines.

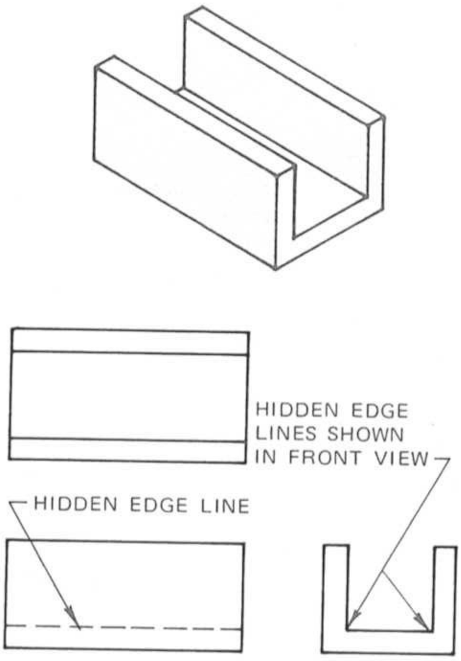


Fig. 3-3-1 Hidden lines.

ASSIGNMENTS

See Assignments 7 through 10 for Unit 3-3 on page 57.

UNIT 3-4
Inclined Surfaces

If the surfaces of an object lie in either a horizontal or a vertical position, the surfaces appear in their true shapes in one of the three views, and these surfaces appear as a line in the other two views.

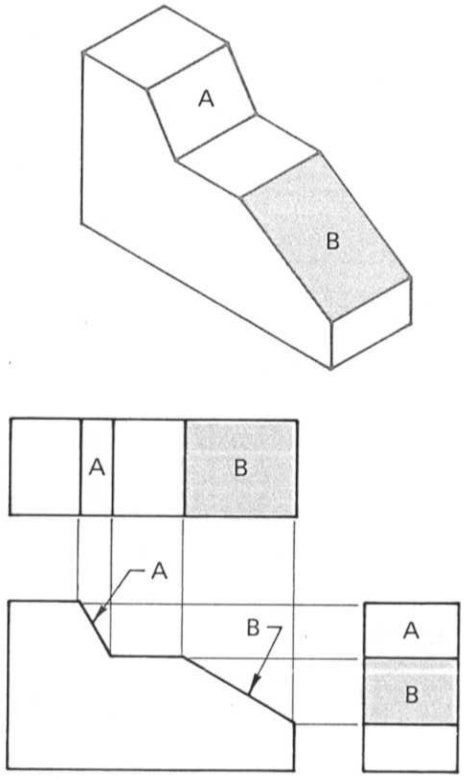
When a surface is inclined or sloped in only one direction, then that surface is not seen in its true shape in the top, front, or side view. It is, however, seen in two views as a distorted surface. On the third view it appears as a line.

The true length of surfaces A and B in Fig. 3-4-1 is seen in the front view only. In the top and side views, only the width of surfaces A and B appears in its true size. The length of these surfaces is foreshortened.

Where an inclined surface has important features that must be shown clearly and without distortion, an *auxiliary* or helper view must be used. This type of view will be discussed in detail in Chapter 13. Figure 3-4-2 shows additional examples of objects having inclined surfaces.

ASSIGNMENTS

See Assignments 11 through 14 for Unit 3-4 on page 60.



NOTE: THE TRUE SHAPE OF SURFACES A AND B DO NOT APPEAR ON THE TOP OR SIDE VIEWS.

Fig. 3-4-1 Sloping surfaces.

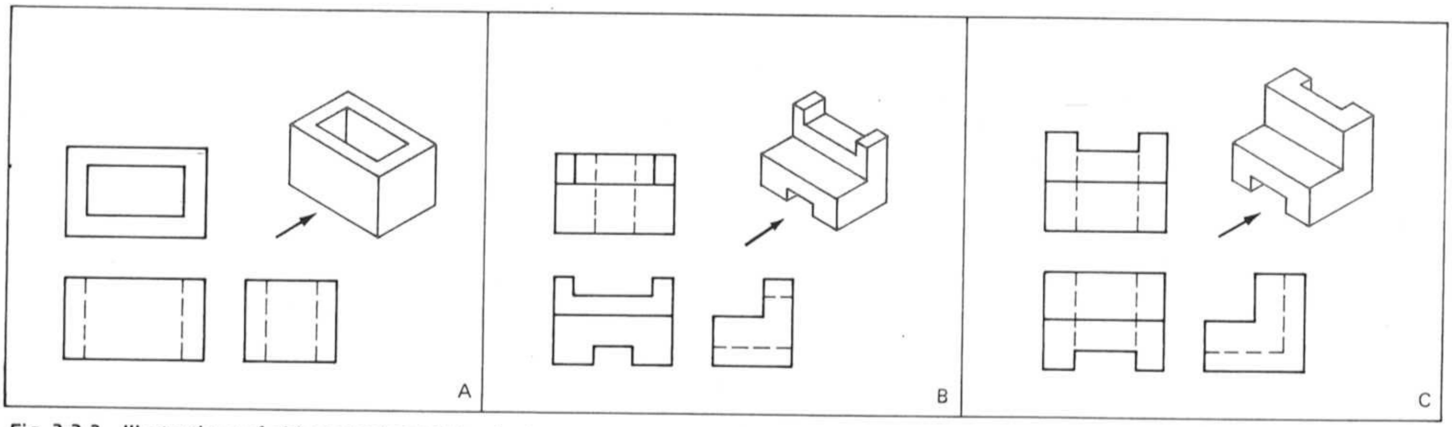


Fig. 3-3-2 Illustrations of objects having hidden features.

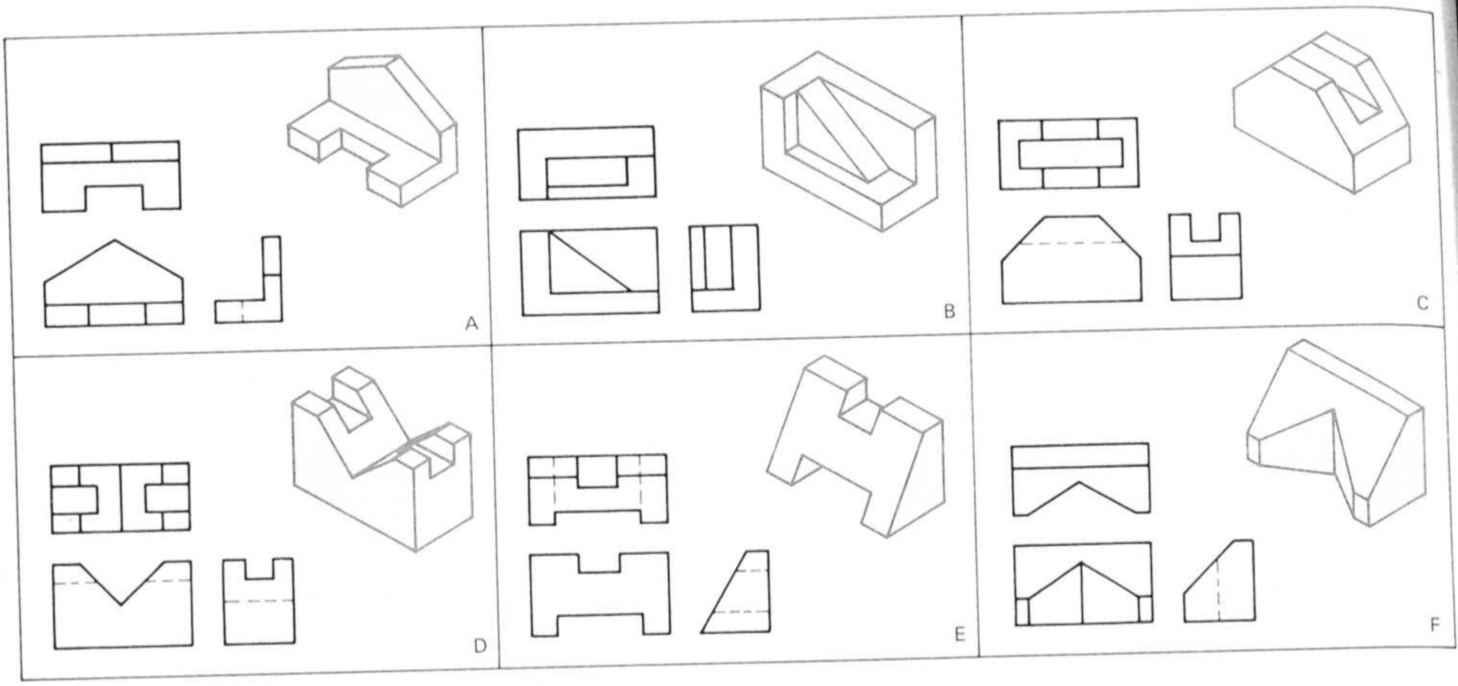


Fig. 3-4-2 Illustrations of objects having sloping surfaces.

UNIT 3-5
Circular Features

Typical parts with circular features are illustrated in Fig. 3-5-1. Note that the circular feature appears circular in one view only and that no line is used to show where a curved surface joins a flat surface. Hidden circles, like hidden flat surfaces, are represented on drawings by a hidden line.

Center Lines

A center line is drawn as a thin, broken line of long and short dashes, spaced alternately. Such lines may be used to locate center points, axes of cylindrical parts, and axes of symmetry, as shown in Fig. 3-5-2. Solid center lines are often used when the circular features are small. Center lines should project for a short distance beyond the outline of the part or feature to which they refer. They must be extended for use as extension lines for dimensioning purposes, but in this case the extended portion is not broken.

On views showing the circular features, the point of intersection of the two center lines is shown by the two intersecting short dashes.

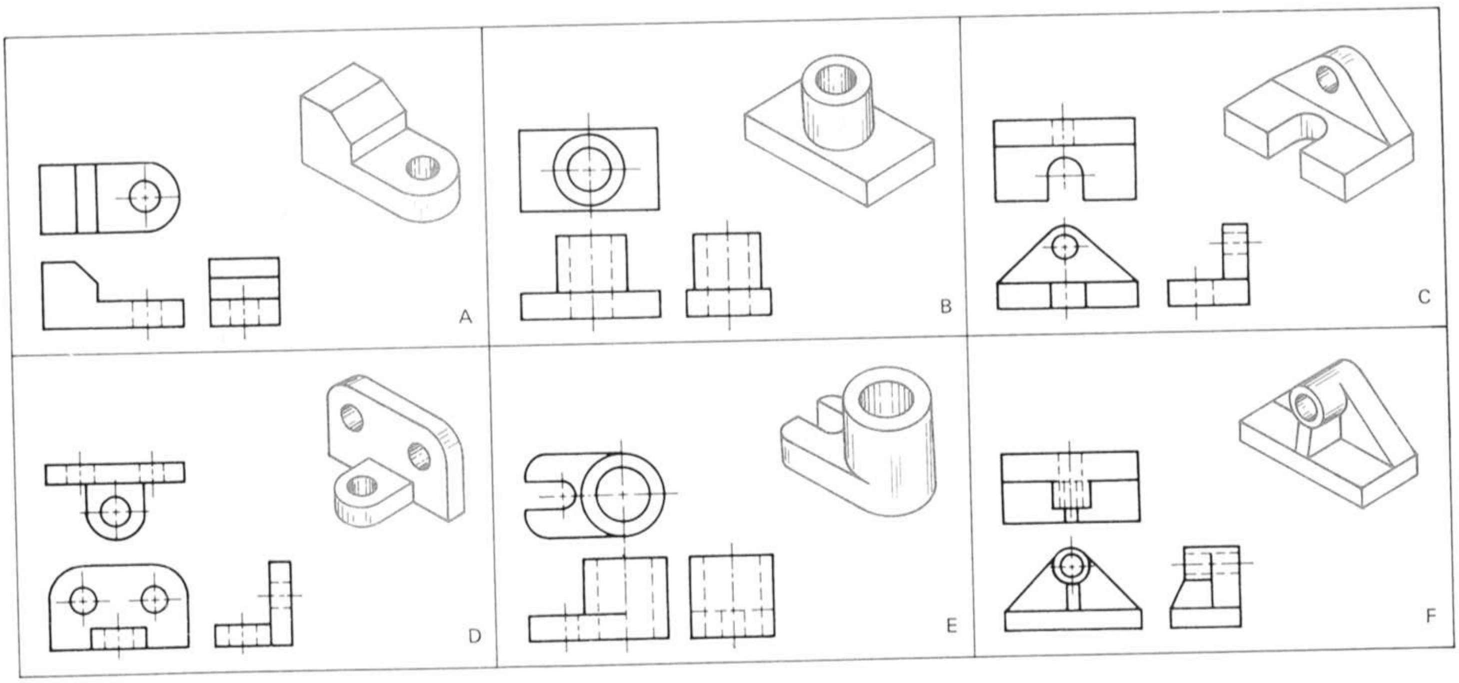


Fig. 3-5-1 Illustrations of objects having circular features.

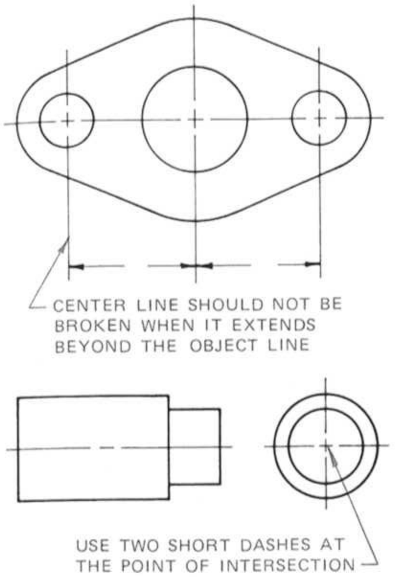


Fig. 3-5-2 **Center line application.**

ASSIGNMENTS

See Assignments 15 through 19 for Unit 3-5 on page 64.

UNIT 3-6
Oblique Surfaces

When a surface is sloped so that it is not perpendicular to any of the three viewing planes, it will appear as a surface in all three views but never in its true shape. This is referred to as an *oblique surface* (Fig. 3-6-1). Since the oblique surface is not perpendicular to the viewing planes, it cannot be parallel to them and consequently appears foreshortened. If a true view is required for this surface, two auxiliary views—a primary and a secondary view—need to be drawn. This is discussed in detail under Secondary Auxiliary Views in Unit 13-4. Figure 3-6-2 shows additional examples of objects having oblique surfaces.

ASSIGNMENTS

See Assignments 20 and 21 for Unit 3-6 on page 67.

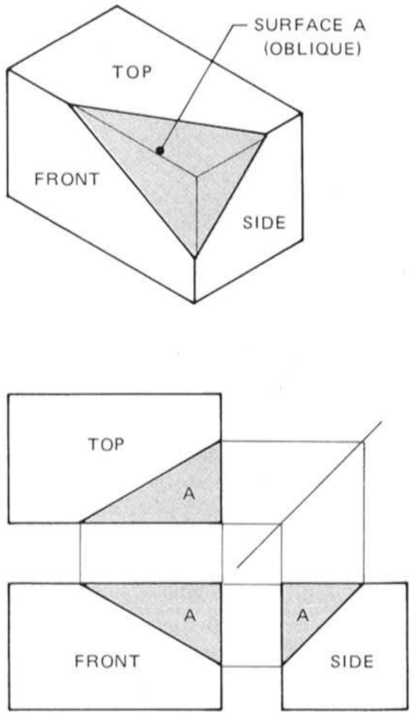


Fig. 3-6-1 **Oblique surface A not true shape in any of the three views.**

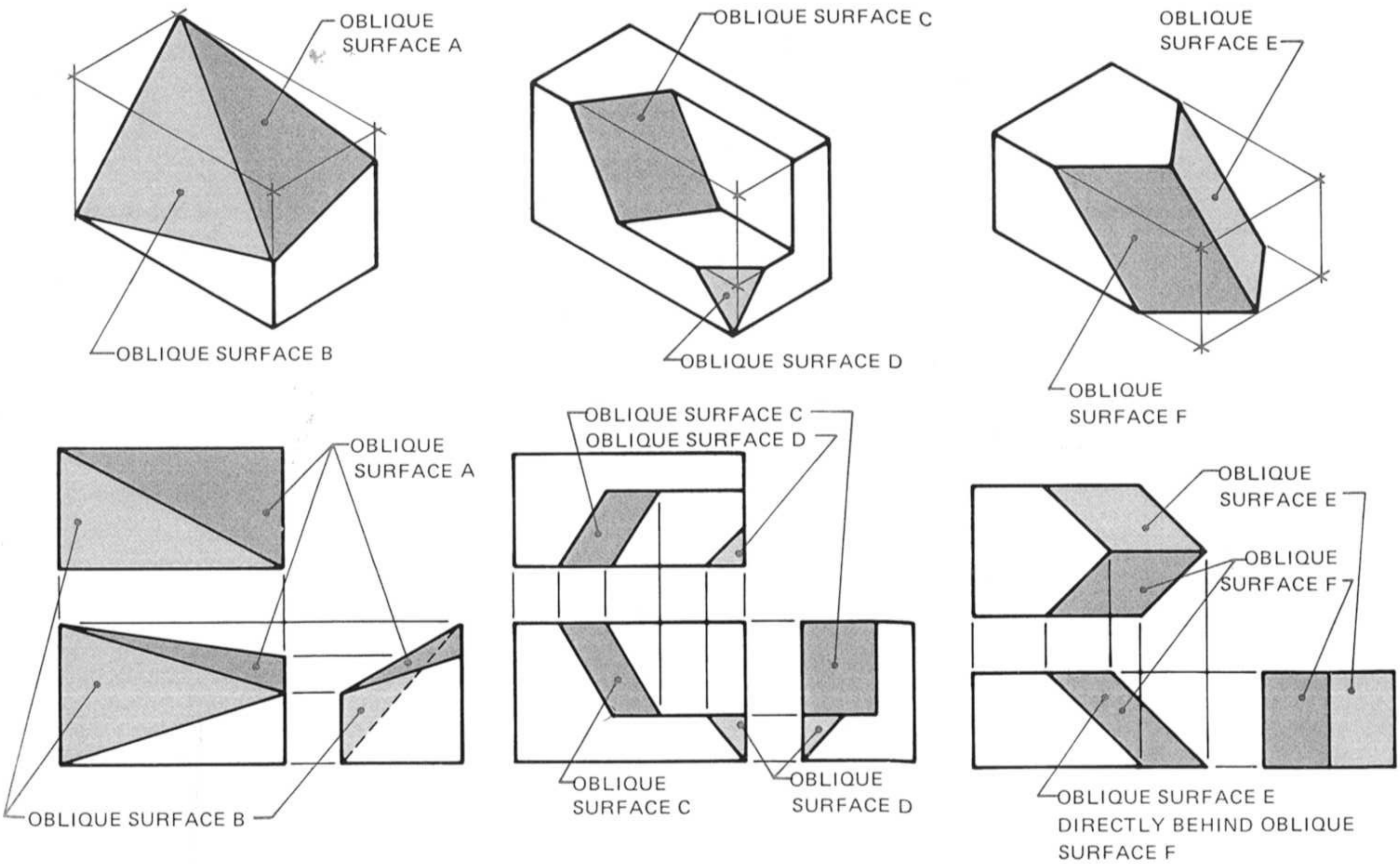


Fig. 3-6-2 **Examples of objects having oblique surfaces.**

UNIT 3-7
First-Angle Orthographic Projection

As mentioned previously, first-angle orthographic projection is used in many countries throughout the world. Today with global marketing and the interchange of drawings with different countries, drafters are called upon to prepare and interpret drawings in both first- and third-angle projection. In first-angle projection, all the views are projected onto the planes located behind the objects rather than onto the planes lying between the objects and the viewer, as in third-angle projection. This is shown in Fig. 3-7-2. The unfolding and positioning of the views in one plane are shown in Fig. 3-7-3. Note that the views are on opposite sides of the front view with the exception of the rear view. A comparison between the views of first- and third-angle projections is shown in Figs. 3-7-1 and 3-7-4. Remember that the views are identical in shape and detail, and only their location in reference to the front view has changed.

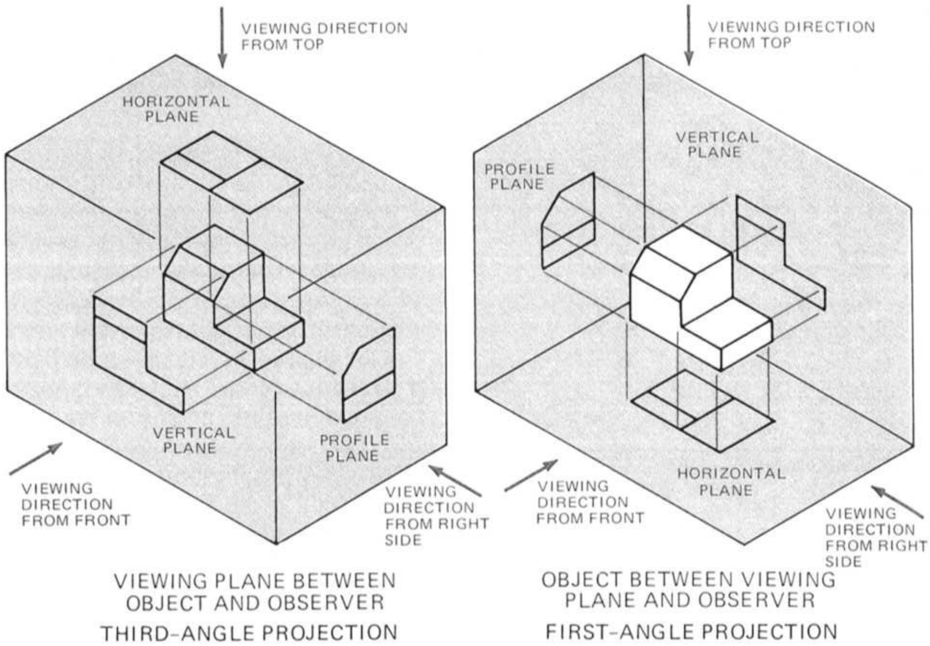


Fig. 3-7-1 A comparison between third- and first-angle projection.

ASSIGNMENTS

See Assignments 22 and 23 for Unit 3-7 on page 68.

Review for Assignment

Unit 2-6 Sketching
Unit 3-1 ISO Projection Symbol

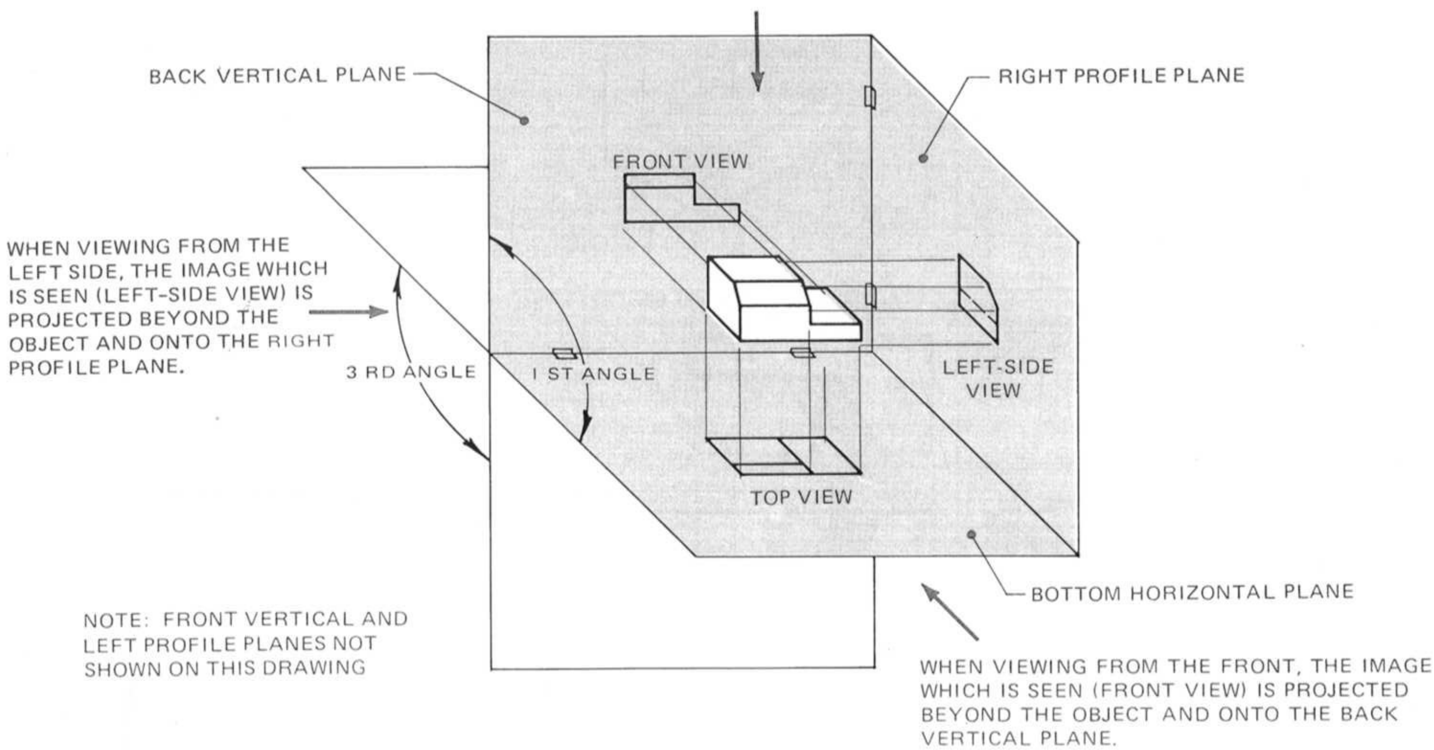


Fig. 3-7-2 Relationship of object with viewing planes in first-angle projection.

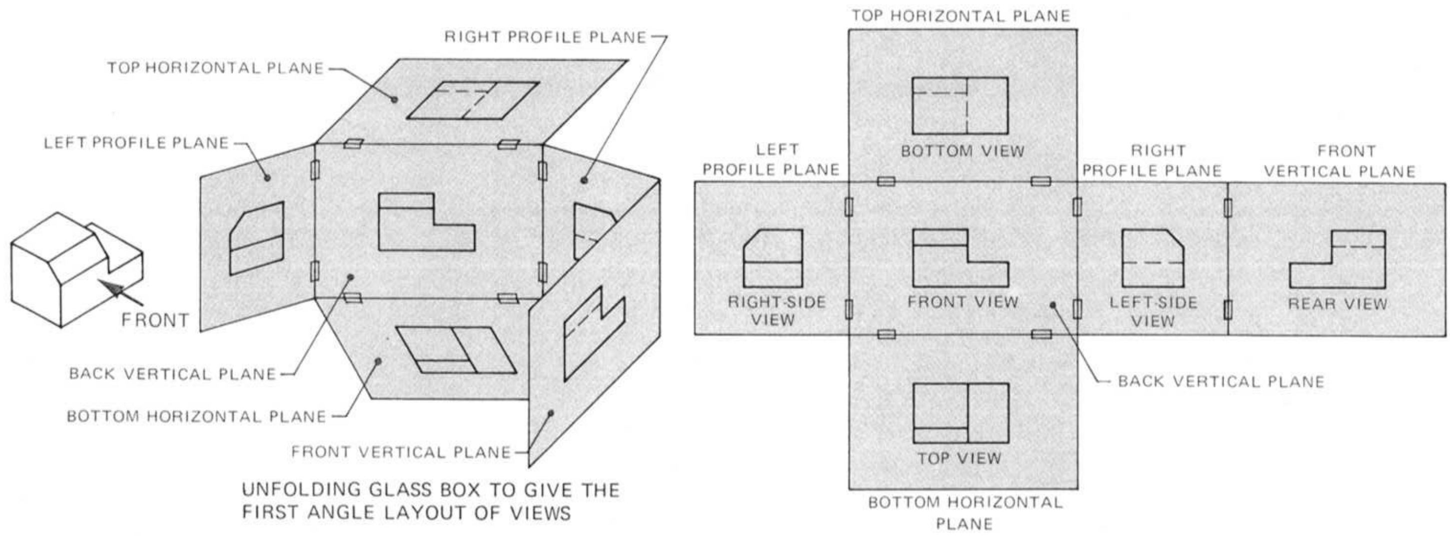


Fig. 3-7-3 First-angle orthographic projection.

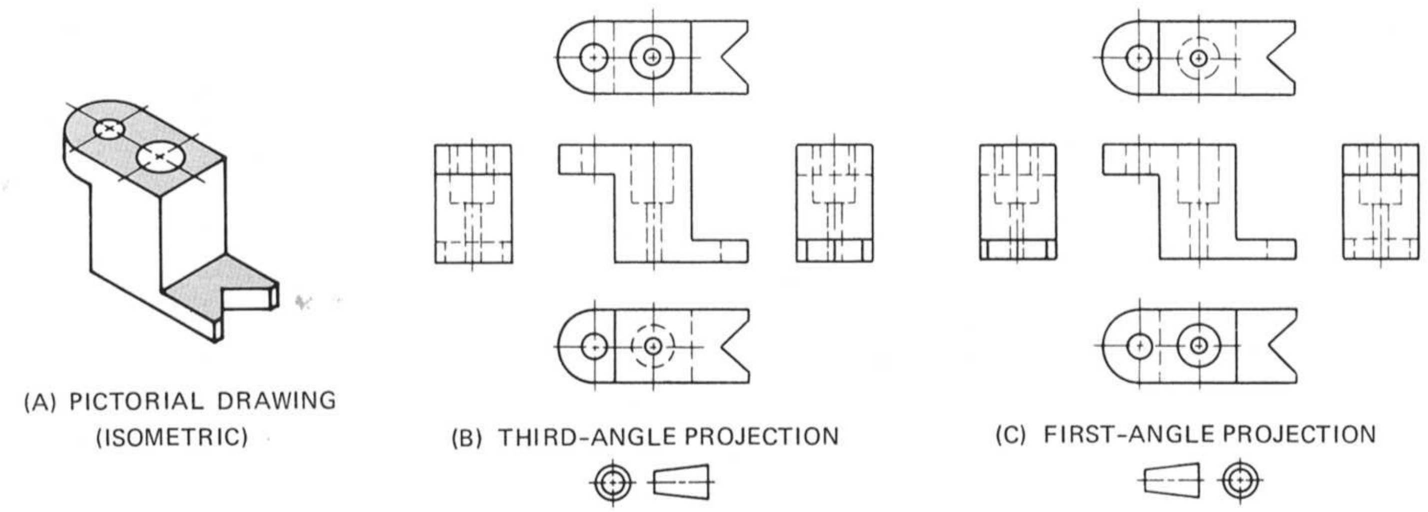


Fig. 3-7-4 A simple object shown in pictorial and orthographic form.

UNIT 3-8
One- and Two-View Drawings

VIEW SELECTION

Views should be chosen that will best describe the object to be shown. Only the minimum number of views that will completely portray the size and shape of the part should be used. They should also be chosen to avoid hidden feature lines whenever possible, as shown in Fig. 3-8-1.

Except for complex objects of irregular shape, it is seldom necessary to draw more than three views. For representing simple parts, one- or two-view drawings will often be adequate.

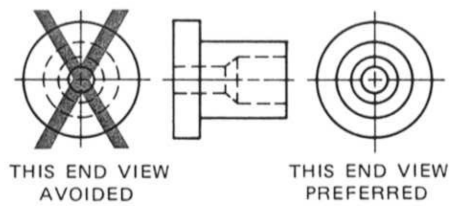


Fig. 3-8-1 Avoidance of hidden-line features.

ONE-VIEW DRAWINGS

In one-view drawings, the third dimension, such as thickness, may be expressed by a note or by descriptive words or abbreviations, such as DIA, ⌀, or HEXAGON ACROSS FLATS. Square sections may be indicated by light crossed diagonal lines. This applies whether the face is parallel or inclined to the drawing plane. These are illustrated in Fig. 3-8-2.

When cylindrical-shaped surfaces include special features such as a keyseat, a side view (often called an *end view*) is required.

TWO-VIEW DRAWINGS

Frequently the drafter will decide that only two views are necessary to

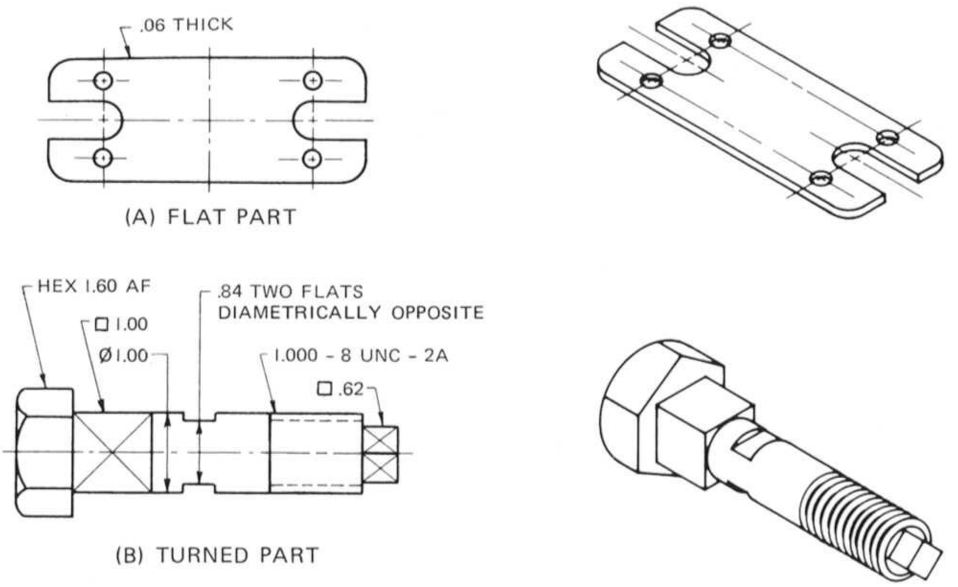


Fig. 3-8-2 One-view drawings.

explain fully the shape of an object (Fig. 3-8-3). For this reason, some drawings consist of two adjacent views, such as the top and front views only, or front and right side views only. Two views are usually sufficient to explain fully the shape of cylindrical objects; if three views were used, two of them would be identical, depending on the detail structure of the part.

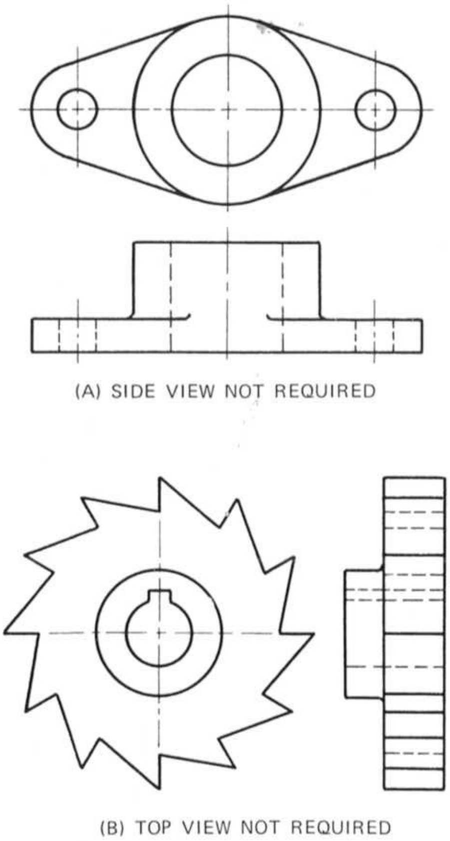


Fig. 3-8-3 Two-view drawings.

ASSIGNMENT

See Assignment 24 for Unit 3-8 on page 69.

Review for Assignments
Unit 2-6 Line Work and Drawing Lines

UNIT 3-9
Partial Views

Symmetrical objects may often be adequately portrayed by half views (Fig. 3-9-1A). A center line is used to show the axis of symmetry. Two short thick lines, above and below the view of the object, are drawn at right angles to and on the center line to indicate the line of symmetry.

Partial views, which show only a limited portion of the object with remote details omitted, should be used, when necessary, to clarify the meaning of the drawing (Fig. 3-9-1B). Such views are used to avoid the necessity of drawing many hidden features.

On drawings of objects where two side views can be used to better advantage than one, each need not be complete if together they depict the shape. Show only the hidden lines of features immediately behind the view (Fig. 3-9-1C).

ASSIGNMENT

See Assignment 25 for Unit 3-9 on page 70.

Review for Assignments
Unit 2-6 Line Work and Drawing Lines

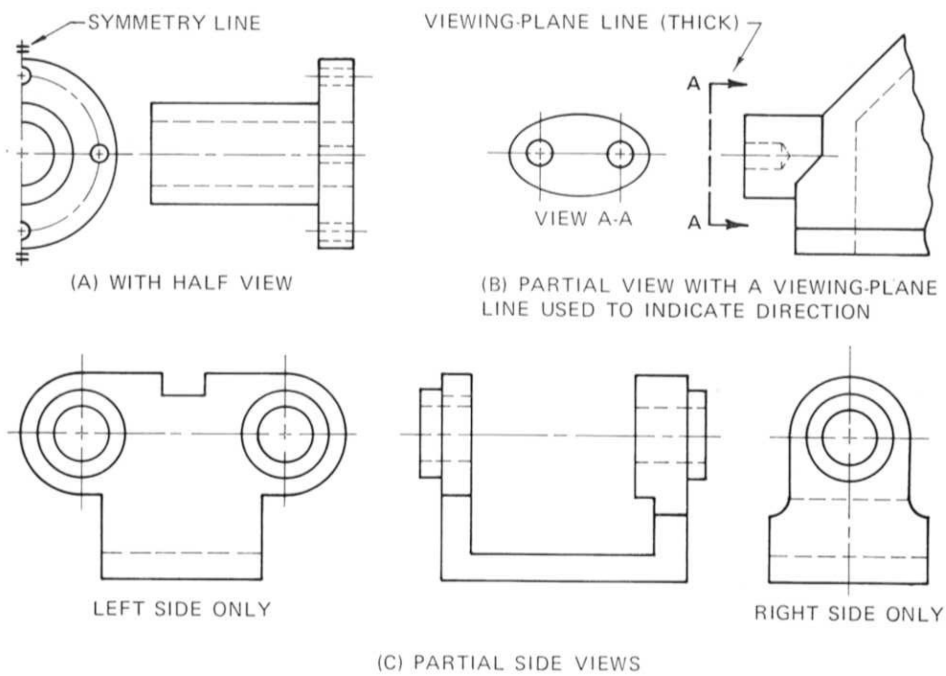


Fig. 3-9-1 Partial views.