MINISTRY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF

TECHNICAL AND VOCATIONAL EDUCATION

ME – 01011

MECHANICAL ENGINEERING DRAWING

A.G.T.I (First Year)

Mechanical Engineering

AGTI YEAR 1, FIRST SEMESTER

ENGINEERING DRAWING

MECHANICAL

M.E 01011

CONTENTS

CHAPTER 1

ENGINEERING GEOMETRY AND GEOMETRICAL CONSTRUCTIONS

1.1 Introduction

Engineering drawing is a graphic language that is used universally by design engineers and engineering technologists to describe the shape and size of structures and mechanisms.

An engineer must understand not only the theory of projection and dimensioning as related to working drawings, but he must be familiar with the idioms and conventions as well.

The technical man is concerned with actual objects, and his drawings shown not only how they appear but how they are. Technical drawing is an exact mean of expression, and accuracy is the main objective.

Engineering drawing offers students an insight into the methods of attacking engineering problems. Its lessons teach the principles of accuracy, exactness, and positiveness with regard to the information necessary for the production of a part. Finally, it develops the engineering imagination that is essential to the creation of successful design.

1.2 Vertical Capital Letters

The standard vertical capital alphabet is shown in Figure. 1.1. With the exception of the I, which has no width, and the W, which is the widest letter of the alphabet, all letters are either 5 or 6 units wide. You can easily remember which letters are 6 units wide simply by recalling the name TOM.Q. VAXY.

Each of the letters in his name is 6 units wide and all others in the others in the alphabet, except the I and W, are 5 units wide.

1.3 Vertical Numerals

All numerals, except the 1, are five units wide. The 3 and the 5 are both based on the shape of the 8. which is made up of a small ellipse centered over a larger ellipse. The 6 and 9 are alike except reversed, and both fit into the elliptical 0 (zero).

It is common practice in dimensioning to make whole numbers $^1/_8''$ long, and fractions $^1/_4''$ high. The numerator and denominator are slightly less than $^1/_8''$ high.

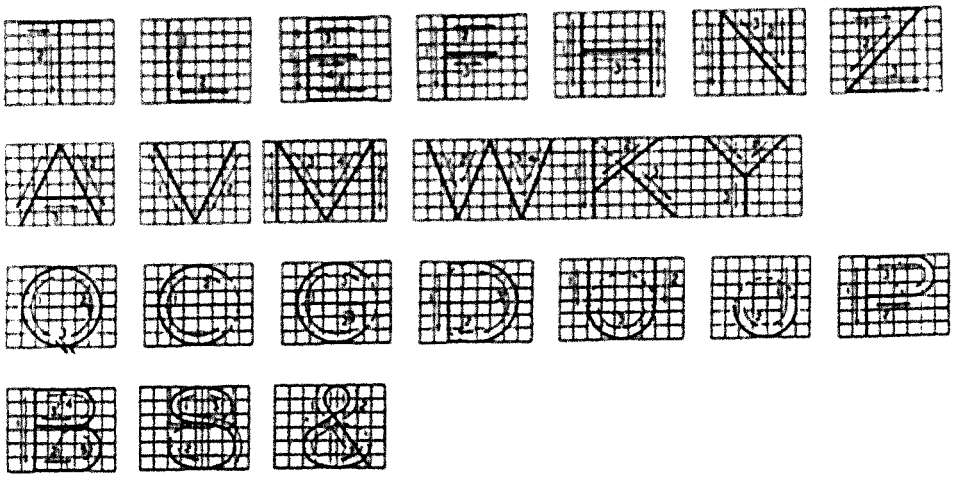
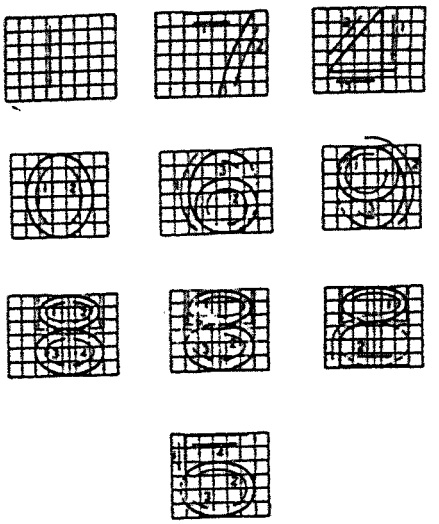


Figure. 1.1 Vertical capital letters



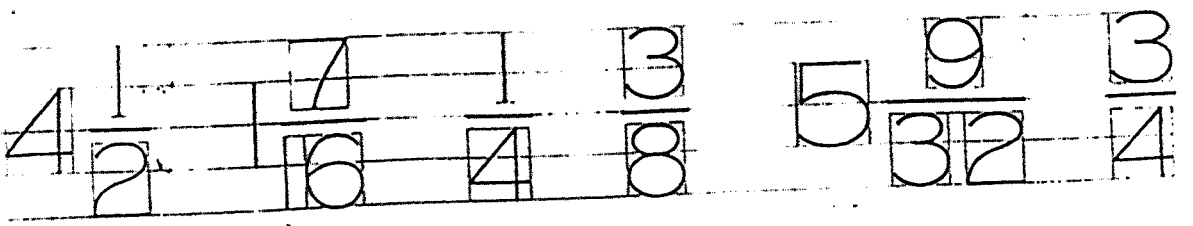


Figure. 1.2 Vertical numerals & fractions.

Figure. 1.3 Spacing letters and words.

1.4 List of Equipment and Materials Used in Drawing

1. Case of drawing instruments
2. T-square
3. 45° Triangle
4. 30 x 60° Triangle
5. Scales
6. Drawing pencils (H, 2H, HB)
7. Protractor
8. Pencil pointer (sand paper pad or file)
9. Pencil eraser
10. Dusting brush
11. Drawing paper
12. Tape or thumb tacks
13. Drawing Board.

1.5 Drawing Pencil Lines

Pencil lines should be sharp and uniform along their entire length. Construction lines should be drawn very lightly so that they may be easily erased. Finished lines should be made boldly and distinctly.

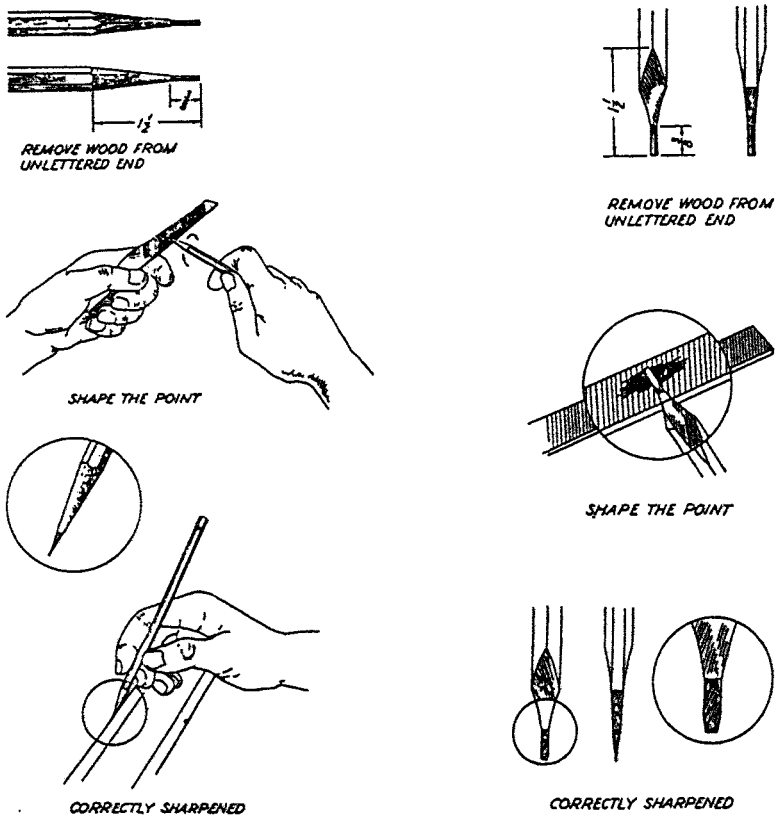


Figure. 1.4 Conical and wedge point

1.6 Inclined Lines

Lines that make angles of 30°, 45°, or 60° with the horizontal may be drawn with triangle in combination with the T-square, as shown in Figure. 1-5.

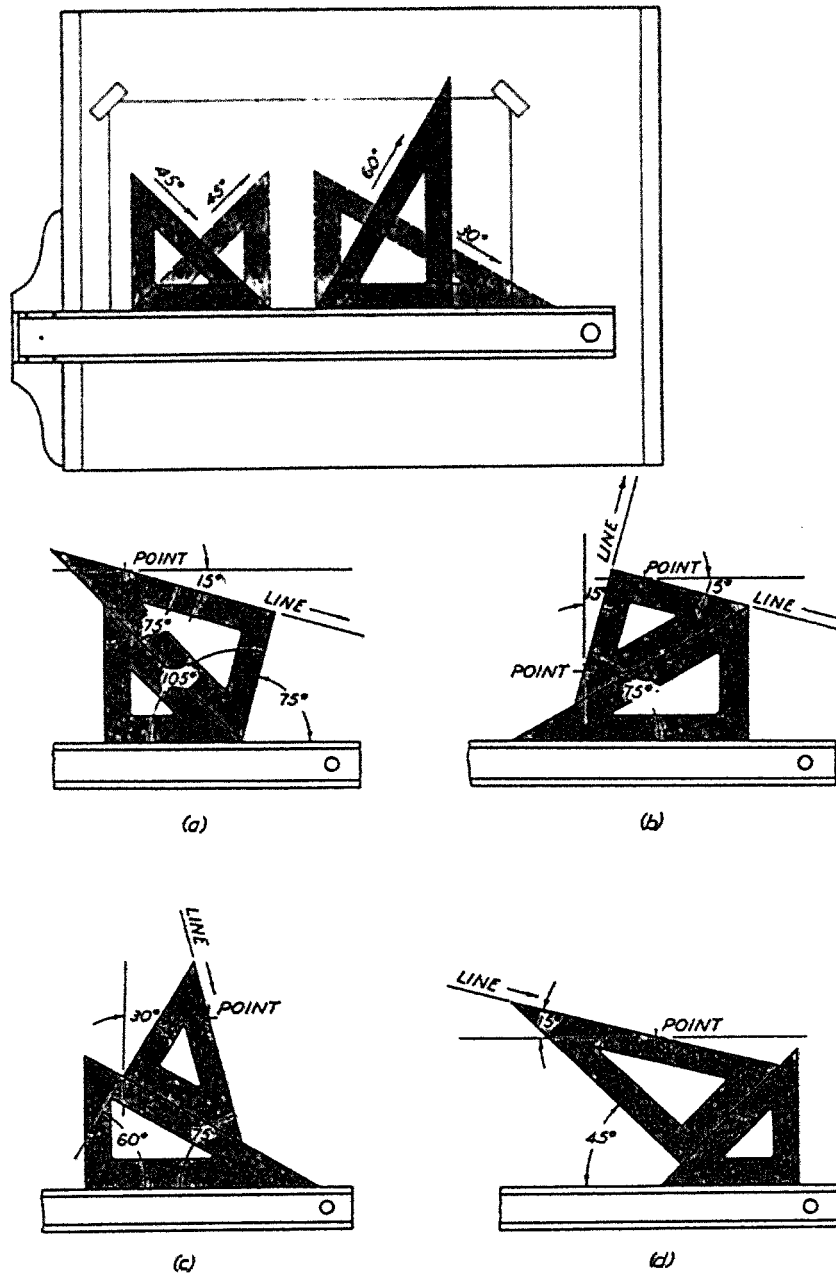


Figure. 1.5 Drawing inclined lines with triangles

1.7. Alphabet of Lines

There are three distinct thickness of lines; (1) thick (border lines, Visible lines), (2) medium (hidden lines), and (3) thin (section lines, center lines, dimension lines, and phantom lines).

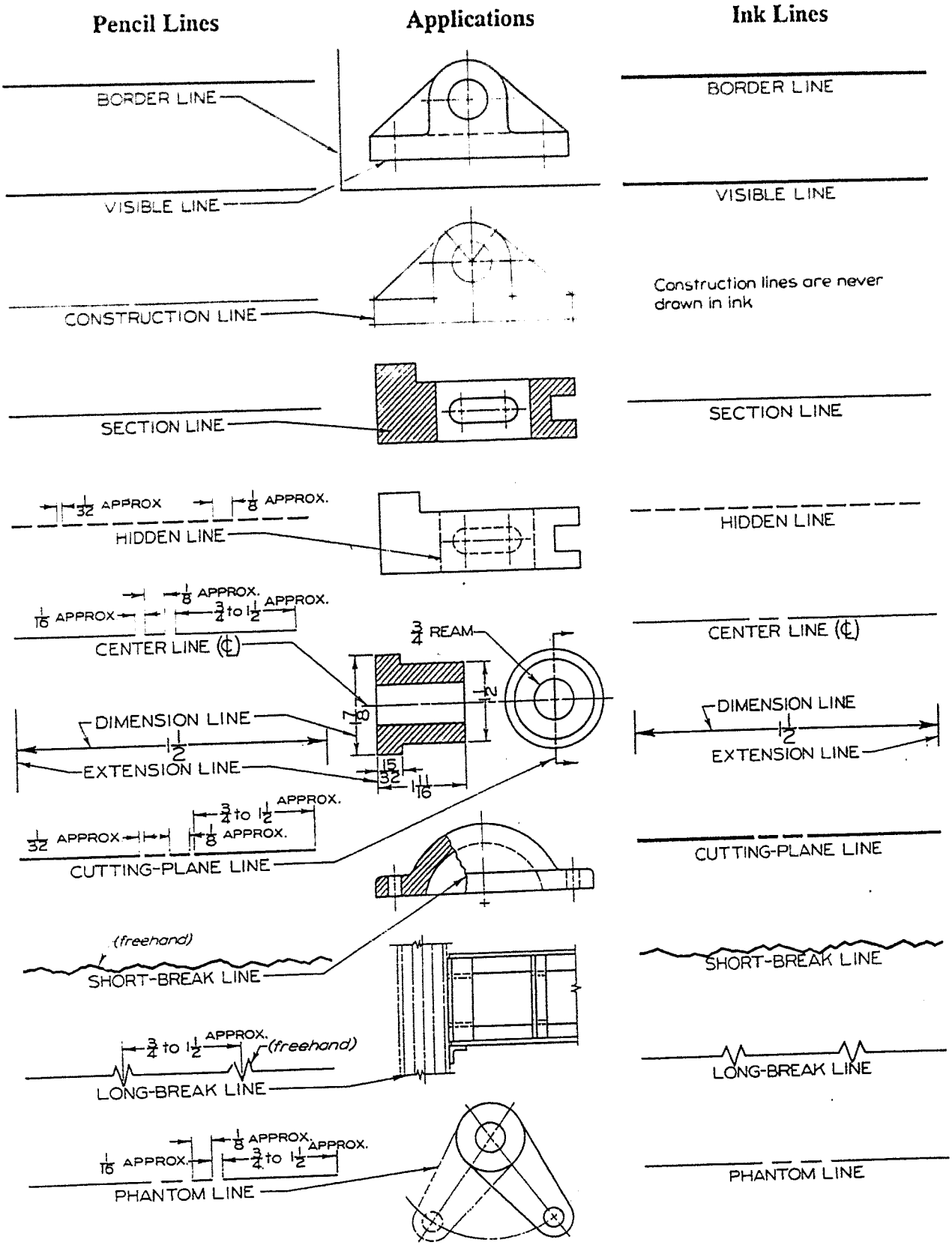


Figure. 1.6 Alphabet off lines

1.8. Geometrical Constructions

(1) To divide a straight line into equal numbers of parts

With scale or dividers, set of the required number of equal divisions on LP making any convenient angle with LM. Join MP and through remaining point draw line parallel to MP.

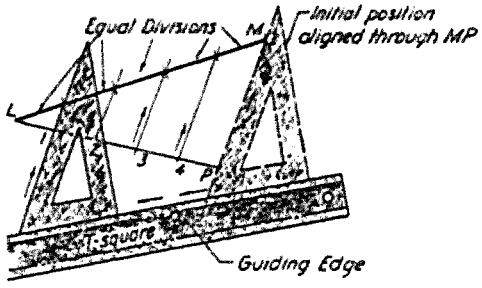


Figure. 1.7 To divide line into equal parts

(2) To construct a square

The construction of an inscribed circle when center and length of one side are given. Using a T-square and a 45° triangle, draw the sides of the square tangent to the circle. This construction is used in drawing bolt heads and nuts.

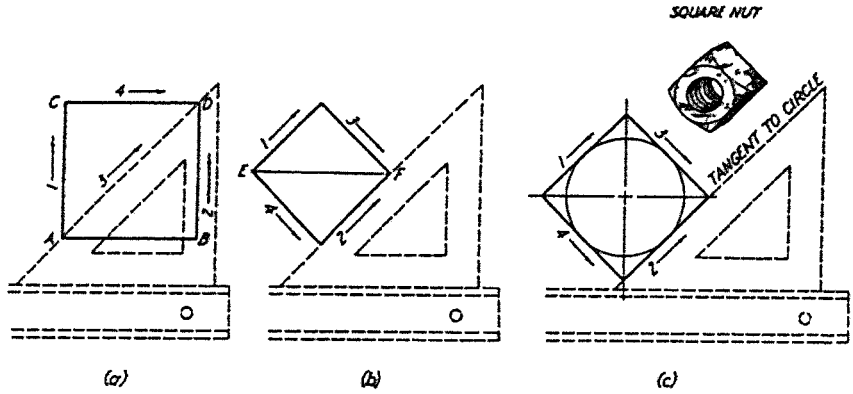


Figure. 1.8 To construct a square.

(3) To construct a regular hexagon.

(a) Given the distance AB across. Draw a circle having AB as diameter. Using same radius and with A & B as centers, strike arcs interesting the circumference. Join these points.

(b) Given corner distance AB. Using triangle and T-square draw line in the order indicated by numeral.

(c) Given the distance across flats. Draw a circle whose diameter equals the distance across flats. Using triangle and T-square, draw tangents.

This construction is used in drawing hexagonal bolt heads and nuts.

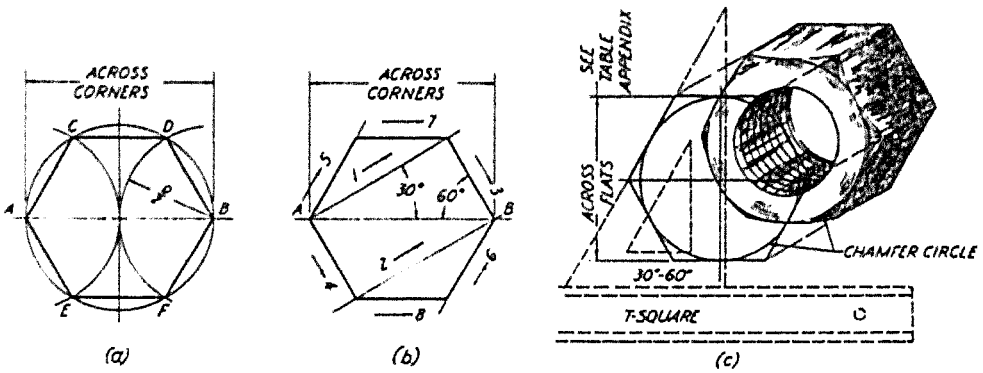


Figure. 1.9 To construct a regular hexagon.

(4) To draw a circular arc of radius R tangent to two lines

(a) Given two lines AB CD. With X as center and radius R, strike an arc cutting the giving lines at T_1 and T_2 . With these two points as centers and the same radius, strike the intersecting arcs locating the center O of the require arc.

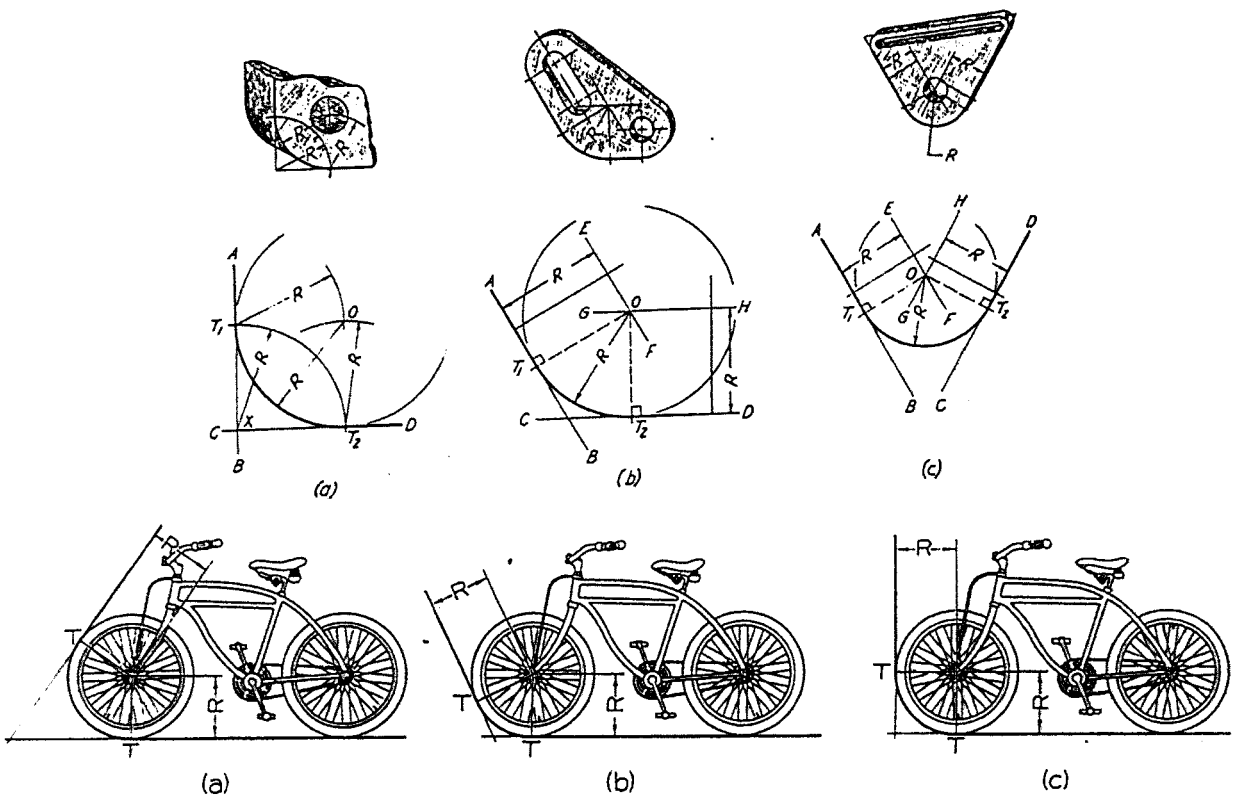


Figure. 1.10 To draw a circular arc tangent to two lines

(b), (c). Given two lines AB and CD and radius R. Draw lines EF and GH parallel to the given lines at a distance R. Intersecting of this will be the center O of the require arc. Mark the tangent points T_1 and T_2 that lie along perpendiculars to the given line through O.

These construction are useful for drawing fillets and rounds on views of machine parts.

(5) To draw a circular arc of radius R1, tangent to a given circular arc and a given straight line.

Draw line CD parallel to AB at a distance R_1. Using the center O and a radius equal to its radius plus or minus the radius of the required arc (R_2 plus or minus R_1) , swing a parallel arc intersecting CD. With center P and required radius R1 draw arc through T_1 and T_2. Mark the tangency points T_1 and T_2.

This construction is also useful for drawing fillets and rounds on views of machine parts.

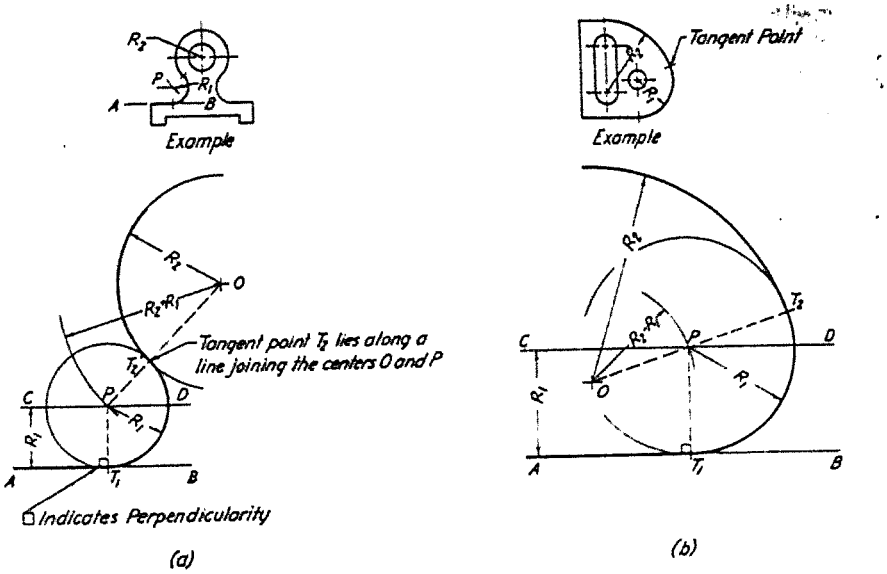


Figure. 1.11 To draw a circular arc tangent to a given circular arc and line.

(6) To draw circular arc of a given radius R_1, tangent to two given circular arc.

Given arcs AB and CD with centers O & P, and radii R_2 and R_3. Let R_1 be radius of the required arc.

(a) Using O as center and R_2 plus R_1 as a radius. strike an interesting arc parallel to AB. Using P as center and R_3 plus R_1 as a radius, strike an intersecting arc parallel to CD. Intersection point S is the center for the required arc. Mark points of tangency T_1 and T_2.

(b) Using O as a center and R_2 plus R_1 as a radius strike an arc parallel to AB. Using P as center and R_2 minus R_1 as a radius, strike an intersecting arc parallel to CD. The points of intersection is the center for the required arc.

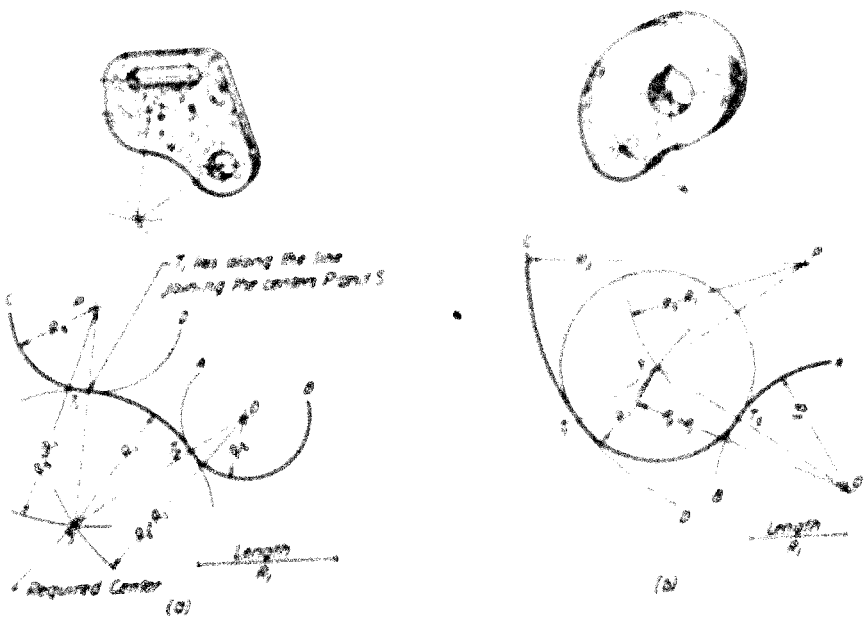


Figure. 1.12 To draw a circular arc tangent to two given arcs.

(7) To draw a reverse (ogee) curve

Reverse curve connecting two parallel lines are shown in Figure. (a) below and reverse curve connecting two nonparallel lines are also shown in Figure. (b) below.

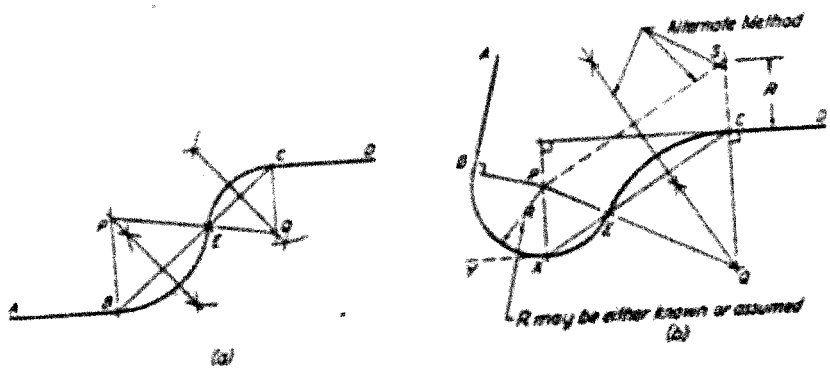


Figure. 1.13 To draw a reverse curve.

(8) To draw a line tangent to two given circles.

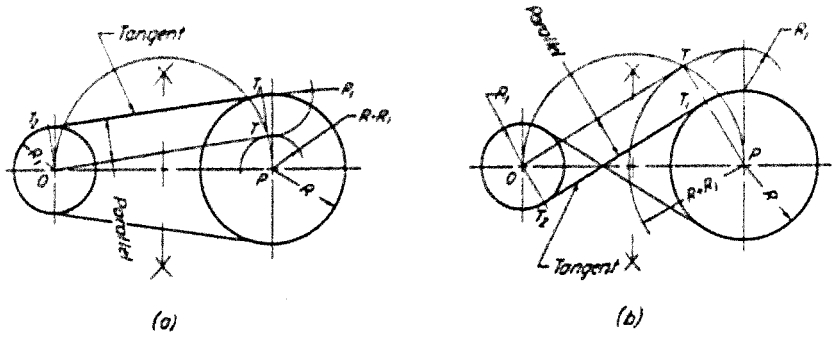


Figure. 1.14 To draw a line tangent to two circles.

(9) Conic sections

When a right circular cone is cut by planes at different angles, four curves of intersection are obtained that called conic sections. They are circle, ellipse, parabola and hyperbola.

Four method of construction for drawing ellipse are shown in the following figures.

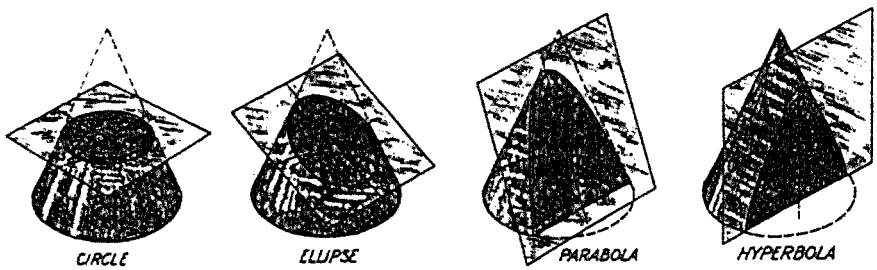
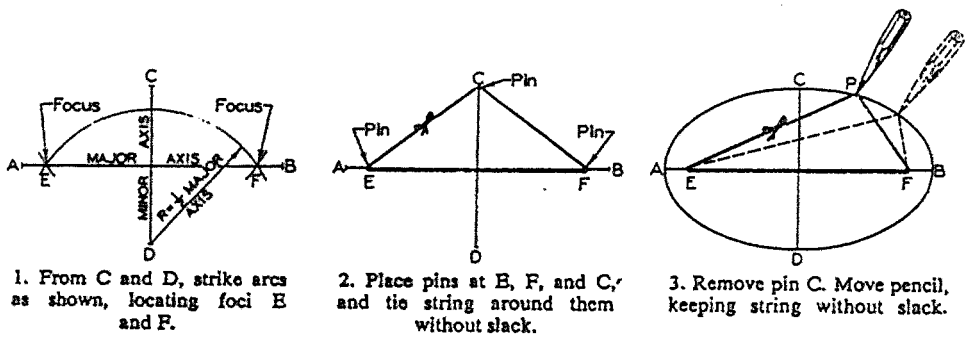


Figure. 1.15. Conic sections.

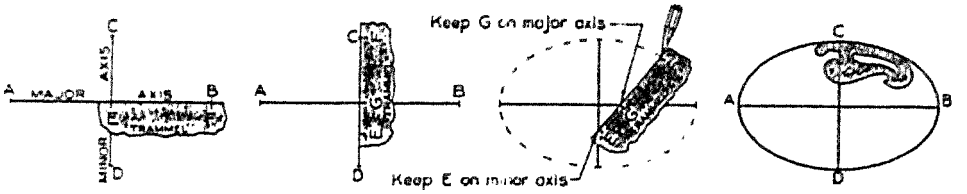


1. From C and D, strike arcs as shown, locating foci E and F.

2. Place pins at E, F, and C, and tie string around them without slack.

3. Remove pin C. Move pencil, keeping string without slack.

Figure. 1.16 To draw "pin and string" ellipse



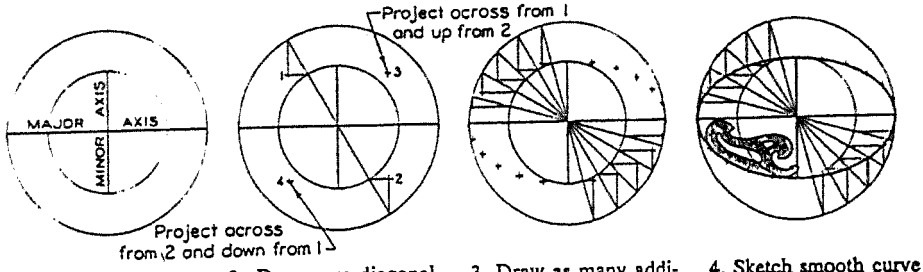
1. On trammel (scrap of paper) mark off EF = half major axis AB.

2. On trammel, set off GF = half minor axis CD.

3. Move E along minor axis and G along major axis. Mark points at F.

4. Sketch smooth curve through points. Then use French curve for final ellipse.

Figure. 1.17 To draw trammel ellipse.



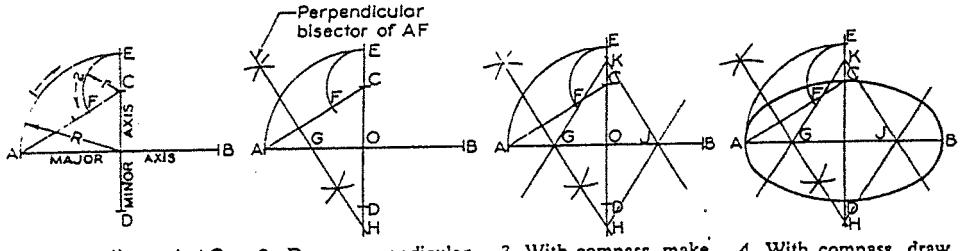
1. Draw light construction circles as shown, using the axes as diameters.

2. Draw any diagonal. At intersections with circles draw lines parallel to axes, as shown, to get 1, 2, 3, and 4.

3. Draw as many additional diagonals as needed, each diagonal getting 4 points.

4. Sketch smooth curve through points. Then use French curve for final ellipse.

Figure. 1.18 To draw concentric - circle ellipse.



1. Draw diagonal AC. Draw arcs 1 and 2 to locate F.

2. Draw perpendicular bisector of AF to locate centers G and H.

3. With compass, make OJ = OG and OK = OH, and draw lines as shown.

4. With compass, draw small arcs from centers G and J and large arcs from centers K and H.

Figure. 1.19 To draw approximate ellipse with compass.

EXERCISE

The problems that follow are to provide practice in using geometrical constructions.

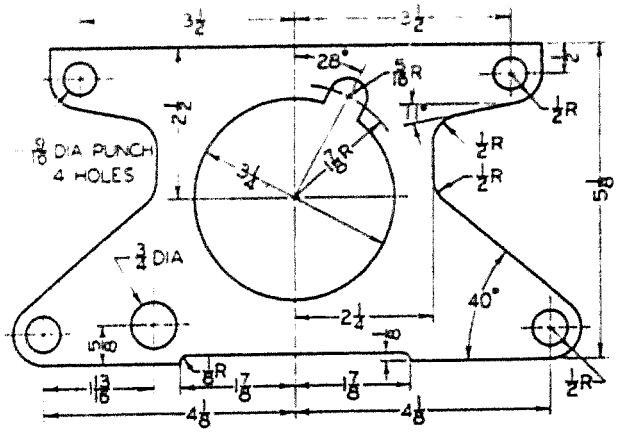


Figure. 1.20 Buick transmission gasket.

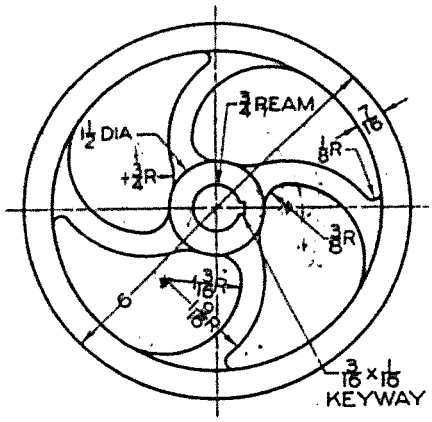


Figure. 1.21 Hand wheel.

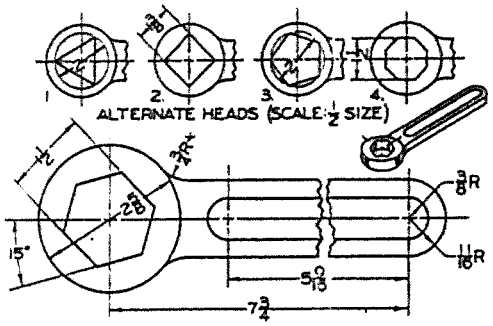
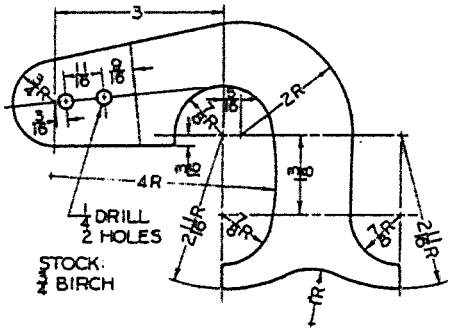
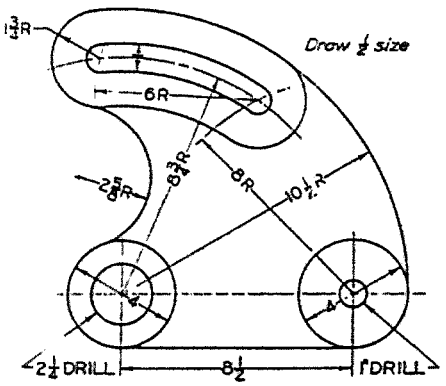


Figure 1.22 Closed End Wrench



Figrue 1.23 Keyhole Saw Handle



Figrue 1.24 Quardrant for Lathe

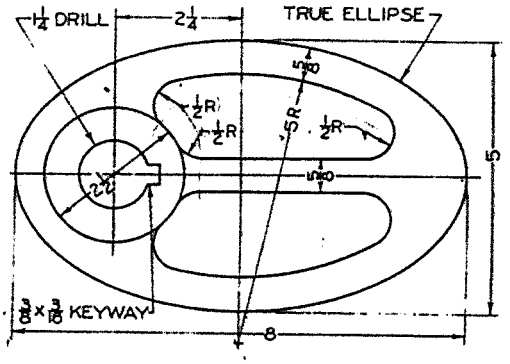


Figure 1.25 Elliptical Cam

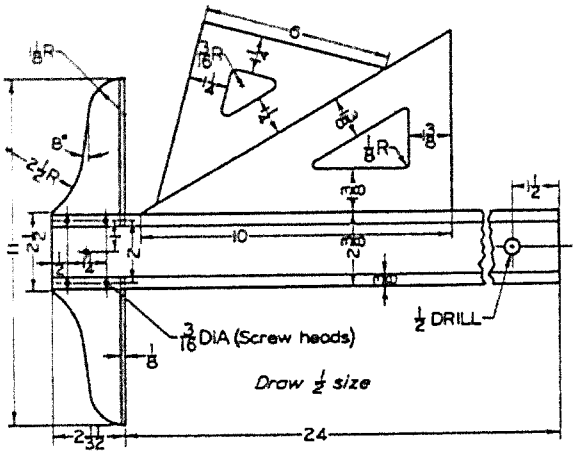


Figure 1.26 T-square and Triangle

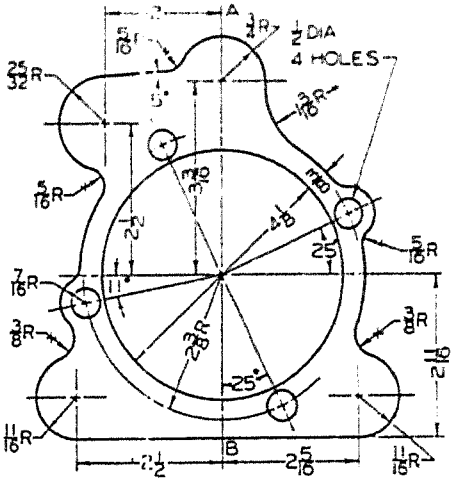
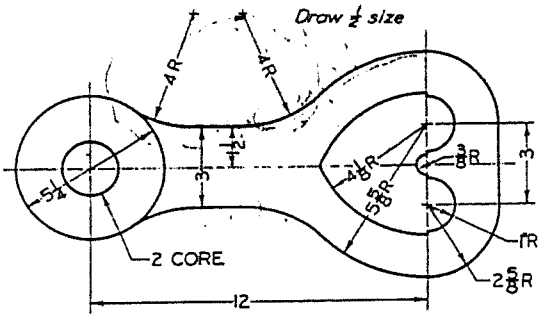


Figure 1.27 Bulck Rear Transmission Gasket



Figrue 1.28 Locomotive Truck Swing Link

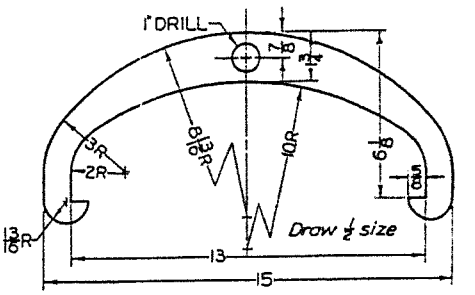


Figure 1.29 Clamp for Laundry Machine

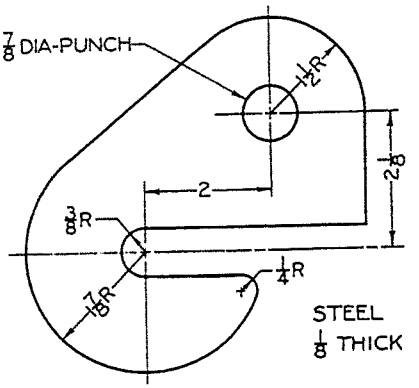


Figure 1.30 Cover Plate

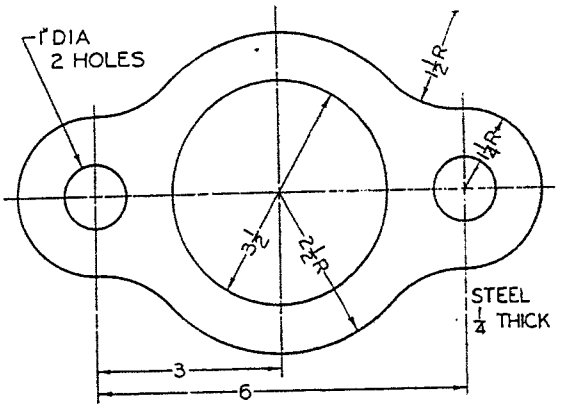


Figure 1.31 Gasket

CHAPTER 2

MULTIVIEW REPRESENTATION AND CONVENTIONAL PRACTICES

2.1 Orthographic Projection (parallel projection)

If the observer is at an infinite distance from the object, the projection lines (projectors) from the eye to the object become parallel to each other and perpendicular to the picture plane. The resulting projection will then be the same shape and size as the front surface of the object. From the practical viewpoint, the projection may be through of as being formed by perpendicular projectors extended from the object to the plane. The view is called an orthographic projection.

Since the view shown in Figure.2.1 (a) does not reveal the thickness of the object, one or more additional projections are necessary to complete the description at (b) and (c).

The picture planes are customarily called the principal or coordinate planes of projection, and the perpendiculars, projectors. In engineering drawing, the planes are usually arranged as shown in Figure.2.1 (a). Since all three are mutually perpendicular, they are called the horizontal, vertical plane 1, and vertical plane 2. It is the usual practice to consider the vertical plane 1 as lying in the plane of the paper to consider the vertical plane 1 as lying in the plane of the paper and horizontal and vertical plane 2 as being revolved into position. (Figure. 2.2)

2.2 First-and Third-angle Projection

If the horizontal and vertical plane 1 are assumed to extend indefinitely on one side of the vertical plane 2, four dihedral angles are formed and are designed as the first, second, third, and fourth angles. The lines of intersection of these planes are called coordinates axes. Their point of intersection is called the origin.

In First Angle Projection the object is placed in first quadrant. Then required vertical planes and horizontal planes are drawn. The object is placed between the plane and the eye (draftsman).

Three planes of projection, VP.1, VP.2, and HP which are 90° to each other, are erected as shown in Figure.2-4. The object is suspended between them with face F parallel to VP.1.

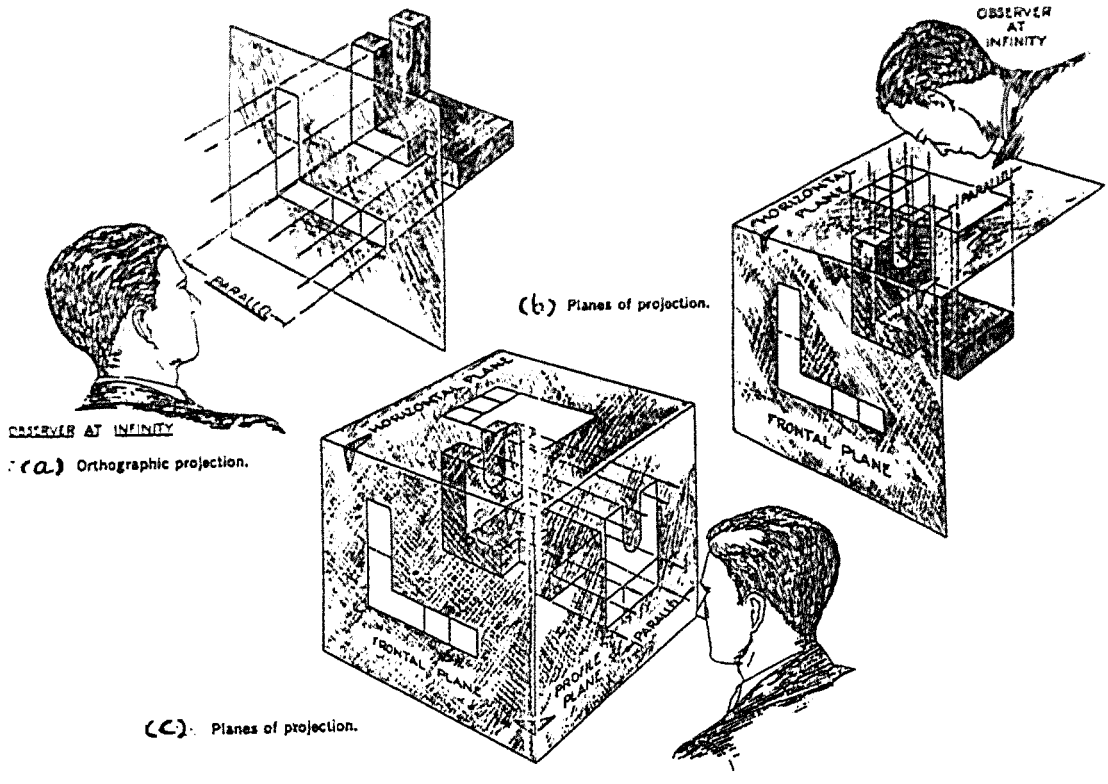


Figure. 2.1 Orthographic and planes of projection

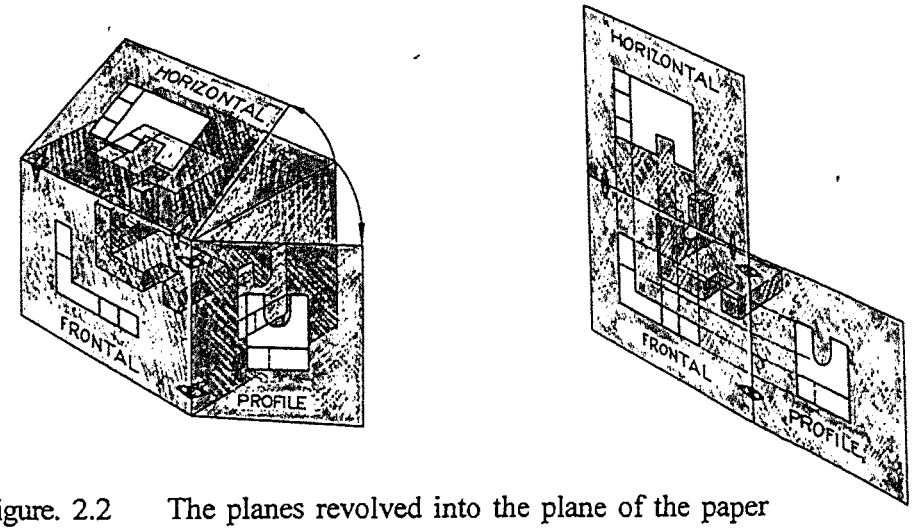


Figure. 2.2 The planes revolved into the plane of the paper

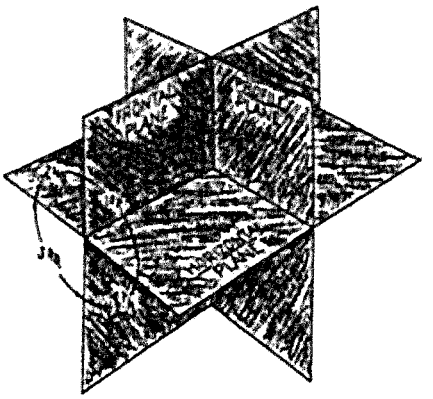


Figure. 2.3 Planes of projection

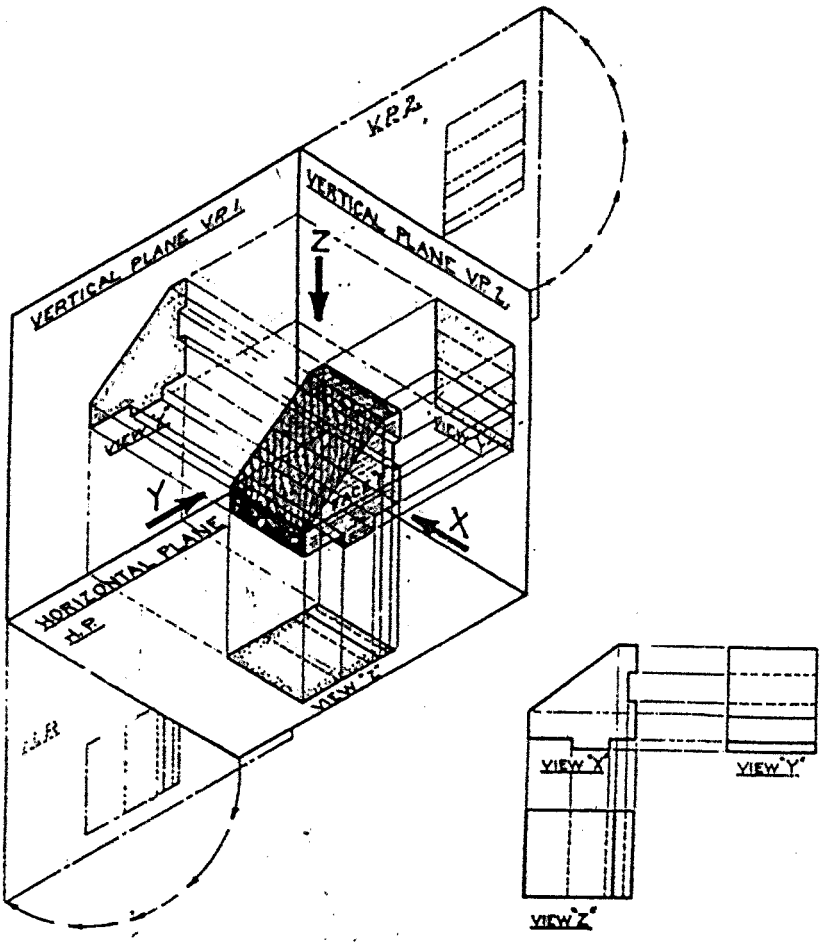


Figure. 2.4 First angle projection

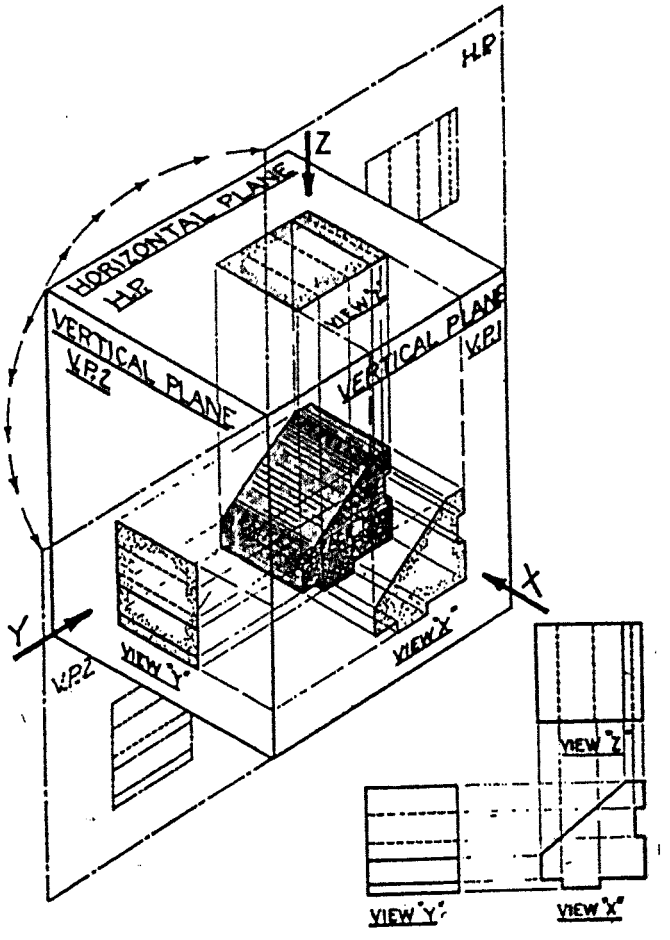


Figure. 2.5 Third Angle Projection

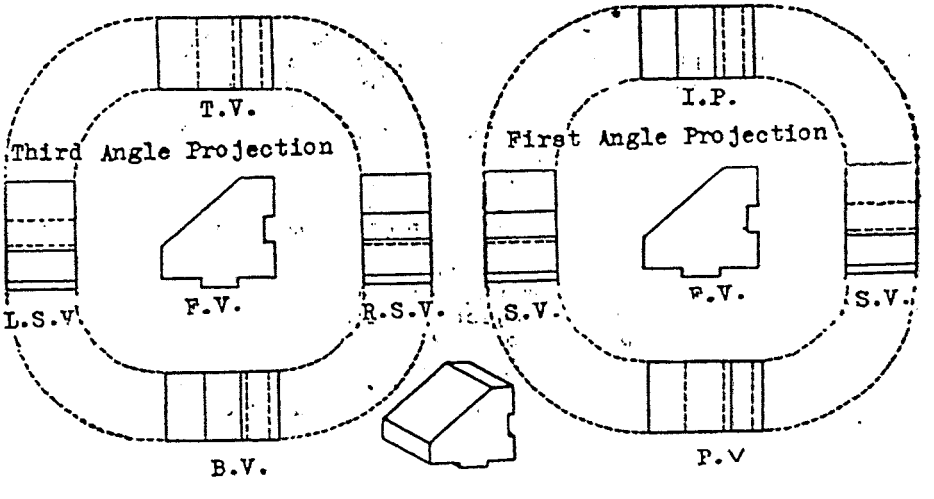


Figure. 2.6 Comparison between first and third angle projection

Initial viewing is in the direction of the Arrow X perpendicular to VP.1 and the view X is projected upon this plane by means of projectors which are parallel to each other and normal to the plane.

In a similar fashion, view Y can be projection upon the plane VP.2 by parallel projectors which are normal to this plane, viewing in the direction of the arrow Y perpendicular to VP.2. When viewed in this direction, certain edged of the block are not visible to the viewer, and these hidden edges of the block are not visible to the viewer, and these hidden edges are conventionally indicated on view Y by dotted lines.

When the object is viewed in the direction of the arrow Z-perpendicular to HP - the view Z can be projected upon the horizontal plane, the projectors again being parallel to each other and normal to the plane.

Third Angle Projection. In this projection, the object is placed in third quadrant. Then required views is draw on the plane which is placed between the object and the eye.

Three planes of projection, VP.1, VP.2, and HP which are at 90° to each other, are erected as shown in Figure.2-5. The objects is suspended between these planes with face F parallel to VP.1. The position of the objects remains unalterted throughout all subsequent operations.

When dealing with third angle projection it is necessary to consider transparent planes. Viewing is initally in the direction of arrow X perpendicular to VP.1, and the view X is projectied back on to this plane by means of parallel projectors which are normal to the plane. Similarly view Y projected on to VP.2, View Z on to HP viewing in the direction of arrow Y and Z respectively.

2.3 The Natural Method of Obtaining the Views

Three principle views of an object, the front, top, and side view were obtained by looking directly at the front, top, and right side, respectively. The observer's position was fixed while the position of the object was changed for each view (Figure.2-7).

The top view is vertically above the front view, and the side view is horizontally in line with the front view.

2.4 The Glass Box Method of Obtaining the Views

It may be considered that planes of projection placed parallel to the six faces of an object form an enclosing "glass box" (see Figure.2.8 (a)). The observer views the enclosed object from the outside. The views are obtained by running projectors from points on the object to the planes.

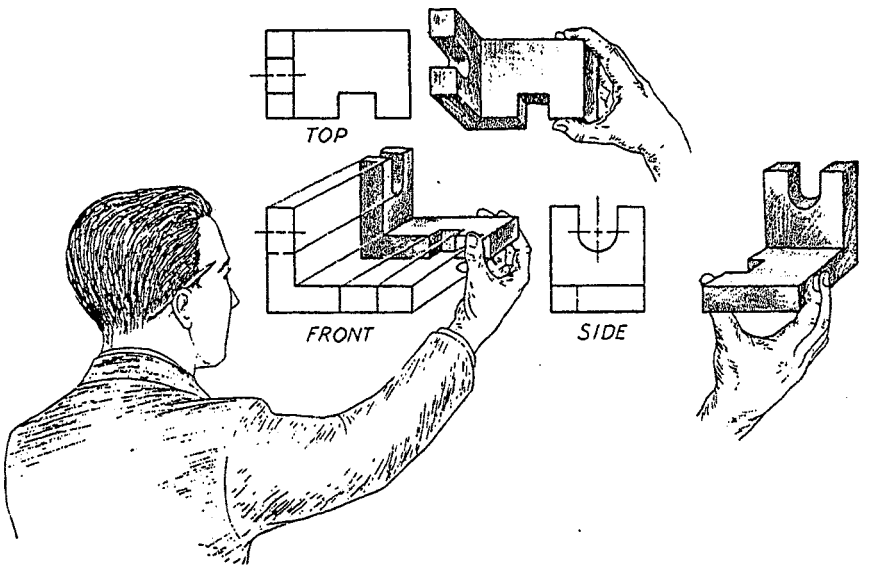


Figure. 2.7 Obtaining three views of an object

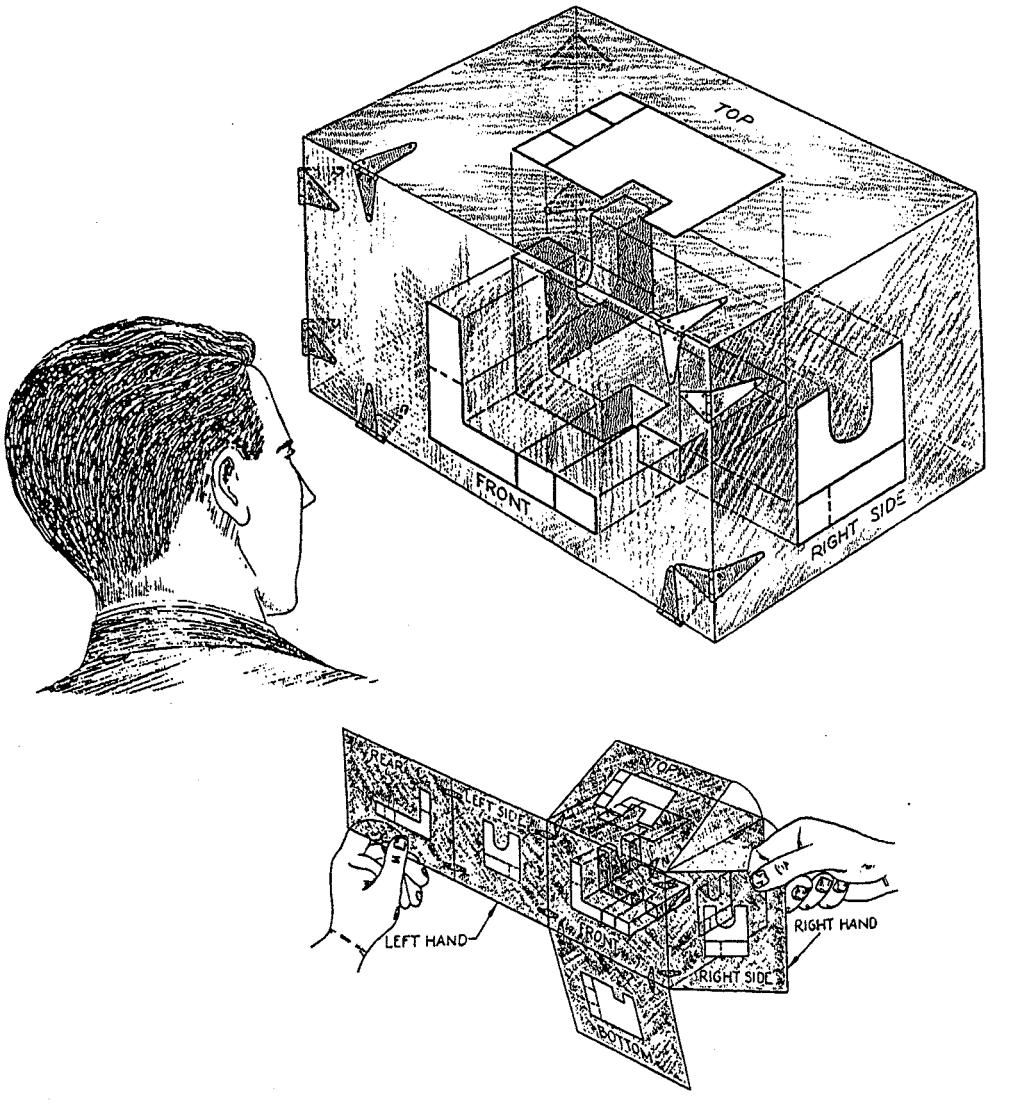


Figure. 2.8 The glass box and its opening

Since the projections on the sides of the three-dimensional transparent box are to appear on a sheet of drawing paper, it must be assumed that is hinged (see Figure. 2.8 (b), so that when it is opened outward into the plane of the paper, the planes assume the position illustrated in Figure.2.9.

In accordance with universally recognized assumption, the top projection must take a position directly above the front projection, and the right side projection must lie horizontally to the right of the front projection. Ordinarily, only three of these views (front, top, and right side) are necessary. A bottom or rear view will be required in comparatively few cases.

2.5 The Principles of Multiview Drawing

The following principles should be studied carefully and understood thoroughly before any attempt is made to prepare an orthographic drawing;

1. The front and top views are always in line vertically. (Figure.2-7)
2. The front and side views are in line horizontally.
3. The front of the object in the top view faces the front view. (Figure. 2-8)
4. The front of the object in the side view faces the front view. (Figure.2-9)
5. The depth of the top view is the same as the depth of the side view (or views). (see Figure.2-10).
6. The width of the top view is the same as the width of the front view. (Figure. 2-10).
7. The height of the side view is the same as the height of the front view. (Figure. 2-10).
8. A view taken from above is a top view and must be drawn above the front view. (Figure. 2.9).
9. A view taken from the right, in relation to the selected front is a right -side view and must be drawn to the right of the front view. (Figure.2.10).
10. A view taken from the left is left-side view and must be drawn to the left of the front view. (Figure.2.10).
11. A view taken from below is a bottom view and must appear below the front view. (Figure. 2.10).

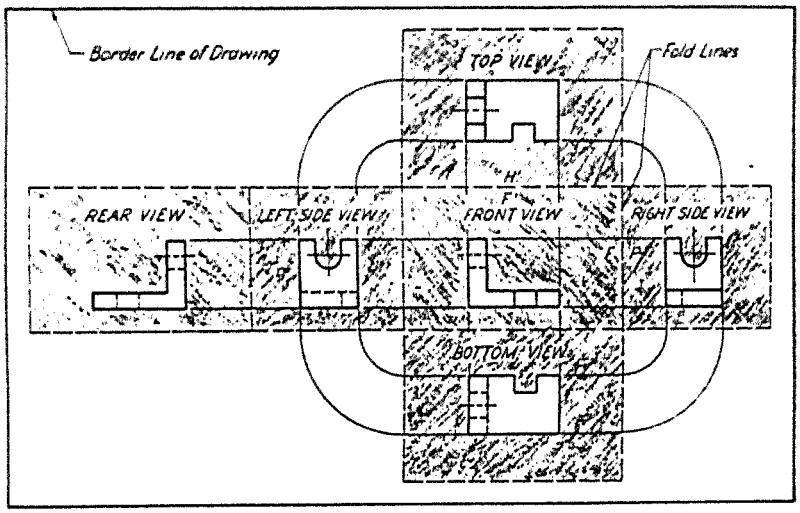


Figure. 2.9 Six views of an object on a sheet of drawing paper

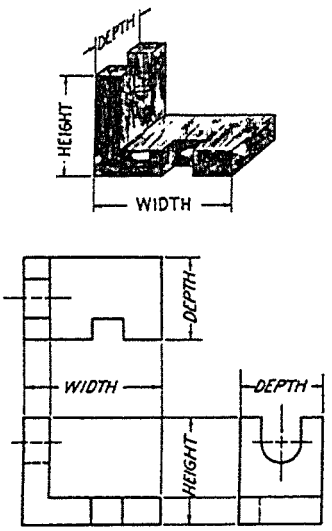


Figure. 2.10 View terminology

2.6 Projection of Lines and Surface

A line may project either in true length, foreshortened, or as a point in a view depending upon its relationship to the projection plane upon which the view is projected. (see Figure. 2.11).

A surface will always project as a line or as area on a view. The area representing the surface may be either a full-size or foreshortened representation.

Note that: (1) when a surface is parallel to a plane of projection, if will appear in true size in the view on the plane of projection to which it is parallel; (2) when it is perpendicular to the plane of projection, it will project as a line in the views; and (3) when it is positioned at an angle, it will appear foreshortened.

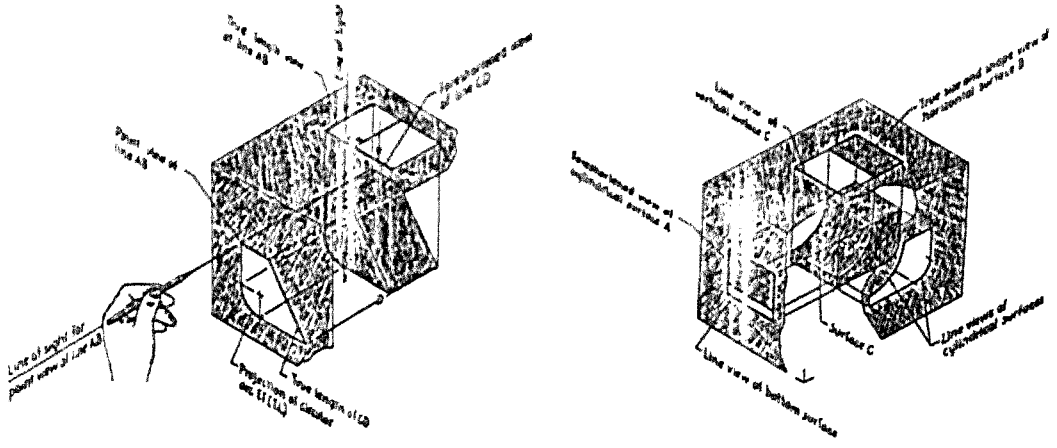


Figure. 2.11 Projected views of lines and surfaces

2.7 Analysis of Surfaces, Lines, and Points in Three Principal Views

An analysis of the representation of the surfaces of a mutilated block is given pictorially in Figure. 2.12. It can be noted that each of the surface A, B, and C appears in true size and shape in one view, and as a line in each of the either two related views. Surface D, which is inclined with foreshortened length in the top and side views, and as an inclines line in the front view.

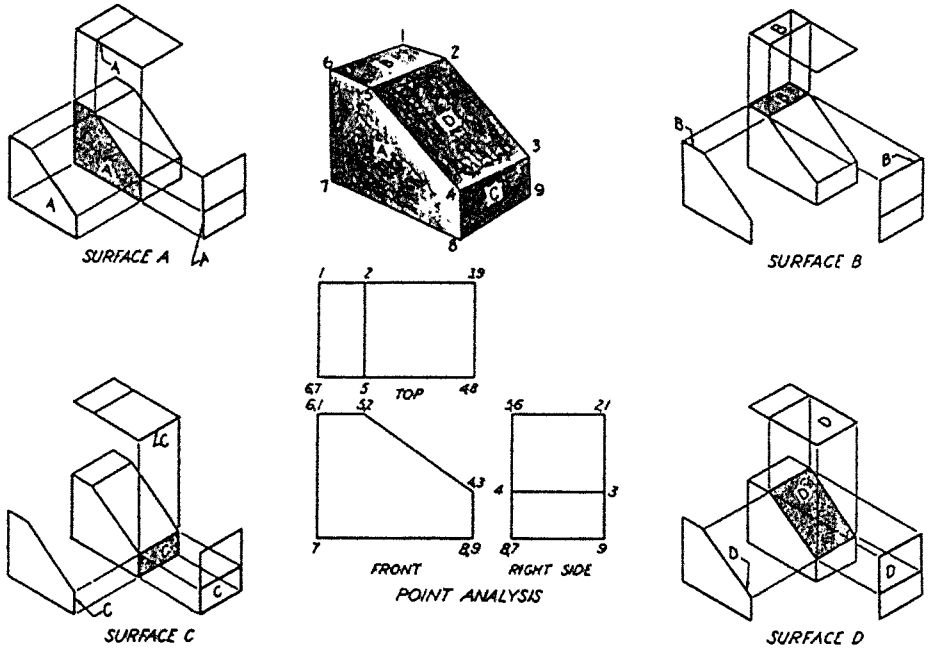


Figure. 2.12 Analysis of surfaces, lines, and points

2.8 The Selection of Views by Elimination

Careful study should be given to the outline of an object before the views are selected. Only those views that are necessary for a clear and complete description should be selected. Superfluous views should be avoided.

Necessary views for drawing that are required (one or two or three views) are shown in the following figures.

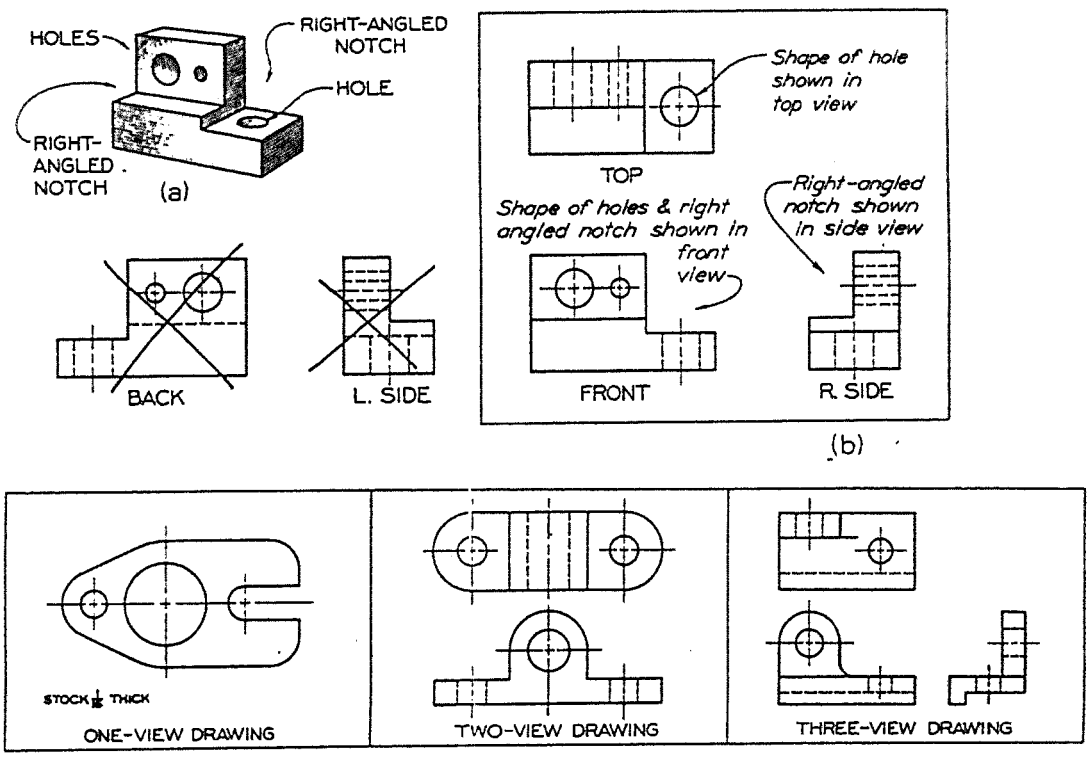


Figure. 2.13 Necessary views

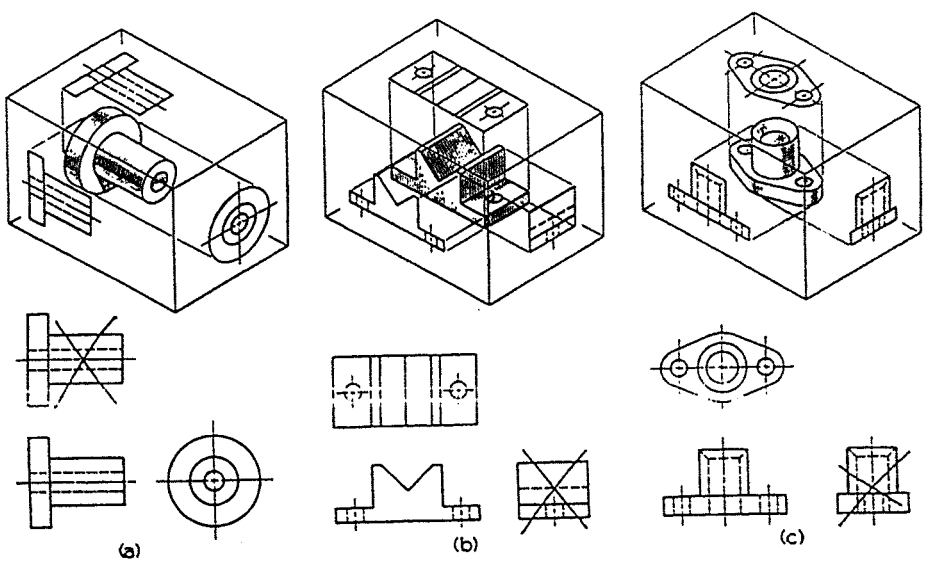


Figure. 2.14 Two-views drawing

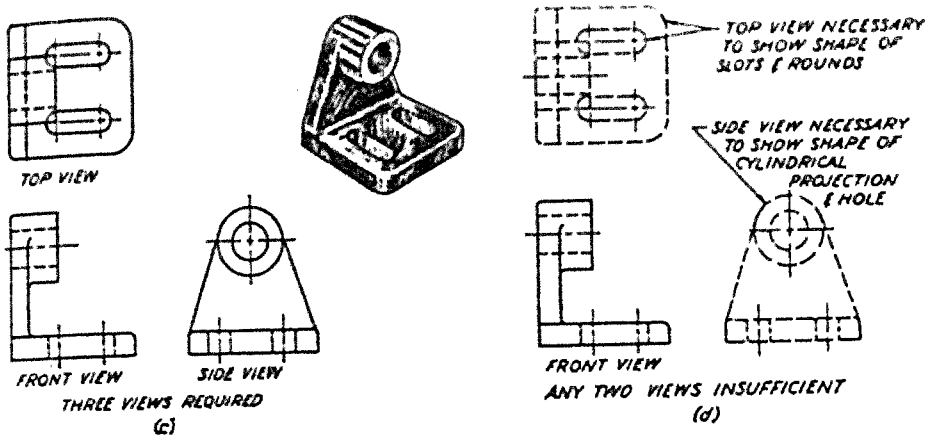


Figure. 2.15 Three-views drawing

2-9 Hidden Lines or Invisible Lines and Their Treatment

Dotted lines are used on an external view of an object to represent surfaces and intersections invisible at the point from which the view is taken.

An invisible line always starts with a dash in contact with the object line from which it starts, unless it forms a continuation of a visible line. (see Figure.2-17C).

The correct and incorrect treatment are shown in figures below.

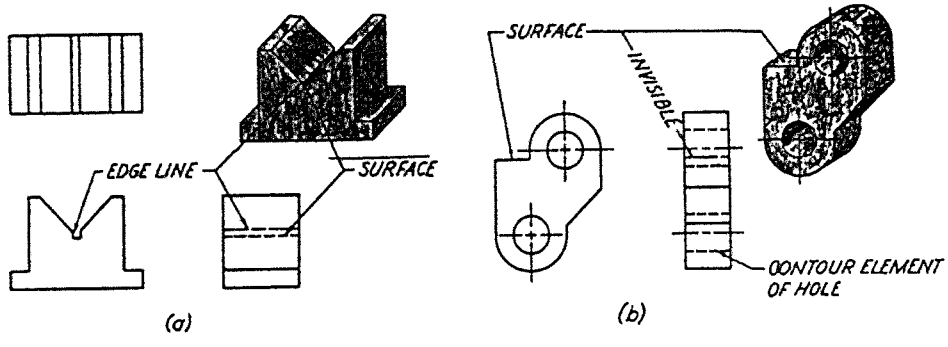


Figure. 2.16 Hidden lines or invisible lines

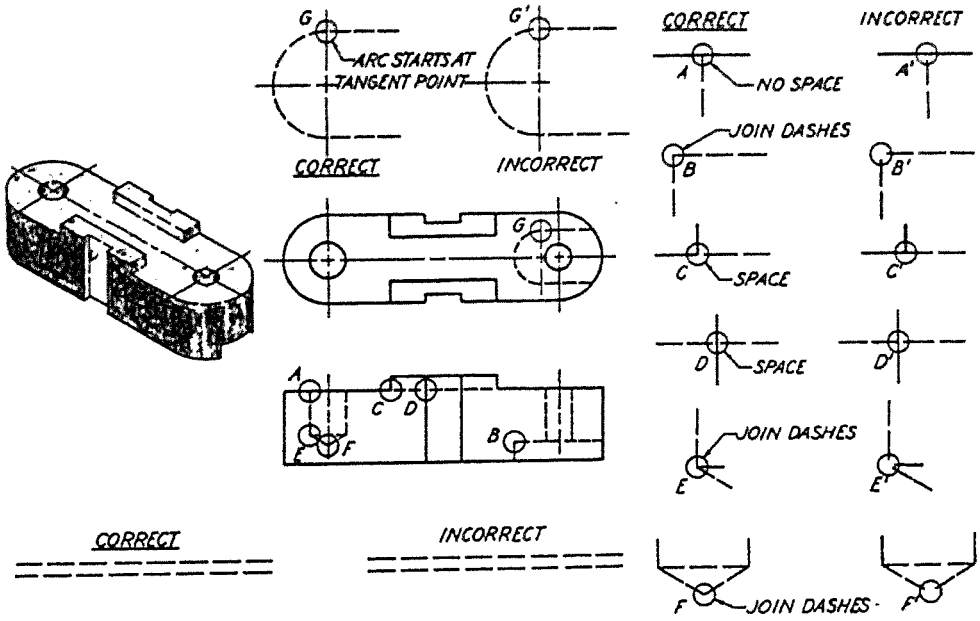


Figure. 2.17 Treatment of hidden or invisible lines

2.10 Precedence of Lines

Solid lines (visible object lines) take precedence over all other lines.

Dashed lines (hidden lines) take precedence over center lines.

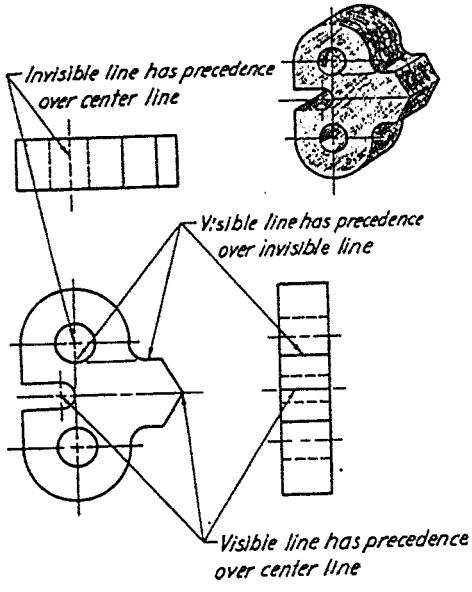


Figure. 2-18 Precedence of lines

A cutting plane line takes precedence over a center line where it is necessary to indicate the position of C.P.

2.11 To Make an Orthographic Drawing

The location of all views should be determined before a drawing is begun. Construct the views simultaneously by projecting back and forth from one view to the other.

The general outline of the views should be drawn lightly with a hard pencil and then heavied with a medium grade pencil.

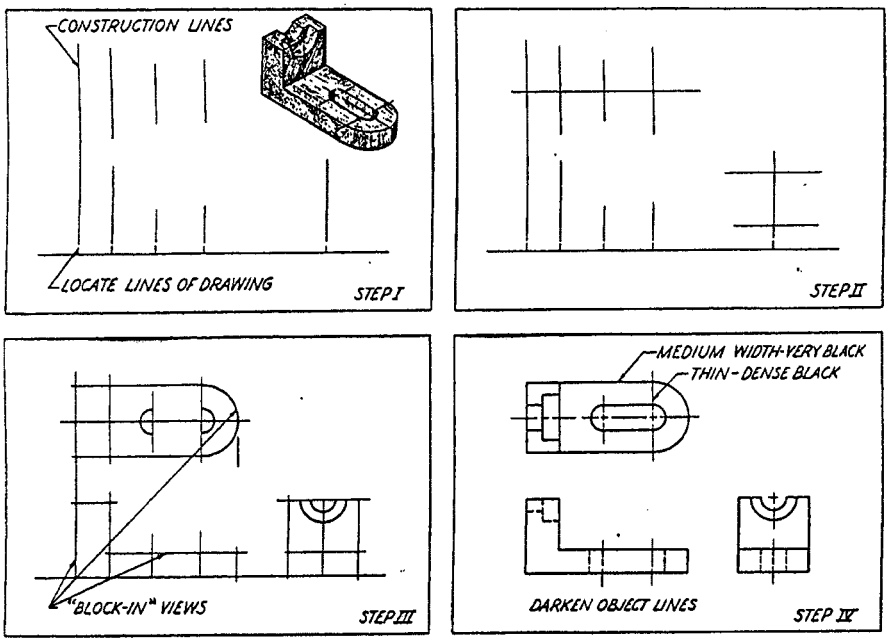


Figure. 2.19 Steps in making a three-view drawing of an object

Although a 45° mitre line is sometimes used for transferring depth dimensions from the top view to the side view or vice versa, as shown in Figure. 2-20 (b) it is better practice to use dividers, as in (a)

The object lines should be very dark and bright, ½" dashes and $^1/_{32}$ in. spaces are recommended for hidden lines. Center lines consists of alternative long dashes (¾" to 1½" long), the short dashes ($^1/_8$"), and the spaces ($^1/_{32}$ in). The following technique is recommended in drawing center line:

1. Where center lines cross, the dashes should intersect symmetrically.
2. The breaks should be so located that they will stand out and allow the center line to be recognized as such.
3. Center lines should extend approximately ½" beyond the outline of the part whose symmetry they indicate.
4. Center lines should not end at object lines.
5. Center lines which are aligned with object lines should not have less than $^1/_{32}$ in. space between the end of the center line and the object line.

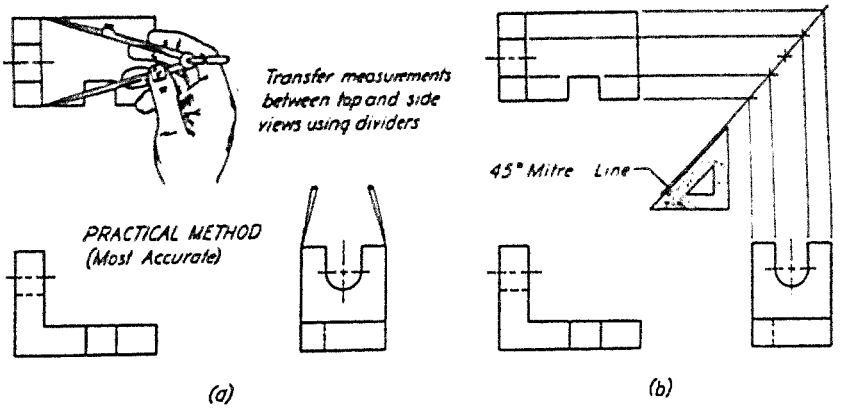


Figure. 2.20 Method for transferring depth dimensions

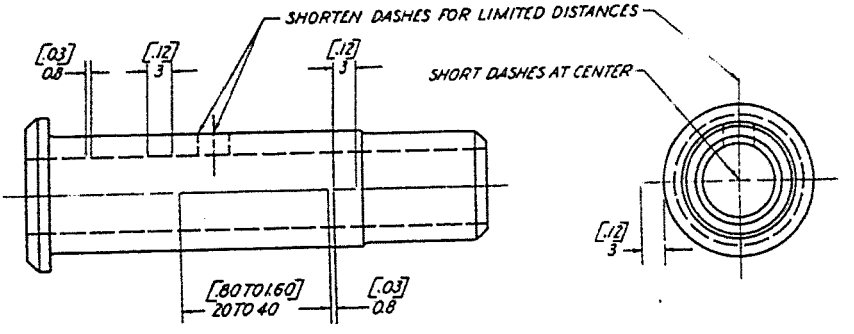


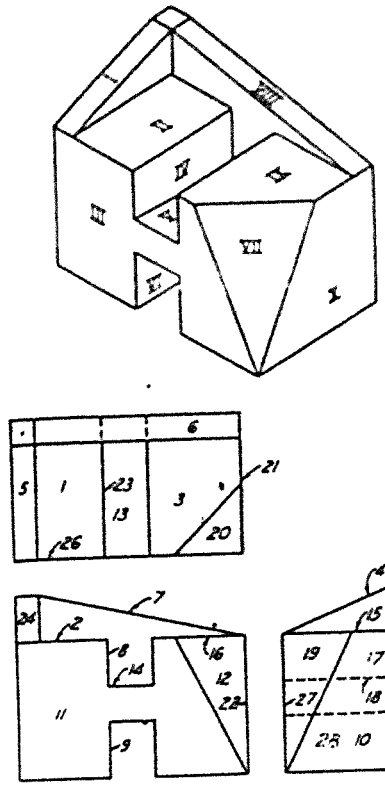
Figure. 2.21 Hidden lines and center lines

2.12 Analysis of Reading the Three Views

Fig. 2.22 shows a pictorial drawing, three views orthographic drawing and a table for analyzing

2.13 Representation of Holes

Machined holes are either drilled, drilled and reamed, drilled and countersunk, drilled and counterbored, or drilled and spotfaced. The form may be completely specified by a note attached to the view showing the circular contour (see Fig. 2.23)



SURFACE NUMBER ON PICTORIAL	PROJECTS AS LINE OR SURFACE		
	NUMBER ON TOP VIEW	NUMBER ON FRONT VIEW	NUMBER ON END VIEW
I	5	24	4
II	1	2	15
III	26	11	27
IV	23	8	17
V	13	14	18
VI	23	9	28
VII	20	12	19
VIII	6	7	25
IX	3	16	15
X	21	22	10

Figure. 2.22 Lines and surfaces

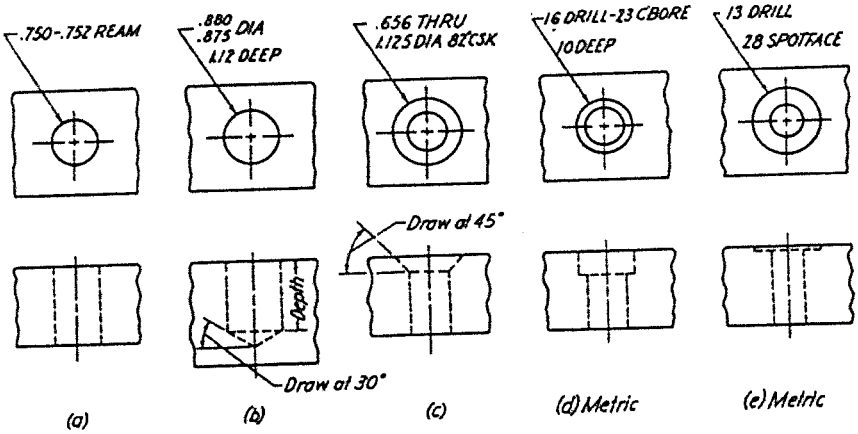


Figure. 2.23 Representation of holes

2.14 Representation of Fillets and Rounds

Interior corners, which are formed on a casting by unfinished surfaces, always are filled in (filleted) at the intersection in order to avoid possible fracture at that point. Sharp corners are also difficult to obtain and are avoided for this reason as well.

Exterior corners are rounded for appearance and for the comfort of persons who must handle the part when assembling or repairing the machine on which the part is used. A rounded internal corner is known as a fillet; a rounded external corner is known as a round. The generally accepted methods of representing intersecting fillets and rounds are illustrated in Fig. 2.24.

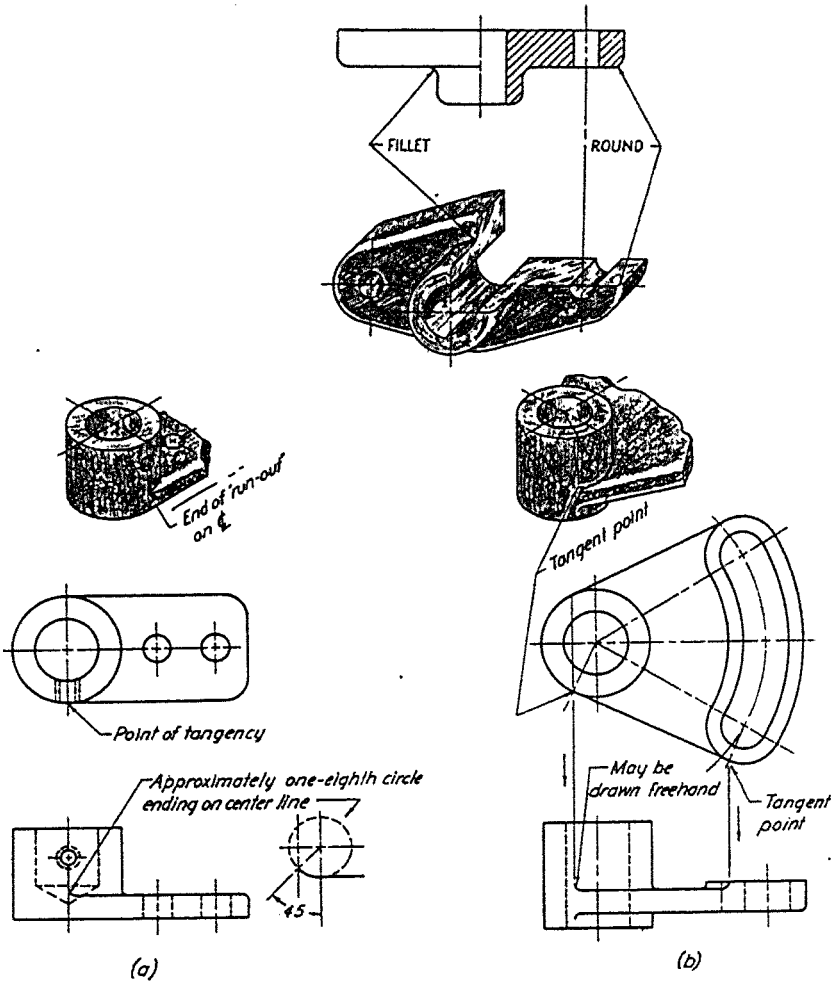
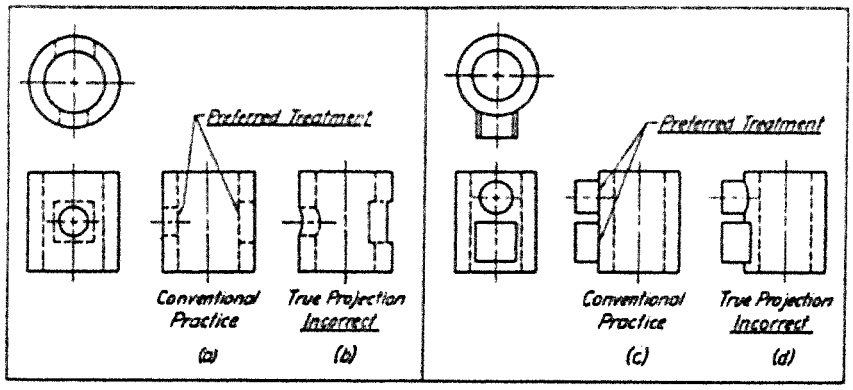


Figure. 2.24 Fillets and rounds

2.15 Conventional representation of intersections relief, neck, or under cut



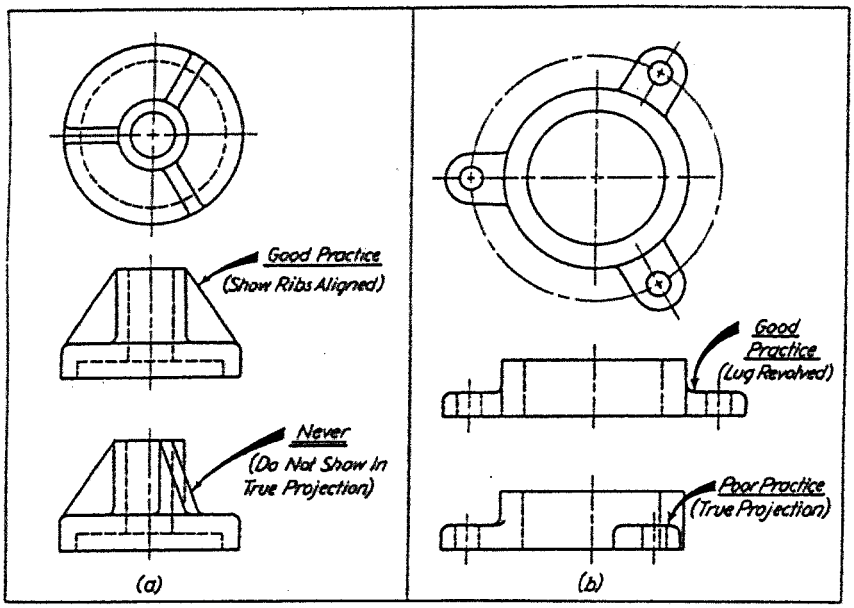


Figure. 2.25 Conventional practice of representing unimportant intersections, ribs, and lugs

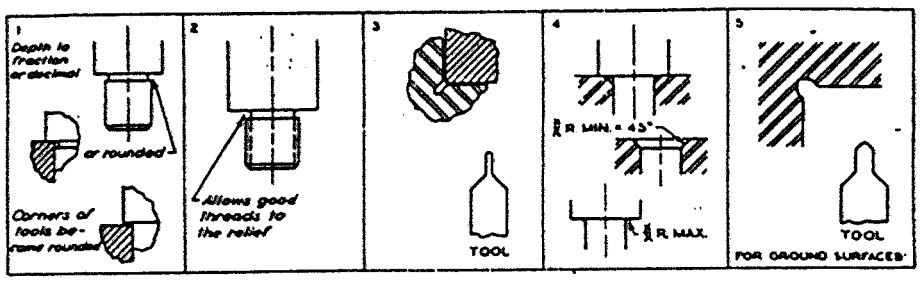


Figure. 2.26 Relief, neck, or undercut

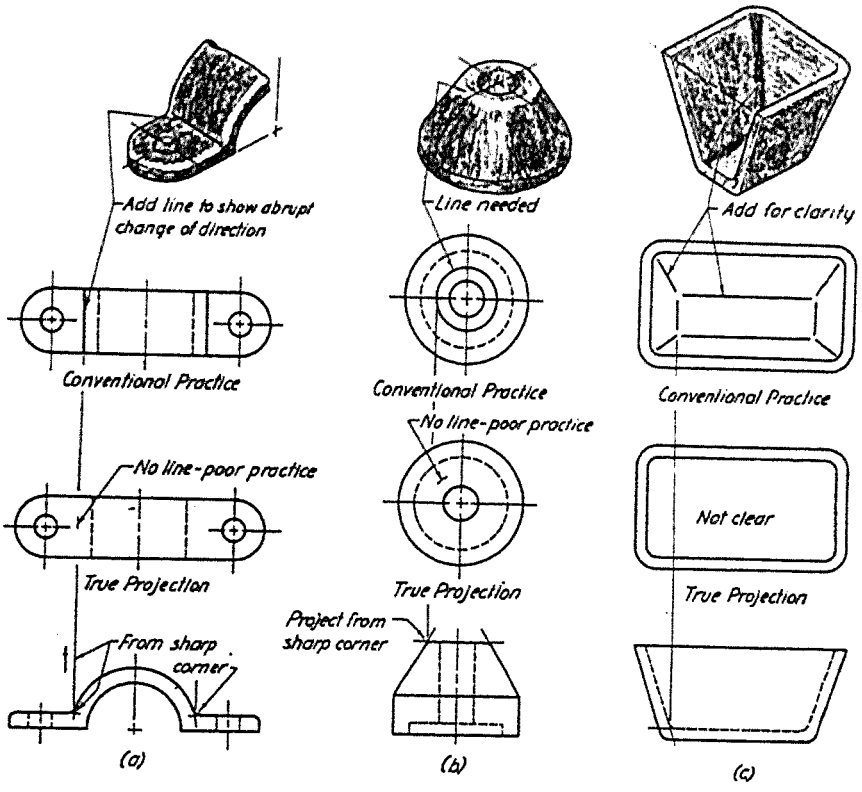


Figure 2.27 Conventional practice of representing nonexisting of intersection

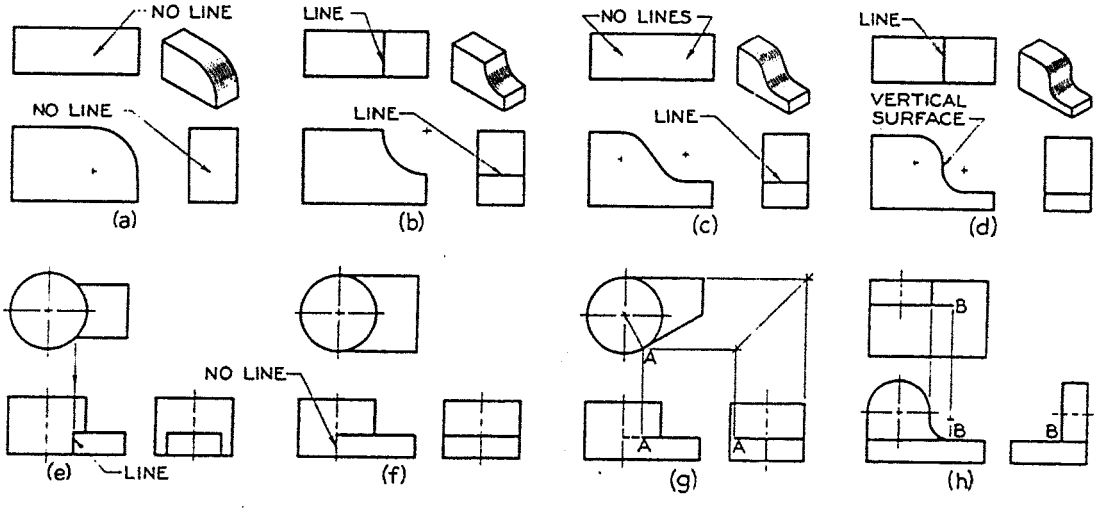


Figure 2.28 Intersections and tangencies

EXERCISES

Draw necessary views for the following problems with instruments. Omit dimensions unless assigned.

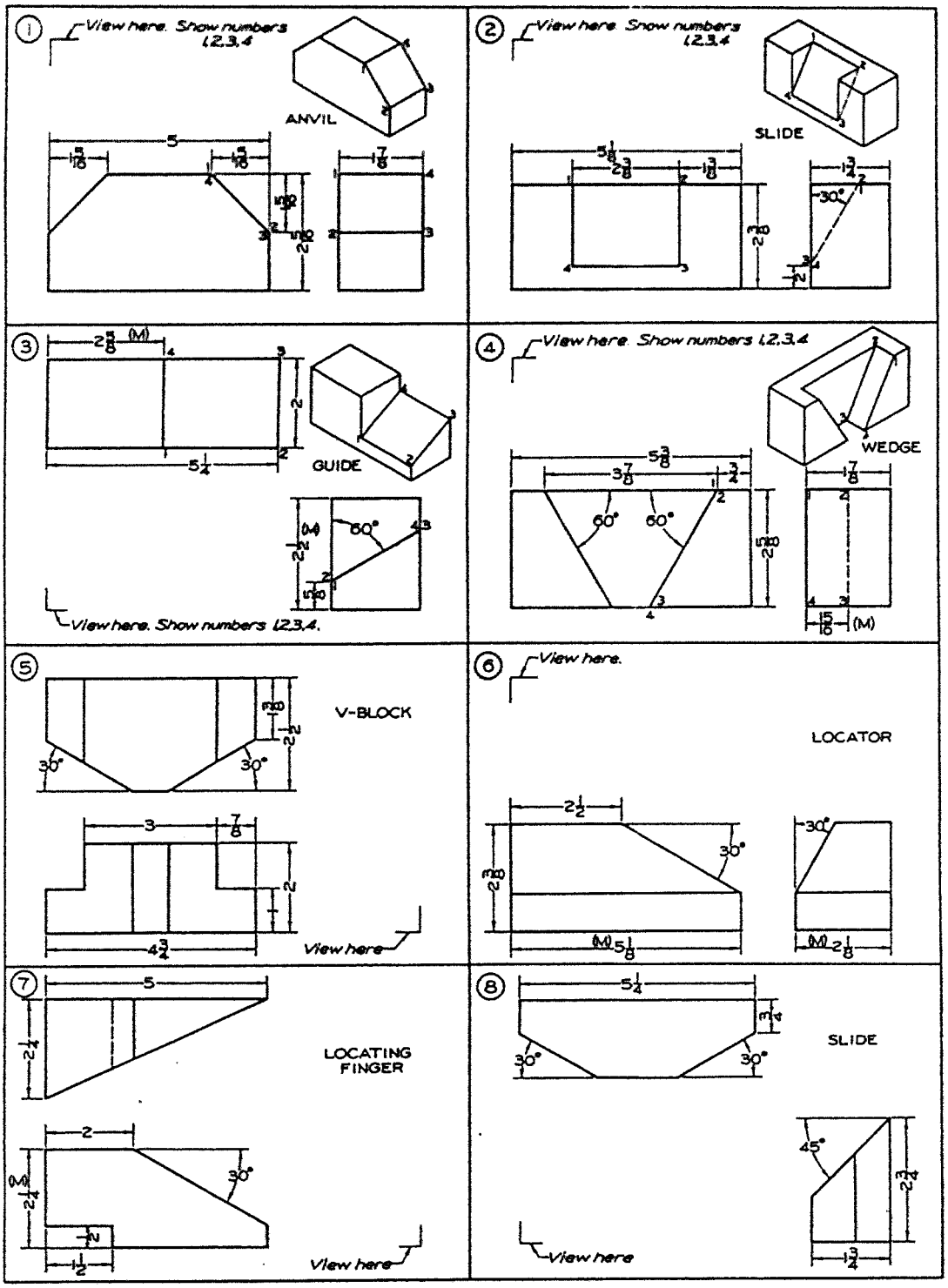


Figure. 2.29 Necessary views constructions

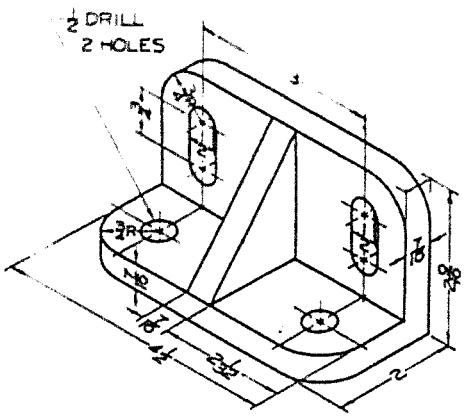


Figure. 2.30 Base bracket

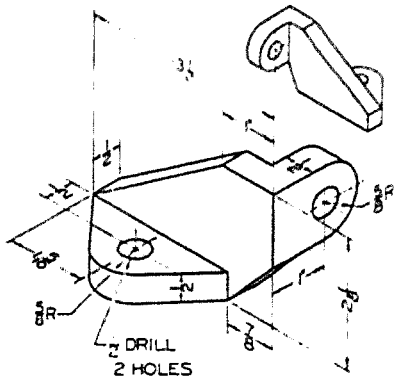


Figure. 2.31 Angle bracket

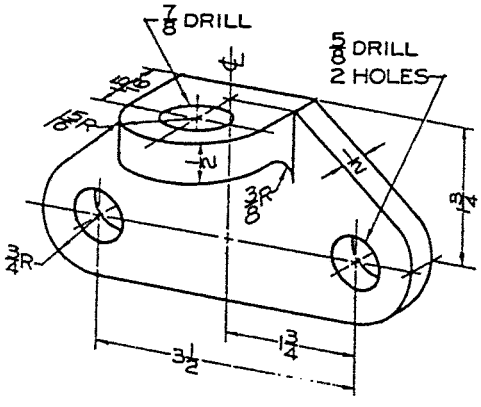


Figure. 2.32 Guide

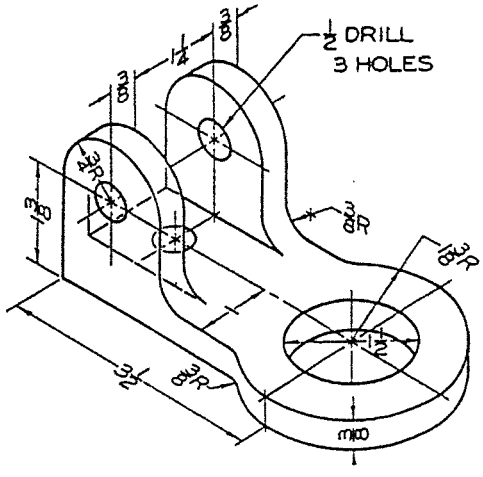


Figure. 2.33 Actuator base

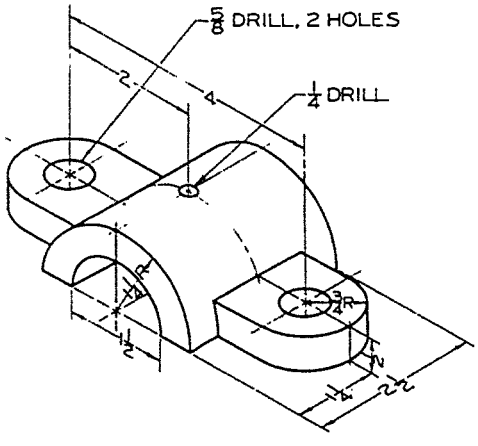


Figure. 2.34 Bearing cam

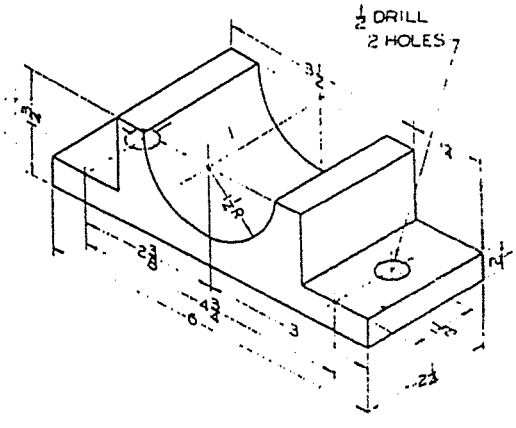


Figure. 2.35 Trunion block

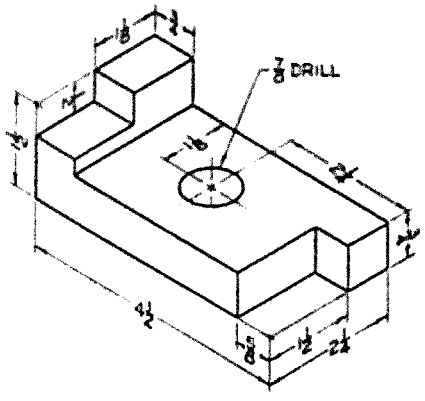


Figure. 2.36 Bearing plate

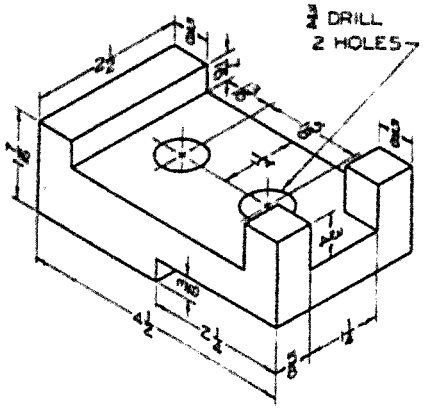


Figure. 2.37 Cross base

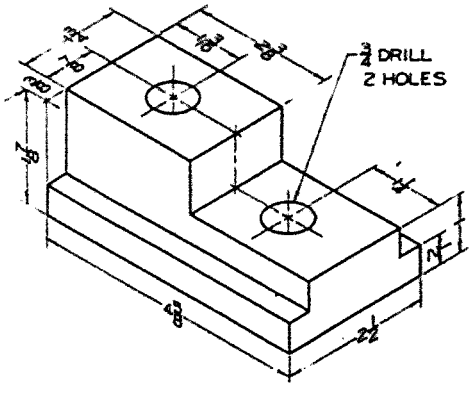


Figure. 2.38 Cutter holder shoe

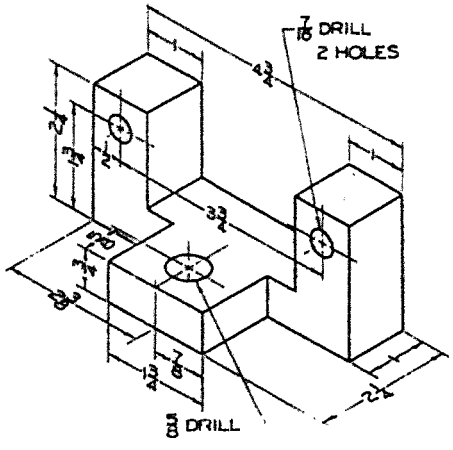


Figure. 2.39 Stating catch.

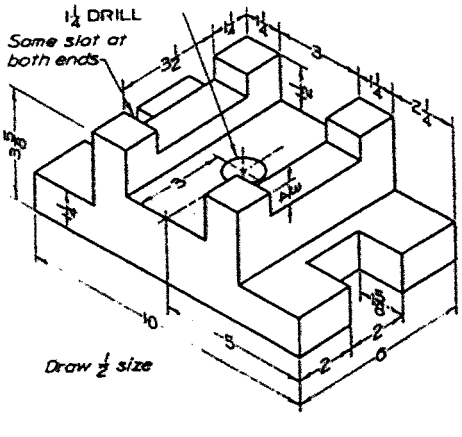


Figure. 2.40 Fixture base

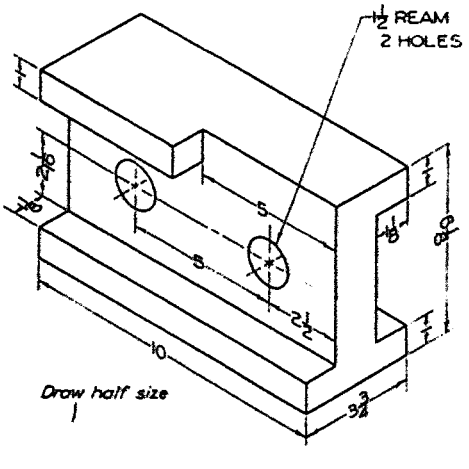


Figure. 2.41 Bed plate

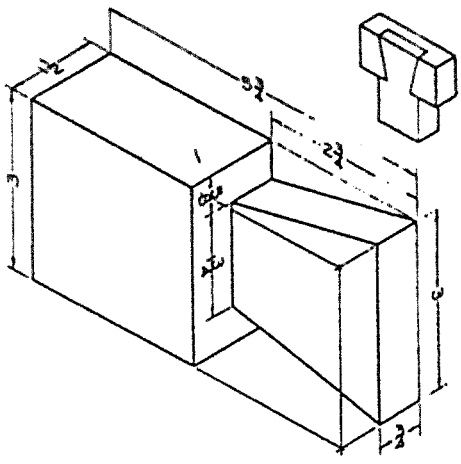


Figure. 2.42 Lap dovetail

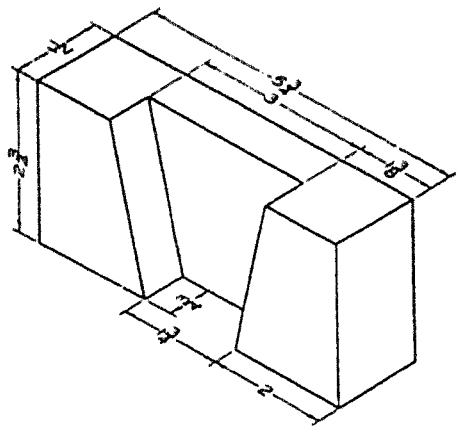


Figure. 2.43 Lap dovetail

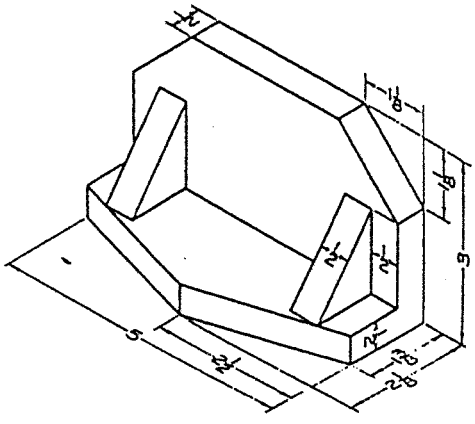


Figure. 2.45 Book end

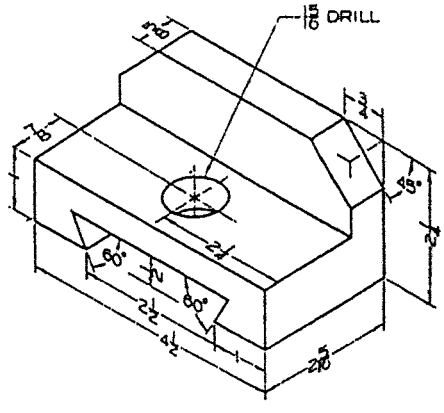


Figure. 2.44 Dovetail slide

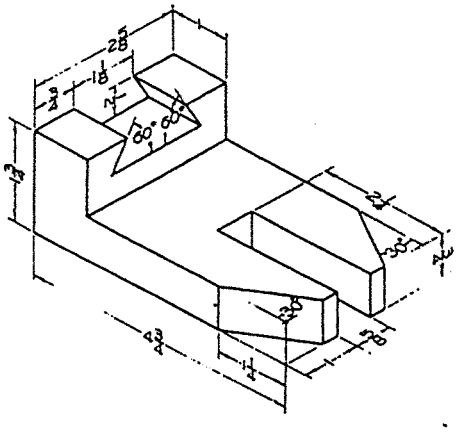


Figure. 2.46 Dovetail finger

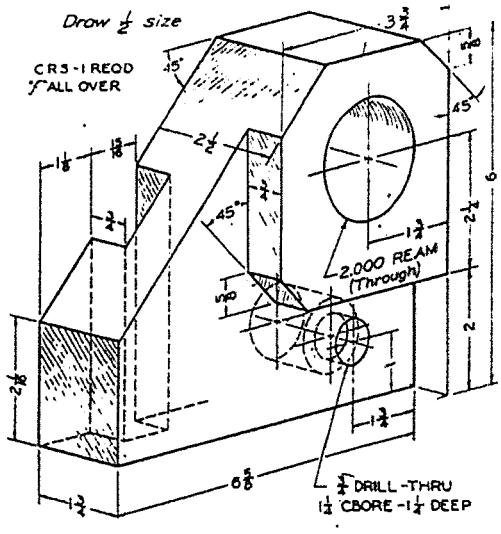


Figure. 2.47 Guide base