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ABSTRACT

This study guide is part of a program of studies entitled Science and Engineering Technician (SET) Curriculum. The SET Curriculum was developed for the purpose of training technicians in the use of electronic instruments and their applications. It integrates elements from the disciplines of chemistry, physics, mathematics, mechanical technology, and electronic technology. This guide provides basic information related to the following topics: (1) lettering and use of equipment; (2) geometrical construction; (3) sketching and shape description; (4) multiview projection; (5) auxiliary views; (6) sectional views; (7) drawing; and (8) charts and graphs. (Author/SK)

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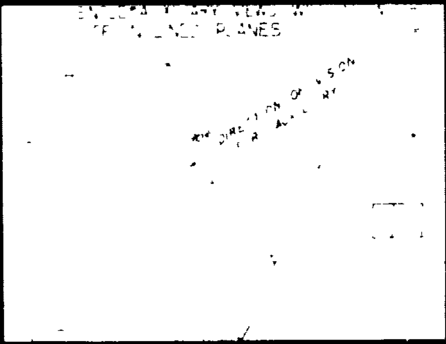

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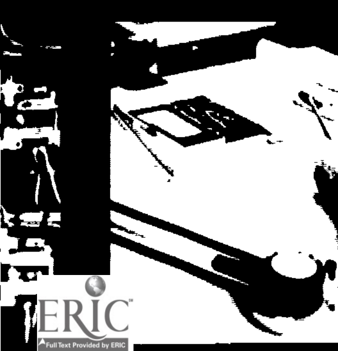

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This study guide is part of a program of studies entitled the Science and Engineering Technician Curriculum. The SET curriculum was developed for the purpose of training technicians in the use of electronic instruments and their applications. It integrates elements from the disciplines of chemistry, physics, mathematics, mechanical technology, and electronic technology.

Science and Engineering Graphics I provides basic information related to the following topics: (1) lettering and use of equipment; (2) geometrical construction; (3) sketching and shape description; (4) multiview projection; (5) auxiliary views; (6) sectional views; (7) basic dimensions; (8) electrical and electronic drafting; (9) welding drawing; (10) pipe drawing; and (11) charts and graphs.

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SCIENCE AND ENGINEERING GRAPHICS I

A STUDY GUIDE OF THE SCIENCE AND ENGINEERING TECHNICIAN CURRICULUM

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CHAPTER I

Introductory Topics

SECTION 1-1 LETTERING

Lettering on technical drawings should be of the single-stroke gothic style and of such quality that a clear diazo print can be made without loss of clarity. The letters may be vertical or inclined but should not be mixed on the drawing. While lower-case letters are used on some drawings, it is accepted practice to use all capitals on drawings related to mechanical or equipment industries. The heights of letters used should vary between the approximate values of 3/32" and 9/32" for different applications but otherwise be uniform and generally independent of drawing size. Figures 1.3 and 1.4 show the style and size lettering recommended by the United States of America Standards Institute.

Figure 1.1 Background area between letters should be uniform.

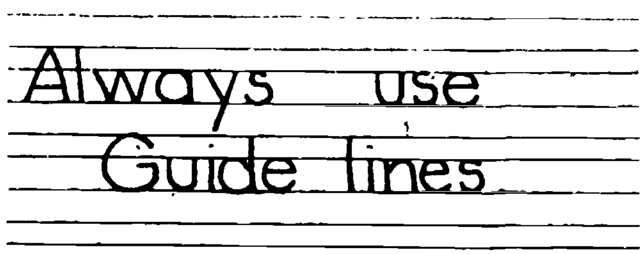

Figure 1.2 Always use guide lines.

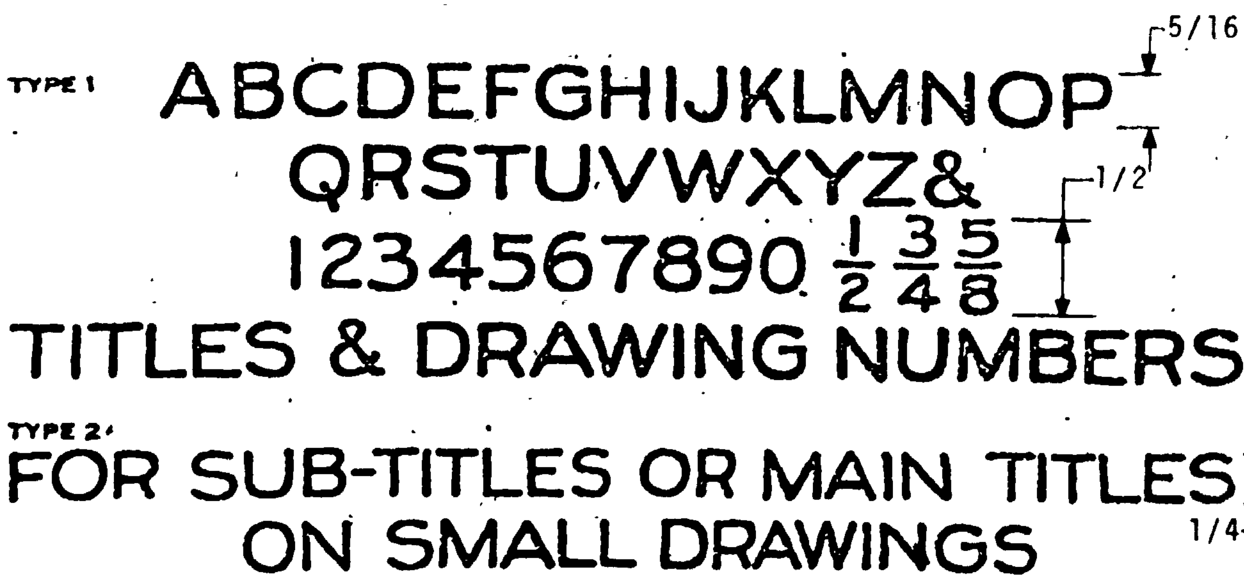

Figure 1.3

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TYPE 3 ABCDEFGHIJKLMNOPQRSTUVWXYZ& 5/32

1234567890 $\frac{1}{2}$ $\frac{3}{4}$ $\frac{5}{8}$ $\frac{9}{32}$ 9/32

FOR HEADINGS AND PROMINENT NOTES

TYPE 4 ABCDEFGHI [illegible]

1234567890 $\frac{1}{2}$ $\frac{3}{4}$ $\frac{5}{8}$ $\frac{23}{64}$

FOR BILLS OF MATERIAL, DIMENSIONS & GENERAL NOTES

TYPE 5

OPTIONAL TYPE SAME AS TYPE 4 BUT USING TYPE 3 FOR FIRST LETTER OF PRINCIPAL WORDS. MAY BE USED FOR SUB-TITLES AND NOTES ON THE BODY OF DRAWINGS.

TYPE 6 abcdefghijklmnopqrstuvwxyz

Type 6 may be used in place of Type 4 with capitals of Type 3.

Figure 1.3 (cont.)

TYPE 1 *ABCDEFGHIJKLMNOP QRSTUVWXYZ&* 5 2

1234567890 $\frac{1}{2}$ $\frac{3}{4}$ $\frac{5}{8}$ $\frac{7}{16}$

TO BE USED FOR MAIN TITLES & DRAWING NUMBERS

TYPE 2 *ABCDEFGHIJKLMNOPQR STUVWXYZ&*

1234567890 $\frac{13}{64}$ $\frac{5}{8}$ $\frac{1}{2}$

TO BE USED FOR SUB-TITLES

Figure 1.4

ERIC

TYPE 3 ABCDEFGHIJKLMNOPQRSTUVWXYZ&

1234567890 $\frac{1}{2}$ $\frac{3}{4}$ $\frac{5}{8}$ $\frac{7}{16}$

FOR HEADINGS AND PROMINENT NOTES

TYPE 4 ABCDEFGHIJKLMNOPQRSTUVWXYZ&

1234567890 $\frac{1}{2}$ $\frac{1}{4}$ $\frac{3}{8}$ $\frac{5}{16}$ $\frac{7}{32}$ $\frac{1}{8}$

FOR BILLS OF MATERIAL, DIMENSIONS & GENERAL NOTES

TYPE 5
OPTIONAL TYPE SAME AS TYPE 4 BUT USING TYPE 3 FOR FIRST LETTER OF PRINCIPAL WORDS. MAY BE USED FOR SUB-TITLES & NOTES ON THE BODY OF DRAWINGS.

TYPE 6 abcdefghijklmnopqrstuvwxyz
Type 6 may be used in place of
Type 4 with capitals of Type 3

Figure 1.4 (cont.)

(EXTRACTED FROM AMERICAN STANDARD DRAFTING MANUAL, LINE CONVENTIONS, SECTIONING AND LETTERING (ASA Y14-2-1957), WITH PERMISSION OF THE PUBLISHER)

LABORATORY

1. The student should be able to do pencil lettering on tracing paper using single-stroke gothic style. The work should include capitals, lower case, whole numbers, and fractions. A diazo reproduction should be clear with no loss of clarity.

SECTION ITEMS

STUDY QUESTIONS

1. How much space should be left between words?

2. What is the angle of slant on an inclined letter?

3. When lettering a fractional number, what is the height of the fraction relative to the height of the whole number?

EXERCISES

1. Lay out sheet, add guide lines (vertical or inclined), and fill in letters as indicated.

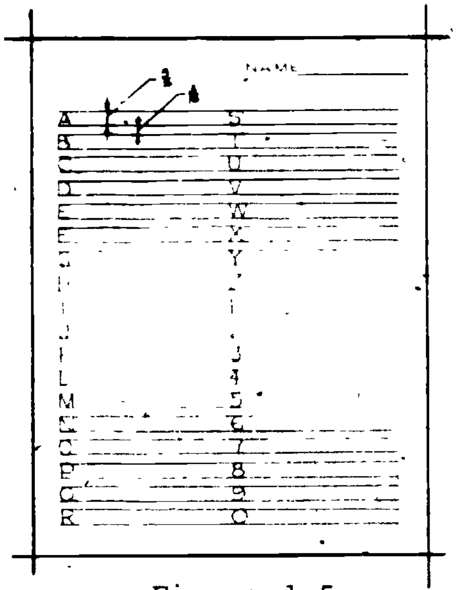


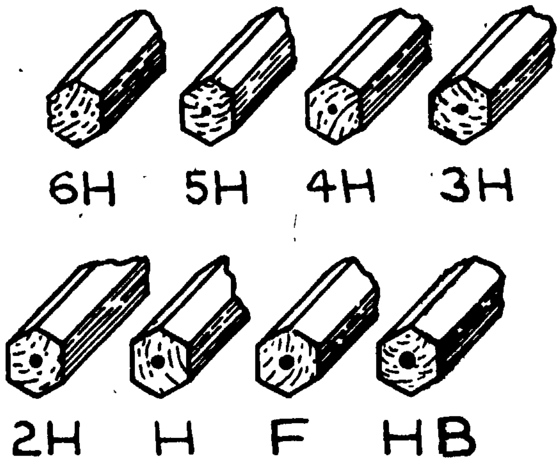
Figure 1.5

SECTION 1.2 USE OF EQUIPMENT

Proper use of equipment is one of the determining factors in producing a quality technical drawing. Some of those instruments most difficult to master have been listed.

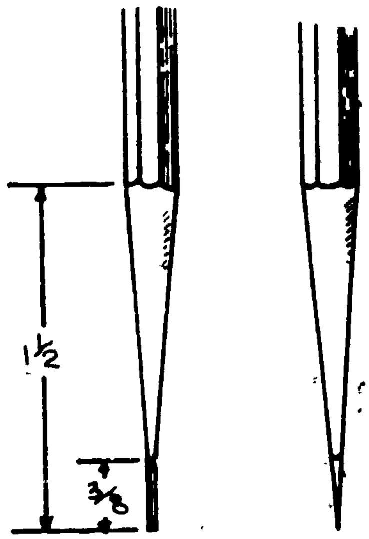
1. Drafting machine - The proper use of a drafting machine can save many hours of drawing time. Its use is not covered here due to the different models available. Manuals giving detailed instructions on the use and care of the drafting machine are available through the manufacturers.

2. Drafting pencil - Good line technique begins with the selection of the correct grade of lead and the proper sharpness on the point.



PENCIL GRADES

Figure 1.6



PENCIL POINTS

Figure 1.7

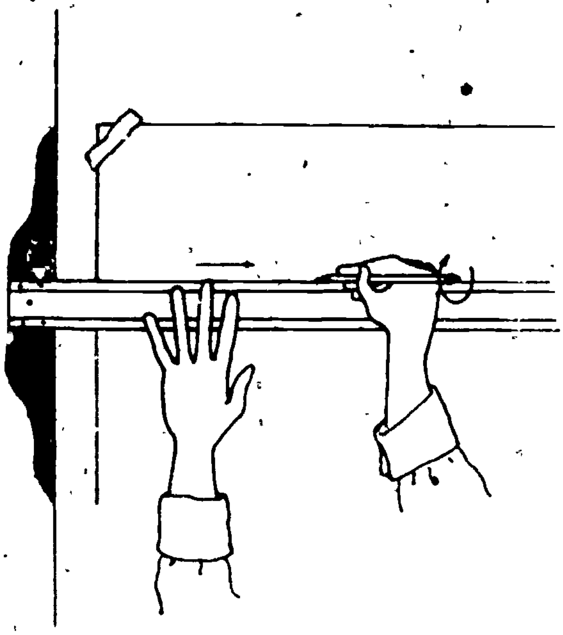
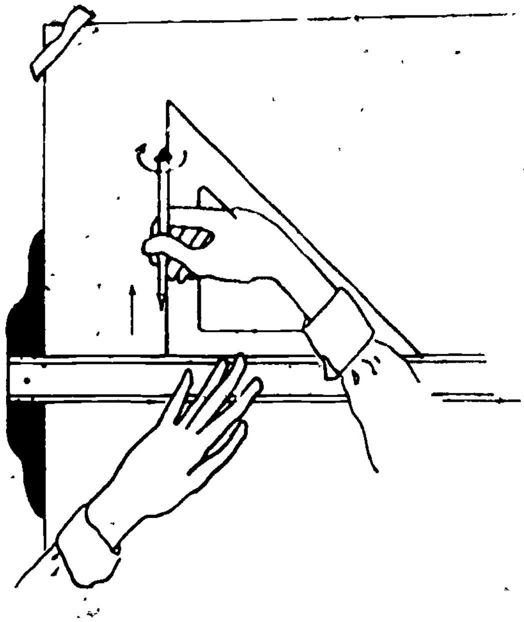


Figure 1.8 Drawing Horizontal Line.
Draw pencil along straight edge.
Rotate pencil to maintain uniform point.



Drawing a Vertical Line

Figure 1.9

3. Scale - Some scales in common use today are the mechanical engineers scale, civil engineers scale, architects scale, and to a lesser extent in this country, the metric scale. It is not uncommon to find triangular scales which incorporate several different types into one multi-purpose scale.

4. Dividers - Dividers are used for transferring measurements and occasionally for dividing lines or arcs into equal parts. Care must be taken when using the dividers so that the legs do not move between taking the measurement and laying it off.

5. Compass - The compass is probably the most important single item of all the drafting instruments other than the pencil and straight edge. The correct choice of lead and proper sharpening technique is essential to the successful use of a compass. Avoid those compasses which do not have a center wheel for adjustment.

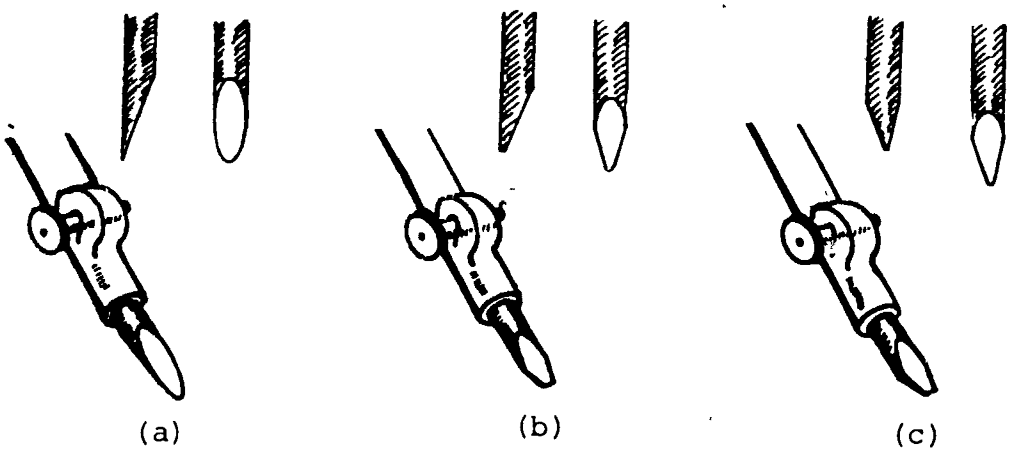
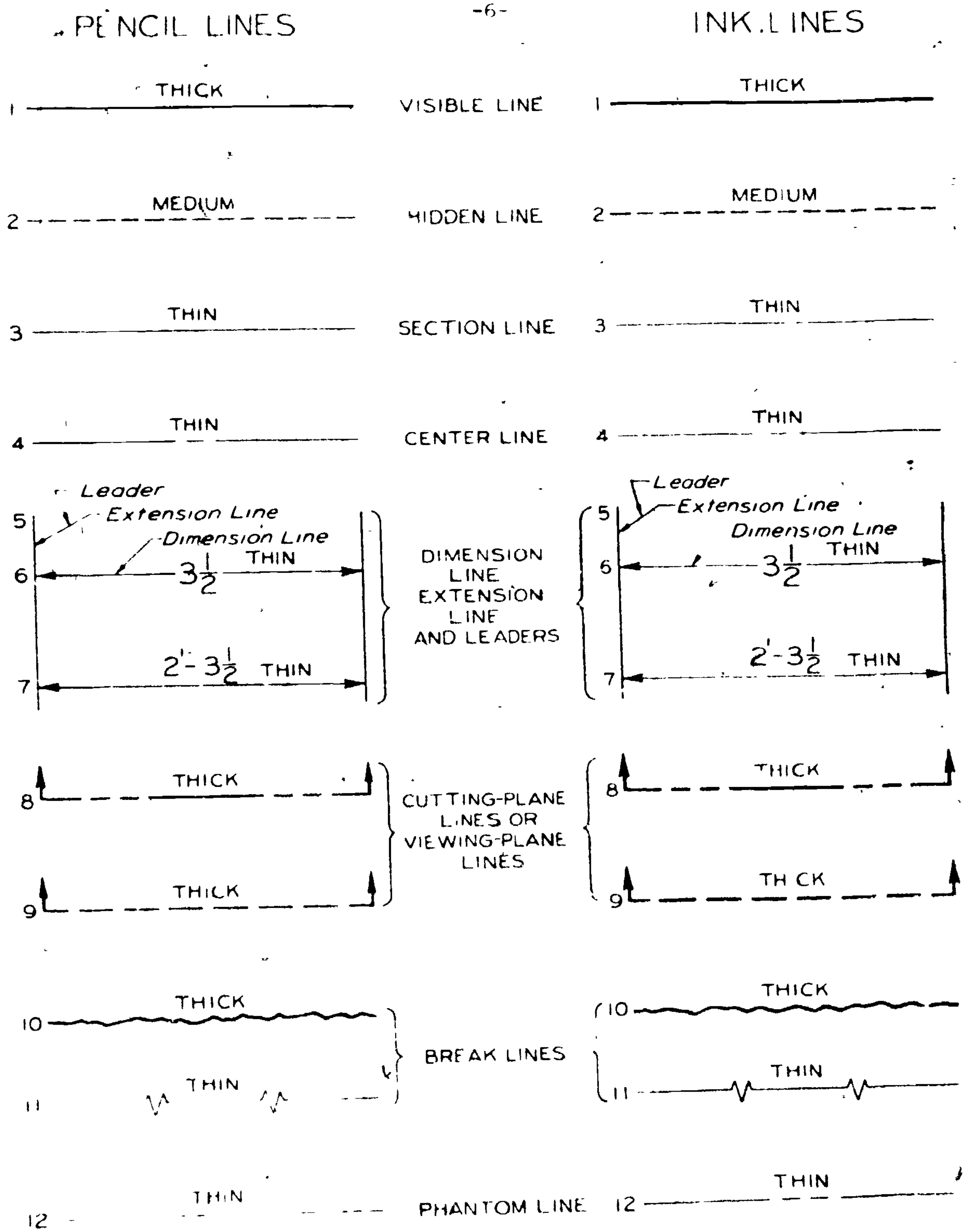


Figure 1.10 Three different methods of sharpening a compass lead.



WIDTH AND CHARACTER OF LINES

Figure 1.11

(EXTRACTED FROM AMERICAN STANDARD DRAFTING MANUAL, LINE CONVENTIONS, SECTIONING AND LETTERING (ASA Y14-2-1957), WITH PERMISSION OF THE PUBLISHER)

6. Eraser and eraser shield - These are relatively inexpensive items by comparison but improper use can result in dark smudges on a vellum drawing. Make sure that the eraser is soft (not artgum) and the eraser shield is metal (plastic is too thick).

7. Irregular curve - These curves are used for the mechanical drawing of free curves and require some practice to use effectively.

8. Circle template - The circle template is particularly useful in drawing small circles (1" diameter or less) where a large bow compass would be difficult to use. When drawing concentric circles with a circle template it's best to lay out first with a small compass.

LABORATORY

1. The student should be able to draw object lines, hidden lines, and center lines using graphite lead for both straight lines and arcs. These lines should be sharp, black, and capable of being reproduced into a diazo copy without appreciable loss of line density and sharpness.

2. The student should be able to draw a layout line to an accuracy of ± 1/32" and to measure a previously drawn line to an accuracy of ± 1/32".

3. The student should be able to take angular measurements within ± 10 minutes using the drafting machine.

SECTION ITEMS

QUESTIONS

1. What grades of lead are best suited for technical drawing?

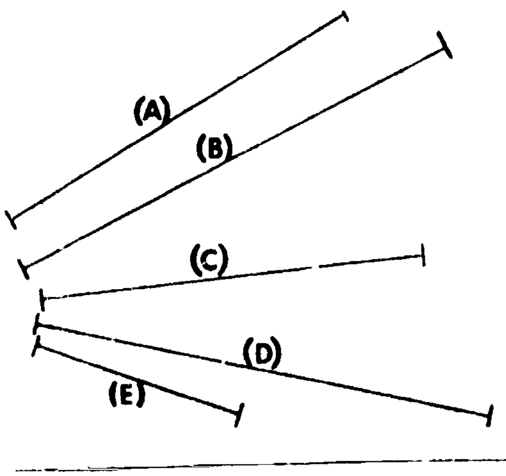
2. Should a compass lead be sharpened into a conical point?

3. Given the following lead grades; 2B, 2H, F, and 4H, which is the hardest? Which is the softest?

EXERCISES

1. Measure the following lines to ± 1/32" on length and ±10' on angles.

Use full scale



Answers

	length	angle
(a)		
(b)		
(c)		
(d)		
(e)		

horizontal line (0°)

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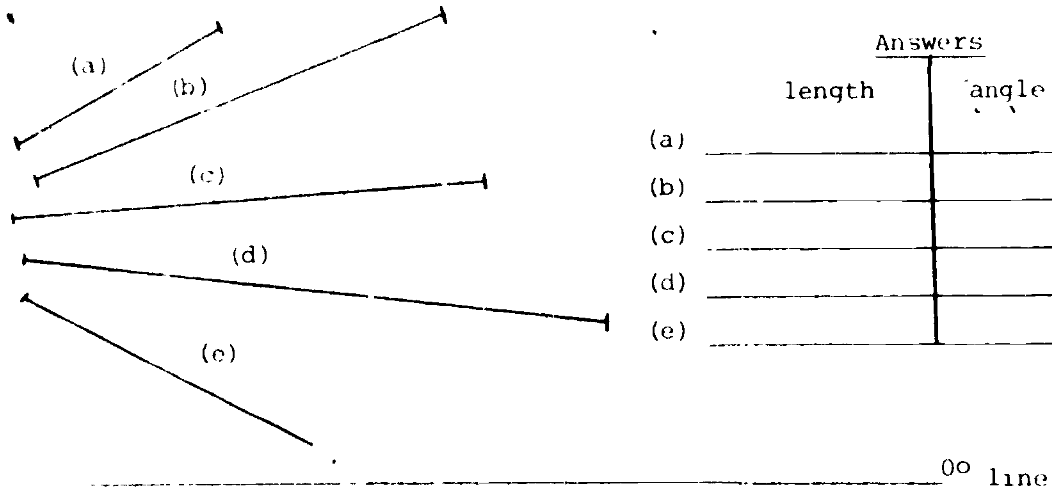
2. Measure the following lines to ± .03" on length and ±10' on angles.

Use full scale



Answers

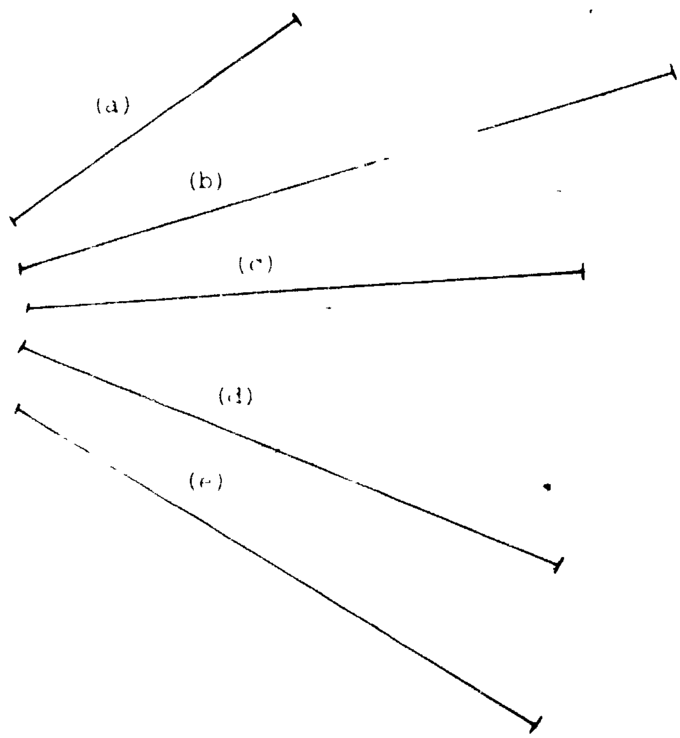
	length	angle
(a)		
(b)		
(c)		
(d)		
(e)		

3. Measure the following lines to ±.80 mm on length and ±10' on angles.

Use full scale

Answers

	length	angle
(a)		
(b)		
(c)		
(d)		
(e)		



4. Make a full scale pencil instrument drawing of the GUSSET in Fig. 1.12. Draw on a 9" x 12" sheet of vellum with a 1/4" border and use title block as shown in Fig. 3.14. Make a diazo print of the finished drawing.

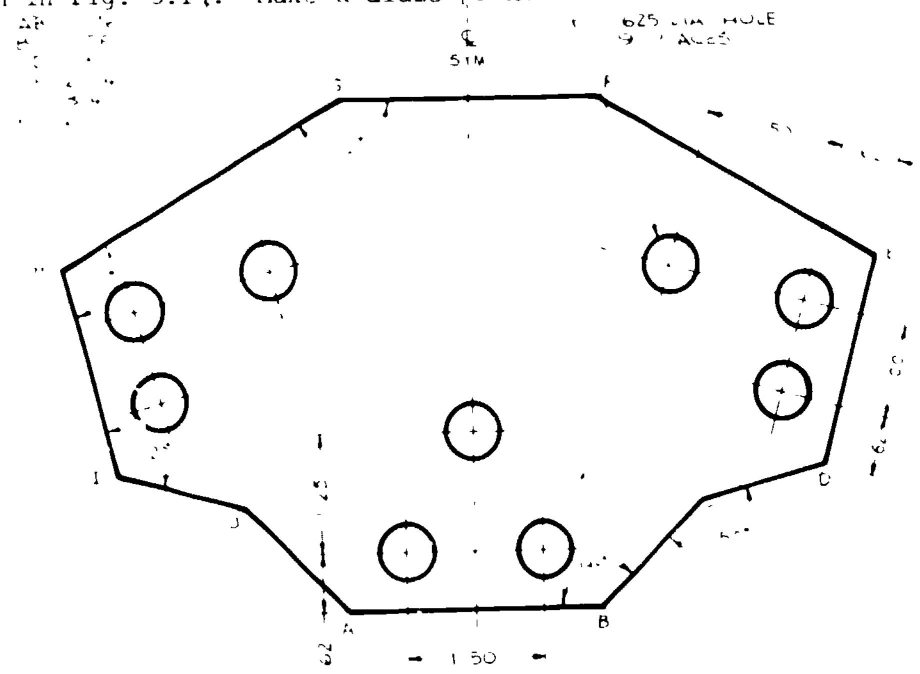


Figure 1.12

CHAPTER ITEMS

EXERCISES

1. Make a full scale pencil instrument drawing of the plate in Fig. 1.13. Draw on a 9" x 12" sheet of vellum with a 1/4" border and use title block as shown in Fig. 3.14. Make a diazo print of the finished drawing.

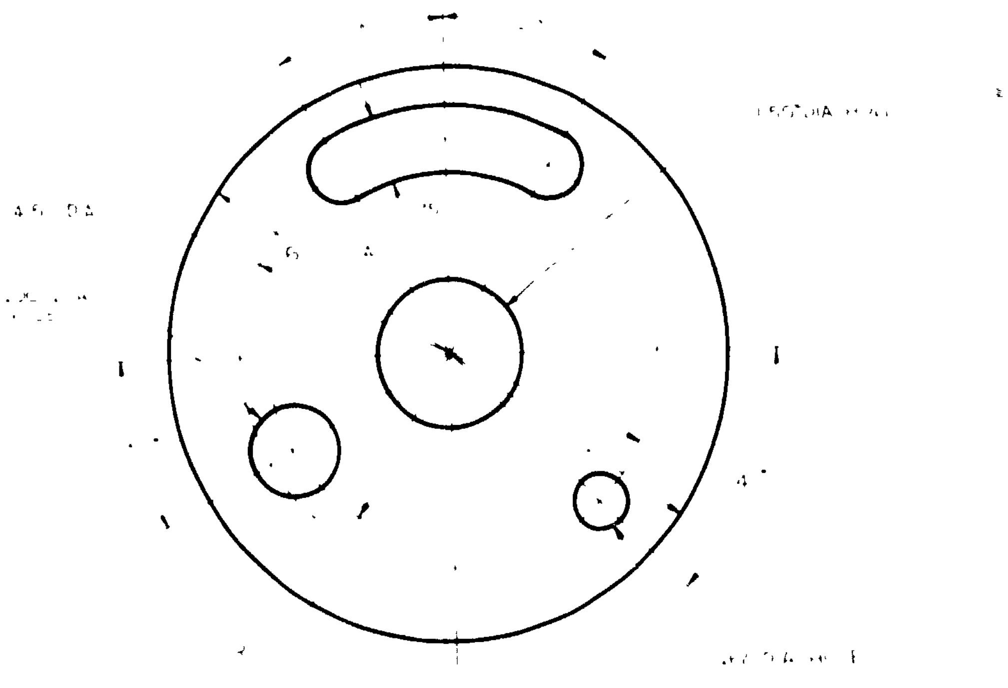


Figure 1.13

ANSWERS - SECTION 1.1

STUDY QUESTIONS

1. A space equal to the size of the letter "[illegible]".

2. [illegible] or [illegible].

3. Twice height of whole number.

SECTION 1.2

STUDY QUESTIONS

1. 6H - HB. Many factors such as drafting media, humidity, drawing surface, and individual technique will play a part in lead selection but generally the following is recommended: 6H - 5H for layout work. 4H - 2H for thin lines (center lines, etc.), H - HB for thick lines and lettering

2. No. Compass leads should be sharpened into a chisel point or an elliptical point.

3. Of that given group of leads the hardest is 4H and softest is 2B.

EXERCISES

1.

	length	angle
(a)	2 3/32	29° 35'
(b)	2 9/16	25° 40'
(c)	2 3/32	5° 00'
(d)	2 1/2	12° 15'
(e)	1 5/32	19° 15'

2.

	length	angle
(a)	1.26	28° 40'
(b)	2.37	21° 05'
(c)	2.56	4° 05'
(d)	3.16	5° 05'
(e)	1.88	26° 15'

3.

	length	angle
(a)	47.50	34° 15'
(b)	93.30	15° 55'
(c)	76.20	3° 15'
(d)	79.20	21° 55'
(e)	82.80	31° 00'

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CHAPTER II

Geometrical Construction

SECTION 2-1 BASIC APPLIED GEOMETRY

Applied geometry is the basis for layout and construction in instrument drawing. While it is not necessary to write geometric proofs to solve problems in applied geometry, it is important to have a general understanding of the principles of plane geometry. The practice of pure geometric construction is time consuming and does not utilize the many accurate instruments available to the draftsman. The illustrations in this section will use the most expedient methods where accuracy permits.

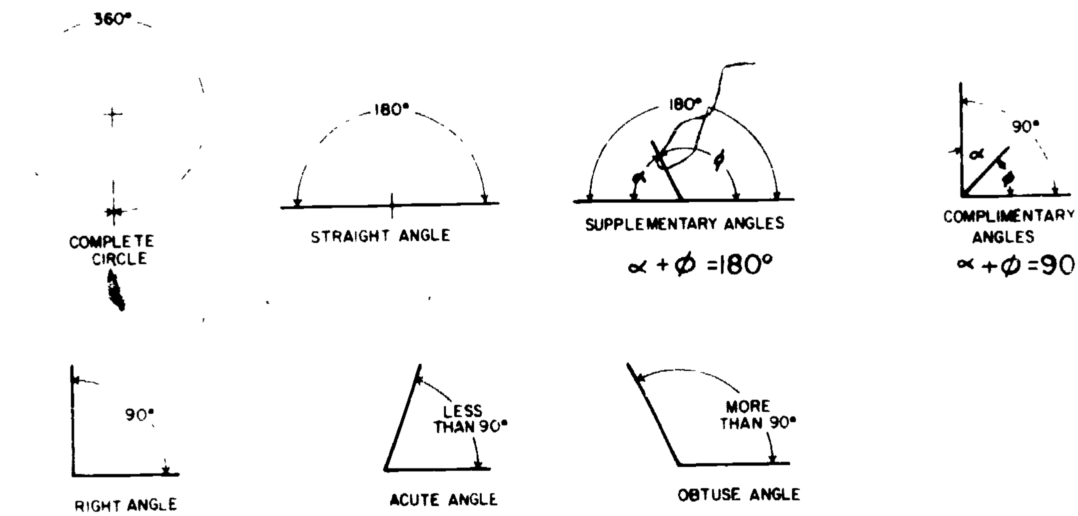


Figure 2.1 Angles

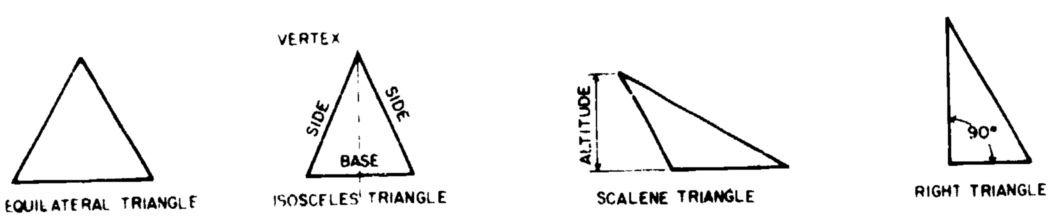


Figure 2.2 Triangles

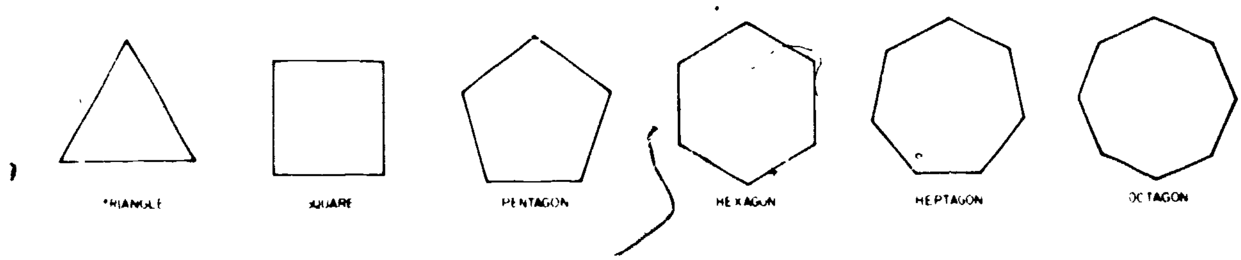


Figure 2.3 The Regular Polygons

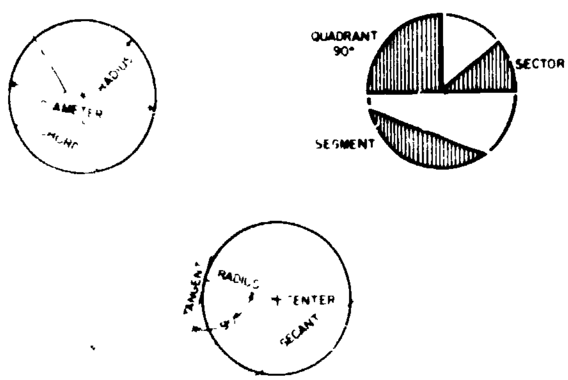


Figure 2.4 Elements of the Circle

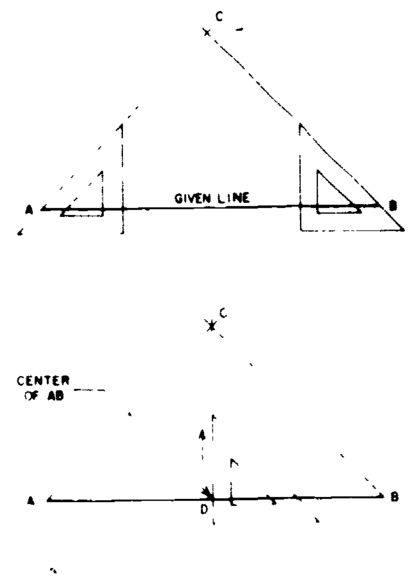


Figure 2.5 To Bisect a Line

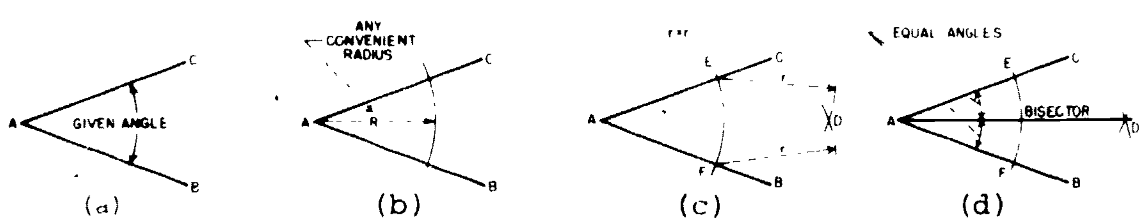


Figure 2.6 To Bisect an Angle

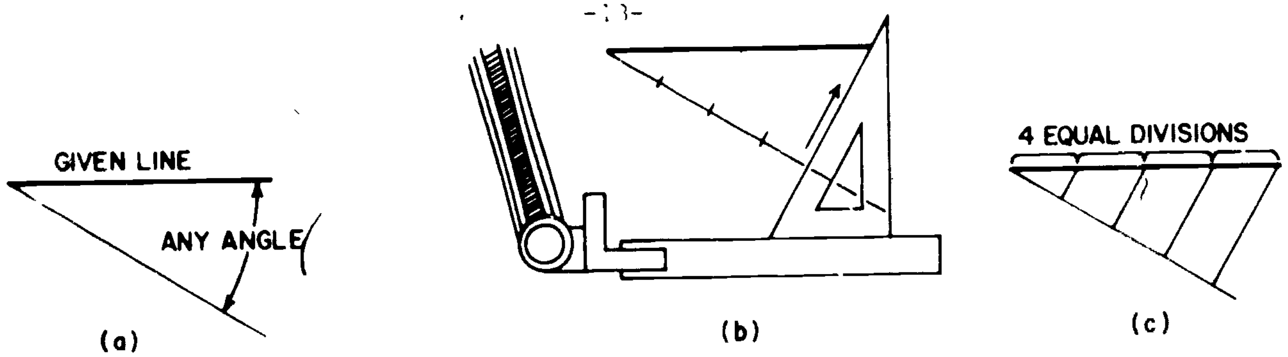
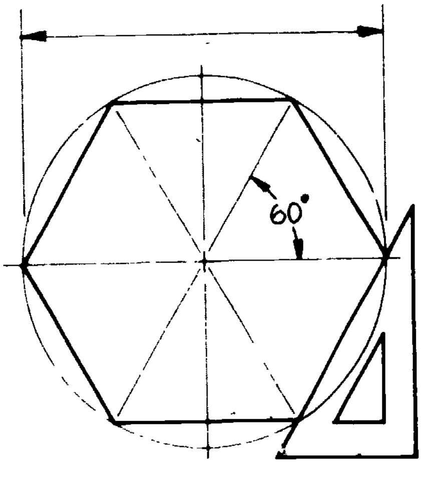
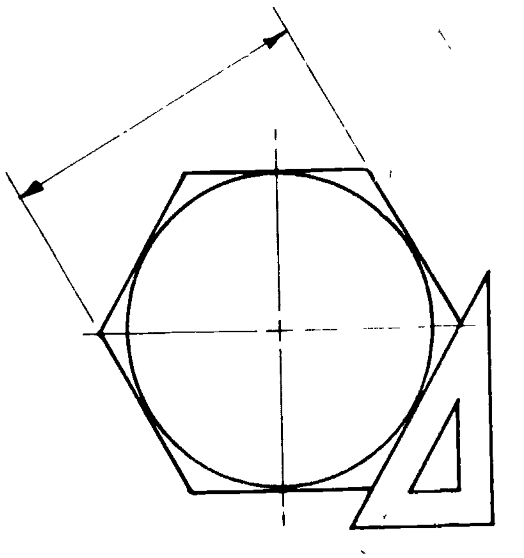


Figure 2.7 To divide a line into equal parts. (a) Draw a line at any angle from one end of given line. (b) Divide angled line into required number of equal spaces. Draw from last mark on angled line to end of given line. (c) Draw parallel lines from each mark dividing given line into equal parts.



Circumscribing Circle - Distance across corners given.



Inscribed Circle- Distance across flats given.

Figure 2.8 To Draw a Hexagon

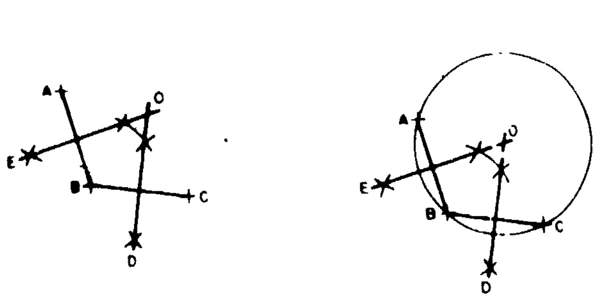


Figure 2.9 To draw a circle through three given points.

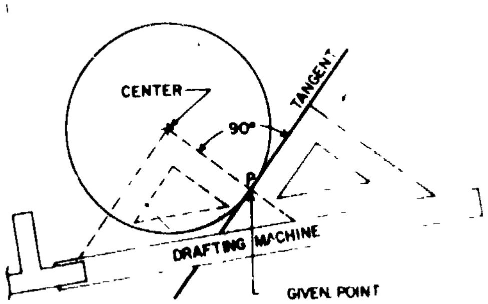


Figure 2.10 To draw a tangent and a circle

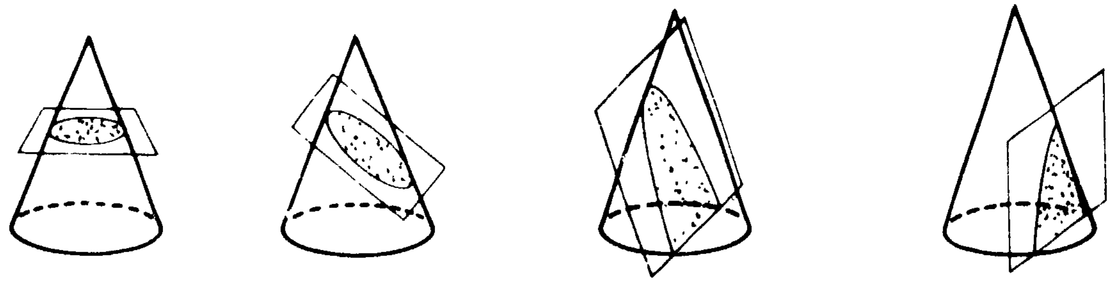


Figure 2.11 The Conic Sections

For all conic sections, a cutting-plane passes through a right circular cone in such a manner that one of the following is formed by the intersection of the surface of the cone and the cutting-plane. The angle between the center axis of the cone and the cutting-plane determines the curve.

Circle -	Cutting-plane is 90° to axis of cone.
Ellipse -	Cutting-plane is inclined to axis of cone. The angle formed is greater than that between the axis of the cone and its elements.
Parabola -	Cutting-plane makes the same angle with the axis of the cone as do the elements of the cone.
Hyperbola -	Cutting-plane makes an angle with the axis of the cone less than that formed between the elements and the axis.

LABORATORY

1. The student should be able to perform basic geometric construction such as bisecting angles and lines, drawings tangents, dividing lines into equal spaces, etc.

SECTION ITEMS

STUDY QUESTIONS

1. How many degrees are in a hexagon?
2. What are complementary angles?
3. What conic section can be drawn with a compass?
4. What is the general term for a plane four-sided figure?

Exercise

Use the format in Chapter III, fig. 3.14, for the following problems. Use a hard lead and leave construction lines. Draw full scale.

1. a. Divide a line 3" long into 5 equal parts.

   b. Construct a hexagon which is 2" across flats.

   c. Construct and bisect a 45° angle.

   d. Locate the tangent point between a line drawn at 30° and a 2" diameter circle.

2. a. Draw a right triangle with one leg 1-1/4" and the other 1-3/4". Construct a circle which will pass through these three points. (Fig. 2.9)

   b. Draw two circles 1" diameter and 2" diameter, respectively. Space them 2-1/2" apart on a line inclined at 30°. Draw all lines which are tangent to both circles and mark tangent points (P_1, P_2, etc.) (fig. 2.10)

   c. Draw a triangle having sides 2.80, 3.25, 2.40. Find its center of gravity and draw the maximum diameter circle that does not fall outside the triangle. What did you discover? Draw a circle through the vertices of the triangle (fig. 2.9). Is this center the same as the center of gravity? What condition would cause the two centers to be the same? (Note: You will need to consult resource material for this problem).

   d. Construct a hexagon which is 2.50 inches across corners.

CHAPTER ITEMS

EXERCISES

1. Make a full size pencil drawing of the LINK in figure 2.12. Draw on a 9" x 12" sheet of vellum with a 1/4" border. Use title block as shown in Figure 3.14. Show all construction. Show all construction.

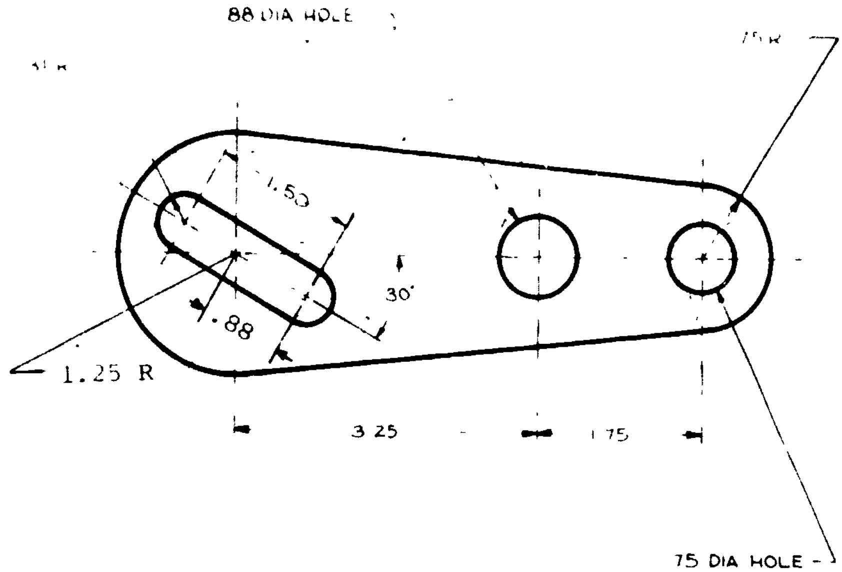
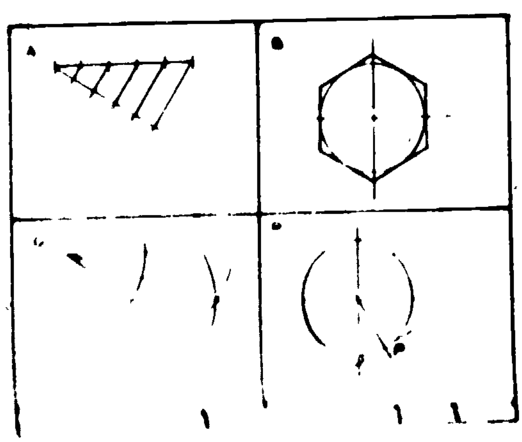


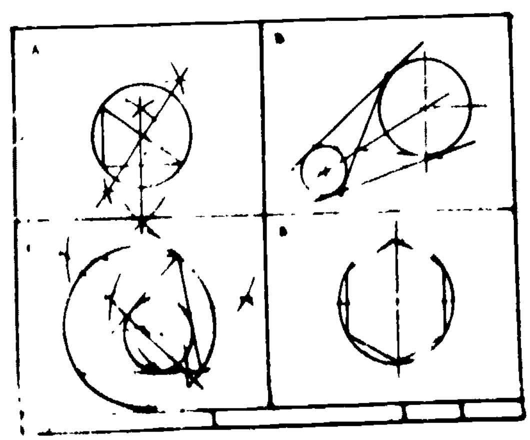
Figure 2.12 LINK

ANSWERS
SECTION 2-1
QUESTIONS

1. 720°
2. Two adjacent angles whose sum is 90°
3. A circle
4. Quadrilateral

EXERCISES

1.


2.


Section 3.1 SKETCHING MATERIALS AND LINES TECHNIQUE

Selection of proper sketching materials is of critical importance in producing a pencil sketch. Once the materials have been selected, the following of established layout methods and line techniques is essential to the success of the finished sketch.

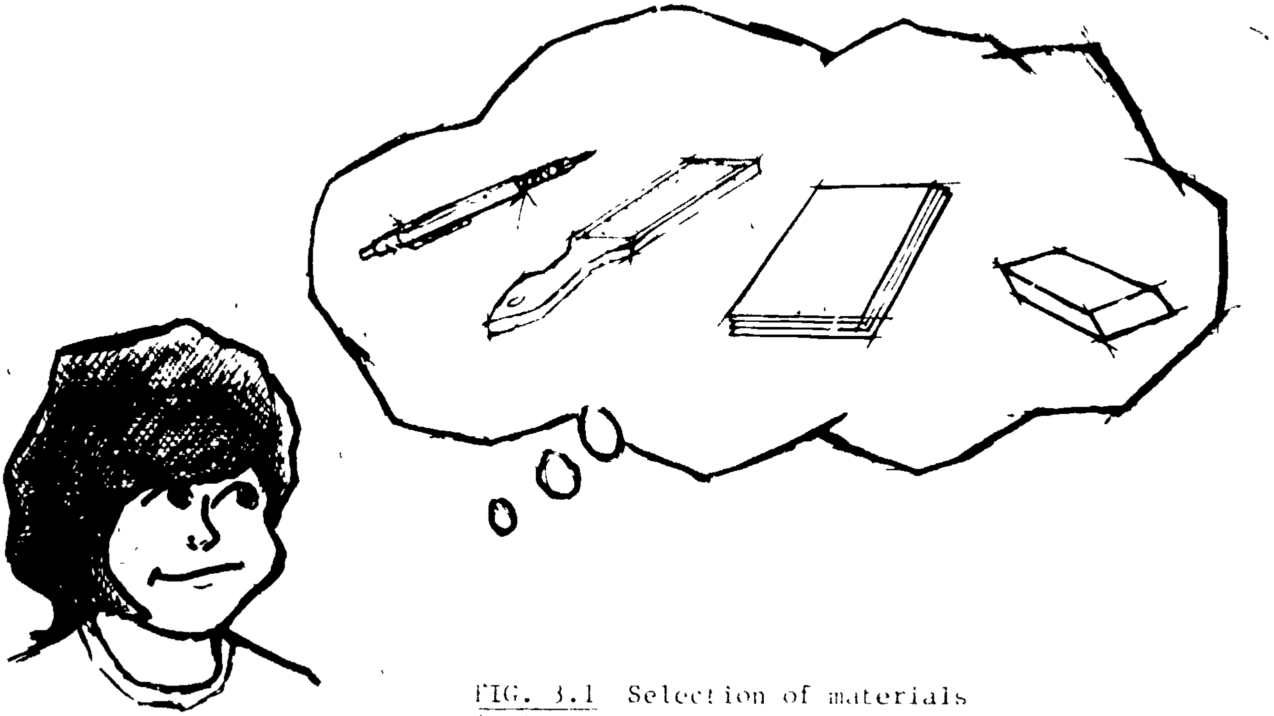


FIG. 3.1 Selection of materials is important

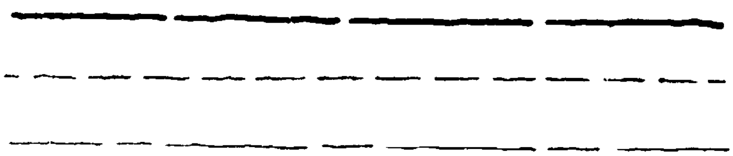


FIG. 3.2 Proper line technique and contrast adds "snap" to a sketch.

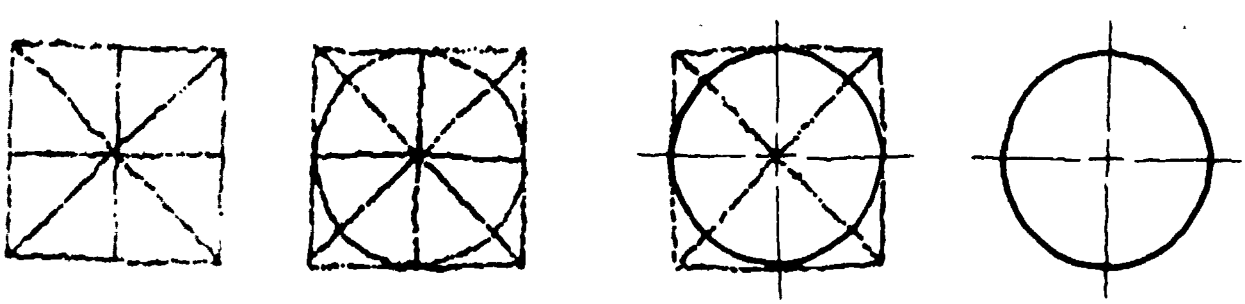


FIG. 3.3 Steps in sketching a circle.

LABORATORY

1. The student should be able to demonstrate the proper line technique for sketching object lines, hidden lines, and center lines.

2. The student should be able to make a one view pencil sketch on grid paper showing a border, title block, and proper line techniques. This sketch may be from a model or another drawing.

SECTION ITEMS

STUDY QUESTIONS

1. Does a center line take precedence over a hidden line?

2. What type eraser is used to remove layout lines from a sketch?

3. How is a pencil sharpened to produce a sketch center line?

4. What grades of pencil lead are best suited for sketching?

5. Where should you be looking when sketching a layout line between two points?

6. Does a visible line take precedence over a hidden line?

7. How is a pencil sharpened to produce a layout line?

8. Where should you be looking when sketching an object line between two points?

9. Is a sketch usually made to a specified scale?

10. Are "measuring aids" ever used to help keep a sketch proportional?

EXERCISES

1. Sketch the line technique exercise in Fig 3.5. Use 9 x 12 paper with 1/4" grid.

2. Sketch the two gaskets shown in Fig. 3.6. Use 9 x 12 paper with 1/4" grid and same format as given.

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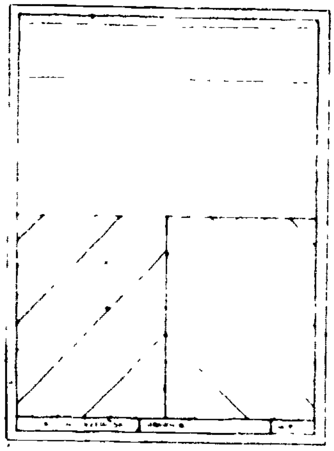


Fig. 3.5

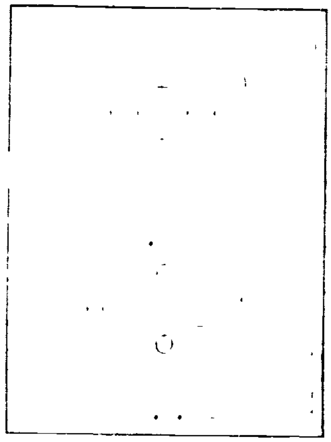


Fig. 3.6

Section 3.2 ISOMETRIC SKETCHING

Pictorial sketching is an excellent way of conveying an idea to either technical or non-technical personnel. Isometric views have the advantage of a uniform foreshortening factor on all axes thereby simplifying the transition from orthographic* drawing to pictorial. Isometric axes are 120° apart with one axis in the vertical position. Any two of these axes define a plane which can be used as a reference in locating points on the sketched object.

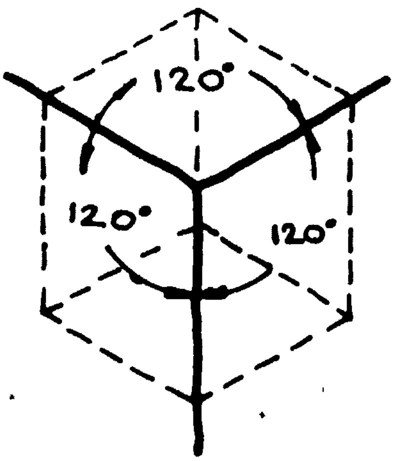


Fig. 3.7 Isometric Axes

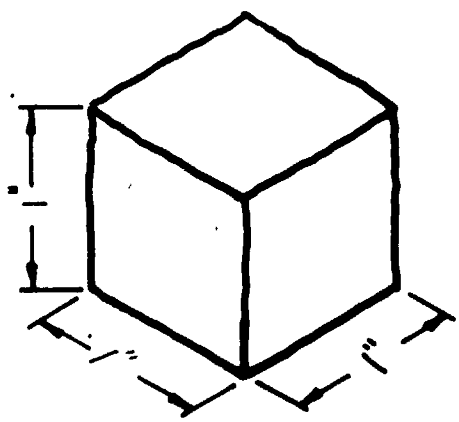
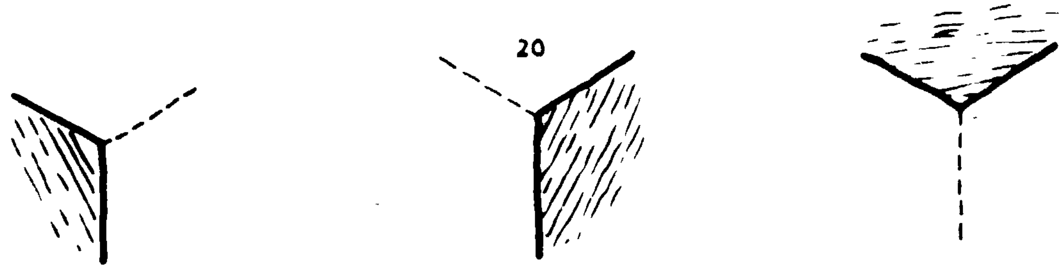


Fig. 3.8 Isometric sketch of 1" cube.

*See Chapter IV

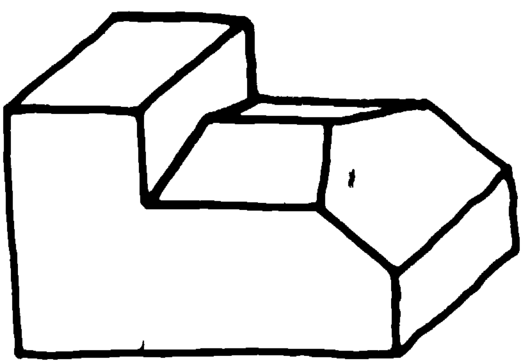


(a) (b) (c)

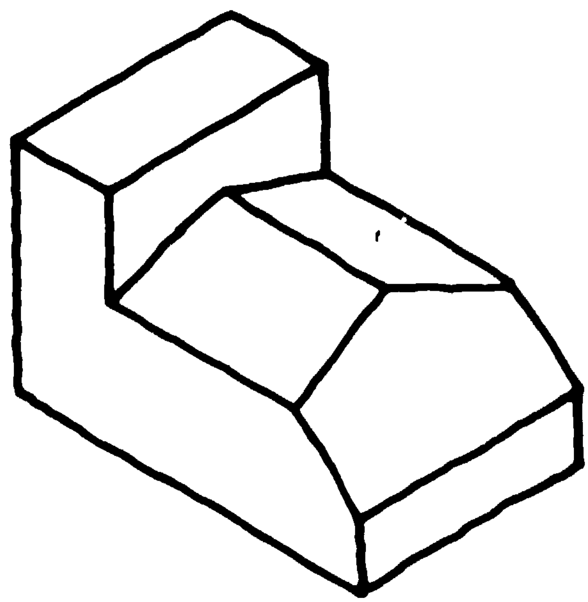
Fig. 3.9 Reference planes defined by two isometric axes include (a) frontal, (b) profile, and (c) horizontal.

LABORATORY

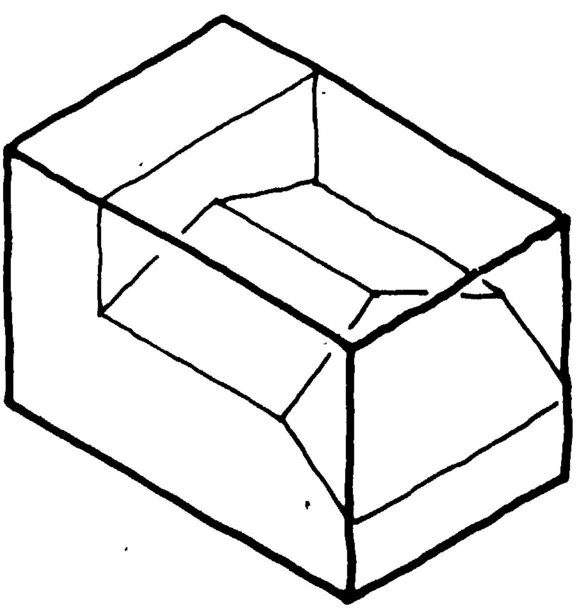
1. The student should be able to make an isometric sketch on grid paper complete with border, title block, and proper line technique. The sketch may be made from a model or a drawing.



(a)

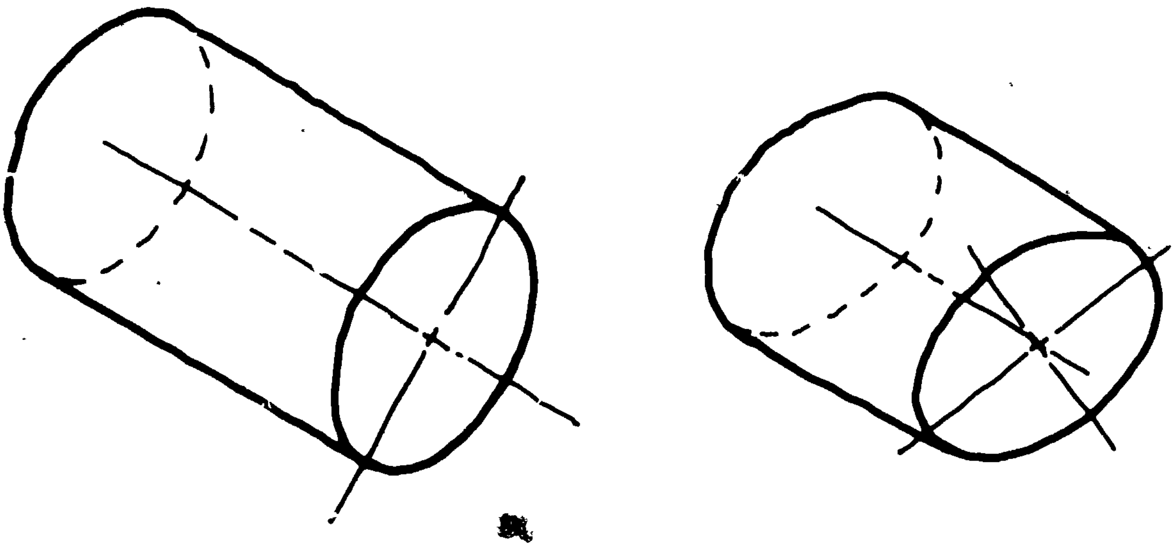


(c)



(b)

Fig. 3.10 Shows the steps in making an isometric sketch. The object to be sketched at (a) reference box to exact size at (b) and finished at (c).



(a) (correct) (b) (wrong)

Fig. 3.11 Circles in isometric views usually appear as ellipses. The end of the right circular cylinder is correctly shown a (a) with minor axis along centerline.

SECTION ITEMS

STUDY QUESTIONS

1. What is the name of the reference plane which touches the side of the object being sketched?

2. What are the measurements made perpendicular to the horizontal plane called?

3. Isometric axes are drawn 120^{o} apart. What true angle is represented by this 120^{o} angle?

4. Can angular measurement be made in an isometric view?

5. Are measurements normally made other than parallel to one of the isometric axes in an isometric sketch?

6. What is the angle of an isometric ellipse?

7. Are hidden lines normally shown in an isometric sketch?

8. What measurements are made perpendicular to the profile plane?

9. When an isometric box is constructed, what is its height, width, and depth with respect to the object being sketched?

EXERCISES

1. On a sheet of 9 x 12 isometric grid paper sketch an isometric view of the object shown in Fig. 3.12. The numbers represent units on the isometric grid. Border and title block will be as in Fig. 3.6.

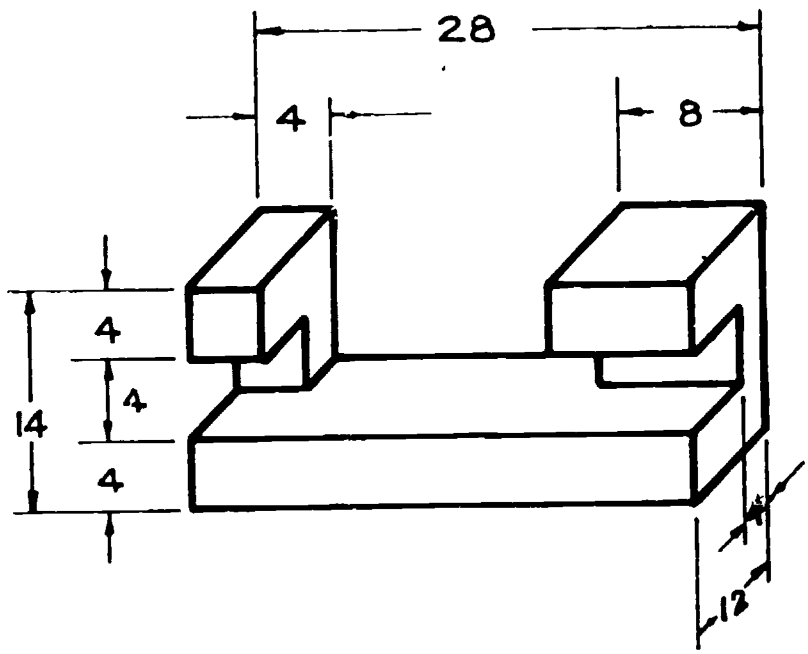


Fig. 3.12

CHAPTER ITEMS

1. Sketch the isometric view of Fig. 3.13 on grid paper. Show border and title block as in Fig. 3.6.

2. Divide a sheet of rectangular grid paper into four equal areas and add border and title block as shown in Fig. 3.14.

   (a) In space I, sketch the view that you would see if looking perpendicular to the horizontal face of the reference box used to sketch the isometric of Fig. 3.13.
   (b) In space III, sketch the view you would see if looking perpendicular to the frontal face of the reference box.
   (c) In space IV, sketch the view you would see if looking perpendicular to the right profile face of the reference box.

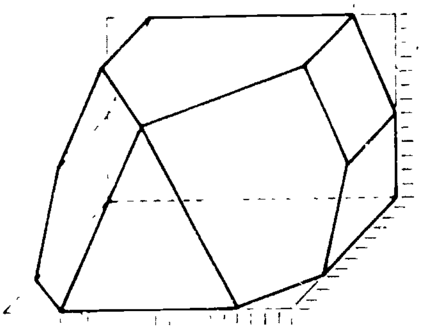


Fig. 3.13

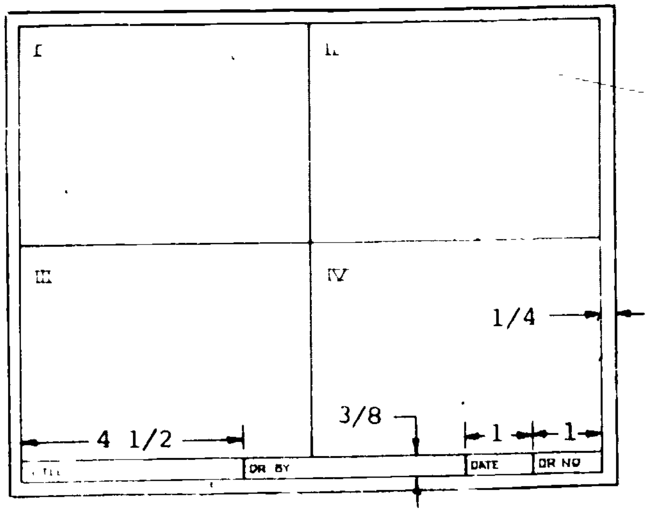


Fig. 3.14

ANSWERS

SECTION ITEMS

SECTION 3.1

1. No. Order of precedence is visible line, hidden line, center line.

2. Artgum.

3. Sharp conical point.

4. F, HB, and B.

5. At the point to which the line is being drawn.

6. Yes. (See answer No. 1)

7. Dull, blunt point.

8. At point of pencil.

9. No. Sketches are made to proportion.

10. Yes. A pencil or a strip of paper may be used to keep sketches proportional.

SECTION 3.2

1. Profile reference plane.

2. Height measurement.

3. 90°

4. No. Angular measurements do not appear as true angles in an isometric view.

5. No. The only measurements which can be made true length are along the isometric axis.

6. $35^{\circ}16'$

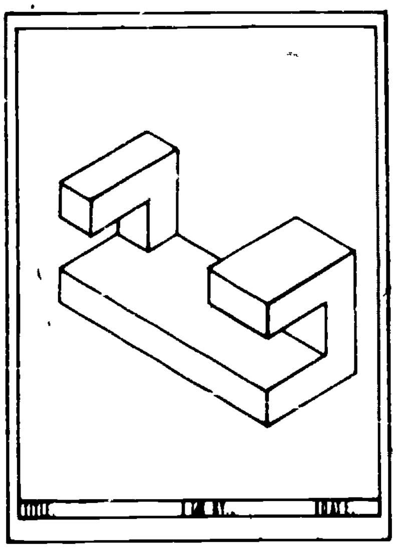
7. No. Hidden lines are usually omitted from isometric views since three surfaces are visible.

8. Width measurements.

9. The isometric "reference box" should have the same height, width, and depth measurements as the object.

EXERCISES

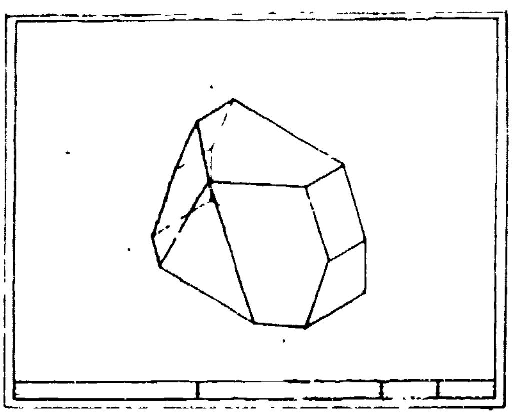
1.



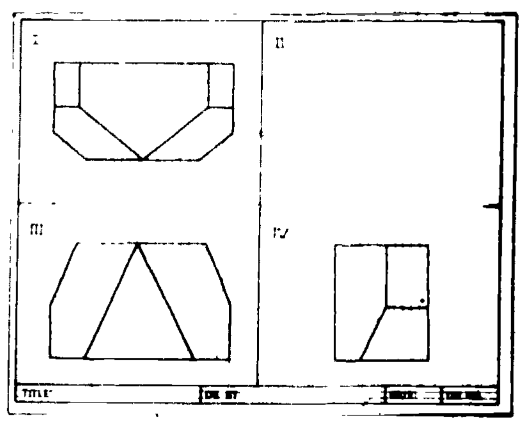
CHAPTER ITEMS

EXERCISES

1.



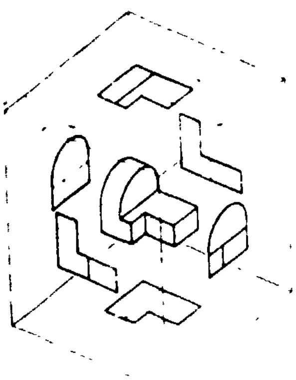
2.



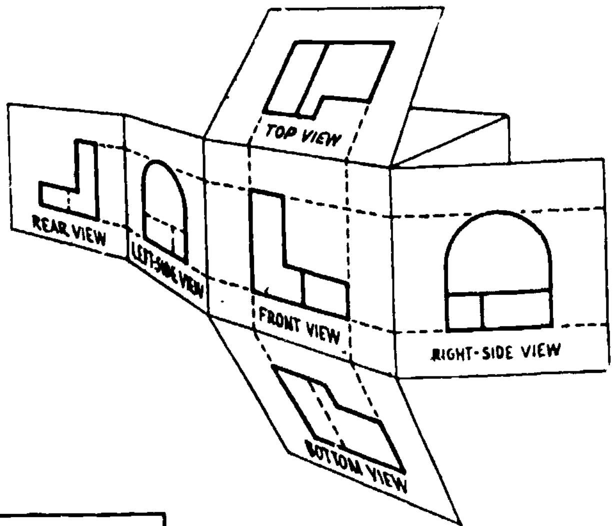
CHAPTER IV MULTIVEW PROJECTION

Section 4.1 Theory of Projection

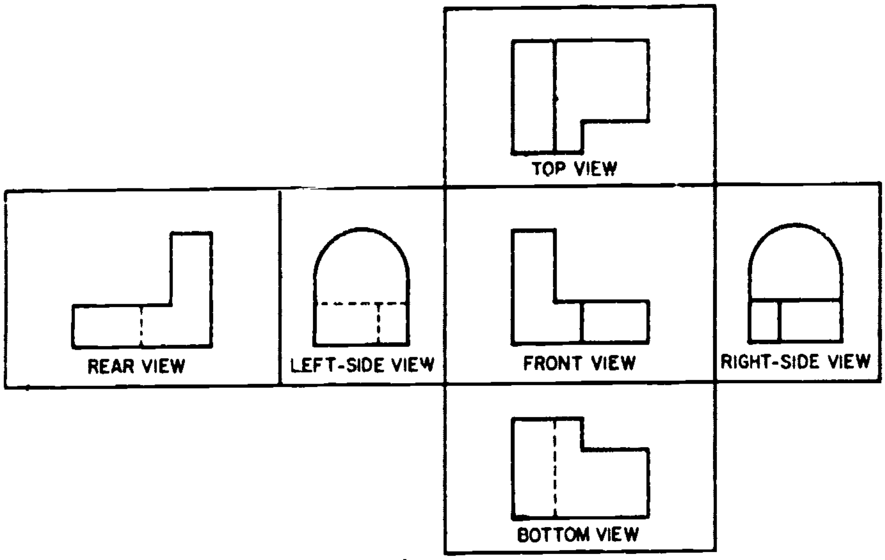
Objects whose exact shape and size are to be conveyed to a machinist or other technical person are best defined through orthographic projection. There are six views in the American National Standard arrangement of views. Multi-view projection is the drawing or sketching of as many of these views as is required to completely describe the object showing all visible and hidden lines.



(a)



(b)



(c)

Figure 4.1 Shows (a) projection of object onto faces of glass box (b) unfolding of glass box (c) American National Standard arrangement of views.

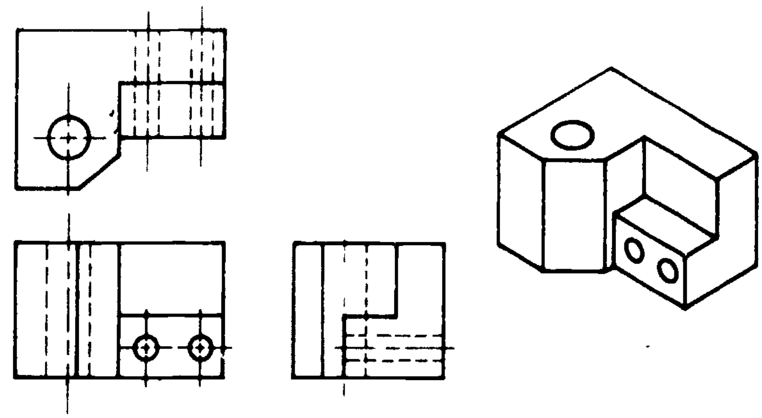


Figure 4.2 Normally three views are sufficient to describe the shape of an object.

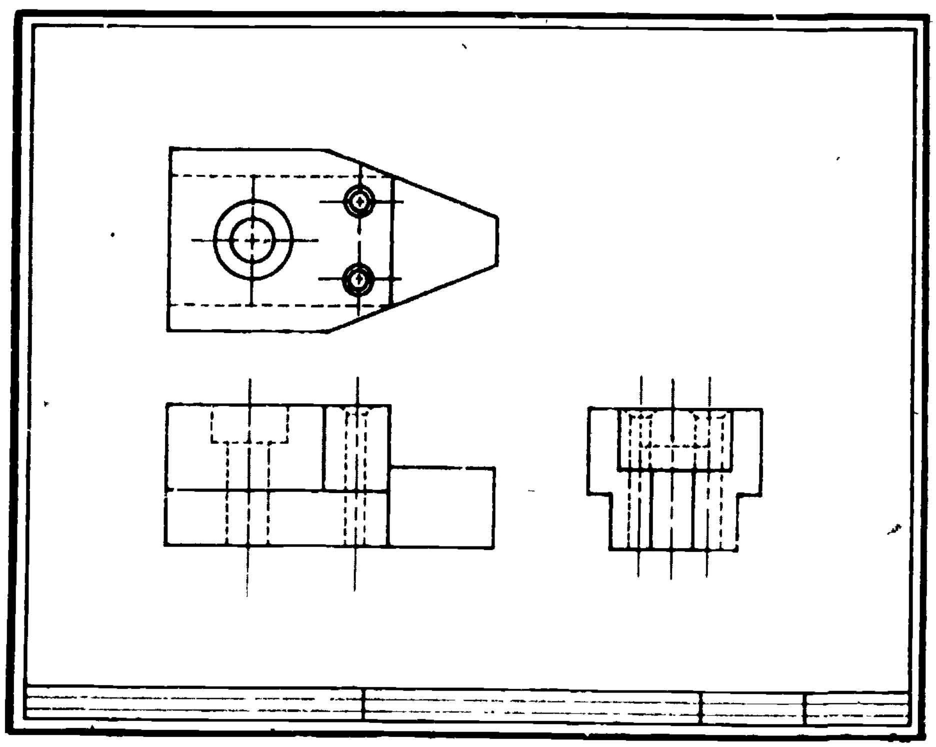


Figure 4.3 Hidden lines are used to describe features that would otherwise not be seen.

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SECTION ITEMS

Study Questions

1. What is meant by orthographic dimension?

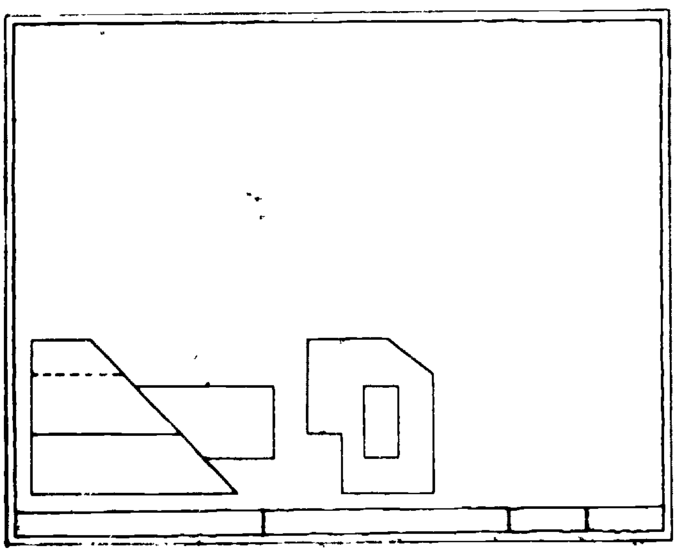
2. What orthographic dimensions can be seen in the front view?

3. What are adjacent views?

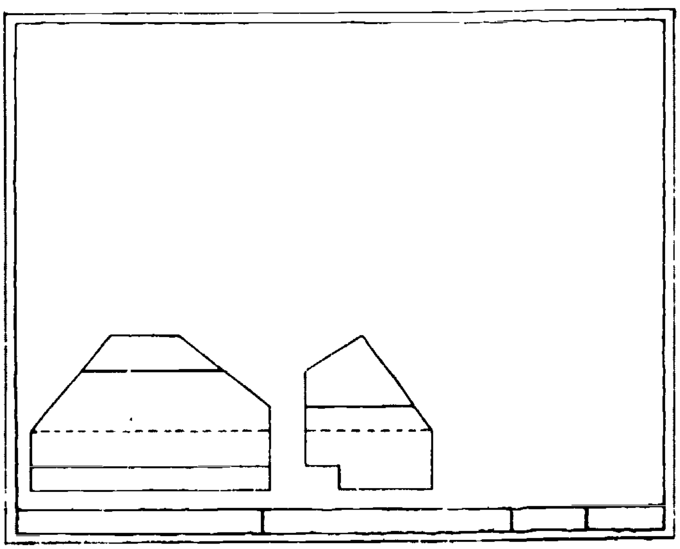
4. In the American National Standard arrangement of views, what views are adjacent to the front view and what orthographic dimension do they have in common?

EXERCISES:

1. Sketch the two given views and add the top view of the objects in Figure 4.4. Use the same format and title block as shown. Sheet size 9 x 12



(a)



(b)

Figure 4.4

LABORATORY

1. Student should be able to sketch three principal orthographic views showing all visible and hidden lines from model or isometric view.

2. Student should be able to sketch third view from two given orthographic views.

SAMPLE PROBLEMS

1. Orthographic view drawn from isometric.

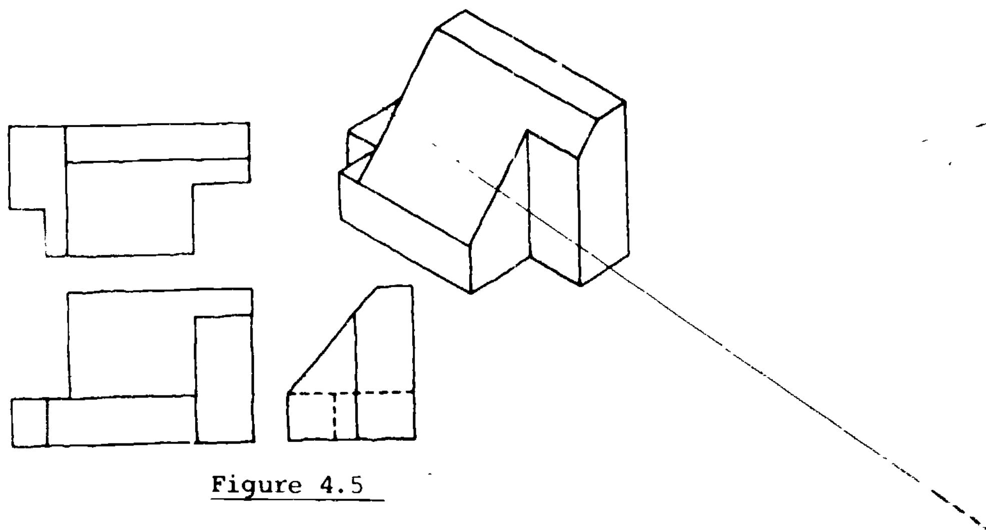


Figure 4.5

2. Orthographic views drawn from two given views.

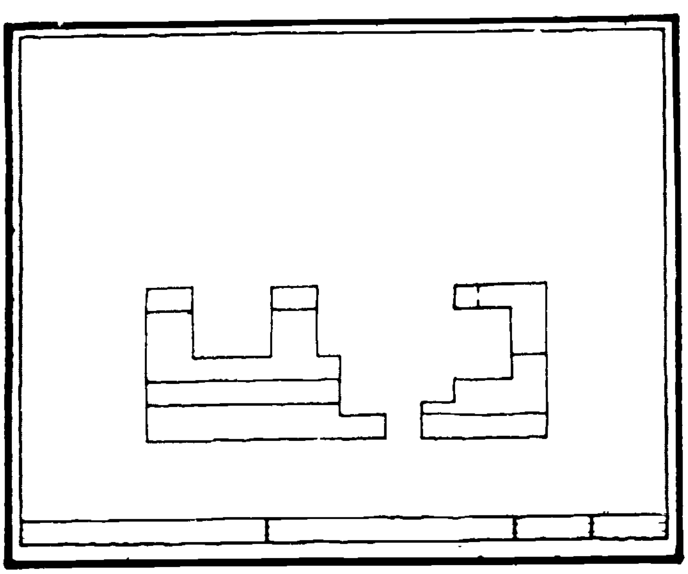


Figure 4.6 (a) Given views

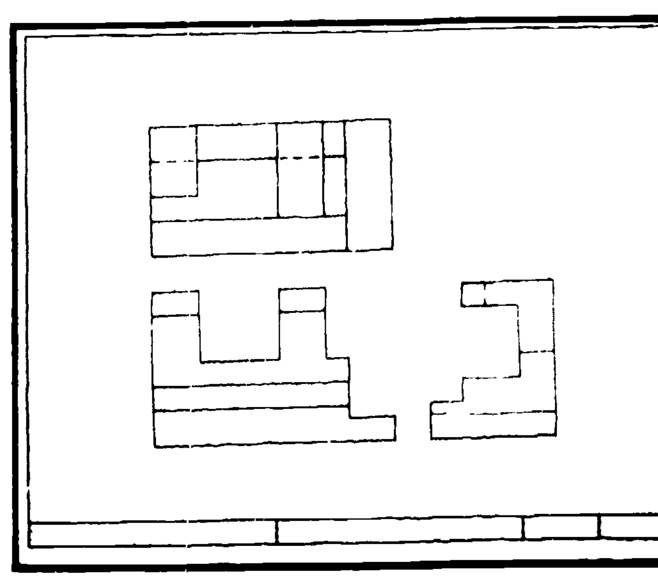


Figure 4.6 (b) Completed third view

ECTION 4.2 Instrument Drawing

Views should be well balanced on the sheet with border lines and complete tle block. After the number of required views has been determined, then portant center lines and outlines are drawn with a sharp 6H pencil. If ree or more views are required, one of the methods in Figures 4.8-4.10 ould be used to transfer measurements. Once the views are accurately drawn, e finish line work is added with an H or 2H lead.

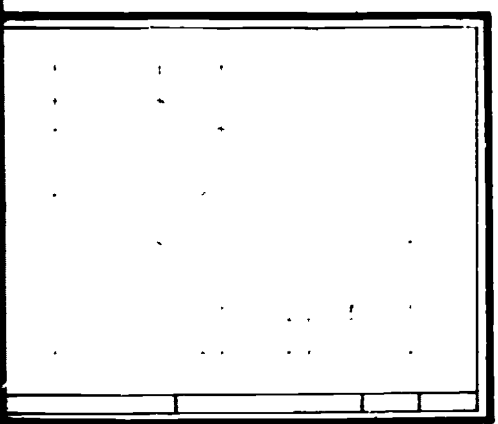


Figure 4.7 Layout balanced drawing with 6H lead.

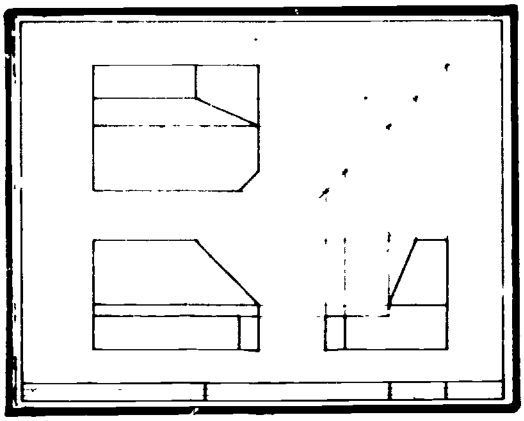


Figure 4.8 Use of mitre line to draw right side view.

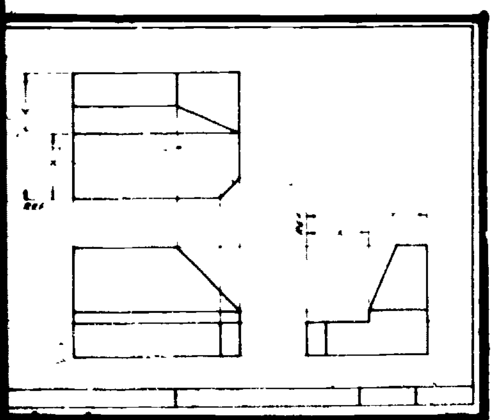


Figure 4.9 Use of dividers to draw top view.

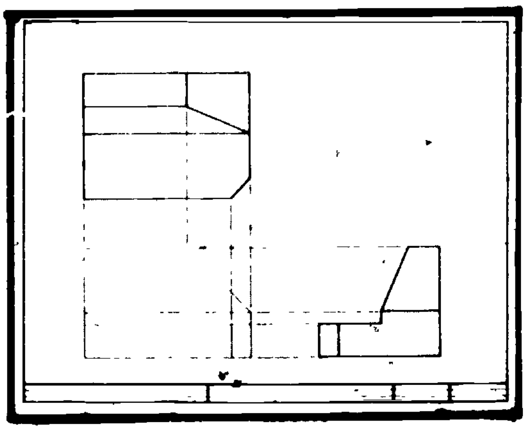


Figure 4.10 Drawing front view from given top and right side view.

LABORATORY

1. Student should be able to make an instrument drawing complete with border lines and title block from a model, pictorial view, or given orthographic views. Drawing should be made on tracing paper and of such quality that a clear diazo print can be made with no appreciable background color.

SECTION ITEMS

Study Questions

1. Are instrument dr ings usually drawn to a specified scale?
2. Are three views always required in an instrument drawing?
3. What is the proper contrast between visible lines and center lines?
4. At what angle is a mitre line drawn?
5. Are hidden lines always shown?

EXERCISE:

1. Reoraw the given views in Fig. 4.11 on9" x 12"tracing pape and add missing view and isometric view. Use format and title block shown in Fig. 3.14. Make a diazo copy of the finished drawing.

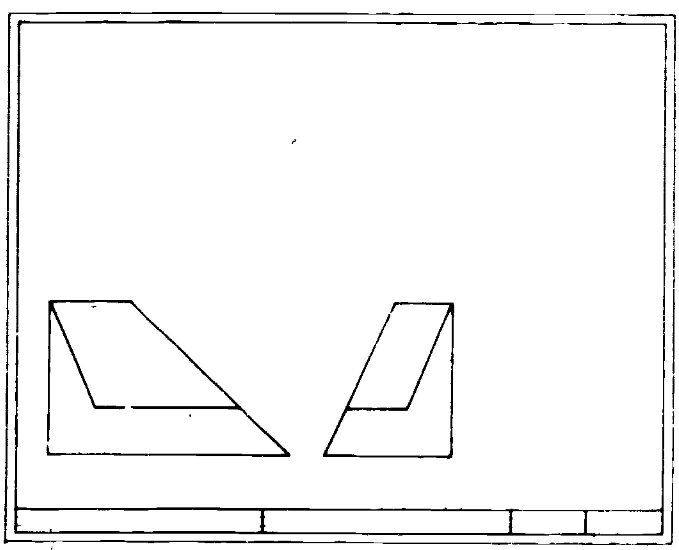


Figure 4.11

CHAPTER ITEMS

1. On a sheet of 9" x 12" vellum, draw the front, top, and right-side views of the object in Fig. 4.12. Use border and title block as shown in Fig. 3.14.

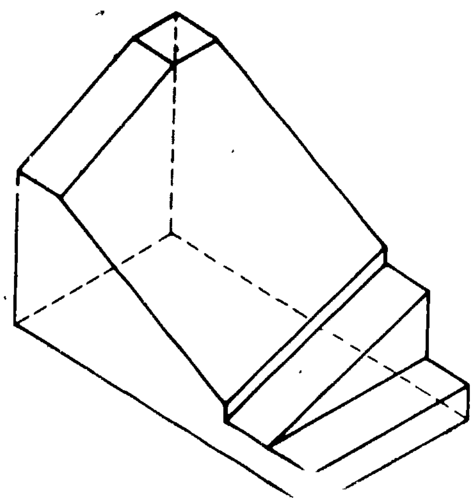


Figure 4.12

ANSWERS

SECTION 4.1

Study Questions

1. Height, width, and depth are orthographic dimensions. They are made perpendicular to the horizontal, profile, and frontal planes, respectively.

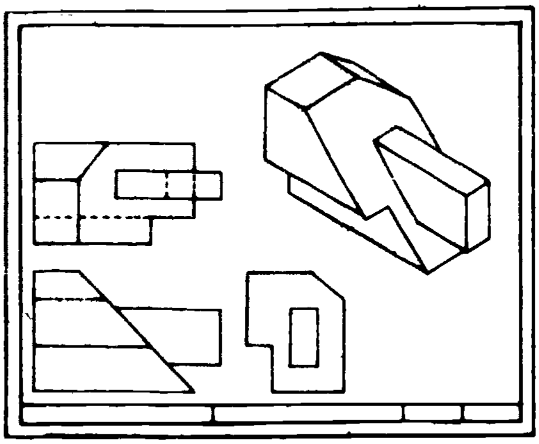
2. Height and width.

3. Views which are separated by a folding line; i.e., front and top views.

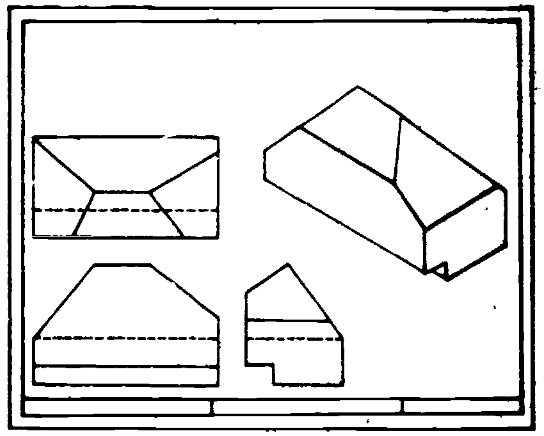
4. Views adjacent to the front view are the top front, left and right side views. They all show the orthographic dimension of depth.

EXERCISES (solution)

1.



(a)



(b)

Figure 4.13

SECTION 4.2

Study Questions

1. Yes. Some example are full size, ½ size, ¼size, etc.

2. No. Drawings require only those views necessary to describe the object. That may be as few as one or more than three views.

3. Visible lines should be drawn twice as thick as center lines.

4. Mitre lines are always drawn at 45°.

5. No. When clarity is not lost by doing so, hidden lines may be omitted.

EXERCISES (solution)

1.

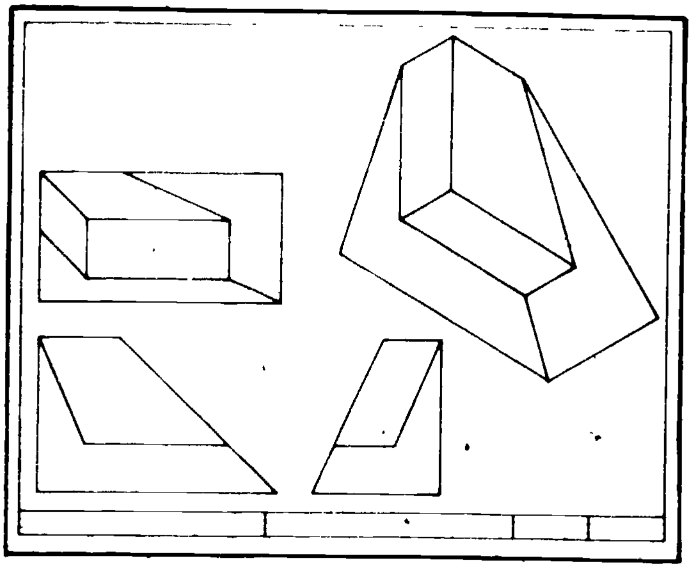


Figure 4.14

CHAPTER ITEMS

EXERCISES

1.

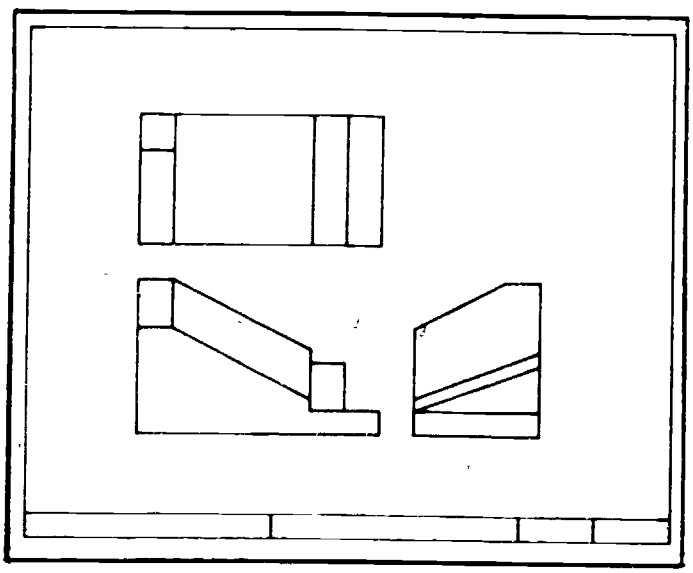


Figure 4.15

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CHAPTER V

Auxiliary Views

SECTION 5-1. PRIMARY AUXILIARY VIEWS

All objects cannot be completely described through the six regular views. In such cases it becomes necessary to "take another direction of sight" in order to describe the object more fully. Orthographic views which are not principal views are auxiliary views. When these auxiliaries are projected from principal views they are primary auxiliary views. Primary auxiliaries show a true orthographic dimension of height, width, or depth depending on the view from which they were projected. Figure 5.1 shows the modified "glass box" used in projecting an auxiliary view. The steps in projecting a primary auxiliary view are as follows:

1. Establish a direction of sight.
2. Project all points on the object parallel to the direction of sight.
3. Construct a folding line perpendicular to the direction of sight.
4. From a view which shows the same orthographic dimension as the auxiliary being drawn, transfer the measurement into the new auxiliary view.
5. Connect points and determine visibility.

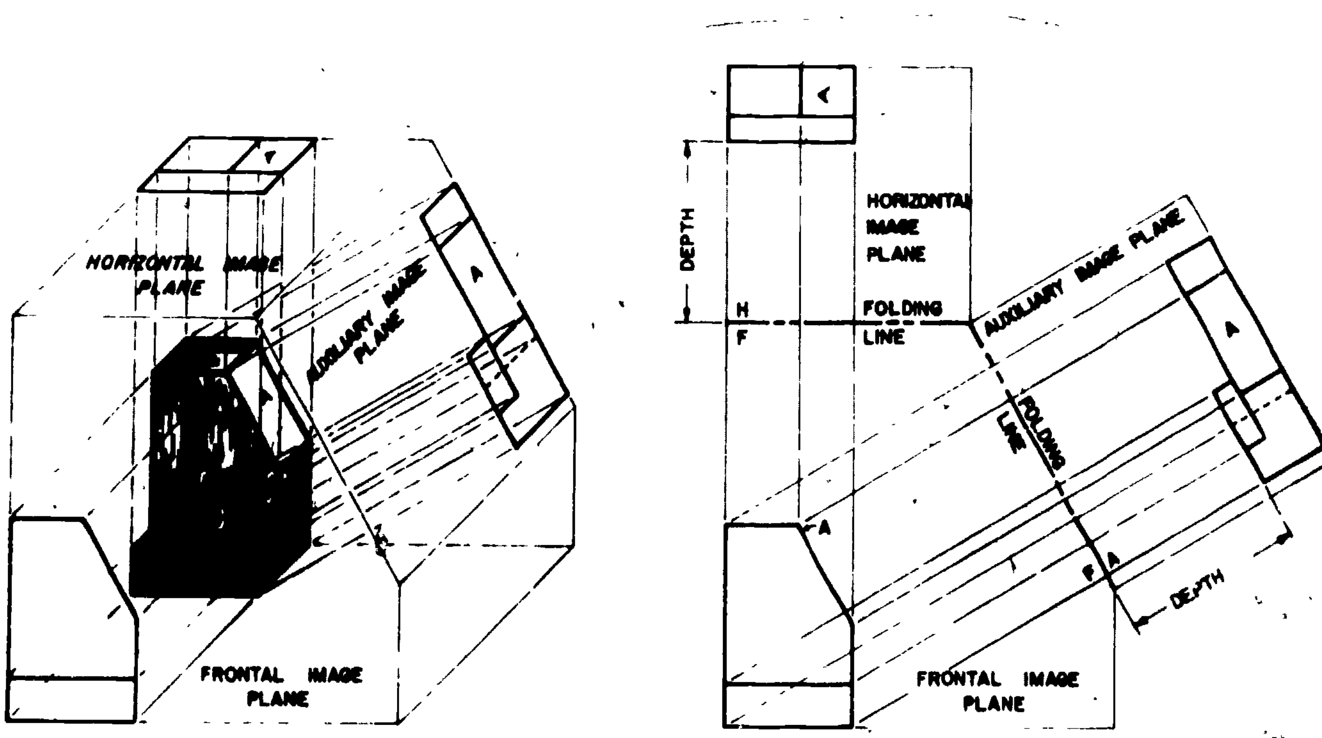


Figure 5.1 Modified Glass Box

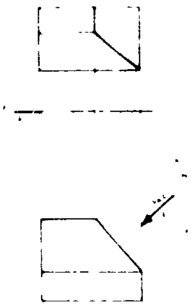


__Figure 5.2__ Establish a direction of sight.

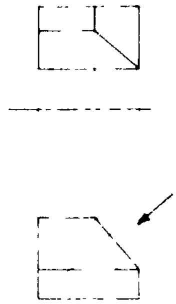


__Figure 5.3__ Project all points parallel to direction of si

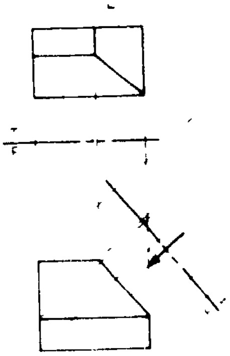


__Figure 5.4__ Construct folding line perpendicular to direction of sight.

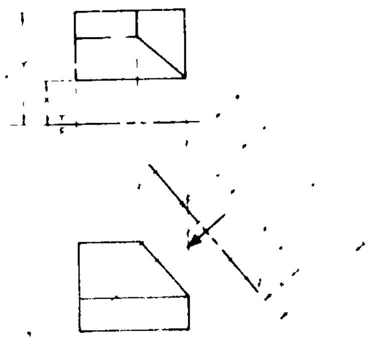


__Figure 5.5__ Transfer measurements

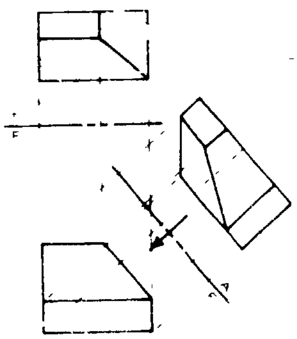


__Figure 5.6__ Determine visibility and connect points.

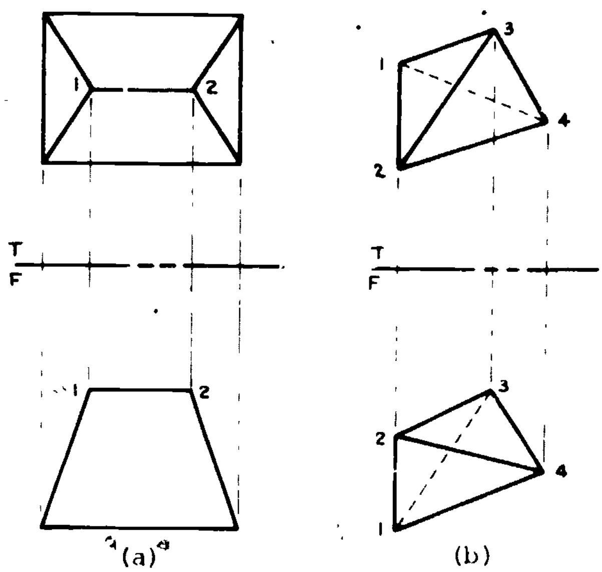
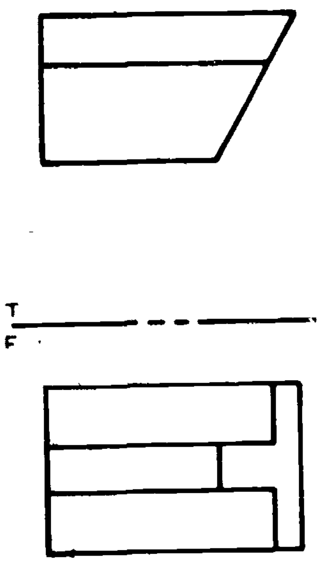
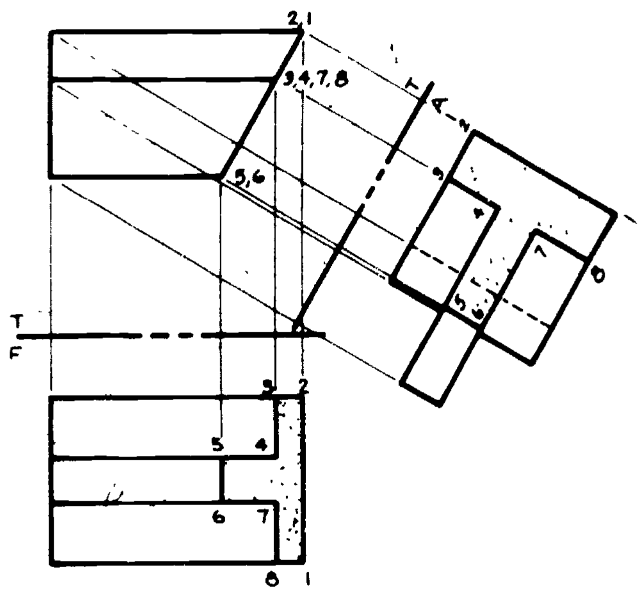


__Figure 5.7__ Visibility can be determined by inspecting adjacent views. (a) Nearest edge is visible. (b) Farthest edge or corner is hidden.

LABORATORY

1. The student should be able to sketch a primary auxiliary view with correct visibility when given any two principal views.





SECTION ITEMS

STUDY QUESTIONS

1. From what view is the auxiliary which shows the true dimension of height projected?

2. What is the angular relationship between the projectors and their respective folding line?

3. What is the angular relationship between the directions of sight for any two adjacent views?

4. How is the true shape of a plane projected?

5. How is the true length of a line projected?

EXERCISES

1. Sketch a primary auxiliary view of the entire object shown in Figure 5.8 which shows the true shape of plane A.

2. Sketch a primary auxiliary view of the cables in Figure 5.9 which show their true lengths.

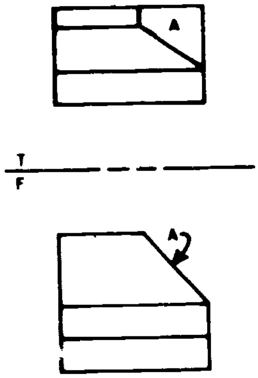


Figure 5.8

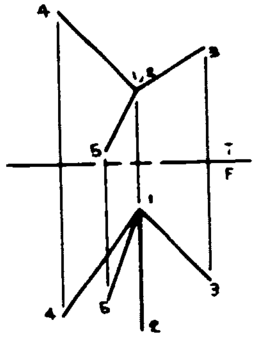


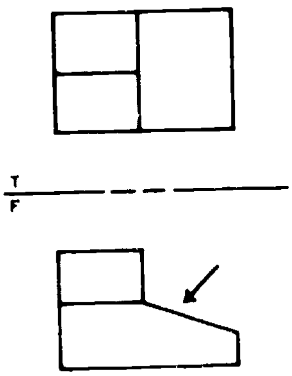
Figure 5.9

CHAPTER ITEMS

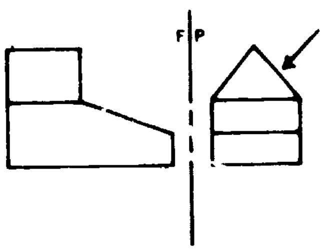
EXERCISES

1. Sketch the indicated auxiliary views showing all visible and hidden lines with correct visibility.

1.



2.



ANSWERS - Section 5.1

STUDY QUESTIONS

1. Top view.

2. They are perpendicular.

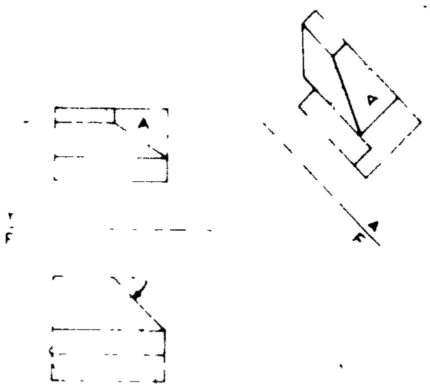
3. The directions of sight are mutually perpendicular.

4. By taking a direction of sight perpendicular to the plane

5. By taking a direction of sight perpendicular to the line.

EXERCISES

1.



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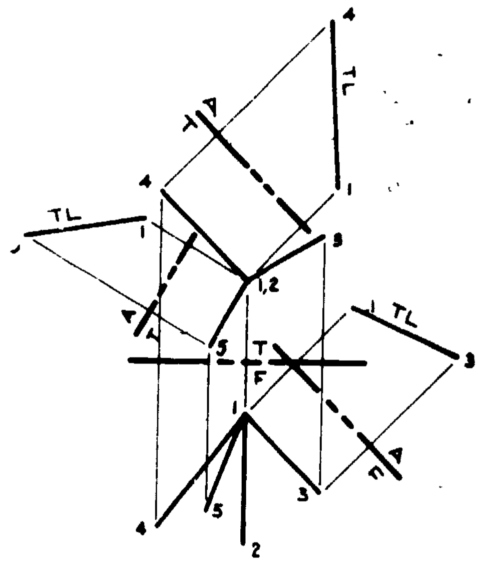
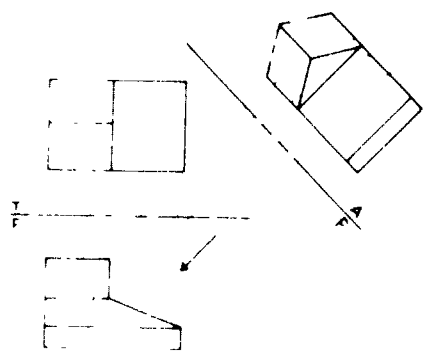
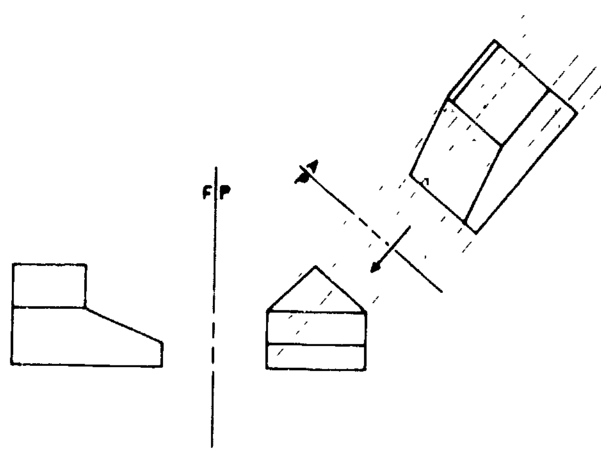


CHAPTER ITEMS





Section 6.1 CUTTING PLANES, SECTION LINING, FULL AND HALF SECTIONS

Sectional views are often used on engineering drawings. The cover sheet on a set of working drawings might be an "assembly section" view or cutaway showing how the parts of a device fit together. Reading a drawing of a part with many hidden internal features is complicated by the hidden lines in the views. By sectioning or opening the part, the internal design of the part is more clearly seen.

Fig. 6.1 Assembly section. This view shows the assembly of parts more clearly.

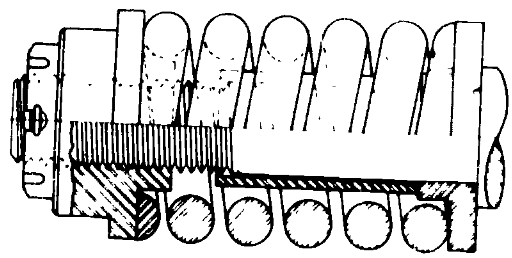


Fig. 6.2 Cutting plane. The basis for showing a section view is to imagine the part being cut so the interior can be seen.

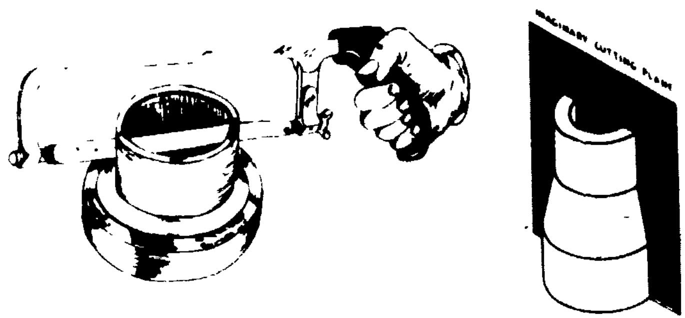


Fig. 6.3 Section lining. A few of the materials are shown. Direction of lining should change on adjacent parts.

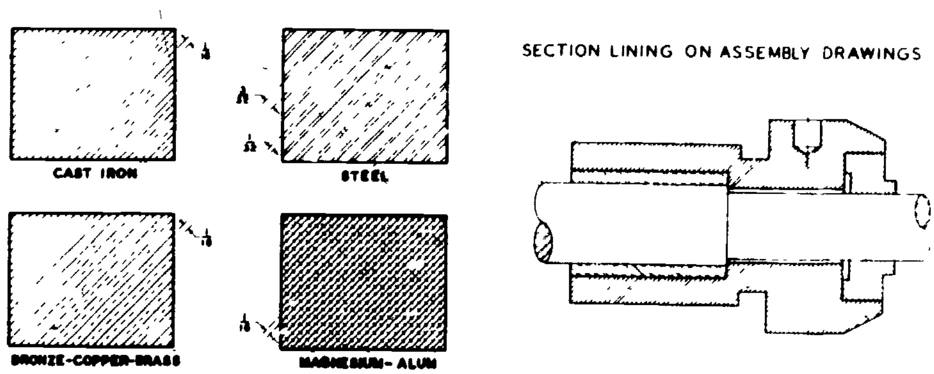
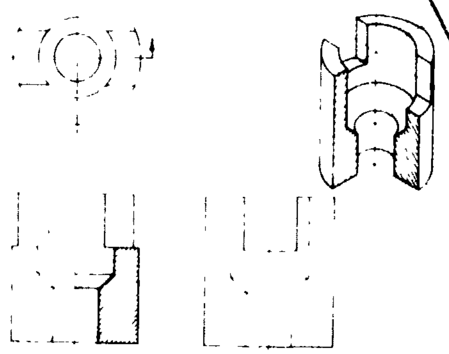


Fig. 6.4 Full section views. The full section is the most commonly used. The entire view is "fully sectioned". Cutting plane location is along the center line of the part.

Fig. 6.4 Half section. This type of view is particularly useful where the part is symmetrical and both exterior and interior features need to be shown.



LABORATORY

1. The student should be able to draw or sketch full and half section views and use the correct section lining representation.

SECTION ITEMS

STUDY QUESTIONS

1. What type of object is best shown in section view ?

2. When should a half section be shown in preference to a full section ?

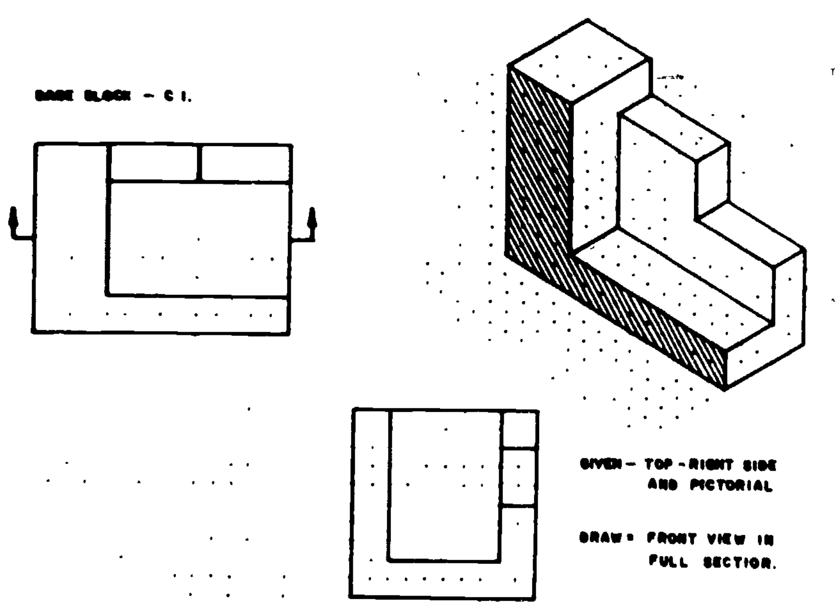
3. Is the spacing for cast iron section lining always 1/8 inches ?

4. Are cutting plane lines always shown in full and half sections ?

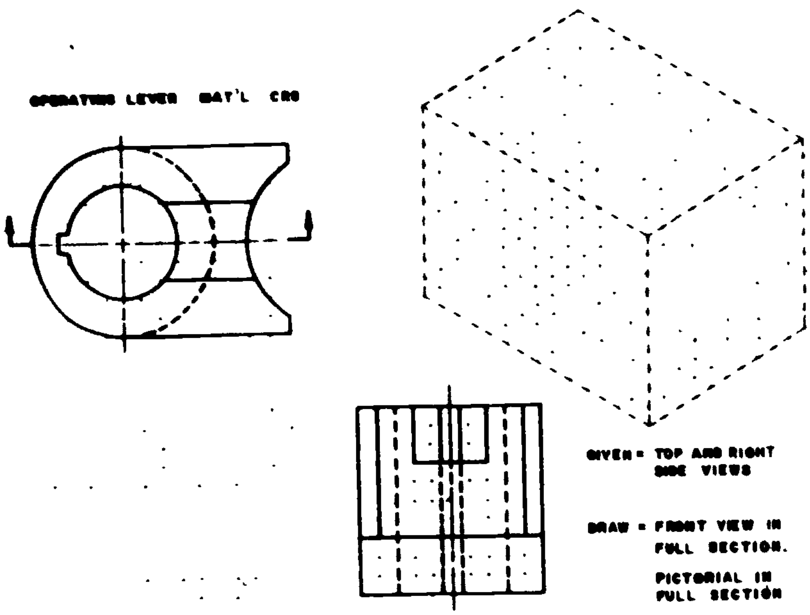
EXERCISES

Sketch the answers to the following problems.

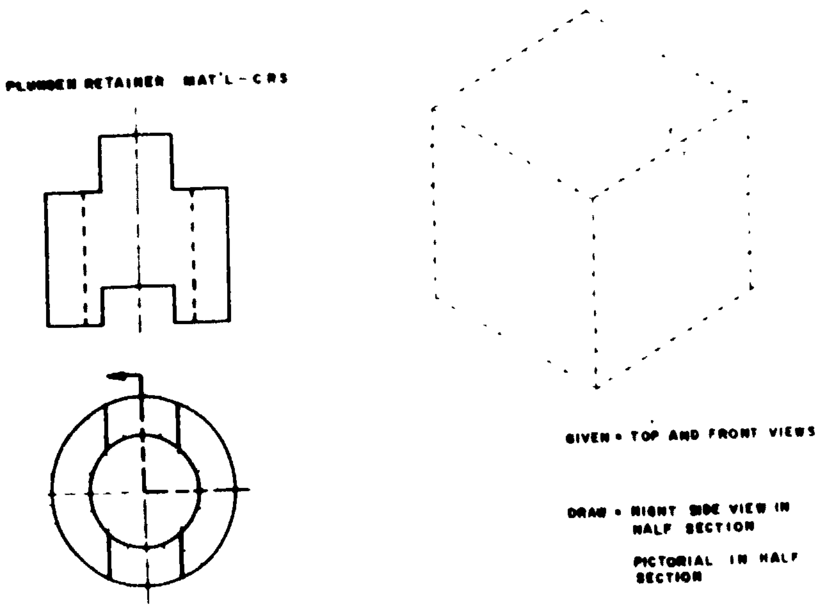
1. BASE BLOCK



2. OPERATING LEVER



3. PLUNGER RETAINER



Special types of sectioned views have been accepted as a means of showing part features more clearly. Rather than draw an entire view in section, it is possible to break out, partial section, or pull out special areas of a part.

OFFSET SECTION

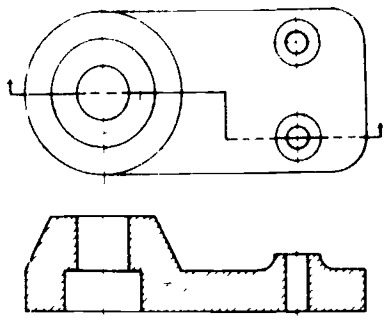


Fig. 6.5 Offset section. Here, the cutting plane is bent or offset to better show part features.

ALIGNED SECTION

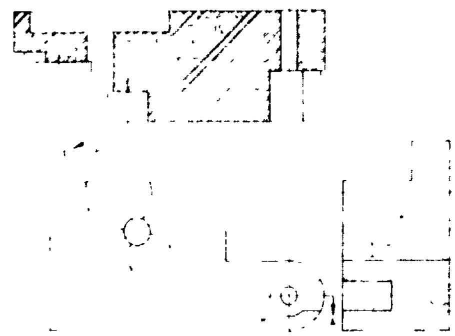


Fig. 6.6 Aligned section. The cutting plane is angled through the part. To show the section view, it is necessary to revolve the points along the section cut back to the direction of projection.

REMOVED

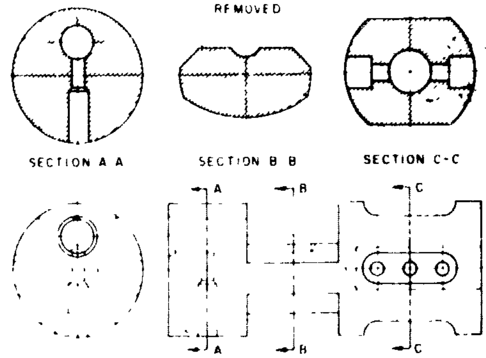


Fig. 6.7 Removed section. The cutting plane line indicates where the section view is cut. The views are shown wherever convienient on the page. Views are identified by A - A, - B, C - C etc.

REVOLVED SECTIONS

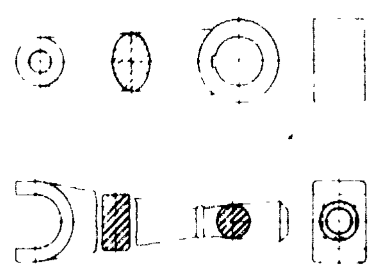


Fig. 6.8 Revolved section. If space is available on the part drawing, a section can be cut and revolved into the view. This aids the reading of the drawing by adding a third dimension to the view.

4

Fig. 6.9 Phantom section. This view shows both internal and external part surfaces. Section lining is shown as dashed lines and material type is not indicated.

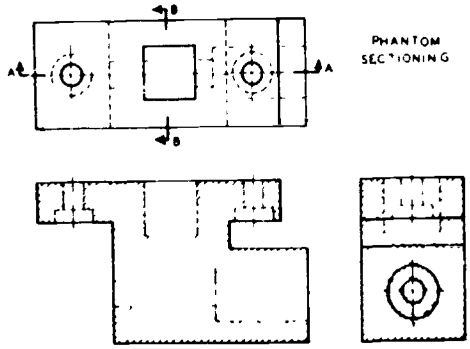
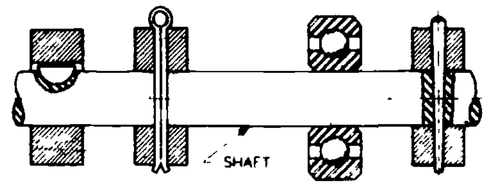


Fig. 6.10 What not to section. Center shafts, bolts, pins, balls, keys etc. should not be sectioned.



LABORATORY ACTIVITIES AND SKILLS

1. The student should be able to draw or sketch section views similar to those shown.

2. The student should be able to choose the best type of section view to show a particular part.

SECTION ITEMS

STUDY QUESTIONS

1. What type of part is best shown with the phantom section?

2. Are the points alongthe aligned section cut projected directly to the adjacent view?

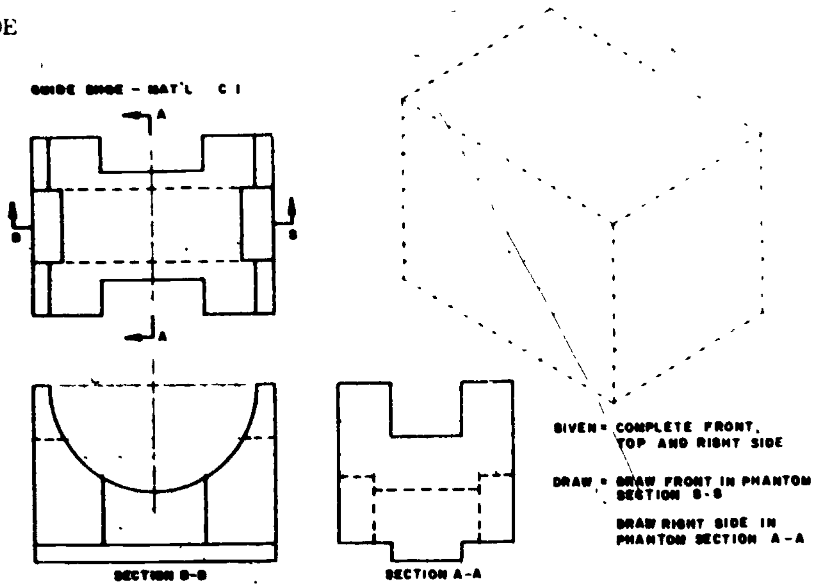
3. What determines whether to use a revolved section view or a removed section view?

4. What do the arrows on the cutting plane lines mean? Why use letters at the end of each arrow?

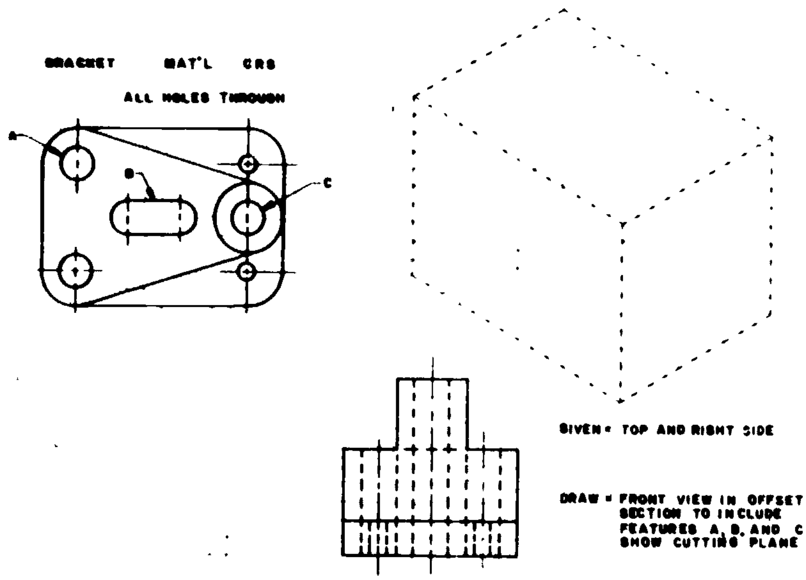
EXERCISES

Draw or sketch the answers to the following problems.

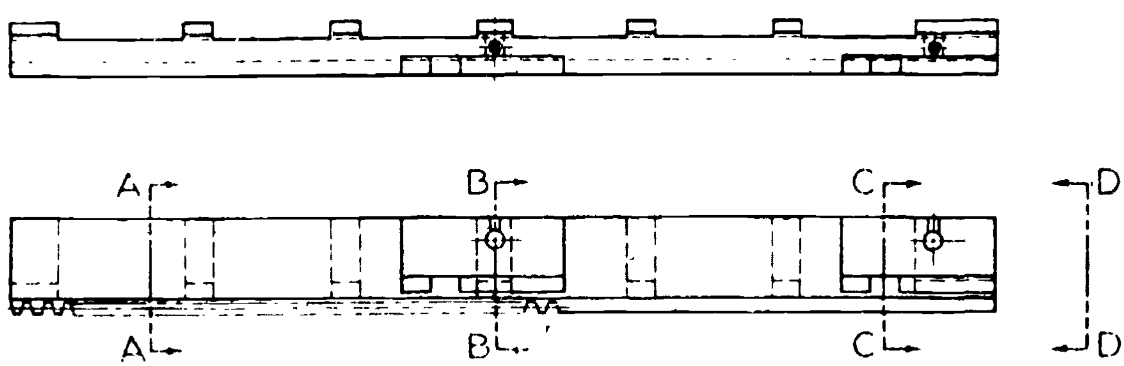
1. GUIDE SHOE



2. BRACKET



3. RACK



CHAPTER ITEMS

QUESTIONS

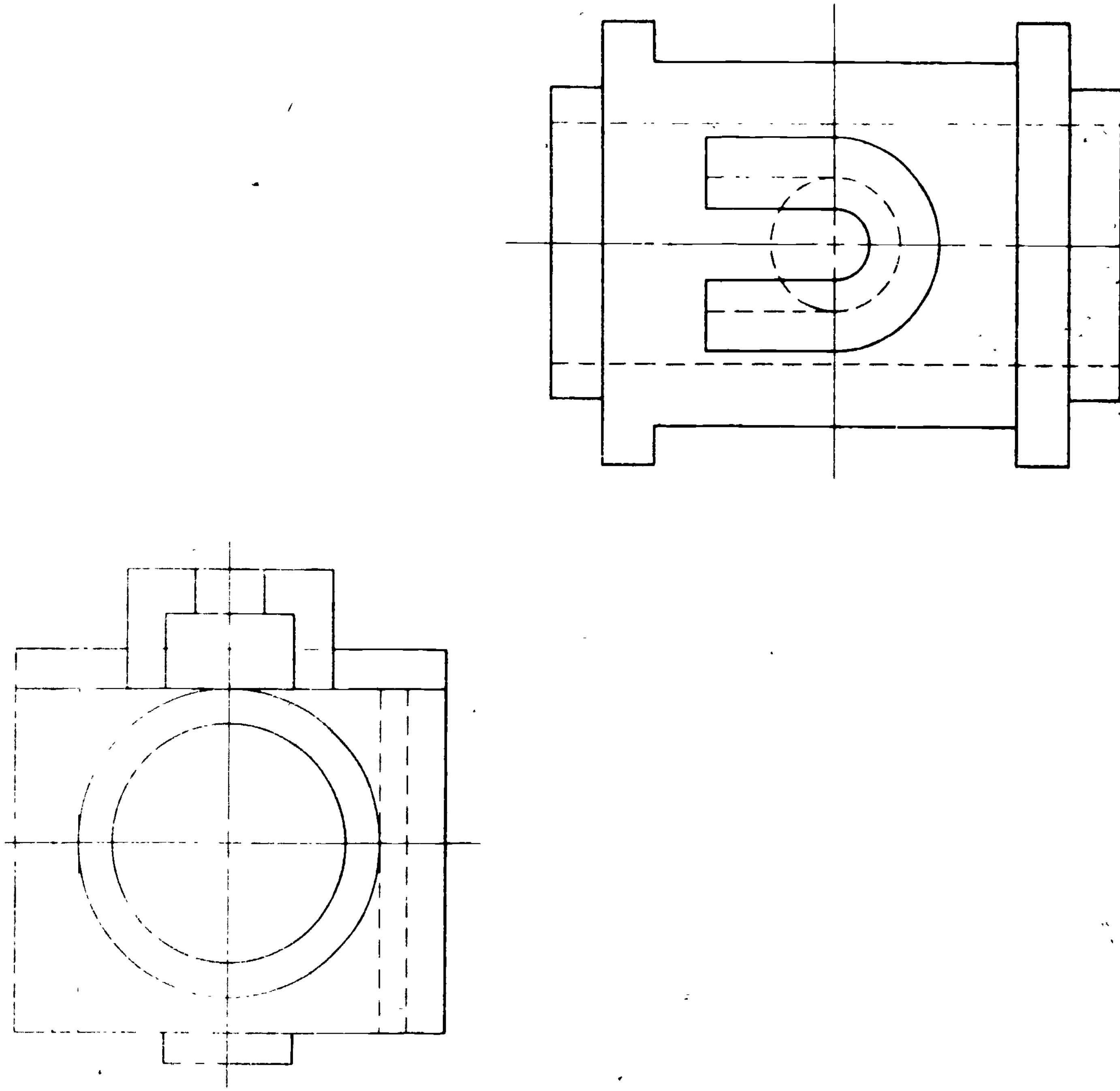
1. When should sectioned views be used?
2. What is the importance of section lining?
3. When would an offset section be preferable to a full section?
4. List the types of section views requiring cutting plane lines.
5. Why are arrows needed for cutting plane lines?

EXERCISES

Solve the following problems.

ERIC

1. TAKE-UP BEARING



[illegible]MPLETE TOP AND LEFT SIDE VIEWS OF A TAKE-UP BEARING

[illegible] 1. BRASS 2. BRONZE 3. 90 CARBON STEEL 4. SAE 1045 5. CAST IRON

[illegible] FRONT VIEW IN FULL SECTION

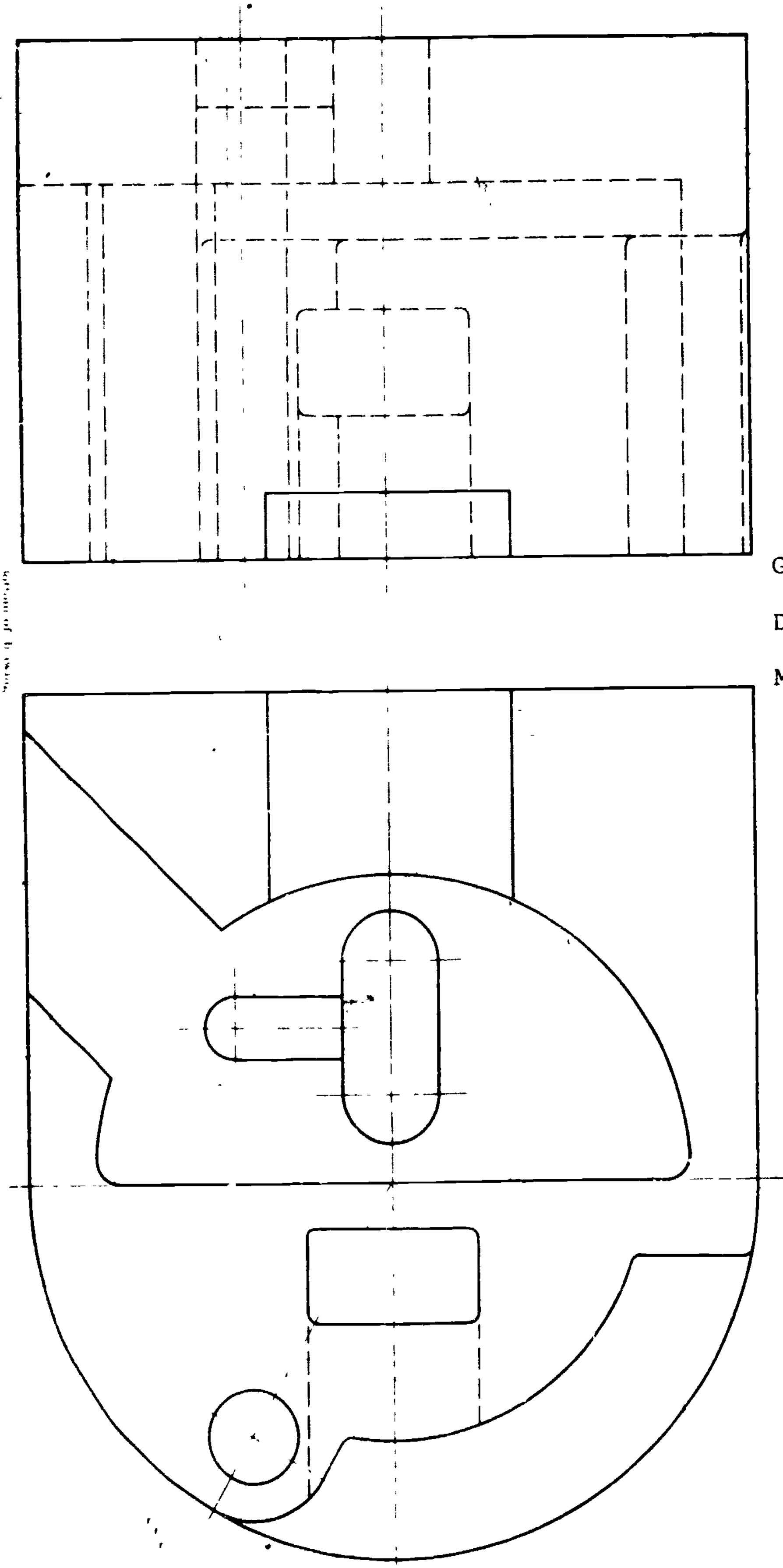
[illegible] FRONT VIEW IN HALF SECTION (Show Hidden Lines In Upper Half)

[illegible] FRONT VIEW IN HALF SECTION (Show Hidden Lines In Lower Half)

[illegible] FRONT VIEW IN PHANTOM SECTION

ERIC Full Text Provided by ERIC

2.



Given: Front and left side views

Draw: Top view in full section

Material - Steel

SECTION 6.1

1. Section views are best for parts that have many internal features that would otherwise have to be shown by hidden lines.

2. A half section should be used when an object is symmetrical and has both internal and external features that need to be shown.

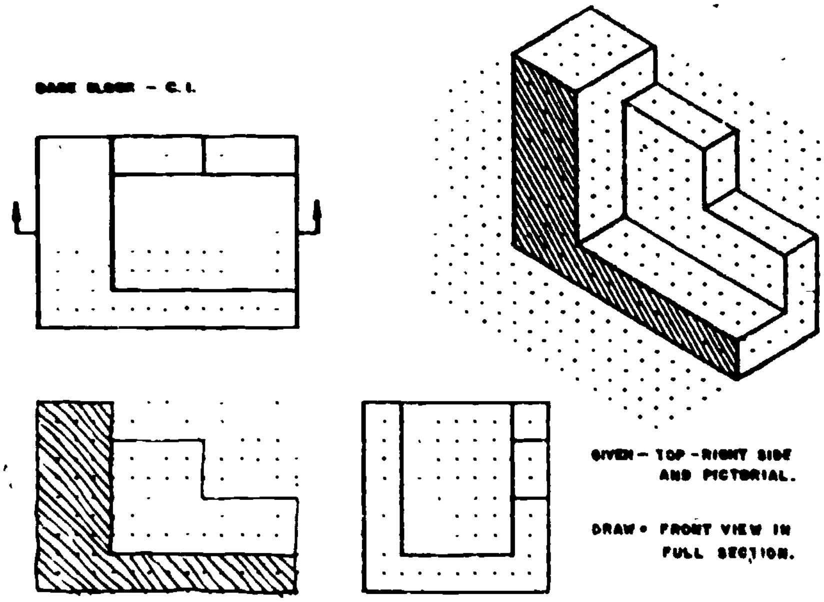
3. No. Spacing of section lines is usually proportional to the overall size of the drawing. Small drawings should have section lines spaced closer.

4. No. Cutting plane lines are often not shown in full and half section views.

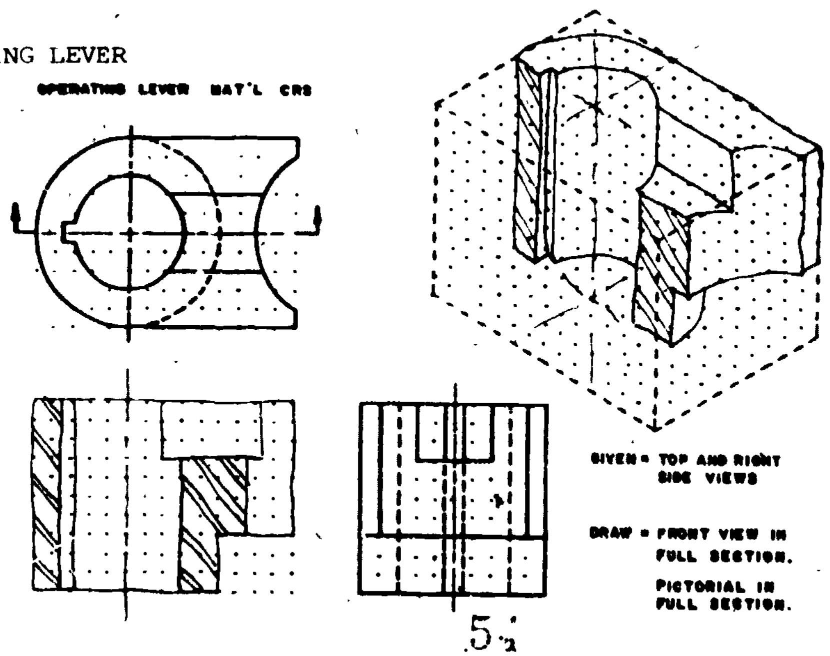
EXERCISES

1. BASE

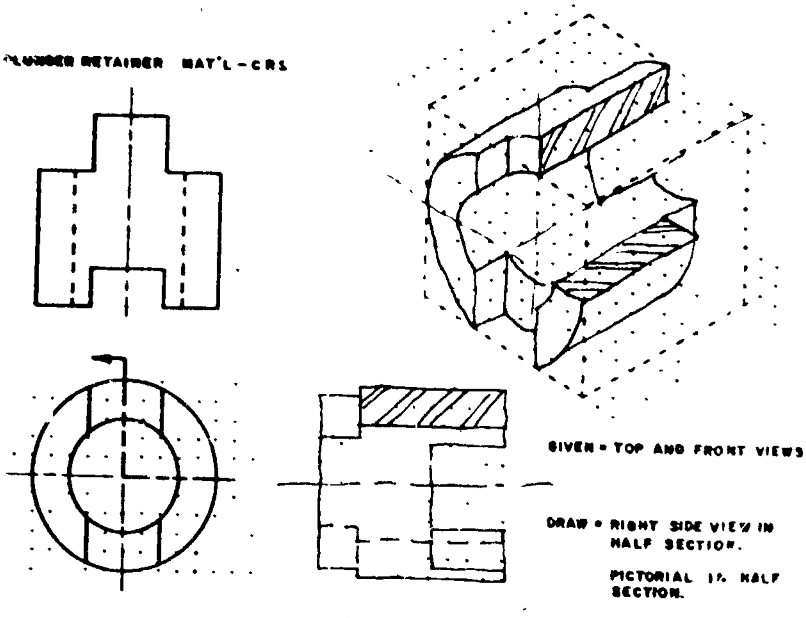
Block



2. OPERATING LEVER



3. Plunger Retainer



SECTION 5.2

1. The phantom section is best for objects with large uncomplicated internal cavaties.

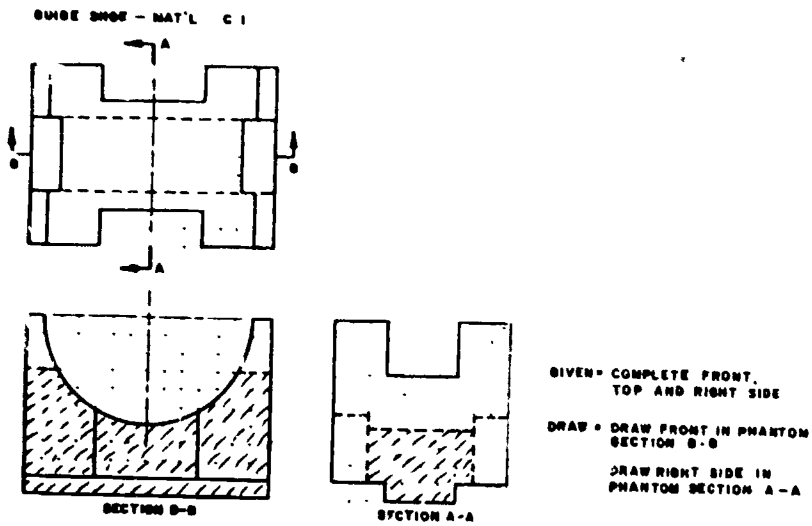
2. No. The intersections along the angled portion of the section cut must first be revolved until perpendicular to the line of signt between the views.

3. Space available on the part drawing. removed section view should be used when too crowded.

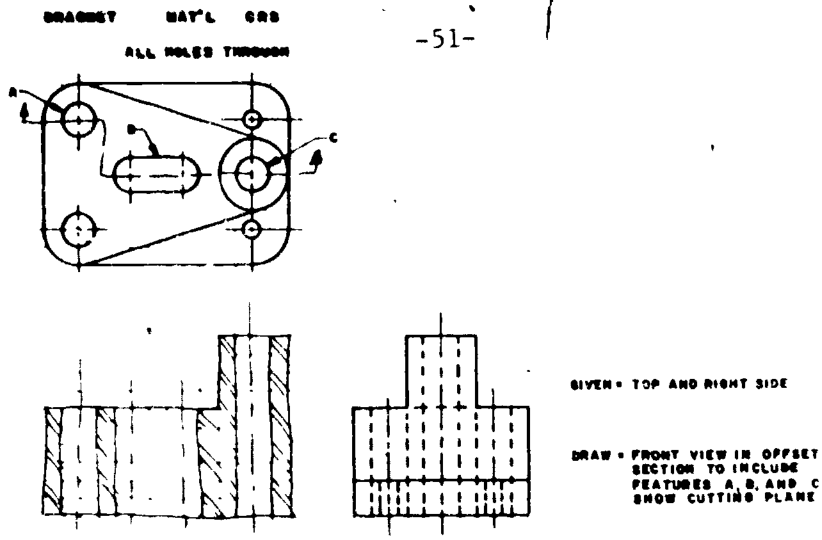
4. The arrows on the cutting plane lines indicate the direction of view. Letters are used to distinguish the various section cuts.

EXERCISES

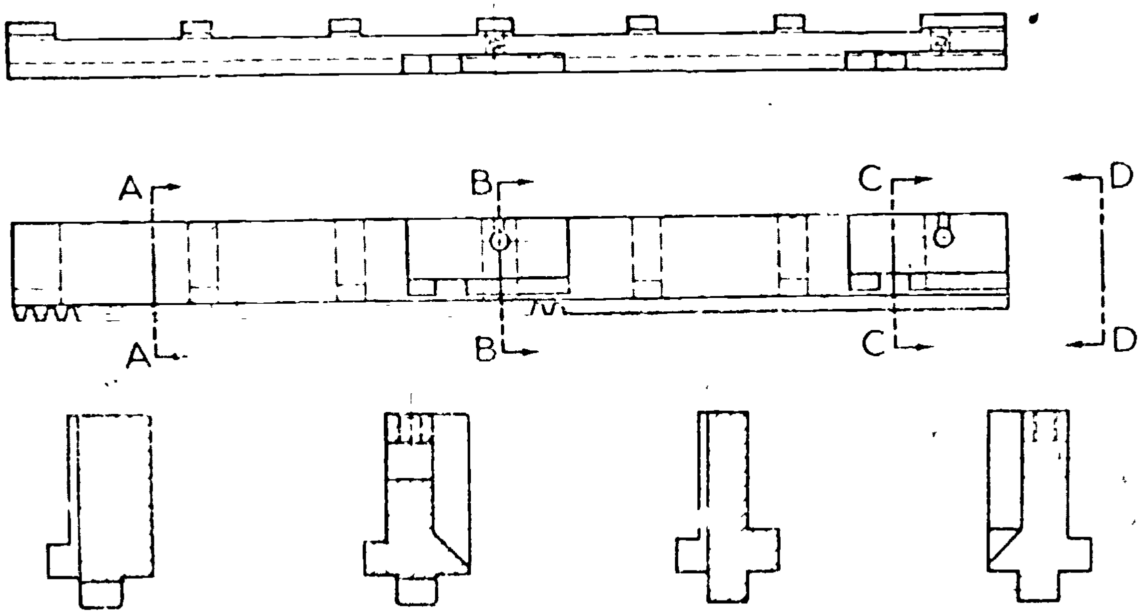
1. GUIDE SHOE



2. BRACKET



3. RACK



SECTION A-A DOUBLE SIZE

SECTION B-B DOUBLE SIZE

SECTION C-C DOUBLE SIZE

VIEW D-D DOUBLE SIZE

REMOVED SECTIONS AND REMOVED VIEW

CHAPTER NOTES

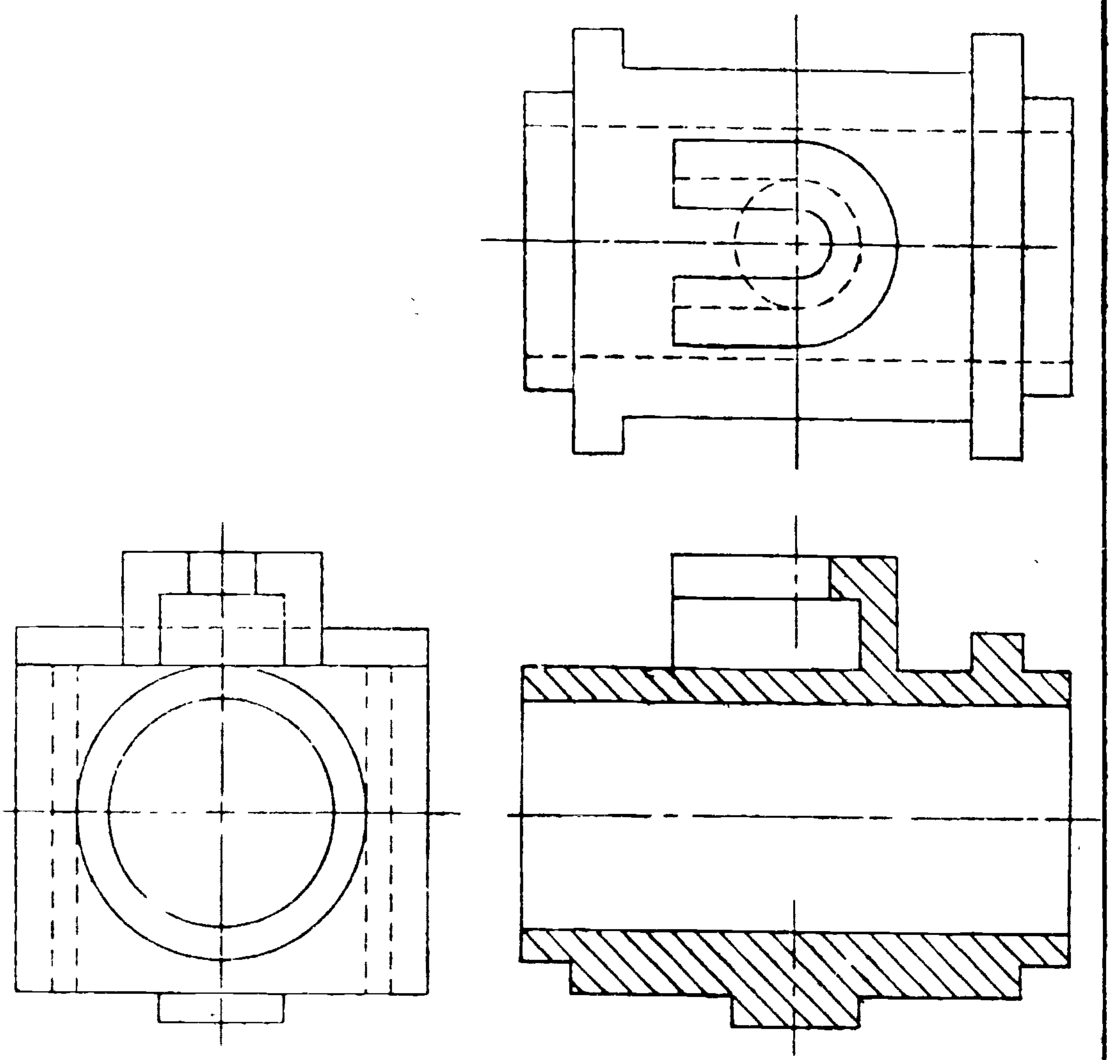
1. Sectioned views should be used when an object has many internal features that would otherwise have to be shown by hidden lines.

2. Section lining defines the solid areas on a part. Various materials can be shown and the direction of section lining can be varied to make parts in an assembly section stand out more clearly.

3. An offset section often allows more part features to be shown than the full section view.

4. All section views do not require cutting plane lines to be shown. Some companys do not show cutting plane lines on the full and half section views.

5. Arrows on cutting planes indicate the direction of view.



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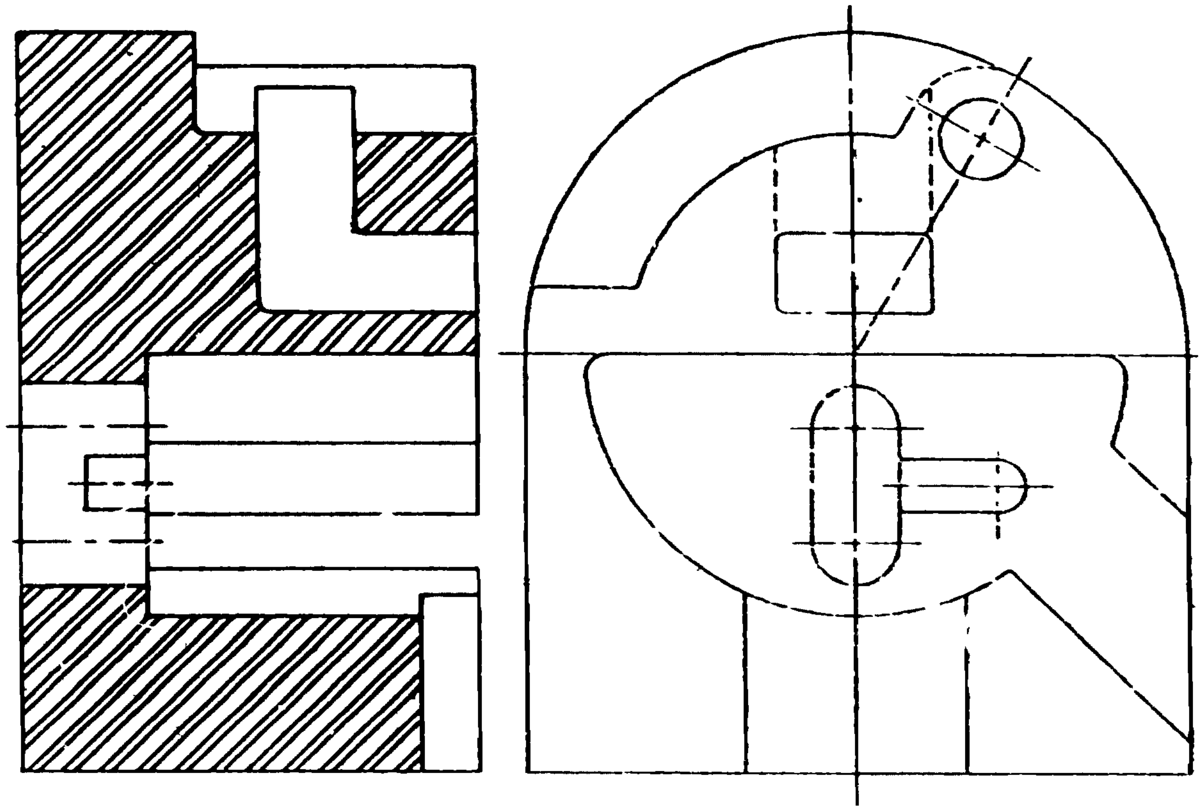
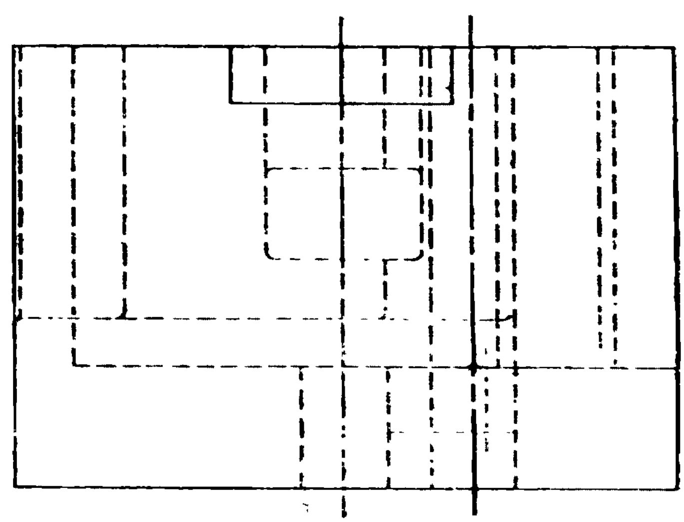




Typical Section View Problem

Section 7.1 MEANS FOR SPECIFYING DIMENSIONS

The part drawing shows the shape of the part. Dimensions must be specified to show the size of the part. Dimensions should conform to accepted standards such as U.S.A.S.I. Y14.5 for style and placement. Too many dimensions can lead to errors in production. Too few dimensions can lead to lost time. Proper form, location and specification are essential for quick interpretation of the drawing.

DIMENSIONING CONVENTIONS

Fig. 7.1 Extension lines, dimension lines, leader lines, arrowheads. A dimensioned part is shown. Note the size, placement, spacing and form for the dimensions.

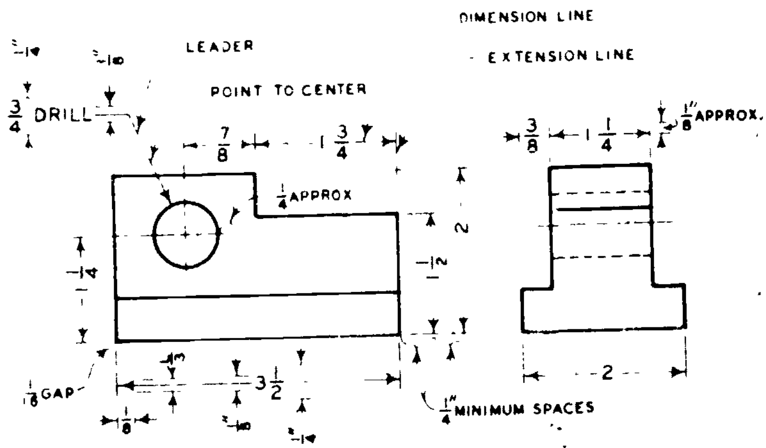


Fig. 7.2 Aligned and unidirectional dimension placement. The unidirectional system is generally preferred.

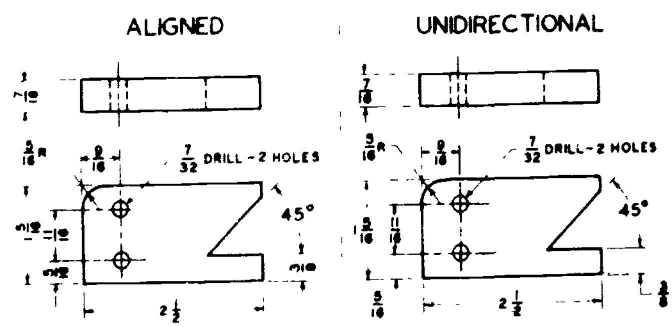
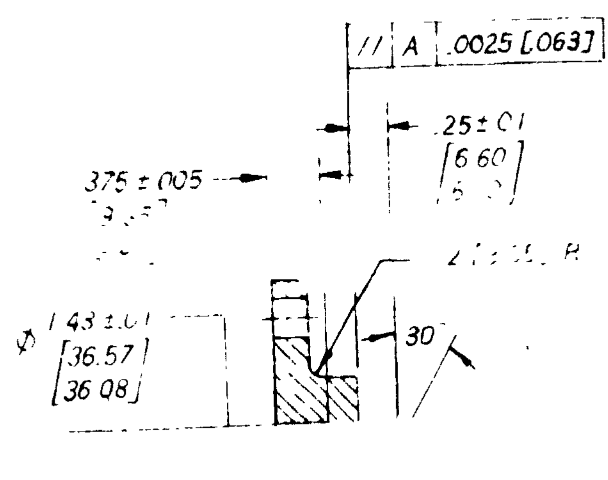
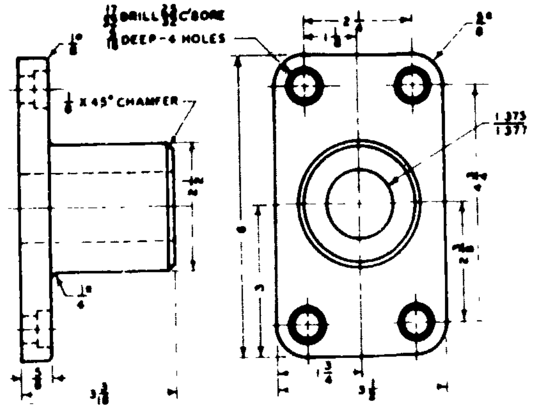


Fig. 7.3 Fractional inch, [illegible] units. [illegible] Dual dimensioning may be specified so both inch and metric units can be shown.



DIM. IN [ ] ARE MILLIMETERS.

Fig. 1.4 Placement of dimensions. In addition to proper size and spacing, a dimension should be located in the correct view. Place the dimension where the shape shows best. Avoid dimensioning to hidden lines. Place the shortest dimensions closest to the part.



A DETAIL WORKING DRAWING

Standard sizes. Many items used in producing parts and assemblies are available in standard sizes. Examples are: screws, nuts and bolts, bearings, pins. Machining stock is available in many materials preformed to accurate size in many shapes like: round, square, hexagon, rectangular etc. Thin metals are specified in gage thicknesses.

LABORATORY

1.. The student should be able to demonstrate the proper line technique in adding extension, dimensior, leader and lettering guide lines to a drawing for dimensioning. Form arrowheads.

2. The students should be able to choose the best placement of dimensions based on shape of part features.

3. The student should be able to convert dimensions between the fractional inch, decimal inch and metric systems maintaining the same relative accuracy.

4. The student should be able to locate tables specifing standard sizes for hardware items, formed stock shapes and sheetmetal gages.

SECTION ITEMS

STUDY QUESTIONS

1. What is the minimum height for lettering on a drawing?

2. If using fractional dimensioning, what is the minimum height for the total fraction?

3. What is the correct line thickness for extension lines?
   What is the correct density for extension lines?

4. Under what conditions should arrowheads be blackend in?

5. Can dimensions be placed within the part drawing itself?

6. If a dimension is specified 3.472 ± .03 inches, what is the metric equivalent?

Section 7.2 STANDARD METHODS OF DIMENSIONING FEATURES

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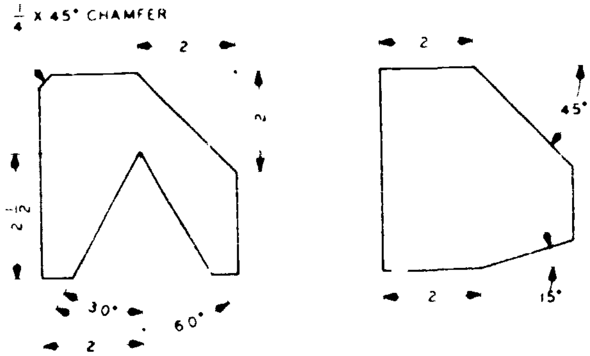


Fig. 7.6 Angles. Angles are dimensioned by giving the length of two sides or by giving one side and the angle in degrees.

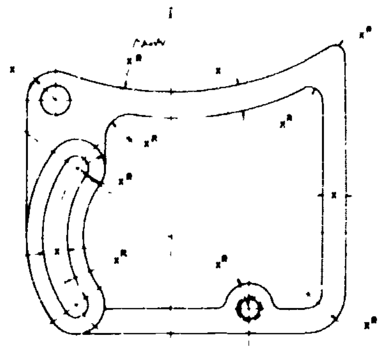


Fig. 7.7 Arcs. An arc is less than a full circle. The radius is generally specified. Important radii should be dimensioned by locating the center and giving the radius from the center. For unimportant radii, rounded corners, etc., just specify the radius.

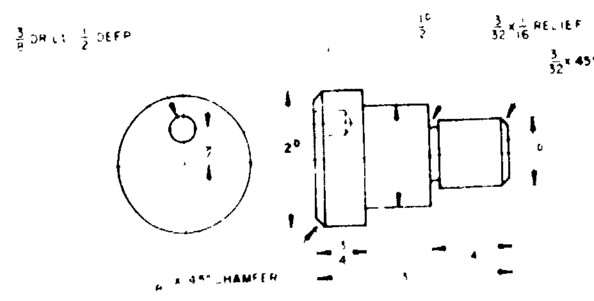


Fig. 7.8 Cylindrical holes and cylindrical parts. Holes are usually specified by dimension in the circular view. Cylindrical surfaces are dimensioned in the non-circular view. The diameter of the cylinder or hole should be given.

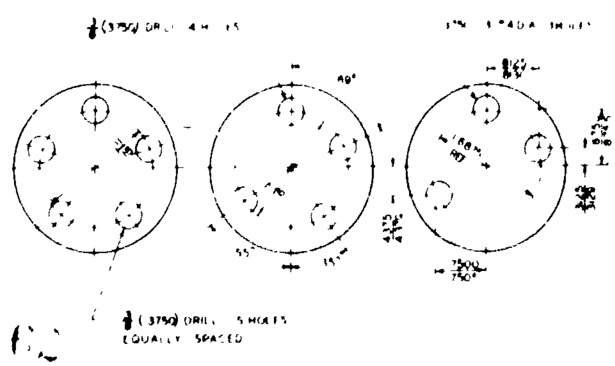


Fig. 7.9 Hole Patterns. The dimension to the center of the hole should be given. Centers can be located by angular or coordinate dimensions.

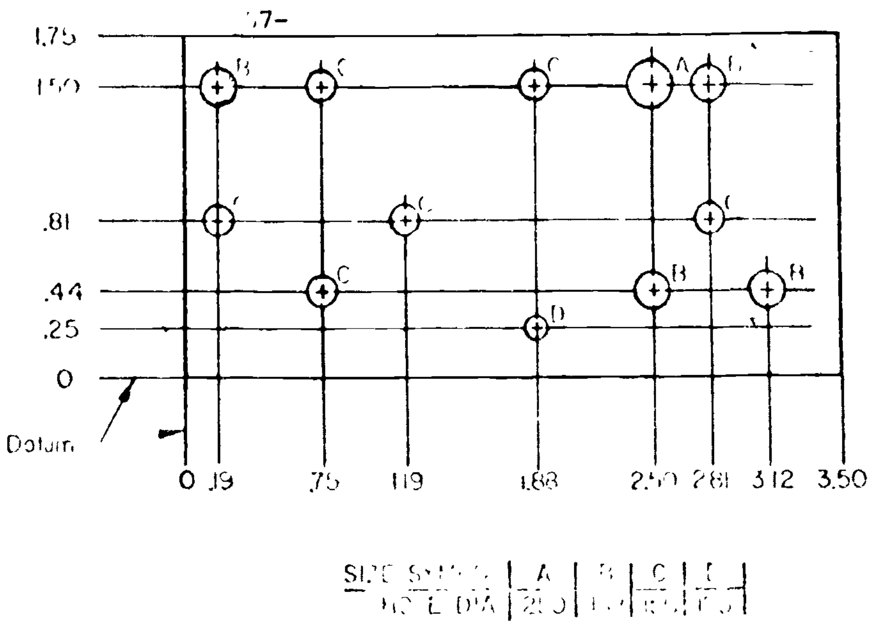


Fig. 7.10 Arrowless dimensioning. Complicated hole patterns in parts can sometimes be dimensioned by distances from a fixed location (datum). Hole sizes can be tabulated.

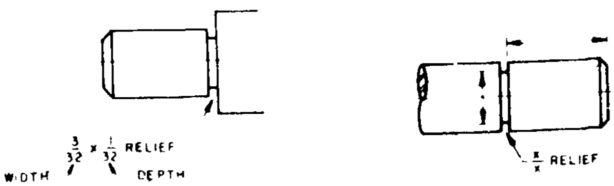


Fig. 7.11. Reliefs. Reliefs are undercut areas used to facilitate machining or assembly of parts.

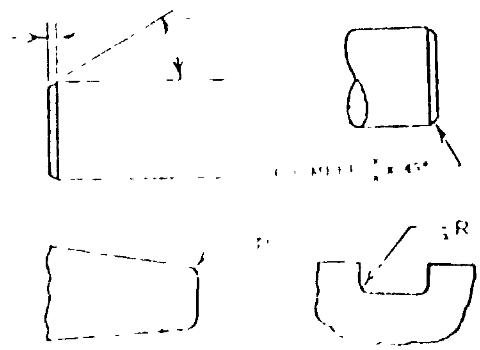


Fig. 7.12 Chamfers and rounded corners. These featurs are designed on parts to break sharp dangerous corners or to facilitate assembly or fabrication of parts.

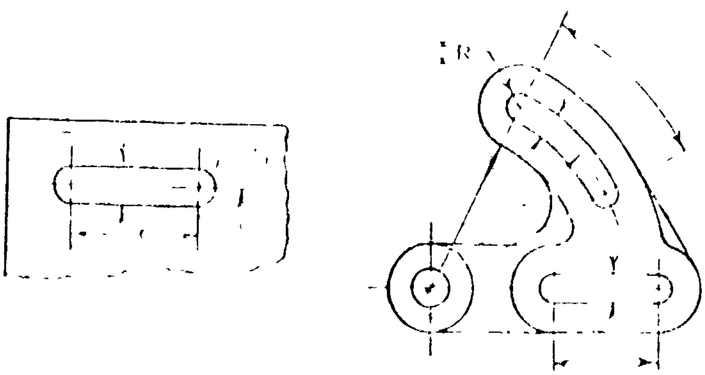
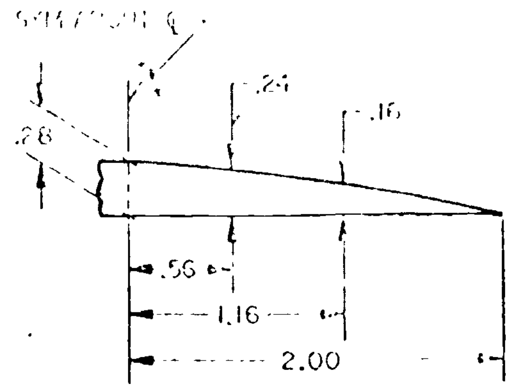


Fig. 7.13 Slots. Machined slots should be dimensioned to center line locations.

Fig. 7.14 Irregular curves. Coordinate dimensions are located along the curve.



LABORATORY

1. The student should be able to place dimensions on part features according to the examples listed.

SECTION ITEMS

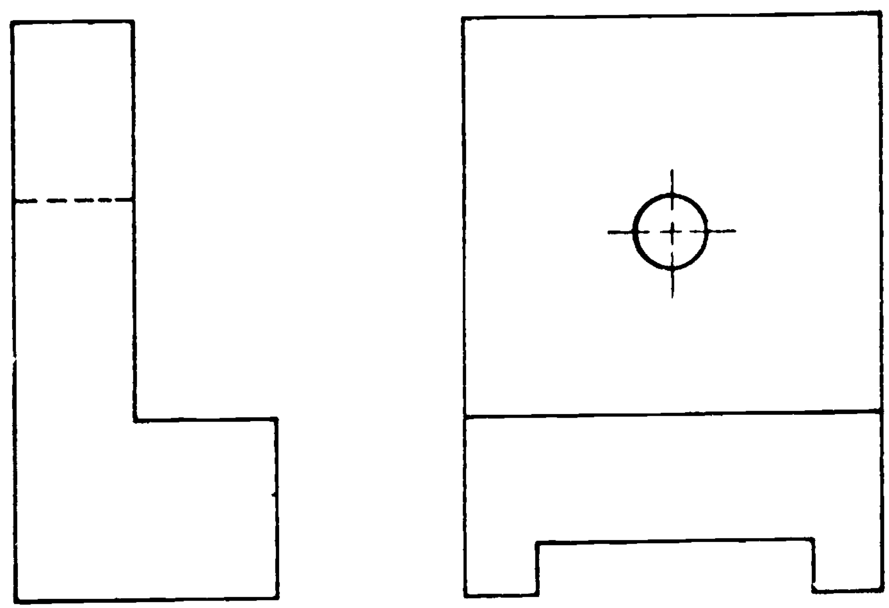
STUDY QUESTIONS

1. Give or sketch two methods of dimensioning an angle.
2. Under what conditions should the center of an arc be located.
3. A hole should be dimensioned in which view?
4. Sketch two methods of dimensioning shafts and cylinders.
5. Show how to dimension a chamfer, a rounded corner.

EXERCISES

Place dimensions on the following part drawings.

DIMENSIONING PROBLEM #1
Fully dimension the part using
fractional inch dimensions.
Use dividers and the scale at
the bottom of the sheet to
determine lengths.

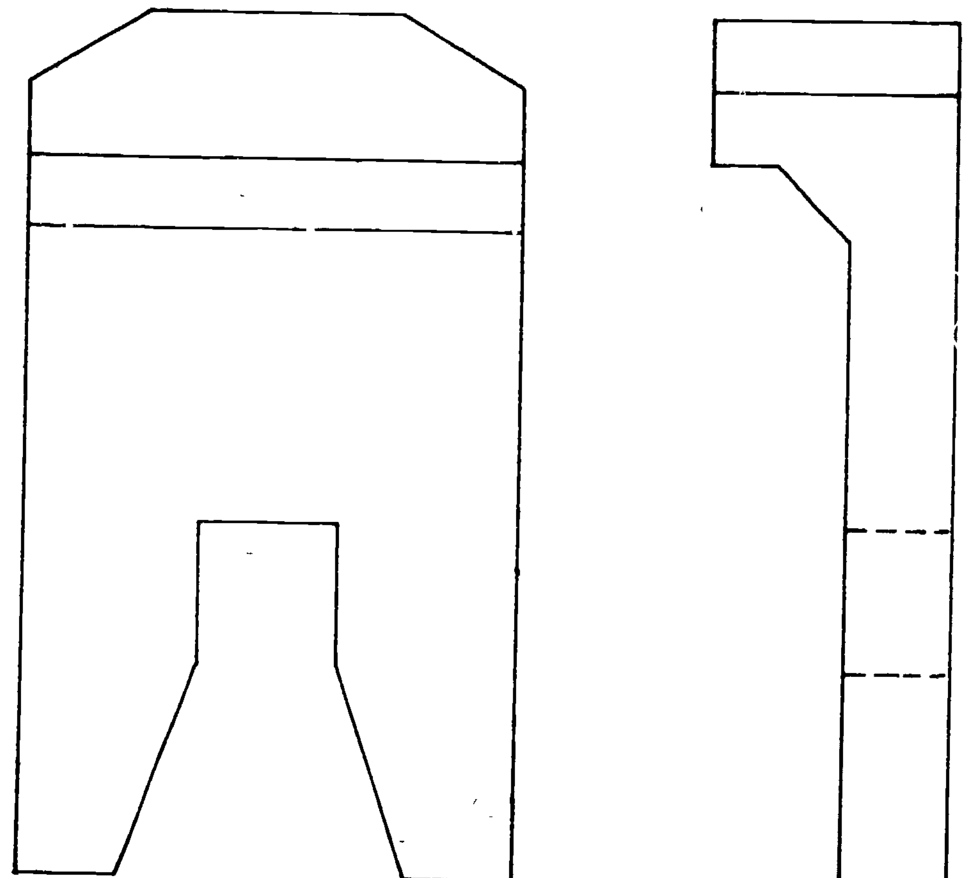


BRACKET

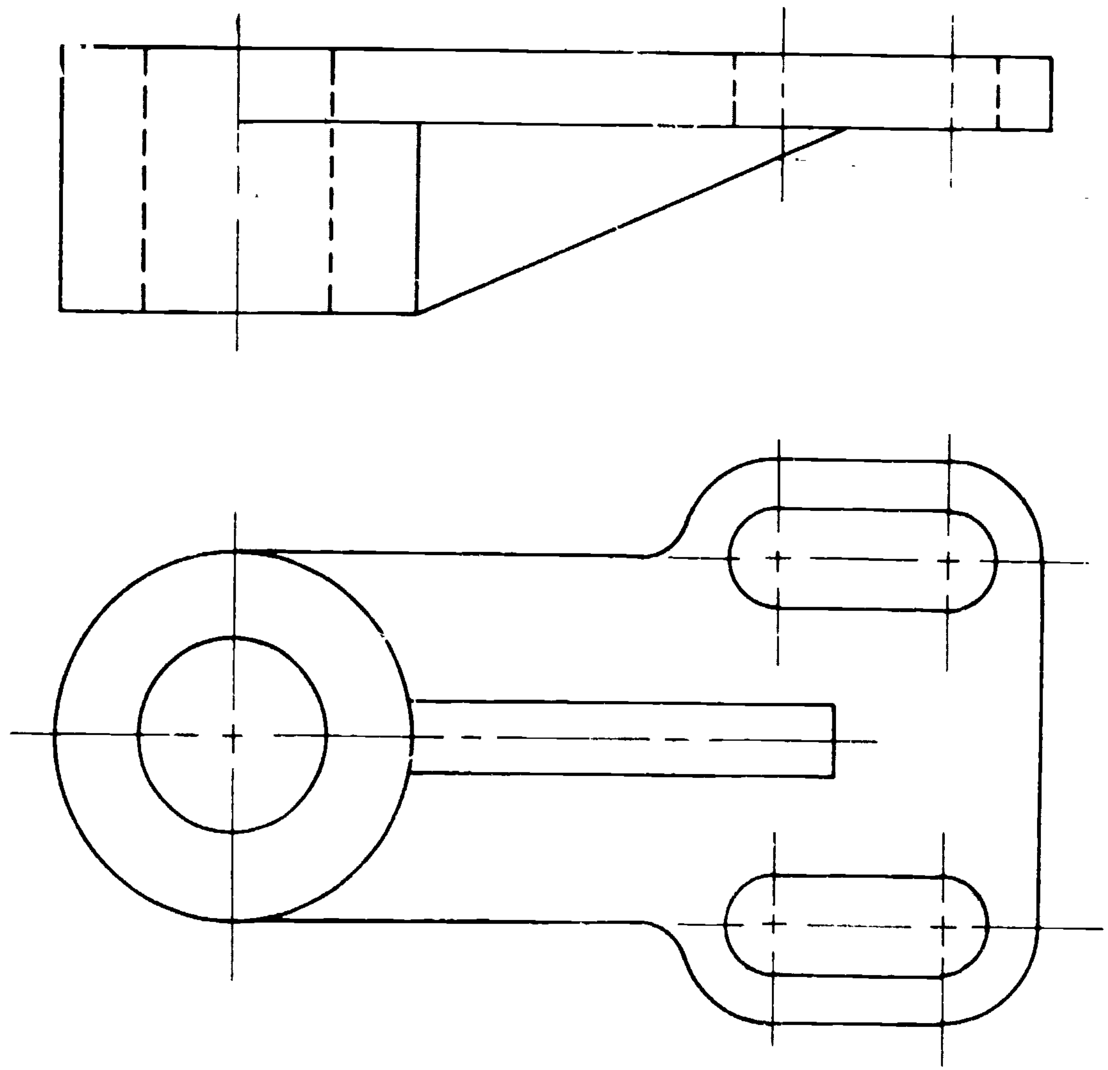
ADD ALL MISSING LINES

SCALE

DIMENSIONING PROBLEM #2
Fully dimension the part using decimal inch dimensions.
Scale = 1/2 size.
(Measure to center of lines to get lengths.)



DIMENSIONING PROBLEM #3
Fully dimension the part using metric dimensions.
Scale = Full size.



Section 7.4 ... MACHINING ...

Information relating to special machining, forming processes, surface finishing, welding and joining processes etc. is often given in note form. These notes must be written in concise form and placed on the drawing in areas away from the dimension and extension lines. Most companies have a standard form for these notes. Following are examples showing the usual note form and standard symbols.

Fig. 7.15 Drill, Bore, Ream. Examples are shown where the actual machining process is named. Some companies prefer showing the size as dia. (diameter) only with no reference to the process.

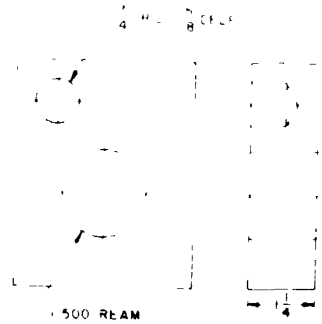


Fig. 7.16 Special hole shapes. These are required for use with head styles on various types of fasteners.

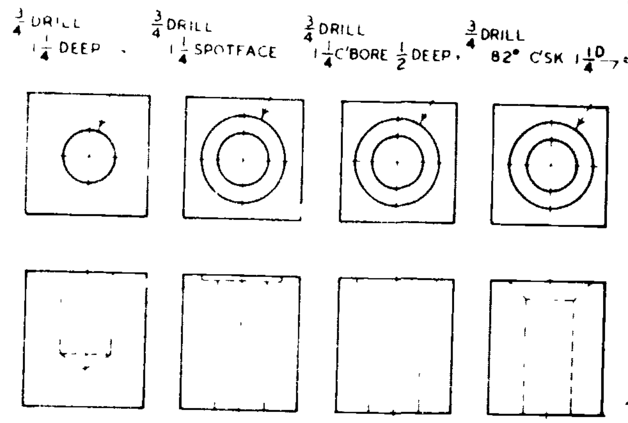


Fig. 7.17 Threaded holes. Whenever threads must be cut inside a hole, the information for the hole size and thread note must be found from standard tables.

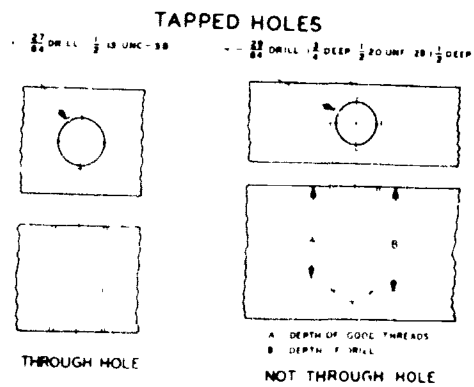


Fig. 7.18 Tapered holes. These are generally used where accurate alignment, self locking, or self retaining of parts is required.

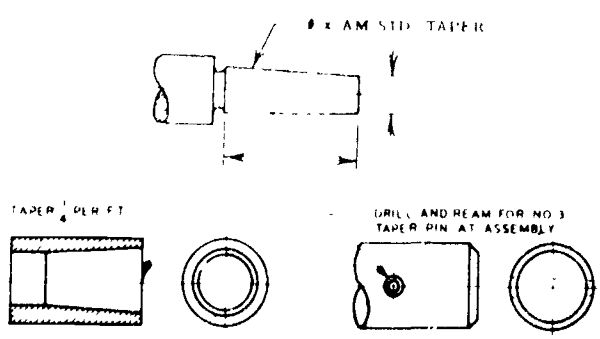


Fig. 7.19 Critical diameters. Limit dimensions may be specified to give the allowable range of sizes for a shaft or hole.

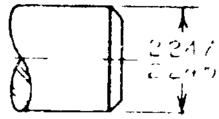


Fig. 7.20 Drill and counterbore sizes. Clearance must be allowed for the body and head sizes for common fasteners. Correct diameters and depths can be obtained from tables or by looking up the fastener head size and adding a small clearance.

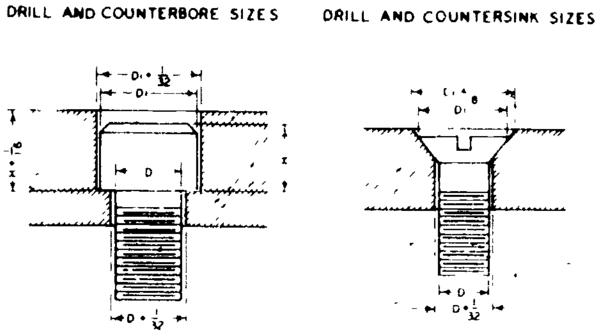


Fig. 7.21 External thread. Thread diameter and number of threads per inch are specified. Information on standard thread sizes and number of threads per inch is obtained from tables.

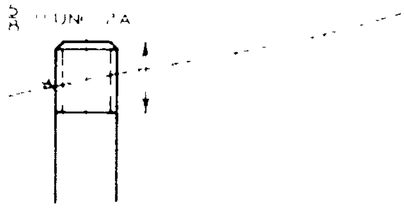


Fig. 7.22 Keys. Keys and keyways are used to prevent slippage between shaft and mating part. Standard types and sizes are obtained from tables.

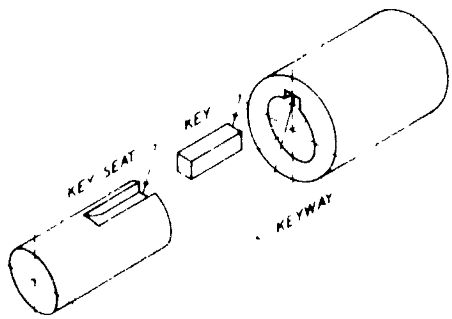


Fig. 7.23 Knurls. Straight and diamond shapes are common. Callout can specify fine, medium or coarse.

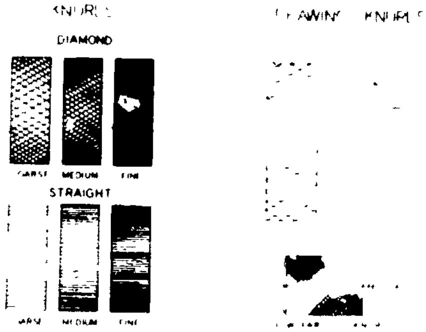


Fig. 7.24 Symbols. Special symbols are used to avoid long notes.

LABORATORY

1. The student should be able to use standard notes and symbols on a dimensioned drawing.

2. The student should be able to write standard thread notes from information in tables for internal and external threads.

3. The student should be able to calculate clearance hole sizes for fasteners.

SECTION ITEMS

STUDY QUESTIONS

1. When a drill depth is specified, is it the entire depth of the hole to the drill point?

2. How deep is a spotface? What is it used for?

3. What is the advantage of a woodruff key?

4. Why is a taper pin used in preference to a straight dowel pin?

5. Can a "blind" hole be threaded all the way to the bottom?

EXERCISES

1. Write a thread note for an external thread on a shaft. Diameter = 3/8 in. Length of thread = 2 1/4 in.

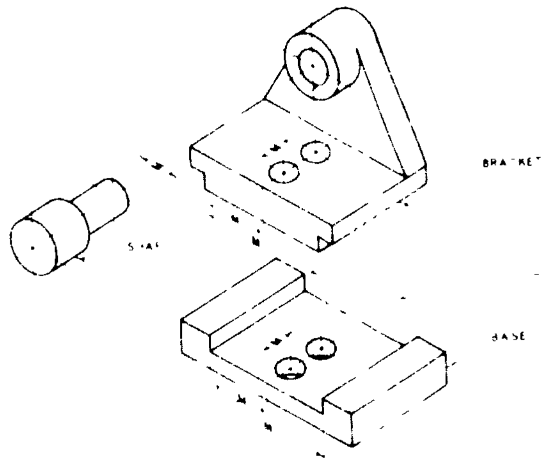
2. Write a thread note for an internal threaded hole. Threads to mate with 1 above, hole is threaded all the way through.

3. Write a drill and counterbore note for a 1/2" dia hexagon socket head cap screw.

4. Write a drill and countersink note for a 3/8" dia countersunk head cap screw.

... have a tolerance. Tolerances may be ... drawing or the tolerances may be directly indicated ... dimension is shown. Choosing the correct tolerance is often a balance between machining cost, part function requirements, and ... capability in a particular company. Close tolerances are usually ... mating part surfaces. When possible, tolerances should be as ... as the part function will permit.

Fig. ... Mating parts. The critical ... dimensions are indicated by the letter "M". Dimensioning of part should begin with the location of these critical dimensions. ... dimensions are ... later.



MATING ...

SIZE ...

LOCATION ...

FUNCTIONAL ...

MACHINE ...

(± .03 in.)

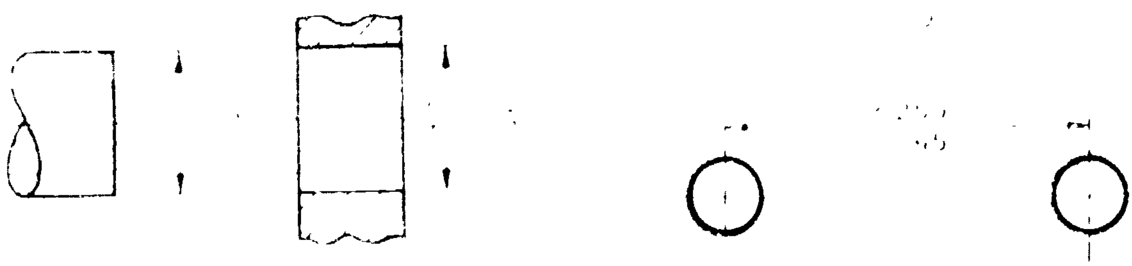
(± .010 in.)

"Tolerances on fractional dimensions ± 1/64 in."

Fig. ... Title block tolerances. ... tolerances apply unless otherwise specified. ... indicate tolerances on decimal dimensions according to the number of decimal places in the dimension as noted. ... appropriate tolerance.

TOLERANCES
X = ± 1
.XX = ± .03
.XXX = ± .010
ANGULAR
OTHER

Fig. ... Limit dimensions. Tolerances closer than title block tolerances must be specified as limit dimensions.



LIMIT DIMENSIONS

NOMINAL SIZE

A DESIGNATION GIVEN TO THE SUBDIVISION OF THE UNIT OF LENGTH HAVING NO SPECIFIED LIMITS OF ACCURACY BUT INDICATING A CLOSE APPROXIMATION TO A STANDARD SIZE. —A SHAFT 2" IN DIAMETER.

BASIC SIZE

THE EXACT THEORETICAL SIZE FROM WHICH ALL LIMITING VARIATIONS ARE MADE. -2.000" IN DIA.

ALLOWANCE

AN INTENTIONAL DIFFERENCE IN THE DIMENSIONS OF MATING PARTS.

TOLERANCE

THE AMOUNT OF VARIATION PERMITTED IN THE SIZE OF A PART.

[illegible]		Tolerances								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	003	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	001	[illegible]	[illegible]	[illegible]	006
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	001	[illegible]	[illegible]	[illegible]	[illegible]	010
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	012
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	015
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	020
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	010	[illegible]	[illegible]

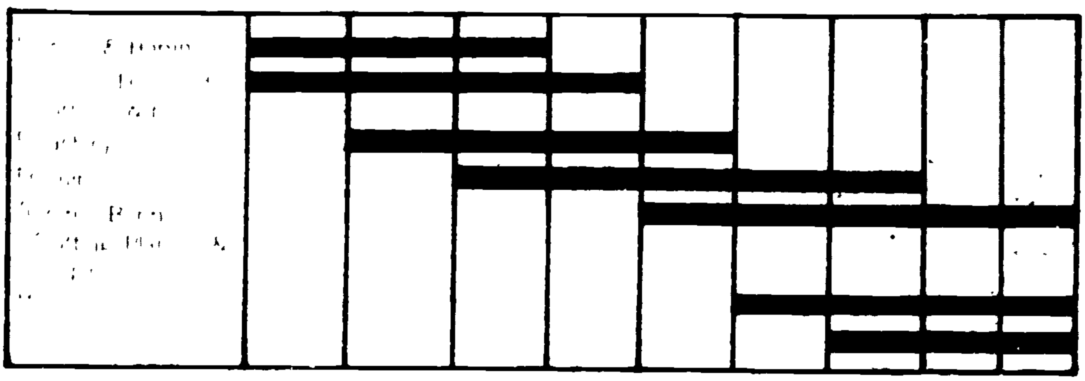


Fig. 7.28 Machine tolerances. If the machining process is known, the tolerance can be specified based on the capability of a certain machine.

... of size for the parts.

Fig. 7.29 U.S.A.S.I. tolerance tables. These tolerances are selected to fit a certain part function. Tolerances are specified without regard to how the part feature is machined.

NOTE: Only a small portion of one table is shown.

Example: Calculate the hole and shaft limit dimensions for a 1 3/8 in. dia. (nominal size) using an RC-6 fit.

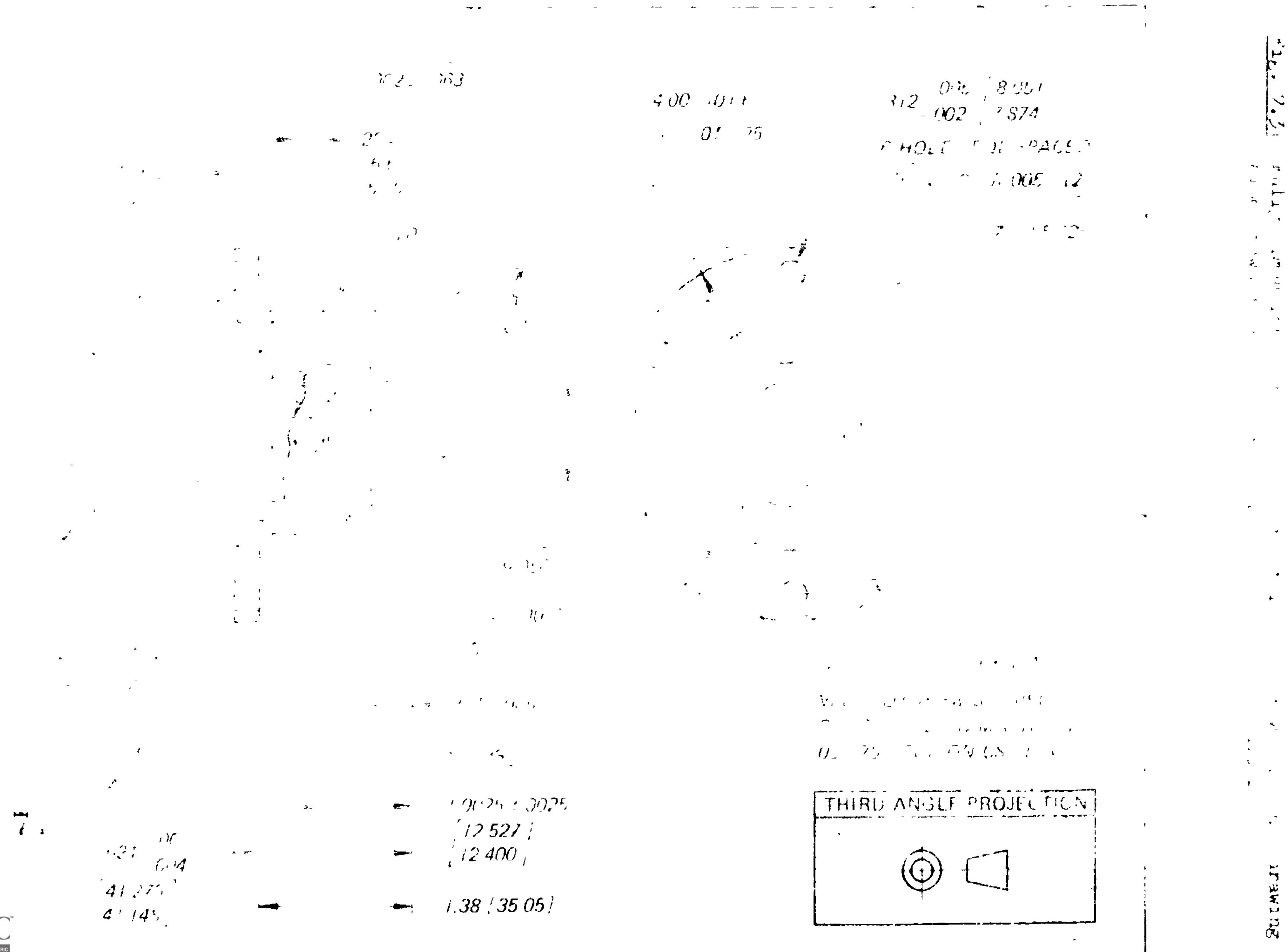
1. Look in the table under RC-6. The 1 3/8" dia nominal size falls between 1.19 and 1.97 inches.
2. Look across to find the plus and minus variation from the nominal size. Notice that these numbers are expressed in thousandths of an inch.
3. Write down the nominal size twice for the shaft calculations and twice for the hole calculations. Add or subtract the limits from the table to get the full limit dimensions.

HOLE		SHAFT	
1.3750	1.3750	1.3750	1.3750
+ .0016	+ .0000	- .0020	- .0036
1.3766	1.3750	1.3730	1.3714
(Max limit)	(Min limit)	(Max limit)	(Min limit)

Positional Tolerances		
	TRUE POSITION	⊕
	CONCENTRICITY [4]	◎
	SYMMETRY [5]	⌯

GEOMETRIC CHARACTERISTIC SYMBOLS			
		Characteristic	Symbol
Form Tolerances	For Single Feature	FLATNESS	⏥
		STRAIGHTNESS	—
		ROUNDNESS (CIRCULARITY)	○
		CYLINDRICITY	⌭
		PROFILE OF ANY LINE [1]	⌒
		PROFILE OF ANY SURFACE [1]	⌓
	For Related Features	PARALLELISM [2]	∥
		PERPENDICULARITY (SQUARENESS)	⊥
		ANGULARITY	∠
		RUNOUT [3]	↗

Fig. 7.30 Geometric Tolerance Symbols. These symbols along with dimensions applied to the symbol are used to show tolerances between related part features.



THIRD ANGLE PROJECTION
[12.527]
[12.400]
1.38 [35.05]

SECTION ITEMS

STUDY QUESTIONS

1. What is a unilateral tolerance? A bilateral tolerance?

2. Using the title block tolerance block in fig. 7.26 what is the implied tolerance on a dimension of 2.?38 inches?
   Rewrite this as a limit dimension.

3. According to fig. 7.?8 what is [illegible] accurate tolerance we can reasonably expect [illegible]

4. [illegible] tolerance [illegible] [illegible] dia shaft? [illegible] of the tolerance range).

5. Calculate the limit dimensions for a 1/2" dia shaft using a RC-5 fit.

6. Convert the answer to prob. 5 into metric equivalents. Be sure to maintain the same relative accuracy.

CHAPTER ITEMS

STUDY QUESTIONS

1. Which dimensions are selected first?

2. Can dimensions be placed on the object?

3. Which dimensions are placed closest to the object?

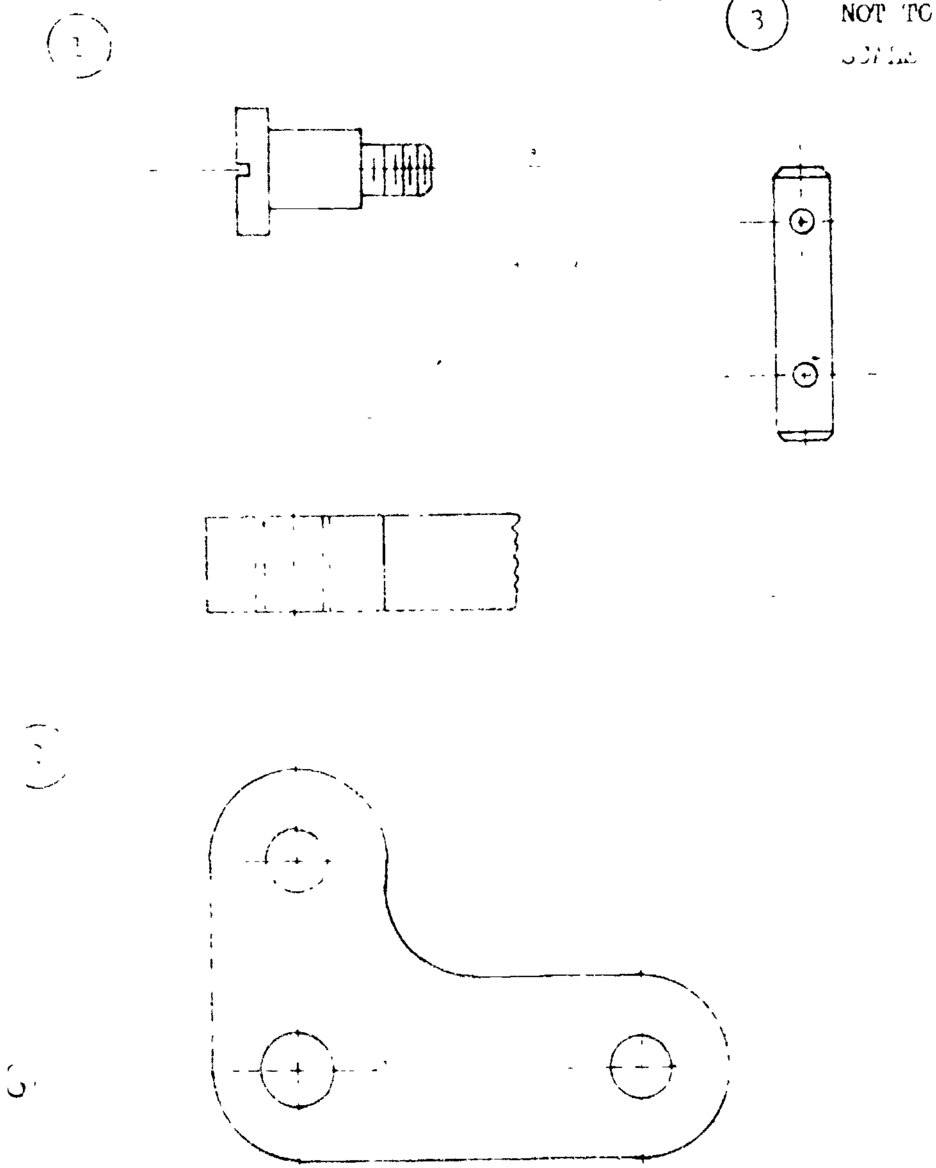
4. A hole should be dimensioned in which view?

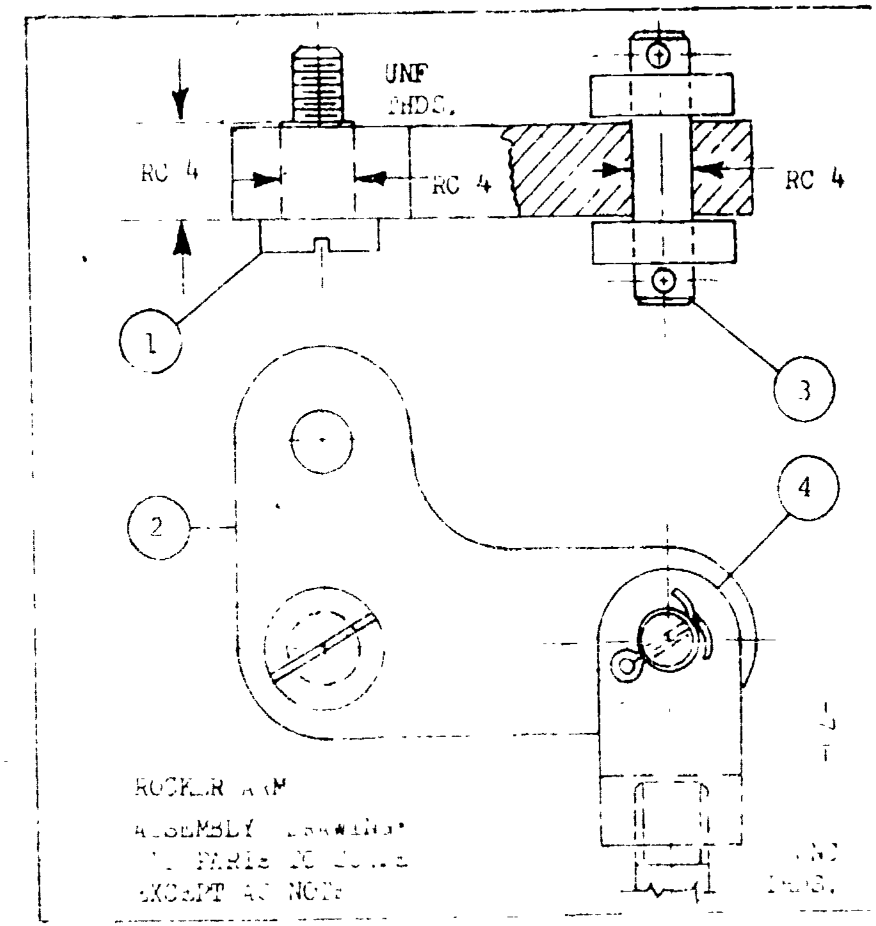
5. Are aligned or unidirectional dimensions prefered?

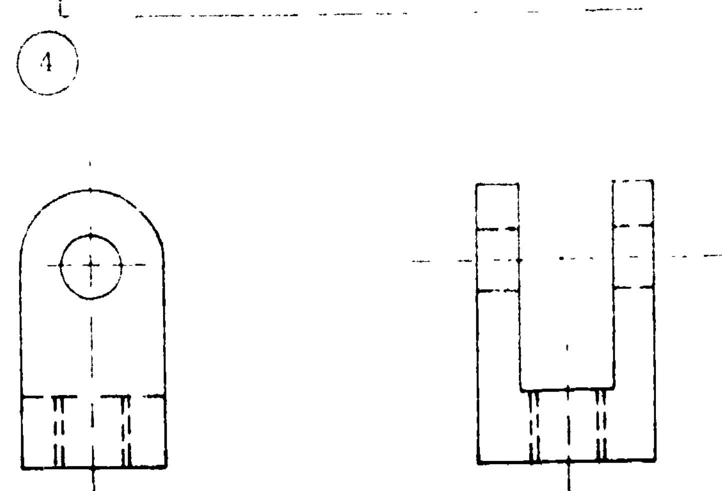
EXERCISES

Fully dimension the following drawing. Use decimal inch dimensions.

NOTE: Rocker arm should pivot freely on 1.







ANSWERS

SECTION ITEMS

SECTION 7.1

1. Minimum height for lettering on engineering drawings is 1/8 in.

2. The total height for a fractional dimension should be at least 1/4 in.

3. Line thickness for extension lines should correspond to "thin" on a line gage chart.
Line density for extension lines should be BLACK.

4. Some companys prefer arrowheads be blackened in especially where the drawings are to be microfilmed.

5. Yes.

6. 3.472 ± .03 in. = 88.19 ± .76 mm rounded off to consistent degree of accuracy.

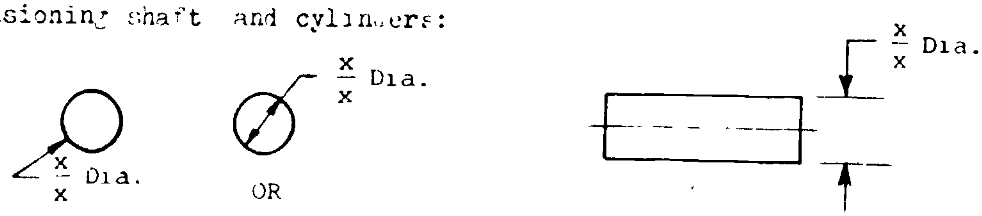
SECTION 7.2

1. Angles can be dimensioned by giving the length of one leg and the included angle or by giving the length of two legs of the angle.

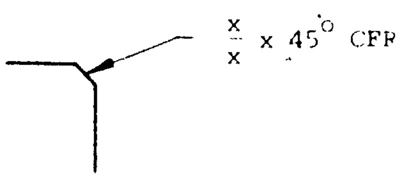
2. The center of an arc should be specified when the radius is a critical location from the center.

3. Holes are usually dimensioned in the circular view.

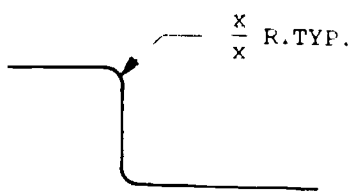
4. Dimensioning shafts and cylinders:



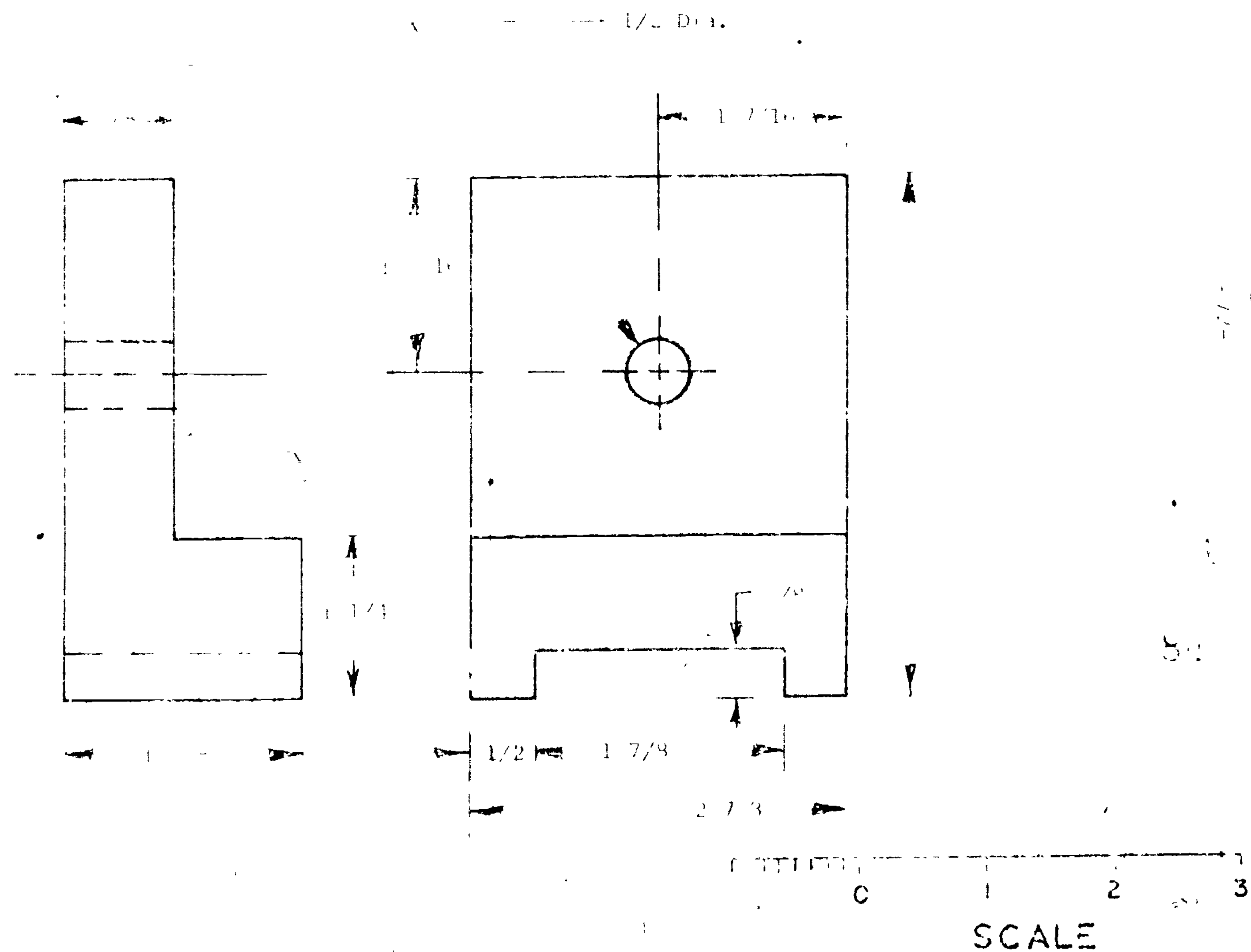
5. Dimensioning a chamfer:

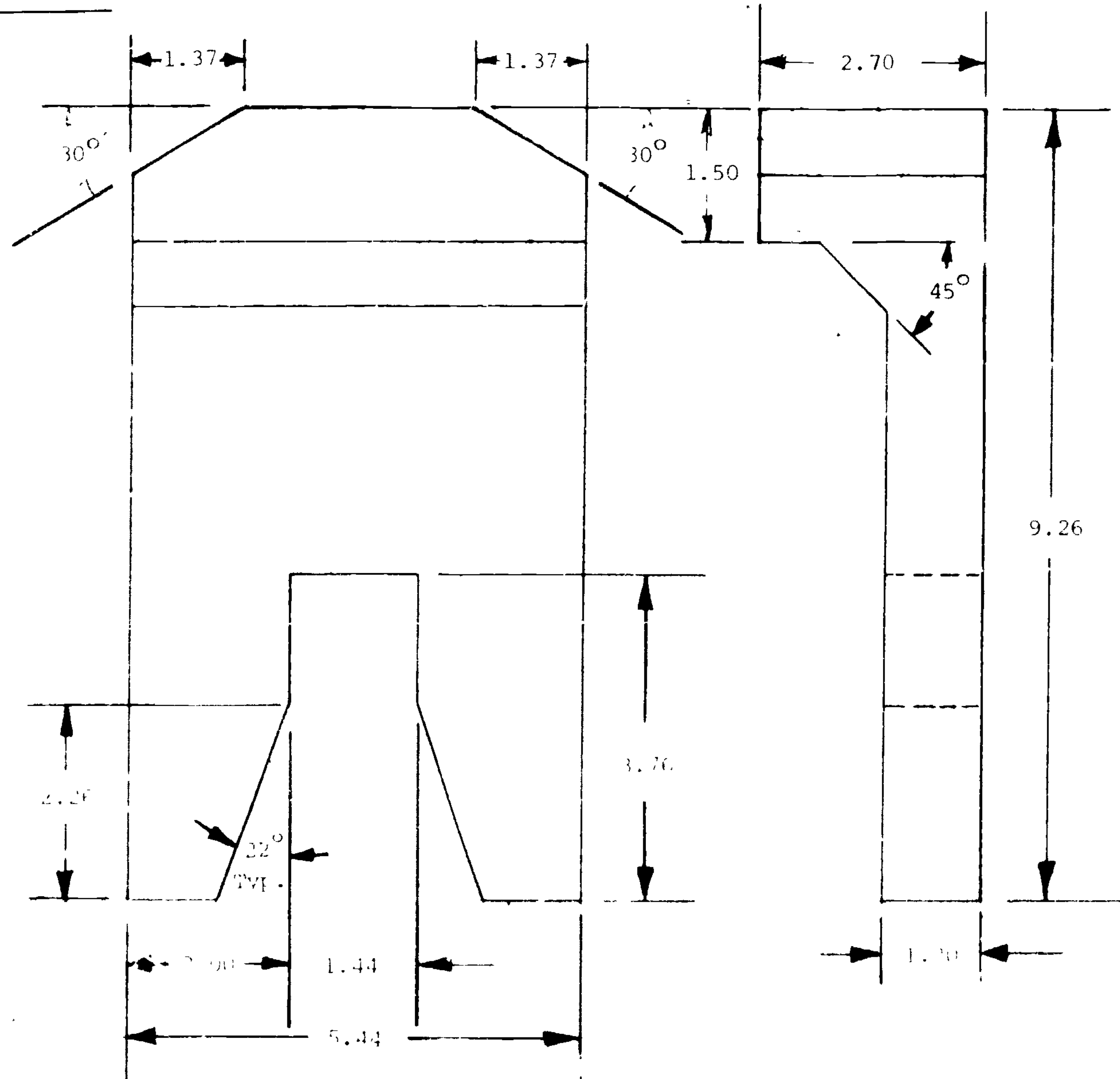


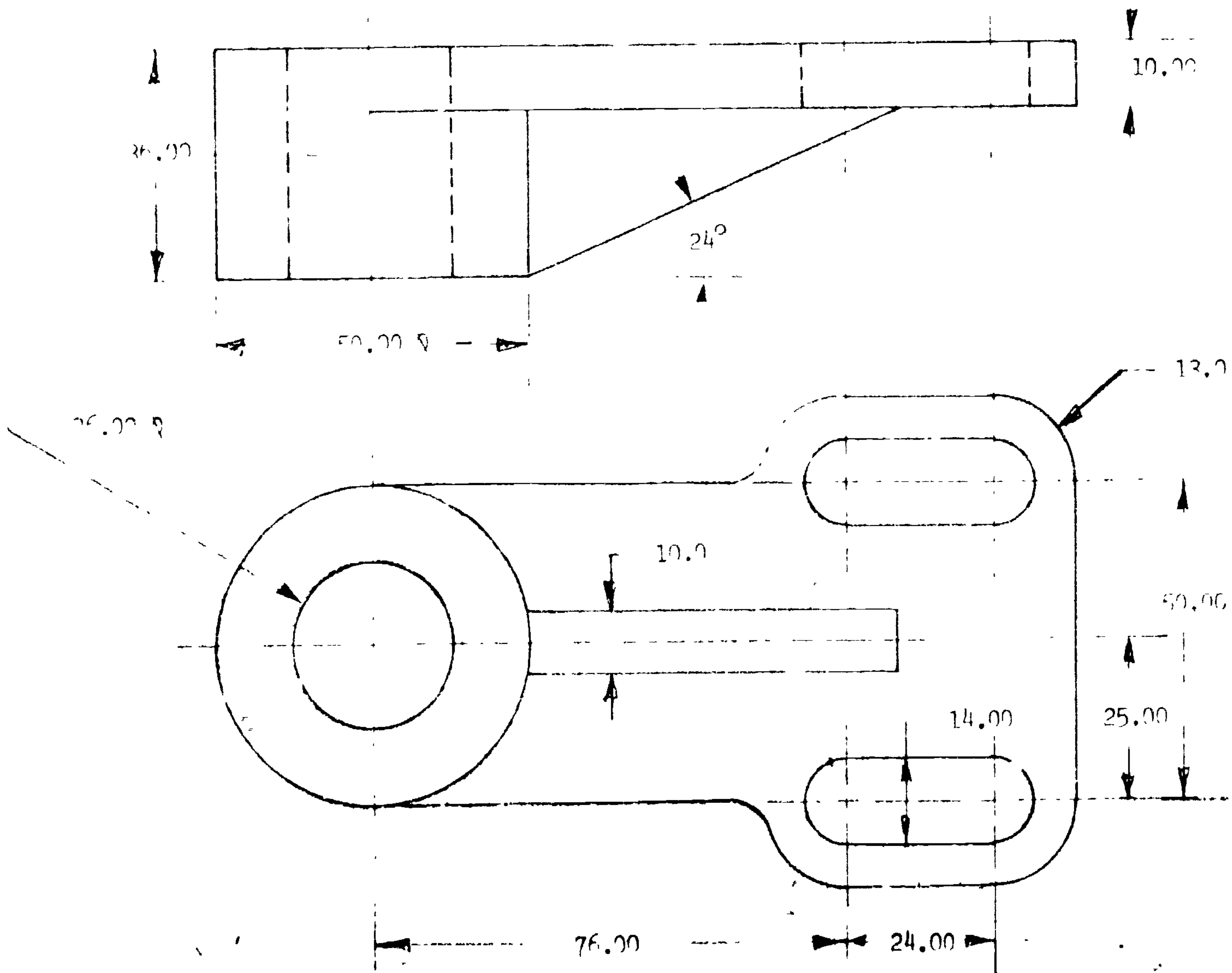
Dimensioning a rounded corner:



EXERCISES


1/2 Dia.
1/2
1 7/8
SCALE
0
1
2
3


1.37
1.37
2.70
30°
30°
1.50
45°
9.26
22°
1.44
5.44


24°
14.00
25.00
24.00

[illegible] cylindrical portion of the hole.

[illegible] left to the machinist to machine [illegible] the [illegible] area. [illegible] area [illegible] under [illegible] surface [illegible] bearing area.

[illegible] there [illegible] the [illegible] assembly.

[illegible] assembly [illegible] work loose.

[illegible] way [illegible] the bottom [illegible]

[illegible]

[illegible]

[illegible]

[illegible] selected [illegible].

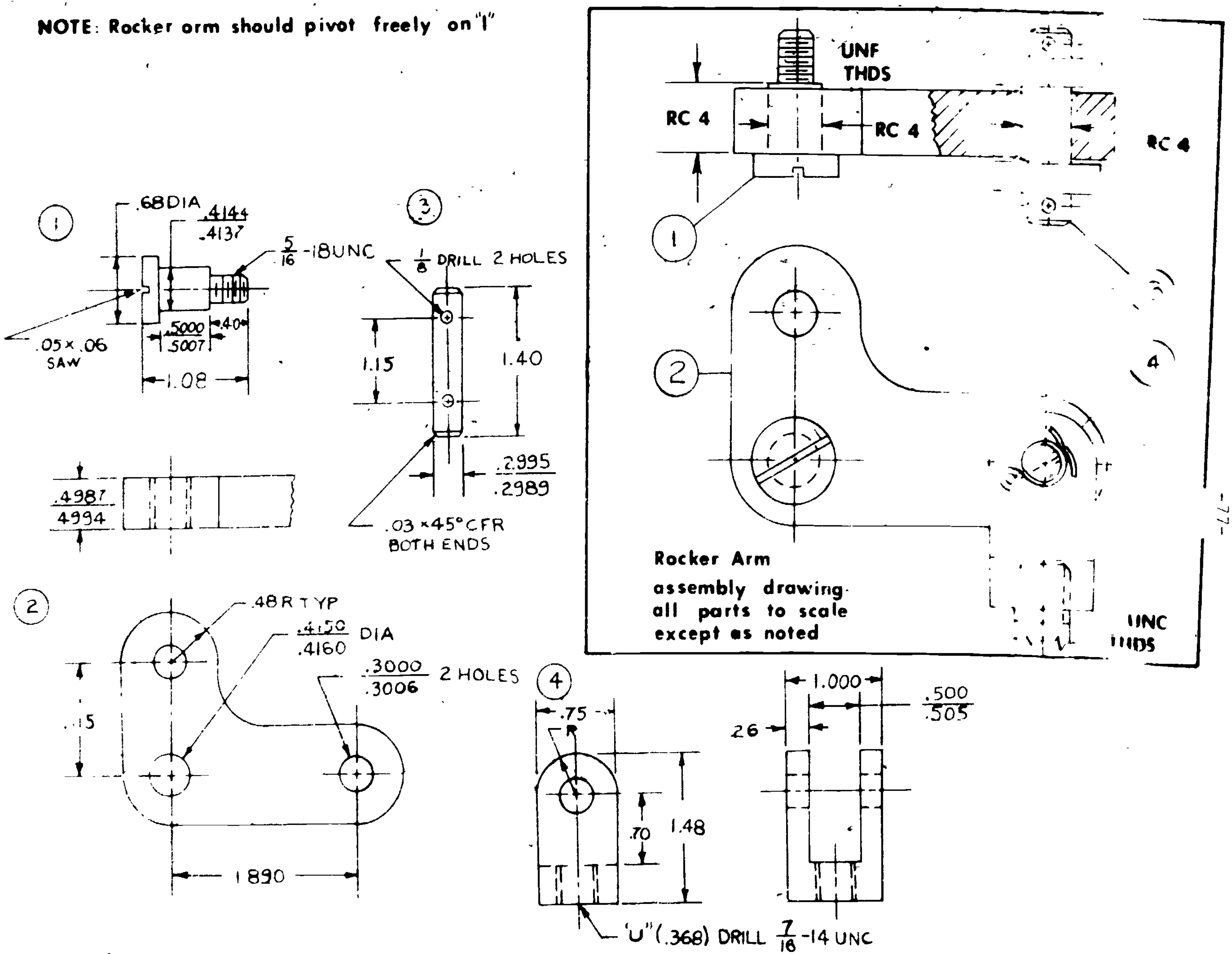
[illegible] dimensions are placed [illegible] to the object.

[illegible] dimensioned in the [illegible] view.

[illegible] dimensions are preferred.

ERIC

NOTE: Rocker arm should pivot freely on "1"



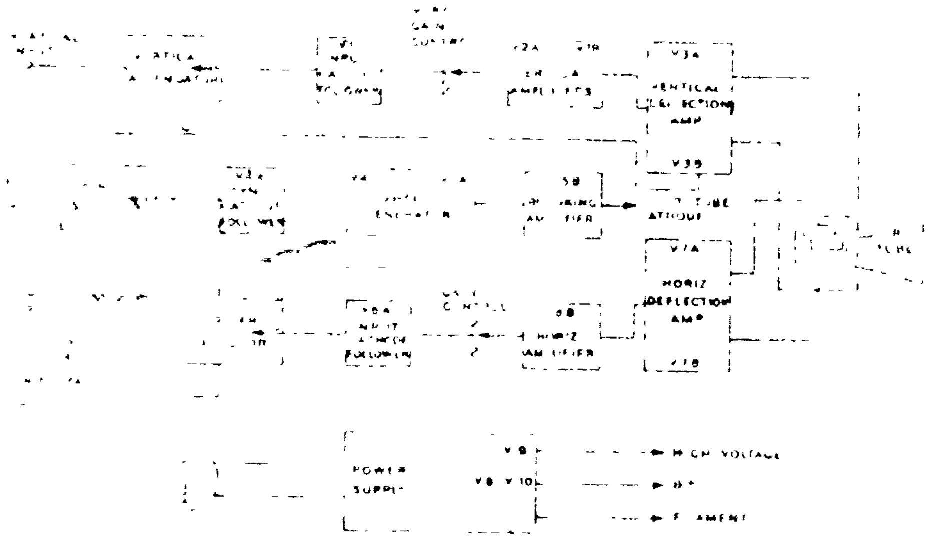
... 8.1 BLOCK DIAGRAMS

Many electrical and electronic systems are designed starting with a block diagram. This type of drawing depicts the function of the major parts of the design and shows signal flow through the system. Once the major functions of the design are decided, then the actual circuit design can begin.

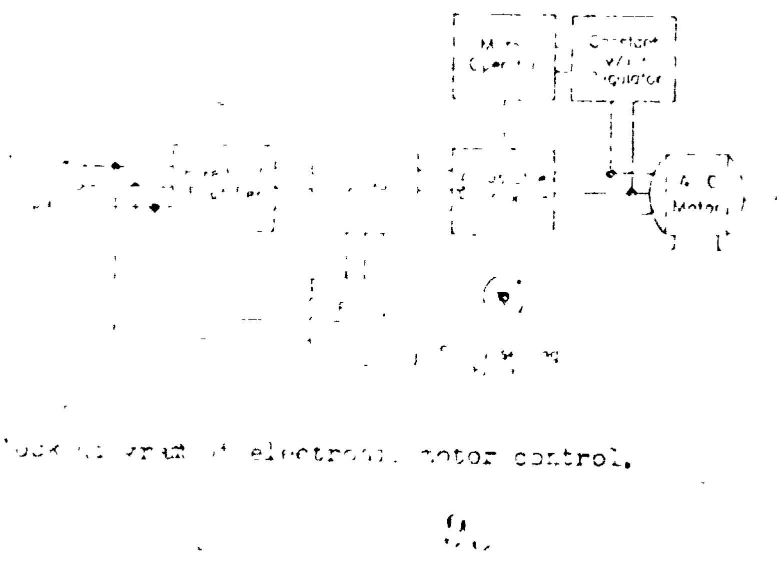
Block diagrams are also included in a set of working drawings, often as the first sheet in the set of drawings, and in instruction and repair manuals. Some diagrams combine blocks with schematic or pictorial elements to give a quick graphic impression of the circuit.

Most block diagrams are drawn according to these basic rules:

1. Only two or three different size "boxes".
2. Space boxes so areas are equal. Keep boxes in rows or columns.
3. Show signal flow with arrows.
4. Label function of each block.
5. Inputs on the left. Main circuits in the middle. Outputs on the right. Auxiliary circuits on the bottom.



... Typical block diagram. The Heath IO-12 Oscilloscope diagram is shown with the use of block, schematic and pictorial elements.



... Block diagram of electronic motor control.

1. The student should be able to layout a block diagram from a rough sketch. The layout should reflect the proper block sizes, spacing and function lettering.

SECTION ITEMS

STUDY QUESTIONS

1. What is the advantage of a block diagram over a schematic diagram?

2. Must blocks always be rectangular in shape?

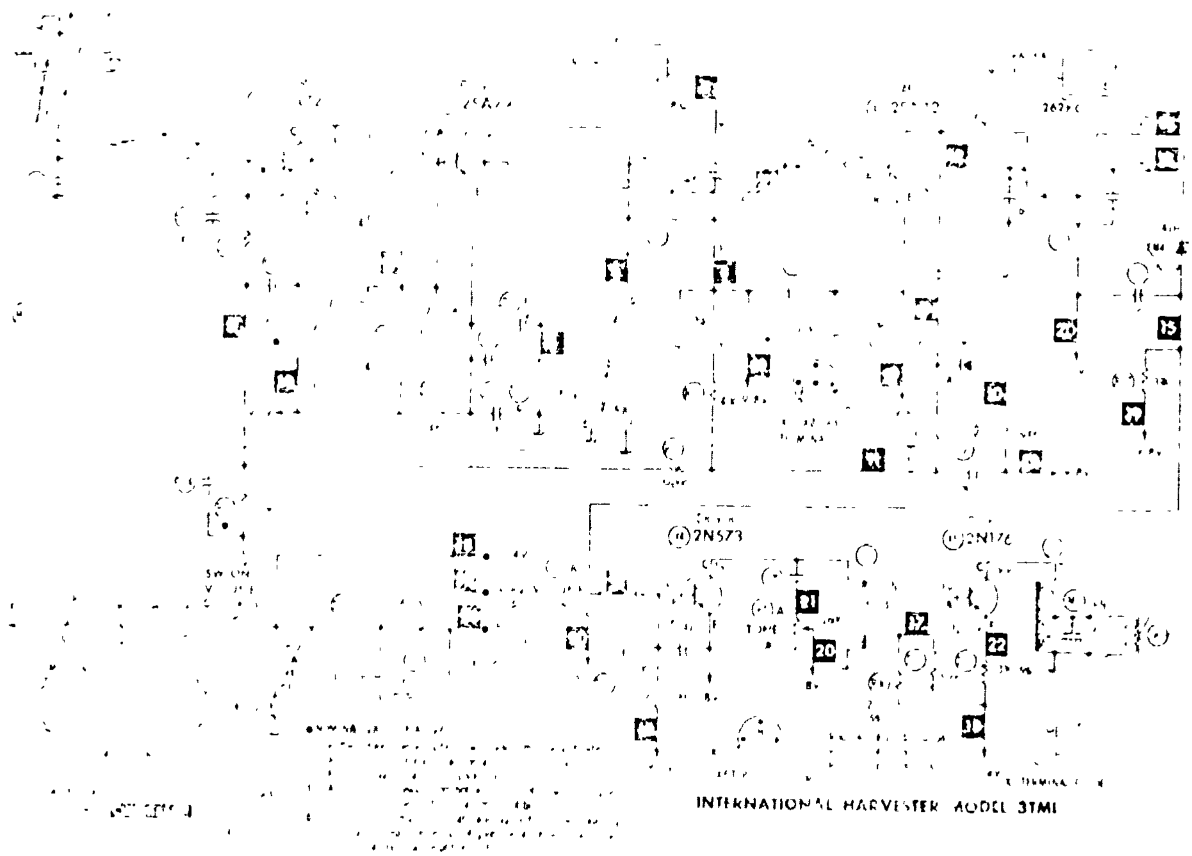
3. What decides the size of a block?

4. How do you determine how many blocks to use?

5. How would a feedback circuit be shown on a block diagram?

EXERCISES

1. Convert the schematic diagram to a block diagram. Use the functions printed next to the transistors. Be sure to show the input and output devices and the power supply.



Excerpted from SAMS PHOTOFACT Vol. 34.

2. Sketch a block diagram for a "Dream Hi-FI System".

SECTION 8.2 CONNECTION DIAGRAMS AND INTERCONNECTION DIAGRAMS

Connection diagrams show the wiring between parts of an assembly. These drawings show the actual wiring inside a particular unit. They are often used to instruct assemblers on how to wire a device and how the wires should be routed.

Interconnection diagrams show the external wiring used to connect a series of individual units. These drawings are often used for field assembly and installation purposes.

Fig. 8.3 Wire coding. Wires used in connection work are usually color coded. The color is either abbreviated on the drawing or shown by code numbers. Wires may also use a base color and one or more color stripes.

Note: A wire coded 2/3 is red with an orange stripe.

Color	Abbreviation	Number
Black	BK	0
Brown	BR	1
Red	R	2
Orange	O	3
Yellow	Y	4
Green	GN	5
Blue	BL	6
Violet	V	7
Gray	GY	8
White	W	9

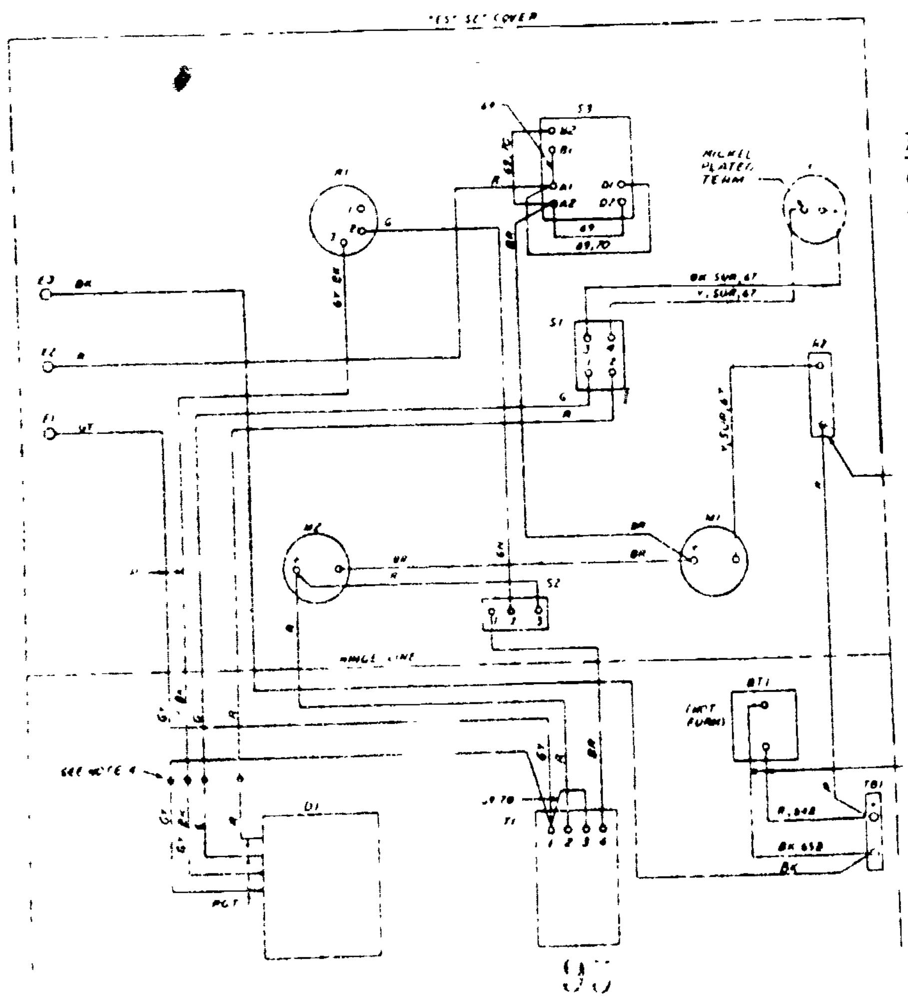
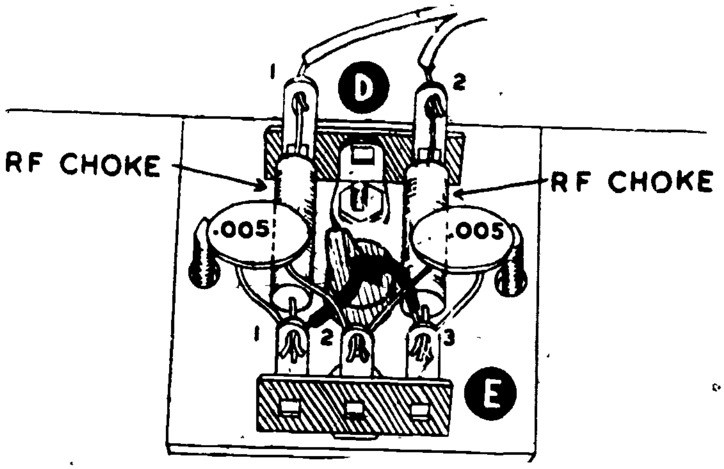


Fig. 8.4 Typical connection drawing. All components are housed in the same enclosure or chassis.

Fig. 8.5 Pictorial type connection drawing.



COLOR	AWG	SYMBOL	METHOD OR PATH	FROM TERMINAL		FROM NOTES	TO TERMINAL		TO NOTES
W-R-Y		ST1	CA2	A1	C	•	[illegible]	4	
BK			CA2	A1	CS		A1	D	
BK			CA2	A1	D		A1	CS	
Y			CA2	A1	E		[illegible]	7	
G			CA1	A2	1		P1	6	
W-B			CA1	A2	2		[illegible]	10	
BR			CA1	A2	3		[illegible]	A	
BR			CA1	A2	3		[illegible]	1	
	RF		SUR	A2	4		[illegible]		
BK			[illegible]R	A2	4S		[illegible]		
PL			[illegible]	A2	5		[illegible]	[illegible]	
V			[illegible]	A2	5		[illegible]	[illegible]	
[illegible]		[illegible]	[illegible]	A2	7		[illegible]	[illegible]	
[illegible]			[illegible]	A2	[illegible]		[illegible]	[illegible]	
[illegible]		[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	
	RF		[illegible]	[illegible]			A2	[illegible]	
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	S	
[illegible]			[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	
[illegible]			[illegible]	[illegible]	A		A2	[illegible]	
R		[illegible]	[illegible]	P1	[illegible]		[illegible]	[illegible]	
[illegible]			CA1	[illegible]	H		[illegible]	1	
[illegible]		SS1	A1	P1	[illegible]		[illegible]	[illegible]	
[illegible]		[illegible]	[illegible]	[illegible]	C		[illegible]	[illegible]	
[illegible]			A1	[illegible]	[illegible]		[illegible]		
[illegible]		[illegible]	CA1	[illegible]	1		[illegible]	[illegible]	
[illegible]			[illegible]	[illegible]	1S		[illegible]	[illegible]	
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		
[illegible]			CA1	[illegible]	[illegible]		[illegible]	[illegible]	
[illegible]			[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	
[illegible]			CA1	[illegible]	[illegible]		[illegible]	[illegible]	
[illegible]			CA1	[illegible]	1		A[illegible]	5	
[illegible]			CA1	TB1	[illegible]		TB1	2	
[illegible]			CA[illegible]	[illegible]	[illegible]		T1	5	

NOTES: [illegible] DENOTES TERMINATION OF SHIELD AND [illegible] PREFIXED BY THE DESIG-NATION OF THE TERMINAL TO WHICH [illegible] WIRE CONNECTS.

[illegible] DENOTES TERMINATION OF A SHIELD [illegible] WHICH A SECOND SHIELD [illegible] TERMINATION.

MS DENOTES MECHANICAL STRAP

SS DENOTES SHIELDED SINGLE

SP DENOTES SHIELDED PAIR

ST DENOTES [illegible] CABLE

• DENOTES [illegible] LETTER

Fig. 8.6 Tabular connection chart. Compare this wiring table with the connection diagram on the following page.

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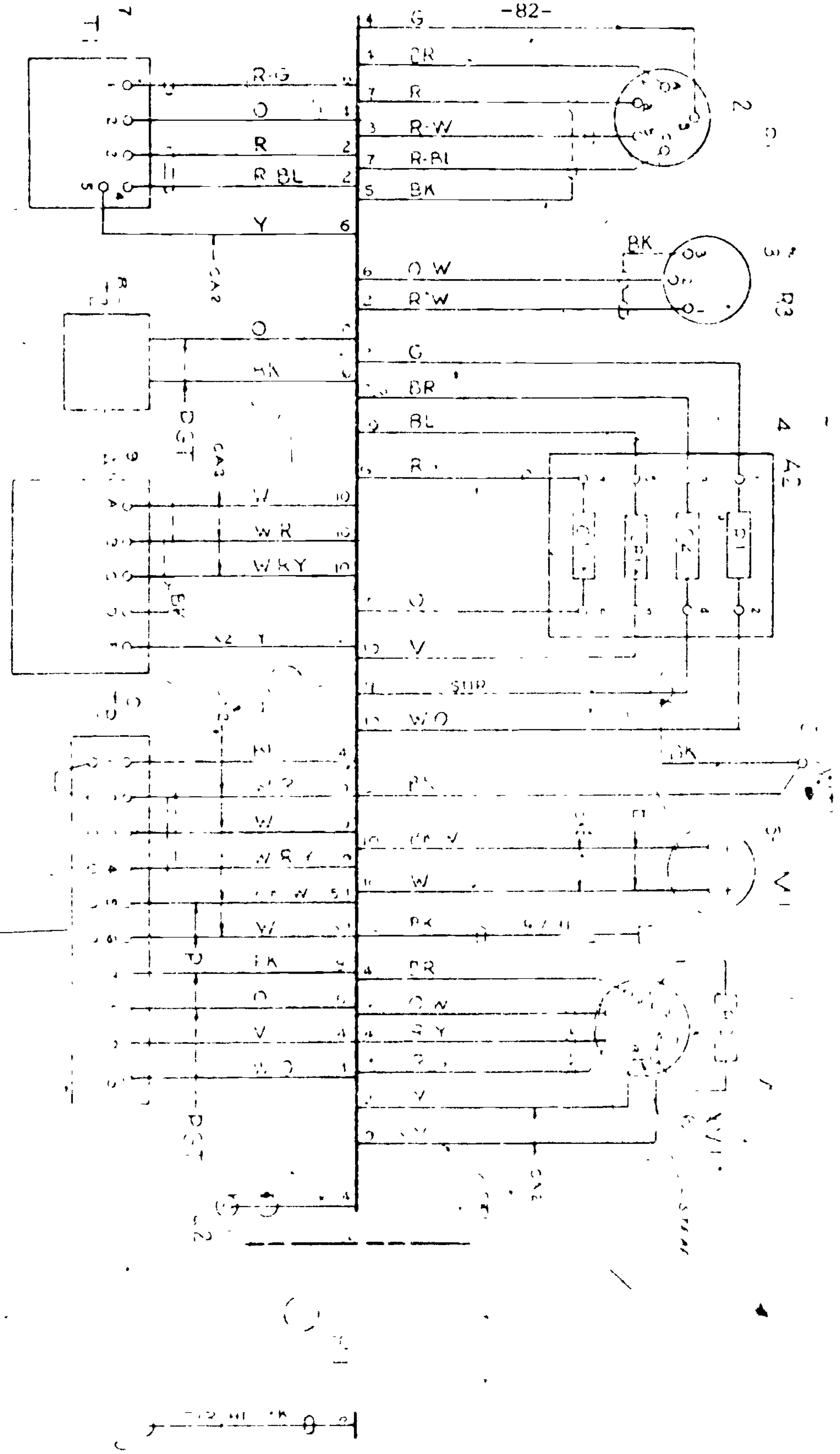
Full Text Provided by ERIC



Fi . .7 . eline type connection diagram. See wiring chart in fig. 8.6.

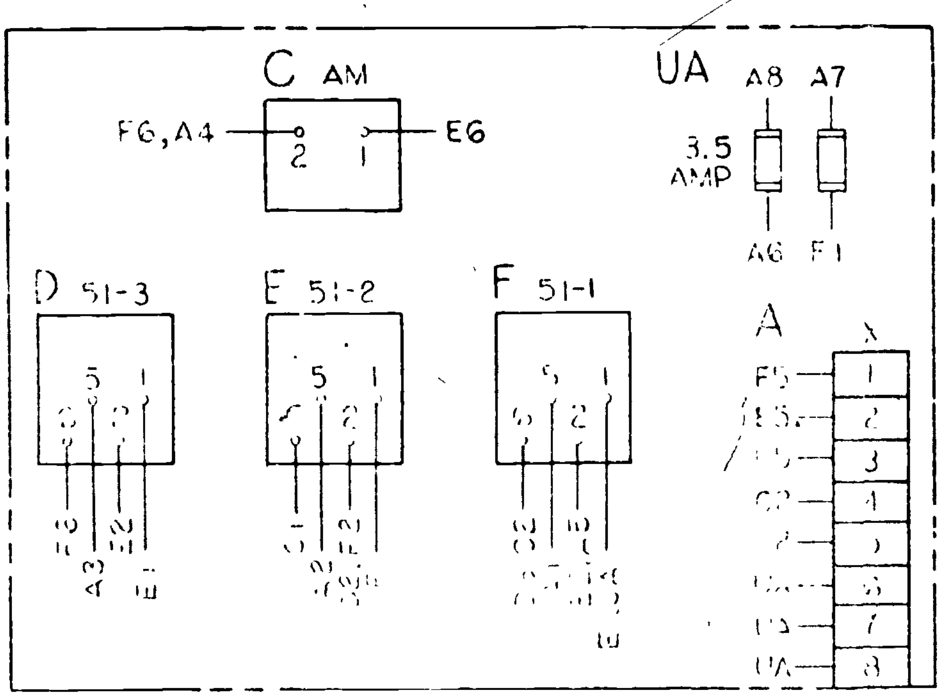


Fig. 8.3 Feed line connection diagram. Wire destinations are given. This type of diagram avoids a maze of crossing lines.

Fig. 8.9 Plug, Jack, terminal board etc. pin identification system.

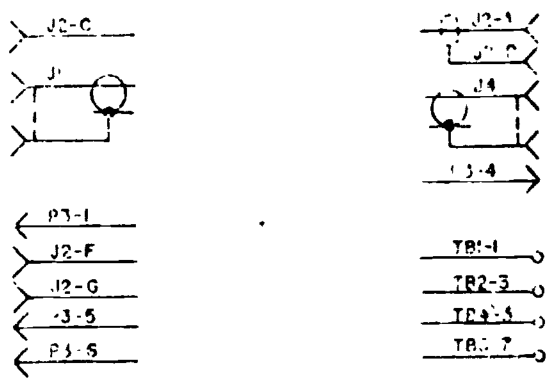
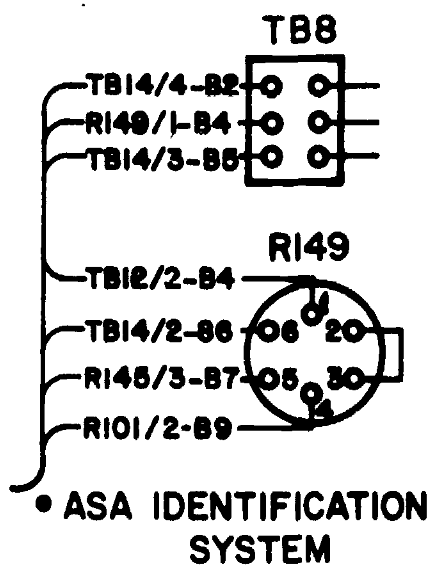


Fig. 8.10 Wire destinations are listed along with wire code. "B2" (B= #22 ga. 2 = red)
Letter identification per chart somewhere on the drawing.



1. The student should be able to draw or sketch a connection drawing.

2. The student should be able to read and write wiring lists or charts.

SECTION ITEMS

STUDY QUESTIONS

1. How are wire colors denoted?

2. Is there a general rule regarding the color wire to use based on the circuit function of the connection?

3. What is the correct identification for terminal 7 on terminal board 3?

4. Is color coding the only method used for marking wires?

5. What is the difference in the feed line, base line and point to point type connection diagrams?

EXERCISES

1. Write a wiring list for parts 5 and 6 on the following drawing. (Not all pin numbers can be shown due to drawing size limitation)

Note: Partial, simplified table is shown.

ITEM NO.	FROM		TO		WIRE COLOR	GAGE
	COMP.	PIN	COMP.	PIN		
15	5	1	4	2	R-BL	22
16						
						22

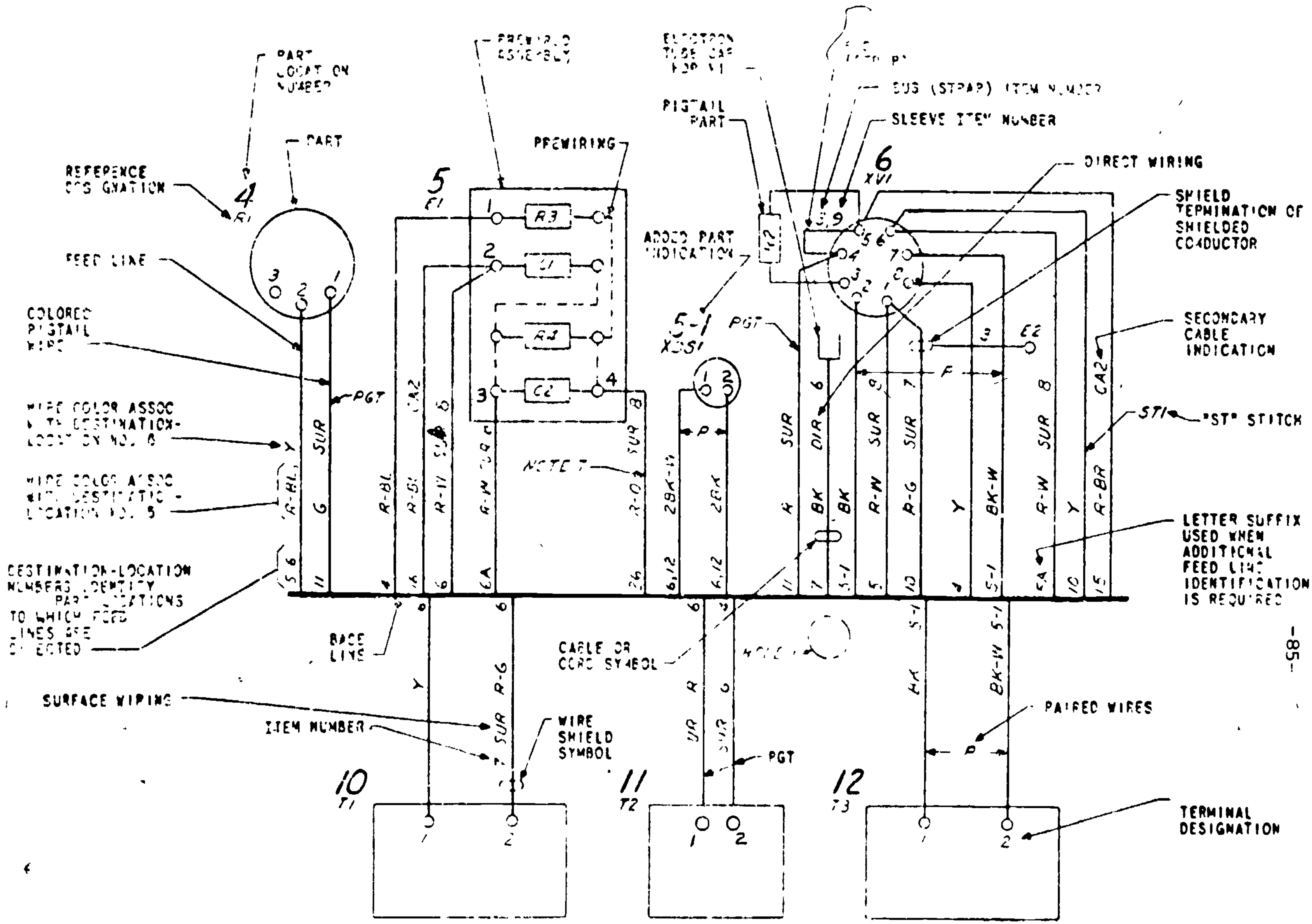
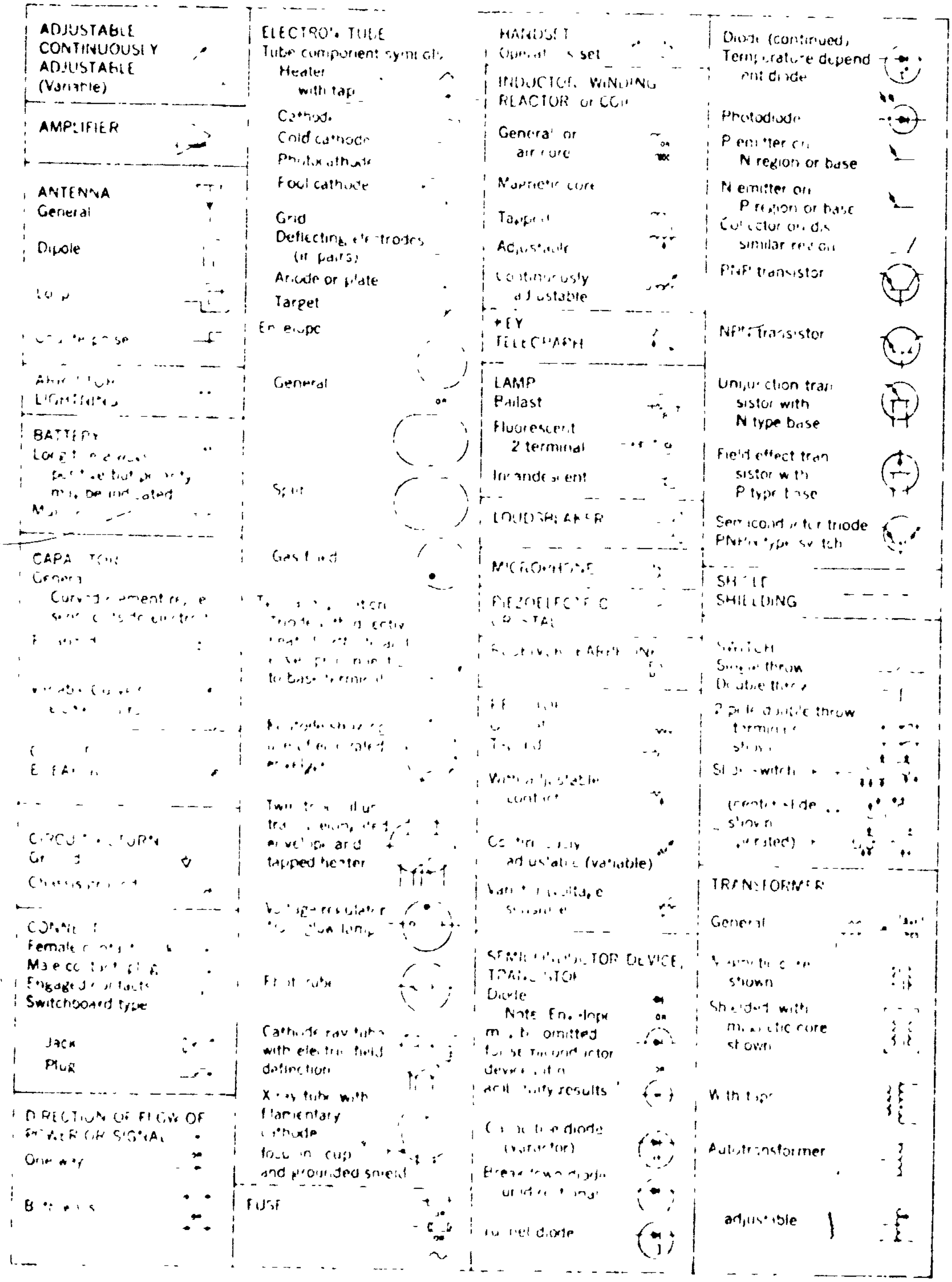


Fig. 8.11 Drawing for exercise no. 1.

Schematic diagrams use symbols to depict the electrical connections to every part in a device. Different techniques are used to draw schematics in various fields; electronic, electrical and architectural. Working with schematics in each field involves knowing the symbols used and the conventional methods of showing the connections.



*ANSI Y32.2 1967

Fig 6.12 Typical schematic symbols used in electronics diagrams.

Note: See exercise 4 in section 6.1 for typical electronic schematic diagram.

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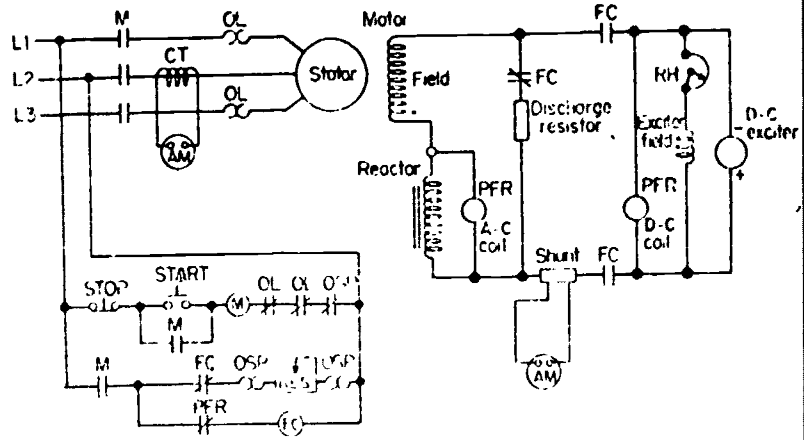


Fig. 8.13 Typical indus' schematic. A.C. motor controller is shown.

S	=	Switch
S_3	=	Three-way switch
	=	Duplex convenience outlet (plug-in)
	=	220 v outlet (plug-in range, etc.)
s	=	Relay
O	=	Outlet (light)
	=	Telephone
(F)	=	Other outlets -- letter inside means type, as fan, heater, etc.
R	=	Any letter by a symbol means something, as R = range, Dim = dimmer, wp = weather proof.

EXAMPLE:

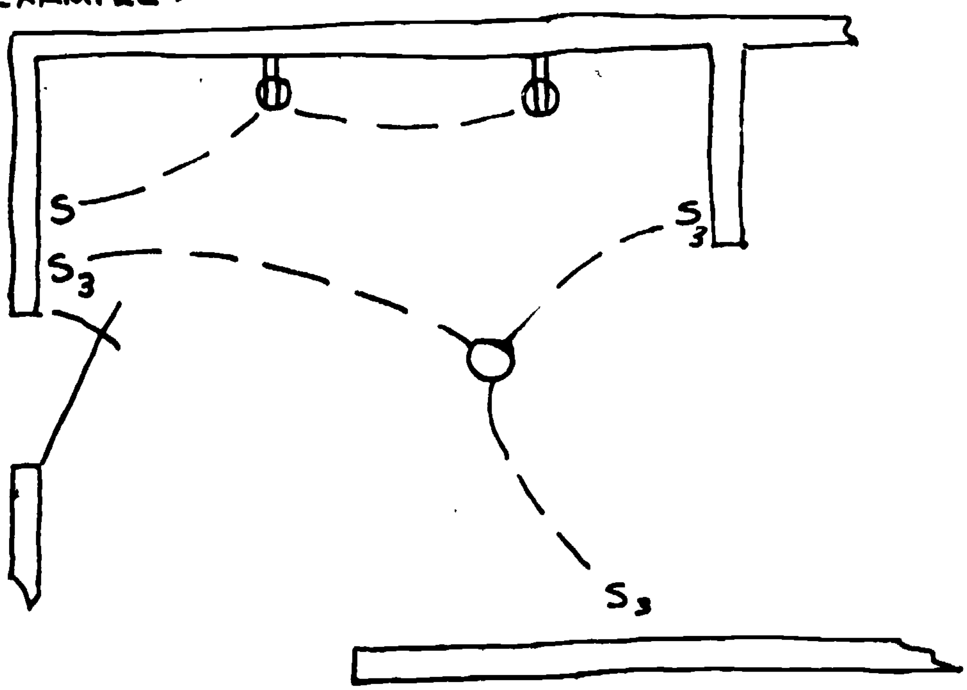


Fig. 8.14 Architectural symbols and sketch of a floorplan with symbols.

LABORATORY

1. The student should be able to sketch a schematic diagram from a prototype or pictorial layout.

2. The student should be able to draw a schematic diagram from a rough sketch.

3. The student should be able to read, sketch and/or draw an architectural schematic.

SECTION ITEMS

STUDY QUESTIONS

1. What is the basis for spacing symbols on schematic diagrams.

2. Must schematic symbols always be placed vertically or horizontally?

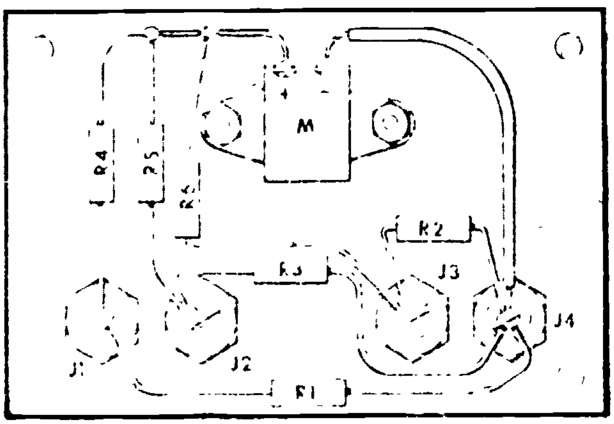
3. What is meant by part "identity" on a schematic diagram. What are the rules?

4. In what ways are industrial schematics slightly different from electronic schematics?

5. In architectural schematics how are 220V circuits shown differently from standard 115V circuits?

EXERCISES

1. Sketch the schematic diagram of the unit shown.



M1	1	Meter
R1	1	Resistor, 330 ohm
R2,3	2	Resistor, 10 ohm
R4	1	Resistor, 22 K ohm
R5	1	Resistor, 1300 ohm
R6	1	Resistor, 2700 ohm
J1,2,3,4	4	Jacks

2. Sketch the floorplan for a classroom, labratory or shop area and show the architectural electrical schematic for the wiring.

SECTION 8.4 LOGIC DIAGRAMS, INTEGRATED CIRCUITS, PRINTED CIRCUITS.

Micro-circuits are fast becoming a standard item in industry. They can be designed with many components inside a common case. These components are wired internally to perform a pre-determined function. Design of complex logic and electronics circuits is greatly simplified since the designer must only pick the proper building blocks. Charts, diagrams and drawings are needed to assure the correct connections, power inputs etc.

Most micro-circuits are wired and mounted to printed circuit boards. Special drawings are needed to produce printed circuits.

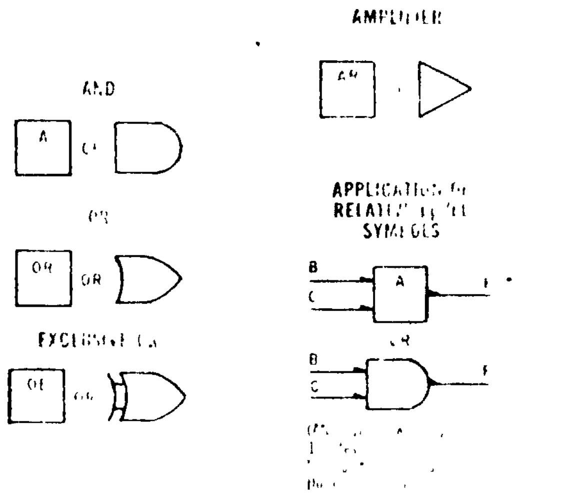


Fig. 8.15 Typical symbols used in logic diagrams.

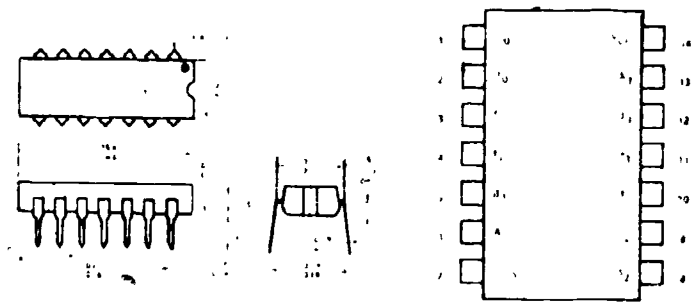
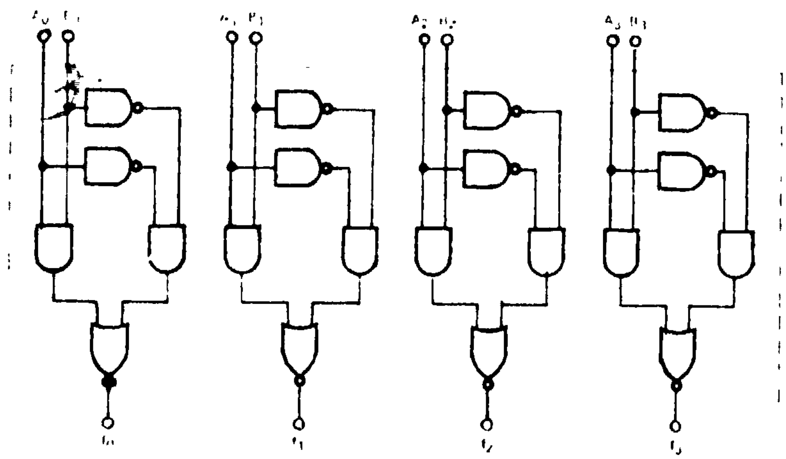


Fig. 8.16 Integrated circuit. This has four separate circuits in one case. Note the input, output and power connections.



A	B	f
0	0	0
1	0	1
0	1	1
1	1	0

Fig 8.17 Internal logic inside the package. Note the four separate circuits and the input/output notations. To the right is a "Truth Table" showing how the circuit reacts to various inputs. "1" = yes or on, "0" - no or off. (This notation can change for some types of logic argument.)

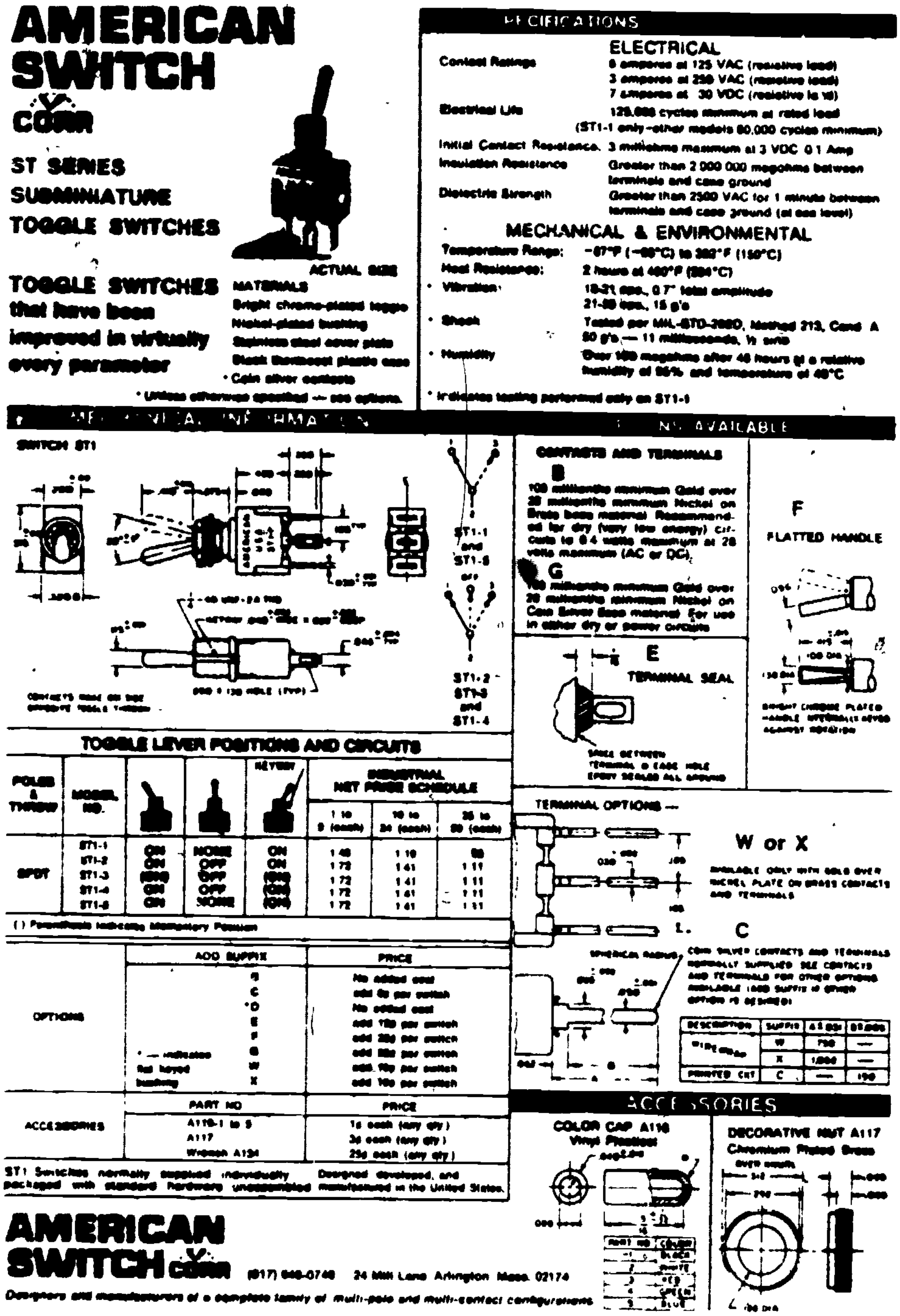


Fig. 8.18 Component outline drawing. The designer must know the electrical and physical charactoristics of every part. Parts manufacturers supply drawings similar to this one for design and purchasing purposes. Fig. 8.16 shows an outline drawing for an integrated circuit.

Style	Powe. at 70°C	Resistance Range	Tolerance	Voltage Rating (RMS)	Dimensions (Inches)			
					A	B	C	D
RCR05	1/8 watt	2.7 ohms to 22 megohms	±5% ±10%	150 V	0.145	0.062	1.0	0.015
RCR07	1/4 watt			250 V	0.250	0.090	1.5	0.025
RCR20	1/2 watt			350 V	0.375	0.140	1.5	0.033
RCR32	1 watt			500 V	0.562	0.225	1.5	0.041
RCR42	2 watt	10 ohms to 22 megohms		500 V	0.688	0.312	1.5	0.045

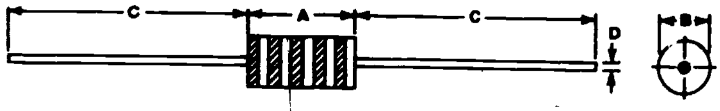


Fig. 8.19 Component outline drawing for resistors. Larger wattage resistors require larger case size. Resistors are available only in the sizes shown.

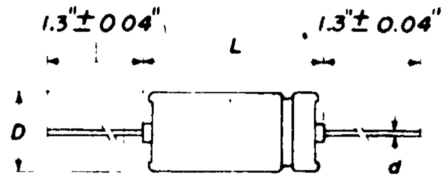


Fig. 8.20 Component outline drawing for one type of capacitor. Capacitors are available in many case styles and sizes.

Can Size	Dimensions (Inches) * D (Maximum)	d	L
1	0.260	0.032	0.690
2	0.260	0.032	0.945
3	0.327	0.032	0.945
4	0.410	0.032	0.945
5	0.410	0.032	1.260
6	0.509	0.032	1.260

* Insulated

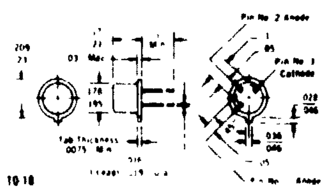


Fig. 8.21 Component outline drawing for a transistor. Transistor case sizes are usually specified as a TO- number (Transistor Outline) Note the connections, emitter, base, collector, pin orientation and spacing.

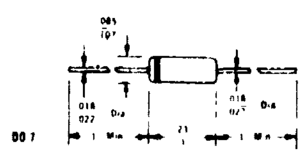
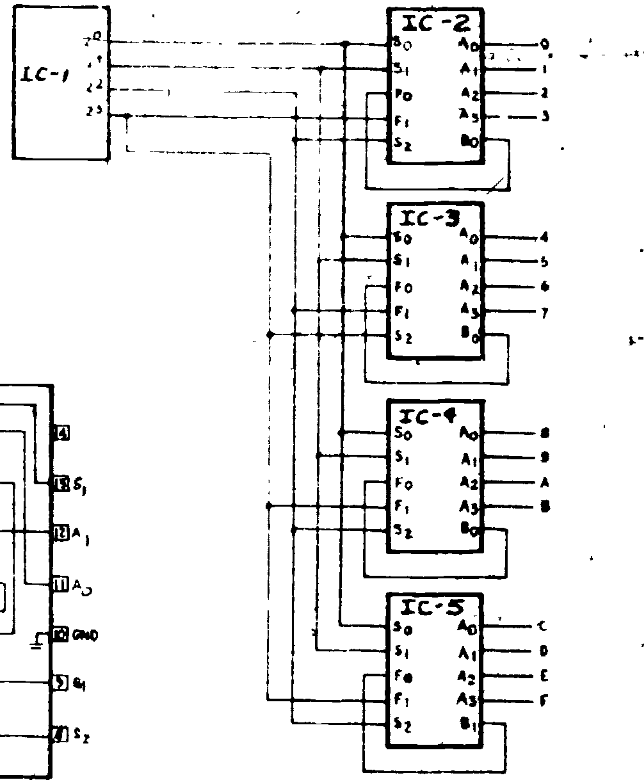
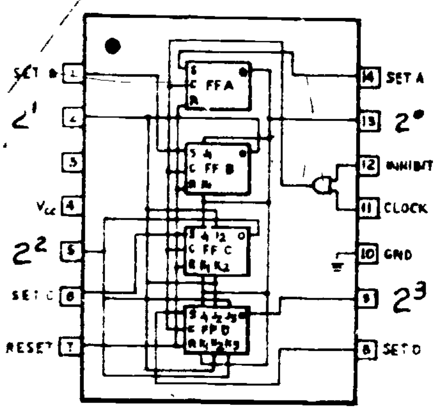


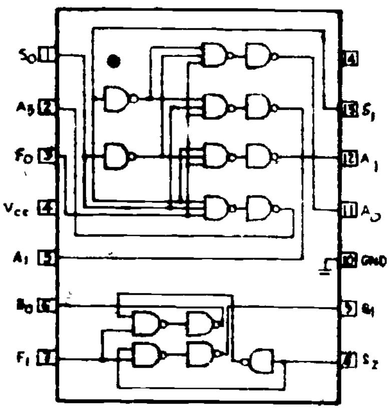
Fig. 8.22 Component outline drawing for a diode. DO - number (Diode Outline) Diodes must be oriented in the circuit correctly. Note the banded end on the diode.

Fig. 8.23 Connection drawing for an integrated circuit logic system. This drawing shows the external connections between logic elements. It does not show the actual connections to the correct pin numbers.





Pin connections for IC-1



Pin connections for IC-2 to IC-5

Fig. 8.24 Pin connection chart for Fig. 8.23.

IC-1	IC-2	IC-3	IC-4	IC-5
4 →	4 →	[illegible] →	4 →	4
10 →	10 →	10 →	10 →	10
13 →	1 →	1 →	1 →	1
[illegible] →	13 →	13 →	13 →	13
5 →	8 →	7 →	8 →	8
9 →	7 →	8 →	7 →	7
	3&6	3&6	3&6	3&9

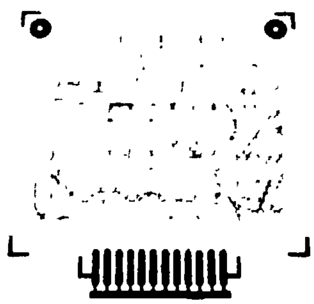


Fig 8.24 Layout printed circuit b… May be full, 2X or … size. Photo negative is needed to produce etched circuit board.

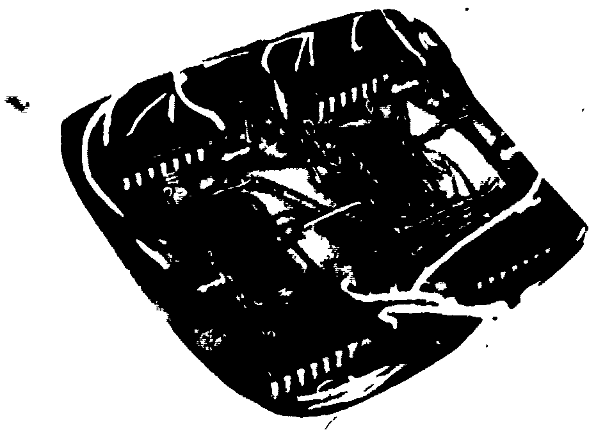


Fig. 8.25 Integrated circuits soldered in place on etched circuit board.

STUDY QUESTIONS

1. Explain the logic functions of; or, nor, and.

2. What can be done on a printed circuit board to avoid crossovers of circuit paths?

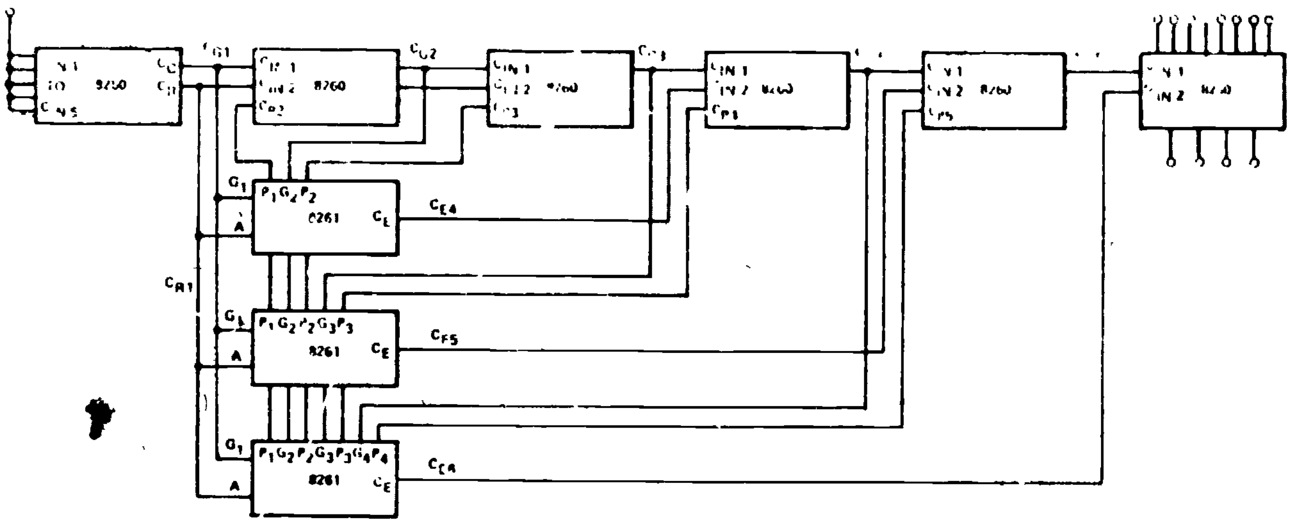
3. Where can you find information on the size and pin functions for integrated circuits?

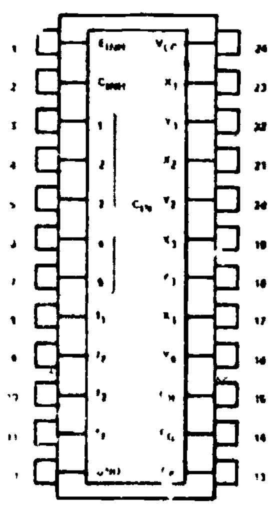
4. Explain the process used in making a etched circuit board.

5. Look up the prices on some of the 7400 series integrated circuits. Would you classify them as expensive or inexpensive?

EXERCISES

1. From the connection diagram and pin connection information given, prepare a pin connection chart similar to fig. 8.24.





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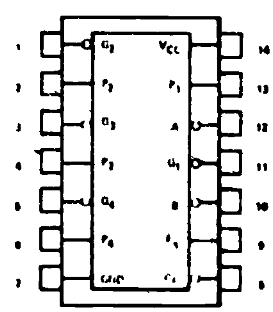

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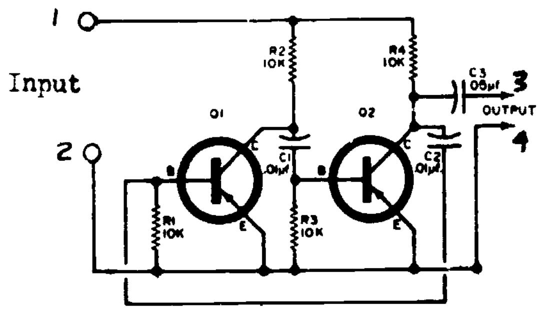
Note: Connect all V_{CC} pins.

Connect all gnd pins.

ERIC

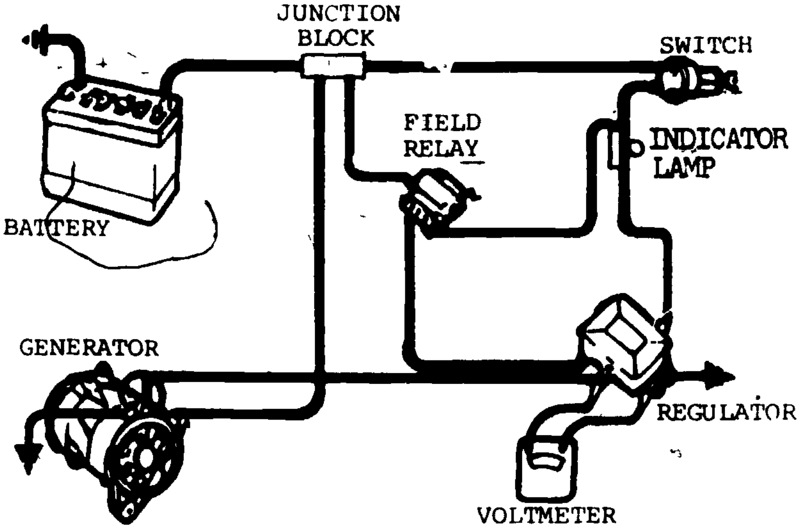
2. Using the data and component outlines in this section, sketch a 2X layout for a printed circuit board for the circuit shown.

   Note: Use 1/2 watt resistors and can size 1 capacitors.
   Use TO-18 size transistor case.



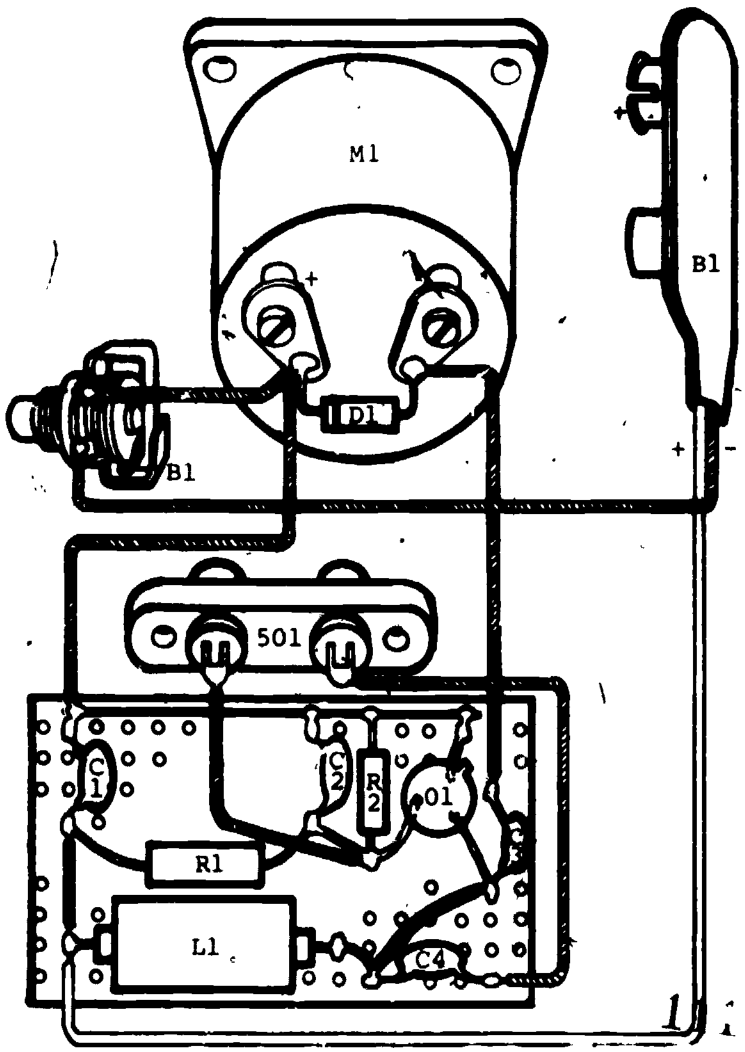
ERIC

1. Sketch a block diagram of the automotive electrical system shown below.

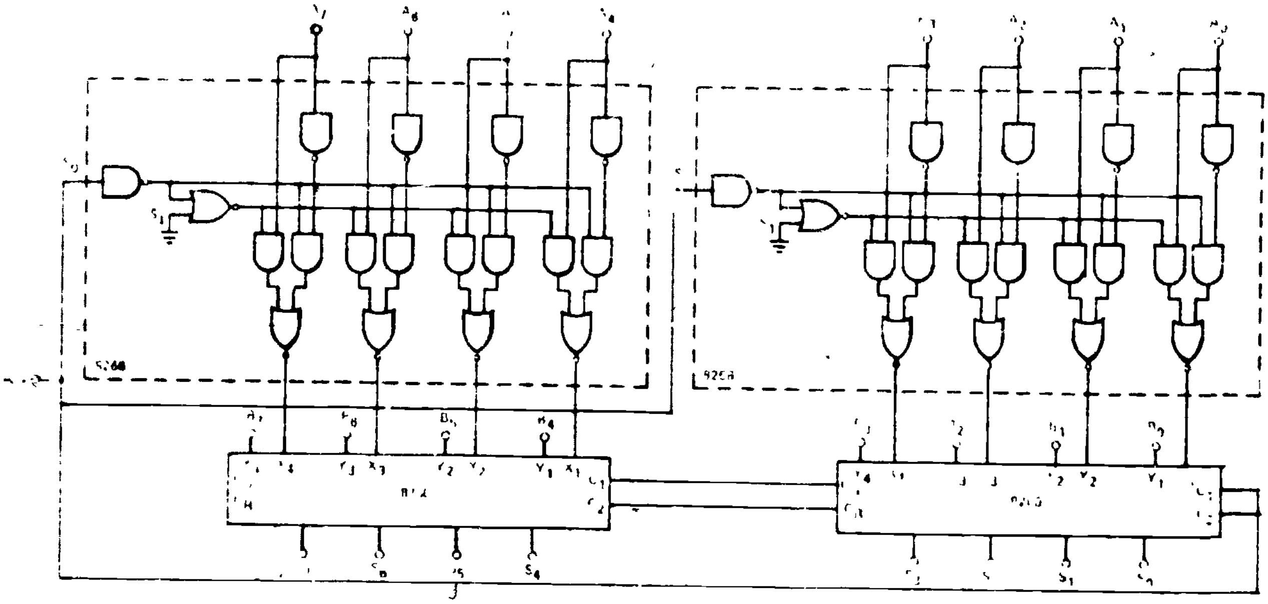


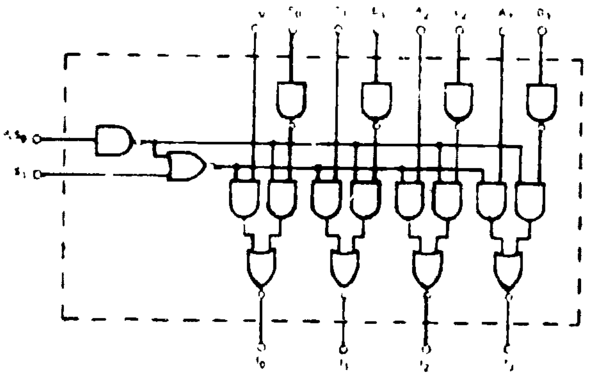
2. Sketch a schematic diagram of the device shown below.

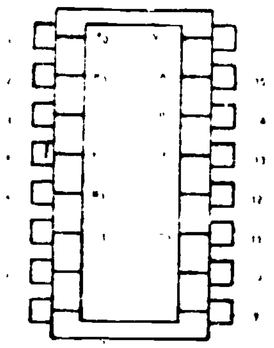
3. Using the component sizes given, sketch an etched circuit layout to replace the "perfboard" unit shown.



4. Write a pin connection chart for the connection diagram shown below.







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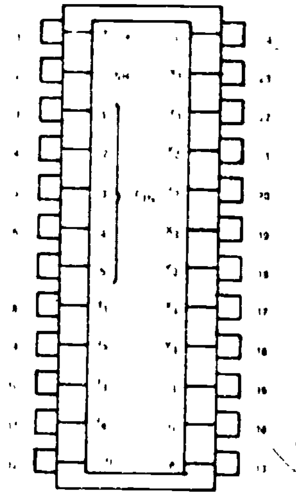


8260

5. Draw or sketch fig. 8.8 as a point to point wiring diagram.

ANSWERS

SECTION ITEMS

SECTION 8.1

1. The block diagram gives an overall picture of the device without regard to the exact components or wiring. It allows much quicker interpretation than the schematic diagram particularly for persons not trained in electrical or electronic circuits.

2. No. blocks sometimes take on the shape of schematic elements.

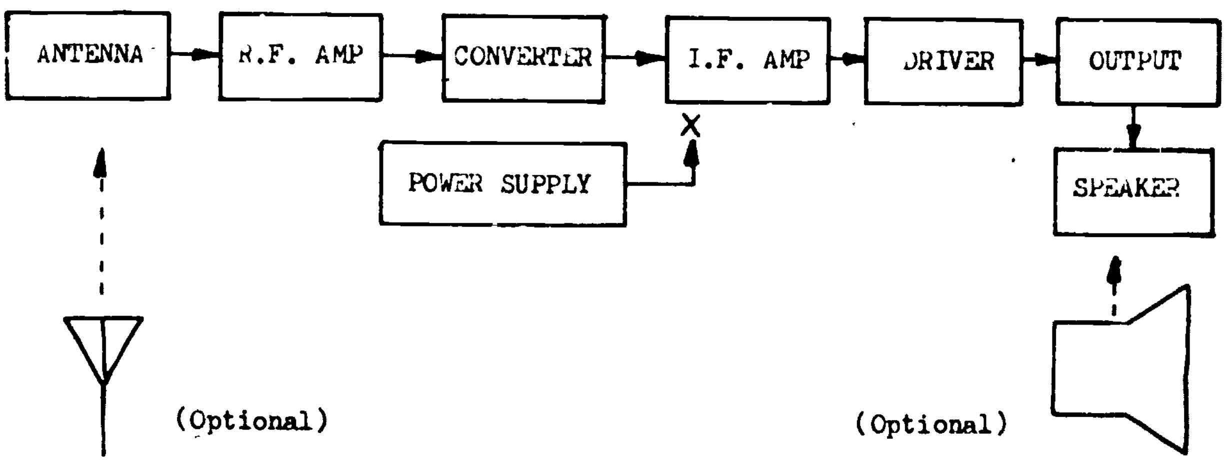
3. Block size is determined by the wording that must be placed in the block.

4. There is no real answer for this question. Block diagrams can be as simple or complex as needed. Every electronic part has a function so the block diagram could be as complex as the schematic diagram.

5. The feedback circuit would usually be shown in the lower middle of the block diagram and the arrows would point to the left toward the inputs.

EXERCISES

1.



2. Inputs could include: F.M. Tuner, A.M. Tuner; Tape decks for 8 track, Cassette, Reel to Reel; T.V. Tuner, Record player etc.

Pre- Amplifier, Video monitor

Power Amplifier

Speaker systems and headphones.

ERIC

SECTION 8.2

1. Wire cplors are denoted by a one or two letter abbreviation or by color code numbers.

2. Yes. High voltage for example is usually red. 115V mains are usually gray.

3. TB3/7

4. No. Wires may be marked by adhesive labels, paint, and sometimes by hot stamping.

5. Feed line shows wire stubs with destination symbols.
   Base line shows all wires in a common single line.
   Point to point shows exact connection of wires.

EXERCISES

NOTE: PARTIAL, SIMPLIFIED TABLE IS SHOWN.

ITEM NO.	FROM		TO		WIRE COLOR	GAGE
	COMP.	PIN	COMP.	PIN		
15	5	1	[illegible]	2	R-BL	22
16	5	2	16	-	R-BL	↑
17	5	2	6	1	R-W	
18	5	3	6	6	R-W	
19	5	4	26	-	R-O	
20	6	1	10	2	R-G	
21	6	2	5-1	2	BK	
R-2	6	3	6	5	—	
22	6	4	11	1	R	
23	6	4	6	5	BUS	
24	6	6	10	1	Y	
25	6	7	5-1	1	BK-W	
26	6	8	4	2	Y	
27	6	CAP	7	-	BK	
						↓
						22

ERIC

SECTION 8.3

1. Equal area concept.

2. Yes. Only in a few circuits (Bridge, delta, "Y" etc) are schematic symbols placed on an angle.

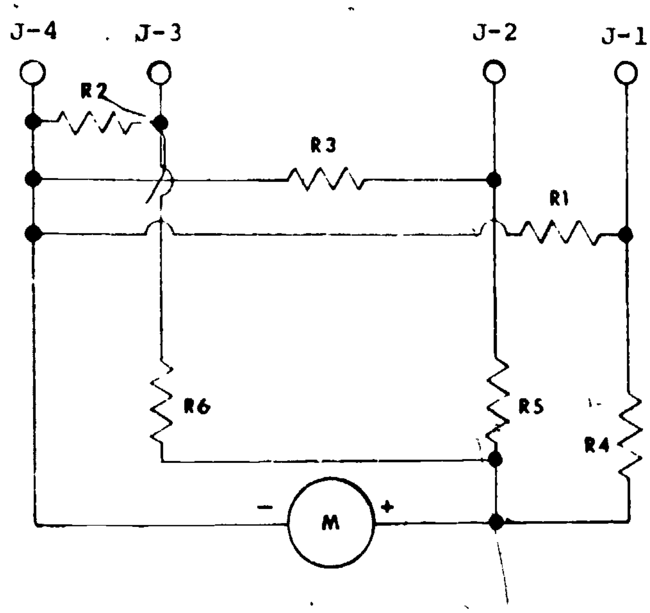
3. Parts must be identified on a schematic diagram. These identifications are related back to the parts list. Basic identifications are: R - 1, C - 15 D - 7 etc. In addition the value, voltage, device number, etc., may be shown to make schematic interpretation easier.

4. Industrial schematics use the block format and variations on some of the symbols.

5. Different plug symbol and three wires instead of two wires.

EXERCISES

1.



2. To be answered locally.

1. These symbols refer to the output conditions of a device based on the input conditions. One explanation might be: (positive logic)

   OR . . . . if input A or B is on, output is on.

   NOR . . . . if neither input is on, output is on.

   AND . . . . if input A and input B is on, output is on.

2. Circuit paths can be routed under components - using the component as a "bridge", double sided boards can be used, jumpers are sometimes needed.

3. No standard reference is generally available. Usually the individual part manufacturer's catalog must be used.

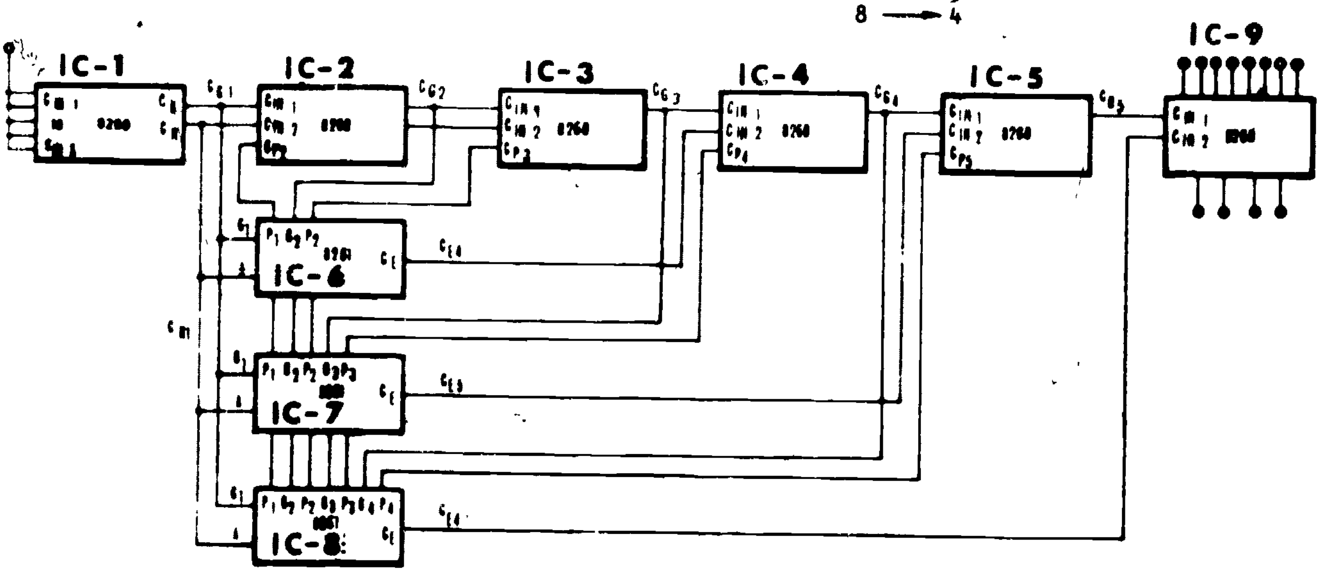
4. Artwork, photo-negative, circuit board exposure, develop circuit image, etch, drill holes.

5. Very inexpensive.

EXERCISES

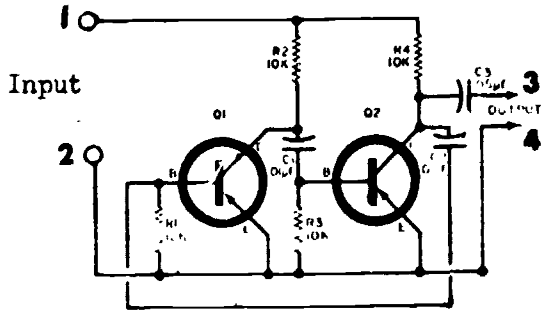
1. Connection diagram may vary depending on the IC-1, IC -2 etc. notation chosen.

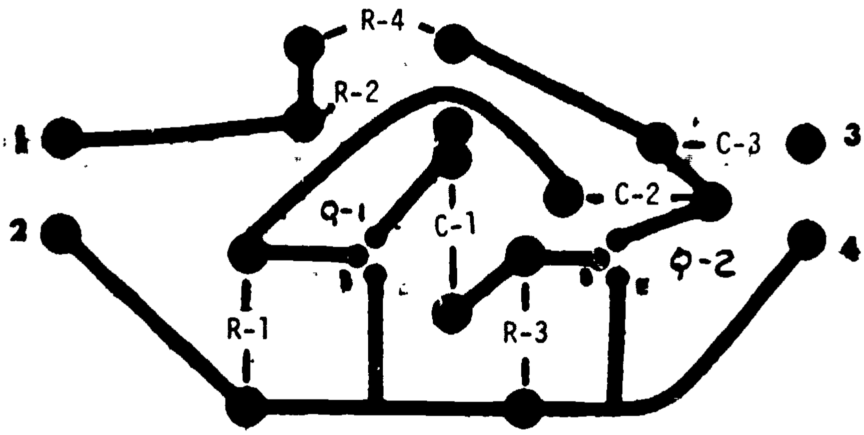
IC - 1	IC - 2	IC - 3	IC - 4	IC - 5	IC - 6	IC - 7	IC - 8	IC - 9
24	24	24	24	24	24	24	24	24
12	12	12	12	12	7	7	7	12
3&4&5&6&7								
14	3				11	11	11	
15	4				12	12	12	
	13				13	13	13	
	14	3			1	1	1	
	15	4						
		13			4	4	4	
		14	3			3		
			4		8			
			13			4		
			14	3			5	
				4		8		
				13			6	
				14				5
							8	4



2. Using the data and component outlines in this section, sketch a 2X layout for a printed circuit board for the circuit shown.

Note: Use 1/2 watt resistors and can size 1 capacitors.
Use TO-18 size transistor case.



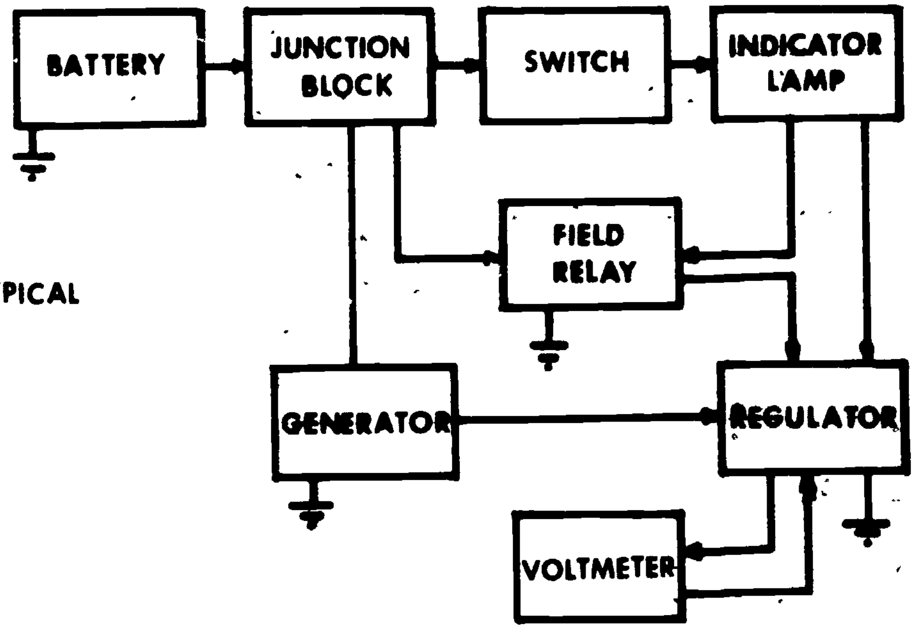


ANSWERS

CHAPTER ITEMS CHAPTER VIII

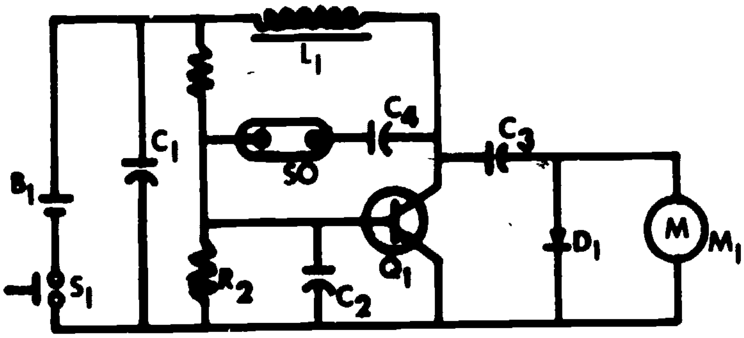
1.

TYPICAL

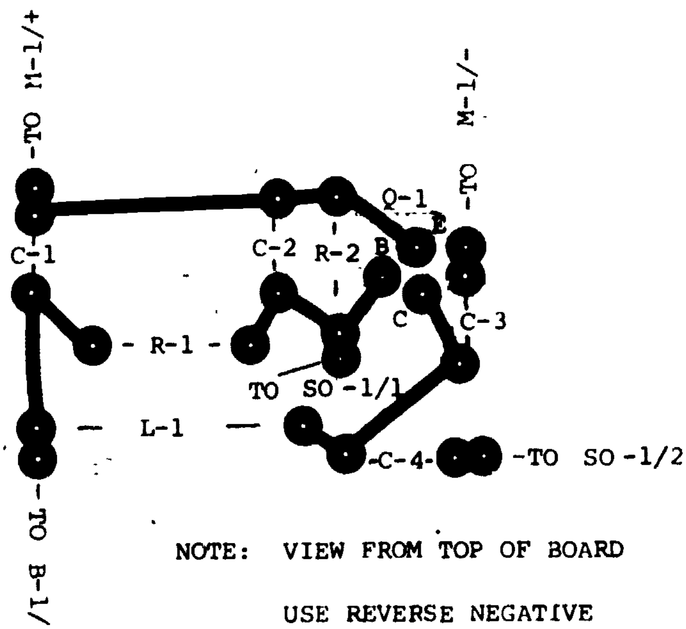


2.

TYPICAL



3



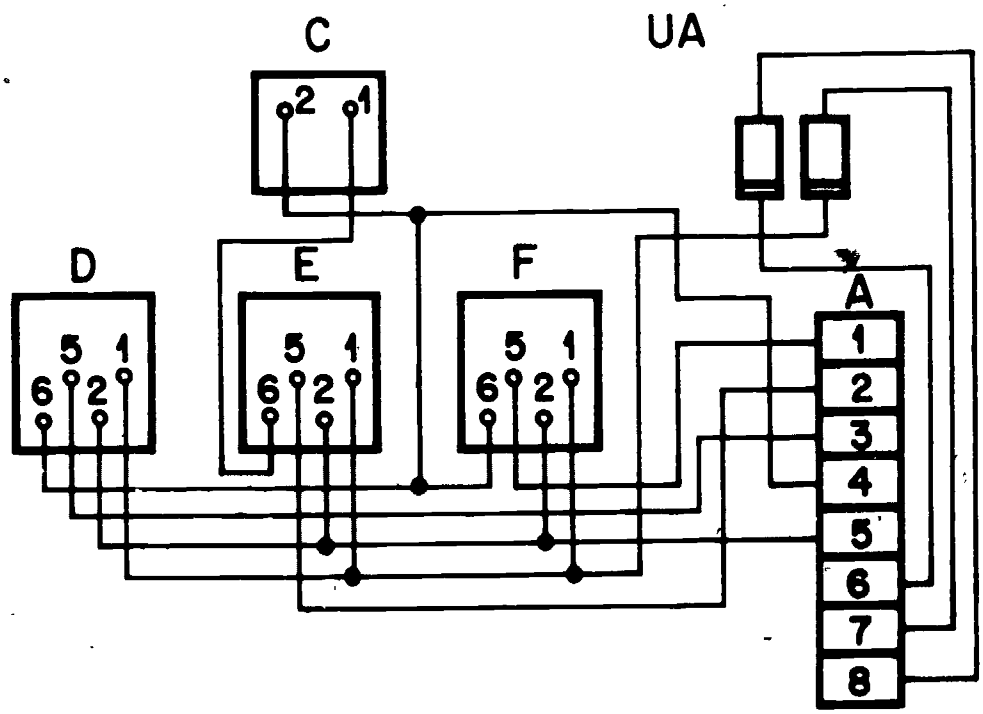
NOTE: VIEW FROM TOP OF BOARD

USE REVERSE NEGATIVE

3. Diagram may vary according to how IC's are labeled.

IC - 1	IC-2	IC - 3	IC - 4	
16	16	24	24	(Ic -1, IC - 2 = 8266)
8 & 7	8 & 7	12	12	
9	9		3 & 4	(IC - 3, IC - 4 = 8260)
1&2	1&2			
5&6	5&6			
10&11	10&11			
14&15	14&15			
3		17		
4		19		
12		21		
13		23		
	3		17	
	4		19	
	12		21	
	13		23	

4.



WELDING DRAWING

SECTION 9-1 PROCESSES, JOINTS, AND SYMBOLS

The joining of two pieces of metal by gas, arc, or resistance welding is an economical means of fabrication especially in the early stages of design. A knowledge of the common welding processes, basic welded joints, and symbols used to represent various welds is a necessity for the technician involved in preliminary design.

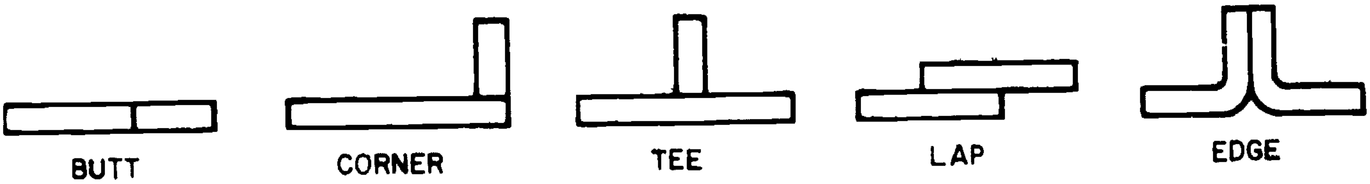


Figure 9-1 Basic types of welded joints.

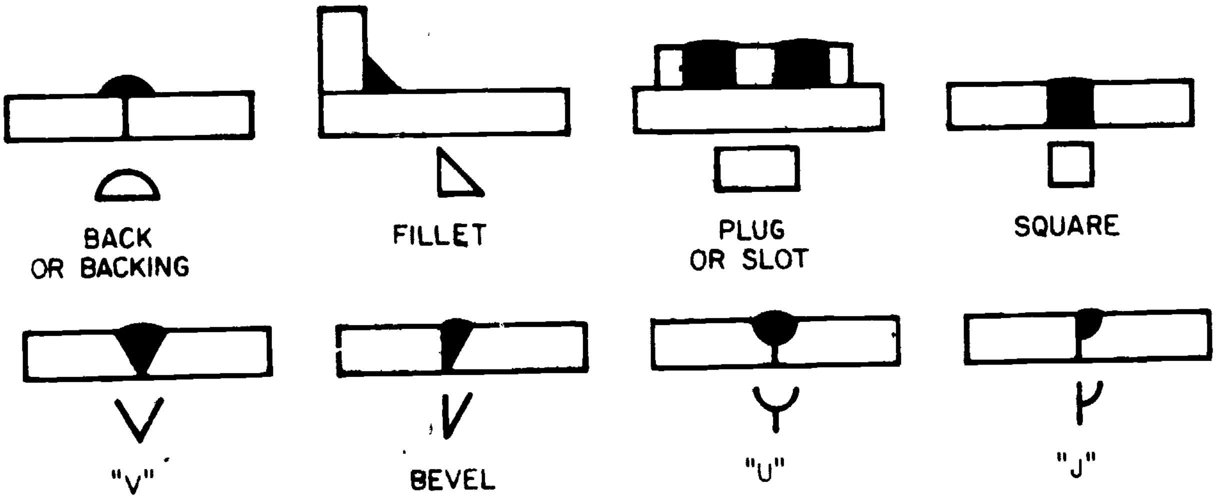


Figure 9-2 Fundamental arc and gas welds with related symbols.

TYPE OF WELD			
Spot	Projection	Seam	Flash or Upset

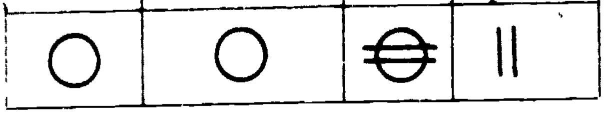


Figure 9-3 Resistance weld symbols.

SUPPLEMENTARY SYMBOLS					
Weld All Around	Field Weld	Melt-Thru	Contour		
			Flush	Convex	Concave

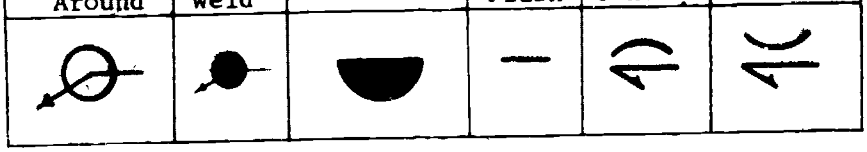


Figure 9-4 Supplementary symbols.

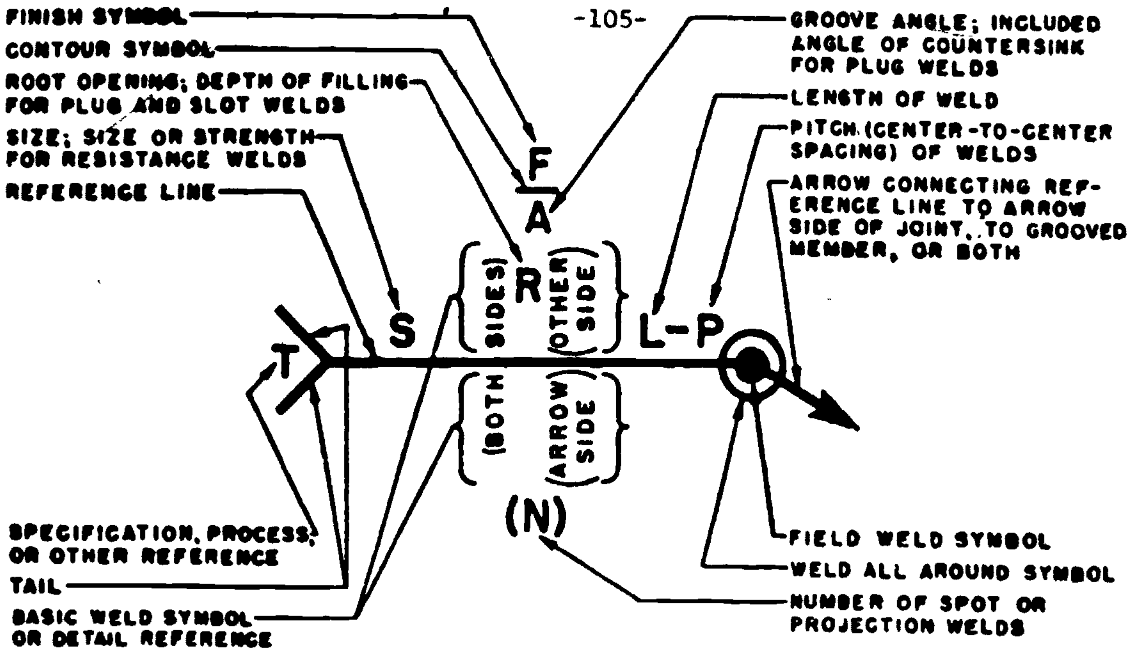


Figure 9-5 Standard location of the elements of a welding symbol.

Due to the standardization of welding symbols, precise information can be placed on a drawing regarding the exact type, size, and number of welds required. The following illustrations show typical examples of various welds.

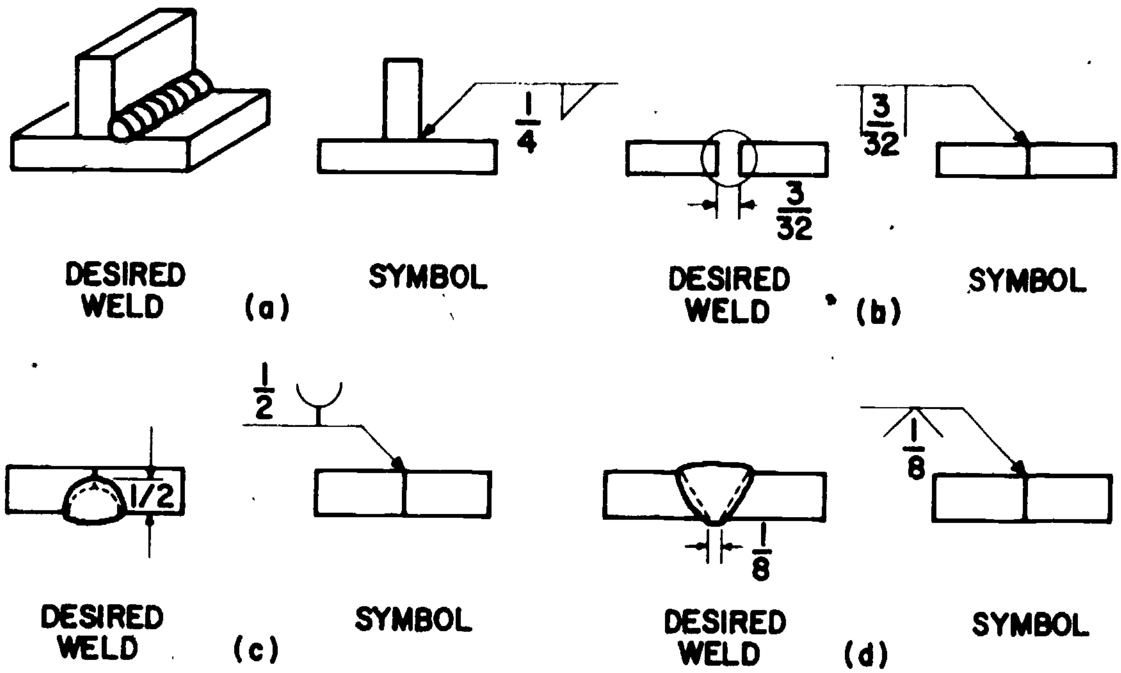


Figure 9-6 Examples of welds.

LABORATORY

1. The student should be able to translate ANSI* welding symbols from a typical cross section into a clear and complete statement describing the required weld.

2. The student should be able to draw the correct ANSI welding symbols and apply them to a typical joint cross section from a word description.

SECTION ITEMS

QUESTIONS

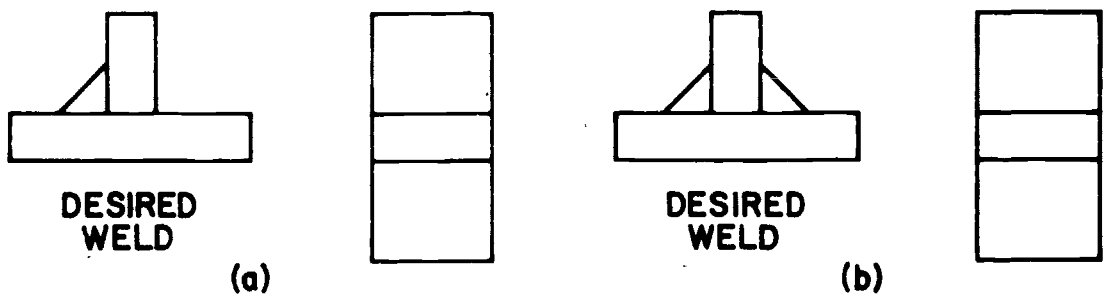
1. What does a field weld symbol indicate?

2. Is edge preparation usually shown on a working symbol?

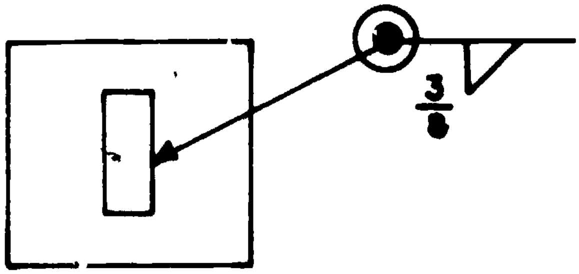
3. Why is welding usually preferred over casting or forging in prototype fabrication?

EXERCISES

1. Draw the symbol for a 1/2" weld on the other side of the joint at (a) and both sides at (b).



2. Describe the following weld.



* American National Standards Institute

CHAPTER ITEMS

1. Make a weld assembly drawing on an A size sheet of vellum using proper ANSI SYMBOLS.

ANSWERS

Section Items

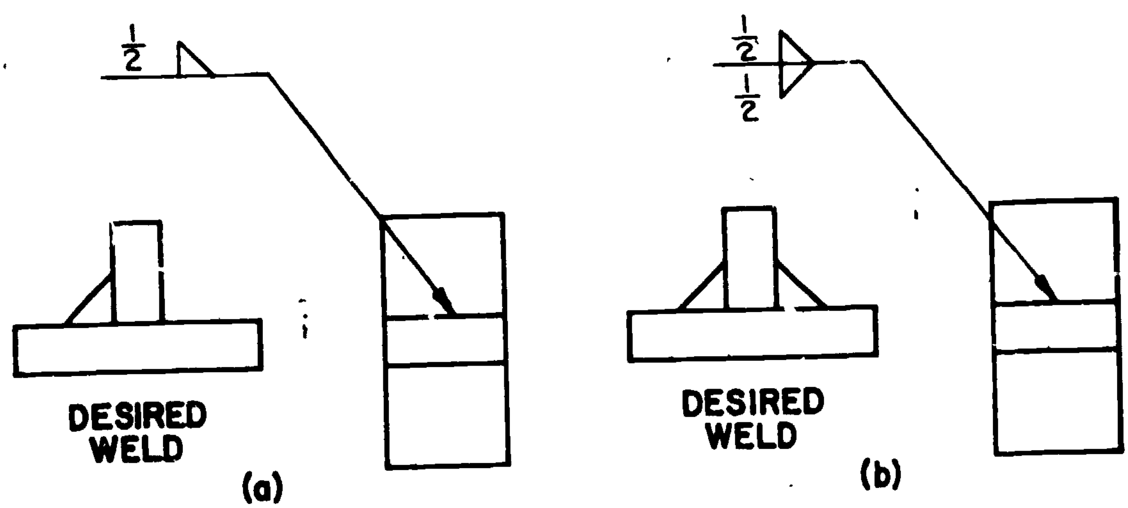
1. Welds made after the initial fabrication.

2. No. With proper weld symbols and notation a picture of the edge preparation is not required.

3. Welding is usually preferred in prototype fabrication because it is cheaper and faster.

EXERCISES (solutions)

1.



2. Field weld all around with 3/8" fillet weld.

CHAPTER X

PIPE DRAWING

SECTION 10-1 JOINTS, FITTINGS, AND VALVES

Pipes which carry a fluid must be joined together and routed in various directions to get the fluid from one point to another. The joints and fittings which are required must form a leak proof seal and, in the case of high pressure lines, must be structurally sound. The flow of the fluid usually requires some control and this is achieved through the use of valves. Pipes are made from ferrous and nonferrous materials with various applications. The material from which the pipe is made and the condition of the fluid being transported are determining factors in the selection of fittings and joints.

Pipe Material

Pipe is available in steel, wrought-iron, cast-iron, seamless brass and copper, or plastic. Their selection depends to a large extent on their application.

Pipe Joints and Fittings

Fittings may be used to join pipes together, change size or direction, or allow for branching. The type of joint and fitting may be screwed, welded, flanged, or soldered depending upon material and application.

Valves

Valves are used to control the flow of fluids in a pipe. The more common types are gate valve, globe valve, and check valve.

LABORATORY

1. The student should be able to select the correct fittings and joints when given a pipe material, size, and application.

SECTION ITEMS

STUDY QUESTIONS

1. What is the purpose of a check valve?

2. Name one kind of joint that can be used in a high pressure steel line?

3. Of the two, which offers the most resistance to flow; a gate valve or globe valve?

EXERCISE

1. Make a list of the pipe and fittings to be ordered for the system shown in figure 10.1. Arrange the list in tabular form under headings of size, pipe length, valves, fittings,etc. Use a scale of 1"=20' for the length of pipe taken from the isometric. Use flanged cast-iron pipe. Pressure in the pipe will not exceed 200 lbs. psi.

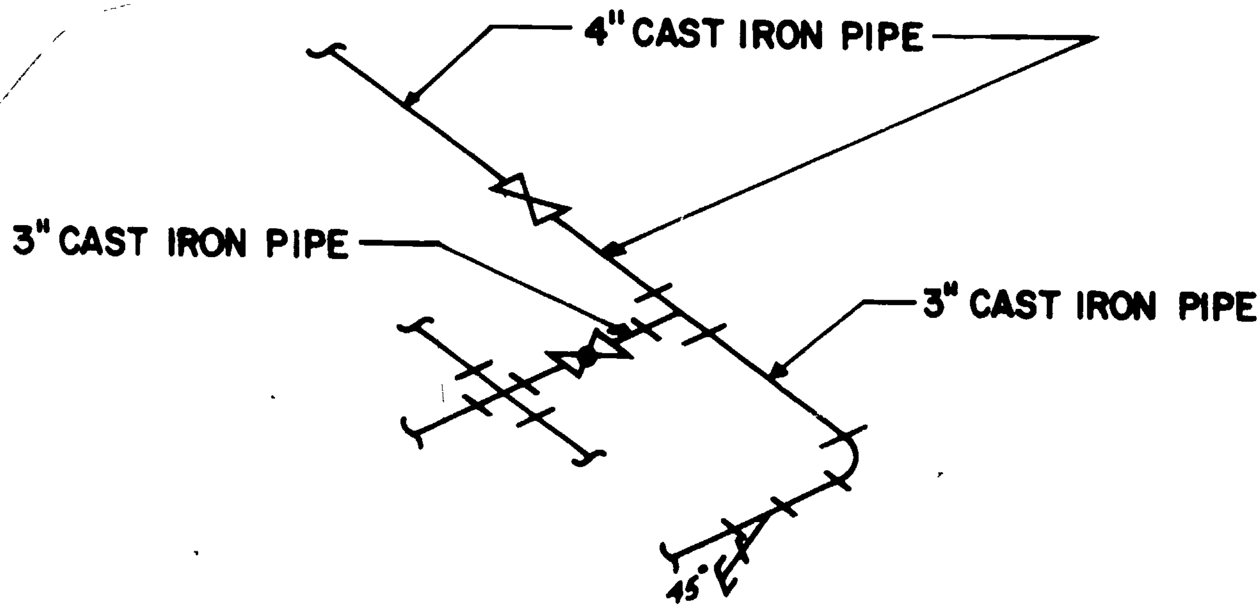


Figure 10.1

SECTION 10-2 SINGLE-LINE AND DOUBLE-LINE DRAWINGS

Pipe drawings are made to show the size and location of pipes, fittings, and valves. A single-line drawing showing ANSI symbols is a fast and convenient way of making a drawing using orthographic or axonometric drawing. Double-line drawings are used when more detail is required in the drawing.

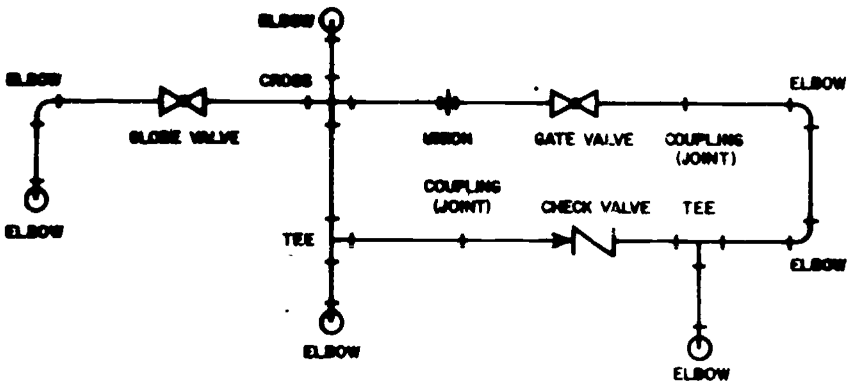


Figure 10.2 Single Line Drawing

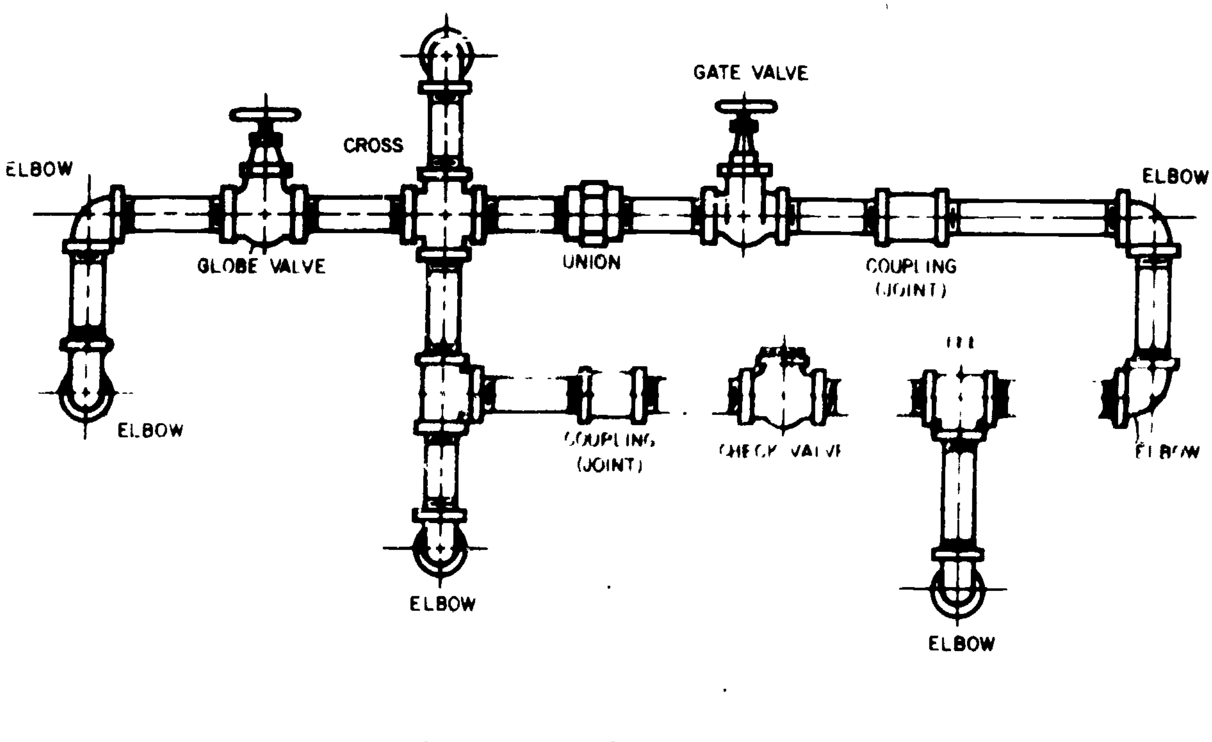


Figure 10.3 Double Line Drawing

LABORATORY

1. The student should be able to make a single-line orthographic or isometric drawing from either word description or double-line drawing.

2. The student should be able to make an orthographic or isometric double-line drawing from a single-line drawing.

SECTION ITEMS

EXERCISES

1. Make a single-line isometric drawing of figure 10.3.

CHAPTER ITEMS

EXERCISES

1. Make a double-line isometric drawing of figure 10.2.

ANSWERS

SECTION 10.1

1. The purpose of a check valve is to allow flow in only one direction.
2. Welded joints.
3. Globe valve. The fluid must go through the valve at right angle to the flow direction.

ERIC

CHAPTER XI GRAPHS

SECTION 11.1 LINE GRAPHS

Line graphs are commonly used in the engineering field because of their visual appeal and ease of interpretation. Some of the more common line graphs are the Rectangular Coordinate Graph, Semilogarithmic Graph, Logarithmic Graph, and the Polar Graph.

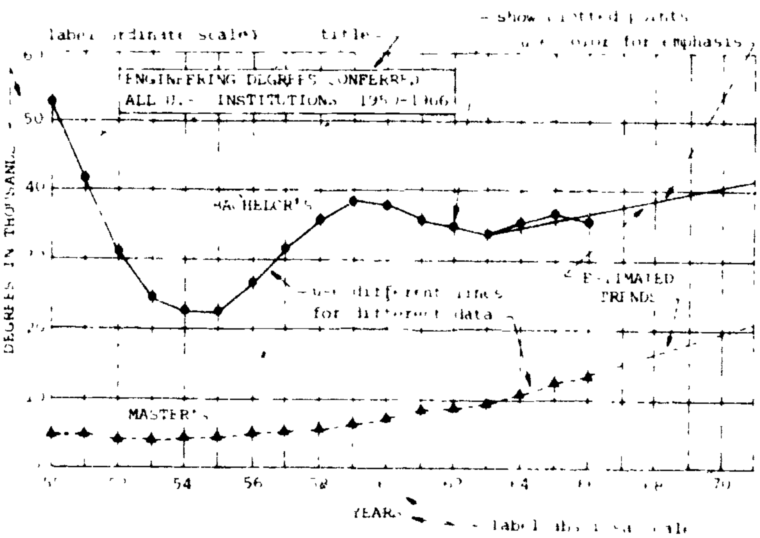
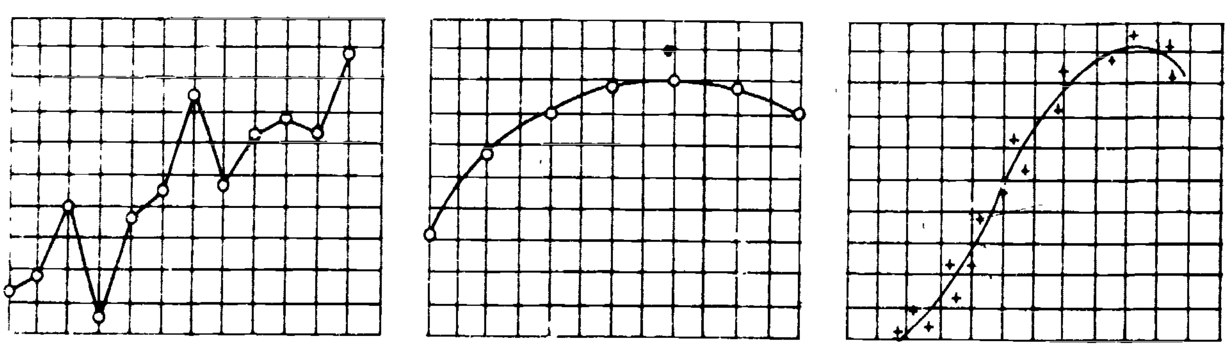


Fig. 11.1 Typical Line Graph

The manner in which a curve is drawn on a graph will depend upon its derivation. If the graph represents discrete values such as temperature or dates it will be made up of straight line segments and pass through all data points as in Fig. 11.2 (a). For a curve that can be easily defined mathematically, it will be smooth and pass through all data points as in Fig. 11.2 (b). A graph representing experimental data may be straight or curved and will take a mean path through the distribution of data points as in Fig. 11.2 (c).



(a) (b) (c)

Fig. 11.2

When constructing a line graph, the following suggestions should be considered:

1. The horizontal scale should usually read from left to right and the vertical scale from bottom to top.

2. All lettering on the graph should read from the bottom or from the left-hand side.

3. The zero line should always be shown except for logarithmic graphs. The diagram should be broken if the scale is such that the zero line would not normally appear on the graph.

4. Important numerical data and formulas should be included on the graph.

5. The title should completely define the graph and be placed so that it is easily found.

LABORATORY

The student should be able to annotate a graph when given the grid, curve, and pertinent data.

SECTION ITEMS

QUESTIONS

1. What four line graphs are most commonly used in the engineering field?

2. On which side of the vertical axis is the label usually placed?

3. Why does the zero line never appear on a logarithmic graph?

4. On which side of the horizontal axis should the label be placed?

EXERCISES

1. Complete the graph in Fig. 11.3 by adding the given information.

Title: STRESS-STRAIN DIAGRAM Soft Steel

Horizontal axis label: Strain in inches per inch

Vertical axis label: Stress in pounds per sq. inch

Scale on vertical axis: each sq. equals 1000 psi

Scale on horizontal axis: each sq. equals .001 in.

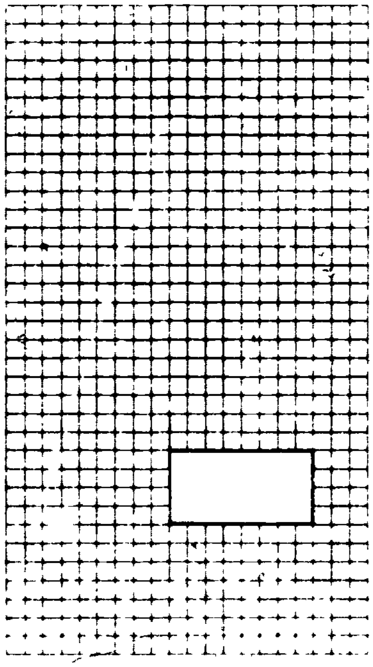


Fig. 11.3

SECTION 11.2 RECTANGULAR LINE GRAPHS

Rectangular line graphs are usually drawn on preprinted grid paper whose horizontal and vertical lines form small rectangles which range in sizes of 1 mm, 1/10", or 1/20" on a side. The horizontal and vertical axes of the graph on which the independent and dependent variables are plotted, respectively, are drawn about 1" inside the grid to allow for lettering.

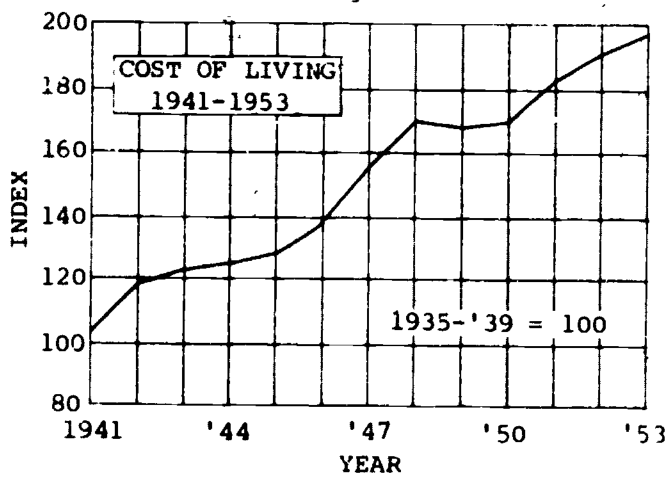


Fig. 11.4 Typical Rectangular Line Graph

LABORATORY

1. The student should be able to pick correct values from a rectangular line graph.

2. The student should be able to construct a rectangular line graph when given a set of data.

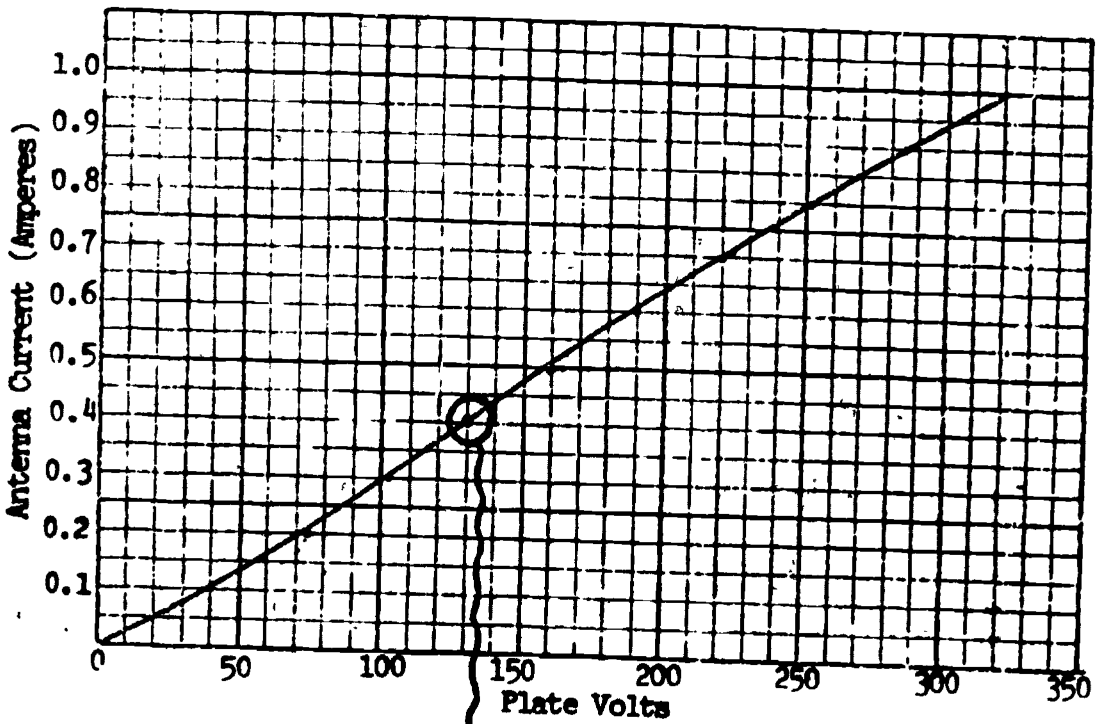
SECTION ITEMS

EXERCISES

1. PLOTTING GRAPHS

Look at the examples of plotted graphs. Notice how certain circled data are related to the line graphs of examples 1 and 2. Now that you have observed how data is plotted to form a line graph choose other given data from the data tables and locate additional points on the graph.

Typical curves with written notations for you to compare. See if you can follow the written information on the graphs.

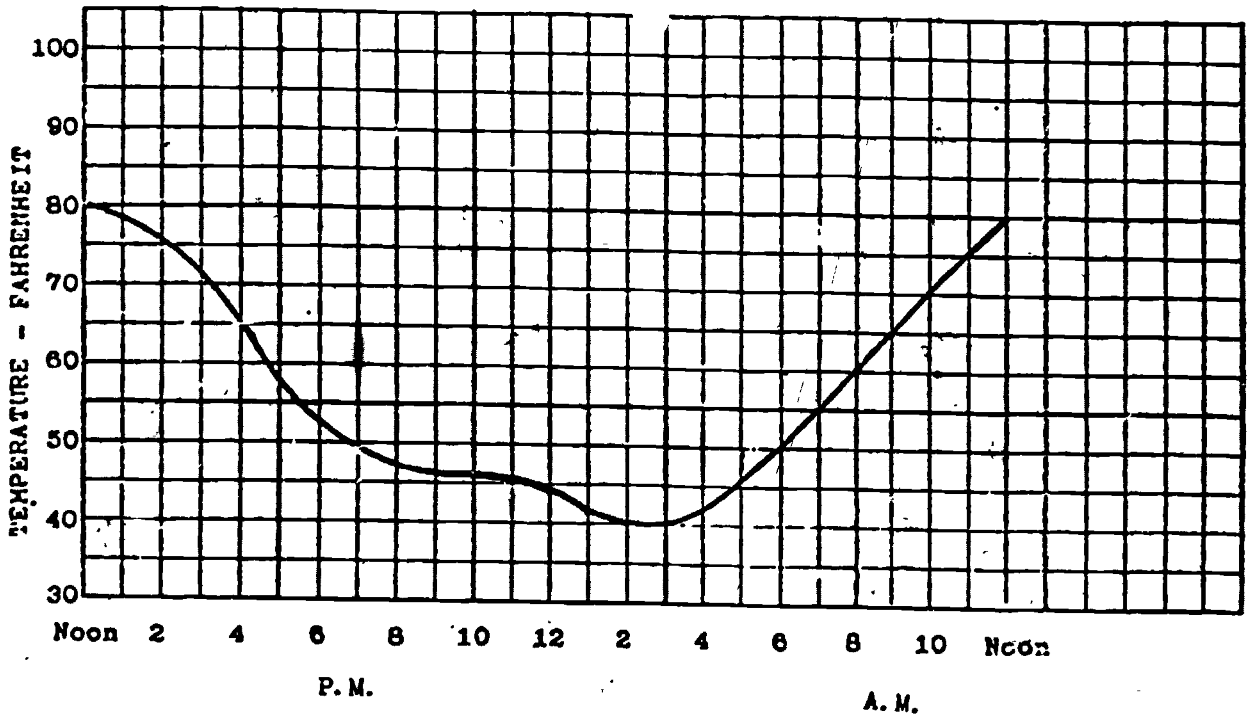


Antenna Current	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	(Amperes)
Plate Volts	40	75	102	130	160	190	220	252	283	320	

Fig. 11.5

2. RECTANGULAR LINE GRAPH

Looking at the following graph, complete the following unfinished material by providing the temperatures in degrees for the given times.



TIME	DEGREES	TIME	DEGREES
NOON	→ 80	MIDNIGHT	
1:00		1:00	
2:00		2:00	
3:00		3:00	
4:00		4:00	
5:00		5:00	
6:00		6:00	
7:00		7:00	
8:00		8:00	
9:00		9:00	
10:00		10:00	
11:00		11:00	

ERIC

SECTION 11.3 SEMILOGARITHMIC GRAPHS

A semilog line graph is one in which two variables are plotted on semilogarithmic coordinate paper to form a continuous straight line or curve. Semilog paper contains uniformly spaced vertical lines and logarithmically spaced horizontal lines. Semilog graphs are useful when the dependent variable has a large range.

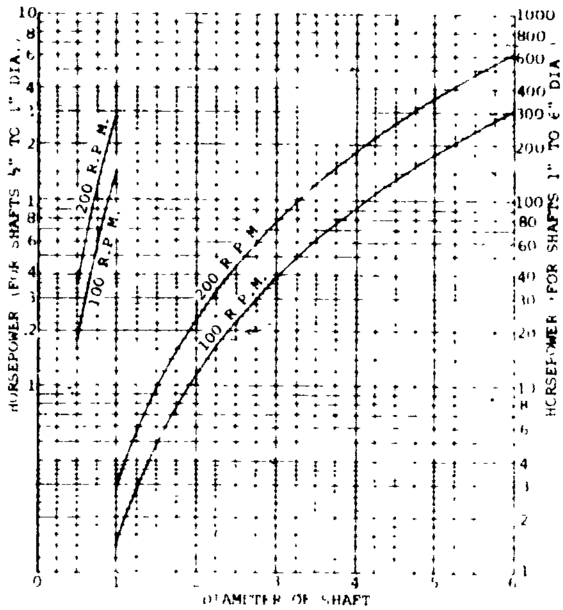


Fig. 11.6 Typical Semilog Graph

LABORATORY

1. The student should be able to pick correct values from a semilog graph.

2. The student should be able to construct a semilog graph when given a set of data.

SECTION ITEMS

EXERCISES:

1. Using a sheet of semilog paper, plot the data in Fig. 11.7.

TEMPERATURE T, ^oF	STRESS S, lb. per sq. in.
1,100	2,700
1,200	1,250
1,300	570
1,400	270

Fig. 11.7

SECTION 11.4 LOGARITHMIC GRAPHS

A logarithmic line graph has two variables plotted on logarithmic coordinate grid paper to form a continuous line or "smooth curve". Log grid paper contains logarithmically spaced divisions on both the vertical and horizontal axes. Log and semilog graph paper can be obtained having as many as five cycles on an axis. Log graphs are used for comparison of large numbers of plotted values in a compact space and for comparing relative trends of several plotted curves on the same chart or graph. Log graphs are not the best form to present relatively few plotted values or for displaying absolute amounts -- but are very good for displaying an extensive range of values used in empirical equations.

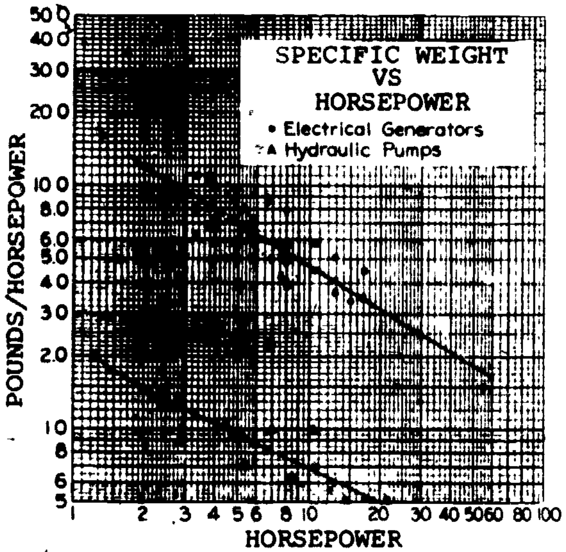


Fig. 11.8 Typical Log Graph

LABORATORY

1. The student should be able to pick correct values from a log graph.

2. The student should be able to construct a log graph when given a set of data.

SECTION ITEMS

EXERCISES

1. Plot the given date on log paper. Choose the number of cycles each way to use most of the paper.

SPEED RPM	CAPACITY CU. FT. PER HR.
1.5	46
2.5	57
4	76
6	90
10	117
15	143
19	170
34	220
60	280
90	355

SECTION 11.5 POLAR GRAPHS

Polar graphs are often used when data is to be examined with respect to various angular positions. The polar graph is different from the previous graphs in that the independent variables are marked off in degrees around the border of the graph and the dependent variables are marked off on the horizontal or vertical radial lines.

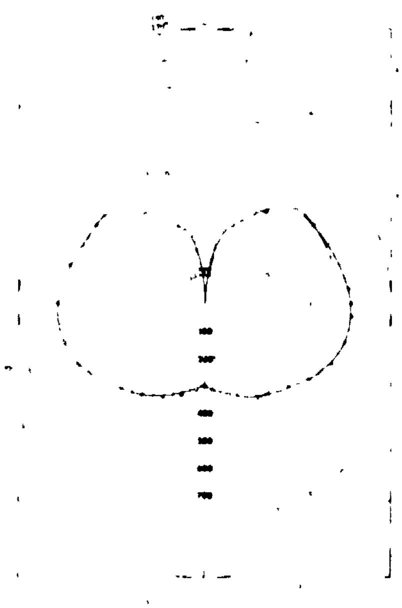


Fig. 11.10 Typical Polar Graph

LABORATORY

1. The student should be able to pick correct values from a polar graph.

2. The student should be able to construct a polar graph when given a set of data.

SECTION ITEMS

EXERCISES

1. Construct a polar graph using the data in Fig. 11.11.

Orientation, degrees	Candle Power
0	130
10	200
20	300
30	310
40	300
50	300
60	290
70	280
80	270
90	240
100	200
110	280
120	285
130	290
140	305
150	320
160	330
170	340
180	330

Fig. 11.11 Candle Power Distribution in a Vertical Plane of an Incandescent Lamp Suspended from the Ceiling.

CHAPTER ITEMS

QUESTIONS

1. Why is a curve sometimes drawn between plotted points on a graph rather than through them?

2. What are the two axes of a graph called?

3. How are the values plotted on the X and Y axes?

4. What are the two variables on a graph called?

5. In reading a graph, how accurate must one estimate?

6. Why are graphs used by scientists and engineers?

7. What is the difference between common rectangular graph paper and semilog graph paper?

8. Why is graph paper printed in various colors; i.e., black, orange, green, purple?

EXERCISES

1. RECTANGULAR LINE GRAPH

- This is the frequency of the output of device "Y" as the temperature of the device is changed.

Temp. $^{\circ}C$	Frequency (MHz)
0	100.0500
2.5	100.0330
5.0	100.0200
7.5	100.0100
10.0	100.0060
12.5	99.9980
15.0	99.9970
17.5	99.9920
20.0	99.9930
22.5	99.9910
25.0	99.9900
27.5	99.9910
30.0	99.9915
32.5	99.9960
35.0	99.9965
37.5	100.0000
40.0	99.9980
42.5	99.9930
45.0	99.9875
47.5	99.9840
50.0	99.9820
52.5	99.9760
55.0	99.9765
57.5	99.9750
60.0	99.9740
62.5	99.9730
65.0	99.9720

2. LOG GRAPH

Graph this data:

y	x
2.0	.1
5.2	.2
9.0	.3
13.0	.4
22.0	.6
30.0	.8
50.0	1.3
72.0	2.0

y	x
95.0	3.0
130.0	5.0
150.0	7.0
170.0	10.0
230.0	20.0
260.0	30.0
280.0	40.0
300.0	50.0

3. SEMILOG GRAPH

Here is some data on frequency response of an amplifier:

Gain (dB)	Freq. (Hz)
20	1
25	2
27	3
29	4
30	5
31	6
32	7
33	8
34	9
35	10
37	20
39	30
40	40
40	50
41	60
40	70
41	80
40	90
39	100

Gain	Freq. (Hz)
40	200
40	300
40	400
40	500
40	600
40	700
40	800
41	900
42	1000
41	2K
40	3K
40	4K
41	5K
42	6K
43	7K
44	8K
43	9K
40	10K

Gain	Freq. (Hz)
40	20K
38	30K
36	40K
35	50K
32	60K
30	70K
25	80K
20	90K
10	100K

Notice that there are five general groups of frequencies; 1-10, 10-100, 100-1000, 1000-10,000, and 10,000-100,000 These are the 5 cycles and the reason you were to get 5 cycle paper. At other times, you may only need 2 or 3 cycles.

ANSWERS

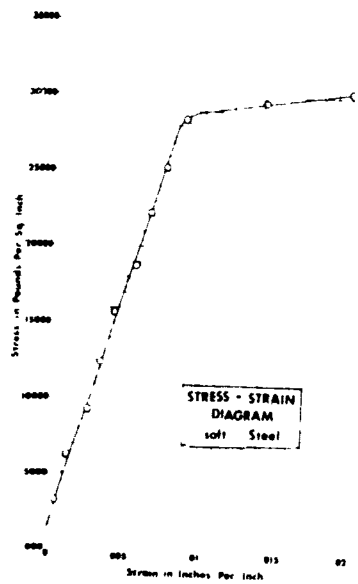
Section 11.1

1. Rectangular line graph, semilog graph, log graph, polar graph.
2. Left side.
3. Because the logarithm of a number approaches infinity as the number approaches 0.
4. Lower side.

ANSWERS TO EXERCISES

Section 11.1 (Engineering Graphs)

1.



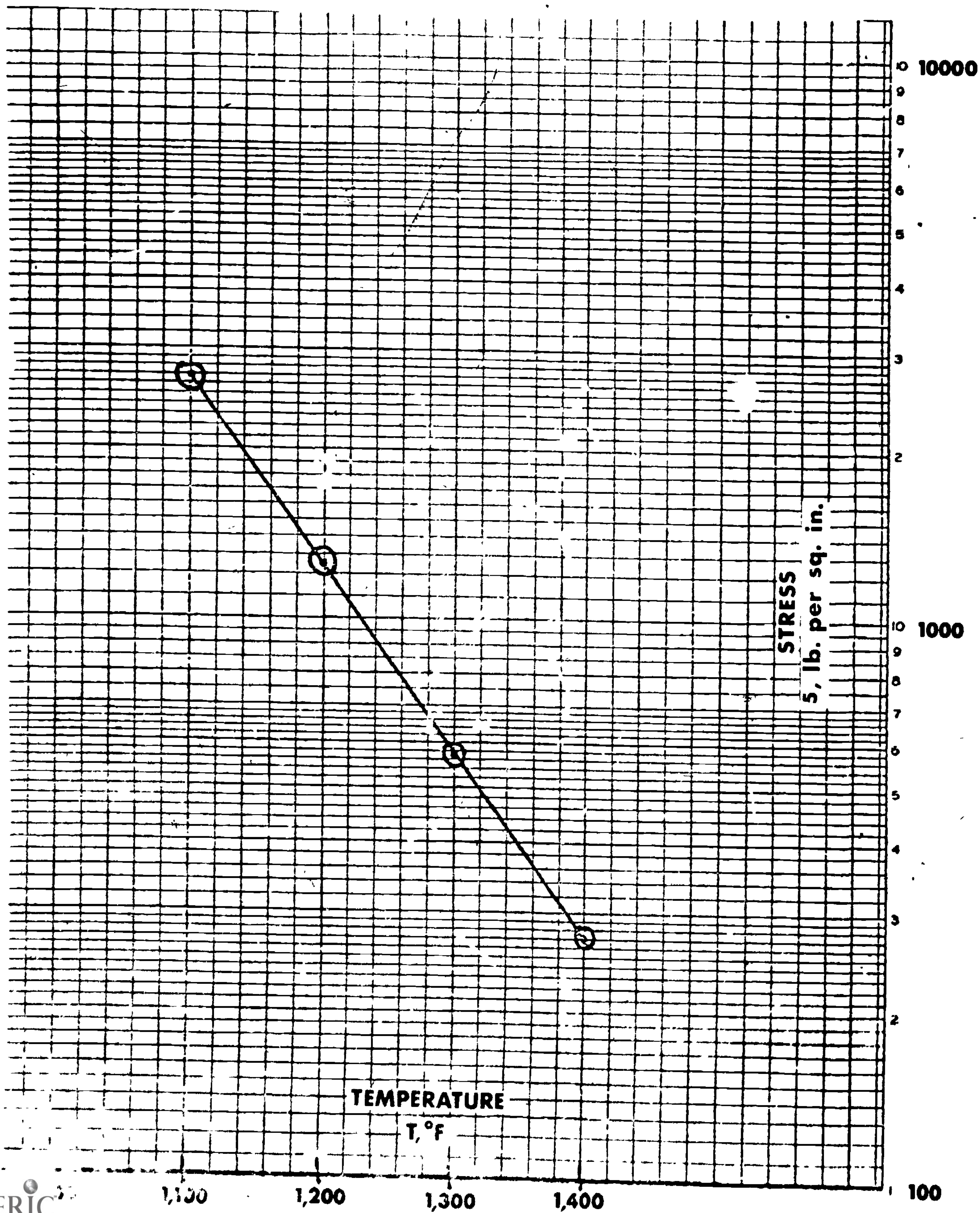
Section 11.2 (Rectangular Line Graphs)

1.

Time	Degrees
Noon	80
P.M.	
1:00	78
2:00	75
3:00	72
4:00	65
5:00	58
6:00	53
7:00	50
8:00	47
9:00	46
10:00	46
11:00	46

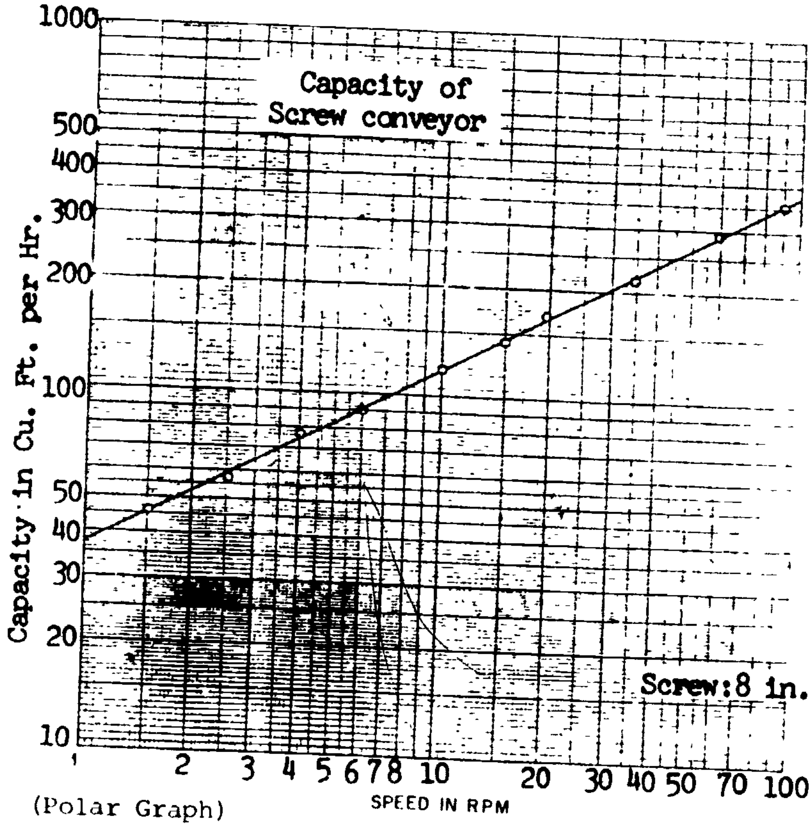
Time	Degrees
Midnight	44
A.M.	
1:00	42
2:00	40
3:00	40
4:00	42
5:00	46
6:00	50
7:00	55
8:00	60
9:00	65
10:00	70
11:00	75

Section 11.3 (Semilog Graphs)



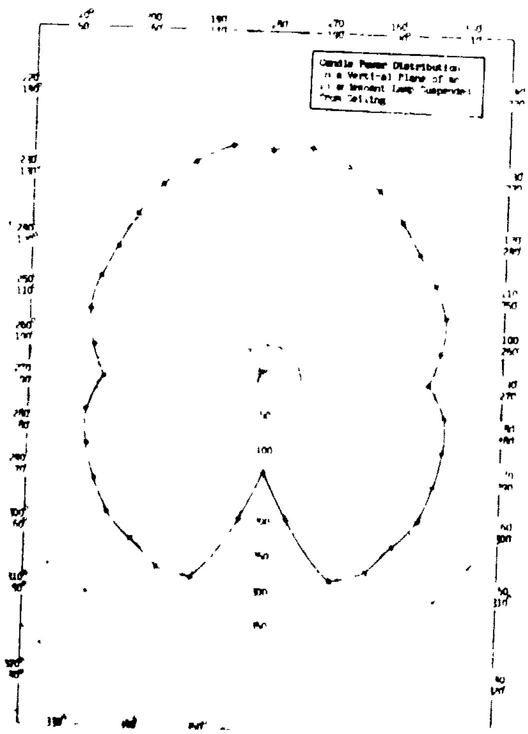
Section 11.4 (Log Graph)

1.



Section 11.5 (Polar Graph)

1.



CHAPTER ITEMS

ANSWERS TO QUESTIONS

1. Experimental data will always have some variation from the "true" values due to errors in reading instruments, slight changes in conditions, etc.

2. The vertical axis is called the Y-axis or ordinate and the horizontal axis is called the X-axis or abscissa.

3. Values along the X and Y axes are positive up and to the right and negative down and to the left.

4. Most physical systems with two variables have one which can be varied, by the experimenter and a second variable which depends on the first. The first is called the independent variable and the second is called the dependent variable.

5. To the nearest half of the smallest scale division.

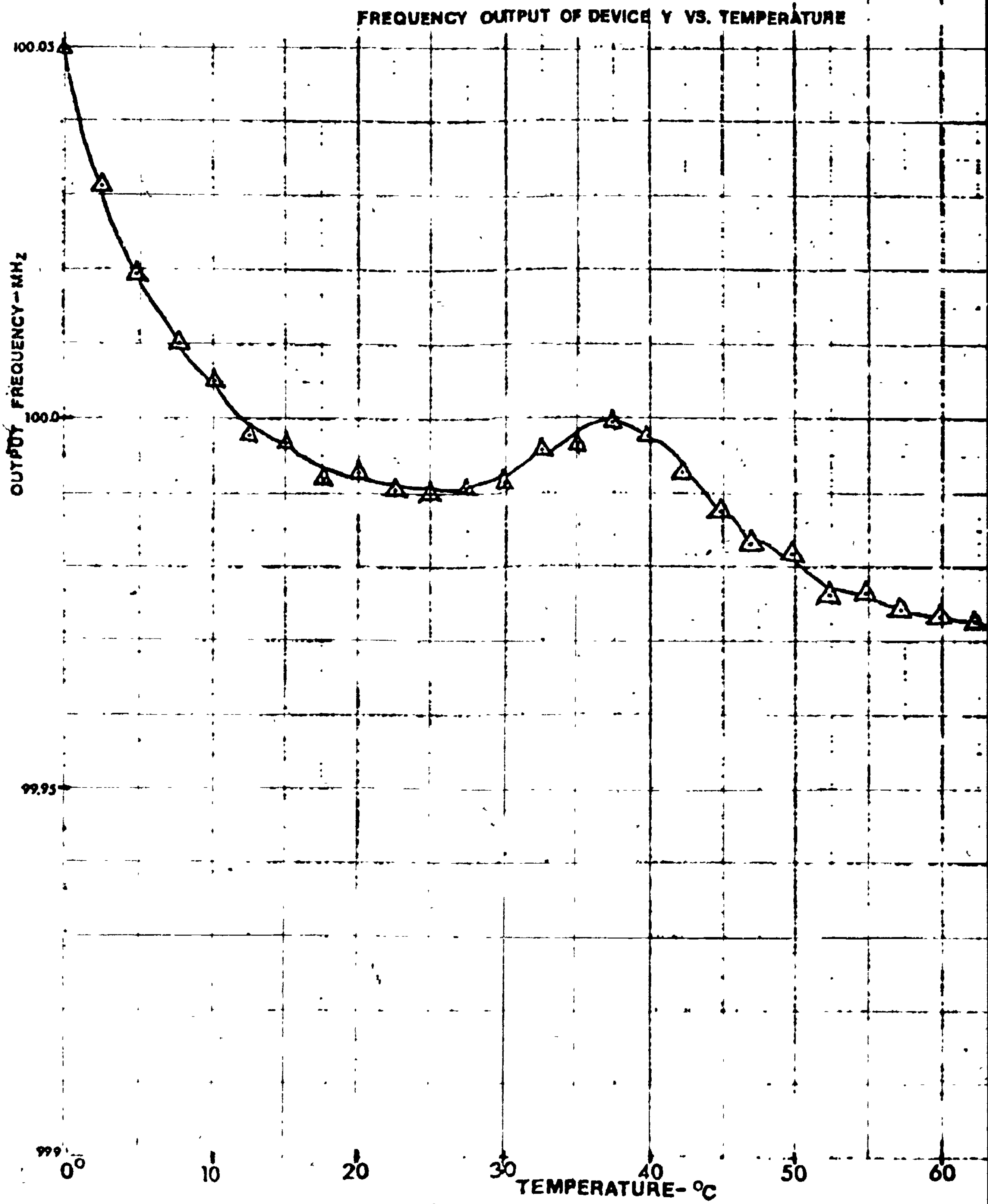
6. They are very descriptive and can be used to clearly show the results of an experiment, how a circuit or device behaves, to present data, and to show the relationship between variables in mathematical equations.

7. Rectangular graph paper has equally spaced linear divisions along the vertical and horizontal axes. Semilog graph paper has equally spaced linear divisions on the short axis and non-linear logarithmic spacing on the long axis.

8. Certain reproduction processes require special colors and sometimes the grid lines are intended to not print script lightly or to print out strong when reproduced for an engineering report.

ANSWERS TO EXERCISES

1. Rectangular Line Graph



2. Log Graph