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BLUEPRINT READING *for* Welders

9th Edition

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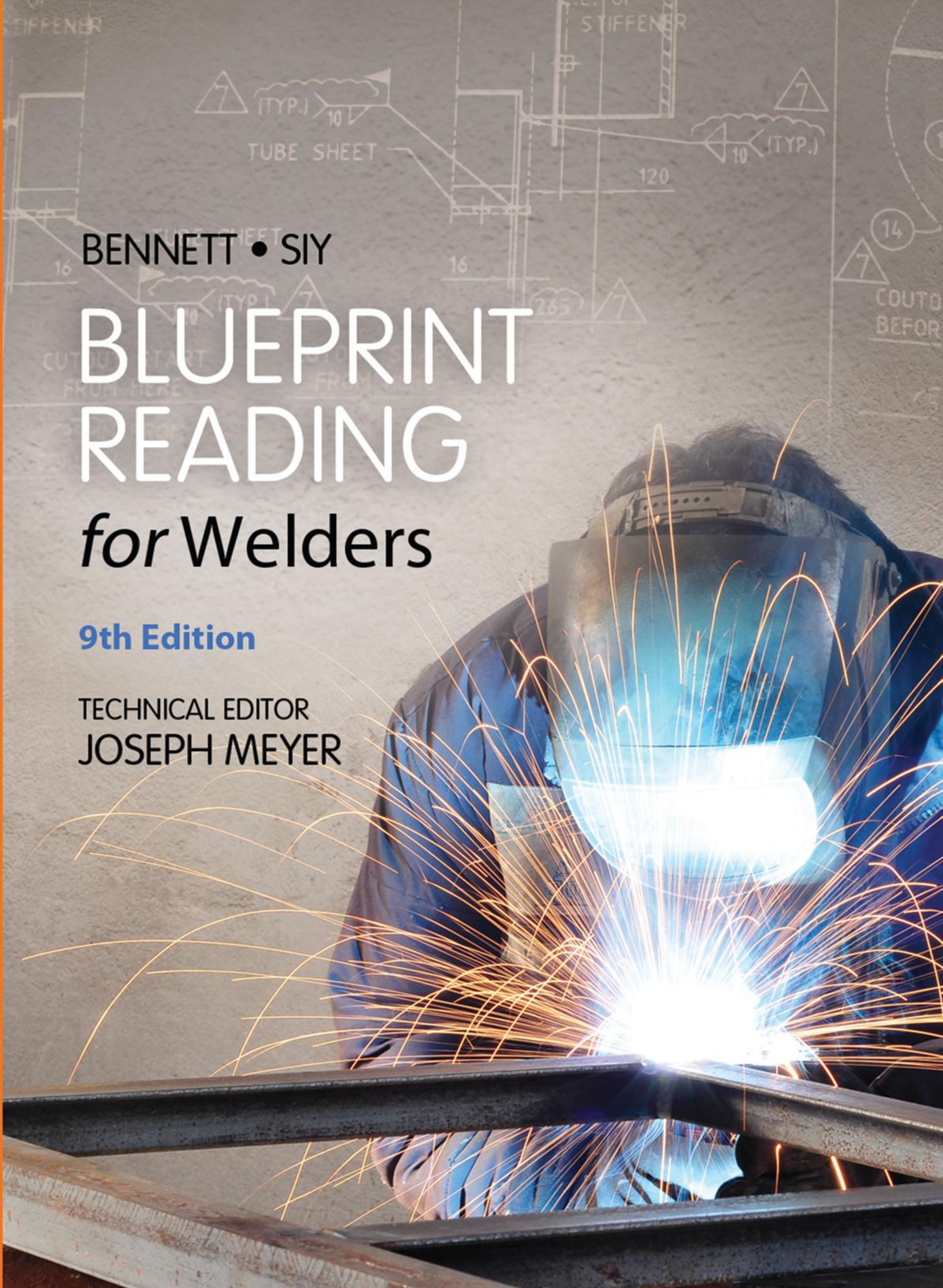
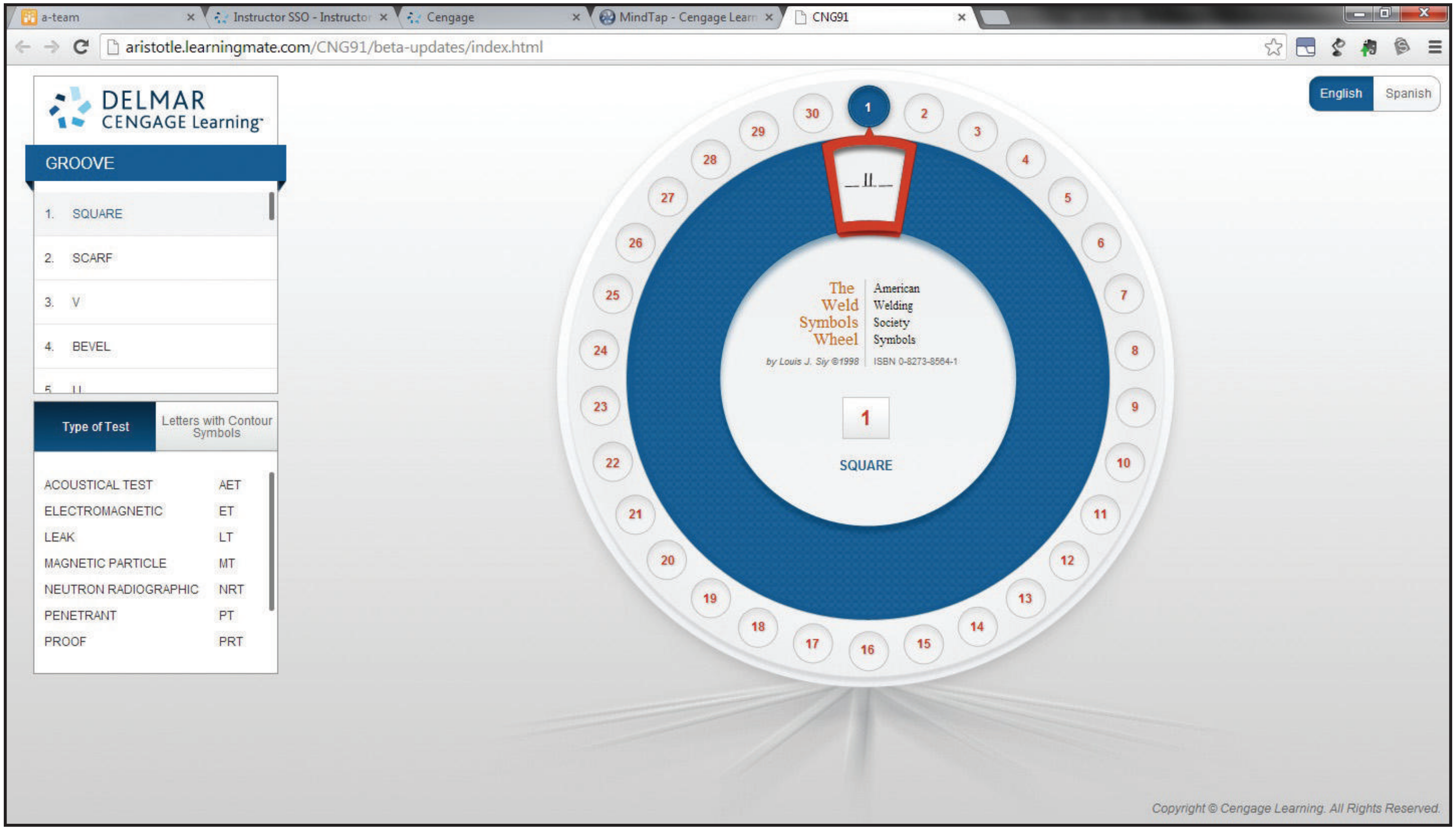


Digital Welding Wheel



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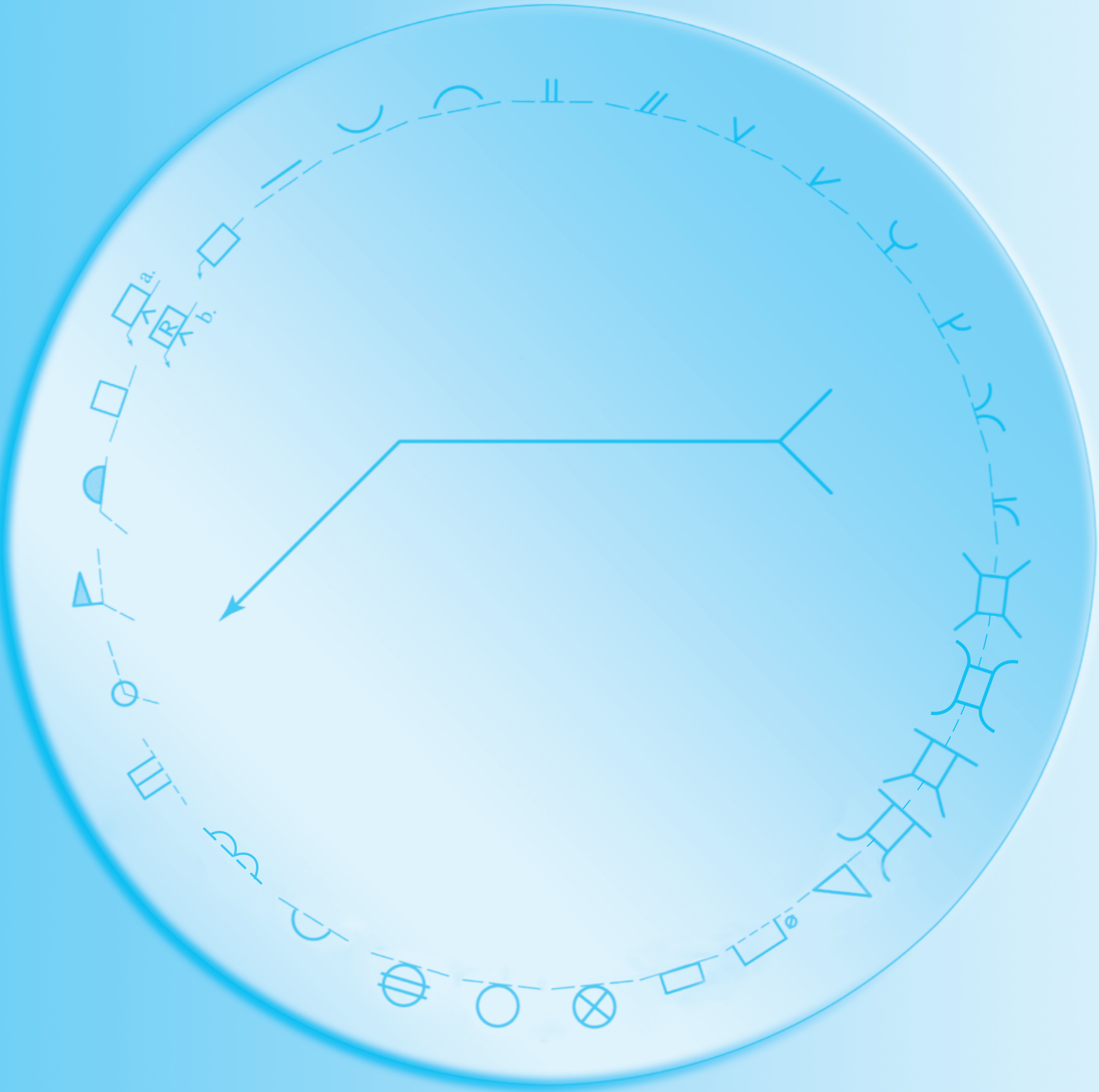

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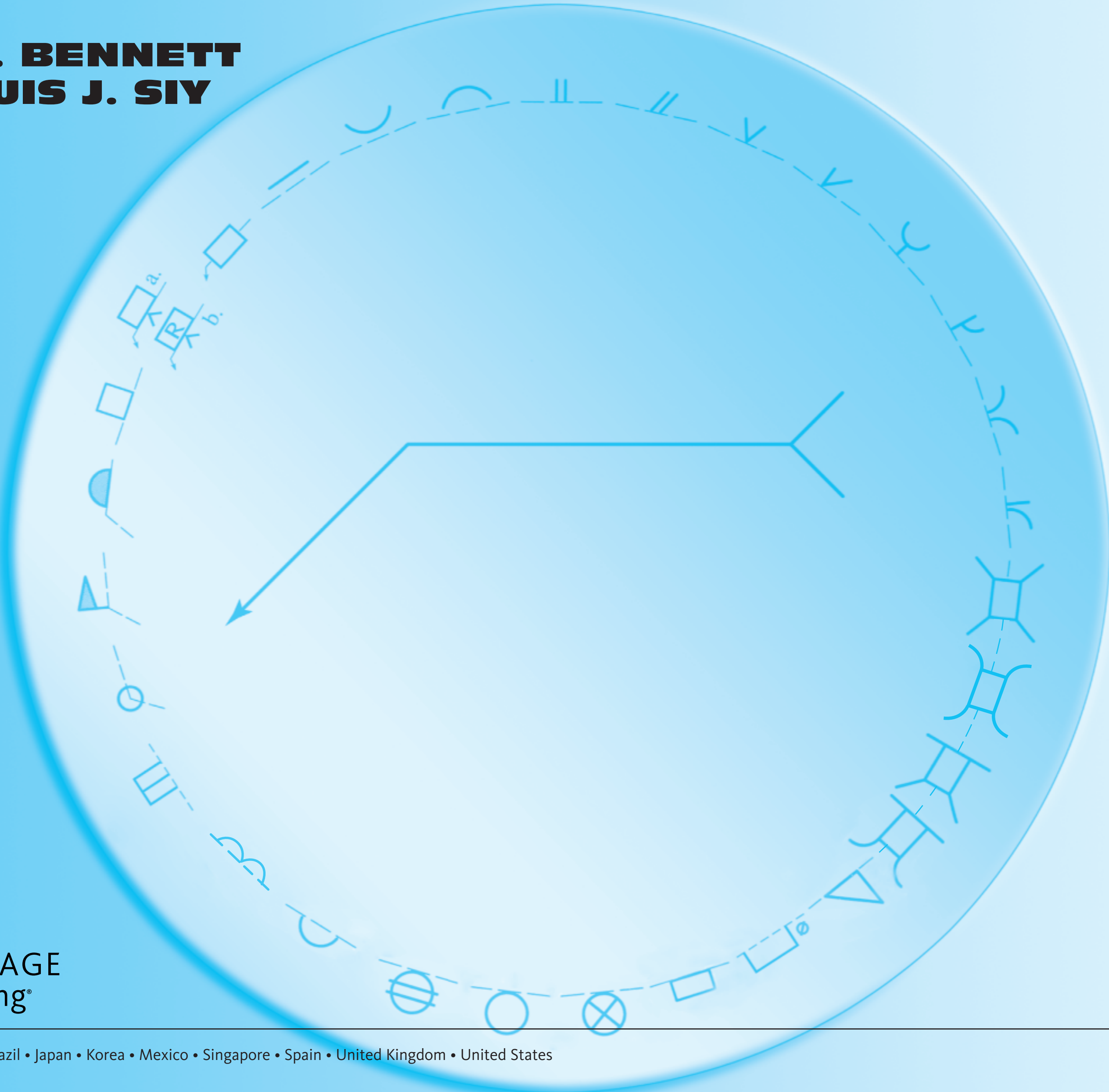
A. E. BENNETT
LOUIS J. SIY



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Library of Congress Control Number: 2013935859

ISBN-13: 978-1-133-60578-2

ISBN-10: 1-133-60578-8

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Clifton Park, NY 12065-2919
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Printed in the United States of America
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CONTENTS

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Index of Tables

Index of Appendices

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PREFACE

The ninth edition of ***Blueprint Reading for Welders*** provides detailed information to help students develop skills necessary to interpret working sketches and prints common to the metalworking field.

The engineering drawing is the medium by which the engineer/designer and drafter convey information to welders, machinists, and other related trades. To use the drawing, the welder is required to understand both conventional drafting symbology and specialized welding symbols. The ability to interpret the drawing is a skill that welders must develop through repeated practice. The text provides ample opportunity for such practice through the use of review assignments, found at the end of each unit.

Information on the purpose and makeup of prints is taught in easy-to-follow steps. The text begins with simple drafting concepts and sketching techniques, then covers the metal structural shapes commonly used by welders. More advanced drafting techniques are described, including auxiliary views; detail views; projections; and sections, detail, and assembly drawings. Once the learner is familiar with the basic drafting concepts and components of drawings, the American Welding Society standard weld symbols are introduced. A substantial part of the text then examines each weld symbol, its representation on a drawing, dimensioning requirements, and specific meaning in different situations. An entire unit is devoted to explaining basic joints for weldment fabrications. Other topics explained in detail include pipe welding symbols and their application, applied metrics and dual dimensioning, nondestructive examination symbols, bills of materials, international standard symbols (ISO) for welding, first-angle and third-angle orthographic projection, geometric dimensioning and tolerancing, and computer-aided drafting.

The appendix section includes updated specification sheets for structural metal shapes, including pipes, and tables for converting decimal, fractional, and whole inches to millimeters.

Folded, tear-out drawings at the back of the text reproduce selected assignment drawings in a larger size for ease of interpretation. The large drawings will allow the student to experience the "hands-on" study of drawing interpretation.

New to This Edition:

- Updated welding terminology in accordance with the American Welding Society A3.0-2010 *Standard Welding Terms and Definitions*
- Updated Welding Symbol content to include the latest changes in accordance with the American Welding Society A2.4-2012 *Standard Symbols for Welding Brazing, and Nondestructive Examination.*
- New content revisions throughout the textbook will allow easier understanding of the topics and interpretation of the drawings. Numerous paragraphs and figures were revised for clarification purposes. All Unit Review assignments have been updated and revised to expand student comprehension of the subject. Many new questions are included as well as improvements to many of the assignment drawings.
- The Instructor's Guide has also been reviewed and extensively modified to allow the instructor to better present, explain, and correct the review assignments.

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Features contained in e.resource include:

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- **Unit Hints:** Objectives and teaching hints provide the basis for a lecture outline that helps you present concepts and material. Key points and concepts can be highlighted for student retention.
- **Lesson Plans:** These list the overview of each unit, state objectives, suggest possible lab equipment, and recommend student assignments and evaluation.
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- **Handouts:** These handouts can be printed or viewed electronically to describe and graphically represent the concepts of first-angle, third-angle, and oblique projection.

The ninth edition of *Blueprint Reading for Welders* continues a dedicated tradition of providing the most comprehensive treatment of AWS, ISO, and pipe welding symbols and their interpretation.

- A virtual Weld Symbols Wheel written in English and Spanish, listing 30 types of welds by name and symbol, type of test and symbol, and letters used with contour symbols to indicate the method of finish.

ACKNOWLEDGMENTS

The authors wish to thank Louis F. Siy, industrial designer of Chase Designs, Incorporated; Andrea Viccaro, Marketing Communications Manager, Boston Retail Products; and the technical staff of the American Welding Society in recognition of their assistance in providing technical evaluation of the manuscript. We would also like to thank the following instructors who provided feedback on the text and revision plan:

Kevin John Furness, Conestoga College, Ontario, Canada

Jeff D. Jantzen, Hawkeye Community College, Waterloo, IA

Lynn Bedient, Eastern Wyoming College, Torrington, Wyoming

Dan Apfelbeck, Northcentral Technical College, Antigo, Wisconsin

Ben McFarland, Gateway Technical College, Kenosha, Wisconsin

Pete Stracener, South Plains College, Levelland, Texas

Frank Rose, Atlantic Technical Center and Technical High School, Coconut Creek, Florida

Myron Wurzer, Clark College, Vancouver, Washington

Kathy Stancampiano, WSWHE BOCES CTE, Saratoga Springs, New York

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Technical data and tables have been provided by the following organizations:

American National Standards Institute

American Institute of Steel Construction

American Society of Mechanical Engineers

American Welding Society

International Standards Organization

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THE PURPOSE AND MAKEUP OF PRINTS

The calculations and ideas of the engineer must be transferred to the welder working in the shop or on a job site. It is usually impractical for an engineer to be present while a weldment is being fabricated. Therefore, the needed information must be supplied by some method other than verbal communication. The most concise method for doing this is the use of detail drawings.

When drawings are prepared manually, they are usually made directly on tracing paper or plastic, which is then used for making prints in the quantities needed. However, the most current method for the production of prints is the use of computers. This latter method is called computer-aided drafting (or design) and is abbreviated as CAD. Using the information "drawn" with the computer, "hard copies" of drawings are printed on paper at very high speeds. The proper use of CAD requires a knowledge of blueprint reading and welding symbols. (For more information see Unit 27.)

There are three basic elements to be found on a print: **lines**, **dimensions**, and **notes** (as shown in Figure 1). **Lines** show the edges of the object, aid in dimensioning the object, and are used in the formation of symbols. **Dimensions** give sizes and locations. **Notes**, giving details of construction not shown by lines, may be in the form of symbols or abbreviations. A note that designates the kind of material, machining process, or standard to be used is often referred to as a specification. Notes or specifications are found adjacent to a view or in a ruled space provided on the print for this purpose.

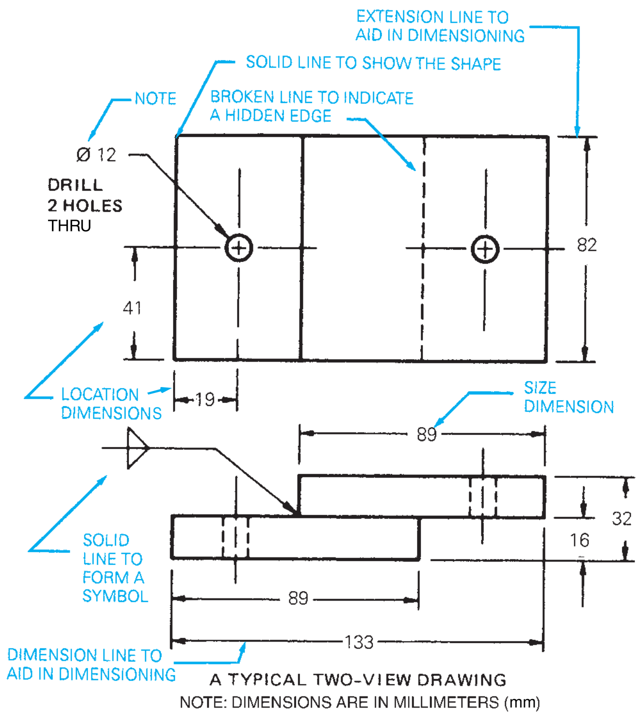

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FIGURE 1 ■ A typical two-view drawing.

A print consists of one or more views, usually the **top**, **front**, and **right side** views of the object. Other views that may be used to describe the object completely are the left side, back, auxiliary, and bottom views. The number and type of views to be shown depend on the shape and complexity of the object. A concept of these views is presented in the units that follow.

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UNIT 1

Basic Lines and Views

BASIC LINES

There are several different types of lines used on a print and each has a different meaning. To be able to interpret a print, the reader should have knowledge of these lines. Table 1.1 can be used as a reference for the common line types usually found on a print. Note that the purpose of each line deals with either the shape of the object or its dimensioning.

BASIC VIEWS

Drawings are made to describe the object in sufficient detail to permit fabrication. Orthographic projection is the method employed to do this. By this method the exact form of the object is shown by various views of the object arranged in a particular order. The selection and arrangement of these views is shown in Figure 1.2. Note the relationship in the placement of the views in the figures.

Type of Line	Description	Purpose
OBJECT LINE	Thick solid line.	To show the visible shape of a part (outline of object).
HIDDEN LINE	Broken line of medium thickness.	To show edges and outlines not visible to the eye.
CENTER LINE	Fine, broken line made up of a series of short and long dashes alternately spaced.	To show the center of circles, arcs, and symmetrical objects and to aid in dimensioning these parts.
EXTENSION LINE; EXTENSION LINE; DIMENSION LINE	Extension lines are fine lines that extend from the object with a slight break between. Dimension lines are fine lines with arrowheads, unbroken except where the dimension is placed.	Extension lines show dimensioning points. Dimension lines touch the extension lines and show distance given by the dimensions.
LEADER	Fine, straight line with an arrowhead or round solid dot at one end. It is usually drawn at an angle.	Points directly to a surface for the purpose of dimensioning or adding a note. A dot is used at the end of the straight line where reference is made to a surface area.

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TABLE 1.1 ■ Common types of lines used on a print.

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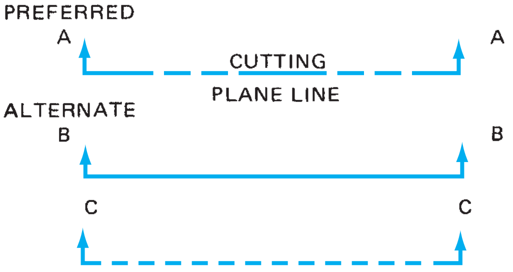
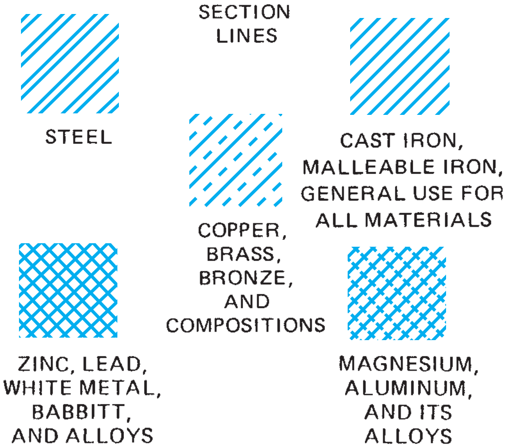
Type of Line	Description	Purpose
 PREFERRED A A CUTTING PLANE LINE ALTERNATE B B C C	The preferred cutting plane line is a heavy, broken line made up of a series of one long and two short dashes alternately spaced. Arrowheads are placed at right angles to the cutting plane line as shown. Alternate cutting plane lines are a solid heavy line or a series of long dashes.	To indicate where an imaginary cut is made through the object. The arrow points in the direction in which the section should be viewed. Letters next to the arrowheads identify the section in cases where more than one section is shown on the drawing. These lines are oriented vertically, horizontally, or at the actual angle at which the part is drawn.
 SECTION LINES; STEEL; CAST IRON, MALLEABLE IRON, GENERAL USE FOR ALL MATERIALS; COPPER, BRASS, BRONZE, AND COMPOSITIONS; ZINC, LEAD, WHITE METAL, BABBITT, AND ALLOYS; MAGNESIUM, ALUMINUM, AND ITS ALLOYS	Series of fine lines—solid or solid and broken—arranged in specific patterns. They may be shown either straight or curved. When shown straight, they are usually drawn at a 45° angle. However, this angle will vary when applied to adjacent parts.	To indicate the imaginary cut surface referred to by the cutting plane line; to represent various kinds of materials.
CHAIN LINE	Heavy, broken line made up of a series of long and short dashes alternately spaced.	Indicates the location and extent of a surface area.
SHORT BREAK LINE 	Heavy, irregular line drawn freehand.	To show a short break (to conserve space on a drawing); to show a partial section.
LONG BREAK LINE 	Ruled, light line with freehand zigzags.	To show a long break (to conserve space on a drawing).
PHANTOM LINE 	Light, broken line made up of a series of one long and two short dashes.	To show alternate positions of a part; to show relationship of existing part to new part; to show machined surfaces.

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TABLE 1.1 ■ Common types of lines used on a print. (continued)

Figure 1.1(a) shows two types of pictorial drawings of a three-dimensional block and Figure 1.1(b) shows three two-dimensional views of the block. By examining each of the three views in Figure 1.1(b), an accurate picture of the shape of each face can be formed. In this case, three views are used to describe the object. Note that the views have a definite arrangement. The top view is placed directly above and in line with the front view; the right side view is placed to the right of and in line with the front view. This arrangement of views is in accordance with third angle orthographic projection referred to in Figure 1.1.

There is no limitation on the number of views that may be used to describe an object. Usually, three properly selected views are sufficient. In cases where more views are needed to illustrate the shape clearly and to make dimensioning easier, the bottom, left side, or back views can by used. Simple parts can be completely described with only one or two views.

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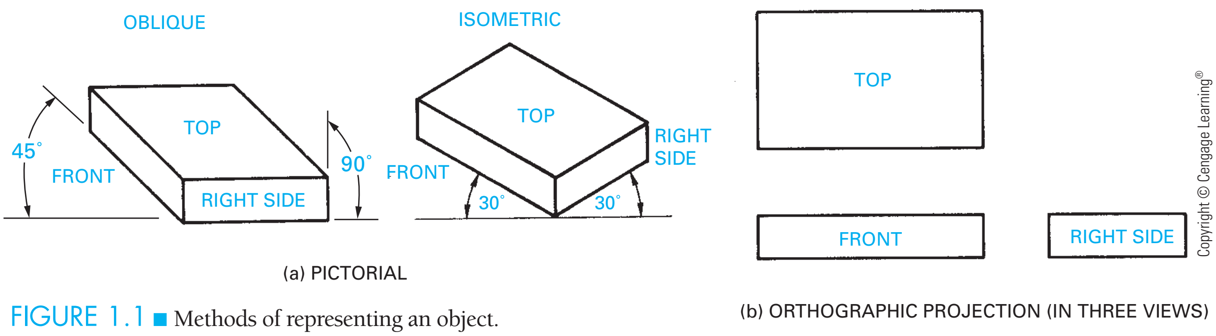

FIGURE 1.1 ■ Methods of representing an object.

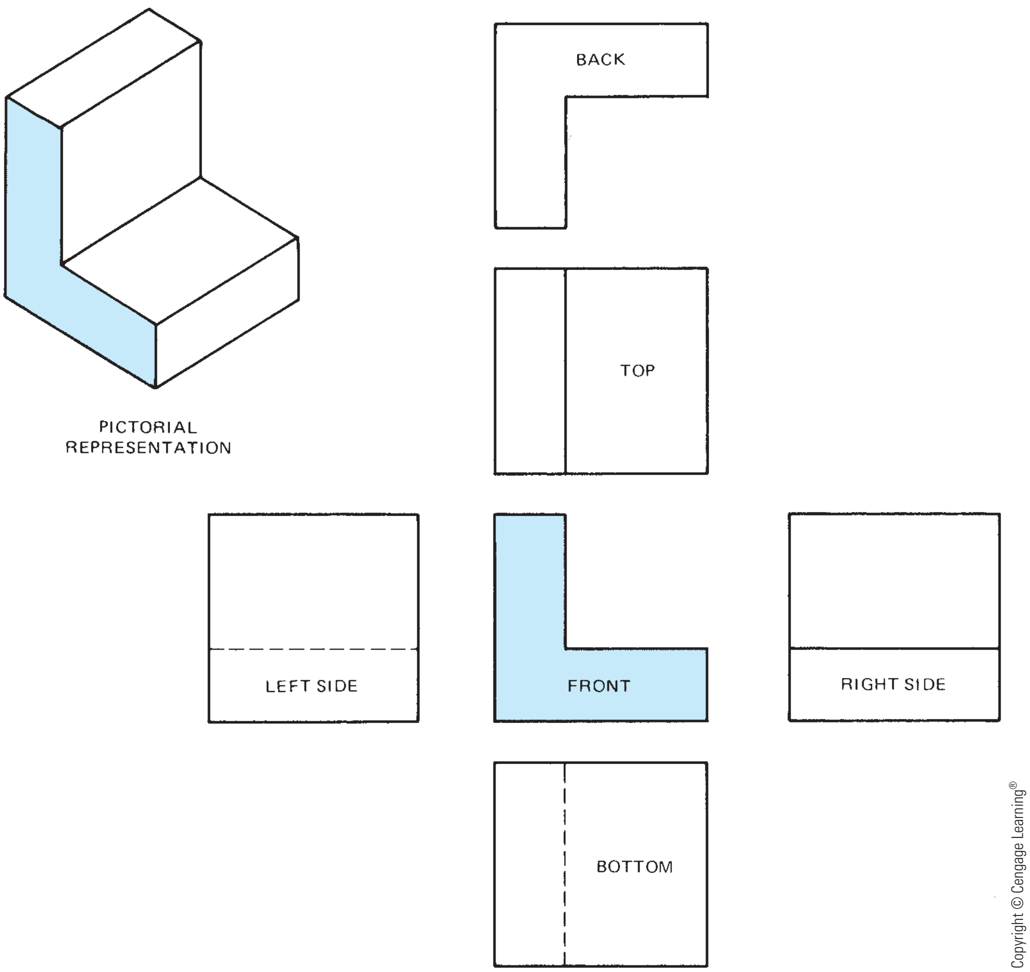

FIGURE 1.2 ■ Locations and alignment of views that may be selected to describe an object on an orthographic drawing.

It should be noted that the front view usually gives the best indication of the shape and detail of the object. This does not mean that the front view necessarily shows the front of the object. For example, if a welding torch is represented on a print, the front of the torch is not shown as the front view since it does not show the shape of the torch as well as a side profile of the torch. Therefore, to simplify the reading of the print, the profile selected for the front view is generally that which best describes the most detailed shape of the object.

All views have a particular position with respect to each other, and have either a horizontal or vertical alignment. These positions, illustrated in Figure 1.2, should be learned.

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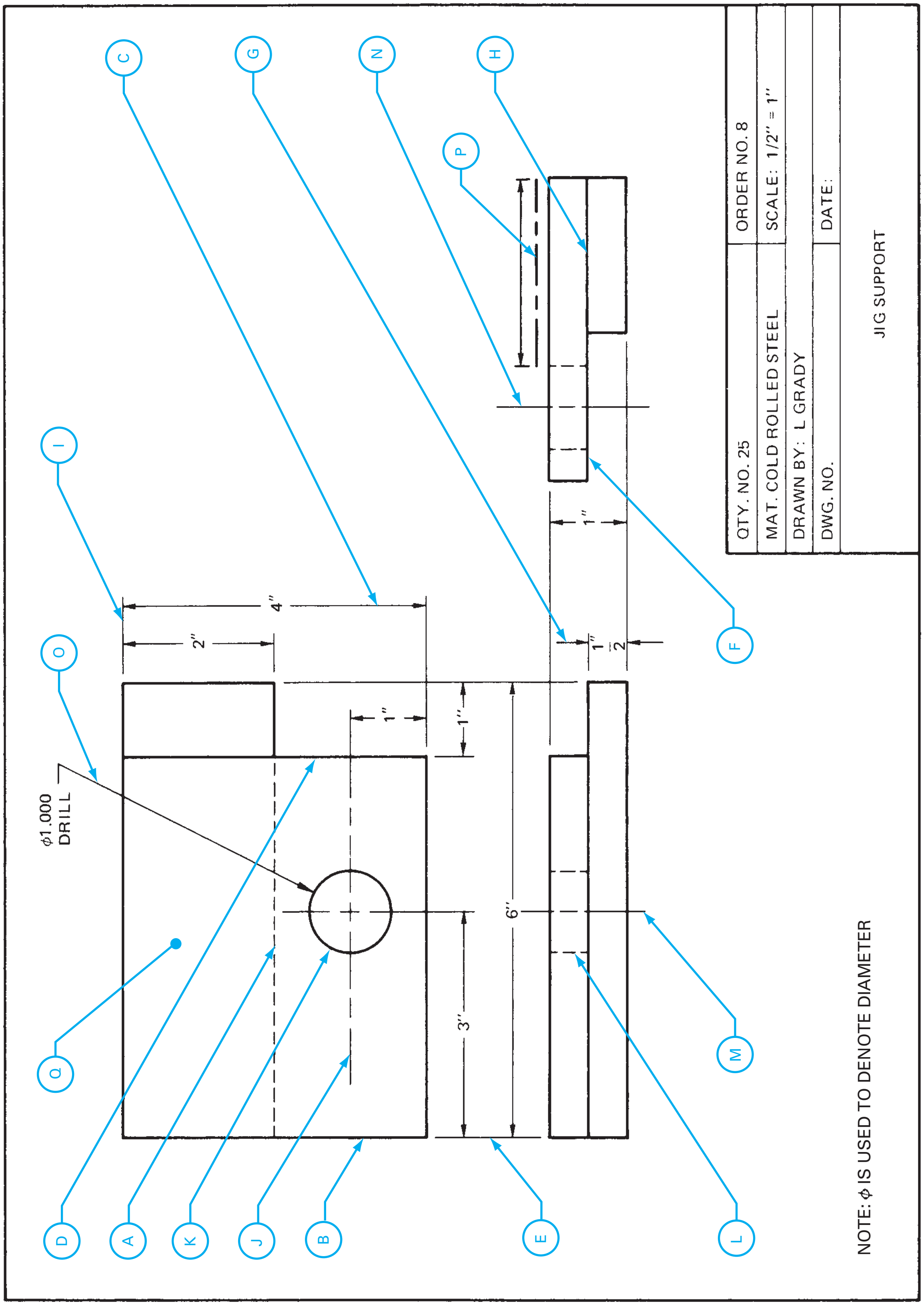

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UNIT 1: REVIEW A

Refer to the drawing, Jig Support, page 4.

1. a. Identify the following types of lines.

Ⓐ ______________________

Ⓑ ______________________

Ⓒ ______________________

Ⓓ ______________________

Ⓔ ______________________

Ⓕ ______________________

Ⓖ ______________________

Ⓗ ______________________

Ⓘ ______________________

Ⓙ ______________________

Ⓚ ______________________

Ⓛ ______________________

Ⓜ ______________________

Ⓝ ______________________

Ⓞ ______________________

Ⓟ ______________________

b. What does Ⓠ have reference to?

____

2. Give the function or functions of the following lines.

Ⓐ ______________________

Ⓑ ______________________

Ⓒ ______________________

Ⓔ ______________________

Ⓙ ______________________

3. Describe the lines shown on the drawing with reference to letters Ⓔ through Ⓟ.

Ⓔ ______________________

Ⓗ ______________________

Ⓒ ______________________

Ⓛ ______________________

Ⓜ ______________________

Ⓟ ______________________

4. a. Identify the kind of material specified to make the part.

____

____

b. Sketch the section line symbol that would be used for this material.

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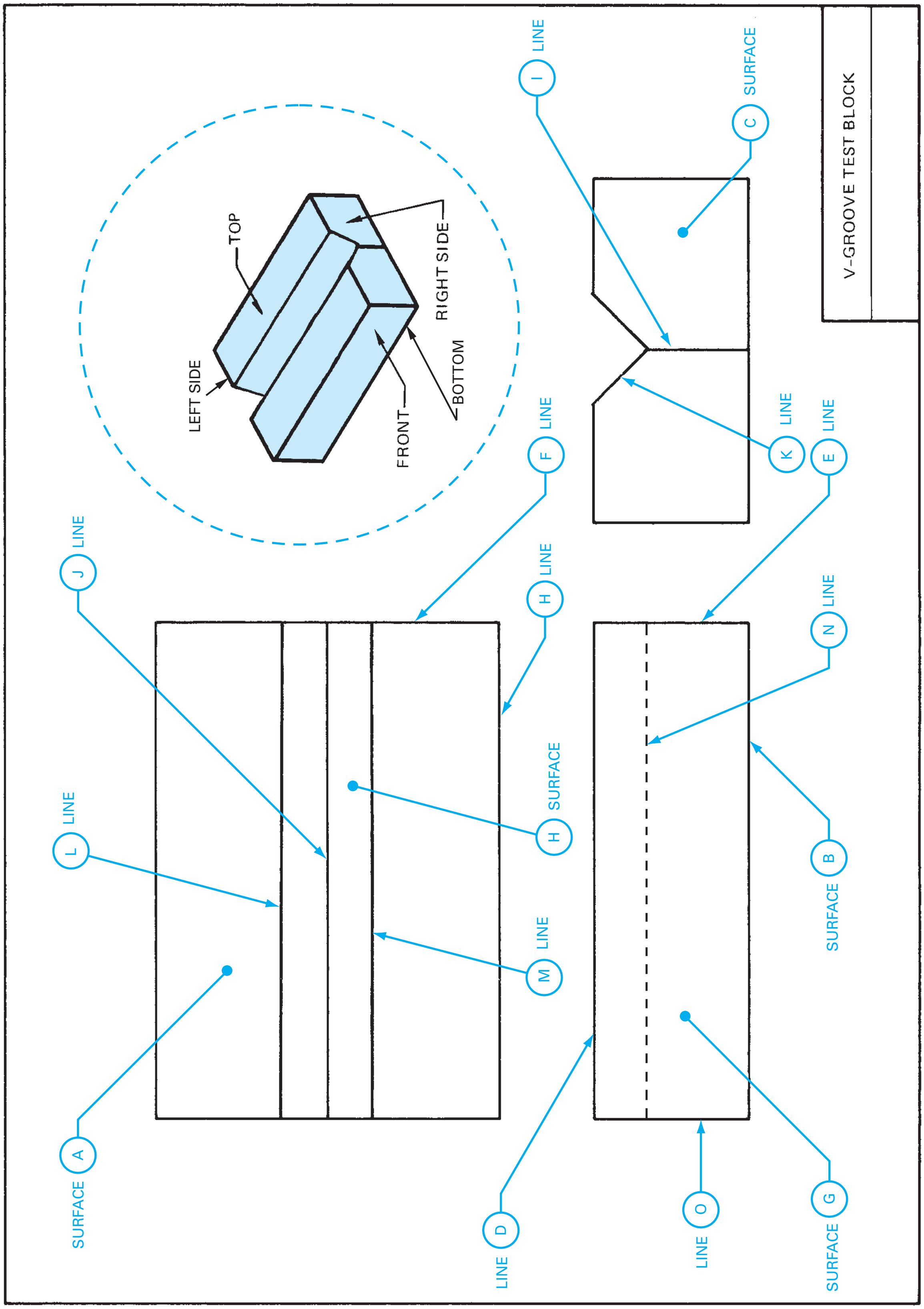

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UNIT 1: REVIEW B

Refer to the drawing V-Groove Test Block, page 6.

1. Why are three views used to show the object?

2. Name each of the views shown.

3. In which two views is the length of the object the same?

4. In which two views is the width of the object the same?

5. In which views is the thickness of the object the same?

6. Which line letter represents surface A in the front view?

7. Which line letter represents surface H in the right side view?

8. Which line letter represents surface C in the front view?

9. Which line letter represents surface C in the top view?

10. Which line letter in the top view represents surface G in the front view?

11. Is surface B shown in the top view?

12. What does the top view have in common with the front view?

13. What does the front view have in common with the side view?

14. What do the top view and right side views have in common with respect to the front view in terms of alignment?

15. What do lines L and M represent?

16. What does the following symbol indicate?

17. Which line letter represents N in the top view?

18. What surface does B represent?

19. What surface letter does line E represent?

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2 UNIT

Sketching

PURPOSE OF SKETCHING

A *sketch* is a freehand drawing used to describe the shape and size of an object. It is a means of quickly expressing an idea. If necessary, it can later be translated into a finished drawing.

Sketches are often used in place of finished drawings, particularly when time and circumstances do not permit preparation of a finished drawing. In such cases, the sizes of the objects in the sketches are drawn in relative proportion to one another. All of the details and data needed to shape or fabricate the part, including dimensions and notes, are added to the sketch.

BASIC SKETCHING TECHNIQUES

Sketching Lines

Lines are first lightly sketched with short overlapping strokes using a pencil with a fairly sharp point. The lines are then darkened and weighted in accordance with their purpose—in the same manner that lines are shown on a finished drawing. Heavy lines are drawn by dulling (rounding) the point of the pencil and applying enough pressure to produce the line weight desired. Refer to Unit 1, Table 1.1 for the kinds of lines used on a finished drawing.

Sketching Arcs, Circles, and Ellipses

One method for sketching an arc is to first construct a right angle (square corner). To assist in sketching the arc, guide points (R) are located on the legs of the angle to indicate where the curve is to begin and end. The points are then connected with a curved line, Figure 2.1. All unnecessary lines are erased after the sketch is completed.

Another method for sketching an arc also begins with a right angle. The two equidistant points (R) are then drawn. These points are connected with a diagonal line so that a triangle is formed. A dot is placed in the center of the triangle, and the arc is drawn so that the curved line connects all three points, Figure 2.2.

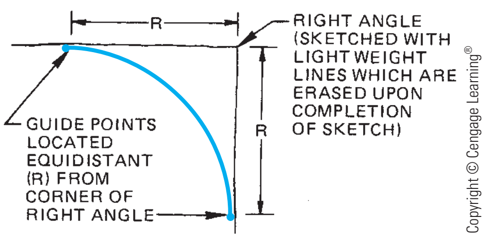

FIGURE 2.1 ■ Using a right angle as a guide for sketching an arc.

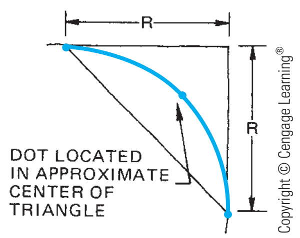

FIGURE 2.2 ■ Using a triangle as a guide for sketching an arc.

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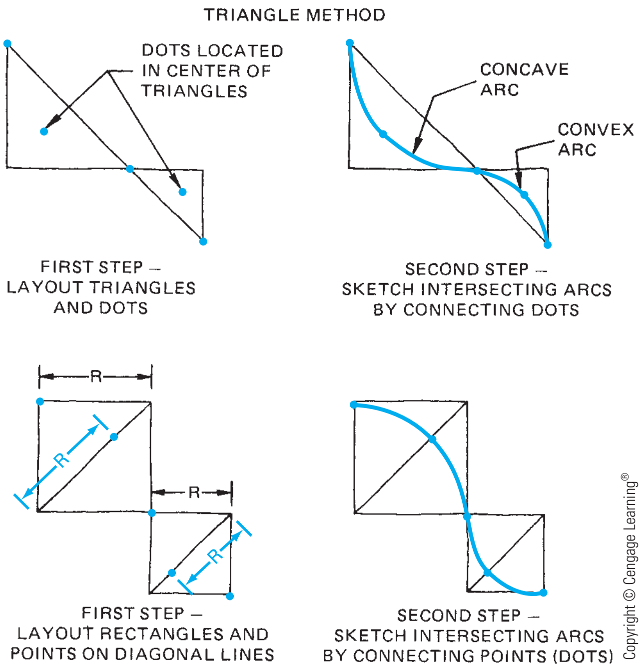

FIGURE 2.3 ■ Methods for sketching intersecting arcs.

To sketch arcs that change direction and meet at a common point (intersect), the procedure shown in Figure 2.3 is followed. Essentially, it is a matter of developing connecting arcs using a combination of any one of the techniques previously described. Note: The letter *R* is used to indicate a radius.

To sketch a circle, the same process for sketching an arc is repeated for all quarters of the circle. Either of the two methods described for sketching an arc may be applied to sketching a circle, Figure 2.4.

On some views of an orthographic drawing, a circle may appear as an ellipse. An ellipse is sketched by laying out a rectangle with sides equal to the major and minor axes of the ellipse, Figure 2.5. The rectangle is then divided into four equal quarters. The dividing lines represent the major and minor axes of the ellipse. Thereafter, the use of triangles, Figure 2.5(a), or rectangles, Figure 2.5(b), as guides permits sketching the ellipse in a manner similar to that for sketching a circle.

In addition to orthographic sketches, oblique or isometric drawings are often used to present an idea or design of a weldment. The latter two types of drawings are three-dimensional (pictorial) drawings, which may be shown alone or in conjunction with an orthographic drawing.

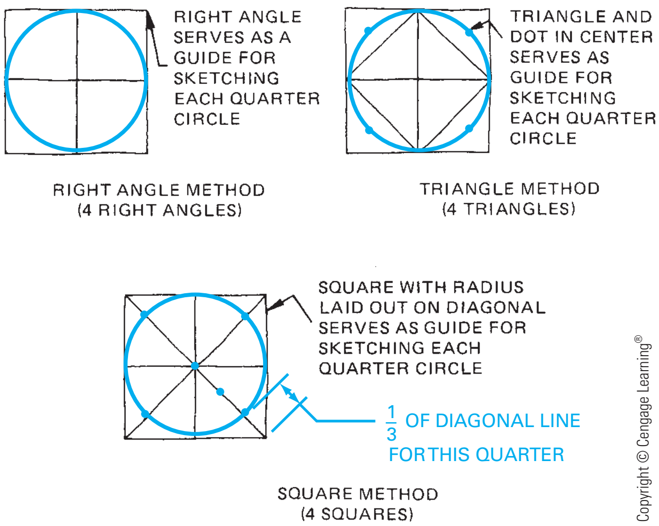

FIGURE 2.4 ■ Techniques for sketching a circle.

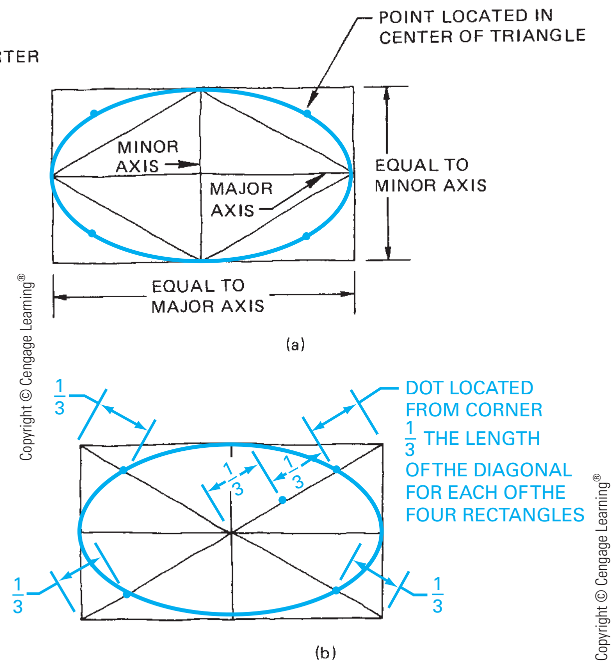

FIGURE 2.5 ■ Methods for sketching an approximate ellipse.

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Oblique Sketching

To develop an oblique drawing, an orthographic view of the object is first drawn that best describes the shape and shows the most detail of the object. For example, the front view of the three-view orthographic drawing of the T-support shown in Figure 2.6 is selected since it shows the shape of the object best.

After completing the orthographic view, draw parallel receding lines at about 45° angles from the corners of the view (either to the right or to the left), as shown in Figure 2.7 and Figure 2.8, to develop the three-dimensional effect. Receding lines are drawn to the right for developing a right oblique drawing and to the left for developing a left oblique drawing. Note: Lines are not usually shown for any part of the object that is not visible. The extent of the receding lines is about one-half the length that would be shown for an orthographic drawing. This is so that the sketch will appear to be true to the original form of the object. The oblique sketch is completed by repeating the same lines shown on the original orthographic view at the terminal points of the receding lines. Note that, on occasion, broken lines may be used to show hidden edges in order to better visualize the object.

Oblique sketches may require the sketching of oblique circles. Variations of oblique circles and how they may be constructed are shown in Figure 2.9. The procedure used for sketching the oblique circles shown in the oblique cube is the same as that given previously for developing a regular circle. Essentially, the procedure followed is to locate points on a rectangle to which a series of arcs is drawn to form the oblique circle.

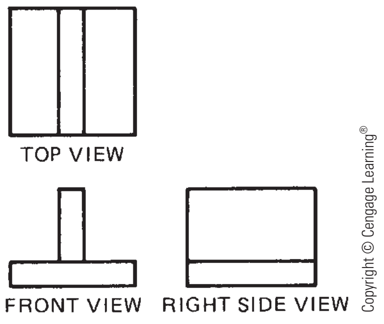

FIGURE 2.6 ■ Three-view orthographic drawing of a fabricated T-support.

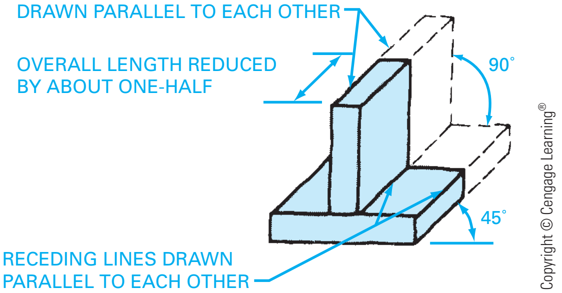

FIGURE 2.7 ■ Right oblique (receding lines drawn to right).

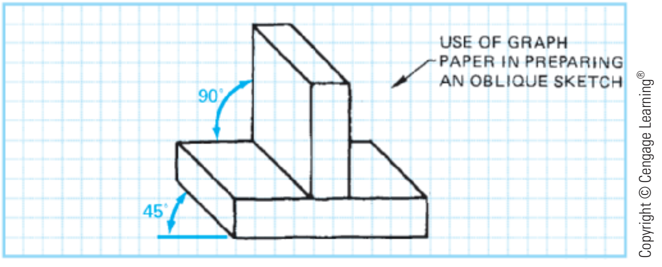

FIGURE 2.8 ■ Left oblique (receding lines drawn to left).

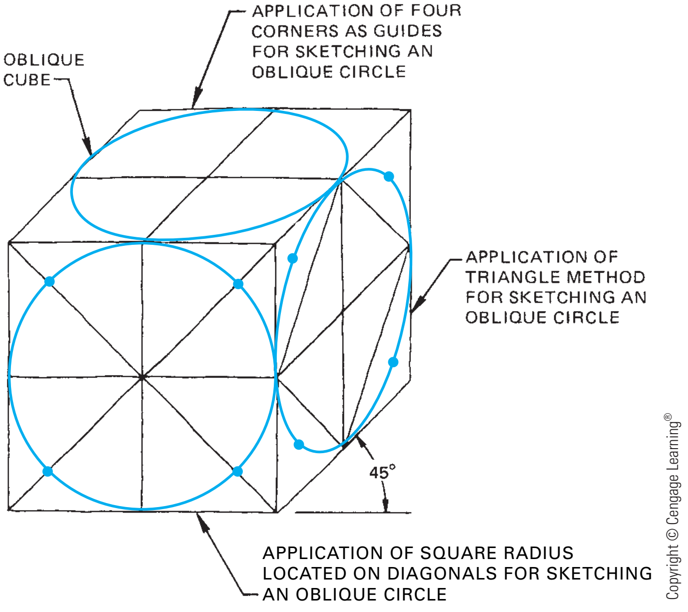

FIGURE 2.9 ■ Variations of oblique circles and methods used for sketching each.

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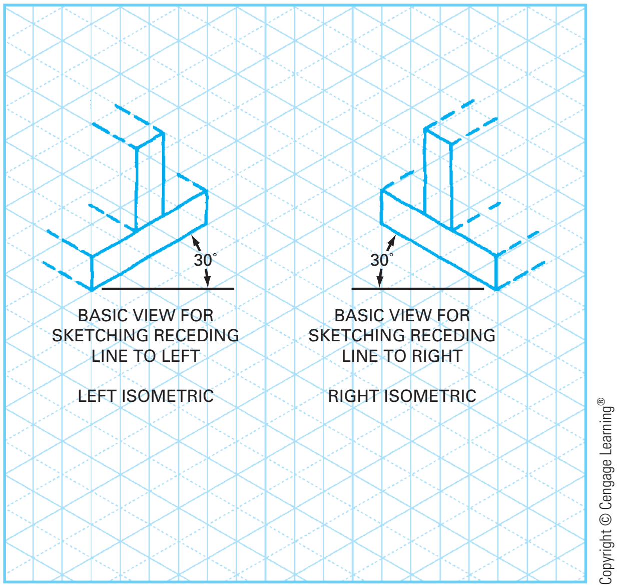

FIGURE 2.10 ■ Preliminary view for sketching isometric drawing of a fabricated T-support.

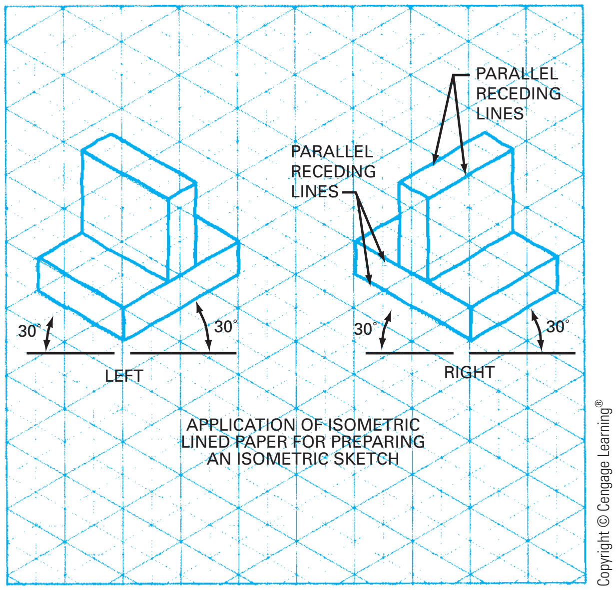

FIGURE 2.11 ■ Left and right isometric sketches of a fabricated T-support.

Isometric Sketching

To develop an isometric sketch, use of isometric graph paper is preferable. An isometric sketch has all of its surfaces shown at 30° angles. In the initial preparation of the sketch, a view of the object that best shows its shape and detail is selected and sketched at a 30° angle, Figure 2.10.

After completion of the basic view, Figure 2.10, parallel receding lines are sketched at 30° angles from each of the corners, Figure 2.11. Only those lines that represent the visible part of the object are shown. The sketch is completed by drawing the back edges at points that approximate the size of the object. Receding lines are reduced in length (foreshortened) to about two-thirds of the orthographic line length.

In cases where surfaces of the object are on different planes, a sequence is followed in developing the isometric sketch, starting from the front face and developing each portion progressively to the back face, in effect building upon the preceding portions, Figure 2.12.

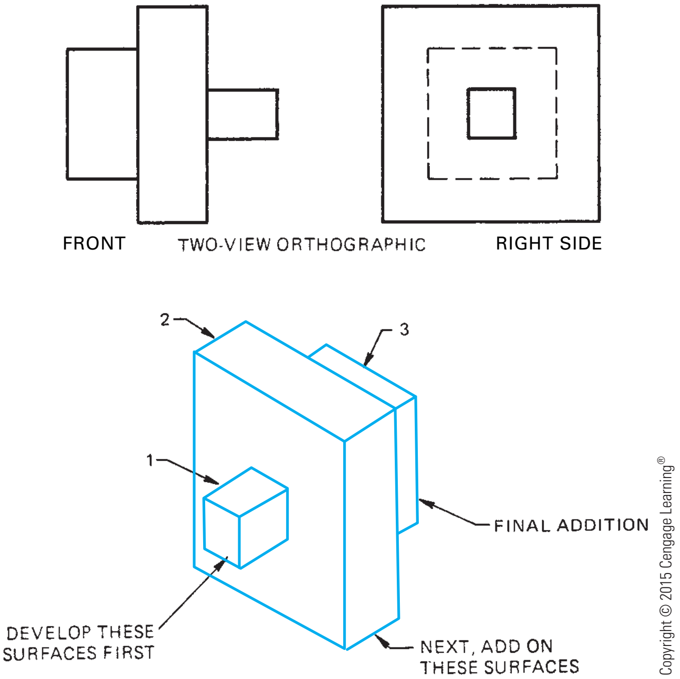

FIGURE 2.12 ■ Method used for developing an isometric sketch having surfaces on different planes.

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For sketching isometric circles, the same basic techniques are applied as for sketching a regular circle. Variations of the isometric circle and how they are sketched are illustrated in Figure 2.13. For sketching isometric and oblique cyclinders, refer to Figure 2.14.

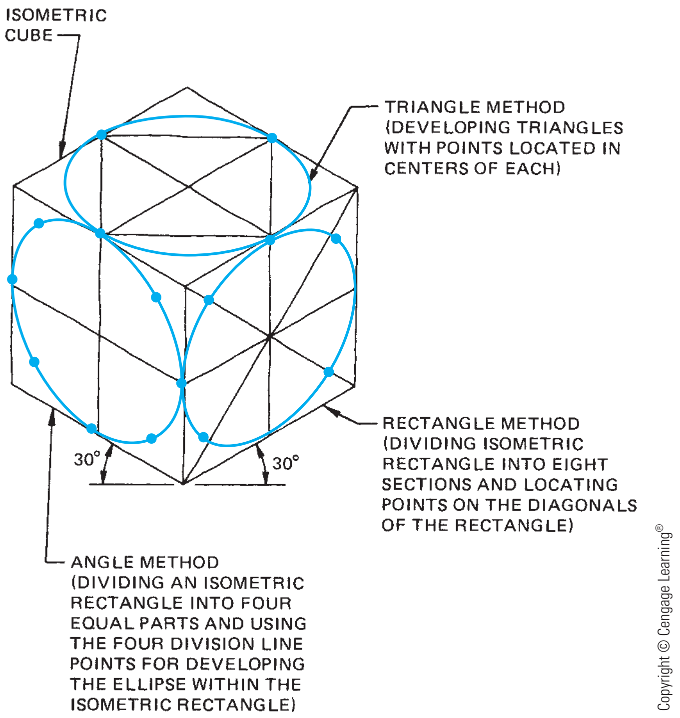

FIGURE 2.13 ■ Variations of isometric circles.

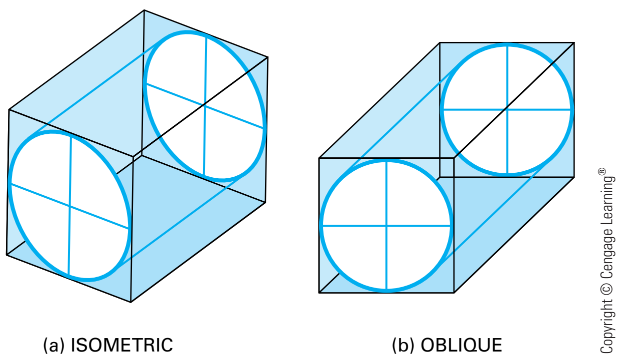

FIGURE 2.14 ■ Method for developing cylinders.

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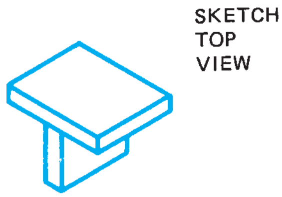
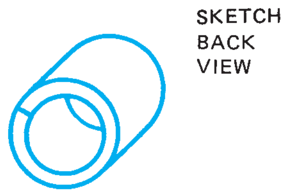
UNIT 2 REVIEW

Graph paper has been provided at the end of this review for your use.

1. Identify the types of sketches illustrated below and sketch orthographic views as indicated for each.

a.


b.


c.


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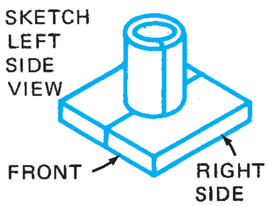
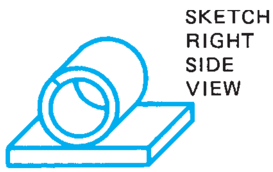
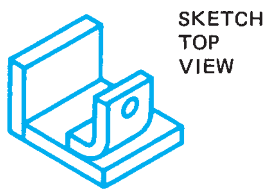
d.


e.


f.


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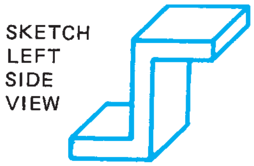
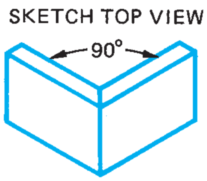
g.


h.


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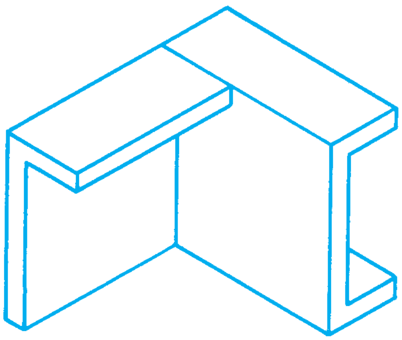
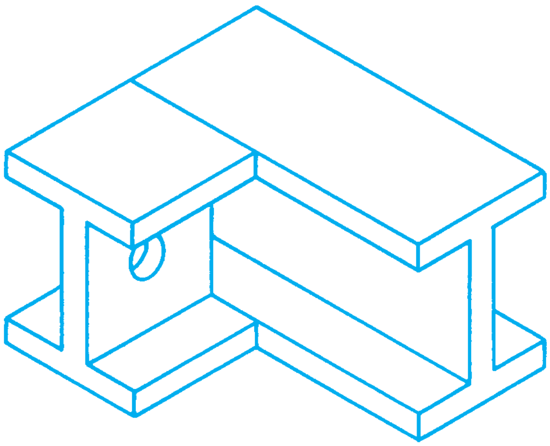
i. SKETCH RIGHT SIDE, TOP, AND FRONT VIEWS (IDENTIFY EACH VIEW)



j. SKETCH TOP, FRONT, AND LEFT SIDE VIEWS (IDENTIFY EACH VIEW)



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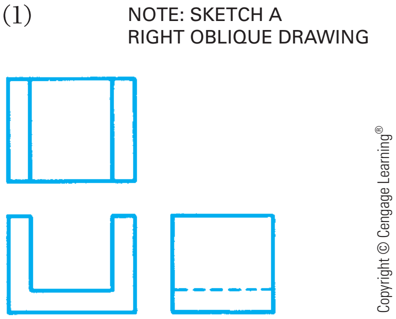
2. a. Prepare oblique sketches for the following orthographic drawings.
   b. Identify each of the views represented in each orthographic drawing.

(1)



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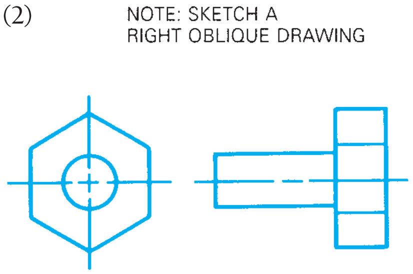
(2)



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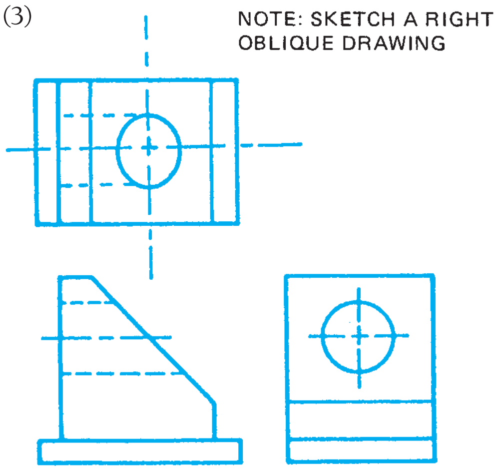
(3)



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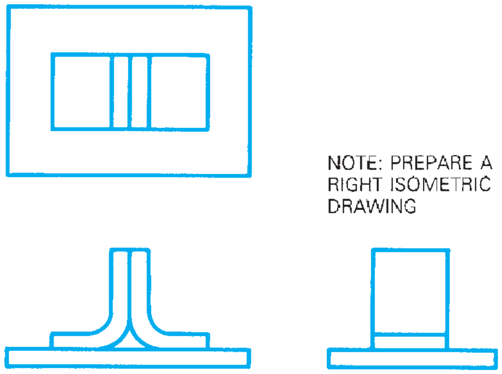
3. Prepare isometric sketches for each of the following orthographic drawings, right or left as specified.

a.



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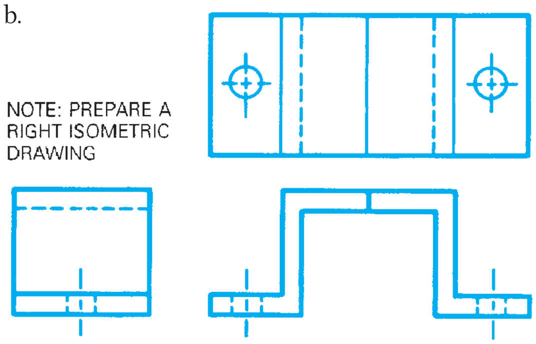
b.



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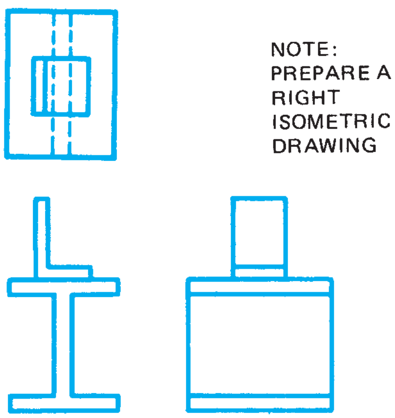
c.



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UNIT 3

Notes and Specifications

In many cases, it is not possible to give all the information needed on a print by the combined use of lines and dimensions. To provide additional information, notes and specifications are used.

A note is lettered information (in capital letters) concerning the details of construction. The note explains, specifies, or refers to the material and/or process needed to make the part. To conserve space on the print, and to save time in preparing the drawing, it is often shown as an abbreviation or symbol.

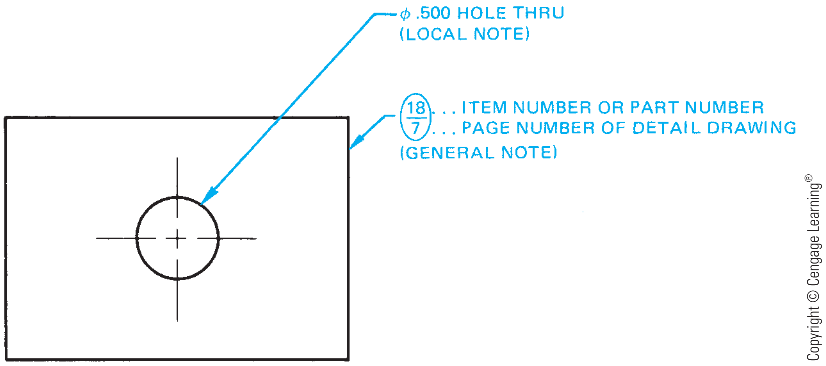

FIGURE 3.1 ■ Application of a local note.

When a note applies to a particular part on an object, it is called a local note. Such a note is placed near one of the views representing the part. A leader indicates the exact point of reference, Figure 3.1. A general note applies to the drawing as a whole and is placed in an open space away from the views so that it can be seen readily.

Examples of general notes are:

1. "Unless otherwise indicated, all fillet welds are ⅜" size."
2. "Unless noted otherwise, root openings for all groove welds are 3⁄16"."
3. "Unless otherwise specified, all welds are to be made in accordance with specification A."

When a note specifies the material required, the welding process to be used, the type and size of electrode, and/or the kind and size of welding rod, it is called a specification. For example, in Figure 3.2 the letter A refers to specification A.

In this case, specification A in the tail of the arrow indicates that No. 20, ¼" bronze rod is to be used for the weld.

Specifications are often located near the views to which they refer. However, when many specifications are required, they are included on a separate sheet and referenced to the drawing.

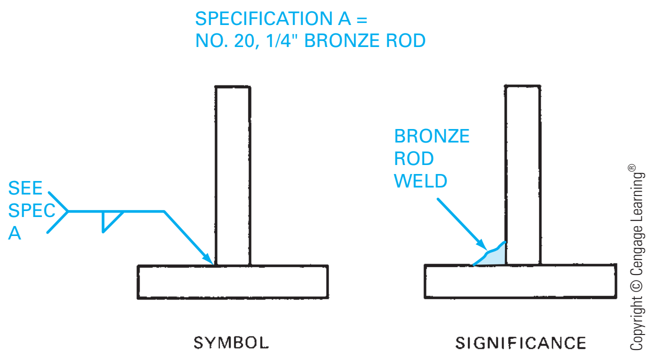

FIGURE 3.2 ■ Application of a specification.

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When a specification is general and applies to all or several views, it may be placed within a ruled space called a title block. It is usually denoted as such by prefacing the information with the word "specification." However, when specifying materials, the word "specification" is not necessarily used, but it is implied. Typical title blocks are shown in Figure 3.3. The information that may be included in the title block consists of:

1. Name of part or project
2. Quantity required
3. Order number
4. Material
5. Scale size used to depict drawing (full, enlarged, or reduced). Value is shown as a ratio.
6. Specification (general)
7. Drawn by
8. Checked by
9. Drawing number
10. Date
11. Tolerances
12. Company name
13. Revision record

The standard sizes of commercial mechanical drawing sheets are identified by the letters A through E.

A = 8½" × 11"
B = 11" × 17"
C = 11" × 22"
D = 22" × 34"
E = 34" × 44"

These letters may or may not be included as part of the drawing identification number.

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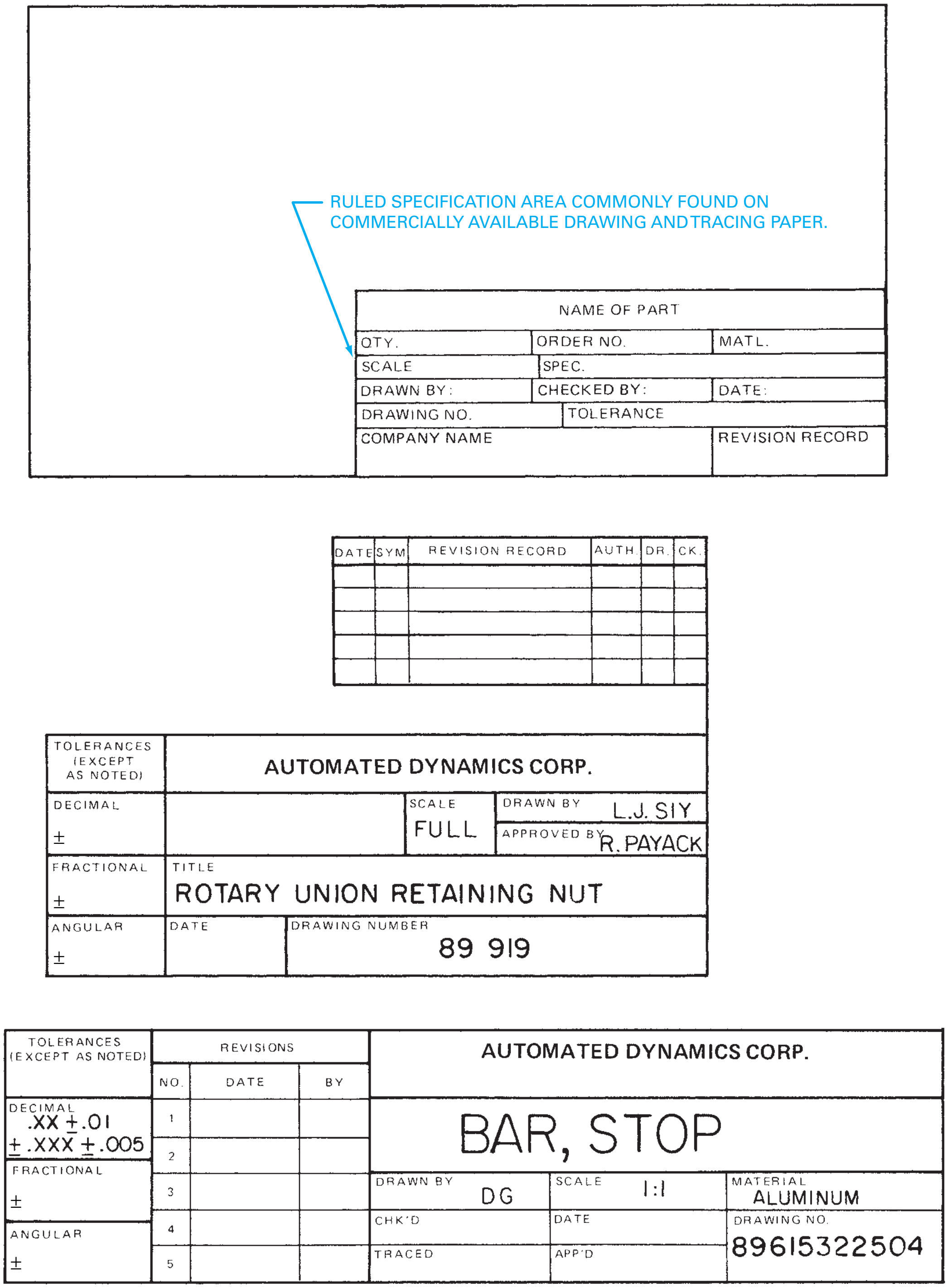

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FIGURE 3.3 ■ Typical drawing master showing ruled title blocks.

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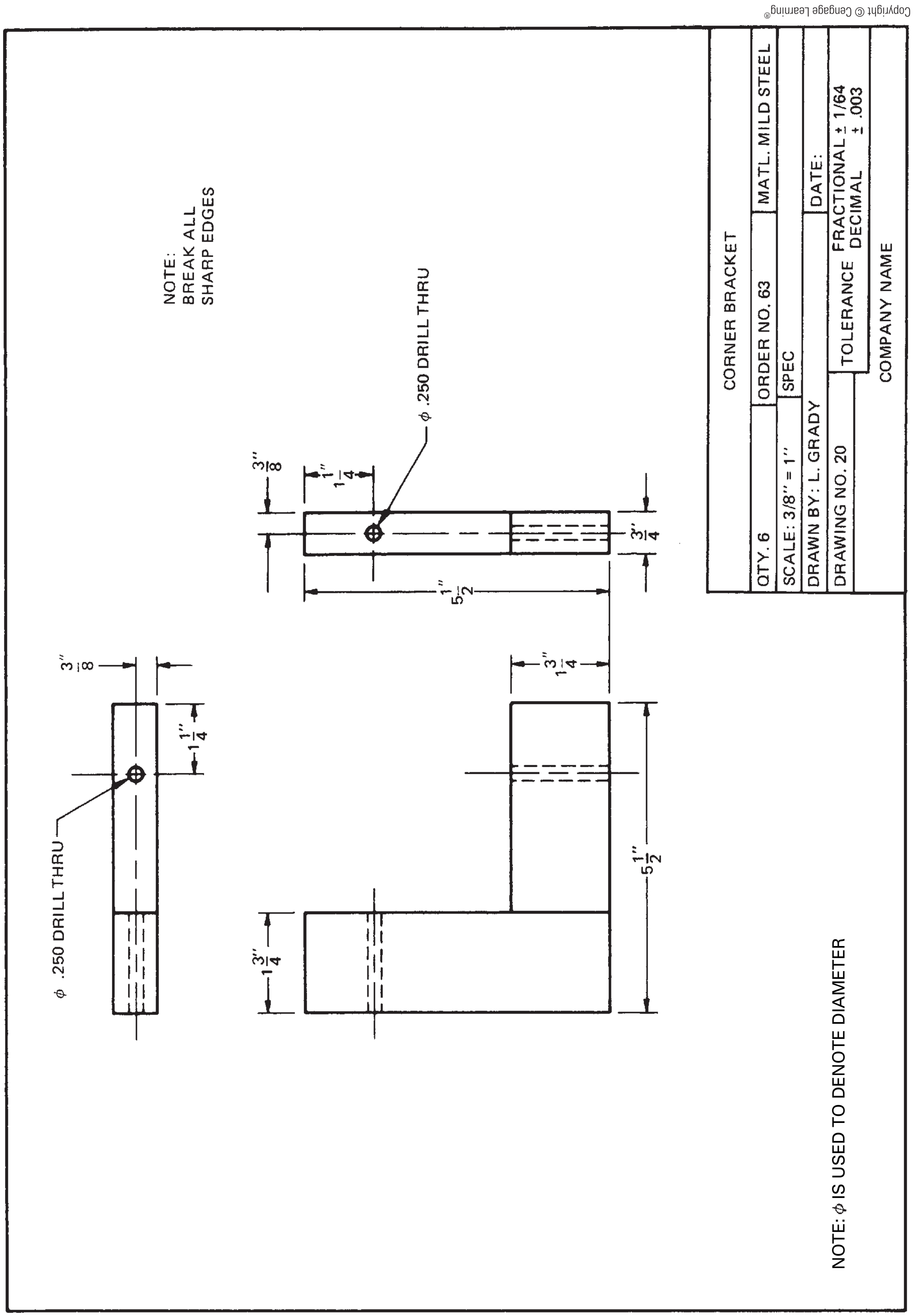

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UNIT 3 REVIEW

Refer to the drawing Corner Bracket, page 20.

1. What is the name of the part?

   ____

2. How many are required?

   ____

3. What is the order number?

   ____

4. What type of material is used?

   ____

5. How many views are shown?

   ____

6. Name each of the views shown.

   ____

   ____

   ____

   ____

7. Which view shows the shape of the object best?

   ____

8. In which views are leaders used?

   ____

9. Name each type of line used in the drawing.

   ____

   ____

   ____

   ____

   ____

10. What four types of lines are used to aid in dimensioning?

    ____

    ____

    ____

    ____

11. What item can be called a general note specification?

    ____

12. What item would be identified as a local note?

    ____

13. How many holes are to be drilled per bracket and how many in total to complete the order?

    ____

14. How deep is each hole to be drilled?

    ____

15. What is the diameter of the holes?

    ____

16. How many pieces are required to fabricate the part? What is the total number of pieces required to complete the order?

    ____

17. What do the hidden lines in each of the views represent?

    ____

18. Define the note, "Break All Sharp Edges"?

    ____

19. Identify an item within the title block that would be described as a specification.

    ____

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4 UNIT
Dimensions

PURPOSE OF DIMENSIONS

Dimensions serve two important purposes:

1. They give the sizes needed to fabricate the part.
2. They indicate the locations where components of the part should be placed, assembled, drilled, or welded. These are known as location dimensions.

Figure 4.1 illustrates the meaning of size and location dimensions. Note that linear dimensions used on a print may be shown in U.S. Customary and/or metric units. Information on metric dimensioning is included in Unit 22. Note that both units of measurement are used on dual-dimensioned drawings.

LINEAR AND ANGULAR DIMENSIONS

U.S. Customary linear dimensions may be given as whole numbers, fractions, and decimals. Preferred practice is to show dimensions in decimals, Figure 4.3. However, dimensions on drawings for weld fabrication operations are generally shown as fractional dimensions, while drawings for machining operations use decimal fractions. Drawings for both (weld) fabrication and machining use decimals or a mixture of both fractional and decimal dimensions for the appropriate type of operation. Also, current practice is to use a unidirectional dimensioning system, Figure 4.2, rather than the former practice of bidirectional or aligned dimensions, Figure 4.3.

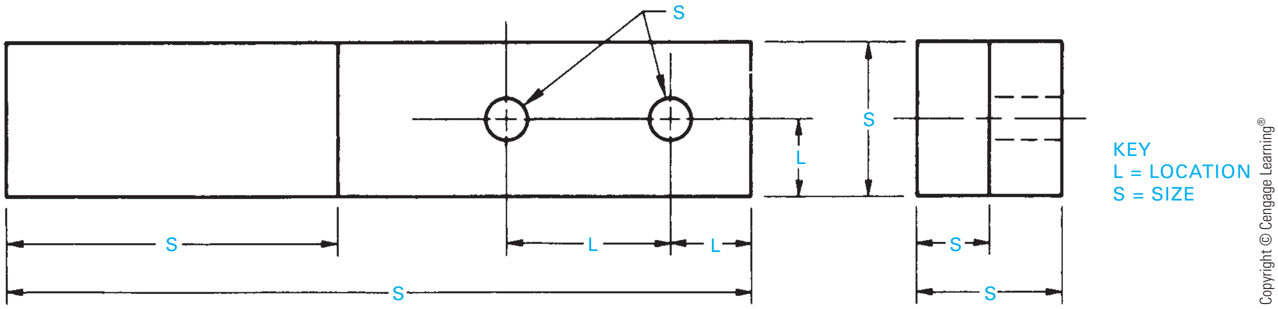

FIGURE 4.1 ■ Size and location dimensions.

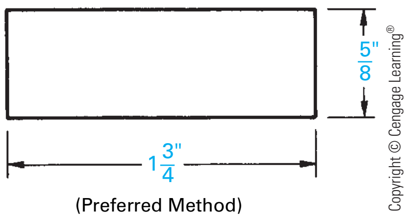

FIGURE 4.2 ■ Fractional dimensions. Unidirectional dimensions are read from the bottom of the drawing.

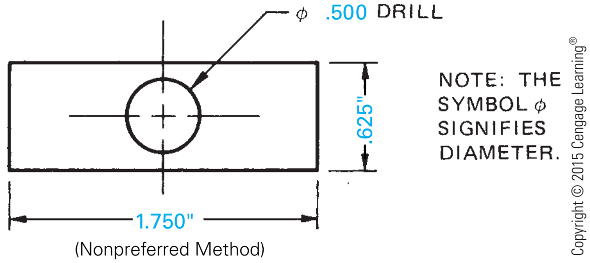

FIGURE 4.3 ■ Decimal dimensions. Bidirectional or aligned dimensions are read from the bottom and right side of the drawing.

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The term common fraction refers to dimensions such as 1⁄64, 1⁄32, 1⁄16, 1⁄8, 1⁄4, and 1⁄2 inch, Figure 4.2.

Decimal fraction dimensions are used particularly when precision sizes are required. For example, when a drilled hole is dimensioned, a decimal dimension is used, Figure 4.3. The word "drill" may or may not follow the dimension. In cases where the hole is to be reamed, the word "ream" may be applied following the dimensions. If the hole is to be flame cut, the words "flame cut" may follow the dimension. The process specified for cutting the hole generally indicates the accuracy required. In instances where a process is not specified, the choice of method is made by the welder. However, consideration must be given to the accuracy required.

Angular dimensions are given when a line is at an angle to a horizontal, vertical, or another angular line. Examples of each are shown in Figure 4.4. When only one member of a joint has an angular dimension, it is called a **bevel**. When both members have angular dimensions, they are combined and called the **included angle**. These angles can be shown in degrees, or in degrees and decimal parts of a degree. Although angular dimensions are sometimes shown in degrees and minutes (60°30'), the decimal fraction (60.5°) for minutes is preferred. Refer to Table 4.1.

Parts with bevels are commonly found on prints for welders. For joints to be welded, a bevel is a sloping edge that extends the full or partial length of the edge, Figure 4.5 and Figure 4.6. The sharp edge formed is commonly called a "**feather edge.**" The root face area along the edge is often called a **land.** Note that for welding purposes a chamfer is often identified and treated as a bevel.

There are several ways to dimension these features. One common method is by the use of a note with a leader. The amount of the bevel is given as a linear and a degree dimension, Figure 4.5 and Figure 4.6.

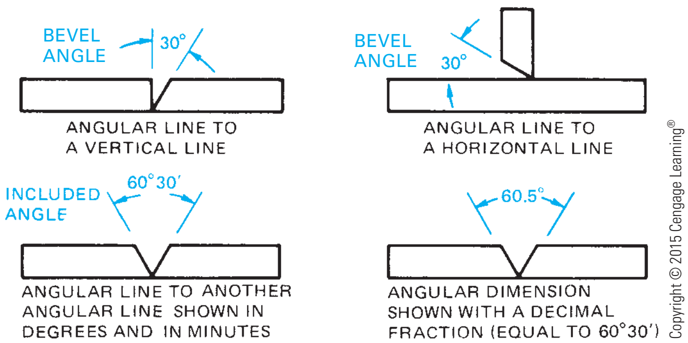

FIGURE 4.4 ■ Dimensioning angles.

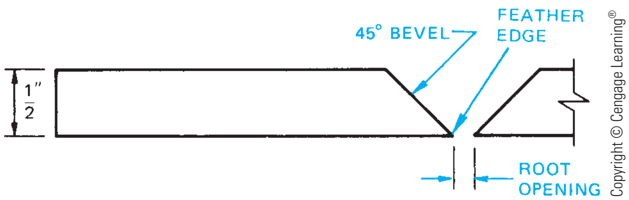

FIGURE 4.5 ■ Bevel dimension—full length.

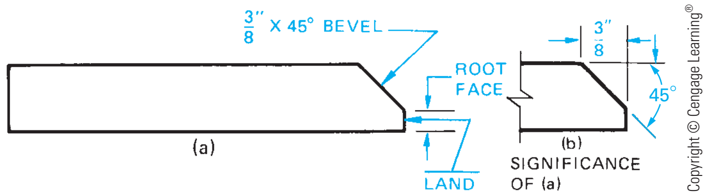

FIGURE 4.6 ■ Bevel dimension—partial length.

Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.
1	.0166	11	.1833	21	.3500	31	.5166	41	.6833	51	.8500
2	.0333	12	.2000	22	.3666	32	.5333	42	.7000	52	.8666
3	.0500	13	.2166	23	.3833	33	.5500	43	.7166	53	.8833
4	.0666	14	.2333	24	.4000	34	.5666	44	.7333	54	.9000
5	.0833	15	.2500	25	.4166	35	.5833	45	.7500	55	.9166
6	.1000	16	.2666	26	.4333	36	.6000	46	.7666	56	.9333
7	.1166	17	.2833	27	.4500	37	.6166	47	.7833	57	.9500
8	.1333	18	.3000	28	.4666	38	.6333	48	.8000	58	.9666
9	.1500	19	.3166	29	.4833	39	.6500	49	.8166	59	.9833
10	.1666	20	.3333	30	.5000	40	.6666	50	.8333	60	1.0000

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TABLE 4.1 ■ Minutes converted to decimals of a degree.

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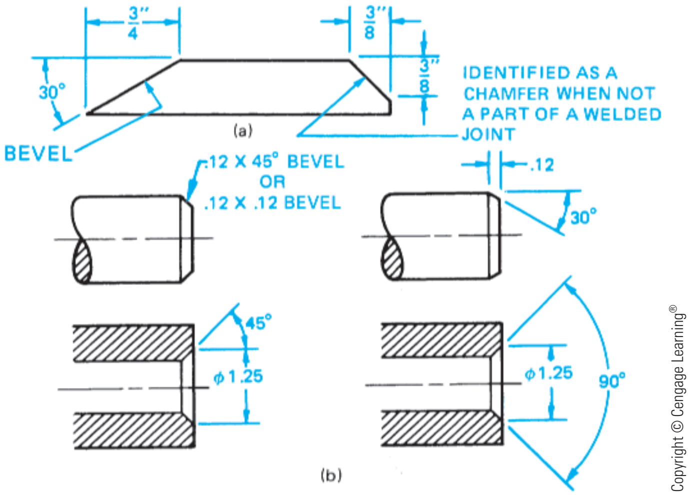

FIGURE 4.7 ■ Methods of dimensioning bevels.

Another method for dimensioning bevels is by using extension and dimension lines. The sizes may be given as two linear dimensions or as one linear and one angular dimension, Figure 4.7(a). When only a portion of the total edge is cut away at an angle for purposes other than welding, the edge is identified as a chamfer. Examples of bevels are shown in Figure 4.7(a) and Figure 4.7(b). Note that the symbol "×" included with the dimensions signifies places, times, or by. For example, 4× (times or places), and 4" × 4" (by).

RADIUS AND ARC DIMENSIONS

When the ends or corners of an object are to be rounded, a radius, arc, or curve is shown and is dimensioned by one of several methods, as shown in Figure 4.8. The methods of dimensioning include the use of an angular dimension and its radius (Figure 4.8a); two linear dimensions that indicate where the arc terminates, and its radius (Figure 4.8b); and a radius and centerlines that indicate the scope of the arc by inspection (Figure 4.8b). In the case of an arc with multiple radii, the dimensions shown are the location dimensions for the radii and the size of the radii, Figure 4.8(c). Note that the letter "**R**" is used to signify radius and is located preceding the dimension. In cases where a diameter dimension is applied, the symbol ∅ is used and precedes the dimension.

For dimensioning rounds, fillets, and roundouts, the radius of the arc with a leader is usually sufficient, Figure 4.9(b).

Other variations in dimensioning radii and arcs are illustrated in Figure 4.9.

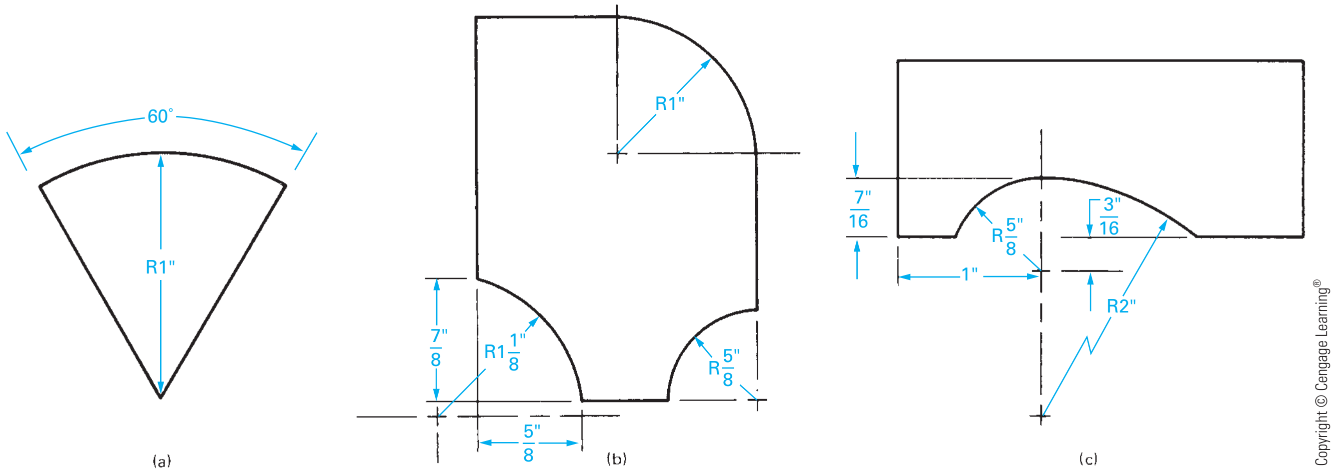

FIGURE 4.8 ■ Dimensioning arcs and radii.

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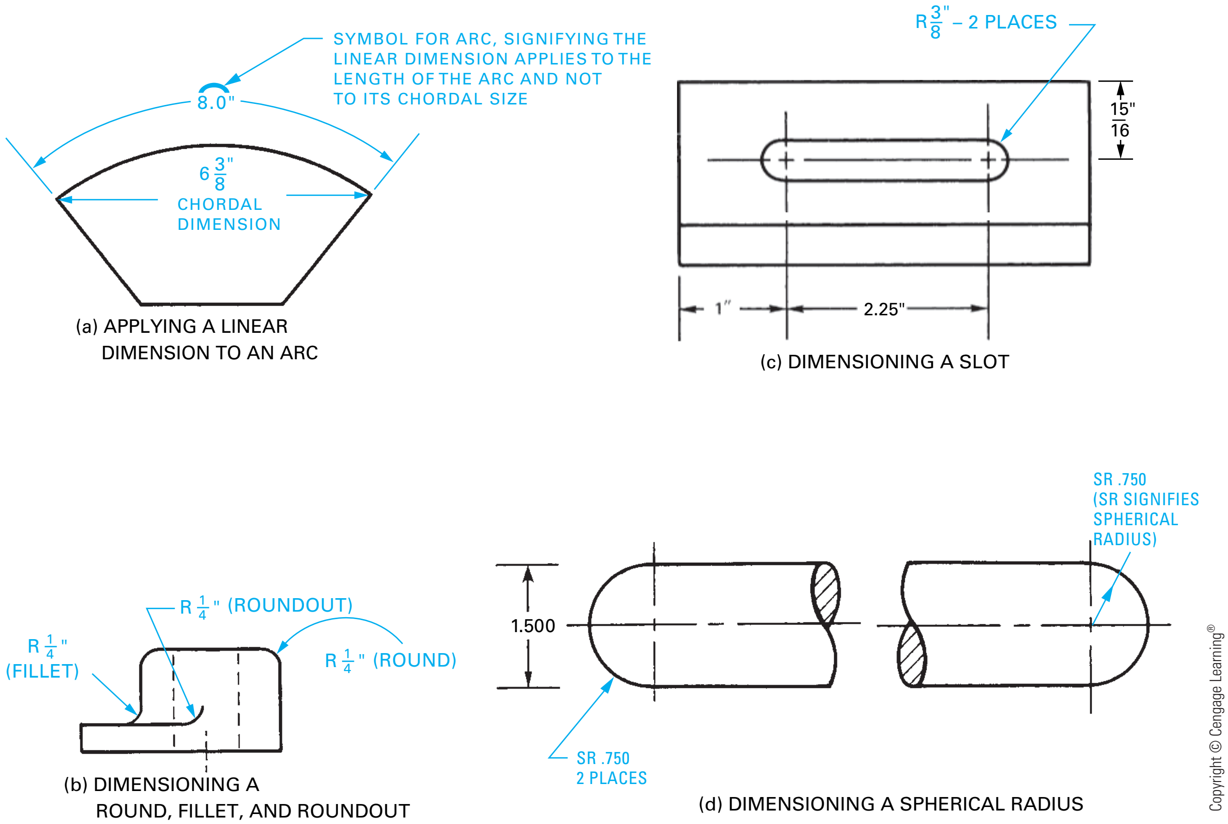

FIGURE 4.9 ■ Variations in dimensioning arcs and radii.

DRILLED HOLE DIMENSIONS

Drilled hole dimensions are shown by the use of a leader and a note. These are usually applied to the view that shows the shape of the hole. The note gives the size of the drill and the number of holes to be drilled, and may also give the depth to which the holes are to be drilled. Holes with no depth dimension are to be drilled all the way through. However, this may also be indicated by adding the word "**thru**" to the drill size dimension. When many identical holes are illustrated, the word "**typical**" or TYP may be used in a note to denote repetitive features on a drawing. The word "**places**" is also used to describe the number of places that have the same size hole or feature.

Note that the hole depth may be indicated by the abbreviation **DP** for "deep" or the depth symbol ↧ . A drill size can be given as a letter size, a number (wire gage) size, a fractional size, or a metric size. Figure 4.10 illustrates the various methods for dimensioning drilled holes.

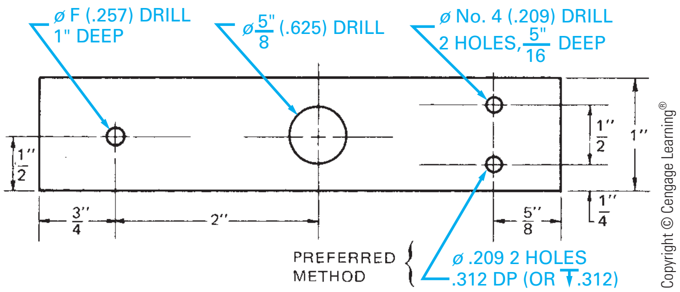

FIGURE 4.10 ■ Methods for dimensioning drilled holes.

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COUNTERSUNK AND COUNTERBORED HOLES AND SPOTFACE DIMENSIONS

Several other types of round holes found on weldment fabrication drawings are counterbored, countersunk, spotfaced, and counterdrilled holes. The methods, abbreviations, and symbols used for dimensioning these holes are shown in Figure 4.11, Figure 4.12, Figure 4.13, Figure 4.14, and Figure 4.15.

Note that the abbreviation DP or the symbol ↧ for depth is applied to the dimensioning for a counterbored hole. The depth of a spotfaced hole is not given since the primary purpose of the hole is to provide a smooth seating surface. The depth of a countersunk hole is also not given. The major diameter of the countersink is provided.

FIGURE 4.11 ■ Representing counterbored, countersunk, spotfaced, and counterdrilled holes.

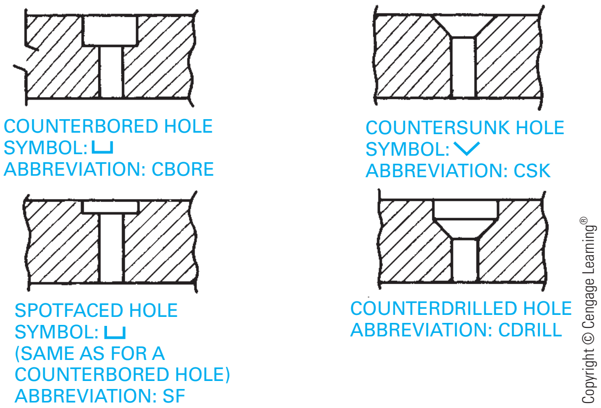


FIGURE 4.12 ■ Methods for dimensioning a counterbored hole.

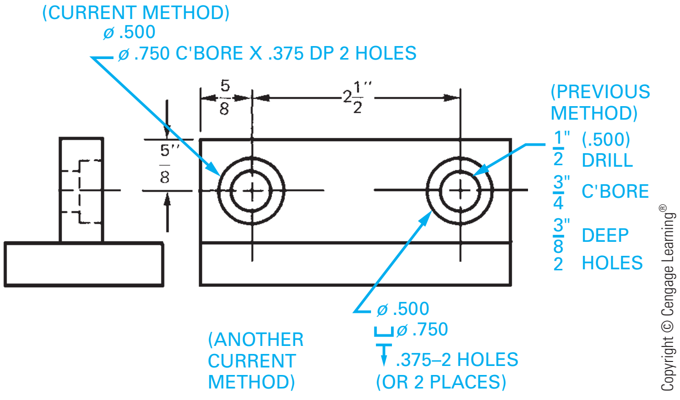
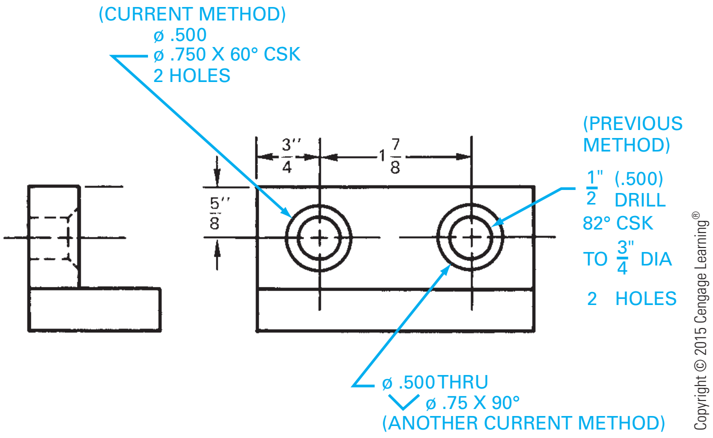


FIGURE 4.13 ■ Methods for dimensioning a countersunk hole.



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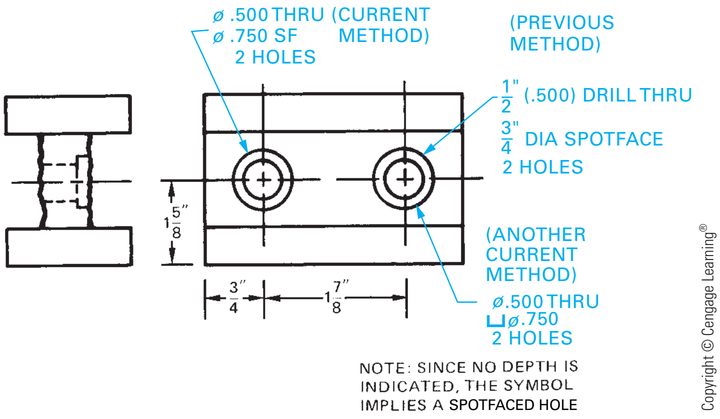

FIGURE 4.14 ■ Methods for dimensioning a spotfaced hole.

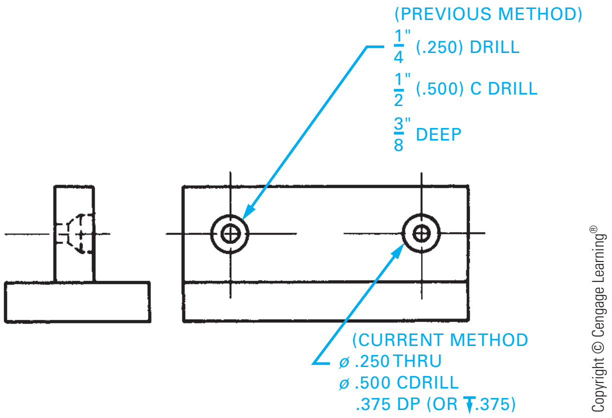

FIGURE 4.15 ■ Methods for dimensioning a counter-drilled hole.

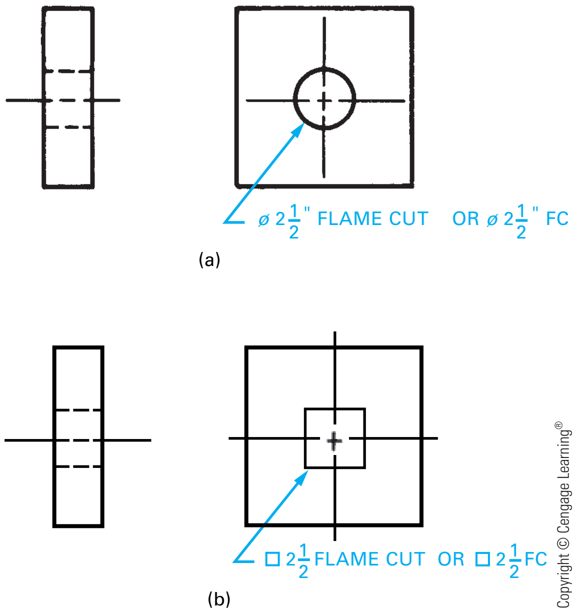

FIGURE 4.16 ■ Methods for dimensioning flame cut holes.

Another hole designation found on a weldment drawing is flame cut. When the hole is to be cut as a round shape, it is dimensioned like a drilled hole, except that the dimension is followed by the words "flame cut" or the abbreviation "FC," Figure 4.16(a). Note that a flame-cut hole is usually large (1 inch [2.54 centimeters] or larger) and is not as precise as a drilled hole. Therefore, its size is usually dimensioned using common fractions rather than decimals. Flame cutting of square holes may also be specified on a print. In such cases, the symbol for square □ may be used, Figure 4.16(b). Note that flame cut sizes are nominal (approximate).

TOLERANCE DIMENSIONS

Tolerance is another important element of dimensioning. It is a figure (or figures) given as a plus (+) or minus (−) quantity that allows for a variation in the dimension to which it is applied. It specifies the amount of error allowed when making a part. Any or all of the fractional, decimal, or angular dimensions found on a print can be given tolerances. When a tolerance is given, it follows the dimension to which it refers, or it is given as a note or specification. For example:

FOLLOWING DIMENSION:

12" ± ⅛"　　　12.740" ± .005"　　　60° ± 2°

NOTE: UNLESS OTHERWISE SPECIFIED TOLERANCES ARE AS FOLLOWS:

FRACTIONAL DIMENSIONS	± ⅛"
DECIMAL DIMENSIONS	± .005"
ANGULAR DIMENSIONS	± 2°

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Tolerances are used to ensure the accuracy and proper fit of parts. This allows assembly and construction with a minimum of rework or adjustment. For example, it is almost impossible to cut a bar of material to an exact length with a manually operated torch. Therefore, a plus and minus tolerance is allowed. If a bar is to be cut 12" long with a ±⅛ tolerance, the largest allowable size is 12⅛" and the smallest is 11⅞".

For many parts, the tolerances are standardized and are found in prepared tolerance tables. If no tolerance is given on a print, it can be assumed that extremely accurate sizes are not required. If such is the case, it is standard practice to use a ± tolerance of 1/64 for common fraction dimensions, a ± .010" tolerance for decimal fraction dimensions shown to two decimal places (.75", 1.25"), and a ± .005" tolerance for decimal fraction dimensions shown to three decimal places (.750", 1.375").

Tolerances may also be expressed or implied by other than + or − values. For example, limit dimensions may be used to specify allowable sizes as follows:

R.362 MIN.	— Signifies the minimum radius (R) should not be less than .362
R.375 MAX.	— Signifies the maximum radius (R) should not exceed .375, may be expressed as .362 − .375
$\frac{.362}{.375}$	— Signifies the range in size that must be within .362 and .375, or a tolerance range of .013 (.375 − .362 = .013)

SCALE SIZES

Dimensions placed on a print may be full, enlarged, or on a reduced scale. A reduced scale size is more commonly used on prints and may be one of the following. The scale size that is used is noted on the print.

1" = 1" (full size)   ¾" = 1"   ½" = 1"   ¼" = 1"   ⅛" = 1"   1:2 mm

However, an enlarged scale size is often used for detail drawings describing small components, for example, ½" = ⅛" or 2:1 mm.

The scale size of a drawing is always in direct proportion to the actual size of the object. The scale is always listed in the form of an equation, although it is actually a ratio. The figure on the left side of the equal sign represents the quantity of measure for the drawing. The figure on the right represents the corresponding quantity of actual measure for the object being illustrated. For example, assume that a scale of ½" = 1" is used and the dimension of the object is 6" long. The linear distance on the print, therefore, is half of the object distance, or 3".

THREAD DIMENSIONS

Weldments very often include threaded parts. Standard thread symbols are used on prints to represent threaded parts. Figure 4.17 shows how external threads are represented. Internal threads (tapped holes) are represented by the symbols shown in Figure 4.18.

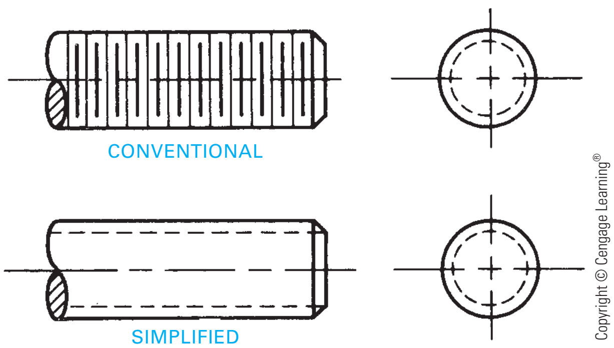

FIGURE 4.17 ■ External thread symbols.

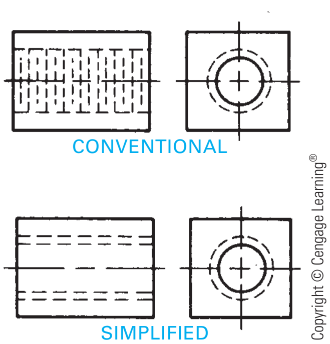

FIGURE 4.18 ■ Internal thread symbols.

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An internal thread can be shown in a section view (cutaway view) by either of the symbols given in Figure 4.19.

Both internal and external threads are dimensioned using a leader followed by the thread specification, Figure 4.20. Note that the elements of the thread specification are also defined in the figure. When the thread is a left-handed thread, LH is added following the class of fit specification. In all other cases, the thread is considered to be a right-handed thread. Formerly, the common V-thread forms were identified as National Coarse (NC) or National Fine (NF). With the inclusion of these thread forms in the metric system, they are more often identified as Unified National Coarse (UNC) and Unified National Fine (UNF).

When a thread class of fit is specified, it is shown in a sequence as illustrated in Figure 4.20. There are three classes of fit that are commonly used. Class I for a loose fit, Class II for a standard fit (as is used for commercially available bolts and nuts), and Class III for a more precise and tighter fit.

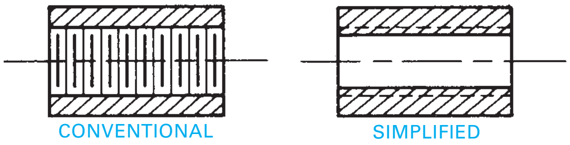

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FIGURE 4.19 ■ Internal thread symbols for sections.

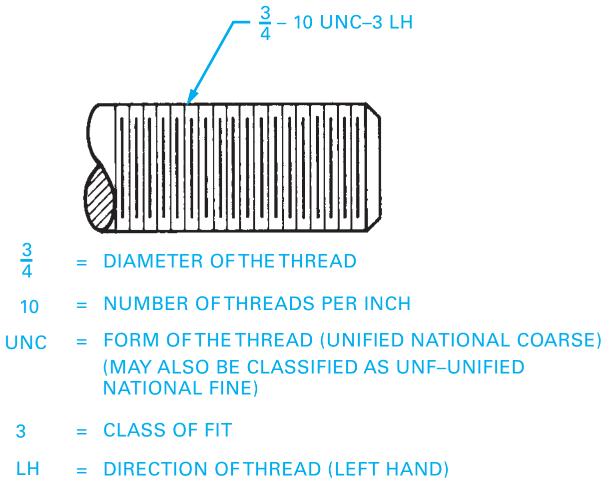

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FIGURE 4.20 ■ Elements of a thread specification.

DIMENSIONING METHODS

There are two basic methods for dimensioning a part: **conventional dimensioning** and **baseline dimensioning.**

The conventional method of dimensioning is illustrated by Figure 4.21. In this method, the overall dimensions of length, width, and height are given. Dimensions A and B are not given because they are easily found by adding the given dimensions. If dimensions A and/or B were given, they would be identified as **reference dimensions**. A reference dimension is shown on a drawing enclosed within parentheses. Reference dimensions are obtained by adding and/or subtracting other dimensions found on the drawing. A reference dimension is used to expedite reading the drawing; however, it is not a necessary dimension. If a part is dimensioned so that the overall sizes are not given, those dimensions that make up the total must be added to find the overall sizes. Fractional or decimal dimensions may be used, but decimal dimensioning is preferred.

Baseline dimensioning, Figure 4.22, differs from conventional dimensioning in that all dimensions originate from baselines. When baseline dimensioning is used, the dimensions normally are expressed as three-place decimals.

Baselines are object lines that usually represent machined surfaces, as indicated by the symbol √. The point of this symbol touches the surface edge to be machined finished. Baselines may also originate from centerlines.

The advantage of baseline dimensioning is that calculations are not required to find a dimension. It is a method commonly used to dimension precision parts. This method does not give rise to the cumulative error that occurs with conventional dimensioning.

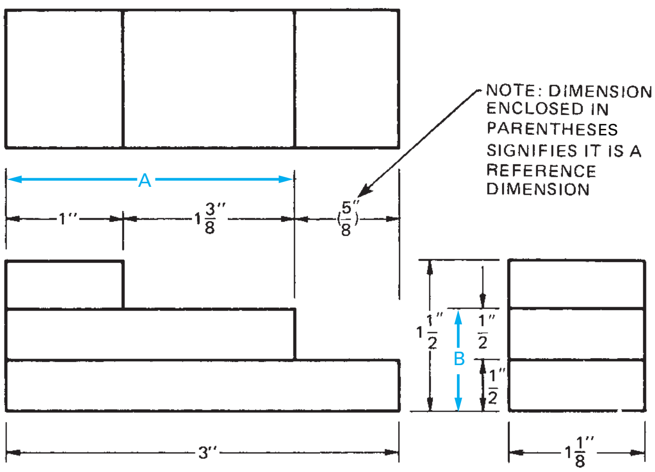

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FIGURE 4.21 ■ Conventional dimensioning (A, B are possible reference dimensions).

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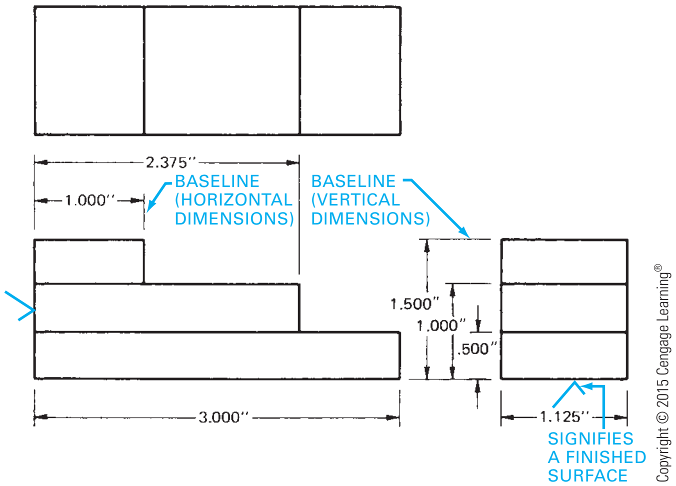

FIGURE 4.22 ■ Baseline dimensioning.

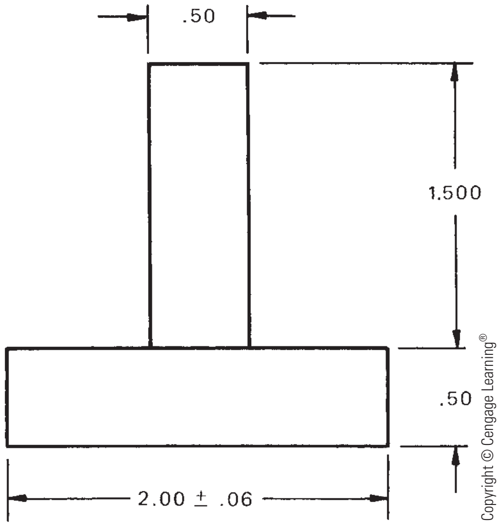

FIGURE 4.23 ■ Reference to a basic size dimension.

OTHER TERMS COMMONLY USED IN DIMENSIONING

Basic size refers to the base size of a part to which a tolerance value is applied. For example, in Figure 4.23, the basic size dimension is 2.00 with a tolerance of ± .06.

Actual size refers to the size of the part when measured.

Nominal size refers to a dimension that represents an approximate size. It is used for general identification of a size, such as for identifying pipe, pipe fittings, and lumber.

Limits of size refers to dimensions that indicate the upper (maximum) limit and the lower (minimum) limit to which the size of a part can be made. Limits may be shown in several ways. Examples follow:

2.50	upper limit
2.37	lower limit

(lower limit) 2.37 – 2.50 (upper limit)

- **Call out** refers to identification of each of the parts on an assembly drawing by means of numbers assigned to the parts.
- The numbers are referenced to a bill of materials to obtain the information needed to produce each part.

DUAL DIMENSIONING

Dual dimensioning refers to the application of both U.S. Customary and metric units (usually in millimeters) of measurement on a drawing, Figure 4.24. It is used on drawings to permit the manufacture of parts in either unit of measurement, depending upon their application and/or where they will be marketed.

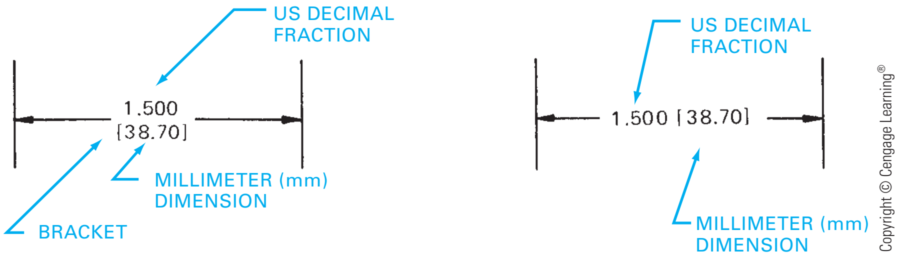

FIGURE 4.24 ■ Examples of dual dimensioning using the bracket method.

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UNIT 4: REVIEW A

Graph paper has been provided at the end of this review for your use.

1. Give two functions of dimensions.

____

____

2. List two ways a dimension can be expressed in U.S. Customary units.

____

____

3. How is a precision dimension usually expressed?

____

4. a. Show by a simple sketch the difference between a bevel and a chamfer.

   b. For welding purposes, is a distinction made between a chamfer and a bevel?

____

5. Show two ways in which the given illustrations might be dimensioned. Apply the dimensions to the illustrations.

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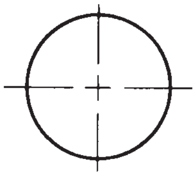
6. Indicate three items of information that might be found in the dimensioning of a drilled hole using a leader.



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7. Identify the type of hole represented by each sketch. Add the dimensions that must be applied to each.

______________________________ ______________________________

______________________________ ______________________________

______________________________ ______________________________

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8. What is the meaning of *tolerance* as applied to dimensions?

____

____

9. Sketch three methods of dimensioning a radius or arc on a print.

10. What are the maximum and minimum sizes for the dimensions shown in the table?

	Dimension	Tolerance	Maximum	Minimum
a.	8"	±1/16"		
b.	7 1/32"	±3/64"		
c.	6' 11 7/8"	±3/16"		
d.	8.902"	±.003"		
e.	1.002"	±.005"		
f.	82°	±5'		
g.	105°	±2°		

11. What is the linear length shown on a print for the dimensions given, when drawn to the scale size specified?

	Dimension	Scale	Size
a.	8"	1/4" = 1"	
b.	18' 6"	1/8" = 1'	
c.	2 1/16"	2" = 1"	
d.	23/64"	3" = 1"	

12. Which of the thread symbols below represent internal threads and which represent external threads?

a. ____________________ b. ____________________

c. ____________________ d. ____________________

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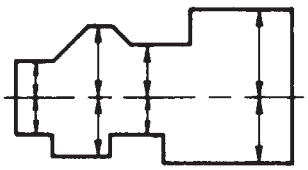
13. List the information that is signified by the following thread specification:

¾–10 UNC–LH

14. Explain the difference between the conventional method of dimensioning and the baseline method of dimensioning.

15. What kind of dimensioning is illustrated in the sketch below?



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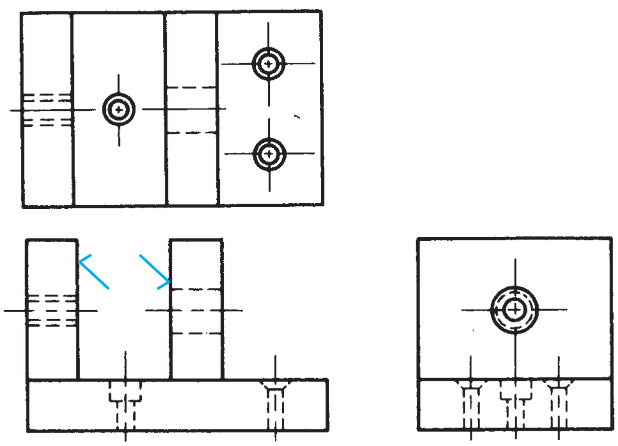
16. a. Apply appropriate dimensions to the different types of holes shown in the part below. Assume any necessary sizes.
    b. Apply the dimension lines required for locating the holes.
    c. Identify the types of holes found in the part.
    d. Explain the significance of the √ symbol shown on the front view.



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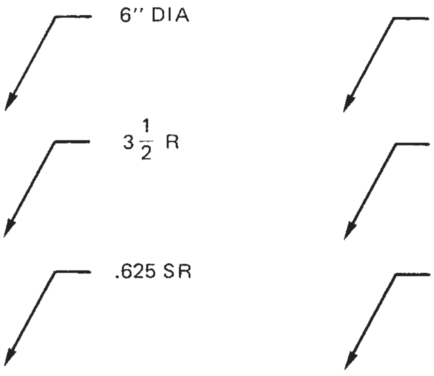
17. Apply the preferred practice of dimensioning to the leaders shown on the right.



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18. Explain what is meant by the term "call out."

19. Refer to the "Roller Support" drawing on page 34 and call out the appropriate items shown on the drawing.

20. Explain the difference between the terms "actual size" and "nominal size."

21. Explain the significance of the following dimensions:

a. ←$\frac{1.75}{1.65}$→ b. ←8.37–8.50→

a. ______

b. ______

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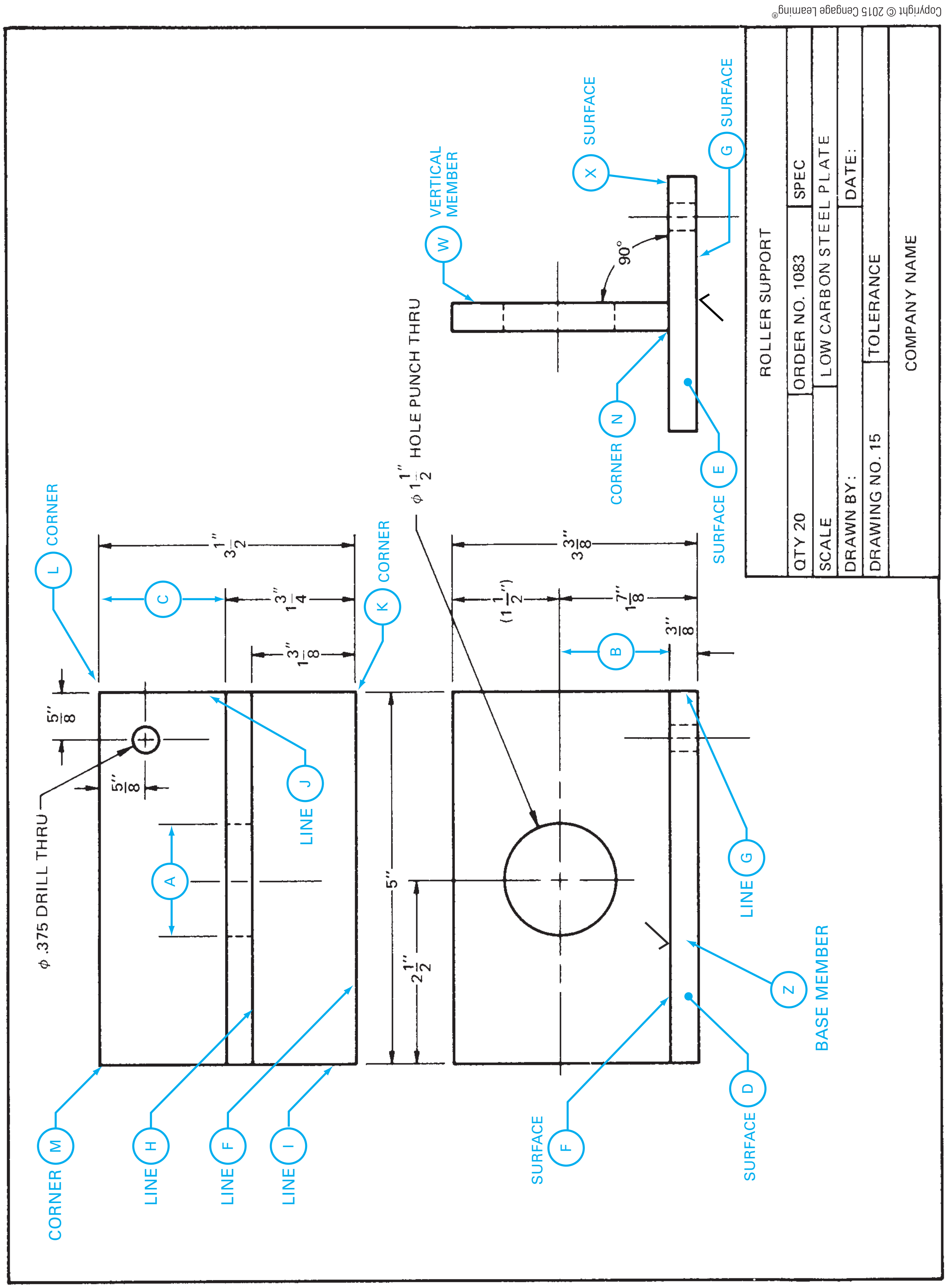

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UNIT 4: REVIEW B

Refer to the drawing Roller Support, page 34.

1. What is the name of the object?

2. How many are required?

3. What type of material is used?

4. What is the overall length of the object?

5. Name the views shown.

6. In which view is the width dimensioned?

7. In which view is an angular dimension used?

8. How many hidden lines are shown?

9. What is the dimension of distance (A)?

10. What is the dimension of distance (B)?

11. What is the dimension of distance (C)?

12. How many holes are there in the completed order?

13. How are the holes to be made?

14. How is the largest hole made?

15. Where is a decimal dimension found on the drawing?

16. Which line letter represents surface (E) in the front view?

17. Which line letter represents line (G) in the top view?

18. How thick is the upright plate?

19. Which line letter represents surface (D) in the top view?

20. Which line letter represents corner (N) in the top view?

21. a. Identify the surface or surfaces to be finished.

    b. Sketch the symbol used.

22. Which dimension would be identified as a reference dimension?

23. Give the location dimensions for the large hole.

24. What is the angular dimension of the upright plate?

25. Identify the hole that can be a nominal size.

26. What is the common fractional size of the hole to be drilled?

27. List the location dimension for the drilled hole.

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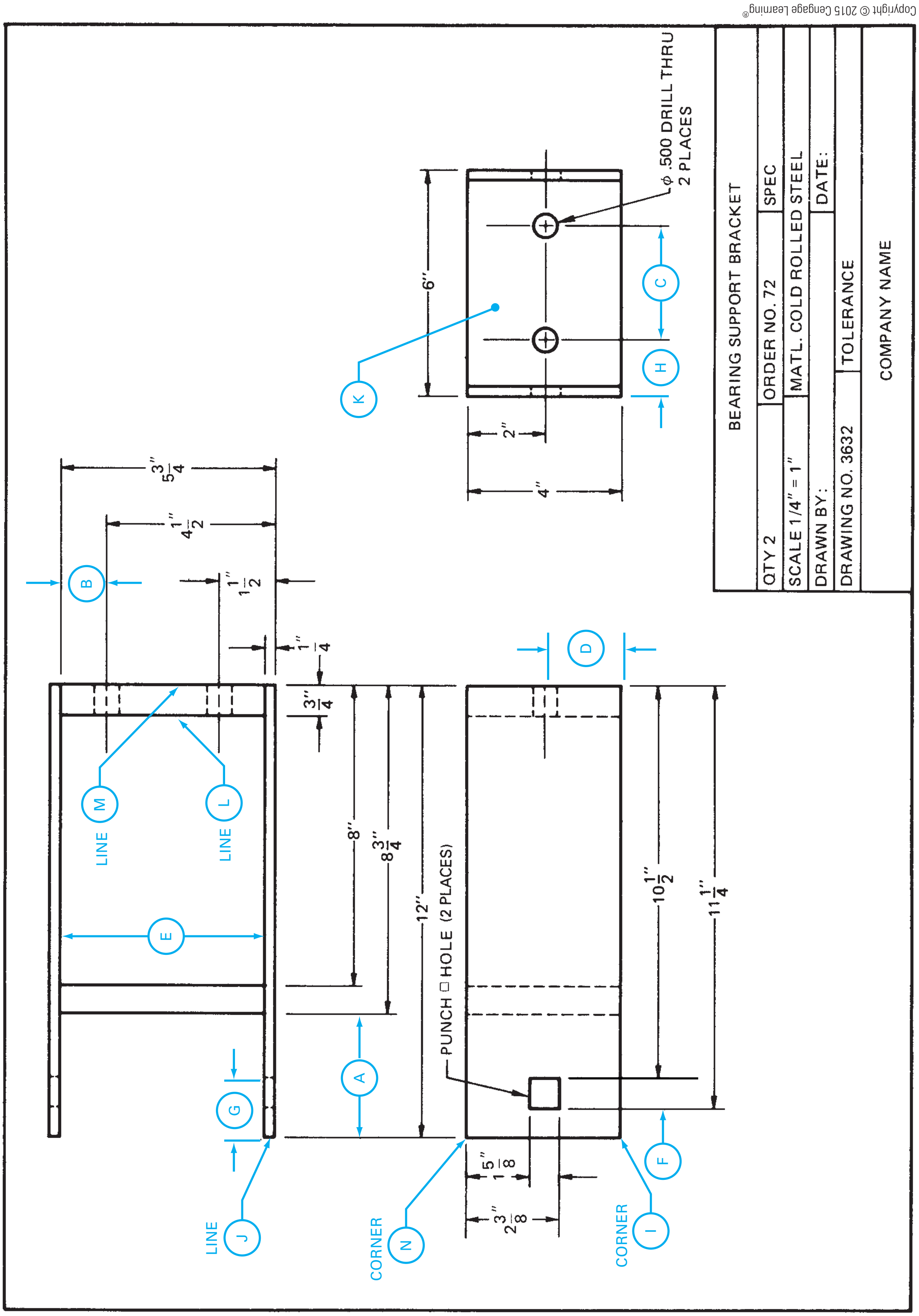

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SUMMARY REVIEW NO. 1

Graph paper is provided at the end of this review for your use.

Refer to the drawing Bearing Support Bracket, page 36.

1. What scale size is used?

2. With reference to the above scale, what linear length on the drawing represents a dimension of 8"?

3. List any notes found on the print.

4. List an item classified as a specification.

5. What are the location dimensions for the drilled holes?

6. List the location dimensions for the square holes.

7. a. What are the dimensions for the following distances?

   (A) ______ (E) ______

   (B) ______ (F) ______

   (C) ______ (G) ______

   (D) ______ (H) ______

   b. If dimension (A) had been included on the drawing, identify the kind of dimension it would be classified as.

8. What line letter in the top view is represented by surface (K)?

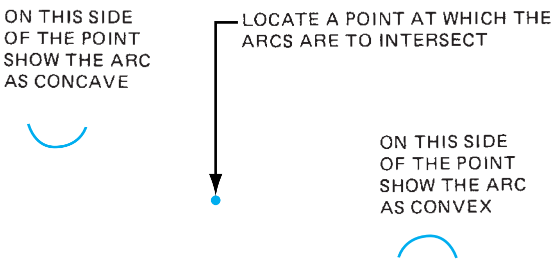
9. What corner(s) in the front view are represented by line (J)?

10. What method of dimensioning is shown to the right of the top view?

11. List the six types of lines found on the print.

12. Convert the common fraction dimensions to decimal fraction dimensions and apply them to the drawing next to the common fraction dimensions.

13. Prepare a sketch that illustrates two intersecting arcs with equal radii. Use one of the techniques previously described in the text. Show all guidelines and points for developing each arc.



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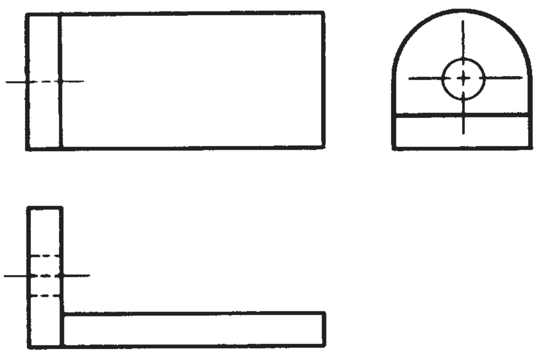
14. a. Prepare a right oblique sketch of the following three-view orthographic drawings.

    b. Which of the orthographic views is incomplete?

    c. Correct the view that is incomplete.



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