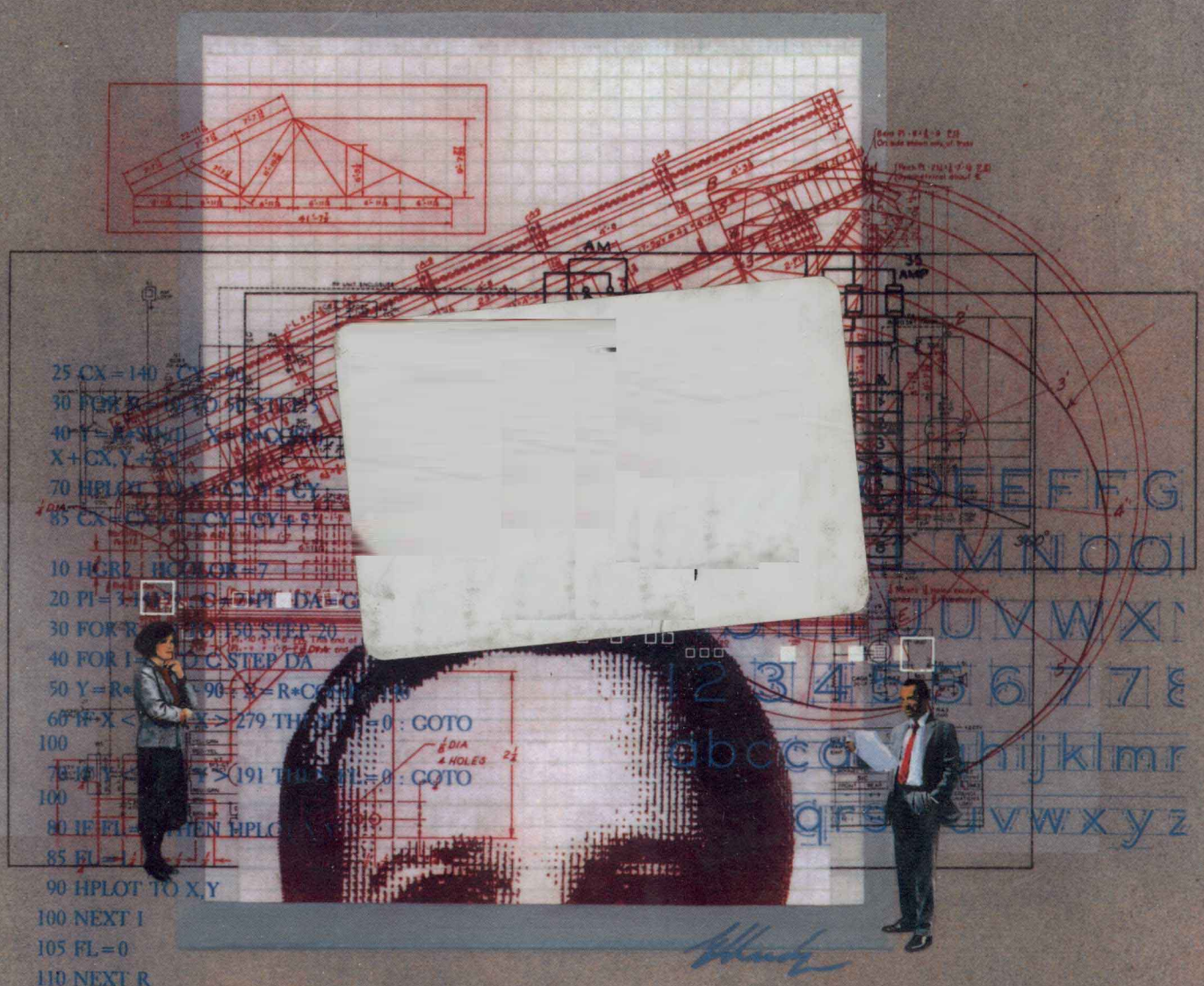
Engineering Drawing and Graphic Technology

FOURTEENTH EDITION



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FOURTEENTH EDITION

Engineering Drawing and Graphic Technology

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ENGINEERING DRAWING AND GRAPHIC TECHNOLOGY

ABOUT THE AUTHORS

ORIGINAL AUTHORS

THOMAS E. FRENCH was an early innovator and subsequent leader in the field of engineering drawing. As head of the engineering drawing department at Ohio State University, he led the department to national prominence and was the recipient of the field's highest achievement award.

CHARLES J. VIERCK continued French's outstanding achievement in the publishing field with his contributions to six editions of the text.

CURRENT AUTHOR

ROBERT J. FOSTER is associate professor of engineering graphics at the University Park Campus of Penn State University, having taught engineering at the college level for thirty years. He is currently program chairman for engineering graphics. He has also worked in industry as a design engineer with the Bendix Corporation, the United States Navy, and Erie Technological Products, Inc.

Foster is the author of *Field Sketching* as well as *Graphic Science and Design* (with French and Vierck) and *Graphical Communication Principles: A Prelude to CAD*, both McGraw-Hill texts. He has been active in the American Society for Engineering Education (ASEE) and its Engineering Design Graphics Division, having been its chairman and the recipient of its Distinguished Service Award.

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PREFACE

THE BOOK

Thirteen editions of this book have been widely used as a class text and reference in engineering drawing. The previous edition featured a major reorganization of core material and introduced computer-aided drafting (CAD). This new edition maintains the general approach and coverage of the previous edition but features expanded coverage in several key areas along with updated standards throughout. More attention is given to applications of computer-aided drafting (CAD); and a new page layout should prove appealing to both students and instructors.

AUDIENCE

It is expected that the text will be useful to students and instructors in high schools, technical institutes, community colleges, and the freshman level in universities. There is material sufficient in breadth and also in depth to be easily used in two three-semester credit courses in engineering drawing. An instructor may pick and choose topics of value to the students.

CONTENT

A first course could consist of the material in Section A, "Basic Graphics," which includes Chapters 1 through 8. It covers use of instruments, lettering, and constructional geometry. Also covered in Section A are topics on orthographic projection, sectional views, pictorial drawing, and dimensioning and tolerancing. Standards of the American National Standards Institute (ANSI) are used throughout. As with all sections, sample problems are offered at the end of each chapter.

Section B, "Elements of Space Geometry," comprises Chapters 9 through 11. Chapter 9 has been expanded to incorporate topics not covered in the previous edition. These topics include parallelism, perpendicularity, angles of lines with planes, and shortest distance problems. Chapters 10 and 11 cover surface intersections and developements.

Section C, "Applied Graphics and Design," has been partially restructured. "Introduction to Design" remains as Chapter 12, but the first few pages now emphasize the social responsibility of the designer. The former Chapter 15 has been moved into Chapter 13 as "Applications of Computer-Aided Drafting." In this chapter computer programming for computer graphics has been replaced with applications of CAD in design. "Production Drawings" and "Presenting Data" round out this section as Chapters 14 and 15, respectively.

Section D is reserved for "Special Topics." Chapters 16 through 22 treat topics within engineering drawings that are valuable but are seen perhaps less frequently in today's drawing classes. The chapters cover in moderate detail specialty topics such as assembly fasteners, gears and cams, welding, electrical drafting, piping, structural drawing, and maps. The student is given reasonable depth in the topics without undue bulk of material.

The appendixes remain a valuable reference for both the instructor and the student. Each standard in the appendixes was reviewed for currency of information. The completeness and accuracy of information provided in the appendixes is one major strength of this graphics text.

WORKBOOK

A new accompanying workbook by Professor Hugh F. Rogers, recently retired from The Pennsylvania State University, provides ample opportunity for student practice. Filled with detailed and original problems, the new workbook (Problems Book III) should enable students to practice what they learn in this leading text. Professor Roger's previous workbooks (Problems Book I to Accompany Engineering Drawing and Graphic Technology and Problems Book II to Accompany Engineering Drawing and Graphic Technology) remain available for instructors wishing to assign alternative practice problems.

ACKNOWLEDGMENTS

I would like to acknowledge the help of colleagues who offered both physical and moral support. Professor Hugh F. Rogers was especially helpful. In addition, the attention given by the following reviewers is much appreciated: Don Chastain, Black Hills State College; Rusty Echols, Texas A&M University; Fred Fink, Michigan State University; Mark Frisna, Wentworth Institute of Technology; Garland Hilliard, North Carolina State University; Robert Mathews, University of Louisville; Robert Miller, Washington Institute of Technology; and Charles Sightler, Midlands Technical College.

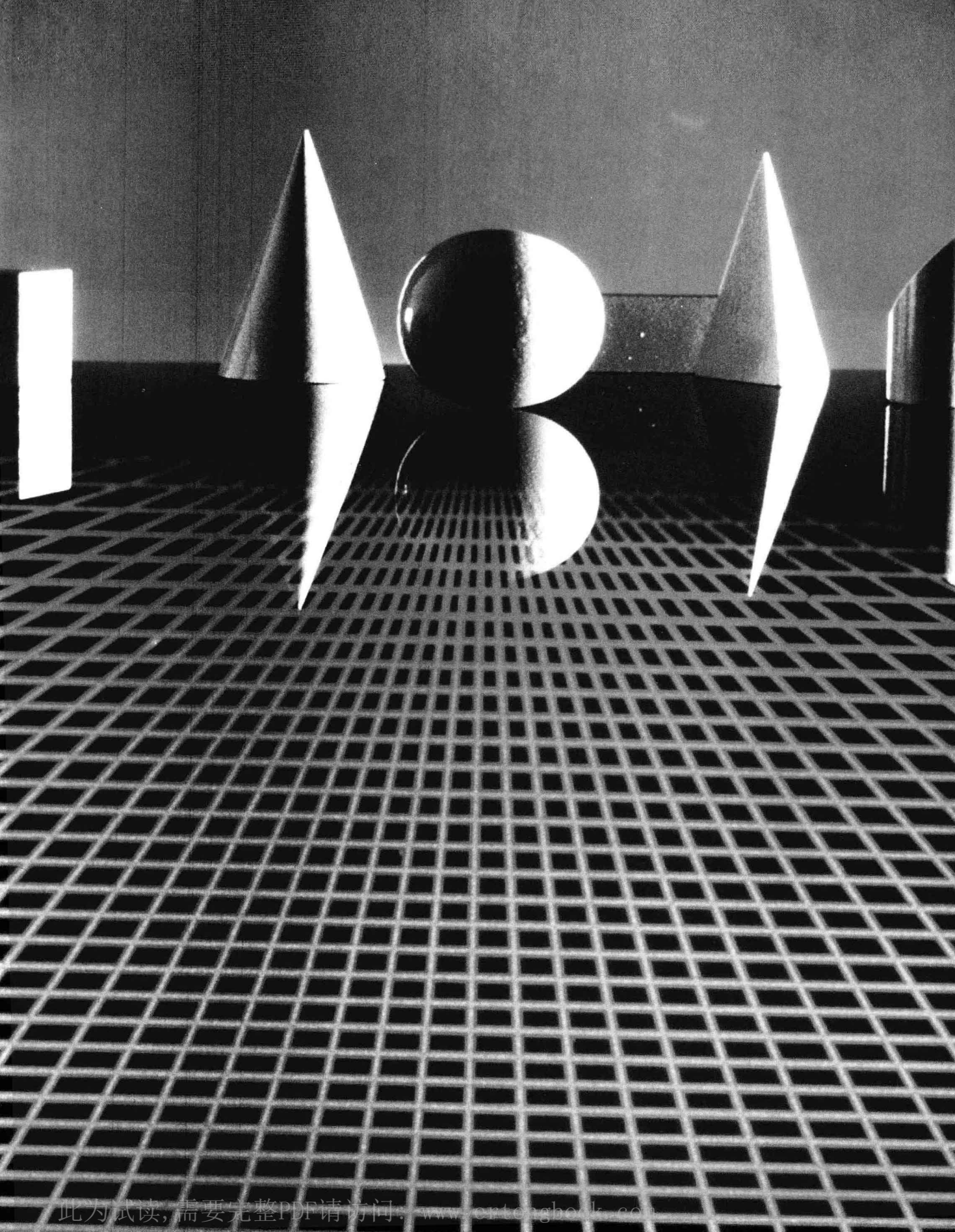
Most welcome are comments from instructors and students as to content, accuracy, and pedagogical approach to the material. Only the infusion of fresh ideas and topics can maintain a classic text which combines traditional integrity with current thinking. The result is designed to effectively help our ultimate consumer, the students.

Roger J. Foster

CONTENTS

D. SPECIAL TOPICS

ENGINEERING DRAWING AND GRAPHIC TECHNOLOGY



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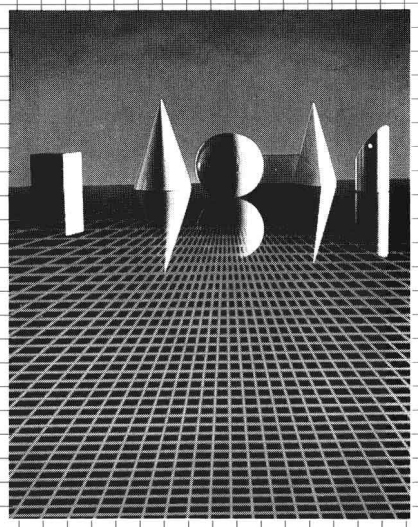
PART A

BASIC GRAPHICS

CHAPTER 1

INTRODUCTION



1. THE NEED FOR ENGINEERING DRAWINGS

People have expressed their thoughts and concepts for many centuries by the use of drawings. Some drawings are pure art, as is the painting of a vase of flowers or a seascape. A music score on a sheet of paper is a form of drawing which relies on symbols to convey meaning.

In engineering and technology technical drawings are widely used. Whether it is an aircraft engine or a child's wagon, the persons responsible for making it need accurate and definitive information on all parts and on how they fit together. Some drawings can be three-dimensional, as in Fig. 1, or two-dimensional, as in Fig. 2. The drawing can be done by computer, as in Fig. 1, or by hand, as in Fig. 2. The designer and drafter have many options available to present technical information. There are many types of engineering drawings and each has its own value and use.

Our object is to study the language of engineering graphics so that we can write it clearly for those familiar with it and read it readily when written by another. To do this, we must know the basic theory and be familiar with its accepted conventions and abbreviations. Since its principles are essentially the same throughout the world, a person who has been trained in the practices of one nation can readily adapt to the practices of another.

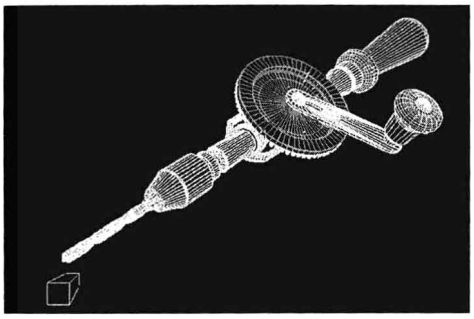


FIG. 1 3-D CAD. *(Courtesy AutoDesk, Inc.)*

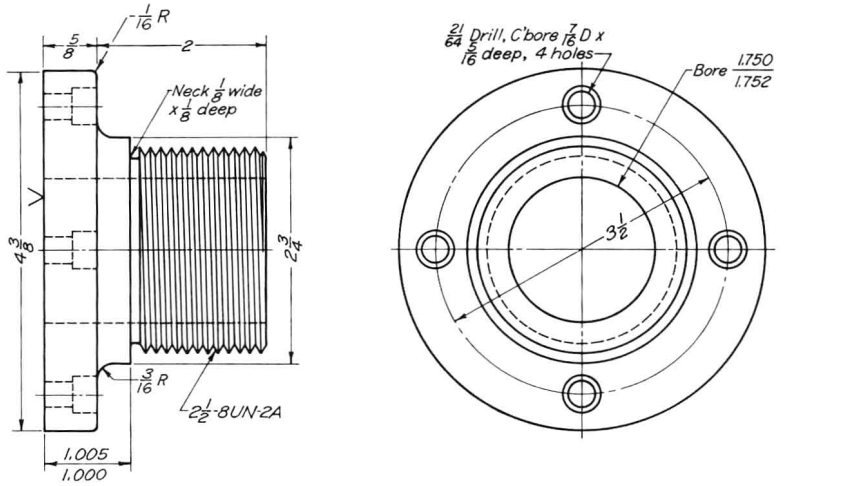


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FIG. 2 Example of a two-view drawing drawn by hand-held instruments. The lettering is freehand.

As a background for study, we will introduce in this chapter various aspects of graphics that will be discussed at length later. It is hoped that this preview will serve as a broad perspective against which you will see each topic, as it is studied, in relation to the whole. Since our subject is a graphic language, illustrations are helpful in presenting even this introductory material. Figures are thus used to clarify the text.

The book is divided into four major parts: basic graphics, elements of space geometry, applied graphics and design, and special topics. We will now take a quick look at each of these four sections.

2. BASIC GRAPHICS

A. Essentials of Graphics: Lines and Lettering Drawings are made up of lines that represent the surfaces, edges, and contours of objects. Symbols, dimensional sizes, and word notes are added to these lines, collectively making a complete description.

Lines are connected according to the geometry of the object represented, making it necessary to know the geometry of plane and solid figures and to understand how to combine circles, straight lines, and curves to represent separate views of many geometric combinations.

We will study the use of modern instruments for mechanical drawing. We will learn how to make basic geometric constructions, using graphic geometry, as in Fig. 3.

B. Methods of Expression There are three methods of writing the graphic language: freehand, with hand-held instruments, and by computer.

Freehand drawing is done by sketching the lines with no instruments other than pencils and erasers, as seen in Fig. 4. It is an excellent method to use during the learning process because of its speed and because at this stage the study of projection is more important than exactness. Freehand drawings are much used commercially for preliminary designing.

Since most drawings are made to scale, instruments are used to draw straight lines, circles, and curves concisely and accurately. Figure 2 is an example of an instrument drawing.

The computer drawing seen in Fig. 5 represents a rapidly advancing aspect of engineering drawing. Computers can drive plotters which produce the actual draw-

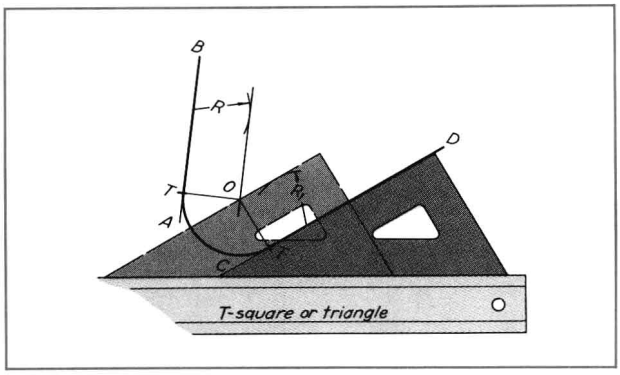

FIG. 3 Graphic geometry. Here one is making an arc tangent to two straight lines.

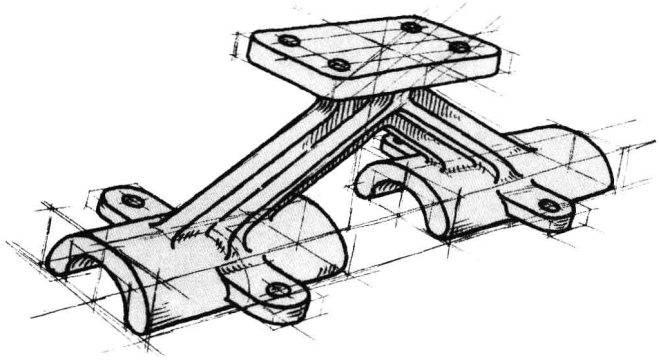

FIG. 4 A two-point perspective sketch.

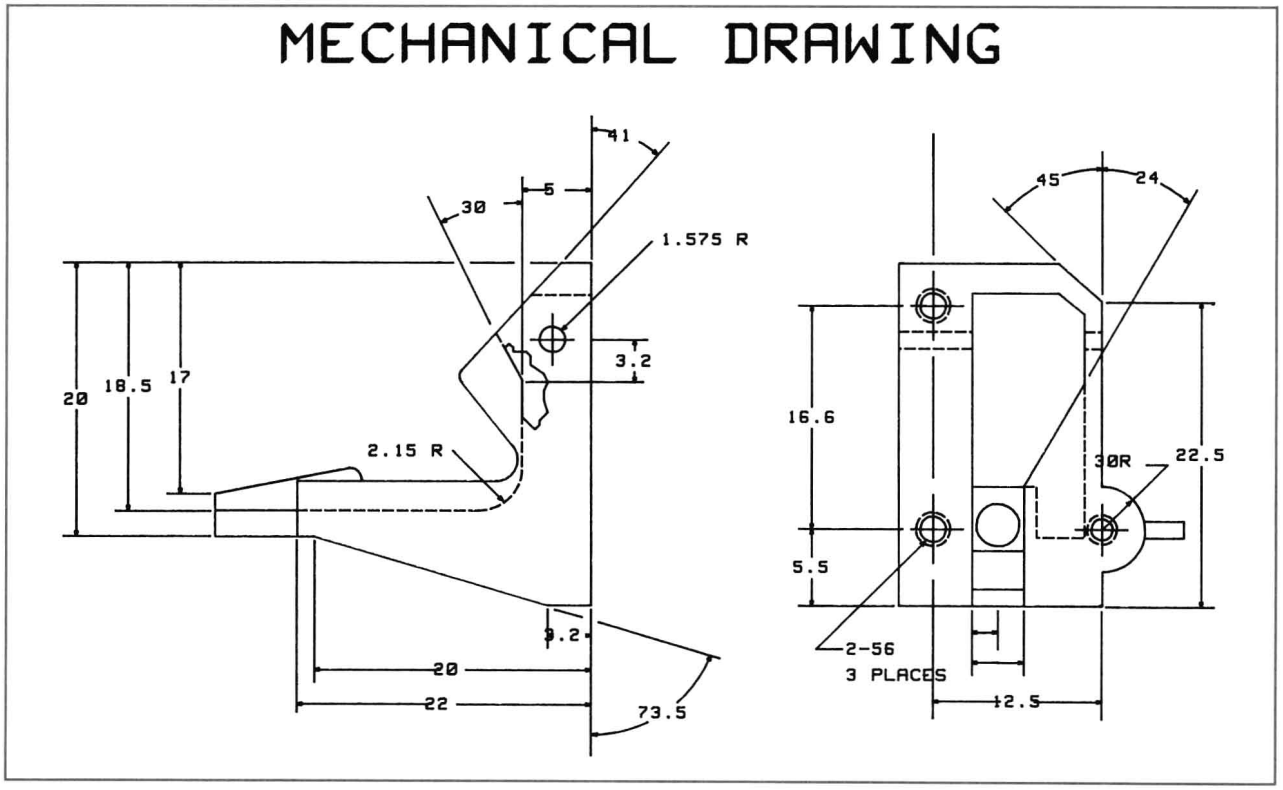

FIG. 5 Example of a two-view drawing generated by a computer-driven pen plotter. *(Courtesy Hewlett-Packard Corp.)*

ing. Computer-generated drawings are at an advantage over hand-done instrument drawings when many drawings are needed but when each has a slight modification over the others, as, say, for designing drive shafts for a common model truck having only different wheelbase options. Also, computer drawings are valuable and almost necessary when complicated shapes, such as jet turbine blades, are to be drawn.

Lettering on drawings can be done in several ways. First, is purely freehand, with templates available to assist the hand. Also available are press-on and dry transfers, which are preprinted. Finally, there is computer-

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FIG. 6 Title of rectangular form.

generated lettering, which can be done in many forms. Figure 6 shows one style.

C. Methods of Shape Description Showing the *shape* of a part is a primary purpose of graphic communication. The designer must select the best method available to show shape.

Two basic techniques are used to indicate shape: two-dimensional and three-dimensional. Figure 2 uses a two-dimensional technique known as multiview projection. Figure 7 uses a three-dimensional technique—in particular, the technique of isometric projection. The method of oblique drawing is seen in Fig. 8, while Fig. 4 shows the effects of using a perspective sketch.

With some two-dimensional drawings one view is sufficient to describe a shape, as in Fig. 9. Some objects need two views to show shape, as in Fig. 10. Still other objects may need three views to fully describe shape. Figure 11 indicates such an object. We will learn in Chap. 5 how two-dimensional projection systems are developed and used. Chapter 7 deals with three-dimensional pictorial drawings.

We also will study sectional views. Such views are used to clarify the internal features of "hollow" parts by cutting into the object to show what is inside. Figure 12 shows two views of an object, with one view "cut in half" to let us see visibly what would otherwise be hidden. Chapter 6 is devoted to sectional views.

D. Methods of Size Description In addition to describing shape, one must give the *size* of features of an object. Size is given by "dimensions," which state linear distances, locations, diameters, and other necessary items.

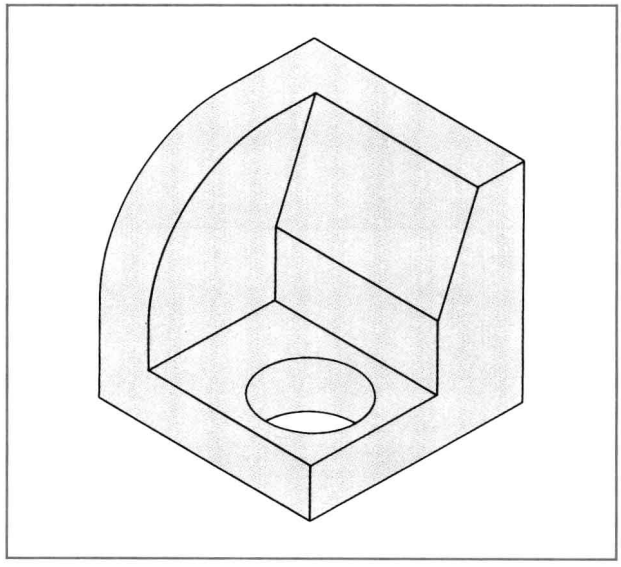

FIG. 7 Isometric drawing. This method is based on turning the object so that three mutually perpendicular edges are equally foreshortened.

A part drawn in multiview projection is shown dimensioned in Fig. 13. The same part is shown dimensioned in Fig. 14, using the oblique-projection form of three-dimensional drawing.

As part of dimensioning, we will study tolerancing, which involves allowing a dimension to vary between a permitted maximum and minimum value. Figure 15 shows a part that is to fit into a slot. The part is always

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