中国工程图学学会图学教育专业委员会推荐

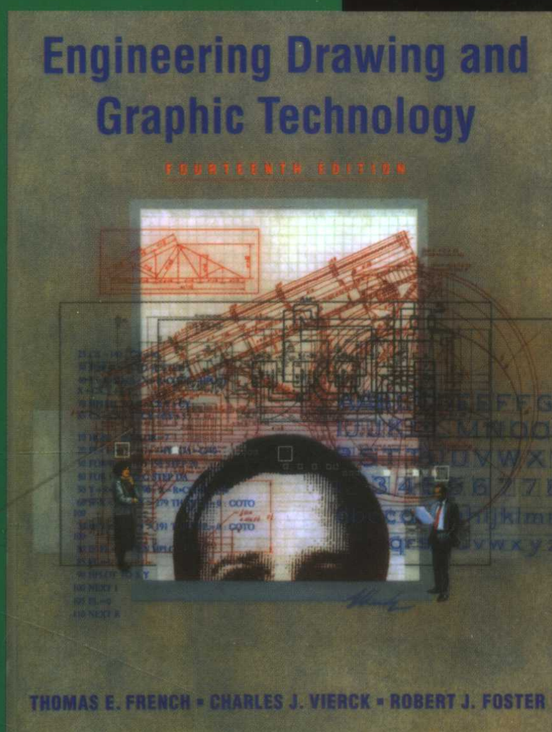
国外大学优秀教材——工程图学系列（影印版）

Thomas E. French, Charles J. Vierck, Robert J. Foster 著

焦永和 改编

# 工程制图与图形技术

## （第14版）




清华大学出版社

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# 工程制图与图形技术

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# Engineering Drawing and Graphic Technology

## (Fourteenth Edition)

Thomas E. French
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# 丛 书 序 言

本套丛书是由清华大学出版社和中国工程图学学会图学教育专业委员会共同策划的。

双语教学是近年来国内高校的教学改革热点之一，目前在数十所高校中已经开展了制图课程的双语教学。

从目前国内开展双语教学的高校使用的教材来看，大体上有以下几种情况：①直接选用欧美原版教材；②中国的制图教师根据我国的教学基本要求改编的原版教材，并以附录的形式讲解投影法和标准方面的差异；③中国的制图教师编写的英文教材；④中国的制图教师编写的中英文对照的双语教材等。

为了给我国高校的制图教师开展双语教学时提供更多的教材选择，也为了使我国高校的广大师生对美国制图课程的现状有更多的了解，清华大学出版社和中国工程图学学会图学教育专业委员会决定出版这套丛书。经过编委会一年多的分析与研究，我们从数十本美国原版教材中选择了 6 本构成了本套丛书，包括机械类的制图教材两本，近机械类与非机械类的制图教材两本，CAD 与计算机图形学方面的教材两本。需要说明的是美国的制图教材并未按照上述方式分类，所谓不同的类别是由本套丛书的编委会根据其内容来确定的。

由于美国原版教材的内容远远多于我国同类教材的内容，编委会根据我国的实际情况，以“教学基本要求”为依据，对其内容进行了删减，在这一过程中，未对原版教材作任何改写，以保证其“原汁原味”的风格。我们希望通过这种方法，给开展制图课双语教学的院校提供一套既能保持原版教材风貌，又符合我国实际情况的英语教材。

最后，清华大学出版社及本套丛书的编委会对积极提供样书供编委会选择的美国麦格劳-希尔公司和培生公司表示衷心的感谢，是他们的积极配合使得这套丛书得以顺利出版。

限于改编者的水平，书中不当之处在所难免，欢迎广大读者批评指正。

国外大学优秀教材——工程图学系列编委会

2007 年 3 月

# 影印版序言

本书原版有22章，分为4篇： A基础图学；B空间几何基础；C应用图学与设计；D特殊题目。书后还有46个附录和1个索引，共计745页。全面覆盖了工程制图与图学技术的主要内容，较好地处理了课程内容的基础性与先进性的关系。

在本书影印时考虑到我国的教学基本要求、授课学时以及现有教材的实际情况，对原书作了必要的删节。具体如下：

(1) 删去第2章后面的比例练习部分，大约4页。这部分内容以英制为长度单位，与我国具体情况不符。

(2) 删去第4章，共19页。这章内容为文字书写基础，所介绍的文字书写规范均为美国标准。

(3) 删去第8章中的部分内容，大约15页。这部分内容为几何公差，所介绍的公差规范均为美国标准。

(4) 删去第11章，共17页。这章内容为展开图的绘制，在我国的教学基本要求中无此内容。

(5) 删去第12章，共21页。这部分内容为设计简介，介绍设计与材料、结构的关系等，在我国的教学基本要求中无此内容。

(6) 删去第14、15章，共84页。第14章介绍加工工具与绘图，第15章介绍数据处理与图形，如用离散点拟和的曲线图、等值线图等，在我国的教学基本要求中无此内容。

(7) 删去第18、19、20、21、22章，共80页。这几章的内容分别为焊接与铆接、电子电气工程图、管路图、结构图、地形图等，在我国的教学基本要求中无此内容。

(8) 删去附录8~44，共62页。这部分内容均为美国标准。

以上删去内容约占全书的45%。

经过删节处理后，本书页眉保留原版书的页码，页脚是连续的新书页码。文中提到的页码均为原版书页码。本书目录保留原版书目录，目录中的页码为原版书页码，与正文页眉处的页码对应，有的内容或页码有可能已被删除从而无法找到，由此给读者带来不便，敬请谅解。

北京理工大学　焦永和

2006年8月

# 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.

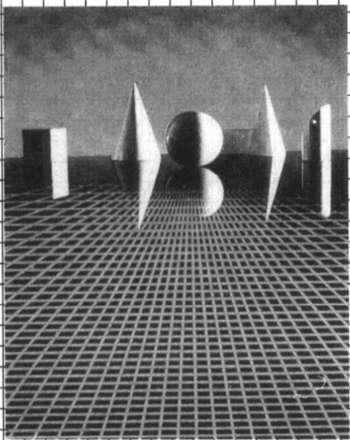
Roger J. Foster

# CONTENTS

## D. SPECIAL TOPICS

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.

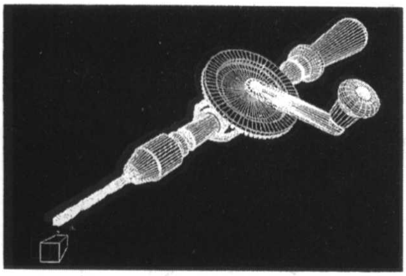


**FIG. 1** 3-D CAD. *(Courtesy AutoDesk, Inc.)*

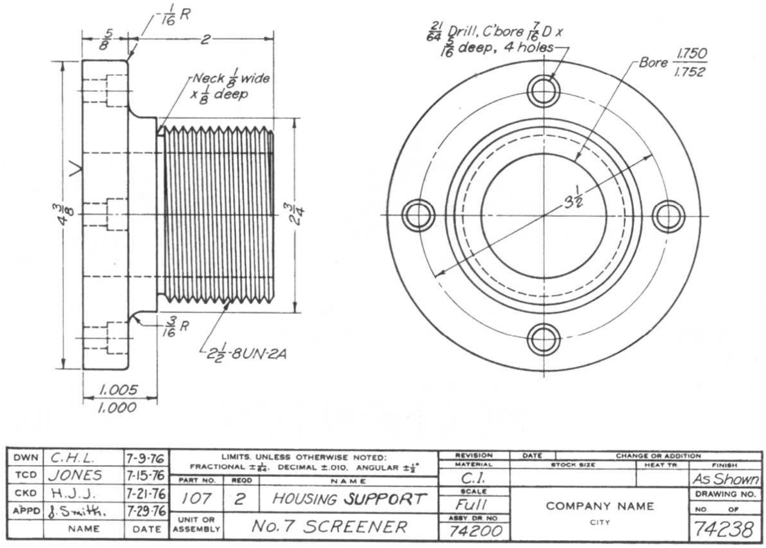



**FIG. 2** Example of a two-view drawing drawn by hand-held instruments. The lettering is freehand.

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-

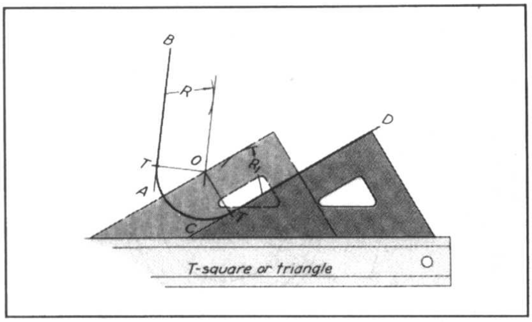



**FIG. 3 Graphic geometry.** Here one is making an arc tangent to two straight lines.

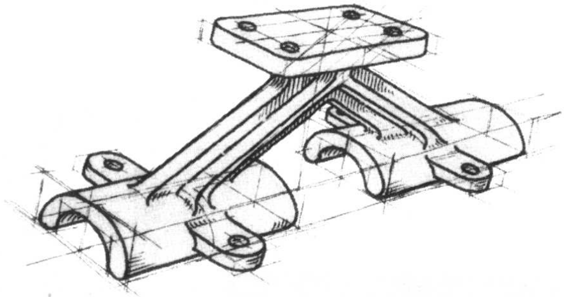


**FIG. 4** A two-point perspective sketch.

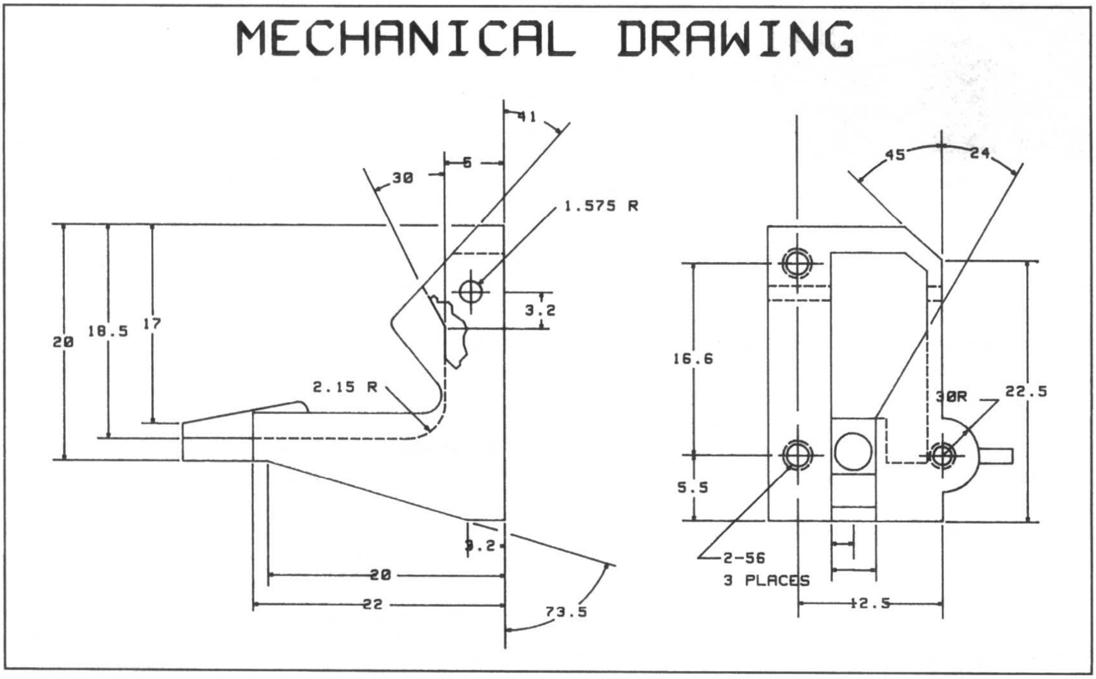



**FIG. 5** Example of a two-view drawing generated by a computer-driven pen plotter. *(Courtesy Hewlett-Packard Corp.)*

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-

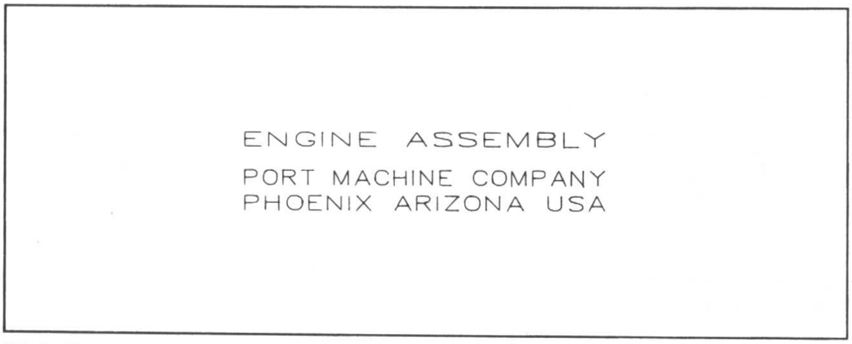



**FIG. 6** Title of rectangular form.

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.

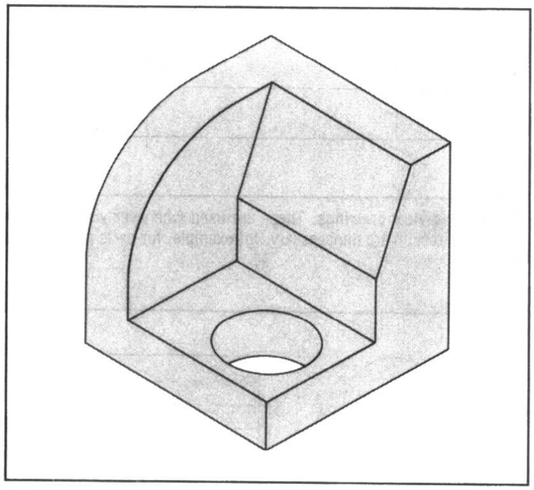


**FIG. 7 Isometric drawing.** This method is based on turning the object so that three mutually perpendicular edges are equally foreshortened.

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

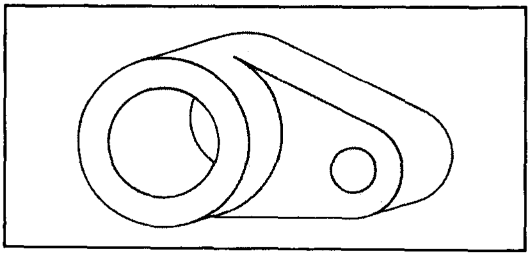


**FIG. 8 Oblique drawing.** This pictorial method is useful for portraying cylindrical parts. Projectors are oblique to the picture plane.

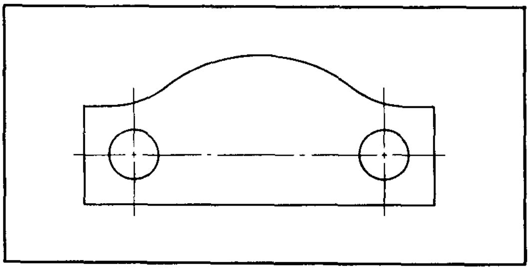


**FIG. 9 One-view drawings.** These are used whenever views in more than one direction are unnecessary, for example, for parts made of thin *material*.

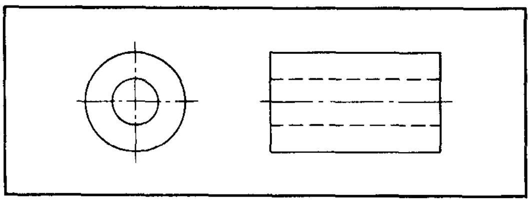


**FIG. 10 Two-view drawings.** Parts such as cylinders require only two views. More would duplicate the two already drawn.

smaller in size than the slot. Therefore the part will fit into the with what is known as a "clearance fit."

Another type of tolerancing is geometric tolerancing, which controls the form of a part in regard to its flatness, perpendicularity, or roundness, for example. The boxed-in symbols in Fig. 16 are controls for various geometric tolerances.

**E. Methods of Measurement: English vs. Metric** There is much more to the description of size than learn-

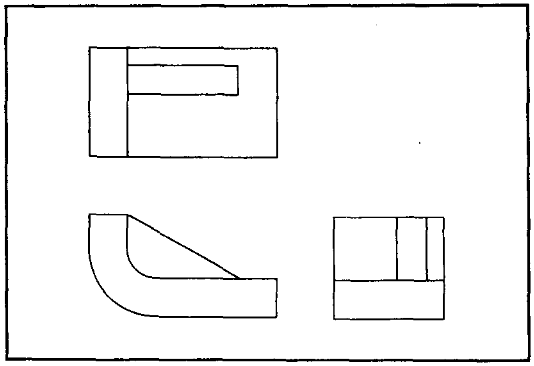


**FIG. 11 Three-view drawings.** Most objects are made up of combined geometric solids. Three views are required to represent their shape.

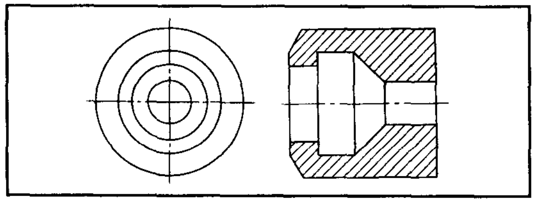


**FIG. 12 Sectional views.** These are used to clarify the representation of objects with complicated internal detail.

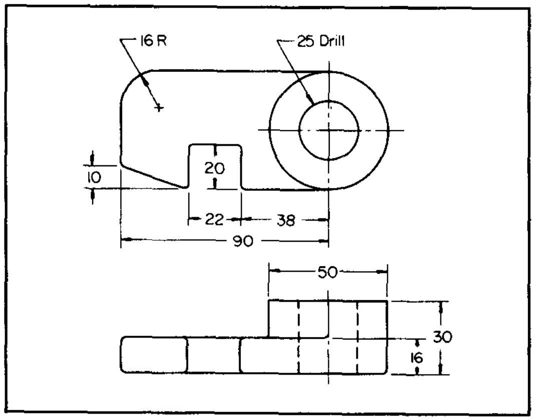



**FIG. 13 METRIC. Dimensioning orthographic drawings.** Dimensions showing the magnitude and relative position of each portion of the object are placed on the view where each dimension is most meaningful.

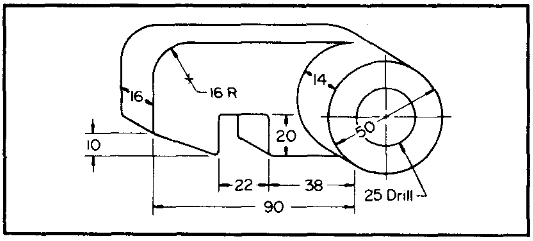



**FIG. 14 METRIC. Dimensioning pictorial drawings.** The descriptions of magnitudes and positions are shown on the pictorial by dimensions placed so as to be easily readable.

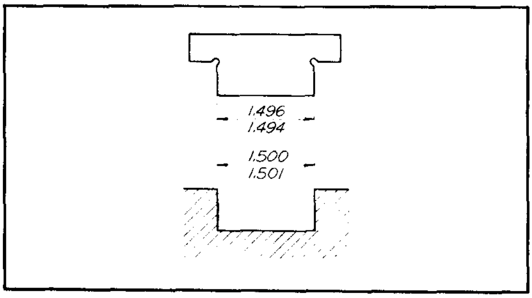



**FIG. 15** An example of limit dimensioning. Tolerance on tongue, 0.002 in.; tolerance on groove, 0.001 in.; min. clearance, 0.004 in.

ing the standards and rules for the placement of dimensions on drawings.

First of all, the system of measurement and evaluation must be known and understood. History records many different evaluation systems. These are well known and documented. Of all recorded methods, two systems have withstood the test of time—the English system and the metric system. The metric system has been adopted and used by almost all countries except the United States.

It is not probable the United States will ever become a fully metric nation, but many U.S. industries are largely metric. Companies having extensive overseas sales, such as aerospace, construction equipment, and automotive, have made major commitments to the use of metric units. The international metric system is known as the *SI system* and is approved by the National Bureau of Standards. Drafters must be reasonably familiar with the metric system. While designers must know well all units of metric (length, substance, current, temperature, light, etc.), a drafter needs to know mainly the unit of length. The metric unit of length is the meter; its subdivisions are the centimeter and millimeter. Common SI unit prefixes and symbols are given in the appendix.

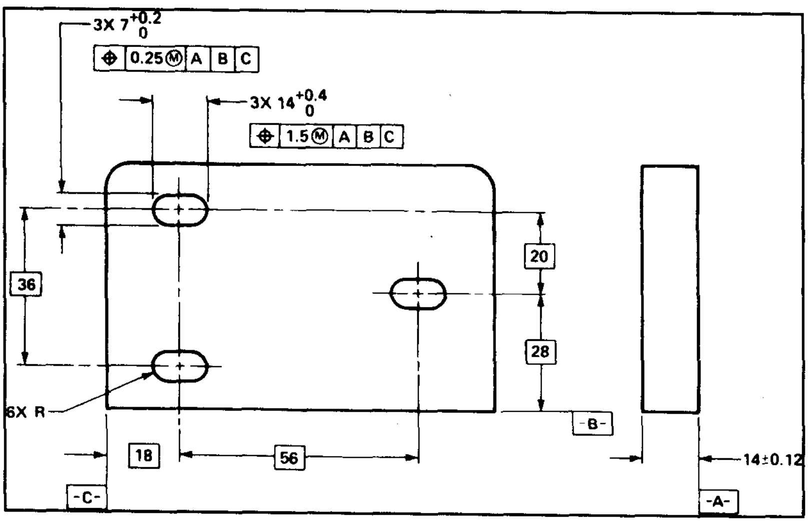



**FIG. 16** Use of geometric tolerancing. (ANSIY14.5M.)

### 3. SPACE GEOMETRY

Space geometry is the application of the theory of projection to the solution of space problems. Machines and structures are made up of geometric elements combined in various ways. The many points, lines, and planes are combined to form parts of a design. The determination of position, clearance, and movement of parts is a vital consideration, and may involve parallelism, perpendicularity, or angularity of the various lines and planes. Analyzing the relationships among points, lines, planes, and solids requires space geometry. An example of space geometry is seen in Fig. 17, where the normal view of an oblique is found.

Auxiliary views can also help to clarify shape. Auxiliary views can be used to show the so-called normal view of a slanted surface. In Fig. 18 an auxiliary view is used to show the true shape of the semicircular portion of the part.

The accuracy obtained in manually solving space problems is often sufficient. For greater accuracy, mathematical or computer analyses are possible. In any case, a graphic representation is helpful for a complete understanding of the space problem.

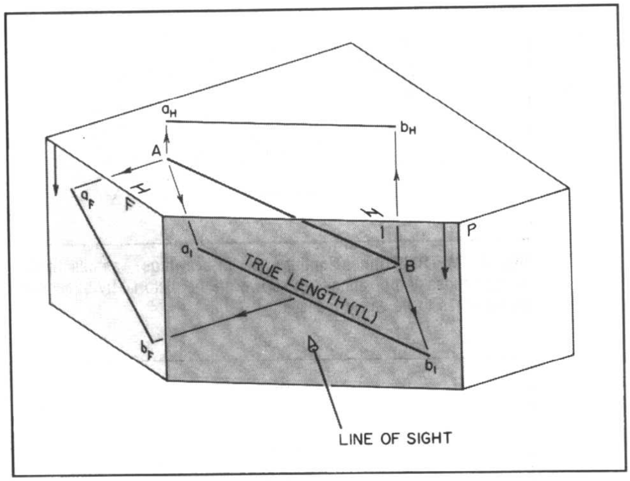



**FIG. 17** Projection box to show a normal view of an oblique line.

### 4. APPLIED GRAPHICS AND DESIGN

The end point of all graphical knowledge is its use in design. Engineering and engineering technology are by definition design-oriented. Design can take various forms, but in general there are three basic forms of design: system design, hardware design, and software design.

System design involves complex networks of interlinking variables, all requiring research and study. An example of a system design is a subway system for a major city. The problem is complex. There are sociological considerations, such as the effect of building construction on neighborhoods. There are vast economic considerations. There are numerous engineering problems, involving many branches of engineering: civil, mechanical, electrical. To handle system design within a single book or even a single course is difficult and rarely undertaken. One usually contributes to system design by being part of a team working on the actual design project.

Hardware design involves finite bits and pieces brought together to form a working product, which could be anything from an electric iron to landing gear for an airplane to a microcomputer. Hardware design is considered to be a subset of system design and is there-

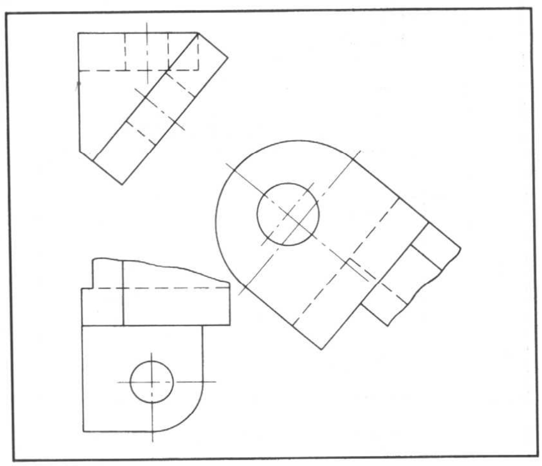


**FIG. 18** Auxiliaries are used to show the *normal view* (true size and shape) of an inclined surface (at an angle to two of the planes of projection).