THE FUNDAMENTALS OF ENGINEERING DRAWING AND GRAPHIC TECHNOLOGY

French and Vierck

Third Edition

THE FUNDAMENTALS OF ENGINEERING DRAWING AND GRAPHIC TECHNOLOGY

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This book was set in News Gothic by York Graphic Services, Inc., and printed and bound by R. R. Donnelley & Sons Company. The designer was John Horton. The editors were B. J. Clark, Peter Karsten, and J. W. Maisel. John F. Harte supervised production.

THE FUNDAMENTALS OF ENGINEERING DRAWING AND GRAPHIC TECHNOLOGY

PREFACE

The graphics of engineering design and construction may very well be the most important course of all studies for an engineering or technical career. The indisputable reason why graphics is so extremely important is that it is the *language of the technician, and engineer,* used to communicate design and construction details to others. No matter how knowledgeable an engineer may be concerning the highly complex technical and scientific aspects of his profession, without a command of graphics he would be completely ineffectual simply because he would fail miserably in transmitting his information to others. All the technical people working under the direction of an engineer also must have the same command of the language. The language of graphics is written in the form of drawings which represent the shape, size, and specifications of physical objects. The language is read by interpreting drawings so that physical objects can be constructed exactly as originally conceived.

Sometimes drawings will be made freehand for technicians to follow in making final finished drawings. At other times, depending largely on complexity, engineers may make accurate instrument drawings to be followed in making final drawings. This, incidentally, does not mean that the engineer never makes a final drawing because, depending largely upon the size of the organization, he may do so. In any case, the engineer must be able to check and approve of the final drawings made by others. Thus, it is absolutely necessary for the engineer to have a comprehensive command of the language.

Technicians must also have a complete command of the language, because as a project is worked on and brought to completion, the sketches and drawings record ideas and really become an integral part of technical thinking.

The study of graphics continues to increase in importance. Leading industries have practically demanded that the schools of engineering and technology include more courses in the curriculum. There has also been much discussion of the importance, the trends, and the procedures in the meetings and publications of the ASME, SAE, ASEE, and other organizations.

This textbook is limited in scope to the fundamentals of graphic representation. However, in Chapter 1, a more complete listing of graphic subjects is given, including the fundamentals of design, screw threads and fasteners, welding and riveting, jigs and fixtures, gears and cams, piping, electric systems, structures, and maps and topography. Coverage of these subjects will be found in Engineering Drawing and Graphic Technology, by the authors of this book (McGraw-Hill, 1972. Library of Congress card number 70-38135).

This textbook represents many years of study not only in teaching, engineering experience, and writing, but also painstaking attention to book design principles and usage. A carefully considered plan to make this book more readable and readily usable has been employed.

The two-column format promotes readability and also provides flexibility in the location and size of accompanying illustrations. The illustrations have been outlined to accent their area, allow the use of captions within the enclosed area, and positively relate caption and illustration. Running heads give the chapter number and title as well as the page number for easy reference and to facilitate the location of assigned material. Each chapter has an opening photograph typifying covered material. The accompanying opening page not only lists chapter title and number but also gives a stylized outline of the topics covered, matching the description given in the table of contents. The table of contents not only gives chapter titles and numbers, but briefly gives details of the chapter subjects. The new type faces for reading material and captions have been chosen for maximum clarity and readability. Figure numbers are individual numbers within the chapter, a simplification made possible because of chapter

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number and title identified on each page spread. This eliminates the necessity of identifying the chapter number with each figure number. Problem numbers are also continuous in each chapter.

The use of color is a strong part of the overall book design. The choice of color and the details of its use have been carefully worked out to give maximum readability and to promote reader interest. Research on teaching methods has proved that page makeup, effective use of color, illustration placement, and caption content aid greatly in the processes of learning and retention.

A book of such scope and completeness requires cooperation between the author and all other persons involved in bringing the work to fruition. The frank, honest, and sometimes extensive discussion with associates is highly valued, along with the assistance of Esther E. Vierck in the total effort necessary to bring this work to completion.

Charles J. Vierck

ENGINEERING DRAWING FILMS

THE FOLLOWING 16-mm sound motion pictures are especially recommended for use with various chapters of this book:

According to Plan. An introduction to engineering drawing (9 min). *For Chap. 1.*

Orthographic Projection. Shape description and the principles of orthographic projection (18 min). *For Chap. 5.*

Pictorial Sketching. Basic principles of axonometric, oblique, and perspective pictorial sketching (11 min). *For Chap. 6.*

Auxiliary Views: Single Auxiliaries. Reviews orthographic projection and explains auxiliary projection (23 min). *For Chap. 7.*

Auxiliary Views: Double Auxiliaries. The theory and practice of double-auxiliary or oblique view (13 min). *For Chap. 7.*

Sections and Conventions. Theory and practice of sectioning and conventional principles (15 min). *For Chap. 8.*

Simple Developments. What simple developments are and how they are used (11 min). *For Chap. 9.*

Oblique Cones and Transition Developments. Animated drawings illustrate oblique cones and transitions (11 min). *For Chap. 9.*

Drawings and the Shop. Relationships between the drawing and production operations in the shop; basic machines (15 min). *For Chap. 10.*

Selection of Dimensions. Principles governing choice of dimensions and their applications (18 min). *For Chap. 11.*

Prints of these films may be purchased from Text-Film Department, McGraw-Hill Book Company.

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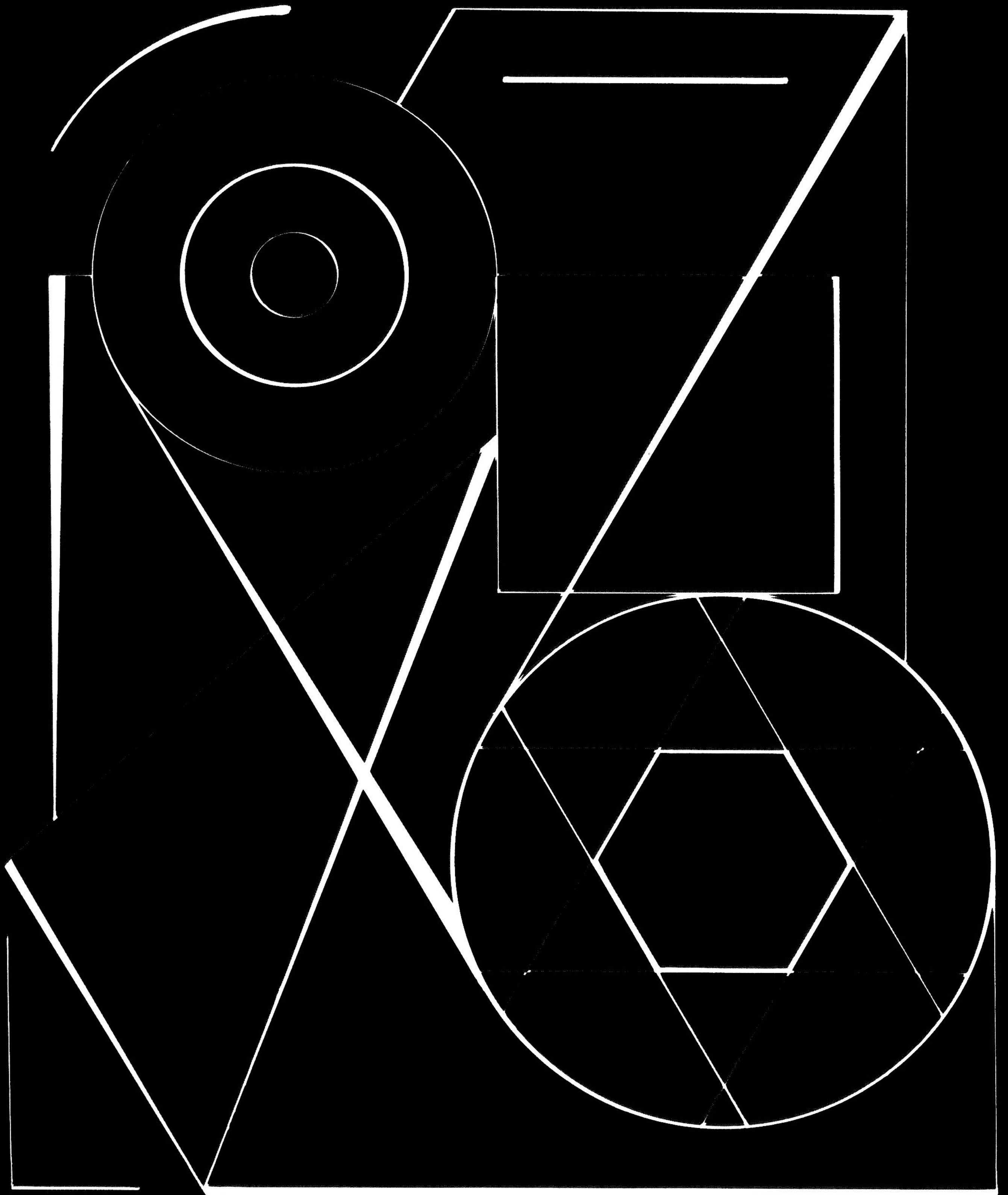


This Chapter Outlines the Graphic Language

Basic Concepts—Writing and Reading

Essentials—Lines and Lettering

Methods of Expression

Methods of Shape Description—Orthographic and Pictorial

Auxiliaries, Sections, Intersections, Developments

Methods of Size Description

Charts and Graphs

The Fundamentals of Design

Basic Machine Elements—Screw Threads, Fasteners, Keys, Springs

Welding and Riveting

Jigs, Fixtures, Gears, Cams

Piping; Drawings of Electrical Systems, Structures, Maps and Topography

Drawings for Engineering Design and Construction

1

INTRODUCTION

This Chapter Outlines the Graphic Language in Theory and Practice

1. The Graphic Language—Theory and Practice.

In beginning the study of graphics, you are embarking upon a rewarding educational experience and one that will be of real value in your future career. When you have become proficient in it, you will have at your command a method of communication used in all branches of technical industry, a language unequaled for accurate description of physical objects.

The importance of this graphic language can be seen by comparing it with word languages. All who attend elementary and high school study the language of their country and learn to read, write, and speak it with some degree of skill. In high school and college most students study a foreign language. These word languages are highly developed systems of communication. Nevertheless, any word language is inadequate for describing the size, shape, and relationship of physical objects. Study the photograph at the opening of this chapter and then try to describe it verbally so that someone who has not seen it can form an accurate and complete mental picture. It is almost impossible to do this. Even a picture such as Fig. 1, although possibly easier to describe, presents an almost insurmountable problem. Furthermore, in trying to describe either picture, you may want to use pencil and paper to sketch all or a part in an attempt to make the word description more complete, meaningful, and accurate, or tend to use your hands, gesturing to aid in explaining shape and relationship. From this we can see that a word language is often without resources for accurate and rapid communication of shape and size and the relationships of components.

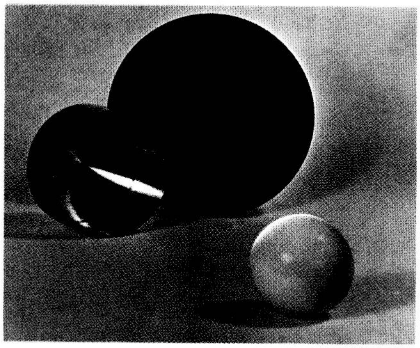


FIG. 1. Try to describe in words the shape, the relative size, and the position of the objects in this picture.

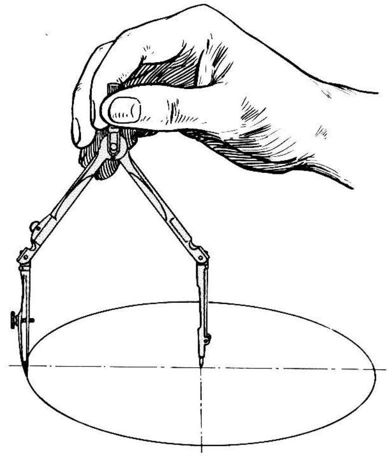
Engineering is applied science, and communication of physical facts *must* be complete and accurate. Quantitative relationships are expressed mathematically. The written word completes many descriptions. But whenever machines and structures are designed, described, and built, graphic representation is necessary. Although the works of artists (or photography and other methods of reproduction) would provide pictorial representation, they cannot serve as engineering descriptions. Shaded pictorial drawings and photographs are used for special purposes, but the great bulk of engineering drawings are made in line only, with separate views arranged in a logical system of projection. To these views, dimensions and special notes giving operations and other directions for manufacture are added. This is the language of graphics which can be defined as *the graphic representation of physical objects and relationships.*

As the foundation upon which all designing and subsequent manufacture are based, engineering graphics is one of the most important single branches of study in a technical school. Every engineering student must know how to make and how to read drawings. The subject is essential in all types of engineering practice, and should be understood by all connected with, or interested in, technical industry. All designs and directions for manufacture are prepared by draftsmen, professional writers of the language, but even one who may never make drawings must be able to read and understand them or be professionally illiterate. Thorough training in engineering graphics is particularly important for the engineer because he is responsible for and specifies the drawings required in his work and must therefore be able to interpret every detail for correctness and completeness.

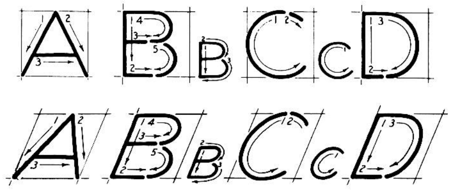
Our object is to study the language of graphics so that we can write it, expressing ourselves clearly to one familiar with it, and read it readily when written by another. To do this, we must know its basic theory and composition, and be familiar with its accepted conventions and abbreviations. Since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

This language is entirely graphic and written, and is interpreted by acquiring a visual knowledge of the object represented. A student's success with it will be indicated not alone by his skill in execution, but also by his ability to interpret lines and symbols and to visualize clearly in space.

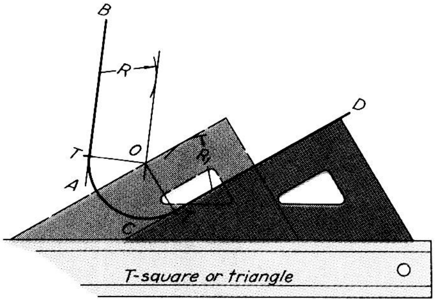
In the remainder of this chapter we shall introduce briefly the various aspects of graphics that will be discussed at length later. It is hoped that this preview will serve as a broad perspective against which the student will see each topic, as it is studied, in relation to the whole. Since our subject is a graphic language, illustrations are helpful in presenting even this introductory material; figures are used both to clarify the text and to carry the presentation forward.



THE USE OF GRAPHIC INSTRUMENTS. Facility in the use of instruments makes for speed and accuracy.



LETTERING. The standard lettering for engineering drawings is known as "commercial Gothic." Both vertical and inclined styles are used.



GRAPHIC GEOMETRY. A knowledge of, and facility in, the construction of lines and geometric figures promotes efficiency.

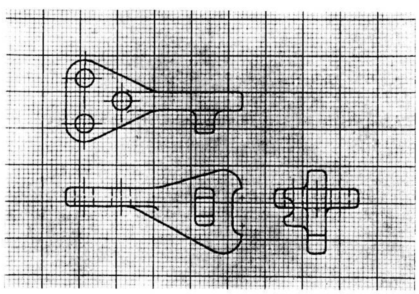
2. Essentials of Graphic Writing: Lines and Lettering.

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. Proficiency in the methods of drawing straight lines, circles, and curves, either freehand or with instruments, and the ability to letter word statements are fundamental to writing the graphic language. Furthermore, 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.

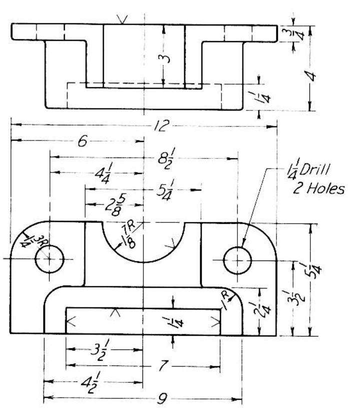
3. Methods of Expression.

There are two fundamental methods of writing the graphic language: freehand and with instruments.

Freehand drawing is done by sketching the lines with no instruments other than pencils and erasers. It is an excellent method during the learning process because of its speed and because at this stage the study of projection is more important than exactness of delineation. Freehand drawings are much used commercially for preliminary designing and for some finished work. Instrument drawing is the standard method of expression. Most drawings are made "to scale," with instruments used to draw straight lines, circles, and curves concisely and accurately. Training in both freehand and instrument work is necessary for the engineer so that he will develop competence in writing the graphic language and the ability to judge work done under his direction.



FREEHAND DRAWINGS. The freehand method is fine for early study because it provides training in technique, form, and proportion. It is used commercially for economy.



INSTRUMENT DRAWINGS. Because of the necessity of drawing "to scale," most drawings are made with instruments.

4. Methods of Shape Description.

Delineation of the *shape* of a part, assembly, or structure is the primary element of graphic communication. Since there are many purposes for which drawings are made, the engineer must select, from the different methods of describing shape, the one best suited to the situation at hand. Shape is described by projection, that is, by the process of causing an image to be formed by rays of sight taken in a particular direction from an object to a picture plane.

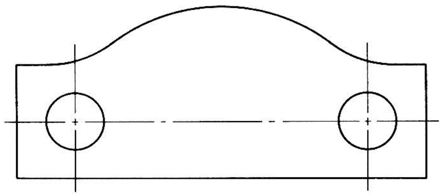
Following projective theory, two methods of *representation* are used: orthographic views and pictorial views.

For the great bulk of engineering work, the orthographic system is used, and this method, with its variations and the necessary symbols and abbreviations, constitutes an important part of this book. In the orthographic system, separate views arranged according to the projective theory are made to show clearly all details of the object represented. The figures that follow illustrate the fundamental types of orthographic drawings and orthographic views.

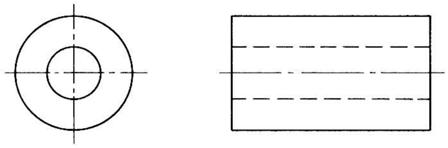
"Pictorial representation" designates the methods of projection resulting in a view that shows the object approximately as it would be seen by the eye. Pictorial representation is often used for presentation drawings; text, operation, and maintenance book illustrations; and some working drawings.

There are three main divisions of pictorial projection: axonometric, oblique, and perspective. Theoretically, axonometric projection is projection in which only one plane is used, the object being turned so that three faces show. The main axonometric positions are isometric, dimetric, and trimetric.

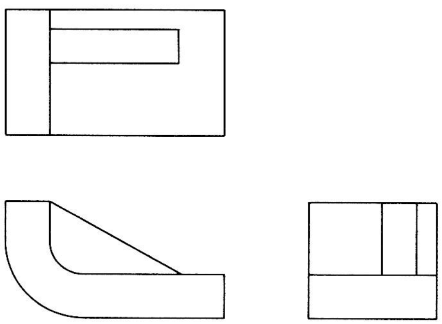
Oblique projection is a pictorial method used principally for objects with circular or curved features only on one face or on parallel faces; and for such objects the oblique is easy to draw and dimension. Perspective projection gives a result identical with what the eye or a single-lens camera would record.



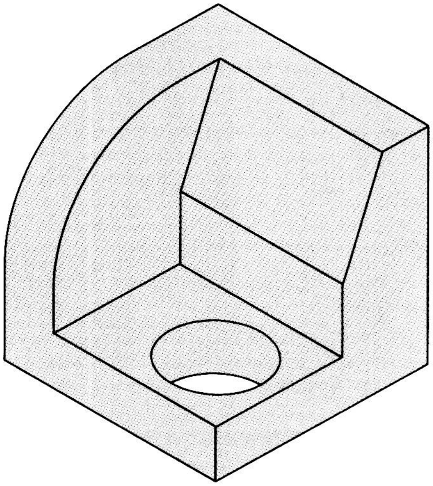
ONE-VIEW DRAWINGS. These are used whenever views in more than one direction are unnecessary, for example, for parts made of thin material.



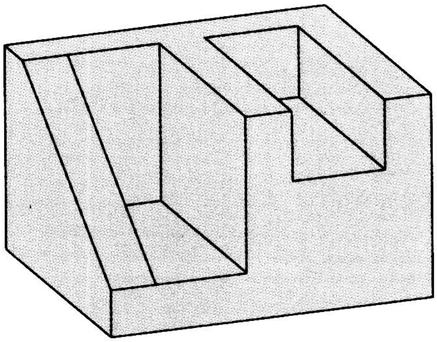
TWO-VIEW DRAWINGS. Parts such as cylinders require only two views. More would duplicate the two already drawn.



THREE-VIEW DRAWINGS. Most objects are made up of combined geometric solids. Three views are required to represent their shape.



ISOMETRIC DRAWING. This method is based on turning the object so that three mutually perpendicular edges are equally foreshortened.



DIMETRIC DRAWING. This method is based on turning the object so that two mutually perpendicular edges are equally foreshortened.

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