

SECOND EDITION

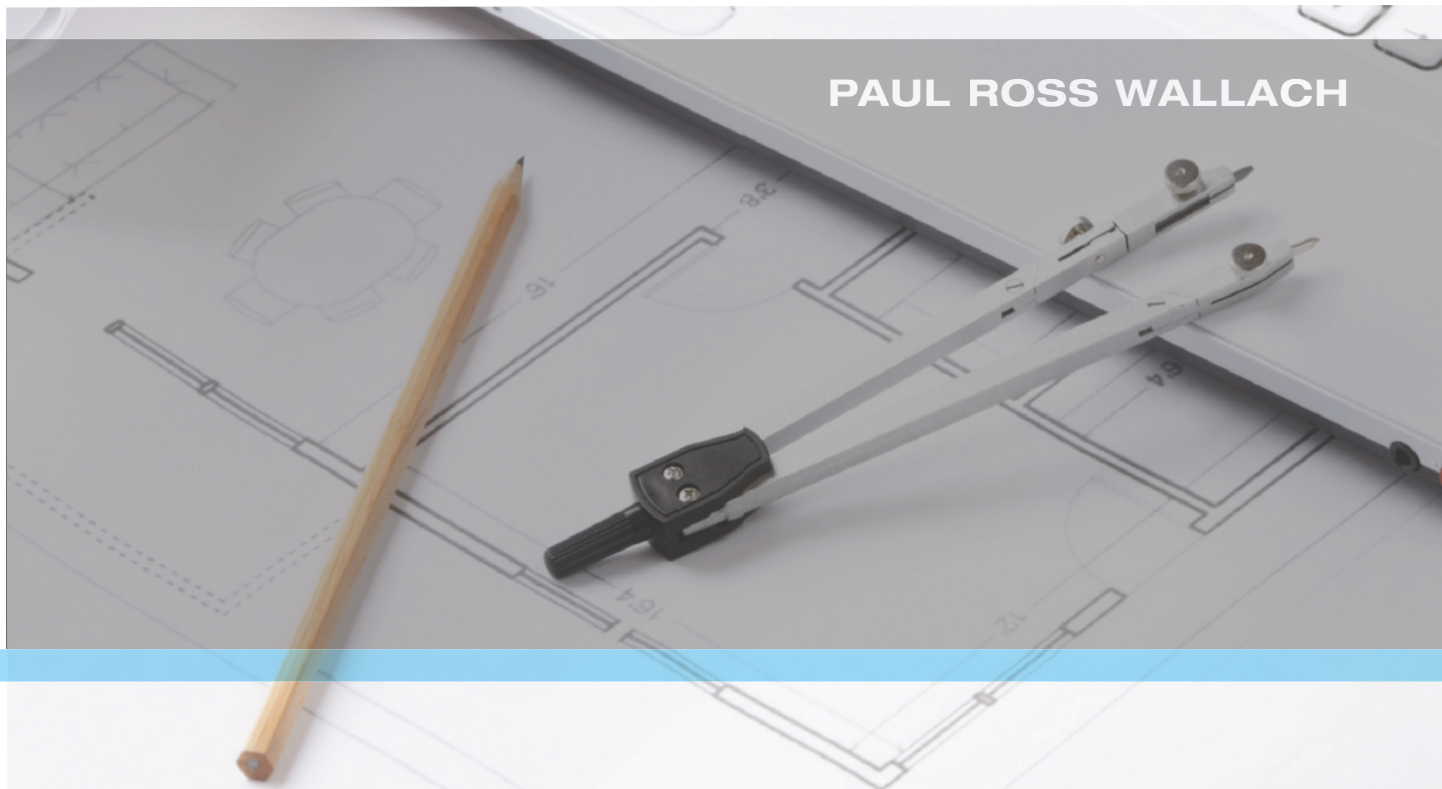
fundamentals of Modern Drafting



PAUL ROSS WALLACH

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Modern Drafting

SECOND EDITION



PAUL ROSS WALLACH



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**Fundamentals of Modern Drafting,
Second edition**

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PREFACE

A Word from the Author

With the increasing development of industry and new breakthroughs in technology, there will always be a large demand for qualified engineers and drafters. With this demand comes the need for qualified schools and instructional materials to provide students with the skills they need to compete in today's workplace.

I would like to welcome you to this student-oriented engineering drawing textbook. *Fundamentals of Modern Drafting* provides the basic information and skill-building procedures of modern design and drafting techniques. The many drafting and design exercises in this text may be performed with either manual drafting, CAD, or freehand sketching techniques. Each chapter is designed to teach basic drafting concepts and skills in a logical order using the latest ASME conventions. The concepts and drawing exercises for each chapter progress from simple to complex. This will ensure beginning students a degree of success and offer sufficient materials for more advanced students. Many of the drafting concepts are presented with visual step-by-step illustrations.

The last chapter contains concise but complete instructional materials and exercises to design and draw residential working drawings.

Note to Instructors

It is critical that the students understand the design and drawing concepts of engineering and architectural drawing *before* they start creating drawings with a CAD system. Designing and drawing with a CAD system without this basic knowledge will not create any good-quality or useful working drawings.

Supplements

The Instructor's Companion Web Site to Accompany *Fundamentals of Modern Drafting* offers free resources for instructors to enhance the educational experience. The Web site contains the following features:

- Slides created in PowerPoint, which outline key concepts from each chapter
- Test bank to evaluate student learning

Features of this Text

Fundamentals of Modern Drafting fulfills the need for an instructional drafting text that will teach the fundamentals of engineering drawing through sketching, instrument drafting, and introductory CAD skills. Some of the special features include the following:

- Each chapter opens with objectives and sets the stage for clear and concise learning.
- Over 1,300 illustrations and photographs help clarify the content and aid students in reading two-dimensional and three-dimensional working drawings.
- Step-by-step procedural illustrations take the students through the concepts of drafting, design, and layouts.
- Key terms are highlighted within the text and listed at the end of each chapter to reinforce important concepts and terminology.
- Each chapter will develop and strengthen specific technical concepts, allowing the student to develop proficiency in solving drafting problems.
- All chapters are organized in a logical sequence; however, each chapter may be used as a stand-alone unit of instruction.
- No previous drafting knowledge is required to use this textbook.
- Exercises at the end of each chapter start with simple concepts and become progressively more complex.
- Students use the following methods to solve end-of-chapter exercises:
 - Freehand sketching
 - Instrument drafting
 - CAD system drawings
 - Special design exercises
 - Engineering change orders (ECOs)
 - Inch-decimal, inch-fraction, and metric units of measure

Chapter Overview

Chapter 1 presents an introduction to modern industry. Specific careers related to drafting also give the students an insight into occupational options.

Chapters 2 through 7 give the student the background needed to learn and draw the basic drafting concepts with: sketching, instruments, drafting supplies, lettering, formats, conventions, and an overview of CAD. The latest ASME standards are used throughout the text. Chapter 5 offers instruction on how students can use their creativity and drafting skills in a design team.

Chapters 8 through 15 teach the students the concepts of mechanical drafting required to design and draw finished multiview drawings, dimensioning, tolerancing, sectional drawings, auxiliary drawings, revolutions, descriptive geometry, development drawings, and pictorial drawings.

Chapters 16 through 24 teach students how to prepare finished working drawings that are required for production: fasteners, drafting systems, working drawings, welding drawings, gear drawings, cam drawings, piping drawings, electronics drawings, jig and fixture drawings, green planning in industry, and architectural drawings.

Standards

The language of drafting is a uniform and standardized system that is used throughout the world. The standards for the U.S. Customary system are developed by the American Society of Mechanical Engineers (ASME). The standards for the metric system are developed by the International Organization for Standardization (ISO). Careful attention was given to the dimensioning and tolerancing chapters (ASME Y14.5).



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Harrison, Tennessee

Ed Wheeler
University of Tennessee at Martin
Martin, Tennessee

“This textbook is dedicated to Mike Robbins”

Introduction to Contemporary Drafting

OBJECTIVES

The student will be able to:

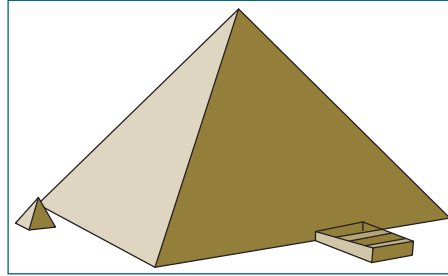
- Relate to the historical development of drafting
- State the importance and need for drafting as a technical communication skill
- State how drafting is used in different industrial fields as the major source of communication
- Identify the roles and responsibilities of various drafting specialists
- Recognize the levels of education, training, and experience required for the various professional and drafting positions

History

Prehistoric people drew crude drawings in the soil and cave walls long before people were able to write (**Figure 1-1**). Drawings have been used throughout history as an art form and a method of communication. As time progressed, drawing instruments and drawing surfaces, such as stone and clay tablets, limestone, wood and **parchment** made from the papyrus plant, were developed and refined. During the years of 3,600 BC. the first Egyptian pyramid was built using detailed construction drawings (**Figure 1-2**). Other historical buildings that used construction drawings for their construction was the **Parthenon** in Greece in 447 BC. (**Figure 1-3**), and the Roman Coliseum in 72 BC. (**Figure 1-4**). These are only a few of the very early structures designed and constructed with detailed drawings on parchment. By the first century AD, Romans were using detailed instrument drawings that were dimensioned for their building projects of roadways, aqueducts, and buildings. It was not until the fifteenth century that two-dimensional working drawings were used to produce products. Note a few of Leonardo da Vinci's (1452–1519) drawings of his inventions from 500 years ago (**Figure 1-5**). Can you tell what their functions are?



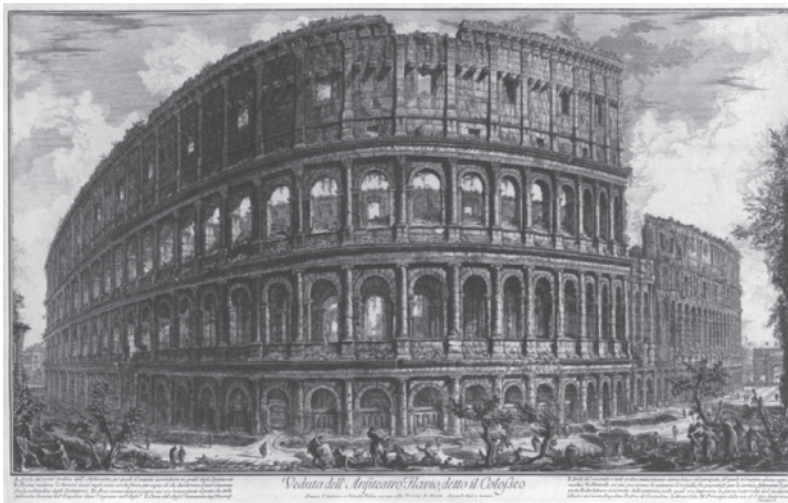
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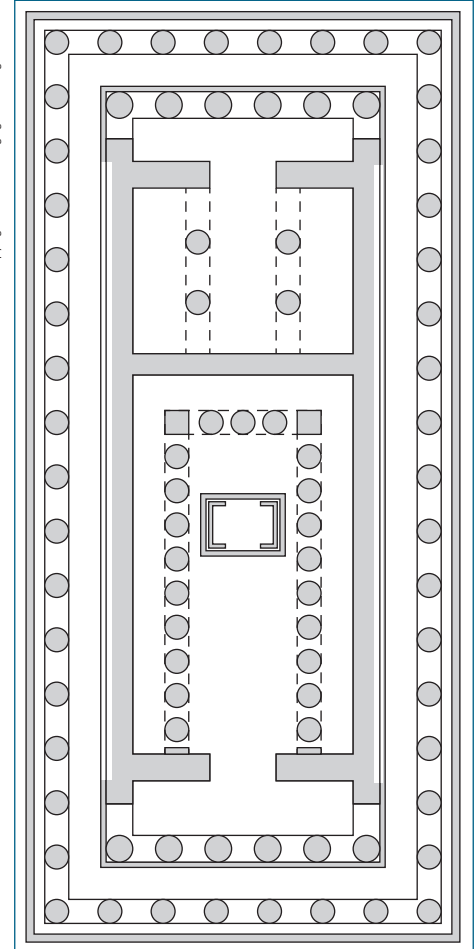
Figure 1-1 Early humans drew crude pictures on cave walls.

Figure 1-2 Egyptian Pyramid.



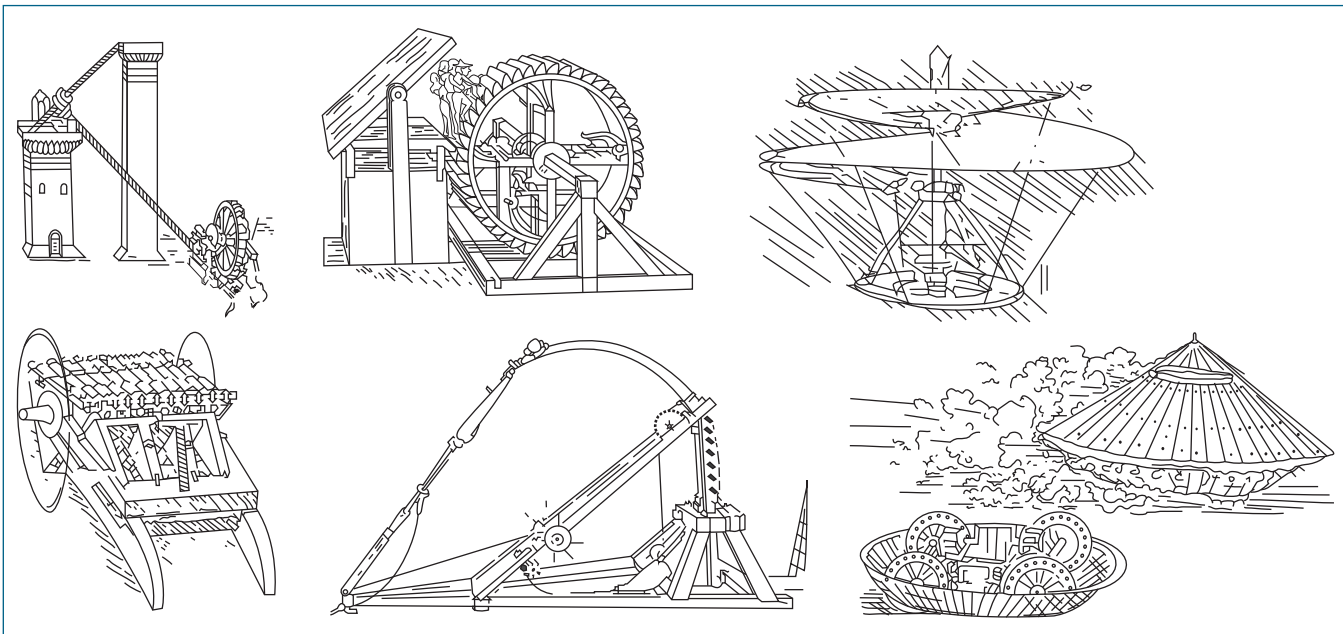
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Figure 1-4 Roman Coliseum.



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Figure 1-3 Floor plan of the Greek Parthenon.



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Figure 1-5 Inventions and drawings by Leonardo Da Vinci.

The Graphic Language

Human beings routinely communicate with each other through speech, written words, body movements, and an assortment of artistic and technical drawings. Verbal, written, and body language are very effective in communicating personal and social ideas or emotions. Only drawings, not language, are effective in describing the precise shape, size, and form of objects. To illustrate this point, verbally describe the spinning wheel in **Figure 1-6** to a friend. Now show the picture to your friend. How good was your verbal description? This exercise should clearly illustrate the Chinese proverb, “A picture is worth a thousand words.”

Drafting is the basic technical form for visual communication. It is the universal language of industry and construction. It will translate the technical ideas, sketches, and the data of engineers and designers into clear, easy-to-read working drawings. Drafting is the basic technical form for visual communication.



Figure 1-6 The spinning wheel was invented in the 13th Century AD.

Today's Technical Working Drawings

Most of the aspects of technical graphics (drawings) are common to all the industrial areas of drafting. The major types of drawings are:

- **Multiview drawings** are two-dimensional (2D) views of the object drawn using orthographic projection (See Chapter 8). The complete shape of the item with its dimensions and details is shown with multiview drawings (**Figure 1-7**).

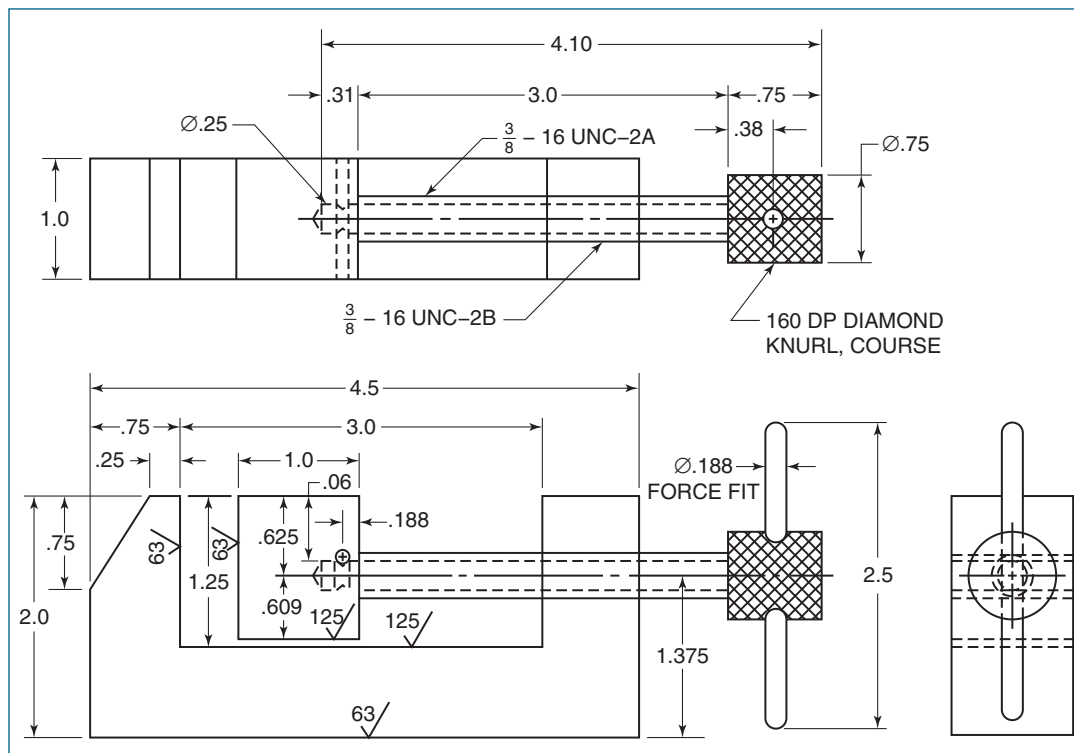


Figure 1-7 Multiview drawing of a machinist vise.

- **Pictorial drawings** are three-dimensional (3D) drawings that show an object as in a photograph (**Figure 1-8**). Usually three adjacent surfaces are shown in one drawing (See Chapter 15).
- **Schematic drawings** (See Chapter 22) use symbols and lines to show the flow of energy or fluids (**Figure 1-9**).
- **Block diagrams** are used to show the flow of a working process (**Figure 1-10**).

The use of **American Society of Mechanical Engineers (ASME)** standardized symbols and engineering drawing conventions makes it possible for technical drawings to be interpreted in all countries regardless of the language barriers. All manufactured products and structures, regardless of simplicity (**Figure 1-11**) or complexity (**Figure 1-12**), will still require a technical working drawing. Complex products may require many hundreds of working drawings (**Figure 1-13**).

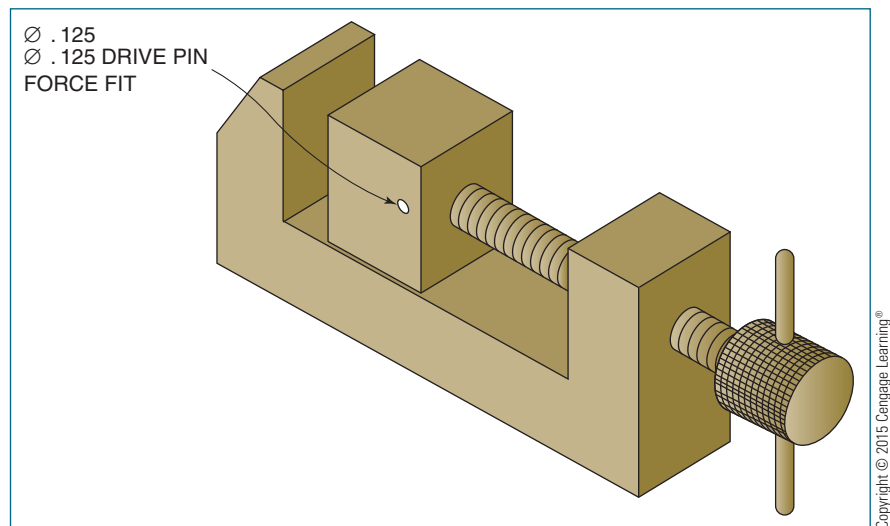


Figure 1-8 Pictorial drawing.

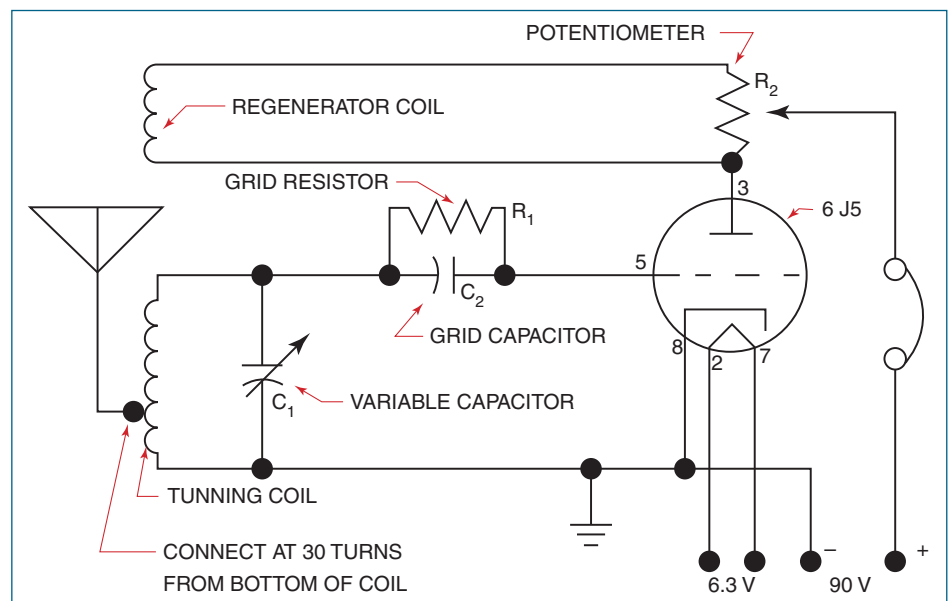
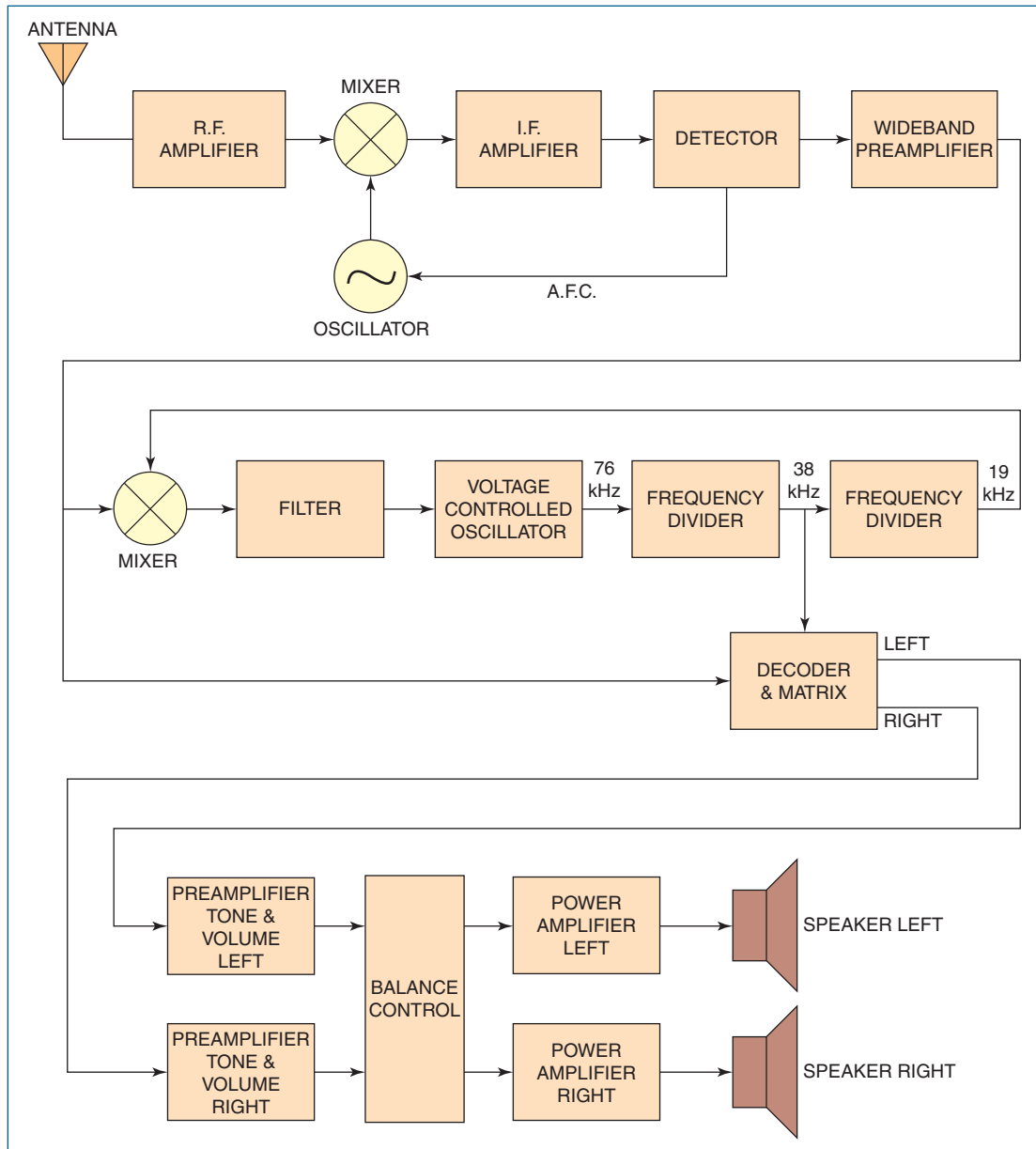


Figure 1-9 An example of an electronic schematic drawing for a small radio.

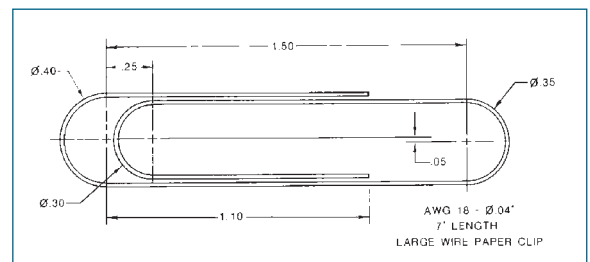


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Figure 1-10 An example of a block diagram for a sound system.

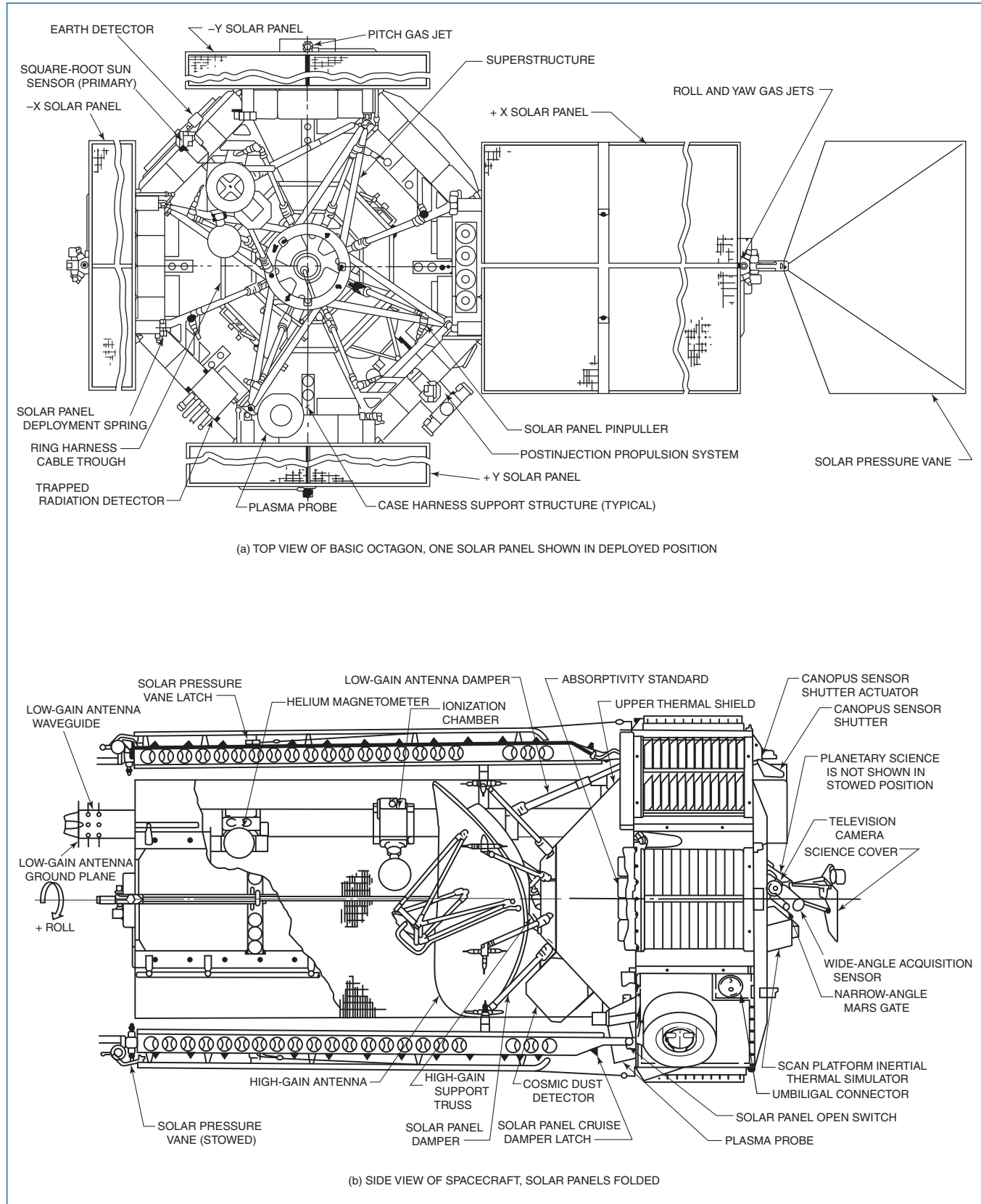
Today's drafters must possess a broad understanding of the drafting knowledge and skills covered in this text. In addition, drafters must gain the specific knowledge of the manufacturing methods and standards in the specific industry where they work. Regardless of the level of responsibility or the drafting specialization, all drafters must:

- Understand the basics of drafting and design
- Be familiar with the basic types of engineering drawings (Figure 1-14).
- Clearly communicate ideas with freehand sketches
- Be proficient with computer-aided drafting and design systems
- Have some skill with manual drafting instruments



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Figure 1-11 The design and manufacture of a simple paper clip requires technical working drawings.



Courtesy of the NASA FOIA program

Figure 1-12 Mariner-Mars Space Craft.

The Graphic Creators

Because each industry is highly specialized, the drafters in each industry must have the knowledge to correctly design and draw each part for manufacture. The personnel involved with designing and producing the working drawings may be placed into three general categories according to their formal education, knowledge, creativity, experience, and work ethics. These categories are top-level professionals, midlevel drafters, and intern-level drafters.

Regardless of the level an individual may reach, she or he should concentrate during the high school years on classes in math, physics, science, and drafting. This will provide a good background to start a formal education or an intern-level position in industry.

THE TOP-LEVEL PROFESSIONAL

The formal education for all top-level professionals is a college degree (BA, MA, or PhD). Often an internship and a state license in a specialty is required. These professionals have the responsibility for the successful designing and manufacturing operations. That is why they draw the largest salaries. Following is a brief description of several professional areas:

- The **aeronautical** and **astronautical engineers** perform a variety of work related to the research, planning, designing, manufacturing, and testing of airplanes, satellites, rockets, and spaceships.
- The **architect** does the planning, designing, environmental study, structural engineering, and supervising of the construction for all types of construction.
- The **cartographer** does the planning and drawings for all types of maps.
- The **civil engineer** plans, designs, and supervises for roads, airports, harbors, dams, tunnels, and most construction systems that are not inhabited buildings.
- The **chemical engineer** plans the research to develop new and improved industrial chemicals for manufacturing processes and production procedures.
- The **developmental engineer** does the data research for the development of new ideas and new products.
- The **drafting/engineering supervisor** coordinates all the workers involved with the production of all the working drawings for specific projects. It is her or his responsibility to get well-designed and error-free working drawings finished on schedule.
- The **electrical/electronics engineer** does the planning, designing, and supervising of the manufacturing of electrical and electronics components such as computer systems, and all other types of electrical/electronic systems.
- The **environmental engineer** does the research and study of the materials and the effect a product may have on the environment. Also called green engineering.



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Figure 1-13 It will take many working drawings to accurately manufacture this robot welder.

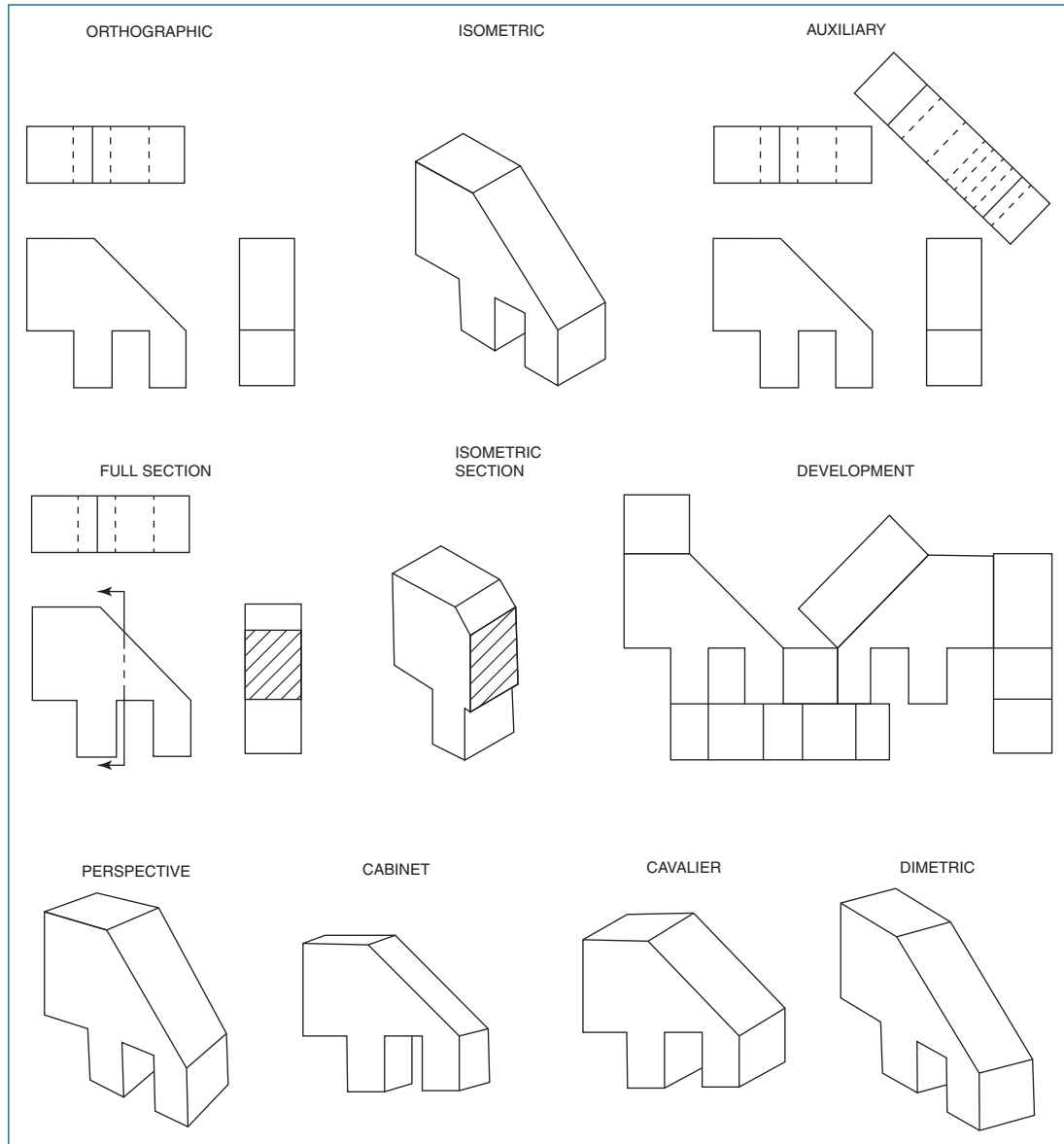


Figure 1-14 Types of engineering drawings.

- The **industrial designer** is a creative person who will use new ideas and materials to design a functional and attractive external package for industrial products.
- The **industrial engineer** and **mechanical engineer** works in all areas of industry, applying the math and physics to machines and parts so they will function properly and safely.
- **Instructor of engineering** or **drafting** is a rewarding position for people who enjoy working with helping others. Teaching positions in secondary schools, technical schools, colleges, and universities are open to people with degrees and/or teaching credentials with industrial experience.
- The **molecular** and **nanotechnology engineers** research and develop products on a molecular level that are used in the medical field and often in industrial products.

- The **robotics engineer** specializes in the design of robotic tools for industry and miscellaneous items such as toys.
- The **tool designer** plans and designs the tools used to produce the manufacturing systems, machinery, and tools for all areas of the industrial production.

MIDLEVEL DRAFTERS

Midlevel drafters are the technicians. It is recommended that they obtain an AA degree from a technical school. They should have a broad and diversified job classification, depending on their education, knowledge, creativity, drafting skills, and attitudes. They are classified as semi-professionals. Most will be supervised by the top-level professionals. Some technicians, even though they do not have a college degree, are highly capable and may perform the top-level job activities, but they will not reach the top salary levels.

Following is a brief description of some of the positions for midlevel drafters:

- The **checker** is an experienced drafter whose responsibility is to see that all the drafters' working drawings are properly drawn and are error-free. This is critical, because correcting an error during production is very expensive.
- The **chief /senior drafter** supervises the drafting personnel and sets the parameters for the standards, practices, schedules, and drawing procedures for the project's set of working drawings.
- The **commercial artist** prepares attractive illustrations for magazines, books, posters, and so on, to help promote recognition and sales of the manufactured item.
- The **design technician** combines design skills and drafting ability, usually working from the top-level sketches.
- The **senior detailer** is skilled in understanding the engineer's concepts and can produce complex working drawings needed for manufacture.
- The **technical illustrator** creates three-dimensional drawings from the working drawings. The drawings are used to view a complicated part for a better understanding, or to show an exploded drawing of all the individual parts to simplify its assembly.

INTERN-LEVEL DRAFTERS

Intern-level drafters do not require a formal technical education, but receive on-the-job training. However, it is recommended that they have some training from a two-year or technical college with drafting and CAD training. Many engineers and technicians will have interns working with them.

The following is a brief description of some intern-level drafting positions:

- The **computer-aided drafting operator (CAD)** must have the CAD skills that are important for all designers and drafters. These are an asset in gaining employment and advancement in the workplace.
- The **junior detailer** prepares simple working drawings from the sketches of the senior detailer and corrects drawing errors marked by the checker.