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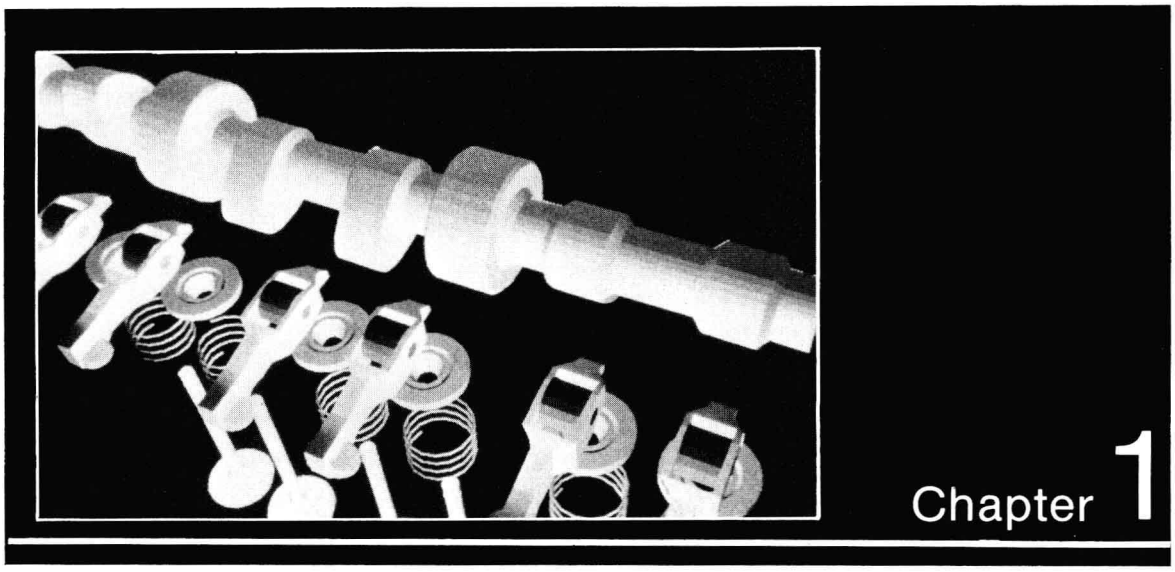

Chapter 1

THE GRAPHIC LANGUAGE

INTRODUCTION

In most engineering and technology programs, learning to communicate graphically is a basic component of the curriculum. Representing the world graphically is a fundamental communications skill used by designers, engineers, and drafters to change their conceptual designs into sketches or engineering drawings. In industry and education traditional methods of creating graphics have been with drawing instruments such as the t-square, compass, triangle, and pencil (Figure 1.1). Recently the computer has been found to be a more efficient tool to graphically represent designs. This use has led to the introduction of CADD (Computer-Aided Design/Drafting)

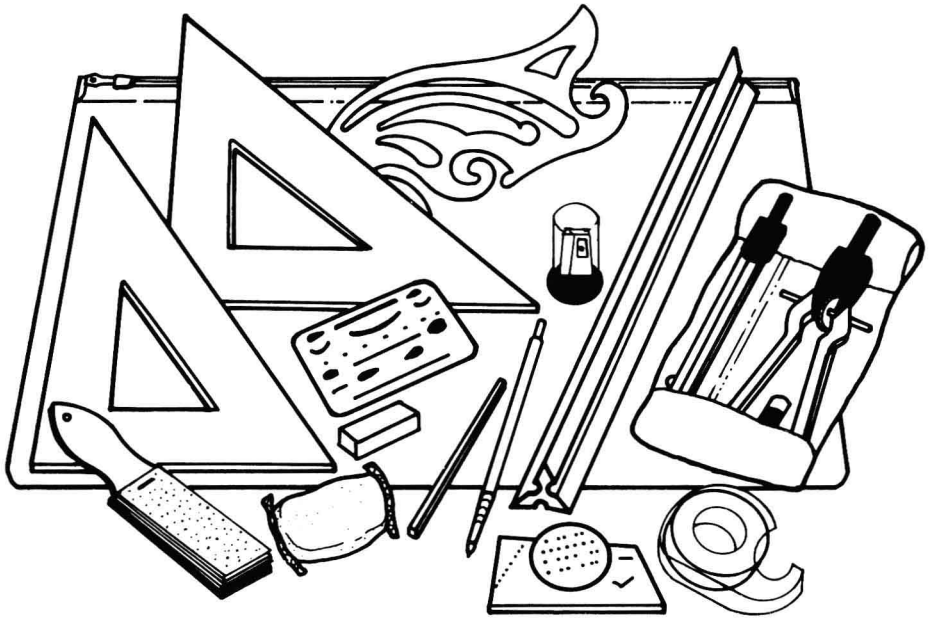

Figure 1.1 Traditional design/drafting tools (Hearlihy & Co.).

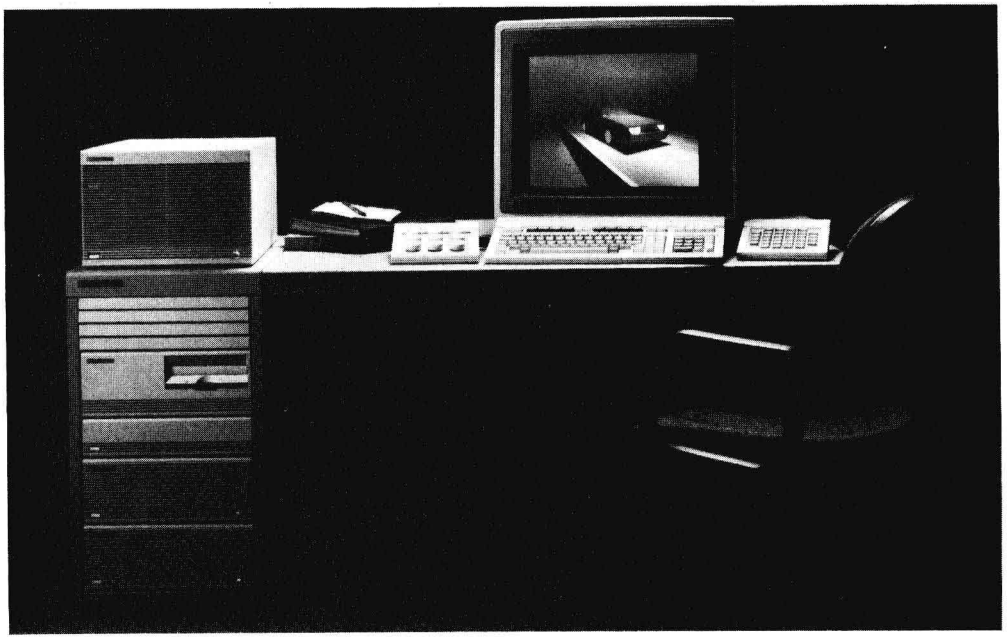

Figure 1.2 CADD workstation used in industry (Hewlett-Packard).

into engineering and technical drawing and other fields that require graphics for communications (Figure 1.2).

CADD is an automated method of generating graphics for designing and drafting through computers and other peripheral devices. It can be used to supplement or replace traditional drafting and designing tools. In industry CADD is rapidly supplementing or replacing the traditional tools used to create engineering drawings.

Until very recently engineering design graphics was taught with the same basic tools that have been in existence since the time of ancient Greece. The pencil, compass, and straight-edge have been the primary tools used by the designer, and in turn, by those learning engineering graphics. In the past decade much of this has changed because the computer, interfaced with CADD software, now can be used as a tool for learning engineering graphics. By the year 2000, the overwhelming majority of drafter/designers will be using CADD rather than the pencil, straight-edge, and compass.

This chapter is an introduction to the use of CADD for engineering graphics. The design process using CADD will be explained and compared to the use of traditional tools. Finally the advantages, disadvantages, and applications of CADD will be discussed.

AUTOCAD TIP

Normally, the break command will take a piece out of an entity. The following procedure describes how to take an entity and break it into two parts.

1. Enter **BREAK** at the command prompt.
2. Pick the entity to break, then enter **F** for the first option.
3. Use the Osnap Intersection option to pick the point where the entity is to be broken.
4. When prompted to enter the second point enter @. This will break the entity into two parts at the point of intersection without removing part of the entity.

OBJECTIVES

After completing Chapter 1, you will be able to:

1. Describe how CADD is used to create engineering drawings,
2. Compare the design process using traditional tools or CADD,
3. List several applications of CADD,
4. List some of the advantages and disadvantages of using CADD.

A HISTORICAL OVERVIEW OF ENGINEERING GRAPHICS

Drawing is one of the oldest forms of communication. It is a universal language that dates before the formal use of verbal language and is so primitive that its history is comparable to that of humans. Through time the techniques needed for graphical communication evolved into a very complex system. By creating pictures people communicated thoughts to one another using graphic language. A **drawing** is a graphic representation of a real thing, an idea, or a proposed design. Drawings may take many forms, but the graphic method of communication is universal and timeless (Figure 1.3).

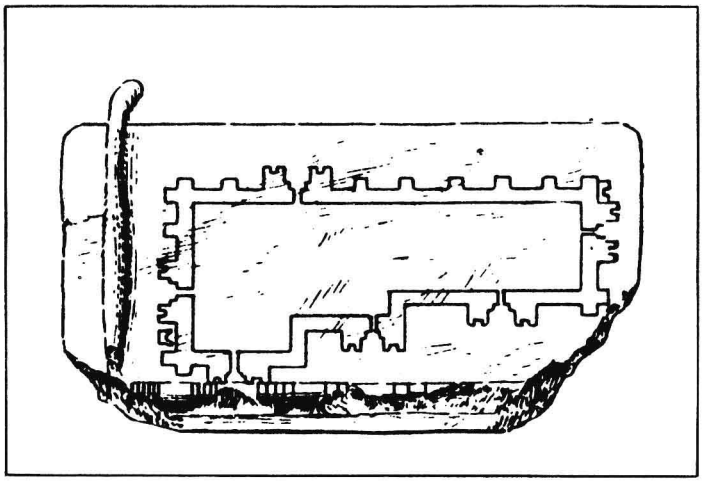

Figure 1.3 Graphic communications have been used since ancient times (From Transactions ASCE, May 1891).

AUTOCAD TIP

Before a linetype can be used on an AutoCAD drawing it must be loaded using the **LINEYTPE** command. To load all the linetypes at one time enter the Linetype command, select the Load option, then enter an * to load all the lines in the ACAD.LIN library.

Drawing has developed along two lines, artistic and technical. **Artistic drawings** have been used to express aesthetic, philosophic, or other abstract ideas. Graphic representation closely parallels human technological progress.

Technical drawings have been used from the beginning of recorded history to assist in the construction of buildings and devices. The theory of projections of objects upon imaginary planes was not developed until the early part of the fifteenth century in Italy. Leonardo DaVinci's treatise on painting is regarded as the first book written on the theory of perspective drawing. In the mid-1700s Gaspard Monge developed the principles of projection that continue to be used today as the basis of engineering drawing. **Engineering graphics** is considered to be the total field of graphical problem-solving and includes two major fields of specialization, descriptive geometry and working drawings.

During the first half of the twentieth century, the modern technology of drafting was established firmly, and the applications of graphic technology were found in engineering, design, manufacturing, production, and architecture. Engineering graphics became a concise, accurate, universal language with its own grammar and style through which engineers, drafters, and designers can communicate with one another and the public.

CADD: The Latest Tool Used for Engineering Graphics

In the last 25 years, major growth has occurred in computer technology and the use of computers to create graphics. The growth of computer graphics has followed closely the evolution of the computer. As computer hardware and software technology became more advanced and less expensive, the use of computers to generate graphics became more common in industry, leading to the development of software that could be used for engineering graphics.

This software and computer hardware came to be known as Computer-Aided Design (CAD) or Computer-Aided Design/Drafting (CADD). The development of software, improvements in hardware technology, and lower costs have led to widespread adoption of CADD systems in industry. Figure 1.4 shows a typical CADD system, which consists of a processor or computer; a monitor used to display drawings; a keyboard for alpha-numeric input; an input device such as a mouse or stylus and tablet used to control the location of drawing entities; and a plotter or hard copy device used to produce drawings on paper.

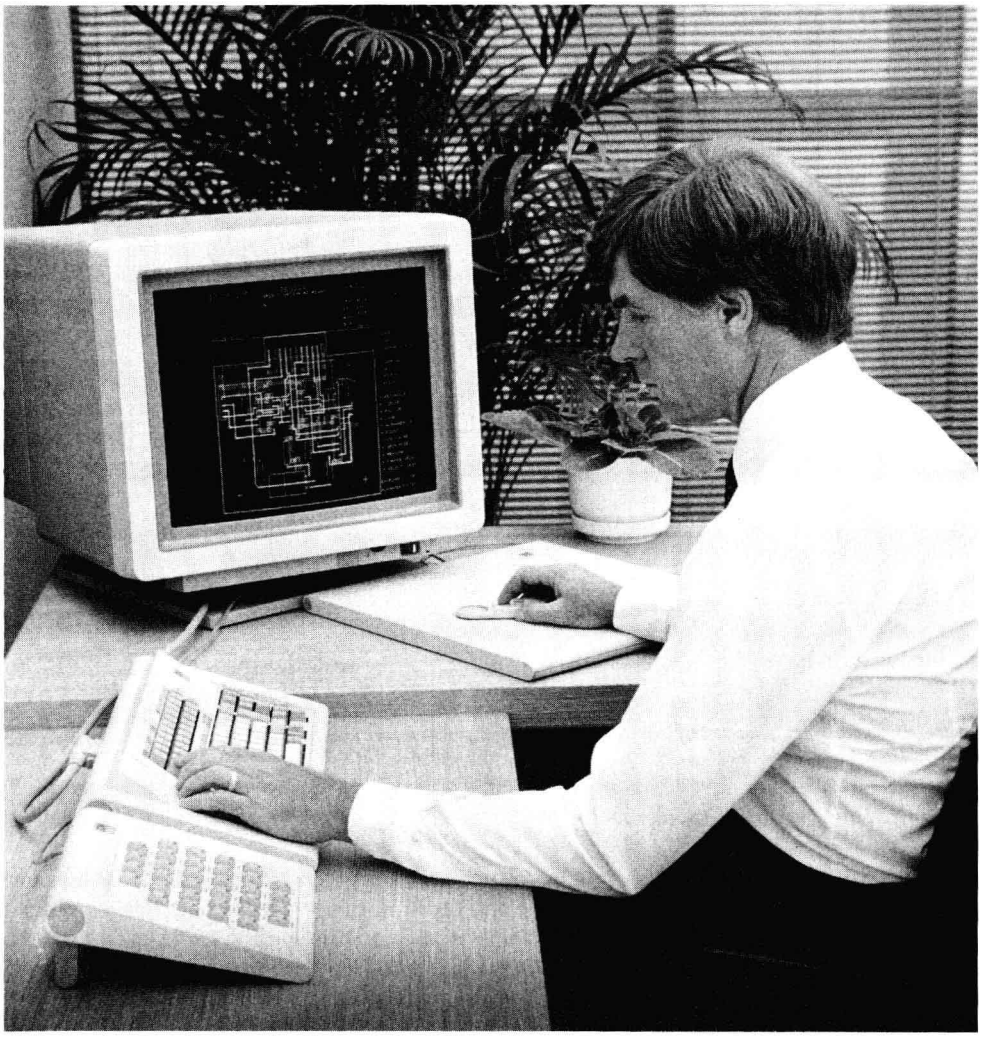

Figure 1.4 CADD workstation with peripheral devices (Courtesy of International Business Machines).

The CADD operator interacts with the system through a series of menu commands that appear on the computer screen to create, modify, and edit a drawing. By using an input device to locate points on the monitor, the operator can create a drawing. The CADD system and skilled operator can draw straight lines, perfect circles and arcs, different line types and thicknesses, various crosshatching patterns, and irregular curves. A CADD system can position and draw standard components in much the same way a template saves time drawing repetitious features on a handmade drawing. The operator can change scale quickly or one can easily zoom in on an object to perform detail work.

After the drawing is completed, dimensions are automatically calculated by the computer and placed anywhere on the drawing by the operator. Notes and labels of numerous styles and sizes can be typed and placed at any position on the drawing. A multicolored plot of any scale then can be made of the completed drawing.

With a trained user a typical CADD system can perform virtually any drawing function that can be done with traditional tools. However, all these operations are initiated by the human operator who interacts with the computer and ultimately controls the input and resulting output. CADD is not a substitute for design experience or ability. CADD is only a tool that can be used to supplement traditional tools. The underlying concepts used in engineering graphics remain the same regardless of the tool chosen to create the graphics. Orthographic projection, descriptive geometry, and other engineering graphics concepts are just as important as they always have been to the person who must communicate graphically. However, with the development of computer modeling traditional methods of communicating graphically will become less dominant in the future.

THE DESIGN PROCESS

The **design process** is used to organize the creative and analytical procedures necessary to satisfy a need or solve a problem. Although many methods have been used to describe the design process, the model depicted in Figure 1.5 has the major components traditionally associated with design. Engineering graphics and descriptive geometry are the tools used in the design process. Just as the written word is the technique used to create written documents, engineering graphics is used to create design documentation (drawings). The tools used for written documents are the typewriter and word processor. The tools used to create engineering drawings are the pencil and traditional tools and now CADD.

AUTOCAD TIP

Sometimes you will be drawing a broken line, such as hidden, phantom, or center, and it appears on screen without breaks. This may be corrected by adjusting the **LTSCALE** setting. Enter Ltscale at the command prompt then enter a number greater than one.

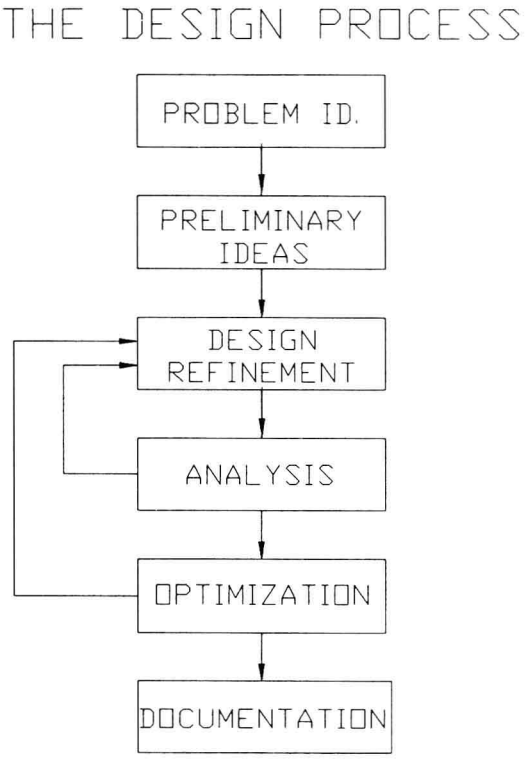

Figure 1.5 A model of the design process.

The Design Process Using Traditional Tools

The traditional tools used in the design process are those normally associated with drafting and model-making. After the problem is identified in stage one, concepts and ideas are collected for stage two, which is usually accomplished by rough sketches using paper, pencil, and eraser. These rough sketches are made quickly so that possible design solutions can be recorded before they are forgotten. From the collection of rough sketches, it is possible to select a compromise solution or solutions for stage three. Rough schematic drawings may be produced to test the design. A design layout made with instruments is produced, from which models can be created or further analysis can be performed.

Stages three, four, and five are highly interactive and iterative steps. A design solution may be analyzed and found to be needing change. This would cause the designer to return to stage three to modify the design. This process of design, analysis, and optimization may occur a number of times before the final design is chosen.

After the design has been analyzed, it will be evaluated in stage five by building models or prototypes. To accomplish this, dimensioned sketches or rough working drawings must be created for the model shop craftsperson. The model or prototype is tested, and any design modifications are noted on the drawings.

After the final design is approved, it is documented with working drawings for the manufacture of the product. The working drawings produced in stage six usually consist of detail drawings of the part(s), a parts list, and an assembly drawing. Traditionally, the design process was accomplished on drawing boards. However, much of the design process now can be performed with CADD.

The Design Process Using CADD

The use of computers for the design and documentation of a product can be grouped into four main areas:

1. Geometric Modeling
2. Engineering Analysis (CAE)
3. Design Evaluation
4. Documentation

These four areas can be interfaced with the last four stages in the design process as shown in Figure 1.6. Powerful CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) systems are capable of replacing traditional tools used for the last four stages in the design process.

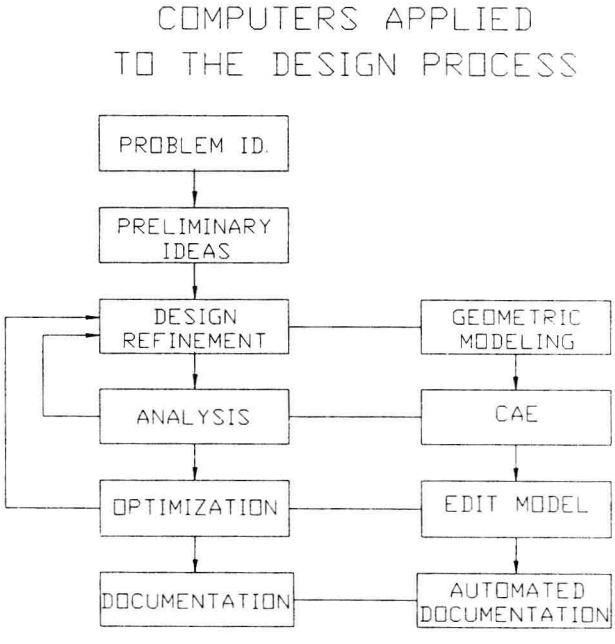

Figure 1.6 The design process integrated with CADD.

Microcomputer-based CADD, such as AutoCAD, traditionally has been used for the last stage in the design process for documentation. **Documentation** can be defined as the creation of the engineering drawings necessary to manufacture the product. This use for documentation is changing rapidly as improved hardware and software are being created. It is now possible to create with AutoCAD a 3D, wire-frame model of a part and surface shade the design using the Render Menu or to create solid models with AME (Advanced Modeling Extension). Many third-party products that have been developed for AutoCAD can be used for the design and analysis of a model. AutoCAD drawing files also can be used on powerful CAD/CAM systems through graphic translators. These procedures will be covered in detail in Chapter 11.

Geometric Modeling

Geometric modeling can be used to supplement or replace traditional tools used in stage three of the design process. A geometric model is a mathematical representation of a design created with a CADD system. Three primary methods of creating a geometric model of a part with CADD are:

1. Wire-frame
2. Surface
3. Solid

AutoCAD can create wire-frame models as shown in Figure 1.7. It is possible also to create surface models (Figure 1.8) or solid models . These mathematical computer models can be analyzed just as a prototype or model can be studied.

AUTOCAD TIP

The space bar or return key is used to repeat the previous AutoCAD command. If you press the space bar or return key twice to repeat the Line or Arc commands the new line or arc will continue from the last endpoint drawn.

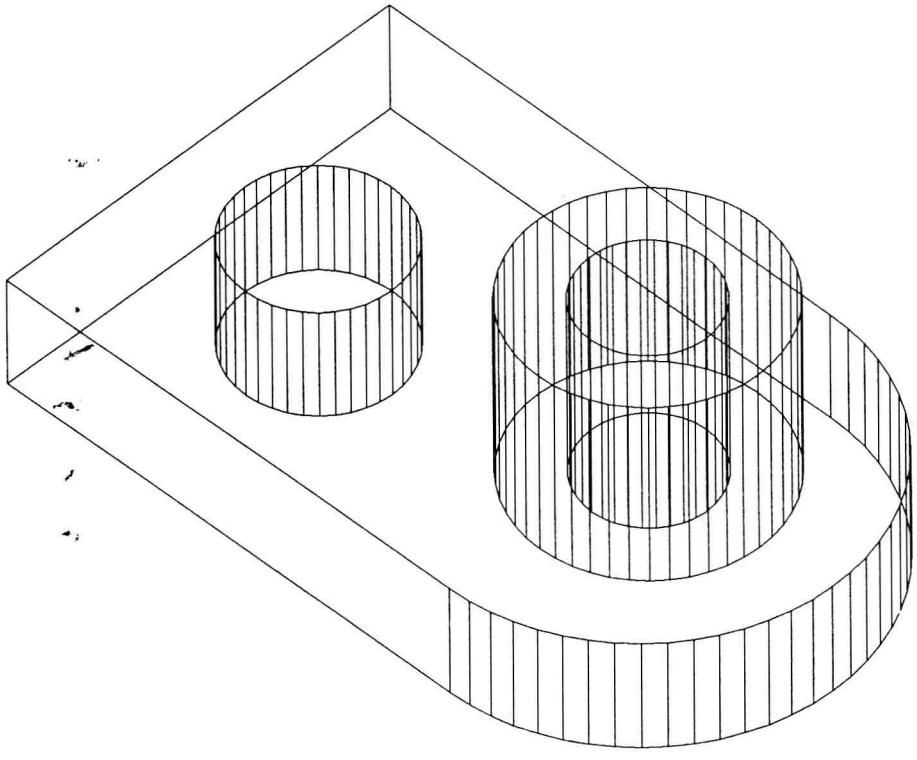

Figure 1.7 3D wireframe model.

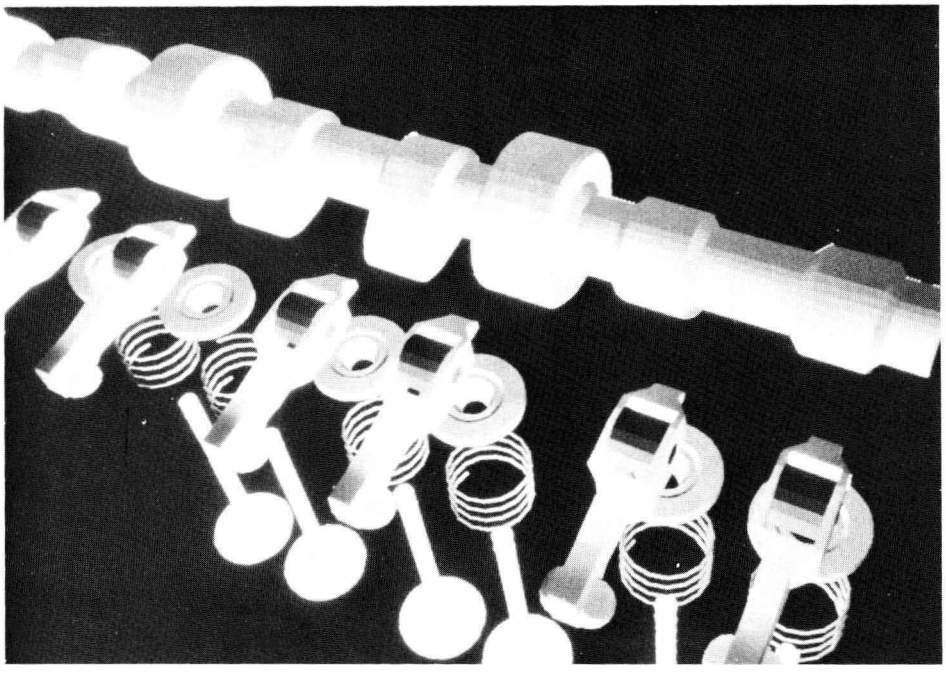

Figure 1.8 Surface model created with a CADD system.

Engineering Analysis

After the geometric model is produced, the computer can be used to analyze the part, as shown in stage four CAE (Computer-Aided Engineering), through various computer engineering analysis programs, such as stress, strain, kinematics, and heat transfer. Many of these programs can be used with AutoCAD drawings through third-party products.

Design Evaluation and Editing

With a CADD system, parts are checked for accuracy through automatic dimensioning. Details are checked by zooming in and magnifying small parts and details. Layering can be used to match parts for fit and accuracy. Three-D models also are checked for interference between mating or for parts that pass close to each other.

Documentation

CADD is used to supplement or replace traditional tools in stage six of the design process. This is what AutoCAD was primarily created to do. AutoCAD is a powerful software package for automated drafting. The basic package also can be modified with the use of its programming language, AutoLISP. Automated drafting procedures include:

1. Dimensioning
2. Cross-hatching for section drawings
3. Scaling
4. Copies
5. Mirror
6. Enlarged details
7. Rotation
8. Isometric and axonometric views
9. Symbols
10. Editing

CAD/CAM

It is now possible with CADD to supplement or replace the traditional tools used in the last four stages of the design process. In addition, once the graphic data base for the part has been created, it is possible to develop the manufacturing data base that can be used for CAM (Computer-Aided Manufacturing).

Traditionally, design and manufacturing were a two-stage process. The engineering drawings were produced by the design drafters and then used by the manufacturing engineers to produce the product, but an integrated CAD/CAM system can provide a direct link between these two processes by automating the design and manufacture of a product and their link. AutoCAD can create the graphic data base necessary for manufacturing. With the use of third-party software and graphic translators, AutoCAD drawings can be utilized for CAM are explained in Chapter 11.

APPLICATIONS OF CADD

CADD can be used to create engineering and technical drawings for a number of different uses. Probably the most common use of microcomputer-based CADD is for documentation or automated drafting. Architectural drawings can be created with CADD using special software such as AutoCAD AEC (architecture, engineering, and construction) Architectural. Pipe layout, HVAC (heating, ventilation, and air conditioning), and other building systems can also be produced with special CADD software such as AutoCAD AEC Mechanical. Electrical and electronic drawing and design also can be created with CADD. Mapping, structural, and technical illustration are other common applications of CADD. Figure 1.9 through Figure 1.13 illustrate some common application drawings produced with AutoCAD.

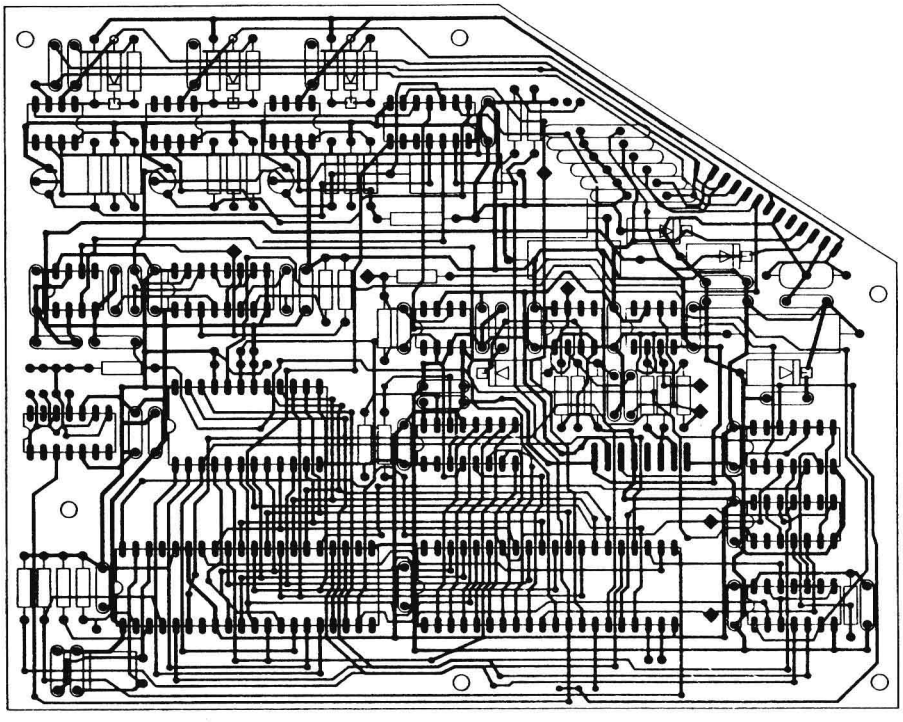

Figure 1.9 AutoCAD-produced electrical drawing (Courtesy of CAD Northwest Inc.).

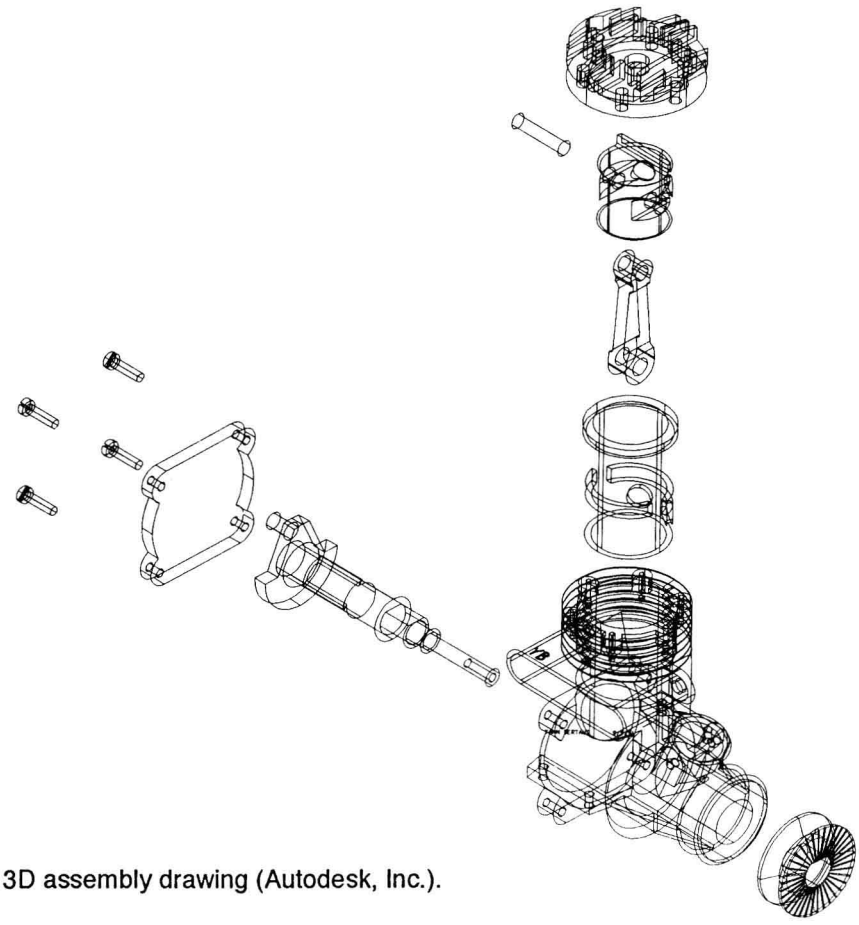

Figure 1.10 3D assembly drawing (Autodesk, Inc.).

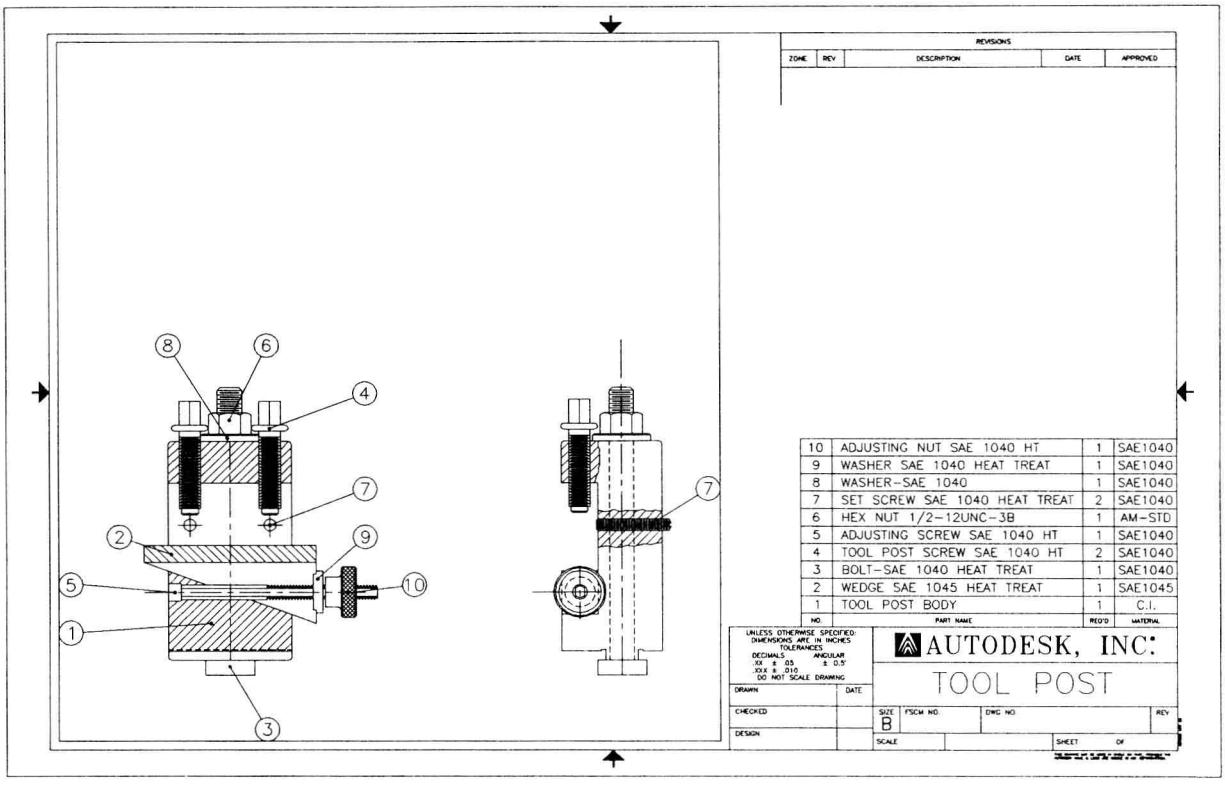

Figure 1.11 Mechanical assembly drawing (Autodesk, Inc.).

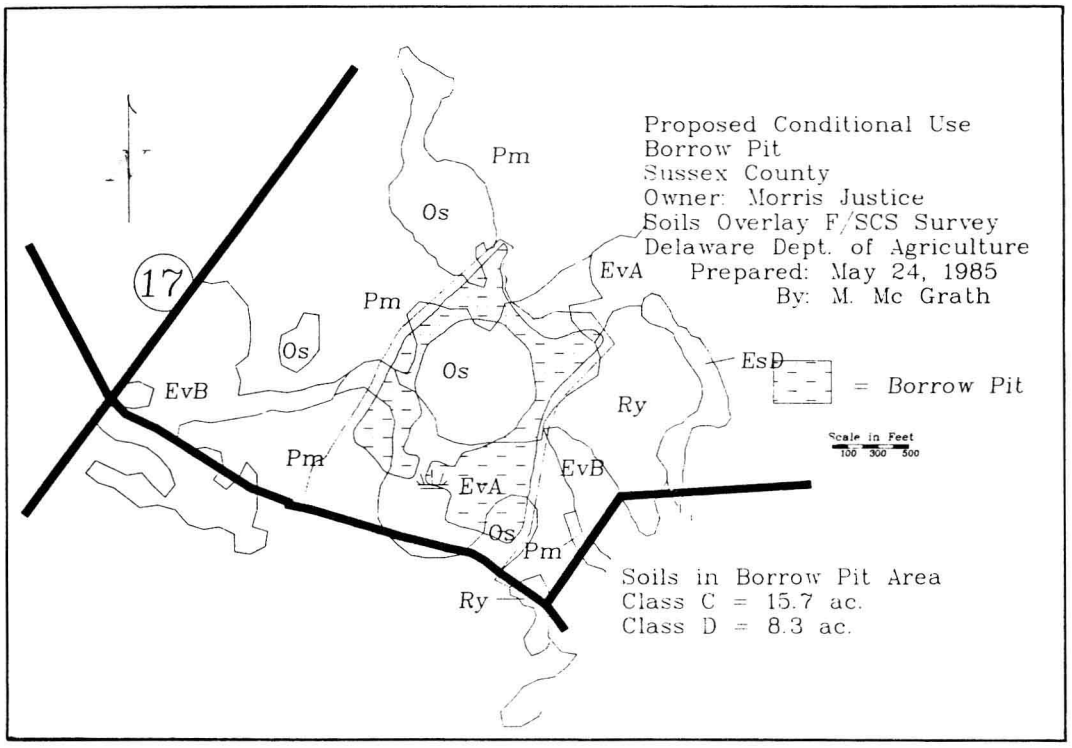

Figure 1.12 Civil engineering drawing (Autodesk, Inc.).

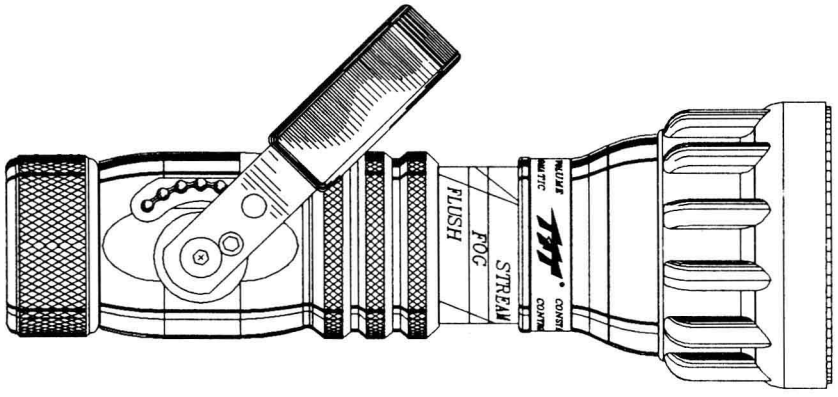

Figure 1.13 Technical illustration (Autodesk, Inc.).

Advantages of Using CADD

There are many advantages to using CADD over traditional tools. Although some advantages are quite apparent, others are more difficult to recognize, such as improved work quality, better control, and greater communication. Advantages of CADD include:

1. Faster production of some types of graphics,
2. Customer modifications that are easier to make,
3. Shorter lead time for the design of similar or family of parts,