CAD WITH COMPUTERVISION

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CONTENTS

PREFACE

This text is the result of many notes and exercises developed while teaching CADD courses at Queensborough Community College, and is also an outgrowth of several CADD seminars taught to industrial personnel. It is directed toward the beginner who has had no previous exposure to a CAD system, but who does possess some fundamental drafting skills.

The Computervision CAD system with CADDS4,4X software is a very powerful tool for 3D design work and has many applications in various engineering and production fields. It is essentially a command-driven system. This means that the user must know the proper command to input in order to execute a specific operation. Techniques for carrying out a complete job must also be known because the system does not guide the user. Thus, this text is intended to satisfy two important needs—to provide a gradual introduction to basic commands and concepts, and to teach techniques for applying commands to practical design problems. Depending upon the number of terminals available per student and the allotted tube time, the text can be used for a one-semester or two-semester course. The one-semester track could involve 2D and 3D training together. The two-semester approach would treat 2D and 3D as separate courses.

Chapter 1 introduces the operator to CAD systems in general, Computervision's Designer systems, and defines some important CAD terms. Fundamental concepts involving model building and detailing within the CADDS4,4X software environment are presented in Chapter 2. The CADDS4,4X graphics language syntax is studied in Chapter 3. The generation of elementary graphic elements such as points, lines, circles, and fillets is also discussed. Polar coordinates, arcs, and additional line commands are developed in Chapter 4. The detailing of 2D models is discussed in Chapter 5. Chapters 6, 7, and 8 cover additional commands for generating 2D geometry and manipulating or editing inserted geometry. Layering plays an important role in CAD design, and is treated in detail in Chapter 9. Basic 3D modeling is introduced in Chapters 10 and 11. Chapter 12 deals specifically with the process of preparing 3D models for detailing. The utilization of stored drawing forms for detailing is also discussed. Techniques and commands for generating 3D surfaces and surface intersections are discussed in Chapters 13 through 15. The methods involved in crosshatching 3D models are considered in Chapter 16. Chapter 17 deals with assembly building and the preparation of figures. The top-down and bottomup approaches to assemblies are discussed, and several lab exercises stress these techniques.

In order to facilitate the learning process, the following features have been included in this text.

- Important commands and their accompanying modifiers are boxed for easy identification.
- Simplified 2D rather than 3D modeling is used in the first half of the text in order to establish a firm foundation in basic CADDS4,4X concepts.
- Each chapter contains many practical examples and ends with a sample lab. The lab presents commands and corresponding graphic results in a logical step-by-step fashion. This approach not only exposes students to the commands just covered in the chapter, but also provides a clear pattern or technique for applying the commands to complete a job.
- A summary of important CADDS4,4X commands is included in an Appendix at the end of the text. The summary provides not only quick reference to an important command, but also the mode for its application and a graphic illustration of its use.
- A complete glossary of important CAD terms is included at the end of the text. All terms are arranged in alphabetical order for quick reference.
- Separate Appendixes have been written to instruct the reader in the creation of key files and form parts. Included in these Appendixes are instructions on how to obtain on-line documentation for commands, and when to utilize important database maintenance commands.

Several people have been helpful to me in completing this text. Professors Norton Reid and Alexander Fesolowich class-tested the manuscript and provided many valuable suggestions. I also wish to express my gratitude to Professor Robert Williams of SUNY Farmingdale for his valuable advice and encouragement. Mr. Mohammed Asim was particularly helpful in providing industrial inputs. Special thanks goes to one of my most talented students, Mr. Herbert J. Frietsch, who assisted me in generating the many CAD illustrations in the text.

INTRODUCTION TO CAD AND DESIGNER CAD SYSTEMS

CHAPTER 1

1.1 INTRODUCTION

In this chapter we will explore the basic concepts of what CAD is, what comprises typical CAD systems, and what applications CAD has in various design disciplines. We will also present a general description of the components and operation of Computervision Designer CAD systems. And finally, we will study recent advances and future developments for CAD systems.

1.2 WHAT IS CAD?

CAD (Computer Aided Design or Computer Aided Drafting) has been in use in industry for the past 15 years. CAD systems are computer drafting instruments, programmed to quickly and accurately execute graphic commands input by an operator (individual). Once an object has been drawn on a CAD system, the system can be instructed to generate different views of it, rotate it, enlarge or shrink it in size, or dimension it. Hard copy drawings of the object can be obtained via an A(8.5 × 11 in) printer or graphics plotter. Many CAD systems also have design analysis and production software that can be automatically applied to the objects drawn. Such functions include calculation of area, volume, centroid, stress analysis, thermal analysis, numerical control, and robotics.

It should be emphasized that CAD systems do not execute drawings and designs on their own, but simply act on instructions given to them by operators.

1.3 SOME APPLICATIONS OF CAD SYSTEMS

CAD systems are continually finding more and more applications in industry, science, and research. Some of the principal industrial applications of CAD are as listed. See also Figure 1.1.

Mechanical Drawings Machine parts, sheet metal layouts, and tool design.

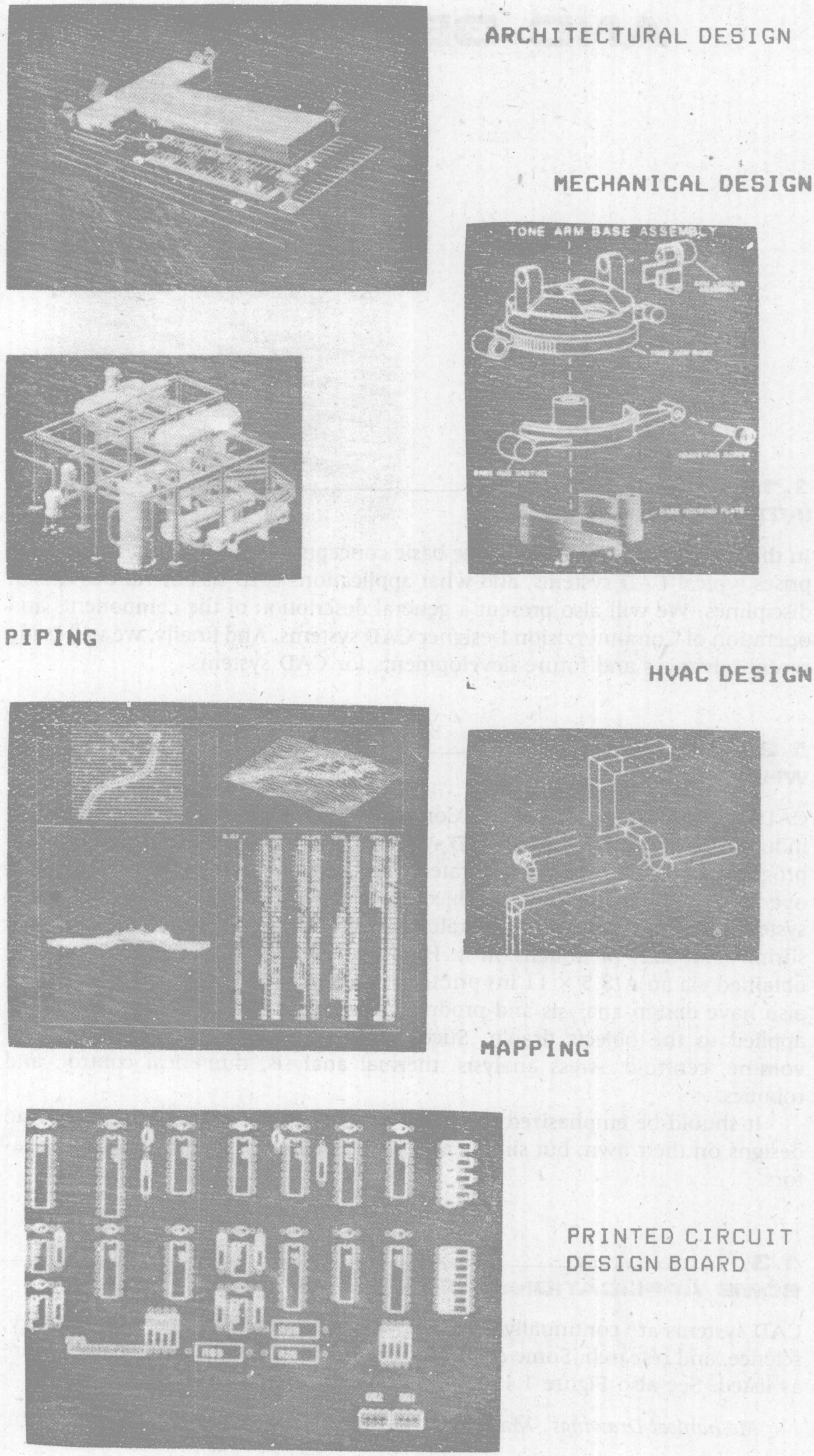


FIGURE 1.1
Several examples of CAD generated drawings with applications in the areas listed on pp. 1 and 3.

Piping Drawings Single line and detailed piping layouts. Determinations of interferences and intersections in piping assemblies.

Printed Circuit Board Drawings Single and multilayered PC boards. Generation of net lists and placement of PC components on boards. Automatic routing of connections to PC components on boards.

Architectural Drawings Generation of working drawings for residential and commercial structures. Plot drawings, section elevations, and room plans, etc.

Mapping Utilization of survey data for the generation of maps. Calculation of volumes, areas, distance, and bearing of lines. Generation of three-dimensional contour maps of terrain. Cut and fill measurements. Execution of cross section and profile plots, and analysis.

HVAC Single-line and double-line detailed duct drawings. Analysis of HVAC loads and flat pattern foldouts of sheet metal duct designs. Creation and use of duct fitting templates.

1.4 ADVANTAGES OF CAD SYSTEMS

CAD systems offer many advantages when used properly. Some of these are listed below:

1. Reduced product development time.
2. Increased productivity. When fully trained it is estimated that six designers on a CAD system can do the work of 19 manual designers.
3. A common database is established. Drawings and manufacturing information is stored by the system in a common database. This information can be accessed immediately by other system operators working in various design and manufacturing areas. The information generated by these users is, again, placed in the same common database.
4. NC (Numerical Control) tapes can be generated automatically by the system so the part can be machined.
5. The system can be called upon to automatically analyze a drawn part for strength, deflection, and thermal effects. Graphic displays of such information can be displayed by the system—deflection shapes of structures, vibration shapes of parts, etc.
6. Complex views of parts can be displayed easily and quickly. These include part rotations, isometric views, auxiliary views, exploded views, etc., that could be very difficult to generate manually.
7. The system can draw a part in one scale and plot the part in any other scale desired. Large shapes, such as aircraft wings and fuselages, can be drawn on the screen in one scale and plotted full size, if desired.
8. Standard symbols used in drawings and standard parts can be stored on the system in a library. When required these parts or information can then be "rubber stamped" into other drawings immediately.
9. Drawings are produced in a clean and legible manner. The system always draws lines, circles, arcs, etc., uniformly and clearly. All text is written by the system upon command, and is very legible. All erasures are done electronically.
10. The system produces drawings with incredible accuracy. Such accuracy

could not be achieved by manual methods. The system can be called upon to measure lengths of lines, arcs, etc. It can also be commanded to measure angles, areas, centroids, moments of inertia and weights for parts, and display clearance values for elements in assemblies.

1.5 WHAT CAD SYSTEMS CANNOT DO

As mentioned previously, a CAD system is simply a computerized drafting tool used by an operator to execute designs. CAD systems cannot think for themselves or generate drawings by themselves. Thus, CAD systems do not replace the draftsman or act as substitutes for the analytical skills all draftsmen must have in order to design. CAD systems simply act to enhance these skills.

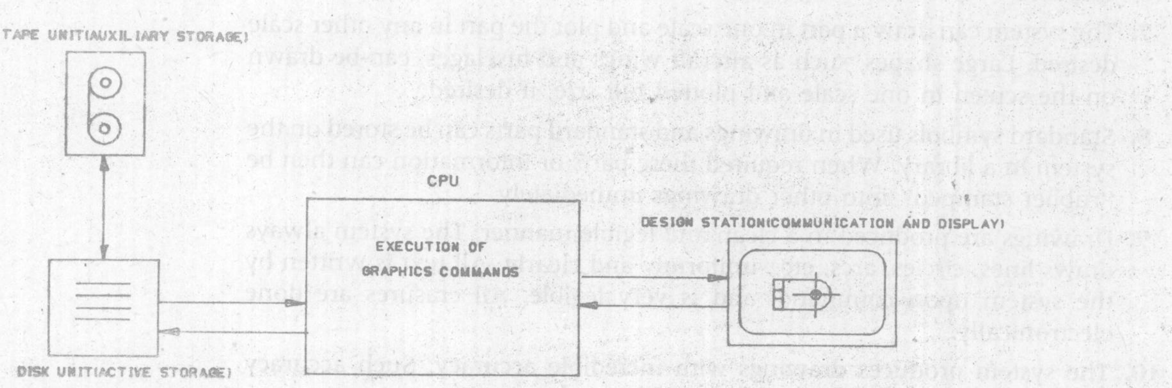
1.6 ELEMENTS OF COMPUTERVISION'S DESIGNER SYSTEMS

Several types of Designer systems are manufactured by Computervision. These include the more powerful Designer V-X and Designer V, the intermediate Designer IV system and the more economical medium-scale Designer M system. These CAD systems consist of hardware and software. Hardware refers to the physical components making up the system. Software refers to the programs that have been written to instruct the system how to carry out graphic commands entered by the operator. The systems are also referred to as "turnkey" since all the hardware and software required for their immediate operation is provided by the manufacturer in one complete package.

Designer CAD systems consist of the following hardware (see Figure 1.2):

1. *CPU* The CPU (Central Processing Unit) or system "brain" receives and executes all graphic commands given to it by a graphic operator.
2. *Disk Storage Unit* The Disk Storage Unit is used to store information the CPU will need to execute graphic commands. The programs that instruct the CPU how to generate graphic entities (lines, circles, arcs, etc.) in response to an operator's graphic commands are stored on the disk. All drawings generated by the system as well as associated manufacturing information are also stored on disk.
3. *Tape Storage Unit* The Tape Storage Unit is also used for storing inactive drawings and manufacturing information. Information stored on the disk

FIGURE 1.2 Typical elements of Designer CAD systems.



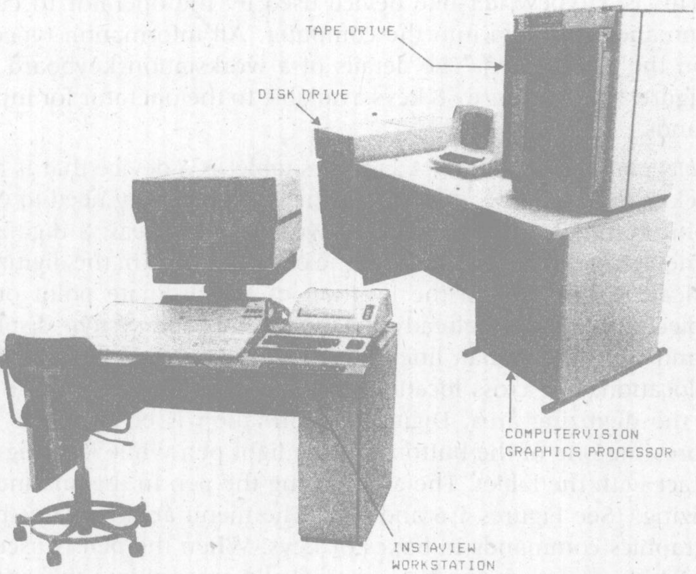


FIGURE 1.3
An illustration of the Designer V system.

can be transferred to the tape. This allows more free storage space on the disk. Any information stored on tape must first be transferred to the disk unit before it can be accessed for use by the CAD system.

4. *Workstation* This unit is used by the graphic operator as a means of communicating with the CAD system. All graphic commands are entered here and all geometry and information generated by the system is displayed here.

1.7 WORKSTATION COMPONENTS

A typical workstation is shown in Figure 1.4. The workstation consists of the following components:

1. *CRT or Graphics Display Monitor* This is a TV-like screen onto which all information given to and received from the computer is displayed—graphic commands, drawings generated, text, etc.

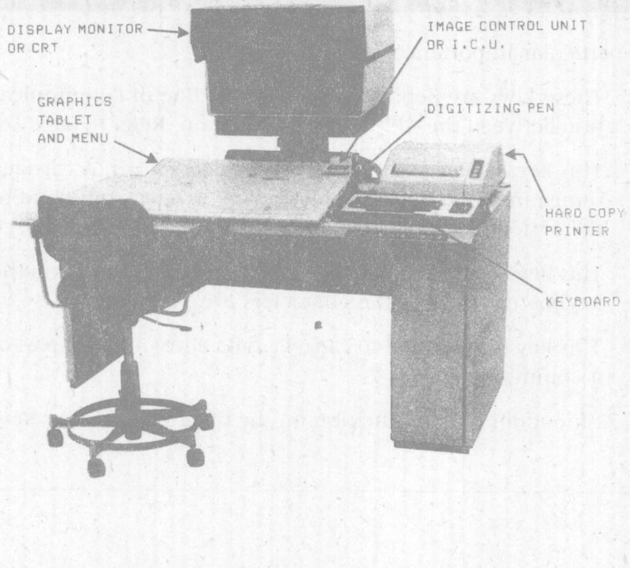


FIGURE 1.4
Components of a typical workstation.

2. *Keyboard* This is a typewriter-like device used by the operator to enter graphic commands and data into the computer. All information typed is displayed on the CRT screen. The details of a workstation keyboard are shown in Figure 1.5. There are 68 keys available to the operator for inputting commands.
3. *Graphics Tablet and Electronic Pen* A graphics tablet is a device that is also used to quickly enter graphic information the computer may need to execute a graphic command. The tablet has two principal areas, a digitizing area and a menu area. The operator uses the electronic pen in the digitizing area to indicate to the system the location of a coordinate point or to identify a piece of geometry already on the screen. The system displays horizontal and vertical crosshair lines on the CRT. Where the lines cross is a digitized location. The cross location moves as the operator moves the pen across the digitizing area. Digitized information is entered into the system by pressing one of the buttons on the light pen while keeping the pen in contact with the tablet. The act of using the pen in this manner is called digitizing. (See Figures 1.6 and 1.7.) The menu area contains programmed graphics commands in boxes or keys. When the pen is used in this area graphic commands can be automatically entered into the system simply by pointing to the appropriate key and digitizing. Thus, the operator has the option of either typing graphics commands using the keyboard or entering the commands using the menu and electronic pen. Refer to Appendix E for a more complete discussion of menus.
4. *I.C.U. (Image Control Unit)* The image control unit is a box which has buttons for controlling the size, location, and orientation of the geometric image displayed on the CRT screen. Separate buttons for enlarging, shrinking, translating, and rotating the image are in this unit. Manipulating the screen image in this way is called "dynamic viewing" and will be discussed in more detail as we proceed.
5. *Printer (Hard Copy Unit)* This device can be used for copying onto paper any information displayed on the CRT screen. This includes all entered graphics commands, system responses to the commands, and geometry generated. Thus, the printer provides a permanent record of the operator's activities at a workstation.

The following keys are of particular importance:

CNTRL R	keys	These keys are depressed to initiate a line of communication between the CPU and a workstation. Refer to page 16.
RETURN	key	This key is depressed to enter a carriage return. A carriage return must be executed after typing in each command to the system. Refer to page 16.
SHIFT	key	This key is depressed to obtain uppercase characters on the keyboard. Some of the characters are ', ", $, etc.
US-DEL	key	This key is depressed to cancel a data entry input as part of a command.

Refer to pages 23, 47, and 72 for additional information on the functions of other keys on the keyboard.

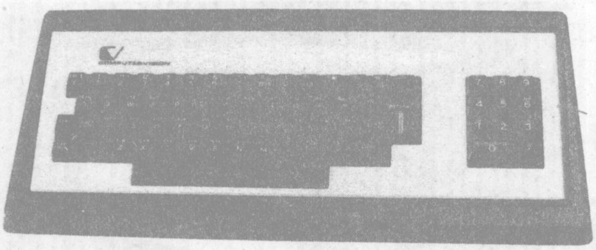


FIGURE 1.5
A workstation keyboard.

1.8 THE GENERAL OPERATION OF DESIGNER SYSTEMS

Designer CAD systems operate in the following general manner:

1. A command is entered at a workstation. This can be accomplished by using any appropriate combination of keyboard, electronic pen, and graphics tablet.
2. The command is received by the CPU. It is decoded and executed with the help of software graphics programs stored on the disk unit.
3. The results of the command are stored in a work file on the disk. These results will be stored in a mathematical code form.
4. The mathematical code stored on the disk will be translated into corresponding geometric results. The geometric results (geometry generated, manipulated, or removed) will be sent to the CRT screen and displayed for the operator to see.

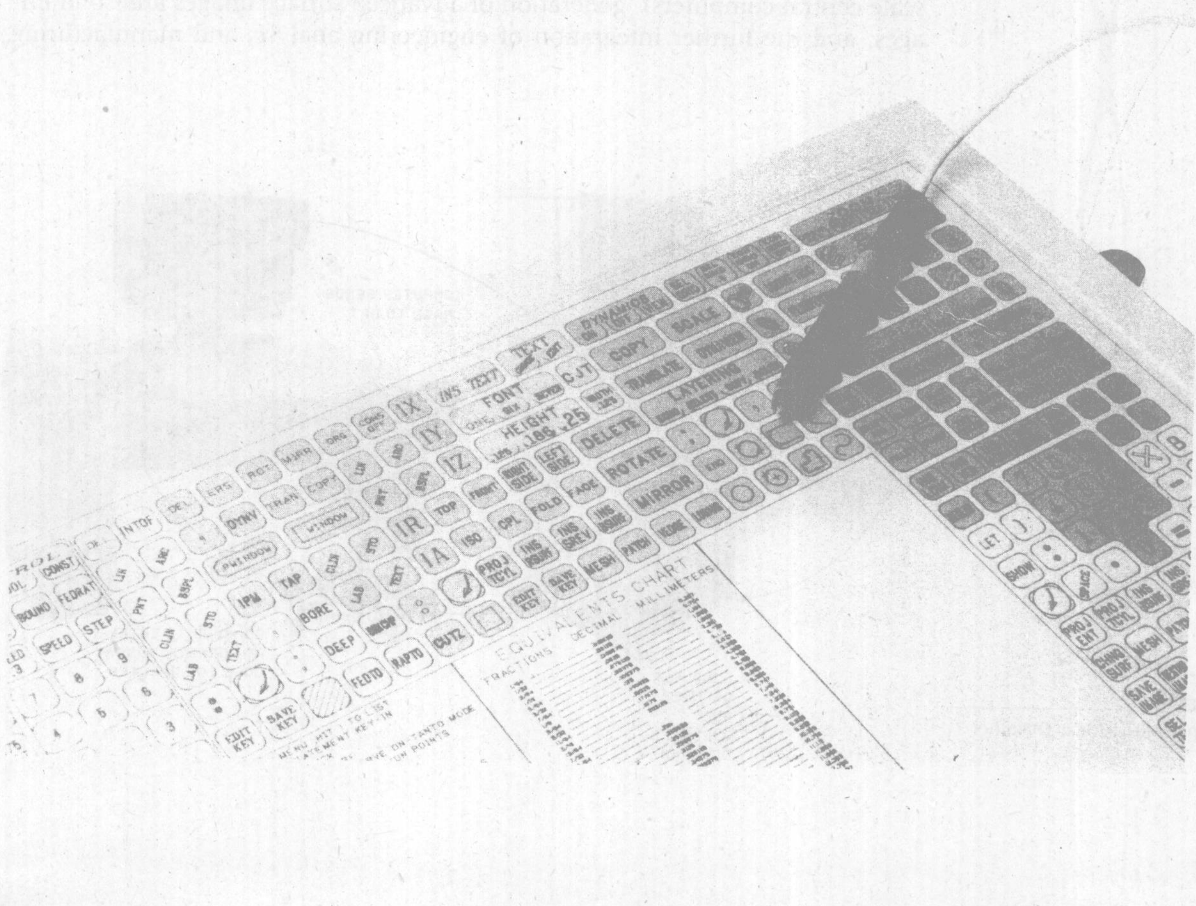


FIGURE 1.6
Closeup of graphics tablet and electronic pen.

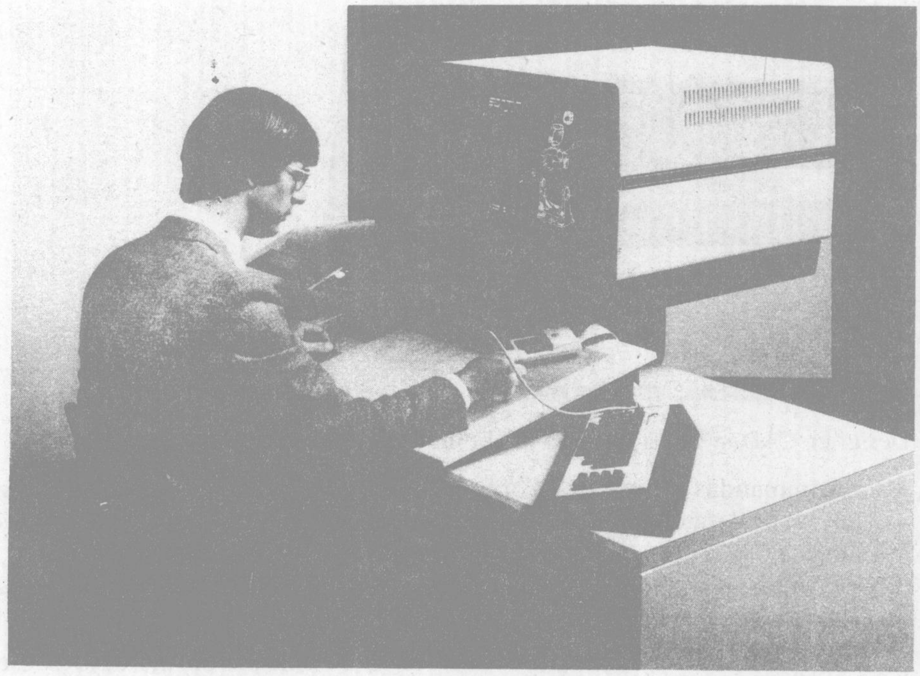


FIGURE 1.7
Entering information into the Designer system by digitizing (using electronic pen and graphics tablet).

1.9 PRESENT AND FUTURE DEVELOPMENTS IN CAD

Recent developments in CAD systems include the use of faster processors (32 bit processing) networking turnkey systems together and to mainframes (large scale central computers), generation of advanced surface images and solid images, and the further integration of engineering analysis and manufacturing

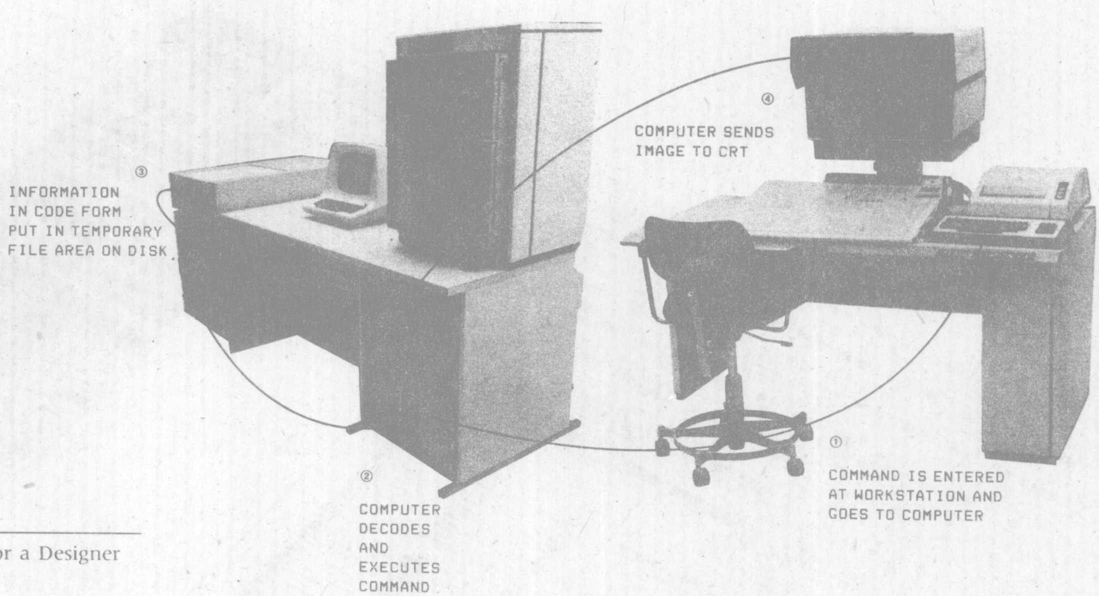


FIGURE 1.8
Sequence of operations for a Designer CAD system.