CAD

DRAWING
DESIGN
DATA MANAGEMENT

E. LEE KENNEDY

The Architectural Press: London

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To three great Kennedys
Sue, Smith, and Brook

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Acknowledgments

As with most endeavors each of us pursues, the fruits of our work are seldom the product of one mind. *CAD* is no exception. Many people helped make the book possible. Some gave encouragement, others advice and support, while many contributed with examples of their work or products.

From the beginning, I wanted the book to be a generic primer on CAD for the design community and one that would dovetail with other books from the Whitney Library of Design, which I have admired since my early days in architecture school.

I have four very special people to thank at the Whitney Library of Design. Former executive editor Stephen Kliment, with whom I developed the concept; former editor Susan Davis, who taught me the value of critical review; senior editor Julia Moore, who showed me how important a good editor can be to the way a book turns out; and associate editor Victoria Craven-Cohn, who gave me complete and intelligent editorial supervision and production support.

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Finally, I would like to express a special note of thanks to several companies for their help and support, and for offering me the use of their computers and software to prepare many of the drawings for this book. Most of the line figures were drawn on a NEC HO3 computer owned by The Miller Organization using MiCAD Systems enhancements to AutoCAD® software. Most of my three-dimensional drawings and the color plates were created on an Apollo computer using Autotrol Technology Series 5000, Plan, and my color software. The early drawings were created on my Apple II+ using a combination of Appleworld (USA Software) and the CAD software I wrote for the Apple in 1981. The line drawings were plotted on Hewlett-Packard, CalComp, and Houston Instrument pen plotters using technical pens on vellum. The one- and two-point perspectives were plotted with ballpoint on Mead Mark 1 coated cover stock, an excellent quality and durable media for presentations, while the dot matrix screen "dumps" were generated on my Integral Data Systems printer. All of my screen photographs were taken with a 35mm Nikkormat using a 50mm F1.4 lens with closeup lens, no color correction, and Kodachrome daylight ASA 64 film. A dark plastic garbage bag taped to the CRT and covering the camera proved to be the easiest way to exclude reflections from the face of the CRT.

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Part I

BASICS

To understand and appreciate CAD (Computer-Aided Design), you need to know something about computers—not a great deal, but something. In the first two chapters, you will learn the fundamentals of CAD. Chapter 1 deals with CAD system components in a very broad way. It is a chapter about whats, not hows or whys. Chapter 2 compares the differences between manual drawing and CAD drawing. This foundation leads you into Part II Drawing.

1

CAD Components

A computer consists of a device that manipulates data for you plus a means to enter variable data and a means to extract answers. Your pocket calculator is a simple computer. You enter numbers (**data**) in the calculator, and it **manipulates** the numbers and displays (**extracts**) the answer. **Alphanumeric computers** manipulate text and numbers only, whereas **graphics computer systems** are used for drawing. CAD graphics computers manipulate alphanumerics and graphics in a manner particularly well suited for applications in architecture, engineering, facilities management, and interior design.

COMPUTATIONAL POWER

Computers, like automobiles, are measured by their speed and power. Computational power is a combination of processing speed and memory capacity. Computational speed is achieved primarily with hardware (the stuff you can physically touch), such as the green boards inside the computer cabinet to which the electronic components are attached. The most visible and best-known piece of hardware is the tiny black rectangle called an **integrated circuit**, or **chip**.

Processing speed is determined, in part, by the bit size, a **bit** being the fundamental computational unit. Speed increases exponentially as bit size grows. Thus, a 32-bit computer processes information much more than four times faster than an 8-bit computer. Bit size has grown over the years, until 8-bit and 16-bit computers have been succeeded by 32-bit computers, the current standard. (There are even 64-bit computers that are used for some graphic displays.)

Numerical calculations affect processing time. Integers are stored in a very efficient manner and consequently can be processed more quickly than real decimal numbers (which may be accurate to many decimal points). The accuracy of a CAD computer far exceeds construction accuracy. Memory size is important because it represents the space available to store data. Memory capacity is measured in bytes. One **byte**, consisting of eight bits, can represent one letter, number, punctuation mark, or special symbol. (See Chapter 13 for a discussion of computer logic.)

A computer contains three different memory areas, each equally important. One stores the fundamental instructions that the computer uses for housekeeping functions; it's called **read-only memory** (**ROM**). The second memory area stores and processes data and instructions in a working memory area called **random-access memory** (**RAM**), also called **core memory** or simply memory. It is here that your software program is executed.

Programs—from word-processing programs, spreadsheets, and database management systems to CAD programs—are called **software**. The software contains the instructions necessary to run your program. As you run software, you enter and use specific data relevant to the problem at hand. You **store**, or **save**, this data in a working file. You use software and files concurrently, and both are kept safe in a third, permanent memory area: an internal hard disk or an external disk drive, cartridges, or magnetic tape.

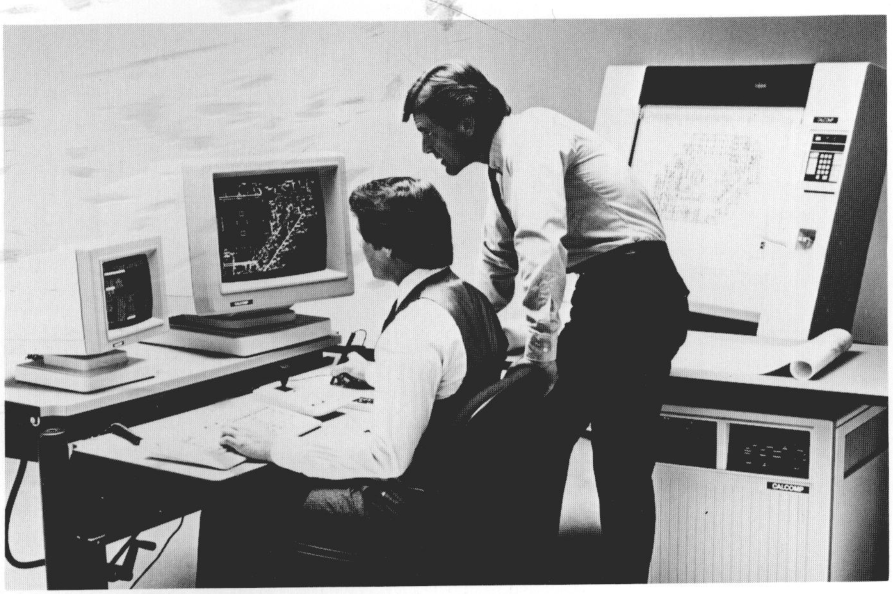
As you will soon discover, identical results can be achieved with computers using different methods. Some of the methods are elegantly simple, while others are as subtle as a sledgehammer. Hardware and software interact in a complex fashion, working in concert to achieve the desired results. Most tasks that can be performed on a large computer can be duplicated on a smaller model—perhaps not with the same speed, power, or simplicity, but performed nonetheless. So, while all computers will "get you there," the power and speed of the more sophisticated hardware and software will be as high as their price.

A FIRST LOOK AT COMPONENTS

The brain of a computer is called the **central processing unit** (**CPU**). The CPU processes information by comparing one item with another (actually one number with another) and then performs this or that procedure according to the governing instructions of the program you are using.

A program always executes the same sequence of procedures, but it accepts different values for a given variable to produce different answers. In order to perform your instructions, a computer has a means of entering data (**input**) and of extracting and displaying data (**output**). It files the results in a **storage device**.

Computers are classified according to their computational power as **mainframes**, **minicomputers** (Figure 1.1), or **microcomputers** (Figures 1.2 and 1.3). But because of rapid changes in technology, these categories are not distinct: a standard feature of one category may be optional in another category today and standard tomorrow. Mainframes traditionally are installed in specially air-conditioned rooms and are too large and bulky to be moved easily; micros fit on desktops; and minis fall somewhere in between. Despite their small size, however, micros may encompass exceptional computational power.

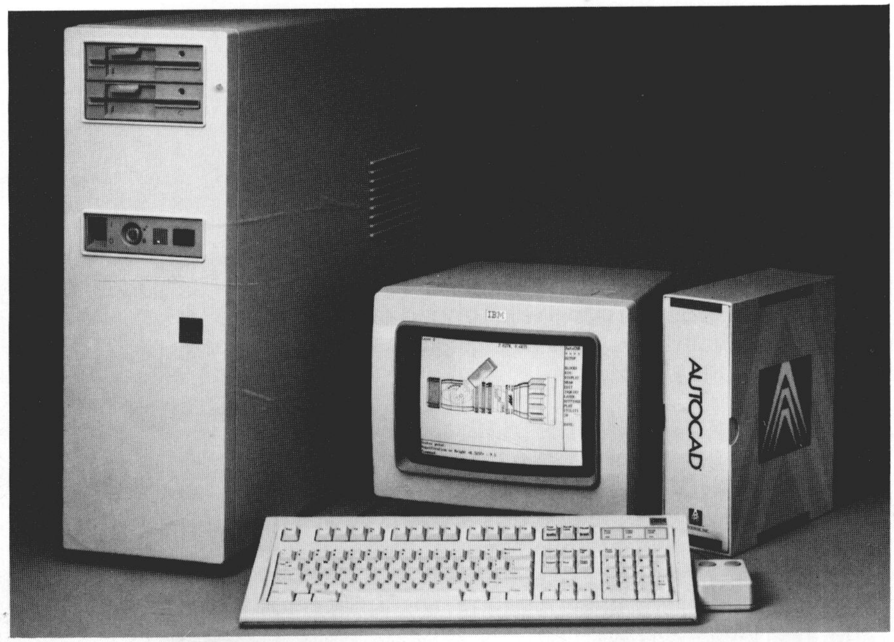


1.1 *Minicomputer CAD system showing all components. (Courtesy of CalComp, a Sanders company)*

Computation: The Central Processing Unit

In a mainframe system, all the computations and memory functions are handled by the CPU, and display functions are managed by multiterminal graphics workstations. Data entered on one terminal is quickly available to any terminal in the system. Modest price and fast, task-specific software have made microcomputer CAD systems popular contenders in the competitive professional CAD market.

Standalone computers are self-contained computers linked in a communications network, appropriately called a local-area network (LAN). Figure 1.4 shows a typical local-area network connection, in which one terminal may be shut down without affecting the performance of the others.



1.2 *Microcomputer CAD system showing integrated components. (Courtesy of AutoCAD® by Autodesk, Inc., Sausalito, CA)*

1.3 *Microcomputer CAD system. (Courtesy of CalComp, a Sanders company)*

1.4 *A local-area network provides the means by which standalone computers can communicate with one another so that data on one terminal can be used by another. (Courtesy of Apollo Computers, Inc.)*

Computer Instructions: The Software Program

Although a computer is capable of performing any logical task, you must tell it what task to perform and how. These instructions constitute a computer program—the software. Because computers are consummately precise, programs must be correspondingly precise. Parenthetically, there are programmers and nonprogrammers—precise and "nonprecise" people, if you will—and little else between. But you do not have to be a precise person or a programmer to *use* a program or a CAD system, and you certainly should not feel intimidated by the mystique of programming. For the time being, you need only know that programming is a precise set of instructions and that the majority of programs fall into four categories: word processing (text manipulation), spreadsheets (number manipulation), database management (data manipulation), and graphics. You will learn more about programming as you progress through the book.

Data Entry: Input Devices and Methods

A computer program solves a given problem using different values that you enter for each variable, such as drawing scale. Data is entered using any of several **input devices** or methods: keyboard, graphic cursor, menu, or digitizer. Giving up the pencil to enter data with such devices as a stylus, mouse, or puck is easy for most people, and you don't have to be a crack typist to operate a CAD computer. Let's look at each means of input in detail.

Keyboard

The original computer input device was the **keyboard**. Because a computer interprets keyboard input exactly as you enter it, the keyboard is the most accurate of all input devices. In early computers, the keyboard served as both the input and the output device. Actually, it was a teletypewriter keyboard. Many keyboards still bear the word *bell* on the G key, a vestige of the time when a bell tone signaled the end of a teletypewriter message.

In many ways similar to the standard typewriter keyboard, it performs all the functions you expect of a typewriter. But five keys merit attention because the computer interprets each in a special manner: the numerals 1 and 0, the uppercase *O*, the lower case *l*, and the carriage return. In reading a typed page , you readily understand the context in which each of the four characters is used, but the computer accepts each keystroke literally; consequently, you must use each correctly. The carriage return will advance a line and return to the left margin, but its primary computer function is to signal the completion of an instruction to the CPU and order its execution. On some computers, this key is called the Enter key.

Three other special features may be included on a computer keyboard. First is a numerical keypad that simulates an adding machine. Like accountants who enter columns of numbers, computer users prefer the numeric keypad over the numbers on the top row of keys. Second, a heavily used keyboard feature on some CAD systems specifies **point entry**. Examples are Key 1, used to enter points; Key 2, to draw a line from the last point; Key 3, to draw a line from the last point in an alternative line texture (such as dashed); and Key 4, to drag and insert figures. Last, a **function keyboard** may be included to perform specific drawing, programming, or other actions that you may define. These keys are called **user-definable**.

Graphics cursors

While it is possible to draw on a computer using only the keyboard, it is generally quicker and more comfortable to use a method that functions like the computer's pencil. These include the stylus, puck, mouse, joystick, and thumb wheels. They control the location of the graphics **cursor**, an image you move anywhere on the CRT screen to indicate a point location. Typically, the cursor consists of two intersecting lines called **cross hairs**. To enter a point on a computer drawing, you center the cross hairs at the desired location and press a point entry key.

The **stylus**, or **pen**, shown in Figure 1.5 is the most familiar computer pencil. It is connected to the computer by a cord and activates a point on the screen when the pen is pressed against the magnetic surface of the **bit pad** (also called a **graphics tablet**). The computer reads the location of the point and displays it on the screen.

The operation of a **puck** is similar to that of the stylus. A mini keyboard atop its boxlike housing can be used to activate points and perform additional functions. A **mouse** and a puck have similar shapes, but with a mouse, the point location is calibrated by the movement of a ball in its base rather than by activating a point magnetically. The mouse can be used on any flat surface and does not require a magnetic bit pad. You should find both the puck and the mouse comfortable and easy to use.

Copied from arcade games, the **joystick** was one of the first CAD pencils. It responds quickly to hand action but inconsistently to drawing movements. **Thumb wheels**, though awkward to master and generally unpopular, provide positive horizontal and vertical movement. Because they are contained in a box that is seldom moved from its location on your desk, you can locate the thumb wheels without looking.

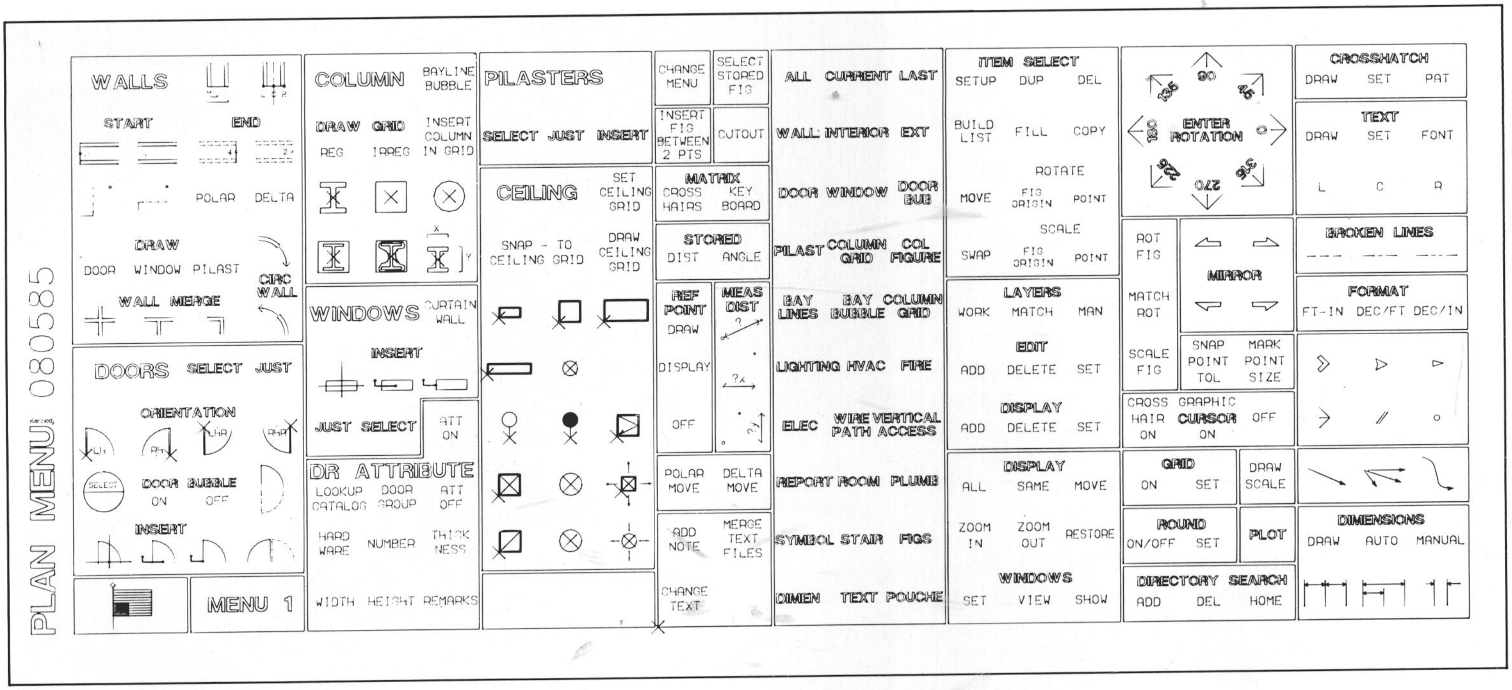
With CAD drawing, you use your drawing hand for drawing and typing, alternately grasping and releasing the graphics input device. For that reason, you will find that reaching for a mouse or a puck is faster and less fatiguing than reaching for a stylus. In most cases, you can grasp either one without looking away from the face of the CRT and with little hand reorientation.

Menus

You can also enter data by a third means, the **menu**. A computer menu resembles a restaurant menu: You select an option from a list of items, using the keyboard or graphics cursor to enter your choice. Menus take many forms: on-screen, attached to bit pads, or separate menu devices. Programs directed by menu input are said to be **menu-driven**, whereas programs activated solely by keyboard entry of commands are called **command-driven**. Most CAD programs employ menus as the primary means of input but also permit the user to enter commands on the keyboard.

A menu is ideal for entering known options and is particularly well suited for work with standardized, repetitive, or complex processes. If a menu cannot cover every variable, it will list common values and ask you to enter unlisted ones. Compare, for example, a program that asks you to enter a drawing name and the scale. The number of possible entries for a drawing name is limitless, whereas there are only about eight commonly used architectural scales. A menu cannot list all the possible

1.5 *The stylus was the first "pencil" used with a magnetic menu board. (Courtesy of Autotrol Technology Corporation)*



1.6 *A digitizer menu attaches to a magnetic bit pad.*

names of drawings, so you have to enter the drawing name from the keyboard; but you could select the scale from a menu.

When you select a graphics menu option, the program executes a segment of the software (a subroutine) or prompts you to enter additional menu items. Virtually all software programs run (are executed) with a menu similar to the ones in Figures 1.6 and 1.7.

CAD graphics menus used for architectural, engineering, and design work combine a matrix of small pictures and short command descriptions into a graphics display that resembles a checkerboard. Each square represents a graphics item from the figure library (see page 141) or an instruction (for example, to set the drawing scale). Graphics programs require menus that often list as many as 500 items. Ideally, all options available on a menu are displayed concurrently for easy access. Figure 1.5 shows a typical preprinted menu attached to the face of a magnetic bit pad.

Menus can also be displayed on the CRT, but graphics menus are too large to display the entire menu on a CRT screen at one time. Consequently, the screen menu is subdivided into smaller segments for easy display, so that each segment occupies a small area of the screen next to your drawing. Screen menus, like the one in Figure 1.7, have become very popular. You select a menu option with the stylus, mouse, or puck by centering the cursor over the desired item and pressing the correct function key. You will find the combination of screen menu and puck to be the fastest and most comfortable of all the various input methods.