MICROCOMPUTERS IN THE BOATYARD:

Microcomputer Basics

Kevin Mitchell
edited by Robert Scher

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I. INTRODUCTION

The age of the microcomputer has arrived. With its expanding memory and power and shrinking price tag, the microcomputer is changing the way Americans learn, play and do business. Much more than a calculator and with a price tag far lower than a main frame computer, the microcomputer can help the small boatyard streamline its overhead, increase the effectiveness of its engineering department and help plan, schedule and control production.

This paper outlines basic microcomputer architecture, describes system components and software, and serves as an introduction and buyer's guide for the potential microcomputer buyer.

II. HARDWARE

In this section we will give a simplified description of how a microcomputer operates internally. It should be noted here that a full understanding of the internal workings of a microcomputer is not necessary for day-to-day use, but a general awareness of basic microcomputer principles and terminology will help the newcomer in making a purchase choice. Before operation principles are discussed, the terminology and various number systems used by the computer industry should be discussed.

At the most fundamental level, all modern digital computers operate with binary numbers (0's and 1's) because they consist of electrical components that can be in only one of two possible states (corresponding to circuitry being either open or closed). These two states can be interpreted as ON or OFF, as TRUE or FALSE, or as 0 or 1. Any set of two distinct states would suffice for the purpose of describing a simple digital device. The point is that all of the computer's internal decision-making and computations involve this so-called "binary logic." If the human operator of digital computers had to continuously communicate with it in the form of binary digits, computing would be a slow and tedious process. Fortunately, most operators rarely have to deal with binary digits. However, hexadecimal and octal (base 16 and base 8, respectively) number systems are often referred to and an understanding of why they are used is helpful.

Historically, people used Roman numerals for counting, addition, and subtraction. However, when it came to multiplication, Roman numerals were inadequate. Of course, ultimately, Roman numerals were supplanted by the Arabic system which we now know as the decimal or base 10 system. Base 16 and base 8 systems arise in computer usage because binary numbers can easily be converted to these number representations and it is easier for humans to work with them. In summary, base 10 is what humans commonly work in, base 2 is the fundamental numerical system of computers, and base 16 and base 8 provide an interface between the two. A table of the first few numbers in the various bases is shown in Figure II-1.

Usually, a binary digit is referred to as a <u>bit</u>. A group of 8 consecutive bits (for instance 10101010) may be called a <u>byte</u>. A <u>word</u> in computer

Figure 1 Number Systems

Base 10 (Decimal)	Base 16 (Hexadecimal)	Base 8 (Octal)	Base 2 (Binary)
0	0	0	0000
1	1	1	0001
2	2	2	0010
3	3	3	0011
4	4	4	0100
5	5	5	0101
6	6	6	0110
7	7	7	0111
8	8	10	1000
9	9	11	1001
10	A	12	1010
11	B	13	1011
12	C	14	1100
13	D	15	1101
14	E	16	1110
15	F	17	1111

terminology usually refers to the basic unit of storage in the computer. A word may be measured in bytes or bits. The microcomputers we will discuss have either a word length of 8 bits (1 byte) or 16 bits (2 bytes). They are commonly referred to as 8-bit or 16-bit microcomputers.

Another term seen quite often is the abbreviation K. Usually, this is used as a symbol for 1000, but in computer terminology K refers to 1024 (2^{10}), so, for example, 16K means 16,384, not 16,000.

Any computer, be it a micro or a super-mainframe, performs numerical manipulations of binary digits at an exceedingly high rate. A computer must be able to:

(1) receive data to operate,

(2) receive instruction on what operations to perform,

and (3) output the results of the operations.

So a simple schematic of a computer may be shown in Figure II-2.

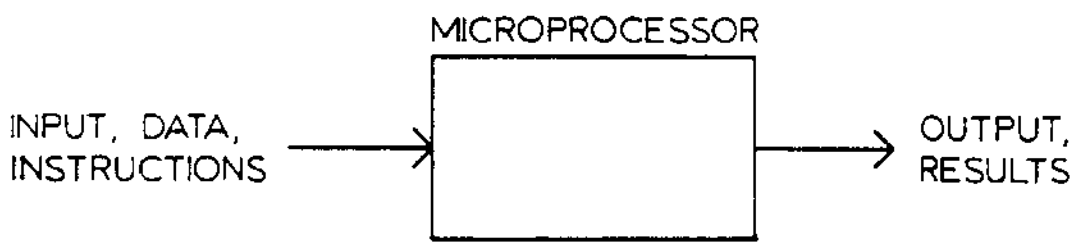

Figure 2

Computers, apart from the extremely sophisticated and exotic "parallel-processors", can perform only one specific operation at a time. However, since these operations are to be performed at a very high rate, the instructions must be readily available. For this reason, every computer must have an electronic memory area for storing not only data and intermediate results, but for program instructions as well. The different types of memory used in microcomputers will be discussed later. Figure II-3 represents the relationship between the microprocessor and memory in our simplified microcomputer.

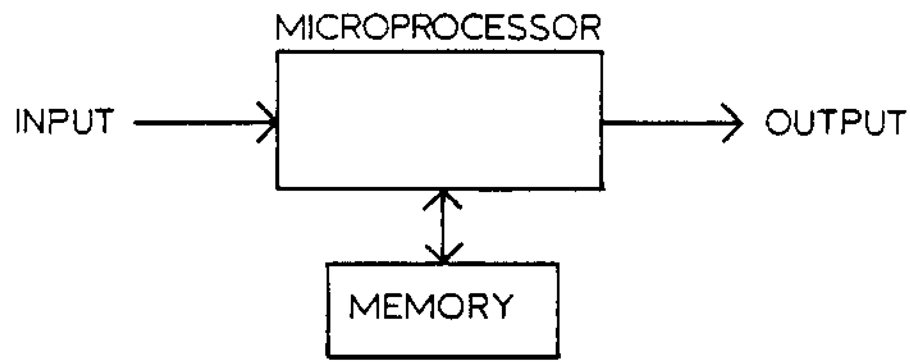

Figure 3

The simplified microcomputer, stage 2

If we look more closely at the part of our simplified computer that does the actual computations (called the central processing unit, CPU, or microprocessor in microcomputers) we can further divide it into an arithmatic-logic unit (ALU) and a control unit, as shown in Figure II-4

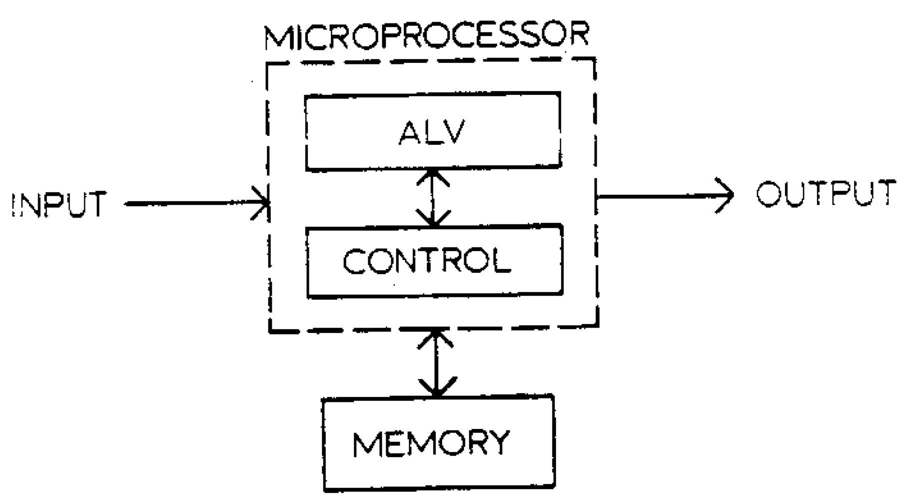

Figure 4

The simplified microcomputer, stage 3

For our purposes, this is a sufficient picture of the structure of a microcomputer. The ALU performs all arithematic and logical data manipulations. The control unit performs the specified flow of information to and from the memory, the ALU, and the program steps, and directs the input and output devices.

Within the microprocessor there are special memory-like spaces that are often referred to as "registers." The number of registers available on a microprocessor depends on its specific architecture, but it is always a relatively small number, compared to the number of separate spaces on the memory.

A simplified sequence of events which might occur during some brief time period when a microcomputer is used to perform some task would be as follows:

(1) The control unit receives an instruction to recall a number from a particular location on the memory and place it in register A.

(2) Second instruction caused another number to be recalled from the memory and placed in register B.

(3) The control unit, with another instruction, sends the contents of register A and register B to the ALU and then directs the ALU to add them.

(4) The ALU sends back the resulting number to the control unit which, according to another instruction, stores the results in register C.

(5) Finally, the control unit sends the content of register C to a specific memory location or to a terminal screen, printer, etc.

The above sequence of events, while simplified, gives some idea of how digital computers operate. The instructions which are given to the microprocessor are coded in binary form. The instructions that the microprocessor understands are collectively called the instruction set. The number of instructions in the instruction set varies, depending on the microprocessor, but typically may be a few hundred. So, no matter what task a microcomputer is asked to perform, in the end, a selection of the few hundred distinct instructions must be arranged in a sequence that will cause the microprocessor to perform this task. Most users will never have to learn or work with the microprocessor instruction set in its internal form. Instead, the typical user will write his program in a so-called "higher-level" language, such as BASIC or FORTRAN. The <u>computer</u> will then translate this program into a form containing only microprocessor instructions. This translation process is very important, and we will return to it later.

For now, a basic understanding of the internal workings of a microcomputer will allow us to look at the different features of various microcomputers.

16-Bit Versus 8-Bit Microcomputers

The two broad classes of microcomputers, 8-bit and 16-bit, represent two generations of microcomputers. The 8-bit microcomputer operates on pieces of data which are 8 bits long. For example a memory location might hold the number 100 in decimal, but it is stored internally in the form of an 8-bit binary number. The 8-bit microprocessor can retrive this 8-bit number from memory and, later, output results in an 8-bit form. The majority of microcomputers on the market today use 8-bit microprocessors. There are different microprocessors used by the current generation of 8-bit microcomputers, but a few are common: in particular the Zilog Z80 and Z80A, the Intel 8080, and the 6502. These different microprocessors generally represent subtle design differences, and some have evolved from earlier versions. Many of the characteristics of a particular microprocessor are defined by the instruction set that the designer builds into them. By computer industry standards, the 8-bit microprocessor is now classic technology. The original 8-bit microprocessors were developed for calculator applications, but gradual improvements have made the 8-bit microprocessor useful for most microcomputer applications.

The 16-bit microcomputer is a newer breed. Of course, 16-bit microprocessors have been used for years in expensive minicomputers (the Digital Electronics Corporation's PDP-11 series is an example), but recently, companies have designed 16-bit microprocessors for use in microcomputers. The 16-bit microcomputer generally represents data in the form of 16-bit lengths. The two 16-bit microprocessors dominating the market right now are the Motorola 68000 and the Intel 8088. Usually, the Motorola 68000 is referred to as a 16/32-bit microprocessor and the Intell 8088, a sort of hybrid, is referred to as an 8/16-bit microprocessor.

In general 16-bit microprocessors are more sophisticated than 8-bit microprocessors. They are able to operate at higher speeds, have a larger instruction set, and most importantly, are able to directly access more memory. A parameter often used in describing a microprocessor is its speed. Usually, the speed quoted is a memory-access speed typically on the order of 2 to 4 MH_Z for 8-bit microprocessors and greater than 4 MH_Z for 16-bit microprocessors.

This access speed is an indication of how quickly a microcomputer will operate but should not be considered as an absolute virtue, since there are other factors involved in how fast a microcomputer operates. Most 8-bit microcomputers are limited to 64K of memory while the newer 16-bit microcomputers might have up to 512K of memory. This memory-size issue will be discussed in more detail later. The Intel 8088 is noteworthy since it is used by the new IBM personal computer. The 8088 is derived from Intel's 16-bit 8086, which is itself far more advanced than the 8-bit chips to be found in most of today's microcomputers. While the 8088 retains all of the 8086's internal 16-bit computing capabilities, it communicates with external devices (such as memory) with an 8-bit data size. The principal advantage of this fact is the ability to incorporate some of the existing 8-bit microcomputer support technology into a new system. A true 16-bit microprocessor such as the Motorola 68000 is more powerful than the Intel 8088 but requires the microcomputer system designers to develop supporting material from scratch with less of the 8-bit technology carried over.

Memory

The largest component of microcircuitry cost is often not the microprocessor itself, but the memory chips. Therefore, one of the major advances in microcomputers in recent years has been the reduction in the cost of memory, due to mass production.

More memory space allows the microcomputer designer to incorporate more sophisticated features in the computer, and it also allows the user a greater range of applications. As mentioned before, one of the main advantages of the new generation of 16-bit microprocessors is their ability to access large amounts of memory.

There are many distinct types of memory used in modern microcomputers. A brief description of some of these follows.

RAM - Random Access Memory

This type of memory is normally of most interest to the average microcomputer user. Random access memory contains user programs and data execution. It can be read from and written to by the microcomputer, but RAM is usually volatile: i.e., when the power is tunred off, RAM contents are lost. Generally, when referring to a computer's memory size (such as 64K, 512K, etc.), the number given is the size of the RAM.

ROM - Read Only Memory

This is a permanent, nonvolatile type of memory. While the size of the ROM in various microcomputers varies, almost all microcomputers will have some amount of ROM. ROM normally contains system programs that will not require changes. For example, many of the simpler microcomputers contain the resident BASIC language on a ROM chip.

RAM and ROM are the types of memory mentioned most often but there are others.

PROM - Programmable Read Only Memory

The PROM chip is similar to a ROM chip except that it can be programmed once by a computer designer instead of being manufactured pre-programmed. It may be thought of as a collection of fuses on a chip, which may be selectively blown. PROM's are often used in microcomputer development by designers.

EPROM - Erasable Programmable Read Only Memory

This is a special type of PROM chip that is reusable. It can be erased by using ultraviolet light; it is an expensive chip, but useful for microcomputer development. There is also a new class of EPROM which can be erased electrically, the so-called EEPROM. A few new terminals and microcomputer incorporate them to allow the user to semi-permanently set certain features on the computer. For example, Radio Shack has introduced a new terminal which has the ability to emulate several different types of terminals. Thus, the user's system requires a certain type of terminal, a series of commands to the Radio Shack terminal will modify the EEPROM. Until the user issues new commands, the terminal will then always circulate the required terminal for the user's system. The features are saved even when the power is turned off.

Bubble Memory

This is a read/write type of memroy simular to RAM; however, it is nonvolatile. Its major drawback has been cost and complexity, and there are only a few microcomputers now on the market with bubble memory. There is intensive research under way in the area of non-volatile fast access read (write memory, and this type of memory may become more common if costs can be reduced.)

Microcomputer Physical Architecture

We have briefly reviewed microprocessors and memory. These components must be physically connected to each other and additional connections must be provided for the various components and input-output devices which form a microcomputer system. The majority of microcomputers today use circuit-board architecture with some form of circuit bus system. A simple example would be a microcomputer composed of a microprocessor, memory, keyboard, and display screen (CRT). A simple diagram which depicts the physical connection is shown in Figure II-5.

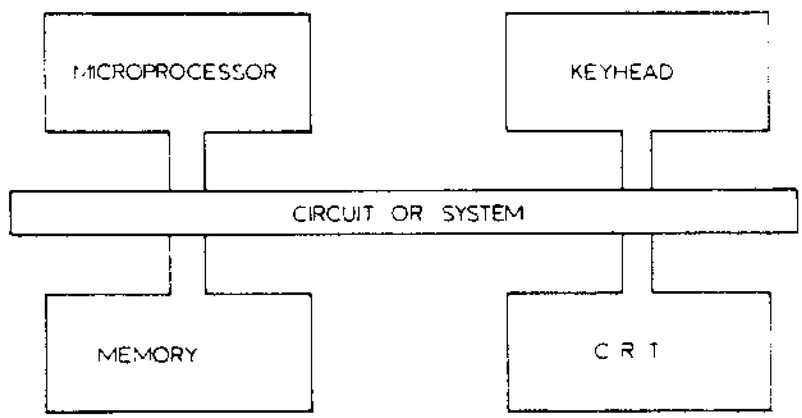

Figure 5

Typical microcomputer architecture

Of course, an actual microcomputer's physical architecture is much more complex, and includes power sources and other components.

The actual methods used by different microcomputer manufacturers to physically connect components, varies but a few catagories of arrangements can be defined.

A very simple microcomputer might have the microprocessor, memory, and input-output features placed on one circuit board, as in a calculator or pocket computer. Most designs of this type are very limited in their ability to expand.

A more common type of architecture involves the circuit bus system mentioned above. Good examples of this type of system are the Apple and IBM personal computers. Sometimes, the microprocessor and some memory chips reside on a circuit board "card" which connects to the circuit bus by being inserted into a slot. Alternatively, the microprocessor, memory chips, and the circuit bus are one unit. Whatever the case may be, there are usually additional empty slots available on the bus to allow the system to be expanded. A special "card," possibly containing additional memory chips, or incorporating special functions, can then be plugged into any available empty slot.

A similar system architecture is available in microcomputers using so-called S-100 systems. The "S-100" is an electronic industry convention referring to the physical characteristics of the edge connector of the circuit board cards. It has 100 "pins" and the individual circuit bus slots have 100 "holes." S-100 microcomputers can be personalized for different applications by selecting the appropriate S-100 cards inserting them into the bus. An advantage of S-100 systems is their ability to be designed around many different microprocessors. Most S-100 microcomputer manufacturers offer various configurations of a basic system, but many S-100 systems are built by the users themselves. There are hundreds of S-100 circuit cards available from various sources able to perform different tasks. The catch here is that although any S-100 card can be connected to the bus, the different boards must also be able to operate together. It is recommended that beginners stick to one manufacturer's S-100 system until he is familiar with the details.

In general, microcomputers with some sort of data bus and expansion slots are preferable to a fixed system. Expansion slots allow a manufacturer to offer refinements and even entirely new features. Also this type of system may be supported by independent manufacturers of microcomputer accesories.

Other Microcomputer Components

In this section we will discuss various microcompter components, including input-output devices and storage systems. As mentioned above, there are various ways in which these components may be connected to the microcomputer. Each manufacturer seems to have a favored method of incorporating individual components, however, there are certain conventions that have become relatively standardized.

Two such connections involve the use of the RS232C and centronics-type parallel connection ports. For example, a microcomputer might have two RS232C connection ports at the rear. Connected to the microcomputer might be a printer and a plotter, each with its own RS232C port. Cables would run from the microcomputer ports to the individual ports of the printer and plotter.

When data is passed between the microcomputer and various.devices, it may be transferred serially or in parallel. Serial communications involves sending one bit of data after another. Parallel transfer will send data in groups of bits, say 8 bits, almost simultaneously, along parallel lines. The RS232C port is usually employed for serial data transfer and the centronics type parallel port for parallel data transfer.

These two types of connections are mentioned by name mainly because they are often encountered in descriptions of how various devices are able to communicate with the microcomputer. At this point, it should be clear that although various devices may have compatible connection ports, this fact is not sufficient to guarantee that these devices are able to operate together. The actual data being sent back and forth must be understandable by both devices.

Viewing Monitors

This device is often taken for granted, but it is important for obtaining the maximum benifits from your microcomputer. A good quality monitor will reduce operator fatigue, present information more effectively, and increase operation speed. Some microcomputers have built in video screens while some allow the user to choose his own. If the display is separate, it usually has its own special attachment port on the microcomputer, but some micros use a standard RS232C port for attaching a completely separate terminal. The terminal would then have both a display screen and a keyboard.

Some of the following features are apparent when looking at the viewing monitor but are actually the result of the microcomputer design. When choosing a microcomputer, look for one that will display at least 80 characters per line and about 25 lines of data. This feature is virtually standard for microcomputers today. An 80 character line corresponds roughly to a type-written line on an 8.5 x 11 inch page. A full 8.5 x 11 inch page will have up to 66 lines, however. Most microcomputers will not display this number of lines, but some of the newer micros, such as the Coruous Concept a 16-bit micro, allow a full typewritten page to be displayed. The Coruous Concept A is unique in that the screen can be placed vertically so that a full page can be viewed or turned to a horizontal position so that up to 132 characters per line can be displayed. This is a very useful feature.

Look for displays where the characters are sharp and clear. There are different combinations of background and character colors for microcomputer displays, although most are white on black or green. Some microcomputers will display reverse images (green or black on white) on the screen. This is useful to highlight certain messages or text. A display which is adjustable in location and viewing angle is a desirable feature since it allows the operator to find a comfortable viewing position.

Many microcomputers are now offered with color display capabilities. Most of these use a separate viewing monitor which the user can select to suit his own needs. He may use a color TV monitor or the more expensive RGB (red, green, blue) display monitors. Most color microcomputers will allow the user to connect a conventional display monitor also. Color graphics can be used effectively in many design applications. Programs can be devised to take advantage of color in visualizing certain relationships, or to point out special conditions in processes. Good quality color display is expensive, however, and it should be remembered that although color images may be viewed on a screen, it is very costly to obtain color output on hard copy.

Another feature available on some microcomputers is the ability to display one or two extra lines of data that remain fixed on the screen, usually at the top or bottom, for the user's convenience. Normally, the lines of data on a screen scroll upwards, but by having an additional region fixed the programmer can display program options in this fixed region, allowing the user to have a menu for instructions in view at all times.

Keyboards

Some microcomputers have a fixed keyboard attached to the display monitor while others have a separate keyboard. In any case, when choosing a microcomputer, look for a full-sized keyboard with standard size keys, and full-scale spaces between keys. All keyboards have the basic typewriter symbols, but most will also have additional keys. A separate numeric keyboard is handy for entering large amounts of numerical data. Cursor control keys and user definable keys are also valuable features. (User definable keys allow a program to assign frequently used commands or functions to single keys.)

DISK SYSTEMS

Floppy Disk Storage Systems

Floppy disks storage technology has helped microcomputers become powerful tools by allowing large amounts of information to be stored and accessed quickly. Early microcomputers used cassette tape recorders as the principal storage medium. While this is a simple and reliable form of storage, it is a very slow and awkward medium for the storage of large amounts of data. The tape must be wound to the point where the desired data is stored before it can be retrieved. Furthermore, cassette tape storage involves the conversion of digital data to audio compatible analog data. If an average floppy disk system can locate and load into memory a program in, say, 4 to 8 seconds, a typical audio cassette tape system would probably take 4 to 8 minutes.

A floppy disk is a magnetic storage medium consisting of a circular plastic disk with a magnetic coating. This circular disk is encased in a square jacket which has openings in it to allow the read/write head of the disk drive to access the disk. Data is stored on floppy disks in a specific pattern composed of concentric circular tracks each divided into angular sectors. This formatting of storage is handled automatically by the disk system. There are 8-inch and 5 1/4 inch disk drive systems on the market now. Within these two size classes, in turn, there are various storage capacities depending on whether data is stored on one or both sides of the disk, and on the density of the data on the disk. In each size range, 8-inch or 5 1/4 inch, there are the following options:

(1) Single sided, single density.
(2) Single sided, double density.
(3) Dual sided, single density.
(4) Dual sided, double denstiy.

Within these ranges the capacity of a single disk may be from 70K bytes (characters) up to 1200K bytes. Other things being equal, an 8-inch diskette will hold at least twice as much data as a 5 1/4 inch diskette. Access rates can vary from 1500 to 15000 bytes per second. An advantage of double density diskettes is that they generally have faster access times than single density diskettes.

Winchester Hard Disk Storage Systems

This is a disk storage system similar in principle to those found on large mainframe computers. The Winchester hard disk unit consists of one or more rigid disks, read/write heads, and associated circuitry sealed in a case. These disks rotate at very high speeds with the read/write heads very close to the magnetic coating. Since the entry of even small particles of dust or dirt can be instantly destructive, the sealed case is essential. Winchester hard disk systems are capable of storing large amounts of data: systems are being offered with 5, 10, or even 20 mega bytes (1 megabyte equals 1000K bytes) of storage. They also have extremely fast access. A particular function taking 30 seconds with a floppy disk system would probably seem almost instantaneous with a Winchester hard disk system. Winchester hard disk systems are very sophisticated units and also expensive, but recently the prices for such devices have begun to drop, and we may expect wider application of these units in the future.

Some General Comments on Disk Systems

All disk systems, whether floppy or hard, require relatively sophisticated controlling hardware and software. We will discuss the software portion in a separate section on operating systems.

A buyer of a microcomputer system will usually be offered various choices of disk storage systems. Many systems have one or two floppy disk drives built into the system as standard. If more drives are desired (usually up to a total of 4) they are contained in a separate case. Some systems, such as the Apple II, have all the disk drives located in their own cases. If possible, buy disk drives sold by the same manufacturer as the microcomputer, to ensure full compatibility. While a single floppy disk drive should be the minimum system considered, a better choice would have at least two drives. Disks must often be copied, and this is an awkward procedure with only one drive. In addition, some applications software requires multiple disk drives. There may be a choice between 8-inch and 5 1/4 inch drives. There are advantages and disadvantages to both. The larger drives, as mentioned above, can store more data, therefore requiring a smaller number of diskettes. However, 8-inch drives are also more expensive. Since the storage capacity of 5 1/4 inch diskettes has increased so greatly with double density, double sided storage, there seems to be a shift in favor of the smaller disks by many microcomputer manufacturers.

Winchester hard disks systems are ideal for storing large amounts of data. In situations where your microcomputer might become a multiuser system (more on this later) a hard disk system is highly recommended. The important characteristic of a hard disk system for this application is its fast access, since more than one person may be using the disk system simultaneuously. Even if you have a hard disk system, you will still need at least one floppy disk drive. While the reliability of hard disk systems is good, you will still want to copy its contents (as a safety procedure) to a floppy diskette which can be stored elsewhere. Purchased software is customarily sold on floppy diskettes, and to transfer your own software to someone else also requires floppies. Some of the larger microcomputers are now offered with one hard disk and one floppy disk system built-in.

Printers

A printer, of course, is an output device that is essential for many practical applications of a microcomputer. In the past, the printer has also been one of the most expensive components of the system. However, there are now many good quality printers on the market at reasonable prices. The two major types of printers used with microcomputer systems are the "dot-matrix" and the "formed character" printer (often of the kind referred to as a "daisy wheel"). In a dot-matrix printer, the print head contains tiny pins arranged in a matrix patter of 5 x 7 or 5 x 9 dots, the pattern of dots yielding the various characters. The formed character printer is much like a typewriter. Typically, there is a circular wheel with petal-like arms (thus, a daisy wheel), with an individual character moulded into each arm end. This wheel rotates under the control of the printer until the proper character is in front of a hammer, which strikes to form the printed character.

Dot-matrix printers usually offer more features, are less expensive, and often print more characters per second than formed character printers. Most can print various graphic symbols, as well as an adequately readable, uppercase alphabet. The graphic features are readily available because each individual pin of the print head can be controlled. The more pins in the print head, therefore, the better the print quality will be. The chief fault of dot-matrix printers is that the print quality from the current generation of printers is not really good enough for professional looking reports or letters. This will change when dot-matrix printers are introduced with higher density print heads containing more pins. Many printer manufacturers are developing such units now. Until then, the formed character printer is the only suitable choice for typewriter quality printouts. Format character printers tend to have available options aimed at emphasizing this advantage.

Two methods are used to feed paper through the printer, namely friction-feed and tractor-feed. Friction-feed operates exactly as a typewriter: the paper is driven by two rubber-faced rollers. Tractor-feed used paper with small holes along the edges which match with the moving pins of the feed device. Tractor-feed is advantageous for general use, because it feeds continuous roll paper more reliably than friction-feed. Some printers are available with both feed systems on a single unit.

Plotters

A plotter provides high quality graphs of plots that are useful for many engineering applications. The chief limitation of most plotters designed for microcomputers is the size of plot they will produce: 8.5 x 11 inches or 11 x 17 inches are typical. To obtain plots of suitable size for most ship drawings requires expensive plotting systems more suited for mini or mainframe computers. Subject to the restriction of small size, however, there is a good selection of inexpensive plotters available. Radio Shack, for example, offers a multi-color plotter for under $2000. Plot production usually requires the user to write programs which provide the x,y coordinates and pen commands to the plotter. Writing plot routines can be a time consuming process. Some plotters, however, are sold with software packages that include programs to produce simple figures such as circles, arcs, straight lines, and even complete graphs. These programs can then be called upon by the user's own programs.

Digitizers

A digitizer is an input device that can electronically interpret coordinates from virtually any object the user wants to lift dimensions from. There are digitizers available, suitable for microcomputers, that allow the user to convert the coordinates of a 3-dimensional object into data for processing. For most of our applications, a 2-dimensional digitizer is adequate. A typical digitizer consists of a flat surface and a small movable input unit, called a "mouse" or cursor. The surface contains sensors which can determine with a high degree of accuracy where the cursor is located. Digitizers accept either a continuous stream of data points input by tracing the figure with the cursor, or discrete points chosen by the user, who places the cursor at the desired point and then presses a button. Digitizers can be used to read options for a program by placing a "menu" on the flat surface and pointing to the desired option with the cursor. However, the major use of digitizers is to input coordinates from a drawing. A good example of digitizer application in our industry is in preparing data for hydrostatic calculations. The body plan of a ship can be digitized in a small amount of time; then; the digitizer data is used as input for a hydrostatics program.

A digitizer requires that programs be written by the user to interpret the data being input. Straight lines are easily handled but curved lines often require interpolation algorithms to define curves in detail from the data points.

Light Pens

A light pen is a device for specifying a particular point on specially-equipped display screen by touching it with the pen. This feature is most useful for selecting options from a menu displayed on the screen, or in interactive graphic design work.

Modems

A modem is a device for transmitting and receiving data over a telephone line, permitting microcomputers to communicate with other systems, regardless of physical separation. The modem converts acoustic signals into the digitized data used by the microcomputer, and vice versa.

There are two types of modems available, the acoustic-coupled modem and the direct-connect modem. The acoustic-coupled modem has cups in which the telephone handset is placed. This type of modem them sends and recieves signals acoustically, through the handset earphone and microphone. The direct-connect modem ties into the telephone electronically, usually with the same modular connector used in the telephone itself. There is no acoustic connection through the handset. The direct-connect modem is preferred for most uses, since it is unaffected by external noise, a common source of interference for acoustic modems. The acoustic-coupled modem is more portable, however, since it requires no additional fittings on the telephone receiver itself.

There are two transmission rates normally used for regular telephone lines: 300 baud or 1200 baud. (A baud corresponds to a bit per second.) A 300 baud modem will send about 30 characters per second and a 1200 baud modem about 120. Generally, 300 baud modems are lower priced than 1200 baud modems. Transmission rates higher than 1200 baud usually require special phone lines.