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YOUR OWN Computer

MARCH 1979

YOUR OWN **Computer**

Introduction To Personal Computers

The personal computer is a recent electronic marvel that is capable of taking an active role in our everyday lives. Its applications are often limited only by ones imagination. Here is a look at what the personal computer is all about and what you need to know to select the system that's best for you.

JEFFREY MAZUR

IF YOU THINK MICROCOMPUTERS ARE JUST A FAD OR you're waiting for them to die out like 4-channel hi-fi, don't hold your breath. They are here to stay and if you plan to keep up to date in electronics you must start learning to deal with computers. Perhaps one of the best ways to do this is to go out and buy one. If you have been thinking about buying a personal computer but can't decide on which one, then the following pages are just for you. In this special section we will investigate personal computers and some of the peripherals available to expand their capabilities. To help you through the confusion of choosing a computer system we will review a few computer basics and outline the factors that should go into making your decision.

The first step towards selecting a computer is simple—STOP! Before you lay down a single dollar on equipment, stop and think carefully about what you are going to do with the computer. Make a list of what you think a computer should do for you and how much you are willing to pay for it. With this in mind, examine the various systems that are available within your budget. When comparing systems, try to normalize their capabilities whenever possible (i.e., don't compare one manufacturer's 4K RAM system to another's 32K RAM system).

The second rule is to use CAUTION when comparing specifications. Unfortunately, there is no standard for rating computers; if you're not careful, you may be misled by the information you receive from manufacturers and dealers. Also beware of claims for fantastic new machines or peripherals that are "not quite available yet." Almost every personal computer manufacturer has had delivery problems on new products (some are still having problems keeping their two-year-old products in stock). Although you will be mainly concerned about the equipment that you are buying, don't forget about the programs (software) that are needed to make your system work. Some computers come complete with much of the operating software already "inside the box," that is, in ROM (*R*ead *O*nly *M*emory); with others you have to buy it separately and load it into the computer. The amount of commercially available applications software may also be important if you don't plan on writing your own.

RADIO SHACK'S TRS-80 microcomputer system.

Finally, when you have decided upon the system that is right for you, go to a reputable computer dealer in your area. Computer sales are seldom a one-shot deal; you will probably be back to buy additional items or may need help in getting your system running. The dealer who sells you a computer knows this and will usually bend over backwards to help you get started. If you know exactly what you want and price is the primary concern, then you can buy from one of the many mail-order firms selling computers. Don't be afraid of losing your money—especially when you can charge it to your credit cards—but be prepared to wait a while if what you want is not in stock. Remember, however, that if you haven't received your order within 30 days, you have the right to ask for your money back. Also remember that the money saved means assistance forfeited.

Uses for a computer

As a quick guide, some of the more common uses for personal computers are listed below. With each is a brief description of the factors that will be of most importance when selecting the type of system you'll need.

Educational—One of the reasons most people buy a personal computer is simply to learn about computers. Any computer can be used as a learning tool, but your degree of experience will usually dictate how

HEATHKIT H9 CRT terminal.

you plan to communicate with the computer. If you are comfortable programming in binary, hexadecimal, or mnemonics, then you could get by with a small single-board computer. If you want your computer to communicate in more English-like terms and let you know when you make a mistake, then you will require extra hardware and software. Another important factor is the documentation and instruction manuals supplied with the computer. Someone with no experience might want a manual that explains the computer's operation step by step without going into the details of how the computer works. Another person might be more interested in detailed documentation (schematics, software listings, etc.) on the computer he or she selects. Wherever the manufacturer's information is lacking, there are numerous books and magazines that may provide a more suitable description.

Personal recordkeeping, filing, data processing—The key words for these applications are memory and speed. Translated into hardware, that spells a floppy disc. If you also want printed output, or hard copy, then you should also investigate what will be required to connect a printer to the computer. There is software available in this area; it might save you days or weeks from writing your own. For small business use, the software should be tailored to the specific needs of the business.

Home security, menu planning, checkbook balancing, etc.—If your main desire for a computer is to do things like this—*save your money.* Unless you have some extremely complicated system in mind, the above tasks would be better handled with dedicated devices that cost less.

Playing games (nongraphic)—All computers can be programmed to play games (in fact you rarely see a computer demonstration that doesn't include one). Nongraphic games range from the simple question-and-answer variety to pseudographic displays using normal ASCII characters. Since all but the simplest games require some form of alphanumeric input or readout, this means having a terminal of some type. If games are your primary concern, then one of the prepackaged home computers such as the Apple II[1], TRS-80[2], PET[3], Atari or Challenger II[4] would be the least expensive way to get into computing.

Playing games (graphic)—Although many computer hobbyists hate to admit it, personal computers are used to play games more than anything else. One of the reasons is because most of them can display graphic images on a video screen. This makes the computer rival (and sometimes exceed) the most sophisticated TV video games on the market. The inclusion of graphics commands in many versions of BASIC (a high-level programming language that uses English-like commands) has made writing your own game programs even easier. Again, the prepackaged home computers have brought graphics (some in color too!) to a low-cost computing system.

The complete system

A computer system can be roughly divided into four parts as shown in Fig. 1. The first choice you will have to make is the *mainframe* or actual enclosure that the computer will sit in. Choosing a mainframe generally implies selecting a particular bus structure (more on this later) as well as which microprocessor IC is going to be used. Mainframes range in complexity from the simplest one-board computer such as the KIM-1[5], up through the Altair[6]-type "box" with its elaborate front panel, to more conventional turnkey (simple front panel) systems. Prepackaged home computers also qualify as mainframes although they include much more within a single enclosure.

One aspect of the mainframe that deserves special attention is expandability. Since the mainframe is only

SOUTHWEST TECHNICAL 6800 system and options.

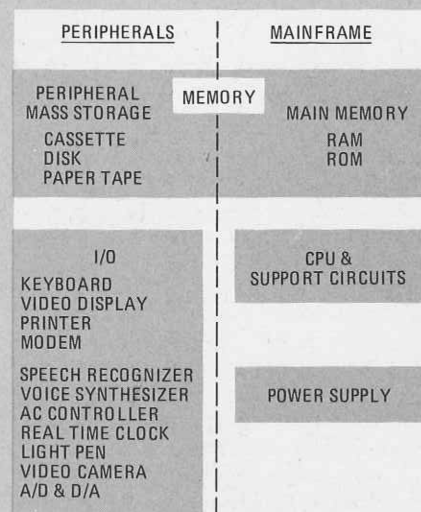


FIG. 1—COMPUTER SYSTEM broken down into components contained within mainframe and peripheral devices.

the beginning of a system, you must allow for the expected additions that you may want in the future. Expandability can be measured by the number of slots available for additional boards, the type and number of external connectors, and by another important factor, power supply capabilities. The power supply is something you want to choose wisely from the beginning, so that you won't have problems later as the system grows. Most large mainframes use standard power supply designs which tend to make them big and heavy. They can easily be compared by the amount of current that they can supply. You can determine what you will need by adding up what all of your components will draw and adding a large safety margin. Don't overlook the possible need for a fan to cool the power supply and all of the various boards. At least one manufacturer (Apple Computer) uses a highly efficient switching power supply in their prepackaged computer system.

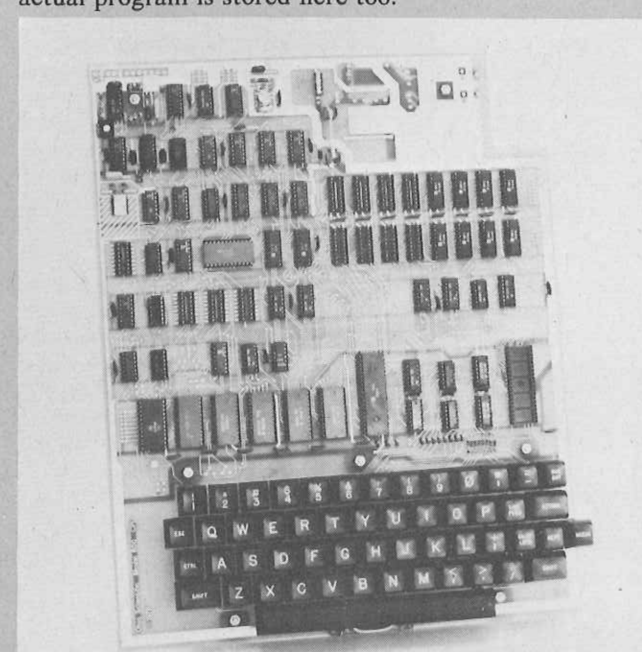
Central processing unit

Although your choice of computer may not be based upon what CPU it uses, you should be aware of the capabilities of the particular microprocessor IC that you get. The most important specification of a microprocessor is its data word length. For most of the computers we are discussing here, this will be 8 bits. However, there are many 16-bit CPU's coming out now as well as older 4- and 12-bit devices. As you might guess, a 16-bit machine has about twice the computing power of a similar 8-bit unit. Another important characteristic of a CPU is its addressing capabilities. This includes its total range of addresses (usually 64K) and the various addressing modes supported by its instruction set. Other factors of concern are the clock frequency (or more importantly, the average instruction time) and the CPU's I/O structure. These factors are only given for reference; in reality, almost any CPU can be used for a given task.

If you plan on buying most of your equipment from a single company, then you may not be too concerned with the bus structure or CPU type. Everything will be designed to "plug in and go." However, if you want to take advantage of the enormous amount of hardware and software available from independent suppliers, then you will definitely be concerned with these two factors. As for the former, the present king is the S-100 bus. Any computer designed around this bus can make use of all the various peripherals manufactured to this standard. There are many other bus standards (although it seems like everybody is starting their own lately), and if the peripherals you desire are available for any particular computer, then that's all that matters. As for CPU selection, the same thing applies. Here, the 8080 has reigned but other microprocessors such as the 6800, Z-80, 6502, etc., are finding their own place. When you go to buy software, you will run into a similar problem of compatibility with your CPU. The main point here is that when you go looking at both hardware and software, remember that not every add-on you see will work with every computer. Check out what is available before you decide on your computer.

Memory

A computer would be worthless without some sort of memory to hold a program and data. In particular, we can define *internal memory* which the processor has direct access to, and *external memory*, or mass storage, which the computer must load into its internal memory before it can be used. Internal memory consists of RAM (*R*andom *A*ccess *M*emory) and ROM (*R*ead *O*nly *M*emory). All of the data that the computer manipulates is stored in RAM along with essential information that allows the computer to keep track of what it is doing. Most of the time, the actual program is stored here too.



OHIO SCIENTIFIC Superboard II.

A major question you might ask is: "How much RAM do I need?" There is no simple answer to this question as it depends on the particular computer, program and data requirements that you have. Most computer dealers can help you make this decision. Fortunately, RAM can usually be purchased in blocks of 2, 4, 8, 16 and 32K bytes at a time (a byte is roughly equal to one character). Thus, you can start with a small amount of memory and add more as the need arises.

Of less importance is the type of RAM that you get. It will either be *static* or *dynamic*. Dynamic RAM's are less expensive (per bit), are available in higher density packages (more bits per chip), and consume less power. For these reasons, they are becoming more popular than static RAM's. Their major drawback is that they require periodic "refreshing" or else they lose the information that was stored in them. This means that extra circuitry is usually needed to insure that the memory is refreshed properly. However, microprocessors like the Z-80 are eliminating this problem entirely with "invisible refresh" circuitry already contained within the IC. Static RAM's are still widely used, especially in older machines that were not designed for dynamic memory. Static RAM's do not require any refresh.

All RAM's lose their memory when power is removed (i.e., they are volatile). Therefore, to keep a program permanently in the computer requires some sort of non-volatile memory. For mass-produced programs such as monitors, BASIC interpreters, etc., a ROM can be used to store the information. A ROM acts just like a RAM whose data has been permanently stored at the time of manufacture. If you wish to store your own programs, PROM's (*P*rogrammable ROM) or EPROM's (*E*rasable PROM) are used. PROM's can be programmed only once—some of them use fuses and are programmed by burning out the appropriate ones. Thus, if you make a mistake or want to change data, they usually have to be thrown out. EPROM's on the other hand are reusable. When you want to reprogram them, they are first erased by exposing the chip to strong ultraviolet light. Newer devices are just coming out that will make nonvolatile storage just as easy to use as RAM's.

ATARI model 800.

When the amount of data exceeds the internal memory capacity, or for permanent storage of programs and data when not in use, we turn to mass storage devices such as magnetic tape, disc, or paper tape. The availability of ordinary cassette recorders has made them a popular choice for mass storage. They are inexpensive, easy to interface, and one cassette can hold millions of bytes. However, they are very slow in transferring data to and from the computer and even slower in finding the correct data on the tape. Some specialized digital cassette systems are available with higher data transfer rates and searching capabilities, but a more popular alternative is the flexible, or floppy, disc drive. This offer is one of the best tradeoffs between price, speed and capacity. Paper tape is used by a small percentage of computer hobbyists; its major advantage is compatibility with larger minicomputer systems. Other devices such as hard discs, bubble memories, etc., are beyond the reach (in terms of cost) of most hobbyists at this time. The increased use of computers, and thus a large amount of memory devices, has made memory technology one of the fastest growing areas in electronics.

Input/output

Getting information to and from the computer is the job of I/O devices. On the input side, a keyboard or terminal is usually used that makes talking to the computer as easy as typing. Other forms of input could come from a modem (telephone linkage), external switches, A/D converter, etc.

The most common form of output from a personal computer is via a video display (either a modified television set or a special CRT terminal). For hard copy, a printer and/or plotter can be added. These are described in greater detail elsewhere in this section.

Specialty devices

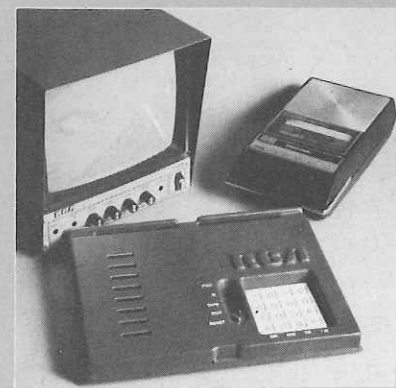
For special requirements, there is a wealth of peripherals that can be added to your computer. For instance, several manufacturers make speech recognition units and voice synthesizers, making it possible to talk and listen to your computer. Light pens make data entry easy as do digitizers, and even video cameras can be used to give your computer "eyes." For applications requiring precise timing or time-of-day information, there are real-time clocks; and AC controllers allow the computer to turn appliances on and off. For the true hardware enthusiast, blank breadboards are also available to build up your own customized circuits.

Software

So far, we have only discussed the actual equipment that goes into making a computer system. However, this is only half of the story. Without a program (software), the computer would just sit there and do nothing. In general, there are two kinds of software: system and applications. As their names imply, system software consists of programs that allow the computer to function as a complete system; in particular, to make your job of writing application software as easy as possible. Some of the system software that you will want to look for are:

Monitor—A monitor (not to be confused with the television device used for video display) is any

YOUR OWN **Computer**



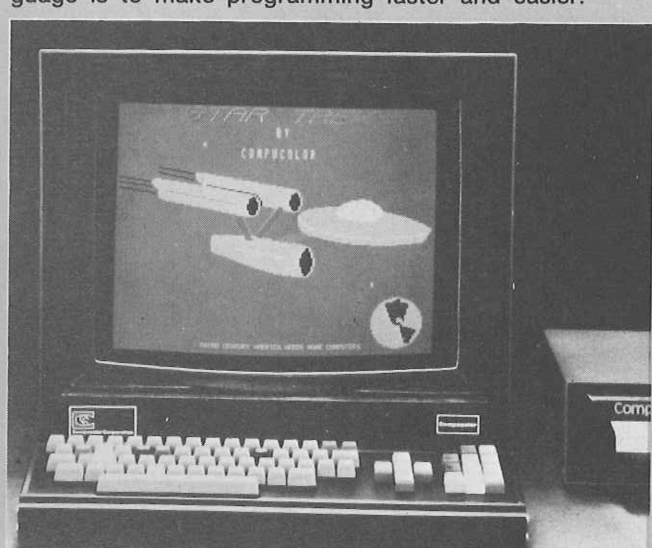
RCA VIP with monitor.

program that allows you to communicate with your computer in terms other than binary 1's and 0's. In most cases, a monitor will allow you to examine, write into, or start execution of a machine language program at any location in memory. Other features such as debugging aids and cassette tape load and store routines may also be included. A monitor is an essential tool when it comes down to seeing exactly what the computer is doing.

Assembler/Editor—Writing programs in machine language is tedious and hard to debug. Changing one instruction in the program can necessitate rewriting much of the rest of the program. With an assembler, the program is written into a text file that can easily be read, documented, altered and debugged. The text file (source code) is then translated into an actual machine program (object code) by the assembler. If there are any errors in the source code, the assembler will identify them, making debugging easier.

I/O, DOS, etc.—These programs are designed for the particular devices to which the computer is connected. They provide the software necessary for transferring data between the computer and the peripheral.

High-Level Languages—To many people, this means BASIC. The purpose of any high-level language is to make programming faster and easier.



COMPUCOLOR SYSTEM has full color graphics.

Languages like BASIC use English-like statements (e.g., LET X=5, A=B+C, etc.) that make learning how to program literally child's play. High-level languages must somehow transform the program into machine language that the computer can understand. This is done with either a compiler or interpreter. A compiler takes a program written in the high-level language and converts the whole program into its equivalent machine code. An interpreter, on the other hand, runs simultaneously with the high-level program interpreting each statement into appropriate machine code one line at a time. Most personal computers with BASIC use an interpreter. Although slower than a compiler, it allows the computer to warn the user immediately when certain mistakes are made.

Remember that unless the system software is in ROM, you will have to load it into the computer from either cassette tape, paper tape, or disc, which will use up some of the RAM that you have. System software is only useful in making the computer easier to program. The actual task that you want the computer to perform must then be programmed into the computer. This is the application software.

Application software

Getting a computer to keep track of payroll, calculate prime numbers, or play chess requires a unique program for that particular application. These may be programs that you write yourself or commercial programs that you can buy and load into your machine.

For doing your own programming, your main concern will be with the languages in which the computer can be programmed. When using assembler/editors and high-level languages, be aware that they are not all equal. There are many versions of the BASIC language for instance; some may be very limited (sometimes called Tiny BASIC) while other versions equal or exceed the original Dartmouth language.

Another concern is with debugging aids that are sometimes included with the language to help you find out why a program doesn't work the way you think it should. Editing, cursor control, graphics and file structures are also important to making programming easier.

Although it may take days, months, or even years to develop a particular program, it takes only minutes to mass-produce copies of it. Because of this, commercial software may be extremely valuable if you don't have the time, skill, or desire to write your own. Prices for personal computing software is relatively inexpensive: usually under $10.00.

Conclusion

Choosing a computer system is not easy. But no matter what computer you get, it will put a new and exciting world of electronics at your fingertips. Buying a computer, however, is only the beginning. As your needs (and budget) grow, you will be interested in adding other peripherals to the system. To help you understand terminals, printers, etc., read on as the next pages describe them in detail. **R-E**

[1]Apple II is a registered trademark of Apple Computer, Inc.
[2]TRS-80 is a registered trademark of Tandy Corp.
[3]PET is a registered trademark of Commodore Business Machines.
[4]Challenger II is a registered trademark of Ohio Scientific.
[5]KIM-1 is a registered trademark of Commodore Business Machines.
[6]Altair is a registered trademark of Pertec Corp.

Printers For Personal Computers

The CRT video display is the most-often-used read-out for personal computers. If you want hard copy, you'll need a printer. Here's how they work.

JEFFREY G. MAZUR

NOT TOO LONG AGO, THE MOST COMMON method of interactive communication with a computer was via a printing terminal (Teletype ASR-33 and Selectric terminals). At first glance, watching one of these machines "type" at 10–15 cps (*C*haracters *P*er *S*econd, or 120–180 words per minute) was rather impressive. However, waiting several seconds for the computer to make a simple reply, or minutes for a small program listing, left much to be desired. At that time, a CRT or video terminal was considered a luxury; its writing speed of 1000 cps or more made it an excellent means of communication. But when you were through working with the computer, you had no written record of what transpired.

Today the situation is quite different. Advances in microelectronics have made the video display much less expensive and almost all personal computers use them as the primary output device. This leaves most hobbyists without any way to generate hard copy. Printers have become the luxury of home computerists, especially when you consider that the price of a good printer may equal or exceed the cost of the computer itself. Whether printed output is your primary goal (generating mailing labels, invoices, tickets, etc.) or strictly a convenience (listing long programs to make them easier to read and debug), the following information should help you choose the right printer for you.

Printer basics

Printers can be classified as either *impact* or *non-impact*, with either complete or matrix character formation. Impact printers operate much like an ordinary typewriter; they rely upon a hard object striking against a ribbon to transfer ink onto the paper.

Non-impact printers use a variety of other technologies to convert electrical signals into readable copy. As for character formation, fully formed characters are printed with a single stroke of an appropriate die. Matrix printing divides the character field into a finite number of cells (dots) in the same way most CRT and video displays do.

These two basic parameters represent many of the tradeoffs that can help you narrow down your choice of printers quite rapidly. For example, while offering good printing speed at low cost, non-impact printers usually require special paper and cannot generate simultaneous multiple copies. So if you want to print mailing labels or multipart forms, you must use an impact printer. For highest quality printing, fully formed characters are desirable; but matrix printers allow special characters and graphics to be printed along with the ordinary text.

Almost all non-impact printers have matrixed characters. Thus we can divide printers into three categories: *fully formed impact, matrix impact* and *matrix non-impact*.

Fully formed impact

This type of printer can range from modified electric typewriters to high-speed drum and band printers. Changing fonts (where possible) calls for replacing the print die. Paper advance can be either friction feed or tractor feed. Furthermore since this is the oldest printer technology, there are many of this type of printer available.

Cheap and dirty

Probably the least expensive approach to making a printer is to add a bank of solenoids to an electric typewriter. The solenoids are positioned over each key and connected to the computer so that they can be actuated at the proper time. Mechanical limitations keep printing speed rather slow (less than 10 cps) and the mechanisms are fairly noisy. But print quality can be very good and the ability to use almost any kind of paper is a real plus for the hobbyist. Some newer models have interchangeable characters on one or two keys that can be used for special applications. If your main desire is to print a large number of letters on your own stationery, this might be an economic solution.

Selectric based printers

Along these same lines, the ball-type Selectric (an IBM trademark) typewriters were made into portable computer terminals. With a top speed of 15 cps, they also double as an excellent typewriter for standard use. Without

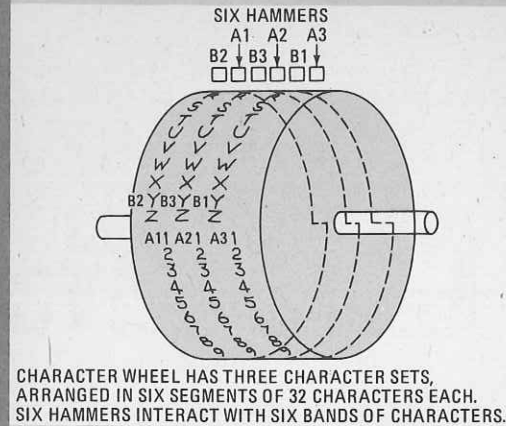


FIG. 1—CYLINDER BASED PRINTING is used in many terminals.

modification, Selectrics require a different electrical code than microcomputers. Additional circuits must be added to make them work with the standard ASCII code. Because of this, most Selectrics can be used for printing only (the keyboard cannot be used as input to the computer). Many suppliers have used or refurbished units for sale at a reasonable price; some include the ASCII conversion. Interchangeable type-balls are available and you can change character fonts easily and quickly.

Teletypes

While on the subject of full-character impact printers, we should mention the Teletype *model 33*'s. These are complete send/receive terminals that were the workhorse of the computer industry not too many years ago. Because there are so many used *model 33*'s available at low cost, many hobbyists have used them as printers. Painfully slow (10 cps) and even more painfully loud (they can make any room sound like a network newsroom), they offer fine print quality and an extra keyboard if you want to use it.

Cylinder drum printers

These printers use a character-studded, rotating cylinder or drum (see Fig. 1). A series of hammers strike the paper against an inked ribbon and the drum to transfer the character onto the paper. The hammers are fired under electromechanical control so they strike the paper at the precise time when the appropriate character on the drum is opposite the hammer. A cylinder printer may contain one to ten complete sets of characters on its face. Thus several characters may be printed before the cylinder must be moved horizontally to its next position.

A drum printer (see Fig. 2) has up to 132 character sets (one for each column that it can print). An entire line is printed at once without any horizontal carriage movement. This type printer consists of a wide range of printers—both in price (from under $400 to over $10,000) and speed [10 cps to 2000 lpm (*L*ines *P*er *M*inute)].

Daisy wheel

These devices get their name from the petal-like construction of their printheads (see Fig 3). A servo-mechanism controls the position of the character wheel so when the correct character petal has been spun into place,

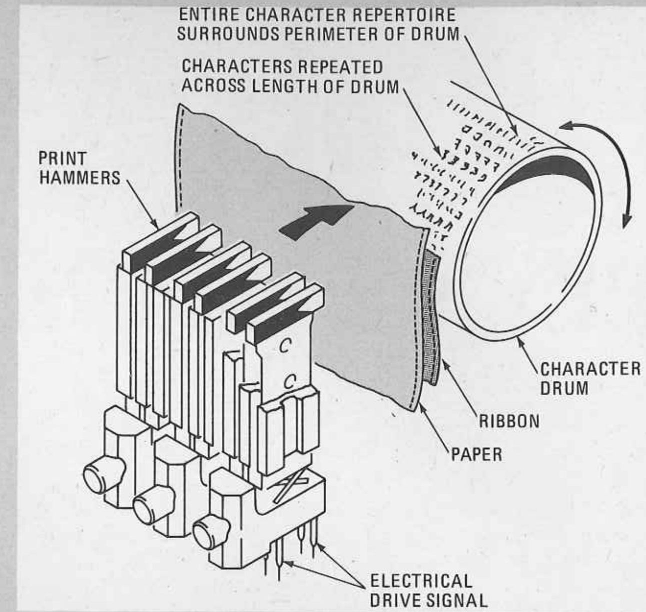


FIG. 2—THE BASIC DRUM IMPACT LINE PRINTER compares the contents of a buffer containing the data to be printed with the position of the desired characters in each print column. At the proper time, the appropriate hammers are activated and the line is printed.

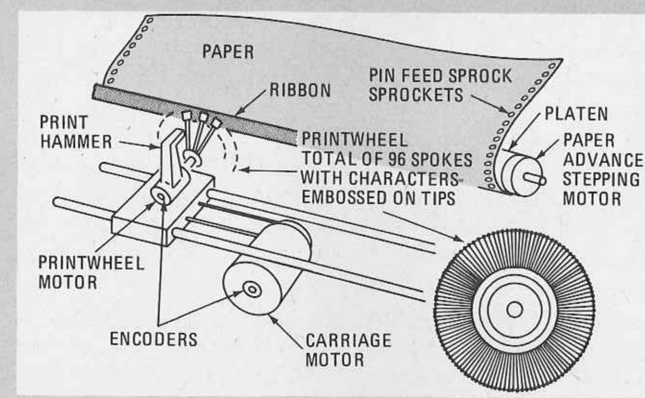


FIG. 3.—A TYPICAL DAISY-WHEEL PRINTER. Many printers use a microprocessor to control the printwheel and the print hammer's impact force.

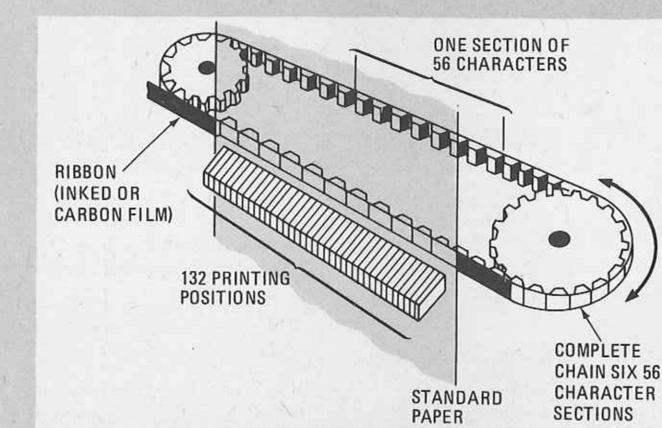


FIG. 4—BAND OR CHAIN PRINTERS are among the fastest units available.

a hammer forces the petal into contact with the ribbon and paper. Their high speed translates into high cost ($2000 +) making daisy-wheel printers a prize that is usually beyond the reach of most hobbyists.

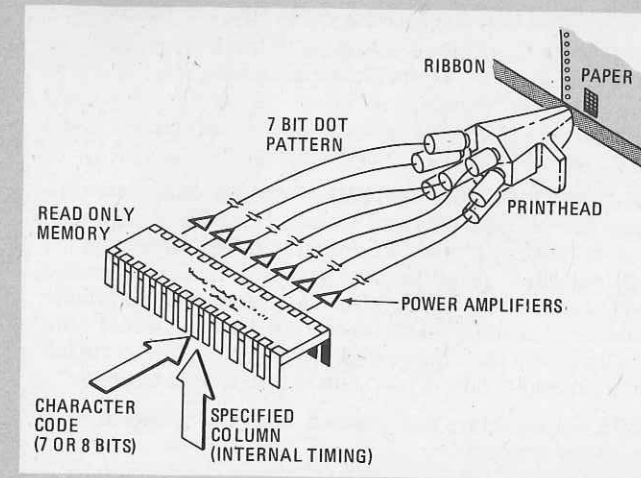


FIG. 5—IN A TYPICAL SERIAL DOT-MATRIX PRINTER MECHANISM like this one from Centronics, a ROM contains the character codes that command the printhead's seven print wires. The ROM's output, fed through power amplifiers, activates solenoids that cause the print wires to impact ribbon and paper.

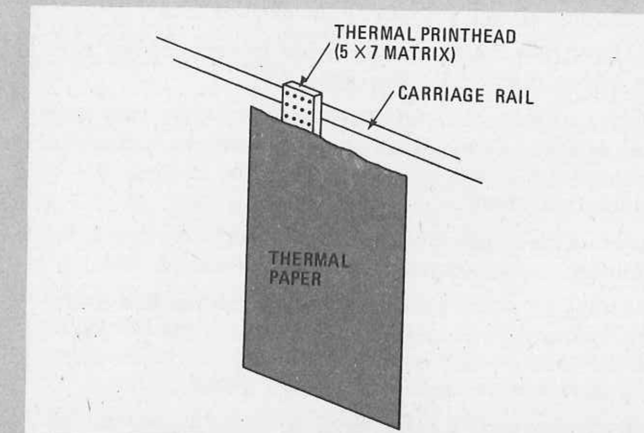


FIG. 6—THE PRINTHEAD OF A THERMAL PRINTER may contain 35 resistive heating elements.

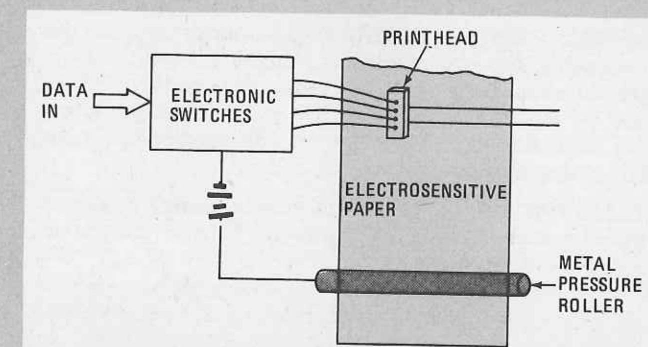


FIG. 7—AN ELECTROSENSITIVE PRINTHEAD creates a spark between the head and the paper. Metal roller completes circuit by contacting paper surface across its full width.

Band printers

At the high end of the impact printer field are the band printers (see Fig. 4). Although currently too expensive for personal computer systems, a brief description of their operation is included. The major difference with band printers is that the character elements are mounted on a continuous band or chain. The band constantly rotates in front of a bank of hammers, one for each column. Again, precise timing is needed to strike the hammers when the appropriate character is in place.

Matrix impact

All printers in this category use a technique similar to that shown in Fig. 5. Because each character is formed by several strokes, more sophisticated electronics are needed to control the printhead. The head itself consists of seven to nine print "wires." Each one is activated separately to print a small dot on the paper. The wires are oriented vertically and the entire printhead moves horizontally along the carriage. After five to seven printing steps, an entire character has been printed and the head moves on to the next column. The most common matrix dimensions are 5 × 7 and 7 × 9. Obviously, the greater the number of printing points, the better the resolution and character quality.

Although there is no mechanical way to change character fonts, different characters can be generated (within the limitations of the matrix) by simple software changes. Graphics are easily printed since most computers generate them in dot-matrix form. Friction or tractor-fed paper as well as labels, tickets, etc. pose no problems.

Fairly high speeds can be obtained with this method and at relatively low cost. In general, dot-matrix printers are much quieter too.

Non-impact printers

The increased need for low-cost, ultra-quiet and ultra-fast printers has spawned the growth of several new printer technologies. Fundamentally, these non-impact techniques prohibit multiple form copying and many require special paper. However, where each method excels, it usually makes up for any drawbacks. Because of the need for special paper, friction feed is used, and the lack of fan-fold paper makes long listings hard to handle. On the pro side, these printers are the quietest ones you can buy.

Thermal printers

Thermal printing requires a specially treated paper. This heat-sensitive paper changes color when heated to a temperature of about 200°F. A thermal printhead, therefore, consists of a series of heating elements mounted so that they can create matrixed characters (see Fig. 6). Speed limitations are imposed by the fact that the elements must cool down sufficiently (after being activated) before the printhead can move on to the next position.

To lower cost, many models print "on the fly"; that is, the head is moved at a constant rate from left to right and the elements are activated while the printhead is moving. Although this causes the dots to smear a little, it can actually improve the print quality. Thermal printers boast high reliability, low cost, nearly silent operation and fairly good readability.

Electrosensitive printers

As with thermal printers, electrosensitive printers require special paper and use a matrix printhead to create hard copy. In this case, a dark paper is coated with a thin conductive layer that gives it a shiny metal-like appearance. This paper is passed in front of a printhead that consists of tiny electrodes connected to a switchable voltage source (see Fig. 7). A pressure roller contacts the surface of the paper to complete the circuit. When the electrodes are switched on, a small spark jumps between the electrode and the paper. This spark burns away the metallized coating at that point leaving the dark paper showing through. Since the gap between the paper and printhead is very small, only about 50 volts are needed to generate a spark.

Most electrosensitive printheads create a column of dots at a time. Moving left to right, they can easily print characters on the fly. An alternative approach is to use one large, stationary printhead, with enough electrodes to cover the complete width of the paper. In this manner, a complete row of dots are created (for all the characters on one line). Several vertical paper motions are needed to complete the line. To print a line at a time, a buffer is needed to store all the characters for that line: therefore, printing cannot start until the entire line has been received. The biggest disadvantage of electrosensitive printers is that the metallized paper makes for poor readability. Making a photocopy of the printed output helps.

Ink-jet printers

The latest advances in non-impact printing have been the ink-jet-type devices. We have included a description of such printers although their cost prohibits use in a personal computer system (see Fig. 8). Basically, ink-jet printers attempt to imitate the operation of a CRT screen. Charged particles of ink are deflected electrostatically to land on the paper in the shape of the desired character.

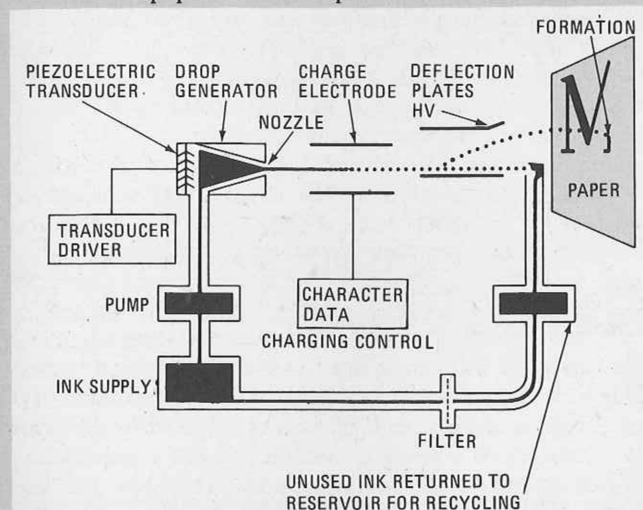


FIG. 8—ONE OF MANY ink-jet printer designs.

Several different schemes have been developed to create the charged ink drops, deflect them and collect the unused ink. This technology promises to greatly increase printing speeds while eliminating all noise except that generated in moving the paper.

Xerographic printers

Another related, and still too expensive, type of printer is the xerographic printer: As you might guess, these devices use an electrostatic/toner design similar to the way photocopy machines work.

Let's wind it up

Other things to look for when buying a printer are paper-feed mechanisms, carriage control and data-handling capabilities. For most applications, friction feed is fine (you can use tractor-feed paper in a friction-feed printer). Tractor feed is only needed when precise alignment of the paper or special forms are used. Above all, be sure that the printer will handle the maximum size paper that you wish to use.

GLOSSARY OF PRINTER TERMS

BAUD RATE—Speed of serial data transmission in bits-per-second. 7 data bits plus a parity, start and stop bit make for 10 bits-per-character. Therefore, the baud rate divided by ten yields characters per second (data rate, not necessarily printing speed).

BI-DIRECTIONAL PRINTING—Printing characters either left to right or right to left. Normally a printhead travels left to right while printing and then returns to the left margin to print the next line. Bi-directional printers will usually check the length of the next line to be printed and then, depending on its current position, either print the next line backwards (right to left) or return to the left margin and print the next line in the normal direction.

CPS—Characters per second. A unit of speed used to quantify printers.

FONT—Character style and size (gothic, script, etc.).

HANDSHAKING—Signals used to coordinate the operation of a peripheral with the computer. A printer might require a signal from the computer to tell it when data is going to be sent and in return might signal the computer when it is ready to receive the data.

HARD COPY—A slang term used to describe any type of written output from the computer.

INSTANTANEOUS PRINTING SPEED—The rate that the printhead can actually print characters. It does not include the time needed to return the carriage to its starting position.

LPM—Lines per minute. Another unit of speed for printers, especially those that print a line at a time.

PARALLEL PRINTER INTERFACE—Connection to the computer whereby the character data is transferred all at one time along seven or eight data lines. Handshaking signals are also used to coordinate printing.

RS-232—A widely used serial interface standard. This standard specifies the voltage levels (bipolar) and connector wiring so that all RS-232 devices will work properly with each other.

SERIAL PRINTER INTERFACE—Connection to the computer whereby all data is transferred over a single pair of wires. Data from the computer is serialized (broken up into individual bits), and synchronization information is added to allow the receiving device to reconstruct the original data.

TELETYPE OR CURRENT LOOP—A serial interface standard which uses a 20 mA (or 60 mA) current to transmit information.

If precise horizontal or vertical tabbing is required, then check out these capabilities of each printer.

Finally, be careful when judging a printer's overall speed. Don't confuse a printer's maximum or instantaneous printing speed with its sustained throughput capabilities. Furthermore, serial printers have a baud rate which may be quite a bit higher than the speed at which it can actually print. If there is any type of input buffer, then the printer can accept a large amount of data in a rapid burst and then print it all out at its own rate.

Not wishing to overlook the obvious, it is imperative that you have the proper interface between the computer and the printer. This will be either a serial current loop or RS-232 standard, or a parallel interface with proper handshaking. Once connected and operating, a printer can be the most valuable addition to your computer. **R-E**

All About Floppys

When you need more storage capability for your personal computer and require faster access speed than a cassette tape recorder, a floppy disc is for you. Here's how to select one.

KARL SAVON
SEMICONDUCTOR EDITOR

ABOUT THE TIME YOU'VE ADDED A SIZABLE CHUNK of memory to your microcomputer system, your tape cassette is working fine with an organized index system, and you spend three-quarters of your waking hours searching tapes and copying from one to another, you're ready for a floppy disc.

Short of a very high capacity hard-disc system, adding a floppy marks the turning point to a new dimension in microcomputing. It is at this juncture that you graduate to professional capabilities. Besides the luxuries of quick filekeeping that are a giant step up in convenience, completely new techniques are opened to you.

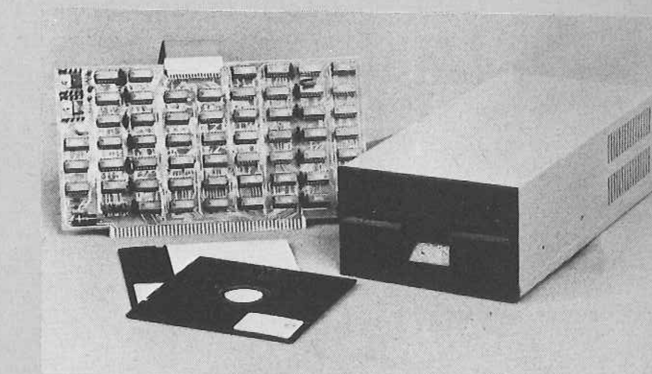
Now Fortran, BASIC and Pascal compilers replace the BASIC interpreter you have learned to live with. The ability to load and overlay versatile operating system programs rapidly into your computer memory really gets you cooking with gas. And for those of you with real-world business and scientific applications, this is the point where you begin solving those extra complicated problems you've been putting aside.

Regardless of specific discipline, most computer users are interested in text editing software; we all have the occasion to write reports and letters. Unfortunately, this software can eat up as much as 75% of your random-access-memory space, and leave room for a mere two pages or less of text.

You may also have a nagging desire to do something substantial in machine language, but find that your sophisticated assembler takes up most of your machine's memory and only lets you assemble a couple of hundred words of code. A floppy ends these kinds of limitations by filling computer memory with only the particular routines needed at any one time. Once the contained function at hand is completed, the next program segment is automatically loaded to attack the next sequential task.

During each processing function, the disc provides convenient addressable storage for numbers or text that don't require the ultra-rapid access of semiconductor memory, but must be close at hand. Business applications use the disc to store a repertoire of bookkeeping programs and provides quick retrieval for statistical processing of the thousands of pieces of information that have been collected.

A floppy disc is similar in appearance to a phonograph record, but is more flexible, and in most cases is physically deformed as the magnetic head and pressure pad contact the disc surface. There are some notable floating



MECA MODEL DELTA 1 floppy disc system

head exceptions that, despite superior media longevity, are not going to fit into your long-term compatibility plans, not to say anything about cost. The disc spins about 360 rpm and stores data on one or both of its surfaces.

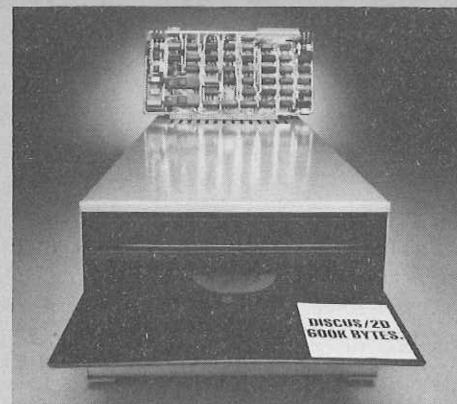
A disc is a random-access device much like program memory. In contrast to the sequential nature of tape, you can locate anything stored on a disc much faster than on a tape and without rewinding. The magnetic head is positioned over circular tracks with a servo-controlled stepper, or voice-coil head positioner. The magnetic disc surface has a life expectancy of 10^6 loaded passes.

Be sure that the disc system has an automatic head lifter that separates the head from the disc after some predetermined time following a read or write operation. Whenever the disc spins, even with the head lifted, there is a certain amount of unavoidable wear caused by the friction between the disc and its protective jacket. The access time to get from one track to another, added to the settling time to load the head in contact with the disc, varies between 10 and 100 milliseconds from product to product. The faster the better.

What size disc for you?

One of the first decisions is to select disc size. Fortunately there are only two: the full size 8-inch disc, and the 5¼-inch minidisc. Obviously the larger disc holds more information than the smaller one and has the higher price tag. The 8-inch disc holds some 3.2 megabits of unformatted data. That is, there are somewhat over three million binary storage locations. However, to keep everything in its proper place requires an indexing and data identification system. Cyclic redundancy codes must be set up to help you know when the data is reliable.

In the widely adopted IBM format, identifiers are written in front of each record; and records are separated by



DISCUS 2D floppy system

gaps. Error checking is done by reading the data back just after it is written (usually on the next disc revolution). Soft error specifications are between 1 in 10^8 to 10^9 bits, indicating how often a bit is read incorrectly. Soft errors are caused by noise and are overcome by simply repeating the read operation. Hard errors, on the other hand, represent permanent defects on the disc and typically occur once in 10^{11} to 10^{12} bits. Seek errors occur about once every 10^6 accesses and are the times when the head undershoots or overshoots the correct track and must go back to track 0 and try again.

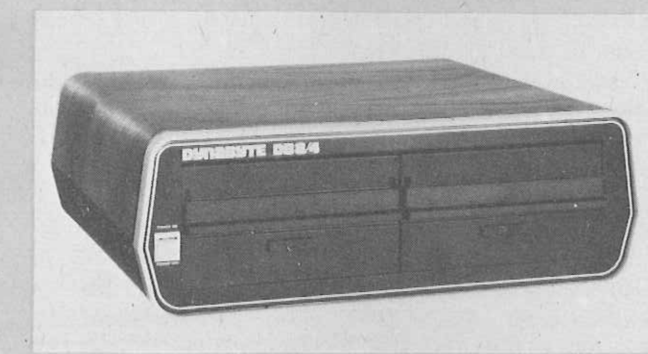

AN 8-INCH FLOPPY DISC system by Smoke Signal Broadcasting

By the time you're finished, the formatted disc capacity has been pared down to 1.9 megabits. When this is divided by 8 bits-per-word, you have some 250,000 words of storage. Transfer rates for the full size disc are about 250,000 bits-per-second. The standard format consists of 77 concentric tracks, each with 26 sectors, and each sector containing 128 bytes. Some discs use hard sectoring where a series of physical holes identify sectors so that less disc overhead is used. If you foresee the need to be compatible with hard sectored formats, make sure the system is expandable to control hard sectored drives.

The 5¼-inch floppy

The 5¼-inch disc works out to about one-quarter the 8-inch capacity; about 72K formatted bytes, with a 125 kilobit-per-second transfer rate. A 5¼-inch drive costs roughly 60% the price of an 8-inch drive, but before you make your size decision let's make one more observation. In the course of using your system you will discover that two disc drives add up to more than just doubled storage capacity. Once you have a single disc drive set up with your favorite programs, operating system, or data, and you finally sit down a moment to think, you will find yourself beginning to shake. On that one record, you figure out you've invested about three months of your life. You realize that it is vulnerable. What should happen if that disc gives you an unrecoverable load error, or one of the kids tries to play it on his phonograph?

Yes, it would be nice to have a copy stowed away. Copying, by loading one program at a time and then saving it on another disc is a long, tedious, annoying procedure at best. Two discs give the invaluable flexibility of copying one automatically to the other, using utility copy programs in a completely painless manner. Running


THE DYNABYTE DB8/4 disc-drive system

system programs such as assemblers and compilers, two discs have the advantage of being able to input data from one disc and storing output on the other. One disc can hold the operating system elements that are called up as required, and the other stores the text, data or other outputs.

A dual disc system that can load both heads at the same time will carry out copy operations with even higher efficiency. Another alternative to consider is to use a single disc, but do archival storage on tape. The tape writing and disc regeneration procedures will be slower than with two discs but still manageable. So when you list the system alternatives be sure to consider multiple disc expansion.

If the cost of a dual-drive 8-inch floppy is just too much of an investment, see if the capacity of a dual minifloppy is sufficient. There are, of course, exceptional situations where a restricted application requires only large storage, and a single-drive is justified.

Several disc systems use double density recording techniques. By using improved, modified FM (MFM) or group code recording (GCR) encoding methods, they pack twice the number of bits on the same size disc. Double density recording methods make room for additional information by eliminating the clock signal. The clock, though, can be recovered through clever decoding algorithms. There seems to be a general feeling that the present reliability is not quite up to what it is for single-density recording, but that should soon be at an equal level.

Check the reliability figure comparisons between single and double density recording, when available, and don't be fooled by reliability claims that cover just the electronics. A couple of clever drives have discovered that the disc has two sides and access twice normal capacity with two

MODEL EAS-EDDS from Electro Analytical Systems

heads. There are reports, though, of disc damage due to the loss of the cushioning effects of the single head and pad combination. Combining double density and double side recording gives the minifloppy the same capacity as the full size floppy disc (with slower throughput).

Interfacing to your computer

The disc must get connected to your computer. Many varieties and degrees of interfacing are available. Unless you're a glutton for punishment, don't go out and purchase a basic disc drive mechanism hoping to save a lot of cash by doing your own interfacing. Several reasonably priced systems are on the market that have been designed by experts, and have been debugged for many, many hours. You would go a long way to duplicate their performance. Many include complete hardware and software packages. The disc controller carries out the head positioning, head loading, sector identification and motor control functions.

Relatively new floppy disc controller IC's have greatly reduced controller complexity and price. They eliminate many IC packages and result in a more reliable, less densely packed controller board.

Usually some form of read-only-memory bootstrap is used to get things started. Until some minimum of software is loaded into the computer, it and the disc will not be able to communicate. Once the basic link has been established, more efficient loaders and operating system program modules can be transferred from disc to computer memory. Many systems require a large chunk of user memory, which may still work out to be cost-effective.

Some elemental systems require various machine language sequences to control disc operations and may require substantial machine language programming effort on the user's part. This is not for most of you. You have the option of obtaining operating system software from the disc drive manufacturer or from some other source. Generally, the first choice is more desirable, since it offers a higher confidence level that the bugs have been ironed out or that you will be kept informed of corrective patches as they are developed.

Most operating systems use a monitor that is transferred into memory. The monitor responds to keyboard commands by either carrying out the simpler tasks itself or calling a more complex executing operating system module from the disc. Know the computer memory requirements to support the program modules. Twenty-four kilobytes is not unusual to support disc BASIC, for example.

The operating system should include utilities for memory and program listings. Look for an initialization procedure that not only formats a blank disc, but allows you to later reconfigure the system when other peripherals or additional discs are added. Usually subtle software changes have to be made in the operating system, and it is highly desirable to be able to go through a documented procedure without having to scrap the whole thing. It is very important to recognize that the floppy disc software not only controls the disc itself, but the *entire microcomputer system*. In effect, the floppy disc operating system becomes the controller for all other peripherals.

All operating systems should include basic delete, rename, directory and copy programs to perform the rudimentary day-to-day jobs you're buying the disc for in the first place. Look for some version of a chain command that lets one program module call in a second from the disc, giving large virtual memory appearance. Operating systems should include methods for keeping track of hard disc errors. A defective sector table is conventionally composed to flag those places on the disc found to be unusable.

Watch the mechanics of the interface. Several disc varieties include single or double board controllers that plug into standard S-100 motherboard slots. Others include the controller as part of the disc system and have a cable and connector that runs over to the computer. Be sure you have included the costs of all the interface components in your estimates. It is not unusual for the interface electronics to cost as much or more than the disc drive itself.

Power supplies are another consideration. Some units may require 30 watts, and some 300 watts, depending on the number of drives and the extent and efficiency of the system. Power supplies are often not included as a part of the disc system and represent additional cost and space.

A couple of floppy systems operate optionally or exclusively through serial RS232C ports. This is OK for some basic data storage requirements where the disc is replacing an outdated paper tape system, but it is too slow for general versatility. After all, the system should give its full performance potential, not just replace paper or magnetic tape.

At the outset try to access your ultimate goals. Does the system you've selected have the capability to expand to 4 or 8 drives for the sophisticated application you have in mind for the future? Exactly what is required to carry out that expansion? Try to combine the technical specifications with the perspectives of experienced floppy users. Experienced users are in a position to quickly point out the weaknesses and advantages of specific systems, which are not mentioned in the data sheets. Talk it over with several members of a local computer club or a computer user at a nearby high school or college. Your choice will rapidly narrow to the two or three systems that are being universally accepted due to their relative freedom from problems, and you will enjoy an exciting new dimension of an already mind-boggling activity. **R-E**

CRT Terminals—Selecting The Right One

To many newcomers to the field of personal computers as well as many more experienced users, the CRT terminal is the most visible component. This article discusses the CRT terminal and tells what to look for when selecting one for your system.

KARL SAVON

THE INNER SECRETS OF YOUR MICROCOMPUTER SYSTEM are best viewed through the eyes of a CRT terminal. Input commands, output listings, and program writing and execution are all supervised from the keyboard and displayed on the screen. The terminal's ease of operation and reliability directly affect the overall utility of the complete computer system.

Theoretically, a computer system can be controlled completely with a series of simple switches and some LED indicators. In fact, that is exactly the way many early microcomputers were equipped. But you can't get much useful work done with such primitive handles. To address these shortcomings, the CRT terminal has emerged as the system focal point, with input facility at a conversational rate and with output capability essentially limited by the calculative speed of the particular program being executed.

Your present computer input/output device may be an intermediate combination of a simple keyboard and an LED alphanumeric display. You're now ready for a higher level of communication. Or you may be in the process of expanding an elementary learning system, having just added memory and maybe a BASIC interpreter in ROM, and are ready for better computer interaction. In either case, the display of a full page of information in response to typed commands announces your arrival out of phase-one and hopefully into the productive application phase.

The transmitter keyboard unit and the display CRT receiver are entirely separate entities except for common power supplies. You can actually purchase the two elements separately. The display looks peripherally like a TV receiver, but don't assume it will have similar performance.

Screen brightness must be high enough for comfortable viewing under prevalent ambient light conditions. Ideally, brightness and contrast should be user adjustable. Color is available where graphic complexity warrants it to emphasize significant display features, or simply for its attraction in personal computer applications. Examine the screen for linearity and resolution. Even though the CRT's tend to use standard television deflection methods and have scan rates close to NTSC standards, many suffer from linearity deficiencies when compared with your living room instrument. Resolution may be greater than most TV receivers, but large screen sizes are generally unjustified except for group demonstrations.

The most common screens measure 12 inches diagonally and use a P4 white phosphor. Many can be optionally equipped with P31 green. If possible, as with any expensive product, examine the terminal through a hands-on trial, preferably connected to a computer similar to your own.

Characters are most often displayed as dot matrices. A character decoder-generator uses a read-only-memory to convert ASCII or other codes into their equivalent dot matrix patterns. Even normally nonprinting character codes are displayed on some terminals. The dot matrix is usually 5 × 7 dots dedicated to the character itself with at least one additional horizontal and one vertical line separating characters and lines. Other common formats are 7 × 10 and 9 × 9 matrices. Larger matrix formats have room for standard lower-case characters. Others simply use smaller versions of the format or font used for capitals as pseudo lower case.

Deluxe character generators give more detail and fancier letters and have correspondingly larger matrix sizes. They are available in languages other than English, including French, German, Swedish and Japanese. If you are interested in APL (*A Programmers Language*) programming, search out the terminals with the nonstandard APL characters. There may be 64, 96 or 128 characters in the sets, and terminals with graphic capability typically include 256 characters. Screen format consists of 1000 to 2000 characters arranged in lines that may be 40, 64, 72 or 80 characters long.

Some terminals let you define your own characters on a dot by dot basis, or by groups of dots. Graphics users must know the number of controllable dots along both axes. And if your graphic applications are serious and extensive, you may want to consider vector graphic capability which lets you do things like define end points and the terminal fills in the rest. Business users will want to explore the terminals that are specifically designed to simulate business forms on the screen.

Automatic right-margin wraparound is a fairly standard feature that permits multiple line entry before a keyed carriage return terminator signals the true end of the line. This feature is very important when a relatively wide column printer is used to create hard copy. For example, using an 80-column printer, it is necessary to accept two 40-character CRT generated lines without an embedded carriage return and line feed. In other words, a carriage-return line feed combination is automatically generated for the CRT screen but is not transmitted to the printer interface.

Terminal types

There are three basic terminal classifications: Dumb, smart and intelligent. Regardless of "intelligence" level, any of the three types may well be microprocessor controlled. Integrated circuit video display controllers are also helping cut component counts roughly in half.

The dumb terminal is the least expensive, little more than a keyboard and CRT display, appropriately called a glass teletype. The glass teletype is much, much quieter than the venerable device it replaces, and for the 80% of the time that hard copy is not needed, the quiet is a welcome relief. Fan cooling may be used to increase reliability, but make sure it is quiet. If the fan noise level is going to be disturbing in a relatively quiet room, you had better select a fanless terminal.

The smart terminal has self-contained editing hardware and firmware usually implemented through a movable cursor. The cursor may take the form of a blinking square or blinking or nonblinking underline. Editing techniques include inserting, writing over and deleting on-screen information. Editing results are displayed immediately with little chance for misinterpretation. System applications that do not tie up the CPU processor during editing sessions offer the alternative of using the computer processor as a controller to make a dumb terminal look smart.

The intelligent terminal approaches a complete microcomputer in function. In addition to the editing facility of the smart terminal, it is programmable. Intelligent terminals may include built-in peripherals such as floppy discs and magnetic-tape-cassette drives. The two higher terminal classes may have addressable cursors. Designated control character codes give left, right, up, down, home and clear functions as well as direct addressing.

Data is normally entered starting with a clear screen at the top left and fills the screen downward, line by line. When the bottom screen perimeter is reached, the entire page scrolls upward, eliminating the top line leaving room for a new entry at the bottom. Page-mode is sometimes supplied as a switch-selectable feature. Page-mode fills the screen from top to bottom but when the page is filled, the screen is cleared and entry begins anew at the top. Memory options for off-screen storage are nearly essential on a CRT terminal using page mode, which may explain its relative unpopularity.

About keyboards

The keyboard has 50 or more keys and may include a separate numeric keypad for voluminous arithmetic input. Touch typists will find formats that put numbers only on the separate keypad very annoying. In fact, many keyboard layouts which may appear similar to a typewriter intermix graphic symbols as upper-case characters and define normal upper-case typewriter symbols as lower case. These arrangements will give the experienced typist headaches as he switches between typewriter and terminal.

Some keyboards have an upper/lower-case switch to generate letters, graphics and control characters from a limited number of keys. Nearly standard typewriter keyboards can be found though. They have a capital lock key and a separate (5th) row of keys for control characters.

Keyboard layout may resemble a typewriter's, but, for example (although unusual), may be simplified by arranging keys in vertical columns. Keyswitch feel varies considerably and you certainly want the switch contacts to be reliable. The quality of the key switches themselves are vital. Some of the most sophisticated keyboards include quadruple redundant reed switches that even operate perfectly if one or more of the contacts become noisy or fail. Highly reliable noncontacting keyswitches use capacitive, photoelectric or Hall-effect sensing mechanisms. The keyboard should incorporate 2-key or n-key rollover so data can be entered at high rates with a minimum of errors. Several keytops are often removable for special application customizing.

Important extra features

Reverse video is a common feature for emphasizing characters or groups of characters as well as extending graphic effects. Sophisticated terminals permit protection of designated screen areas from accidental erasure and can selectively blink several characters simultaneously. A rare feature is the ability to emphasize text by doubling the character width. Character dimming or brightness modulation is another fairly common feature.

There are a couple of seemingly unimportant features that are of interest to specific groups of users. For example, when the cursor approaches the end of the line an audio tone may sound, analogous to the typewriter bell. Tone trigger position is occasionally programmable. These terminals invariably can trigger the tone from a computer instruction, normally the ASCII 7 print command. Several or all keys may be auto repeating. After a prescribed time out following key closure, the keyboard system generates a fixed rate character repetition.

Once in a while problems are caused by the convention of automatic line feed following carriage return. You normally expect the CRT display to increment or line feed once each time the return key is hit in typewriter fashion. However, some tabbing operations require carriage returns without line feeds. If the computer automatically sends out carriage-return line-feed combinations for either carriage return or line feed, the display format will alternate blank lines with printout. The terminal should include a switch or jumper option to disable automatic line feeds. But you may have to add this feature yourself; it isn't difficult.

Interface connections

The terminal may interface to the computer through serial or parallel connections. Serial formats are conventionally RS232C asynchronous sequences of start, data, parity and stop bits. Word format may be DIP switch or jumper selectable since universal asynchronous receiver transmitter IC's are easily programmed by voltage levels on specific terminals. Even or odd parity and the number of stop bits are selected to be compatible with 9, 10 or 11-bit computer formats. The standard RS232C interface uses bipolar signal levels but the same basic format is used in TTL-compatible single polarity systems. Another widely used serial interface is teletype-compatible where series current loops of 20 or 60 milliamps are established.

Serial communications between the computer and terminal is half or full duplex. In half duplex, the computer and CRT receive data at nonoverlapping intervals. While typing the keyboard signal is routed to both the CRT and the computer so that the input is displayed. If the connection between terminal and computer were broken, the CRT would still respond, and it would only be later due to lack of computer response that you would know something is wrong. In full duplex, the two directional paths can operate at the same time. When the computer receives a character from the keyboard it responds by echoing the same character which is then displayed by the CRT. Serial transmission rates are between 75 and 19,200 bits per second.

Parallel interfaces can handle much higher data rates and are usually carried out with eight parallel data lines and a couple of handshaking leads. Parallel interfacing is a synchronous operation and signals are generated to tell when data has been accepted, when the receiver is busy and cannot accept data, and when data is valid. Parallel outputs are often three state; they have an open state so several terminals or other peripherals can operate in parallel on the same data lines.

Terminals can interface directly to the *IEEE Bus* when properly equipped or through adapters. The *IEEE Bus* is a parallel 8-bit bus that can send device selection address information over the same leads. Crystal-controlled baud-rate generators offer the best tolerance to variable environmental conditions. Some serial terminal interfaces have separate transmit and receive baud-rate generators that allow the two paths to be split or operate at different data transfer rates.

The *7-bit American Standard Code for Information Interchange* (ASCII) is the nearly universal standard now in use. Five-level Baudot code is just about extinct for CRT computer terminal applications. Several graphics terminals expand ASCII to an 8-bit code that doubles the character-set boundaries to 256. IBM EBDIC format is an 8-bit encoding format offered by a number of manufacturers.

Modems and data transmission

Modem options allow terminals to be connected via the phone lines to remote computers or other terminals. Modems use frequency and phase-modulation techniques that when combined with error detection and correction techniques give reliable data transfers. While this is the method overwhelmingly used by time-sharing systems, more and more private computer users are turning to modems to access their machines when away from home. Acoustic couplers provide nonelectrical phone-line connections at limited data transmission rates. Computer information exchange networks are becoming common where club members access a disc-based computer system over phone lines.

Data transmitted from the terminal to the computer is sent on a character-by-character basis as in the glass teletype or may be sent a line or page at a time. Larger block transmission gives the operator the opportunity to correct errors before digestion by the computer.

CRT terminals often have parallel or serial hard-copy adapter interfaces that directly drive printers to create hard copy of selected pages. This interface is similar to the computer interface except simpler, being one way.

If you plan to do your own maintenance ask about serviceability. Are sockets used? Do the printed circuit boards slide out for easy access? Is there built-in diagnostic software? And most important of all be sure that the terminal you select will be capable of easily handling the tasks you intend to set before your computer. **R-E**

FLOPPYS

MANUFACTURER	MODEL	SIZE (Inches)	SECTOR TYPE (Hard/Soft)	NO. OF SECTORS (Per Track)	NO. OF TRACKS	FORMAT	DENSITY (Single/Double)	SIDES (Single/Double)	MAX. CAPACITY (K Bytes of Data Per Drive)	BUSS	CONTROLLER BOARD AVAIL (Y/N)	CONTROLLER BOARD INCL (Y/N)	OPERATING SYSTEM AVAIL (Y/N)	OPERATING SYSTEM INCL (Y/N)	EXTENDED BASIC AVAIL (Y/N)	EXTENDED BASIC INCL (Y/N)	PRICE
ALTOS COMPUTER SYSTEMS	ACS8000-1	8	S	26	76	IBM	S	S	500	ALTOS 50	Y	Y	Y	N	Y	N	$3,840.00
	ACS8000-2	8	S	26	76	IBM	S, D	S	500	ALTOS 50	Y	Y	Y	N	Y	N	$4,500.00
	ACS8000-3	8	S	26	76	IBM	S	D	1000	ALTOS 50	Y	Y	Y	N	Y	N	$4,800.00
	ACS8000-4	8	S	26	76	IBM	S, D	D	1000	ALTOS 50	Y	Y	Y	N	Y	N	$5,300.00
	ADD-2	8	S	26	76	—	S, D	S	1000	NA	Y	N	Y	N	Y	N	$2,960.00
	ADD-3	8	S	26	76	—	S, D	S	1000	NA	Y	N	Y	N	Y	N	$2,000.00
CENTRAL DATA CORP.	—	5½	S	9	35	256 BYTES/SECTOR	S	S	81	S-100	Y	Y	Y[1]	Y[1]	Y[1]	Y[1]	$ 799.00
COMMODORE BUSINESS SYSTEMS	2040	5½	S	19	35	OWN	S	S	170	IEEE 488	Y	Y	Y	Y	NA	NA	TBA
COMPUTER INTERFACE TECHNOLOGY	CIT TRS-80	5½	S	10	40	—	S	S	64	TRS-80	Y	N	N	N	N	N	$ 499.00
COMPU/THINK	DKH642	5½	S	—	40	—	S, D	S, D	400	PET	—	Y	—	Y	6	6	$1,295.00[7]
DATATRONICS	FD-277/99	8	S	26	77	IBM 3741	S, D	S, D	1200	S-100	Y	Y	Y	Y	Y	N	$1,995.00 UP
DYNABYTE INC.	DB 8/2	5½	S	32	77	IBM	S, D	S, D	630 (SS) 1200 (DS)	S-100	N	Y	Y	Y	Y	N	$4,395.00
	DB 8/4	8	S	52	77	IBM	S, D	S, D	1000 (SS) 2000 (DS)	S-100	N	Y	Y	Y	Y	N	$2,995.00
ELECTRO ANALYTIC SYSTEMS INC.	EAS-FDDS	8	S	26	77	IBM 3740	S, D	S, D	500	S-100 LSI-11 UNIVERSAL	Y	Y	Y	N	Y	N	$2,195.00

MANUFACTURER	MODEL	SIZE (Inches)	SECTOR TYPE (Hard/Soft)	NO. OF SECTORS (Per Track)	NO. OF TRACKS	FORMAT	DENSITY (Single/Double)	SIDES (Single/Double)	MAX. CAPACITY (K Bytes of Data Per Drive)	BUSS	CONTROLLER BOARD AVAIL (Y/N)	CONTROLLER BOARD INCL (Y/N)	OPERATING SYSTEM AVAIL (Y/N)	OPERATING SYSTEM INCL (Y/N)	EXTENDED BASIC AVAIL (Y/N)	EXTENDED BASIC INCL (Y/N)	PRICE
FINDEX INC.	–	5½	S	–	–	–	D	D	–	S-100	Y	Y	Y	Y	Y	Y	–
	–	8	S	–	–	–	D	D	–	S-100	Y	Y	Y	Y	Y	Y	–
HEATH CO.	WH17	5½	H		40				102+	OWN	Y	Y					$ 675.00A
INNOTRONICS CORP.	410	8	H, S	26	77	IBM	S, D	S, D	789	PDP8	Y	N	Y	N	Y	N	$ 495.00
	420	8	H, S	32, 16, 8, 1	77	IBM	S, D	S, D	789	PDP11	Y	N	Y	N	Y	N	$ 505.00
	3400	8	H, S	–	77	IBM	S, D	S, D	789	LSI-11 S-100	Y	N	Y	N	Y	N	$1,555.00
ITHICA AUDIO	550	8	H	16	77	OWN	S	S, D	250 (SS) 500 (DS)	S-100	Y	N	Y	N	N	N	$ 456.00[2]
	552	8	H	16	77	OWN	S	S, D	250 (SS) 500 (DS)	S-100	Y	N	Y	N	N	N	$ 630.00[2]
MECA	DELTA-1	5½	H	10	35	–	D	S, D	–	S-100	Y	Y	Y	Y	Y	Y[3]	$ 744.00[4]
MIDWEST SCIENTIFIC INSTRUMENT	6800A	5½	S	16	77	OWN	S, D	S	160	SS-50	Y	Y	Y	N	Y	N	$2,995.00[5]
	FD-8	8	H	–	–	OWN	–	–	315	SS-50	Y	Y	Y	N	Y	N	$1,395.00
PERCOM DATA CO.	TFD-200	5½	S	10	35	256 BYTES/ SECTOR	S	S	–	TRS-80	Y[8]	–	Y[8]	–	Y[8]	–	$ 399.00
	LFD-400	5½	H	10	35	256 BYTES/ SECTOR	S	S	89	SS-50	Y	Y	Y	Y	Y	–	$ 599.95
PROCESSOR TECHNOLOGY	HELIOS II	8	[18]	32	77	ALTERED IBM	S	S	375	S-100	Y	Y	Y	Y	Y	Y	$3,200.00

MANUFACTURER	MODEL	SIZE (Inches)	SECTOR TYPE (Hard/Soft)	NO. OF SECTORS (Per Track)	NO. OF TRACKS	FORMAT	DENSITY (Single/Double)	SIDES (Single/Double)	MAX. CAPACITY (K Bytes of Data Per Drive)	BUSS	CONTROLLER BOARD AVAIL (Y/N)	CONTROLLER BOARD INCL (Y/N)	OPERATING SYSTEM AVAIL (Y/N)	OPERATING SYSTEM INCL (Y/N)	EXTENDED BASIC AVAIL (Y/N)	EXTENDED BASIC INCL (Y/N)	PRICE
QUAY CORP.	80FDC	5½, 8	S	5½-16 8-26	5½-35 8-77	IBM 3740	S	S	5½-125 8-400	S-100	Y	N	Y	N	Y	N	$ 395.00
	90F/MPS	5½, 8	S	5½-16 8-26	5½-35 8-77	IBM 3740	S, D	S	5½-125/250 8-400/800	OWN	Y	N	Y	N	Y	N	$1,295.00[9]
RADIO-SHACK	261160[19]	5½	S	10	35	OWN	S	S	89.6	TRS-80	–	Y	Y	Y	–	Y	$ 499.00
	261161	5½	S	10	35	OWN	S	S	89.6	TRS-80	–	Y	Y	Y	–	Y	$ 499.00
SMOKE SIGNAL BROADCASTING	LFD-68	8	S	–	77	IBM	S	S	500	SS-50	N	Y	N	Y	N	Y[10]	$1,895.00[11]
SOUTHWEST TECHNICAL PRODUCTS CORP.	DMF-1A	8	S	32	77	FM	S	D	1200	SS-50	Y	Y	Y	Y	Y	Y	$2,095.00
	MF-68	5½	S	–	35	IBM	S	S	85	SS-50	Y	Y	Y	Y	Y	Y	$ 895.00K $ 995.00A
TARBELL ELECTRONICS	1011	5½ 8	S	26	77	IBM	S, D[12]	S, D	256SS	S-100	Y[13]	Y	Y[14]	N	Y[15]	N	–
THINKER TOYS	DISCUS 2D	8	S	26/8	77	IBM	S, D	S, D	600	S-100	Y	Y	Y	Y	Y	Y	$1,149.00
XITAN	ALPHA	5½, 8	S	5½-33 8-26/56	77	IBM	S, D	S	5½-330 8-512	S-100	Y	Y	Y	Y	Y	N	$2,195.00
NORTH STAR COMPUTERS[20]	MDS-A-D	5½	H	10	35	–	S, D	S, D	180	S-100	Y	Y	Y	Y	Y	Y	$ 699.00K $ 799.00A

NOTES:
NA NOT APPLICABLE
TBA TO BE ANNOUNCED
– NO INFO FROM MFR
SS SINGLESIDE
DS DOUBLESIDE

[1] 2650-BASED
[2] ADD $175.00 W/CONTROLLER
ADD $ 75.00 W/COMPLETE SOFTWARE
[3] ADD $195.00
[4] +CP/M $98.00
[5] WITH 32K PROCESSOR
[6] INCLUDED AS PART OF PET BASIC
[7] PLUS MEMORY COST
[8] FROM RADIO-SHACK
[9] WITH 16K RAM
[10] AND FORTRAN
[11] DUAL DRIVE
[12] UNDER DEVELOPMENT
[13] $190.00 KIT, $265.00 ASSMB.
[14] CP/M $100.00
[15] CBASIC-2 $100.00, TBASIC $36.00
[16] BARE BOARD
[17] USES DIGITAL RESEARCH CP/M
[18] FIRM SECTOR/COMBINATION
[19] INCLUDES TERMINATION RESISTOR ONE REQUIRED
[20] TOO LATE TO ALPHABETIZE

CRT TERMINALS

MANUFACTURER	MODEL	TYPE	TYPE	INCLUDES KEY-BOARD (Y/N)	CAN USE AS STAND ALONE TYPE-WRITER (Y/N)	CHAR. PER LINE	CHAR. PER INCH	VAR-IABLE TYPE-FACES (Y/N)	LINES PER MINUTE	INTERFACE
BOOTSTRAP ENTERPRISES INC.	9112	THERMAL	MATRIX	N	N	12	10	N	60	PARALLEL
	9120	THERMAL	MATRIX	N	N	20	10	N	60	PARALLEL
CENTRONICS	P1	ELECTRO STATIC	MATRIX	N	N	80	8-10	N	–	PARALLEL
	S1	ELECTRO STATIC	MATRIX	N	N	80	8-10	N	–	PARALLEL
	779-1	IMPACT	MATRIX	N	N	80	8-10	N	–	PARALLEL
	779-2	IMPACT	MATRIX	N	N	80	8-10	N	–	PARALLEL
	703	IMPACT	MATRIX	N	N	80	8-10	N	600	PARALLEL
COMMODORE BUSINESS MACHINES	2020	IMPACT	MATRIX	N	N	80	10.6	N	70	PARALLEL
	2022	IMPACT	MATRIX	N	N	80	10.6	N	70	PARALLEL
	2024	IMPACT	MATRIX	N	N	80	10.6	N	70	PARALLEL
ELECTRONIC SYSTEMS	TRENDATA 1000	IMPACT	WHOLE CHAR	Y	Y	134 OR 155	10 OR 12	Y	–	SERIAL
FINDEX INC.	DEC WRITER	IMPACT	MATRIX	Y	Y	132	10	N	–	SERIAL
GRE DATA PRODUCTS	PRINTER-FACE II	IMPACT	MATRIX	N	N	40/80	5/10	Y	–	S-100
HEATH COMPANY	WH14	IMPACT	MATRIX	N	N	80, 96 132	–	N	–	PARALLEL SERIAL
	LA36 DEC WRITER	IMPACT	MATRIX	Y	Y	132	10	N	–	SERIAL
INTEGRAL DATA SYSTEMS INC.	IP-125[4]	IMPACT	MATRIX	N	N	80 (STD) 132 (OPT)	10 STD 8.3, 12, 16.5 (OPT)	N	50-80 CPS	SERIAL, PARALLEL
	IP-225[5]	IMPACT	MATRIX	N	N	80 (STD) 132 (OPT)	10 STD 8.3, 12 16.5 (OPT)	N	50-80 CPS	SERIAL, PARALLEL
INTERNATIONAL ELECTRONIC EQUIPMENT CORP.	ORIDATA CP110	IMPACT	MATRIX	N	N	80	10	N	70[6]	PARALLEL
INTERNATIONAL PERIPHERAL SYSTEMS INC.	1622	IMPACT	–	Y	Y	UP TO 300	5 TO 15	Y	TO 150	SERIAL PARALLEL

MANUFACTURER	ENCODED	CHAR. BUFFER-ING (Y/N)	HALF SPACING (Y/N)	PROPORT. SPACING (Y/N)	MECH-ANISM	HOUSING INCLUDED (Y/N)	PAPER ROLL (Y/N)	PAPER WIDTH (Max. In.)	SHEET (Y/N)	WIDTH (Max. In.)	OTHER	PAPER	PRICE
BOOTSTRAP ENTERPRISES INC.	ASCII	Y	N	N	NEW	Y	Y	2½	–	–	–	THERMAL	$ 295.00
	ASCII	Y	N	N	NEW	Y	Y	2¼	–	–	–	THERMAL	$ 349.00
CENTRONICS	ASCII	Y	N	N	NEW	Y	–	–	–	–	–	ELECTRO-STATIC	$1,245.00 UP
	ASCII	Y	N	N	NEW	Y	–	–	–	–	–	ELECTRO-STATIC	$1,245.00 UP
	ASCII	Y	N	N	NEW	Y	Y	8.5	–	–	–	ANY	$1,245.00 UP
	ASCII	Y	N	N	NEW	Y	Y	14.5[2]	–	–	–	ANY	$1,245.00 UP
	ASCII	Y	N	N	NEW	Y	–	–					
COMMODORE BUSINESS MACHINES	ASCII	Y	N	N	NEW	Y	Y	8½	–	–		ROLL	$ 695.00
	ASCII	Y	N	N	NEW	Y	Y	8½	–	–		FORMS	TBA
	ASCII	Y	N	N	NEW	Y	Y	8½	–	–		EITHER	TBA
ELECTRONIC SYSTEMS	ASCII	Y	N	Y	REFUR-BISHED	Y	Y	15	Y	15	–	ANY	$1,395.00
FINDEX INC.	ASCII	Y	N	N	NEW	Y	–	–	–	–	–	–	$2,200.00
GRE DATA PRODUCTS	ASCII	Y	N	N	NEW	N	Y	8½	Y	8½	–	TELETYPE	$ 895.00
HEATH COMPANY	ASCII		N	N	NEW	Y	Y	9.5	Y	9.5	–	ANY	$ 895.00
	ASCII	Y	N	N	NEW	Y	Y	14⅞	Y	14⅞		TRACTOR	$1,495.00
INTEGRAL DATA SYSTEMS INC.	ASCII	Y	N	–	NEW	Y	Y	8.5	Y	8.5		ANY	$ 799.00
	ASCII	Y	N	–	NEW	Y	Y	8.5	Y	8.5		ANY	$ 949.00
INTERNATIONAL ELECTRONIC EQUIPMENT CORP.	ASCII	Y[7]	N	N	NEW	Y	Y	TTY PAPER	–	–	–	–	$ 650.00
INTERNATIONAL PERIPHERAL SYSTEMS INC.	ASCII EBCDIC	Y	Y	Y	NEW	Y	Y	14⅞	Y	14⅞	–	–	–

MANUFACTURER	MODEL	TYPE	TYPE	INCLUDES KEY-BOARD (Y/N)	CAN USE AS STAND ALONE TYPE-WRITER (Y/N)	CHAR. PER LINE	CHAR. PER INCH	VAR-IABLE TYPE-FACES (Y/N)	LINES PER MINUTE	INTERFACE
INTERNATIONAL PERIPHERAL SYSTEMS INC.	1612	IMPACT	–	Y	Y	UP TO 300	5 TO 15	Y	TO 150	SERIAL
M.P.I. INC.	TP-40	IMPACT	MATRIX	N	N	40	12	Y[1]	75	SERIAL
	IP-40	IMPACT	MATRIX	N	N	40	12	Y[1]	75	PARALLEL
	BP-40	IMPACT	MATRIX	N	N	40	12	Y[1]	75	PARALLEL
	SSP-40	IMPACT	MATRIX	N	N	40	12	Y[1]	75	SERIAL
	MP-40	IMPACT	MATRIX	N	N	40	12	Y[1]	75	PARALLEL
MICRO COMPUTER DEVICES, INC.	9710	IMPACT	WHOLE CHAR	Y	Y	135 OR 155	10 OR 12	Y	–	SERIAL PARALLEL
MICROMAIL	TC810	IMPACT	MATRIX	N	N	132	10 16.5 (OPT)	N	–	SERIAL
PRINTER TERMINALS CORP.	879	IMPACT	MATRIX	N	N	80 OR 132	–	N	75	SERIAL PARALLEL
PROCESSOR TECHNOLOGY	SOL	IMPACT	DAISY WHEEL MATRIX	N	–	130	1 TO 120	Y	–	SERIAL PARALLEL
RADIO SHACK	261150	IMPACT	DOT MATRIX	N	N	132	16.5	N	–	PARALLEL
	261152	IMPACT	DOT MATRIX	N	N	132	16.5	N	–	PARALLEL
	261151	ELECTRO-STATIC	DOT MATRIX	N	N	64	9	N	–	PARALLEL
	261153	ELECTRO-STATIC	DOT MATRIX	N	N	20-60	3.5-11	N	VARIES	PARALLEL
SOUTHWEST TECHNICAL PRODS	PR-40	IMPACT	MATRIX	N	N	40	12	N	70	PARALLEL
TELPAR INC.	PS-48C	THERMAL	MATRIX	Y	Y	48	10	N	30	ALL
VAMP INC.	IBM 745	IMPACT	WHOLE CHAR.	Y	Y	135	12	Y	–	PARALLEL

MANUFACTURER	ENCODED	CHAR. BUFFER-ING (Y/N)	HALF SPACING (Y/N)	PROPORT. SPACING (Y/N)	MECH-ANISM	HOUSING INCLUDED (Y/N)	PAPER		SHEET (Y/N)	WIDTH (Max. In.)	OTHER	PAPER	PRICE
							ROLL (Y/N)	WIDTH (Max. In.)					
INTERNATIONAL PERIPHERAL SYSTEMC INC.	ASCII EBCDIC	Y	Y	Y	NEW	Y	Y	14⅞	Y	14⅞	–	–	–
M.P.I. INC.	ASCII	Y[2]	N	N	NEW	Y	Y	17	Y	17	–	ANY	$ 749.00
	ASCII	Y[2]	N	N	NEW	Y	Y	4	N	–	–	ANY	$ 585.00
	ASCII	Y[2]	N	N	NEW	Y	Y	4	N	–	–	ANY	$ 585.00
	ASCII	Y[2]	N	N	NEW	Y	Y	4	N	–	–	ANY	$ 485.00
	ASCII	Y[3]	N	N	NEW	Y	Y	4	N	–	–	ANY	$ 425.00
MICRO COMPUTER DEVICES, INC.	ASCII	Y	N	N	NEW	Y	Y	15	Y	15	–	ANY	$1,850.00
MICROMAIL	ASCII	Y	N	N	NEW	Y	–	–	Y	15	–	TRACTOR ANY	$1,695.00
PRINTER TERMINALS CORP.	–	–	–	–	–	–	✓	–	–	–	–	–	$1,395.00
PROCESSOR TECHNOLOGY	ASCII DIRECT	8	Y	Y	NEW	Y	–	–	Y	14⅞	–	ANY	$3,695.00
RADIO SHACK	ASCII	Y	N	N	NEW	Y	Y	–8½	Y[1]	8½	LABELS CARBON	ANY	$1,299.00[1]
	ASCII	Y	N	N	NEW	Y	Y	8½	Y[1]	8½	LABELS CARBON	ANY	$1,599.00[2]
	ASCII	Y	N	N	NEW	Y	Y	4	N	NA	–	ELECTRO-STATIC	$ 599.00
	ASCII	Y	N	N	NEW	Y	Y	6	N	NA	–	ELECTRO-STATIC	$ 499.00
SOUTHWEST TECHNICAL PRODS	ASCII	Y	N	N	NEW	Y	Y	3⅞	–	–	–	ANY	$ 250.00
TELPAR INC.	ASCII	Y	N	N	NEW	Y	Y	5.5	–	–	–	THERMO	$ 700.00
VAMP INC.	ASCII	Y	Y	Y	REFUR-BISHED	Y	Y	14	Y	14	–	–	$ 750.00

NOTES:

[1]DOUBLE WIDTH CHARACTERS
[2]200 CHARACTERS
[3]1 CHARACTER
[4]FRICTION FEED
[5]TRACTOR FEED
[6]BIDIRECTIONAL
[7]FULL LINE (80 CHARACTERS)
[8]MATRIX (YES), DAISY WHEEL (NO)

CPS (CHARACTERS PER SECOND)
TBA (TO BE ANNOUNCED)

CRT TERMINALS																							
		PARALLEL I/O				KEYBOARD					VIDEO DISPLAY			TEXT									
MANUFACTURER	MODEL	NO. LINES	HAND-SHAKING	COMPAT-IBILITY	SERIAL I/O COMPAT-IBILITY	NO. KEYS	NO. USER DEFINABLE KEYS	CURSOR	UPPER CASE	LOWER CASE	GRAPHICS	COLOR	RESO-LUTION	CHAR. PER LINE	NO. LINES	DOT MATRIX	SCROLL-ING	BLACK ON WHITE	WHITE ON BLACK	HIGH-LIGHTING	UPPER CASE	LOWER CASE	PRICE
DATATRONICS		9	Y		RS-232C	91	8	AD	Y	Y	Y	N	–	80	25	7x9	Y	Y	Y	Y	Y	Y	$ 995.00
FINDEX INC.		46	Y		RS-232C	77	0	Y	Y	Y	N	N	–	40	6	Y	Y	–	–	–	Y	Y	–
HAZELTINE	1500	–	–	–	TTY RS-232	74	0	Y	Y	Y	N	N	–	80	24	7x10	Y	Y	Y	Y	Y	Y	$1,225.00
	1510	–	–	–	TTY RS-232	81	0	Y	Y	Y	N	N	–	80	24	7x10	Y	Y	Y	Y	Y	Y	$1,395.00
	1520	–	–	–	TTY RS-232	81	0	Y	Y	Y	N	N	–	80	24	7x10	Y	Y	Y	Y	Y	Y	$1,650.00
	1400	–	–	–	TTY RS-232	53	0	Y	Y	N	N	N	–	80	24	5x7	Y	N	Y	N	Y	N	$ 850.00
HEATH	H9	–	–	–	RS-232C	67	N	Y	Y	N	Y	N	–	80 20	12 48	5x7	Y	N	Y	N	Y	N	$ 530.00K
MICROMAIL	SOROC IQ120	–	–	–	RS-232C	69	0	Y	Y	Y	N	N	–	80	24	5x9	Y	N	Y	Y	Y	Y	$ 795.00
	SOROC IQ140	–	–	–	RS-232C	102	32	Y	Y	Y	N	N	–	80	25	5x9	Y	Y	Y	Y	Y	Y	$ 345.00
MICRO-TERM INC.	ACT V/ MIME	–	–	–	RS-232C	63	0	Y	Y	Y	N	N	–	80	24	5x9	Y	N	Y	Y	Y	Y	$ 795.00 $ 865.00
	ACT-IA	–	–	–	RS-232C	63	0	Y	Y	Y	N	N	–	64	16	5x9	Y	N	Y	Y	Y	Y	$ 400.00
NETRONICS		–	–	–	RS-232C	53	–	Y	Y	Y	N	N	–	34 64	16	5x7	Y	N	Y	N	Y	Y	$ 149.00
PHONE 1 INC.		–	–	TTY3277	RS-232	74	–	Y	Y	Y	32 CHAR	N	80x 24	80	24	7x9	Y	–	Y	Y	Y	Y	$ 850.00
RADIO SHACK					–	53	0	Y	Y	N	Y	N	127 X 47	64	16	Y	Y	N	Y	N	Y	N	$599.00
SMOKE SIGNAL BROADCASTING		3	Y	S-100	S-100	72	46	Y	Y	Y	Y	N	–	64	16	8x10	Y	N	Y	Y	Y	Y	$ 625.00
SOUTHWEST TECH. PRODUCTS INC.		8	Y	–	RS-232	68	–	Y	Y	Y	Y	N	–	80	20	7x12	Y	[1]	[2]	N	Y	Y	$ 795.00
TELECOMMUNI-CATIONS SER. CO.	3360	25	N		RS-232	–	–	Y	Y	N	N	N	–	82	–	5x7	OPT	–	[1]	N	Y	N	–
	3000	25	Y		RS-232	–	–	Y	Y	N	N	N	–	72	–	–	Y	–	[1]		Y	N	–
U.S. ROBOTICS INC.		–	–	–	RS-232C	66	–	Y	Y	Y	N	N	–	80	24	7x10	Y	Y	Y	N	Y	Y	$ 799.00
VECTOR GRAPHICS		1	N		NO	71	0	Y	Y	Y	Y	N	900 LINES	80	24	Y	Y	Y	Y	Y	Y	Y	$ 765.00

NOTES: K KIT
A ASSEMBLED
[1]WHITE ON GREEN
[2]GREEN ON BLACK
[3]RED
[4]LIMITED
[5]USER SELECTABLE

BUILD THIS

String Synthesizer

Part 2—Continuing the discussion of the electronic string music synthesizer. This unique instrument gives the soloist and small groups the background needed to enhance performance

MARVIN JONES

BEFORE PRESENTING THE CONSTRUCTION details, we will conclude the circuit discussion started last month with a description of the middle-octave mixing and chorusing circuit and the power supply.

The middle-octave piano keying circuit is exactly like the high- and low-octave circuits, but the middle-octave strings section is slightly different to accommodate the switchable split-keyboard feature. The string keying starts off the same; C6 charges through R15 and D17, and the sustain control affects the discharge time of C6 via R16 and D18. Resistors R17 and R18 apply the envelope voltage of C6 to two diode keying networks—one for violins, one for cellos. Here the differences begin. The two diode keying circuits are designed to each provide two identical outputs. The basic philosophy behind the split keyboard circuitry is: "Feed an identical signal to both the upper AND lower mix buses, and remove the one you DON'T want."

So where the low-octave strings are connected to the appropriate low-mix buses and the high-octave strings are connected to the high-mix buses, the middle-octave strings are simultaneously applied to both. The logic level available on the split select bus (SPL) is used to determine which of the two signals will be grounded out. The voltage levels on the SPL bus are directly related to the front panel switch position. Low-octave split point is represented by a low voltage. High-octave split point is represented by +V appearing on the SPL bus. The single NAND gate (IC3-c) remaining from the waveshaping circuit is used to invert the SPL signal. When the front panel split switch is at position 1, the keyboard is being split between the low and middle octaves. Thus, you want the middle octave to be applied to the high-mix bus.

So, the ground potential appearing at the SPL bus is used to forward bias the shunt diodes, D31 and D32, causing the low-string mix signals from the middle octave to be shunted to ground. The diodes connected to the high-string mix buses, D29 and D30, are being driven by the SPL inversion which is now at a high level. Thus, the diodes are inactive. When the SPLIT switch is in the high, or No. 2 position, the SPL bus is at a high level allowing the signal to pass to the low-mix bus. The inverter now produces a low output, shunting the high-mix signals to ground.

The chorusing circuitry is shown in Fig. 4. Most of this circuitry is contained on one PC board, with the exception of front panel controls, jacks, and so on. The resultant signal mixes from the front panel HIGH and LOW mix controls are applied to string inputs A, B, C and D. IC10-a serves as a unity-gain mix and buffer amplifier. Capacitor C20 rolls off the high-frequency content of the input signal to avoid any intermodulation with the clocking frequency of the analog delay lines. Bias trimmer, R66, sets a DC level at the output of the buffer (IC10-a) so the analog delay lines will be biased for minimum distortion and maximum dynamic range. The buffered input signal is applied to two delay lines (IC8 and IC9) plus the output amplifier, IC11.

Thus, the composite string signal at the output consists of one original signal and two independently delayed and modulated signals. In one path, the signal is delayed by IC8-a and dropped across the delay line load, R69. Capacitor C23 eliminates the high-frequency clocking signal that is superimposed on the audio signal as it passes through the delay line. Op-amp-IC10-b is a gain stage to make up for losses encountered in the delay line and C25 provides additional filtering of high frequencies to help smooth the audio signal. The output of IC10-b, which also rides the bias level determined by R66, is passed through another stage of analog delay, IC8-b. The delay line output is again filtered and applied to the output mix amplifier, IC11. Delay time IC9 and its associated circuitry operates identically to the delay line circuitry of IC8. This second independent delay line has its signal also applied to the output mix amplifier.

The remaining stage of IC10 is used to buffer and drive the piano signal outputs. The signal from the piano mix bus (MXP) is dropped across R86, and buff-