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FOCUS ON MICROCOMPUTERS

Computers for use in very small businesses, and many of the so-called "personal" computers are often one and the same. Interestingly enough, this was the case from "Day One" when POPULAR ELECTRONICS *introduced the Altair 8800 computer in January 1975. At that time, data from the Altair kit supplier made it clear that some 60% of the kits purchased were for business use.*

This wasn't surprising since PE readers include many people associated with business in managerial capacities, and numerous small business owners (physicians, lawyers, etc.). Indeed the 1979 version of the PE Market Study reveals that some 33% of its almost half a million subscribers still use microcomputers for business only. An additional 31% use them in a combination of business and personal applications, and about 35% for personal applications only.

Choosing a Computer for a Very Small Business

BY JOHN ZITZ*

THE US GOVERNMENT identifies a *small* business as one that employs up to 250 people and has an annual gross income of up to $5-million. However, small businesses that can use computers to advantage may be much smaller than that, ranging down to a single user in a part-time business operation. These types of operations are often called "very small businesses."

System cost, naturally, plays an important role. An enterprise grossing $50,000 yearly cannot afford a $20,000 computer or its equivalent in time-sharing systems. Like any capital investment, a data-processing system should be justified by the return it can be expected to produce. Experience has shown that a single computer and its operator can do the work of several people, either saving the cost of some salaries and benefits or freeing personnel for other tasks. In some cases, the computer will have enough extra data-handling capacity to allow the business to expand with little or nothing in the way of increased computing costs.

Perhaps more important, the computer is very fast and can keep the businessperson informed about the status of affairs today, not the way they were last week. Further, since the computer eliminates many hours of manual clerical work and can deliver its output in a compact precise form that obviates a good deal of "paper shuffling," it can create more time for the research, decision making, and creativity that are the real essence of an entrepreneur's function.

Besides its obvious functions in accounting, inventory and production control, and the like, a computer can also—with the right software—handle secretarial functions such as appointment planning. Mailing lists, telephone files, library catalogs, and similar collections of data can be created, alphabetized, updated, and printed as desired. With the addition of a text-editing program a computer can process correspondence. Form letters, for example, can be written, recalled, and personalized with great facility.

Requiring no rest or sleep and only occasional maintenance, a computer can be used 24 hours a day; even when the business is closed. Both hardware and software are available to let the computer "watch over" sensitive systems such as refrigerators, air conditioners, water pumps, etc. It can also sense intrusion, fire, smoke and other emergency conditions and perform some predetermined function when an alarm is activated. Communication with the computer at any time is a possibility, even from remote points across the country using a telephone attachment called a modem. This means that salesmen can communicate orders, or get product information over the phone line when they desire. Businessmen who generate new

*PCE Microcomputer Systems, Sacramento, CA.

ideas at night can, via a terminal and modem at home, put these into effect or at least record them while they are fresh. It is even possible to run an enterprise by "remote control."

The System. Just as vehicles, regardless of their make or model, are pretty much the same under their metal skins, computers are too. The former have engines, suspensions, transmissions, etc., as main working parts while the latter have memory, central processor units, input/output modules, interfaces, etc.

Vehicles can be optimized for business or pleasure depending on the options selected, and the same is true of computers. For business use, you need a machine that has enough computing power and enough options to handle both your present and anticipated future requirements. This is why it always pays to take a look at *all* the options for a particular computer, since as your business grows, you may require functions not needed at the present.

A few years ago, computer enthusiasts who wanted to use a "hobby-type" computer for business would explore what microprocessor was being used, what type of bus was offered, and so on. The growth of the moderately priced computer market has changed all that. Consequently, software is *the single overriding consideration* in buying a business-oriented computer today.

For most applications, the "computer" will be a keyboard, video display and printer, all attached to a small enclosure in which the actual data manipulations are performed. There may also be another enclosure containing the disk storage system. Sometimes a keyboard and printer or video display are combined in a single unit called a terminal. This can be located near or remote from the computer.

To enable the computer to be used by personnel trained in normal secretarial skills, the keyboard should have a conventional typewriter format, with comfortably spaced and easy-to-the-touch keys. If a lot of numeric entries are to be made, a separate keypad is a definite convenience.

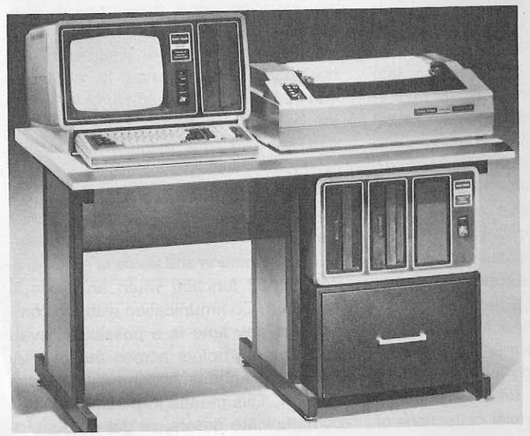
Quality of the video display is also important as it will determine the extent of eyestrain (which may result in possible entry or reading errors) if the display is used for extended periods. The usable screen should measure at least 12″ diagonally and have a contrast that is comfortable to the eyes. The characters should be sharp, and free from glare. They should be crisp from edge to edge across and from the top to the bottom of the screen, and should exhibit very little nonlinearity. Dual-brightness or inverted (black-on-white instead of white-on-black) characters are useful for special attention-getting displays, as is the capability of rendering color. The system should display at least 80 characters on 24 lines for business applications. Many small computers project only 16 lines of 64 characters per line—somewhat limiting for ledger and similar entries.

The printer, or hard-copy device, should be selected for its type face, speed, and noise level (some are quieter than others). It should be of sturdy construction and have adjustable columns for different width paper. The paper should be tractor or pin fed from the carriage to keep the paper secure in its place and free from misalignment—a necessity for automatic printing of checks and for keeping columns in proper vertical order.

Printer prices increase directly with the speed and quality of the print, and it is up to the purchaser to determine just what he wants. The need for upper- and lower-case characters and for multiple copies is a consideration, too.

The disk system is also determined by the amount of data you expect to store. Obviously, the larger the disk system, the more data can be stored. Keep Parkinson's Law in mind—data expands to fill the available disks. Small (so-called 5″ disks) can hold up to 90K bytes of data (enough for several hundred inventory entries), while the so-called 8″ disk can support up to 240K bytes of data. There are dual disk systems that increase data storage in one package, and there are dual- and quad-density and double-sided disk systems that maintain package size but greatly increase storage capacity. If your business is large enough, it may even pay you to take a look at the more expensive hard disk systems that can hold many millions of bytes of data. If at all possible, a business person should have at least a dual-disk system since it pays to make a backup copy of a completed disk for emergency use.

Since the most important consideration is software, it pays to make certain that the computer system you choose has a good selection available for it.



Radio Shack TRS-80 Model II Microcomputer with Line Printer III, External Disk System.

Compucolor II Model 3 Computer with color video display.

While, in some cases, special "emulator" programs that allow one machine to mimic another for which a desired item of software is available, this approach lowers the effective operating speed of the processor to a mere fraction of normal. Clearly, a modest (less costly) installation humming along with efficient software is preferable to a fancy one that limps because its software pinches. If it would be beneficial for your purposes to use COBOL or FORTRAN instead of BASIC, be sure your system is compatible with these languages.

Cost And Operation. The cost of a computer system is not just what the store charges you to take the package home. Maintenance and later expansion, for example, are obvious sources of additional cost. The great nemesis of all system planning is changing needs. A system that can be altered to suit all contingencies will cost more than one that is specialized, but it may be worth the difference in the long run. The choice between the two depends on the nature of your business. We will try to develop here rational guidelines that, taking the special nature of computers into account, will help to minimize costs.

"Off the Shelf" or "Custom". One attractive and low-cost approach is to buy standard hardware and software packages. If your application is commonplace, you may be able to purchase application programs that have already been written and field-tested. Packages exist for inventory applications, payroll, general ledger, accounts/payable and receivable, etc. With good knowledge of your business requirements, you could purchase a system that is optimized for the packages you need, while allowing for system integration, and expansion.

To have custom software written specifically to your needs by a reputable analyst and then have a hardware system implemented around that software, is another possible alternative. The pitfall is that the exclusivity of your system may inhibit changes in the future should they become necessary.

A middle path between these two extremes is to purchase a system that is mostly "off the shelf" and make minor adjustments as necessary. Many private vendors will have the resources to make these modifications if they are not too extensive and may even include them in the overall price of the system. In any case, all software and hardware modification should be in the hands of reliable consultants. A largely "off the shelf" system with canned software included in its price would range from about $4,000 to $8,000, depending on the peripherals put into the final system.

One difference between a "business computer system" and a "computer system that means business" is in the planning done in anticipation of breakdown and further expansion. The usual vendor warranties are enough to absorb the cost of initial problems until the system is finally "up and running." The reliability of the electronic technology that goes into computers is such that a business computer under normal use should not encounter a debilitating breakdown in well over a year of use. Even then, the most common breakdowns in a microsystem are not electrical but mechanical. Switches, motors, drivers actuator arms, and wheels fail far more often than electronic components.

Superficially attractive as all-in-one computers are, they are not for business. When a single functional part of an all-in-one computer fails, the whole machine goes down and, in many cases, must be sent to the factory for repair. The independent modular approach allows the offending module to be removed and repaired, often while a temporary replacement is substituted. This keeps the system reliability high despite the failure of individual modules. In the case of duplicate systems in one installation, modules can be temporarily "swapped" until replacements arrive.

External Problems. One of the hidden causes of computer component failure is noise transients and voltage spikes from electrical equipment such as motors, tools, etc., that are passed to the computer via the power lines. Not only can such "hash" and power-line surges damage components, they can also interfere with computer operation. It is essential that a well-engineered computer system have hash and power surge suppression built into its power supply. This can eliminate considerable hidden cost in operation.

Options. Another interesting power-supply option protects your computer against momentary power-line "black-outs". The capacitors in a good heavy-duty power supply can maintain their

Commodore PET 2001 Series Professional Computer.

Exidy Inc. Sorcerer Computer with dual-disk drive and video display.

charge for about a fifth of a second after the mains go down. This is time to kick in a back-up power supply without losing data or causing the system to "crash". An uninterruptable power supply can be added to a system fairly inexpensively and may, once in a while, save the day.

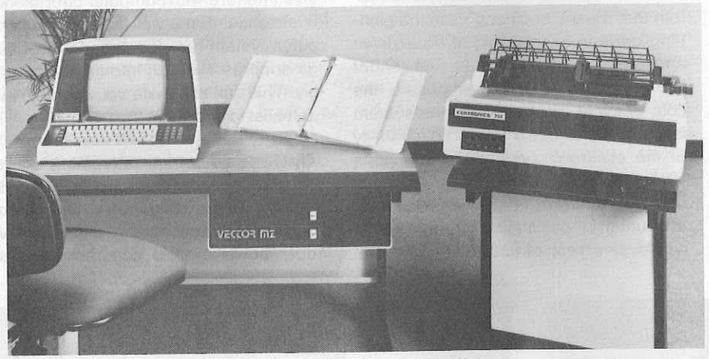
What About Protecting the Data? Computer failure can wipe out valuable data. However, if one takes the normal precautions of keeping backup disks and tapes, the likelihood of a serious setback is reduced. Cassette tapes and recorders are relatively cheap compared to disks and disk drives and are a cost-effective means of data protection. The high access speed of the disk is not a factor when all you are looking for is long-term archival storage. A small routine for transferring the data stored on a disk to a cassette is not difficult to implement and might even be part of the DOS (Disk Operating System) provided with the computer.

Security. Principally, this involves protecting the data physically from theft, destruction or tampering. Such protection is not difficult to implement if the entire system is in your premises, where access to it can be controlled. But what if data must be transmitted by telephone, other hard-wire lines, or mail?

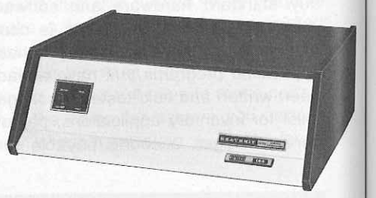
Hardware and software for encrypting data have just begun to appear on the market and will probably be included in total systems in the near future. For example, special chips which can encode data at high speeds, could be incorporated as part of the input-output interfacing of a data-transmission module. Here is another instance in which the modular approach to the computer design facilitates expansion of an existing system.

When To Buy. Is there a "right time" to buy a computer? Should the small business lease a computer, timeshare on a larger computer, or buy one outright? In the past, the high cost of computers and their relative inaccessibility made timesharing at a cost of several hundred dollars per month seem attractive. The low cost of microcomputers today has made this a more dubious proposition. The cost of the timeshare terminal alone is approximately 25% the cost of a microcomputer-based business system. Add to this the monthly cost of computer services and telephone line hookups and the total over a year rapidly approaches the cost of an entire small computer system. And of course, there is no equity.

Timesharing should only be considered when access to a large, computationally powerful computer is needed, as might be the case in engineering or scientific applications or those that generate volumes of statistical analyses. For the standard small-business-scale applications, even where sizable inventory accounting is involved, eight-bit microprocessing is the most cost-effective way to go. In short, for most very small businesses, don't borrow, don't lease—buy! And if you feel that your business is ready for the system, now is the moment of decision. ◇



Vector Business System—MZ Computer with dual floppy drive, MT Terminal, and Centronics 702 Printer.



Heathkit H11A 16-bit Computer has provisions for business peripherals.

Apple II Color-graphics Computer.

Ohio Scientific C8P DF System—Challenger 8P Computer, dual-disk drive, terminal, monitor, peripheral control devices.

Personal Computers

BY IVAN BERGER

IF YOU WANT a personal computer for nonbusiness purposes, there is a host of different types available to you. Which one you choose will largely depend on your intended applications and the money you wish to spend.

Is your main interest in learning about computer circuits as well as programming? If so, you might consider building a computer kit. Here one's choice could be between an expandable building-block type or a full-blown computer or even a complete system contained in one package.

Do you essentially want to make a few plug-in connections, apply ac power, and start right off making things happen? Then you can choose from assembled versions of some of the foregoing or an "appliance" computer. You might also be guided by which computers are popular in local computer clubs or which give you the most flexibility in choosing peripherals, buying or exchanging software, etc. Computer choices range from low-cost single-board systems, to all-in-one intelligent terminals, to micro mainframes plus many peripherals.

Microcomputers are used for a wide variety of purposes; for program development and teaching oneself to program; for small mass mailings; for education in noncomputer subjects; to handle home data such as recipes, Christmas-card lists and the checkbook; to control appliances; to play games; for computer-generated music or speech; for mathematical computation; for word processing to develop cleanly-typed reports, papers, letters, etc.; and for some business applications.

The more such applications you have, the more sense computers (basically all-purpose devices) make. For some single applications, in fact, alternatives to the computer make more sense. If all you want is to play games, for instance, get a programmable video game, and have done with it. The game will probably cost less, and put more interesting, cartoon-like graphics on your TV screen.

Similarly, if all you need to do is complex calculation, consider a programmable calculator. Again, the cost will be less—and you'll be able to carry the calculator with you at all times.

But calculators can play only limited games, and TV games have only limited calculating ability, if any (not counting the small but growing number of games that can be converted into full-fledged computers). If you're interested in both these applications at once—or in any of the others so far mentioned—you'll need a full-fledged computer.

But which one? All computers have some similarities: They all have some sort of *input* device to enter programs and data, some sort of *output* device to verify the input data and show what results the computer comes up with when the program runs. They all have *processors*, the chips that do the actual computing; and *memory* to hold programs and data while they're being used. But the types of input, output and processor differ, as do the amount of memory and the number of accessories or *peripherals* which can be used with the system.

Input and Output. The most visible differences between computer systems are usually in their input and output (I/O, for short) facilities. These are the channels of communications between the computer and you. The computer and you speak very different languages, and one measure of I/O sophistication is how cleverly the system can disguise that fact.

In its most primitive (and, today, rarest) form, the system will communicate in *binary*, a numbering system based on twos. A completely binary I/O system would have a row of eight switches to input each 8-bit computer command or data "word" and eight lights per "word" for output.

More commonly, the system will translate such binary numbers as "11000000" into either an octal (base-8) number such as "300" or a hexidecimal (base-16) number such as "CO." (Since hex numbering requires more digits than our base-10 decimal system, it follows the digits 0-9 with the letters A-F.) Many low-priced, single-board computers have calculator-like keypads and displays for use with either octal or hex input and output.

But octal and hex are only more sophisticated ways of talking *machine language*, the instructions that computers understand directly. Machine-language programs run very quickly, and don't use much memory. But they're cumbersome to write since you must not only learn at least a hundred or so instructions and how to use them, but must learn them as abstract numbers like "CD" or "305".

Consequently, keypad-and-display computers are only useful, as is, for writing very short programs, especially programs designed to interact with other devices rather than with people. Control applications are often a perfect match for these computers. Here, the limitations of keypad programming aren't serious, and the computers are small and cheap enough to be assigned to specific devices, or sometimes the computers are even built into the devices.

But most such computers also have *ports* for communicating with other I/O devices. Connect one to a *terminal*, which combines a full typewriter-like keyboard with a video display screen or a printer, and you can work with other programming languages which use the entire alphabet and other symbols.

With the keyboard's full set of characters at your command, you can program in assembly or high-level languages. *Assembly* language is just a word-for-word translation of machine language from abstract numbers into more easily-memorized abbreviations. In 8080 assembler, for example, the instruction "return if not zero" is "RNZ". In machine language, it would be either "CO" (hex), "300" (octal) or "11000000" (binary). A program called an *assembler* translates the mnemonic abbreviations into machine code, as well as performing such useful tricks as letting you call subroutines (frequently-invoked subprograms) by name, instead of remembering their memory addresses.

But that's still doing things the computer's way, not yours. *High-level languages*, such as BASIC or PASCAL, use standard English words (though sometimes in abbreviated form) to represent whole sequences of computer operations. In BASIC, for example, "PRINT SQR(SIN(Y))" will make the computer tell you what the square root of the sine of Y is. An assembly-language program for that would probably fill up this column.

Just as with assembly language, a special program is needed to translate your BASIC or other high-level language program into the computer's commands. That program can be read into the computer from a tape, or can be permanently built into the computer's memory. If you use BASIC a lot, it is a great convenience to have it instantly on tap whenever you turn the computer on. If you don't, this feature won't make much difference to you.

The typewriter keyboard and video screen are the most common microcomputer I/O devices, but there are variations and alternatives available. Many of these systems let you not only display letters and numbers (*alphanumerics*) on the screen, but "draw" pictures (*graphics*) on the screen as well. The pictures are often rather crude, being composed of clearly-noticeable blocks, but they're useful for such applications as games, graphing mathematical functions, and in business for bar-graph and other displays that are easier to understand than tables of numbers. Color makes the games more exciting and the bar-graphs more readable. This raises the cost of the computer, naturally, but may well be worth it for your uses.

Graphics programs written in BASIC run very slowly; for speed, you'll have to use assembly-language programs. Bear that in mind if you plan to write your own graphics. If you want fast graphics at low cost, you'll find a few graphics-capable machines with hex keypad input for machine-language programming.

Even alphanumeric video displays differ. Some computers have built-in video monitor screens. Others are usually sold with a video screen in a separate cabinet. Still others include video output circuits to feed signals to a video monitor screen. To feed it to a regular TV receiver, though, you'll have to convert that signal to a modulated radio-frequency one by passing it either through an *r-f modulator* or through a video-cassette recorder, if you have one. Not all computer/recorder combinations work well, though; nor do all r-f modulators (the latter cannot be legally sold separately unless it's in kit form.) Try to check out your combination in the store or on a money-back guarantee. Computers with built-in r-f modulators are beginning to appear, too. This feature makes more sense in home systems, where there's likely to be a TV receiver available, than in a business or industrial system.

There are also differences in how much information you can put on the video screen. Alphanumeric displays are available with 16 lines of 64 characters each, or less, and with 25 lines of 80

characters, or more. Similarly, graphics displays differ in the number of vertical and horizontal elements they can show—the amount of picture detail, in other words. The more information you can pack on one screen, the more you can take in at one glance. But more detailed displays cost more, and require higher-resolution monitors. As a result, high-density displays often cannot be used with r-f modulators and regular television receivers.

Keyboards are more standardized. The basic differences are in keyboard "feel" (more likely to matter to an operator who already knows touch typing than to a hunt-and-peck operator) and in the presence or absence of separate numeric keypads. These keypads are very worthwhile in applications involving large amounts of numerical entries, such as in business accounting or in scientific computation. It's far quicker to punch numbers into a calculator-like nest of keys in a compact bunch than to use a row of number keys spread out across the top of the keyboard.

That's fine for most applications, but not for word processing.

Word processing systems are mostly used for business, where it costs lots of money to turn roughly-typed or written drafts into smoothly-typed letters and reports. On a typical word-processing system, the operator can enter text, make corrections of all kinds, then command the computer to print out a perfectly-typed, finished copy. If it's a form letter, the computer can turn out a separate copy for each name and address on its list. Such systems are being adopted by offices, by free-lance writers and others.

Most small computers communicate with you through video screens. For most applications, this makes perfect sense: video systems are fast, silent, reliable, and don't use up paper.

But there are times when it definitely pays to have a permanent record of the computer's output. Word processing is an obvious example, but so are accounting (including your personal checkbook), alphabetizing of lists, or even for making written records of your programs that you can send to friends or carry with you while you look for problems and improvements. Properly programmed, a computer could print out your shopping list in the order in which the items appear on your supermarket's shelves.

In the early days of small computers, Teletype® printing terminals were the most common I/O devices. Today, video screens—on terminals or connected directly to the computer—are. But most systems do allow separate printers to be added to the system. If this is important to you, check how easily the printer can be added to any system you're considering, and how much the printer and its connections will cost.

Inside the Computer. It's no accident that we've been talking only about externals so far. For the input-output communication channels between you and the computer have far more to do with its utility than the circuits inside.

The most important of these circuits is probably *memory*. You'll find computers here with as few as 256 "bytes" of memory, each *byte* being an 8-bit computer "word" that can represent a single alphanumeric symbol or a single computer command. You'll also find that several are expandable to as many as 65,536 bytes, variously abbreviated as either "64K" or "65K".

Most systems, though, fall into the 2K to 32K range. Memory costs money, so the more you have, the more the system costs. But the more memory you have, the longer the programs you can store, and the more data you can have available for them to work on.

There are two types of memory: RAM and ROM. *RAM* (Random-Access Memory) is used for temporary storage of programs and data and for the results of program runs. The contents of RAM can be changed at will, and many of them change constantly during the running of a program. But those contents also fade out within seconds when the power is turned off.

That's where *ROM* comes in. ROM (Read-Only Memory) doesn't forget—but you can't readily change it, either. Hence, ROM is used to hold vital programs which you'll use all the time, such as those which instruct the computer how to accept input from the keyboard. Some computers have BASIC in ROM, too—on others, you have to load in the BASIC language program from a tape each time you use it.

Most computers have more RAM than ROM. Typically, a system will wind up having about 2K of ROM (about 8K or 10K with BASIC in ROM) and 16K or more of RAM (less, if BASIC is in ROM, since that frees the RAM space that BASIC would otherwise occupy). They may start with less, but sooner or later, more memory is added.

Some inexpensive systems, usually the single-board, keypad-and-display type, have very limited RAM space on board (perhaps 1K or 2K). Most of these allow other boards to be connected with more RAM. But unless your application is a simple one using machine-language or assembly-language programs (device control, for example), be sure any system you buy can be expanded to include enough memory for all your needs. There's no hard-and-fast rule about how much is enough, except that many systems seem never to have enough memory—you can always use more.

Mass Storage. Programs, other than those in ROM, must be fed into the computer every time you turn the system on or switch from one program to another. Entering them each time from the keyboard or keypad is ridiculously time-consuming, and almost inevitably leads to errors. So it's vital to have some easy, fool-proof way to save programs and re-enter them.

The use of punched paper tape has virtually died out, since it's a slow and noisy procedure. Most small computer systems standardize instead on cassette tape, either built in or as an accessory program storage device. Most such systems convert programs and data into tones which can be recorded on ordinary audio cassette recorders, but a few record digital pulses, not audio tones, which requires a special recorder. Cassettes, especially audio cassette systems, are fairly slow (they require several minutes to load BASIC, for example). But they're faster than paper tape, use tape you can buy almost anywhere, and usually make extra use of a cassette recorder you already own. Cassette programs are not always interchangeable between different computer makes, though a few cassette formats (chiefly Tarbell and Kansas City) available as accessories for many computers, have achieved fairly wide use.

A very few personal computers also have "canned" programs in ROM memory cartridges that look like 8-track audio cartridges. They cannot be used interchangeably with different brands of computers, though.

If you need reliable loading (cassettes sometimes have to be loaded several times before you get them right) quicker loading, and faster access to a wide variety of programs and data, then it's time to consider *floppy disks*. Floppies are basically magnetic recording tape cut into disks instead of ribbons. They use digital recording, and are very fast—BASIC or other long programs typically load in seconds. They also speed up access to programs and data. Getting from the first program on the disk to the last is a matter of moving the head a few inches from the outside to the inside track. In contrast, getting from the first to the last program on a C-60 cassette means moving about 250 *feet* of tape past the head.

Unlike cassettes, disks allow greater interchangeability between computer systems. This is especially true for systems based on the 8080, 8085 or Z80 processors. Many companies sell 5¼-inch disk programs written for use with these systems. Furthermore, Digital Research's CP/M operating system (and CP/M software available from such companies as Lifeboat Associates) simplifies interchange of programs. from different computers using the foregoing processors.

The processor is, for the most part, less important than the system you use it in. If you're programming in BASIC or some other language, you'll find as much difference between versions of BASIC running on a common processor as between versions running on altogether different ones. If you program in assembly or machine language, you'll find unlike processors very different to work with, but you'll also find that every processor has its firm adherents, with each processor's advantages being balanced by disadvantages relative to other processors. The best way to choose is to settle for whatever processor is in the system which best suits you, and for which the programs you need are already available.

Structure and Expandability. Any computer system worth its salt is designed to allow expansion. Your needs may grow or change; your budget will certainly grow, allowing you to make additions piecemeal.

Computer systems can be expanded in a variety of ways, and a given computer may use several of them. The simplest way to expand a system is to plug more integrated circuits into sockets already provided for them. This is usually done to expand RAM and ROM memory, and only for moderate expansions. Many single-board computers use this method, but so do some larger ones.

A more popular and more versatile route to system expansion is to plug in additional circuit boards. This implies that the computer will have some sort of *bus structure*, which is a group of signal, data, address and power lines into which boards can be plugged in any order. Several bus systems are in use, some are used in just one model of computer, others are used in many.

Boards are available for a very wide variety of purposes: to expand memory; to add more I/O circuits for additional terminals, printers and the like; to generate speech or sounds; to accept voice input; to tell the computer what time it is; to allow the user to build circuits of his own; to control other devices; to communicate by phone with other computers and terminals; to test integrated circuits; to add graphics capabilities; to send and receive Morse code; to interface with computers using other buses; to speed math processing; and many more possibilities.

Some computers, chiefly very compact ones, require a separate "box" to hold more than a minimum of extra memory, I/O and other circuits. Others combine approaches, with an expansion box that's built around an S-100 bus.

Peripherals. Much system expansion occurs outside the computer, of course. With the right programs and I/O circuits, a computer (even the kind whose built-in keyboard and video screen make it a terminal unto itself) can support several terminals around an office or house. For a very few machines, there are even programs available which allow several terminals to operate at once.

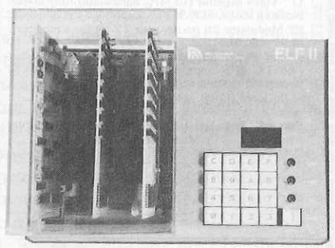
Even a one-terminal system can frequently use an add-on printer, for all the reasons already cited. But the application has a lot to do with which printer should be selected. The main choices are between dot-matrix and character printers; between impact, electrosensitive and thermal printing systems; and between printers offering upper-case (capitals) only and those offering both upper and lower case. (See "Printer" article that follows.)

Modems are another useful accessory, allowing your computer to communicate with others by telephone. Originate-only modems, the least expensive type, let your computer call up others. Originate/answer types also let others call you up. Some of the latter type also have "auto answer" facilities, so they can answer calls even in your absence.

The Systems Approach. When you buy a computer, you're not just buying a computer. You're starting a *system*. So your choice should be governed by the entire system it belongs to, and how well that system suits your application. Can the system be expanded to keep pace with your future needs? Can you get the peripherals you need—disk drives, modems, printers, device control boards, or whatever? How easily can you add any extra memory you may need, and at what cost? How many companies supply equipment to use with this system? Do you have near-future use for a business purpose? And, most important of all, is software available to make this system do what you want and need it to do? If the answer to all these questions is yes and cost is in your ballpark, then you've found the right system. ◇

(Focus continues on page 63)

COMPUTER KIT EXAMPLES



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How to Buy a Computer Printer

BY ALEXANDER W. BURAWA, Features Editor

Sooner or later, if you own a personal-computer system, you'll want to add a hard-copy printer. For example, a home user might want to keep printouts of programs in case he "blows" them on his tapes or disks, or have recipes that can be taken into the kitchen instead of a video monitor or terminal. A small businessman, on the other hand, would need a printer even more—for generating letters, billing information, stock-inventory lists, etc. Thanks to the introduction of lower-priced models, anyone can now seriously consider adding a hard-copy facility.

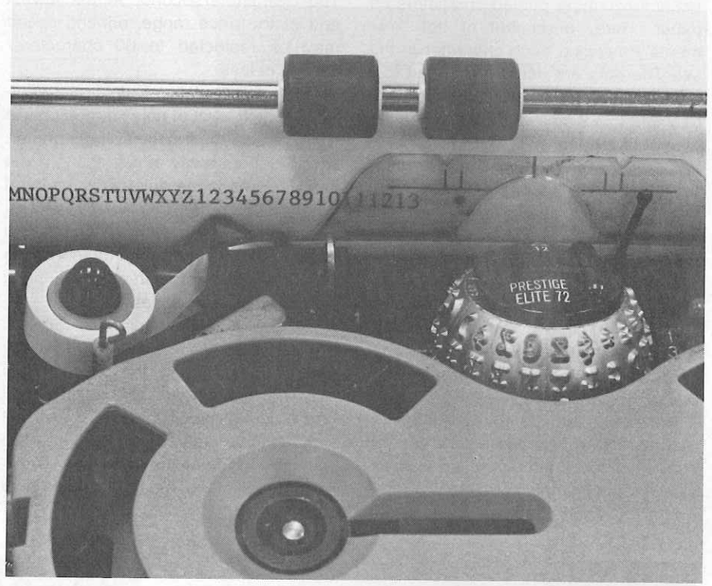
In this article, we will discuss the various types of printers available and explain how each operates. Our objective is to provide guidance on selecting the printer that is just right for the purpose, based on such features, as performance and cost.

Some Generalizations. Hard-copy printers are considered to be one-way machines that provide a permanent copy of whatever appears at the appropriate output port of a computer. This computer peripheral generally has no facility for "talking to" the computer (although there are terminals, such as a teletypewriter, that permit two-way communications, including hard copy).

A number of factors contribute to the price of a printer, the most important being the printing mechanism used, number of characters per line, and printing speed. As a general rule, the greater the number of characters per line and/or the faster the operating speed, the more expensive the printer. For example, a 40-column (40-character/line) thermal printer of the type used with many calculators is much less expensive than a line printer that prints at a rate of 500 lines/minute and has a capacity of 80 characters/line or more.

All computer-controlled hard-copy printers can be classified as either "impact" or "nonimpact" in design. Characters and symbols can be printed either fully formed or in a dot-matrix format. Finally, printers can be classified as either "serial" or "line." Individual printers vary immensely in terms of operating features, capacity, reliability, print quality, cost, etc.

At one time, all hard-copy printers were referred to as "line" printers. Today, a line printer generally means a device that prints an entire line of characters simultaneously. To differentiate between this type of printer and those that print each character individually across the page, the term "serial" has come into common usage. Unfortunately, a few manufacturers continue to refer to their serial printers as "line" printers. In most cases, however, you can determine which is which by referring to manufacturer specification sheets. Serial-printer speeds are generally given in characters/second (cps) with no mention of lines/minute (LPM), while line-printer speeds are almost invariably given in lines/minute and may or may not include characters/second. If in doubt, ask your dealer.



IBM Selectric uses interchangeable "golf ball" printhead for selectable-font, preformed solid characters.

Dot-matrix characters (bottom) may be more difficult to read than solid characters (top).

Character Format. Impact printers with solid, fully formed characters abound for high-quality typefaces used for business letters, business forms, magazine and book printing, etc. These can be found on Teletype® cylinders, IBM Selectric® "golf" balls, "daisy" wheels, drums, chain-print mechanisms, and embossed "bands." In general, fully formed type carriers provide both upper- and lower-case alphabetic characters, numbers, punctuation marks, and special symbols (if any are required). Additionally, many offer a choice of different type fonts, such as Roman, italic, bold, etc. The exception here is the cylinder printhead, which is limited to upper-case alphabetic characters, the numerals 0 through 9, and a few punctuation marks and symbols.

Dot-matrix printing is the other technique for forming printed characters on paper. Here, a number of dot "elements" make up each character in the set. The dots are usually arranged in a matrix consisting of 4 to 7 dots horizontally and 7 to 9 dots vertically. When the elements are limited to 7 or fewer dots vertically, the character set may not contain lower-case letters because of problems with legible descenders.

Dot-matrix-formed characters are not continuous and may, as a result, lead to problems in legibility, especially if the matrix is made up of very few elements. (Some very expensive dot-matrix printers generate so many elements per character that individual characters appear to be continuous.)

Printheads that use the dot-matrix format of generating characters can be used in impact printers and are used exclusively in nonimpact printers.

Impact vs. Nonimpact. Like an ordinary typewriter, all impact printers require force to print a character on paper. In the great majority of impact printers, the printhead is forced with hammer-like action against the paper through an inked ribbon. In rare cases, the selected character in the printhead is held stationary while a hammer drives the paper and inked ribbon against the character slug or matrix from the *rear* to accomplish the printing task.

Almost without exception, impact printers are considerably slower than their nonimpact counterparts, averaging less than 60 characters/second for serial printers. While some serial printers that use the dot-matrix printhead may be capable of operating at speeds of up to 330 characters/second, few in the lower-price ranges can achieve better than 100 characters/second. At the lowest end of the price range, printing speed may be restricted to 60 characters/second or less.

One characteristic of all impact printers is a high level of noise during operation. Noisiest of all is the cylinder printer, which clatters away at distracting noise levels. Perhaps the quietest is the band printer, which is, relatively speaking, unobtrusive. Even with its high noise level, the impact printer is often the one most preferred for high-quality printing and/or multiple-copy capability.

By comparison, nonimpact printers are almost silent in operation, the only sound coming from the mechanisms that move the head across the paper and feed the paper upward for the next line. Unfortunately, two disadvantages are common to all nonimpact printers—inability to make multiple copies and sometimes very low legibility of the dot-matrix-formed characters.

Nonimpact printers form their characters by any of the following techniques: thermally, electrosensitively, electrostatically, Xerographically, and ink jet. For limited budgets, all but the first two can be eliminated from consideration.

Impact Printers. Here is a rundown on moderately priced impact printers:

Cylinder. The printhead used in this type of printer was one of the earliest to gain popularity (the old Teletype used it). The cylinder printhead gets its name from the shape of the character carrier. In operation, the cylinder rotates and moves up and down to carry the appropriate character into striking position. Then a hammer strikes the cylinder, forcing the selected character against the paper through an inked ribbon.

One can buy a used cylinder printer from a surplus dealer at low cost. Its multiple-copy capability, using carbon-paper-interleaved rolls, is a major advantage. Disadvantages include a 10-character/second printing speed, just passable print quality, no lower-case alphabet, limited symbol availability and very noisy operation.

Golf-Ball. The spherical "golf" ball printhead was developed by IBM for its Selectric typewriter. Similar in concept to the cylindrical printhead, the golf ball is a sphere on which the printing character set is embossed. Operation is also basically similar to the cylinder printer, except that the ball itself strikes the paper through an inked ribbon without help from a hammer. Also, it features both upper- and lower-case characters.

(continued on page 66)

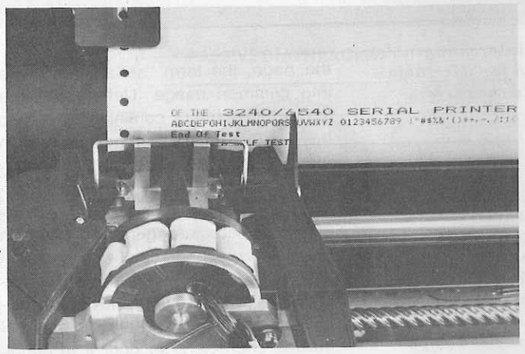
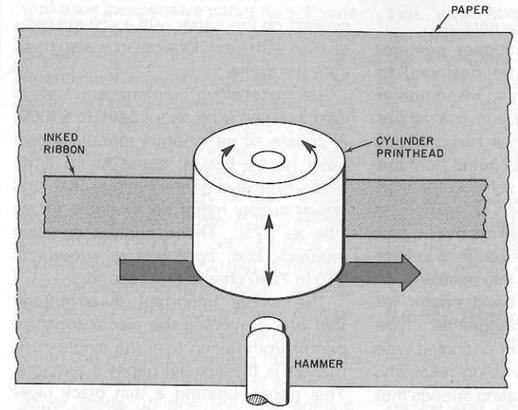
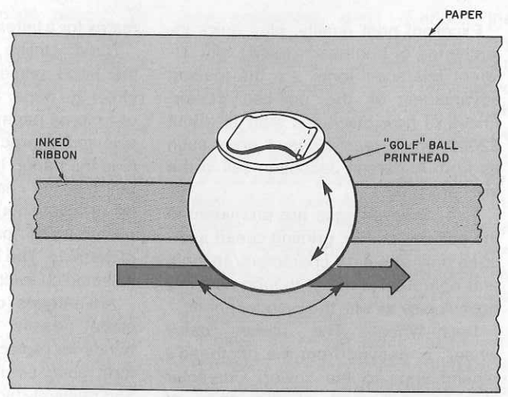


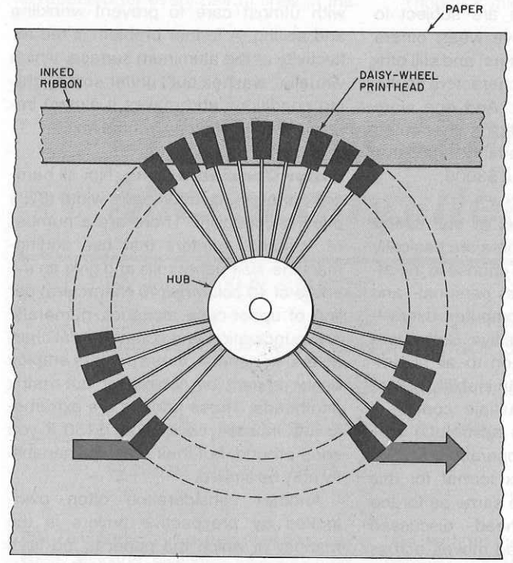
Photo courtesy Precision Data

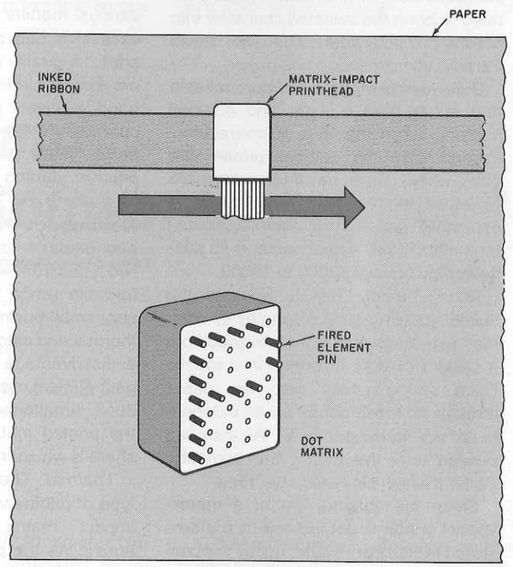
Matrix printhead is used exclusively in nonimpact and in some impact printers.

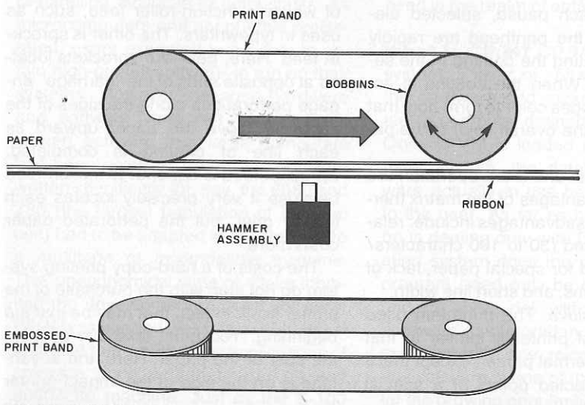
Printing band produces preformed characters but legibility is only fair to poor.











Illustrated (clockwise from upper left) are cylinder, IBM golf ball, dot matrix, impact, band, and daisy wheel printheads.

Excellent print quality, plus quick interchange of printheads (balls) with different character fonts are the leading advantages of the golf-ball printer. Prices of new machines start at about $2000, while reconditioned ones such as from Anderson Jacobson sell in the area of $1200.

Two disadvantages are prominent in the golf-ball printer: printing speed averages only about 15 characters/second, and operation is noisy, though certainly not as noisy as with the cylinder printer.

Daisy-Wheel. The name "daisy wheel" is derived from the printhead's resemblance to the flower. Character slugs are located at the ends of "spokes" that radiate from a hub. Under computer control, the hub is rapidly rotated to bring the selected character into striking position, where a hammer drives the slug against ribbon and paper.

Daisy-wheel printers are more reliable and faster than cylinder and golf-ball printers, averaging 45 to 55 characters/second. Like the golf-ball printer, the daisy-wheel printer has interchangeable type-font printheads. Its print quality is especially good. The major disadvantage of the daisy-wheel printer is its relatively high price of $3000 to $5000.

Matrix-Impact. This is perhaps the fastest growing type of printer in common use. Each character is formed from a pattern of dots arranged in a matrix. Each dot is struck onto the paper through an inked ribbon by an independent "pin" in the printhead. As the head passes over the paper, the computer "tells" it which pins are to be "fired."

Since the chracter set of a matrix-impact printer is determined by patterns stored in ROM or PROM, not by the configuration of the printhead, character fonts can be changed easily, allowing unique symbols to be created almost at will. This matrix approach also makes it possible to have limited graphics mixed with printed characters. Speed is generally higher than with other types of impact printers—up to 330 characters/second in the most expensive serial printers and as low as 30 characters/second at the low-price end. Reliability, relatively quiet operation, and low cost (about $900 to start) round out the advantages of the matrix-impact printer.

The major disadvantage of this type of printer is that legibility may be poor because the characters are not continuous. The problem becomes progressively worse as the number of dots in the matrix for a letter become smaller.

Band. Unlike other impact printers, the band printer can be designed to strike the paper through an inked ribbon or to force paper and ribbon against the selected character with a hammer *behind* the paper. It gets its name from the fact that the character set is embossed on a continuous metal or reinforced polyurethane "band" that fits over a pair of bobbins. The bobbins rotate to set the selected character slug into position.

Advantages of the band printer include: easily interchangeable type bands for replacement or changing type font, good print quality, high reliability, and relatively high operating speeds that range from 30 characters/second on up.

Disadvantages are charactersitic of various models. Some are subject to excessive belt and drive wear, others print low-quality characters, and still others wear out individual characters on the band relatively rapidly. And one worn character means replacing the entire band. Finally, these are fairly expensive printers, starting at about $3000.

Nonimpact Printers. In the nonimpact-printer category, there are basically two types from which to choose in the affordable range of most personal- and very-small-business computer users—thermal and electrosensitive. Both share a disadvantage common to all nonimpact printers, namely, an inability to produce simultaneous multiple copies of the printed matter. An advantage they share is whisper-quiet operation.

Thermal. The matrix format for this type of printhead is the same as for the impact matrix printhead discussed above. As the printhead moves across the specially treated paper, it pauses at each position where a character is to be printed. At each pause, selected elements inside the printhead are rapidly heated, activating the coating in the selected areas. When the coating is activated, it changes color to form dots that contrast with the overall color of the paper itself.

Very low cost and silent operation are the major advantages of the matrix thermal printer. Disadvantages include: relatively low speed (30 to 100 characters/second), need for special paper, lack of preprinted forms, and short line width.

Electrosensitive. The printhead used in this type of printer is similar to that used in the thermal printer, except that it vaporizes selected points of a special coating on the paper with a *voltage* rather than with heat. Operation is also basically the same.

Electrosensitive printers are low in cost, ranging from about $400 to $3000. A couple of peripherals manufacturers have hinted that at some future time, electrosensitive printers minus case and power supply might be available for as little as $250. These printers are also relatively fast, operating at speeds of 160 to 2200 characters/second.

The single important disadvantage that has prevented the electrosensitive printer from taking over the single-copy market is the special paper it requires. This paper, bearing a thin black layer and an even thinner coating of aluminum, is very fragile and must be handled with utmost care to prevent wrinkling and soiling. A further problem is the reflectivity of the aluminum surface, which virtually "washes out" under some lighting conditions and makes it almost impossible to photocopy printed text.

Other Considerations. Not all hard-copy printers have full-page-width (8½") printing capability. There are a number of "column" printers that use adding-machine-size paper rolls and give an average of 40 columns (40 characters) per line of upper-case alphabet, numerals, and punctuation and some special characters. In general, these printers employ either impact or nonimpact dot-matrix printheads. These printers are extremely low in cost, as little as $150 if you shop around, but their graphics capability may be limited.

Another consideration often overlooked by prospective buyers is the manner in which the paper is fed from the supply roll or folded stack. There are two alternatives here, the most common of which is friction-roller feed, such as used in typewriters. The other is sprocket feed. Here, gear-like sprockets located at opposite ends of the "carriage" engage perforations along the sides of the paper to move the paper upward as each line of printing is completed. Sprocket-feed is superior to friction-feed because it very precisely locates each line of print, but the perforated paper costs more.

The costs of a hard-copy printing system do not stop with the purchase of the printer itself; in fact, that may be just the beginning. You must take into account the cost of the paper. Here, the advantage is on the side of the impact printer that uses inexpensive paper rolls. Prices are considerably higher for the special papers required for thermal and electrosensitive papers. And, where available, accordion-folded, sprocket-feed forms can be very expensive. Last but not least, you must allow for maintenance. A formed-character impact printer will generate much steeper maintenance and repair costs than a nonimpact matrix printer, if only because the former has more mechanical elements.

While most machines print in one direction only (left to right), others print bidirectionally. In a bidirectional printer, when the printhead sweeps from left to right and comes to the end of a line, the paper feeds up one line and printing continues from right to left. This process is repeated for every pair of lines in the text, eliminating "carriage return." To accomplish bidirectional operation, these printers have built into them a one-line data-storage buffer.

Finally, not all printers have the same "typing" density. Full-width printers can have as few as 5 and as many as 16.5 characters/inch across the page and as few as 5 and as many as 12 lines/inch down the page. High-density printing can save considerably on the cost of paper but may be difficult to read.

Buying Hints. Most of the prices quoted in this article are manufacturer suggested list. Dealers in the microcomputer marketplace, however, often sell below list and, on occasion, considerably below. So, it pays to shop around.

Though it might be preferable to buy new equipment, don't overlook the used-printer market. Occasionally, very expensive printers that have been taken out of a large system will be refurbished and sold in satisfactory operating order at a fraction of their original price. Be sure you get a warranty, though.

If you own or plan to buy a video terminal—that is, a keyboard-video monitor system—it would be wise to purchase only a one-way printer. Having a two-way one would make the typing facility redundant unless you also wish to own an electric typewriter.

Finally, try to get some "hands-on" experience with the printers you have in mind. Visit your local computer store and, if possible, other computer users who already have hard-copy printers to see which fills your needs. ◇

CP/M: The Standard Microcomputer Software Interface?

BY DOROTHY SIEGEL*

This semi-universal software interface is already providing tremendous advantages for 8080 and Z80-based computer users. Its extension to other systems may not be far off.

IN THE early days of personal computing, toggling switches and watching LEDS constituted the only means of data-handling available to enthusiasts. As microcomputers and peripherals proliferated, users expected to be able to obtain high-quality software to run on their systems. However, because hardware and software were not standardized, proven software that large computers had been using for years and software written specifically for, say, the 8080 and Z80 (the largest population of chips in use) had to be adapted to accommodate a multitude of incompatible systems. This uneconomical state of affairs inhibited the development of good software. What was needed was a quasi-universal interface that would allow applications of software once written to run on any 8080/Z80 machine. Just as the S-100 bus became the 8080/Z80 standard for hardware, CP/M (a registered trademark of Digital Research) is filling this need in the realm of software.

What Is CP/M? CP/M is an operating system, a layer of software that masks the hardware and makes it "impersonate" a computer defined by CP/M itself. Once CP/M is loaded on a microcomputer system, the details of the hardware actually in use become irrelevant to the user. As far as he is concerned, he is dealing only with CP/M; the operating system does the rest. Similarly, a program need only be designed to run under CP/M, not with any particular hardware configuration. This ability to mate virtually any microcomputer and any software is one of the main reasons for the growing popularity of CP/M.

CP/M consists of a monitor control program plus some utility programs, principally a text editor, an assembler and a debugger. Together, these programs comprise a complete and independent software-development package that enables the user to create, edit, debug, assemble and run programs using one, two, three, or four floppy or mini-floppy disk drives. It can be used with any of the family of 8080- or Z80-based micro-processor that have at least 16K of memory.

The heart of the CP/M is the disk operating system (FDOS). It relieves the user of all housekeeping tasks, creating and manipulating files, and coordinating communication between peripherals. The FDOS acts as a supervisor for other programs, whether they are utilities like CP/M's own editor, application pro-

*Lifeboat Associates, New York, NY.

grams like inventory control, or translators for high-level programming languages like BASIC, COBOL, FORTRAN, and PL-1.

The FDOS can be further subdivided into the BIOS or Basic Input/Output System, which provides machine language interfacing to the I/O devices, and the BDOS, or Basic Disk Operating System, which provides disk and file management. Together, the BIOS and BDOS supervise the I/O hardware. BDOS allocates disk space for new files and maintains a record of disk storage in use and available. When a program demands storage, BDOS determines the disk addresses to be employed, and performs disk I/O through the BIOS drivers. For example, when an application program such as an editor or an assembler needs to write data to a file, it calls BDOS function #21 to write a record. BDOS does the necessary calculations and calls the BIOS with four different operations: select disk, set track, set sector, and perform data write.

The Console Command Processor (CCP) is the user interface to the rest of CP/M. It executes its own set of commands, such as DIR to list the file names on a diskette or ERA to erase a file. There are five such built-in commands that the CCP can perform. When the hardware is first activated, or a program run has ended, CCP is loaded "by default." But when a program such as a BASIC interpreter is executed, CCP's 2K of memory is released for use by the program and becomes part of the TPA or transient program area as shown in Fig. 1.

The TPA is the section of memory where a program is loaded for execution. For example, when "BASIC" is typed to the CCP, the FDOS loads the binary command file BASIC.COM at 100H (the H denotes hexadecimal or base-16 notation) and transfers execution to the start of the BASIC program.

CP/M's transient commands (see Table) reside not in memory, but on the CP/M disk, ready to be loaded by the CCP. The user can load one of the transient commands supplied with CP/M, such as the CP/M editor (ED). Or, as in the example with BASIC above, he can create his own transient commands, even using an editor, assembler or debugger obtained from another source. When the user wishes to edit a file, he types "ED." When he wishes to run BASIC, he types "BASIC." And when he wishes to list the files on the disk, he types "DIR." The manner in which the system copes with these different tasks is unimportant to the user seated at the console.

The "standard" CP/M for most machines with an S-100 bus (such as the Altair, IMSAI, North Star, Cromemco, etc.) has programs loading at address 100H (Fig. 1). A second "standard" CP/M, for computers with firmware at low memory addresses (such as the TRS-80, Heath H-8, and Poly 8813), has programs running at 4300H. Major software houses such as Digital Research and Microsoft have produced versions of their products for both standards.

Why CP/M? The decision to make CP/M easily transportable between different computer systems was a recent one. In 1973, when Intel introduced its 8080 microprocessor, Gary Kildall of Digital Research designed a PL/M cross-compiler to generate code for the new device. He separately designed an 8080 operating system, CP/M (for "Control Program for Microprocessors") ver.1.0, that he later configured for the 8080-based systems built by Omron and Digital Microsystems. In 1976, when IMSAI asked him to implement CP/M on their 8080-based computer, Digital Research redesigned CP/M (ver.1.3) to be transportable between different machines with standard 8" IBM diskettes. CP/M started becoming a popular system for microcomputer users who owned 8" disk drives, and it was possible for users with dissimilar hardware to start swapping disks and programs.

In 1977, Larry Alkoff of Lifeboat Associates configured CP/M to work on the North Star minifloppy disk system. Enthusiastic response to word of its existence led Lifeboat to offer CP/M configurations for almost every other minifloppy and floppy disk system—single and double density, single and double sided, hard and soft sectored, 5¼" and 8", and with any disk controller. Today, CP/M is available from Digital Research, from disk system manufacturers, and from distributors like Lifeboat for virtually all 8080/Z80-based computer disk systems sold.

The popularity of CP/M mushroomed. It was inexpensive compared to systems software for large computers, and it provided a machine-independent environment for the wider world of software. For

(Continued on page 73)

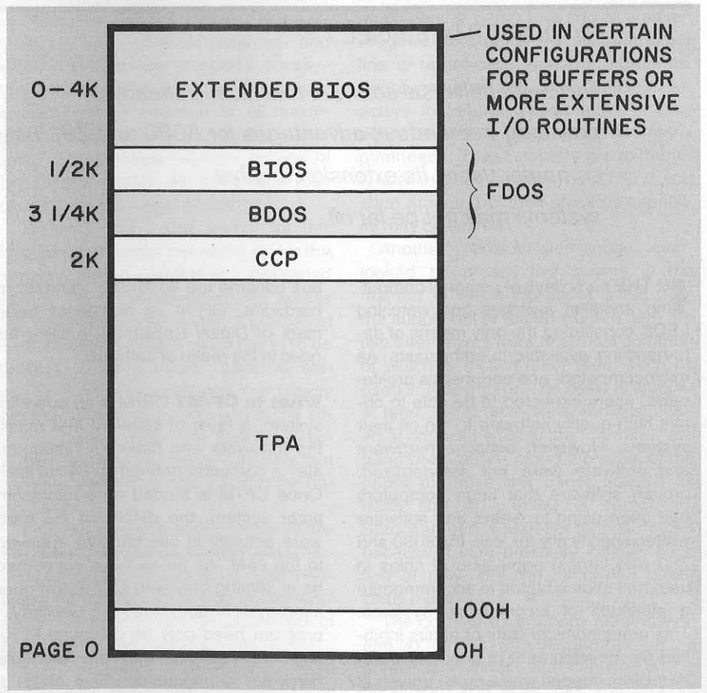


Fig. 1. System memory map for the CP/M microcomputer software interface.

(Continued from page 68)

example, when CP/M is used, the same version of Microsoft Disk Extended BASIC will execute identical BASIC programs on a North Star Horizon, an Ohio Scientific Challenger, or a Cromemco System 3 Computer. This standardization and broadening of the market has helped to promote the writing of high-quality software.

A spartan operating system, CP/M is designed for the most efficient use of the limited memory most users had back in 1976. It is also economical with disk space, not requiring contiguous blocks of space on the disk in order to create continuous files. The system is forgiving, which makes it difficult for a user to inadvertently destroy his program. Furthermore, CP/M is well-conceived, reliable, and thoroughly debugged.

A wide variety of CP/M software is available from dozens of sources. There are application packages such as word-processing and mail-list programs, payroll, and general ledger; utility packages such as TEX (a text formatter for Digital Research) and Macro-80 (a relocating Macro Assembler from Microsoft); and language programs in which to develop or run application programs. Two recent releases are a BASIC Compiler and two Compilers for the language "C". CP/M offers the luxury of a selection among more than a dozen BASIC's, three FORTRAN's, three COBOL's, an APL, a PL-1 and innumerable assemblers, editors, and business packages.

Computer users who are still dependent on the equipment manufacturers can benefit from CP/M. With a nonstandard DOS supplied by the manufacturer, their machines constitute a captive software market. If the manufacturer, either because of bankruptcy or a change in plans, fails to supply that market, the users are in trouble. For instance, the availability of CP/M software for the Processor Technology Helios disk system should offer more than a little comfort to the recently orphaned owners of these systems.

Communication Using CP/M. Users of CP/M having similar disk systems can exchange disks. Users with dissimilar disk systems can communicate programs and data via telephone lines or they can exchange listings. They have the further alternative of using Lifeboat Associates' media conversion facilities to convert a CP/M disk from one system's format to a CP/M disk in another.

Other communication possibilities have been fostered by CP/M. Ward Christensen and Randy Suess of the Chicago Area Computer Hobbyist Exchange (CACHE) devised a computerized dial-in "corkboard and pushpin" community bulletin board—a modern-day version of a wall full of index cards.

CP/M TRANSIENT COMMANDS

STAT—List the number of bytes of storage remaining on the currently logged disk, provide statistical information about particular files; and display or alter device assignment.
ASM—Load the CP/M Assembler and assemble the specified program from disk.
LOAD—Load the file in Intel "hex" machine code format and produce a file in machine executable form which can be loaded into the TPA. (This loaded program becomes a new command under the CCP.)
DDT—Load the CP/M debugger into TPA and start execution.
PIP—Load the Peripheral Interchange Program for subsequent disk file and peripheral transfer operations.
ED—Load and execute the CP/M text editor program.
SYSGEN—Create a new CP/M system diskette.
SUBMIT—Submit a file of commands for batch processing.
DUMP—Dump the contents of a file in hex.
MOVCPM—Regenerate the CP/M system for a particular memory size.

Note: These are commands supplied with CP/M. Any programs acquired by the user are added to his repertoire of Transient Commands.

In its first 16 months of operation, CBBS (Computerized Bulletin Board System) handled 16,000 calls. Ward reports that often the entire operation is automated, with a user's computer calling the CBBS computer. CBBS's have reportedly cropped up in Pasadena, Boston, Maynard (Mass.), Atlanta, Dallas, and Beaverton (Oregon), all employing the CACHE supervisory software and CP/M. Ward feels that CP/M made implementation of CBBS much easier, and he uses standard CP/M utility programs to maintain it. Eventually, CP/M Users Groups may use on-line computers with modems to transfer files.

For the Future. Feedback from CP/M users has led Digital Research to plan for the introduction of a more expensive, more sophisticated, upwardly compatible operating system, MP/M. This Multi-Programming Monitor supports processes arranged by priority for handling events in real time, yet it is designed so that CP/M programs can run with it. The MP/M is about four times the size of CP/M and costs about twice as much.

If the advent of microcomputers is seen as a revolution, surely the development of advanced, universal operating systems must be too. By unifying the software market and making it worthwhile to design sophisticated programs for the micros, CP/M (and MP/M to come) has unleashed these machines and put them to work. ◇