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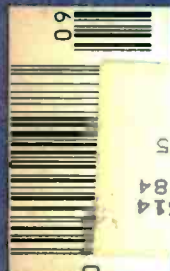
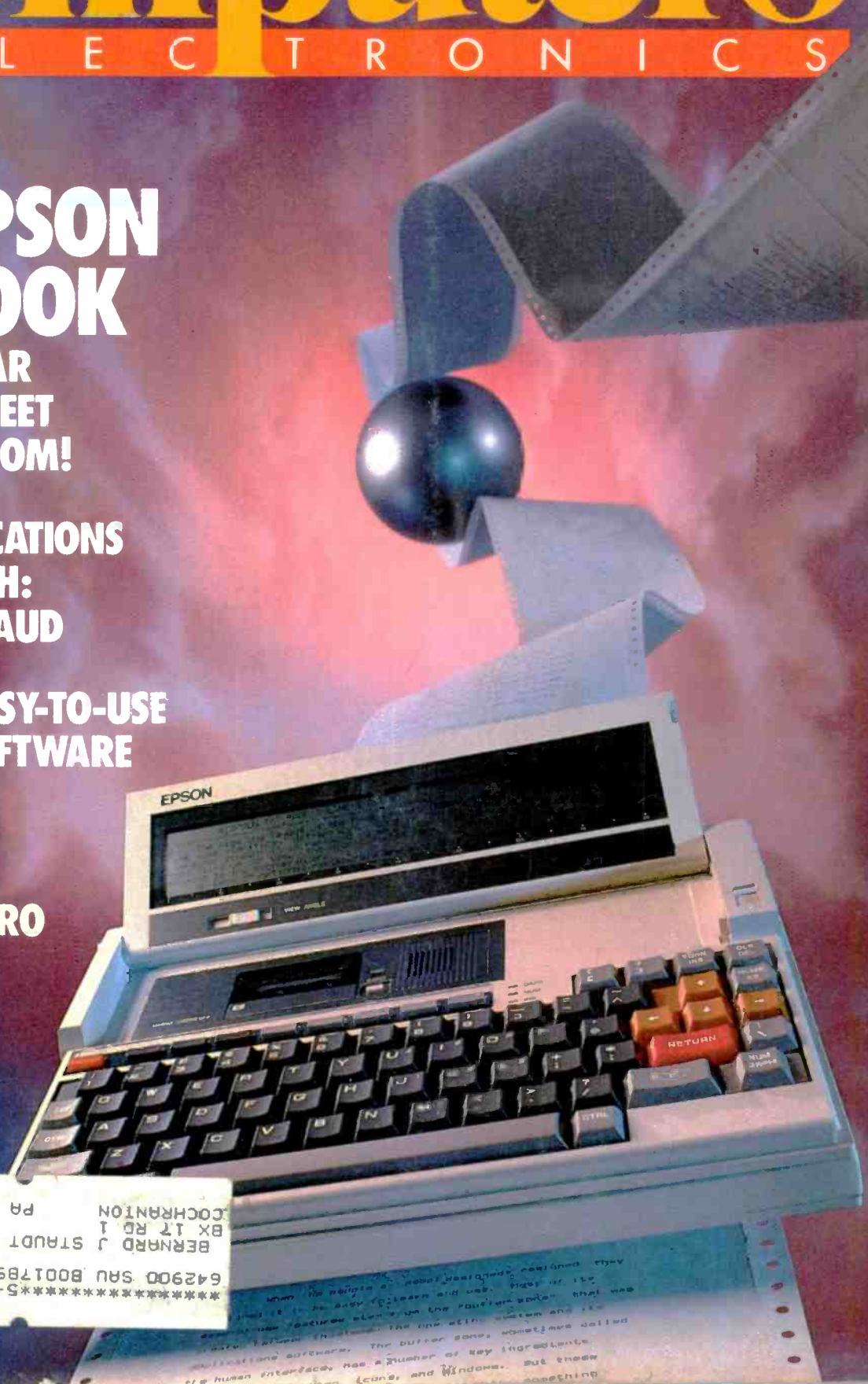
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Computers & ELECTRONICS

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SETH R. ALPERT

EDITORIAL



SELECTING hardware is no easy matter. You have to consider so many things—operating system, compatibility, availability of peripherals, amount of memory, and price and performance, to name a few. As hardware items continue to get more similar, however, it becomes considerably less likely that you will make a serious blunder, whatever you choose.

Choosing software can be that much harder because even *de facto* standards are absent. Typically, as you begin, you will not even know all the selection criteria. Finding the right software is of major importance for computer owners wishing to enhance their systems. For first-time buyers it is vital, because one really should let the software choice drive the hardware choice. But for all potential buyers, a major software purchase can mean an agonizing decision with few reliable sources of information. Knowing that a bad decision can waste not only hundreds of dollars but countless hours doesn't make it any easier. Here are some guidelines that might help.

How to Choose Software

To begin with, you should think carefully about what you want the software to help you accomplish and select a product category that seems to be aimed at your type of problem. Then decide on the features you need for the applications at hand and for conceivable future applications. Of course, there are all the more or less obvious things, such as ease of use, power and efficiency. In addition, there will be other features that are relevant only to the particular type of product that you are considering. You might not even know what they are, or, if you know the buzz words, you might not understand what they mean and whether

they are important. For example, does it really matter whether your database management system is relational, whatever that means?

The next thing to do is to acquire better information. Look at books and at magazines (both for their articles and their advertisements). Asking salespeople at computer stores is worth a try, but watch out, because many of them may know even less than you do. Sometimes reading and talking to people helps, sometimes it simply makes things more confusing. If you are among the lucky few, you have an opinionated and trusted friend who has the nerve to identify the best product for your purpose. Someone who has had hands-on experience with software you are considering is ideal for this consulting.

The point is to do some research and narrow your choice down to a handful of products. Now you've got to make the final decision. Question: is it any help at all to know how well a given product is selling or how good a track record its developer has? This is an interesting question, which occurred to me when I recently heard one of our free-lance authors ardently expound seemingly contradictory positions on the subject in the course of a single two-hour meeting.

One view is that if a product has sold in large volume—Wordstar, for example—then it has to be good, because all of those people couldn't be wrong. I am sure that there is a grain of truth in this, but of course you can fool all of the people some of the time. Thus, while volume offers some assurance of quality, either in performance or ease of use or both, it is no guarantee.

Another position is that if you know where to look, you can find really great software that works and does not cost an

arm and a leg (or at least is cheaper than competing products). Boiled down, the theory here is that there are developers who have created great products but who don't have the funding or inclination to mount an advertising and marketing campaign and get their products on the best-seller charts. Perhaps the product isn't selling in volume yet because the marketing blitz is yet to begin. After all, the VisiCalcs, 1-2-3s, dBase IIs, and Wordstars of the world had to start somewhere, didn't they?

I'm sure that you can see the contradictions inherent in these two positions. They can't both be correct, can they? Of course they can!

To see how, think about the analogy of choosing a book. After you select the broad subject matter—perhaps it is murder mysteries—how do you choose a single title? One approach is to check the best-seller charts. Sometimes you end up with real quality, but you can just as easily end up with mass-market fluff. Another approach is to go to the classics, straight to the Agatha Christies and Dashiell Hammetts of the field. Often you will get a good read that way. But generally, you will be missing out on all the sex and violence found in the newer releases. Both approaches have their risks. Unfortunately, you won't know whether you've made a good choice until after you have read the book.

Road Test Software

To a large degree, I am afraid that the same is true of choosing software. Your best hope of avoiding disappointment is to follow the general guidelines here and to do one more thing: kick the tires and take the product for a test drive. You know what you want to accomplish, so get your retailer to let you sit at a machine with a demo copy of the software he wants to sell you and its manual and see if you can get it to do some of what you want it to do. It will take some time, but it is worth it, and besides you will have already limited the number of packages under consideration. Of course, a hands-on session is not the same as living with a product through your first major application. Still it is the best way of determining, before you lay out any cash, whether it suits your unique personality and needs. ♦

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LETTERS

"Documentation Is a Pain!"

As a technical writer for more than 10 years, I have heard the words above from engineers and managers more times than I care to remember. So I think Les Solomon was right on target in his "Computer Hardware" column for May, "Logic is Our Business and Business Could Be Better," when he identified the need for better manuals.

Before we line up our sights on the publications department, however, let's identify the causes of poor technical manuals.

First is upper-management perception. Too often the manuals are treated as afterthoughts or "necessary evils." The successful company identifies documentation as an integral part of the overall product.

Second is poor product development scheduling. Even if documentation is considered in the schedule, last-minute changes in software and other aspects of the equipment are often made just as the equipment is being crated for shipment. Adequate lead time is needed to create good manuals.

Finally, there is lack of engineering input. Most engineers have an aversion to writing. Yet, even the crudest engineering log is an invaluable source of information to a technical writer.

Good documentation is possible, and the customer should settle for nothing less.

—DAVID NOTTKE
 Oak Park, IL

No Y for Cipher

I have some corrections to your article in the June 1984 issue concerning cryptographic security.

The glossary on page 93 is incorrect in a couple of definitions. Cryptology is the main subject, which is divided into cryptography and cryptanalysis. Cryptography is the science of producing ciphers for one's own use. Cryptanalysis is the science of breaking other's ciphers.

The greatest error is the spelling of "cipher." Where that "y" came from is a mystery to me. It makes one wonder if the authors are really educated in cryptography if they don't know how to spell "cipher."

When I was in the Navy and State Department engaged in cryptography we often got ciphers (for sale) from "inventors." Almost invariably the letter

would close with a statement somewhat as follows: "Even I, the inventor, cannot break it."

—RALPH V. ANDERSON
 Holton, KS

Cypher is a British variant on cipher. Sorry for the inadvertent encryption.

—Ed.

Adam Enthusiast

When reading Forrest Mims's column "Experimenting with Coleco's Adam" in your April issue, I was glad to see that someone felt the same way about the Adam that I do. My family has owned one for approximately four months, and I am constantly discovering new capabilities that Adam has.

Although I am only 13, I have been around computers for many years and really enjoy programming. I am very knowledgeable of the many commands and control keys used in programming the Adam. I also find the built-in word processor to be of good quality and easy to use. I have used it for everything from typing letters to writing reports.

—DOUG DUSSAULT
 Burlington, WI

Kaypro 4 Plus 88

In his article "Kaypro 4 Plus 88" (March, p 79), Charles Rubenstein clearly outlined the capabilities of the Kaypro 4 with the additional 8088 coprocessor. However, I would like to point out a mistake in the article regarding the use of the RAM disk. He says that the RAM disk feature allows programs to have rapid I/O without the expense of a hard disk. "It is only implemented when requested; and, since it is dynamic RAM, it is reset when warm/cold booted."

My experience is that the RAM disk is not reset when it is warm booted—only when it is cold booted. This is an important point because it allows the user to change disks in the two disk drives and warm boot the computer without having to reload the RAM disk.

—ED O'CONNELL
 Elmira, NY

Disk Correction

In the July issue, the disks shown in the article "Store It with Light" on page 63 should have been identified as being from Storage Technology Corp. and Optical Storage, Inc.

—Ed.

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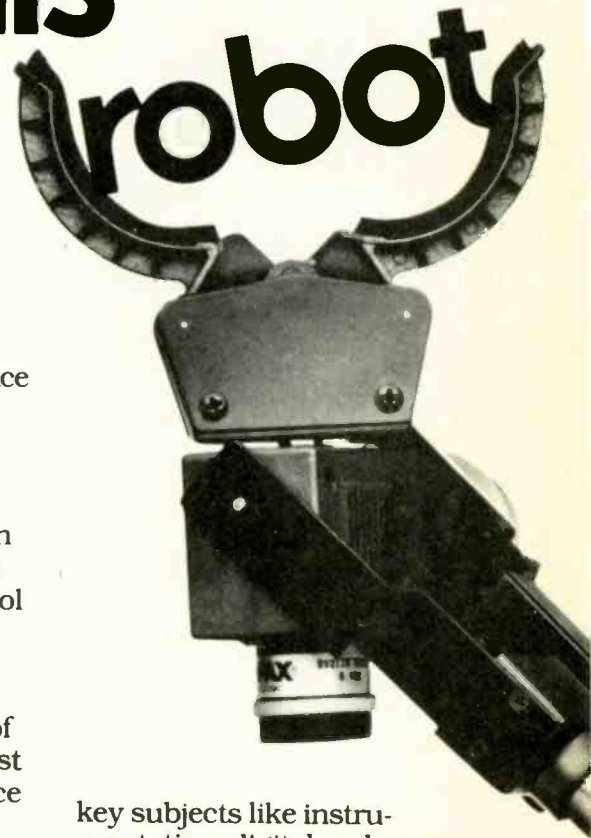
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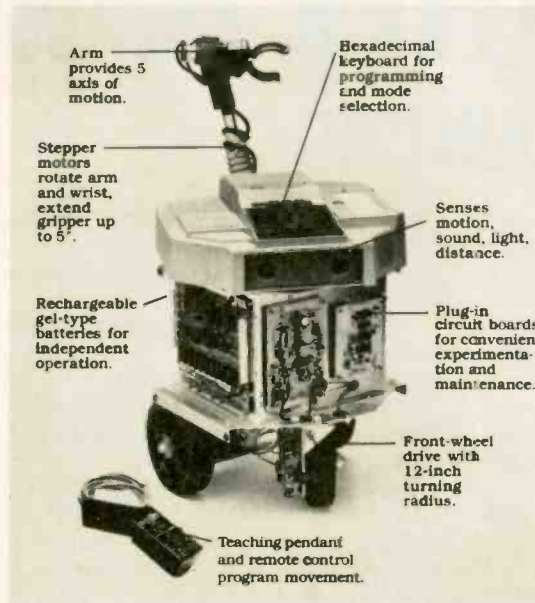
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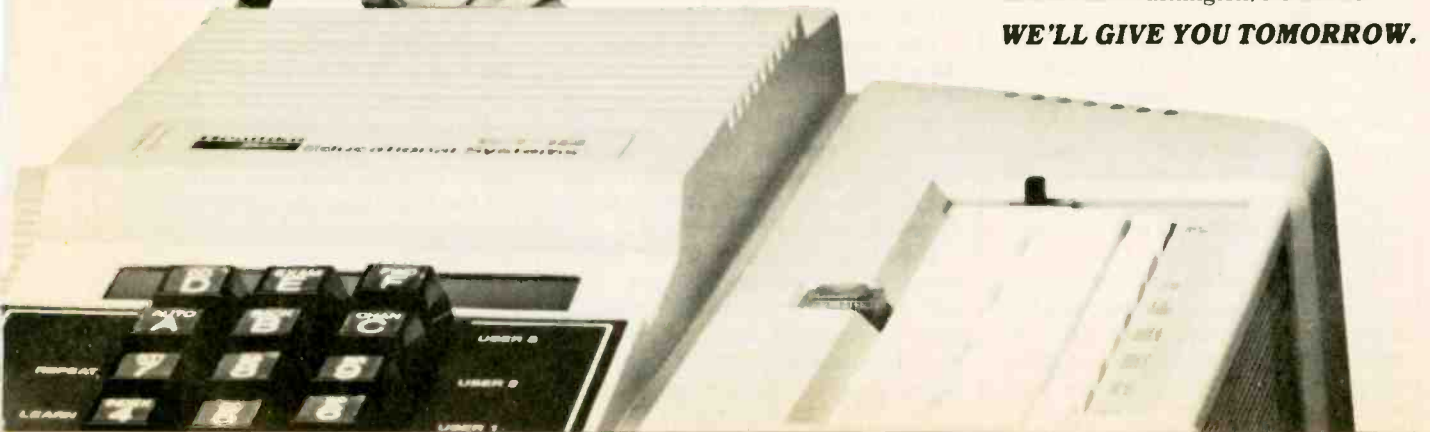
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LES SOLOMON ON

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SURFACE MOUNTING

POINT-TO-POINT wiring, the component interconnection technique used in the very early days of the electronics industry, was superseded by a vastly improved approach called the "printed circuit," or "pc," board.

The "wiring on a board" technique eliminated intercomponent cabling and allowed more components to be mounted and interconnected in a relatively small space. Since each pc board is theoretically identical to the original engineering model, another benefit was a reduction in wiring errors.

Printed circuit construction became the backbone of the electronics industry because it not only allowed for machine

nique, called "surface mounting," will also generate great changes in the electronics industry, particularly with microcomputers.

Although "surface mounting" may not be a familiar expression, it has been hiding among us for quite a while.

Where has it been? On your wrist, inside your digital wristwatch, and in your pocket, in a low-cost calculator.

Take a look at a typical low-cost digital watch or calculator and try to visualize the complex electronics that must be in it to accomplish the broad range of functions that come in the slim little package. Then consider the price, the reliability, and the power supply!

ers. In fact, you may not recognize any components on the board.

The surface-mounting technique allows all the components to be machine mounted (actually soldered) on one side of a support substrate and accounts for the low cost of the item.

The ICs may be difficult to recognize since they do not come in the familiar multi-pin DIP packages, but appear as flat pellet-like "chips" whose metal "lands" (the inputs and outputs of the IC) are directly soldered to the conducting pattern of lines deposited on the surface of the support (usually ceramic) substrate and protected by a thin layer of plastic.

All the other surface-mounted components also appear in pellet form, with each component lead directly soldered to the substrate pattern. Because of this new fabrication technique, you will find it difficult to identify a resistor, capacitor, or transistor. Even the LCD display is of "minimal" manufacture.

But, no matter how it looks, the system works as advertised and is extremely safe from damage due to shock, vibration, and moisture. Since very low-power CMOS (and its derivatives) are used to create the semiconductors, and the device uses a very low-power LCD readout, the power source can be one or two physically small, low-cost cells.

Let us look at another area.

Many new multi-function ICs now starting to appear are actually formed from several "chips" of tried-and-tested conventional ICs, all mounted and interconnected on the same substrate to produce a single, complex IC. This approach could be called the semiconductor version of surface mounting.

In the area of small size, keep in mind that when you look at most discrete electronic components, you are actually looking at a package that is much larger than the component it protects. You may be surprised how small an IC really is if you break away the plastic case and look at the actual chip (try it using a defunct IC).

The same size reduction can also occur in many other components associated with ICs. For example, when operating voltages and powers are very low (as they would be in a CMOS circuit), ca-

creation of the pc board itself, it also permitted machine installation of the various discrete components that made up the circuit. Manufacturers were therefore able to mass produce their products and greatly reduce manufacturing and selling costs.

The pc approach reached its peak with the mounting of the integrated circuit within the familiar multi-pin dual-in line package (DIP). This combination appears in all types of electronic systems ranging from test instruments to such consumer items as radio, TV, and audio equipment to computers and their associated plug-in devices.

We are now on the verge of the next evolutionary step in electronic product construction, one that may force the ubiquitous pc board to join point-to-point wiring in history. This new tech-

Today, you can buy, for a few dollars, a battery-powered pocket calculator having functions that exceed many of the million-dollar computers used in WWII. In fact, imagine what a comparable watch or calculator would have cost only a few years back?

One usually unconsidered fact about these low-cost digital devices is that in most cases it is cheaper to buy a new watch or calculator than it is to get one repaired (sometimes to even buy new batteries). At least as far as watches and calculators are concerned, we live in the age of "throwaway" electronics.

If you have a defunct digital watch, open it and observe the "pc board." You will note that it looks quite different from the multi-IC, dense, conventional pc boards used in physically larger electronic systems such as personal comput-



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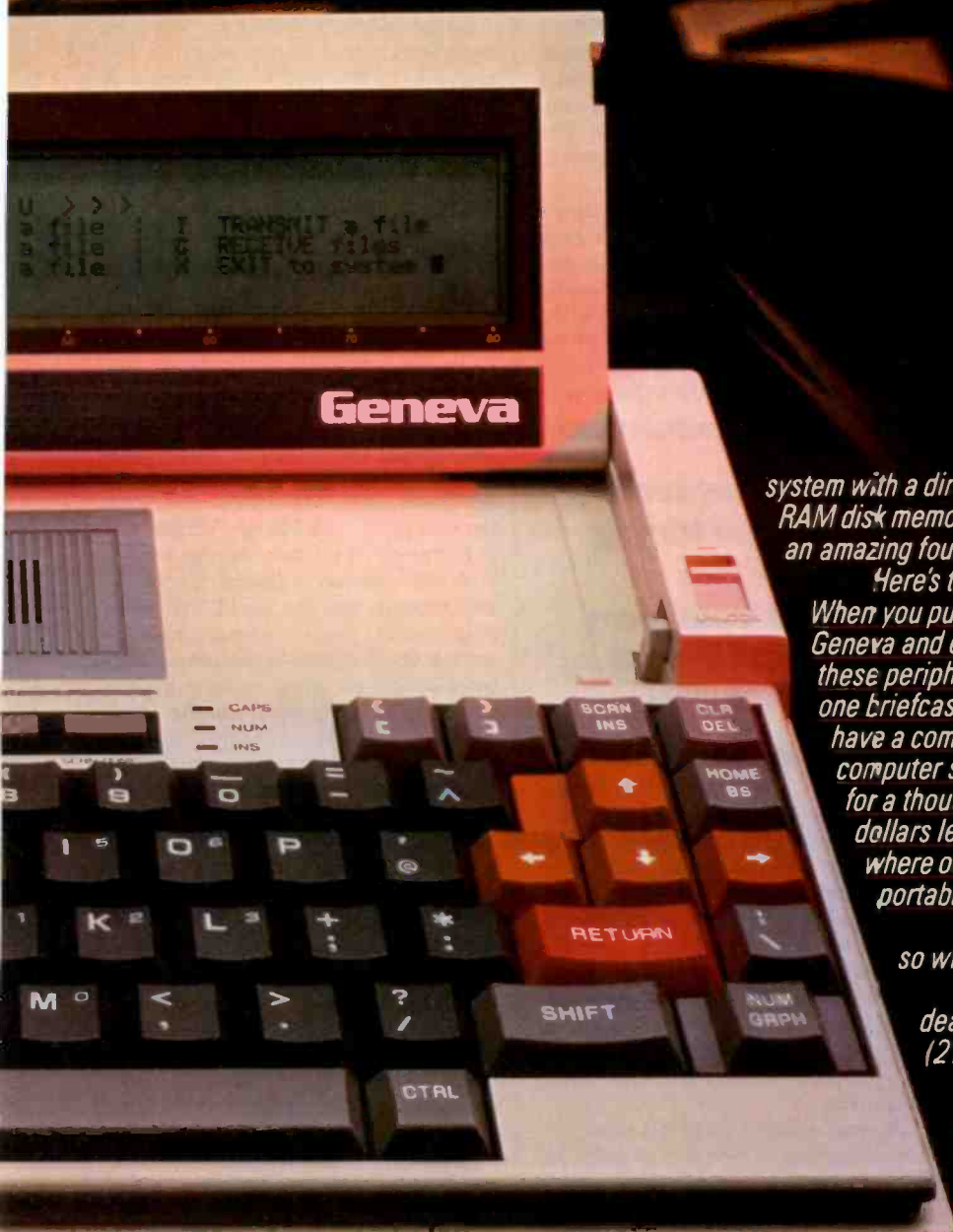
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G E N E V A

capacitors and resistors can exist in very small semiconductor chip form, ready to be surface mounted (soldered) along with the IC chips.

Thus, a number of chips and other electronics components can be interconnected to form a "surface mounted" system. The reliability of this technique is so high that many manufacturers combine and interconnect a number of chips on one substrate, and the assembly does not have to be electrically tested.

Because of the low manufacturing costs, if a board using surface mounting fails during its checkout, it is cheaper to throw it away and replace it with another, similar, board rather than go through the expense of troubleshooting, removing, and replacing one chip. This is similar to what is done today with a low-cost digital watch or calculator.

We have come to the point in our current technology where the semiconductors are more reliable than the sockets that some computer manufacturers still use. That is why, in present-day systems using conventional DIP semiconductors, you see more soldered-in semiconductors and fewer and fewer sockets.

On the other hand, passive components, such as resistors, capacitors, and inductors, which are more tolerant of high temperatures than semiconductors, have always been directly soldered to the pc board.

There is one potentially dangerous hitch to the solder-in technique. The act of high-temperature soldering an IC to a board (as used at present) has damaged more ICs than almost anything else. Solder can crack due to the difference in thermal expansion between the component and the board pads. Also, the combination of solder and the metal used for the traces can leach, which may be a potential source of short-circuits.

This is one of the reasons manufacturers are looking for other soldering and bonding techniques, particularly for surface mounting.

One manufacturer is experimenting with a surface-mounting technique that uses conductive epoxy to form the "foil pattern" which is screen printed on the substrate (similar to the copper traces on a conventional pc board). Then, small "dots" of non-conductive epoxy are placed on the substrate where the various pellets will be placed. When the substrate, with components, is subjected to a temperature of 150 to 200 C, both epoxies cure, and the surface mounting is complete. This technique eliminates the relatively expensive pretinning, prebaking, and flux-removal steps conventional copper-trace/solder pc boards need.

Although at present more expensive than soldering, the use of epoxies requires less expensive mounting equipment. As an added benefit, since electrically conductive epoxy is not rigid, the finished surface-mounted boards can tolerate a higher thermal cycle during long periods of operation in a small enclosure having a minimum of heat exchange.

Another company is testing a technique called "vapor-phase" to be used in a reflow solder mode. In the reflow approach, the pellet lands and their associated contacts on the substrate are coated with solder. The hot vapor penetrates between the densely packed board components causing the solder to melt. The resulting solder reflow makes the electrical and mechanical connections.

Surface mounting also allows the use of double-sided substrates, with each side having a completely different and independent function, since there are no (unwanted) interconnects between the two sides of the thin substrate. For example, one side may carry the CPU, I/O ports, and various control chips, with

Surface mounting has been hiding at the end of your arm in your digital wristwatch

RAM and ROM chips on the other side. When required, interconnections between the two sides would be via minute electrically conductive plated holes in the substrate.

Now consider a portable computer using surface-mounting techniques. The smallest useful physical size of such a system is determined by the display, keyboard, and mass storage system. Of course, this is true today with the current crop of battery-powered "lap" computers.

The major difference is that using surface mounting, it becomes possible to create a battery-powered lap portable having all the attributes of present-day lap and conventional line-powered "desk mounted" microcomputers, including many megabytes (yes, megabytes) of internal RAM.

Such large mounts of memory for a lap computer can come via two routes.

The first is when a semiconductor

manufacturer mounts and interconnects a number of "chips" of a known good memory device on the same substrate to produce a single physically small device having a considerable number of bytes.

As 256K-bit RAM devices become more available, you will not need too many of these small substrates to create quite a large memory. Due to the small physical size of such a composite "super chip," the lap computer can use many of these devices, thus allowing many megabytes of memory.

Large memory capacities will also come from semiconductor research. For example, IBM recently fabricated a 1-megabit DRAM (dynamic RAM). All it takes is eight of these to form a 1-megabyte memory for a personal computer. Don't look for this RAM to come on the market for a while as it is still in the development stage (also, the "chip" is somewhat unwieldy). Similar high-density semiconductor research is being performed in Japan.

Besides allowing maximum memory for the computer, these massive amounts of storage in a small space will also allow the use of "semiconductor disks," thus eliminating the attendant noise, size, weight, and power requirements of conventional mechanical disk drives, even the upcoming "third-height" drives.

If transportable data storage and/or "canned" software is desired, the removable storage medium could well be in microcassette form, a magnetic tape approach that holds several hundred kilobytes on a very small cassette using a very small low-power cassette drive system.

Besides small size and very low power requirements, another major benefit that comes with surface mounting is that when tried and tested "chips" are combined with the surface-mount approach, the result will be much better electronic system reliability.

Since all components on the surface-mounted boards will be operated well within their voltage and signal specifications (they will be battery powered) and hopefully within their specified environmental conditions, the mean time before failure will be very long—possibly longer than the lifetime of the user. If this sounds far fetched, consider the punishment that a digital watch takes during its lifetime, yet "it keeps on ticking." Compare this with the treatment that a more expensive portable computer will get.

In the rare event that a system does go down, it will simply be a case of replacing the faulty board and throwing the old one away. That will be the legacy of surface mounting. ♦

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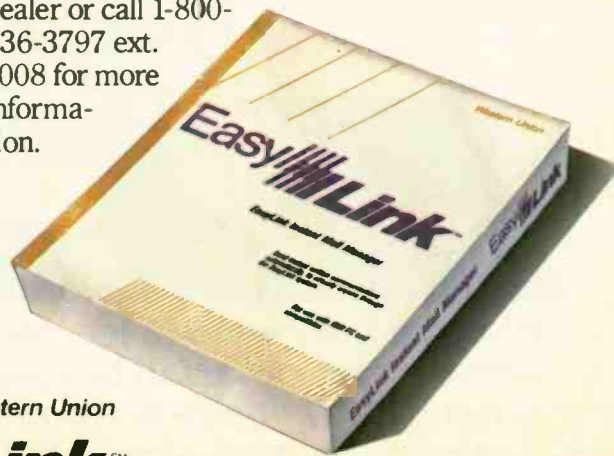
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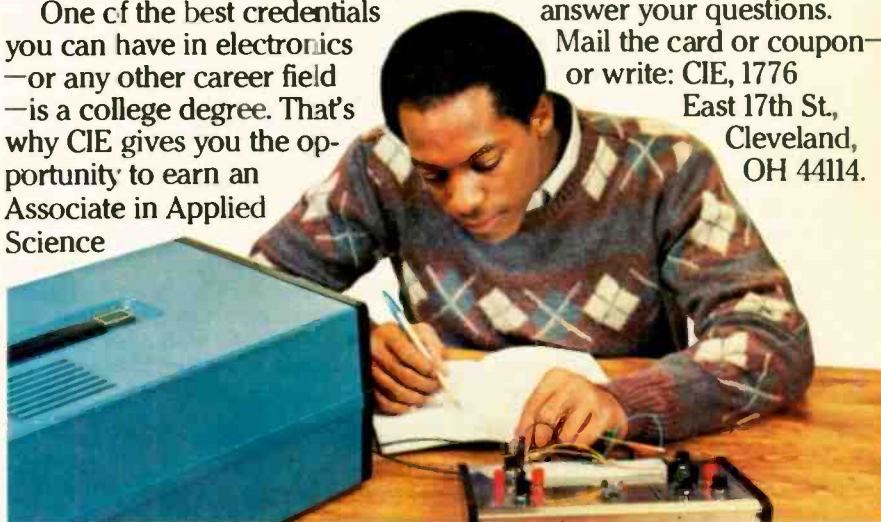
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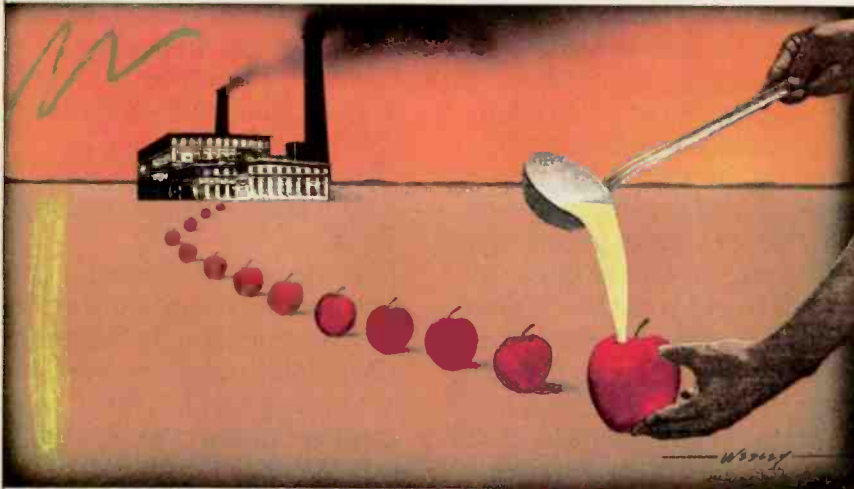
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Apple Juice

► Apple reports that the Macintosh is so successful that the company has begun plans for a second highly automated factory to make the system. When this plant comes on line in 1985 Apple expects to be making 4000 Macs a day. Apple claims Mac production is so highly automated that labor costs only 1 to 2 percent of the total. We were told Apple has set a goal of shipping 400,000 Macs by year-end; if the goal is met, the 350 employees in the Mac group will get an extra month's salary.

Apple also disclosed that it is planning to release a Mac version with a hard disk and 512K of memory (the current unit

has 128K). The larger memory size would permit Apple to release a concurrent DOS for the unit. The unit, currently called "the Fat Mac," would include higher-speed serial ports (the current unit has two ports) running at up to 5 MHz (current maximum is 1 MHz) that can better support an external hard disk. When Fat Mac is released (for around \$3000) the price of the standard Mac is expected to drop under \$2000.

It looks like Apple is working toward making the Lisa and Mac brands into "full product lines." Apple also appears to be working on versions of Lisa and Mac based on the Motorola 68020 microprocessor. The 68020 is a true 32-bit

Rumors & Gossip

► Chuck Peddle, developer of the 6502 microprocessor and early Commodore computers and until recently president of Victor Technologies, is back in business. He has formed an R&D company in Scotts Valley, CA. . . . Atari, we hear, is ready to introduce the 7800, a new, improved, video game compatible with the popular 2600. (Atari is estimated to have sold more than 15 million 2600 models.) . . . Sharp is reported to be showing samples of a new electroluminescent display panel to several computer manufacturers. It is 80 characters × 25 lines, 1.5" thick. Hewlett-Packard is rumored negotiating with Sharp to use the display in its kneetop computer, which currently has an 80 × 16 display. HP expects to be the first to use the device; introduction may come before

year-end. The unit HP will use is believed to be the one that Apple and Gavilan Computer will be using in their systems. . . . A daisywheel printer interface for the Macintosh is supposed to be in development by Apple. . . . Rumors have it that IBM is developing a new home computer system using the Microsoft MSX operating system. . . . Recently, Bill Gates, Microsoft president, said that the IBM has "a year or two to go" before 80286 technology takes over as the prevailing microcomputer standard. . . . It's in the air that IBM is working on a notebook-sized portable computer using the 8088 with bubble memory and a single disk drive. . . . IBM is said to be also developing a 3½" hard disk drive storing 20M bytes. They are expected to use these new "micro-Winchesters" in systems they intro-

CPU with memory management and other features that can better support multi-tasking/multi-user environments.

Apple seems to be starting a sales program with colleges willing to order at least \$1 million of Lisa and Macintosh machines for faculty, staff and students. They will give discounts of at least 35%. IBM and DEC are reportedly offering 50% to 70% discounts to schools placing large orders.

Rumors also have it that Apple is negotiating with AT&T, Wang Laboratories and NBI to sell the Lisa and Macintosh systems to large corporate accounts on an OEM basis. AT&T would sell versions of the Mac with an integrated phone via its phone centers. This is seen as an admission that Apple had done poorly, against IBM, in selling the Mac and Lisa to the Fortune 500 market. Apple, which has 100 people in its national accounts sales force, stated over a year ago that it planned to increase the staff to 200-300 by this time.

The Case of the ROMless Micros, etc.

► A trade association from Taiwan has asked President Reagan to veto a recent International Trade Commission decision to ban the import of ROMless counterfeit Apple computers into the U.S. They claim the decision would impede legitimate international trade. According to Apple, these machines are

duce next year and to offer them to other computer makers. . . . There are reports that Eagle Computer is having problems with cash flow and poor sales and is considering some layoffs. . . . We hear that Digital Research will soon release "Crystal" a software developer toolkit with many routines that can be merged and integrated into programs to reduce development time and to provide such features as menus, graphics and multi-tasking. . . . With sales of the PCjr not measuring up to expectations, IBM is reported to be considering selling the jr in mass market outlets. . . . Finally, IBM lap-size portable rumors keep coming down the grapevine. The latest originates in Europe, where they say IBM is testing a machine made by Matsushita with bubble memory, ROM software and a display of 8 lines by 80 characters.



copies of Apple II computers in all respects expect the copyrighted ROM, which is installed after the units enter the U.S.

The U.S. Customs Service, in Seattle, recently seized a large number of allegedly counterfeit copies of the IBM PC, after IBM registered its copyright with Customs and identified the copies. IBM is following in Apple's footsteps in attempting to protect its copyrights.

Law's Clause Draws Roars

▶ Japan is in the process of enacting a new software protection law that places control under the Ministry of International Trade and Industry (MITI) rather than under the courts, as in this country. This change, viewed as an incentive for Japan's developing software industry, is feared by some in the U.S. software industry.

Under the law, developers will furnish MITI with copies of their programs. MITI will examine each for originality and performance quality, register them for a period of 15 years, and arbitrate all disputes.

The U.S. is currently complaining to Japan that this new law is highly protectionist.

Random News

▶ Tandy may begin protecting its software products from being copied with a system called "Prolock." Prolock uses a laser-aided technique to "fingerprint" disks physically. It is expected to be used this fall on educational software products. . . . The National Security Agency is reported to be installing a \$100 million speech recognition computer system to monitor phone communications and detect "subversive" behavior. . . . Sharp has announced a \$350 four-pen plotter with both parallel and serial interfaces. . . . Apple is also expected to introduce a laser printer for the Mac using the Canon mechanism. . . . Saber Technology Corp., Anaheim, CA, has announced the highest-resolution CRT display system yet. It can display 1664 x 1248 pixels on a 19" screen. The

unit uses a 6-MHz National 32032-based processor. To store all the display information, 2M bytes of memory are needed.

. . . Mitsubishi Electric of Japan has disclosed its development of a new slimmer pancake motor for disk drives that is expected to reduce the size of 3½" and 5¼" floppy disk drives. . . . Dataquest, a market research outfit, reports that last year notebook-sized computers made up 3% of systems sold, a number they predict will rise to 7% this year and to 30% by 1988. . . . Sony has introduced a color monitor using its Trinitron CRT, that it claims will display 1280 x 1024 pixels.

PC for Four

▶ IBM, we hear, is beta-testing a multitasking version of MS-DOS for their forthcoming 80286-based system. We expect an announcement on this new system from IBM before year-end and initial system shipments next year.

Digital Research (DRI), however, got there first. It has been delivering a multi-processing DOS with PC-DOS compatibility since July. The product, called Concurrent PC-DOS, will run up to four PC-DOS or CP/M tasks concurrently on a standard PC. It contains a true windowing system and communications support. DRI has also introduced a plug-in board for the PC that turns Concurrent PC-DOS into a system that will support up to four users. The board and associated software is called "StarLink." It appears that DRI has a lead of 6 to 9 months over IBM's introduction of a multi-user PC system.

An LCD in Color

▶ Seiko Instruments and Electronics, Ltd., Japan, may be producing a new multiple-color liquid crystal display for personal computer use. Called the FT1616, the LCD will display eight colors on an array of 64 x 160 pixels (picture elements). The unit is 170 x 100 mm overall by 200 mm thick and includes the drive electronics and a fluorescent tube for backlighting. The display area is 105.6 x 42.4 mm. A 64 x 240 pixel display is expected to go into production this fall. A unit 640 x 200 pixels (the size of the display used in the IBM PC) is in development for possible introduction early next year.

Quotation of the Month

▶ From John Roach, president, Tandy/Radio Shack: "We are in a technology industry where promotion and distribution are more important than technology."

Getting Junior to Sell

▶ As we have mentioned in the last two columns, sales of PCjr have been disappointing. One survey reports that stores handling the units have been selling an average of only four systems a month and are left at month's end with an average of 13 units unsold. Another survey that had estimated that IBM would ship more than 500,000 *jr*s in 1984 has slashed the figure. In May they anticipated sales of only 100,000 units. Changes IBM has been implementing since the late spring might, however, raise sales figures to 200,000 for the year. IBM has already lowered PC prices; more enhancements are in the works. The company has notified dealers that they will receive credits for units they have bought at full price, including units already sold, and will be rebilled later. IBM has also eliminated cancellation penalties and finance charges dealers were responsible for in handling *jr*s. How is that for dealer protections?

To attract more business users, IBM may be offering as options an improved keyboard and a second disk drive. It also looks like advertising for the *jr* will become more oriented to business and more extensive.

In addition, IBM is hoping to boost sales by encouraging software houses to bring out programs for the *jr* as quickly as possible.

Reports have reached us that IBM has sent out requests for quotations on PCjr parts for 1985 production that indicate that the company plans to build 1.5 million units next year. (It appears that they ordered enough PCjr parts for 3 million units this year.)

The question now is: Can these changes in hardware and advertising overcome the PCjr's slow start. ◇



FORREST M. MIMS III

THE COMPUTER SCIENTIST

ANALOG COMPUTER TECHNIQUES FOR DIGITAL COMPUTERS

Now that incredibly powerful, low-cost *digital* computers have become commonplace, it's easy to overlook the importance of the venerable *analog* computer. Indeed, most users of today's personalized digital computers know little or nothing about analog computing.

As a longtime analog computer enthusiast, I'm happy to report that analog computers are alive and well in 1984. In this two-part series I'll cover analog computer basics and examine ways to apply simple analog techniques to any personal computer with a pair of analog joystick ports.

Why Analog Computers?

Since very few users of personal computers are even aware of analog computers, they stand to miss significant opportunities. Creative hardware and software users can benefit by adding to low-cost digital computers some of the operating techniques used with analog machines.

That's because some of today's analog machines incorporate digital logic and even entire digital computers. Such machines are sometimes called *hybrid* computers.

Because the basic principles of the electronic analog computer were developed as long as 50 years ago, it's only natural to wonder what advantages ana-

log machines can possibly have over their digital counterparts. One major advantage is the ability of an analog machine to realistically *simulate* or *model* systems whose performance can only be described by interdependent sets of linear or non-linear differential equations having many variables. For example, analog computers can easily simulate the level and extent of flooding that results when a river's watershed receives an overabundance of rain. Likewise, analog machines can simulate the operation, over a wide range of conditions, of aircraft, ships, chemical manufacturing plants, nuclear reactors, and many other systems.

In all these examples, the analog computer can provide *real-time* solutions to the problem at hand because the computer functions as an electronic model whose parameters can be changed as fast as an operator can turn a dial.

For instance, assume you're the operator of an analog computer programmed to simulate the operation of a new sports car. Dials on the machine's control panel allow you to instantly specify the car's weight, dimensions and speed. Switches allow you to select such options as retractable headlights and various kinds of external rear-view mirrors.

Though our hypothetical analog computer incorporates an analog "front

end," most of its output devices are familiar to users of digital personal computers. In addition to a printer they include a cathode-ray tube and an x-y pen plotter, both of which represent, graphically, the car's performance. Figure 1 summarizes the complete system in a block diagram.

As you vary the car's design parameters, the various output devices almost immediately display the results. The printer lists the fuel efficiency (in miles per gallon) and aerodynamic drag coefficient that result from any combination of parameters you have selected on the control panel.

Yes, a digital computer can be programmed to provide the same results. One way would be to have the computer step through every conceivable variation in the car's parameters and provide listings and plots of the resulting performance possibilities. But this method would require more operating time and would produce far more information than you need.

Furthermore, the all-digital approach removes the human-machine interface, the direct link between operator and computer that allows a human being to incorporate creativity, intuition, experience and knowledge in the design of a new sports car. In other words, the analog computer gives you all the advantages that result when you can casually change the parameters of the hypothetical sports car and instantly see the results.

I hope you're now convinced that analog computers have much to offer. So how can the owner of a *digital* computer get into *analog* computing.

Fortunately, some basic analog computer techniques can be effectively used with any digital machine equipped with one or more analog-to-digital converters. In other words, if your computer has a pair of analog joystick inputs, chances are you can develop programs that will digitally simulate the ultimate simulator, the analog computer.

In this and next month's column we'll explore this topic in some detail. Let's begin by rediscovering some analog computer basics.

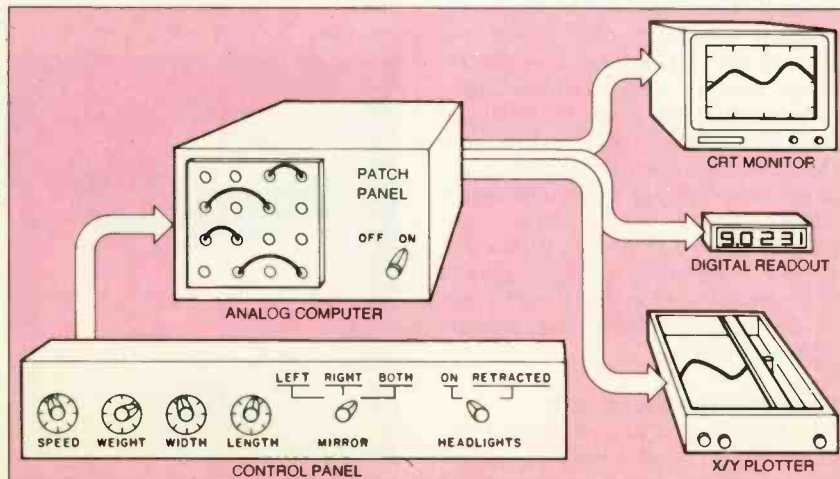


Fig. 1. Analog computer sports car simulator.

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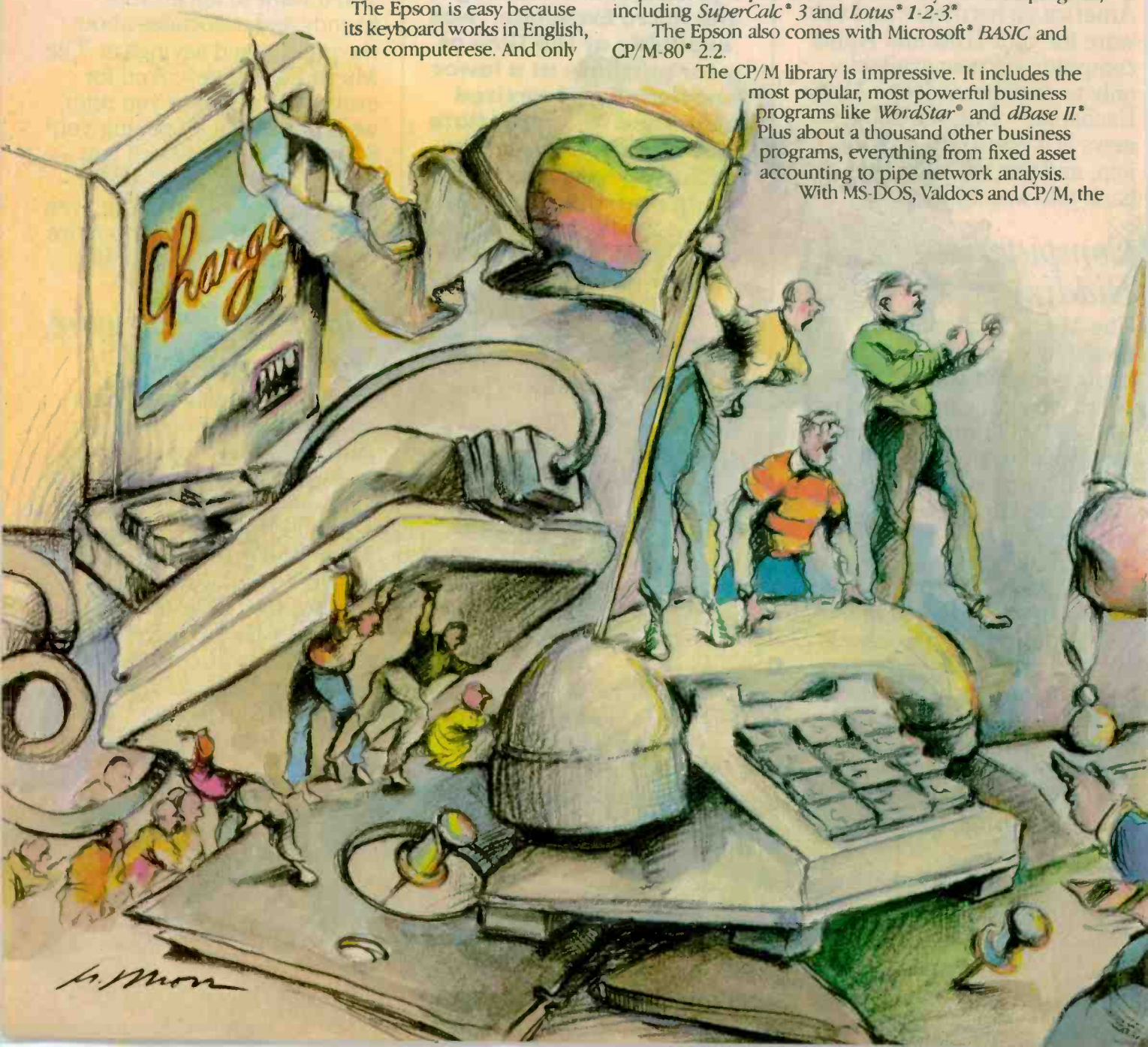
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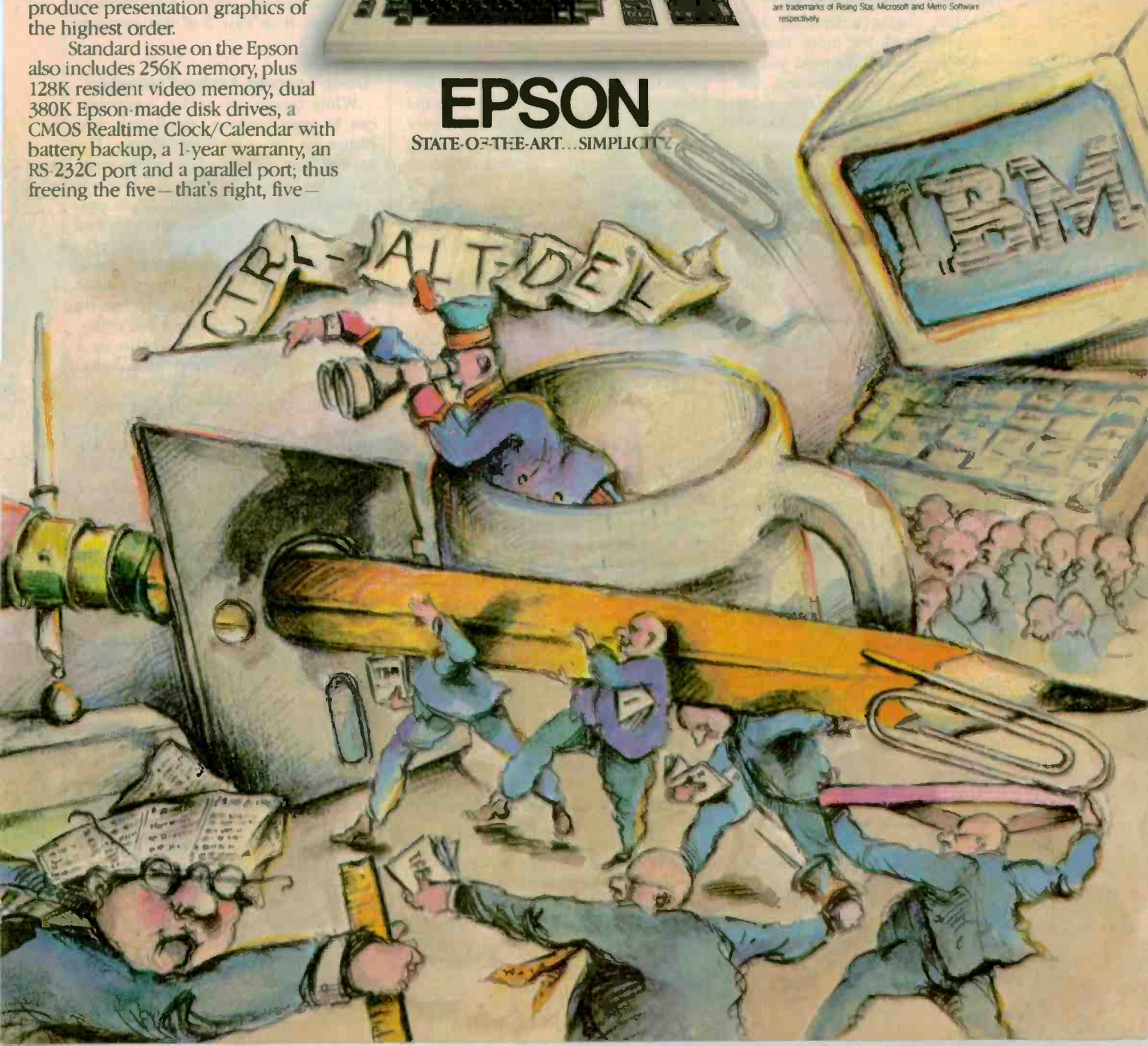
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Computer Scientist

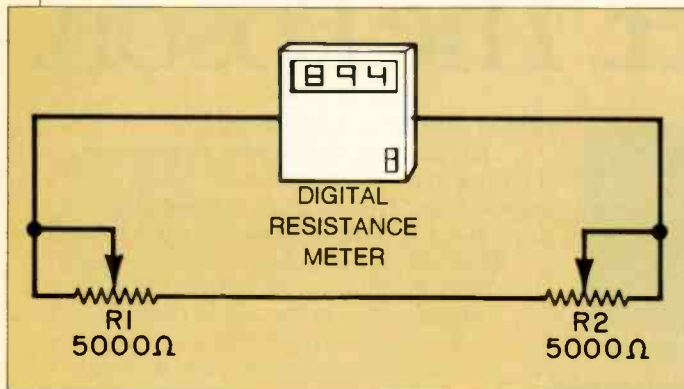


Fig. 2. Variable resistor analog addition circuit.

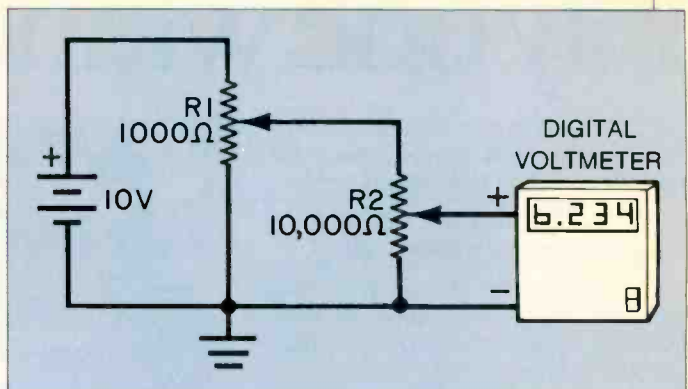


Fig. 3. Variable resistor analog multiplication circuit.

Analog Computer Basics

Mechanical analog computing machines have existed for more than a thousand years. One of the most widely used analog computing machines, the slide rule, was made obsolete only a decade ago by the portable scientific calculator, a digital microcomputer containing in its ROM stored programs dedicated to solving specific mathematical problems.

It's well-known that digital computer circuits process electrical signals that occupy one of two discrete levels. A floating or disconnected state, the so-called *third state*, may also be present. For example, when various circuits are connected to a common bus, to prevent confusion only *one* can be allowed to place a signal on the bus. The others are effectively isolated from the bus by circuits called three-state buffers or gates.

Analog computers process signals over a wide and continually variable voltage range. It's therefore much easier for analog computers to represent and perform mathematical operations upon numbers that have been represented by voltages.

On the other hand, digital computers are much more precise than analog machines and are therefore essential when paychecks, bank balances, loan statements, budgets and the like are being calculated.

Sometimes, however, the precise results offered by digital computers are superfluous. For example, would you prefer to read from a digital display that your car's fuel tank is 26.2 percent full or glance at an analog gauge that reveals you have about a quarter of a tankful remaining? Even if you prefer the digital readout, the reading is only as accurate as the *analog* sensor that measures the level of the fuel and the *analog-to-digital* circuit that drives the readout.

On a grander scale, an analog computer programmed to simulate a rain-

drenched watershed might predict a flood crest of 15.2 feet with an error range of ± 1 percent. A digital computer simulation might give a more precise prediction of 15.187568439731 feet. But since both predictions are subject to the same input errors (e.g., the uniformity and quantity of rainfall, condition of the soil, vegetation type and density), *both* provide a figure of *about* 15.2 feet. If you're not convinced, ask yourself which value the radio announcer will read over the air to an audience of potential flood victims.

Analog computers provide real-time solutions to problems

The preceding example also illustrates the role analog sensors play in many kinds of dedicated (single function) digital computer systems. Though the digital portion of such systems may have ten- or twelve-place accuracy, the accuracy of the analog sensor is considerably less, probably no more than a few tenths of a percent. Moreover, the overall response of an individual sensor may *not* be uniform with other sensors.

All in all, miniature analog computers might well be at least as effective as their digital counterparts in dedicated applications involving analog sensors. Then why aren't they as popular?

In my opinion, a principal reason is that analog circuit design is fast becoming a lost art. Another reason is that the microprocessor arrived *before* sophisticated single-chip analog computer chips. This technology gap provides some interesting opportunities for creative com-

puter enthusiasts, and I'll have more to say about it in Part 2 of this two-part column.

Do-It-Yourself Analog Computers

While large-scale analog computers can be very complex, small-scale machines can be surprisingly simple. For example, though practical analog computers are designed around precision operational amplifier circuits, simple analog computers can be constructed from a few potentiometers and a multimeter.

Figure 2 shows an *analog adding machine*. This ultra-simple circuit requires only two inexpensive potentiometers equipped with pointer knobs and scales. The circuit can display its results on a conventional analog meter or a digital multimeter.

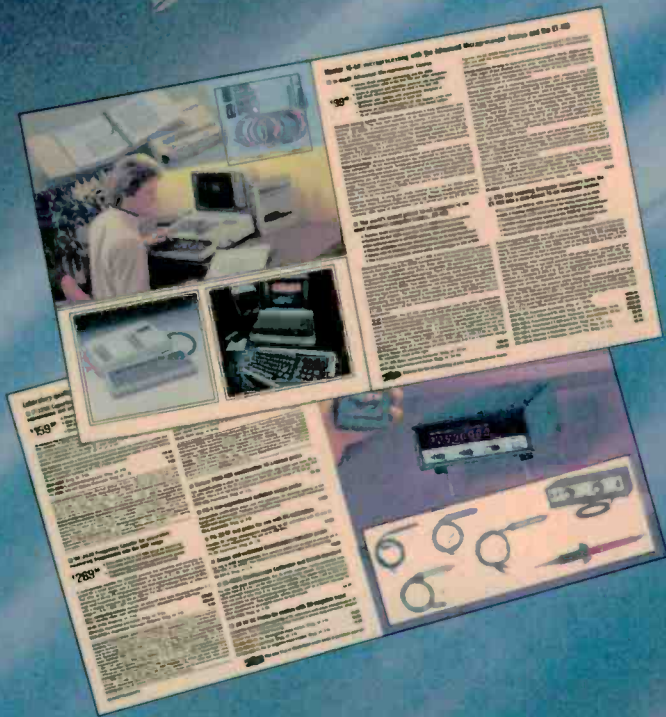
If each potentiometer has a resistance of 5,000 ohms and if each ohm represents a unit, then this analog adder can sum any two numbers of up to 5,000 and provide a total of up to 10,000. Simply by changing the potentiometer scales, a form of programming, the machine can be set to add virtually any pair of numbers provided that an appropriate correction factor is applied to the value displayed by the multimeter.

Figure 3 shows how the two potentiometers in Fig. 2 can be rearranged or *re-programmed* to provide an *analog multiplication machine*. Here the potentiometers are connected as *voltage dividers* across a 10-volt power supply.

How does the multiplier work? Ignoring the value of the potentiometers, assume each is equipped with a scale having eleven equally spaced lines. The scale for R1 is marked 0 through 10 while that of R2 is marked 0 through 1 in increments of 0.1.

When R1's pointer is rotated to the 5 position on its scale, its wiper is at its center position and the voltage appearing across the wiper and ground is half the input value, or 5 volts. Likewise,

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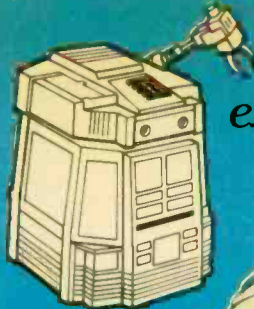
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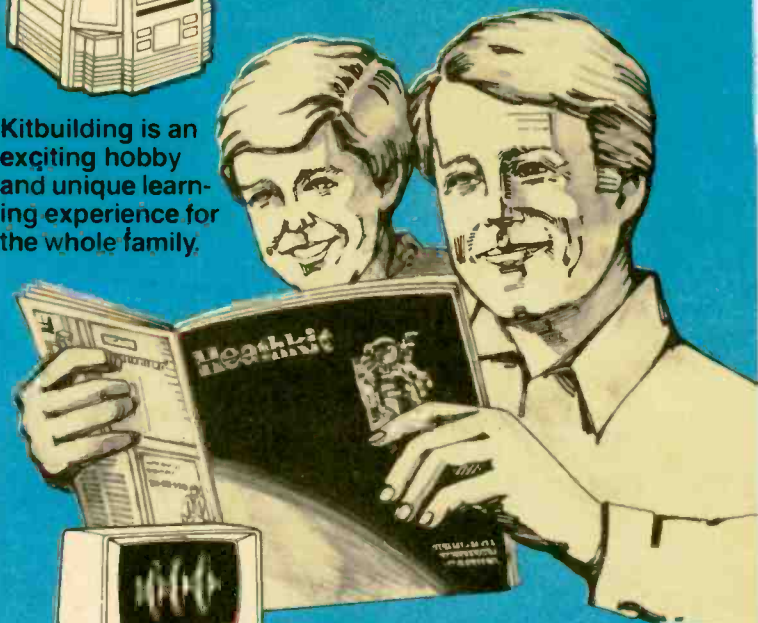
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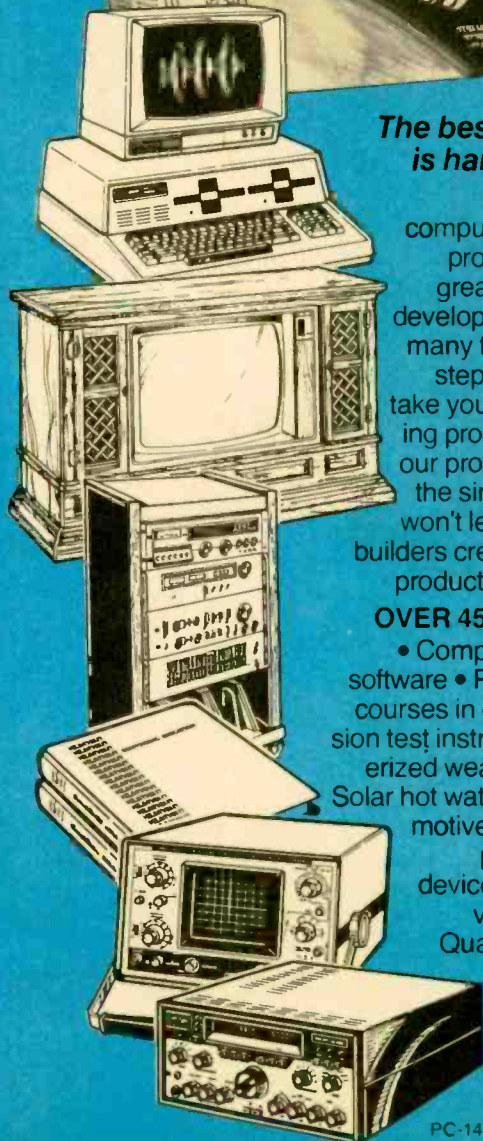


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Computer Scientist

when R2's pointer is rotated to the 0.5 position on its scale, its wiper is also at its center position, and the voltage across the wiper and ground is half the input value, or 2.5 volts. This output voltage is the product of the two potentiometer settings ($5 \times 0.5 = 2.5$).

The simple addition and multiplica-

this circuit is the product of the feedback resistance (R2) and the input voltage (V_{in}) divided by the input resistance (R1). Therefore, the basic circuit in Fig. 4 can perform multiplication and division.

Figure 5 shows how the circuit in Fig. 4 can be slightly modified to enable it to

ship between the voltage drop across a *pn* junction and the current flowing through the junction makes possible this important analog computer function block.

Op-amps can provide many other functions useful in analog computers, including integration, differentiation, raising exponents and function generation.

As you can see, the op-amp is to analog computers what the logic gate is to digital computers. Op-amps, however, are much more temperamental than logic gates. Sensitive to temperature changes, high-accuracy op-amp function blocks require precision resistors having a tolerance of 0.1 percent.

These drawbacks are a major reason why analog computers were soon surpassed by more dependable and predictable digital computers. In recent years, however, analog computer function modules have been fabricated with on-chip resistors having unprecedented accuracies. One such circuit, the Analog Devices AD534, includes a dozen on-chip resistors trimmed to a high degree of accuracy by a pulsed laser.

When first introduced five years ago, its manufacturer called the AD534 the first single-chip analog computer. Since this chip can multiply, divide or square two input voltages or take the square root of a single input voltage—all with an accuracy of ± 0.25 percent—the AD534 certainly qualifies as a powerful

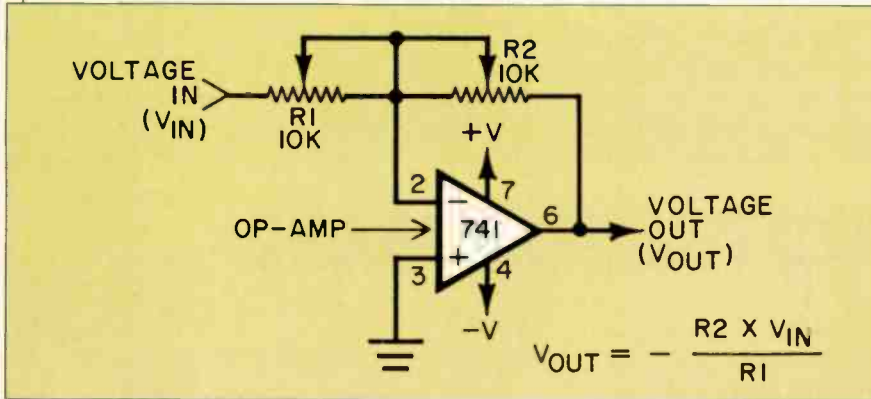


Fig. 4. Basic operational amplifier variable resistor multiplier.

tion circuits in Figs. 2 and 3 can be made more accurate by using multi-turn precision potentiometers. Ten-turn dial potentiometers are an excellent, albeit rather expensive, choice.

Moreover, both the addition and multiplication circuits can be combined into a single circuit that can be reconfigured by means of a *patch panel* equipped with switches or removable plugs and wires. By doing so, a *programmable* analog computer can be created.

Experienced circuit designers can replace the requisite programming wires, plugs and switches with *analog gates*. A digital word (i.e., binary number) much like a digital computer's machine language instruction, can then be used to tell the computer to add or multiply. The analog computer can be greatly expanded using such techniques. And it can be controlled using familiar but, by comparison, more easily programmed digital computer techniques.

Activating the Analog Computer

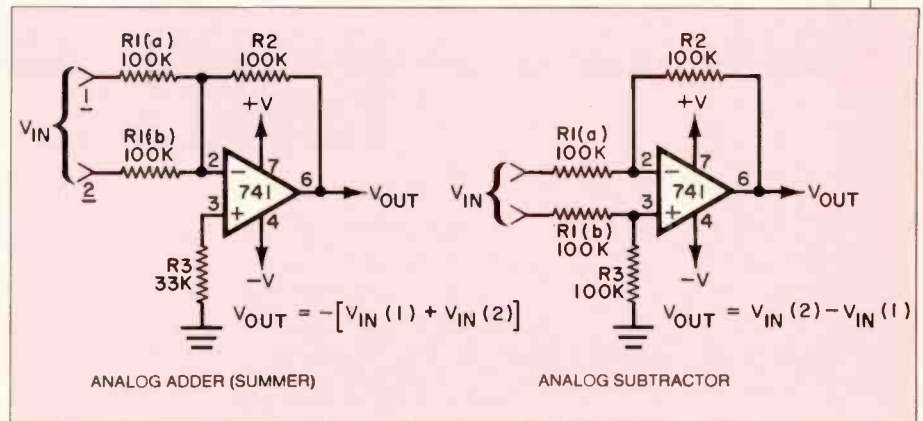
The basic variable resistor analog computer discussed thus far is a *passive* device. Far more versatile performance can be had by adding *active* electronic circuits, the most important being the *operational amplifier*. First developed by George H. Philbrick in the mid-1930s for use in an early all-electronic analog computer, the op-amp, as it is usually called, uses feedback from its output to one of its two inputs to control precisely its amplification factor or *gain*.

Figure 4 shows a very basic op-amp *function block*. The output voltage of

perform addition and subtraction. More than two voltages can be combined by adding additional input resistors to the adder (summer) circuit.

The summer in Fig. 5 can average the sum of two or more input voltages by making the ratio R2/R1 equal to the number of input voltages. For instance, if each of two input resistors [R1(a) and R1(b)] has a resistance of 100,000 ohms,

Fig. 5. Basic operational amplifier variable resistor multiplier.



then changing R2's resistance to 50,000 ohms will cause the output voltage to equal the average of the two input voltages.

More precise multiplication, division and square root extraction can be performed by means of an op-amp operated as a logarithmic amplifier. This is accomplished by substituting a diode or transistor in the feedback loop of an op-amp. The natural logarithmic relation-

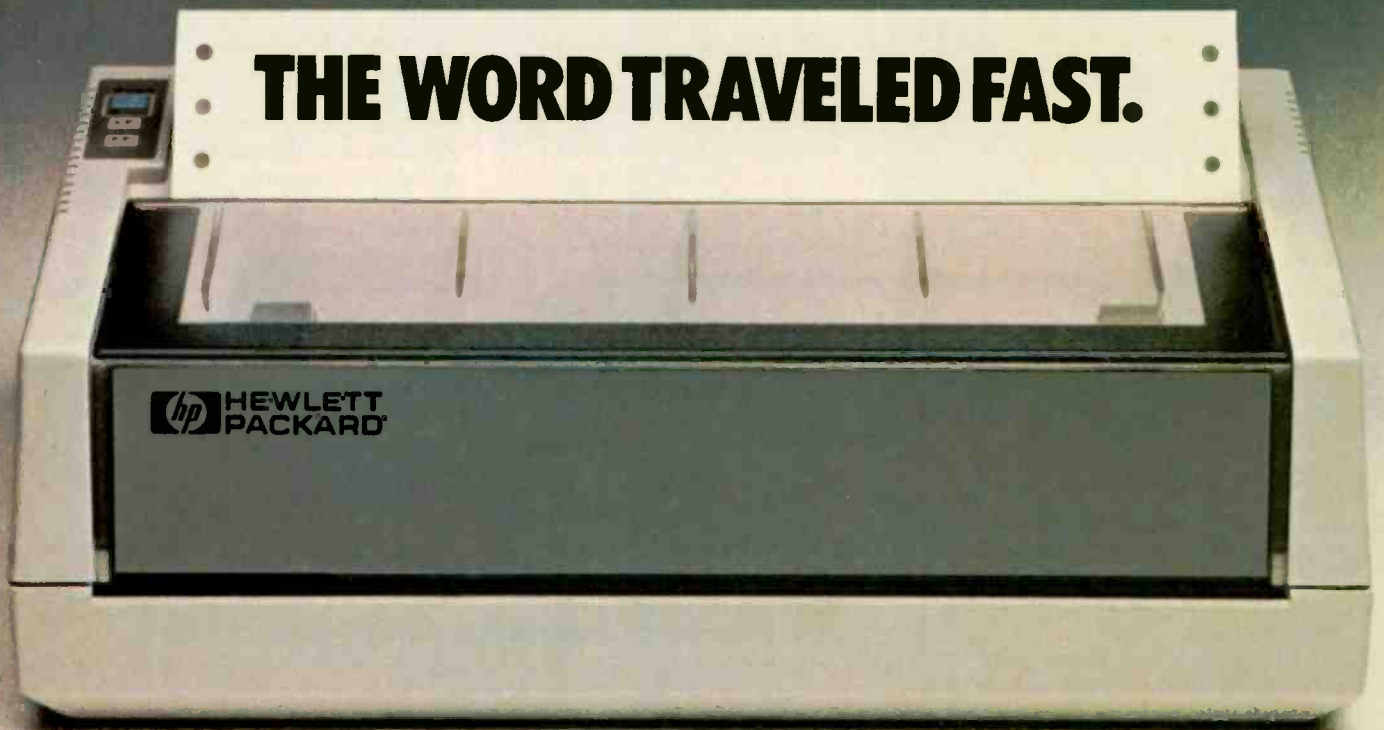
analog processing chip. I'll have more to say about it and similar chips in Part 2.

Simulating an Analog Computer with BASIC

If you enjoy experimenting with hardware, you can assemble a surprisingly powerful analog computer from a few op-amps, an AD534, a patch panel and a digital multimeter. Alternatively, you

(Continued on page 113)

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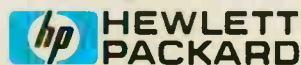
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HARDWARE REVIEWS



EPSON PX-8 LAPSIZE COMPUTER

A 5-pound portable that sports ROM-based WordStar, BASIC, and spreadsheet software

BY JOSEPH DESPOSITO

Although several lapsize computers sell for under \$1000, all suffer from a lack of software. Now, however, Epson has produced a lapsize computer, the PX-8, which uses the CP/M operating system—thus it can access one of the largest software bases available for micros. For software starters, the PX-8 comes standard with Portable WordStar, Calc and Scheduler in ROM capsules.

The size and layout of the PX-8 are reminiscent of Epson's HX-20 (the first lapsize computer), with some significant differences. Gone, naturally, is the 4-line by 20-character display; it is replaced by an 8-line by 80-character LCD that flips up for use. The microcassette tape drive in the HX-20 is also present in the PX-8.

Missing, however, is the microprinter. Suggested retail price of the PX-8 is \$995.

A bevy of optional peripherals is available to enhance the standard PX-8. Chief among them are a 3½" disk drive and a 120K RAM disk, which sell for \$599 and \$460, respectively.

General Features of the PX-8

The PX-8 is a 5-lb bundle. With dimensions of 11.7" W × 8.5" D × 1.9" H, it is almost identical in size to its predecessor. For traveling, a molded plastic cover fits over the keyboard, the LCD folds down flat over the microcassette recorder and speaker, and a plastic handle slides out from the front of the case. In use, the handle retracts, the cover comes off, and the display tilts up to an appropriate viewing angle. Two legs at the back of the unit can swing down to adjust the angle of the keyboard.

On the rear panel of the computer are two 8-pin miniature DIN plugs, which are the serial (printer) and RS-232C (modem) ports. Three phono jacks are used for the speaker output, an analog/

digital (A/D) input, and barcode reader port. A recessed reset switch lies along the left side of the unit, while the power switch is along the right. The latter is under software control, which means that the machine can be programmed, in conjunction with a built-in clock, to turn on and off automatically.

Rechargeable nickel-cadmium batteries are housed in a compartment on the underside of the computer. There are two batteries, main and backup. The main battery runs for about 15 hours, depending on I/O operations. When it needs recharging, the backup battery protects the contents of memory. An adapter that plugs into the back of the unit is used to recharge the batteries, which takes about 8 hours.

Another compartment on the underside gives the user access to the computer's removable ROMs and an 8-pin DIP switch. The switch is used to customize the keyboard for any of seven different languages.

Inside the Machine

The PX-8 has three microprocessors.

```
*** MENU screen *** 03/01/84 (WED) 04:26:07 54.5k CP/M ver 2.2 PAGE 1/1
C:PIP
C:PIP COM C:STAT COM C:SUBMIT COM C:XSUB COM
C:FILINK COM C:TERM COM C:CONFIB COM B:BASIC COM
```

Fig. 1. Startup menu screen shows the CP/M ROM as the C drive and the BASIC ROM as the B drive.

TABLE I—PX-8 OPERATING SYSTEM MODULES

The operating system of the PX-8 is functionally divided into several units which are referred to as modules. Some of them are part of the CP/M operating system and others supplement it.

- **System Display module.** Enables the microcassette tape to be operated manually and also to check and reset some of the system parameters.
- **Password module.** Makes it possible to stop unauthorized users from using the PX-8 without knowing an entry password.
- **MENU module.** Displays program files and data files on the screen and makes it easier for the user to run any

program file by selecting it on the screen, using the cursor keys rather than having it to type the full name.

- **Screen dump module.** Used to make a copy of the current screen on a printer.
- **Console Command Processor (CCP).** This is the part of the CP/M operating system which interprets command strings typed on the keyboard. This module includes the CP/M built-in commands (Dir, Type, Ren, Era, Save and User).
- **Basic Disk Operating System (BDOS).** This is the part of the CP/M which manages disk files. It also treats the ROM capsule and RAM as disk devices.

- **Microcassette Tape Operating System (MTOS).** Manages microcassette files.

- **Basic Input/Output System (BIOS).** This part of the CP/M acts as the interface between the operating system and input/output devices, e.g., the screen, keyboard and RS232 interface.

- **Microcassette Input/Output System (MIOS).** I/O interface between MTOS and microcassette firmware.

- **Clock module.** Controls alarm and wake functions and updates time displays.

- **System activator.** Controls system activation, deactivation, the auto-start function and initialization.

The main processor is a Z-80-compatible CMOS CPU. Additionally, a 6301 processor is used for display and input/output control, and a 7508 processor controls interfacing with the keyboard and the A/D converter. A block diagram of the system configuration is shown on page 38.

Standard memory of the PX-8 is 64K RAM and 32K ROM, controlled by the Z-80. 6K of video RAM and 4K ROM are controlled by the 6301.

The ROMs, as mentioned, are accessible to the user. In the old HX-20 users were warned against inserting CMOS ROMs themselves, owing to the sensitivity of CMOS chips to damage by static electricity. In the PX-8, however, Epson has devised a package (not an enclosed ROM cartridge, as in other computers) in which the ROM chip is seated, but exposed. With careful handling, the user can insert and remove the ROMs, which may contain the CP/M operating system, BASIC, Portable WordStar, Portable

Calc, or other programs. Removing one ROM capsule and slipping in another is fairly straightforward though not nearly as easy as using a ROM cartridge. Under CP/M, each ROM is identified as a "disk drive." ROM 1 is seen as the B drive and ROM 2 as the C drive in the standard configuration, but they may be changed through the CP/M CONFIG program.

Access to the system bus is available through a connector on the back panel. It's through this bus that optional peripherals, such as the RAM disk, can be connected.

The Display

The PX-8 uses a liquid-crystal display for video output. It displays 8 lines of 80 characters each in the text mode and has a resolution of 480 x 64 dots in the graphics mode. The hinged display tilts up for viewing to a variety of angles. For "fine tuning" the display, there is a "view angle" slide adjustment just below the screen.

The display dimensions are approximately 1½" x 9". Alphanumeric characters stand about ⅛" high, which can make for some difficult viewing since characters are constructed with single rows of dots (the normal method). Other lap-size computers deal with the problem either by displaying larger characters or by using a more elaborate (and readable) character set. One other deficiency of the character set is that lower case characters such as p, j, g do not have true descenders.

An additional difficulty with the dis-



RAM disk attached to the PX-8.

play is that the retrace lines are visible under fluorescent lighting, although under incandescent lighting they are not.

To conserve power, the screen display automatically switches off if there has been no keyboard input for 10 minutes or for an interval, between 1 and 255 minutes, the user sets.

The Keyboard

One of the most noticeable improvements of the PX-8 over the HX-20 is the feel of the keyboard. The keys are firm to the touch and excellent for typing. There are 63 alphanumeric and special keys. There is also a row of nine one-third size keys. Five of them are function keys, and four are designated STOP, ESC, PAUSE and HELP.

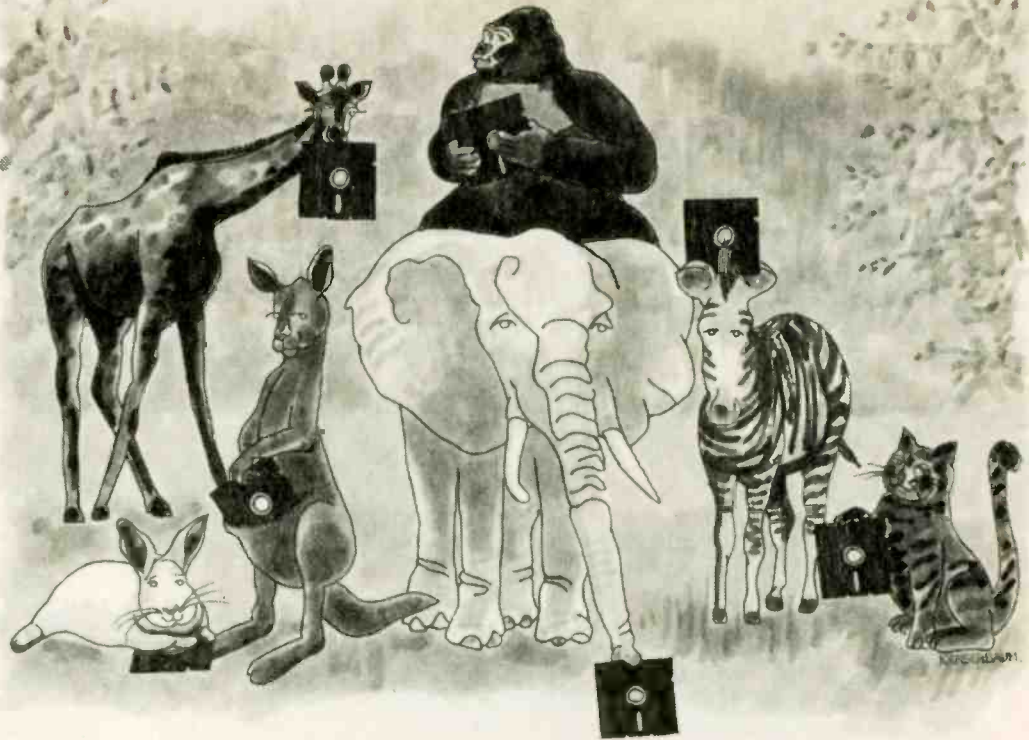
The standard keys are color coded—dark grey (alphanumerics), light gray (special keys), red (return), and orange (four separate cursor keys)—which en-

Battery-powered 3½" drive.



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Product Description	Super Disk Part #	CE quant. 100 price per disk (\$)	Wabash Part #	CE quant. 100 price per disk (\$)	BASF Part #	CE quant. 100 price per disk (\$)	3M Part #	CE quant. 100 price per disk (\$)
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8" SSSD Shugart Compatible, 32 Hard Sector	_____	_____	F31A-P	1.79	_____	_____	_____	_____
8" SSDD IBM Compatible (128 B/S, 26 Sectors)	_____	_____	F131-P	1.89	_____	_____	8SSD-P	2.39
8" DSDD Soft Sector (Unformatted)	_____	_____	F14A-P	2.09	_____	_____	8DSDD-P	2.89
8" DSDD Soft Sector (256 B/S, 26 Sectors)	_____	_____	F144-P	2.09	_____	_____	_____	_____
8" DSDD Soft Sector (512 B/S, 15 Sectors)	_____	_____	F145-P	2.09	_____	_____	_____	_____
8" DSDD Soft Sector (1024 B/S, 8 Sectors)	_____	_____	F147-P	2.09	_____	_____	8DSDD-1024-P	2.89
5 1/4" SSSD Soft Sector w/Hub Ring	8431-P	1.14	M11A-P	1.19	_____	_____	_____	_____
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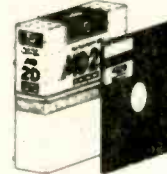
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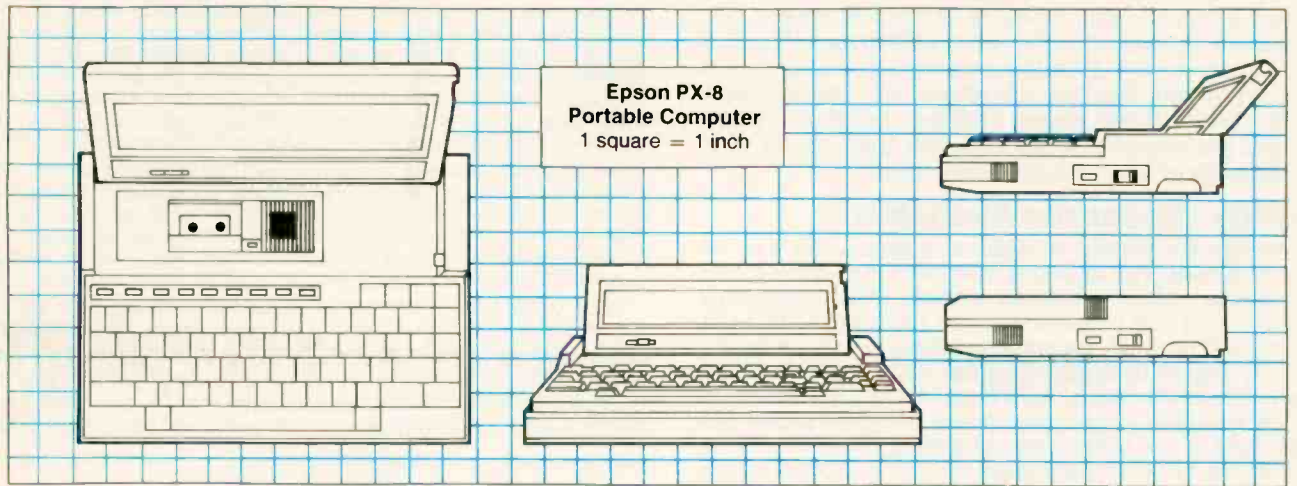
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hances the aesthetic appeal of the computer. Key markings are in white.

There is a type-ahead buffer and most keys have an auto-repeat feature. The keyboard also has a number of other sophisticated features. For example, if you press NUM/GRAPH and an alphabetic key simultaneously, a graphic such as a miniature telephone or airplane is displayed on the screen. Also, pressing NUM/GRAPH and the shift key sets up a block of keys as a numeric keypad. Though there are just five function keys, pressing shift in conjunction with the keys gives you five more. You can program all "ten" function keys.

Mass Storage

The primary storage device for the PX-8 is a built-in microcassette recorder. The tape it uses holds 10K-50K bytes of data per side (maximum number of files is 12). The recorder can be controlled manually or with software.

RAM disk storage is also available on the standard unit. You can set aside a portion of memory for data and programs as large as 24K.

For users who need more storage, Epson manufactures a 3½" disk drive and 60K and 120K RAM disks. The disk drive plugs into the serial port at the back of the unit and provides its own serial port for a printer or second drive. Thus, the peripherals are connected in "daisy chain" fashion to the computer. The drive, which is battery operated, was designed by Epson to be compatible with 3½" Sony (or similar) micro-floppies. It uses double-sided, double-density disks that have a capacity of 360K bytes. Dimensions of the drive are 4.7" W x 8.4" D x 2.3" H; weight is 3.3 lb.

The RAM disk attaches directly to the underside of the computer and tilts it about 15 degrees. It has a write-protect switch that's used to disable the write

function, if desired. (In other words, you may read from the disk but not write to it.) In addition to the 60K and 120K RAM disks, Epson also sells a Multiunit for \$360, which combines a 60K RAM disk and direct-connect modem. (As separate products, the 60K RAM disk costs \$329, while the direct-connect modem costs \$180.)

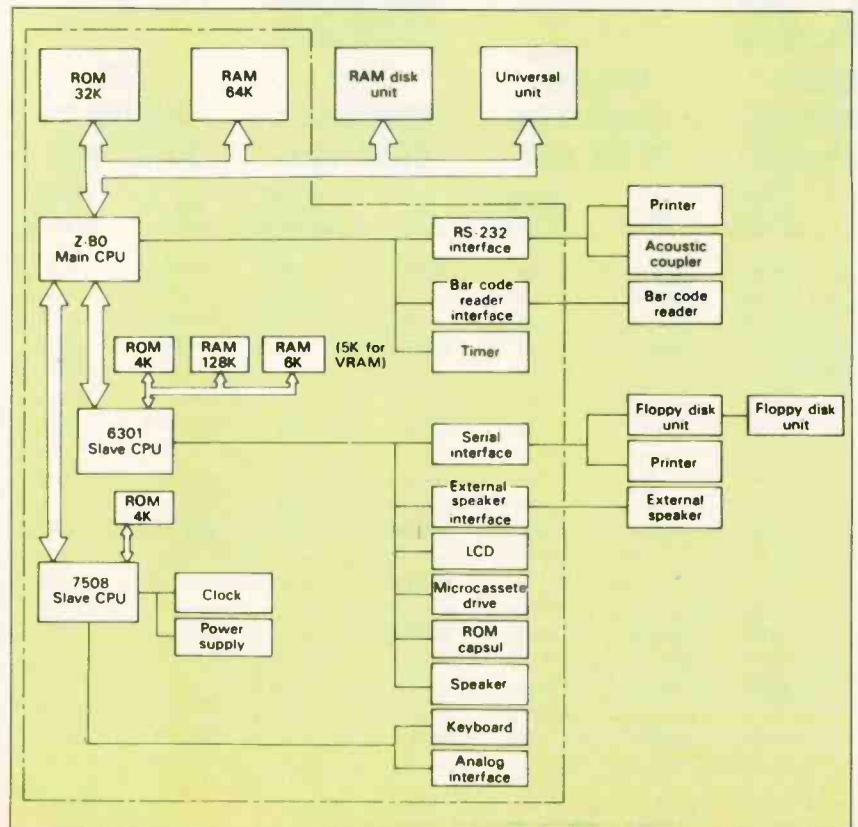
Operating System and Language

The PX-8 uses an extended version of

the CP/M 2.2 operating system, which exists in a ROM capsule. The menu screen shown in Fig. 1 appears upon startup. As you can see from the figure, the CP/M ROM is designated as the C drive. You can access the files shown simply by moving the cursor to the name and pressing return. Or, a more traditional option lets users modify the system through the System Display program so that the prompt C> is

(Continued on page 92)

Block diagram of the system configuration of the PX-8.



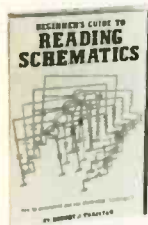
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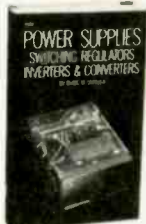
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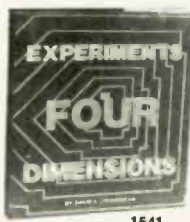
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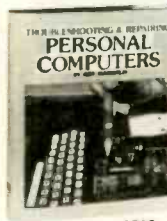
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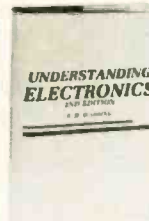
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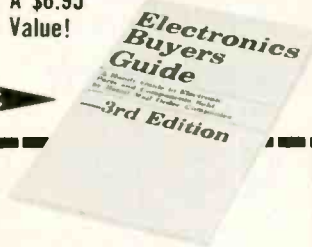


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SOME computer manufacturers forego technical improvements for compatibility; others stress technical superiority over compatibility. In either case a buyer should know the tradeoffs. In its computers, Stearns emphasizes technical developments, such as special function keys, for more flexibility and ease of operation.

While Stearns does sell a computer with two 5¼" floppy drives, 128K RAM (expandable to 896K), and a 12" black and white monitor for a suggested retail price of \$2995, we tested the XT version. A more elaborate configuration, it has 384K RAM, a 10 Mb hard disk, and a double-sided 5¼" floppy drive. Comparable to the IBM PC-XT, it sells

for \$6195. (No applications software or languages are included in the price.)

Stearns offers some rare options, for example, a monochrome monitor with an eggshell phosphor and a monitor for word processing that can display 54 80-character lines (similar to a standard sheet of paper).

Other hardware available from Stearns includes an external hard disk drive that can add 10 or 20 Mb of disk storage and a streaming tape backup unit capable of archiving a 20-Mb disk in less than 10 minutes.

Stearns has also aimed for ease of operation with its software products. The unit we tested included such popular packages as Lotus 1-2-3 and Wordstar enhanced with up to 40 "soft" function key commands. The result is a significant reduction in the time it takes to learn and use these programs.

The Stearns Look

The Stearns XT comes in the usual three pieces: keyboard, monitor and main processing unit. The processor cabinet measures 5½" by 15½" by 22", about 3" wider than the IBM PC. Owing to its sleekness, however, the Stearns unit looks smaller than the IBM. On the front panel are half-height disk drives. On the rear apron are connectors for a video monitor and two serial ports and the exit port for forced air circulation.

The Innards

Under the hood of the main process-

ing unit is an 8-MHz 8086 CPU. Not only does the 8086 have a clock speed faster than the 4.7 MHz of the IBM PC's 8088; it also is a true 16-bit unit. A socket is available for an 8087 math coprocessor.

The Stearns unit is powered by an air-cooled switching power supply similar in size but larger in capacity than other computers in its class. A Shugart SA455 floppy and Miniscribe hard disk handle the mass storage chores. The floppy drive is dual-sided, with 320K of formatted storage per side. Both disk drives perform well, except that the spindle motor of the hard drive is noisy.

The bus structure of the Stearns uses 96-pin sockets. Since IBM PCs have 62-pin sockets, Stearns users will not be able to use plug-in boards designed for the IBM units. Six slots are available on the motherboard to enhance the unit's performance. Five are for Stearns-type boards, two of which are used in the standard configuration for the disk controller and the monitor display adapter. (In the version we tested, two more are used for 256K memory and a parallel port.) Stearns has combined several functions on the two standard boards to ease the requirements for extra slots. The disk controller card handles both floppy and hard disk operations and the display card has outputs for both the monochrome monitor and a serial printer. A sixth slot, similar to an IBM bus socket, is designed to accept IBM PC boards, but by the time of this writing,

Stearns could not cite any cards that would function in the slot.

Other standard features include an RS-232 serial port and a battery-backed clock. Like many other computers, the Stearns does not name the connectors, which could be frustrating to users.

Keyboard

The Stearns keyboard, manufactured by Microswitch, is full-sized, with 94 full-travel keys. It can be tilted into two different positions. CAPS LOCK, PROG, NUM LOCK and S1-S4 keys have LEDs to indicate when they are in use. The keyboard is somewhat less noisy than the IBM PC's and requires a rather light touch.

The main keyboard area has the standard *qwerty* typewriter configuration. Dedicated keys include several that are unique to the Stearns unit. The STOP-SCN key can halt scrolling of a list on the screen; the PROG key instantly assigns to any key a character string that can be recalled by pressing the key and the assigned single key. The assignments are lost on power off, however. The PRINT key allows the screen contents to be dumped to the printer; the FUNCT key changes the mapping of each of the function keys (F₁-F₁₀) to one of four possible values. The new values are displayed on line 26 of the screen so that the operator does not have to memorize the 40 possible function-key operations. These "soft" keys are one of the Stearn's strong points.

A numeric keyboard provides the familiar arithmetic functions along with S₁-S₄, which the manual states are to be used with Concurrent CP/M.

Video Display

The unit we tested came with the standard black and white 12" monitor whose rated resolution is 720 horizontal by 364 vertical pixels. Character definition is

very good even out on the edges of the screen. Even though color-phosphor monochrome screens are currently fashionable, this one was very satisfactory, even for extended periods of time.

A feature unique to the Stearns is a display format on line 26 that shows the current value of the soft-function keys. Although the feature takes a little getting used to, it can save a lot of time in the long run.

Stearns also offers 12" monochrome monitors with amber, green, or eggshell phosphor screens (for an additional cost of \$39) and a 15" monitor. The latter displays 54 lines of text and two more lines for status and soft functions, has a plug-in board, and sells for \$1300. The monochrome display card that comes standard with the unit differs from the IBM PC's in that it supports graphics. A color card is also available.

Software

Stearns markets a variety of software items tailored to their hardware. We sampled operating systems and word processing, database manager, spreadsheet, and communications applications.

The operating system supplied with the Stearns is IBM DOS 2.10 in the familiar IBM package. ST-DOS and Concurrent CP/M are available options.

Two word processors are available from Stearns: the popular WordStar by MicroPro and WordPerfect by Satellite Software. The database manager is Ashton-Tate's dBase II. (*Everyman's Database Primer* by Robert A. Byers comes with the Stearns unit to help the user get started.) Also available is MicroSoft's Multiplan electronic worksheet, to handle the "what-if" questions.

An asynchronous control program (ACP) enables a user with a modem to communicate with other computers and information networks. Stearns includes elaborate documentation to help explain communications jargon. The Hayes Smartmodem hardware is supported by this software.

Such software packages as WordStar can be purchased off the shelf and run on the Stearns. Enhanced programs sold by Stearns, however, include such niceties as the soft-key functions.

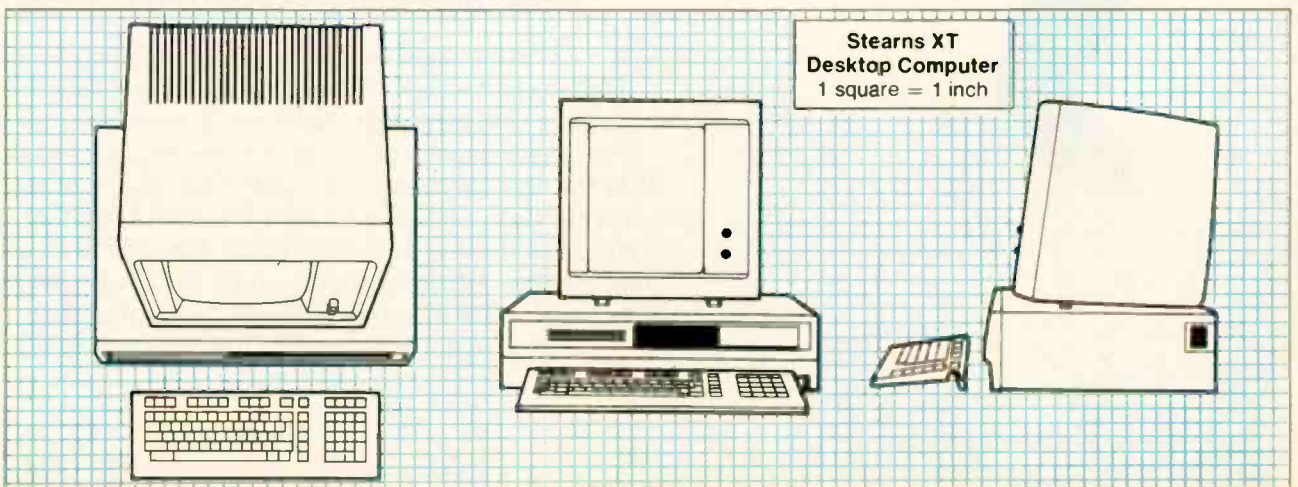
Compatibility

Since the Stearns is not hardware compatible with the IBM PC, you can expect some problems using software that talks to the hardware directly, such as disk utility programs, games, and windowing facilities.

The use of different controller chips for the CRT and the disk drives leads to some trouble. The "acid test" programs take over the machine at the BIOS level or even, in some cases, at the actual chip level, which causes problems for compatibles that don't use the same BIOS interface or IC complement. A windowing facility that runs on the IBM monochrome adapter would not operate on the Stearns.

(Continued on page 114)

Overview	
Product:	Stearns Computer
Manufacturer:	Stearns Computer Systems 10901 Bren Rd. E. Box 9384 Minneapolis, MN 55440
Suggested Retail Price:	\$6135
Dimensions:	22" W × 15½" D × 5½" H
Operating Systems:	Stearns DOS, MS-DOS 2.0
Other Features:	8086 CPU, 384K RAM, 10 Mb hard disk, 5¼" double- sided floppy drive



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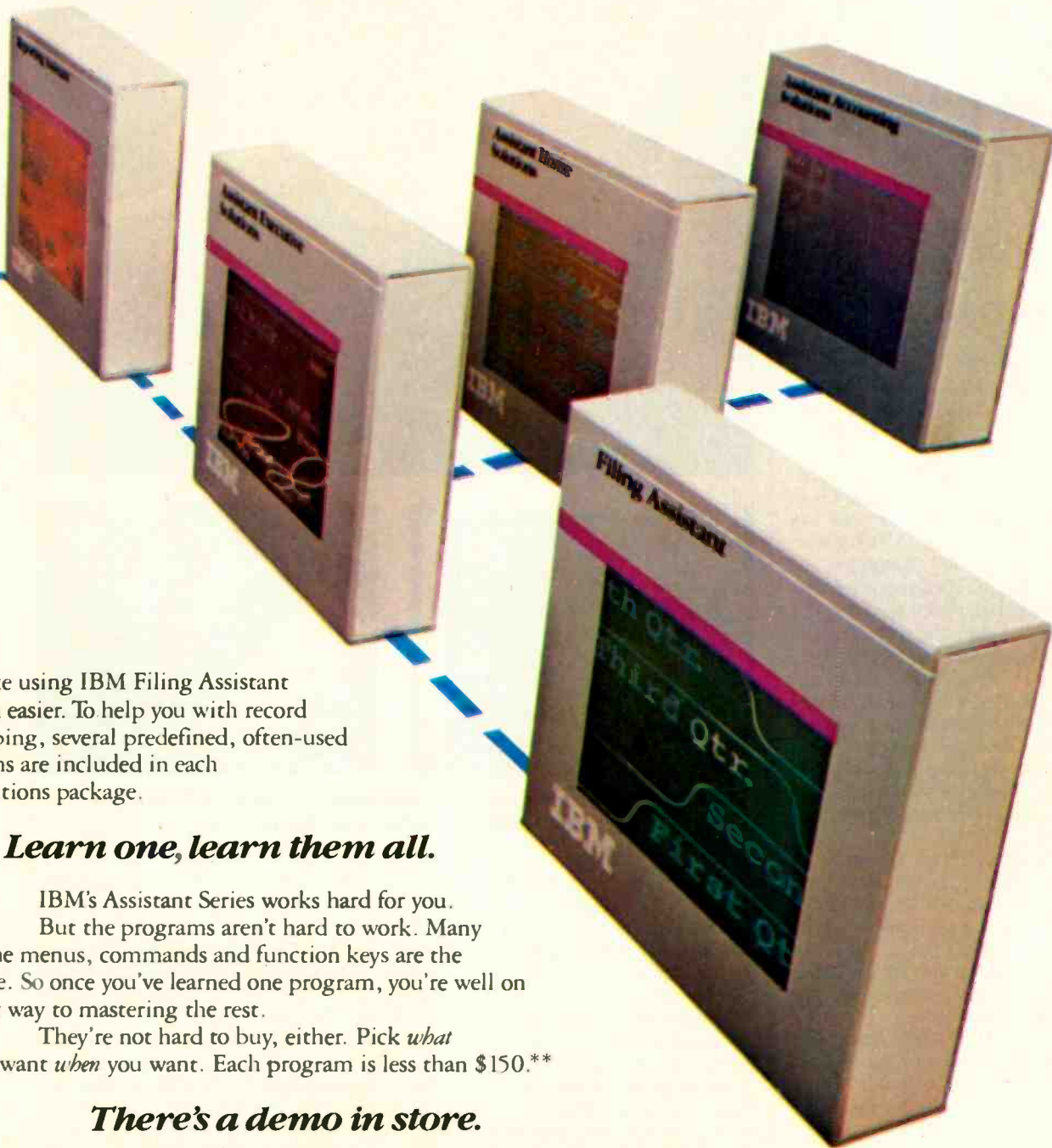
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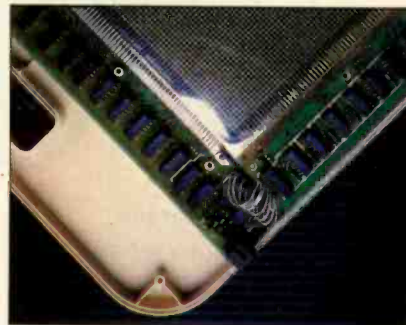
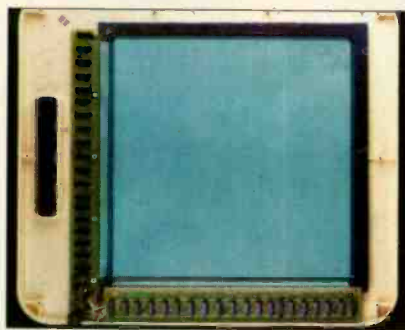
BY CHARLES RUBENSTEIN

Most microcomputers are controlled by keyboards, but joysticks, paddles, light pens and touch-sensitive tablets are rapidly becoming important ancillary input devices. We tested two examples of the latter: the Atari Touch Tablet and Chalk Board, Inc.'s PowerPad. The Atari tablet (suggested retail price \$89.95) is for the Atari family of microcomputers and includes a 16K ROM cartridge software package called AtariArtist. The PowerPad is compatible with the Atari series, the Apple II series, the IBM PC and PCjr, and the Commodore 64 and VIC 20. The PowerPad comes with an interface cable for the particular computer you are using and for some models includes drawing software. (We reviewed the Apple II Plus compatible PowerPad, which retails for \$149.95.)

The Atari Touch Tablet

The Atari Touch Tablet, at nearly 1 lb, is very similar to the Koalapad, which we reviewed in September 1983. With dimensions of $9\frac{3}{8}'' \times 7\frac{1}{16}'' \times 1\frac{3}{8}''$, however, the Atari tablet is 50 percent bigger than the Koalapad and its recessed active pad surface ($5\frac{5}{16}'' \times 4\frac{9}{16}''$) is 70 percent larger. Both units have pairs of push buttons, one on either side above the active area, which function much like the fire buttons on a joystick.

The active area on the Atari consists of two plastic sheets coated with resistive film. They are separated by an array of over 1200 non-conductive bumps, each 0.2" to 0.25" from its neighbor. The electronics of the unit translates a "short" between the resistive layers on the pad surface into a resistive x-y coordinate output (similar to the operation of a joystick). The active area is protected by a plastic sheet that can be lifted up to allow drawings, etc., to be inserted under-



The powerPad uses two plastic grid sheets to form 100 switches per square inch or 14,400 switches per pad.

neath for copying or tracing onto the screen.

With the Atari tablet, you can use a triangular stylus in addition to your finger, a pencil, etc. The stylus, which plugs into the rear of the unit, contains a convenient push-button switch that allows you to operate the pad with one hand. Using it gives more the feeling of writing or drawing and is more accurate than finger pointing. The stylus is slimmer than any finger and pinpoints its location better than an "averaged" location for a finger.

Software

The software that comes with the Atari Touch Tablet is Island Graphics' Micro Illustrator. It is a drawing program that uses a graphics menu for creating color pictures on the screen. The program is extremely easy to use, allows for either keyboard or stylus selection of menu elements, and either cassette tape

or DOS 2 diskette (DOS 3 is not yet supported) storage/recall of pictures.

The Chalk Board PowerPad

The Chalk Board PowerPad is a much larger touch tablet than the Atari model. Its dimensions are $20'' \times 17'' \times 1.5''$ and its weight is $4\frac{1}{2}$ lb. The recessed active area is $12'' \times 12''$. Built into the left side of the pad is a handle. However, the unit cannot be used while hanging from the handle; it is only convenient for right-handed use. The active area of the PowerPad is over six times the size of the Atari tablet area. Unlike the Atari tablet, or the Koalapad, the PowerPad does not have push buttons for hardware switching. Instead, you can define any area of the tablet under software control as a "command button." Location of command buttons is guided by a plastic overlay that accompanies each software package. For example, in the PowerPad version of the Micro Illustrator pro-

gram, five software defined (overlay) areas of the pad's top edge are used instead of switches for pen and menu control. Although much larger than its sister pads, the PowerPad is comfortable used on desk (or knee) and has non-slip feet.

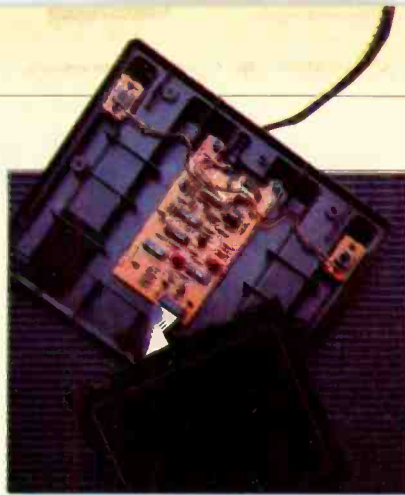
PowerPad Electronics

Unlike the analog (resistive film) Atari or Koala tablets, the PowerPad uses crossbar switches to achieve 100 discrete digitally defined positions per square inch. The membrane switch "sandwich" has a top layer of protective plastic and foil shield. Underneath is a plastic sheet that has a y-axis grid of 10 conductive 0.05" lines per inch with non-conductive bumps between each line. Beneath is another plastic sheet with an x-axis grid. Together the grids form 100 switches per square inch or about 14,400 crossbar switches per pad.

Inside the case are 36 CMOS 4051 single 8-channel (bidirectional transmission gate) multiplexers, which function as a hardware scanning circuit. This circuit translates "shorts" between x and y crossbars into unique 16-bit numbers. A maximum of 20 complete scans is done each second, one column at a time from the top right-hand corner to the bottom left-hand corner. If you place an object on the pad, all covered switch closures are reported to the computer and the scan may be slowed as the pad waits for the computer to receive a 16-bit serial stream of coordinate data from each closure site. As noted earlier, the active area is protected by a removable plastic sheet that is customized to each software program.

Software

As with the Atari tablet, a version of



Atari's resistive pad connects to an interface board.

the Micro Illustrator software package comes with the PowerPad. The software is available on disk for the Apple II series of computers.

Several other software packages are available, a few of which we looked at. One of them, the PowerPad Programming Kit, is an advanced graphics package complete with test programs. It covers the software techniques you need to write your own programs using the PowerPad. You can create your own pad-handling routines and establish your own command buttons. As noted, command buttons function like the push buttons on the other pads, but tens of buttons are available rather than two. The buttons can be used as simple on/off switches or to call subroutines, and they can be defined within BASIC and/or machine language programs.

Bear Jam is a program that uses 25 command buttons. It is a children's game that encourages parents to work with their preschoolers to recognize and compare six basic shapes and six colors. Once the child outgrows the simple games, a provision allows the parent or child to create new games.

LogiMaster is a game with a 34-command-button overlay that allows you to play several variations of the popular Mastermind game. It even lets you create your own version of the game.

Finally, Leo's Links is a golf game controlled with 35 command buttons. You play on predefined courses until you're ready to create your own course. This is a golf simulation that requires the player to understand the basic physics of golf.

Each program package consists of a manual, a software program on cartridge/disk, and a plastic overlay showing the predefined command buttons. PowerPad software packages range in price from \$29.95 to \$49.95.

Comments and Conclusions

The Atari and PowerPad touch tablets give users the same general ability—to skip the keyboard and enter information into the computer by moving a finger or a stylus over the touch-sensitive surface. Each has certain advantages. The PowerPad has several software packages available for it, and it can sense many pressure points simultaneously. The Atari tablet is much easier to handle.

The big question, however, is whether or not you would derive a continuing benefit from either of these items. You would require a strong need for drawing software to really benefit from either. The software programs that Chalk Board offers (other than Micro Illustrator) do not seem worth an investment of \$150-\$200 (including hardware). And Micro Illustrator itself has a narrow focus, whose novelty could wear off quickly.

To sum up, both products function well and are worth the price—to those who need them. ♦

	<table border="1"> <thead> <tr> <th colspan="2">Specifications</th> </tr> </thead> <tbody> <tr> <td>Product:</td> <td>PowerPad</td> </tr> <tr> <td>Manufacturer:</td> <td>Chalk Board, Inc. 3772 Pleasantdale Rd. Atlanta, GA</td> </tr> <tr> <td>Dimensions:</td> <td>20"W × 17"D × 1.5"H</td> </tr> <tr> <td>Weight:</td> <td>4½ lb</td> </tr> <tr> <td>Suggested Retail Price:</td> <td>\$149.95 (for the Apple II series)</td> </tr> <tr> <td>Features:</td> <td>Micro Illustrator software</td> </tr> <tr> <td>Product:</td> <td>Atari Touch Tablet</td> </tr> <tr> <td>Manufacturer:</td> <td>Atari, Inc. 1265 Borregas Ave. Sunnyvale, CA 94086</td> </tr> <tr> <td>Dimensions:</td> <td>9¾" × 7⅞" × 1⅞"</td> </tr> <tr> <td>Weight:</td> <td>1 lb</td> </tr> <tr> <td>Suggested Retail Price:</td> <td>\$89.95</td> </tr> <tr> <td>Features:</td> <td>AtariArtist ROM cartridge</td> </tr> </tbody> </table>	Specifications		Product:	PowerPad	Manufacturer:	Chalk Board, Inc. 3772 Pleasantdale Rd. Atlanta, GA	Dimensions:	20"W × 17"D × 1.5"H	Weight:	4½ lb	Suggested Retail Price:	\$149.95 (for the Apple II series)	Features:	Micro Illustrator software	Product:	Atari Touch Tablet	Manufacturer:	Atari, Inc. 1265 Borregas Ave. Sunnyvale, CA 94086	Dimensions:	9¾" × 7⅞" × 1⅞"	Weight:	1 lb	Suggested Retail Price:	\$89.95	Features:	AtariArtist ROM cartridge
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SOFTWARE REVIEWS

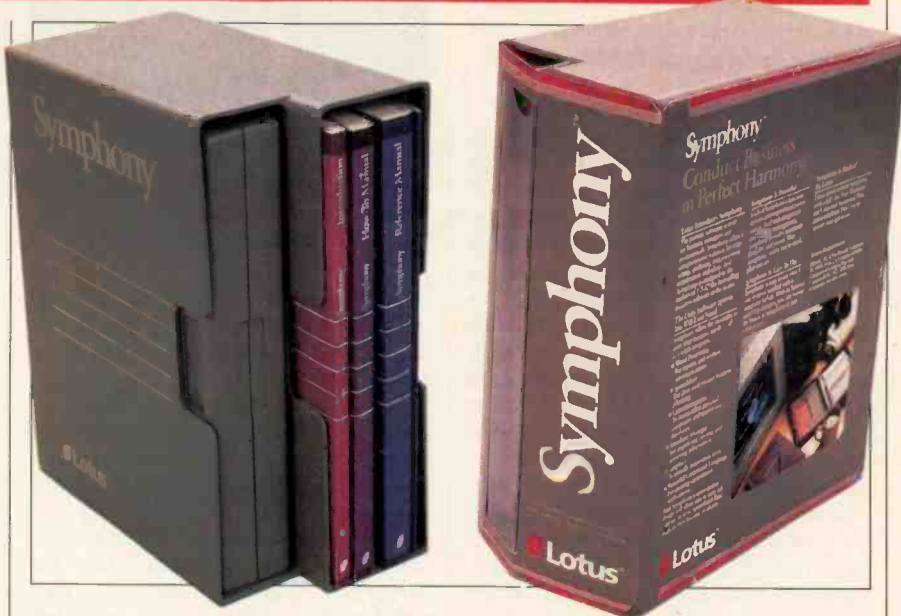
SYMPHONY

Powerful new integrated software from Lotus Development Corp., the makers of 1-2-3

BY LEE D. ZIMSKIND

A long-awaited integrated software package has arrived from Lotus Development Corporation. The makers of 1-2-3 have released Symphony. Rumors that Lotus was developing a package to integrate word processing with their existing product circulated for months before the formal announcement. When they finally unveiled the package, it sounded too good to be true: Not only would Symphony integrate word processing, spreadsheet and graphics capabilities, but it would also include communications and database facilities. So with some enthusiasm I began to review Symphony.

I was disappointed to find that I would not be able to run Symphony on the 256K machine that I had been using to test other software. The minimum requirement for Symphony—320K bytes of RAM—gave me a good excuse to purchase the extra memory and the clock that I had been wanting. Symphony also requires a graphics monitor if you want to produce graphics on your screen—it



is not possible to use the graphics capabilities on a standard IBM monochrome monitor with monochrome adapter.

Installing Symphony is time-consuming. First of all, you must make back-up copies of all the diskettes in the package—six of them. Then you create a Driver Set, which provides Symphony with the specifics about the hardware you are using—type of monitor, printer, modem. In theory, you can create as many drivers as you want, but my program diskette only had room for two. Each driver is given a name by the user, with "Lotus" the default. The documentation is very thorough, and since the process of creating drivers is completely menu-driven, the documentation is almost superfluous. For example, when selecting a printer, you are presented with a list of 31 items to choose from.

Implementation

The basis of Symphony is a single large worksheet composed of cells organized into rows and columns—a maximum of 8192 rows and 256 columns, subject to memory limitations. You address the cells by row number (from 1 to 8192) and column label (A,B,...,Z, AA,AB,...,IV); for example, the address of the cell in the 55th column and 15th row is BC15. Although you only address the cells in this manner when you are in the spreadsheet mode, Symphony always organizes the data this way.

At any time only one worksheet is available in the memory of the computer. You can organize this worksheet into different areas in order to use the various

types of applications in Symphony; for example, you may want to write a memo using word processing with a spreadsheet in the middle. Or, to be even more sophisticated, you may want to capture information from a remote computer system within the body of a memo.

Symphony uses windows to give the user a method of organizing the worksheet. Windows are defined as rectangles within the worksheet through which you can view a portion of the data. You may define as many windows as desired. You can use them to show different parts of the worksheet or overlap them to show different views of the same part of the worksheet. You must be careful when using overlapping windows because changes to a cell in one window may affect the value in the other windows. The size of a window and its position on the screen are user-controlled: You can have a spreadsheet and an associated graph on the screen concurrently and see dynamically the results of "what-if" questions. For purposes of writing this review I created a window with an outline which I was able to consult while I wrote the text.

Symphony uses different kinds of windows for each of its applications—spreadsheet, word processing, graphics, communications and forms. The window type determines the appearance of the window and the commands that are available. Some of the function keys are used consistently regardless of application (F1, F6, F9, F10). Others, dependent on the window type (F2, F3, F4), make things a bit difficult for the beginner but

Overview

Product: Symphony
Publisher: Lotus Development Corporation
161 First St.
Cambridge, MA 02142
Price: \$695 (\$200 to registered owners of 1-2-3)
Computers: IBM PC or PC-XT, Compaq
Hardware Requirements: 320K RAM, two 320K floppy drive disks or one 320K floppy drive and a hard drive
Operating Systems: PC-DOS 2.0 or 2.1, MS-DOS 2.0 or 2.1
Features: Integrated system, word processing, data base management, graphics, and communications capabilities

**IT'S A SMALL MIRACLE HOW HEWLETT-PACKARD
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PROCESSING, A TELECOMMUNICATIONS MODEM
AND COMPLETE IBM CONNECTABILITY INTO**



THE PORTABLE.

For years business people had to choose between the power of a desktop computer and the limited capabilities of the first portables. That problem was solved when Hewlett-Packard introduced The Portable.

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1-2-3™ from Lotus,™ America's most popular spreadsheet, file management and business graphics program, is permanently built into The Portable. So is Hewlett-Packard's word processing program, MemoMaker. Just press the key and you're ready to work.

The Portable even has a built-in modem and easy-to-use telecommunications software to send

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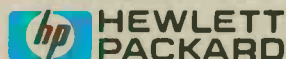
The Portable's rechargeable battery gives you 16 hours of continuous usage on every charge.

Finally, you can work comfortably on a full size keyboard and an easy-to-read 16-line by 80-column screen. And it all folds shut to turn The Portable into a simple nine-pound box.

The Portable. A small miracle...perhaps. But then consider where it came from.

See The Portable and the entire family of personal computers, software and peripherals at your authorized Hewlett-Packard dealer. Call (800) FOR-HPPC for the dealer nearest you.

Setting You Free



Symphony

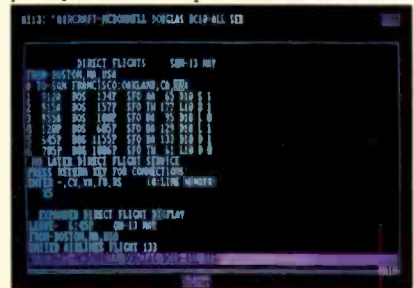
are easy to remember with practice. In addition, a function key template is available.

The method of invoking commands is consistent across all applications. Regardless of the type of window currently in use, pressing the F9 key displays a list of "services" or functions: Window, File, Print, Configuration, etc. The F10 key displays a menu of alternatives that depend on the type of window currently in use; for example, the word processing menu includes Search, Replace, Justify, and Format, while the communications menu includes such functions as Phone, Log-in, and File-Transfer. You invoke a command by moving the cursor to the desired selection and pressing return. As each command is highlighted by the cursor, additional information about the selection is displayed in a text line above the options. Alternatively, you can select functions by typing the first letter of the choice. You can cancel selections by pressing the ESC key. Selecting a command may result in the display of a new menu of options. The names of the commands are reasonably self-explanatory and the description in the text line is usually sufficient, but more details are available through a Help facility that is easy to use.

Although the documentation available at the time of writing this review was preliminary, it appears extensive and clearly written. The package comes with a tutorial, but, like the various reference cards and templates, it was not completely implemented in time for this review.

Six diskettes are included in the package, but after you have loaded Symphony into the computer and placed the Help and Tutorial diskette in the drive, the only function that requires you to change diskettes is printing a graph. However, beginning a session, whether with a hard disk or a two-diskette system, is more cumbersome than with some other packages.

The feature that differentiates Symphony from other products is its true in-



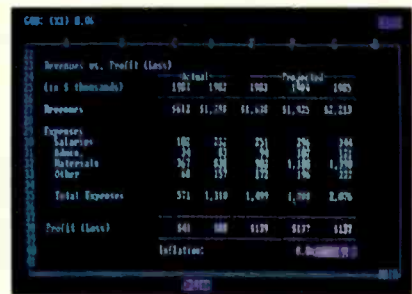
A communications session—airline reservations on CompuServe

tegration. Because a window type is not permanently assigned, it can be changed with one key stroke. Thus you can easily integrate information of different types—word processing, spreadsheet, graphs, forms—within one working document.

I particularly liked the use of color. It made the screen easier to read and was easier on the eyes than is only black and white on a color monitor.

Word Processing

When you select Document as the window type, the default format line is displayed at the top of the screen. You have complete control over the settings for the format line (left and right margins; tab interval; left or even justification) through the Configuration Service. The window is available immediately for entering text. The default mode for word processing is Insert mode, with the INS key used as a toggle to switch to



The Symphony spreadsheet is 8192 rows by 256 columns

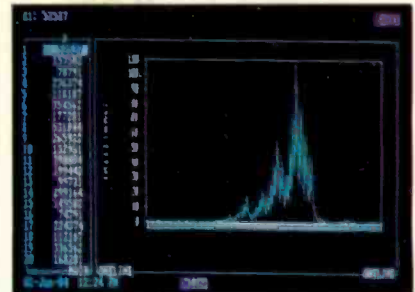
Overstrike mode. Word wrap is also assumed in the default settings.

Cursor control is good. You can move around the document by character, word, line or phrase. It is easy to move to the beginning or end of a line, paragraph, page or document. There is even a Speed Search for finding the next occurrence of a single character. With one key stroke you can, in addition, ask where you are on the printed document.

Most of the usual facilities are available: copy, move and erase blocks of data; search and search-and-replace for strings of data. You can specify automatic justification after execution of the block and string commands. Unfortunately, after basic character insertion or deletion you must invoke a format command to adjust the text.

Unlike many other packages, Symphony treats underlining and boldfacing as special printer functions similar to italicizing, superscripting and subscripting. As a result, it takes several keystrokes to use these features, and they do not appear on the screen as they

Symphony can display data and graph it simultaneously



will in the printed material. Lotus also supplies a set of international characters for use with appropriate printers.

Symphony supports multiple formats within the same document. You are able to insert format lines at any point. You can name them and invoke them easily by name. Using the multiple format feature, you can also obtain different kinds of indentation within a document, including hanging indents. Although there is no decimal tab, it is not a major shortcoming because of the ease with which you can incorporate spreadsheets into word processing documents. It is even possible to mix word processing and spreadsheet entries on the same line of a document, although it is easier if they occupy different lines.

Spreadsheet

As one would expect of a product from Lotus Development Corporation, the spreadsheet capabilities of Symphony are extensive. Space does not permit a detailed comparison with 1-2-3. However, users of 1-2-3 will have some learning to do since the method of invoking commands is not the same: The Slash commands of 1-2-3 have been replaced with the F10 commands in Symphony.

A "sheet" window contains a border with row numbers and column labels. The default setting for column width is 9 spaces, but the width of a column may be easily reset. All of the standard features of spreadsheets—moving, copying and erasing cells or ranges of cells—exist in Symphony. Also included are all the usual formatting capabilities for text and numeric cells. Specifying cell calculations is easy, and the usual mathematical and business predefined functions exist. In addition, new functions have been added for string manipulation and statistical calculations.

Since Lotus 1-2-3 is well known and considered almost as the standard of spreadsheet programs, I will not dwell on the spreadsheet capabilities of Symphony except to say that it contains all of

(Continued on page 111)



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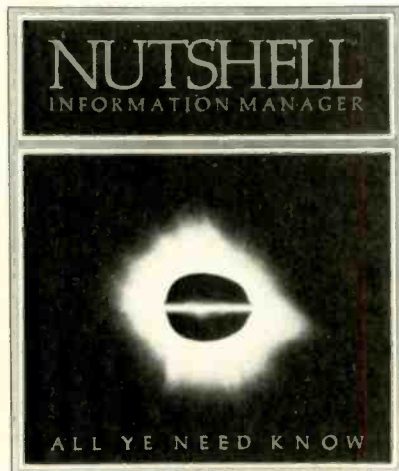
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NUTSHELL

Easy-to-use information management for 16-bit computers

BY TERRY EDWARDS



SOME of us don't need really high-powered databases. We just need to be able to set up simple data entry forms and put in and pull out the data. Of late, several such databases have appeared, among them Ashton-Tate's Friday! and Software Publishing's PFS File. Another recent entry is Leading Edge's Nutshell Information Manager.

Nutshell, which is intended for IBM PCs and "100% compatibles" (such as Leading Edge's own computer), was written to take advantage of the abilities of 16-bit microprocessors (over 8-bit microprocessors) to handle very large files. Here are some of Nutshell's specifications:

- Records per field: 60,000
- Characters per field: 16,000,000
- Character per record: 16,000,000
- Records per file: 2,000,000,000
- Files per disk: no limit (rather, limited only by disk capacity)

Leading Edge claims that Nutshell can locate a unique record in 2 seconds in a 100-record file. Nutshell automatically indexes all fields, automatically maintains indexes, supports five types of data (text, numeric, date, calculated, or summary). It uses a hierarchical file structure. Nutshell has the capacity to input and output data in ASCII format.

Using Nutshell

Installing Nutshell is simple and

straightforward. Because it is designed to run on the IBM PC and similar computers, installation only entails copying the original disk onto a formatted disk containing PC-DOS or MS-DOS. It is then ready to run.

Nutshell is preinstalled for Epson dot-matrix printers. A choice of "other" is available. There is a separate installation program for the C. Itoh Prowriter printer, called "Protrax," distributed by Leading Edge.

The Nutshell package contains two disks: a tutorial disk and the master disk. The tutorial disk is a complete version of Nutshell with built-in prompts. It presents Nutshell's main features in a style that is consistent and easy to understand. Prompted by the tutorial, you are led through Nutshell's basic operations, which eases the learning process considerably.

After a tour through the Nutshell instruction disk, I turned to the master disk to see whether Nutshell could be put to practical use. I created a membership file that included some financial information to test the program's computational abilities.

The program came up on the screen just fine, with a fancy line graphic of the Nutshell logo. The first screen with which you interact presents the copyright notice, a graphic of a file drawer and the command ENTER FILENAME: . . . Unfortunately, Nutshell does not allow you to look at the disk directory at this point—you're expected to know the file name in advance. (There's a way around this, though. I created an AUTOEXEC.BAT file that, when the computer was powered up, listed the disk directory and then, on command, brought up Nutshell.)

The Browse Screen

Once you have typed in a file name, Nutshell presents its "Browse" screen.

The Browse screen is Nutshell's work area. It can display the contents of a file—the field names and the contents of the fields.

If you have entered the name of a file containing data, the Browse screen will display the first record in the file. If you typed the name of a nonexistent file, Nutshell will display an empty Browse screen and notify you that no such file exists. Thus, the Browse screen acts as a kind of "home base" from which you begin and to which you return when a specific action or activity is complete.

You can retrace your steps from any place in Nutshell, by using the ESC key. It takes you back to the previous screen, that is, it will return you to the function

or screen you were last using.

The Browse screen is divided into three parts: a header, the body and a menu. The left side of the header line gives the function key assignments: F1:HELP, and cp7F2:MENU. These function key assignments, as well as those of the cursor keys, are consistent throughout Nutshell. The same key always performs the same function. While you are in the midst of trying to master a new program, you'll like knowing that some consistency exists.

On the near-right side of the header line, Nutshell tells you how many records are available. When you have just brought up a file, the header line will show the total number of records in the file. When you have performed a selective search, it will display the number of records found in the search.

On the far-right side of the header line, an arrow indicates whether you can use the PGUP or PGDN keys on the PC's numeric pad to move to the next record. With the same keys and the CTRL key you can also move to the end or beginning of a file.

At the bottom of the screen is displayed a menu. Pressing the F2 key (see above) automatically places the cursor over the menu's first command. You can then use either the right-arrow or left-arrow cursor keys—or the first letter of the command—to move the cursor to the command you wish to use. To invoke a command, just press ENTER. While this is straightforward and relatively quick, Nutshell also gives you the option of bypassing the menu and entering a command directly by pressing the ALT key and then typing out the command. This is a nice touch that will increase the efficiency of those who like to use direct

(Continued on page 124)

Overview

Product: Nutshell Information Manager
Price: \$395

Supplier: Leading Edge Products, Inc.
55 Providence Highway
Norwood, MA 02062

Operating Systems (s): PC-DOS, MS-DOS
System

Requirements: IBM PC or compatible
with 256K RAM.
Two disk drives
recommended

Opinion: Nutshell is a high-quality product that works as advertised. If you are looking for an uncomplicated file management program for home or small-business use, you would do well to consider this one.



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by Casio's innovative sheet key technology, this handy feature makes complicated scientific equations easier to solve because the major function keys are displayed oversized on their own keyboard.

Like our FX-90, our FX-450 (\$34.95) has a 10 + 2-digit LCD display and a keyboard with touch-sensitive keys. But the keys are double size and the number of functions increases to 68. Most importantly, it lets you calculate with the speed of light—and eight other commonly used physical constants, including

Plank's constant and atomic mass. It also makes computer math calculations and conversions in binary, octal and hex equally easy to use.

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REAL WORLD

Devices to link your micro with the physical world for monitoring and control applications

“OF what practical use is a personal computer?”

In the days before electronic spreadsheets and word processors, this question was asked by technoskeptics everywhere.

“You can balance your checkbook,” was one standard reply.

“Learn to write programs,” another would answer.

“You can play games,” someone else said.

“I could use it to control my home,” still another would retort.

Home control! Ah, there was the stuff of dreams. Since the 1939 World’s Fair (and probably even earlier) pundits have been predicting the automated home. Now, 45 years later, the low-cost personal computer—the gadget that can realize this vision—has arrived.

But where is the automated home?

For one thing, electronic spreadsheets and word processors attracted many of

the people who would have developed the products necessary for a computerized home. For another, home automation would just simply cost too much. Were automated “ham and eggs” really worth the thousands of dollars necessary to get things cooking? Obviously not.

Nevertheless, a few souls did press on. Technology advanced. And today there exists a surprising variety of innovative and reasonably priced devices that allow users to control or at least connect, their



INTERFACES

BY JOHN CONWAY

computers to the real world. Called interfaces, these devices, coupled with a personal computer make possible automated home security, environment control, even weather prediction.

Types of Interfaces

Computers lead pretty sheltered lives. Their insides, tightly controlled, low-noise, low-voltage habitats, cannot tolerate extremes of temperature (or extremes of anything, for that matter). Life

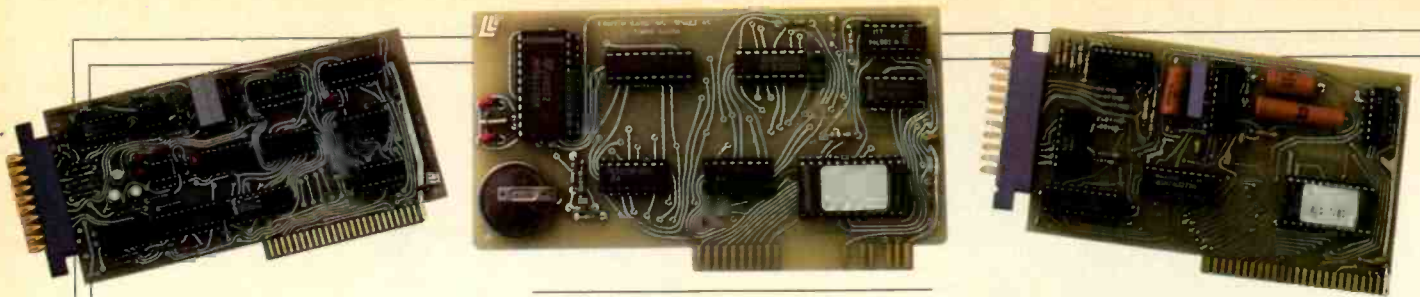
in the outside world, as we all know, is considerably rougher.

To have computers control the world outside them, we must use interfaces—devices that translate rough-and-tumble real-world stimuli into electrical signals (for that's all computers understand) at levels appropriate to their delicate works. In turn, interfaces also beef up computers' relatively puny outputs so they can convey instructions to other devices.

Computer interfaces fall into three categories (Fig. 1):

- *Computer-controlled switches (CCS).* Electromechanical devices (such as relays) and solid-state switches (such as triacs) that provide simple on/off input or output control functions.

Photo equipment credits; CVM and counter, Hewlett-Packard; oscilloscope, Heath Co.; anemometer, Watrous & Co., Inc.; computer, Park Plaza Computer Center; computer screen by Nick Ciancaglini.



Above and on the facing page are boards for interfacing computers to the real world and the devices they control.

- *Digital-to-analog (D/A) converters.* Solid-state devices that convert the digital output of a computer into analog voltages or currents (or both) to be used in the outside world.
- *Analog-to-digital (A/D) converters.* Solid-state devices that convert analog voltage or currents into digital form intelligible to computers.

Computer-Controlled Switches

Computer-monitored switches provide the broadest class of readily available real-world input signals. They monitor pressure, temperature, humidity,

light, sound, and liquid levels. They detect whether doors, windows, vents, or valves are open or closed as well as a variety of similar "binary" conditions. Fortunately, as a source of inputs, computer monitoring of switches is simplicity itself.

To monitor a switch, the computer's I/O port is programmed to test or "poll" the status of the input pin connected to the switch of interest. As the switch opens or closes, the computer receives a high or low (1 or 0) input signal. If the voltage passing through the switch ranges between 2.4 to 5 V dc, a simple

TTL or CMOS inverter provides a suitable interface or "buffer." To monitor higher voltages, input isolation is necessary.

An opto-coupler between the computer and switch provides 1000 V or more of protection. This isolator will usually prevent a system from suffering damage from such accidents as short circuits or overvoltages.

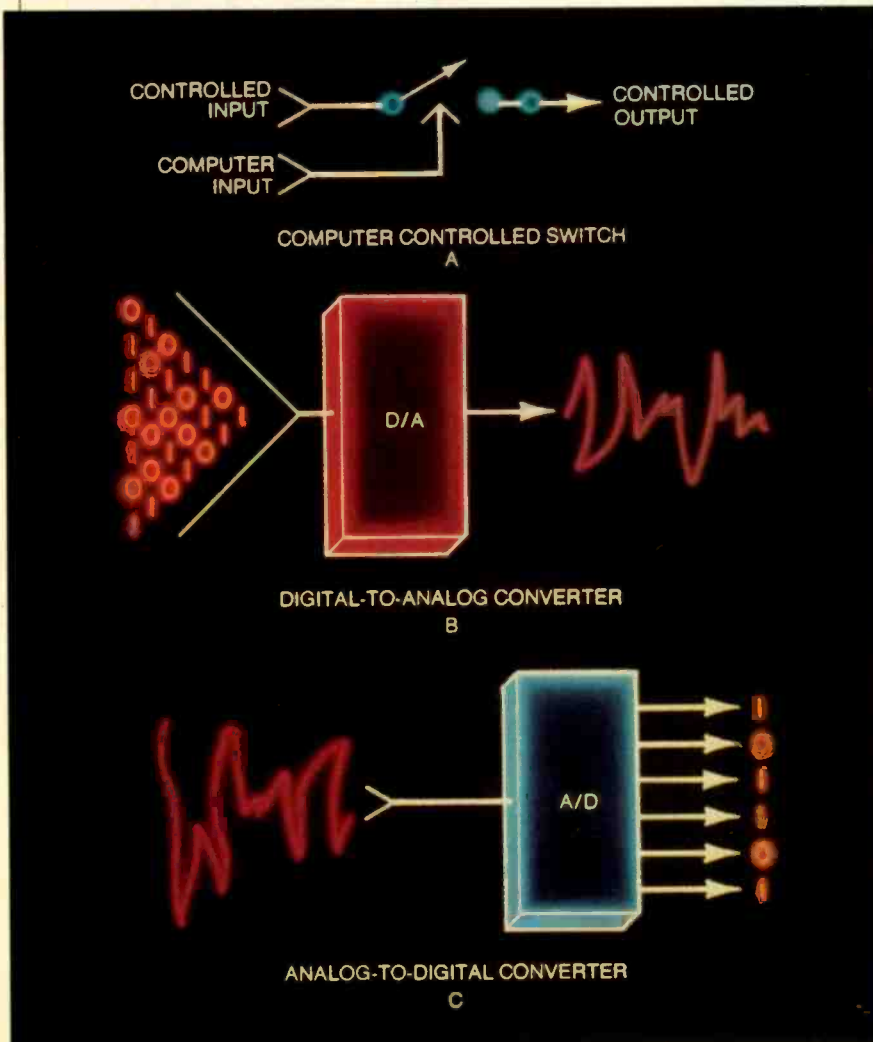
The isolator consists of an LED that illuminates a phototransistor when powered with a current of less than 20 to 30 mA. Obviously, the state of the outboard switch, sensor or transducer determines whether or not current flows through the LED. The diode's glow triggers the light-sensitive transistor into conduction or ON. The TTL/CMOS-compatible output of the coupler provides a corresponding binary HIGH or LOW signal optimized for use as a computer input. Since light connects the optocoupler's input and output, only those signals exceeding the maximum dielectric voltage of this "light pipe" arrangement can cause a failure of the input interface.

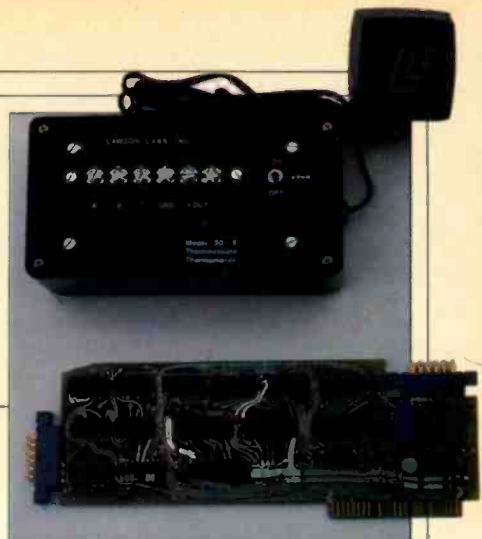
Computer-controlled switching (the inverse of switch monitoring) is the most basic of all output control methods. CCS devices span a wide range of switching technologies from simple electro-mechanical relays to transistors, silicon-controlled rectifiers (SCRs) and triacs. The end application usually determines the choice of switch.

Electro-mechanical relay-based interfaces are best suited for high-current applications, where speed is not a significant factor. Their extremely low contact resistance (measured in micro-ohms) makes them especially useful for battery-based systems. Relays can easily handle hundreds, even thousands, of amperes and provide built-in isolation. Unfortunately, few offer response times much faster than 500 μ s. Also, because they are mechanical, the number of operations before failure is reduced to tens of thousands.

Solid-state switches or relays eliminate many of the problems associated with their electromechanical counterparts, but not without revealing some problems of their own. For example, transistors provide an excellent way to

Fig. 1. Interfaces fall into one of three categories.





switch direct currents and offer fast response times, long life and low turn-on currents. Yet, since the transistor is essentially a one-way valve, ac control or reversing dc control typically involves four transistor bridge circuits. These can become quite expensive as power ratings increase. Transistors also produce a voltage drop across the C-E or D-S junction—a drop that robs power and makes heat sinking necessary.

SCRs and triacs offer the fast response times and solid-state reliability of transistors and also higher current ratings, lower voltage drops and reduced cost relative to power. They are natural for high-power circuit applications. Nevertheless, they suffer from a peculiar property called "latch-up." When an SCR or triac is gated ON, the switch remains closed until current flow is reversed (during ac-zero crossing, for example, or via capacitor-induced commutation) or until current flow ceases altogether. This limitation makes them unsuitable in simple dc systems.

Wide Range of Switch-Class Products

Products that utilize CMS or CCS techniques and technologies range from devices consisting of nothing more than opto-couplers or relays with transistor-buffer front ends to complex devices that communicate over the ac wiring in your home and control appliances, lights, or just about any device that lends its operation to ON/OFF control.

Here are a few CMS/CCS products currently available:

- The Switcheroo series of CCS modules gives owners of most popular personal computers an inexpensive control interface. The system consists of a computer-specific motherboard that accepts a variety of electro-mechanical relay modules. Modules include SPST, DPDT, polarity reverse and multi-vibrator functions. Each Switcheroo motherboard can hold up to eight control modules. Expansion kits permit control of up to 64 modules. Program listings explore applications in such areas as radiotelegraphy, telephone dial-

ing, and appliance and toy control. Adapters allow direct control of motorized/electronic Fischer-Technik, Lego, Erector and Capsela model building kits.

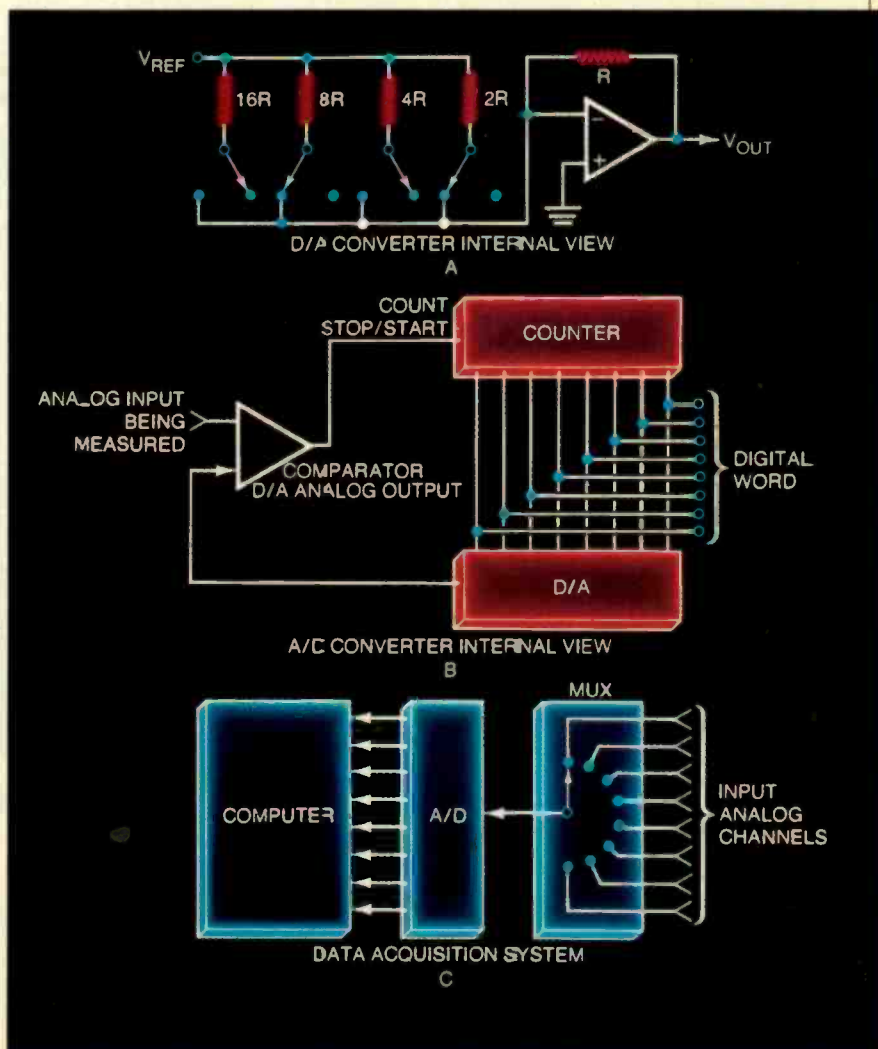
- The A32 I/O and A16 I/O boards, plug-compatible with the Apple II, II+ or IIe expansion slot, increase the input and output capabilities of this popular personal computer. The I/O lines of each board are user-configurable in any combination of inputs and outputs and each open-collector line can sink 100 mA. Boards also come equipped with up

to four isolated interrupt lines. Included software allows easy Applesoft "BASIC &" calls to control the units.

A companion product, the R16 T/B adds screw terminals to the I/O boards.

- The CDFR controls up to two permanent magnet motors from a conventional parallel output (printer) port. Four models cover an output range from 6 to 48 V dc at 7 to 40 A for each output.

Fig. 2. D/A and A/D converters and a data acquisition system.



INTERFACES

You can control speed and direction information from your computer or by remote joystick (DIP switch-selected). BASIC PRINT, BASIC OUT or assembly language routines direct the operation of the unit. Output circuitry for relayless pulse width modulation is optically isolated from the CDFR control logic and your computer to eliminate ground loops.

- Users who desire an all-in-one class of real world interface should consider the ADC-1. It combines a 16-channel A/D data acquisition system with four digital inputs, six digital outputs, an ac line carrier remote control (up to 256 control modules possible) in a single compact unit. In operation, the ADC-1 connects to any computer equipped with an RS-232 interface. Software listings for virtually all popular personal computers come as standard equipment. A wide variety of sensors, transducers, and control modules of the BSR X-10 type round out the system.

- The SmartHome-I allows your personal computer to act as a security sys-

tem and appliance controller. The system consists of a command control unit that connects to any RS-232 port, a variety of security sensors, output control modules (BSR X-10 or Leviton type) and applications software packages. SmartHome-I communicates to the remote control modules and sensors over the ac wiring in your home. Applications software is icon-based and joystick programmed. At present, the device is compatible with Apple II and IBM PC and PCjr computers.

Converters Extend Scope

Digital-to-analog converters fill many needs for applications requiring continuously variable sources of power. These devices convert digital signals into a voltage or current proportional to the value of the digital signal. Though a primitive D/A converter can be fabricated from a resistor/capacitor filter, most basic D/A designs consist of stabilized resistor ladders with digital inputs from eight to sixteen bits in width (Fig. 2A). For each ascending bit in a word, the D/A produces

an analog output with twice the value. D/As find use in music generation, motor control, lamp dimming.

Since the A/D converter acts as a mirror image of the D/A, its strengths lie in its ability to convert everyday signals into varieties that are computer-understandable. Interestingly enough, the basic tracking type A/D is nothing more than a D/A converter with a comparator/counter rear end (Fig. 2B). Circuitry internal to the A/D directs the analog input to one side of a comparator. The other side of the comparator is fed by the output of a D/A converter. A counter (or similar circuit) quickly runs through all possible digital combinations. When the analog output of the D/A matches that analog input of the outside world, the comparator changes state. This signals the A/D that it has found a digital word combination equivalent to the analog input being measured. The conversion is complete! In practice, this entire operation occurs in a few milliseconds or microseconds.

(Continued on page 104)

Clockwise from lower left are data acquisition systems from Vantec, Ragers Labs, Data Translation, Remote Measurement Systems, and Vaisala, Inc.



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KEYBOARDS: THE POWER AT YOUR FINGERTIPS

The inner workings of the primary pathway to your machine

BY TJ BYERS

COMPUTER keyboards are like steering wheels on cars: If the feel is not just right, operating the machine is a chore, not a pleasure. And, as any veteran micro user knows, although keyboards may look alike, they vary dramatically in mechanical structure and function.

Keyboards were invented along with the typewriter. They made writing quick, convenient and—above all—clear. Today they are the means of communicating with computers, the interface between the user's thoughts and the enormous processing powers of the computer.

Keyboard Technology

A keyboard is really nothing more than an array of switches arranged in a logical order. Pressing a key activates an electrical signal that the computer interprets as information. There are several different ways by which the electrical signal can be generated by the key action. Two are capacitive switching and ferrite core switching.

Capacitance switching has found widespread appeal because of its low cost and high reliability. Basically, a capacitor is nothing more than two pieces of metal separated by an insulator. The value of the capacitance is inversely proportional to the distance between the two plates. In a capacitive switch, one metal plate is fixed to a solid backing; the second plate is attached to the keyswitch plunger (Fig. 1). When the plunger is de-

pressed, the movable plate comes closer to the bottom plate, increasing the capacitance of the switch.

The plates of the switch are connected to an oscillator whose frequency is determined by the capacitance. As you increase the capacitance by moving the plunger down, the oscillator's frequency decreases. A phase-locked loop (PLL) senses this frequency and removes the input signal. To prevent erroneous interpretation of a partial key depression, the PLL sets a threshold—the minimum frequency change that must be detected for a signal to be generated.

Ferrite core keyswitches also rely on changing electrical parameters. They use inductive coupling. When you depress the key, a ferrite rod on the key-stroke plunger slides into a transformer core (Fig. 2). The transformer, loosely coupled, is composed of two coils of wire close to each other: a primary power coil and a secondary sensor coil. When the rod is inside the transformer, it increases the coupling between the coils. Then a pulse generated in the primary coil is transferred to the sensor coil and an output signal is generated. When the switch is released, the concentrated magnetic field and the coupling between the coils disappears.

Ferrite core switches achieved wide acceptance in the early 1970s and have been used successfully on many comput-

TJ Byers is the author of numerous books on electronics and computers.

er keyboards. They offer high performance at a relatively low price and are virtually immune to failure due to dust, spills and other common office hazards.

Mechanical Switches

The old standby in switch technology is, of course, the mechanical switch. Long before there were ferrite core or capacitance devices, mechanical switches were hard at work. Unfortunately, they are prone to contact bounce. (When you push the key once, the switch contacts may open and close several times.) Debouncing circuits, however, are fairly cheap to incorporate, so mechanical keyboards are still in wide use.

Mechanicals are divided into keyboards and keypanels, depending on the way the key unit is constructed. A keyboard is an assembly of individual switches placed on a common field. The typewriter is a perfect example of keyboard design. Keypanels, on the other hand, are built as one unit, with the identity of the individual switches hidden behind an overlay, usually of plastic. The Timex 1000 uses a keypanel.

The hard mechanical keyboard, the oldest of the mechanical keyswitching technologies, generally performs switching with either gold cross point or bifurcated wiping contacts (Fig. 3). The latter are the type of contacts you would normally find in a wall switch or other electrical equipment. Although they cost very little, they suffer from excessive contact bound and metal fatigue, which

PHOTO BY MICHEL TCHEREVKOFF

Keyboards

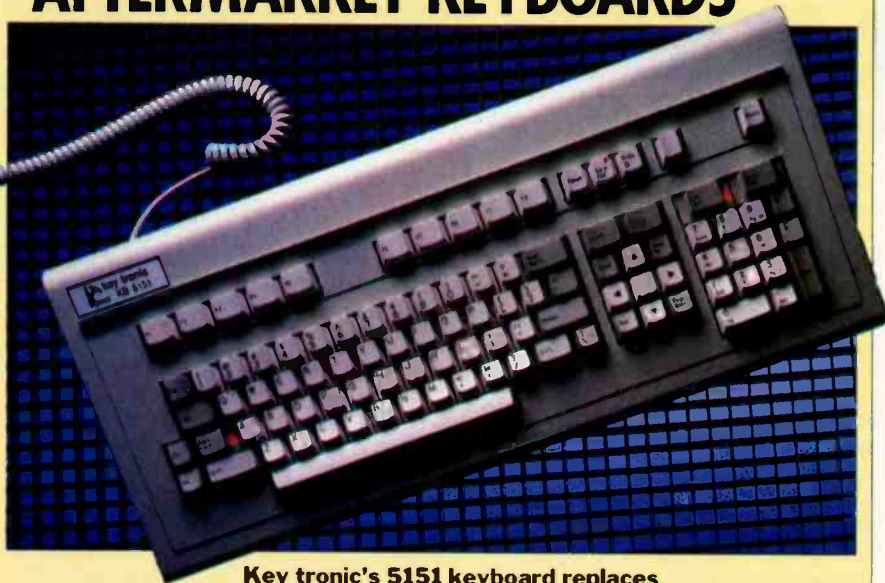
eventually overcome them. Recent advances in switch technology, however, have greatly reduced contact bounce while extending switch life, and you will find these contacts in many keyboard designs.

Keypanels are relatively new to computer users. Switch designs for keypanels come in three distinct types: domeswitches, membranes and conduc-

tor. The dome's inherent flexibility allows it to snap down with a sprightly feel. When released, it springs back to its original shape.

A plastic overlay is normally laminated over the field of domeswitches. The plastic serves two purposes. First, it seals the keypanel components from contamination by moisture and dirt. Second, it usually sports a legend with symbols

AFTERMARKET KEYBOARDS



Keytronic's 5151 keyboard replaces IBM's with a more logical layout.

YOU are probably now looking at your present keyboard and wondering what you can do to upgrade it to the quality you would like to have. Well, you can do a lot.

Aftermarket keyboards are big sellers, especially among IBM owners. Why IBM forsook its finely tuned Selectric keyboard in favor of the one it used on its PC is anybody's guess.

Fortunately, you aren't stuck with it. No fewer than half a dozen independent keyboard manufacturers offer replacement keyboards for the PC. They range from capacitance to mechanical.

Despite its apparent bumbling, IBM had the foresight to make its keyboards

detachable. One of the ergonomic suggestions put forth by the DIN committee was removable keyboards. That was one suggestion IBM decided to follow. Changing keyboards is as simple as pulling the cord out of the old board and plugging in the new one. In a matter of seconds, you can change the entire ergonomics of your computer.

IBM is not alone in this respect, not by a long shot. Replacement keyboards are available for the Apple, Victor and many other machines. In some cases, however, you may be required to complete the exchange, but none are so complicated that the entire job cannot be performed in less than an hour. ♦

tive elastomers.

A *domeswitch keypanel* (Fig. 4) contains stainless-steel, dome-shaped disks attached to a printed circuit board. The latter is etched with silver-plated copper lines, one of which passes under the center of the dome and another that connects to the dome. When you depress the key, the pressure collapses the dome, making contact with the center conduc-

that correspond to the switch functions. These graphics are essential to the user because most keypanels are flat, opaque structures, without graphics, so you have no hint where the switchpads are hidden.

Conventional *membrane keypanel* technology uses three layers of polyester film sealed under a plastic overlay (Fig. 5). The outer layers of the film are

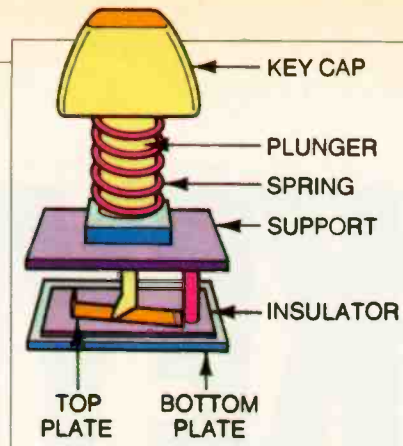


Fig. 1. Capacitance keyswitch.

screened with a pattern of switching points using conductive silver ink. The images are aligned so that corresponding switch points touch. Separating these two layers is an insulating sheet of polyester. Holes are punched through the insulating sheet where the contact points are to meet (Fig. 6). When you apply pressure to the keypanel, the plastic deforms, allowing the two metal screenings to make contact through the hole.

The thickness of the spacer layer is a major factor in the actuation force of the switch, with switch travel often measured in thousandths of an inch. The entire keypanel is usually glued to a rigid substrate to prevent the keyboard from flexing during normal operation.

A cousin to the membrane keypanel is the conductive rubber, or *elastomer keyswitch*, shown in Fig. 7. An elastomer switch is constructed from a single sheet of rubber and a printed circuit board. Into the thin rubber sheet is molded a dome lined with a carbon graphite. The printed circuit board is printed with two plated copper paths that pass very close to each other; both tracks pass under the rubber dimple.

Unlike membrane keypanels, elasto-

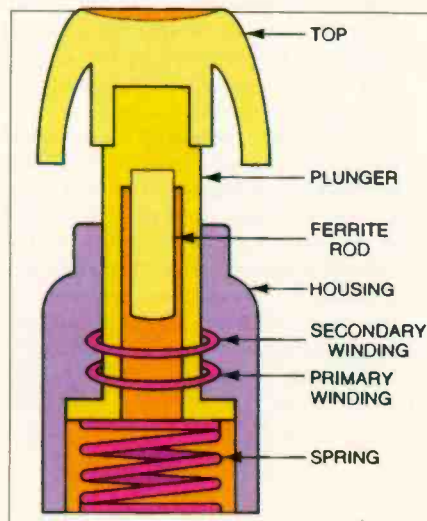


Fig. 2. Ferrite core keyswitch.

mer keyswitches need no insulating layers. The contour of the dimple keeps the carbon pad from touching the circuit board wires in its relaxed state. When the rubber dome is depressed, however, the carbon conductor makes contact with the copper strips and completes the circuit.

Until recently, elastomer keyswitches had relatively short lifespans, which limited their acceptance. New developments in elastomer technology (mostly by the Japanese), however, have extended keyboard life by more than 500 percent, and conductive elastomer technologies, like those in membrane applications, have been used in either keypanel or keyboard construction.

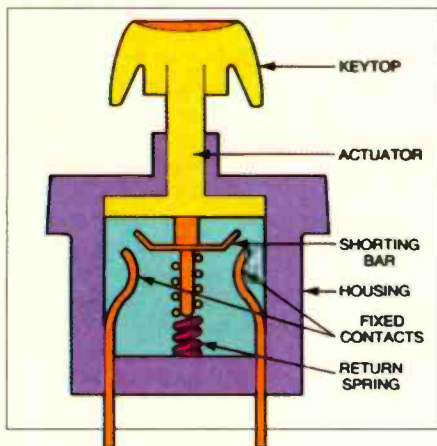


Fig. 3. Mechanical keyswitch.

Ergonomics

A lot of attention is given today to ergonomics—the investigation of what makes interactions between humans and machines most effective. The goal of ergonomics is standards that will net the greatest efficiency by matching the needs of one to the other. Of course, the keyboard is perfectly suited for ergonomic concerns.

Ergonomic considerations focus on *keyboard profile*, the distance from the bottom of the keyboard to the top of the keys, and the length of the keystroke, or the distance the key must travel to complete the switching function. Generally, keyboard profiles are divided into three categories: low, DIN (also called standard ergonomic) and micro.

The low profile, established in 1975, has a typical keyboard height of 1.5". Before introduction of this standard, keyboard profiles ran 2" and more, with no two alike. Low-profile keyboards normally use full-travel keyswitches that have strokes ranging from 0.150" to

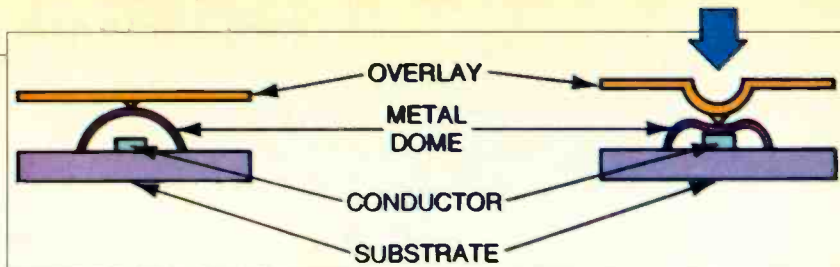


Fig. 4. Metal dome in keypanel gives tactile feedback.

0.190". In this range is the distance found on most Touch-Tone telephones. Low-profile keyboards are the favorite of keypunch operators and word processors.

The DIN standard keyboard was devised in 1980 by West Germany's Deutsche Industrie Normenausschuss. The DIN specifications set the maximum keyswitch height at 30 mm, with the keyboard mounted at any angle between zero and 10 degrees from horizontal. Keystroke travel is set between 0.120" and 0.150".

Microprofile keypanels are the result of membrane-type keyswitches, like the conventional membrane keyswitch and the conductive elastomer keyswitch. Key height is at most 3/4"; there is no lower limit. The keystroke travel distance depends upon the keypanel and the technology employed. A typical microprofile keypanel uses keystrokes of 1/16". Membrane keypanels often have keystrokes of less than 0.015", which has earned them the nickname "touch panels."

Keyswitch Feel

Another ergonomic consideration is the feel of the keyswitch. Feel is very

important because it lets the user know when a switch has been actuated and when it hasn't. *Linear keyboards* provide feedback by the feel of the length of the stroke. The operator assumes contact is made when the key bottoms out. Touch-Tone phones use linear keyswitches.

Shorter stroke keyboards, however, often use switches that give *tactile* feedback. They require a greater force to initiate the switching action than to sustain it. You feel this action as a click on the fingertip. Domed keyswitches are tactile. Depressing a domeswitch, you feel the metal cover snap over at the point of contact.

Other types of keystroke feel include sponge and touch. *Sponge* switches have springs inside them that increase finger pressure as the keys bottom out. It is a form of linear switching. *Touch* switches have no feel to them at all. A familiar application is the membrane keypanel found on a microwave oven. Audio generators are sometimes used with touch panels to give audible feedback. A membrane keypanel can also be made tactile, by installing a metal dome over the membrane sandwich prior to laminating the overlay.

On domeswitch keypanel, each lead at left is a row or column.





Fig. 5. Membrane keypad with legend overlay.

Key Contour

The contour of a key provides the nesting the fingertip experiences when using the keyboard. Flat keytops are common and the least expensive to manufacture. Unfortunately, they don't

Keyboard Layouts

Keyboard layout is like religion and politics: not a good topic for light conversation. What is satisfactory for one person is absolutely unacceptable to another.

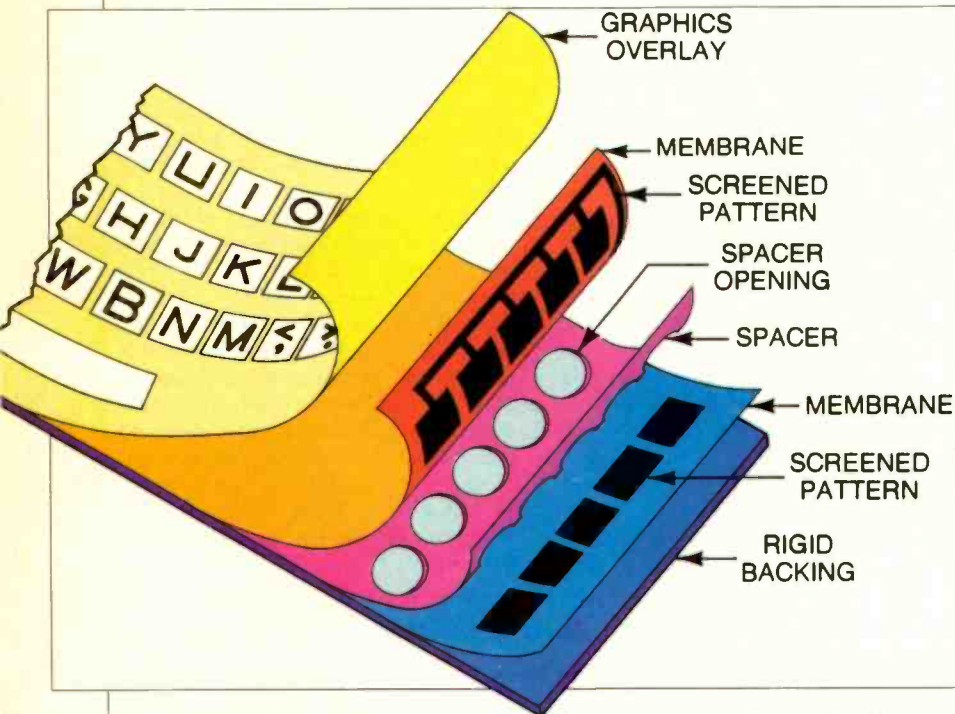


Fig. 6. Patterns screened on membranes form switch contacts.

conform well to the shape of the human finger. By far the design most ergonomically satisfactory is the sculptured keytop. In fact, sculptured keys are what DIN stipulates for its ergonomic keyboards. Sculptured keytops are used for typewriters and telephones. The keys have hollowed tops that accommodate the fingertips and provide natural wells that prevent the fingers from readily sliding off the keys.

Keypans, obviously, don't have keytops. More often than not, the panel is flat with no contour to it whatsoever. Bumps and ridges are sometimes molded into the keypad to make locating keypads easier. In some cases, to help position the operator's fingers, embossed rims are formed around the keypad area.

Most manufacturers tend to stay with the tried and proved arrangement of the typewriter keyboard. In this type of keyboard, the keys are in four rows of approximately 10 to 12 keys per row. Each row is offset to the row above it to make

it easy to reach the keys when touch typing. Touch typing is the game your teacher played with you in typing class by removing the letters from the keytops and forcing you to memorize the keyboard—no peeking permitted.

All keyboards today have legends. Contrary to what you may think, the legends aren't there for the benefit of us hunt-and-peck typists who staunchly refuse to undergo the rigors of learning to use more than one finger. No, the legends are there to let you know what layout the keyboard has.

The design familiar to most typists is the QWERTY system. Look at the second row on your keyboard. Notice how the letters read QWERTY from left to right? This is the keyboard most schools teach, and it is by far the most popular.

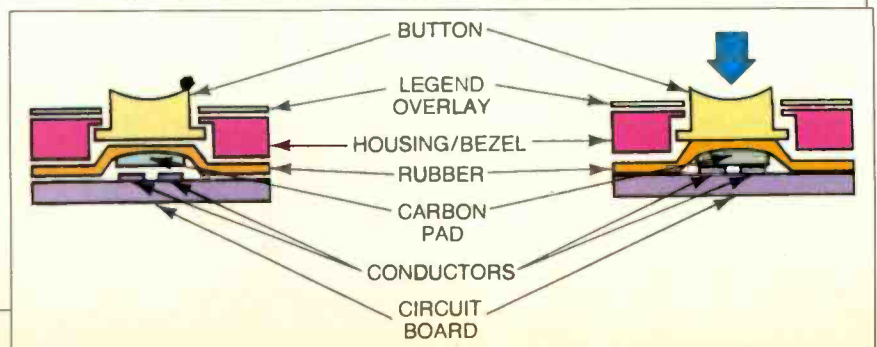
Its layout is designed to accommodate the movement of the human hand. The pattern is supposed to lead to the most efficient use of the fingers and produce the fastest results without causing the typebars of the machine to jam. Not everyone agreed. It wasn't long before a competing design, known as the Dvorak system, made its debut. Underlying the Dvorak keyboard is the assumption that the most-used keys should be placed where they're easiest to reach.

This conflict began more than 100 years ago, just after the invention of the typewriter, and hasn't yet cooled. (Some alert readers may note a parallel between IBM and Apple.) A few keyboards, for example, the Apple IIc, have circumvented the problem by offering both systems at the flick of a switch.

And last, and probably least, is the ABCDEF approach. But even devout hunt-and-peck typists find this arrangement clumsy at best, and, fortunately, it has little application in computers.

We spend increasing amounts of time with our fingers on the keys and less and less with pens and pencils in hand. Still, most of us are not yet able to interact with machines in ways that are faster and more effortless than are keyboards. Until such means are widespread, every millimeter of keyboard design counts. ♦

Fig. 7. On elastomer keyswitch, carbon pad closes circuit.





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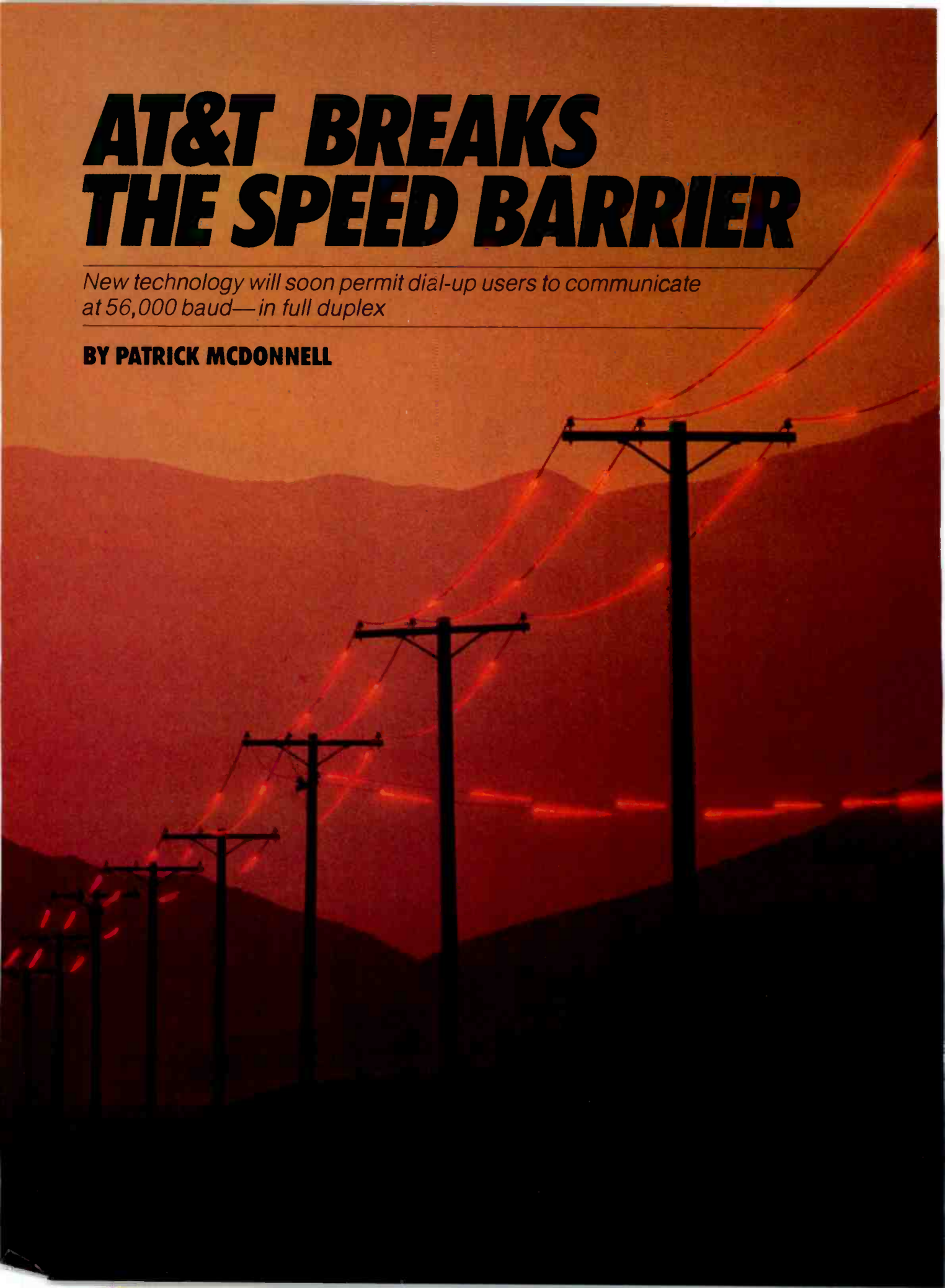
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GX-393

AT&T BREAKS THE SPEED BARRIER

*New technology will soon permit dial-up users to communicate
at 56,000 baud—in full duplex*

BY PATRICK MCDONNELL





EVERYONE who owns a modem remembers the agony of deciding whether it was worth the extra money to be able to send at 1200 rather than 300 baud. Soon that will be history. AT&T has announced it is testing circuitry that will allow ordinary telephone lines to transmit data at a rate of 56,000 baud. If that isn't enough, the new service will be in full duplex.

This high-speed network, called CSDC (circuit switched digital capability), will enable users to transmit data more cheaply than sending computer tapes. Facsimile transmission will be vastly improved. Using the proper analog-to-digital conversion techniques along with CSDC, users will also be able to send high-fidelity music and speech more easily than is currently available even on special dedicated lines.

All this is likely to be in place by the end of 1985. Right now it is being tested by Illinois Bell.

Megabauds from Ma Bell

CSDC is the outgrowth of work at Bell Labs begun in the early 1960s to raise the fidelity of phone calls, lower their cost, and increase their speed. Before those efforts could produce CSDC they yielded piggyback calls, pulse-coded modulation with the T-carrier system, electronic switches, "smart" switches, and time-compression multiplexing.

Everyone over the age of 30 remembers the hissing and roaring that accompanied long-distance calling over 20 years ago. Until the early 1960s two or more conversations were sent over the same lines by a technique known as frequency division multiplexing or frequency translation. Since telephone lines, or loops, can transmit signals with frequencies as high as 150 kHz and voice only has a bandwidth of 300 to 4000 Hz, telephone engineers were able to piggyback as many as 16 conversations on one line. They split the two-wire conversation into a four-wire transmit-receive arrangement and sent it on carrier tones.

Multiplexing was the backbone of the long-distance network for years. It suffered from two major shortcomings, one technical and one economic. Since the wires were carrying analog signals, every time they passed through an amplifier in a repeater station, noise was amplified along with the signal. The longer the call traveled, the more amplifiers it passed through, and the more noise it collected.

The second problem was that it took four parallel lengths of wire to handle 16 conversations. The phone company regarded this quadruplication as less than economical. Not only was there all that wire, but there had to be many repeaters on the line to amplify degenerating analog signals. Other problems—distortion, echo and crosstalk—made the repeater circuitry extremely complex and expensive.

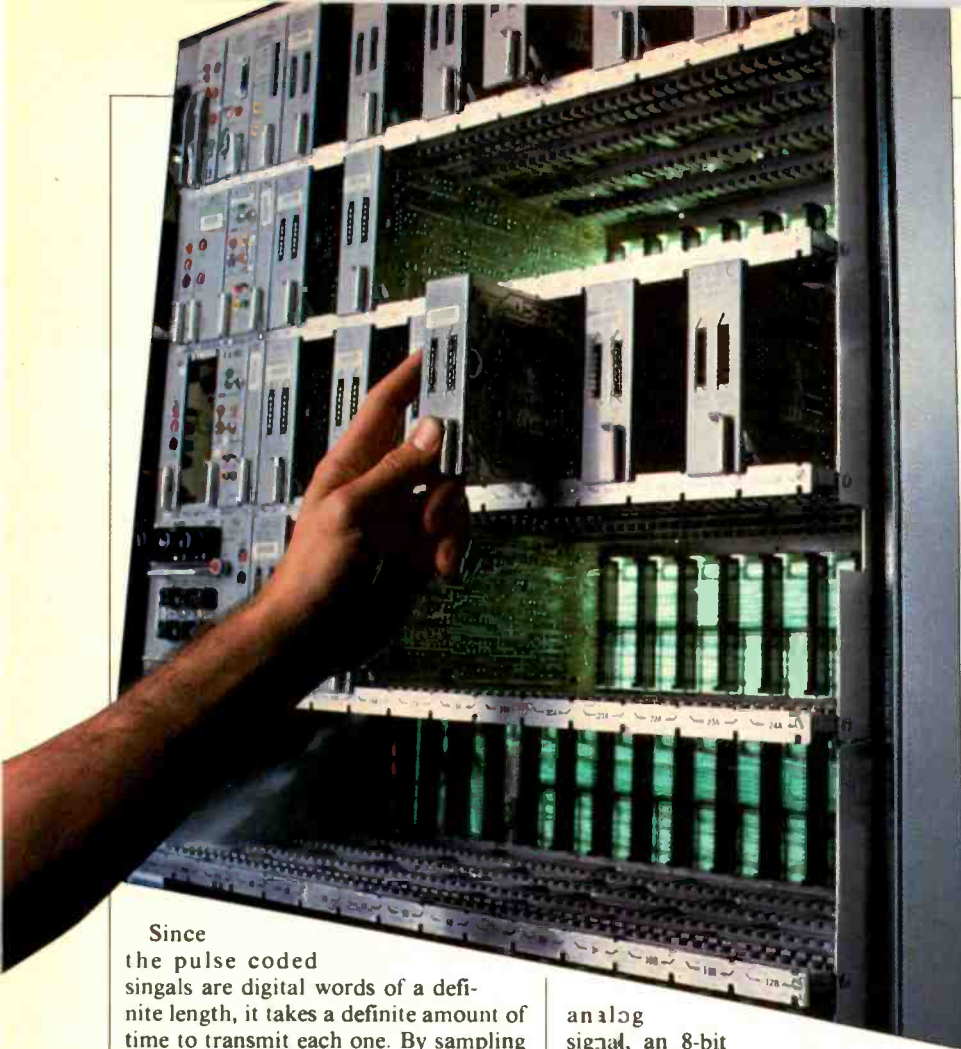
The T-Carrier System

In the early 1960s the T-carrier system, a higher-grade transmission network, changed everything. Based on pulse coded modulation, it was able to stack 24 conversations instead of 16. Pulse coded modulation (PCM) is a multiplexing scheme in which the analog signal is sampled at regular intervals and then transmitted as a series of pulses on the phone line. With the signal digitally encoded, the function of the repeater is different. Instead of amplifying the original signal, as it did with frequency modulation, the repeater can simply recopy the bit pattern, effectively generating a new signal. Transmission noise was greatly reduced.

Bell also changed the method for multiplexing signals. Time division multiplexing, which permitted Bell to send multiple signals on the same line by sampling the individual signals, replaced modulating carrier frequencies.

Patrick McDonnell is a free-lance writer who specializes on computer topics.

PHOTO BY BARRY BLACKMAN



Since the pulse coded signals are digital words of a definite length, it takes a definite amount of time to transmit each one. By sampling several different lines in sequence and transmitting resulting digital words in a particular order, with time division multiplexing it became possible to send multiple signals on the same line.

The biggest obstacle to increased multiplexing and high speed data transmission was the time it required to switch from one line to the next. The standard switch in the telephone company was always some sort of relay. Since these are electro-mechanical, even the fastest switch needed several milliseconds to operate as well as extensive supporting circuitry. These requirements limited the maximum number of lines a telephone exchange could handle to 65,000. With the development of electronic switches that could change state in a few nanoseconds, each switch was able to handle 65,000 lines. Finally the baud rate could leap.

The higher baud rate for time division multiplexing became a function of the speed of the new electronic switches—several nanoseconds, the rate of the frequencies the local metallic loops could handle—150 kHz, and the rate at which the analog signal had to be sampled. Analog sampling had to be at least twice the maximum frequency present in the signal. Since voice has a maximum bandwidth of about 4000 Hz, the sampling rate was set to be 8000 Hz. To digitize an

analog signal, an 8-bit word is created for each sample: 7 bits are used to encode the signal, and the eighth bit is used for various control purposes. Since the T-carrier can multiplex 24 channels, each section of the encoded signal has to carry 24 8-bit samples plus one extra bit to signal the end of the section. Therefore, there are $24 \times 8 + 1 = 193$ bits being transmitted at a rate of 8000 per second. Multiplying yields 1544 kHz, which translates into 1.544 megabaud, the basic carrier rate of the T-carrier system. The maximum rate at which data can be sent over any one of the individual channels of the system is 8 bits at 8000 Hz, or 64

Digital office timing component synchronizes clocking functions.



CSDC equipment being tested in New Jersey Bell's central office in Murray Hill, NJ.



kilobaud. The T-carrier system was operating at the end of the 1960s. After initial testing, AT&T introduced its dataphone data communication service, based on it. The new service offered end users high-quality voice services and data transmission at speeds of 2.4, 4.8, 9.6 and 56 kilobaud. The drawbacks were, among others, that special transmission lines not available everywhere, called the digital data system, had to be used. To expand the service AT&T introduced an improved, smart, electronic switch and "dataports," which provided a means of direct individual access to any of the channels in the network similar to direct memory access and interrupts in a computer. Now local telephone companies could dial into the system, and the network grew quickly.

The smart switch incorporated micro-processor technology. By using onboard memory the switch could diagnose itself, monitor the quality of the transmission lines it was controlling, and, in general, increase the capacity of the digital data system and guarantee the integrity of the data it carried.

The switch could also be programmed to recognize which lines were carrying high-speed data and route the transmissions over lines and through exchanges that were equipped to handle them. It could easily eliminate from the digital network exchanges with only conventional equipment. The resulting digital

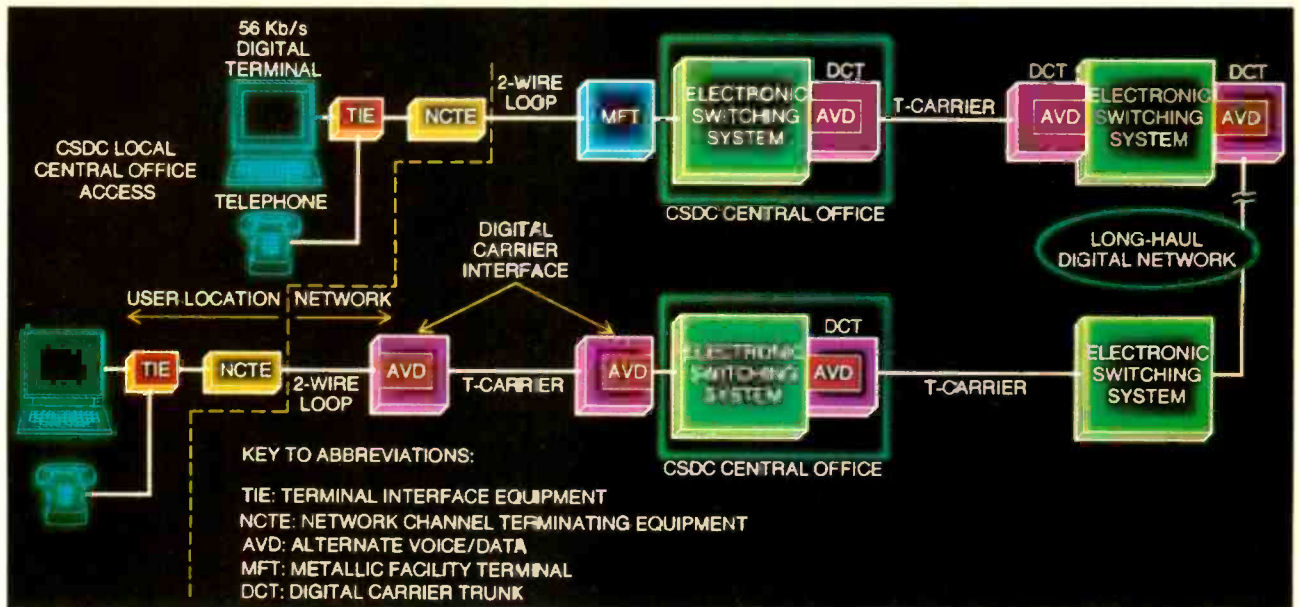


Fig. 1. Block diagram of the circuit switched digital capability

signal paths, based on a combination of the T-carrier system and the new programmable electronic switch, was called the digital carrier trunk. The problem left was to provide full duplex 56-kilobaud service to any conventional two-wire telephone line.

Time Compression Multiplexing

The local loops and switching circuitry were already capable of handling the bandwidth necessary for high-speed data transmission. The solution to the problem of bringing CSDC to conventional telephone lines was found in a technique known as time compression multiplexing, a refinement of the time division multiplexing scheme for the T-carrier system (Fig. 1).

In time compression multiplexing, data sent on local loops are grouped into sections of equal length. Each of these sections is compressed and sent over the lines in a controlled burst at a higher

rate. When a section reaches the receiving end, it is expanded again and restored to its original condition.

Full duplex operation is made possible by carefully synchronizing the received and transmitted bursts so that when the station at one end is receiving, the one at the other end is transmitting. How large each section of data should be is a function of not only the data rate but also the quality and length of the loop. Designing for the worst case set the size of the data segment at 199 bits and the burst rate at 144 kilobaud. Remember that the basic rate of the T-carrier system was set at 1.544 megabaud, more than ten times faster. Since the maximum baud rate for the user of the system is 56 kilobaud, the compression necessary is on the order of 2.5 to 1. In each burst, 168 bits are reserved for the transmitted data, 4 bits are for control, 3 bits for synchronization, and the remaining 24 bits for future expansion—the system is capable of data

transmission at 64 kilobaud.

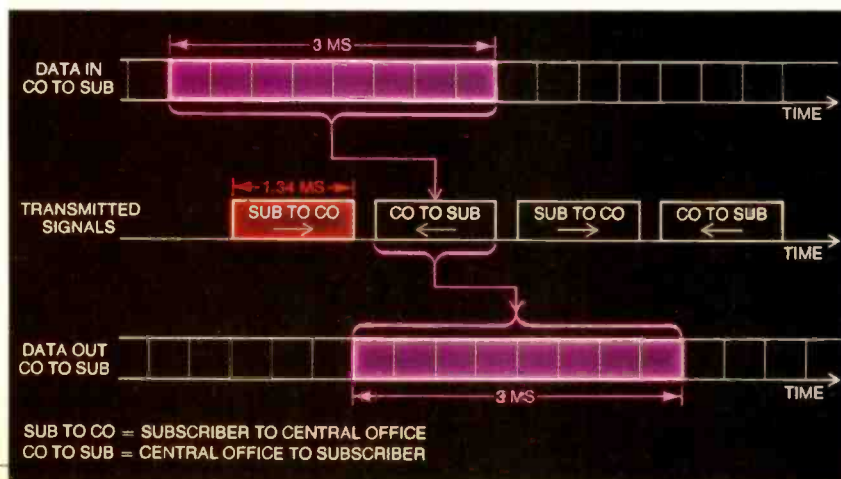
As can be seen in Fig. 2, the time allowed for each burst is 3 milliseconds, but the actual burst only lasts 1.34 milliseconds. The margin of 1.66 milliseconds allows for propagation delays and eliminates the possibility of echoes by providing time for the received burst to decay before the transmitted burst is sent.

Constant checking during the operation ensures that the burst remains synchronized. In fact, absolutely no transmission takes place at all until both ends are locked to each other. When data transmission is started, both the transmitting and receiving ends are slaved to a master clock at the AT&T exchange. As soon as clock synchronization is achieved, burst synchronization is begun by locking the receiving end into a repeating 11-bit code that has a duration of 1.34 milliseconds, the same length as the burst of compressed data.

When the bursts are locked into each other, full duplex transmission of actual data begins. Synchronization is con-

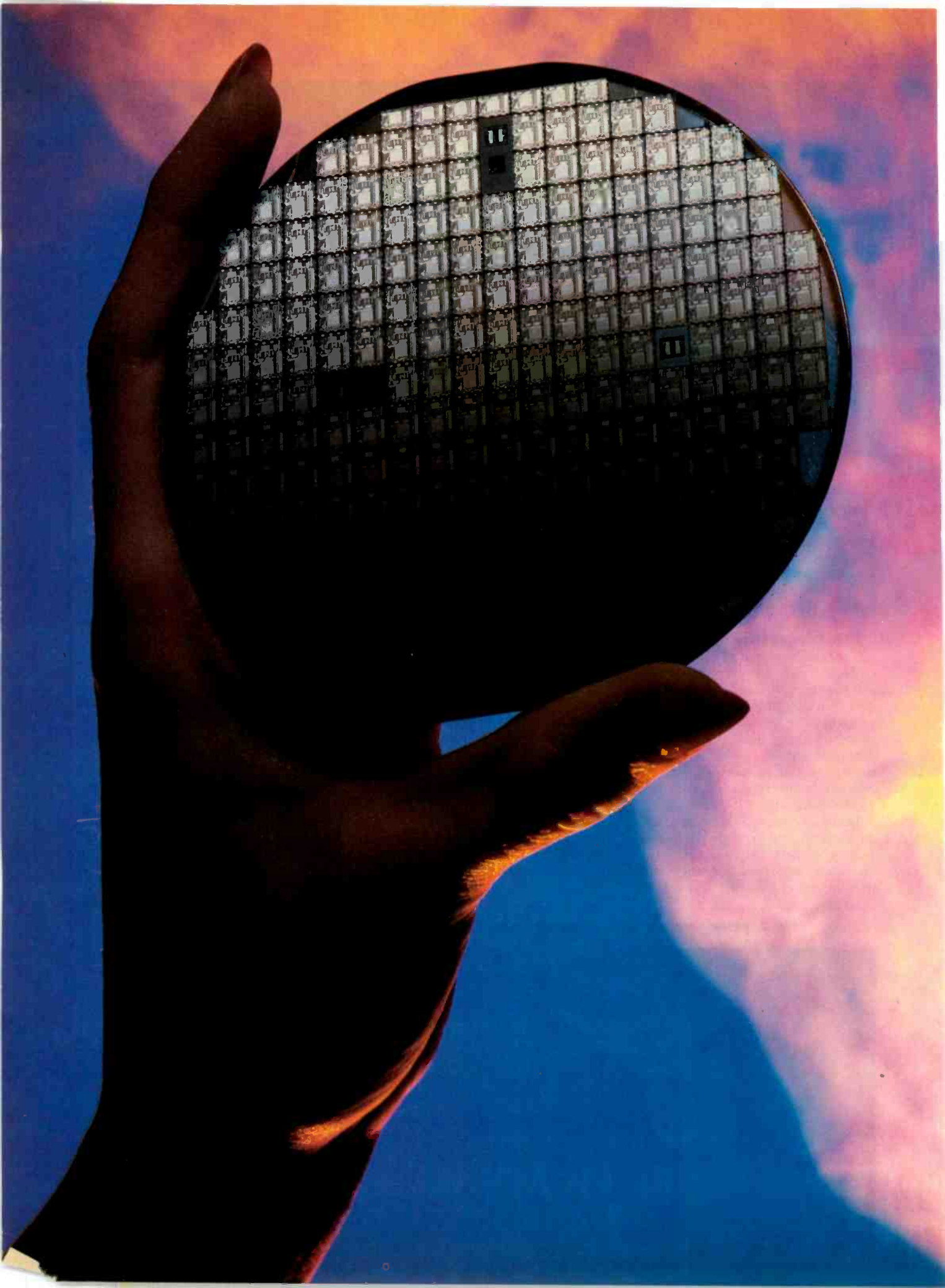
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Fig. 2. Timed compression multiplexing burst timing.



Voice and data capability is tested with a special set.





CMOS TAKES THE LEAD

Its speed and low power consumption spark the new generation of lap-size portables

BY GENE PATTERSON & JIM MAGOS

A NEW age is dawning in semiconductor technology that has far-reaching implications for the entire electronics industry. At the forefront of the dawning age is CMOS (complementary-symmetry metal-oxide semiconductor) technology, which promises to fill the needs of equipment designers with devices ranging from the very simple to the ultra-complex. It has been estimated that, by 1990, at least \$15 billion of the projected worldwide IC market of \$40 billion will be for CMOS devices.

Ever since their development at RCA's David Sarnoff Research Laboratories in Princeton, NJ in the early 1960s, CMOS devices have steadily moved to the forefront of digital and linear IC technologies.

Today, almost every semiconductor manufacturer carries a line of CMOS devices, with some firms developing greatly improved versions: Originally conceived as a gate-level, logic-device family, CMOS technology, and its offsprings, now span the full range of digital circuitry from microprocessors and memory chips to the semicustom gate-array and standard-cell devices that figure prominently in the emerging very-large-scale integration (VLSI) technology. (See "The Incredible Shrinking Circuits," *C&E*, April 1984.)

The use of CMOS is also growing in such linear circuits as operational amplifiers and analog-to-digital (A/D) converters and is fast becoming a key technology for the emerging telecommunications and data communications markets. In light of its wide acceptability, most knowledgeable observers expect CMOS to become the dominant technology as we move toward the twenty-first century.

Some Background

CMOS is one of three types of semiconductor technology

that use MOSFETs (metal-oxide field-effect transistors). The other two are PMOS (p-channel MOS) and NMOS (n-channel MOS). However CMOS technology is unique in that it combines both PMOS and NMOS transistors on a single chip. The principal advantage of doing this is that it yields a device that consumes substantially less power than any other form of IC semiconductor.

In both structure and performance, all MOS devices dramatically differ from the transistors used in bipolar devices, the other major type of IC technology. Bipolar technology was made famous by the popular transistor-transistor logic (TTL) family of ICs.

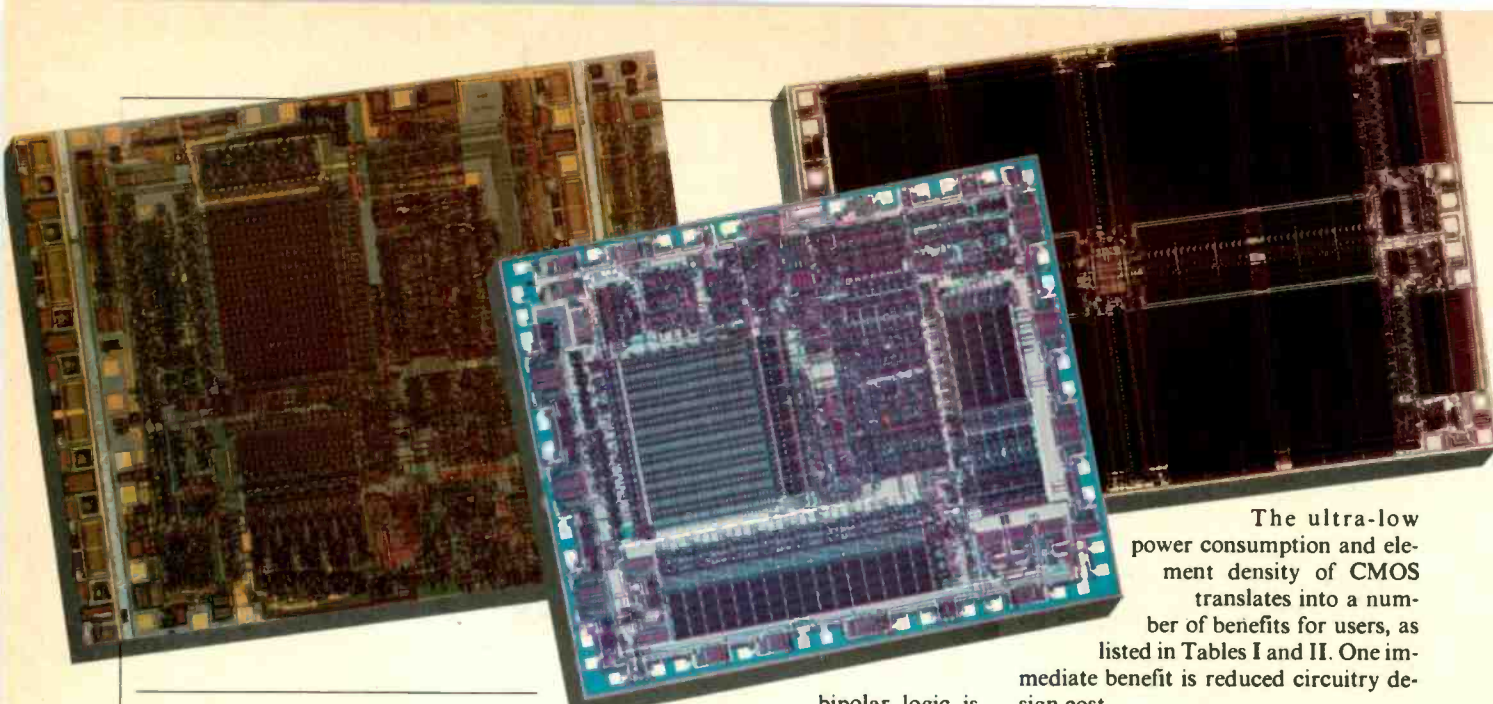
Although both bipolar and MOS transistors can be described ideally as switches, their operating characteristics are exactly opposite. While the bipolar transistor is a *current*-controlled switch that has a low input impedance, a MOS transistor is a *voltage*-controlled switch having a high input impedance. (Interestingly, the MOS switch is much like the old-fashioned vacuum-tube switch, which also was voltage controlled and had high input impedance.)

Bipolar technology offers two distinct advantages over other IC technologies—it can handle high current and operate at high clock speed. On the negative side, however, it also consumes high power, requiring hefty and more expensive power supplies and, frequently, expensive cooling fans or blowers. Though CMOS devices operate at slower speeds than bipolar devices, they make up for this deficiency by being almost perfectly suited for basic logic devices right on up through the ultra-dense circuitry required by VLSI circuits. (To understand how basic CMOS devices operate and are constructed, see the "CMOS Top to Bottom" sidebar.)

Because of its high power consumption, hence chip heating,

At left is a silicon wafer containing 220 microcomputer 1805 IC's (courtesy RCA). Incomplete squares are for wafer alignment.

PHOTO BY PETER ANGELO SIMON



CMOS chips, shown above are, left to right, a Motorola logic unit, an RCA CDP 1805A microprocessor, and an Intel 51C4 RAM chip.

bipolar logic is unsuited to VLSI designs. These fundamental differences account for the diverse roles played by the two types of technology in the world of digital and linear ICs.

The ultra-low power consumption and element density of CMOS translates into a number of benefits for users, as listed in Tables I and II. One immediate benefit is reduced circuitry design cost.

If an IC technology's power demand is very low, as in the case of CMOS, designers need less expensive and less sophisticated power supplies and limited or no cooling devices.

CMOS TOP TO BOTTOM

FROM the most complex microprocessor circuits to the simplest gates, deep within all CMOS devices is a basic circuit element called an *inverter*. As shown in Fig. A, a CMOS inverter is composed of a p-channel MOS transistor and an n-channel transistor on the bottom. Because n- and p-channel transistors have diffusions of opposite polarity dopings, they operate with voltages of different polarity. Thus, a positive input voltage turns on an n-channel device but turns off a p-channel device. Conversely, a zero voltage (ground in Fig. A) at the input to the inverter turns on the p-channel transistor on the top and turns off the n-transistor on the bottom. Note at the bottom of Fig. A that both transistors can be represented as switches to simplify explanation of the device's operation.

This simple CMOS circuit performs the most basic of logic functions in a digital system—that of inversion. (An inverter is sometimes called a NOT gate, which is derived from the fact that what appears at its output is *not* what is applied to its input. That is, if a logic 1 is applied to its input, the output is then a logic 0).

If the voltage applied to the input terminal of the inverter in Fig. A is positive, the p-channel switch turns off and disconnects the output terminal from the positive supply voltage. The output terminal is, therefore, at ground potential

because the n-channel switch is turned on and connected to ground. Now, if the voltage at the input is zero, the p-channel switch turns on and connects the output terminal to the positive supply line. This time, the n-channel switch turns off.

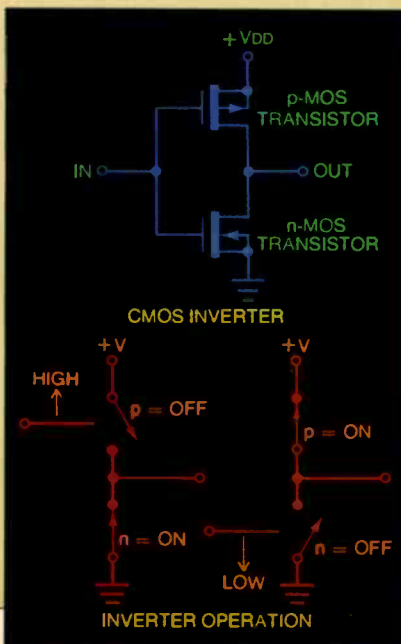
In an actual CMOS IC, p- and n-channel transistors are fabricated on a silicon substrate, as shown in Fig. B. The key terminal of either transistor is the gate. In the original CMOS technology, the

gate was made of metal. The gate formed one plate of a capacitor, whose other plate was the substrate of the device. The two plates were separated by silicon dioxide (SiO_2), an insulating material. Because the gate input is a capacitor, the input current is extremely low (for descriptive purposes, it can be assumed to be zero).

When the output of one CMOS inverter drives the capacitive input of another inverter, no resistive (IR) voltage drop occurs in the drain circuit as a result of the almost nonexistent input current. Therefore, the output voltages can rise or fall to their full positive or negative levels (power-supply positive or ground). Moreover, since one transistor is on and the other is off, the net current in the drain circuit, called quiescent current, is extremely low and is typically in the nanoampere (10^{-9}) range. For this reason, CMOS devices consume the least power of any semiconductor technology.

Another observation that can be made from Fig. A and the operating description given above is that this operation can occur over a wide power supply range. Also, the ideal switching voltage is 50% of the positive supply voltage. That is, a 1.5-volt switching level for $V_{DD} = 3$ volts and a 9-volt switching level for $V_{DD} = 18$ volts. Over a temperature range of -55° to $+125^\circ$ C, this switching voltage varies less than $\pm 1\%$ of the supply voltage.

Fig. A. CMOS inverter operation.



When low operating power is combined with high-density, multi-purpose CMOS ICs, the savings come in the form of less costly support components and raw materials consumption, which results in minimized "real estate" required for the circuitry.

Dramatically reducing the physical size of a product and providing the mi-

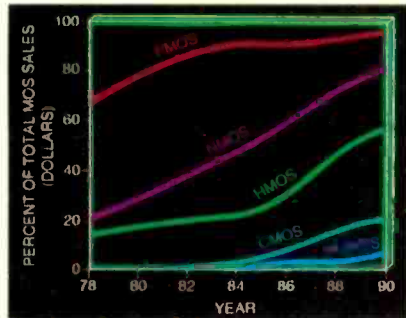


Fig. 1. Expected use of MOS technologies through 1990.

nuscle amount of power a circuit demands, with a lightweight battery pack, make possible sophisticated portable products. In fact, CMOS is the only technology considered by designers of such products as the latest crop of true portable, lapsed personal computers.

The second advantage of CMOS is its wide operating voltage range. One typical CMOS (the 4000 series) family, for example, can operate at supply potentials ranging from a low of 3 to as high as 18 volts. With this broad range of operation, voltage regulation is rarely a necessity and long battery life can be expected.

In contrast, most TTL devices are limited to operation at 5 volts, which must be regulated to within ± 0.25 volt and requires expensive high-current and well-regulated power supplies.

Another parameter that favors CMOS over TTL is its switching level stability over wide temperature ranges. As shown in Table I, the common and inexpensive



Making CMOS chips at Motorola.

plastic-packaged CMOS IC is designed to operate at temperatures ranging from -40° to $+85^{\circ}$ C, which fills the needs of most industrial and consumer applications. The more expensive ceramic-packaged CMOS devices are designed for more rigorous conditions, being able to operate over the full military temperature range from -50° to $+125^{\circ}$ C.

The advantage of using even plastic-packaged CMOS, instead of other types of ICs, can readily be appreciated when

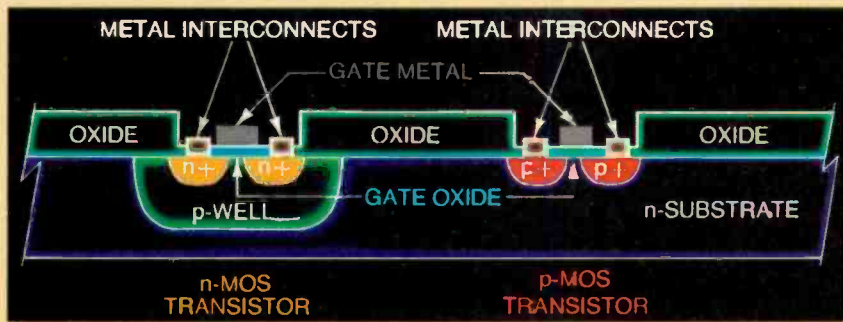


Fig. B. Both p- and n-channel transistors are on one substrate.

Processing Breakthrough

Some years ago, a significant processing breakthrough occurred in MOS technology that had far-reaching consequences. This was the development of the silicon gate as a replacement for the metal gate. In silicon-gate technology, a conducting form of silicon serves as the gate material instead of metal. The silicon gate both improved the performance of CMOS devices and allowed the gate to be formed before the drain and source were diffused (Fig. C). In this process, a patterned polysilicon material is used to define the gate area so that the following source and drain diffusions are self-aligned to the gate. This arrangement significantly reduces gate-to-drain capacitance as well as chip size. The process, called self-aligned silicon gate, is now standard in all CMOS digital devices.

Among the advantages of the self-aligned silicon-gate process, compared to metal-gate, are lower operating power consumption, greater speed, higher den-

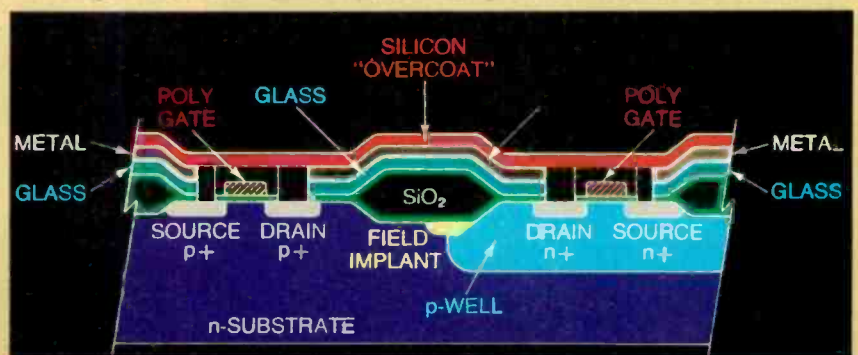
sity, and lower operating voltages. Silicon-gate MOS devices are characterized by low power consumption and high density. By contrast, bipolar TTL devices are characterized by low density and high operating power. Silicon-gate CMOS devices now have the speed of LSTTL devices. Newer, smaller-geometry TTL families are available with higher speed, but less power than already rel-

atively high-power LSTTL devices.

Not content to stand still, manufacturers have forged ahead in processing technology with the development of self-aligned silicon-gate CMOS on a sapphire-insulated substrate. Called CMOS/SOS (CMOS/silicon-on-sapphire), the process yields the highest-frequency MOS circuits. In the fabrication technique, a thin film of heteroepitaxial silicon is deposited on a sapphire substrate. High-speed devices are possible because the process eliminates many of the parasitic capacitances of conventional structures. Distributed parasitic capacitance causes frequency limitations.

In addition to high speed, CMOS/SOS ICs have the highest resistance to nuclear radiation. This makes them the preferred technology for use in aerospace and certain military systems. \diamond

Fig. C. The silicon gate improved the performance of the CMOS.



INTEL INTRODUCES FIRST CMOS RAMS

BY LES SOLOMON

BECAUSE of its very low power requirements, Complementary Metal Oxide Semiconductor (CMOS) technology is the key ingredient in the production of battery powered, truly portable computers.

The first use of CMOS was in RAM applications that could provide nonvolatile battery backed-up memory systems. Such systems have the ability to maintain data even if they lose external power for an extended period of time. Also, the

low standby power requirement allowed these systems to maintain data for long periods of time even when powered from relatively low-power batteries.

However, there was a payment.

The "horsepower" of these systems is measured by the "speed-power product", a combination of gate delay (how fast the chip operates) and power dissipation (standby and active). Although the power requirements of CMOS is far less than that for TTL, CMOS was much

slower (it has a poor speed-power product).

However, computer designers decided that the low power requirements outweighed the somewhat slower speed, so they elected to use CMOS in their portable computers.

In the search for low power, yet faster elements, several improved variations of CMOS were introduced. Among these are HMOS and NMOS which have been used in CPU chips.

one considers that NMOS, PMOS, and bipolar devices are usually rated for operation between 0° and +70° C. This restriction puts non-CMOS devices under a definite handicap in certain extended-temperature-range applications, such as the abusive under-the-hood environment where many automobile engine controls are located. Here, CMOS is favored because its stable temperature characteristics can withstand the wide fluctuations that are normally experienced under a wide range of conditions. Other wide-temperature-range applications that fall into CMOS's domain are in space, military, consumer, and industrial systems that require very stable operation over a wide temperature range.

Still another characteristic that elevates CMOS above the other IC technologies is its high immunity to electrical disturbances, commonly known as "noise," generated within a system or induced from external sources. Digital IC specifications generally list noise-immunity voltage and noise margin for each device.

Noise-immunity voltage, either a logic high or a logic low, is a noise voltage that at any one input to a logic device does not cause a false signal to propagate through the system. The noise margin is the difference between the specified in-

put voltage of a device and its specified output voltage.

CMOS provides the highest noise immunity or noise margin of any current logic family. By contrast, TTL offers a logic 0 (VIL MAX) of only 0.8 volt and an output potential of 0.4 volt (VOL MAX). Thus, noise margin is only 0.4 volt, compared with 1.45 volts for CMOS. Consequently, outside noise is more likely to affect TTL's operation than CMOS's.

Furthermore, CMOS logic operating at 15 V has a specified 5 V of both high- and low-level noise immunity. Because of its greater immunity to noise, CMOS can serve in applications associated with high levels of electrical noise, such as in factories where heavy machinery is used and in cars where the ignition solenoids and other devices generate high-energy noise.

CMOS in Perspective

With its multiplicity of technical advantages over other semiconductor technologies, CMOS is already becoming the dominant IC technology, especially for digital circuits.

Illustrated in Fig. 1 is the expected use of MOS technologies through the end of this decade. Projections indicate that CMOS will experience the most dramatic growth of all such technologies. By

1990, it will command about 50% of the IC market, up from about 20% at present.

HCMOS, a new high-speed version of CMOS aimed primarily at logic devices, is included in the 50% total. Over the same period, the use of NMOS will remain about the same as it is now, while PMOS will be on the decline as a digital technology.

PMOS is the oldest of the MOS semiconductor processes, having its origin in dynamic shift registers in the late 1960s and dynamic memory devices in the early 1970s. It was comparatively easy to manufacture but now has such major drawbacks as: the requirement for two power supply voltages, rather than the single voltage now required for all other technologies; it is slow; it is very temperature limited; and it consumes appreciable power, compared to CMOS.

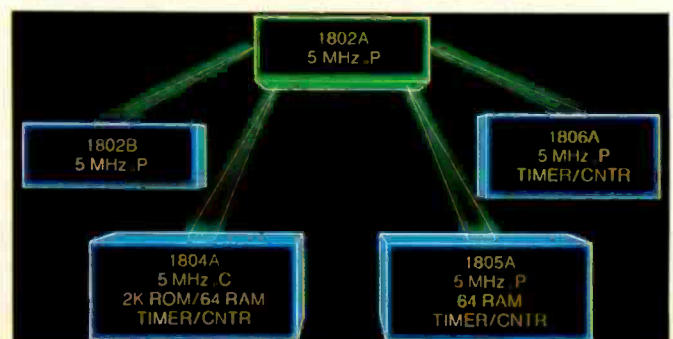
During the early 1970s, the more difficult to fabricate NMOS appeared on the scene just in time to catch the phenomenal growth of microprocessors and memory devices.

The major advantage of NMOS over PMOS is that its current carriers are electrons rather than holes. This is significant because the greater mobility of electrons means that the same-size NMOS transistor is two to three times



Fig. 2. (Left) Power dissipation of different types.

Fig. 3. (Below) Evolution of the CDP 1800 CMOS.



Now, Intel has introduced CHMOS[™] (Complementary High performance Metal Oxide Semiconductor) whose speed-power product represents a six-fold improvement over their HMOS III technology, and a 25-fold improvement over HMOS technology used in 1977.

Currently, Intel is using this new technology in its 51C256H and 51C256L dynamic RAM chips capable of storing 256K x 1 bits of data. These devices are pin compatible with the recently introduced

64K CHMOS and HMOS DRAMS.

The 51C256H features a Ripplemode cycle time of 65 nanoseconds, has a 120-nanosecond access time, and is designed for high-bandwidth applications such as graphic displays. Ripplemode provides the ability to randomly read or write up to 512 bits within a single row in one access. The 51C256L, also using Ripplemode, has an access time of 150-nanoseconds and requires only 230 microamperes for data retention, making this chip ideal

for portable computers.

Because of the high cell capacitance of CHMOS, soft errors are essentially eliminated. For example, these DRAMs are claimed to be over 100 times more resistant to soft errors than existing HMOS or NMOS 64K dynamic RAMs.

Since it is possible to access these chips at over 15 million bits per second, this makes the CHMOS DRAMs compatible with high-performance CPUs such as the Intel iAP286 operating at 8MHz. \diamond

faster than its PMOS counterpart. Looked at another way, for a particular speed, an NMOS transistor is smaller than the PMOS version; hence, NMOS chips are smaller. NMOS also runs at lower threshold (turn-on) voltages and can operate from a single +5-volt supply, making it compatible with other logic technologies.

As a result of its advantages over PMOS, NMOS became, and still is, the leading technology for the fabrication of microprocessors, memory chips, and VLSI in general.

Interestingly, however, neither NMOS nor PMOS was much of a factor in logic "family" ICs (inverters, gates, flip-flops, counters) and other devices classified as small-scale integration (SSI). This vast arena was dominated by TTL bipolar technology. When the competition came from CMOS, the two logic semiconductor technologies split off into different applications areas, with TTL being used for high-speed computers and CMOS being used for most other applications.

Computers have been, and will continue to be, not only the fastest growing market in the electronics industry, but the major consumer of ICs as well. Though CMOS logic is used in computer systems, its current strength is in peripherals in which its slower operating speed can be tolerated. However, there are a couple of CMOS limitations that remain. The worst, called "latchup," is due to the smaller and smaller geometries used in the dense chips. New deposition techniques appear to be solving this problem.

Current Activity

Dramatic changes are now occurring in the semiconductor industry, including the reversal of the traditional roles of digital technologies. One of the most far-reaching is the emergence of a new class of very low power CMOS logic that runs at the same clock speed as the popular LSTTL (nonsaturating low-power Schottky TTL).

The speed/power characteristics of

the major semiconductor technologies used in logic devices are plotted in Fig. 2. Note that the new high-speed CMOS family is about 10 times faster than its conventional CMOS predecessor and is just as fast as LSTTL. While both CMOS and LSTTL operate at the same speed (typically 9-nanosecond average propagation delay time), the difference in quiescent power dissipation overwhelmingly favors CMOS.

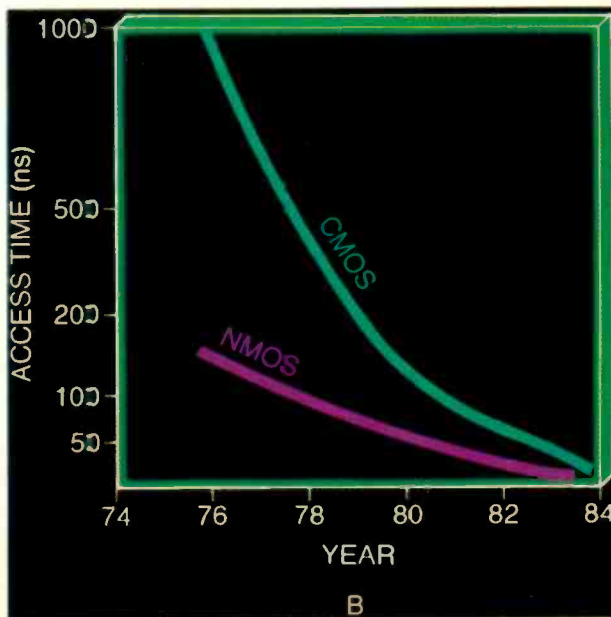
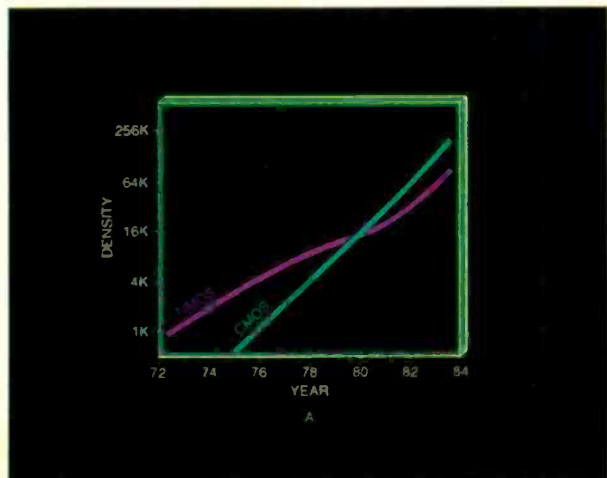
As shown in Fig. 2, dc power dissipation for CMOS is barely measurable on the power scale, while for LSTTL it is about 1.5 milliwatts. Generally, then, CMOS dissipates about 0.1% the quiescent power of LSTTL logic.

The arrival of fast CMOS has great significance to circuit designers. It makes possible, for the first time, bipo-

Gene Patterson and James L. Magos are staff members of the Solid State Division of RCA.

(Continued on page 108)

Fig. 4. Density and access time for static RAMs of NMOS and CMOS.





Xerox PARC

—Heroes of the micro revolution

A look at the think tank where many feel it all began

BY MARTIN PORTER

WHEN Apple introduced its Macintosh last winter, memories were stirred in scientists who have seen the personal computer grow up over the past ten years.

While the press extolled Mac's innovations—its mouse, high-resolution graphics, icons—the unit is actually reminiscent of a machine that predates personal computing altogether, the Alto. Although the Alto was not as personal as today's products in size or cost, it was a prototype for distributed processing. It also set the stage for such subsequent innovations as the local area network (LAN), laser printing, Smalltalk (a combination of a programming language and a graphics package), bitmap display and overlapping windows.

Alto and these corollary features originated where many other of today's leading-edge technologies have their roots: Xerox PARC. It is no surprise that the Xerox Palo Alto Research Center has an

aura of almost Olympian proportions in the microcomputer industry.

The numerous features that originated there are now widely exploited in the marketplace by firms like Apple and Microsoft, where outstanding Xerox alumni migrated as they scattered throughout the industry. Other PARC scientists are making their marks elsewhere as well: Convergent Technologies, 3Com, GRiD and DEC. Even though VisiCalc co-author Dan Bricklin never worked there, he commented that PARC is a national human resource. His statement is often repeated these days, even by Xerox executives who make sure you know they are only joking.

Today, however, Xerox isn't eager to talk about its premiere R&D facility

Martin Porter is a contributing editor of PC magazine. He writes frequently about electronics for several publications.

whose past is so much more celebrated than its present. Talking about the past isn't popular at any facility in an industry where last year already seems like the Bronze Age.

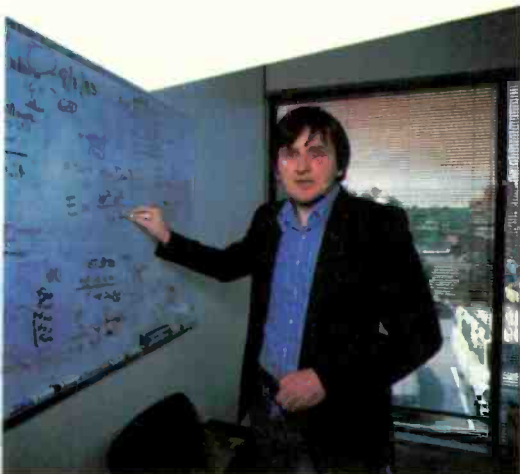
The Golden Age of PARC

The personal computer business of 1984 was very much in gear at PARC ten years ago. The golden age of PARC occurred from 1971 to 1976. Then Xerox, fat from a decade of enormous growth and profits, gave the youngest and most talented computer scientists in the world a blank check and an opportunity to define the paperless office of the future. The Mansfield amendment in 1969 had dried up all nonmilitary Department of Defense money, pinching tight research programs at universities. An independent lab like PARC could only benefit. It became known as the best computer science department in the United States.

Bob Taylor is given credit for assem-

bling the staff at the computer science lab. He had been the administrator of the Pentagon's Advanced Research Projects Agency (ARPA), the U.S. space agency that preceded NASA. He is remembered as the man with the money at ARPA in the 1960s, when some argue the true golden age of computing occurred. At PARC he collected people the way a connoisseur might collect Tiffany glass. While he couldn't print money, he was able to offer creative freedom without pressure: no rush to get a product to market, no need to teach classes of undergraduates, no push to politic for tenure.

Taylor hand-picked the entire team. Smalltalk author Alan Kay recalls that the hiring period for any new employee took days and involved extensive evaluation of what that person could add. "Every new person was a celebration," he remembers. In fact, it was a commonplace in the industry that out of the top 100 PhDs in computer science in the country each year, General Motors got the most, followed by Bell Labs, but Xerox PARC

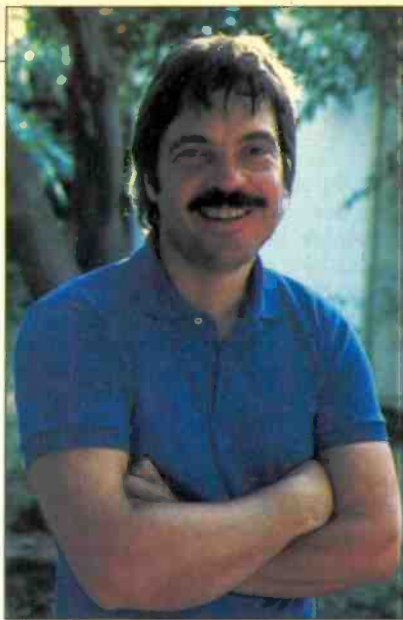


Charles Simonyi wrote the Bravo editor while at PARC.

got the 10 best.

PARC was guided by Taylor's idea that a think tank needed to be more a fertile medium and less an institution. It was mainly a matter of getting good people in and leaving them alone, according to PARC alumnus Alan Kay. "You just had to mix together the right combination of minds, and the result would be scientific dynamite."

Kay remembers Xerox PARC in the early 1970s as a place populated by wild-eyed scientists in their twenties. They were left to "follow their noses" without a marketing executive looking over their shoulders. They spent hours ruminating about the future in a lounge scattered with bean bag chairs and sought pro-



Alan Kay conceived of Dynabook, the forerunner of Alto.

gramming inspiration in the middle of the night from the video game precursor, Space War. "There was simply nothing we couldn't do," he recalls.

According to Larry Tesler, a PARC alumnus who went to work at Apple in 1980, "The main thing driving PARC was the realization that in 10 or 25 years you would be able to get a lot of power into a low-cost product." Taylor and his staff also realized that personal computing, not time-sharing or data processing, was the wave of the future.

According to Charles Simonyi, now at Microsoft but at PARC the author of the Bravo editor, the dream that was realized at PARC was that humans would be able to communicate with computers through graphics rather than through text, simply by pointing.

Communicating with computers in the most "human" way was what led many of the researchers to consider their Alto stations more as personal secretaries than as personal computers. As an in-joke some signed their memos "B. A. Ear," a name formed from the initials for Bravo and Alto and the code name Ear of the PARC laser printer. In fact, the elusive B.A. Ear has been credited in university dissertations on the work of PARC.

Enter Alto

At a summer ARPA symposium Kay first conceived of Dynabook, the long-term project that bore as a first fruit, Alto. Kay had seen one of the first plasma panels at a lab at the University of Illinois. When he joined PARC that image became a prototype for a lap-size computer, very much like the popular TRS-80 Model 100, but even more like a Convergent Technology Workslate with a bigger screen. The dream machine could go on line, could store several million

characters, and had a touch-sensitive screen. It would come bundled with word processing, Smalltalk and even a video game or two.

Alto appeared then as an interim Dynabook. There had been previous attempts at building personal computers as early as the the 1960s at MIT's Lincoln Labs. What set Alto apart from early attempts was the emphasis its designers put on communication with the silicon beast and on developing its software.

The story of how the Alto was finally put together varies, depending on whom you talk to. The two most common stories, though, incorporate a bit of anti-establishment defiance: Either it was built—in three months in the spring of 1973—to disprove a research manager's statement that it couldn't be done or it was bootlegged against his wishes while he was out of town. Either way, the Alto was never designed as a marketable item, but as a prototype upon which the scientists could test out their software and hardware ideas. Even after several thousand machines were built and installed throughout PARC, at other Xerox facilities, and then in offices of the Federal Government, the machine remained out of production.

The basic system of the original Alto included a video display and a three-button mouse in addition to a standard keyboard and finger keyset, 2.5M byte disk, Ethernet interface, and 64K 16-bit semiconductor memory expandable to 256K. It looked like a sleek and contemporary workstation with a dishwasher-sized CPU built under its counter. It wasn't quite Alan Kay's Dynabook, but it was a start.

The PARC Legacy

For Xerox the most important out-



Larry Tesler left PARC to go to Apple and direct the Lisa Project.

Xerox PARC

come of PARC was laser printing: It has already become a business bringing in \$250 million a year for the company. It is expected to grow further with a new generation of low-cost laser printers next year. For the computer industry, however, PARC was a source of new products, ideas and inspiration. Dan Bricklin recalls, "a lot of people were turned on by that place even if they never worked there."

Bringing new technology to real life was never

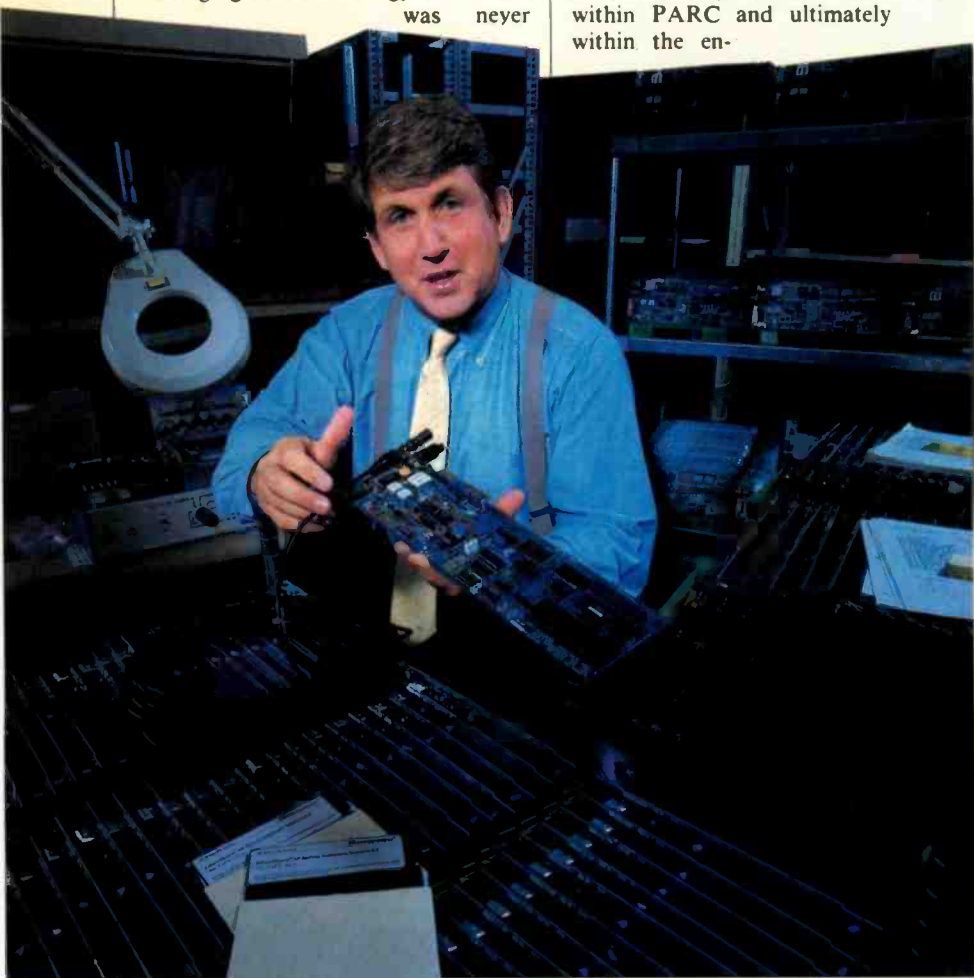
1980. Ethernet, which is one of 250 systems licensed from Xerox, transports information in "packets" along coaxial cable.

Establishing some sort of network with the Alto had been one of the earliest design aims of the PARC research team. Communication among computers for resource sharing was advanced by ARPA, in fact. The Ethernet was designed in consort with the Alto in 1973 and eventually interlinked the Altos within PARC and ultimately within the en-

issue of over 2 million shares of stock. It is now shipping about 400 new Ethernets per month. In all it has shipped 15,000 of the connections since it began manufacturing them in March 1981. Most recently 3Com announced it will be the supplier of hardware to go into a Xerox Ethernet for the IBM PC and its compatibles.

One of Metcalfe's classmates, John Ellenby, also went from PARC to a more commercially oriented company. Now he is in charge of GRiD's Compass, an \$8000 high performance lap computer; at PARC he had been in charge of taking Alto II to the buyer. A test market of the plan was nixed by Xerox corporate in favor of the Xerox Star in 1980. The Star utilized Alto ideas, particularly icons, but has so far been a marketplace dud. Although Ellenby, like many, maintains that Xerox probably missed the boat in several product areas, he feels that the public underestimates the contribution that laser printing has had on the company. "Xerox was pioneering a whole new business. The fact that they didn't know it themselves is rather sad."

Larry Tesler left PARC to work for Apple in 1980. There he directed the Lisa project, which brought to fruition much of his work at PARC. At PARC he had devoted his main efforts to making Smalltalk a productive programming environment, as well as to improving such user interfaces as the mouse (which was not developed at PARC but by Doug Engelbart at Stanford Research Institute), and to making the use of graphics, icons and menus more convenient. The bitmap display, which Tesler has developed at Apple, coordinates every screen dot from a single chip and offers increased control and definitions. "It was something whose value Xerox PARC demonstrated on a relatively inexpensive computer (Alto costs about \$20,000) and Apple just bought it to a much lower-priced computer (Macintosh costs about \$2500). The style of user interface that was developed first as Smalltalk, we imitated. That includes using a mouse, overlapping windows and a command language relatively free of modes. Later the Star systems came out and we borrowed the use of icons... However, a



Bob Metcalfe invented Ethernet and founded 3Com Corp.

the aim of the researchers at PARC. In fact, in the pursuit of marketplace realities several of the more prominent PARC alumni left to start businesses of their own or join more product-oriented companies. In their new settings they realized, in products and markets, potentials of ideas that had germinated at PARC.

Bob Metcalfe, the inventor of Ethernet, for instance, founded 3Com Corporation, which supplies Ethernet local area networks for IBM PCs and compatible computers, after he left PARC in

tire Xerox Corporation.

Today Ethernet is generally agreed to be the industry standard for local area networks. The use of LAN is becoming an established business strategy, with companies as diverse as DEC and Apple using the Ethernet standard. Ethernet has brought modest revenues to Xerox and serves as the basis of the company's newest Xerox team office systems approach.

Metcalfe's company, 3Com, though, is catching more fish in its Ethernet. 3Com went public in early April with an

PHOTO OF CHARLES SIMONYI
BY CLYDE KELLER
PHOTO OF ALAN KAY BY
NEIL REICHLINE
PHOTOS OF LARRY TESLER
AND BOB METCALFE
BY MIKE CARR

(Continued on page 110)



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TAPE BACKUP FOR HARD DISKS



New products that aid in the vital backup of fixed disks

BY ED TEJA

ANDREW Seybold is worried about your data. It isn't safe stored on a hard disk inside your microcomputer. He and other experts who spoke at a recent forum on "Data Issues in Microcomputer Applications" issued warnings to people and businesses. If they don't take advantage of available technology to back up the data stored on hard disks onto some sort of removable media, they are in for a rude awakening. And it isn't just the possibility of a disk failure that you should worry about. Once you are happy with the promised MTBF (mean time between failures) of the drive, you should be aware of still other types of failure.

According to Tallgrass Technologies

Corp. president, David Allen, with the only copy of your data left inside the machine, you are vulnerable to losing it through a variety of catastrophies, including:

- ♦ operator neglect or error,
- equipment failure,
- disruption due to power loss or electrical interference.

The trend toward widespread use of microcomputers in big business makes the magnitude of the problem even more serious. Joseph Duncan, an economist at Dun & Bradstreet, estimates that over

Ed Teja is a free-lance technical writer who often contributes to C&E.

70% of firms with more than 500 employees have microcomputers. Over 80% of these micros, Duncan says, are used by professional and technical people. If you are using a microcomputer in your work or integrating systems for professional applications, you should learn right now what data-processing professionals have often learned the hard way—the most reliable fixed-disk drive can fail to protect your data.

Scope of the Problem

As the smaller Winchesters (particularly the 5¼" drives commonly used in desktop computers) begin to provide more and more storage for fewer dollars, the task of backup becomes increasingly

difficult. Backing up a 5M-byte Winchester disk with floppies might be reasonable; backing up a 40M-byte Winchester with conventional floppy diskettes is unthinkable. Both the incredible amount of time it would take to put 40M bytes of data on floppies and the large number of diskettes required should be enough to make you search for new alternatives.

But if diskettes aren't the best backup solution, what media can do the job? Tape, of course.

The Perfect Backup Medium

The standard choice for backup medium in large computer systems has traditionally been magnetic tapes. Look in any bank's or insurance company's computer center and you'll see that they've invested thousands of dollars in tape drives. Tape drives, especially the newer models, boast three attributes that make them unusually attractive for backup:

1. They store large amounts of data in



A side view of the self-threading Interdyne drive.

a variety of convenient package sizes.

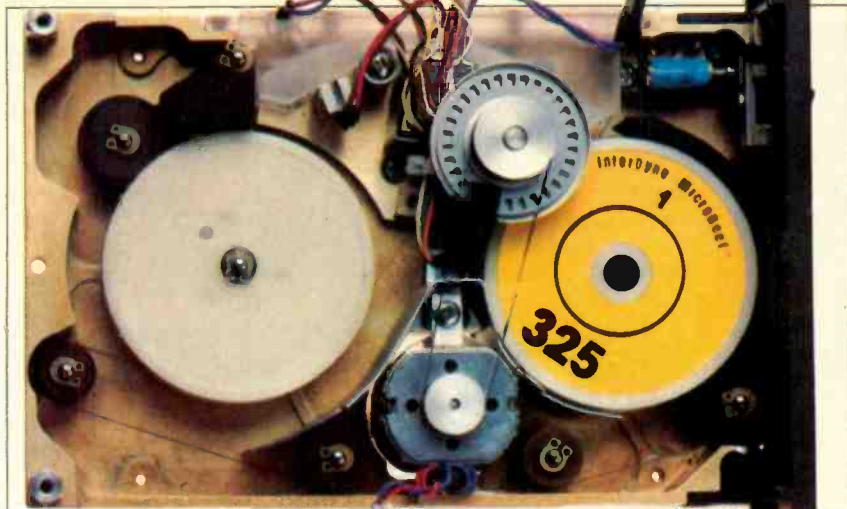
2. The medium is easily interchangeable, which makes it available for other systems.

3. Tape isn't prone to damage (you can mail tapes more easily than diskettes).

Generally speaking, therefore, magnetic tape is an ideal medium for archiving essential programs and data. So why haven't we seen more tape systems in the microcomputer market? Cost. Backup is an added expense. Only now that microcomputers are commonly performing business and work-related tasks is the safety of backup becoming what buyers might consider a reasonable expense.

The Perfect Backup Device

What should you expect from a tape drive designed especially for data backup? What are the characteristics of the perfect backup device? Ray Freeman, management consultant with a special interest in tape drives, asked this question of a cross section of users and concluded that a reasonable backup device would cost between one-half and one-third of the price of the disk drive and



Interdyne's 40-megabyte 3 1/4" tape drive.

perform its backup chores (backing up an entire disk) in less than 15 minutes.

From a practical standpoint, the time constraint (less than 15 minutes to back up the disk) means that you'll want to restrict your search to streaming recording. In streaming mode the tape drive

records 960 bytes. Consequently, streaming drives make much more efficient use of available tape than start/stop drives. How much of a difference overall? A streamer will use 97% of the tape for data, whereas a start/stop drive recording 512-byte blocks will use only 35% of the tape for data. The rest is overhead of one sort or another.

If you are selecting a backup device for a microcomputer, you'll make your choice from one of three categories:

- storage subsystems,
- tape cartridge drives,
- other tape systems.

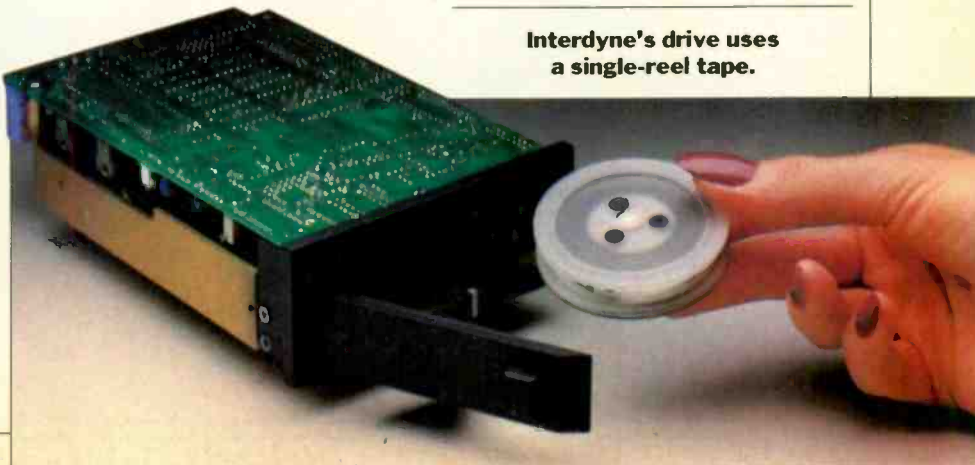
A Complete Package

The subsystem category is the easiest to understand, partly because someone else does the bulk of the work for you. A manufacturer packages both the hard disk and some form of backup in a single package. Typically, a single system command instructs the subsystem to back up the hard drive at the end of the work day. But developing subsystems for microcomputers is tricky. Although the success of a design depends a great deal on the ultimate end-user pricetag, it must be every bit as reliable and easy to use as those designed for larger computer systems. To produce good equipment the

records at high speed (typically 90 ips) without stopping between data blocks. Thus the gaps between data blocks (the interrecord gap) can be quite small.

To a streaming tape drive, these gaps are just markers. A 13-byte interrecord gap does the trick. There's no need to worry about stopping the drive. In start/stop drives, however, the drive does stop at the end of every block. Thus the gaps have to be large enough to allow the drive time to stop. The interrecord gap on a typical start/stop drive has to be

Interdyne's drive uses a single-reel tape.



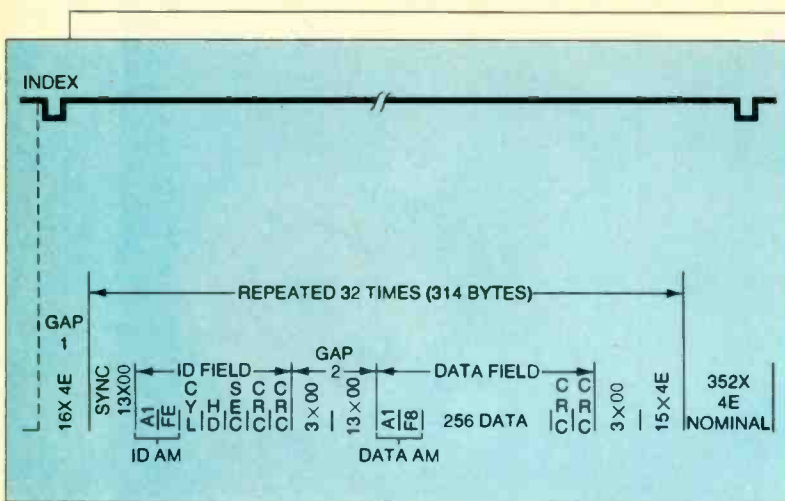


Fig. 1. A disk format of 256 data bytes/sector.

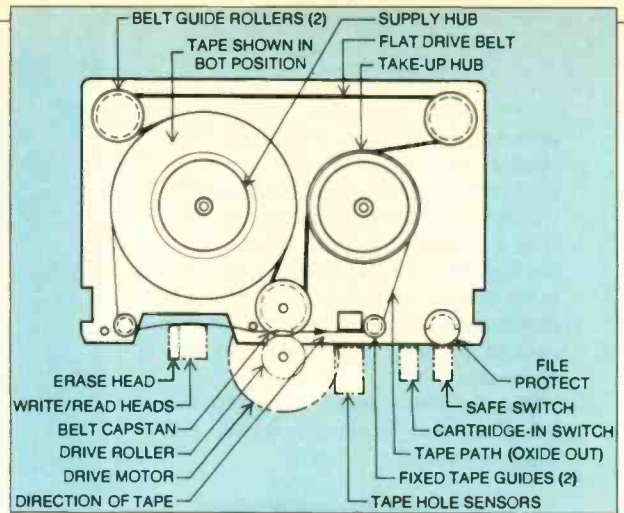


Fig. 2. Makeup of a tape cartridge.

subsystem designer has to be innovative.

Tallgrass Technologies Corp. begins putting innovation to work in a controller design that makes the most of whatever disk drive is used. The firm's Hardfile technique formats the disk in track, rather than in sectors. In a normal disk format of 256 data bytes/sector (Fig. 1), each sector contains 58 bytes that aren't data—these bytes (called overhead) are used for spacing and providing information such as address marks. A 256-byte sector, therefore, actually takes up 314 bytes of the available space in the track. Multiply this overhead times the number of sectors per disk and the overhead penalty mounts up quickly.

A typical 5 $\frac{1}{4}$ " Winchester disk can store 10,416 bytes/track, but after formatting (with 256-byte sectors) it can store only 8912 bytes/track. How does this work in practice? On a small Winchester disk drive that furnishes 12.7M bytes of unformatted data space, a conventional 512-byte sector format produces 10M bytes of storage; Tallgrass's Hardfile approach produces 12.5M bytes of storage.

Thus, Tallgrass's subsystems give your system an improved ratio of cost/M byte—a conventional method of measuring the cost-effectiveness of competing storage techniques—over many other techniques without doing anything but looking at data storage differently.

You could, of course, create a system that would reap these benefits yourself. Just do what Tallgrass did. But then you'd have to write the software and develop the hardware to support these nonstandard data structures. The point of the subsystems is that the strategy has been developed and debugged for you. The unusual format is transparent to your computer system. To put these savings into a clear perspective, consider that the firm's TG-3006 subsystem combines a 6M-byte hard disk and 20M bytes of cartridge drive storage for a retail price of \$2995. An interface package, including interface hardware (the card plugs into any expansion slot) and software, costs \$149 for an IBM PC/XT and \$169 for Texas Instruments' Professional Computer. For more disk-intensive applications the firm offers subsystems

that provide as much as 140M bytes of hard disk and 60M bytes of tape backup (\$9495 retail).

Another advantage of subsystems is that they offer a means of performing data backup without host computer intervention. This means that a single command can instruct the subsystem to take care of backup. A built-in buffer memory large enough to hold an entire 10K disk track lets transfers take place at high speed. And the buffer aids normal system performance as well, holding the entire track in memory for DMA transfers of data to the host computer.

Cartridge Drive Technology

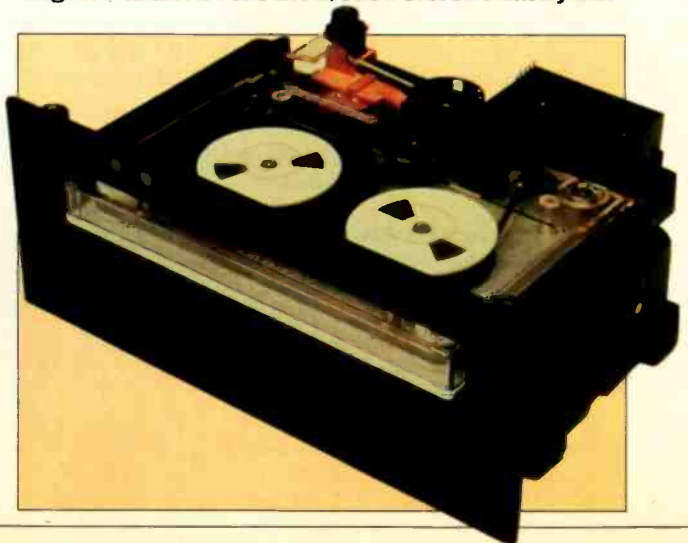
Data subsystems are quite useful, but they don't meet every microcomputer system's needs. A bare tape drive can prove more effective if, for example, your system already has a hard disk and all you need is backup. Adding a tape drive means that you can select the exact tradeoff of performance and cost.

The most popular tape drives these days are the $\frac{1}{4}$ " streaming cartridge

Fig. 4. Wangtek 5000E cartridge drive.



Fig. 5. Northern Tel's MTC/6109 stores 75M bytes.



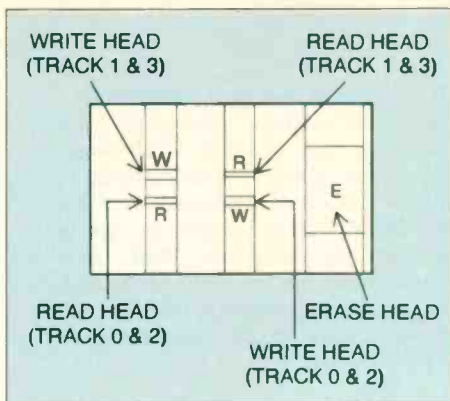


Fig. 3. Read-after-write head.

tape drives. The cartridge developed by 3M in the 1970s (Fig. 2) contains a mechanical system of belts, guide rollers and capstans. Putting tape in a cartridge makes it easy to use. Most of the drives make use of the industry standard DC-600 and DC-300 tape cartridges.

Today's cartridge drives can provide performance to match your backup needs. Archive Corp., for example, offers tape drives that can back up 40M bytes of disk in eight minutes and back up 20M bytes in four minutes on 9-track tape. Its 4-track models can back up 20M bytes in four minutes, running at 90 ips, and 12 min, running at 30 ips. Even including the time to change the cartridge, it takes only nine minutes to back up a 40M-byte disk using a 20M-byte 4-track cartridge running at 90 ips. Because the drive uses separate read and write heads, with the read head following the write head (Fig. 3), error checking can take place dynamically.

Tallgrass carries its unique views on formatting over to tape as well. Unhappy with the proposed QIC standard (see the box entitled "Setting Standards"), Tallgrass defined the PC/T-11 (personal computer tape) format, which puts 60M bytes of storage on a standard DC-600A

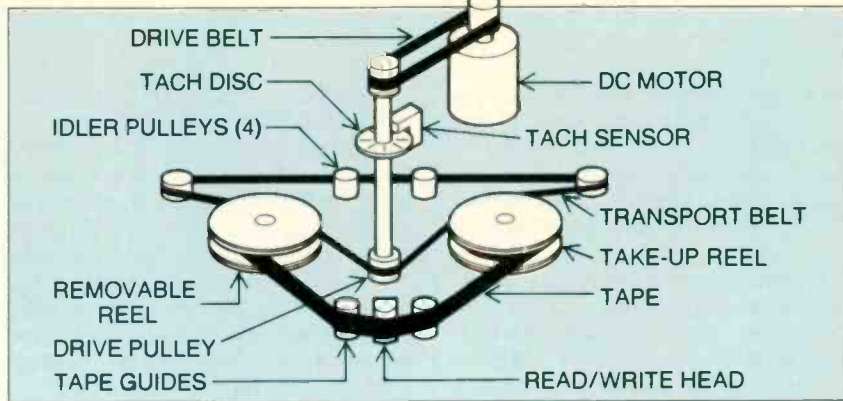


Fig. 6. Interdyne's device uses a self-threading system.

cartridge. This format blends start/stop and streaming formats together, providing smaller interrecord gaps than typically found on start/stop drives, yet furnishing an ID for each record. These records act as markers that the drive can use to define the location of an individual record. Thus, even though you are using the drive for high-speed backup, you can still replace individual records on the tape. Other manufacturers—Archive, Data Magnetics and Wangtek—have signed an agreement to use PC/T-11 as a standard format.

The HCD-75 Data Cartridge System from 3M's Data Recording Products Division uses cartridges for both start/stop and streaming backup modes. This lets you use the drive as more than just a backup drive. With start/stop recording, access to data is slower than it would be with a disk drive, but it is usually much quicker than access to data on a streaming drive. In harsh environments, the ruggedness of cartridge tape can outweigh its slowness in acting as the primary storage device. The drive can transfer data at 35K bps and features either a proprietary 3M interface or a SCSI controller.

Wangtek's enhanced 1/4" cartridge

drive, its Series 5000E (Fig. 4), can use either a DC300XL (450') or DC600A (600') cartridge to store from 20 to 60M bytes. The transport senses the type of cartridge you've inserted and automatically makes the necessary adjustments, such as modifying the bias voltage to compensate for different light transmis-

TAPE DRIVE MANUFACTURERS

Archive Corp.
3540 Cadillac Ave.
Costa Mesa, CA 92626

Entrepo
1294 Lawrence Station Rd.
Sunnyvale, CA 94086

InterDyne
157 Topaz St.
Milpitas, CA 95053

Irwin Magnetics
2311 Green Rd.
Ann Arbor, MI 48105

Memtec
Keewaydin Dr.
Salem, NH 03079

Northern Telecom Inc.
Memory Products Div.
100 Phoenix Dr.
Box D
Ann Arbor, MI 48106

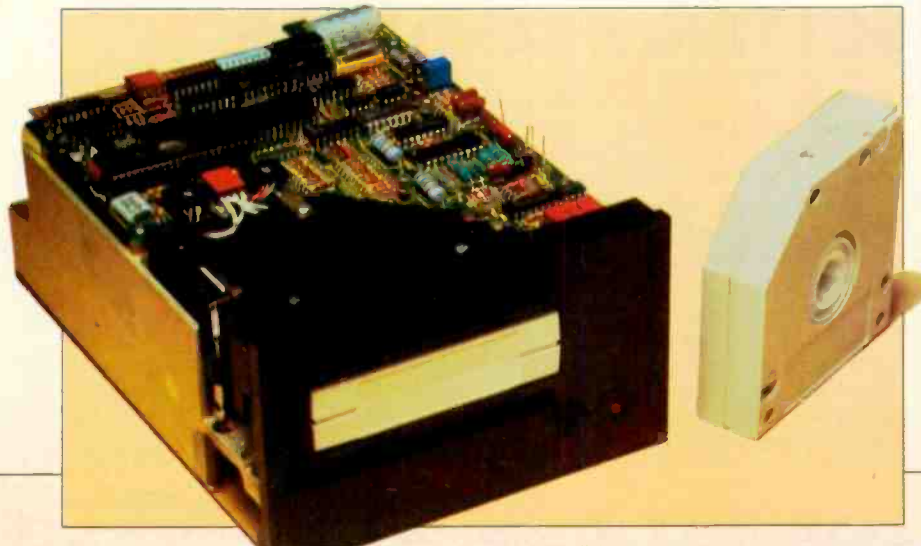
Tallgrass Technologies Corp.
11100 W. 82nd St.
Overland Park, KS 66214

Tandon Corp.
20320 Praire St.
Chatsworth, CA 91311

3M
Department DR83-25
Box 33600
St. Paul, MN 55133

Wangtek
41 W. Moreland
Simi Valley, CA 93065

Fig. 7. Tandon's TM951 puts 50M bytes on a reel.



sitivity characteristics. The drive also positions the head to the center of the tape's QIC-24 track reference burst to eliminate head-alignment problems. The automatic head-alignment will compensate for differences among machines up to 0.011".

Another drive that changes its operating parameters according to the cartridge comes from Northern Telecom. Its MTC/6109 (Fig. 5) stores 75M bytes on a 600' cartridge and 45M bytes on a 450' cartridge and is fully compatible with the 9-track QIC-24 standard. A 12-track version of the drive (Model MTC/6112) can store up to 100M bytes on a 600' cartridge and still read 9-track QIC-24 recorded tapes.

These are but a few of the drives on the market using standard cartridges. If you've got the space these drives require, you should easily be able to find one that meets any reasonable performance needs.

Sometimes space is the most important system resource. Small becomes not only better, but essential. For those applications, Memtec Corp. has opted to use a smaller-than-standard cassette for its 40M-byte Model 440 as well as its half-height Model 420 (20M bytes) and Model 410 (10M bytes). The front-loading cassette drives can back up 40M bytes (Model 440) or hard disk in nine minutes. It takes four minutes to back up 20M bytes of data on a 4-track tape.

The media for 40M-byte storage is a 450' 9-track cartridge that uses 0.15" tape. The cartridges sell for \$5 and are intended to last for five years (or 20,000 passes).

There are only three moving parts in the drive transport and two moving parts in the cartridge. This simplicity contributes to the drive's reliability. The manufacturer boasts a 7000-hour MTBF.

Irwin Magnetics puts 10M bytes on

DC-600 media, but in the smaller DC-100A sized cartridge. The entire drive fits in the same space as a half-height 5¼" floppy disk drive and interfaces to an SA450 standard floppy disk interface. The Model 110 is suitable for use in transportable computers. And Irwin goes itself one better with its Model 210. Using the same cartridge, interface and storage density, the unit takes the space of a 3½" drive.

Other Magnetic Tape Alternatives

The search for lower cost storage has led to interesting solutions. At Entrepo, designers began with a smaller-than-average cartridge and tied the ends of the tape together to form an endless loop. The cartridge, dubbed a Microwafer, is about the size of a standard business card, but thicker.

Entrepo's Microwafer tape transport can access data easily, yet its construction requires a minimum of moving parts, which helps to keep costs down. When you insert the data cartridge into the drive, the capstan presses through the tape against a rubber wheel mounted in the cartridge. When the capstan turns, it turns the wheel and pulls the tape from the reel.

The Microwafer drive isn't in volume production yet, but the firm hopes to produce them for under \$50. Each \$1.50 cartridge stores up to 128K of data (a 62' tape formatted in 512 byte sectors). A 10' tape cartridge could store 17K of data.

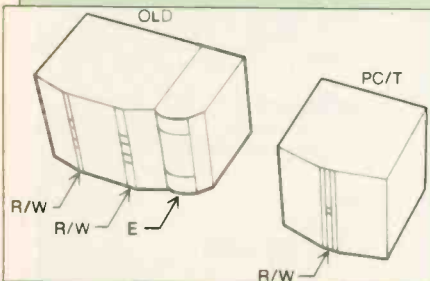
The search includes formats other than tape cartridges. One possibility is a throwback to reel-to-reel tape. Tape drive manufacturers moved to cartridges in the first place because of their convenience, but with today's technology, packaging tape in a cartridge isn't

(Continued on page 96)

OPTIMIZING HEAD DESIGN

TALLGRASS Technology sees weaknesses in the complex head designs that other manufacturers use in their cartridge tape drives, especially the configuration

Tallgrass's new head design is shown at the right.



found in the form of the QIC standard. The standard calls for a head with two read gaps, two write gaps and an erase gap—five gaps total. As a result, the head is costly, and maintaining azimuth between the gaps proves difficult. Thus you'll find a simpler head, with a single gap, in Tallgrass's own tape drives. The head actually overwrites a tape, rather than erasing it.

The three crowns of the more complex head, shown in the diagram, divide the tape tension. But the tension in a cartridge is already quite low. Divided in this manner, it's rough to keep the tape in reliable contact with each crown. With the single crown, the problem doesn't exist. ♦

SETTING STANDARDS

UNLIKE most computer peripheral industries, the cartridge-tape manufacturers have established some standards that make the interchange of data between machines not only possible, but practical. The working group for data cassette compatibility, D/CAS, has established several standard recording and interface standards that it hopes will promote the use and acceptability of cassette-tape products.

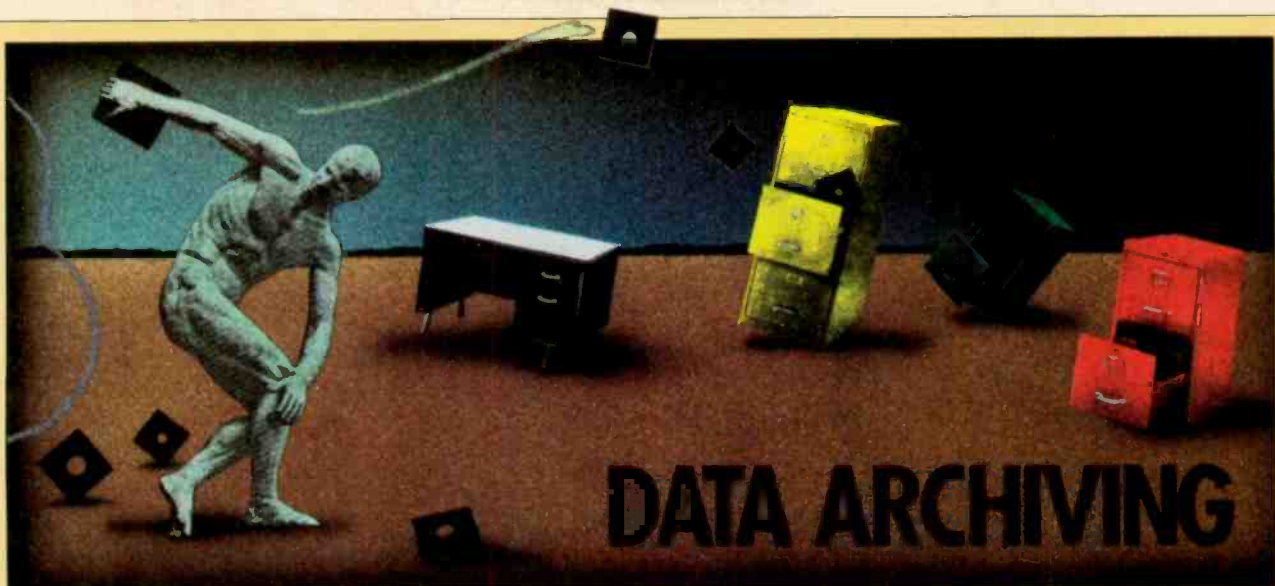
The hardware standard is called the QIC-02 (quarter-inch cartridge). The standard provides a minimal in-

terface for the drive's basic functions but still allow a great deal of variety in implementing special functions. It works with a majority of existing controllers and provides a basis for system designers who don't want their products to be made obsolete by improvements in backup technology. A system with a QIC-02 interface should prove to be a safe bet.

For those who want to ensure that data recorded on one cassette machine can be accessed by another machine—perhaps in another system at a later date—the QIC-24 specifies

a precise recording format. This 9-track standard includes a reference burst on track zero that individual drives can use for dynamically aligning the head before playing data back. This reference burst will reduce off-track errors that occur over time. The format is group-coded recording (GCR), which uses two 4-bit nybbles encoded into a 5-bit word. Each W shown in Fig. A denotes a 5-bit word.

Laying out the tracks in a serpentine fashion (Fig. B) puts the beginning of track 1 at the same end of the tape as the end of track 4. This allows



BY ROBERT HONE

If you have a messy desk like mine and sometimes leave your floppy disks in the clutter, you're asking for trouble. A floppy disk left flat on a desk can easily be pushed under a telephone, where one ring can obliterate the data on it. There are ways to considerably reduce—or even eliminate—the hazard of lost data. Here, we'll explore the hazards common to floppy disks and detail some of the steps that can prevent recorded data from being irretrievably lost as a result of carelessness or accident.

The Causes

Information is stored on a floppy disk as tiny magnetic charges in the oxide coating. A disk drive changes the magnetic fields with a small, precise electromagnetic device, called the drive head.

Disk drive heads aren't the only devices that produce magnetic fields. Any electromagnet produces a field that can affect the data recorded on a disk. Typical examples include the deflection system in a TV receiver, the electromagnet that rings the bell of a telephone, and any electrically driven motor. As a rule,

these electromagnets are large compared to the disk drive head and aren't very precise. When a floppy disk gets too close to them, say, within six inches, any data on the disk is either erased or rendered useless.

Data on a floppy disk can also be lost through contamination of the recording medium by dust, fingerprints, smoke, and other foreign matter. A typical dust or smoke particle can render many bytes of data useless by blocking the drive head when an attempt is made to read that portion of the disk and can permanently damage the disk medium and head with scratches. Likewise, oil on fingers can interfere with the reading of data by placing a film on the medium that can prevent the drive head from making contact with the recorded surface. To protect against such contamination, floppy disks have inner woven linings that are designed to pick up dust and oil. Additionally, most of the sensitive medium itself is covered by plastic, with only small selected areas showing through.

Heat is yet another hazard for floppy disks. It doesn't take much heat to de-

stroy a disk. As little as 120° F can seriously warp the Mylar material on which the oxide is deposited and which contains the recorded data. Therefore, don't leave floppy disks by a window, on a radiator, in a car, or near any other heat-generating device—period!

Disk Storage

The simplest way to store floppy disks is in the cardboard boxes in which they came. Doing so, however, can eventually lead to just the kind of problem you wish to avoid. Opening and closing the box fatigues the cardboard, which breaks down into a fine paper dust that can easily contaminate any disks stored in the box.

Much better approaches to storing floppy disks can be had with other storage devices. For \$10 or less, you can obtain a plastic diskette filing box that reduces the possibility of contamination by dust and other airborne particulates. These boxes each hold about 20 diskettes and usually have dividers. They're available in a wide range of colors, which helps in organizing your disks according to software type.

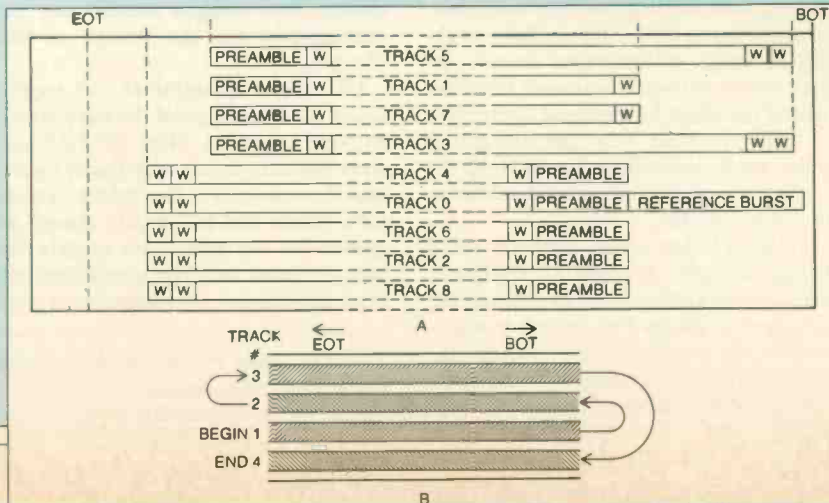
(Continued on page 96)

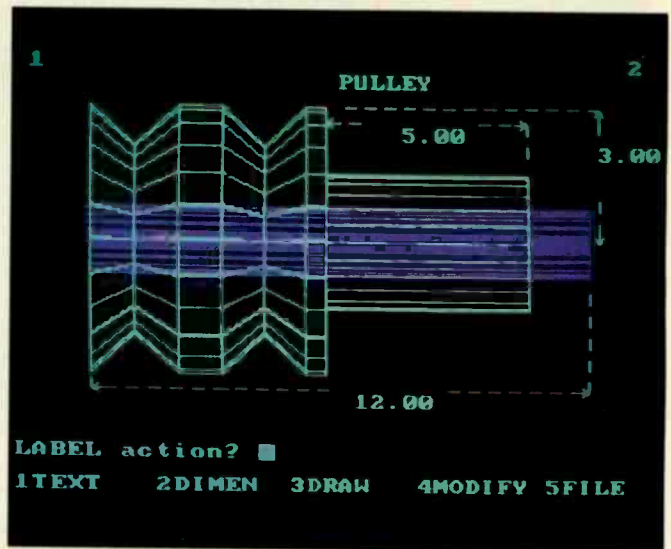
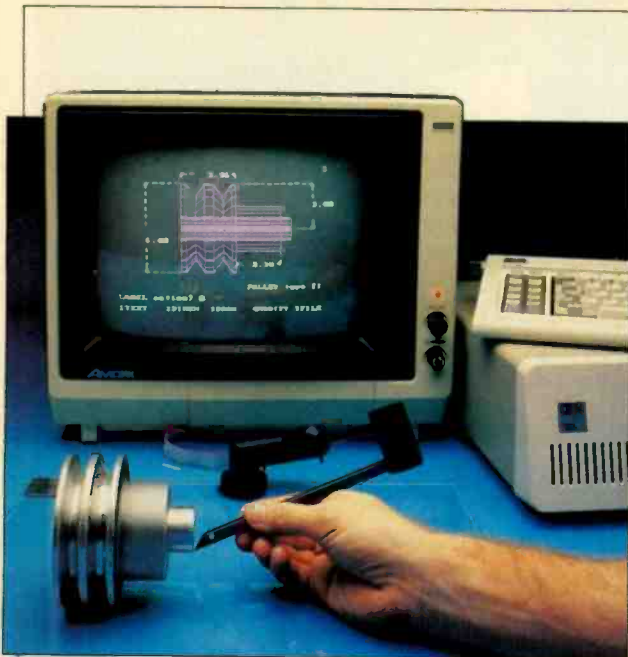
Figs. A & B. Layout of the QIC-24 standard system.

the drive to continue reading or writing data without waiting for a costly tape rewind.

The D/CAS group has also introduced a variation of the QIC-24 standard, called D/CAS-6. It defines a 4-track tape, preferred by some 1/4" cartridge tape users. This standard has been submitted to the American National Standards Institute for consideration as a standard.

For more information on the QIC standards or D/CAS group, contact Freeman Associates, 311 E. Carrillo St., Santa Barbara, CA. ◇





ENGINEERING DESIGN ON MICROS

New software and hardware give micros the power of expensive engineering design systems

BY ALEX LEE

WHEN CAD and CAE—computer-aided design and computer-aided engineering—are in the picture, usually minicomputers or mainframes are somewhere in the background. Sophisticated workstations for drafting and analysis ordinarily require the support of powerful computers. Now, however, personal computers are edging into the engineering workplace by performing tasks ranging from drafting to design of integrated circuits. In fact, clever software engineers have designed packages for personal computers (mostly the IBM PC) that are giving those units capabilities found until recently only on workstations that cost as much as \$50,000.

In its broadest sense computer-aided design includes any use of computer graphics for architectural or engineering design or drafting. For electronic applications, like printed-circuit or IC design, computer-aided engineering is the term. Using the data derived from CAE sys-

tems in physical production is called computer-aided manufacturing (CAM).

Engineers have been using CAD and CAE for years with peripheral equipment linked to mainframes. With this technology, they can create and quickly manipulate either solid or wire-frame representations of objects. CAD is a powerful tool because it allows them to change their designs interactively and immediately see the results of their changes.

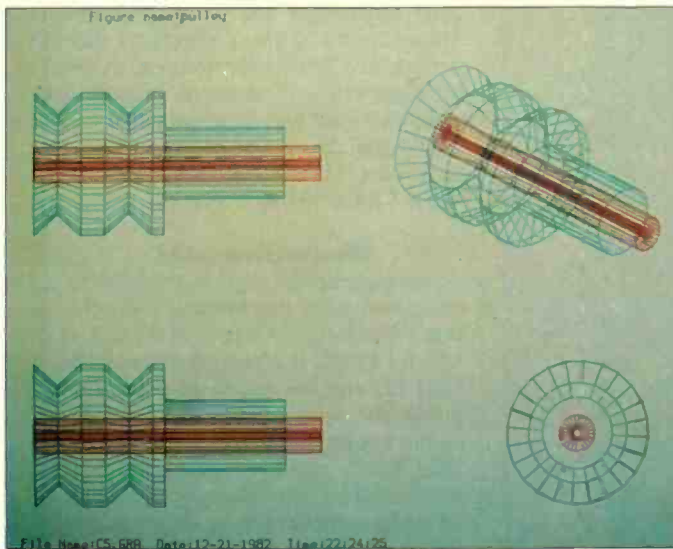
Of course, mainframes can support CAD activities beyond the capacities of PC CAD systems. Most PC CAD systems can only create wire-frame figures, and those in only a few colors. Greater CPU power and larger data storage are needed for the megabytes of data that many-colored solid representations may need. In addition, the resolution in pixels

Alex Lee writes frequently on industrial applications of computers.

is much lower in PC CAD than in mainframes. Moreover, engineers limited to PCs cannot analyze figures using finite-element analysis, which can be done on a mainframe. By that means they can define with mesh sections individual elements of a figure for stress and other forces.

For budding architects, engineers, and drafters, however, a PC-based system is probably sufficient. Even though these fledgling systems do not have all the speed or capabilities of full-blown workstations, for many engineering tasks they will be adequate. Most of the sophisticated CAD functions that only mainframes can handle are rarely utilized, anyway.

For CAD applications, a PC will usually need 512K bytes of RAM, a hard disk, and a coprocessor. The user enters data into these systems either with a lightpen or a digitizing tablet. (These two means of data entry are common to mainframe and PC CAD systems.)



In the three photos at the left, the Space Tablet is used to draw a pulley. Thirteen digitized positions are required—one to identify the axis and 12 for the ring structures with the same axis. In the center photo, the dimensions and text labels are added to the drawing. At the immediate left is the plotter output showing top, front, and isometric views of the pulley.

Of course there are differences among the various PC CAD systems. Some are sold as unbundled software; some as graphics engines; some as turnkey setups. Applications also range from 2D to 3D to IC design.

Autodesk's AutoCAD

Autodesk, Inc., of Mill Valley, CA, markets its AutoCAD program for precision and freehand drawing in two dimensions for 15 different microcomputers and more than 30 peripherals. AutoCAD has sophisticated capacities. It can pan, zoom, copy and move objects, rotate them, erase them and also store them. AutoCAD also has the capacity to redraw quickly and repeatedly any figure entered into the system's database in any desired rotation and x-y scaling.

The system lets the user draw points, lines, traces, arcs, circles and irregular shapes. Repetitive patterns can be gener-

ated automatically, and text can be integrated into drawings. Lines and tracings may be drawn to the resolution of the display or plotter used. In addition, the system calculates the correct ending angle on each segment of a multiple-segment trace. Circles can be created either by specifying a center point and radius or by citing any three points that lie on the circumference. Arcs, likewise, can be drawn by specifying three points. A designer can also fill in quadrilateral or triangular sections.

An ASCII drawing-interchange file format permits AutoCAD drawings to be used with other programs. As a result, drawings can be transferred to other computers via modem. Drawings created with AutoCAD may also be sent to professional CAD systems built by Intergraph Corporation in Huntsville, AL.

AutoCAD is written in the C language for systems ranging from the CP/M-80 machines having 8" floppy disks to the IBM XT. It costs \$1000 for

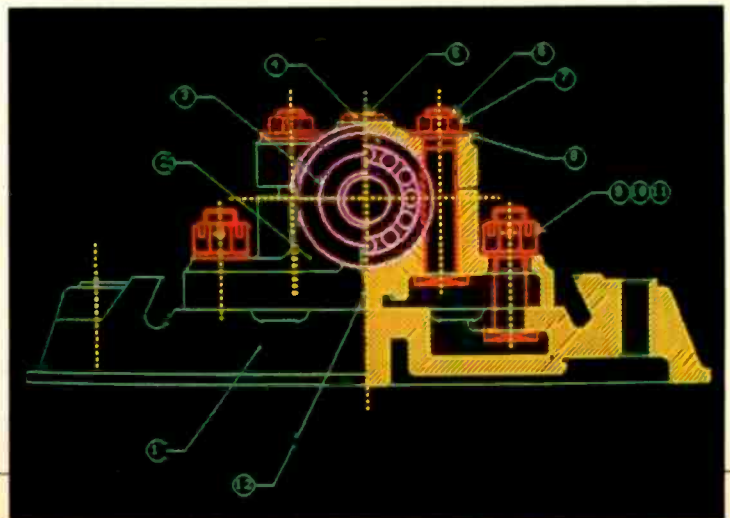
the standard setup and \$1500 for setups that include dimensioning, cross-hatch pattern fill, partial delete, axis commands for ruler lines, sketch modes, and a units command for both dimensions and coordinates in feet and inches.

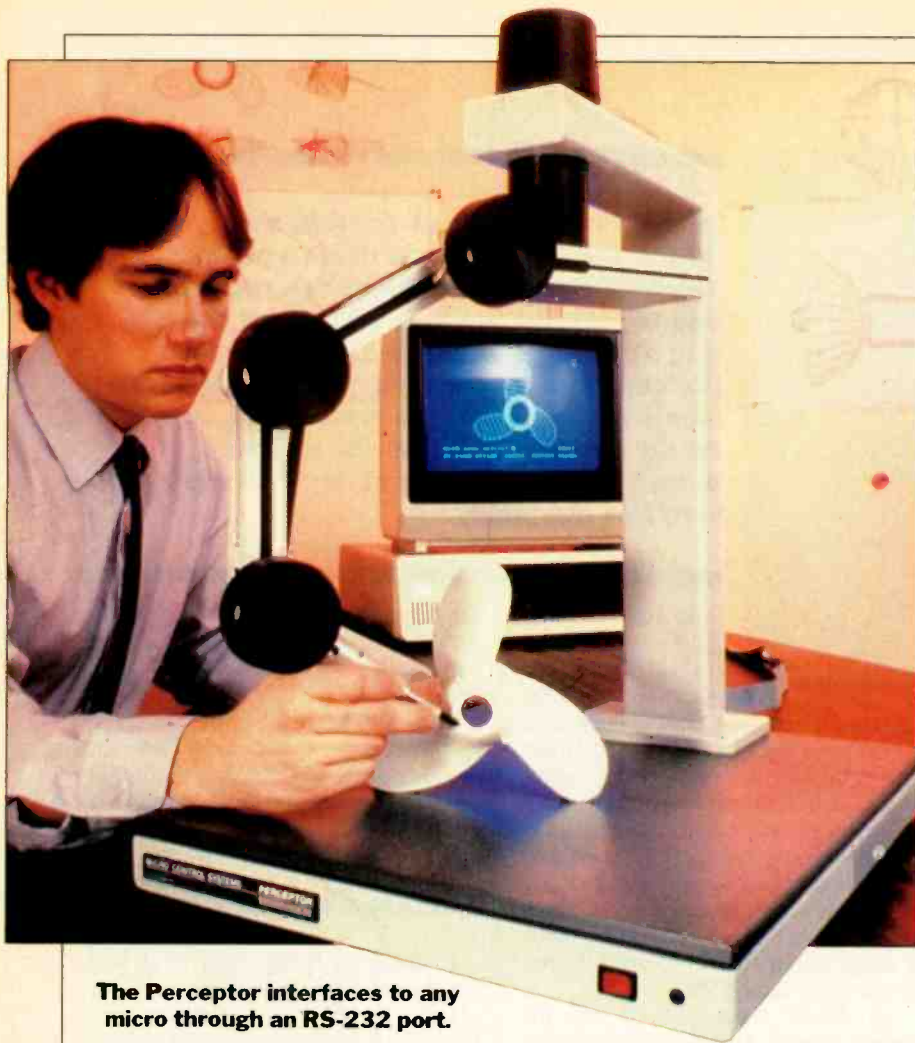
This type of software gives the user little more than line sketches. Anyone who desires the third dimension will need to look further.

IGC's High-Resolution Graphics System

IGC, Inc., of Hauppauge, NY, is well-known for its high-resolution graphic systems. It offers a 3D turnkey setup that can create solid images and manipulate them without host intervention. The system costs under \$30,000. It integrates the firm's RGC-1000 high-resolution controller and software from Cubicomp Corporation, Berkeley, CA. It uses an IBM PC with at least 512K bytes of memory, an Intel 8087 coprocessor, keyboard, command monitor, RGC-1000 display generator and a high-resolution 19" monitor. Special features of the controller allow an operator to zoom, pan

A typical application on the Mindset computer is Caddraft—on the left is an architectural site plan showing a building and landscaping; on the right is a cross section of a ball bearing assembly.





The Perceptor interfaces to any micro through an RS-232 port.

and window any portion of a 3D image without host-computer intervention. The system also includes a 16-bit DMA interface that permits the PC to talk directly to the display generator at 170K words/second.

With the Cubicomp software, a user can create complex solid-model geometries, remove hidden lines and hidden surfaces, execute smooth shading, do anti-aliasing, move the light source, clip, and insert text.

An interactive menu-driven command structure makes it simple to represent an object, which is displayed with a resolution of 1280 by 1024 pixels with up to 256 colors from a palette of 16.7 million available colors.

The RGC-1000 can be ordered to zoom, flip or pan the image across the viewing screen into as many as four independent windows, each of which can display a portion of the image.

MicroControl System's Space Tablet

For some applications, three dimensional drawing, even in millions of colors, isn't enough. MicroControl Systems, Inc., Vernon, CT, manufactures 3D digitizing equipment that transforms

the IBM PC or Apple IIe into a remarkable engineering tool. Through its Space Tablet, a mechanical 3D digitizer, and Advanced Space Graphics software, the system can depict an image of a solid so exact that it can be altered, measured, and experimented on.

Like other CAD programs, this one can scale, rotate, and move images about an axis, duplicate a figure, even in mirror image, draw arcs and circles, examine simultaneously three orthogonal views of an object, add text, automatically dimension angles and lengths, and drive several plotters and printers. Drawings or models can be copied by tracing physical objects. Alternatively, the tablet can be used as a 3D joystick to create imaginary shapes. The complete system costs \$1995.

The Space Tablet has many applications. A sensor or probe can be attached to its arm to perform 3D field mapping. For example, a thermometer attached to the tablet arm can be used to measure the temperature of hot air generated by a hair dryer. The 3D isotherms can be produced by interactively positioning the arm and recording its coordinates. Other types of data can also be mapped with this method. For applications that re-

quire more rigor and more flexibility, MicroControl System's Perceptor digitizing arm offers 7-mil resolution. It can interface with any computer because it includes a Z80 microprocessor that can send digital data to any computer with a serial port. The system costs more than Space Tablet: \$9500.

Mindset Computer

Among graphics engines, the Mindset computer, from the Mindset Corporation, Sunnyvale, CA, is one of the best; it sells for \$2495. It is compatible with the IBM PC and has enhanced computing power for image processing and bit-mapped color display. It relies upon the Intel 80186 microprocessor, which is augmented by two custom microprocessors. Mindset can support a resolution of 640 by 400 pixels and can display 16 colors out of 512 when the resolution is reduced to 320 by 200 pixels.

Chancellor Computer's Symgraph/Cadgraph

For a user more interested in depicting schematics, printed-circuit boards, and even ICs than in creating 3D images, other systems offer effective features. Though many circuits designed with these systems have to be breadboarded to be tested, these programs enable engineers to set everything up and in many cases download the information to larger CAE systems.

Chancellor Computer Corporation, Mountain View, CA, offers a complete setup for schematic and printed-circuit board design on the IBM PC/XT. A medium-resolution system costs \$13,500 and contains a schematic editor, a net-

Drawing with the Space Tablet.



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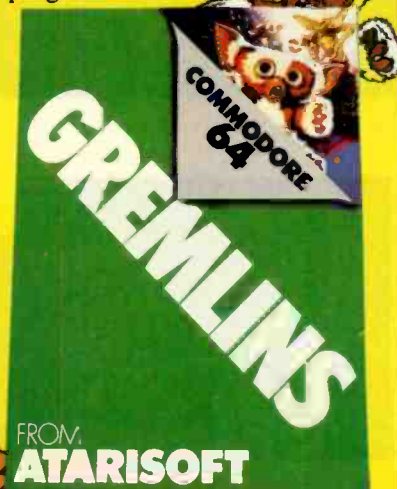
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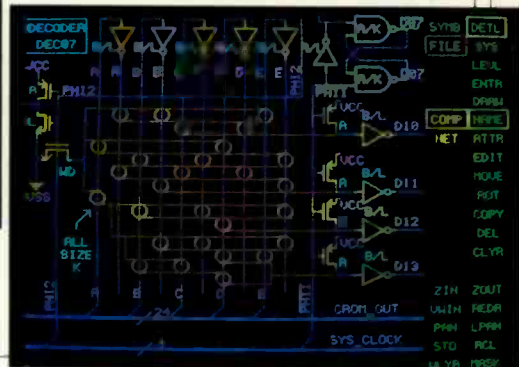
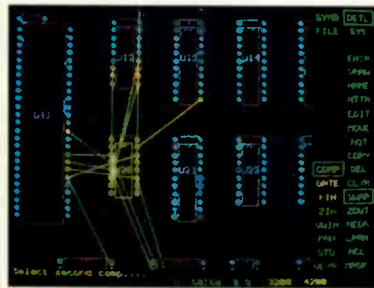
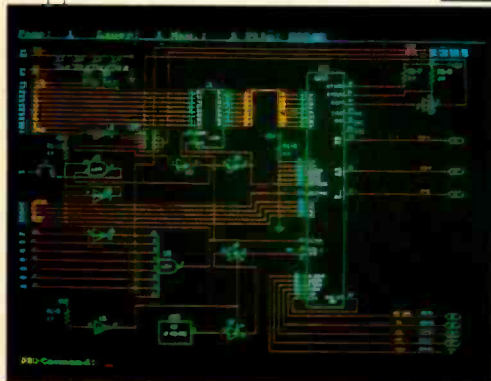
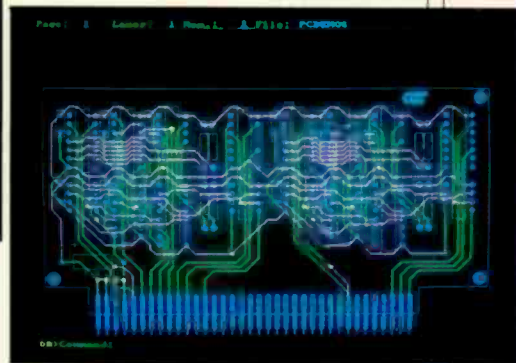
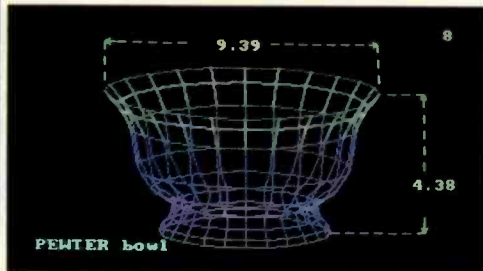
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ARE COMING
SOON TO A SCREEN
NEAR YOU.**



Clockwise from top left: PC Logs, Space Tablet, Cadgraph, PC Caps, PC Cards, and Symgraph.

list extractor, and also a layout editor.

The Symgraph schematic editor is used for both schematic entry and symbol creation. In the schematic entry mode, the package acts as a hierarchical wiring editor that supports the representation of electronic designs at multiple levels: function, block, gate, and discrete device. In addition, it may also be used to draw block diagrams and flow charts.

A menu prompts the user, who selects options with a mouse or digitizing tablet. The user can then create and modify menus or choose items out of a library of standard logic, discrete and TTL components provided with the editor. It is also possible to create new symbols and enter them into the database. Moreover, text can be associated with the symbols or wires.

The software also lets the user manipulate the image as a 2D drawing system does through commands including COPY, MOVE, ROTATE, PAN, and ZOOM. Information can be taken from the schematic editor and transferred to a net list, which is a listing of the nodes in a circuit that must be connected by wires. The net list extracts information for the schematic database and generates a bill of materials. It also lists the pin connections for every node.

Once the schematic is completed, the

engineer can use it to generate pc board artwork through the Cadgraph documentation package, which supports boards having up to 50 layers.

A user can also define power and ground planes as well as drill points, solder masks, and hole sizes. A library of predefined component patterns permits the generation of artwork that may be

There is a mainframe quality in the PC Logs package, which is an interactive logic simulator

used to create a pc board. Once the design is complete, it may be output to a printer.

Personal CAD Systems

Personal CAD Systems, Inc., of Los Gatos, CA, goes one step further, offering packages for the IBM PC and links for every phase of design and even some of simulation. It includes drafting tools, which could be used by the engineer designing a device, and electronic packages, that let the engineer work electron-

ics within or around this device.

Three packages are available for electronic design: PC Caps, PC Cards, and PC Logs. Accompanying these packages are utilities to organize and update the database once changes are made to the design.

PC Caps is a schematic capture package with many of the features of professional workstations. It can help an engineer to lay out a circuit or check against wiring mistakes, such as shorts or design-rule errors. One helpful feature is its ability to stretch like a rubber band fastened at one end, when dragging a component around the screen with all its connections intact in real time.

PC Cards provides similar features for pc board layouts. It supports the creation of multiple-layer pc boards, can build traces in a rat's-nest fashion, and check for design errors. It taps the data in the PC Caps and PC Nodes packages, which generate a net list from PC Caps, to create a finished board.

There is a "mainframe quality" in the PC Logs package, which is an interactive logic stimulator. As any designer knows, coming up with a design and building it is only going half the way. A breadboard prototype will always reveal success or failure. With PC Logs, a de-

(Continued on page 107)

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Epson PX-8

(Continued from page 38)

displayed upon startup. In addition to the files shown in Fig. 1, CP/M on the PX-8 has a number of built-in commands, namely: Dir, Era, Ren, Save, Type and User.

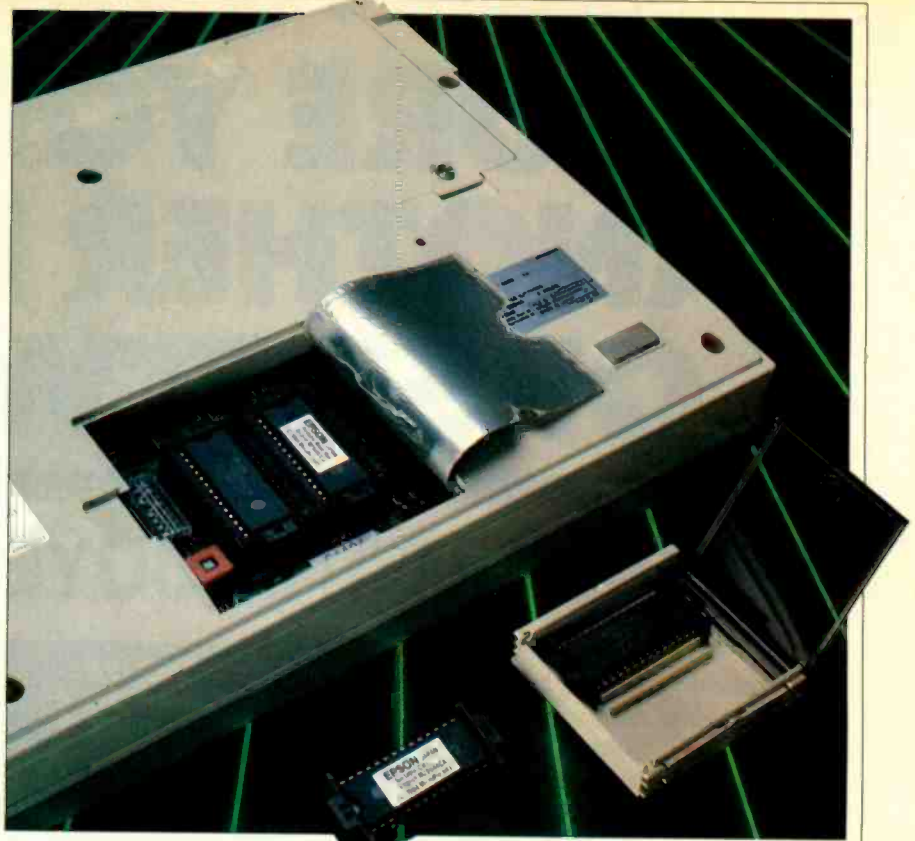
The PX-8 operating system is divided into 11 modules—some are part of CP/M and others supplement it. A listing of the modules with explanations appears in Table I. Some noteworthy ones are the Password module and the Clock module. The Password module gives your system a measure of protection against unauthorized use. You choose a password and assign it to the system. Upon startup, "Password" appears on the screen display and you must enter the correct password to proceed further. With the Clock module, you can set the internal clock to either sound an alarm or turn on the system at a specified time.

The language that comes standard with the PX-8, on ROM capsule, is an Epson enhanced version of Microsoft BASIC. Enhancements include a powerful screen editor, graphics statements to take advantage of the 480 x 64 display, and statements to select various screen operating modes, to support the PX-8's RS-232 port, to operate the micro-cassette drive in the same way as a disk drive, and to allow control of the PX-8 power supply.

Applications Software

For those who want to use the PX-8 for other than programming, there are two ROM module programs from MicroPro called Portable WordStar and Portable Calc/Scheduler. The modules contain "full-blown" word processing and financial modeling software. Although the small screen size puts some limits on program possibilities, as much power is available on the PX-8 as on comparable desk-top systems.

Although WordStar is in ROM and



ROM modules for the PX-8 can be inserted and removed by the user.

you may use it with a RAM disk, it doesn't appear significantly faster than disk-based versions of the product. There are some enhancements in the PX-8 version of WordStar, but some of the usual features are missing, among them, the help menus, file directory, renaming function, and soft hyphen entry. Additionally, MailMerge, SpellStar, and StarIndex are not available with Portable WordStar. However, there are ways of circumventing many of these deficiencies. For example, you can call up directories and rename files in the operating system. Also, Portable WordStar's Opening Menu includes two options called Transmit and Receive that enable you to transmit and receive files to and from a desktop unit running standard WordStar.

Using WordStar on the PX-8 will take some getting used to, even for those experienced with the product. One difference is due to the auto-repeat feature and type-ahead buffer of the keyboard. If you hold down a cursor key to move the cursor, you'll very likely overshoot your mark, since the cursor keeps traveling after you release the key. Another difference involves screen scrolling. New lines scroll onto the screen one character at a time (similar to the way text scrolls onto a terminal), which is not the case with standard WordStar. Though both characteristics result from features of the sys-

tem and not the software, they will be evident when you use WordStar and are processing large amounts of text.

Portable Calc and Portable Scheduler are available together on one ROM capsule. Portable Calc displays six rows and eight columns of a worksheet of 256 rows by 64 columns. Although we did not give the program a vigorous workout, it appears to compare well with similar programs found on desktop systems.

Portable Scheduler uses the PX-8's built-in clock and tone generator to provide calendar and alarm. When you enter the program, you're greeted with the day, date, and a schedule listing for the current part of the day (morning or afternoon). Function keys allow you to scroll forward or backward by half days or show a calendar of the next 30 days. You can set an alarm for any time on the half-hour. It will sound even if the unit is turned off or if you are running another program.

Some applications are available through CP/M, notably TERM and FILINK, which are communications programs. TERM can be used to link the PX-8 with a remote computer. However, it is a bare bones program. Users who need a more sophisticated communications program will have to obtain it from a source other than Epson right now. FILINK is a specialized program used

(Continued on page 99)

Specifications

Product: PX-8
Manufacturer: Epson America, Inc.
3415 Kashiwa St.
Torrence, CA
Dimensions: 11.7"W x 8.5"D x 1.9"H
Weight: 5 lb
Operating System: CP/M 2.2
Suggested Retail Price: \$995
Features: 8 line x 80 character LCD, microcassette tape, 32K ROM, 64K RAM, Microsoft BASIC, Portable WordStar, Portable Calc/Scheduler

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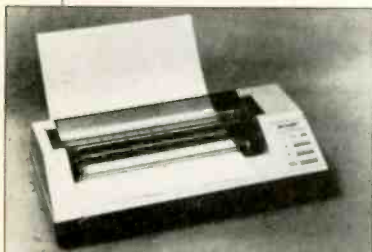
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NEW PRODUCTS

FOUR-COLOR PRINTER

A four-color letter-sized plotter from Sharp Electronics uses black, blue, green and red. The colors can be programmed to change automatically. The plotter accepts paper up to 8½" wide but can also plot on postcard-size documents. An RS-232C serial and Centronics-style parallel interface are built-in as standard features. The CE-515P plotter will be bundled with Softkey's Keychart software, which is compatible



with the IBM PC. The plotter may also be driven by micros that use BASIC if they are equipped with a printer interface cord or I/O port. \$399

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CUT-SHEET FEEDERS

Vivitar is marketing a line of four cut-sheet feeders for popular computer printers. Feeders are available for selected models of C. Itoh, Diablo, Facidata, Morrow, NEC, Philips, Sanyo, Televideo, Toshiba, and Silver-Reed printers. No tools are needed to attach the feeders to the printers, nor is there any need for making electrical connections. With a feeder installed on a printer, up to 200 sheets of paper can be handled, and the printer has forms-handling capabilities, including super/subscribing and all other special functions contained in software. Paper positioning is adjustable between 7" and 14". Ribbons and printwheels can be changed, and envelopes, checks, and labels can be inserted without removing the feeder. Less than \$400.

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COMPUTER SECURITY DEVICE

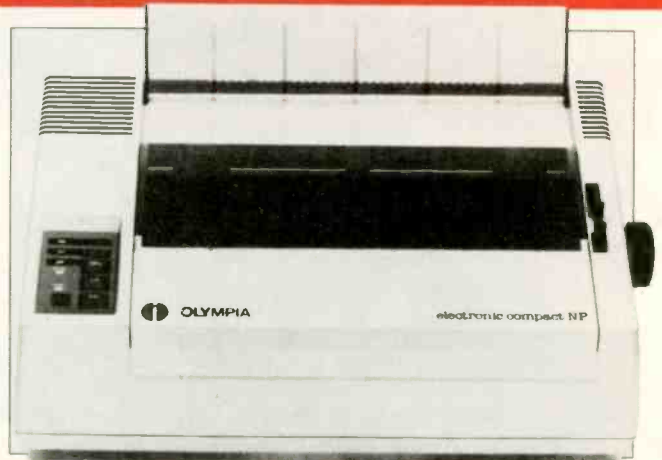
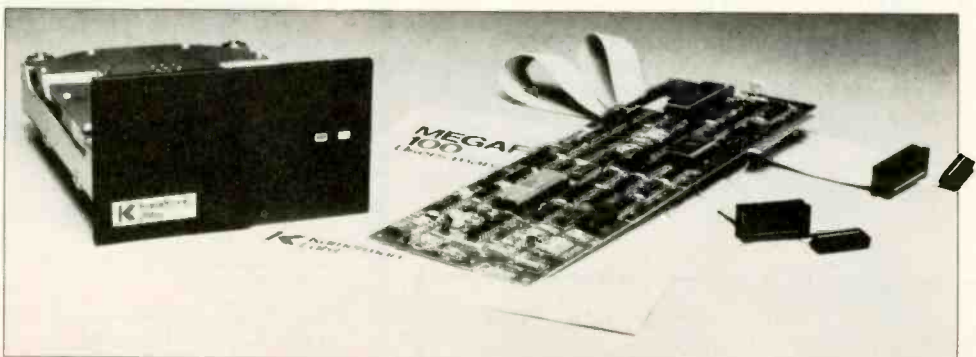
Adalogic's Gateway password device provides protection against unauthorized access to computers. The stand-alone device requires entry of both correct ID code and a password. If three incorrect codes are entered consecutively, the modem is automatically disconnected. The same occurs if time runs out in the user-defined time-limit logon mode. Up to 20 passwords and user ID codes, each containing up to 20 alphanumeric and special characters and spaces, are easily defined and changed. The menu-driven Gateway keeps a record of all successful and unsuccessful log-on attempts, even if power should be interrupted from its nonvolatile memory. The RS-232 full-duplex serial device can operate at 300/1200 baud on dial-up lines or 300/1200/9600 baud on leased lines. It automatically handles even, odd, mark, space, and no parity. \$395. Gateway is transparent to the host computer.

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10-Mb HARD DISK

A comparatively low-cost 10-Mb hard disk, from Kameran Labs, is called the Megaflight 100. The disk is compatible with the IBM PC and XT, Compaq, Leading



DOT MATRIX PRINTER

The Electronic Compact NP is a new dot matrix printer from Olympia USA. The printer comes with a parallel Centronics-compatible interface and features a 9-pin print head capable of a full 96-

character ASCII set with descenders and seven international character sets. It has a print buffer of 2000 characters and a built-in tractor feed that can accommodate fan-fold paper up to 10" wide. \$499.

Circle No. 85 on Free Information Card

SOFTWARE SOURCES

Graphics Program. Inkwell systems has released a 3.0 updated version of Flexidraw, their interactive software and light pen package for the Commodore 64 computer. The enhancements include the addition of 16 hi-res colors, a telecommunications program, new disk handling functions and expanded drawing capabilities. Flexidraw's expanded drawing capabilities include faster routines for lines, circles and boxes, "rubberbanding" and an "eraser" for quick editing. \$149.95

Circle No. 92 on Free Information Card

Edge, Corona PC and Corona Portable, Eagle PC and Eagle Spirit, Tava PC and other IBM-compatible computers. The hard disk uses the DOS 2.0 or 2.1 software drivers. The Megaflight 100 system

includes a hard disk drive unit with a capacity of 12.76 Mb unformatted and 10 Mb formatted, plus the disk controller card with plugs and cables. \$895

Circle No. 86 on Free Information Card

TRANSPORTABLE COMPUTER

Companion Computers' CP/M 2.2 Companion compact transportable personal computer is built around a 4-MHz, Z80A CPU and features 64K of user RAM and 192K of RAM disk. Supplied with a 5 1/4" floppy disk drive (up to two more drives can be added externally), the computer can read and write in IBM, Kaypro, Morrow, and Osborne double-density formats. I/Os supplied include two RS-232C serial with automatic (110 to 19,200) baud

rate selection, one parallel that defaults to Centronics standard, and a buss for adding external drives and 256K of additional RAM and ROM are provided. CP/M 2.2 and utilities are provided with the computer. The computer connects between a terminal and a host computer to run CP/M independent of the host or to log communications with the host for later use. CP/M 2.2 Companion measures 14" x 7" x 4" and weighs 8 lb. Simple connection to terminal can be made.

Circle No. 71 on Free Information Card



SOFTWARE SOURCES

AI-Based Software. Microrim's R:base Clout microcomputer software with artificial intelligence (AI) components is now available for PC-DOS, MS-DOS, CTOS, BTOS, and UNIX systems. The natural-language interface is designed for use with the company's R:base series of relational database management software. It has a built-in dictionary of 200 words and allows the user to add his own vocabulary. On installation, Clout reads the attributes in the existing database and adds them to the dictionary. It then allows the user to continue building the dictionary with synonyms for words or operations associated with the database. The process begins with a dialog with the user, who queries the computer with a word or series of words not already in the database vocabulary. The user is then asked to define unfamiliar terms. Clout also has the ability to search through the database to retrieve records based on adjectives or qualifying terms. A special feature is the program's ability to make inquiries into five different files simultaneously from the 40 files currently available in R:base. \$195.

Circle No. 72 on Free Information Card

RGB COLOR VIDEO MONITOR

Princeton Graphic Systems' new Model SR-12 is an RGB color video monitor that can display up to 16 colors simultaneously and offers both text and graphics display capabilities. The 12" diagonal screen can display up to 25 rows of 80 columns per row in the text mode and 690 by 480 pixels in the noninterlaced graphics mode. Video bandwidth is rated at 25 MHz, and mis-convergence is listed at 0.5



mm maximum in the center of the screen, 1.0 maximum in the corners. Power consumption at 120 volts ac is 95 watts. The monitor is supplied with a standard DB-9 (nine-pin) cable. \$799.

Circle No. 91 on Free Information Card

DISKLESS LAN COMPUTER

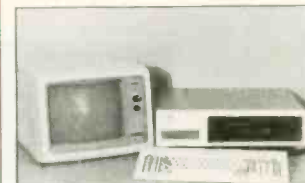
Chase Technologies' Model DL diskless local area network personal computer boots directly to the SPC (Server PC) hard disk. The computer features: 8088 CPU; socket for 8087 co-processor; Orchid PCnetPlus Multifunction card with 128K of RAM and BNC T connector; high-resolution amber video monitor with interface card; IBM-like detached keyboard; and 9 expansion slots (3 long, 3 short available to the user). RAM can be expanded to a system total of 640K. The DL is



DISPLAY ADAPTER

An 80-column display module for the Commodore C-64 computer is available from Batteries Included. The plug-in Model B.I.-80 module is said to eliminate the problems of snow, fuzziness, hashing, and interference encountered with other units. It can easily be switched between the 40- and 80-column modes, and it can be used with Commodore Models 1701 and 1702 color monitors or any monochrome video monitor. The device is fully self-initializing and comes with an 80-column operating system and BASIC 4.0 programming language, including documentation and description of use. Also available from Batteries Included is the BusCard that allows a Commodore-compatible disk (including hard disk) and virtually any printer to be added to the C-64. The device is both hardware and software invisible. The display adapter comes with a full machine-language monitor that includes assemble and disassemble commands.

Circle No. 74 on Free Information Card



claimed to be fully compatible with all hardware and software that runs under DOS 2.0 or 2.1 PCnet Local Area Network and has the ability to use any of the 256 PCnet addresses. System requirements: PCnet and PC-DOS 2.0 or MS-DOS 2.0. Options include: Orchid Turbo card with high-speed 80186 co-processor; parallel and serial port card with clock/calendar; color monitor and graphics card; floppy disk drives; printer sharing anywhere in network; and hard disk system. \$2395.

Circle No. 73 on Free Information Card

Tape Backup (Continued from page 84)

the only way to make tape easy to use. Interdyne has developed a single reel self-threading system with a fixed read/write head. Measuring only 1.625" x 4" x 6", the transport contains the unremovable take-up reel (Fig. 6). The self-threading scheme works equally well in drive models using either 1/4" (for up to 20M bytes of storage) or 1/2" (for 40M bytes) tape. The entire package is the same size as a 3 1/2" disk drive.

Tandon Corp's TM951 (Fig. 7), puts a twist on the idea of tape backup. It takes the same space as a 5 1/4" floppy and

stores 50M bytes on a single self-threading reel of 1/2" tape. The reel comes in a proprietary 1" x 3 1/2" cartridge. The cartridge more closely resembles the kind of cartridge you'd expect to see in a video recorder than a digital recorder, but Tandon expects them to catch on quickly.

As Times Goes On

The advent of recording and interface standards for at least the conventional 1/4" cartridge part of the tape industry bodes well for the future prospects of

tape technology. You can use the units that adhere to the standard and know that data is safe, even from progress.

Drives that use other recording methods have futures that are less certain, but you'll continue to see nonstandard drives in the marketplace. These drives satisfy needs for more storage or better performance, smaller package size or just a lower price. Nonstandard problems can require nonstandard solutions. A manufacturer that violates current standards just may offer the best solution for your system needs. ◇

Data Archiving (Continued from page 85)

Larger filing boxes store up to 50 diskettes for \$25 or less. Beyond this, there are available in the marketplace a number of miniature storage cabinets that flip open or have drawers that slide out and are able to accommodate as many as 200 diskettes, depending on size. Most such cabinets come with locks that prevent unauthorized individuals from getting to the disks, and all have dividers.

Make sure before you purchase filing boxes or cabinets in which to store disk-

ettes that they're made from antistatic materials. Otherwise, your disks can be zapped by static electricity on dry days.

A better way to protect your diskettes is to store them in individual packages. These come as small plastic envelopes similar to those used in photograph albums. The envelopes can be organized in a variety of ways. If many people must use the same group of diskettes, a rotary stand can give everyone easy access. These storage devices work much like an

ordinary kitchen lazy susan and can accommodate 100 or more diskettes.

A notebook type binder can store up to 24 minifloppies or 12 8-inch floppies in a very small space. Like the plastic filing boxes mentioned above, the looseleaf binders are available in a variety of colors. Since the binders can be stored upright like notebooks, they can be placed on a bookshelf, right next to the manuals that came with the disks.

If you like working out of a file cabinet

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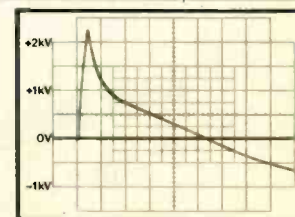
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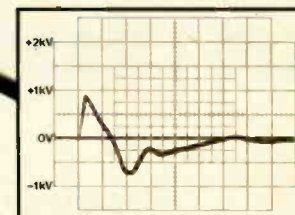
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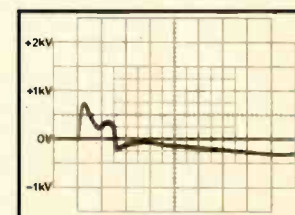
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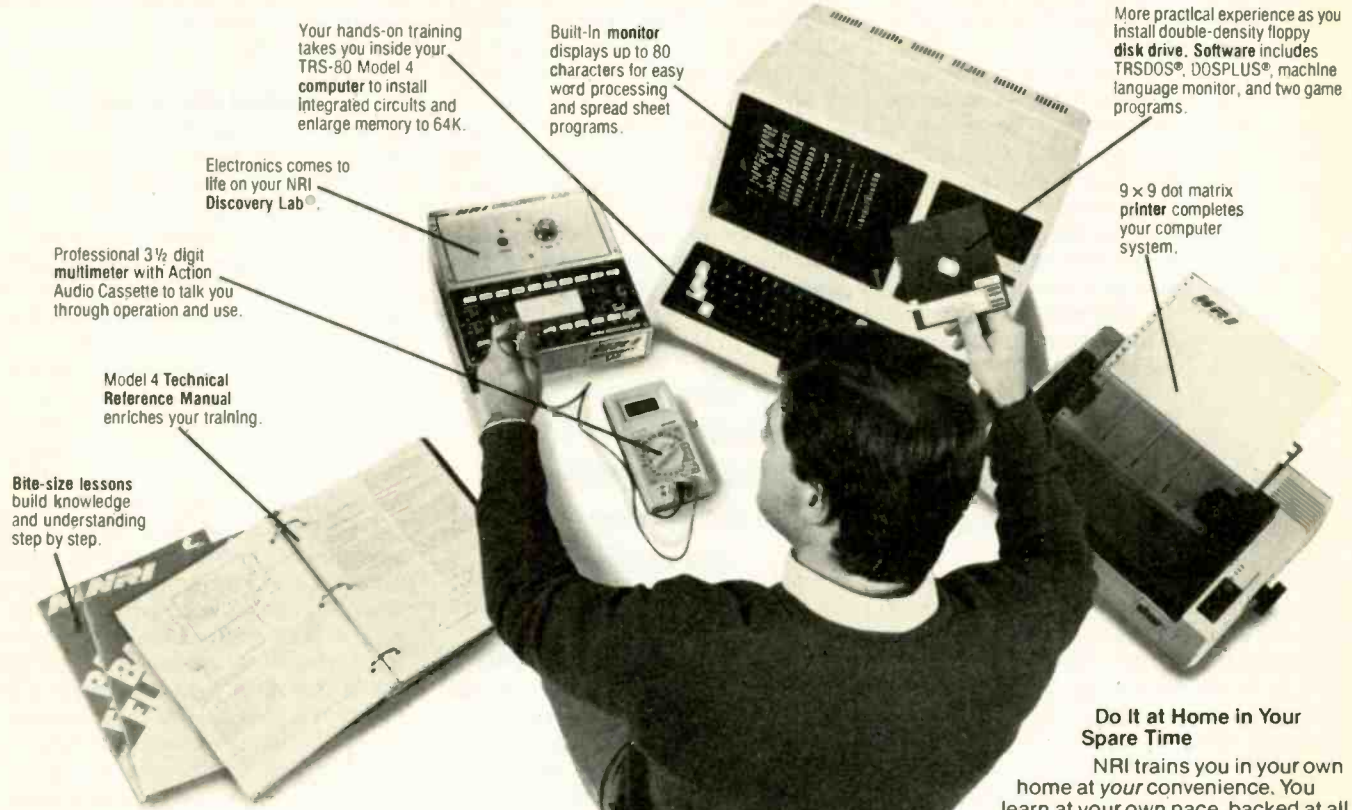


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TRS-80 is a trademark of the Radio Shack division of Tandy Corp.

Data Archiving

or desk filing drawer, diskette holders in the form of hanging files are available. Each holder is designed to accommodate two 5¼- or one 8-inch disk.

As careful as you are with your diskettes, you can never totally eliminate the possibility of data loss. A power loss to the computer, an incorrect command, or even a machine malfunction can destroy data on a disk mounted in a drive. If you should lose, say, a mailing list for a new company you are starting or, worse yet, the billing records, you can be in a very bad situation. The only way to protect against such data loss is through a system of routine backup.

Backing Up Data

You can back up data in a number of ways that vary widely in cost, time required to perform the backup, and time to retrieve the backed-up data once the original data is lost.

The least expensive way to back up data is to make a printed hard copy of the data on paper. But the time required to rekey the data into your computer from the hard copy can range from hours to days, negating any original cost-saving advantages. If you need to know only a small part of a file and be able to read it at any time, hard copy has the advantage that you don't require a computer to read it. And hard copies of mailing lists help keep things going until the computer is fixed or the data retrieved.

Another relatively inexpensive way to ensure against data loss is to copy a diskette onto another diskette. Most computer operating systems have a copy command that makes this a simple task.

Backing up all your diskettes can take a long time. A number of programs neatly runs the backup problem. Jet, which runs in only the IBM PC and PC-XT, uses special commands that copy data from one diskette to another faster than the usual copy command. It copies the disk block by block, instead of the usual file by file method of the copy command. Jet costs \$40 and is well worth the investment if you must frequently make duplicates of your disks.

Backed-up diskettes are worthless if, due to improper storage, they aren't ready when you need them. You can store backups in a container like the one used for your first copies. But since they are your "insurance policy" against total loss, they may need more protection than the work diskettes you use in day-to-day operations.

If your data is very important, think about investing in a small safe. Since floppy disks are heat sensitive, safes to

store them and other computer media are specially made to resist heat, as well as provide the usual protection against theft. Prices for safes are not inexpensive, though, ranging from about \$1200 on up.

Another good policy to follow is storage of backup disks in a location other than with your working copies, even if it's only one room away. Should an accident occur in the first room, chances are good that the room in which the backups

Any electromagnet produces a field that can affect the data recorded on a disk

are stored will be spared the damage that happens to the working copies.

If your data is important enough, you may want to store it off-site. Most banks hire firms to pick up the tapes with the day's data on deposits and withdrawals for delivery to specially protected storehouses. Some of these storehouses are touted to be earthquake and even nuclear bomb proof. The cost of using such a service is about \$30 for pickup within or near a large city and \$35 a month for storage.

Beyond Floppy Backup

If you have a hard disk system, the demands for ease of recovery are much greater, since the data that can be lost can be dozens to hundreds of times the volume on a single floppy disk. It could take weeks to reenter manually, through the keyboard, 10M of data lost from a hard disk system. A backup method that uses some kind of computer medium, therefore, is essential. The easiest way (and usually most convenient, since most hard-disk-based computers have at least one floppy drive as well) is to back up your hard disk data onto a set of floppy disks.

About 40 double-sided, double-density 5¼-inch floppy diskettes are needed to back up a 10M hard disk fully. Using this approach, it takes up to two hours to back up a 10M hard disk, but the Jet program mentioned above for the IBM PC and Back-Up 3 and Back-Up 2 for the Apple hard disks cut this time to about 30 minutes.

A faster way to back up hard disk data is with a cartridge tape system. The systems available are fully discussed in the accompanying article.

Optical Alternative

If you're looking for permanent storage, you might want to investigate the new laser optical disk medium now becoming available. Depending on the size of the disk such a system is designed to use, you can obtain up to a 1000M (1G) storage capacity. This is the amount of storage available on about 3000 double-sided, double-density minifloppies.

With the optical disk system, permanent storage is in the form of holes burned by a laser into a reflective layer on a glass disk. The disks aren't subject to data loss from the types of contaminants that can spell disaster for floppies.

Laser optical disks have many of the attributes of the "ideal" storage medium. They aren't subject to data loss from dust, dirt, smoke, liquids, or electromagnetic fields. Within reason, they're relatively immune to the temperatures that would ordinarily render a floppy disk useless. On the negative side, the disks have glass substrates that won't tolerate abusive handling without shattering, nor can they be erased and be rerecorded as magnetic media can.

Projected prices for laser optical disk systems are in the range of \$6000 to \$8000, with the disks themselves being about \$200 each. What makes the optical system viable is its relatively low per-byte cost, since they are able to store as much data as thousands of floppy disks.

The Considerations

In deciding which backup method to use, keep in mind a few factors. One, if the method you choose takes more time than you want to spend, you probably won't use it, which means that whatever you spent for it will have been too much. Two, balance your time in making backups against cost. A more expensive method may make sense if you wouldn't have the time to use a less-expensive method.

A third factor to consider is how often you'll want to make backups. Though experts differ on how often you should back up your data, the best rule to follow is: If you need the data, back your disks up immediately!

Closing Comment

Through proper care, you can prevent most accidental data losses, but bear in mind that no matter how careful you are, data can still be lost. So it's wise to invest in some sort of backup system and use it *before* you lose important data. ◇

Epson PX-8
(Continued from page 92)

only for sending and receiving WordStar files between the PX-8 and Epson's desktop computer, the QX-10.

The PX-8 comes with four manuals—the User's Manual, BASIC Reference Manual, Portable WordStar, and Portable Calc/Portable Scheduler. Epson manuals are always well written, though sometimes not thorough enough. The User's Manual, however, is very thorough and provides most of the information a serious computerist would need to get optimum use from the machine. (For even more extensive information, OS and Technical Reference manuals are available.)

The BASIC manual is also excellent, providing the user with a reference to all the commands, plus a wealth of examples to illustrate them. Again, a typically well written Epson manual.

Both the WordStar and Portable Calc/Scheduler manuals were produced by MicroPro. Though some of their manuals have been criticized in the past, these are as good as the most recently revised manuals that accompany their standard products. They are on a par with those produced by Epson.

The PX-8 and its peripherals offer a complete, portable package

Conclusions

With the PX-8, Epson has taken gigantic strides in placing the full power of a desktop computer into a moderately priced portable unit. For people familiar with the CP/M operating system and MicroPro products, this machine should be enormously popular. For those computerists familiar with other operating systems, however, I believe the machine will have less appeal. Those who are new to computing and attracted to the machine will face a serious dilemma—whether or not to invest the time necessary to learn two fairly complex pieces of software: CP/M and WordStar.

The machine does have its faults, notably a screen display with less than optimum readability and software that does not interact well with keyboard features. Its overall utility, however, far outweighs these minor problems. The PX-8 and its peripherals offer users a complete system in a portable package. Though the ultimate wish list might include such features as a 24-line screen display, Epson has produced an extremely capable portable at a very affordable price. ◊

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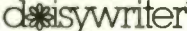
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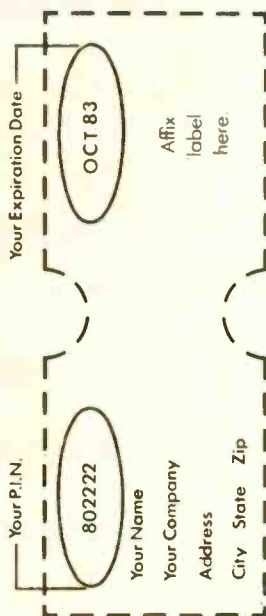
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AT&T

(Continued from page 69)

stantly maintained and checked by means of the three-bit code that comes at the end of each burst.

The time compression multiplexer described in the sidebar (on page 102) is the heart of the CSDC system. Once the system is in operation it will be located in the local exchange. What the user will see is a black box (leased from the local phone company) containing the terminating equipment that connects to the two-wire telephone line. The circuit in the box will be a variation of the standard hybrid arrangement used to split two-wire transmission into four wires. The user will see eight wires: two for data transmission, two for data reception, two for voice and two for switching back and forth between the data and voice modes. The user will be able to have equipment designed to connect directly to the CSDC or adapt the CSDC to one of the standard terminal configurations, such as the RS-232.

Considering the complexity of the entire CSDC system, using it will be remarkably easy

Using CSDC

Considering the complexity of the entire CSDC system (Fig. 2), using it will be remarkably easy. You will dial a special access code to get connected to the system even if your local exchange doesn't have CSDC equipment on the premises. As long as the exchange is on the digital data trunk (the T-carrier), the access code will automatically route the call to the nearest exchange with the equipment. Once you answer the phone a normal voice conversation can take place. When both parties agree, they can switch to the data mode and back to the voice mode. You will hear warning signals if the two ends of the call are not in the same mode. There will be no limit to the number of times you can switch between the two modes.

The advantages possible with 56-kilobaud transmission are endless. Since data can be sent in a short time, it may prove to be cheaper to use CSDC to transfer batch data than to transport computer tapes. Direct dial modems will be able to start dumping data automatically as soon as the connection is made

With CSDC, a high-resolution copy will take less than 4 seconds

between the two telephones. An offshoot of high-speed data dumping is quick facsimile transmission. Now the most expensive machines can transmit low-resolution 8 1/2" x 11" copies in about 30 seconds; most other equipment can take up to 6 minutes to do it. With CSDC a high-resolution copy will take less than 4 seconds.

By operating in the data mode and using the proper analog-to-digital conversion techniques, you will be able to send and receive high-fidelity speech and music with a greater bandwidth than is currently available even on special dedicated lines. By using the proper terminal software, you will be able to mix graphics with high-fidelity voice. At the moment, graphics can be sent over a dial-up line at a maximum rate of 4.8 kilobaud. CSDC will increase it tenfold.

Security can also be improved with the increased baud rate. The digital and analog techniques now used for voice scrambling have severe limitations. Digital means are limited to the baud rate possible on a standard loop; analog types are not very secure. Both methods often result in distorted sound, half-duplex operation and poor audio quality. CSDC's dial-up service is likely to lead to a new digital encoding scheme providing tighter security and better fidelity of speech.

Even if your computer cannot handle the 56-kilobaud rate of CSDC you will benefit. If you transmit at only 4800 baud you will enjoy a fourfold increase over the 1200 baud that you may be using now. If your transmission is now at 300 baud, it will become 16 times faster.

The number of uses for CSDC is anybody's guess. Once it is in operation, there are sure to be new hardware and software packages to take advantage of its possibilities. Although most of the applications mentioned are aimed at businesses, the expanding hordes of home computerists will be sure to find ways to use the service that even AT&T can't anticipate. ◇

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TIME COMPRESSION MULTIPLEXING

The heart of the CSDC system is the time compression multiplexer; and the heart of the multiplexer is the VLSI (very large scale integration) chip that was developed for it.

Four separate areas of ROM were built into the chip to handle different phases of the compression-expansion procedure. A 448 x 14 ROM and a 448 x 12 ROM control the receive and transmit operations, respectively. Two other 2K blocks of ROM contain the algorithms needed to scramble and unscramble the data sent over the line. (Scrambling ensures that the loop only handles data and prevents errors being generated when a user is either not sending data or is sending a long string of zeros.) The entire scrambling operation is completely transparent to the user.

Two 128-byte RAMs are input and

output buffers for storing the compressed data after it is received and before it is transmitted. Because so much memory is used, the architecture of the IC has an internal 8-bit data bus with serial input and output ports. Data is received and transmitted serially bit by bit but is handled internally in parallel at the byte rate. This lowering of the operating speed and the use of CMOS fabrication technology have reduced the dissipation of the VLSI chip to less than 15 milliwatts.

The ROMs that control receiving and transmitting are designed so that when one is operating, it turns the other off. This alternation helps prevent overlapping of data and consequential errors. When the chip receives data it checks for errors and breaks it into 7-bit segments. It adds an eighth bit and reads the com-

pleted segment into the RAM at an 8-kilobaud rate. When 24 bytes have been stored in RAM, the data is compressed and a burst is formed by reading the data out at a high rate. At the same time, as each byte is read out, the scrambling algorithm is applied and the byte is XORed (exclusive or'd) with the code. Then the byte is converted from parallel to serial format and the data is clocked out onto the T-carrier transmission line.

When the burst is received at the other end, it is converted from serial to parallel, and the last three bits are synchronized. If errors are detected in four consecutive bursts, the receiving multiplexer sends a code to the transmitter that halts data flow and restarts the burst synchronizing procedure. Once synchronization is reestablished, data transmission starts again. ◇

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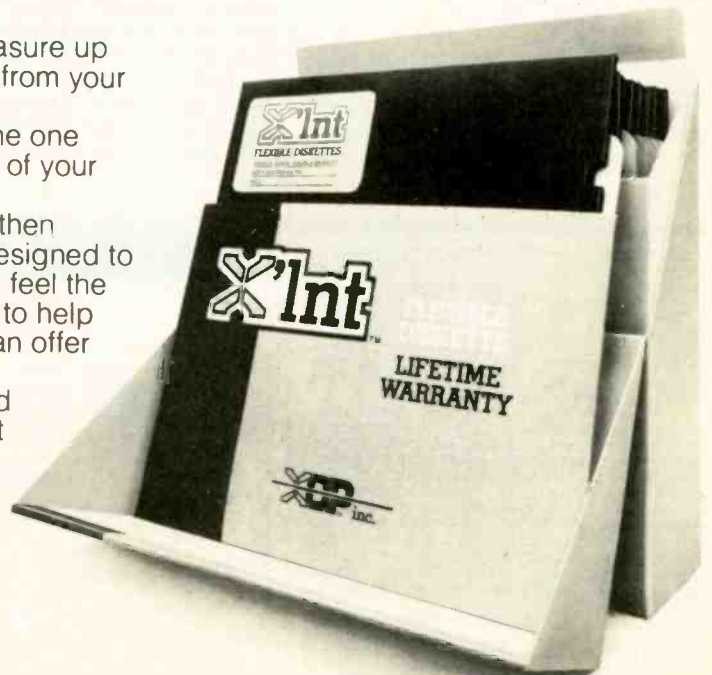
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Interfaces

(Continued from page 58)

A wide variety of A/D converter technologies exist. Types that use successive approximation and dual slope integrating rely on counter/comparator logic. Others employ charge balancing and flash inputs. The various types differ in their respective abilities to perform a conversion with a certain accuracy in a certain time. In practice, most of the "plug-in and run" A/D interface products operate with the A/D technology transparent to the user. Naturally, the cost of the A/D is proportional to the speed and accuracy with which the converter operates.

By adding a multiplexed front end to the D/A and A/D, manufacturers have created the data acquisition system (DAS), an interface device capable of capturing and converting a number of different analog signals (Fig. 2C). Since the bulk of the cost of a converter lies in the D/A-comparator-counter section, the DAS provides a low-cost solution for multiple inputs, at the sacrifice of speed.

Conversion Products Stress Flexibility

Manufacturers offer conversion prod-

ucts ranging from discrete cards to complete hardware/software systems geared for particular applications.

- The microprocessor-based Starbuck 8232 is a complete data acquisition and control system that connects to any computer equipped with a standard serial RS-232 communications port. It in-

Most plug-in and run A/D interface products operate with the A/D technology transparent to users

cludes eight protected analog input lines, eight protected digital input lines and eight opto-isolated digital output lines.

- The AOM-12 4-channel D/A and AIM-12 32/16 channel A/D converter card pair offer high accuracy and high speed for your S-100 bus (IEEE 696) system. Onboard DIP switches set the ad-

resses for each board. Multiple boards may be used for giving or taking data to or from the outside world.

- The Home Automatic Weather Station (HAWS) is a complete hardware and software package that allows amateur or professional meteorologists to monitor changing weather. The HAWS system contains sensors and conversion circuitry that allow VIC 20 or Commodore 64 computers to measure temperatures from +140 F to -130 F, relative humidity from 0 to 100% and atmospheric pressure from 1060 mBar to 3 MBar. Obtaining these weather values from HAWS requires nothing more than loading a tape or disk and pressing a few keys. Additional programs cover comfort factors, chill factors, cloud altitude estimating, metric-to-English conversion, trend graphing and forecasting.

- The Analog Interface Board offers an eight-channel A/D and an eight-channel D/A converter system to owners of the TRS-80 Color Computer, Commodore 64, Apple II and IIe and Timex 1000/1500/2068. Each channel has 8-bit resolution. The analog chan-

(Continued on page 106)

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50076	062	25	4	2.39
50077	062	50	8	4.25
50078	032	33	1.5	1.31
50079	032	88.5	4	2.47
50080	032	175	8	4.57

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11302	14	.59	.54	.48
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11304	18	.73	.66	.55
11305	20	.99	.90	.75
11306	22	1.12	1.02	.85
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11204	18	.18	.17	.15
11205	20	.20	.18	.16
11206	22	.22	.20	.18
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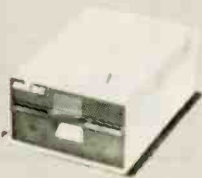
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Interfaces

(Continued from page 104)

nels act as mapped memory for high-speed operation. Fast Fourier transform software is available for magnitude and phase analysis.

• The Lawson Labs control products line provides Apple II (+ & e) users with a broad range of data acquisition and control devices. The Model 34 (\$325) is an 8-channel 12-bit DAS that accepts inputs from 0 to 10 V dc. The Model 14 (\$195) Analog Interface card combines a 4-channel 10-bit A/D converter with an opto-isolated 4-bit latched output port. A multiplexor card (Model 17 \$140-\$160) allows any Model 34 or 14 input channel to be expanded to 8 or 16 independent channels. Last, but not least, the Model 24 control module (\$120-\$180), also used in conjunction with the 34 or 14, provides from one to four double-pole single-throw relays rated 0.5 A. All models feature overvoltage protection up to 200 V dc.

• The single-board DT2808 from Data Translation extends an already impressive line of data acquisition and control interfaces. It provides 16 channels of

• The Keithley DAS Series 500 is a complete family of measurement and control cards that plug into a central system controller chassis. With measurement speeds up to 30,000 data points per second, conversion accuracies of 12, 14 and 16 bits, and the capacity for hundreds of analog and digital input/output channels, the Series 500 can accommodate a variety of applications. Direct transducer connection, programmable signal conditioning, and optional signal isolation eliminate the need for devices for external signal conditioning. The Soft500 integrated software package, an extension of floating point BASIC, ties the Series 500 together.

A Few Pointers

The list of new interface products and manufacturers grows monthly. In the midst of this product blitz, how best can users determine the quality of a particular interface product?

• The better devices are designed to protect as well as interface your personal computer. Look for inputs protected from short circuits and overvoltages and outputs isolated by optics or transformers or relays.

• Beware the differences between digital I/O and true switched relay I/O. Digital I/O is designed to control such power-hungry digital devices as printers and solid-state power circuitry. It cannot directly control appliances, lamps, and motors, for example. Relay-based I/O, either electromechanical or solid-state (power transistors, SCRs or triacs) can readily switch loads that would fry most digital I/O circuits.

• Finally, for those systems that communicate over home ac wiring, make certain that the communication protocol corresponds to such nonproprietary standards as those established by the BSR Corporation (known as the X-10 protocol) and Leviton. They guarantee that a source of low-cost switch modules, the controlled end of the system, will be available from sources as close as your local hardware or department store.

Nothing to It But to Do It

Don't be discouraged if this tutorial seems complicated. In practice, the user does not need to understand the workings of the latest generation of interface devices to use them. Most devices fall into the "plug it in and turn it on" category.

All of the manufacturers represented will be more than happy to supply literature and additional information if you desire. ◇

The list of new interface products and manufacturers grows monthly

A/D with 10-bit resolution, two channels of D/A with 8-bit accuracy and 16 lines of digital input/output. The IBM-compatible card contains an onboard microprocessor that acts as the interface between the DT2808 and the PC and also tends to simplify user access to the board's functions. PCLAB, a complete real-time software package, supports all board functions as callable BASIC subroutines. An optional screw panel allows for easy connection of user signals.

• The PCVISION Frame Grabber is a real-time video digitizer and display module capable of capturing a standard television camera signal at a rate of 30 frames per second. It stores the image in an onboard 512 × 512 × 8-bit frame memory and simultaneously displays the stored image on an external monitor. The image stored in the frame memory can be accessed by the computer to implement algorithms for image enhancement, feature extraction, pattern recognition and image transmission and archiving.

Engineering Design

(Continued from page 90)

sign can be simulated before a wire has been wrapped.

Outputs from this program may be viewed in real time as graphical waveforms, analogous to those produced by an oscilloscope or a logic analyzer. It can simulate both at the logical gate and transistor or switch levels and model high-level functional blocks like ROM and RAM.

PC Logs supports three logic states (low, high and unknown) in four driving strengths (supply, driving, resistive, and high-Z). This organization allows modeling of most devices. In addition, variable delays along with spikes and zero-delay oscillations may also be modeled.

This combination of packages is not inexpensive: The software alone costs over \$10,000. Together, however, these packages give an IBM PC the CAE capabilities that systems costing over \$100,000 did not have a few years ago.

FutureNet's Dash-1 and STRIDES

The most complicated of design tasks, IC design, is brought to the PC by FutureNet Corporation of Canoga Park, CA. Its software packages—Dash-1, a

CAD is also here for avocational use

schematic design package, and STRIDES (structured interactive design system), which adds on to Dash-1—let an engineer construct a drawing tree within one system. This structure extends the capability of Dash-1 to doing IC design.

Because the system supports up to 99 levels of hierarchy, a design can start out as a "black box" and eventually reach the logic gate level. Both top-down and bottom-up design strategies can be accommodated with the system.

In addition, Dash-1 and STRIDES establish links between the IBM PC and large CAD systems. As a result, pin lists, net lists, and lists of materials can be downloaded to more powerful CAD systems, like those from ComputerVision or IBM.

In just a few years CAD has descended from the heights of mainframe computers. Now, with a PC in one hand and—for some applications at least—a moderate number of dollars in the other, a designer or engineer working alone or in a small office can tap the versatility of computer-aided design. In fact, CAD is here for avocational designers, too. ♦

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CMOS Technology

(Continued from page 75)

lar-level performance with the power, voltage range, temperature range, and noise-margin enhancements of CMOS. RCA, for example, has developed a special TTL-compatible CMOS family to provide pin-for-pin and functional replacements for all of its TTL functions. The basic family is intended primarily for new all-CMOS designs.

Summarized in Table II are the key parameters of CMOS, NMOS, and

est versions run at clock frequencies of 5 MHz, compared to the 3.2 MHz of the CDP1802A. Higher clock frequencies can be expected in the very near future.

The second trend is improvements in semiconductor processing, which allow a larger number of system functions to be incorporated on a single chip. For example, the CDP1804A contains 2K bytes of read-only memory (ROM), 64 bytes of random-access memory

RAM is more complex (thus occupying more chip area) than that of a ROM, total storage capacity of RAM chips is much smaller than for ROMs. At present, static RAMs are commonly available in 16K-bit sizes, though 64K-bit chips are appearing now. By comparison, per-chip ROM storage can be as large as 256K bits, or four times the capacity of RAMs.

However, dynamic RAM is not dead. Since a dynamic RAM requires a lower number of system clocks to operate, this helps to reduce the chip power requirement and improves operating speed. Because of the reduced area required by dynamic memory cells, 256K RAMs are currently available. New CMOS technology has also increased speed to a cycle time of 120 nanoseconds, also allowing a data cycle time of 65 ns, resulting in a data bandwidth of approximately 16.5 MHz.

Users can look forward to two trends in memory technology. The first is that densities (number of bits per chip) will continue to increase. Just as important, the speed of memory devices continues to increase. These two developments, compared to NMOS technology for static RAMs, are plotted in Fig. 4.

A complete system requires support devices to transfer data between the processor and memory, handle input/output (I/O) functions, perform timing functions, and other so-called house-keeping chores. A wide range of peripheral chips is available in CMOS technology to support the microprocessor and memory.

Manufacturers are producing a broad variety of CMOS chips such as keyboard interface devices, interrupt controllers, real-time clocks, UARTs (universal asynchronous receiver/transmitters), and video controllers, among others. These and other devices permit designers to construct systems by assembling building blocks of fully compatible components.

View Down the Road

From the foregoing, it is obvious that the decade of the 1980s and beyond holds great promise for CMOS—and offshoot—technology. Because of its inherent characteristics, CMOS technology stands on the doorstep of technology leadership across the broad range of integrated circuits. ♦

TABLE I—CMOS BENEFITS

Key Characteristic	Benefit
Very low power consumption	(a) Low power supply cost
Typical values at 1 MHz/5 V	(b) No cooling fans (lower cost/small size)
Gate 1 mW	(c) Battery operation/standby/portable
Counter 3 mW	
8-bit Micro 5 mW	
4K RAM 20 mW	
Very low standby current	Allows backup storage with small/low-cost battery
For example: 16K CMOS RAM: 15 μ A/3 V/70°C	
High noise immunity	Operates reliably in noisy environments without special filtering (e.g. process controllers)
For example: 1.5 V at VDD = 5 V	Reliable operation in hostile conditions (e.g., automotive, engine control, military)
Wide temperature range:	
Plastic: -40 to +85°C	
Ceramic: -55 to +125°C	

LSTTL. The speed enhancement made possible by new processing advancements gives CMOS a substantial advantage against the other devices.

A Complete Family

While CMOS logic gradually overtakes TTL, the advantages of the technology are also continuing to make an impact on microprocessor and memory ICs. As the chip density of NMOS devices increased, the heat due to power dissipation increased. This forced the industry toward CMOS because, although its speed compares favorably with NMOS, its power requirements are far less, thus reducing on-chip heat to an acceptable level.

What is even more important is that certain CMOS processors (the 80C86 and 80C88 for example) can maintain their internal registers and data values with the clock stopped. This means that system current demands are greatly reduced, thus increasing battery life.

When CMOS is specified for peripheral devices, a power saving of 50:1 can be expected. A power saving of 5:1 can be expected when using CMOS memories. The first 8-bit CMOS processor, the CDP1802, was introduced by RCA in 1976.

The family tree shown in Fig. 3 traces the evolution of a typical "family" of CMOS microprocessors (in this case, the CDP1800 series). Two trends are evident. First, the speed of CMOS microprocessors is steadily increasing. The lat-

(RAM), and a timer/counter circuit, in addition to the basic microprocessor function elements.

Since users obtain all the power, temperature, and noise-margin benefits associated with CMOS technology, these microprocessors can be applied in equipment in which it may be extremely difficult to use either a bipolar or an NMOS processor.

As microprocessor-based systems become more memory-intensive, the need for high-density, low-power memory devices increases.

Since a static RAM requires far less control circuitry than dynamic RAM, most CMOS technology advances are being made in this area.

Low-power CMOS EEPROMs (electrically erasable PROM) have lower power dissipation, better noise immunity, and better temperature insensitivity than their NMOS counterparts. They are making inroads in the "permanent" memory area as used in battery-powered portable computers.

These two types of memory chips are projected to undergo the largest growth increases of any memory devices between now and 1990.

Because the basic storage cell of a

TABLE II—CMOS CHARACTERISTICS

	Type		
	LSTTL	NMOS	CMOS
Gate delay	8 ns	8 ns	8 ns
Power (F/F at 1 MHz)	20 mW	8 mW	2 mW
Noise immunity	0.4 V	0.4 V	1.5 V
Temperature range (commercial)	-40 to +85°C	-40 to +85°C	-55 to +125°C
Supply tolerance	± 0.25 V	± 0.25 V	3-18 V



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Xerox PARC

(Continued from page 78)

lot of people adopted ideas from PARC. Apple just put enough money behind it and invested in driving its cost down to something everybody could afford."

Charles Simonyi also admits that companies like Microsoft, where he works, and even the entire industry owes a lot to PARC. He credits PARC's contribution not to how unique the scientists were but to the special circumstances they were given. "Other people have held the same dream but didn't have the freedom to develop it in a laboratory." Now he prefers to speak about the present: "What's going on now is a lot more exciting. The innovations that were once introduced by academics and at facilities like PARC now come from the industry."

New PARCs

PARC not only inspired new products and new ideas; it also has spawned similar environments at other companies. Steve Jobs, Apple chairman and cofounder, visited PARC in 1979 and was inspired enough to invest in the Lisa and Mac technology. In the publicity that accompanied the debuts of these

products, he acknowledged his debt to PARC and its impact on Apple products. He has also collected former PARC employees, including Larry Tesler, who went to work at Apple in 1980 and Alan Kay, who arrived by an indirect route. After his years at PARC, Kay went first to Atari, where his job meant "politicking, keeping my finger in the dike and following my nose." Even as a chief scientist at Atari, Kay had a hard time trying to rationalize the need for basic computer research. The "bean counters," as he likes to call accountants, had the final word. At Apple he can expect a difference, especially because Jobs seems eager to resurrect the magic of Xerox PARC in developing its newest line of 32-bit machines.

New Gardeners at PARC

The golden age at PARC officially ended when a new research management entered and Bob Taylor left last. Others had taken their leaves in the late 1970s when corporate headquarters in Stamford, Connecticut, took a more active interest in PARC operations. Scientists at PARC started to feel pressed to make

their work more relevant to the Xerox bottom line. In the spring of 1983 Xerox appointed a new PARC director, William Spencer, a Bell Labs veteran who is particularly oriented in turning the lab toward the marketplace.

Taylor hasn't retired. He, with members of the original PARC team, is in the process of establishing a new computer research facility in Palo Alto, with another corporate parent, DEC (Digital Equipment Corporation).

Though details are few, it appears that DEC, a company that has a solid standing in personal computers and is well-entrenched as the minicomputer leader, needs the ideas that only a think tank expert and talent collector like Taylor can offer.

While Taylor is reluctant to talk about a center that isn't even completely built, he did put the new DEC center and PARC in a long perspective: "If you're going to try and connect the present with the past, I would suggest going back to the ARPA days. The whole thing has been a continuum. PARC is not anything special in that continuum. It was just a midway point." ◇

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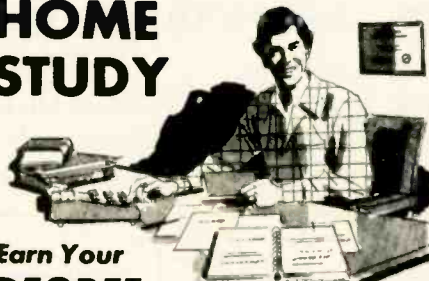
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Symphony

(Continued from page 50)

the virtues of its predecessor. One feature that has been enhanced over the 1-2-3 implementation is the ability to freeze entries on the screen. You can freeze rows at the top and/or columns at the left borders of the window, which is particularly useful in a large worksheet where it is difficult to remember which data is in a particular row or column.

Graphics

Symphony breaks little new ground with its graphics capabilities. Available formats are line graphs, bar graphs, stacked bar charts, pie charts, exploded pie charts, and high-low graphs. The latter two graph types are not available in 1-2-3. All of the normal capabilities of labeling, creating titles, shading or cross-hatching, and scaling are found in Symphony.

The thing that is new in Symphony—and in some of its competitors—is the ability to display on the screen simultaneously the data and the graph. This is particularly useful because you can dynamically see the effects of changing a data element on a graph. Unfortunately, it is not possible to print graphs with text other than labels and titles.

Symphony can display data and graphs simultaneously

Databases

A Symphony database is a specific organization of a worksheet. Each column of the worksheet contains a field in the database. The first row of the worksheet contains the field names; each row thereafter contains one data record. You enter data one record (row) at a time. The advantage of using the database format over a spreadsheet is it gives you the ability to set up forms for data entry. You can customize a form to give information about the item to be entered and to do edit checks on the entries. Data entry forms can be set up so that entry clerks see only the parts of the database relevant to them. For example, a manager could set up a payroll database with multiple data entry forms—one for entering confidential information about an employee (e.g., the hourly rate) and one for a clerk to enter the number of hours worked. Since each field in a record is really a cell in a spreadsheet, fields can also be calculated using all the power that is normally available in a spreadsheet. In the case of the payroll database, an employee's weekly wage could be calculated

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Symphony

culated by means of the spreadsheet.

Once you have created the database, you can extract information in the format you specify. For example, from the payroll database you could extract a list of employees who worked more than 40 hours in a week. Capabilities exist within Symphony for ordering the database entries (sorting) based on any field and for report generation. Because of the integrated nature of Symphony, you can set up a form letter using the word processing facility and insert the names and addresses from a database. You can control the order in which the letters are printed, e.g., alphabetical or zip code order.

Symphony is a worthy contender in the integrated software competition

Communications

Symphony includes a means of exchanging information with other computers. The communications package includes facilities for storing phone numbers and automatic log-in procedures. You can also define settings such as auto-dial or auto-answer for your modem. Using the communications package of Symphony you can have the PC act like a "dumb" terminal to a mainframe computer. I found it relatively easy to emulate a VT100, call a VAX computer and run a program to extract some data, capture the data directly into a Symphony spreadsheet and graph it.

Add-on Applications

With Symphony you can access other applications and return to the same place within your Symphony session. At this time two such applications have been implemented, DOS and the Symphony tutorial. I was able to exit to DOS from a Symphony spreadsheet work session, create a print file using Supercalc, and return to Symphony. This capability will permit Lotus and others to expand Symphony to include new applications. For example, Lotus plans to market spelling-checker and appointment calendar add-ons by the end of this year.

Importing Data from Other Programs

After some manipulation I was able to take a file created using Supercalc and import it into Symphony. I found that it was advantageous to separate the text

and the numbers into separate files before importing the information. Symphony was unable, however, to import numbers with imbedded commas properly. I could not, of course, import the formulas for calculation; I had to re-enter them using the spreadsheet facilities of Symphony. Importing a text file from another word processor was relatively easy.

Symphony also provides a translation utility for dBASE-II and Visicalc files. The translation utility works both ways—that is, you can import files into Symphony or export files from Symphony to the other programs. Symphony will work without translation on 1-2-3 files, except that you first must rename files with a different file type.

Command Language

One place where Lotus has made improvements to 1-2-3 is in macros. Often you find that you are repeating the same series of keystrokes over and over again. Within Symphony you can create a macro by using the Learn facility to Teach the keystrokes to the computer. When you invoke the macro, the same series of keystrokes will be repeated automatically.

Lotus has applied the concept of a macro to more complex sets of problems. For example, Lotus claims that you can develop your own menus, similar to the ones used in Symphony, but tailored to your particular application. Thus you might create a database application to catalog the items in your home for insurance purposes and create commands such as NewItem, DeleteItem, RevalueItem.

Symphony provides a language of more than 80 commands. Evaluating the language, which includes arithmetic, logical (including decision-making), string and statistical functions, is beyond the scope of this review.

Conclusion

Symphony is a very powerful system whose particular strength lies in its complete integration of its various facilities. It is a worthy contender in the integrated software competition. If you do a lot of spreadsheet work and would like to be able to be able to incorporate text with tables and charts, then this may be the package for you. I wish that it included dynamic reformatting in the word processing module and did not require the use of two disks to start the system (in order to include the Help facility). In a package of this complexity and magnitude, however, these are very small annoyances. ◇

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Computer Scientist (Continued from page 31)

can learn a great deal about the flexibility and power of analog computers by simulating a simple machine with the help of any personal computer having analog joystick ports.

Suitable computers include Radio Shack's TRS-80 Color Computer, the Apple IIe and the IBM PC family. Consider, for example, the PCjr, a machine having two analog joystick ports. Each port supports two potentiometers and two on-off switches. Therefore, a simple analog control panel having four potentiometers and four switches can be constructed.

In Part 2 of this column, I'll describe how to assemble such a panel from readily available parts. In the meantime, you can easily experiment with an analog input for your computer by using its joysticks as analog input devices.

For example, the listing that follows converts the PCjr into an analog input machine that provides the sum, difference, product and quotient of any two joystick values:

```
10 'PCjr ANALOG COMPUTER
    SIMULATOR
20 CLS
30 X=STICK (0) : Y=STICK (1)
40 LOCATE 6, 15
50 PRINT "X =" : X ; "Y =" : Y
60 LOCATE 8, 15
70 PRINT "X*Y =" : X*Y
80 LOCATE 10, 15
90 PRINT "X/Y =" : X/Y
100 LOCATE 12, 15
110 PRINT "X+Y =" : X+Y
120 LOCATE 14, 15
130 PRINT "X-Y =" : X-Y
140 GOTO 30
```

Though this program is specifically designed for the PCjr, it can be easily adapted for use with any other machine having joystick inputs. When the program is run, the monitor displays a table showing the current joystick values (X and Y) and the results of the four basic arithmetic operations. Here's the table that was displayed when the joystick handle was moved to a random position:

```
X = 110   Y = 78
X*Y = 8580
X/Y = 1.410256 -02
X+Y = 188
X-Y = 32
```

Many other arithmetic operations and other enhancements can be added to this basic program: The X and Y values can be variables in an equation that is plotted on the display. Moving the joystick to change the variables would then almost

simultaneously alter the shape of the plotted curve. Similarly, the X and Y values can be used to set, via the joystick, the aspect ratio of an ellipse having a fixed diameter, as in this PCjr listing:

```
05 'PCjr VARIABLE ASPECT
    RATIO ELLIPSE
10 CLS
20 SCREEN 1,0
30 X=STICK (0) : Y=STICK (1)
```

```
40 CIRCLE (160,94),
    20,,,X/Y
50 CLS
60 GOTO 30
```

When this routine is entered and run, a flashing blue ellipse or circle appears. Moving the joystick's handle changes the aspect ratio of the ellipse.

Finally, a second joystick can be added.
(Continued on page 114)



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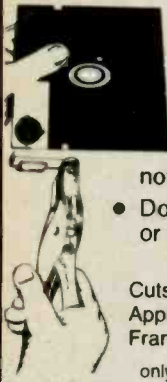
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Computer Scientist (Continued from page 113)

ed to provide a total of four variables. If the joysticks are equipped with trigger buttons, from two to four user-selectable status conditions or preprogrammed numerical values can be inserted into the mix of available options.

In Part 2 I'll describe various ways to make and use a simple analog control panel for a personal computer. I'll also describe the surprisingly simple architecture of a futuristic, single-chip analog/digital microcomputer.

For more details about do-it-yourself simple analog computer circuits, see the "Experimenter's Corner" columns in the January and February 1979 issues of *Popular Electronics*. Both have been reprinted in *The Forrest Mims Circuit Scrapbook* (McGraw-Hill, 1983). ◇

Stearns

(Continued from page 43)

On the other hand, many PC DOS compilers, assemblers and interpreters worked without problem. Lotus 1-2-3 only needs a small patch provided by Stearns to work properly. Software that uses the high-level interface to DOS, including many of the popular data processing packages, will run without any problems.

Performance

In several benchmark tests, I compared the Stearns with the IBM PC-XT: floppy disk, hard disk, CPU speed, and a combination of these. I was interested in the effect of the faster clock speed and the 16-bit data bus. I found the Stearns to be roughly 2.5 times faster than the IBM XT, except in floppy disk applications, in which it was 1.5 times faster.

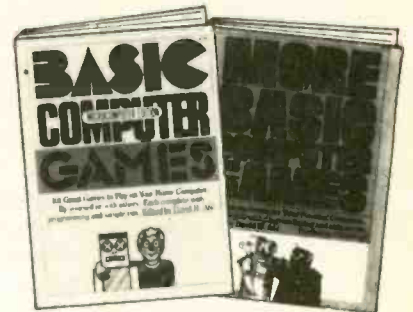
Summary

The Stearns is a well-built machine offering a substantial performance improvement over the IBM PC and many other computers that are compatible with the IBM. The programmable keyboard and function key display on line 26 of the monitor enhance its performance and set it apart from the competition.

Potential buyers will have to weigh performance against compatibility and availability of software. The company does intend to market compatible versions of popular software packages through its dealers.

Without a doubt, this machine is well-suited both for word processing and data processing, especially where speed is essential. This computer is a strong entry in the field of IBM PC compatibles and is well worth considering. ◇

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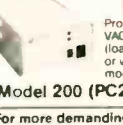
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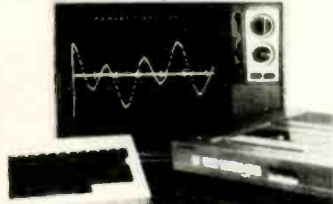
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Nutshell

(Continued from page 52)

command as their means of entry.

The menu's options are comprehensive. The FIND, MODIFY, and DELETE commands operate on the record being displayed. The ADD command presents a blank data-entry screen for the addition of a new record.

The DEFINE and LAYOUT commands are versatile and easy to use. When you invoke DEFINE you are presented with a screen that lets you start naming fields. After you have a field you give the data type (text, numeric, date, etc.). Nutshell automatically assigns a default length to each field. I found that you cannot insert new fields once a line has been entered, so prepare your layout on paper before you commit yourself to putting it on disk.

Perhaps the most powerful command available from the Browse menu is LAYOUT. Once you have defined your file structure, Nutshell gives you great flexibility in determining how it is to be displayed. Nutshell's full screen editor can be used to create data-entry screens, data-display screens, and report layouts. Leading Edge claims that Nutshell has a capacity of two million layouts per file (provided there is sufficient disk space to hold them all). It is not at all difficult to construct layouts with headers, footers,

control breaks, totals and subtotals.

The SORT command doesn't really sort. Since all data fields are indexed, the use of SORT creates a new index or indexes. When a file contains data, the records are presented in the order of original data entry until a sort is performed. Modified records are not reindexed until you are finished working with the file that is being modified.

The PRINT command uses the layout currently in use, but gives you the option of switching to another. Once printing has been started it can be stopped at any point and later restarted. You can also modify the print control options.

In Summary

I found Nutshell to be easy to learn and pleasant to use. A keyboard overlay included with the package saves constant searching through the manual (unfortunately, there is no place to store the overlay when you're not using it).

While the manual, at over 252 pages, is not trim, the individual pages are uncluttered and well illustrated, although some of the reproductions of screen images are difficult to make out. The instructions, however, are clear and precise; the program should present no one with any great difficulties. ◇

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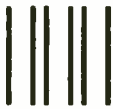
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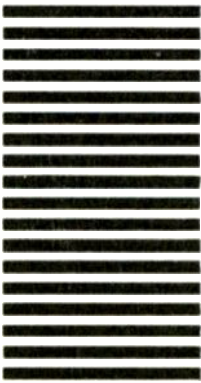
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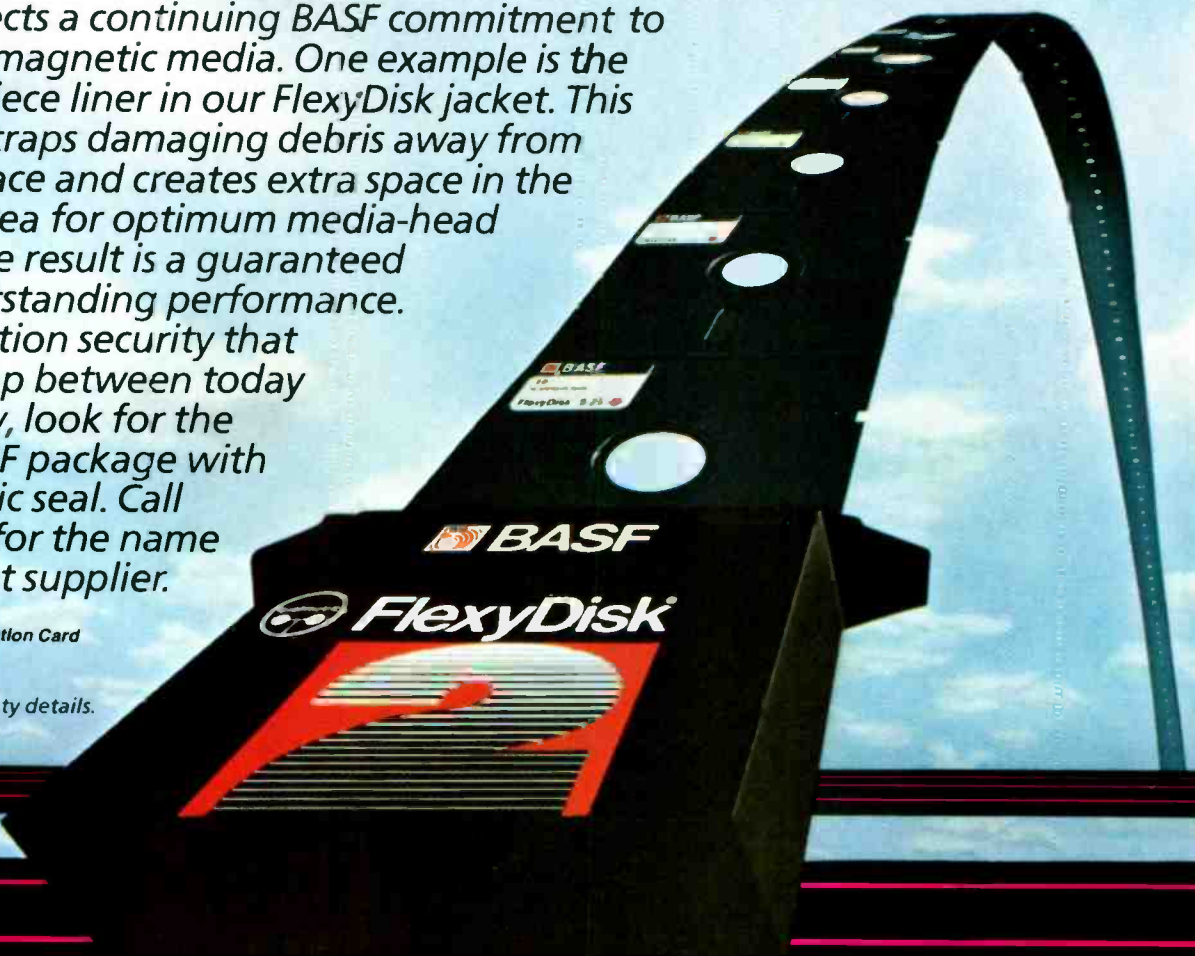
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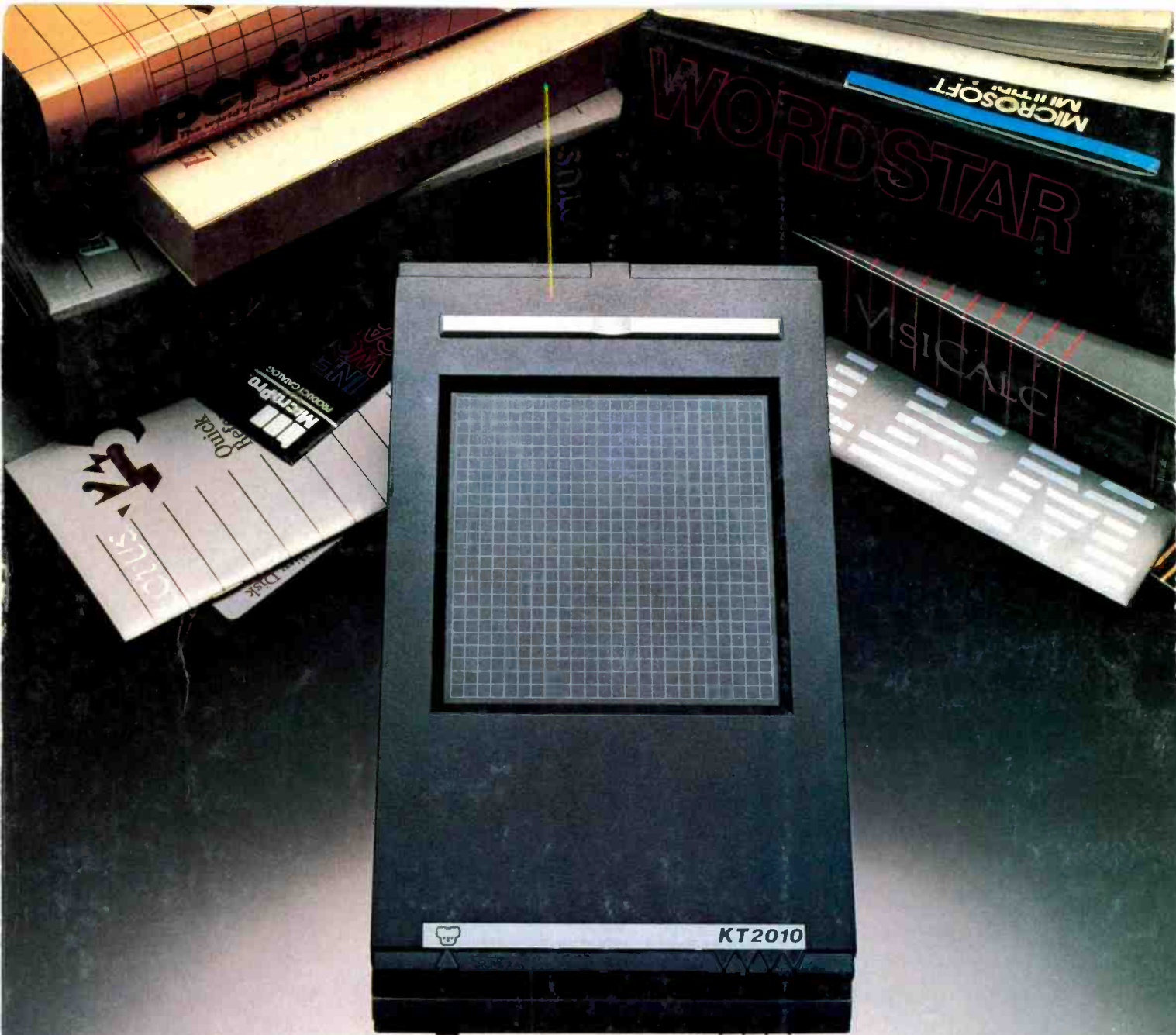


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