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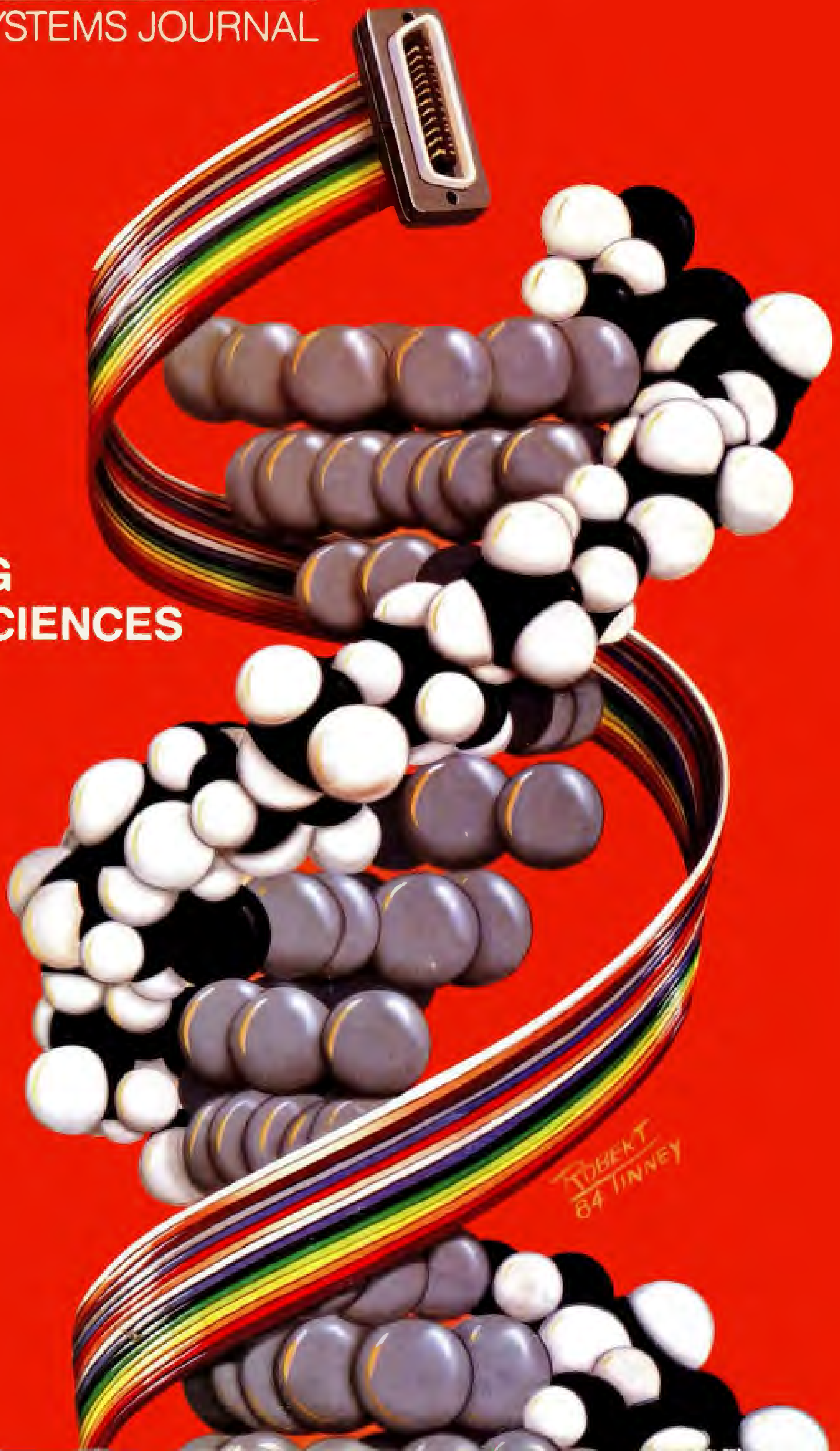
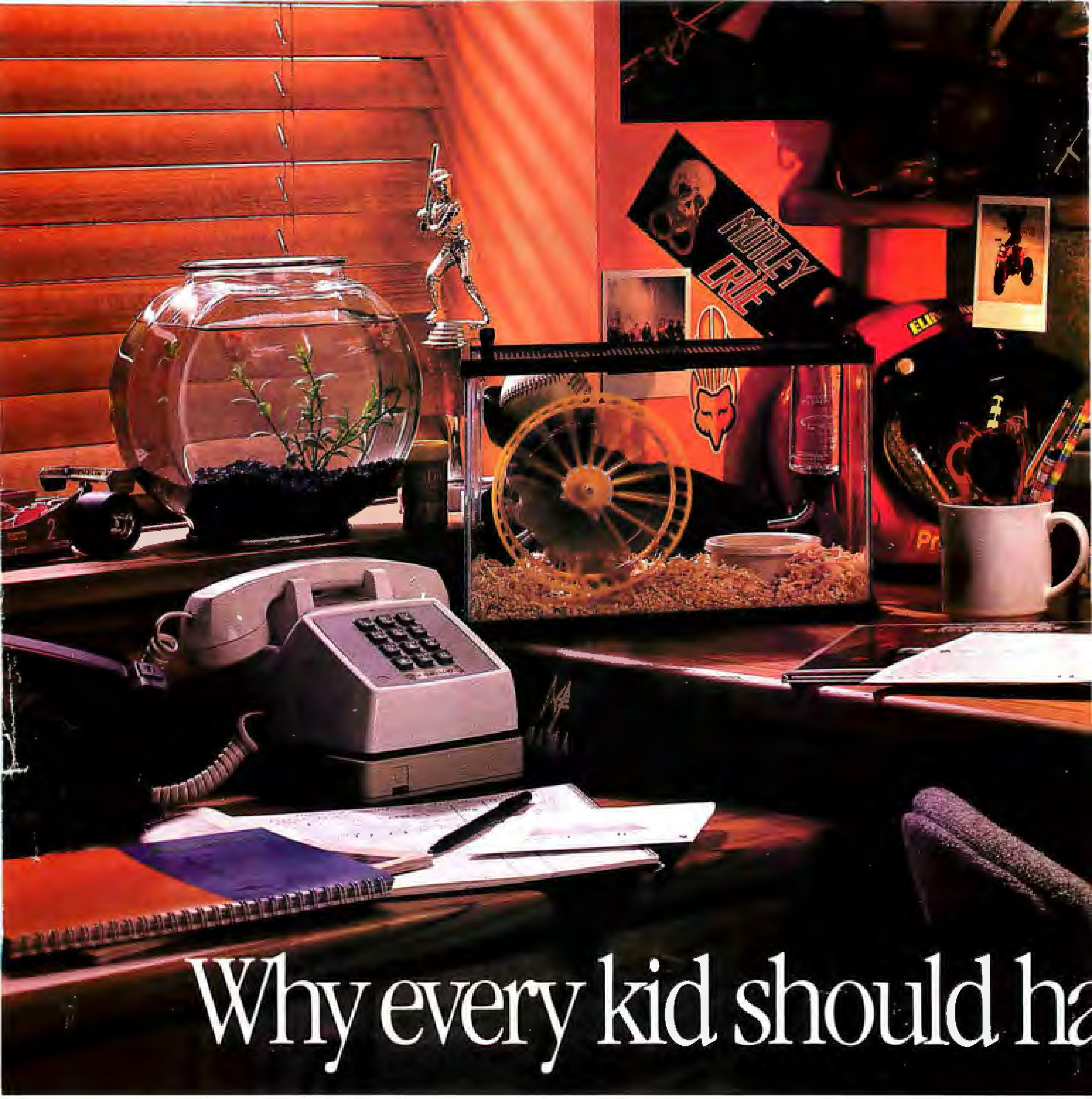


COMPUTING AND THE SCIENCES



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Today, there are more Apples in schools than any other computer.

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Which is why it makes good sense to buy them an Apple® IIc Personal Computer of their very own.

The IIc is just like the leading computer in education, the Apple IIe. Only smaller. About the size of a three-ring notebook, to be exact.

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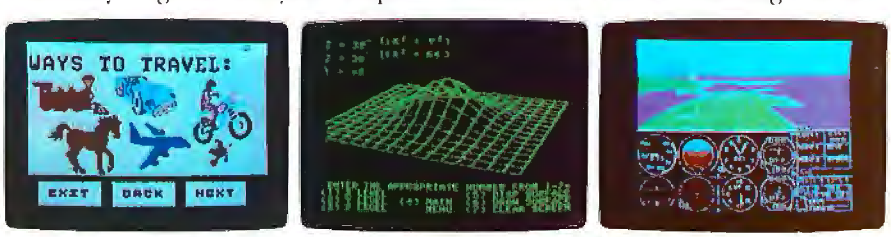

With a IIc, your kid can do something constructive after school. Like learn to write stories. Or learn to fly. Or even learn something slightly more advanced. Like multivariable calculus.

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And the Apple IIc comes complete with everything you need to start computing in one box.

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As well as a long list of built-in features that would add about $800 to the cost of a smaller-minded computer.

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To learn more about it, visit any authorized Apple dealer. Or talk to your own computer experts.

As soon as they get home from school.

C·O·N·T·E·N·T·S

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REVIEWS

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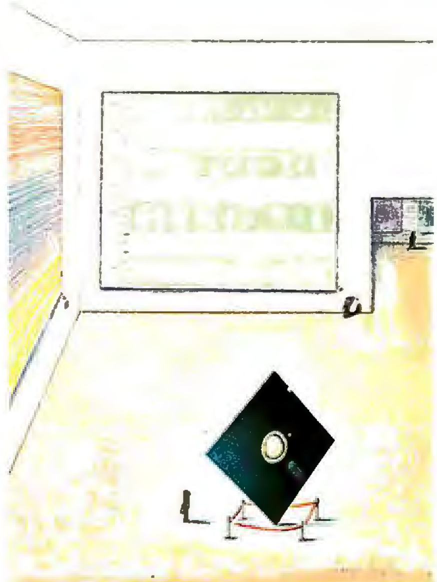

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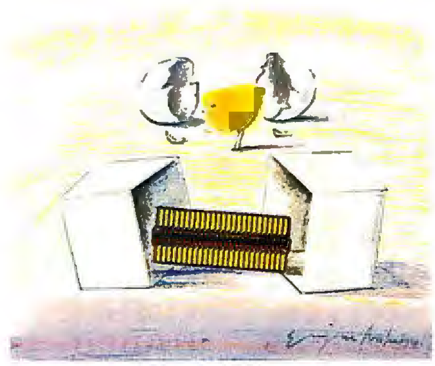

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SERVICE AND SUPPORT

When computers are working they keep us entertained, or at least occupied. That's why happy customers seldom praise the retail stores and mail-order businesses that sold them their computer equipment, and why we hear much more criticism of computer dealers. Often retail salespeople are decried for knowing little about the computers and software they sell and mail-order firms for providing less customer support than retail stores.

But the reality varies from store to store and transaction to transaction. I have had nothing but good experiences with mail-order companies, including free replacement of 100 floppy disks when three of ten in the first box wouldn't format properly. I've bought software, a modem, a printer, and various supplies through phone orders to mail-order businesses.

My experiences in retail stores have been mixed. I once heard a salesman tell a customer that Pickles and Trout were programming languages (they actually were two people who produced a version of CP/M for the Tandy Model II). On another occasion the sales staff of a retail store refused to go through the bother of taking an order for VisiCalc or to hold a copy for me from the next shipment. I went back several times only to find VisiCalc sold out again and no one willing to take my order. (Finally, I bought VisiCalc through mail order and had no problems.) On the other hand, the retail salespeople at the computer store where BYTE made some recent purchases not only know what they are doing but also give technical support when things go wrong.

STREET ADDRESSES

There is room for improvement in both mail-order and retail computer sales practices. The great concern with mail-order businesses is well expressed in a letter we received from John C. Gunn, director of consumer affairs for Priority One Electronics of Chatsworth, California: "Although we are primarily an industrial distributor, a measurable portion of our revenue comes from our 'mail-order' ads. We frequently hear horror stories about some poor soul who sent his money to a mail drop or post office box somewhere. . .and never saw any product or a dime of his dough. Incidents such as this hurt all of us."

Priority One took an interesting practical step to counteract this problem. "To assist in protecting unwitting consumers from unscrupulous advertisers," Gunn writes, "we lobbied strongly for the passage of a bill introduced by California Assemblyman Jack O'Connell. This law requires all advertisements in our state to carry the street address of the company placing the advertisement." We commend Priority One for its efforts to protect the interests of customers of mail-order businesses.

REMOTE DIAGNOSTICS

The convergence of computer and communications technologies offers an unprecedented opportunity for improving customer support. When a personal computer is connected to the telephone system through a modem, and if the operating system and hardware are still capable of taking input from the serial port, then someone at the other end of the telephone line should be able to take control of the computer and put it through a series of diagnostic tests.

The availability of such remote diagnostics would be a great convenience for computer users, retail stores, mail-order businesses, and manufacturers. Remote diagnostics would be much less expensive than shipping costs and would reduce or eliminate the problems sometimes caused by the consumer's inability to describe a problem in a way meaningful to technicians. Instead of lugging the machine back to the store or packing it up for shipment, the consumer could just connect the computer to the telephone and watch the diagnostics at work. In many instances, the consumer could learn what was wrong and how much it might cost to fix before sending out the equipment. The service organization would know what type of repair was coming and be prepared to fix it. In some cases the machine wouldn't have to be sent out at all; there could be a software fix or a board swap.

Some companies already furnish diagnostic disks. These disks are valuable, but because of a lack of information needed to interpret the results of the tests, they tend to leave the customer poorly informed. Remote diagnostics would permit the service organization to use additional tests to identify the problem more precisely and then to tell the customer more about the extent of the repairs and potential costs.

Since repair bills can range from $75 to more than $1000, mystery breeds distrust. Consumers often express suspicion about repair costs of the automobile and other familiar machines. Similar feelings of distrust about repairs of computer equipment could become much more pervasive. Remote diagnostics could reduce mystery and improve consumer confidence in the computer industry. We hope the use of remote diagnostics becomes standard industry practice.

—Phil Lemmons, Editor in Chief

Staff-written highlights of late developments in the microcomputer industry.

CP/M for the Macintosh

IQ Software, Fort Worth, TX, is selling a version of CP/M-68K for Apple's 128K-byte Macintosh for $395, including Digital Research's C Compiler and Macro Assembler. CP/M 2.2 emulation is available for $195 extra but runs only on a 512K-byte Macintosh. A 512K-byte Macintosh is also required to access the mouse and pull-down menus. CP/M-68K disks are not compatible with other Macintosh disks.

Superex, Micromax Unveil Macintosh Business Software

Superex Business Software, Yonkers, NY, announced 25 new products for the Macintosh, priced from $20 to $800. The least expensive item is also the only hardware product introduced: MacSpeak is a $19.95 external speaker. All products should be available this month.

Also included are business programs for cost estimating, time billing, inventory, finance, business letters, sales, and wholesaling. A complete accounting package with Accounts Payable and Receivable and General Ledger modules is $750. A Home Executive program is $90.

Four engineering packages—for civil, mechanical, chemical, or electrical engineers—are $100 each. A MacScience series includes Physics or Chemistry formulas for $100 each. Statistics and job-hunting programs were also announced.

Micromax, San Diego, CA, introduced Gallery, a business-accounting software series. The Finance module, which includes General Ledger, Accounts Payable and Receivable, and Cash Disbursement, is $795; industry-specific vertical applications are also planned.

Conetic Introduces Desktop Management Software

Conetic Systems Inc., San Leandro, CA, introduced Higgins, a specialized relational database program for the IBM PC XT or PC AT that includes an appointment calendar, telephone/address file, expense report, and message features. Information entered into the program is linked to related files; for example, the telephone directory is checked when an appointment is made. Information for up to seven people can be tracked on one computer. A local-area-network version that exchanges nonprivate schedule information is also available. The single-user version of Higgins is $395.

Lantech Offers UNIX-like Operating System for $129

Lantech Systems Inc., Dallas, TX, announced uNETix 2.0, a multitasking operating system for the IBM PC that it says is compatible with AT&T's UNIX operating system but costs just $129. Using optional $100 window-management software, PC users can execute up to 10 applications concurrently; one of those could be a PC-DOS application running under Lantech's $50 PC Emulator.

While a hard disk is recommended, Lantech says the operating system can run on a two-disk system. A separate version of uNETix is available for use in local-area networks.

Smalltalk for PCs

Digitalk, Los Angeles, CA, introduced Methods, a Smalltalk-80 object-oriented development system for the IBM PC. The $250 system includes a compiler, debugger, and text editor; it uses a text-based windowing system with pop-up menus. Methods requires an IBM PC with 512K bytes of RAM and two 360K-byte disk drives.

Software Systems, San Francisco, CA, is also developing a Smalltalk for the Apple II, with later versions planned for 8088- and 68000-based systems.

(continued)

Software Teledelivery Efforts Falter

At last year's Winter Consumer Electronics Show, several companies announced or discussed plans for electronic delivery of software. Some, including Xante, Romox, and Cumma Technology, planned to download to erasable programmable read-only memory (EPROM) cartridges at dealer terminals. Others, including Control Video's GameLine and the Nabu Network's cable service, downloaded programs directly to computers or video games.

Xante, Romox, and Cumma have all ceased operations, mainly because of poor dealer response and the general collapse of the cartridge video-game market. Nabu's cable-TV-based software-downloading service continues to operate in Ottawa, Ontario, despite financial troubles. Control Video Corp., Vienna, VA, said poor distribution and the general video-game slump led it to cancel its GameLine service for the Atari 2600 VCS.

Control Video is now testing a new service which allows subscribers to play 20 games available each month as often as they wish for a $14.95 monthly fee, which includes rental of a 2000-bps modem from BellSouth. MasterLine is now available for Apple II and Commodore 64 owners in Atlanta, Los Angeles, Houston, and Washington, DC.

Separately, NBC announced that it would cancel the NBC Teletext service in late January.

NANOBYTES

Intel introduced the 82588 single-chip local-area-network controller. The 82588 can be used in low-cost baseband or broadband networks—including such IEEE 802.3 protocols as IBM's PC Network and the developing STARLAN—at speeds up to 2 megabits per second. Initial pricing will be $45 each in large quantities. . . . **Laserstore**, Princeton, NJ, plans to sell a 2.5-gigabyte write-once optical streaming-tape drive. The drives should be available in large quantities in mid-1986 for about $2500. . . . **Multi Solutions** announced a licensing agreement with **Computer Engineering & Consulting** of Tokyo, under which CEC will translate Multi Solutions' S1 operating system for Japanese computers. Currently, S1 runs on several 68000-based computers and is being translated by MSI for the IBM PC AT. The agreement guarantees a minimum of $40 million in royalties, according to Multi Solutions. . . . **WATCOM Products Inc.** has released two products developed at the University of Waterloo in Canada. WATFILE is a $295 data-management system for the IBM PC; JANET/2 is networking software for IBM's PC Cluster system. . . . **Alphacom** announced a 133-character-per-second printer at $249 that it says is compatible with Epson's RX-80. . . . **Corvus** and **NEC** have agreed to jointly develop a single-chip controller for Corvus's Omninet local-area network. Currently, an Omninet controller requires three chips developed by Corvus. . . . **Advanced Micro Devices** now offers a 10-MHz version of the 80186 processor. . . . **Phoenix Software**, Norwood, MA, has developed an IBM PC XT-compatible ROM BIOS and is developing software compatible with IBM's PC AT. Phoenix's earlier IBM PC-compatible ROM BIOS code has already been licensed by **AT&T**, **Kaypro**, **Tandy/Radio Shack**, **Wyse Technology**, and **Zaisan**. . . . Rumors that **Tandy** would begin selling **ACT** computers in its Radio Shack stores are apparently false. Instead, the two companies announced a joint venture to operate a chain of computer stores in Europe, called **TA ComputerWorld**. The stores will sell both Tandy and ACT computer products. . . . **AST Research** announced RamStak, a memory-expansion board for the Apple Lisa computer. The board can add up to 2 megabytes of memory to the Lisa; with 512K bytes, it's priced at $1395. . . . **Mosaic Electronics**, Oregon City, OR, announced Access-M, an expansion card for the Commodore 64 adding up to 1 megabyte of memory. The standard $195 card includes 64K bytes of RAM and RAM-disk software; additional memory is plugged into the card. . . . PortaAPL, a $275 APL interpreter for the Macintosh, was introduced by **Portable Software**, Cambridge, MA. PortaAPL adds a full-screen editor and access to many Macintosh ROM toolbox routines to the standard APL language but requires a 512K-byte Macintosh. . . . **C Line Inc.**, Chicago, IL, announced a dBASE II-to-cEnglish converter. The $795 program converts standard dBASE II source code into cEnglish, which is then translated by the $900 cEnglish program into C, which is in turn compiled into machine language by a C compiler.

Slide Cat FROM KODAK INTRODUCES:

THE CAT-QUICK SLIDE-MAKERS THAT WILL MAKE YOU GRIN.

CP/M PLUS FOR THE MODEL 4

Editor's note: In the following sequence of letters, reader William F. Crowell *addresses* Tandy *Corporation Chairman* John Roach, BYTE *(having received a copy of Crowell's letter) responds to* Crowell, *and* David Krebbs *of* Tandy *replies to* Crowell.

Dear Mr. Roach,

I am a longtime computer customer of Tandy Corporation. I presently own two Model Is, a Model 4, and a Model 4P. For over 18 months now, since it was first announced, I have been waiting to receive a working version of Model 4 CP/M Plus.

First, I had to wait 13 months after Tandy announced the product before it was even released. (However, this didn't stop Tandy from advertising the product as available during this entire period of time, presumably to sell more Model 4s to customers who want to run CP/M Plus.) I immediately bought a copy. As you know, however, the original release was *full* of bugs.

I volunteered to beta-test the new preliminary version 1.1, which I did. I immediately discovered that random access failed miserably. Then I observed from the source code, RANDOM.ASM, that *virtually nothing* had been done to implement random access on the Model 4 hardware environment.

Tandy calls this an operating system? How could the company even release it in the first place without random access? Also, the BIOS is supposed to emulate a DEC VT-52 terminal, but it doesn't. Many of the VT-52 control codes don't work. Further, the promised CBASIC has never been released, and there is no release date that I am aware of.

How is it that Tandy is able to release so much *other* TRS-DOS software, but it takes over 17 months now to merely write a correct BIOS for CP/M Plus? This rather obviously represents a violation of the antitrust laws.

Why haven't the popular magazines reported this irresponsible and reprehensible conduct by Tandy? Are they afraid of losing your advertising?

You are hereby placed on notice that I will attempt to file a class-action suit against Tandy Corporation for consumer fraud, breach of contract, antitrust, and possibly other causes of action unless working versions of CP/M Plus and CBASIC are available for purchase and the working version of CP/M Plus is provided to purchasers of the original version within 30 days of this date.

I am sorry to take such an unfriendly tone in this letter, but apparently threats of legal action are the only thing that Tandy understands.

WILLIAM F. CROWELL
Attorney
Oakland, CA

BYTE replies:

We called Mark Yamagata of Tandy regarding CP/M Plus for the Model 4. Mr. Yamagata quickly admitted that there were bugs in the product. He added that the new version was almost ready but that one more bug had to be worked out. He said the new version would be available by the end of October. He also said that all registered users would be advised of the new version, which will be available to them at no charge. We hope the new version solves the problems you've encountered with CP/M Plus; if not, or if Tandy fails to ship the new version, please let us know so we can report on it.

As to magazine policies on publishing letters to the editor, we receive far more letters than we can publish. We try to choose those of greatest interest to the greatest number of readers. When we receive copies of complaints like yours, we generally call the company involved and try to obtain information about how the problem can be solved. If a solution appears imminent, we call the author of the letter and inform him or her. By the time we could publish the letter, the reason for the complaint will have disappeared.

In this case, the solution appears to have been "imminent" for a long time. We hope that CP/M Plus is now fully functional on the Model 4.

Tandy replies:

Dear Mr. Crowell,

I regret your problems with Model 4 CP/M Plus, but I can do no more than to repeat some of the points that I mentioned during our previous telephone conversations. You are correct in observing that Model 4 CP/M Plus got onto the market later than we originally intended and that the initial release had bugs. This, as you know, is not at all unusual with software. Virtually all software packages do contain bugs when they are first released, and these bugs are subsequently removed as later versions of the software packages come into the market.

From your letter I infer that you do not regard the version of Model 4 CP/M Plus that we are now selling as a "working version." I must respectfully disagree. It is the position of Tandy Corporation that our Model 4 CP/M Plus software package is quite adequate for the purposes for which it is intended, and retail sales to date, as well as user feedback, indicate that the public agrees with us. I am sorry if this particular software package is not suitable to you in some way or ways, but you will understand, I trust, that it is not possible for us to design our products so that they are perfectly acceptable in every respect to every single member of the buying public.

Regarding your comments on the VT-52, please note that the first release of the Model 4 CP/M Plus manual did contain errors on the decimal values assigned to the VT-52 emulation codes. The correct codes have been sent to you by Mr. James Brown, of this office, and a Publication Change Notice has been submitted for future editions of the manual. You will find that the VT-52 control codes will work correctly with the information that Mr. Brown sent to you.

(continued)

LETTERS POLICY: *To be considered for publication, a letter must be typed double-spaced on one side of the paper and must include your name and address. Comments and ideas should be expressed as clearly and concisely as possible. Listings and tables may be printed along with a letter if they are short and legible.*

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Enclosed please find a BASIC program that utilizes random-access procedures to retrieve and store data. At this time, we are not able to duplicate any inherent flaws with random-access procedures in CBASIC under CP/M Plus.

Let me advise you as well, by the way, that the catalog number for Model 4 CBASIC is 26-2217, and it is now available in our stores at a retail price of $99.95. In fact, it was released in June of this year.

I repeat my previous offer to you: if you wish to have a full refund on the Model 4 CP/M Plus package that you purchased, just send me the complete package (media and manual) together with a copy of your sales receipt. I shall then see that a check is cut and sent to you at once. I make this offer to you in an effort to retain your goodwill.

I do not pretend that our position, as I have stated it above, will be perfectly acceptable to you, but I trust that at least you now understand it clearly. We do appreciate your past business, and I hope that we shall be favored with more of it in the future.

DAVID KREBBS
Radio Shack Computer
Customer Services

A PIRATE CONFESSES

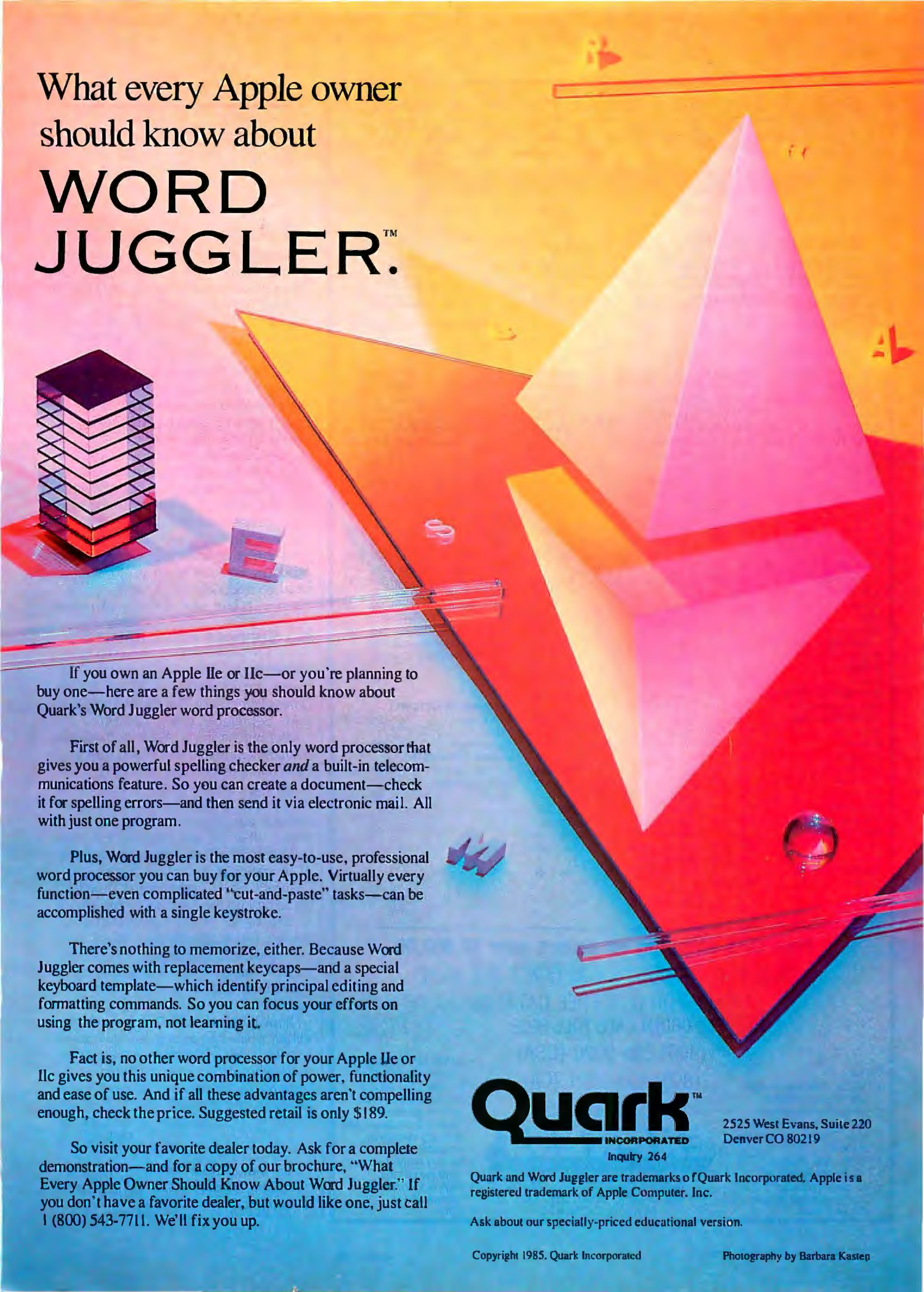
This is an open letter to software vendors and dealers. It has been prompted by various letters and articles that I have read recently concerning why otherwise ethical people would "pirate" software.

I do not advocate the piracy of software. It is nothing short of theft. However, I have been guilty of pirating a package or two for one reason: I refuse to spend my money on software that I cannot be sure will run on my machine. No vendor that I know of will offer you a money-back guarantee on its software package. I work on mainframe computers for a living, and very few vendors of mainframe software will not let you have a 30-day trial on one of their packages.

I understand that the volume of dollars spent on a mainframe package is considerably more than what personal computer users spend for their software packages; however, we personal computer users do not work with the same size budgets as mainframe users.

Some software vendors do in fact offer demonstration disks, but the disks that I've seen flash lots of colors and text describing the products but do not give you an opportunity to use the products and

(continued)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determine if they will satisfy your needs. I try to study a product as much as I can from reviews in the trade publications. I then select one or two similar packages and attempt to find people who are using them. I obtain a copy (or the original) and the product's documentation, and I try the package out for a month or so. If I like the product, I then purchase a "legitimate" version of it, or else I erase my copy or return it to the lender. In this respect I am probably more ethical than most in that I will buy a legitimate copy of any software that I intend to use on my machine for any length of time after I have already obtained a pirated version of it.

I seek only to protect my investment, and I will discontinue this practice when I can obtain a full-function demonstration disk of a package that I intend to purchase. I somehow expect that quite a number of software vendors would be opposed to a 30-day trial arrangement because their products wouldn't stand up to head-to-head competition.

NAME AND ADDRESS WITHHELD

No Support from Apple

I would like to confirm the lack of available Apple documentation noted in Dennis Doms's letter ("A Call for Better Apple Support," September 1984, page 14).

After purchasing an Apple IIc in May to complement my IIe while I was traveling, I was immediately confronted with a lack of technical details needed to connect my "non-Apple" peripherals to the IIc. What are the pin connections on the serial ports? What are the memory locations that control baud rate, characters per line, ACIA status, etc?

Since I travel extensively I thought I could pick up the *Apple IIc Reference Manual* in one of the many authorized Apple dealers I visit when out of town. After visiting over 30 stores in New York, New Jersey, southern California, and Oregon, I have been unable to find the reference manual.

I hope that letters like Dennis's and mine will stir Apple into getting the publications into the hands of the thousands of Apple users who want to know all there is to know about one of the most revolutionary products of our times.

GEORGE W. ZIEGLER, JR.
Mahwah, NJ

I read with interest Dennis Doms's letter describing his problems obtaining Apple documentation.

(continued)

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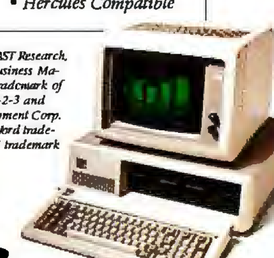

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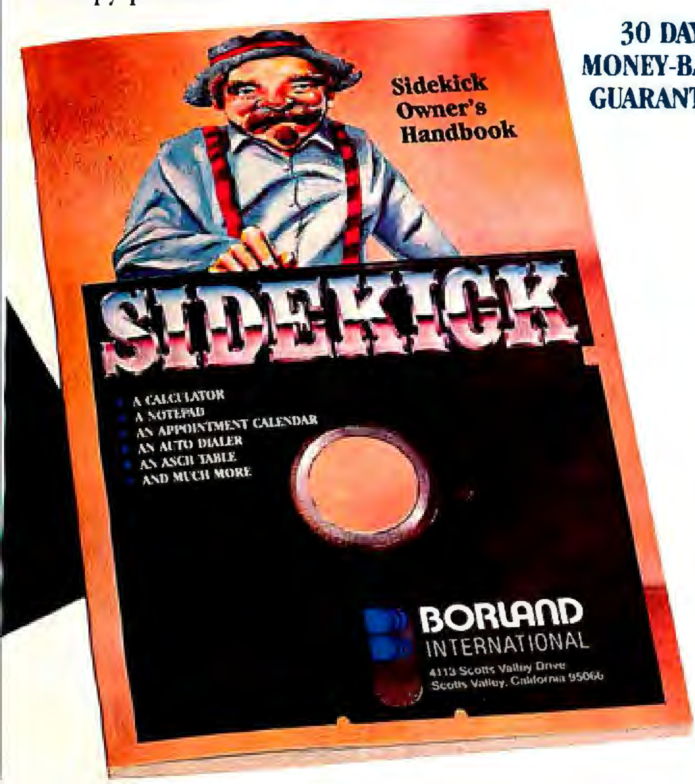

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After several years of CP/M experience, I purchased an Apple IIc in May. I have written and phoned Apple in Cupertino, the Apple distributor in Charlotte, and two Apple dealers. The response I have gotten is difficult to accept. Based on the information I have to date, the *Apple IIc Technical Manual, ProDOS Technical Manual,* ProDOS Users Kit, and *Applesoft Technical Manual* volumes 1 and 2 are unavailable and there is no official date for delivery.

My choice of the IIc was based on the promise of true portability by the end of 1984. The present availability of carrying cases and portable power supplies coupled with the continued assurance, by Apple, of the flat-screen display in 1984 will provide the hardware I expected when I chose the IIc. The total lack of technical information for the IIc and the operating system will make software development almost impossible.

DON OVERTON
Atlanta, GA

I found the letter by Dennis Doms concerning the lack of technical support by Apple for its new ProDOS System very true. I am one of those newcomers to computers. It is indeed a nightmare trying to make sense out of Apple ProDOS from the scant instructions supplied with the Apple IIe.

For months I have been trying to buy several of Apple's manuals on ProDOS, especially *BASIC Programming with ProDOS.* The authorized Apple dealer has no idea when his shipment will come in.

In my opinion any machine, no matter how excellent it may be, is no better than the instructions that teach the operator how to use it. It seems a pity that a company that can spit out machines at such a terrific rate cannot supply the bare tools the operator needs to operate that machine. Imagine that same company's concern if, when its new production line was ready to roll, it found it had few instructions on how to operate it.

DAVID D. PERRY
Ridgecrest, CA

TAKE BACK YOUR MAC

I am outraged. Apple's original descriptions of the Macintosh, as quoted in the press, made it clear that the Macintosh was a 512K system that was being released in a temporary 128K version due to failures on the part of Apple's suppliers. Now we are told (in defiance of the experience of any user of the machine) that the 128K Macintosh is a useful computer and will continue to be sold at the original price, while a 512K version will cost $1000 more. What's more, any purchaser of the earlier 128K machine who desires to upgrade to 512K must pay the $1000 difference in price. This policy is as blatantly unscrupulous a case of bait-and-switch as was ever practiced.

As a professional programmer, I was intrigued and excited by the concept of the Macintosh and eagerly awaited the release of the real, 512K, machine. As a consumer, I am disgusted by Apple's business practices and have no intention of throwing good money after bad. I am especially frustrated by this decision of Apple's, since I am sure that it will strangle the Macintosh in its cradle, and so my already substantial investment in the machine will have been for nothing.

KIRK RADER
Los Angeles, CA

I openly plead for a programmer or programming team somewhere to develop RAM-disk software to use the 512K RAM on the "fat Mac" as a RAM disk as well as for memory.

A logical configuration to emulate the 128K Mac would be 128K memory with a 384K RAM disk. Later, variable options of more memory and less RAM would be nice, but they are not essential initially. Good programs like Microsoft Word can use disk I/O to make files larger than memory and would not be limited by the main-memory constraint, but rather only by the RAM-disk memory constraint.

Such a RAM disk must permit copying data to and from it, programs to and from it, and opening it. So designed, the system and major programs that use disk overlays could be loaded into RAM, with consequent lightning-speed operation. I believe such software is essential for the Mac to appeal to business. It would also make software development itself easier and faster.

I've checked, and apparently Apple's own programming philosophy is opposed to this concept. If someone does do this, I hope he or she sells it for a reasonable price ($50 or less) or else releases it accessibly into the public domain. Without such a development, my company will probably never buy a Mac and will probably never develop software for it.

DON SLAUGHTER
MicroCost Software
Seattle, WA

Perhaps two of the most often used words throughout articles dealing with the Macintosh are "potential" and "wait." The Macintosh was introduced over nine months ago, and still there is a lack of varied and practical software available for the computer. On the day of its introduction Apple announced that "hundreds" of software companies had already had the Macintosh for up to two years. Software for the machine would be available in a torrential flood in a matter of weeks. Nine months later a real word processor (i.e., capable of handling more than eight or nine pages) is still not available, nor can I find a spelling checker, a true database manager, or a high-level language. If software companies have had over two years to work on their products and still have not fully developed what could be considered "standard" software products, just how long is the Macintosh software-development cycle? Is Apple truly supporting its software developers?

Added to the problem of third-party software is the lack of support software from Apple itself. Nine months after the computer was introduced, an assembler has not even been made available, nor is a communication program like MacTerm available yet. Neither of these programs is particularly tricky to write, and, in fact, Apple must have had a 68000 assembler in house for quite a while (rehosting an assembler from the Lisa to the Macintosh takes over nine months?).

Many trade magazines and journals apparently wonder about these same problems. Often an attempt is made to rationalize Apple's tardiness and lack of support. The most common story is: "The Macintosh is a radically new computer requiring programmers to adapt to a completely different kind of style, and besides, 128K of memory makes for a tight squeeze on programs. When the 512K Macintosh is available, all kinds of fancy programs will appear and life will be wonderful again."

Well, the 512K Macintosh was recently announced. Now I can easily find several stores advertising the 128K Macintosh for $1600 and the 512K Macintosh for $2400. Yet Apple wants the people who have already paid $2500 to fork over another $995 for the 512K upgrade. The entire computer obviously costs far less than $1000 to make, since that is the price the university consortium schools pay, and you can be certain that Apple is not so dedicated to education that it would pass up this additional source of profit.

If 128K is such a burden on software developers, why wasn't the computer released *after* the expanded memory was available? This would have given developers more time to work on their software as well. If Apple felt it just had to be in the market with a machine like the 128K Macintosh, why was it priced so high? At least Apple could have promised all the early purchasers a fair price (or even no cost) on the upgrade.

I truly feel that Apple has treated its customers unfairly and with a certain amount of contempt. Prior to owning any Apple product I had a great deal of trust and respect for the company. In fact, it was that trust and respect that convinced me to buy a Macintosh even though I was aware of its limitations. I felt certain that Apple would take care of its customers. However, since buying a Macintosh, that trust and respect has gone. Even though I could recommend no alternative, I would not advise anybody to buy a Macintosh. Instead, I would recommend waiting until Apple straightens up or until another company recognizes the void and fills it.

R.S. LUEBKEMAN
Rancho Cucamonga, CA

CHOOSING A CAMPUS COMPUTER

We have recently undertaken a project to introduce the use of microcomputers in the junior/senior Physical Chemistry course at the University of Florida. Although the students are reasonably mature and mathematically sophisticated, they have shown a surprising reluctance to "get their feet wet" via hands-on work with the microcomputers available for the course (six Sanyo MBC 555 units, chosen for their low price, reasonably good graphics, and ability to use the 8087 math coprocessor).

There are several problems in introducing a microcomputer course as described above at a large state institution such as the University of Florida (35,000 students), where no requirement exists that students purchase a microcomputer (not to mention a specific brand of microcomputer). Even if money were available to fund purchase of sufficient machines to handle approximately 4000 technical students per year, along with space to house them, there remains the possible objection that the entire enterprise would be at least "type-specific." Thus we might select MS-DOS, Microsoft BASIC, and WordStar, which would slant the situation toward IBM PCs and/or compatibles. This might lead to a loud chorus of objections from Macintosh supporters, for example.

(continued)

While some may disagree, I feel that the situation is more acceptable if reasonable alternate-brand selections do exist, such as the IBM PC, Seequa Chameleon, Eagle, Zenith 150, Tava, Tandy 2000, etc. However, selection of a unique machine such as the Macintosh is virtually an endorsement of a specific brand rather than type, to the exclusion of all others.

I would be interested in hearing from others concerning this dilemma. Please write to me at the Chemistry Department, University of Florida, Gainesville, FL 32611.

ROBERT J. HANRAHAN
Gainesville, FL

ICONS ARE ARCANE

Circa 5000 years ago, writing was invented in ancient Mesopotamia. This earliest known script, cuneiform, was derived from pictographic symbols that became stylized and standardized in form. Eventually it became mixed with phonetic elements until it was almost entirely phonetic. Our alphabet is most probably ultimately derived from ancient Egyptian—also originally a pictographic system. The point is this: Over thousands of years a phonetic and finally alphabetic system was developed. To anyone who has gone through the painful process of learning cuneiform or Egyptian, the superiority of the alphabet is readily apparent. A pictographic system (Apple's "icons") requires that the user learn many, many symbols. My contention is that though users may find icons more "user friendly," ultimately, as systems and software become more complex, the icon system will become more unwieldy and arcane than present systems.

As a humanist who uses computers extensively in my work, I would like to see user interfaces developed for micros that are faster, more streamlined ("elegant"), and smarter ("knowledge-based") to aid in the learning process. It doesn't take the uninitiated user long to grow impatient with the Mac.

ANN MARCHANT
Berkeley, CA

BRAVO, BORLAND!

This is the kind of letter I would like to be able to write more often. It's about the people at Borland International, who distribute Turbo Pascal and, if we are lucky, a lot of other programs.

I've already spoken to Borland's programmers about a problem, and with a completely satisfactory result. The latest event was my ordering of the Commodore 64 CP/M version of Turbo Pascal. When it arrived, it was an MS-DOS disk, which I couldn't use. I scribbled a note on the invoice and mailed the whole package back the same day, the same way it arrived, at a cost of about a dollar in postage.

Today the United Parcel Service truck pulled up and delivered the correct replacement package—Second Day Air. It cost Borland $4. That is class.

WILLIAM T. POWERS
Northbrook, IL

SAGE DEFENDED

I wish to respond to Dr. Richard Peskin's appraisal of Sage computers ("A Second Opinion on the Sage," September 1984,

(continued)

page 18) as lacking "many architectural features needed for multiuser, multitasking applications." This is a gross distortion of the facts, since, from the beginning, Sage has supplied an excellent multiuser BIOS capable of supporting not only multiple users but multiple operating systems running simultaneously. I know of no other supermicro that can make this claim. Even single-user operating systems such as Softech's UCSD p-System appear to be multiuser on the Sage as multiple copies are run in memory partitions isolated by the Sage MU BIOS. The BIOS allows easy configuration of each user's time slice and priority, flexible mapping of RAM disks (yes, more than one!), memory and disk partitions, and serial ports and peripheral devices. Different operating systems may be allowed access to shared disk space.

At last count, at least 11 operating systems are supported, including CP/M 68K, Volition's Modula-2 system, HyperFORTH, and Whitesmiths's UNIX-like multiuser Idris. The Idris implementation currently available was ported to the Sage by Rakon, an Australian company. Rakon's version reportedly runs 2.5 to 5 times faster on the same hardware as Logos Information Systems' (Dr. Peskin's firm). In this light, Dr. Peskin's opinion about Sage can hardly be characterized as "objective technical assessment."

The new products announced in September by Sage (now Stride Micro) will have a hardware memory-management option to support UNIX System V with Berkeley enhancements. They also run faster (10 MHz standard, 12 MHz optional), support hardware floating point, utilize the industry standard VME bus, come standard with Omninet networking hardware, and are even lower in cost.

JAI GOPAL SINGH KHALSA
Millis, MA

IMPROVING THE IBM KEYBOARD

Where I work we have IBM PCs and XTs in abundance. People are always griping about the poorly designed keyboard, i.e., the long reach to the Return key and the dual-function 10-key pad/cursor controls that perform only one of their roles at a time. The complaints peaked around budget time, when data entry to spreadsheets became a paramount hassle. We found a partial remedy, however. Instead of switching between the 10-key pad and the cursor controls by using the Num Lock key, we found it easier to divide the labor between our two hands by locking in the 10-key pad for data entry and then, to move to another cell, holding the left shift key down with our left hands and moving the cursor with the 10-key pad that then functions as a cursor control.

Granted, this is not a perfect solution, but the roar did quiet. Now we'd like to know how to solve the problem of the reach to the Return key.

W. TRAVIS GOOD
Summit, NJ

SOFTWARE SWAPPING

In response to "Dear Thieves" (August 1984, page 18), William Wright has expressed the opinion that it is entirely

(continued)

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Bruce Webster, Softalk IBM: March 1984
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Inquiry 34

wrong and dishonest to copy software, even for one's own use. He is absolutely right. But his statement is incomplete.

The software industry, in general, has shown a total disregard for honesty in its marketing. A large portion of the available software is sold without proper testing. It is tested by us, after we pay a ridiculous price for it. Customer support just does not exist, and the documentation is often a joke. According to the "rules" I must buy WordStar for each machine in the office. And I do not have backup protection with some software. Even after paying their price I am held ransom!

My complaint is not against all software publishers. Lotus, for example, has done a wonderful job of documentation and service.

Mr. Wright is right. But incomplete. Two wrongs don't make a right. But as long as the publishers are so blatant in their dishonesty, software swapping will be with us.

DAVE CHURCHER
Rye, NH

SWIFT REMARK

I really got a big laugh out of Paul Bernstein's letter ("Computers and Lawyers," August 1984, page 16) about the "argument" between him and his fellow lawyer Robert Wilkins over whether lawyers need to know "terms such as RAM, bps, . . . 'and other foreign, often unnecessary technical terms.'" That from lawyers, ". . . a Society [that] hath a peculiar Cant and Jargon of their own, that no other mortal can understand, and wherein all of their Laws are written, which they take special Care to multiply; whereby they have wholly confounded the very Essence of Truth and Falsehood, of Right and Wrong."

No comment could better be made on the subject than that by Jonathan Swift in *Gulliver's Travels*, Part 4: A Voyage to the Country of the Houyhnhnms, Chapter 5.

WILLIAM E. WHITE
Miami, FL

MODULA-2: OVERRATED?

After reading all those pro Modula-2 and Ada articles in BYTE (August 1984), I at first feared I was the only one who harbors mixed feelings concerning these languages. I was relieved to find David V. Moffat's "UCSD Pascal vs. Modula-2: A Dissenting View" (page 428).

While I don't agree with all of Mr. Moffat's views (e.g., that the lack of publications on Modula-2 will become less

(continued)

distinct in the future), I'd like to point out a couple of items that have escaped mention so far.

The improved readability of Modula-2 source, achieved by the no-longer-needed BEGIN...END brackets that contain Pascal compound statements, is obviated because of the END statement that terminates all control structures apart from REPEAT. I would have preferred a specific end statement for each control statement, like ENDDO, ENDWHILE, ENDLOOP, ENDIF, etc.

Pascal's lamented rigid order in which declarations have to be made shows its main advantage when it comes to software maintenance. I wouldn't want to look for that doubly defined global variable that crept in when an existing program was extended, were it possible to declare said variable anywhere near the procedure that used it first, let alone in some external module.

I find Modula-2's IF not much of an improvement over that of Pascal as far as nested IFs are concerned, the latter of which I tend to avoid and use logical expressions instead. Taking Robert J. Paul's recipe example ("An Introduction to Modula-2," August 1984, page 195), wouldn't you agree that

```
IF     (oregano IN recipe[1])
     AND
       (thyme IN recipe[1])
THEN
  WRITELN( 'Use oregano & thyme' )
ELSE
  WRITELN( 'Use only thyme' );
```

is easier to understand than what appeared on page 198?

EDMUND RAMM
Kaltenkirchen, West Germany

What a shame that you did not include the article "UCSD Pascal vs. Modula-2: A Dissenting View" by David V. Moffat in the theme section of your August issue; it would have provided some balance in what was an informative but rather biased section.

I write to support Mr. Moffat's thesis that Modula-2 has yet to be proved a significant improvement over UCSD Pascal. Having used UCSD Pascal since 1980, I can link in assembly-language routines, build libraries, and write units with hardly a second thought. For programmers, the inequality of

Benefits of Modula-2 > Cost of software + time to relearn + time to rewrite old routines

must be clearly shown to be true. I have yet to be convinced that the benefits outweigh the value of Pascal experience. Could it be that those software companies that have sold thousands of Pascal compilers in the past few years now fear that they are beginning to saturate the market and are promoting Modula-2 as a means of maintaining company profits?

One small point: Am I the only one who finds that dozens of ENDs, some for IFs, some for FORs, some for LOOPs, make Modula-2 programs less easy to read than Pascal programs?

STUART A. BELL
Sidmouth, Devon, England

(continued on page 416)

F·I·X·E·S A·N·D U·P·D·A·T·E·S

BYTE'S BUGS

C Listing Bug

Bob Bonomo picked out a bug in the C source listing for the quicksort function in the October BYTE Japan. (See "Bits and Pieces" by William M. Raike, page 369.)

In listing 1 on page 374, the third WHILE statement should read:

```
while (j > i && strcmp(base[j], pivot) >=0)
```

Our thanks to Mr. Bonomo.

A Case of Misidentification

A caption in our product description of the Tandy 1000 incorrectly identifies a screen display. (See "The Tandy 1000" by G. Michael Vose, December, page 98.)

On page 101, the caption identifies the screen display on the right as being produced by DeskMate. The photo actually depicts a screen from IBM's HomeWord, a word-processing program that also runs on the Tandy machine. HomeWord is produced by IBM's Entry Systems Division in Boca Raton, Florida.

Penny Wise, Pound Foolish?

A note arrived from Paul Hills of Launceston in Cornwall, England, telling us that we misstated the annual subscription fee for his club's newsletter. (See Clubs & Newsletters, August, page 68.)

The 6809 User Group Newsletter is available for £3 annually. Overseas subscriptions are $4.70 in the U.S. and $6 in Canada.

Weather Report Incorrect

Charles S. Barnaby, vice president of the Berkeley Solar Group, sent us a clarification concerning the computer service that his company offers. In Matthew Lesko's article "Low-Cost On-Line Databases" (October, page 167), it was incorrectly stated that the Berkeley Solar Group offers "the latest weather."

The Berkeley Solar Group has a large collection of weather data; however, this data is based on records at least several years old. The data is suitable for use with building energy-analysis software. Portions of this information are available through interactive inquiry but the bulk of it serves as input for hour-by-hour building simulation programs.

The weather data is available for users of the Berkeley Solar Group's building energy-analysis software, which includes such programs as DOE-2, CALPAS3, and FCHART. The data can be used for other purposes, but its purchase must be negotiated on a case-by-case basis.

We thank Mr. Barnaby for clarifying this inaccuracy on our part. The Berkeley Solar Group can be reached at 3140 Martin Luther King Jr. Way, POB 3289, Berkeley, CA 94703, (415) 843-7600.

Books Have American Distributor

Jeffrey A. Blackman of the Computer Science Press in Rockville, Maryland, sent us some information about five books mentioned in the November Books Received section (page 495).

The books, *A First Course in Formal Language Theory, From Logic to Computers, LISP Programming, Microcomputers and Their Commercial Applications,* and *UNIX for Users,* are all published by Blackwell Scientific; however, they are distributed in North America by the Computer Science Press.

If you wish to order these books, contact Computer Science Press Inc., 11 Taft Court, Rockville, MD 20850, (301) 251-9050.

Windy Day Bug

Mark R. Parker of Seattle, Washington, saw an error in listing 1, the Module WindyDay, in Eric Eldred's review "Volition Systems' Modula-2" (June, page 353).

In the procedure OpenWindow (page 356), the line:

```
Open (wind, 0, 1, 39);
```

should read:

```
Open (wind, 0, 0, 1, 39);
```

because a call to open requires five parameters. The omitted second zero places the message at the upper left-hand corner of the screen.

Also, the comment "Phony" should be changed to "little busy bee."

New Telephone Number

Microserve in Tyler, Texas, which was mentioned in the October BYTE, has a new telephone number for its network. (See "Low-Cost On-Line Databases" by Matthew Lesko, page 167.)

The new telephone number is (214) 581-3722.

Photo Credits Due

We inadvertently neglected to credit Lee Wright, a freelance photographer based in Medford, Massachusetts, for snapping the photos that accompanied Henry Brugsch's article in the *Guide to the Apple Personal Computers,* a special supplement to the December BYTE. (See "Apple's New Modem and Access II," page A58.)

We apologize for this oversight.

Address Change

Sinclair Research, whose ZX Spectrum+ was featured in the December BYTE What's New, has relocated. (See page 435.)

The new address is Sinclair Research, Berkeley Square House, London W1X 5LB, England; tel: 01-499 2666; Telex: 265212.

FEEDBACK

More on POPLOG

In the October BYTE U.K., we inadvertently listed Aaron Sloman as the distributor for POP-11 and POPLOG, a pair of tools available to researchers in artificial intelligence. (See "Pop and Snap" by Dick Pountain, page 381.)

Mr. Solman informs us that POPLOG is marketed in the U.S by Systems Designers Ltd. International, Suite 201, 5203 Leesburg Turnpike, Falls Church, VA 22041, (703) 820-2700. In the U.K., it's available from Systems Designers Ltd., Systems House, 1 Pembroke Broadway, Camberley,

(continued)

Surrey, GU15 3HX; tel: 0276 62244.

Mr. Sloman has informed us that "POPLOG is now the main official AI software development environment in the U.K. for Prolog and POP-11. The existing 'toy' LISP component (suitable for teaching) is being replaced by COMMON LISP."

POPLOG, according to Mr. Sloman, comes with a large collection of on-line help files, teaching files, and libraries of utilities and demonstration programs. Mixed languages are supported, and a multiwindowed screen editor VED can be used with all three main languages. It runs on VAX computers under VMS and Berkeley UNIX. It's also available "on a growing number" of M68000-based UNIX machines. In North America it's $10,000, with a ninety-percent (90%) discount for educational institutions.

"At present," writes Mr. Sloman, "POPLOG is too big for most personal computers. Our hope is that it will not be long before machines with at least 2 megabytes of RAM and 40 to 100 megabytes of backup storage will be cheap enough to make POPLOG much more widely available for educational use."

Speaking of Least Squares

Steven A. Ruzinsky saw a number of doubtful statements in Marco Caceci and William Cacheris's article "Fitting Curves to Data" (May, page 340). He cites these remarks:

> This is called the least-squares criterion. For random errors randomly generated (usually a reasonable assumption), this is the best criterion of all.

"This is simply untrue," says Ruzinsky. "In order for least squares to be the best criterion, the errors must have independent and identical normal (Gaussian) distributions. In situations meeting this requirement, least squares can be a maximum likelihood estimate of the parameters. For situations where the errors are not Gaussian, least squares is suboptimal. A good counter example to the authors' statement is the case where the errors have a binary distribution, e.g., a random sequence of 1s and −1s. In this case, I believe one will find a minimax fit (also called "Chebyshev" or "l ∞") much more statistically efficient than least squares."

Mr. Cacheris notes that the first statement was intended to be broad and that least-squares analyses are often used under less than optimal conditions since the results can be checked by various methods, such as sensitivity analysis.

"Least-squares method is certainly best when the errors have identical distributions . . . [which] we mentioned towards the end of our article when describing sensitivity analysis. We state that several synthetic data sets . . . are made by *adding identical normal distributions* to the errorless curve. Thus, the least-squares fits to these synthetic data sets are the best fit to these data sets and the values of the parameters obtained should approach the experimental data's values of the parameters if the error in the experimental data has identical normal distributions."

Electronic Yellow Pages in LA

The vice president of Buy-Phone Inc., David Lappen, sent us information about his company's database, which was left out of Matthew Lesko's article "Low-Cost On-Line Databases." (See October, page 167.)

Buy-Phone is an "electronic yellow pages" system serving the Los Angeles area. It has more than 10,000 listings in 25,000 search categories, ranging from current movie listings, restaurant and department store offerings, to computer outlets.

Access is free of charge to users. Businesses pay $150 for a year's worth of advertising; ads can be changed daily at no extra cost. Personal ads, which are also free, can be posted for two weeks.

At 300 bps, call Buy-Phone at (213) 474-0270. At 1200 bps, call (213) 470-4679.

BYTE'S BITS

Public-Domain Software Library

The Houston Area League of PC Users (HAL-PC), a group of 1000-plus IBM Personal Computer fans, maintains a library of public-domain and "shareware" (i.e., pay if you like it) software. Disks are available from the library for $2 per disk. For a listing of titles, send a self-addressed, stamped envelope to Nelson Ford, HAL-PC Librarian, c/o The Public Library, POB 61565, Houston, TX 77208.

Software authors wishing to share their public-domain or shareware programs are encouraged to contact the group president, Duane Hendricks. Other users groups interested in trades should contact Jack McClure at POB 610001, Houston, TX 77208. ■

THE NCR PC IS COMPATIBLE WITH PEOPLE, TOO.

Getting along with all kinds of people is one of the most endearing qualities of the NCR PC4.

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The NCR PC even comes with two special self-teaching programs that will have you computing in a matter of minutes. NCR PAL shows you how to use the computer itself. NCR TUTOR introduces you to word processing, spreadsheets and other popular business programs.

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For the name of your nearest dealer, call toll-free: 1-800-544-3333. In Nebraska call: 1-800-343-4300.

Inquiry 230

NCR

A BETTER PERSONAL COMPUTER. IT'S EXACTLY WHAT YOU'D EXPECT FROM NCR.

Things you should know about monitors

Resolution The quality of a color monitor's image is directly related to its resolution. The greater the number of dots available within a given area for displaying an image the greater the resolution.

The PRINCETON SR-12 monitor features an extraordinary 640x480 (non-interlaced) resolution. The result is an extremely high quality, flickerless image with text that approaches monochrome quality. When used in conjunction with the PRINCETON Scan-Doubler card, the SR-12 runs from a standard IBM or equivalent color card, maintaining complete compatibility with all IBM software.

Dot pitch The image on an RGB color monitor is made up of a series of tiny dots. Dot pitch measures the distance between those dots. Anything finer than .38mm is considered high resolution.

The PRINCETON HX-12 RGB color monitor, with a dot pitch of .31mm, offers the finest resolution in its class. The HX-12 delivers 16 crisp, sharp colors including clean whites without color bleed—a not-so-easy accomplishment in an RGB monitor.

Price All Princeton monitors set the price/performance standard in their class. The SR-12 at $799 compares favorably with monitors costing hundreds more. The HX-12 is in a class by itself at $695.

The PRINCETON MAX-12, with easy-on-the-eyes amber phosphor, sets the standard for monochrome monitors at $249. The MAX-12's dynamic focusing circuitry ensures sharpness not only in the center but also in the edges and corners. And it runs off the IBM PC monocard—no special card is required.

All three monitors feature a non-glare screen and an IBM compatible cable. A PCjr adapter cable is also available for the HX-12. And to see your Great Ideas from the best possible angle, you can put your Princeton monitor on the Princeton Undergraduate Tilt and Swivel Base for only $39.95. **Or, while supplies last, get the Undergraduate FREE with the purchase of a MAX-12 monitor.**

Image The ultimate test of any monitor is how the image looks to your own eyes. Compare the Princeton monitors side-by-side with the competition at Computerland, Entre or your local independent dealer.

Do it soon. You and your Great Ideas deserve the best.

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Little wonder C. Itoh printers are No. 1 worldwide, with over 2.2 million sold annually. And with the StarWriter Y10 we're aiming to keep it that way.

To meet your own perfect 10, just see your local C. Itoh printer dealer. Or for more information call 1-800-423-0300.

Or write C. Itoh Digital Products, Inc. 19750 South Vermont Avenue, Suite 220, Torrance, CA 90502.

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DIGITAL PRODUCTS

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Inquiry 38 for Dealers. Inquiry 39 for End-users.

Tandy Unveils $999 Notebook Computer

Radio Shack's battery-powered notebook-size Model 200 has a flip-up 16-line by 40-column LCD and a built-in 300-bps auto-dial modem. The Model 200 comes with 24K bytes of RAM and 72K bytes of ROM, and it includes word-processing, spreadsheet, telecommunications, and address-book programs. Memory can be expanded with two 24K-byte banks of RAM, for a total of 72K, and a 32K-byte ROM chip.

The system's keyboard has 60 full-travel sculptured keys, 12 special- and general-purpose function keys, and a power switch that is automatically depressed when the LCD/cover is closed. A cassete interface and parallel and serial ports are standard. The Model 200 weighs 4½ pounds and measures 11¾ by 8½ by 2$\frac{3}{16}$ inches.

Although the Model 200 uses the same processor as the Model 100, changes in ROM will prevent Model 100 machine-language programs from running on the Model 200; BASIC programs will work on both. Other differences are a modified cursor key cluster, enhanced word-processing features, Microsoft's Multiplan spreadsheet in ROM, calculator function available from any program, and optional pulse or tone dialing. Normal battery life is 10–16 hours depending on RAM size, or you can install rechargeable nickel cadmium (nicad) batteries.

The Model 200 will retail for $999; 24K-byte add-on modules cost $249.95 each. Contact Tandy/Radio Shack, One Tandy Center, Fort Worth, TX 76102, or your local Radio Shack store.
Inquiry **600**.

Datavue Portable Includes Disk Drive, 80 by 25 Display

Quadram's Datavue 25 is a 14-pound portable computer with a 360K-byte 5¼-inch disk drive and a pivoting 80-character by 25-line LCD. It features an 83-key keyboard that communicates with the computer through infrared signals. The Datavue 25 has an 80C88 microprocessor, a real-time clock, 128K bytes of memory, and serial and parallel ports. It is powered either by an AC adapter/recharger or by built-in batteries that last up to four hours.

Monochrome graphics are available in either 640 by 200 resolution or 320 by 200 resolution with four levels of gray. An internal 300-bps modem is an option. Memory can be expanded to 256K bytes using 64K-byte chips or to 1 megabyte using 256K-byte chips. Quadram also plans to release an external IBM PC-compatible bus-expansion chassis and an external second floppy-disk drive.

The Datavue 25 should be available in March for $2195. Contact Quadram, 4355 International Blvd., Norcross, GA 30093, (404) 923-6666.
Inquiry **601**.

Model 1131 Compass Has 128-column LCD

GRiD Systems' Model 1131 Compass is a portable computer with a 25-line by 128-column electroluminescent display (ELD). GRiD says that the durable 10-pound computer is built to stand a shock equal to 130 Gs. The Model 1131 features 256K bytes of RAM (expandable to 512K bytes), 384K bytes of nonvolatile bubble memory, a 300/1200-bps auto-dial/auto-answer modem, and the MS-DOS operating system in ROM.

The Compass Model 1131 costs $6795; with 512K bytes, it's $7995. The price of the original Model 1100 is now $4250. Contact GRiD Systems Corp., 2535 Garcia Ave., Mountain View, CA 94043, (415) 961-4800.
Inquiry **602**.

(continued)

Visage Videodisc Software Development System

Visage has introduced a series of products for developing interactive videodisc software. Using an IBM PC or compatible personal computer, a standard videodisc player, and Visage's controller card and software, developers can create interactive programs for educational applications using images from videodiscs overlayed with computer-generated text and graphics.

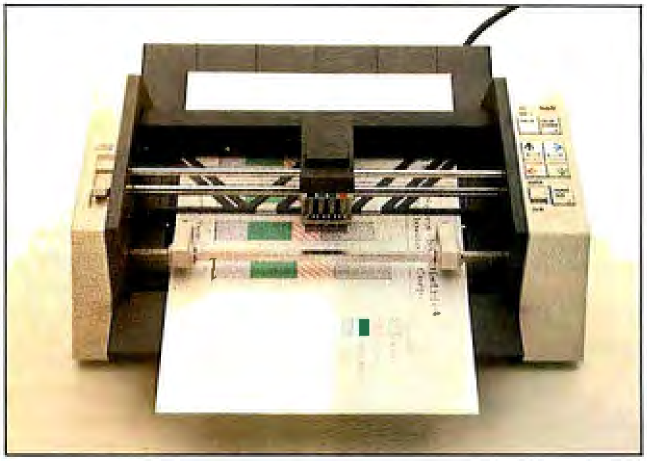
Visage's V:Link 1000 includes an IBM PC expansion card and language-interface software, which together support NTSC graphics with 256 by 192 overlay capabilities. The V:Link 1500 adds the ability to switch between a 256 by 192 overlay and a 320 by 200 nonoverlay image, while the V:Link 1550 allows both 256 by 192 and 320 by 200 graphics to be overlayed on videodisc images. Prices range from $1150 to $2150.

The V:Station 2000 family all feature IBM PC-compatible computers with 256K bytes of RAM, one or two floppy disks, the V:Link 1550 graphics board, and a 13-inch RGB color monitor. Some of the V:Station configurations also include medium- or high-resolution touchscreens, 10-megabyte hard disks, and 512K bytes of memory. Prices range from $5995 to $10,850.

Visage's products support the KoalaPad, Bit Pad, and Microsoft Mouse as graphics input devices. Optional support packages allowing the Visage software and hardware to be used with BASIC, Pascal, dBASE II, and 8088 assembly language cost $295 each. V:Paint I and II, $500 each, use the Microsoft Mouse ($125 extra) to create images. Cables are available to link the V:Link card to Sony, Pioneer, RCA, and Hitachi videodisc players.

Visage supplies its V:EXEC and V:Draw software and one language interface with all V:Link and V:Station products. Contact Visage Inc., 12 Michigan Dr., Natick, MA 01760, (617) 655-1503.

Inquiry 603.



NEC Introduces Four-Color Plotter

Britewriter is a four-pen color plotter that NEC says is compatible with Hewlett-Packard plotters. The Britewriter can plot at a speed of 60 millimeters per second (mm/s) in low-speed mode and 112 mm/s in high-speed mode. Characters can be drawn at 4.6 cps in one color or 2.6 cps in four colors. The plotter comes with black, blue, green, and red felt-tip pens; an optional set of colors includes violet, orange, brown, and pink pens. The plotter can be used with plain paper or transparencies up to 8½ inches wide.

The Britewriter is available with parallel or RS-232C serial interfaces. It features a 256-byte character and instruction memory and supports the ASCII character set. Because it uses the same commands as Hewlett-Packard 7470 and 7550A plotters, it works with most graphics programs that support Hewlett-Packard plotters.

The Britewriter plotter will retail for $599. Contact NEC Information Systems Inc., 1414 Massachusetts Ave., Boxborough, MA 01719, (617) 264-800.

Inquiry 604.

Commodore Announces 128K Computer

Commodore's B128 runs any program written for the Commodore 64 and has a number of additional capabilities. This sytem has 128K bytes of memory, expandable to 512K, and it can display 80 columns by 25 lines of text in color on an optional monitor. In addition to the 8500 processor, which is used to run Commodore software, the B128 includes a 2-MHz Z80 coprocessor to run most CP/M-80 programs.

The 92-key keyboard has a numeric keypad, 4 cursor keys, 4 numbered shiftable function keys, and 4 special-purpose function keys. Like the 64, the B128 can display 16 colors and 8 independently movable sprites and can generate sound in three voices each with a range of eight octaves. The B128 comes with the same serial, expansion, user, and joystick ports as the 64; it also includes video interfaces for a standard television or an RGB or NTSC monitor.

Commodore also introduced a faster disk drive for the Commodore 64 and B128. It transfers data to the 64 at 320 cps, or to the B128 at 2000 cps, or, when running CP/M, 3200 cps.

The Commodore B128 will sell for less than $400. Contact Commodore, Computer Systems Division, 1200 Wilson Dr., West Chester, PA 19380, (215) 431-9100.

Inquiry 605.

(continued)

NEW PRODUCT NEWS FROM TELETEK

Systemaster II. Responding to market demand for speed and increased versatility, Teletek is proud to announce the availability of the next generation in 8-bit technology — the new Systemaster II! The Systemaster II will offer two CPU options, either a Z80B running at 6 MHz or a Z80H running at 8 MHz, 128K of parity checked RAM, two RS232 serial ports with on-board drivers (no paddle boards required), two parallel ports, or optional SCSI or IEEE-488 port. The WD floppy disk controller will *simultaneously* handle 8" and 5¼" drives. A Zilog Z-80 DMA controller will provide instant communications over the bus between master and slave. Add

sult is un-
uenteu
performance.
Systemaster II will run under CP/M 3.0 or TurboDOS 1.3, and fully utilize the bank switching features of these operating systems.

SBC 86/87. As the name indicates, Teletek's new 16-bit slave board has an Intel 8086 CPU with an 8087 math co-processor option. This new board will provide either 128K or 512K of parity checked RAM. Two serial ports are provided with individually programmable baud rates. One Centronics-compatible parallel port is provided. When teamed up with Systemaster II under TurboDOS 1.3, this 5MHz or 8MHz multi-user, multi-processing, combination cannot be beat in speed or feature flexibility!

Teletek Z-150 MB. Teletek is the first to offer a RAM expansion board designed specifically for the Z-150/Z-160 from Zenith. The Teletek Z-150 MB is expandable from 64K to 384K. Bring your Z-150 up to its full potential by adding 320K of parity checked RAM (or your IBM PC, Columbia, Compaq, Corona, Eagle, or Seequa to their full potential). The Teletek Z-150 MB optionally provides a game port for use when your portable goes home or a clock/calendar with battery backup!

Evaluate the Systemaster II, SBC 86/87 or Teletek Z-150 MB for 30 days under Teletek's Evaluation Program. A money-back guarantee is provided if not completely satisfied! All Teletek products carry a 3-year warranty.

Specifications subject to change without

TELETEK

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(916) 920-4600
Telex #4991834
Answer back — Teletek

Inquiry 310

Yes,
I'm interested
in information
regarding:
☐ Systemaster II
☐ SBC 86/87 ☐ Z-150 MB

Name ____________
Company ____________
Address ____________

2B

Modular Robot Kit

Cybot's Tutor is a modular robot with a five-axis arm designed for educational and training uses. Because the robot can be dismantled and reassembled many times, it helps you understand how robotics work.

The package includes the robot arm, complete with five motors and a gripper, and the Controller module, which has one free S-100 card slot for custom applications, a standard RS-232C serial port, and an interface for an optional "teach pendant." You can control the robot arm by sending ASCII commands from a personal computer through the RS-232C port or by directly manipulating the arm with the teach pendant.

Also available is an Optical Encoder Set. Since the set indicates the actual position of one of the motors (five are needed to monitor all five axis motors), a full feedback loop can be used to make sure the robot arm is precisely where it's supposed to be.

The complete Cybot Tutor robotics kit costs $3395. The optional teach pendant is $129.95. Each Optical Encoder Set is $70. Parts of the robot kit can be purchased separately. Contact Cybot Inc., 12510 128th Ave. NE, B-5, Kirkland, WA 98034, (206) 823-4156.
Inquiry **606**.

Computer Satellite Service

Satellite Broadcast Network has announced a satellite service that will transmit financial and news information to personal computer owners. SBN plans to have the service operational in May. You will need a 12-GHz satellite-receive antenna, a low-noise amplifier, a solid-state receiver, and SBN's demodulator; all are available from SBN for $695. SBN will also charge a fee for access to each type of information, starting at about $25 per month.

SBN will use multiple 9600-bps channels. Some channels will broadcast news and weather information, others will transmit stock and commodity prices. One channel might permit downloading of software sample programs, while another could include special-interest database information. A user could place a request for special database information with modems and telephone lines, but the response could be broadcast via satellite to avoid phone charges. A special header code would ensure that only one person could decode the information.

Contact Satellite Business Network Inc., 212 West Superior St., Chicago, IL 60610, (312) 266-9844.
Inquiry **607**.

Sord Adds 80 by 25 Display to IS-11

Sord has released a version of its IS-11 Consultant computer with an 80-character by 25-line liquid-crystal display and a built-in 300-bps modem. The 6½-pound IS-11C has 80K bytes of RAM (expandable to 144K), 72K bytes of ROM, a 128K-byte microcassette tape drive, 62 full-travel sculptured keys plus 8 special function keys, and a CMOS Z80A microprocessor running at a speed of 3.4 MHz. In addition to parallel and serial ports, the IS-11C can interface with a bar-code reader, a separate numeric keypad, and optional 64K-byte ROM cartridges. Word-processing and communications software are standard in ROM.

The IS-11C should be available this month for $1495. For more information, contact Sord Computer of America Inc., 645 Fifth Ave., New York, NY 10022, (212) 759-0140.
Inquiry **608**.

(continued)

PERSONALITY PROBLEM?

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The Connector is a revolutionary product that allows DOS applications to run on the IBM PC/AT or XT under VENIX/86 (the first licensed AT&T UNIX operating system for the IBM PCs) or PC/IX. That means you can add one or more terminals to your AT which run programs using multi-user VENIX/86 to share the disk and printer. Switch between UNIX and DOS at the console with a single command. And run more than one task simultaneously. Like running a spelling check in the background while you print a report and run Lotus 1-2-3™ or dBaseII™.

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UNISOURCE

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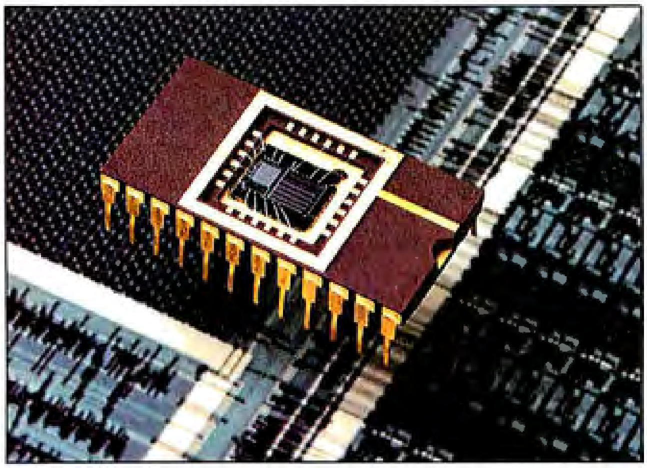
Inquiry 318

Digital Filtering Chip for Speech Processing

Kurzweil Applied Intelligence has introduced the KSC 2408 digital filter chip for use in sound-processing applications.



Each of the eight filters in the KSC 2408 processes 24 bits of information (with 48 bits accumulated at a time). Each of the filters processes information in a given frequency range; Kurzweil says that dozens of filters—or many 2408 chips—would be needed to divide up the frequency spectrum of the human voice enough to make speech recognition possible.

The 2408 can process sound up to a sampling frequency of 125 kHz (125,000 cycles per second) if only two filters are activated; if all eight filters are activated, the maximum sampling rate is 32 kHz. Since the chip is programmable, it can be used for other types of digital filtering, including high-pass, band-pass, or low-pass.

Kurzweil plans to market a 10,000-word vocabulary speech-recognition system and is working on development of a voice-activated typewriter. Company founder Raymond Kurzweil earlier developed the Kurzweil Reading Machine, which can read text for the blind regardless of the typeface, and the Kurzweil 250 digital keyboard (music synthesizer).

The Kurzweil 2408 digital filter chip costs $81 for a 3-MHz version or $101 for a 6-MHz version; quantity discounts are available. Contact Kurzweil Applied Intelligence Inc., 411 Waverley Oaks Rd., Waltham, MA 02154, (617) 893-5151.
Inquiry 609.

Twelve Million Instructions per Second

According to Cromemco, its Maximizer coprocessor subsystem executes an average of 12 million instructions per second. The Maximizer features a 2900-series ECL (emitter-coupled logic) bit-slice processor running at 48 MHz. It also has 16K bytes of 50-ns RAM, 16 dual-port registers, and 4096 48-bit words for downloaded microcode instructions. Cromemco says the chip's speed is enhanced by the use of a 60-ns multiplier chip and a doubly pipelined instruction path. Most instructions execute in 62.5 ns, though some may take as long as 125 ns.

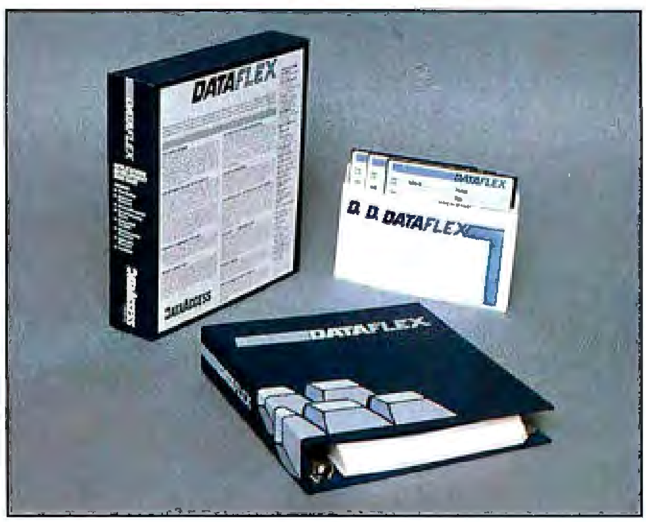
The Maximizer comes on two S-100 (IEEE-696) bus boards that plug into Cromemco's microcomputers. The system runs under the company's Cromix operating system, and it will soon run under UNIX System V as well.

The Maximizer supports FORTRAN, Pascal, and C. Also available is MAXASM, a microcode assembler used to write custom microcode for applications where execution speed is critical.

The Maximizer retails for $3495; the MAXASM Microcode Assember costs $2995. Contact Cromemco Inc., 280 Bernardo Ave., POB 7400, Mountain View, CA 94039, (415) 964-7400.
Inquiry 610.

Data Access Enhances Database Program

Data Access Corporation's DataFlex 2.1 is a 16-bit version of the company's multiuser relational database programming system. It permits over 16 million records per file, up to 250 files, each as large as the operating system will handle (up to 2 gigabytes, 32 megabytes in MS-DOS), and use of unlimited RAM.



The package includes a relational database command language, a custom menu system, and an application generator. Versions of the program are available for such operating systems as MS-DOS/PC-DOS 1.1 through 3.1, CP/M, CP/M-86, Concurrent CP/M-86, MP/M, MP/M-86, and TurboDOS. DataFlex also operates under a number of networking systems.

Pricing depends on the computer, operating system, and number of users; a single-user IBM PC version is $995. A separate run-time version is available. For details, contact Data Access, 8525 Southwest 129 Terrace, Miami, FL 33156-6565, (305) 238-0012.
Inquiry 611.

(continued on page 421)

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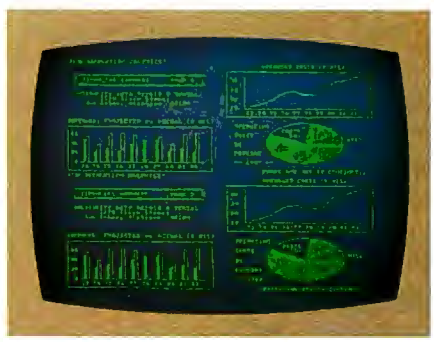

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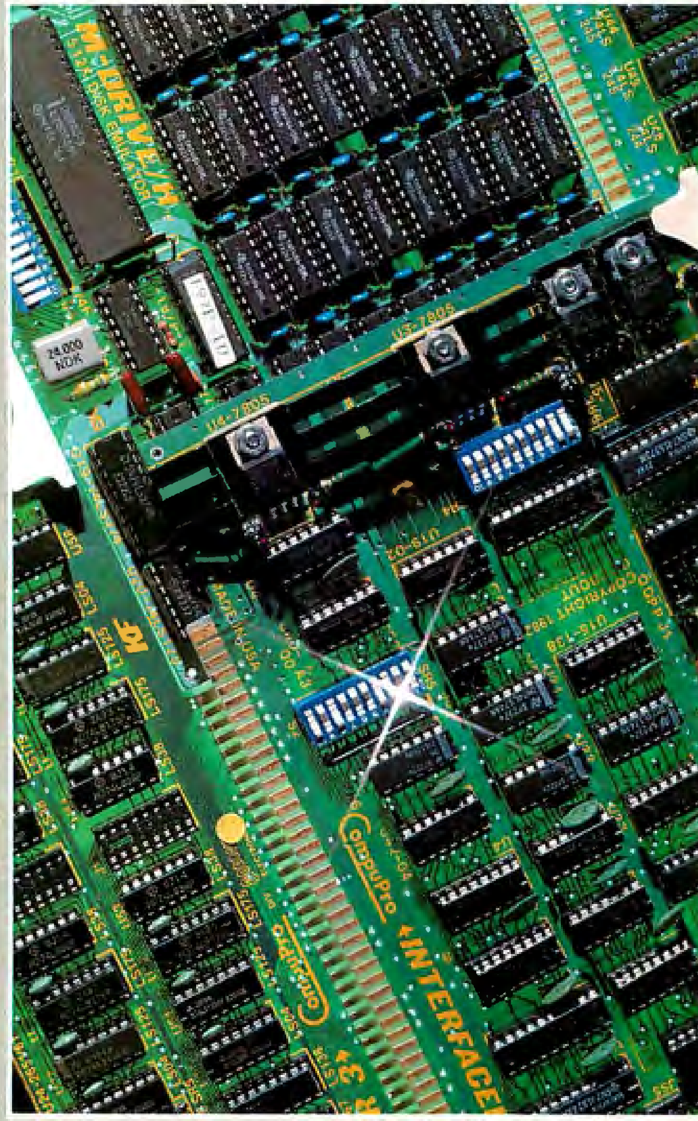

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A·S·K B·Y·T·E

Conducted by Steve Ciarcia

CORONA COMPATIBILITY

Dear Steve,

I've had my Corona PC for about a year now, and for the first time I've run into an incompatibility with the IBM PC. The problem is that the IBM PC has an extra open socket built into it to add a ROM or EPROM, and the Corona doesn't. A few programs on the market make use of this socket, including a genetics program I am interested in. Is there a fairly simple way to add an extra ROM chip?

Another problem is that my BIOS is written on a 28-pin 2764, while the chip for the genetics program is on a 24-pin 2732A. How can I use the 2732 in my Corona, and what is the difference between a 2732 and 2732A anyway?

Yet another problem is the Corona's incompatibility with IBM graphics. To get graphics on the IBM, you must buy a graphics color card, which uses memory locations B800 to BC00 hexadecimal. On the Corona, different RAM locations are used for graphics. Is there a way to modify programs that need the color card (e.g., Flight Simulator) so that they will work on the Corona? It may not be that difficult because there is a graphics driver by HST, which if loaded before Lotus 1-2-3, enables 1-2-3 to draw graphs perfectly on my screen.

RICHARD BERMAN
King of Prussia, PA

You should be able to add a ROM to the Corona by installing it on an expansion board with the proper interfacing circuitry. This could be built on a PC prototyping board, such as those produced by Vector Electronic Co., POB 4336, 12460 Gladstone Ave., Sylmar, CA 91342, (818) 365-9661. Since all 20 address lines are available in the I/O channel (expansion slots), you can set up the addressing as required for the ROMs with your genetics program. There could be interference between the Corona's BIOS ROM and the add-on ROM. IBM uses 40K bytes out of the 48K bytes of reserved ROM space, and I suspect that the Corona uses the same space to preserve compatibility with IBM.

The 2732s are programmed at +25 V, while the 2732As require only 21 V.

A possibility exists that the HST graphics-driver program you mention may allow you to run the new Microsoft Flight Simulator on your Corona but not the original version. The new version can be loaded from DOS with the command FS, so a driver can be loaded ahead of the program. The original version could be loaded only by rebooting, which of course wipes out the graphics driver. See your dealer for a demonstration before you buy because there may be other incompatibilities not fixed by the HST driver.—Steve

SOURCE BOOK NEEDED

Dear Steve,

As a computer counselor, I help clients with hardware and software purchases, checking sources and buffering clients from high-pressure salespeople. Since I am not affiliated with any computer manufacturer or outlet, I do not limit my clients to the selections of a particular store. However, this lack of affiliation means that I do not receive promotional materials, which limits my effectiveness. Can you recommend any source book that lists various computer manufacturers and gives at least minimal specifications on their products?

PATRICIA SELK
Stafford, VA

Many sources of information of the type you need are available. First, most computer magazines, including BYTE, publish reviews of microcomputers, peripherals, and accessories. These are a good source of unbiased information.

Second, you can get promotional information from manufacturers by writing to them on your letterhead, explaining your needs. Their addresses are available in ads in BYTE and other magazines and are frequently published in buyers guides and directories available at most computer stores and many bookstores.

A third source is companies that specialize in publishing survey reports on this type of equipment. One of these is Datapro Research Corporation, 1805 Underwood Blvd., Delran, NJ 08075, (800) 257-9406.—Steve

DRIVE-HEAD PROBLEM

Dear Steve,

I bought an Atari 800 and two Atari 810 disk drives three years ago. Some time ago, one of the drives began to have problems. Before realizing that it was only a burned-out IC, I measured the head's resistance with a digital tester. Since then, the drive seems to be able to write but does not read. I think I've magnetized the head. I tried to demagnetize it with various methods (including the use of a commercial head demagnetizer for cassette recorders), but I haven't had any success. If you think I must replace the head, could you tell me where I could buy it?

ODINO CIAI
Buenos Aires, Argentina

Digital testers normally do not supply enough current to damage a disk-drive read/write head. You did not say whether you could write to a disk and read it from the other drive. It is possible that the alignment of the head was disturbed when you were making your tests. Try some cross-checks to see if that is the case. Also, check the obvious things, such as dirt on the head and a worn head-load pad. The head-load pad is a little felt pad that keeps the disk in contact with the head. If it is worn, data may not be properly read or written. Check the continuity of the read head with an ohmmeter or your digital tester. If the head coil is open, see if there is a mechanical break in the wiring.

If you are convinced that the head is defective, a replacement can be obtained from Micro Peripherals Inc., 9754 Deering Ave., Chatsworth, CA 91311, (213) 709-4202.—Steve

SHARING FILES

Dear Steve,

We have several Eagle PCs in our analytical laboratory, all of which use two pieces of software: pfs:File and Lotus

(continued)

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Inquiry 178

1-2-3. Because each computer is producing data that is eventually compiled into the same reports, it would be a great timesaver to have the systems all sharing a common hard disk containing the basic software as well as the data files.

Does this type of data-file sharing require an elaborate LAN (local-area network) setup? It seems that a simple multiple linking of the PCs to a large hard disk would serve our purpose nicely, or are we greatly oversimplifying the problem?

We are considering moving up to a true relational database-management system such as dBASE II (or III) or Condor but are still unsure that the file-sharing system we have in mind will work.

Your advice on just how complicated (or simple) such a system could be would be greatly appreciated and would surely help us out of a real quandary.

CHARLES HARPER
Dallas, TX

Your situation appears to be one that does not require an LAN—yet! But you would probably be better off if you did plan for one, especially if you intend to move up to a true relational database system. Even your simple file sharing could cause some potentially disastrous problems without the "safety net" of true LAN software. I am referring to problems that occur when two individuals access the same file simultaneously. Under certain conditions, it is quite probable that when two people write to the same file at nearly the same time, the resulting file will be incorrect from either's point of view. Worse yet, a condition called "fatal embrace" can essentially hang up the entire system until it is manually reset. Another point to remember is that not all software is ready for multiple users, although most LANs provide some mechanism to make it usable while avoiding the problems I've mentioned.

Two suppliers featuring LAN hardware and software are Corvus Systems and Orchid Technology. Another possibility is to purchase an IBM PC AT and IBM's networking software (when it becomes available).

Corvus can be reached at 800-4-CORVUS. Orchid Technology is located at 47790 Westinghouse Dr., Fremont, CA 94539, (415) 490-8586.—Steve

TRACK BALLS ARE BETTER

Dear Steve,

I use my Z-100 almost exclusively for word processing and other nonnumerical data-manipulation tasks. I find the number pad to the right of the keyboard useless except for the cursor-control keys, which I think are tedious and clumsy.

What about this: replace the number pad with a track ball for cursor control. Or even better, an upside-down mouse (I never could understand why they had to run around on a tabletop—mine is always too cluttered) with one or two appropriate function buttons.

Is this possible? Am I the only one who would use such a gizmo? Where can I go for information on how this might be done?

MICHAEL R. THOMAS
Port Arthur, TX

Some people who use track balls and mice claim that they would never go back to using cursor-control keys again. That is why several companies are making these devices for micros. Your idea to incorporate such a device into a keyboard is a good one, but it will have to be done by keyboard manufacturers. There is no easy or economical way to modify your Z-100 keyboard, due to the differing natures of keyboards and mice and their interaction with a particular program. A keyboard sends a unique code to the computer for each key as it is pressed. A mouse or track ball does not generate the same code when it is used, and the information it does generate usually enters the computer through a different port.

Add-on mice are sold with utility software that translates the signals from the mouse into usable information. A word processor, for example, has been written to accept the control codes generated by certain keys (the cursor keys) and always expects those codes to come from the keyboard. Most current software is not written to take advantage of mice or track balls and would have to be modified to use these devices. Of course, Microsoft's Word program was written specifically for a mouse. Other programs are appearing that also use mice.—Steve

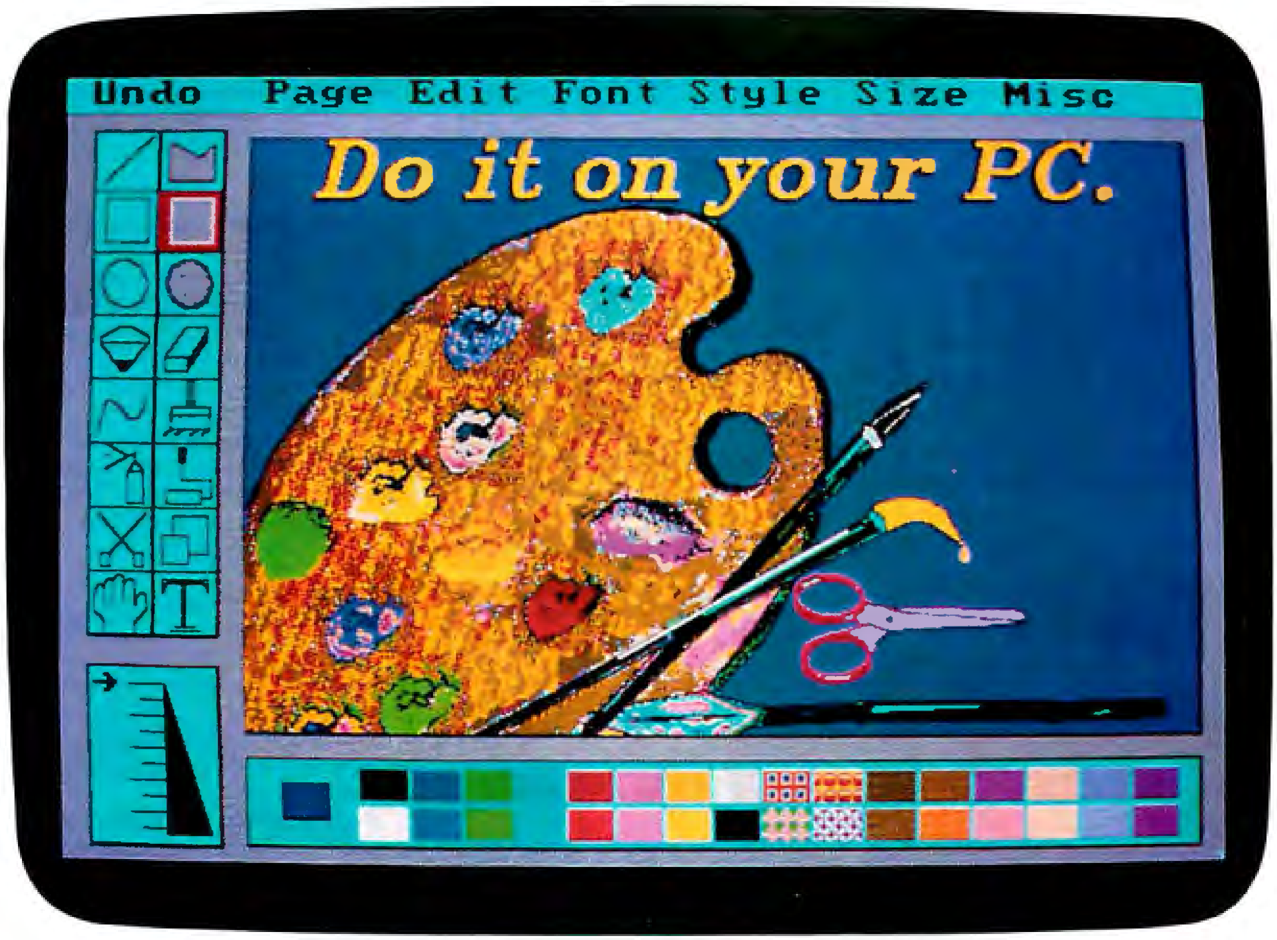
POWER-LINE POLLUTION

Dear Steve,

I greatly appreciated your article "Keep Power-Line Pollution Out of Your Computer" (December 1983, page 36). A nearby lightning flash once damaged a transistor board in my RCA television.

To protect my IBM PC, I am using the Radio Shack filter strip (cat. #26-1451).

(continued)



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You'll be able to cut, paste, and move things around. Even enhance graphs, text, and images from other programs like Lotus 1-2-3, Microsoft Word, and SuperCalc 3.

But don't stop with painting. PC Paintbrush also gives you an electronic type shop to work with. Several fonts, from Olde English to Computer. Each in seven styles (boldface, italics, underline, etc.) and seven sizes.

All of which makes it great for designing everything from fliers and report covers to greeting cards and birthday banners. (For a wall-sized work of art, just print sideways.)

The possibilities are endless. But the best way to see for yourself is to see for yourself. Get a demonstration at your nearest computer store.

Then, draw your own conclusions.

Imsi™ SOFTWARE PUBLISHERS Inquiry 352

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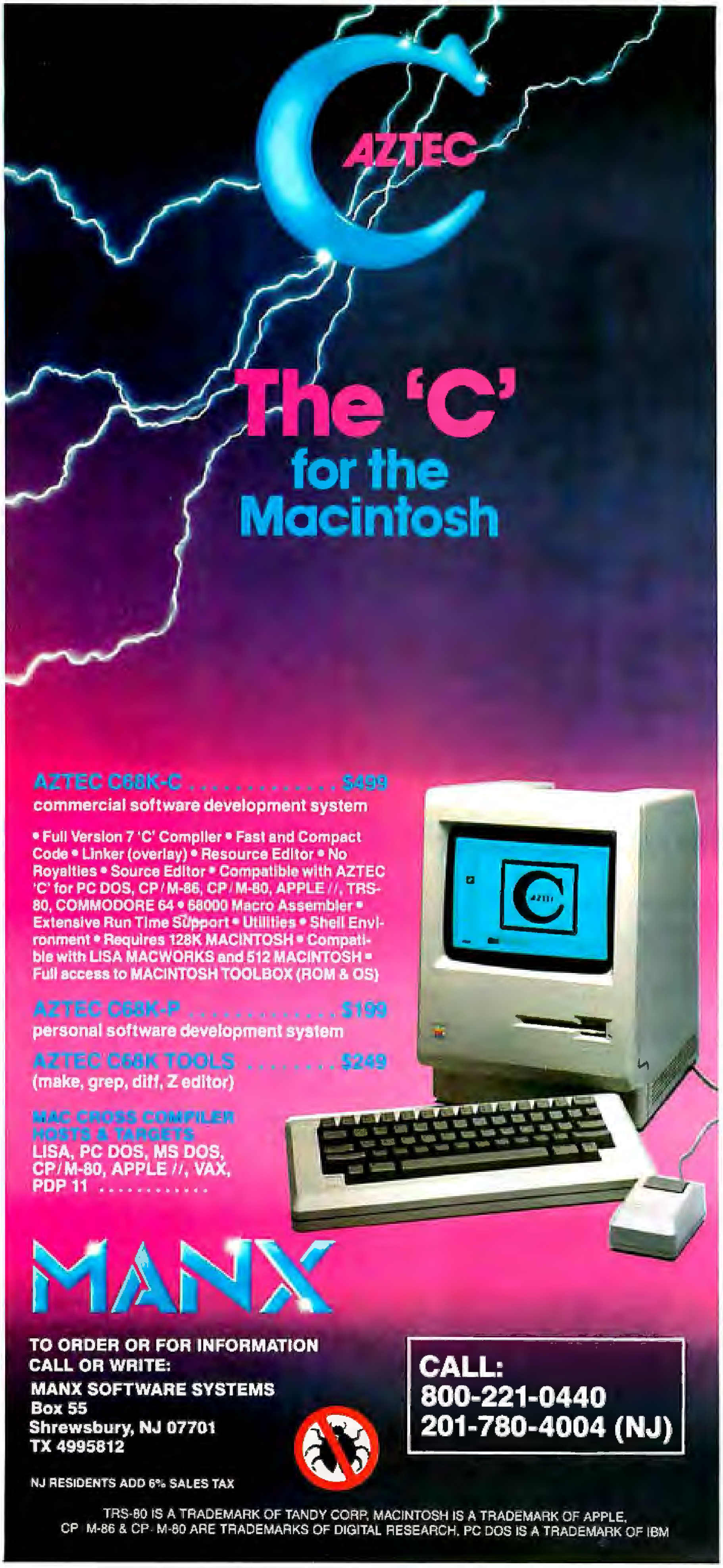

Would you please answer the following questions?

Is it necessary to connect my IBM PC Color Display Monitor to the 0.5-A monitor outlet on the filter, as recommended for Radio Shack monitors?

My PC is connected to the 1.25-A processor outlet. Is this all right?

I could not determine from your article where the MOVs are to be soldered on this unit. Could you tell me where they go?

Is it advisable to remove disks from drives before turning the main power switch on?

I also need your help on a different problem. We have often found that our telephone bills contain calls we did not make. The telephone company doesn't charge us for these calls, but this involves an examination of each bill and checking with Ma Bell to determine whether we made suspect calls.

The computerized telephones being introduced are becoming more sophisticated, but none, as yet, keeps a record of outgoing calls. Is it possible to modify such a unit or to inexpensively build a device that would do this?

I have one Touch-Tone and two rotary-dial telephones, and I would like the new unit to be attached to one of them that would record outgoing calls on all three.

SIDNEY BELMAN
Teaneck, NJ

The Radio Shack filter strip was originally designed for the TRS-80 Model I computer, and the filters for each outlet were designed to handle different types of noise. The outlets have current limitations because the filters have current limitations. As long as the current ratings are not exceeded, any socket can be used.

The IBM PC is rated at 200 W at 120 V AC. This works out to 1.66 A, which is in excess of the 1.25-A rating of the filter.

It is not necessary to remove disks from the drives before turning on the PC. It was a problem on the TRS-80 Model I, but the PC has an autoboot feature that allows the disk to be inserted prior to it being turned on.

Recording outgoing telephone calls can be accomplished by a simple pulse-counter circuit connected to a computer. The computer would poll the line to see if a call were being made and then read and store the output of the pulse counter. A suitable pulse-counter circuit can be found in Telephone Accessories You Can Build *by Jules H. Gilder (Hayden, 1976).*

(continued)

C COMPILERS FOR
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Shipping: per compiler next day USA $20, 2 days USA $6, 2 days worldwide $75, Canada $10, airmail outside USA & Canada $20
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A simpler circuit, not requiring a computer, would consist of a tape recorder to record the pulses. The tape could then be played back through the pulse counter to see what numbers were dialed. The tape recorder could be controlled by the pulse detector.—Steve

COMPUTERIZED HOME

Dear Steve,

I am planning to build a house and would like to provide for computer control in my home. Can you offer any suggestions?

PAUL W. MARSH
Urbana, IL

With the almost daily announcement of some computerized device, it makes sense to provide a means for installation in the home. However, it is difficult to know what devices will ultimately be required.

I will be presenting a series of three articles, beginning in April, covering the construction of the Circuit Cellar home-control system.—Steve ■

Between Circuit Cellar Feedback, personal questions, and Ask BYTE, I receive hundreds of letters each month. As you might have noticed, at the end of Ask BYTE I have listed my own paid staff. We answer many more letters than you see published, and it often takes a lot of research.

If you would like to share the knowledge you have on microcomputer hardware with other BYTE readers, joining the Circuit Cellar/Ask BYTE staff would give you the opportunity. We're looking for additional researchers to answer letters and gather Circuit Cellar project material.

If you're interested, let us hear from you. Send a short letter describing your areas of interest and qualifications to Steve Ciarcia, POB 582, Glastonbury, CT 06033.

IN ASK BYTE, Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to

Ask BYTE
c/o Steve Ciarcia
POB 582
Glastonbury, CT 06033

Due to the high volume of inquiries, personal replies cannot be given. All letters and photographs become the property of Steve Ciarcia and cannot be returned. Be sure to include "Ask BYTE" in the address.

The Ask BYTE staff includes manager Harv Weiner and researchers Bill Curlew, Larry Bregoli, Dick Sawyer, and Jeannette Dojan.


ZORK I
INFOCOM
ZORK II
INFOCOM
ZORK III
INFOCOM
A LOCKED DOOR. A DEAD MAN.
And 12 Hours to solve the murder.
DOCUMENTARY EVIDENCE
DEADLINE
The WITNESS
SOMEBODY'S GOING TO TAKE THE DEEP SIX!!
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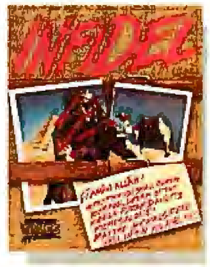
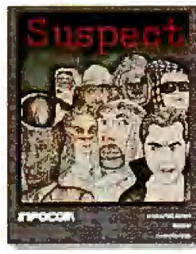


AND NOW FOR SOMETHING INCOMPLETELY DIFFERENT!

In CUTTHROATS,™ the plot involves a motley band of hardbitten salts who get wind of a shipwreck laden with sunken treasure near the remote island where you live. In exchange for your diving skills, they offer you a piece of the action. Your challenge: survive them, the perils of the deep, and escape with the treasure and your life. Good luck!

THE HITCHHIKER'S GUIDE TO THE GALAXY™ by Douglas Adams is the most mind-boggling story we've ever published. In the person of Arthur Dent, you'll chortle as your planet is demolished. You'll yelp with laughter as your life is threatened by a galaxy of horrors. Your sides will positively split as you search the universe for... well, you'll find out. Maybe.



In SUSPECT,™ our newest mystery thriller, you're a reporter who gets the scoop on the society event of the year—the murder of a Maryland Blue Blood at a fancy costume ball. Great! Except you're the prime suspect. And if you can't find the real killer, your next by-line could be in the obituaries.

Incomplete, yes.

But it's not just because we're always bringing out new stories in the Infocom interactive fiction collection. Nor is it simply due to the fact that with all the writing and re-writing, honing and perfecting that we put into every one of our stories, our work is seemingly never done.

The real reason is: an Infocom work of fiction can never be complete until you become a part of it.

You see, as hard as we work at perfecting our stories, we always leave out one essential element—the main character. And that's where you enter in.

Once you've got Infocom's interactive fiction in your computer, you experience something akin to waking up inside a novel. You find yourself at the center of an exciting plot that continually challenges you with surprising twists, unique characters (many of whom possess extraordinarily developed personalities), and original, logical, often hilarious puzzles. Communication is carried on in the same way as it is in a novel—in prose. And interaction is easy—you type in full English sentences.

But there is this key difference between our tales and conventional novels: Infocom's interactive fiction is active, not passive. The course of events is shaped by the actions you choose to take. And you enjoy enormous freedom in your choice of actions-you have hundreds, even thousands of alternatives at every step. In fact, an Infocom interactive story is roughly the length of a short novel in content, but because you're actively engaged in the plot, your adventure can last for weeks and months.

In other words, only you can complete the works of Infocom, Inc. Because they're stories that grow out of your imagination.

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*Use the IBM PC version for your Compaq, and the MS-DOS 2.0 version for your Wang or Mindset.

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Power surges, spikes and line noise are responsible for 70–90% of all PC malfunctions. They can wipe out memory in your PC, taking hours of hard work with them. They can zap your delicate chips, sending your PC in for costly repairs. Master Piece clips surges and spikes at a safe level. You end up with an IBM that's more accurate and reliable.

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● VISIT WITH APPLE USERS—Ideas, information, and the latest computer news are available to members of the Arkon Infosystem, a 24-hour 300-bps bulletin-board system operating in Toronto, Canada. Upload, download, electronic mail, and public messages are a few of its features. Also included are 20 conferences, 10 megabytes of storage, and on-line help. The annual fee for using the system is $19.95, but inquirers can log on under the "Guest" user function. Questions about the system can be sent through the (F)eedback-to-sysop function of the Arkon Infosystem at (416) 593-7460. Other details are available from David Fingold, Arkon Infosystem, 409 Queen St. W, Toronto, Ontario M5V 2A5, Canada, (416) 593-9653.

● CHAMELEON ADVOCATE The National Chameleon Users Group (NACHUG) produces a newsletter, *The 80/88 National Newsletter*, that contains hardware and software reviews, updates, and a users forum. Member discounts are provided on peripherals and accessories. Membership is $12 a year. Contact Steven Bender, NACHUG, POB 28360, Queens Village, NY 11428.

● SIG, NEWS FOR PUBLIC-DOMAIN SOFTWARE *PC-SIG News*, a newsletter from the PC Software Interest Group (PC-SIG), is devoted to public-domain or user-supported software for the IBM PC and compatible computers. It lists the disks in the library, updates recent disk arrivals, and encourages patches and feedback from users. The members have compiled a directory with a subject index and listings. Contact the PC Software Interest Group, Suite 130, 1556 Halford Ave., Santa Clara, CA 95051.

● C-CLUB IN RIVER CITY The River City Commodore Club is a nonprofit organization that meets twice a month to promote interest in all Commodore computers. The group features a large club library, help groups, and basic and advanced tutorials. For details, write River City Commodore Club, POB 4298, North Little Rock, AR 72116.

● COMPUTER AND SOFTWARE LAW—The Center for Computer/Law, a nonprofit educational institution, provides research and educational services in computer law. The Center produces *Computer/Law Journal*, an international journal on the legal issues of computers, telecommunications, and the information industries. It also publishes a quarterly law review, *Software Law Journal*, that contains scholarly articles from computer law experts, as well as a bibliography of software law and a directory of recent cases. Contact the Center for Computer/Law, POB 3549, Manhattan Beach, CA 90266.

● MANY SHARED BENEFITS—The First Attache/2001 User Group (FAUG) produces a monthly newsletter titled *Where It's Att*. Members meet quarterly, have access to public-domain library disks, and receive support by telephone and networking. The club can be reached on CompuServe at 70346,63. Annual dues are $35. Contact Charles Raisch, FAUG, 1827 Haight, San Francisco, CA 94117-2791, (415) 221-3415.

● NO TIME LIMITS SET YET—In northern Idaho a 24-hour bulletin-board system called I-PACE features Atari downloads. Passwords are not required, no time limits are set, and people add to it frequently. The BBS number is (208) 772-9421. Contact Robert Marshall, POB 5123, Coeur D'Alene, ID 83814, (208) 772-5922.

● CHRISTIAN COMPUTERISTS—Christian programs, a member's exchange, a monthly newsletter, and discounts on computer supplies are available from the Elect Christian Computer Club. For details and a free issue of the newsletter, *E₃C Electletter*, write to the Elect Christian Computer Club, Department LA1, POB 31022, Chicago, IL 60631-0022.

● TRIANGLE dBASE USERS GROUP—Members of a users group for dBASE II and III meet at 7:30 p.m. on the second Wednesday of each month in the Dreyfus Auditorium of the Research Triangle Institute in Research Triangle Park, North Carolina. A bimonthly newsletter is available on CompuServe (70156,404), and a public-domain library of application disks is planned. Annual dues are $10. Send a self-addressed, stamped envelope for a sample newsletter to Rich Slatta, Triangle dBASE Users Group, 2618 Davis St., Raleigh, NC 27608, (919) 782-8926.

● NEWSLETTER WITH FOCUS—Users of Lotus 1-2-3 and Symphony can focus on applications with *Learn Mode*, a monthly newsletter from Systems Consulting. Among its features are book reviews, solutions to problems, questions and answers, and updates on Lotus products. Article contributions are welcome. *Learn Mode* is $30 for 12 issues. Request a complimentary copy of the first issue from Systems Consulting, POB 982, Palo Alto, CA 94302, (415) 326-8605.

● FRIENDLY USERS Business computer users in the Chicago metropolitan area form the Tandy Business Users Group, which meets on the third Wednesday of each month. The monthly newsletter, *T-BUG*, contains a schedule of coming events, workshops, and forums, profiles, meeting notes, news releases, and product announcements. An-

(continued)

CLUBS & NEWSLETTERS *is a forum for letting BYTE readers know what is happening in the microcomputing community. Emphasis is given to electronic bulletin-board services, club-sponsored classes, community-help projects, field trips, and other activities outside of routine meetings. Of course, we will continue to list new clubs, their addresses and contact persons, and other information of interest. To list events on schedule, we must receive your information at least four months in advance. Send information to BYTE, Clubs & Newsletters*, POB 372, *Hancock*, NH 03449.

nual dues are $35 and include a one-year subscription to the newletter. For an application and further details, write Carlos Hidalgo, *T-BUG*, 311 Longview Rd., Waukegan, IL 60087, (312) 623-9661.

● EXCHANGE ATARI NEWS
The Atari Computer Club of the Palm Beaches produces a monthly newsletter, *The Pokey Press*, that features club news, pen pals, participating businesses, news from shows, and software and product reviews, and welcomes the exchange of newsletters with other Atari groups. Contact Jim Woodward, Atari Computer Club of the Palm Beaches, Apt. B-101, 15993 Southwest 8th Ave., Delray Beach, FL 33444.

● SPECIALIZED NEWS FOR ACADEME—Theories in the field of word processing are addressed in *Research in Word Processing Newsletter*, a nine-month publication from the Liberal Arts Department of the South Dakota School of Mines and Technology. It functions as a clearinghouse of information relevant to computer-based writing instruction at all educational levels and contains original research, article abstracts, bibliographies, and software evaluations. Article submissions are welcome. Contact The Editors, *Research in Word Processing Newsletter*, Liberal Arts Department, South Dakota School of Mines and Technology, Rapid City, SD 57701-3995.

● FOR NEW VENTURES
A monthly newsletter, *Compu-Venture*, contains software reviews and information on how to make money using your microcomputer. Subscriptions are $20 a year. Contact Microcomputer Software & Consultants, POB 1039, Mount Vernon, NY 10550.

● MORE FOR ENCORE
Encore 100 and 200, two software-based portable network analyzers that are designed for data-communications monitoring, diagnostics, and emulations, now have a users group sponsored by its manufacturer, Digitech Industries. A newsletter, *Encore Communicator*, serves to solve user problems or print user programs. Application engineers answer hardware and software questions and supply needed information. To receive a business-reply registration form, contact Joseph Luciano, Digitech Industries Inc., 66 Grove St., POB 547, Ridgefield, CT 06877, (203) 438-3731.

● COMMODORE IN SILVER
The Silver State Commodore Users Group of Las Vegas, Nevada, meets at 7:30 p.m. Wednesday nights at the local YMCA. The $4 per month dues entitle members to vote and to copy any of 35 public-domain programs. Though most members use Commodores, the group is not limited to a particular computer. The club offers ongoing classes in BASIC, program demonstrations, and assistance. Contact Karen Douglas, Silver State Commodore Users Group, POB 81075, Las Vegas, NV 89180.

● FOR THE FORTUNE
Users of the multiuser Fortune 32:16 can join /u/fortune, a group that meets in Cambridge, Massachusetts, on the first Thursday of each month. Meetings include presentations of new software, small group discussions, and user support. A monthly newsletter is produced. For complete information, contact Josh Lobel or Mark Palmerino, /u/fortune, Suite 28, 20A Prescott St., Cambridge, MA 02138, (617) 876-4763. ■

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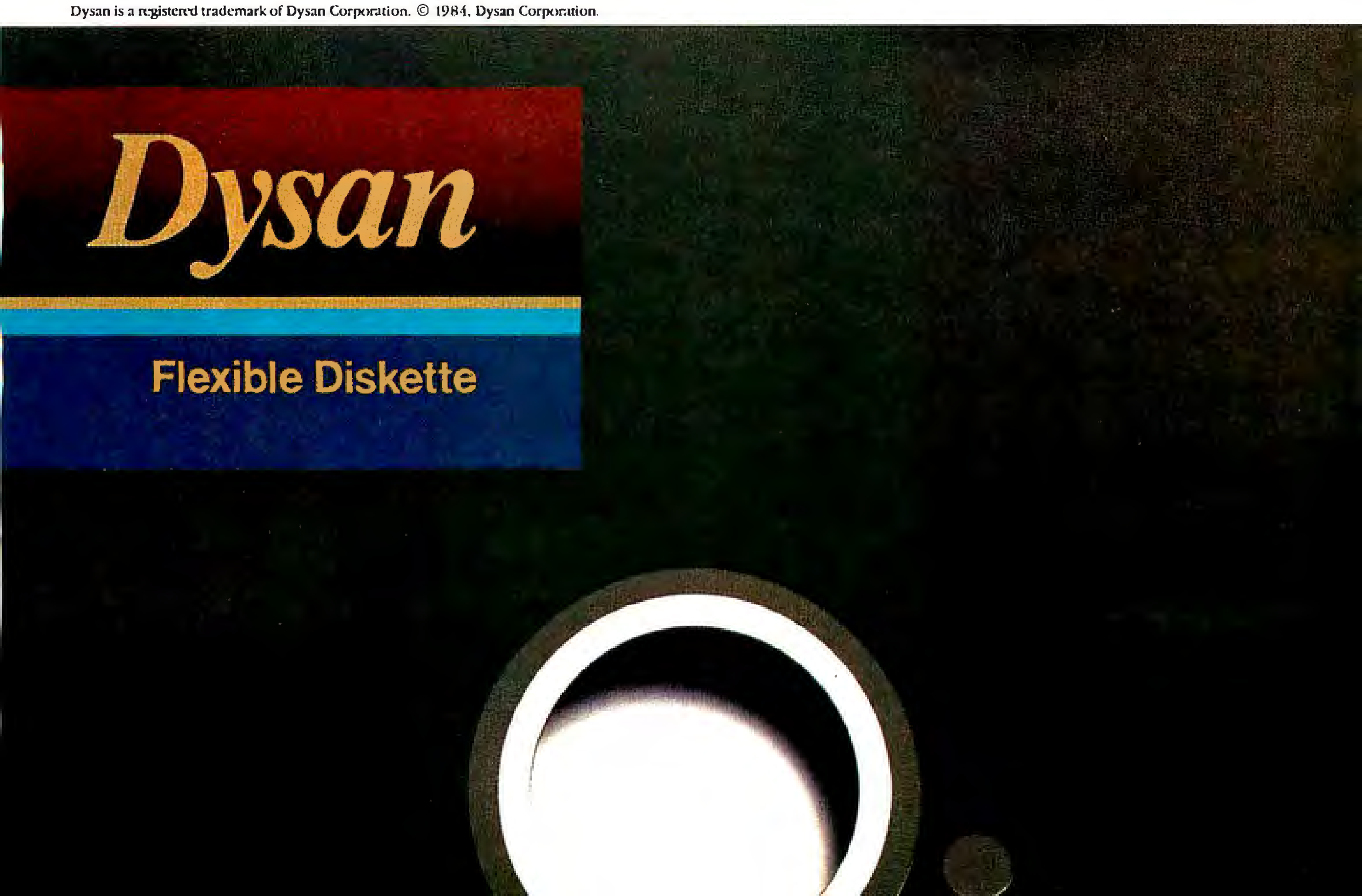
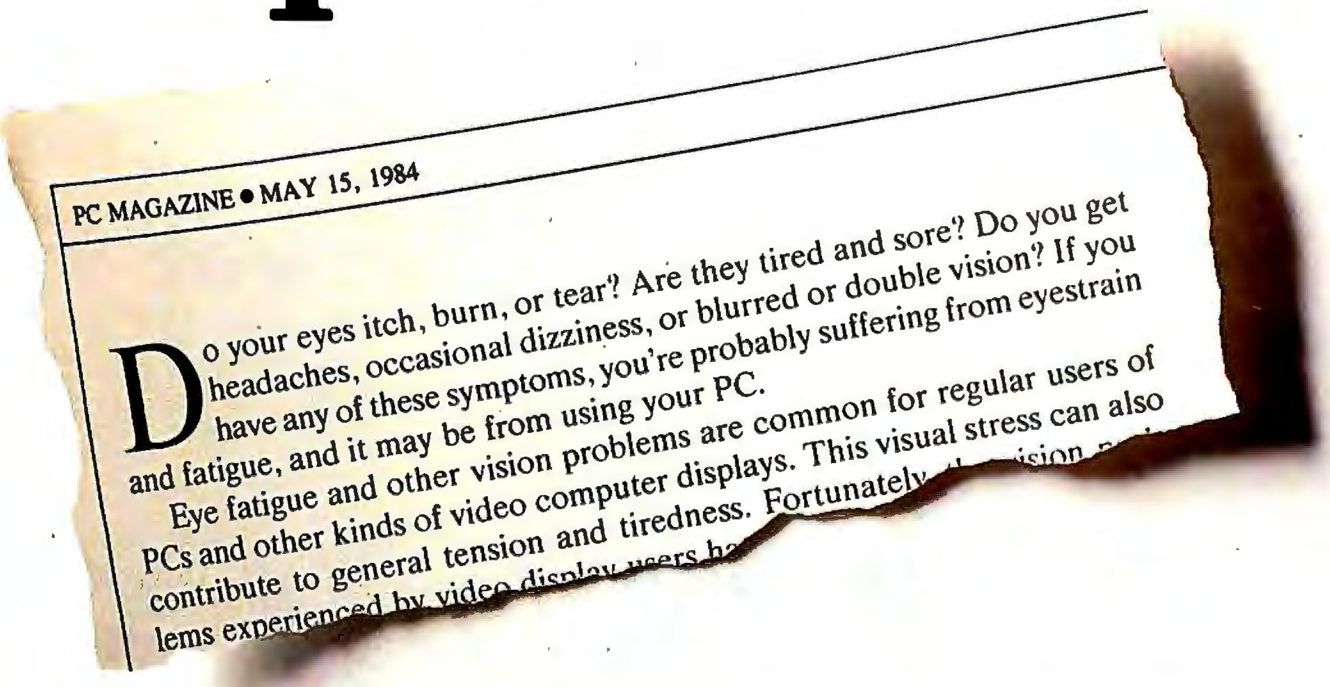


Sooner or later, you'll have to face this computer problem.



PC MAGAZINE • MAY 15, 1984

Do your eyes itch, burn, or tear? Are they tired and sore? Do you get headaches, occasional dizziness, or blurred or double vision? If you have any of these symptoms, you're probably suffering from eyestrain and fatigue, and it may be from using your PC.

Eye fatigue and other vision problems are common for regular users of PCs and other kinds of video computer displays. This visual stress can also contribute to general tension and tiredness. Fortunately

Better sooner.

Better Sooner.

Computers don't ever get headaches.

But the people who use computers do.

Quite clearly, as PC Magazine spells out, that's not the only trouble they're having.

In case you're tempted to dismiss this as trivial, there are two things you should be aware of:

First, more than twenty states are already preparing legislation to force some improvements.

Second, if computer users suffer, so does business.

Because computers are only as fast and accurate as the people who operate them.

You are not a machine.

Computers are designed by engineers.

They usually know a lot about technology but very little about people.

Which is why so many computers are technically impressive but strangely unnatural to use.

Computer-induced problems (%)	
Eye strain	55%
Back pain	43%
Headaches	30%
Shoulder	25%
Hand/wrist	18%
Neck pain	15%

(Source: "Ergonomic Principles in Office Automation" Pub. 1983 by E.I.S. AB, Sweden.)

Ericsson, in its very Swedish way, has always believed that excellent ergonomic design isn't a privilege.

It's a right.

That it isn't a noble gesture but demonstrably good for business.

It's an attitude that has made Ericsson No. 1 in Europe twice over:

First, as the giant of European telecommunications.

Then again as Europe's biggest workstation company by far.

(You couldn't ask for a better marriage of technology for the future.)

Here is one example of how they got there.

It's the first of a whole range of computers to be introduced in the U.S.A.

The Ericsson PC. It's Ergo-Intelligent.™

Ericsson has spent $300 million finding ways to make people and computers work better together.

Here are some of the results.

Ergo-Screen.™

Aspirin gets rid of a headache. Ergonomics gets rid of the cause.

The Ericsson PC monitor has a non-glare screen.

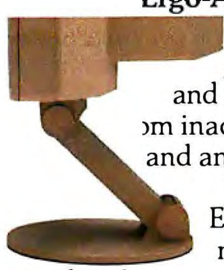
With restful amber characters on a specially developed, low-fatigue background color.

Even the shape of the actual characters was specially developed to allow easier recognition of difficult to distinguish letters like O and Q.

On the monochrome monitor, the resolution is double that of IBM's, so clarity is remarkable.

You can even have characters and graphics on the same screen.

Ergo-Arm.™



Thousands of people get neck and muscle pain from inadequate height and angle adjustment.

The Ericsson Ergo-Arm lets you move your screen exactly where you want it.

Better than back pain, wouldn't you agree?

Ergo-Touch.™

The keys are full-size and the layout is ergonomically planned for greater accuracy and speed.

Yet the keyboard is 20% more compact and less than half the weight of IBM's.

Even the cord is adjustable to suit left- or right-handers.

Ergo-Color.™

Even the color of the case is ergonomically selected to be restful to the eye over many hours.

Ergo-Space.™

The system unit is one-third smaller than IBM's.

It even fits under your desk in a vertical rack.

So your desktop is your own again.

IBM Compatible.

Many companies claim to be compatible.

Some are. Some are stretching the truth.

The Ericsson PC boasts the highest compatibility rating there is.

It's operationally compatible.

You can take advantage of thousands of PC-compatible programs already available.

In fact, with the best-selling software, the program and data disks are interchangeable with those of the IBM PC.

Service. Not Excuses.

Ericsson wouldn't give you anything less than on-site or carry-in service. The choice is yours.

3 Free Offers.

Ericsson will send you revealing literature on ergonomics.

Also a detailed brochure on the Ericsson PC.

And arrange a hands-on test if you ask for it.

Call toll-free 1-800-FOR-ERGO.

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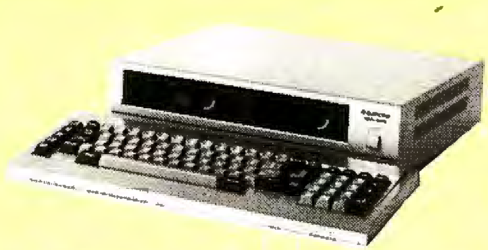

Sanyo 555-2's Now 51 Dollars Less

For months a competitor has been selling Sanyo 555-2's for a bit less than Scottsdale Systems no more. Of course, we still include more free software like (1) Sketch, (2) 15 Games, (3) Dotemote (4) Diagnostics and Utilities, (5) P.C. Filer, and (6) I.S. Manager. And now we have the best price for the 555-2, as well as the other models.

Plus if you mention this ad when you buy your Sanyo from Scottsdale you can buy an RS-232 port or an extra 128K of RAM at the same time for a mere $69.

To paraphrase Bogey if you don't buy your Sanyo from Scottsdale Systems you'll regret it: maybe not today maybe not tomorrow, but soon and for the rest of your life.

The Silver Fox™ Trots Through Lotus like 1,2,3

The Silver Fox has always run hundreds of programs originally written for the IBM-PC. Now with its new compatible video board and GW Basic it runs the most popular and powerful software in microcomputing, including Lotus 1 2.3, dBASE II, Multiplan the PFS series and even Flight Simulator. Yet you still get an incomparable combination of hardware and software at a price that invites comparison.

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Standard equipment also includes a better keyboard, and a 12" high-resolution, green monochrome monitor, with a full 25x80 column display. And although the Silver Fox doesn't have "compatible" expansion slots you can add serial ports, modems, plotters, printers, joysticks, and 8087 co-processor, and/or a hard disk.

Because the Silver Fox is born on a totally automated line in Japan it is simply more reliable than PC's that are assembled by hand. So we back each Silver Fox with a one year limited warranty four times the industry standard.

FREE SILVERWARE

Were this not enough, each Fox comes with the best free software bundle in the business including:

MS-DOS 2.11	Sketch	Spell
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If you're looking for maximum compatibility, minimum prices, nationwide service, you should consider buying a Columbia from Scottsdale Systems. Each system comes with MS-DOS 2.1, Basica 2.0, Perfect Writer, Calc, Speller, Filer, Fast Graphs, Home Accountant Plus, Space Commanders, ATI Tutorials, and T.I.M. IV data base manager. We have the best prices on all Columbias including the new 1600-1V Plus or VP Plus with 256K, keyboard, and video card for:

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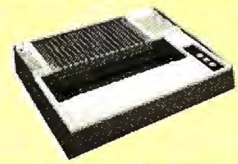

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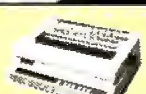

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PROGRAMMING
Günter Enderle, Klaus
Kansy, and Günther Pfaff
Springer-Verlag
New York: 1984
560 pages, $39

DATA STRUCTURES AND
PROGRAM DESIGN
Robert L. Kruse
Prentice-Hall
Englewood Cliffs, NJ: 1984
486 pages, $29.95

ALAN TURING:
THE ENIGMA
Reviewed by
G. Michael Vose

"And thus it was that . . . thinking in his spare time, an English homosexual atheist mathematician . . . conceived of the computer." This startling claim is at the heart of the first major biography of Alan Mathison Turing (1912-1954), a man whose legacies include the Turing machine and the Turing test. Andrew Hodges has uncovered the genius of this complicated man and recorded the evolution of his ideas within the unique context of the tumultuous times in which he lived. Hodges's fascinating study adds new information to the history of computer science, counters its all-American bias, and claims a rightful place for the eccentric Alan Turing.

Revising history is a risky endeavor. The task demands rigorous scholarship and the courage to successfully challenge the assumptions of the past. Hodges's *Alan Turing: The Enigma* brims with painstaking research and emphatic interpretation. No less an authority than the *New York Times* (December 4, 1983, section 7, page 80) has labeled this volume a work of major literary importance.

This praise derives from the wealth of ideas exposed and illuminated in the book, from lucid discussions of complex mathematics to revelations about the secret cryptography work accomplished by Turing and others during World War II. Through this work, the fortunes of war contributed significantly to the creation of the British computer.

In Bletchley Park, a London suburb, the cryptography group worked to decipher codes generated by the German army's Enigma machine. While Turing's inventiveness was instrumental in breaking these codes, his life was full of naive contradictions, similar in nature to the Nazis' refusal to believe that the codes of their cipher machine could ever be broken.

Hodges is sympathetic to the idea that the Allied victory in WWII hinged on the battle in the Atlantic in which Hitler's U-boats tried to isolate Britain by cutting off her sea supply routes to the West. Here, the breaking of the Enigma codes made the difference between victory and defeat because deciphering German naval messages helped transatlantic convoys avoid the U-boat wolfpacks. But it is Hodges's contention that Turing came up with the major formulations of modern computer science that makes this biography so significant.

Of course, the Universal machine (now known as the Turing machine) that Turing conceived in 1935 and described in a 1936 paper called "On Computable Numbers, with an Application to the Entscheidungsproblem" has rightful-

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ILLUSTRATED BY IVAN POWELL

ly taken its place as a seminal computer science idea. It was central to Turing's lifelong inquiry into the idea that machines could be intelligent. However, his later, little-publicized ideas about how computing machines might work form the bulk of the biographer's most interesting revisions to the historical record.

During his Enigma-deciphering work, Turing designed and helped construct a machine called the Bombe, an electromechanical device that calculated the permutations of the Enigma's enciphering rotors. It used relays as switches and was a specialized, high-speed calculating machine. Turing's work on the Bombe enabled others in the Bletchley Park group to develop the Colossus, the machine that some historians consider the first computer. The Colossus began service in December of 1943, but Turing played no part in its design or construction. In conceiving and building the Bombe, however, and later machines like the Delilah (a telephone-voice enciphering device), Turing began fermenting the ideas that he would later develop to construct a version of his Universal machine.

The distillation of these ideas appeared in "Proposed Electronic Calculator," a late-1945 report prepared in conjunction with his new responsibilities as senior scientific officer with the Mathematics Division of the National Physical Laboratory (NPL) in Bushy Park, Teddington. In this report, Turing laid out plans to construct a machine later named the ACE (automatic computing engine), a project in response to the American scientific community's efforts to build a digital computing machine. The plan outlined the construction of a true automatic electronic digital computer with *internal program storage*, a fully developed scheme broader in scope than those conceived by John von Neumann and others. But to Turing it was an old idea.

An Innovator

The stored-program concept was a natural one to Turing because it was essentially the same idea that he developed in connection with the "instructions on paper tape" idea that was central to his Universal machine. The ACE report described how the stored-program concept would apply to a computer. The report's discussion of how the machine's instruction tables would be created leads to Hodges's claim that Turing ". . . invented the art of computer programming." This art, in Turing's words, would find that "Instruction tables will have to be made up by mathematicians with computing experience and perhaps a certain puzzle-solving ability." Turing later wrote routines, in conjunction with J. H. Wilkinson (see the interview on page 177), to perform floating-point arithmetic that enabled programmers to multiply two numbers without knowing what was really happening inside the machine, thus presaging the development of high-level languages. His notes for the ACE report talk about "subsidiary" routines and about "burying" and "unburying" an area of memory containing information vital to a program returning from a subsidiary routine. (This is known today as "pushing" and "popping" the stack.) He even envisioned the use of remote terminals, claiming that "It would be quite possible to arrange to control a distant computer by means of a telephone line."

Although he left the NPL before the ACE machine was built because he was unable to deal with the politics of bureaucracy, Turing nonetheless walked through the front door of British computing. Taking up the post of Deputy Director, Royal Society Computing Laboratory at Manchester University, he arrived in time to witness the fruition of the other English attempt to build a computer. Driven by the efforts of M.H.A. Newman (a former professor of Turing's and the first reader of "Computable Numbers") and Cambridge mathematician M.V. Wilkes, the university assembled a team of wartime electronics engineers and Bletchley Park mathematicians to work on developing a computing machine. The major difference between the Manchester machine and Turing's ACE was the type of memory used. The ACE used acoustic delay lines made of thin tubes filled with mercury, capped on each end by piezoelectric crystals. A signal traveling between crystals through the mercury was "stored" for a microsecond. The Manchester machine used electrostatic tubes, primarily cathode-ray tubes that stored information as a charged phosphor, refreshed every millisecond, on the tube's screen.

Less encumbered by bureaucratic entanglements than the NPL, the university's computer, later called the Mark I, executed its first program on June 21, 1948. Turing became a programmer of the Mark I; for the rest of his life, which presumably ended by his own hand a scant six years later, he worked on research that interested him but led to no significant discoveries. But during this time he exchanged ideas with other Manchester faculty members, including Michael Polyani, whose disdain for the idea of intelligent machines gave rise to the debate that spurred Turing's creation of the test that later carried his name. The Turing test was put forth in an article called "Computing Machinery and Intelligence" in the October 1950 issue of *Mind*. Its now-famous central thesis was that if a machine's response to interrogation was indistinguishable from a human's, then the machine exhibited intelligent behavior.

Hodges's treatment of the intellectual accomplishments of Turing's life is a major contribution. The book is a fountainhead of stimulating thought—discussing Turing's ideas on the determinism/free-will dialectic, for example—and historical minutiae. Hodges reveals, for example, that Mark I program code was written in base 32 arithmetic notation, a modification of Baudot teleprinter conventions. Turing found it easy to think in this notation and confused his colleagues by writing base 32 numbers on the blackboard when explaining an idea. A slash (/) was the symbol that represented the number 0 in this notation and is the likely origin of today's convention of writing 0s with

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a slash through them (also a good way to differentiate 0 from the letter "O"). Turing was also fascinated throughout his life by the natural occurrences of flower petals, fir-cone florets, and sunflower seeds in a Fibonacci number sequence.

Aside from its contributions to the historical record, this book is a fascinating human story. Turing's disdain of social conventions, his lack of social graces, and his individuality brought him both pleasure and pain. Though not a psychological history, *Alan Turing: The Enigma* explores the human side of the man who gave life to some remarkable ideas. Equally important, the study remains aware of the role played by the circumstances of a man's life in the development of his thought. Turing's ideas could have taken a much different tack were it not for a world war and a German cipher machine.

The major unanswered question about Alan Turing is why he took his life. There was a homosexual scandal, resulting in a conviction for violation of sexual decency laws, and a subsequent agonizing year of drug treatment with female hormones. But his suicide came a full year after the end of the treatments and probation for his offense. Hodges closes his book with a 15-page discussion of government debates about excluding homosexuals from sensitive scientific and research posts for fear of their susceptibility to blackmail and coercion. But he never satisfactorily answers the question, Why suicide? Turing's mother never accepted this verdict, claiming that Alan's death was accidental. If Hodges explored the other possibilities, he doesn't reveal his findings.

Though minor, there is one flaw in this book: it is plagued with editing and typographical errors, no doubt a result of the complexity of the manuscript. Anyone interested in the idea of intelligent machines should have no problem overlooking these errors. The book is nevertheless a major work in the history of computer science. Well indexed and containing 28 pages of bibliographic notes, it is a valuable resource for information about the people who created the technology and the papers they wrote describing their ideas.

G. Michael Vose *is BYTE's senior technical editor for theme articles. He can be contacted at* POB 372, Hancock, NH 03449.

COMPUTER GRAPHICS
PROGRAMMING
Reviewed by Judith L. Maggiore

The Graphical Kernel System (GKS) is the international standard for computer-graphics software. *Computer Graphics Programming* is an important addition to the standard document defining GKS because it explains concepts, examples, and figures that could not be included in the standard document. Günter Enderle, Klaus Kansy, and Günther Pfaff are in a good position to write about that

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 Inquiry 152

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standard because they have been involved in its design and review for several years.

The history of computer graphics has been one of fragmentation and separation. The subject is broad, covering areas including computer-aided design (CAD), business graphics, mapping, video games, and more. Each area had its own preferred hardware for displaying pictures. CAD applications used vector-refresh devices, while business graphics used storage tubes and pen plotters. The introduction of raster devices led to even more diversity. Software was tailored to take advantage of the capabilities of a particular device. As well as being device-dependent, computer-graphics software was also application- and system-dependent. There was little relation between the software used to design circuits and the software used to draw histograms. This situation meant that graphics programs were useful only for the application, operating system, and device for which they were specifically designed.

As graphics devices became less expensive, more people discovered computer graphics. The advantages of being able to display data as pictures are obvious. Once the prohibitive cost was removed, computer-graphics users proliferated. These new users of computer graphics were not interested in designing whole new systems—they were interested in using computers to draw pictures.

At this point, the field was ripe for a standard. The development of this standard began in the mid 1970s, with many organizations participating. In the United States, standardization was initiated in 1974 by the Association for Computing Machinery's Graphics Standards Planning Committee, part of the special-interest group on computer graphics. This work was taken over by ANSI (American National Standards Institute) committee X3H3, one of the major contributors to the review of GKS. The work of all the committees in various countries was consolidated under the auspices of the International Standards Organization (ISO) and eventually led to the development of GKS. The authors estimate that there were 50 man-years of effort devoted to the development of the graphics standard.

Computer Graphics Programming has something for everyone. The novice to computer graphics will find the definitions of graphical terms and concepts very valuable. Experienced graphics users and experts will find the book the best help available for understanding GKS. Applications programmers who plan to use an implementation of GKS will probably use this text daily as a reference. Implementors of GKS will find the sections on device and language interfaces and implementation styles invaluable. Students and teachers on either the undergraduate or graduate level can use *Computer Graphics Programming* as a text or reference for a course in computer graphics.

WELL ORGANIZED

The authors have organized this book very well. Section I contains an overview of the standard's general concepts

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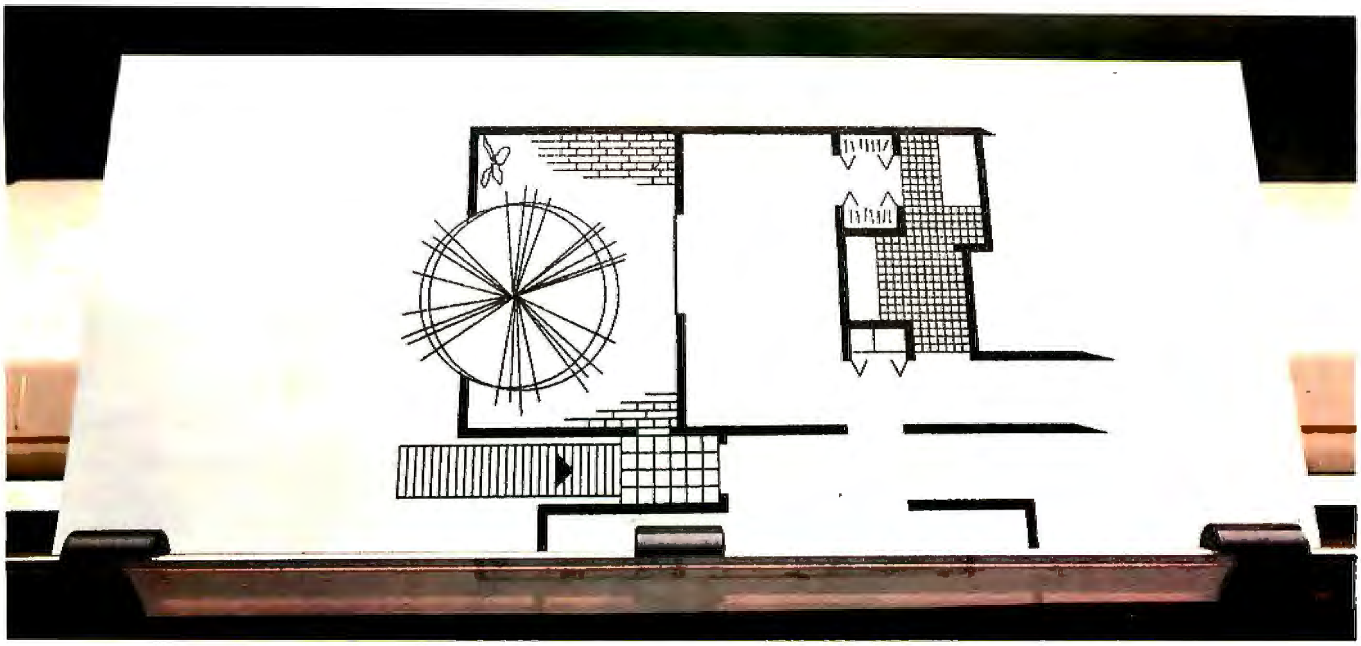

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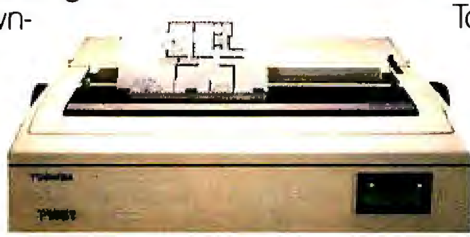

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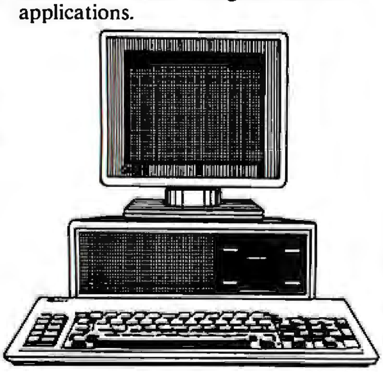

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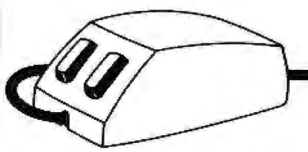

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and vocabulary. The precise and clear definitions of graphical terms and concepts presented in this section should go a long way toward clarifying the vocabulary we need to talk about computer graphics. These basic terms and concepts form the basis of the more formal description of GKS found later in the book. Included in this section are chapters on the principles and goals used in the design of GKS and the interfaces to GKS. Since GKS is designed to be device- and system-independent, it must be interfaced on one side to a specific language and on the other to the graphical hardware. Chapter 6 is especially useful because here the authors provide concise definitions of all the main ideas used in GKS. These definitions are followed by chapters that supply additional detail and amplification about each concept.

The second section describes the process of the development of the GKS standard. The authors sketch briefly the history of computer graphics and the events that led up to the final GKS document. The most interesting part of this section is chapter 3, which presents some of the issues the developers of GKS had to resolve. Arguments pro and con on each issue and the ultimate decision of the committee are discussed.

Section III, the largest part of the book, is a detailed description of the functional capabilities of GKS. Enderle, Kansy, and Pfaff explain all the functions and data structures relevant to GKS.

The definitions of the functions are presented in two parts. First is the language-independent version, taken directly from the GKS standard document. Next is the FORTRAN definition. Following the function definitions are examples of programs or program fragments using GKS. The examples are presented in both Pascal and FORTRAN and very clearly show typical uses of GKS by applications programmers. The book also includes some exercises intended to help students and teachers.

Section IV will be most useful to the implementors of GKS, those people who will write the subroutine package that makes GKS available to applications programmers. This section covers methods of implementation, implementation styles, interfaces to devices, and interfaces to specific languages. A mapping of the abstract data structures of GKS to FORTRAN data structures is included. Other topics in this section are graphics metafiles, validation of GKS implementations, and three-dimensional extensions to GKS.

EVALUATION

This book clarifies an area that is often confusing and obscure. Terms and concepts are excellently presented. Anyone seriously involved in the use of GKS will find this book invaluable.

More pictures and illustrations should have been included. A book on computer graphics needs lots of pictures. The second problem is minor. The use of the English language seems awkward at times.

(continued)

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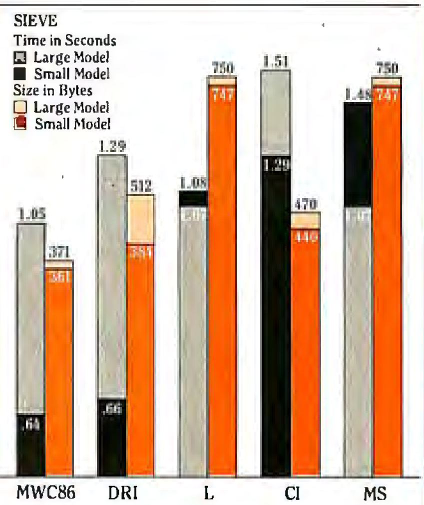

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It's too early to tell what effect GKS will have on the computer-graphics industry. It will be interesting to see how GKS stands up in light of recent developments. Whatever the future of GKS, it is a very important development now, and *Computer Graphics Programming* is indispensable to anyone wishing to understand and use GKS.

Judith L. Maggiore programmed graphics for three years prior to teaching computer science classes and computer-graphics seminars at Keene State College (Mathematics Dept., Keene, NH 03431).

DATA STRUCTURES AND PROGRAM DESIGN
Reviewed by Edward Brent

The boundary between writing programs that merely get by and designing programs that perform complex tasks efficiently is one that many programmers never cross. Yet it is a boundary that is fundamental to the development of programming as a discipline. People who program by the seat of their pants and hold their programs together with the electronic equivalent of spit and baling wire must give way to trained programmers who develop finely crafted, efficient, and maintainable programming solutions to difficult problems. The selection and design of appropriate data structures and algorithms is a crucial element of professional-quality programming. The central role of data structures in professional programming is insightfully examined by Robert L. Kruse in *Data Structures and Program Design.*

AUDIENCE

In the preface Kruse indicates this book includes all the topics of specific courses recommended and offered by ACM (Association for Computing Machinery) Curriculum '78. The prerequisite for the book is a first course in programming, or equivalent experience, and elementary experience with Pascal.

I find the book suitable for a second course in computer programming. However, it could also be of value to programmers not enrolled in a computer science course but interested in upgrading their programming skills.

But the issues of selecting appropriate data structures should not be relegated to a second course on computing. Because the selection of data structures is such an important aspect of quality programming, it should not be left for more advanced books.

Kruse consistently highlights the distinction between abstract structures and their implementations. He begins by addressing the programming principles of top-down refinement, program design, and review and testing; he illustrates these principles with extended examples.

In chapters 2 and 5, Kruse discusses the more important structures: stacks, queues, and other lists in both contiguous and linked representations and binary trees. He

(continued)

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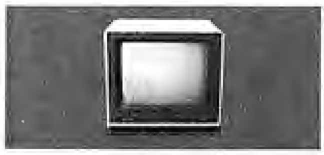

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BOOK REVIEWS

covers more advanced applications of trees, including AVL (Adelson-Velskii and Landis) trees, contiguous representation of binary trees, lexicographic search trees, and external searching. There is no discussion of graphs.

Kruse examines algorithms for searching, looking up tables, accessing hash tables, and sorting. He presents an in-depth study of recursion. The author works out large, complex programs in detail, and he develops programs to index text and to evaluate mathematical expressions.

In the appendixes, Kruse discusses techniques from combinatorial mathematics for assessing algorithms analytically. He also covers methods for manually removing recursion and presents standard syntax diagrams and tables for Pascal.

Pascal and Clear Examples

Kruse illustrates principles using Pascal programs that have been tested on several compilers. I endorse this strategy; others have used pseudolanguages. For people using Pascal, the book is eminently useful and educational. You can enter the programs and try your own modifications.

The book contains many in-depth examples of applications of data structures to programming problems. Realistic examples include Conway's game of Life, a text-indexing program, and a program that evaluates mathematic expressions.

I lost count of the number of times I came across valuable nuggets of information or explanations that clarified concepts I had read about in other books but failed to understand. Where other authors simply use pointers, Kruse discusses how pointers can be created even in languages in which they are not implemented.

It is apparent that much of Kruse's time preparing this text was spent trying it out on students, polishing the prose, and clarifying important points. This book stands head and shoulders above others in making difficult concepts understandable.

Unfortunately, while Kruse covers most of the fundamental data structures I expected, he does not include a chapter on graphs. Graphs are an important data structure different enough from other data structures so as to require individual consideration. They have significant practical applications for scheduling programs, flow programs, and trip planning.

Data Structures and Program Design excellently covers data structures and algorithms for operating on them. Kruse is readable, covers topics in great depth, and does so without losing the reader. I recommend the book for a second course in any formal computer curriculum or as a resource and reference book for programmers who seek to improve their programming skills on their own. ■

Edward Brent, an associate professor of sociology and family and community medicine (108 Sociology, University of Missouri, Columbia, MO 65211), has recently completed a post-doctorate fellowship in which he studied the role of data structures in artificial-intelligence programming.

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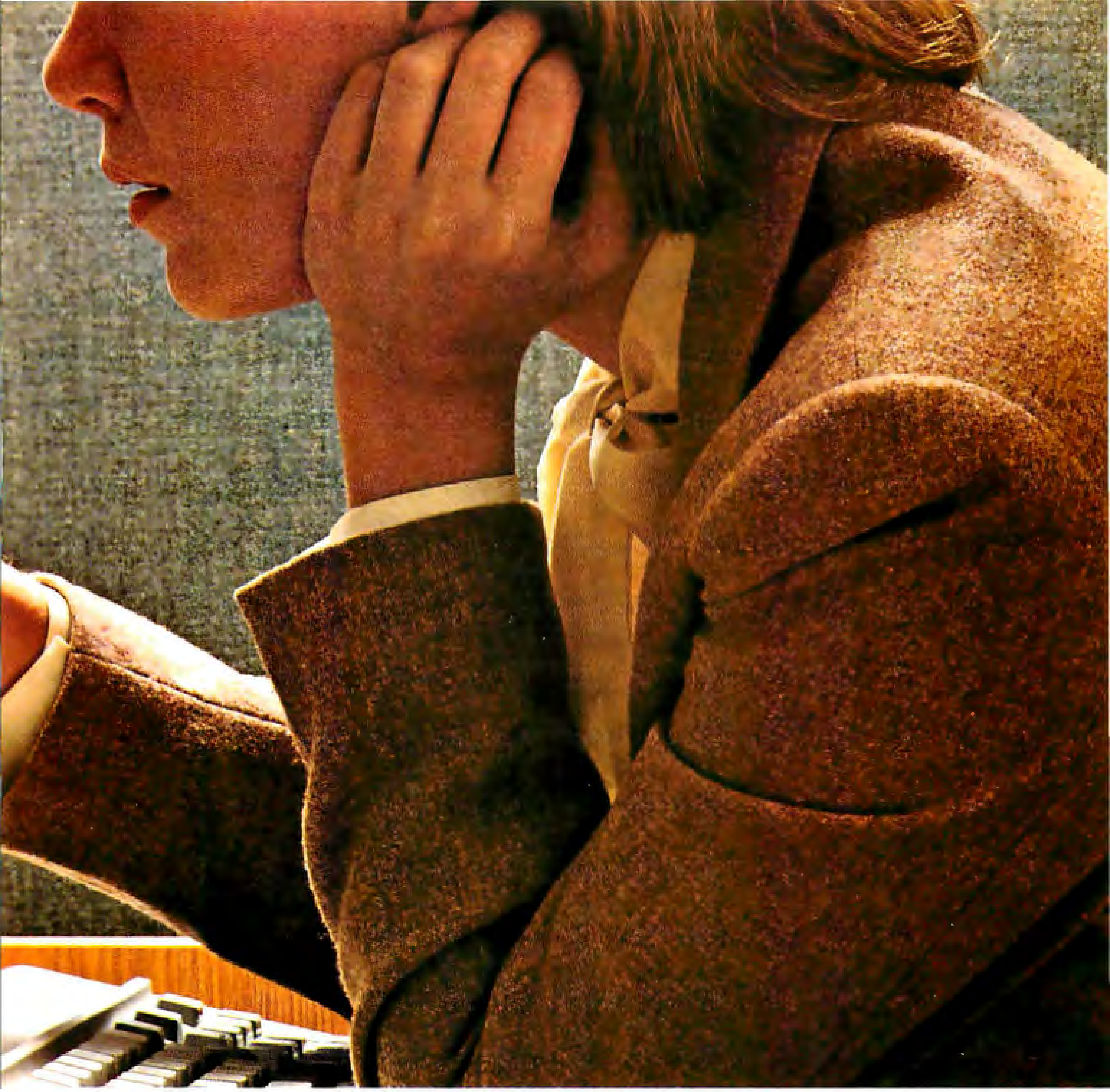

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GRAPHWRITER COMBO	$389
MS CHART	$159
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PC PAINTBRUSH	$ 89
PFS: GRAPH	$ 95
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STATPAK-NWA	$329
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STAR ACCOUNTING PARTNER	$249
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Hardware *

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AST MONOGRAPH PLUS	$Call
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February 1985

● AI, EXPERT SYSTEM BRIEFING—Artificial Intelligence and Expert Systems: What Business Must Know Today to Reap the Benefits Tomorrow, Marriott Copley Place, Boston, MA. A one-day executive briefing. The fee is $790. Contact Lee Burgess, Professional Development Programs, Rensselaer Polytechnic Institute, Troy Building, New York, NY 12180-3590, (518) 266-6589. *February* 11

● SOFTWARE MANAGEMENT CONTROL—Configuration Management of Software Programs, San Diego, CA. Intended to show those working in software management how to control development, maintenance, and operational costs. The cost is $730. Contact Stod Cortelyou, Continuing Engineering Education, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-8520. *February* 11–13

● NETWORK COMPONENTS EXPLAINED—Data Communications Network Components, Atlanta, GA. A thorough overview of the use, operation, applications, and acquisition procedures of 25 major communications components. The fee is $795. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *February* 12–14

● INTERACTIVE INSTRUCTION—The Third Conference on Interactive Instruction Delivery, Sheraton Towers Hotel, Orlando, FL. Contact the Society for Applied Learning Technology, 50 Culpeper St., Warrenton, VA 22186, (703) 347-0055. *February* 13–15

● COMPUTERS FILL EDUCATORS' TALL ORDER The Fifth Annual Conference of the Texas Computer Education Association, Hyatt Regency Hotel, Austin, TX. The theme is "New Directions for Education Using Modern Day Technology." Contact TCEA Conference, POB 2573, Austin, TX 78768. *February* 13–16

● PC SYMPOSIUM The 1984 UNM Personal Computer Symposium, University of New Mexico, Albuquerque. Exhibits, seminars, and demonstrations of personal computer systems for business, education, and professional offices. Contact the Tau Beta Pi Honor Society, c/o Dr. Randy Truman, Department of Mechanical Engineering, University of New Mexico, Albuquerque, NM 87131, (505) 277-6296. *February* 15–16

● COCO CONVOCATION RainbowFest, Irvine Marriott, Irvine, CA. A show for users of the Radio Shack TRS-80 Color Computer. More than 50 exhibitors are expected. Contact Falsoft Inc., POB 385, Prospect, KY 40059, (502) 228-4492. *February* 15–17

● MICROS FOR EDUCATORS—Association of Teacher Educators National Conference, Riviera Convention and Resort Hotel, Las Vegas, NV. Exhibits and demonstrations of microcomputers, microcomputer products, and communications equipment will be featured. Contact Peter C. West, Learning Center, College of Education, Gabel Hall 8, Northern Illinois University, DeKalb, IL 60115, (815) 753-1241. *February* 18–19

● MANAGE YOUR COMPUTER—Managing Computer Resources, Wintergreen Learning Institute, Wintergreen, VA. Focuses on networking, system design, performance evaluation, and operational difficulties encountered by managers and executives. Rates vary from $570 to $769, depending on accommodations. Contact Dr. M. D. Corcoran, Wintergreen Learning Institute, POB 7, Wintergreen, VA 22958, (800) 325-2200; in Virginia, (804) 325-1107. *February* 18–22

● COMMUNICATIONS FOR EXECS—Info/Central, O'Hare Exposition Center, Chicago, IL. A computer and communications show and conference for executives and data-processing managers. Topics: mainframes, microcomputers, telecommunications systems, and micrographics. Contact the Show Manager, Info/Central, 999 Summer St., Stamford, CT 06905, (203) 964-8287. *February* 20–22

● MODULA-2 ENGINEERING—Software Engineering with Modula-2, Atlanta, GA. A course emphasizing methods for building large-scale software systems in Modula-2. Prerequisite: knowledge of Ada or Pascal. The fee is $495. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *February* 20–22

● BUSINESS GRAPHICS Computer Business Graphics, Bonaventure Intercontinental Hotel, Fort Lauderdale, FL. Contact Carol Every, Frost & Sullivan Inc., 106 Fulton St., New York, NY 10038, (212) 233-1080. *February* 20–23

● MAC IN SPOTLIGHT MacWorld Exposition, Brooks Hall, San Francisco, CA. A hands-on festival of Macintosh hardware, software, and peripherals. Contact World Expositions, Mitch Hall Associates, POB 860, Westwood, MA 02090, (617) 329-7466. *February* 21–23

● COMPUTER FAIRE The Fourth Annual IEEE Computer Faire, Huntsville, AL. Sponsored by the Institute of Electrical and Electronics Engineers. Contact Terry Mizell, POB 5188, Huntsville, AL 35805, (205) 532-2036. *February* 22–23

● COMPUTERS IN MEXICO The First International Computer and Communications Exposition and Conference: MexCom '85, Mexico City,

(continued)

IF YOU WANT *your organization's public activities listed in BYTE's Event Queue, we need to know about them at least four months in advance. Send information about computer conferences, seminars, workshops, and courses to BYTE, Event Queue,* POB 372, *Hancock,* NH 03449.

EVENT QUEUE

Mexico. This show features mini- and microcomputers, software, office automation equipment, and communications exhibits. Contact Mex-Com, Suite 219, 3421 M St. NW, Washington, DC 20007, (703) 685-0600. *February* 25–28

● FARM AUTOMATION
Agri-Mation, Palmer House Hotel, Chicago, IL. This conference and exposition will focus on the role of automation in agriculture. Contact the Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-1500. *February* 25–28

● DYNAMIC COMPUTING
Dynamics on Microcomputers, University of Michigan, Dearborn. A course and workshop for engineers. Contact Professor R. E. Little, University of Michigan, 4901 Evergreen Rd., Dearborn, MI 48128, (313) 593-5241. *February* 25–*March* 1

● HIGH-TECH IN FOCUS
High-Tech '85 Exhibit and Seminar, Thunderbird Motel, Bloomington, MN. More than 100 manufacturers will exhibit terminals, peripherals, data-communications equipment, and digital test instruments. Admission is free. Contact John Bastys or Barb Mueller, Countryman Associates Co., 1821 University Ave., St. Paul, MN 55104, (612) 645-9151. *February* 26–27

● MICRO-AIDED MANAGEMENT—Microcomputer-aided Maintenance Management System, Ramada Inn, Airport, Milwaukee, WI. This course shows how computers can help improve the maintenance functions of any organization. The fee is $60. Contact Unik Associates, 12545 West Burleigh, Brookfield, WI 53005, (414) 782-5030. *February* 27

March 1985

● DISCOVER UNIX
Discover UNIX, various sites throughout the U.S. A two-day seminar exploring such topics as the UNIX file system, shell interpreter, text editors, programming languages, and system tools. The fee is $595. Contact Data-Tech Institute, 57 Lakeview Plaza, POB 2429, Clifton, NJ 07015, (201) 478-5400. *March*

● COMPUTERS FOR SALE
Computer Supermarket, San Mateo County Fairgrounds, San Mateo, CA. A gathering of retailers, manufacturers, distributors, and potential consumers of a wide variety of computer-related products. Contact Microshows, Suite 203, 1209 Donnelly Ave., Burlingame, CA 94010, (415) 340-9113. *March* 2–3

● FOSE SOFTWARE SHOW
Federal Office Systems Exposition (FOSE) Software '85, Convention Center, Washington, DC. Workshops, symposia, and exhibits of software. Contact Rosalind Boesch, National Trade Productions Inc., Suite 400, 2111 Eisenhower Ave., Alexandria, VA 22314, (800) 638-8510; in Virginia, (703) 683-8500. *March* 4–7

● MINI/MICRO
Mini/Micro Southeast-85, Georgia World Congress Center, Atlanta. A conference and exposition. Contact Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965. *March* 5–7

● DESIGN SHOW
The 1985 National Design Engineering Show, McCormick Place, Chicago, IL. More than 600 CAD/CAM system and electronic component companies will exhibit. Contact the Show Manager, National Design

Engineering Show, 999 Summer St., Stamford, CT 06905, (203) 964-0000. *March* 11–14

● DATACOMM FROM ALL ANGLES—Data Communications: Technology, Techniques, and Applications, Tarrytown Hilton, Tarrytown, NY. This seminar covers existing and emerging technologies, data compression techniques and applications, multiplexers, protocol conversion, data security, and local-area networks. The fee is $150. Contact Glasgal Communications Inc., 207 Washington St., Northvale, NJ 07647, (201) 768-8082. *March* 12

● ACM COMPUTER CONFERENCE—The Thirteenth Annual ACM Computer Science Conference: CSC '85, New Orleans Marriott, LA. An employment register, social events, technical programs, award presentations, and exhibits are highlights of this show. Contact Della T. Bonnette, Conference Chair, Computing and Information Services, University of Southwestern Louisiana, Lafayette, LA 70504, (318) 231-6306. *March* 12–14

● EDUCATIONAL CONFERENCE—The 1985 Microcomputers in Education Conference, Arizona State University, Tempe. The theme for this conference is "Tomorrow's Technology." Emphasis will be placed on integrating computer technology and languages into the educational environment. Exhibits will be featured. Contact Donna Craighead, Payne B47, Arizona State University, College of Education, Tempe, AZ 85287, (602) 965-7363. *March* 13–15

● SIMULATION IN SUNSHINE—The Eighteenth Annual Simulation Symposium, Tampa, FL. A forum for the interchange of ideas, techniques, and applications among those working in simulation. Contact Alexander Kran, IBM Corp., East Fishkill Facility, Hopewell Junction, NY 12533. *March* 13–15

● INTERFACING WORKSHOP—Personal Computer and STD Computer Interfacing for Scientific Instrument Automation, Virginia Tech, Blacksburg. A hands-on workshop with participants wiring and testing interfaces. The fee is $450. Contact Dr. Linda Leffel, C.E.C., Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 961-4848. *March* 14–16

● SHOW IN DELAWARE The Seventh Annual Delaware Computer Faire, Delaware State College, Dover. Current technology for use in the classroom, office, and home will be displayed. Workshops, demonstrations, and sessions on the use of computers in the classroom are planned. Contact Dr. William J. Geppert, State Supervisor, Mathematics, Department of Public Instruction, Townsend Building, POB 1402, Dover, DE 19903, (302) 736-4885. *March* 16

● CLASSROOM COMPUTING TECHNIQUES Instructional Strategies for Integrating the Microcomputer into the Classroom, University of Wisconsin, Madison. A special emphasis is placed on strategies that have already proved successful. Hands-on sessions will be offered. Contact Dr. Judith Rodenstein or Dr. Roger Lambert, University of Wisconsin, 964 Educational Sciences Building, 1025 West Johnson St., Madison, WI 53706, (608) 263-4367 or 263-2704. *March* 18–19

(continued)

EVENT QUEUE

● EXPOSING THE MYTH OF MICROS—Public Awareness Seminars, Hyatt Regency, Los Angeles, CA. A seminar that shows nontechnical businesspeople how a microcomputer could be used to increase productivity. Contact International Microcomputer Industries Association, Suite 175, 21 Tamal Vista Blvd., Corte Madera, CA 94925, (415) 924-1194. *March* 18–19

● COMPUTERS AND TELECOMMUNICATIONS COMTEL '85: International Computer and Telecommunications Conference, Infomart, Dallas, TX. Contact COMTEL '85, Suite 600, 13740 Midway Rd., Dallas, TX 75244, (214) 458-7011. *March* 18–20

● TECHNOLOGY AND EDUCATION—The First Annual Conference on Technologies in Education, University of Arizona, Tucson. This conference will focus on the effective implementation of research in educational technology. Contact Steve Louie, NACCIS, Suite 125, 2200 East River Rd., Tucson, AZ 85718, (602) 323-6144. *March* 18–20

● ROBOTICS TECHNOLOGY UPDATE—The Second Annual Robotic End Effectors: Design and Applications Seminar, Holiday Inn Livonia-West, Livonia, MI. More than 25 companies will exhibit. Contact John McEachran, Special Programs Department, Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-1500, ext. 382. *March* 19–20

● AI FOR ROBOTS Aircon 2: The Second Annual International Conference on Artificial Intelligence for Robots, Stouffers Concourse in Crystal City, Arlington, VA. A conference designed to promote a dialogue between experts and users of artificial-intelligence systems. The theme is "Toward Intelligent Robots: The Droids Are Coming." Contact Cindy Mega, IIT Research Institute, 10 West 35th St., Chicago, IL 60616, (312) 567-4024. *March* 21–22

● EDUCATION AND COMPUTING—Educational Computing Today, Westin Hotel, Renaissance Center, Detroit, MI. Kindergarten, elementary, high school, and college educators will share educational computing experiences. Contact Michigan Association for Computer Users in Learning, MACUL/ICCE Conference, POB 628, Westland, MI 48185, (313) 595-2493. *March* 21–22

● ELEMENTARY COMPUTING—University of Delaware Second National Conference: Computers and Young Children, University of Delaware, Newark. The emphasis is on programs for children 4 to 8 years of age. Contact Dr. Richard B. Fischer, Division of Continuing Education, University of Delaware, Newark, DE 19716, (302) 451-8838. *March* 21–22

● WINTER COMDEX COMDEX/Winter, Convention Center, Anaheim, CA. One of the largest shows in the microcomputer industry. Contact The Interface Group, 300 First Ave., Needham, MA 02194, (800) 325-3330; in Massachusetts, (617) 449-6660. *March* 21–24

● DATABASE SYMPOSIUM The Fourth Annual ACM SIGACT/SIGMOD Symposium on Principles of Database Systems, Portland, OR. This conference covers developments in the theoretical and practical aspects of database

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systems. Contact David Maier, Department of Computer Science, Oregon Grad Center, 19600 Northwest Walker Rd. Beaverton, OR 97006. *March* 25–27

● OPTICAL STORAGE TECHNIQUES—The Third Annual Conference on Optical Storage of Documents and Images, Shoreham Hotel, Washington, DC. Contact Technology Opportunity Conference, POB 14817, San Francisco, CA 94114-0817, (415) 626-1133. *March* 25–27

● CAI INVESTIGATED
The Twenty-Sixth International Conference of the Association for the Development of Computer-based Instructional Systems, Philadelphia, PA. Presentations and panel discussions will explore the research and use of computers for direct instruction. Interest groups for educators. Contact ADCIS International Headquarters, Miller Hall 409, Western Washington University, Bellingham, WA 98225. *March* 25–28

● INTEGRATION, COMMUNICATIONS, COMPUTERS
IEEE INFOCOM '85, Washington, DC. Papers will address such issues as architecture, protocols, gateways, and support. Contact Tom Stack, IEEE INFOCOM '85, POB 639, Silver Spring, MD 20901, (301) 589-8142. *March* 25–28

● MACHINE VISION EYED
The Applied Machine Vision Conference and Vision '85 Exposition, Cobo Hall, Detroit, MI. Contact Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0777. *March* 25–28

● JOINT CONFERENCE IN MINNESOTA—Updata '85: The Seventh Annual Minnesota Joint Computer Conference, Radisson South Hotel, Bloomington, MN. A conference for data-processing professionals. The theme is "Meeting Tomorrow's Challenge Today!" Contact Mick Williams, Standard Iron, 4990 North County Rd. 18, New Hope, MN 55428, (612) 533-1110. *March* 28–29

● WESTERN EDUCATORS MEET—Western Educational Computing Workshops, University of California, Santa Cruz. A series of workshops and demonstrations that give educators hands-on experience with computer application packages and computer hardware. Contact Hal Roach, Computer Services, Mount San Antonio College, 1100 North Grand Ave., Walnut, CA 94542. *March* 28–29

● WEST COAST FAIRE
The Tenth Annual West Coast Computer Faire, Moscone Center, San Francisco, CA. This is one of the largest computer shows. Contact Computer Faire Inc., Suite 201, 181 Wells Ave., Newton Falls, MA 02159, (800) 826-2680; in Massachusetts, (617) 965-8350. *March* 30–*April* 2

● COMPUTERFEST
The 1985 Greater Baltimore Hamboree and Computerfest, Maryland State Fairgrounds, Timonium. Exhibits, flea market, and forums highlight this annual event. Admission is $4, and the gates open at 8 a.m. Contact Baltimore Amateur Radio Club Inc., POB 95, Timonium, MD 21093-0095, (301) 561-1282. *March* 31

● FOCUS ON SOFTWARE
Softcon, Georgia World Congress Center, Atlanta. The Spring and Fall Softcons have been merged into this event. Nearly 3000 software vendors are expected to participate. Seminars, panel discussions, forums, and

workshops are planned. Registration is $35 for exhibits-only admission or $195 for a four-day conference and exhibits badge. Contact Softcon, Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000. *March 31–April 3*

● TELECONFERENCING SEMINAR—Teleconferencing in the Marketplace, International Congress Centre RAI, Amsterdam, The Netherlands. A seminar for users and suppliers of teleconferencing services and facilities. For further information, contact International Congress and Convention Association, POB 5343, 1007 AH Amsterdam, The Netherlands. *March 31–April 3*

● MICROPROCESSOR IDEA EXCHANGE—The 1985 Microprocessor Forum, Bally's Park Place Casino Hotel, Atlantic City, NJ. Tutorials, forums, and exhibits will be held. A robotic maze contest will be held. On April 1 and 2, the 1985 IEEE VLSI Test Workshop will be held. Contact IEEE Computer Society, Suite 300, 1109 Spring St., Silver Spring, MD 20910, (301) 589-8142. *March 31–April 4*

April 1985

● GULF COAST SHOW The Second Annual Gulf Computer & Office Show, Rivergate Convention Center, New Orleans, LA. Seminars, workshops, and product displays. Contact Gulf Computer & Office Show Management, c/o 119 Avant Garde, Kenner, LA 70065, (504) 467-9949. *April 2–4*

● MEET SOME NETWORKS Introduction to Network Architectures, Atlanta, GA. This course provides an understanding of the role of network architectures and explains their many forms. The fee is $795. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *April 2–4*

● ENGINEERING WITH MODULA-2—Software Engineering with Modula-2, Atlanta, GA. See February 20–22 for details. *April 3–5*

● COMMUNICATIONS TECHNOLOGY FOR THE NONVERBAL—The Fourth Annual Conference on Communication Technology: Technology and Nonspeaking Children, Joseph Stokes Auditorium, Children's Hospital of Philadelphia, PA. Up-to-the-minute information on the use of technology with nonverbal children will be presented. Concurrent sessions will address ongoing research, computers, and treatment strategies. The registration fee is $95. Contact Joan Bruno, Children's Seashore House, 4100 Atlantic Ave., POB 4111, Atlantic City, NJ 08404, (609) 345-5191, ext. 278. *April 12–13*

● GRAPHICS Computer Graphics '85, Dallas, TX. Tutorials and technical sessions on architectural and engineering computer graphics, artificial intelligence, business graphics, and CAD/CAM. Contact National Computer Graphics Association, Suite 601, 8401 Arlington Blvd., Fairfax, VA 22031, (703) 698-9600. *April 14–18*

● OPTICAL STORAGE INVESTIGATED—The 1985 Materials Research Society: Symposium D, Golden Gateway Holiday Inn, San Francisco, CA. A mass-storage technologies symposium in-

(continued)

EVENT QUEUE

vestigating optical data storage. Contact D. H. Davies, Symposium Co-Chair, 3M, 420 North Bernardo Ave., Mountain View, CA 94043. *April* 15–18

● INDUSTRIAL SOFTWARE EXPO—The Second CIMCOM: Industrial Software Conference & Exposition, Disneyland Hotel, Anaheim, CA. Contact Computer and Automated Systems Association of the Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-1500. *April* 16–18

● TRAINING AND TECHNOLOGY—The Third Annual Technology in Training and Education (TITE) Conference, Antler's Hotel, Colorado Springs, CO. A conference designed to facilitate the interchange of ideas and to explore ways that computers and technology can be applied to education and training. Contact Lt. Colonel McCann, 1985 TITE Conference, USAFA/DFSR, USAF Academy, Colorado Springs, CO 80840-5751, (303) 472-4195. *April* 16–19

● NETWORK CONTROL AND MANAGEMENT—Network Management/Technical Control, Marriott Copley Place, Boston, MA. Diagnostic and test instruments will be among the products displayed. Contact Louise Myerow, CW/Conference Management Group, 375 Cochituate Rd., POB 880, Framingham, MA 01701, (800) 225-4698; in Massachusetts, (617) 879-0700. *April* 18–19

● PATIENT CARE AND COMPUTERS—The Second Annual Physicians and Computers: Applications in Patient Care, Las Vegas Hilton, NV. This conference addresses the concerns of doctors, nurses, dietitians, pharmacists, administrators, and medical record administrators. Contact Beverly J. Johnson, University of Southern California School of Medicine, Postgraduate Division, 2025 Zonal Ave. KAM 318, Los Angeles, CA 90033, (213) 224-7051. *April* 19–21

● COMPUTER FESTIVAL The Tenth Annual Trenton Computer Festival, Trenton State College, Trenton, NJ. Highlights talks, tutorials, user-group activities, exhibits, computer-graphics theater, games, and a 50-acre outdoor electronics flea market. Contact Ms. Marilyn Hughes, Trenton State College, Hillwood Lakes CN 550, Trenton, NJ 08625, (609) 771-2487. *April* 20–21

● AIDS FOR EDUCATORS AEDS/ECOO '85: The Twenty-Third Annual Convention of the Association for Educational Data Systems (AEDS), Hilton Harbour Castle, Toronto, Ontario. The theme is "Computing Knows No Borders." Contact AEDS/ECOO '85, c/o OISE, 252 Bloor St. W, Toronto, Ontario M5S 1V6, Canada. In the U.S., AEDS/ECOO '85, 1201 16th St. NW, Washington, DC 20036. *April* 21–27

● SPEECH IN FOCUS Speech Tech '85, Vista International Hotel, World Trade Center, New York City. Speakers and exhibitors will focus on voice synthesis and recognition. Registration is $195. Contact Media Dimensions Inc., POB 1121 Gracie Station, New York, NY 10028, (212) 772-7068 or 680-6451. *April* 22–24

● PUBLIC NETWORK OPERATIONS—X.25 and

(continued)

EVENT QUEUE

Packet Switching Networks, Atlanta, GA. This course covers the internal operations of a packet-switching network and its implementation. The fee is $795. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *April 23–25*

● TRADE SHOW, CONFERENCE—Electro/85 and Mini/Micro Northeast-85, New York City. Topics: artificial intelligence, communications and networks, consumer electronics, high-density data storage, and personal computing. Contact Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965. *April 23–25*

● COMPUTER APPLICATIONS EXPLORED Perscomp '85, Sofia, Bulgaria. An international conference on the applications of personal computers and the problems encountered in using them. Contact Dr. Marcel Israel, Bulgarian Academy of Sciences, Institute of Industrial Cybernetics and Robotics, 1113 Sofia, Acad. G. Bonchev St., Bl. 12, Bulgaria; tel: 72-46-98; Telex: 22836 ITKR BG. *April 23–26*

● MICROS IN EMPIRE STATE—The Fourth Annual New York Computer Show and Software Exposition, Nassau County Coliseum, Uniondale, NY. Contact Ann Katcef, CompuShows, POB 3315, Annapolis, MD 21403, (800) 368-2066; in Annapolis, (301) 263-8044; in Baltimore, (301) 269-7694; in the District of Columbia, (202) 261-1047. *April 25–28*

● VIRGINIA COMPUTING The Fourth Annual Virginia Computer Show and Software Exposition, Pavilion, Virginia Beach, VA. Contact Ann Katcef, CompuShows, POB 3315, Annapolis, MD 21403, (800) 368-2066; in Annapolis, (301) 263-8044; in Baltimore, (301) 269-7694; in the District of Columbia, (202) 261-1047. *April 25–28*

● EQUIPMENT SALE Produx 2000: Wholesale Expo '85, Civic Center, Philadelphia, PA. Contact Vertical Marketing Corp., POB 557, Bala Cynwyd, PA 19004, (800) 523-3882; in Pennsylvania, (215) 457-2303. *April 26–28*

● C FOR ENGINEERS C Programming for Engineers, University of Michigan, Dearborn. A short course and workshop. Contact Professor R. E. Little, University of Michigan, 4901 Evergreen Rd., Dearborn, MI 48128, (313) 593-5241. *April 29–May 3*

● COMMERCIAL AI, HIGH-TECH CONFERENCE AI '85: Artificial Intelligence and Advanced Computer Technology Conference/Exhibition, Convention Center, Long Beach, CA. Technical sessions, panel discussions, and product displays are planned. Contact Tower Conference Management Co., 331 West Wesley St., Wheaton, IL 60187, (312) 668-8100. *April 30–May 2*

● MEETING ON LINE National Online Meeting, Sheraton Centre Hotel, New York City. Formal paper presentations, product review sessions, exhibits, and special workshops and seminars transmitted via satellite. Contact Thomas Hogan, National Online Meeting, Learned Information Inc., 143 Old Marlton Pike, Medford, NJ 08055, (609) 654-6266. *April 30–May 2* ■

INSTANT LAN

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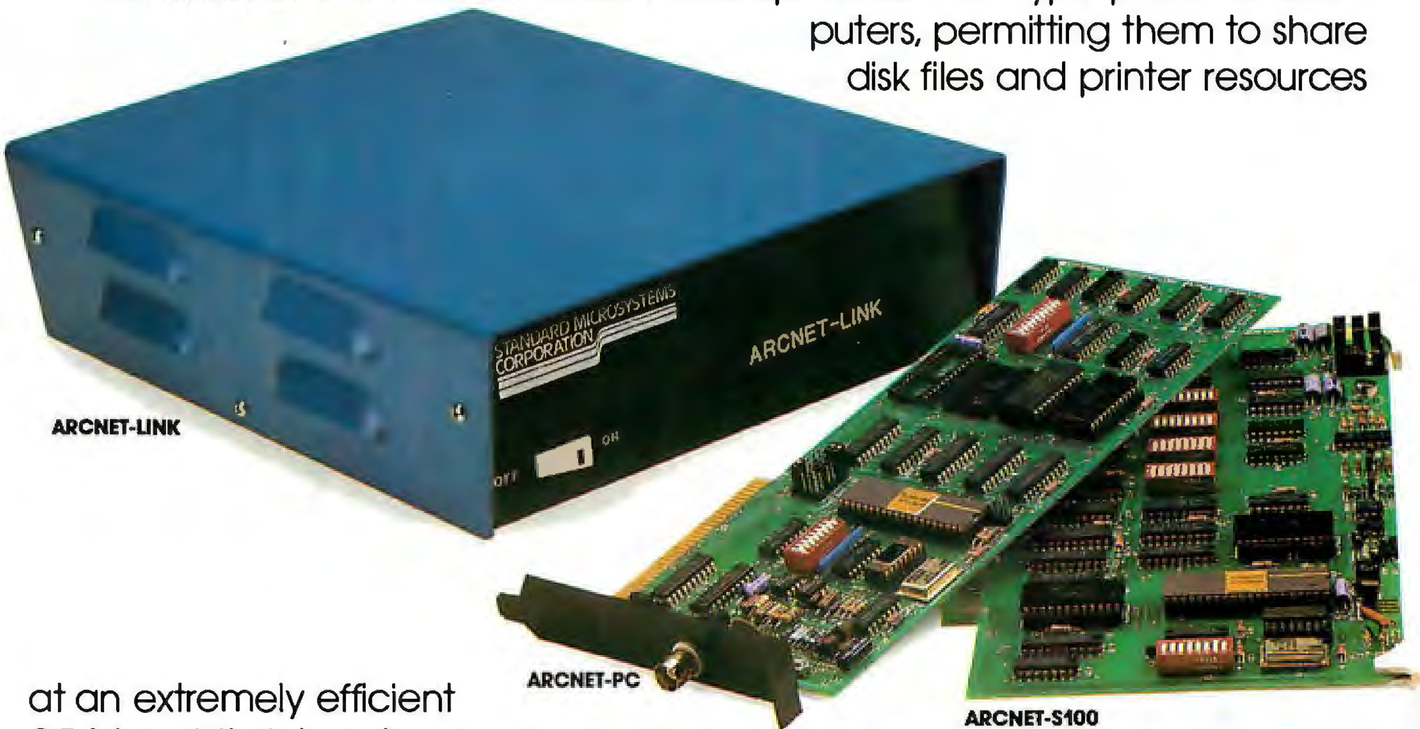

The **ARCNET-S100** board links up to 255 S100 computer systems, providing the S100 computer user with a high performance local area network.

The **ARCNET-LINK** is a self-contained unit that provides a simplified interface between equipment with a programmable asynchronous RS-232 port and an ARCNET® local area network.

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Features

THIS MONTH BYTE presents a variety of features including two product previews.

Developed under the name "Pisces," Hewlett-Packard's Integral Personal Computer includes UNIX System III in a transportable package. This product preview by Phillip Robinson, technical editor on our West Coast staff, takes an introductory look at the Integral, its major subassemblies, and its capabilities and limitations. The Integral uses a built-in electroluminescent flat screen and ink-jet printer, but the big news is its incorporation of UNIX in ROM.

The Macintosh continues to provoke lots of love/hate feelings. To bolster its attractiveness to business environments, Apple introduced AppleTalk, a local-area network, and the first two in a series of peripherals designed to be networked. AppleTalk, previewed this month by John Markoff and Phillip Robinson, is a departure from what we often consider fundamental to a local-area network concept. With only a printer and file server currently available, AppleTalk is an interesting approach.

If you are ready to commit your code to EPROM but don't have access to an EPROM programmer, or if you would like to learn more about the process, read Ciarcia's Circuit Cellar. This month, Steve shows us how to build an EPROM programmer inexpensively. This unit attaches to your computer's serial port and uses your computer's intelligence. It is also fully documented and is easily expandable to work with future EPROM designs.

Translating programs among various languages (or even between two languages) is a wonderful concept but generally difficult to implement. In "C to Pascal," Ted Carnevale describes some of the conventional approaches and problems he discovered while trying to move a graphics subroutine library in C to a Pascal environment. He also provides us with a program that makes the process less tedious.

The theme of the March 1984 BYTE was simulation, an intriguing topic once relegated only to rooms full of computers. While microcomputers really can't compete with the fast, large-scale simulations that run on the CRAY-1 and other supercomputers, Don Stauffer uses a microcomputer to "Simulate a Servo System," using an electronic weighing scale as an example of servo-system simulation.

Jeffrey L. Star also capitalizes on the power of the microcomputer in his article "Introduction to Image Processing." While commercial broadcast television limits gray-scale reproduction to about 12 levels and human vision covers a restricted spectrum, image-processing systems usually can deal with at least 32 gray levels and over 16 million unique colors. And, interestingly, there are a couple of image-processing programs available for microcomputers.

—Gene Smarte, Managing Editor

PRODUCT PREVIEW

THE HP INTEGRAL PERSONAL COMPUTER

BY PHILLIP ROBINSON

A new all-in-one system makes UNIX truly portable

The Hewlett-Packard Integral Personal Computer is a complete, transportable computer system designed around UNIX (System III). (See photo 1.) With the UNIX kernel in ROM (read-only memory), an electroluminescent (EL) flat screen, a 3½-inch floppy-disk drive, a built-in ink-jet printer, and Hewlett-Packard's Personal Applications Manager (PAM), the Integral is a marvel of advanced personal computing technology.

HISTORY

A big team worked on the Integral, which, during development, was known by the name "Pisces." Some of the team's members I met were Jon Brewster (user interface), Ray Fajardo (software), Tim Williams (section manager), Doug Collins (hardware manager), and Andy Rood (operating system).

While the hardware development of the Integral began in the fall of 1982, the software development had begun a year earlier. In fact, several projects were merged to come up with the Integral. The original design called for desktop functions in a transportable box: 80 characters by 25 lines on the display, a full-size printer (not thermal), and a real keyboard. When the project began, many of the elements that would meet those requirements didn't exist. To assure that those devices would be ready in time, Hewlett-Packard (HP) had to get intimately involved in the particular technologies. For example, HP decided early on to use an EL screen and an ink-jet printer. At the time, EL technology was in its infancy and HP had to become a major factor in the EL marketplace.

BRASS TACKS

The Integral's logic board is a generic 68000 8-MHz system supplemented by a few special fillips: a memory mapper for UNIX and a proprietary graphics chip. The 68451 MMU (memory-management unit) chip wasn't used for memory mapping because it slows the memory cycle quite a bit—it would reside between the processor and RAM (random-access read/write memory). Instead, only the top address bits are mapped, and while that mapping is going on, the lower-half addressing of the RAM also is proceeding. This leaves the RAM's speed unaffected while still giving reasonable page sizes.

The RAM comes as a standard 512K bytes (with 32K more for the display) made up of 256K by 1 bit DRAMs (dynamic RAMs) with no parity chips. You can purchase 256K and 512K RAM boards separately and insert them into the Integral's two internal slots. By using extender boxes (which plug into one of the slots, sit underneath the Integral, and provide five slots) you can have up to 5.5 megabytes of RAM. When the 1-megabyte RAM cards become available (soon after introduction) you'll be able to use the full logical RAM space of 7.5 megabytes. The Integral also has 256K bytes of ROM, which holds the operating system. I'll discuss the Integral's ROM a little more in the UNIX section that follows.

The custom graphics processing unit (GPU) chip was designed and made by HP in Corvallis, Oregon. According to Jon Brewster, a lot of effort went into the chip, which handles window scrolling, window moves, line drawing, and soft character fonts. The GPU is a big chip: it has a 16-bit ALU (arithmetic logic unit), a 16-bit data path, and a barrel shifter.

The engineering and a nearly silent fan enable the Integral to work in some severe environments—up to 40 degrees centigrade and 80 percent humidity. (The humidity limit is 95 percent without the disks, which are the most susceptible to moisture problems.) According to HP, some of the humidity testing involved just taking the machine outside—remember,

(continued)

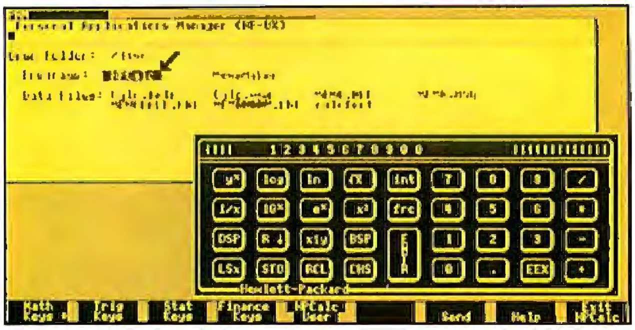
Editor's note: The following is a BYTE product preview. It is *not* a review. We provide an advance look at this new product because we feel it is significant. A complete review will follow in a subsequent issue.

Phillip Robinson is a senior technical editor at BYTE. He may be contacted at 1000 Elwell Court, Palo Alto, CA 94303.

PHOTOGRAPHED BY PAUL AVIS

Photo 1

Photo 2:
HP's *Personal Applications Manager* (PAM) *and Calculator.*



this was all done in moist Oregon.

No Featherweight

HP says that the Integral is the only complete product around (i.e., with both a full screen and a printer) that you can really carry and that will fit under airline seats or in overhead racks. Regardless, this machine definitely remains in the transportable category. It is smaller than other transportables—such as the Kaypro—but still weighs 27 pounds.

In one test, HP dropped the Integral from a meter up. It still ran.

Reliability

I asked what sort of reliability the Integral will have when it is actually carted around. "You'd be amazed," replied an HP spokesperson, who recited numerous tests with glee. For instance, in one test they dropped the system from a meter up: it sustained some cosmetic damage but still ran (although that isn't guaranteed). When something did break during testing, HP made the necessary changes to the components or case. Further testing included vibrating the system, checking for condensation, and giving prototypes to marketing people.

Another ramification of this reliability obsession is that HP won't soon introduce a hard-disk version of the Integral. Though HP engineers admittedly had considered the possibility, it seems they don't trust the ruggedness of the hard disks they've seen. Beyond that, the design team believes that RAM disks and ROM-based operating systems give hard-disk performance without the problems.

Service

Service for the Integral will be available through dealers or HP, with the standard 90-day warranty offered in the U.S. Because of different legal requirements, the warranty period will be one year in Europe. You will also be able to purchase extended service agreements.

I/O Capabilities

The Integral has only a single port on the back, an HPIB (Hewlett-Packard Interface Bus) socket. If you need more I/O (input/output) capabilities you have to put I/O boards in the slots (for example, an RS-232C card, which should be immediately available).

Another form of I/O is provided by the keyboard and mouse sockets. These sockets are called Human Interface Loop (HIL) ports and can handle other devices, such as graphics tablets. Hewlett-Packard has standardized the protocol for these ports throughout many of its wide range of products.

Display

The Integral's electroluminescent, flat-screen display is a centerpiece. Although the display isn't manufactured at HP, the HP engineers worked closely with the vendor to assure readability and reliability. In fact, each time I talked to an HP engineer I was assured that the "slight shadowing" on the prototype screen had been corrected. Unfortunately, I never saw the shadow. Maybe eyes trained on LCDs (liquid-crystal displays) aren't yet ready to analyze an EL flat-screen critically. The screen is also fast—with no phosphors to fade, it could be faster than a CRT (cathode-ray tube). The only color choice is amber.

With 512 by 255 pixels in an area 8 inches wide and 4 inches tall, the Integral screen is twice the size of the Grid Compass screen—the only other well-known example of an EL on a microcomputer. Because the screen is so thin, the Integral could probably be the shallowest system you have ever put on a desk. While transportables of the Osborne and Kaypro variety have to be unbuttoned and then tilted over, taking up much of the depth of a desk, the Integral retains its standing position, with only the keyboard folding down to occupy writing space.

An EL display is clearer than a CRT because there's no focus problem. As project manager Tim Williams noted dryly, "If a dot lights up, a dot lights up."

The Integral has a variety of fonts and a font editor that lets you create your own. An antireflective coating and a circular polarizer for glare reduction combine to improve your

Photo 3:
PAM, *with* HP's *MemoMaker.*

view of the already crisp images.

KEYBOARD

The Integral's low-profile keyboard (photo 4) is a compact adaptation of a new HP standard keyboard that will be used with portables, desktops, and terminals. The keyboard has completely soft mapping because it will be used in a number of countries: the Corvallis division of HP gets half of its business from outside the United States, so German, French, Spanish, and British versions of the Integral also were set for introduction in January. Another effect of European sales is that the arrangement of the keyboard (and of other system elements such as the display and fonts) had to meet European ergonomic standards.

The Integral PC's electroluminescent, flat-screen display is its centerpiece.

The keyboard consists of a full-size QWERTY layout with sculpted keys surrounded by special function keys. My first impression is that the keyboard is not especially quiet but is fast and easy to type with. The numeric keypad on the right side is closer to the alphabetic keys than on many other HP keyboards: the engineers had to squeeze it inward because of the requirements of portability. The cursor keys are below the numeric keypad.

Several of the numeric keys also have special functions, which are printed on the keys, such as Insert Line and Delete Character. The Integral also has: a Select key, used to shift the active window on the screen; Extend keys, which, in conjunction with the alphabetic keys, produce special characters; a Reset/Break key and a Stop key, placed in the extreme top left to prevent frustrating accidents; and eight programmable function keys, part of the standard HP user interface. The bottom lines of the Integral's screen display the changing definitions of the function keys.

MASS STORAGE

The mass-storage capacity of the Integral consists of one HP-standard, 3½-inch floppy-disk drive with hard-shell disks that hold 710K bytes each. One of my first reactions to the machine was, "Why is there only one floppy-disk drive?"

"One disk is cheaper than two," says HP's Andy Rood. "So the question is: 'Why two?'"

Normally manufacturers include two disk drives to provide enough total storage, separate storage devices for programs and data, and backup capability.

According to HP, the Integral's single floppy-disk drive, RAM, and ROM meet these needs: the very high density of the floppy-disk drive provides enough total storage; the separation of programs and data is accomplished partly by the ROM and partly by the RAM disk; and because the operating system is in ROM instead of on a disk and the RAM of the Integral automatically includes a RAM-disk function, you can put programs on the RAM disk and data files on the floppy. As an added benefit, RAM-disk programs run faster than those on a floppy disk. Finally, the development team felt that the high-density floppy and the RAM disk made up a perfectly capable pair of devices for backing up files. For those reasons, and to save on space and power, the team decided to leave out a second disk drive.

The use of ROM for the operating system was a big challenge: UNIX likes to have a disk drive at its disposal. The HP team had to "tune" their UNIX so that it didn't do that. The ROM solution provides that the root file is on the RAM disk, so when UNIX comes up, the only file system it presumes to exist is the RAM disk.

You can have more mass storage (externally) if you want it. Through the Integral's I/O interface you can use any of HP's many storage peripherals. All of the software drivers—such as for a hard disk—are already built in.

THINKJET PRINTER

One of the features that makes the Integral unusually "integrated" is the built-in ink-jet printer (see "The Hewlett-Packard ThinkJet Printer" by Mark Haas in the January BYTE, page 337). The ThinkJet is also a product of the Corvallis division of Hewlett-Packard and the Integral team was intimately asso-

(continued)

Photo 4:
The Integral Personal Computer's keyboard.

ciated with its development.

As an ink-jet printer, the ThinkJet is quiet and fast. The characters it produces are near letter quality. The ThinkJet can print in a number of different fonts and can also handle black-and-white graphics. The Integral's keyboard has a Print key that immediately cues a dump of the screen's contents to the ThinkJet.

Although the Integral is compatible with UNIX System III, it emulates other versions.

One small drawback of the printer's placement is that there is no good place to put the paper—that is, if you put the pile of blank paper just behind the computer, the system takes up a lot more room.

The ThinkJet is generally simple to load and use but doesn't have a platen knob. Therefore, you have to be careful not to overrun when using the line-feed and form-feed buttons.

MOUSE

The Integral's optional mouse is HP's standard two-button, mechanical contraption that uses a steel ball beneath a circular palm grip. The plug-in position (on the left side of the unit) is slightly awkward for a right-handed user because the cable must run behind the keyboard. The mouse's left button is called the "clicking" button (for selection) and the right is called the "right" button (for mode changing).

SOFTWARE

The Integral runs HP-UX 2.1, which HP calls a "vanilla" UNIX environment, and the Personal Applications Manager (photos 2 and 3), HP's operating-environment shell (see "The HP 150" by Phil Lemmons and Barbara Robertson in the October 1983 BYTE, page 36, and "The HP 110" in the June 1984 BYTE, page 111). The Integral's windows emulate terminals that report back at 9600 bits per second, have 80 characters by 24 lines, and use normal escape sequences. As Tim Williams puts it, "We think the UNIX wave is just beginning. And as the UNIX wave rolls along we want to roll with it and help it to grow." Ray Fajardo noted that a lot of development time was devoted to making the Integral run most UNIX software without modification. The primary goal was System III compatibility: a secondary goal was flexibility. The system can dynamically configure drivers and make operating-system patches on the fly, so the environment is standard yet can be specialized by independent software vendors. According to HP, HP-UX's flexibility enables it to emulate Venix, System V, and other UNIX derivatives. Over 50 utilities, commands, and standard applications are included with the system.

How hard was it to put UNIX in ROM? "We first did it the same way we do a disk operating system," says Andy Rood. "We just took what would have been our 200K boot image, put it in ROM, and put a little power-on preamble that copied it to RAM just as a bootstrap up for disk." They then embellished the first version by making the code execute directly from the ROM and made some flexibility modifications by linking ROM through RAM jump tables. Any bugs that turn up in the ROM now can be masked by intercepting and isolating ROM routines. The kernel is in the ROM and is treated as another disk device. At the time the machine is started, the ROM disk—which has both the PAM shell and the traditional UNIX init process—is configured. The ROM looks like shared memory for user libraries and programs. There also is a demon in the background to do the disk handling. The HP-UX system is supported by real-time extensions (BCD [binary coded decimal], HPIL [Hewlett-Packard Interface Loop], HPIB, RS-232C, and instrumentation I/O) and device-independent libraries, as well as HP Technical BASIC.

USER INTERFACE

The Integral's user interface (windows, graphics, function keys, and optional mouse) were Jon Brewster's responsibility. He explained that the original reason for windows was to provide users with more than one interface to the product. HP had discovered that even novice users use multitasking

Photo 5:
The Integral PC with keyboard in place.

and keep multiple programs on the display. The windowing system, then, had to allow novices to do multitasking without worrying about foreground, background, priorities, and scheduling. Because the mouse was to be (and is) optional, the windows had to work well with and without it. Also, unlike the Macintosh, the Integral allows you to move windows while they are being updated: windows are moved by animating a sprite (which resembles a corner of the window) and positioning it—rather than moving the entire window. Thus, you can hide windows (they appear as title lines in the lower left of the display), stretch them (by choosing a new bottom right corner with a sprite), move them (by choosing a new top left corner with a sprite), and shuffle them (the top window being the only one with which you can interface directly, although the others can still be active).

The Integral's user interface lets you move, hide, stretch, and shuffle windows.

APPLICATIONS

According to HP, a variety of software packages will be available within 60 days of the Integral's introduction. These include Microsoft's Multiplan, Officeware's Script and Plan, Ashton-Tate's dBASE III, HP's MemoMaker, Data and Calculator, HP-UX software development tools, and others.

More software is being developed both at HP's personal software division and by independent vendors who have already been alerted to the Integral's introduction. Also, because of the compatibility of HP Technical BASIC, many programs for other HP systems, such as Series 200 and 500 products, will immediately run on the Integral.

DOCUMENTATION

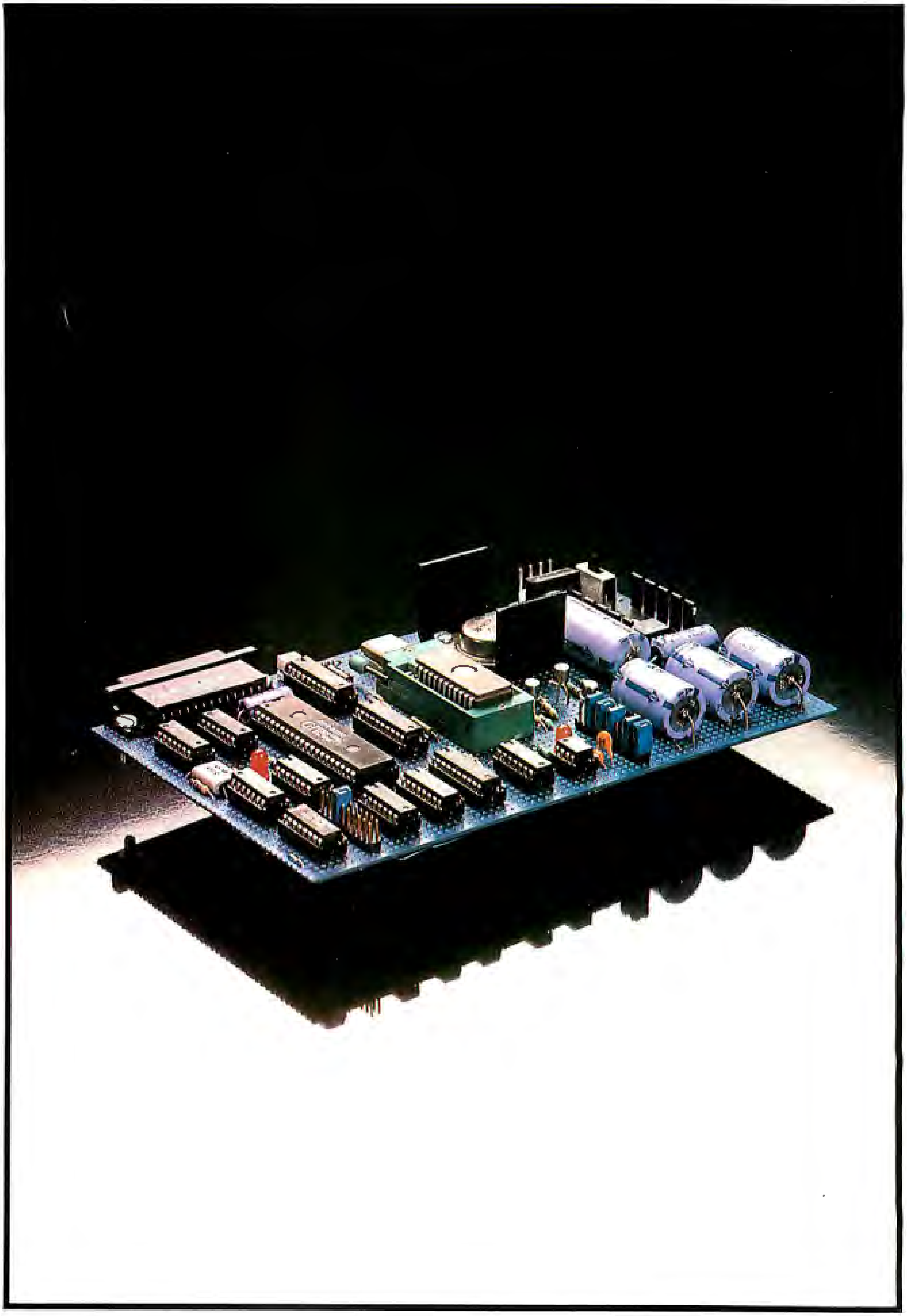
Although the documentation I viewed was only in the draft stage, HP has given plenty of attention to the literature explaining its system. The documentation is clear and thorough. Beginners will spend the most time with the *Personal Tutor* disk and booklet, a tutorial that takes an estimated eight hours to fully absorb. Lessons include use of the mouse, windows, and the organization, viewing, printing, and creating of files. The Integral's documentation also includes a cartoon booklet that explains how to set up and start up the system, and a reference guide. HP claims that the documentation, user interface, and PAM will have novices working on the system within 30 minutes.

PRICE AND CONCLUSIONS

The Integral Personal Computer is priced at $4990 (with HP-UX, PAM, and HP Windows). Although the price is high for a single-disk-drive system, the perceived price/value ratio depends on what class of computer you compare the Integral to. HP would like it to be compared to the higher-performance (and higher-priced) UNIX machines, rather than MS-DOS transportables such as the Compaq.

The big question is, who will buy the Integral? Perhaps business and technical professionals whose requirements push the limitations of today's 16-bit MS-DOS machines. Certainly computer science students and engineers will see many advantages to a complete UNIX system they can take home. And with the benefits of multitasking, HP may pull in more people: imagine having several data-communications cards, each hooked to a different electronic information service, and all communicating while you work on a spreadsheet and a word processor.

The HP Integral Personal Computer's advantages include: state-of-the-art technology; the "everything you need in one box" design; engineering that looks absolutely solid, and a multitasking environment—all from a company with a great engineering track record. On the minus side: the list of software available for the Integral PC is short, and the price may be too high. But for those who need advanced computing power and who want to cast their votes against the IBM PC and its various compatibles, the HP Integral Personal Computer may be the best argument yet for biting the bullet and switching to UNIX. ■



PHOTOGRAPHED BY PAUL AVIS.

BUILD A SERIAL EPROM PROGRAMMER

BY STEVE CIARCIA

An inexpensive way to put your programs on a chip

Over the years, many articles have been published on programming EPROMs (erasable programmable read-only memories). The number of articles alone indicates the value of an EPROM programmer and the interest expressed in the subject. True-blooded computer experimenters consider an EPROM programmer as essential a tool as a soldering iron and a DVM (digital voltmeter).

Most EPROM programmers designed for personal computers are implemented as bus-dependent I/O (input/output) peripheral cards that use computer-specific, machine-language driver programs. By eliminating the need for an enclosure and using the system power supply, a relatively cost-effective unit can be produced. Unfortunately, if I designed such a unit, it probably wouldn't be for the computer you own.

For computer users who don't have expansion buses or who want their EPROM programmer to be transportable between systems, the only alternative is a stand-alone EPROM programmer attached to a serial port (much like a modem). Making it a separate peripheral device, however, necessarily increases its cost. In fact, external serial-port EPROM programmers are frequently two or three times the cost of board-level units.

A certain portion of the cost is due to its separate power supply and enclosure, but most of the expense is attributed to the features that manufacturers generally incorporate in the devices. The majority of stand-alone serial-connected programmers are, in fact, designed as intelligent EPROM programmers that have the basic processing power and memory of whole computers. I have taken this approach on previous designs. Such devices perform well and require little assistance from the host system beyond the data to be programmed.

This time I'm approaching the problem differently. I've decided to keep it simple and design the most universally applicable and cost-effective programmer that I can.

The latest Circuit Cellar EPROM programmer is a serial-port programmer that has the speed of a turtle, the intelligence of the mightiest computer (that is, it has absolutely no smarts of its own), and is as functional as a doorstop between uses. On the positive side, it's fully documented, universally applicable, and easily expandable to ac-

(continued)

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. He is the author of several books about electronics. You can write to him at POB 582, *Glastonbury,* CT 06033.

commodate future EPROM types.

The serial-port programmer can be operated from almost any system with a serial port. The driver software is written completely in BASIC with no machine-language routines. The serial-port programmer offers all the hardware features to program 2716, 2732, 2732A, 2764, and 27128 EPROMS through a serial port, including: RS-232C compatibility, no handshaking necessary, internal power supplies, jumper-selectable EPROM types, and jumper-selectable data rates.

The BASIC-language driver program included offers features such as:

- menu-driven operation using single keystrokes
- a help routine that can be called at any time
- single-byte or burst-write modes
- read or copy EPROM
- optional programming from a disk file
- verify after write
- verify EPROM erasure
- screen-dump routines by page or byte
- single-stepping mode
- software-controlled read/write mode select
- BASIC driver that can be user-modified

Reviewing EPROM Basics

A personal computer, even in its minimum configuration, always contains some user-programmable memory or RAM (random-access read/write memory), usually in the form of semiconductor-memory integrated circuits. This memory can contain both programs and data and can be read or modified as needed.

Any of several kinds of electronic components can function as bit-storage elements in this kind of memory. TTL (transistor-transistor logic) type-7474 flip-flops, bistable relays, or tiny ferrite toroids (memory cores) are suitable, but they all cost too much, are hard to use, and have other disadvantages.

In personal computer and other microprocessor-based applications, the most cost-effective memory is made from MOS (metal-oxide semiconductor) ICs (integrated circuits). Unfortunately, data stored in these semiconductor RAMs is volatile. When the power is turned off, the data is lost. Many ways of dealing with this problem have been devised, with essential programs and data usually stored in some nonvolatile medium.

In most computer systems, some data or programs are stored in nonvolatile ROM (read-only memory). A semiconductor ROM can be randomly accessed for reading in the same manner as the volatile memory, but the data in the ROM is permanent. In a mask-programmed ROM, the data that can be read is determined during the manufacturing process. Whenever power is supplied to the ROM, this permanent data (or program) is available. In small computer systems, ROM is chiefly used to contain operating systems and/or BASIC interpreters—programs that don't need to be changed.

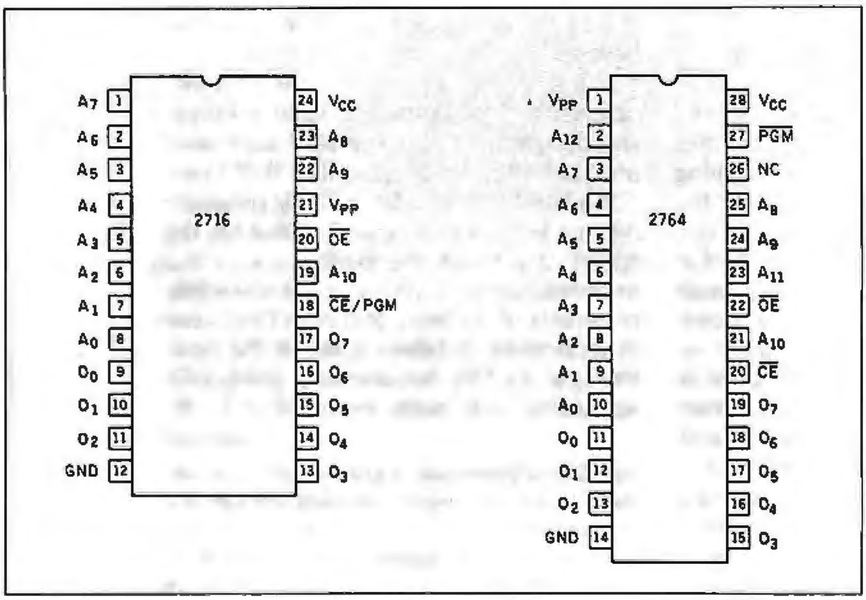


Figure 1: *Pinouts of the* 2716 *and* 2764 EPROMs.

Another type of ROM is the PROM (programmable read-only memory). A PROM component is delivered containing no data. The user decides what data it should contain and permanently programs it with a special programming device. Once initially programmed, PROMs exhibit the characteristics of mask-programmed ROMs. You might label such PROMs as write-once memories.

The EPROM, which is ultraviolet-light-erasable, is a compromise between the write-once kind of PROM and the volatile memory. You can think of the EPROM as a read-mostly memory, used in read-only mode most of the time but occasionally erased and reprogrammed as necessary. The EPROM is erased by exposing the silicon chip to ultraviolet light at a wavelength of 2537 angstroms. Conveniently, most EPROM chips are packaged in an enclosure with a transparent quartz window.

How an EPROM Works

EPROMs store data bits in cells formed from stored-charge FAMOS (floating-gate avalanche-injection metal-oxide semiconductor) transistors. Such transistors are similar to positive-channel silicon-gate field-effect transistors, but they have two gates. The lower or *floating* gate is completely surrounded by an insulator layer of silicon dioxide; the upper *control* or *select* gate is connected to external circuitry.

The amount of electric charge stored on the floating gate determines whether the bit cell contains a 1 or a 0. Charged cells are read as 0s; uncharged cells are read as 1s. When the EPROM chip comes from the factory, all bit locations are cleared of charge and are read as logic 1s; each byte contains hexadecimal FF.

When a given bit cell is to be burned from a 1 to a 0, a current is passed through the transistor's channel from the source to the gate. (The electrons, of course, move the opposite way.) At the same time, a relatively high voltage potential is placed on the transistor's upper select gate, creating a strong electric field within the layers of semiconductor

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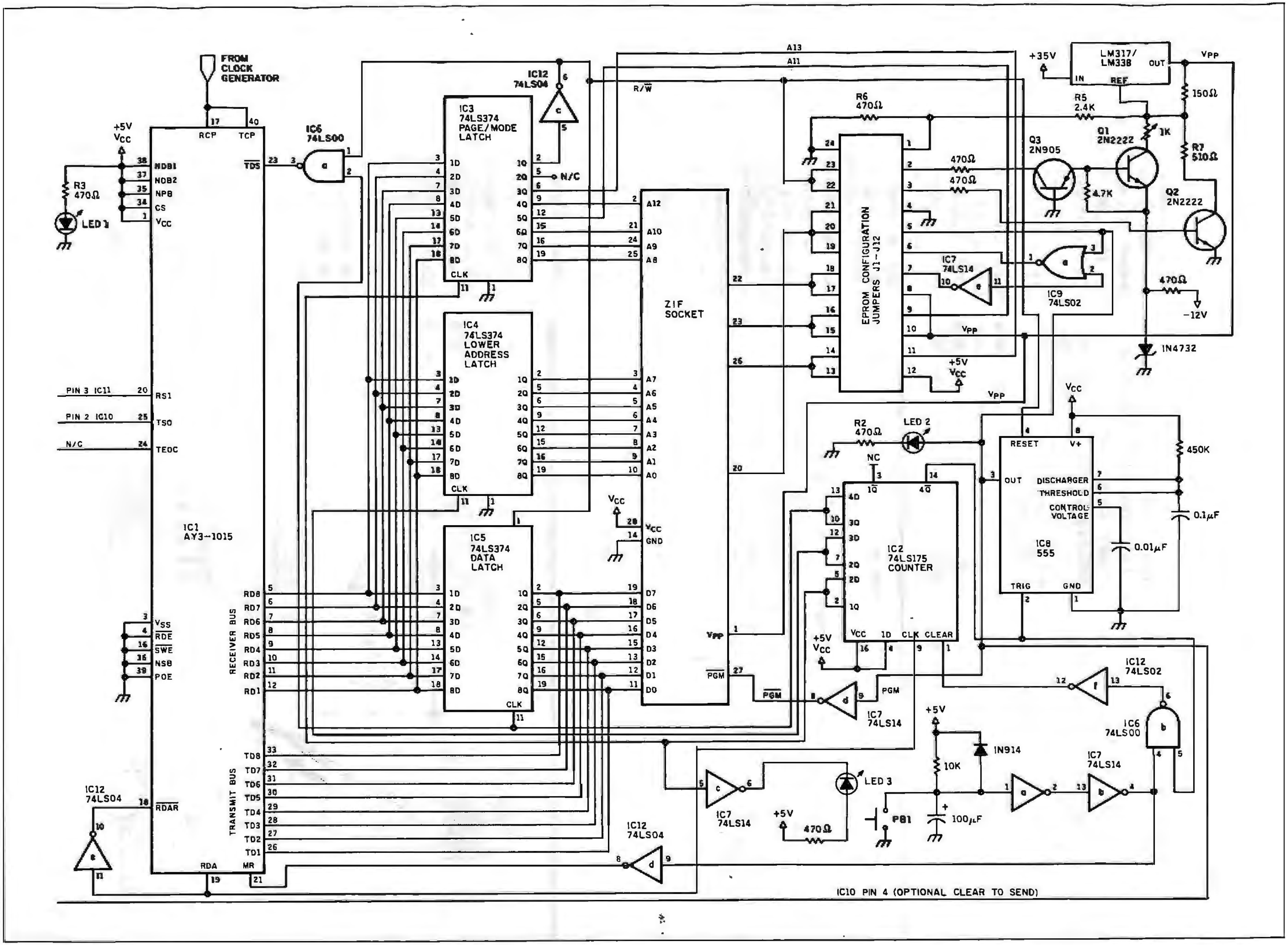

Figure 2: *The serial-port EPROM programmer.*

material. (This is the function of the +21- or +25-volt [V] V_{PP} charging potential applied to the EPROM.) In the presence of this strong electric field, some of the electrons passing through the source-drain channel gain enough energy to tunnel through the insulating layer that normally isolates the floating gate. As the tunneling electrons accumulate on the floating gate, the gate takes on a negative charge, which makes the cell contain a 0.

When data is to be erased from the chip, it is exposed to ultraviolet light, which contains photons of relatively high energy. The incident photons excite the electrons on the floating gate to sufficiently high energy states that they can tunnel back through the insulating layer, removing the charge from the gate and returning the cell to the 1 state.

The 2700 family of EPROMs contains bit-storage cells configured as individually addressable bytes. This organization is often called "2K by 8" for a 2716 or "8K by 8" for a 2764. Figure 1 shows the 2716 and 2764. The completely static operation of these devices requires no clock signals. The primary operating modes include read, standby, and program (program-inhibit and program-verify modes are important primarily in high-volume applications).

Control inputs are used to select the chip and configure it for one of these operating modes. In the program mode, particular bit cells are induced to contain 0 values. Both 1s and 0s are present in the data word presented on the data lines, but only the presence of a 0 causes action to take place. To program the 2716 EPROM, the V_{PP} input is made +25 V and the $\overline{OE}$ input is at a high TTL level. Then, the TTL-level data to be programmed for a specific address is set up on the 2716's data lines, and the address is set up on address lines A0 through A10. After a setup time of at least 2 microseconds (μs), a high TTL-level programming pulse 50 milliseconds (ms) long is applied to the $\overline{CE}$/PGM input. Addresses to be programmed may be specified in any order.

The 50-ms programming pulse must be applied once for each location to be programmed (under no circumstances should a constant high level be applied to the $\overline{CE}$/PGM input in the program mode). Repeated 50-ms pulses to the same location are acceptable, but any pulse width greater than 55 ms might destroy the chip. The minimum pulse width is 45 ms.

Table 1: *Power supply and ground pin numbers for figures 2 and 3.*

IC Number	Type	Ground	5 V	12 V	−12 V
IC1	AY3-1015	pin 3	pin 1		
IC2	74LS175	pin 8	pin 16		
IC3,4,5	74LS374	pin 10	pin 20		
IC6	74LS00	pin 7	pin 14		
IC7	74LS14	pin 7	pin 14		
IC8	NE555	pin 1	pin 8		
IC9	74LS02	pin 7	pin 14		
IC10	MC1488	pin 7		pin 14	pin 1
IC11	MC1489	pin 7	pin 14		
IC12	74LS04	pin 7	pin 14		
IC13	CD74HC4040	pin 8	pin 16		

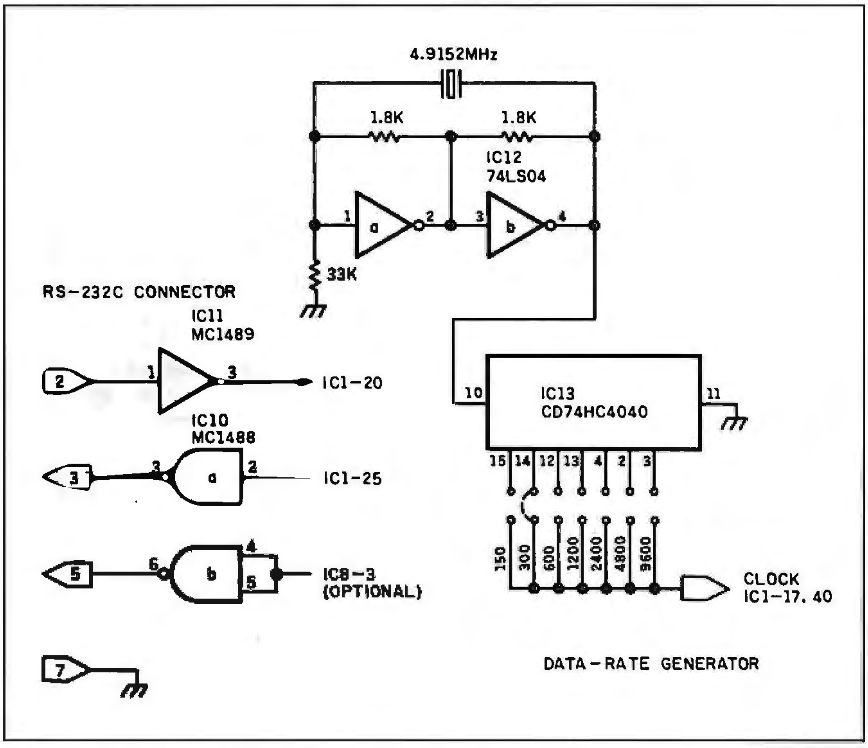

Figure 3: *Serial interface and data-rate generator.*

CIRCUIT DESCRIPTION

Figures 2, 3, and 4 show the schematic drawings for the serial-port EPROM programmer, the RS-232C interface, and the four-voltage power supply. Table 1 shows the power-supply connections for the schematics. The main element in figure 2 is the AY-3-1015 UART (universal asynchronous receiver/transmitter). The UART converts serial information sent from the computer into parallel information used in the programmer. This parallel data appears on pins 5 through 12 of the UART receiver bus. The UART can also pass information back to the computer by converting any parallel information present on pins 26 through 33 of the transmitter bus into serial information. The serial information is received from the computer on pin 20 and transmitted to the computer on pin 25.

A logic high level on pin 21 resets and initializes the UART. This level is generated as a power-on reset (PWR) every time the power to the programmer is turned on or the manual reset button pressed. This PWR also clears the receiver character counter, IC2.

UART pins 35 through 39 set the format of the serial transmission between the computer and the programmer. (I chose to hard-wire these options rather than provide option switches that are rarely used.) As shown, the UART is configured for an 8-bit character length with 1 stop bit and parity checking inhibited. If your computer requires 2 stop bits, connect pin 36 to +5 V instead of ground. The programmer will operate at any desired data rate up to and including 9600 bits per second (bps). A software delay loop keeps the programmer from being swamped.

The programmer requires 4 bytes to be sent from the computer for each location read from or written to in the EPROM. This 4-byte protocol eliminates the need for incremental counters and sophisticated decision logic in the programmer. It does, however, reduce the speed of read and erasure-verification operations.

The first 3 bytes received are latched a byte at a time into latches IC3, IC4, and IC5. The latching pulses are generated by IC2, which is configured as a 4-bit byte counter. Each time a byte is received by the UART, an RDA (received data available) pulse is generated at pin 19 of the UART. This pulse is used to clock IC2 and is gated back to the RDAV (reset data available) line, pin 18, to clear the receiver section of the UART. As the counter clocks, the leading edges of its output latch the data from the UART into IC3, IC4, or IC5. The counter is reset by the PWR line or when the fourth byte is received.

The first byte received by the programmer contains the most significant 3 to 6 bits of the EPROM address (depending upon the EPROM type) and 1 bit to select either the read or write mode of operation. A logic 1 in bit 7 sets the write mode; a logic 0 sets the read mode.

The second byte contains the lower 8 bits of the EPROM address.

The third byte contains the data to be programmed into the addressed location when it is in the write mode or a dummy character when in the read mode.

The fourth byte contains dummy data in both the read and write modes. When the counter increments with the reception of the fourth byte, it causes IC2 to reset. The time between setting this output bit and clearing the counter is about 100 nanoseconds (ns). This short pulse concluding the setup of the address and data is used to trigger the actual programming pulse to the EPROM.

The programming pulse to the EPROM is generated by IC8, which is configured as a 50-ms one-shot (triggered by the reception of the fourth byte). The programming pulse is fed to the EPROM at several different locations, depending on which EPROM is being programmed and how the EPROM selection jumper block (see figure 5) is configured.

The one-shot is functional only when the mode select line (R/$\overline{W}$, read/not write) IC3 pin 2 is a logic 0, setting the write mode. The mode select line is also used to select the programming voltage ranges of the various EPROMs. When configured for a 2732 or a 2716 EPROM, a low on the mode select line sets the V_{pp} supply to a 25-V level. For all other EPROM types, the V_{pp} supply is set to a 21-V level.

Depending on the configuration of the jumper block, the mode select line sets the proper TTL levels at the $\overline{CE}$ and $\overline{OE}$ pins to place the various EPROMs in the read or write mode. A logic high on the mode select line causes the V_{pp} supply to drop to 0 V for the 2732 and 2732A EPROMs and to 5 V for the other types.

The mode select line also functions as the output enable line of data latch IC5. When the programmer is in the write mode, data from the UART is latched and directed to the EPROM data bus for programming. When the programmer is in the read mode, IC5's output is disabled, and the EPROM data-bus contents are transmitted back to the computer.

LEDs (light-emitting diodes) 1, 2, and 3 indicate when power is on and when read and write pulses occur. They are not necessary to the operation of the programmer and are merely included as visual aids.

Figure 3 shows the serial-interface connections and the data-rate generator. IC10 and IC11 are standard RS-232C transmitter and receiver chips that conform to the EIA (Electronic Industries Association) standard for RS-232C transmission. (If your computer needs a handshaking signal, the 50-ms write pulse can be connected to the clear-to-send line. It is not used with the software presented in this article.) The serial-communication rate between the programmer and the computer is jumper-selectable. A 4.9152-MHz oscillator is divided down through a CD74HC4040 (it must include the HC designation to accommodate the high frequency) to produce the appropriate clock rate for the UART.

Figure 4 shows the power supply used with the programmer. The power transformer I chose was 22 V CT (center tap), but any transformer from

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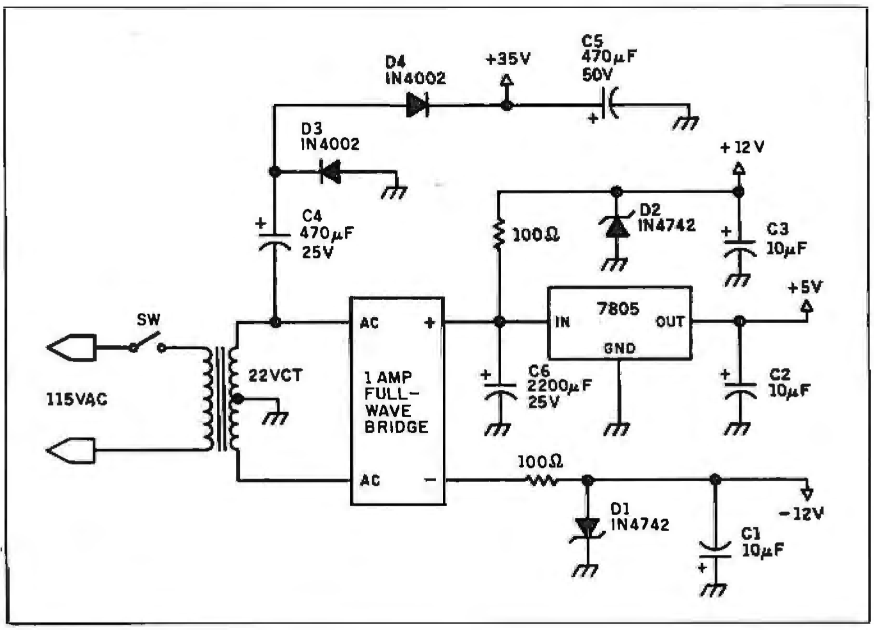

Figure 4: *Power supply.*

22 to 25.6 V CT is adequate. The secondary output of the transformer is full-wave rectified, filtered, and then regulated to +12 V, +5 V, and −12 V. Only the +5-V supply needs an actual IC regulator; less stringent zener regulation is adequate for the 12-V supplies to the RS-232C drivers.

The 35-V output consists of components C4, C5, D3, and D4 connected as a cascade voltage doubler with half-wave rectification. This configuration produces an input of approximately 32 to 34 V to the LM317/338 regulator. The minimum acceptable voltage at the input is 28.5 V (for a 25-V output). If you use a higher-output transformer than 22 V CT, be careful that the input to the V_{pp} regulator doesn't exceed 35 V. If it does, additional preregulation may be necessary to use this circuit.

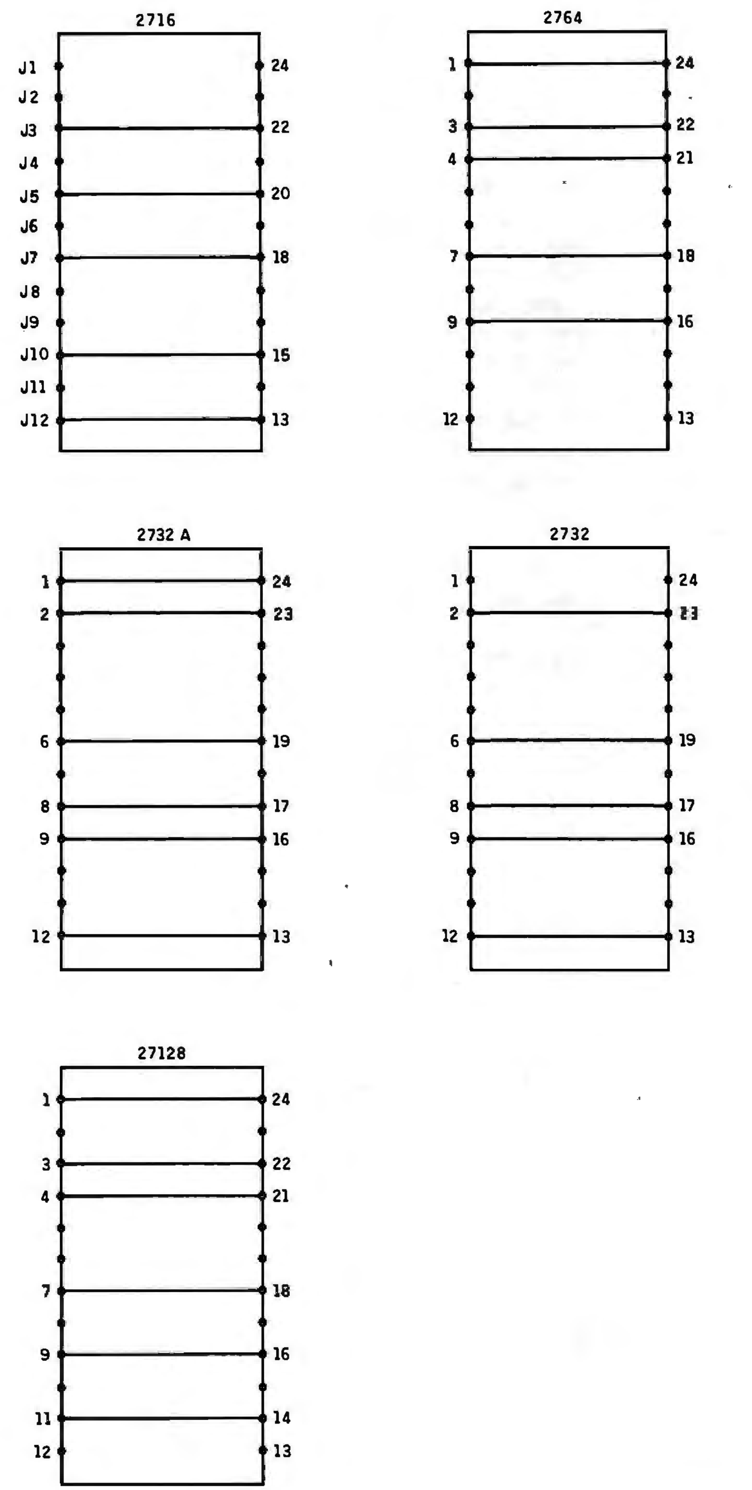

Figure 5: *Configuration jumpers.*

Figure 6 shows the programmable V_{pp} supply. The 2732A EPROM requires the programming voltage to be pulsed between 0 and 21 V, while a 2716 requires a pulse between 5 and 25 V. The supply is controlled by the jumper connections and the mode select line. With jumper #1 across R6, the supply is configured for a maximum V_{pp} level of 21 V. When it is removed, the supply has a maximum voltage of 25 V.

The minimum V_{pp} level is set by two jumper-selectable programming circuits, which are also connected to the regulator's output set point-adjust line. When jumper #2 is installed, a two-transistor circuit is enabled, which applies −1.2 V to the adjust line. The result is a 0-V output from the regulator. When jumper #3 is installed, the reference-adjust line is set to allow a +5-V regulator output.

Interacting with Hardware

The operation of the serial programmer should become clear by following an example of a write operation followed by a read operation. This is the sequence that would necessarily occur during a standard write-and-verify cycle.

First, the EPROM programmer is cleared and set to the read mode by the power-on reset pulse (which can be generated by pressing a button or by turning the programmer on) so that it is ready to receive the first character. If we plan a write cycle, the first character must contain a logic 1 in bit 8 to activate the write mode. The upper 3 to 6 bits of the EPROM address (the page address that depends on the size of the EPROM) must also appear in the first 3 to 6 bits (bit 0 through bit 5) of this first character. Each character of data to be programmed into the EPROM is sent to the programmer as a 4-byte transmission with the programming address specified each time.

Table 2 indicates the allowable bit patterns for this first character received by the programmer.

For our example, assume that the

data byte C3 (hexadecimal) is to be written into the first byte of page 4 in the EPROM. In this case, the first character received by the programmer should be 1x000100. The receipt of this character pulses IC2 and latches the page address and mode select bit into the page/mode latch, IC3. The mode select bit selects the EPROM for a write cycle, turns on the V_{PP} supply to the EPROM, releases the reset line on the timer, activates the output enable line of the data latch, and shuts off the transmission gate of the UART.

The second character sent contains the lower 8 address bits for the EPROM. To program the first location in page 4, the rest of the address must then be 00000000. This character sets the second stage of the counter and latches the lower address location into the lower address latch, IC4.

The third character, 11000011 (C3 hexadecimal), contains data to be programmed into the EPROM. When this character is received, the counter latches the data into the data latch, IC5.

The fourth character sent is a dummy character that may contain any value. This fourth and last character simply clocks IC2 and triggers the 50-ms programming pulse. When the one-shot times out, the programmer is still in the write mode. It has to be set to the read mode by initiating a read cycle.

The four characters sent in our present example of a write sequence are 1x000100, which sets the write mode and upper address; 00000000, which sets the lower address; 11000011, which sets the data byte (C3 hexadecimal); and xxxxxxxx, dummy data.

The read sequence is similar to the write sequence. The first character

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Table 2: *Allowable bit patterns.*

Page	Write Mode	Read Mode
0	1x000000	0x000000
1	1x000001	0x000001
2	1x000010	0x000010
3	1x000011	0x000011
4	1x000100	0x000100
5	1x000101	0x000101
6	1x000110	0x000110
7	1x000111	0x000111
.	.	.
.	.	.
64	1x111111	0x111111

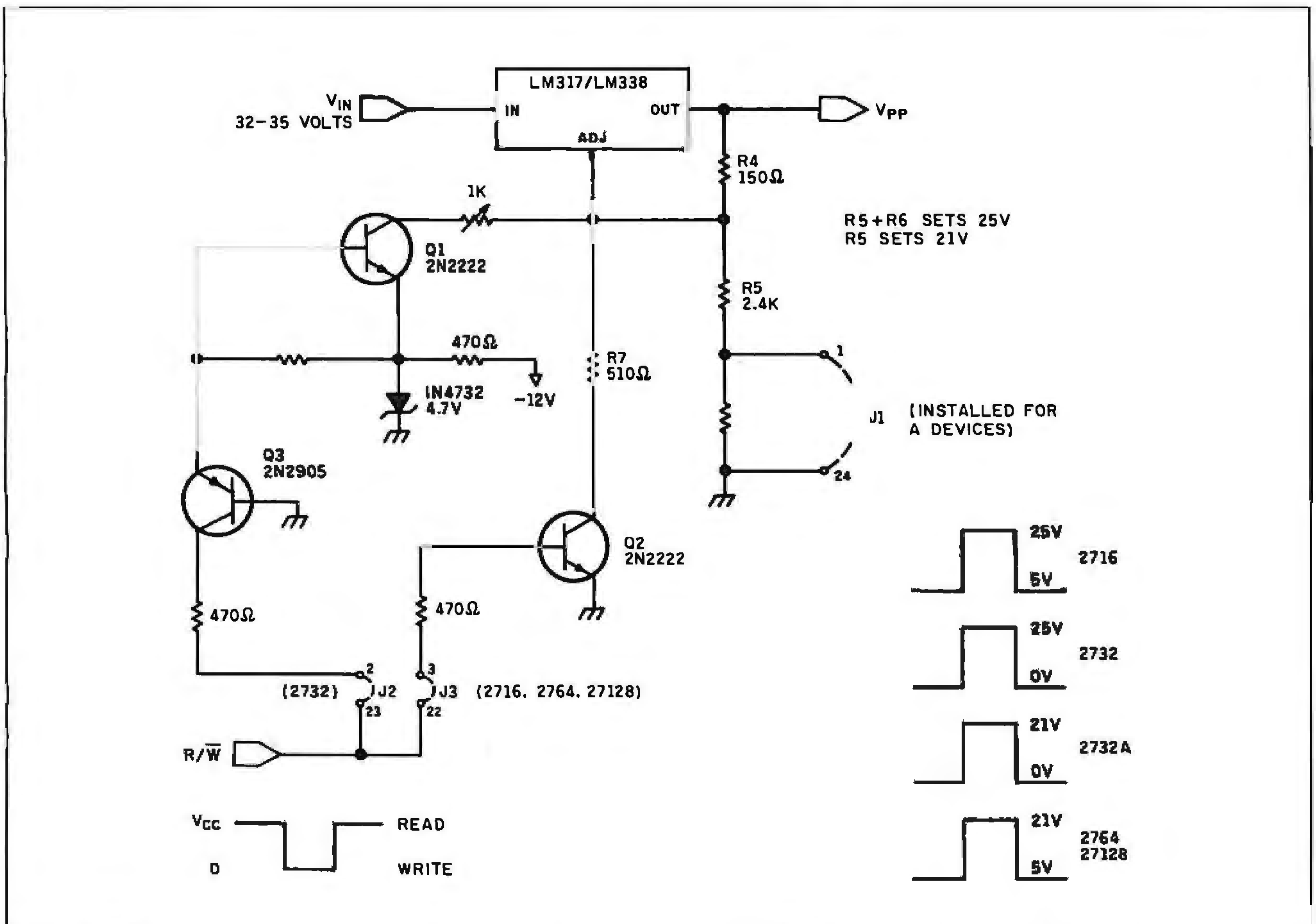


Figure 6: *Close-up of the programmable* V_{PP} *supply.*

sent again contains the upper bits of the address, but bit 8 is now set to logic 0 to put the mode select line high (read mode). A logic 1 on the read/write line deactivates the programming one-shot and tristates the data latch, IC5.

Again, the first character is latched into the page/mode latch, and the second character is latched into the lower address latch. With IC5 tristated, the EPROM's data output is placed on the UART transmitter bus. The third character is a dummy character that is used to clock IC2. This signal causes the UART to transmit the data on the transmitter bus to the computer. The fourth character is then sent to the programmer to reset the counter.

The four characters that must be sent in the verify sequence of our example are 0x000100, which sets the read mode and upper page address; 00000000, which sets the lower address; xxxxxxxx, which gets the data byte from the EPROM (C3 hexadecimal); and xxxxxxxx, which resets the programmer.

PROGRAMMER SOFTWARE

The driver program shown in listing 1 could have been written in any language that supports input and output ports. [*This program is available for downloading from* BYTEnet *Listings at* (603) 924-9820. *You can also receive it by sending an* IBM PC-*formatted disk and return postage to* Steve Ciarcia.] BASIC was chosen because it has wide appeal in the personal computer field and because most systems with serial I/O ports support BASIC. The software (flow-diagramed in figure 7) was written specifically for the IBM PC but can be easily modified to conform to most other systems that also support Microsoft BASIC. The program was written with a short MAIN program module that calls a number of subroutine modules. This modular approach makes modifying, debugging, or ex-

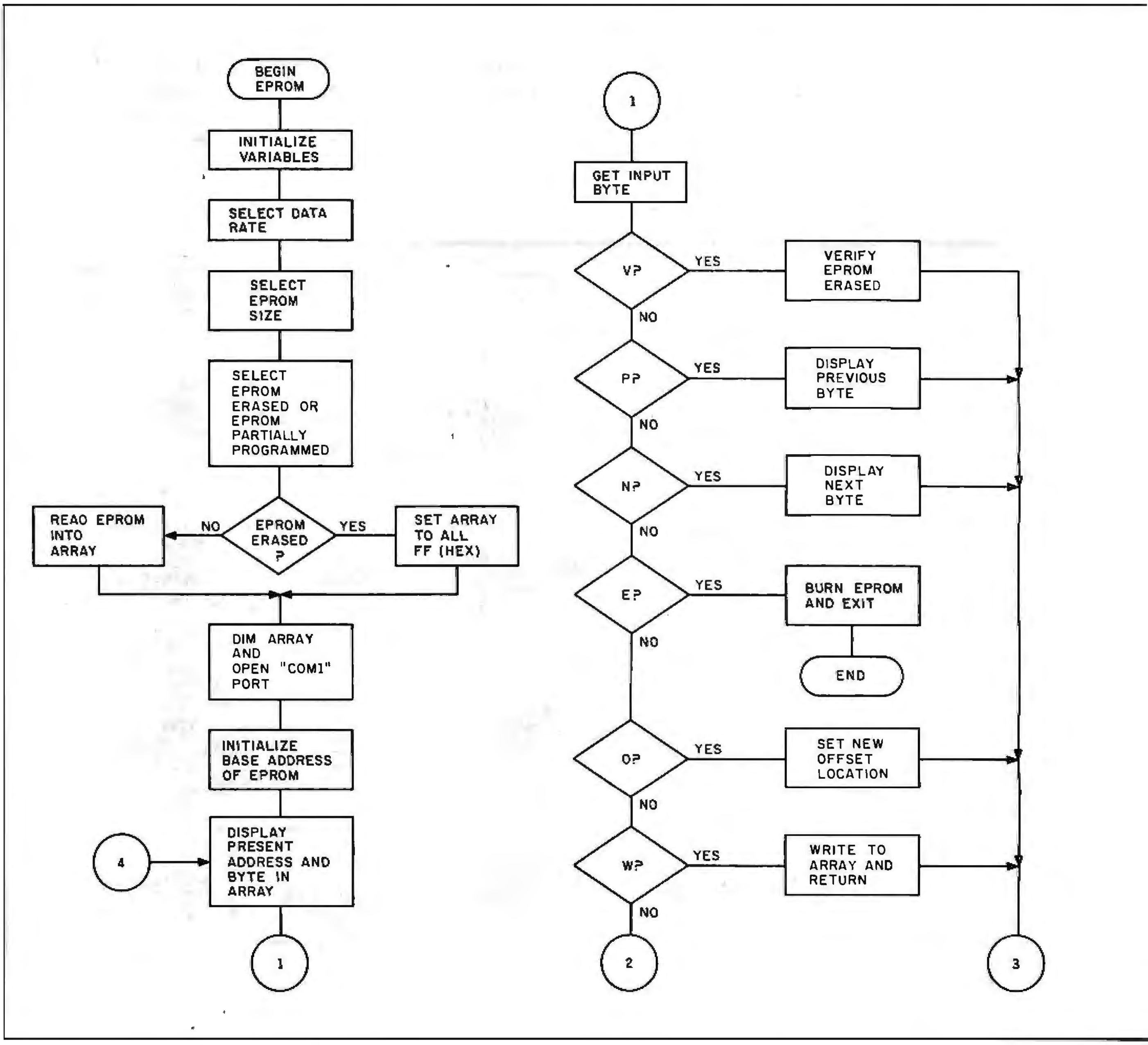


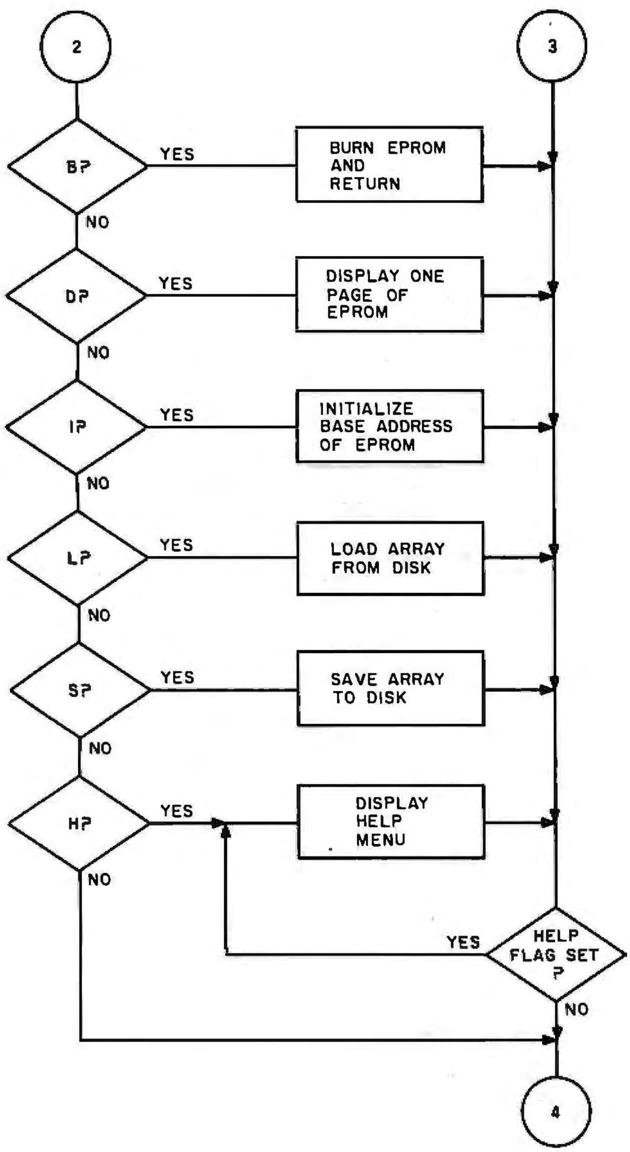
Figure 7: A *flowchart of the driver program.*

panding the software a much easier task. Examining the driver software should provide enough understanding so that any additions or changes desired can be easily implemented.

The program modules that access the serial port are labeled READ A BYTE and WRITE A BYTE in listing 1. These sections contain the only software modules that are hardware-dependent and that need to be configured to your particular system.

The WRITE module performs the actual program burn of the data into the EPROM. The first statement sends the page address to the serial port with the value of bit 8 set to 1. This is accomplished by combining the page address with the value 128 (10000000 binary). The page address is calculated elsewhere in the program before entering this module. The next statement sends the lower address contained in the variable BYTE to the serial port. This value is also calculated by the program prior to entering the WRITE module.

The statement "PRINT #3,DATUM" sends the data to be written into the EPROM to the serial port. The last statement in the WRITE module is a timing loop that causes the program to pause while the 50-ms timer in the serial-port programmer times out.



The READ module requests a data byte from the programmer and receives the byte from the serial port. It accomplishes this by sending a page address and byte address to the serial port as in the WRITE module. In this case, bit 8 of the page address is set to 0 to inform the programmer that a read cycle is being performed. The next two lines send a dummy data value and a strobe to the serial port to complete the read sequence. The values of DUMMY and STROBE are set in the INITIALIZATION module. The data sent by the serial-port programmer is received in the variable RDATA.

Once these modules have been configured to your system, it is a simple matter to write and read data from the programmer. Simply define the PAGE and BYTE address variables along with the DATUM value and send them to your serial port by calling the appropriate module. The rest of the program in listing 1 shows methods for doing this.

The approach used in the program is to place any data to be programmed into the EPROM in an array so that it can be reviewed and edited prior to burning it permanently into the EPROM. The array name is appropriately called ARRAY( ). The high-order byte of every element in ARRAY() stores a flag bit indicating that the lower-order byte of the element is data to be programmed. This method allows the program to write to only those locations in the EPROM where a valid data value has been entered in ARRAY().

Each time a data value is put into ARRAY(), the value is combined with 256 to set the flag. When it is time to send all the data to the EPROM, the flag is checked in each element, and only those elements with the flag bit set are sent to the EPROM. This process is repeated until all the flagged elements have been programmed. The initial values for ARRAY() are taken directly from the EPROM by reading each location and storing the values in ARRAY().

Several methods of entering data into ARRAY() are used in the program. One method is to enter each data value directly from the keyboard; another method is to fill ARRAY() by reading an already-programmed EPROM. Finally, a disk file previously

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Listing 1: EPROM *programmer routines.*

```
1000 REM  ===============================
1010 REM                SERIAL EPROM PROGRAMMER
1020 REM                          written in
1030 REM             MICROSOFT BASIC for the IBM PC
1060 REM  ===============================
1070 REM INITIALIZATION ROUTINE
1090 KEY OFF
1100 LINE25$="BAUD RATE=\  \EPROM=\  \ BASE PAGE=\  \"
1110 BR$="0000":EP$=BR$:BP$=BR$
1120 DEFINT A-Z:ON ERROR GOTO 4600
1130 STROBE=255:DUMMY=255:PAGE=0:BYTE=0:DATUM=255
1140 K$="VPNEOWHDIBSL":FORMAT$="PAGE=\\  BYTE=\\  DATA=\\"
1150 MIMAGE=0:MCRADDR=&H3FC:DELAY=100
1160 REM  ===============================
1170 REM MAIN BODY OF PROGRAM — KEYBOARD SEQUENCE
1190 GOSUB 2250
1200 PRINT"========== SERIAL EPROM PROGRAMMER =========="
1210 PRINT"                          BAUD-RATE SELECTION"
1230 PRINT"The SERIAL PORT programmer can operate at several different baud"
1240 PRINT"rates. Select the baud rate for your system from the list below:"
1260 PRINT"     (1) 300 baud"
1270 PRINT"     (2) 600 baud"
1280 PRINT"     (3) 1200 baud"
1290 PRINT"     (4) 2400 baud"
1300 PRINT"     (5) 4800 baud"
1310 PRINT"     (6) 9600 baud"
1330 PRINT"Enter the number of your selection —> ";:BAUD$=INPUT$(1)
1340 PRINT BAUD$:BAUD=VAL(BAUD$):IF BAUD>0 AND BAUD<7 THEN 1360
1350 PRINT"<<<<< BAUD-RATE SELECTION ERROR >>>>>": GOTO 1330
1360 BR$=STR$(300*2^(BAUD-1))
1370 GOSUB 2250
1380 PRINT"========== SERIAL EPROM PROGRAMMER =========="
1390 PRINT"                          EPROM-TYPE SELECTION"
1410 PRINT"The SERIAL EPROM programmer has the ability to program several"
1420 PRINT"different EPROMS. Select the type of EPROM from the list below:"
1440 PRINT"     (1) 2716"
1450 PRINT"     (2) 2732/2732A"
1460 PRINT"     (3) 2764"
1470 PRINT"     (4) 27128"
1490 PRINT"Enter the number of your selection —> ";:ESIZE$=INPUT$(1)
1500 PRINT ESIZE$:ESIZE=VAL(ESIZE$):IF ESIZE>0 AND ESIZE<5 THEN 1520
1510 PRINT "<<<<< EPROM-TYPE ERROR >>>>>":GOTO 1490
1520 DSIZE=1024*2^ESIZE:PAGES=DSIZE/256
1530 EP1$=STR$(16*2^(ESIZE-1))
1540 EP$="27"+RIGHT$(EP1$,LEN(EP1$)-1)
1550 DIM ARRAY(DSIZE)
1560 GOSUB 2250:GOSUB 4790:GOSUB 2250
1570 PRINT "========== SERIAL EPROM PROGRAMMER =========="
1580 PRINT "                          CONDITION OF EPROM"
1600 PRINT"If the EPROM you are programming is fully erased then select"
1610 PRINT"'EPROM ERASED' from the selection list below. This will save"
1620 PRINT"the time required to read the EPROM into memory. If the EPROM"
1630 PRINT"has been partially programmed then select 'PARTIALLY PROGRAMMED'"
1640 PRINT"and the EPROM will be read into memory prior to programming."
1660 PRINT"    (1) EPROM ERASED"
1670 PRINT"    (2) EPROM PARTIALLY PROGRAMMED"
1690 PRINT"Enter the number of your selection —> ";:ERA$=INPUT$(1)
1700 PRINT ERA$:PRINT:ERA=VAL(ERA$):IF ERA=2 THEN 1740
1710 IF ERA<> 1 THEN PRINT"<<<<< SELECTION ERROR >>>>>":GOTO 1690
1720 PRINT"<<<<< INITIALIZING MEMORY — PLEASE WAIT >>>>>"
1730 FOR I=0 TO DSIZE-1:ARRAY(I)=255:NEXT I
1740 ON BAUD GOTO 1750,1760,1770,1780,1790,1800
1750 OPEN "COM1:300,n,8,1,rs,cs,ds" AS #3:GOTO 1810
1760 OPEN "COM1:600,n,8,1,rs,cs,ds" AS #3:GOTO 1810
1770 OPEN "COM1:1200,n,8,1,rs,cs,ds" AS #3:GOTO 1810
1780 OPEN "COM1:2400,n,8,1,rs,cs,ds" AS #3:GOTO 1810
1790 OPEN "COM1:4800,n,8,1,rs,cs,ds" AS #3:GOTO 1810
1800 OPEN "COM1:9600,n,8,1,rs,cs,ds" AS #3
1810 GOSUB 2250
1820 PRINT "========== SERIAL EPROM PROGRAMMER =========="
1830 PRINT "                          BASE-PAGE INITIALIZATION"
1850 PRINT"The SERIAL EPROM programmer is driven by a keystroke-oriented"
1860 PRINT"program. The keys are defined in a HELP menu. This help menu"
1870 PRINT"can be displayed at any time by typing the letter (H) after"
1880 PRINT"the program has been initialized."
1890 PRINT:PRINT
1900 PRINT"To initialize the program you must enter the base page"
1910 PRINT"address of the EPROM. This address is generally a HEXADECIMAL value"
1920 PRINT"corresponding to the beginning page of an even 2K-byte boundary."
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1930 PRINT"For example 00,08,B0,B8,etc."
1950 GOSUB 3770:REM                          SET BASE ADDRESS
1960 IF HFLAG=1 THEN HFLAG=0:GOTO 1950
1970 IF ERA=1 THEN 2000
1980 PRINT"A MEMORY IMAGE OF YOUR EPROM IS BEING MADE"
1990 GOSUB 3890:REM                          MAKE MEMORY IMAGE
2000 GOSUB 2880:REM                          DISPLAY HELP MENU
2010 PRINT:PRINT
2020 PRINT"YOUR PRESENT LOCATION IS:"
2030 GOSUB 2320:REM                          READ AND DISPLAY DATA
2040 PRINT"COMMAND —>";
2050 IKEY$=INPUT$(1)
2060 IF IKEY$>="a" AND IKEY$<="z" THEN IKEY$=CHR$(ASC(IKEY$) AND 95)
2070 K=INSTR(K$,IKEY$):IF K=0 THEN PRINT "WHAT ?";:GOTO 2050
2080 HFLAG=0
2090 ON K GOSUB 3430,2380,2440,2160,2500,2660,2880,3550,3760,3980,4240,4400
2100 REM        V   P   N   E   O   W   H   D   I   B   S   L
2110 IF HFLAG=1 THEN GOSUB 2880
2120 IF HFLAG=1 OR IKEY$="H" THEN 2010 ELSE 2030
2130 REM  ======================================
2140 REM BURN EPROM AND END OPTION
2160 GOSUB 3980
2170 IF IKEY$<>"N" THEN RETURN
2180 CLOSE:END
2190 REM  ======================================
2200 REM MAIN BODY ENDS HERE — SUBROUTINE MODULES FOLLOW
2220 REM  ======================================
2230 REM DISPLAY STATUS LINE
2250 CLS:LOCATE 25,1:PRINT USING LINE25$;BR$,EP$,BP$;
2260 PRINT "COMMANDS: ";K$
2270 LOCATE 3,1,1:RETURN
2280 REM  ======================================
2300 REM DISPLAY LOCATION AND DATA
2320 RDATA=ARRAY(PAGE*256+BYTE) AND 255:REM        GET DATUM FROM ARRAY
2330 PRINT USING FORMAT$;HEX$(BIAS+PAGE),HEX$(BYTE),HEX$(RDATA)
2340 RETURN
2350 REM  ======================================
2360 REM DECREMENT ADDRESS
2380 IF PAGE=0 AND BYTE=0 THEN RETURN ELSE BYTE=BYTE-1
2390 IF BYTE=-1 THEN PAGE=PAGE-1:BYTE=255
2400 RETURN
2410 REM  ======================================
2420 REM INCREMENT ADDRESS
2440 IF PAGE=PAGES-1 AND BYTE=255 THEN RETURN ELSE BYTE=BYTE+1
2450 IF BYTE=256 THEN PAGE=PAGE+1:BYTE=0
2460 RETURN
2470 REM  ======================================
2480 REM OFFSET TO NEW STARTING ADDRESS
2500 ADD$="":PRINT:PRINT"ENTER NEW LOCATION IN HEXADECIMAL (hhhh) —> ";
2510 L$=INPUT$(1):PRINT L$;
2520 IF L$>= "a" AND L$<="z" THEN L$=CHR$(ASC(L$) AND 95)
2530 IF L$="H" THEN HFLAG=1:RETURN
2540 IF L$="Q" THEN PRINT:RETURN
2550 ADD$=ADD$+L$:IF LEN(ADD$)=4 THEN PRINT ELSE 2510
2560 PAGE$=LEFT$(ADD$,2):BYTE$=RIGHT$(ADD$,2)
2570 CON$=PAGE$:GOSUB 3110:IF SUM=-1 THEN 2500
2580 PAGE=SUM-BIAS
2590 IF PAGE>PAGES-1 OR PAGE<0 THEN PRINT"<<<<< OUT OF RANGE >>>>>":GOTO 2500
2600 CON$=BYTE$:GOSUB 3110:IF SUM=-1 THEN 2500
2610 BYTE=SUM
2620 RETURN
2630 REM  ======================================
2640 REM WRITE TO ARRAY — BYTE BY BYTE
2660 XFLAG=0:DATUM$="":PRINT"<<< WRITE MODE >>>  ENTER DATA IN HEXADECIMAL (hh) —> ";
2670 D$=INPUT$(1):PRINT D$;
2680 IF D$>="a" AND D$<="z" THEN D$=CHR$(ASC(D$) AND 95)
2690 IF D$="H" THEN HFLAG=1:RETURN
2700 IF D$="Q" THEN PRINT:RETURN
2710 IF D$="X" THEN XFLAG=1:DATUM$="":GOTO 2670
2720 DATUM$=DATUM$+D$:IF LEN(DATUM$)<>2 THEN 2670
2730 PRINT:CON$=DATUM$:GOSUB 3110:DATUM=SUM
2740 IF SUM=-1 THEN 2660
2750 IF (ARRAY(PAGE*256+BYTE) AND 255)<>255 AND XFLAG=0 THEN 2830
2760 DATUM=DATUM OR 256:REM                   TAG LOCATION AS WRITTEN TO
2770 ARRAY(PAGE*256+BYTE)=DATUM:REM           WRITE DATUM TO ARRAY
2780 GOSUB 2320:REM                           DISPLAY WRITE TO ARRAY
2790 IF BYTE=255 AND PAGE=PAGES-1 THEN RETURN
2800 GOSUB 2440:REM                           INCREMENT ADDRESS
2810 GOSUB 2320:REM                           DISPLAY NEXT LOCATION
2820 GOTO 2660
```

(continued)

```
2830 PRINT:PRINT"<<<<<< ILLEGAL WRITE TO PREVIOUSLY PROGRAMMED LOCATION >>>>>>"
2840 RETURN
2850 REM ==================================================
2860 REM HELP ROUTINE
2880 GOSUB 2250:REM                                    CLEAR SCREEN
2890 PRINT"To initialize the program you should enter the beginning page"
2900 PRINT"address of the EPROM to be programmed. This value is used when"
2910 PRINT"printing to the screen and as a bias value in the write modes."
2920 PRINT"The following single-letter commands are used to control the"
2930 PRINT"modes of the EPROM programmer:":PRINT
2940 PRINT"     (I) INITIALIZE BASE-PAGE ADDRESS — base address is ";BIAS$;"00"
2950 PRINT"     (V) VERIFY ERASURE"
2960 PRINT"     (N) DISPLAY NEXT BYTE"
2970 PRINT"     (P) DISPLAY PREVIOUS BYTE"
2980 PRINT"     (O) OFFSET TO NEW PAGE AND BYTE"
2990 PRINT"     (L) LOAD ARRAY FROM DISK"
3000 PRINT"     (S) SAVE ARRAY ON DISK"
3010 PRINT"     (W) ENTER BYTE WRITE MODE          (use Q or H to exit, X to edit)"
3020 PRINT"     (D) HEXADECIMAL DUMP TO SCREEN"
3030 PRINT"     (B) ENTER 'BURN EPROM' MODE"
3040 PRINT"     (H) ENTER HELP MODE                (from any input statement)"
3050 PRINT"     (E) EXIT PROGRAM"
3060 RETURN
3070 REM ==================================================
3080 REM ***** CONVERT HEXADECIMAL TO DECIMAL *****
3090 REM ENTER WITH HEXADECIMAL STRING IN CON$, EXIT WITH DECIMAL VALUE IN SUM
3110 SUM=0
3120 FOR I=1 TO LEN(CON$)
3130   X=ASC(MID$(CON$,(LEN(CON$)+1-I),1))
3140   IF X<48 OR X>70 THEN SUM=-1:I=LEN(CON$):GOTO 3190
3150   IF X>57 AND X<65 THEN SUM=-1:I=LEN(CON$):GOTO 3190
3160   IF X<64 THEN X=X-48 ELSE X=X-55
3170   SUM=SUM+(X*16^(I-1))
3180   IF SUM>255 OR SUM<0 THEN SUM=-1
3190   IF SUM=-1 THEN PRINT"<<<<< INPUT ERROR >>>>>"
3200 NEXT I:RETURN
3210 REM ==================================================
3220 REM WRITE A BYTE
3240 WPAGE=PAGE OR 128:REM                     SET WRITE PAGE (W/R=1)
3250 PRINT #3,CHR$(WPAGE);:REM                 SEND WRITE PAGE
3260 PRINT #3,CHR$(BYTE);:REM                  SET WRITE BYTE
3270 PRINT #3,CHR$(DATUM);:REM                 DATA TO WRITE
3280 PRINT #3,CHR$(STROBE);:REM                WRITE STROBE
3290 FOR DEL=1 TO DELAY:NEXT DEL:REM           WRITE DELAY
3300 RETURN
3310 REM ==================================================
3320 REM READ A BYTE
3340 PRINT #3,CHR$(PAGE);:REM                  SET READ PAGE (W/R=0)
3350 PRINT #3,CHR$(BYTE);:REM                  SET READ BYTE
3360 PRINT #3,CHR$(DUMMY);:REM                 DUMMY DATA SENT
3370 PRINT #3,CHR$(STROBE);:REM                READ STROBE
3380 RDATA=ASC(INPUT$(1,#3)):REM               INPUT DATA
3390 RETURN
3400 REM ==================================================
3410 REM VERIFY ERASURE
3430 PRINT:PRINT"VERIFYING THAT EPROM IS ERASED":PRINT
3440 BYTE=0:PAGE=0
3450 FOR PAGE=0 TO PAGES-1:V$=" OK"
3460   FOR BYTE=0 TO 255
3470     IF (ARRAY(PAGE*256+BYTE) AND 255)=255 THEN 3490
3480     V$="<<<<<< NOT ERASED >>>>>>"
3490   NEXT BYTE:PRINT"PAGE";PAGE;V$
3500 NEXT PAGE
3510 BYTE=0:PAGE=0:RETURN
3520 REM ==================================================
3530 REM DUMP TO SCREEN
3550 GOSUB 2250
3560 FOR LN=1 TO 16
3570   DPAGE$=RIGHT$("0"+HEXADECIMAL$(BIAS+PAGE),2)
3580   DBYTE$=RIGHT$("0"+HEXADECIMAL$(BYTE),2)
3590   PRINT USING"\\";DPAGE$;DBYTE$;": ";
3600   FOR D=1 TO 16
3610     DDATA$=RIGHT$("0"+HEXADECIMAL$((ARRAY(PAGE*256+BYTE) AND 255)),2)
3620     PRINT USING"\\";DDATA$;
3630     IF PAGE=PAGES-1 AND BYTE=255 THEN D=16:LN=16
3640     GOSUB 2440:IF BYTE MOD 16=0 THEN PRINT:D=16
3650   NEXT D
3660 NEXT LN:PRINT:PRINT
3670 IF PAGE=PAGES-1 AND BYTE=255 THEN PRINT"<<<<<< END OF EPROM >>>>>":RETURN
3680 PRINT"ENTER (C) TO CONTINUE OR (Q) TO EXIT DUMP —> ";:IKEY$=INPUT$(1)
3690 IF IKEY$>="a" AND IKEY$<="z" THEN IKEY$=CHR$(ASC(IKEY$) AND 95)
```

```
3700 PRINT IKEY$:PRINT:IF IKEY$="C" THEN 3560
3710 IF IKEY$="H" THEN HFLAG=1:RETURN
3720 IF IKEY$="Q" THEN RETURN ELSE 3680
3730 REM  ====================================
3740 REM SET BIAS ADDRESS
3760 GOSUB 2250
3770 BIAS$=" ":PRINT:PRINT"ENTER BASE-PAGE ADDRESS IN HEXADECIMAL (hh) —> ";
3780 B$=INPUT$(1):PRINT B$;
3790 IF B$>="a" AND B$<="z" THEN B$=CHR$(ASC(B$) AND 95)
3800 IF B$="H" THEN HFLAG=1:RETURN
3810 IF B$="Q" THEN PRINT:RETURN
3820 BIAS$=BIAS$+B$:IF LEN(BIAS$)<>2 THEN 3780
3830 PRINT
3840 CON$=BIAS$:GOSUB 3110:BIAS=SUM:PRINT:PRINT:IF SUM=-1 THEN 3770
3850 PAGE=0:BYTE=0:BP$=BIAS$+"00":GOSUB 2250:RETURN
3860 REM  ====================================
3870 REM READ EPROM TO ARRAY
3890 PAGE=0:BYTE=0:GOSUB 2250
3900 GOSUB 3340
3910 ARRAY(PAGE*256+BYTE)=RDATA:IF BYTE=0 THEN PRINT"READING PAGE";PAGE
3920 BYTE=BYTE+1:IF BYTE=256 THEN PAGE=PAGE+1:BYTE=0
3930 IF PAGE<=PAGES-1 THEN 3900
3940 PRINT:PAGE=0:BYTE=0:RETURN
3950 REM  ====================================
3960 REM WRITE ARRAY TO EPROM
3980 GOSUB 2250
3990 PRINT"<<<<<< BURN ALL PROGRAMMED BYTES ?? >>>>>>"
4010 PRINT"TYPE (Y) TO PROGRAM EPROM"
4020 PRINT"(Q) TO RETURN TO PROGRAM"
4030 PRINT"(H) TO DISPLAY HELP MENU"
4040 PRINT"(N) TO RETURN TO PROGRAM FROM 'BURN' MODE"
4050 PRINT"TO ABORT PROGRAM IN 'EXIT' MODE."
4060 PRINT:PRINT"ENTER SELECTION —> ";:IKEY$=INPUT$(1)
4070 PRINT IKEY$
4080 IF IKEY$>="a" AND IKEY$<="z" THEN IKEY$=CHR$(ASC(IKEY$) AND 95)
4090 IF IKEY$="N" THEN RETURN
4100 IF IKEY$="H" THEN HFLAG=1:RETURN
4110 IF IKEY$="Q" THEN PRINT:RETURN
4120 IF IKEY$<>"Y" THEN 3990
4130 FOR ADD=0 TO DSIZE
4140    DATUM=ARRAY(ADD):IF DATUM <256 THEN 4190
4150    DATUM=DATUM AND 255:BYTE=ADD MOD 256:PAGE=(ADD-BYTE)/256
4160    PRINT "BURNING ";:GOSUB 2320
4170    GOSUB 3240:GOSUB 3340
4180     IF RDATA<>DATUM THEN PRINT "<<<<<< DATA NOTVERIFIED >>>>>>"
4190 NEXT ADD
4200 PRINT:BYTE=0:PAGE=0:RETURN
4210 REM  ====================================
4220 REM SAVE ARRAY IN DISK FILE
4240 GOSUB 2250:PRINT"THE DISK FILE CREATED HERE WILL CONTAIN ALL THE DATA"
4250 PRINT"PRESENTLY CONTAINED IN YOUR EPROM MEMORY IMAGE AND"
4260 PRINT"WILL BE ASSIGNED THE FILE EXTENSION 'PRM'."
4270 PRINT"THE FOLLOWING IS A LIST OF EXISTING DISK FILES WITH"
4280 PRINT"THE FILE EXTENSION '.PRM'.":PRINT:PRINT
4290 FILES "*.PRM":PRINT:PRINT
4300 INPUT"ENTER THE FILENAME OF YOUR NEW DISK FILE —> ",FILENAME$
4310 IF FILENAME$="H" OR FILENAME$="h" THEN HFLAG=1:RETURN
4320 IF FILENAME$="Q" OR FILENAME$="q" THEN RETURN
4330 OPEN "O",#1,FILENAME$+".PRM"
4340 FOR I=0 TO DSIZE-1:PRINT #1,(ARRAY(I) AND 255);
4350    IF I MOD 256=0 THEN PRINT "SAVING PAGE";I/256
4360 NEXT I:CLOSE #1:RETURN
4370 REM  ====================================
4380 REM LOAD ARRAY FROM DISK
4400 GOSUB 2250:PRINT:PRINT"THE FOLLOWING IS A LIST OF FILENAMES WITH THE FILE"
4410 PRINT"EXTENSION '.PRM'":PRINT:PRINT
4420 FILES "*.PRM":PRINT:PRINT
4430 INPUT"ENTER A FILENAME FROM THE LIST ABOVE —>",FILENAME$
4440 IF FILENAME$="H" OR FILENAME$="h" THEN HFLAG=1:RETURN
4450 IF FILENAME$="Q" OR FILENAME$="q" THEN RETURN
4460 OPEN "I",#1,FILENAME$+".PRM"
4470 FOR I=0 TO DSIZE-1:INPUT #1,DATUM
4480    IF I MOD 256=0 THEN PRINT "LOADING PAGE";I/256
4490    IF DATUM=255 OR DATUM=(ARRAY(I) AND 255) THEN 4560
4500    IF ARRAY(I)<>255 THEN 4520
4510    ARRAY(I)=DATUM OR 256:GOTO 4560
4520    PRINT"<<<<<< ILLEGAL INPUT DATA FROM FILE >>>>>>"
4530    PRINT"<<<<<< ATTEMPT TO WRITE OVER PROGRAMMED LOCATION >>>>>>"
4540    PRINT"<<<<<< PROGRAM HAS BEEN ABORTED >>>>>>"
```

(continued)

```
4550   CLOSE#1:END
4560 NEXT I:CLOSE #1:RETURN
4570 REM  ======================================
4580 REM DISK-ERROR ROUTINE
4600 IF ERR=53 AND ERL=4290 THEN PRINT"NO PRM FILES":RESUME 4300
4610 IF ERR=53 AND ERL=4420 THEN PRINT"NO PRM FILES":GOTO 4670
4620 IF ERR=53 AND ERL=4460 THEN PRINT"UNKNOWN FILE":GOTO 4670
4630 IF ERR=61 THEN PRINT "DISK FULL":GOTO 4670
4640 IF ERR=57 THEN PRINT"RESET EPROM PROGRAMMER":GOTO 4670
4650 IF ERR=67 THEN PRINT"UNKNOWN FILENAME, DON'T TYPE '.PRM'":GOTO 4670
4660 CLOSE#1:PRINT "UNKNOWN ERROR #";ERR;"IN LINE #";ERL
4670 PRINT"PRESS ANY KEY TO CONTINUE --> ";:IKEY$=INPUT$(1):PRINT
4680 IF ERR=57 THEN RESUME 0
4690 HFLAG=1
4700 RESUME 2110
4710 ON ERROR GOTO 0
4720 REM  ======================================
4730 REM CONFIGURATION ROUTINE
4750 DATA 255,255,196,255,196,255,196,255,255,196,255,196
4760 DATA 026,196,255,255,255,196,255,196,196,255,255,196
4770 DATA 196,255,196,196,255,255,196,255,196,255,255,255
4780 DATA 196,255,196,196,255,255,196,255,196,255,196,255
4790 IF ESIZE=1 THEN RESTORE 4750
4800 IF ESIZE=2 THEN RESTORE 4760
4810 IF ESIZE=3 THEN RESTORE 4770
4820 IF ESIZE=4 THEN RESTORE 4780
4830 LOCATE 1,22:PRINT :"JUMPER CONFIGURATION"
4840 LOCATE 3,30:PRINT CHR$(201);CHR$(205);CHR$(205);CHR$(187)
4850 FOR I=4 TO 15
4860   LOCATE I,30:PRINT CHR$(199);"  ";CHR$(182);"J";I-3
4870 NEXT I
4880 LOCATE 16,30:PRINT CHR$(200);CHR$(205);CHR$(205);CHR$(188)
4890 FOR I=4 TO 15
4900   READ JUMPER
4910   LOCATE I,31:PRINT CHR$(JUMPER);CHR$(JUMPER)
4920 NEXT I
4930 LOCATE 4,38
4940 IF ESIZE=2 THEN PRINT"NOTE: INSTALL J1 FOR 2732A EPROMs"
4950 LOCATE 18,20:PRINT "If jumpers are not properly configured"
4960 LOCATE 19,20:PRINT "shut off programmer and set jumpers,"
4970 LOCATE 20,20:PRINT "then turn programmer back on."
4980 LOCATE 22,20:PRINT "Press any key to continue --> ";
4990 A$=INPUT$(1):RETURN
```

created with a SAVE command in the program can also be used to enter the data.

A help routine is provided in the program to assist the user during the operation of the programmer. It consists of a menu that contains all the choices available in the driver program. The routine can be entered from any location in the program by typing the letter H. A screen-dump routine and an EPROM erasure-verification routine are also provided.

In Conclusion

The serial-port EPROM programmer isn't designed for volume programming. It's intended to be a cost-effective, transportable programmer that doesn't become outmoded with each new computer and system bus. You'll also find, cleverly embedded in every programming cycle, enough time for you to take a well-deserved coffee break.

Circuit Cellar Feedback

This month's feedback begins on page 393.

Next Month

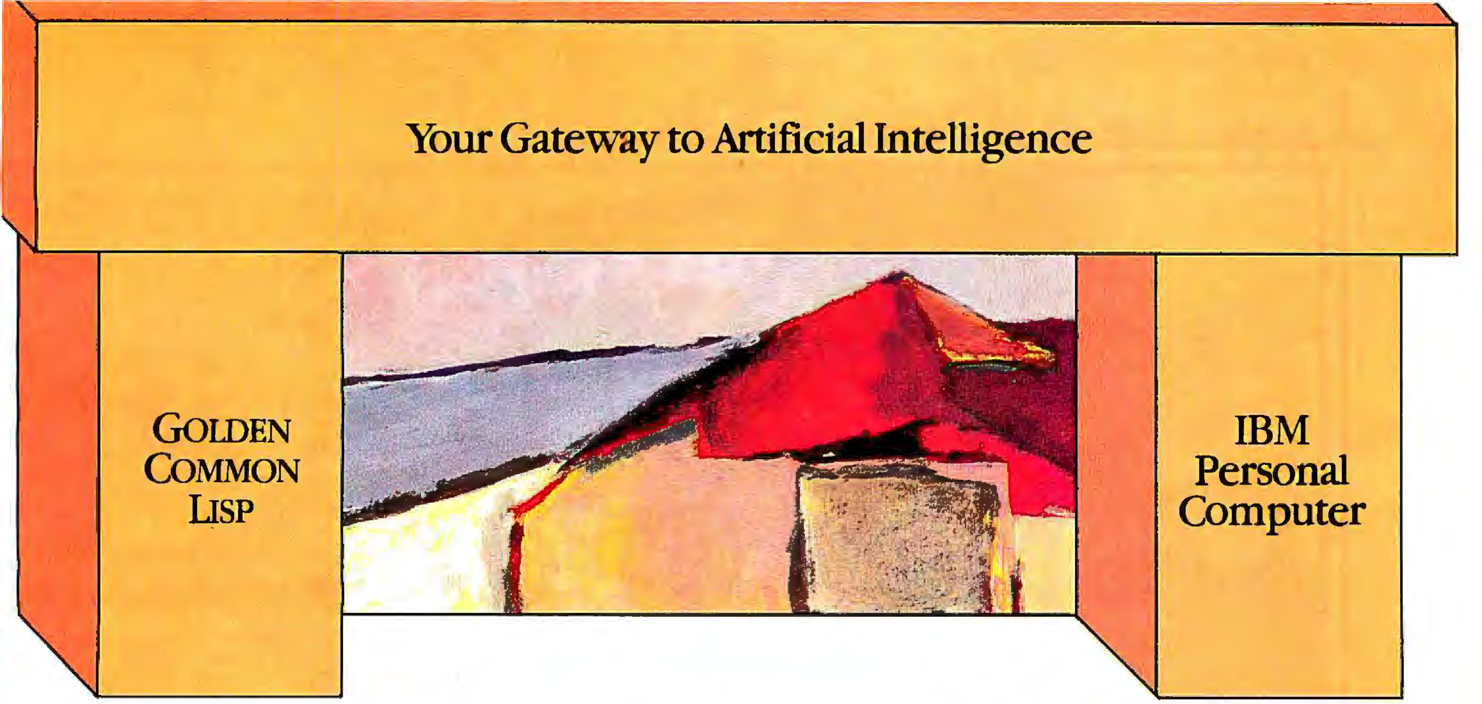
I've always been intrigued by home control and electronic messaging. In March, I'll tackle the subject in earnest, beginning with a Touch-Tone Interactive Message System. ■

Special thanks to Larry Bregoli for his software expertise.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in reprint books from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I covers articles that appeared in BYTE from September 1977 through November 1978. *Volume* II covers December 1978 through June 1980. *Volume* III covers July 1980 through December 1981. *Volume* IV covers January 1982 through June 1983.

To receive a complete list of Ciarcia's Circuit Cellar project kits, circle 100 on the reader-service inquiry card at the back of the magazine.



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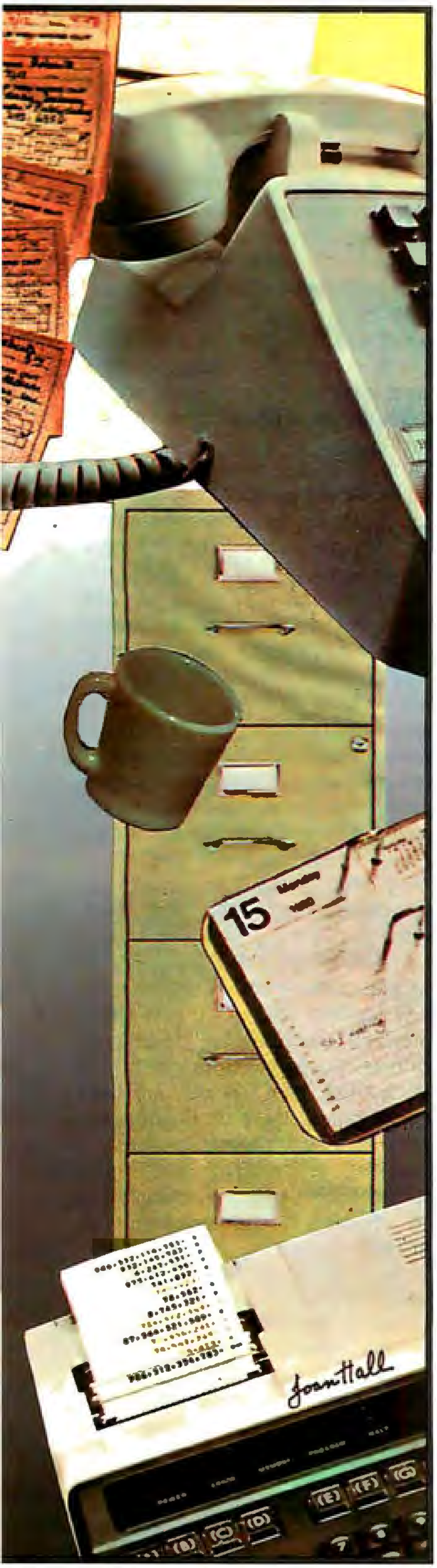

P·R·E·V·I·E·W

THE MACINTOSH OFFICE

BY JOHN MARKOFF AND PHILLIP ROBINSON

Editor's note: The following is a BYTE *product preview. It is not a review. We provide this advance look at this new product because we feel it is significant.*

ON THE FIRST ANNIVERSARY of the introduction of the Macintosh, Apple Computer has introduced AppleTalk, which is a new local-area network (LAN), and a series of intelligent networked peripherals, including a laser printer and file server. The company hopes these products will make the "Macintosh office" a popular choice for work groups in large and small corporations.

AppleTalk and the laser printer are scheduled to be shipped in March.

The network was developed to serve as a small-work-group interconnect system, as a tributary to larger high-speed local-area and long-haul networks, and, in its most basic form, as a peripheral bus between an Apple computer and dedicated peripheral devices.

The new Apple LAN concept is a radical departure from common industry thinking about LAN design (for

(continued)

John Markoff and Phillip Robinson (1000 Elwell Ct., Palo Alto, CA 94393) *are* BYTE *senior technical editors.*

ILLUSTRATED BY JOAN HALL

AppleTalk networks the Macintosh and a new laser printer.

more information on Apple's plans for the future see the text box "Steve Drops By" on page 124). Instead of providing a high-bandwidth channel to link personal computers to each other and to larger remote computers, Apple designed its LAN to be a low-speed, low-cost network for small work groups.

The AppleTalk architecture relies on the distribution of "intelligence" in network peripherals and on the clever use of the network's limited speed. Apple is betting that the principal barrier to networking office microcomputers has until now been cost. By focusing on an LAN that is optimized to share resources among small groups, the company hopes to achieve a better match to the organization of the typical office.

Since the introduction of the Macintosh, Apple has changed the name of its LAN from AppleBus to AppleTalk. When Apple first described the LAN, the company emphasized the network's role in providing the Macintosh with "virtual" serial slots for peripherals as an alternative to the open hardware architecture of the Apple II. As it is released, AppleTalk goes beyond this. However, you may still be able to daisy-chain peripherals by adding a smart network controller. But for now, Apple has decided to leave this option to third parties. One manufacturer, Tecmar Inc. has already demonstrated the ability of its 68000-based hard-disk system to control both an ImageWriter and an Apple modem.

Apple is moving toward putting microprocessors in all or most of its peripherals. This design philosophy, plus the standardization on the Zilog SCC (serial-communications controller) chip that is now used in the Lisa, Macintosh, and Apple IIc computers, will make the task of networking peripherals simpler.

At the time of AppleTalk's introduction, Apple is only demonstrating the LAN with a *prototype* 20-megabyte intelligent file-server hard-disk system, which you will need for network applications such as electronic mail and print spooling. However, we were told that the hard disk will be announced in August 1985 and it will cost $3500. An electronic-mail communications package for AppleTalk is also scheduled to be announced at the same time.

The company is also discussing a variety of future network products such as a bridge to link individual AppleTalk networks, an interface to the recently announced IBM PC LAN, communication servers, network databases, and as many as 50 third-party hardware and software development projects based on AppleTalk. Details of these products aren't yet available; therefore, it is difficult to assess AppleTalk at present. But after several false starts at developing a LAN, Apple is moving toward making it possible to link its products in office and other workplace settings.

APPLETALK

The heart of AppleTalk is the Macintosh serial-communications chip, a two-channel Zilog 8530 SCC that provides synchronous and asynchronous data communications at up to 230.4K bits per second (bps) using a self-clocking data format. (The 8530 will provide data communications at speeds as high as 1 megabit per second, using an external clock. Corvus Systems Inc. has also used this higher-speed scheme in its Macintosh implementation of the Omninet LAN.)

At the physical level, AppleTalk consists of a shielded twisted-pair trunk cable with modules that are passively connected to computer and peripheral nodes via a short drop cable. An individual AppleTalk network can have up to 32 nodes and has a packet-switching protocol and a data rate of 230.4K bps using FM 0 modulation (a bit-encoding technique that provides self-clocking) over a maximum distance of 300 meters.

Externally, AppleTalk is simple, consisting of the connection modules, each of which has two miniature DIN three-pin connectors, and a DB-9 port that connects to the printer port on the Macintosh via a 2-meter cable. Inside each connection module are resistors, a capacitor, and a small transformer, designed so that the link is transformer-isolated and not susceptible to any kind of radio-frequency interference (RFI) or static discharge.

Apple calls the connector modules self-terminating, which keeps you from worrying about line termination and, in combination with the transformer, lets you add nodes to the network and remove them without disrupting network functions. A 100-ohm terminating resistor is included in each connector box, and there are two switch connections that are opened when the miniature DIN connectors are inserted. If both connectors are used, the switches are open, but if one of the connectors is not used, the terminating resistor is connected across the line.

AppleTalk uses a dynamic-addressing scheme that ensures that each node on the network has a unique 8-bit address (there is also a mechanism for internet communications across bridges and through gateways). The AppleTalk destination address is used to "filter" frames at the data-link layer. Frames are not accepted unless their destination address matches the address of the receiving node. The SCC chip facilitates this process by performing the address-recognition function in hardware.

AppleTalk doesn't require that a particular node's address be permanently recorded or set with jumpers. The advantage of this is that you can move computers and peripherals between networks and install them by simply attaching them to the network. For example, Apple claims you can bring your Macintosh to the network, plug it in, insert a disk, and turn it on. No special network configuration is necessary. Setting of the node address takes place when the computer first looks at some nonvolatile memory to find a previous address it has saved, or when it computes a new address based on the generation of a pseudorandom number. The computer then tests the address to see if it already exists on the network by sending a special packet to the address. If the address is already in use, the node there will answer and a new guess must be gen-

(continued)

STEVE DROPS BY

We met Burrell Smith and Bud Tribble and the rest of the Macintosh office design crew in the Macintosh headquarters, one of the many Apple buildings in Cupertino, California. After moving beyond the lobby, we heard someone play a pretty piece of music on a grand piano in the center of a large open area that also had sofas and a Ping-Pong table. On the left was the Matisse room; we used the Picasso room on the right. During the introduction, someone mentioned that Steve would drop by later. When Steve Jobs did drop by, he had some interesting things to say about Apple's plans and strategy.

"We hope to be able to offer people two things based on the Macintosh technology. The first, using the graphics and the power of that box, is radical ease of use. That was the first benefit of the Macintosh and that's the one we've really been trumpeting this last year.

"We are just now beginning to demonstrate the second great benefit of that graphic user interface—capabilities that you can't do on any other computer. You can't do the kind of project management you can do on Mac, you can't do stuff you can do with MacDraw, you can't print out entire forms or create forms on other computers. It will take something like the LaserWriter to really drive that home. As we roll out the next pieces that complement the workstation, I think it's going to become very clear to people why the graphic user interface is so important.

"Ultimately, we think that these products are going to be used to help people communicate with each other. Not analysis, not computationally intensive things for their own sake, but things to help people communicate much as the telephone did. And in terms of communication, look at middle-manager productivity in particular. Yes, we collect information, we analyze it, but then we draw conclusions from it and we need to communicate those conclusions to people around us.

"We communicate in two ways. One, with paper, and the paperless office, which generates more paper than the traditional office; we've all found that out because we give people tools that generate the paper. So we've got to improve the quality of visual communication, improve the ability to communicate via paper. That includes overhead transparencies, which I think are going to be a big use for the printer. We can do that through the software tools on the Mac and through the ability to print them.

"The next way that we can radically improve communication is to electronically link up people. We can start to do things like mail, electronic scheduling, and a variety of things that will improve how we communicate with each other. The result of improving those two ways of communication, I think, is going to be startling, when coupled with the fact that you can learn how to use the system in a half hour.

"I also think we're holding true to our vision of trying to remove the service and support requirements from the equation of success so that we don't have to send out a person at a thousand dollars per half day to help you install your computer system.

"AppleTalk plugs together and you don't have a chance to forget to hook up the terminator plugs because there aren't any, and you don't have to set the thumb-wheel switches because there aren't any, and you don't have to run the network master-configuration program because there isn't any. You just plug it together like a telephone or stereo and it works. And its very, very difficult to do wrong. Those little things are what keep you from having to go out and hold people's hands, run them through half-day training courses, and things like that.

"We think that networking is going to start from the bottom up in small work groups. If you've got four people on the network, which is a typical number to start with, it will cost $150 per person for the head end. So you've got to have about $1000 to hook up a computer to the net. It may be worth it someday when there's a lot of great software. But, right now not many are going to pay a thousand bucks to hook up a $2000 computer to a network.

"And that's what AppleTalk is all about. Nobody's hooking up to nets because there isn't enough software that makes it worthwhile. There isn't enough software that runs in nets because if you write software to run in a net, there's nobody to sell it to because there aren't any nets. So it's a circular problem. No nets, no software; no software, no nets. We want to break through that logjam with AppleTalk costing 50 bucks a computer.

"We just wish the whole world would standardize on a net. We'd all be happy. Just give us the jacks in the walls everywhere; we'd have no problem calling it the IBM net or the AT&T net, but it's not coming together. Ultimately, we feel that [the standard] network in the office is going to be the digital phone switch and not something that Apple or IBM comes up with. It turns out that the rates at which the digital-phone-switch standards are emerging (the CCITT [Comité Consultatif International Téléphonique et Télégraphique] standards) are very close to AppleTalk rates. They're about anywhere from 64 kilobits per second up to maybe 192 kilobits per second.

"So the rates we have chosen will probably map well to the ultimate rates of what will be the office network. And that's how the voice-data integration will take place, through a digital CBX, not through our network or IBM's network. The decision that we made was fundamental: put intelligence in the peripherals. The really interesting thing that's happening isn't the products themselves, it's the software standards that are being set. As an example, PostScript is more important, in a way, than the printer [the LaserWriter]. "Though we think that particular printer is what's going to make PostScript a standard."

erated by the new arrival.

AppleTalk divides node addresses into two classes: server node and user node. The system reserves 255 possible addresses; hexadecimal address FF is a special "broadcast" address used to reserve the line for transmission as part of the network's scheme.

AppleTalk is based on an open system architecture (see figure 1). Apple has published detailed information on the suite of network protocols that comprise AppleTalk and has held a number of seminars to aid third-party vendors that are developing software and hardware applications for the network.

The AppleTalk protocols implement a packet-switching scheme that provides functional correspondence with the International Standards Organization (ISO) Open Systems Interconnection (OSI) model. Protocols equivalent to the ISO OSI layers 1 through 5 (physical, data link, network, transport, and session) are at the core of AppleTalk.

The access scheme to the network is based on a CSMA/CA (carrier sense multiple access with collision avoidance) model. Although both AppleTalk and Ethernet are based on a bus topology, they differ in the way they handle the problem of data collisions on the network.

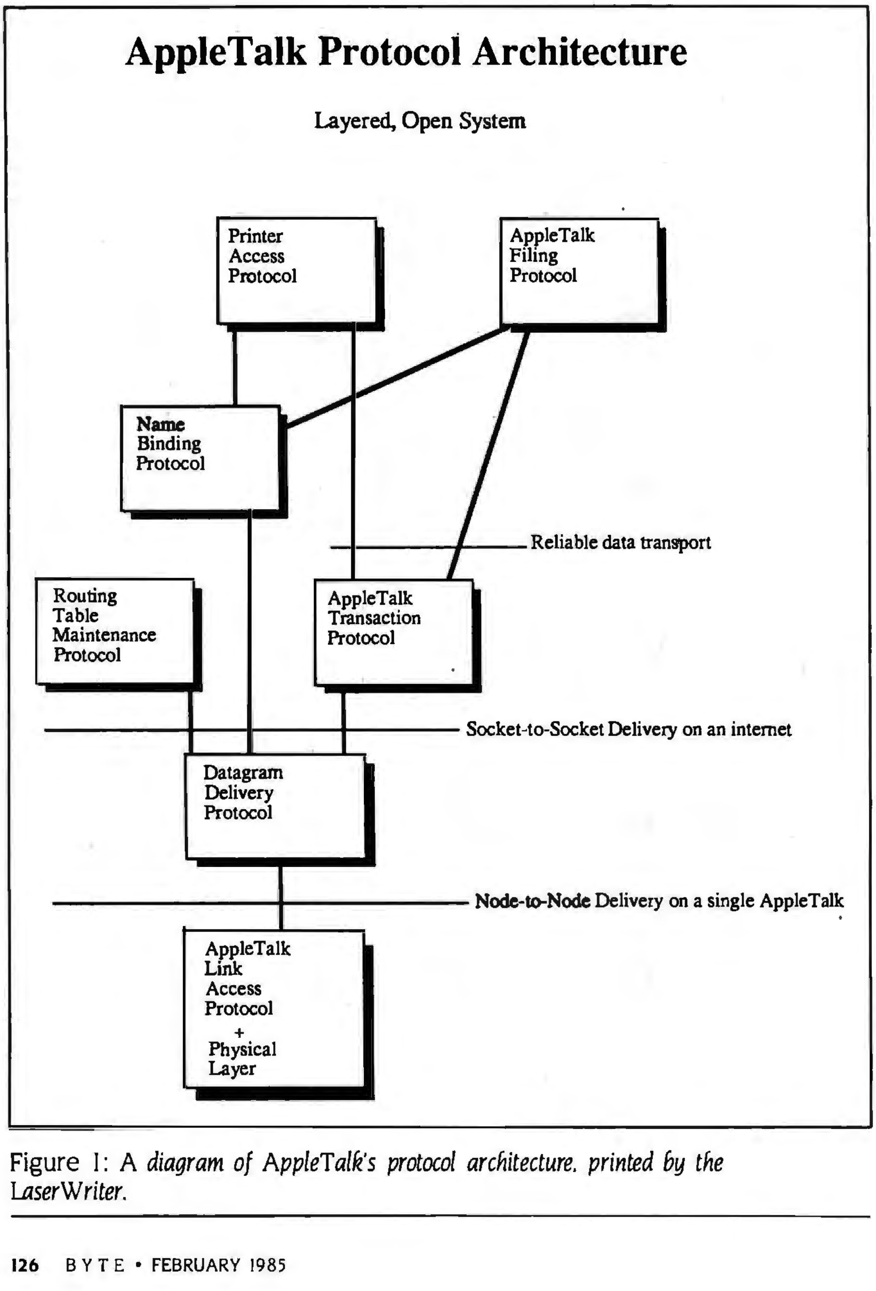

Figure 1: A *diagram of AppleTalk's protocol architecture, printed by the LaserWriter.*

Ethernet provides hardware capability for detecting collisions. AppleTalk, on the other hand, implements collision avoidance in software at the data-link level. The AppleTalk Link-Access Protocol (ATLAP) software handles the address-assignment mechanism, the frame format, and the frame transmission and reception process.

In the AppleTalk collision-avoidance scheme all transmitters wait until the line is idle. This time interval is determined by the generation of a pseudorandom number whose range is adjusted based on perceived bus traffic.

As part of this scheme each transmitter can send special broadcast frames (addressed to all nodes in the network) that reserve the line by informing other nodes that it is preparing to send a packet. The transmitters use directed frames (or packets) to send data to a single address on the network.

While a transmitting node is sending to a receiving node, a dialogue takes place. If a collision occurs during the dialogue, the sending node backs off and tries again, adjusting the randomly generated time interval. This adjustment follows a linear backoff algorithm that changes dynamically in response to recent network-traffic history. If the node detects collisions among recently sent packets, this suggests higher loading and greater contention for the bus. Thus, the random wait that is generated is calculated over a larger range, effectively spreading out the different contenders for the line.

Apple reports that it has extensively tested AppleTalk's CSMA/CA protocol and is satisfied with its ability to remain stable under heavy network loads.

In addition to ATLAP, AppleTalk consists of a variety of other protocols that generally correspond to other levels of the ISO OSI model.

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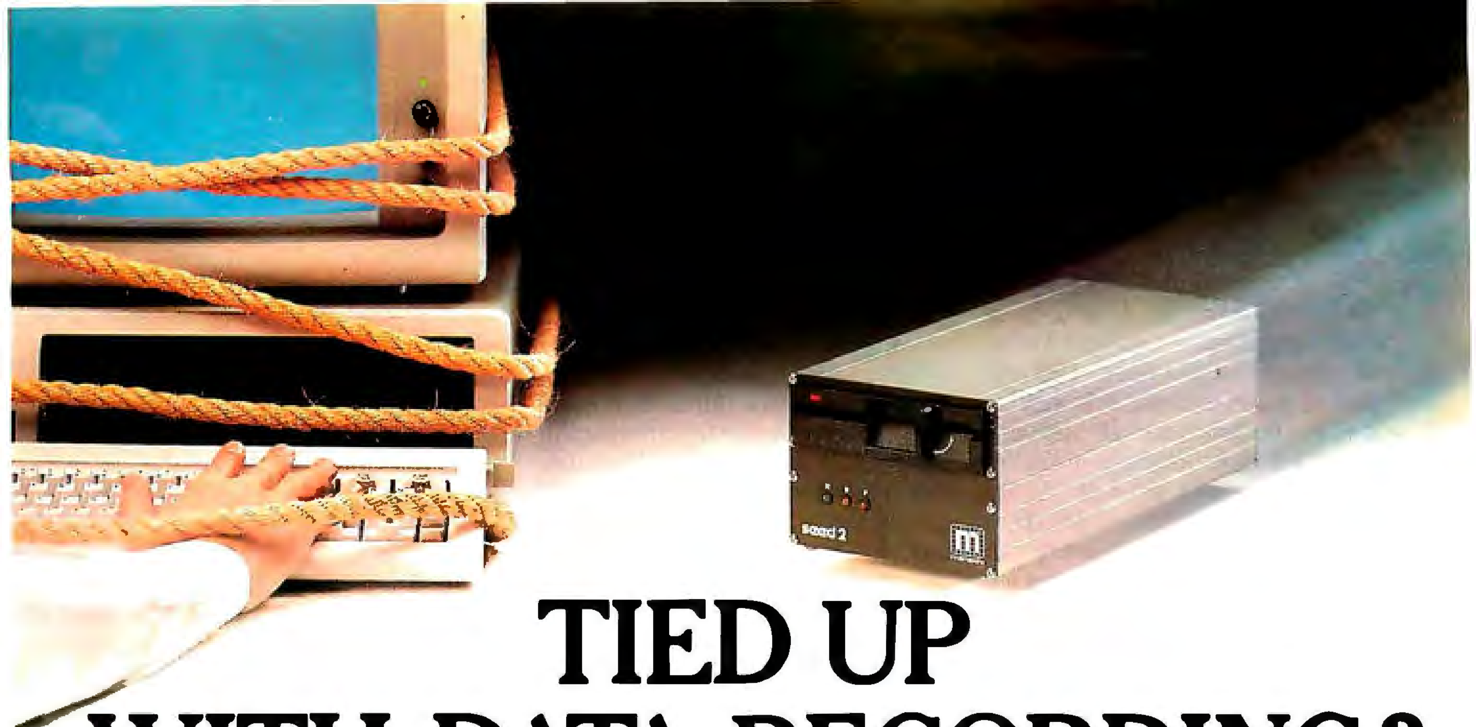

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While ATLAP handles node-to-node delivery of packets on a single AppleTalk network, a Datagram Delivery Protocol (DDP) extends this mechanism to socket-to-socket delivery. Sockets are logical entities in the individual nodes of a network. An individual socket is identified by a 1-byte address. Therefore, there can be as many as 256 different socket addresses on a single node. The DDP is designed to provide addressing and packet delivery between several AppleTalk networks connected by a bridge. A bridge might consist of a single node connected to two AppleTalk networks or it might consist of two nodes, each connected to a separate AppleTalk network, connected by a communications channel.

Additional protocols include a routing table maintenance protocol (RTMP) that permits any AppleTalk node to "discover" network routing information, such as the number of the LAN to which it is directly attached; a name-binding protocol (NBP) that permits users to access network addresses by names rather than numbers; and the AppleTalk transaction protocol (ATP), designed to ensure loss-free delivery of packets from a source socket to a destination socket.

On the Macintosh, these protocols are implemented as 5.5K bytes of code written in assembly language. Because the SCC chip handles address recognition, the network protocols take no system overhead unless a particular node is directly addressed over the network.

Initially, AppleTalk will link groups of Macintosh computers to the LaserWriter laser printer, an impressive 68000-based electronic printing system that will provide hard-copy output of any text or graphical image that can be displayed on the Macintosh screen. The special significance of the LaserWriter is that it is integrated with PostScript, a page-image-description language developed by Adobe Systems, a start-up company founded by a group of electronic-printing experts who recently left Xerox Corporation (see the text box "Adobe Systems and the PostScript Language" below). PostScript is essential to the viability of AppleTalk because it permits extensive compression of the information the LaserWriter needs to print bit-map images.

Laser Technology

Laser printers are fast, quiet, and capable of high-resolution printing. Until recently, they have also been very expensive, ranging from $50,000 to $400,000.

A laser printer has a raster-scanning laser that projects the print image onto an electrostatically charged photosensitive drum. A set of rotating mirrors manipulates the beam—the laser itself doesn't move. Wherever the laser beam touches the drum, the static charge is nullified. Toner (particles of colored plastic) is then attracted to those points. The printer rolls paper against the drum and the toner sticks to the paper. Finally, a hot fuser permanently affixes the toner by melting it onto the page.

The price of laser printers has dropped dramatically because of developments such as Canon's LBP-CX marking engine. That engine, which is also used in Canon's personal copiers, combines several fundamental printer components into a single, inexpensive, disposable cartridge. Because those same components—including the toner and drum—frequently needed repair and replacement on laser printers, the Canon engine greatly improves reliability.

The LaserWriter's disposable cartridges (made by Canon) cost $99 each and will print approximately 3000 pages. That puts the price in the range of 3 cents per page. The LaserWriter prints on ordinary copy paper but can also use bond paper, European and legal-size paper, transparencies, envelopes, labels, or even business cards. Several different toner

(continued)

Adobe Systems and the PostScript Language

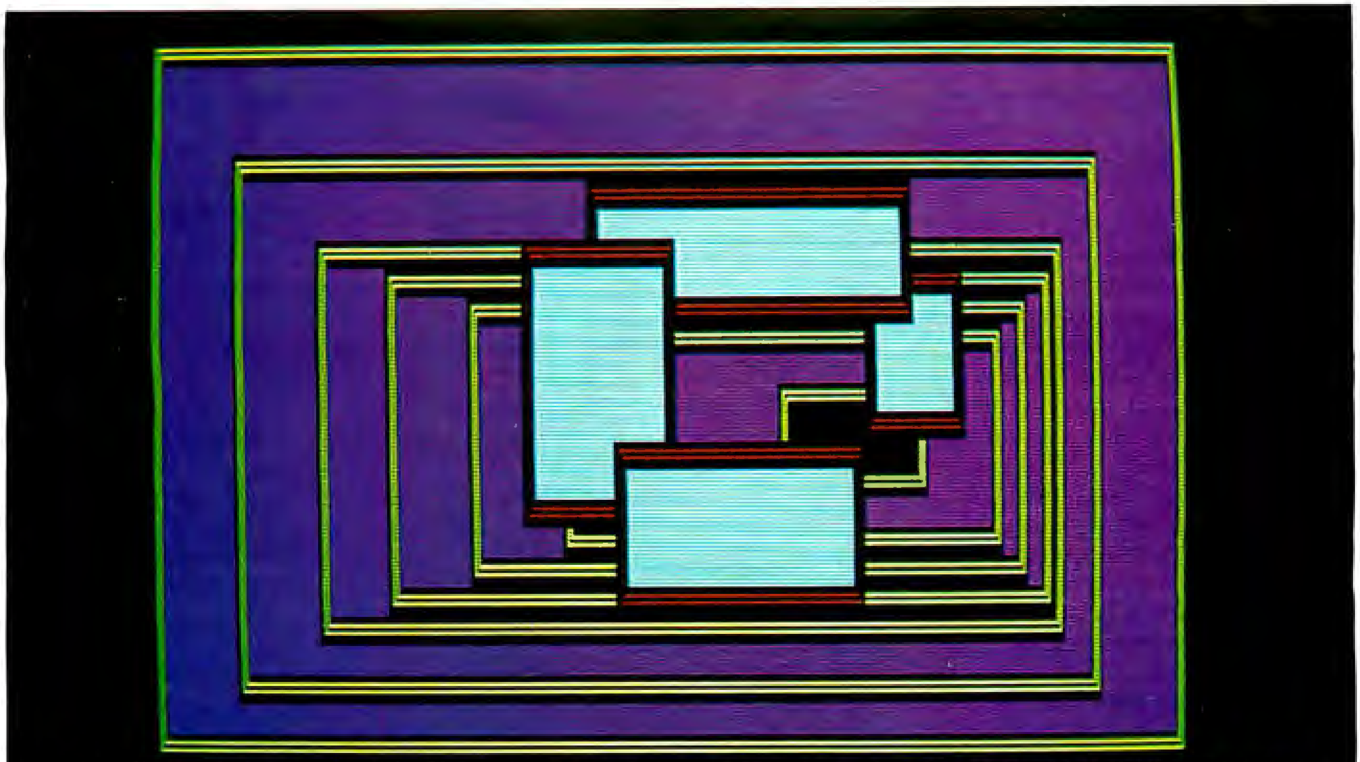
Adobe Systems Inc., of Palo Alto, California, was started by a number of researchers who left Xerox's PARC (Palo Alto Research Center). In particular, John Warnock, president of Adobe, was a principal scientist at PARC for raster-graphic display techniques. Charles Geschke, the executive vice-president, was a manager of the Imaging Sciences Laboratory at PARC.

Adobe is trying to make PostScript—their text and graphics language—a business standard. Unlike most print-file description languages, PostScript is not a static, data-structured written description: it is a programming language. When the Macintosh communicates with the LaserWriter, it actually sends a program across AppleTalk.

According to Geschke, "When the program arrives at the 68000 in the printer and begins executing, it has one very interesting side effect, namely, it drives the video on that laser and produces output. But it is really a program description that is generated on the Macintosh and is executed on the printer." By using PostScript, the amount of information sent across AppleTalk can be trimmed, in some cases, to just 10 percent more than the raw ASCII (American Standard Code for Information Interchange) data.

PostScript is completely encoded in the printable character subset of 7-bit ASCII code and so is completely invisible across any kind of communications line, not just AppleTalk. PostScript can handle any material: text, line-art, photographics, and even color (for printers that can use it). While photographic images are sent as bit maps, graphics are sent as commands and the fonts are sent as mathematical outlines (based on Bezier cubics) that can be stroked, filled, scaled, oriented, or used as clipping boundaries. And it is flexible, as Geschke pointed out. "If you're really into graphic art you can adjust the shape of the half-tone dot, the shape of the tonal production curve, the orientation of the screen, and its frequency."

Adobe isn't only working with Apple. You'll be seeing PostScript in other systems from other companies.



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The Canon engine is used in the LaserWriter and many other new laser printers, from Hewlett-Packard's $3495 LaserJet to the $10,000 QMS 800. These laser printers can turn out eight pages a minute and yet make only about as much noise as a copier. All of these machines can print at the same 300-dots-per-inch resolution. While far better than standard dot-matrix printers, they aren't up to the 1200 dots per inch or better that phototypesetters produce (see figures 1 and 2 for samples of the LaserWriter's output). Still, unless you're a graphics expert, it is hard to distinguish this resolution from typeset text. The difference between the various Canon-based laser printers is in the controllers; each manufacturer uses its own controlling computer.

Because the laser scans synchronously across the page, image dots must be fed to the laser at exactly the right time. That requires data storage in the printer itself. Shipping data to the printer memory as a simple bit map would take too much time for most users. An RS-232C port running at 19,200 bps (bits per second) would take nearly 7 minutes to send the 7,920,000 bits for a single page; even the speedier AppleTalk network would take half a minute. To ease that bottleneck, most manufacturers put some form of intelligence, such as encoded graphics instructions and preloaded fonts, into the printer controller. Then the computer need only send a condensed form of the print image to the printer controller.

The least intelligent controllers have limited printing capabilities. The Hewlett-Packard LaserJet, for instance, can only print 6 square inches of graphics per page and has a limited set of character fonts. On the other hand, the expensive QMS printer uses a standard Tektronix terminal emulation (a set of graphics protocols). For example, instead of sending a bit map of a circle to that printer, a computer only needs to send the Tektronix instruction to print a circle of a certain size, shape, and position.

LaserWriter Hardware

The Apple LaserWriter printer can generate a variety of fonts and high-quality graphics with the help of a powerful built-in computer and the PostScript language.

The LaserWriter's internal computer-controller board was designed by Burrell Smith, a key figure in the Macintosh design group, and is built around an 11.2-MHz 68000 processor, 1.5 megabytes of RAM (random-access read/write memory), and 0.5 megabyte of ROM (read-only memory). The ROM contains the PostScript code.

The laser-printer project's design goals were formed when Adobe Systems suggested that a laser printer could offer graphics without giving up letter-quality text. Part of this involved making the printer controller as intelligent and as fast as possible, so that encoded information could be sent over the AppleTalk LAN to spare the network a huge overhead burden.

Of the LaserWriter's 1.5 megabytes of RAM, half a megabyte is used for temporary scratch-pad buffers and font caching and a full megabyte is devoted to the screen. The LaserWriter has other small memory components, such as a static RAM cache of 4K bytes that allows the 68000 to process faster by executing inner loops without any wait states. In addition, Apple built into the hardware one of the most common input transfer modes. Burrell Smith said, "We do a classical OR between contents of memory and the data you wish to enter to the frame buffer—in a single bus cycle."

Apple is a high-volume producer. To that end, it has kept the component count on the board low—there are only 34 chips plus memory and resistor packs. In comparison, one competing laser-printer controller board has close to 150 chips. The LaserWriter board has been designed, as was the Macintosh, for automatic insertion and test. The chip technology used is generally the same as for the Macintosh: 25-nanosecond PAL (programmable-array logic) chips, 256K-byte dynamic RAM chips, and 256K-byte ROM chips. Smith noted, "What we're trying to do is take relatively expensive technologies and

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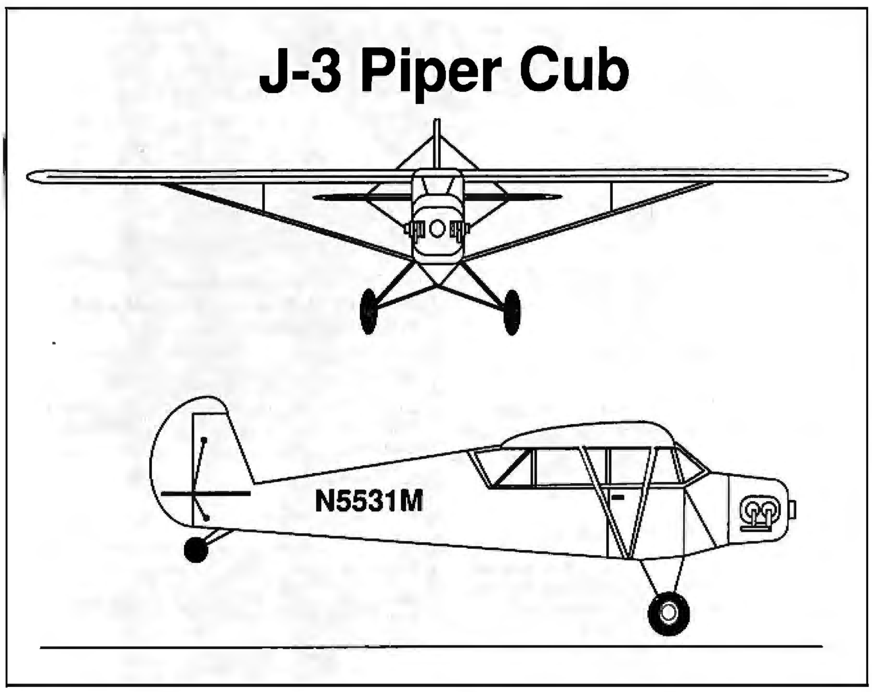

Figure 2: *Sample output from the LaserWriter.*


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Once the print image has been completely set in the RAM, the printer needs to ship it out to the laser apparatus as quickly as possible. That task is aided by the 68000, which helps drive the video electronics. The central processor stores the data in two FIFO (first-in/first-out) memories. That scheme allows a minimum amount of bus contention between the microprocessor and memory. Everything on the board is a slave to the 68000. That flexible architecture is expoited, for example, by the margins of the page to be printed. When the margins move inward, the frame buffer used for generating the bit map is actually reduced in size—allowing more RAM to cache the fonts.

The Macintosh has nonvolatile parameter memory that allows it to remember certain modifiable control settings between uses. Apple decided to further explore that scheme in the LaserWriter by putting in a 0.5K-byte EEPROM (electrically erasable programmable ROM), which is expandable to 2K bytes. As Smith points out, that is "equivalent to 16,000 DIP (dual-inline package) switches."

The AppleTalk port isn't the only way to drive the LaserWriter. There is also a DB25 connector with completely programmable RS-232C protocols. Adobe indicated that they and others would provide packages that will use translators or emulators to drive Tex, Troff, Scribe, and other mainframe-style composition systems.

What sort of performance does the built-in computer offer for the LaserWriter? According to Smith, when it is combined with perfect hardware, the printer is capable of turning out a page in 6 seconds. With the Apple controller, "We're expecting a 10-second average time per page," he says.

Anything that can be put on the Macintosh screen can be printed by the LaserWriter. When you use the Printer Chooser desk accessory to select the LaserWriter printer instead of the ImageWriter, the Macintosh calls a new printer driver. On the Macintosh, all screen graphics are based on QuickDraw routines called from ROM. Bud Tribble, the Macintosh software manager, says, "The LaserWriter's strategy is different than the ImageWriter's. Even though all the Macintosh's QuickDraw routines are in ROM, every entry point to QuickDraw has a handle on it that allows us to trap out that call and go someplace else. That's what happens during printing to the LaserWriter driver. We trap out all the QuickDraw calls, and when that call comes along, the system translates it to the equivalent PostScript call, which ships it over AppleTalk to the laser printer and prints out." For now, the printer works

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According to Tribble, "A page of QuickDraw calls are translated into approximately 4K bytes of PostScript language, which are then shipped over AppleTalk at ¼ megabit per second—4K bytes per page is really no great load compared to the 8 million bits required to represent a full bit-map page."

Because of this strategy, MacDraw and MacPaint documents produce different outputs. All of the elements in MacDraw exist as graphical objects: a rectangle is stored as a rectangle, a circle is stored as a mathematical circle, etc. In MacPaint, all the data storage takes place on the bit map. Those 80-dots-per-inch bit maps must be resolved for the higher-resolution LaserWriter. So Bill Atkinson developed a scaling and smoothing program that sits in the laser printer itself.

In fact, there is a fairly close correspondence between QuickDraw and PostScript objects. The Macintosh downloads into the laser printer a preamble of PostScript code that helps it quickly interpret QuickDraw objects. For example, to paint a RoundRec (a QuickDraw command), you would have a RoundRec subroutine residing in the LaserWriter. Half the translation takes place in the Mac, half in the LaserWriter. Text is sent as ASCII (American Standard Code for Information Interchange) data along with font, orientation, fill, scaling, and position information.

Apple has built Times Roman, Courier, Helvetica, and many existing Macintosh fonts into the LaserWriter, which handles these fonts intelligently. For example, once a character is built it is cached and remembered as long as possible. Additionally, the LaserWriter driver in the Macintosh permits direct generation of PostScript commands. Both Adobe and Apple expect independent developers to make use of this facility. Apple reports that there are already more than 20 active, independent LaserWriter software projects. ■

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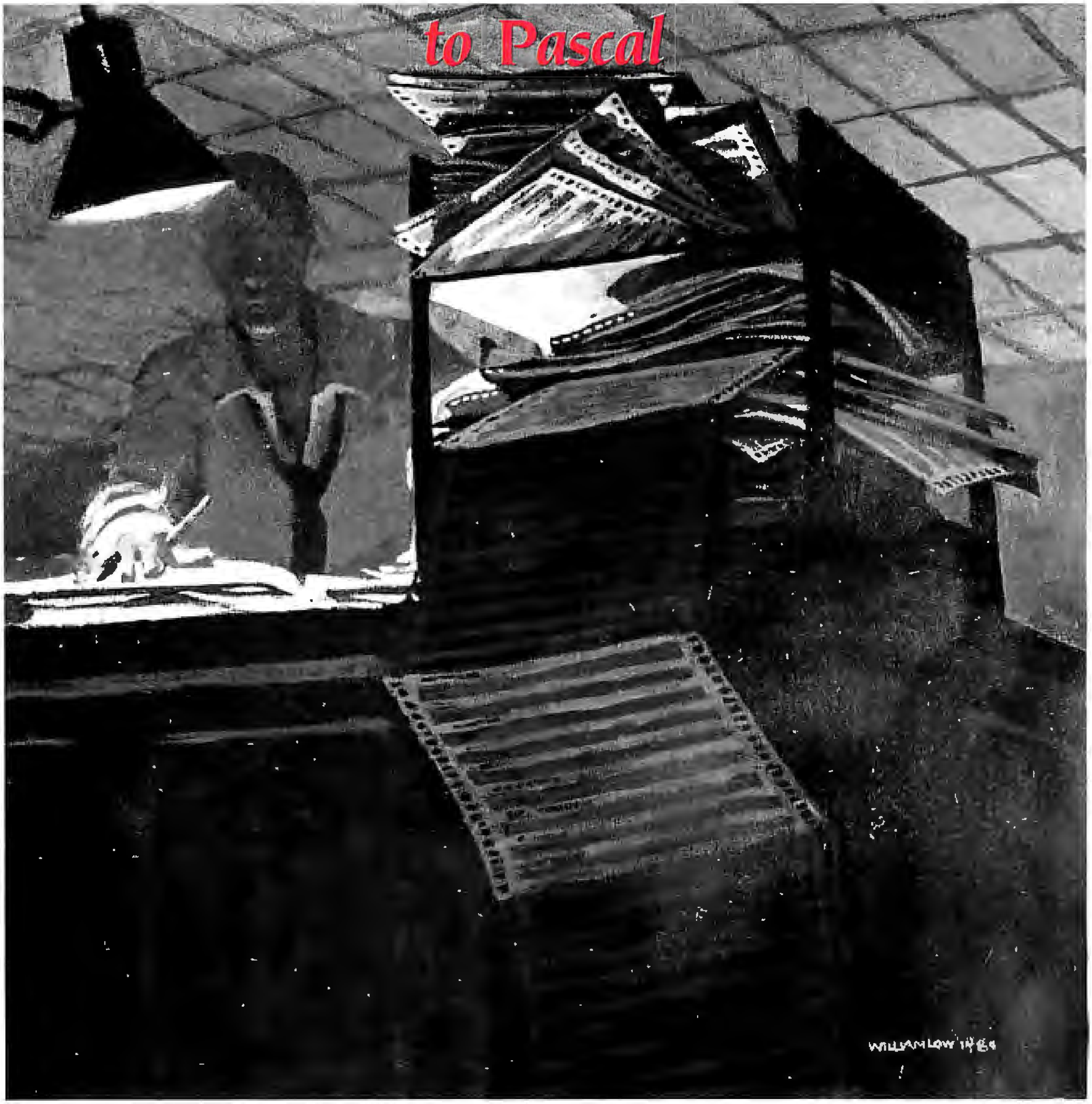

A *program to take the tedium out of converting* C *programs to* Pascal

ILLUSTRATED BY WILLIAM LOW

BY TED CARNEVALE

No matter how much you prefer a particular programming language, there are times when it is necessary to use a different one. I found myself in this situation recently after I had written a graphics subroutine library in C for the Pixeltronics high-resolution graphics display board that uses the NEC 7220 GDC (graphics display controller) chip. Since the display was attractive, I decided to incorporate the routines into our lab's high-speed data-acquisition system.

The data-acquisition program, which controlled A/D (analog-to-digital) conversion and signal averaging, was compiled with Digital Research's Pascal/MT+ compiler. I chose this implementation of Pascal because it supports floating-point operations using the AMD (Advanced Micro Devices) 9511A, a high-performance arithmetic coprocessor that allows faster on-line data averaging and scaling. To run the A/D converter at top speed, special drivers were written in assembly language. The package's weak link was its subroutine to display data on a nonstorage oscilloscope, using the D/A (digital-to-analog) section of the converter board. The time required to sweep multiple traces across the oscilloscope screen limited the maximum rate of data acquisition.

It didn't seem practical to rewrite all of the data conversion software in C just to use the graphics display. Furthermore, we would have to write new drivers to use the AMD 9511A for floating-point calculations in C. Worse yet, the floating-point format and dynamic range of the AMD 9511A are radically different from their counterparts in our version of C (Software Toolworks C80 with optional floats and longs).

For a while I considered linking the rel (relocatable) files produced by C80 (which contain the graphics routines) to the erl (extended relocatable) files generated by Pascal/MT+ (which contain the data-conversion routines). This proved to be especially cumbersome for two reasons.

First, both of these languages use the stack to pass parameters to subroutines. Pascal/MT+ assumes that the subroutine will pop the parameters from the stack, which has the side effect of restoring the stack pointer to its position before the subroutine call. However, C80 expects the calling program to restore the stack pointer. Therefore, repeated calls from a Pascal program to C subroutines would make the stack grow larger and larger, potentially overwriting vital regions of memory. Circumventing this problem requires the crude but effective dodge of inserting a special "unstack" routine after each C routine call, so that the stack pointer would be properly restored.

The second problem is more difficult to deal with and relates to the fact that Pascal lacks local static variables. LINKMT, the linker for Pascal/ MT+, issues error messages when it encounters certain conditions in the data segment. Some of my graphics procedures used local static variables, and these modules could not be processed by LINKMT.

In theory this can be overcome by using LIBMT to convert the Pascal erl files to rel files and then linking them to the C80 rel files with Microsoft's L80. But somehow I could never get this technique to work right. Even if L80 could have produced a functioning mongrel, it would have been needlessly bulky, since the graphics drivers would have their own arithmetic and logic routines extracted from the C library with much needless duplication of similar functions provided by the Pascal library. Still, if it had worked I would have used it.

Having failed to weld C routines to Pascal, I had to rewrite the graphics drivers in Pascal. At first this seemed less awful than it really was. There are enough similarities between these two descendants of ALGOL that major revisions are not necessary for most simple routines. Many of the required changes can be done with any editor using global search/replace commands. For example, C's block delimiters { and } are direct counterparts of Pascal's begin and end.

This method is fine if you only have to translate a few short programs, but it has some major problems otherwise. Suppose you accidentally replace the C comment delimiters /* and */ with { and } before replacing the block delimiters with begin and end? And how about the different uses of = in C and Pascal? If you replace each = with :=, then C's

(continued)

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Listing 1: *The C-to-Pascal program, written for the Software Toolworks C80 compiler.*

```
/*   C to Pascal — filter to replace C punctuation and certain key words with
                              their Pascal equivalents.

C form            Pascal form
   "                 '
   {                 BEGIN
   }                 END;
<tab>             <2 blank spaces>
   ()                <nothing>
   &&                AND
   ||                OR
comment start     {
comment end       }
   ==                =
   !=                <>
   =                 :=
   printf            writeln
   scanf             readln
   while             WHILE

Usage: ctp <infile >outfile
*/

#define EOF -1
#define EOS '\0'

main ()
{
        char c,*letter,word[100];
        int wordlnth;

        letter=word;
        wordlnth=0;
        while ((c=getchar()) != EOF) {
                if (isalpha(c)) letter[wordlnth++]=c;
                else {
                        if (wordlnth>0) {                    /* word ready to check */
                                letter[wordlnth]='\0';
                                wtest(word);                 /* pass or replace it */
                                wordlnth=0;                  /* reset index */
                        }
                        ctest(c);                          /* process following char */
                }
        }
}       /* note: the last word in the file will be missed if it is immediately followed
by EOF with no intervening nonalphanumeric character. This is not a problem for
Pascal or C program sources. However, a general-purpose word filter would have
to check for a nonzero wordlength after EOF is reached. */

wtest(word)
char *word;
{
        char *swapword;

        swapword=word;
        switch (word[0]) {                      /* test first letter, then rest of word */
        case 'p':  if (strcmp(word,"printf\0")==0) swapword="writeln\0";
                   break;
        case 's':  if (strcmp(word,"scanf\0")==0) swapword="readln\0";
                   break
        case 'w':  if (strcmp(word,"while\0")==0) swapword="WHILE\0";
                   break;
        default:   break;                   /* pass unchanged */
```

(continued)

The C functions printf *and* scanf *could be replaced by* writeln *and* readln.

equality test == becomes :=:=, <= turns into <:=, and >= becomes >:=.

You could step manually through the file, verifying all replacements one at a time, and this might not take too long if you have excellent eye-hand coordination. If you're really good, you might catch most of the errors before your compiler does. However, I wouldn't even attempt it. I was faced with the task of editing 27 separate files, totaling about 30 pages of drivers and test programs to convert from C to Pascal. After manually translating three of these to Pascal, I decided to write a "filter" that would do as much of the dirty work as possible.

The first step in developing this C program, called CTP.C (see listing 1), was identifying what substitutions could by made easily, reasonably, and safely by an unsupervised, i.e., noninteractive, program. The C functions printf and scanf could be replaced by writeln and readln. Where necessary, the ln suffixes can be deleted manually at the same time the argument lists are revised.

The only other word substitution that I made was to capitalize WHILE. It is a trivial matter to change the program to perform case substitutions on other words (e.g., for or if). You will also want to replace switch with case and delete any case that appears in the C source. In addition to the block and comment delimiters, the nonalphanumeric characters that I decided to replace included tab (replaced with two spaces, my own format preference for Pascal), double quote, empty pairs of parentheses, logical "and" (&&), logical "or" (!!), and the various uses of =.

(continued)

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```
        }
        swap(swapword);
}
ctest(c)
char c;
{
        switch (c)  {
        case '"':  putchar('\' ');
                   break;
        case '{':  swap("BEGIN\0");
                   break;
        case '}':  swap("END;\0");
                   break;
        case '\t':  swap("    \0");
                   break;
        case '&':  swapif('&', '&'," AND   \0");
                   break;
        case '|':  swapif('|', '|',"OR 0");
                   break;
        case '(':  swapif('(', ')',"\0");               /* () simply deleted */
                  `break;
        case '/':  swapif('/', '*'," {\0");
                   break;
        case '*':  swapif('*', '/'," }\0");
                   break;
        case '!':  swapif('!', '=',"<>\0");        /* != -> <> */
                   break;
        case '<':
        case '>':  putchar(c);          /* <x and >x are passed unchanged */
                   c = getchar();
                   putchar(c);
                   break;
        case '=':  identassign();       /* == -> = , = -> := */
                   break;
        default:   purchar(c);
                    break;
        }
}
swap(s)
char *s;
{
        while (*s! = EOS) putchar(*s+ +);
}
swapif(first,second,replacement)
char first,second,*replacement;
{
        char c;
        if ((c = getchar()) = = second) swap(replacement);
        else {
                   putchar(first);
                   putchar(c);
        }
}
identassign()
{
        char c;
        if ((c = getchar())! = '=') {                   /* assignment */
                   putchar(':');
                   putchar('=');
        }
        putchar(c)'
}
```

The next question was how to perform the substitutions. I decided the program should read through the file one character at a time, building words and testing them one at a time, while checking nonalphanumeric characters for any necessary replacements. For my purposes, I defined a word as a string of alphanumeric characters bounded by nonalphanumeric characters (including underline and numerals). This convention places restrictions on the labels that can be used in a program. For instance, printf1 would change into writeln1, and new__scanf would become new__readln. If you use reasonable prudence in choosing names, you will avoid such undesired side effects.

An array of type char is used for temporary storage of each word. This array is arbitrarily much longer than any variable, function, or constant label that I am ever likely to use. Words are built one character at a time, starting with the first alphanumeric character encountered. The appearance of a nonalphanumeric character signals the end of each word. An index variable keeps track of the length of the word, and a pointer indicates the location for the next character.

When a nonalphanumeric character is found, the length of the word is examined. If the word length is nonzero, the program branches to a string comparison and conditional replacement routine. This routine handles each word in a similar fashion. It seemed easiest to use C80's strcmp (string compare) function to identify replaceable words. This function is not difficult to simulate if it is lacking from any particular C implementation.

Nonalphanumeric characters are treated in a somewhat different manner. Some, like tab or ", are simply replaced directly. Others, like / or &, are replaced only if followed by a second character such as * or another &, respectively. The various = constructs are all handled differently.

For the sake of convenience, I used a UNIX-like command-line specification for input and output filenames.

(continued)

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Listing 2: *Sample output of the CTP.C program, a partial processing of the program's own source file.*

```
#define EOF -1
#define EOS '\0'

main
BEGIN
  char c,*letter,word[100];
  int wordlnth;

  letter:=word;
  wordlnth:=0;
  WHILE ((c:=getchar) <> EOF) BEGIN
    if (isalpha(c)) letter[wordlnth++]:=c;
    else BEGIN
      if (wordlnth>0) BEGIN   { word ready to check }
        letter[wordlnth]:='\0';
        wtest(word);   { pass or replace it }
        wordlnth:=0; { reset index }
      END;
      ctest(c);   { process following char }
    END;
  END;
END;
```

The typical command line reads

```
CTP <INFILE.XXX >OUTFILE.YYY
```

Listing 1 is my current version of CTP.C. Listing 2 is part of the file CTP.PAS produced by using CTP to process itself.

This filter program was designed to perform simple substitutions. It passes #define, #ifdef, and #include statements unchanged. It does not label functions or procedures, generate type definitions, reorganize variable declarations, or perform other radical alterations. Nor does it eliminate the need for program restructuring to compensate for major differences between C and Pascal (the lack of local static variables in Pascal being one of the more annoying problems). However, it does remove most of the error-prone aspects of building a Pascal program on the framework of a C program. ■

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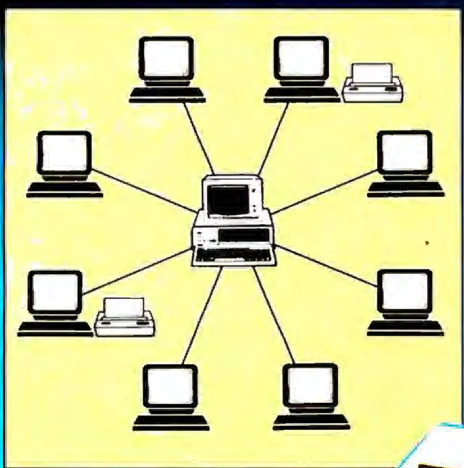

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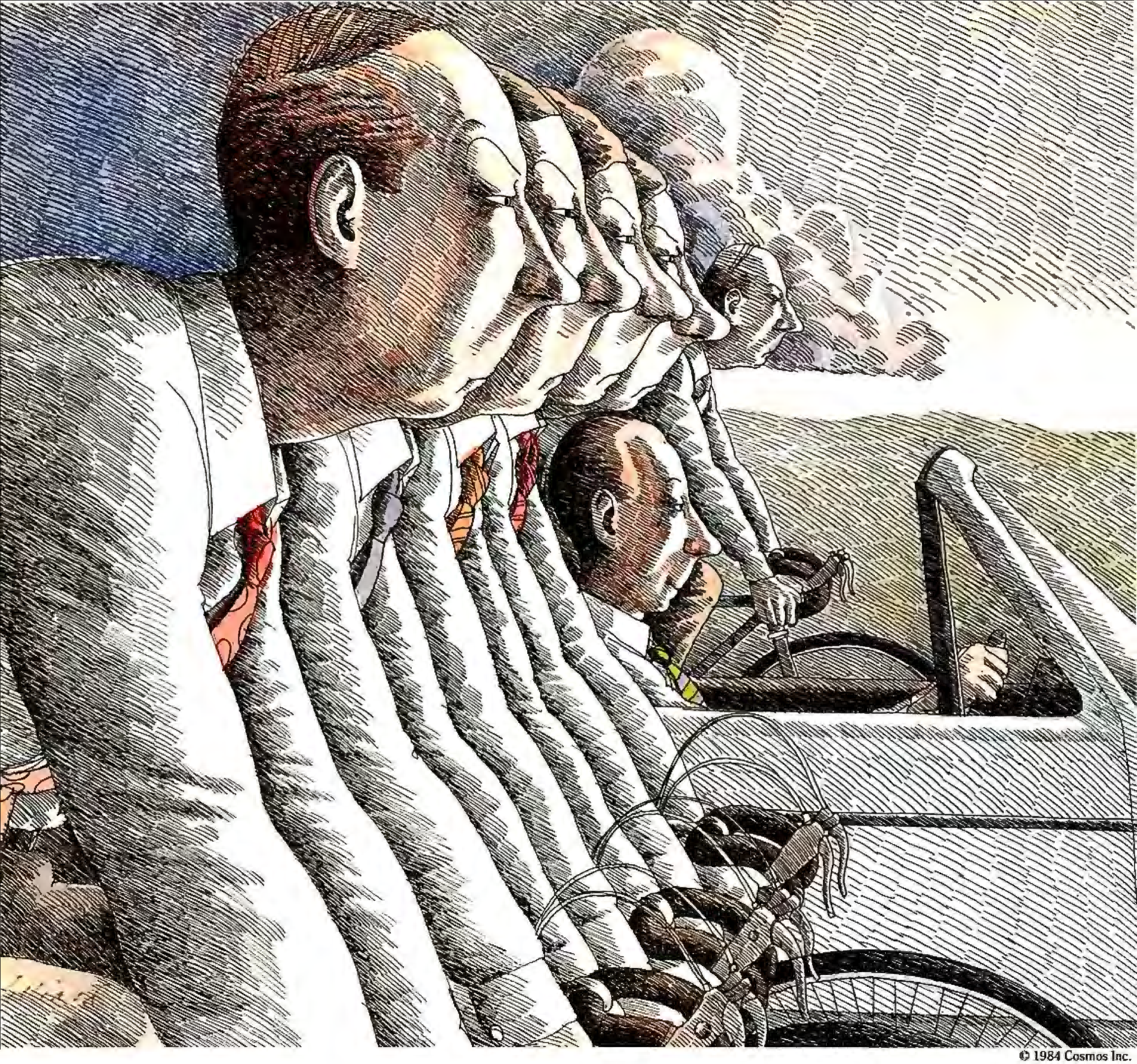

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BY DON STAUFFER

SIMULATE A SERVO SYSTEM

Letting the computer handle the math eases the designer's job

A servo mechanism is essentially a small motor that controls a larger motor. A servo-control system consists of the logical instructions needed to guide the servo mechanism. Control systems were brought out of the laboratory and into practical use about the time guided missiles were developed for World War II. The original vacuum-tube type was big, heavy, and expensive, but integrated-circuit (IC) technology has reduced the size of control-system technology as well as others. Now, almost the entire servo-control electronics package fits into a single IC, as in present model-airplane radio-controlled servos. Consequently, the cost of these systems has been reduced so that they are now found in automobile cruise-control systems, stereo turntables and tape decks, kitchen appliances, and home-workshop tools.

A reduction in the size and cost of servo-control systems, however, has not reduced their complexity. The design of servo-control systems remains one of the most intricate of the electrical engineering sciences. However, the computer's simulation ability has simplified the designer's job. Simulation is now a common part of the servo-control system engineer's tool kit, and similar simulation, though not as complex, can be effected with home computers.

As an example, let's design an electronic weighing scale. Figure 1 is an illustration of how such a scale would be arranged. A balance beam forms the main part of the scale, along with the weight pan on the left. On the right side, instead of the normal balance weights, we attach a solenoid. The solenoid is designed so that the pull on the solenoid armature is directly proportional to the current in the coil. A sensor, such as a low- *(continued)*

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friction potentiometer, forms an error detector that gives a voltage proportional to the angle by which the scale is out of balance. The servo-control system uses this error signal to change the current through the solenoid to eliminate the imbalance. The current in the solenoid coil is now proportional to the weight in the pan, and a current meter is calibrated to read in weight units.

Figure 2 is the type of diagram a designer would draw for this kind of feedback servo-control system. The circle at the left represents a summing junction. The output to the right of the junction is the sum of the inputs to the other two (or three) quadrants. As shown here, the junction indicates the difference between the commanded or desired quantity, Q_c, and the actual quantity, Q. The servo-control computer operates on this difference and outputs a voltage to the actuator. The actuator is a physical device, usually a force transducer that drives the quantity to be controlled either up or down so that the actual value equals the desired value. At this point the system is balanced, and the error signal (or feedback) will remain at zero unless some perturbing force displaces the system or a new input value is commanded.

A servo-control designer is concerned with several aspects of the system's behavior. First and foremost is stability. That is, does the system indeed act to reduce the error, and not, as servo-control systems have a habit of doing, actually cause the error to increase wildly? How soon will the system reach a new equilibrium? If it takes too long to settle down, the system may not be usable in practice. Is the amount of error that remains after the system reaches a new equilibrium sufficiently small? Ideally, you'll have no error but in practice you'll probably have some and will have to decide if it is tolerable.

Without simulation you have to use complicated differential equations to try to predict a mechanism's behavior. Computer-based simulation does the math for you. In addition, simulation lets you design more complex servos, whose behavior could not be predicted easily by normal differential equation methods. Figure 3 charts a typical simulation. After setting the initial conditions, the program enters the iterative loop (input, model, output, update). It scans user or process input to see if conditions are to be changed. If the simulation is supposed to be continuous, such as the physical simulation we will be working with, input is best done with a keyboard-monitoring routine to keep the program running between inputs. The heart of the simulation is the next step—the math model. In this block, the computer performs its mathematical operations on the equation that describes the system being simulated. Almost any system or

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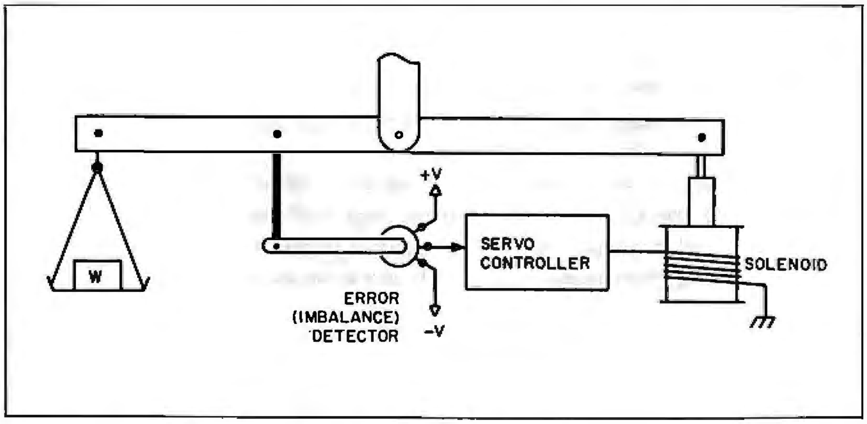

Figure 1: *The servo system holds the balance beam level.*

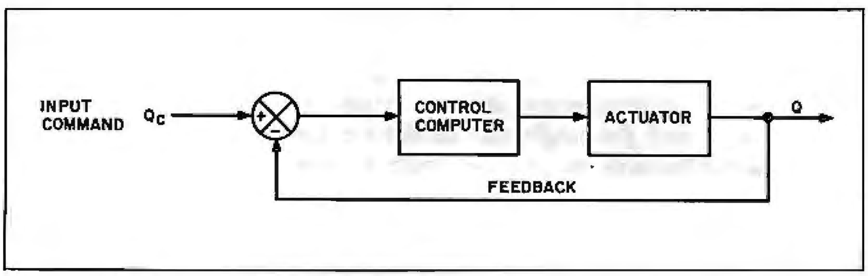

Figure 2: *A servo system operates by measuring the difference between the commanded and actual values of some quantity and uses a function of that difference to drive an error-reducing actuator.*

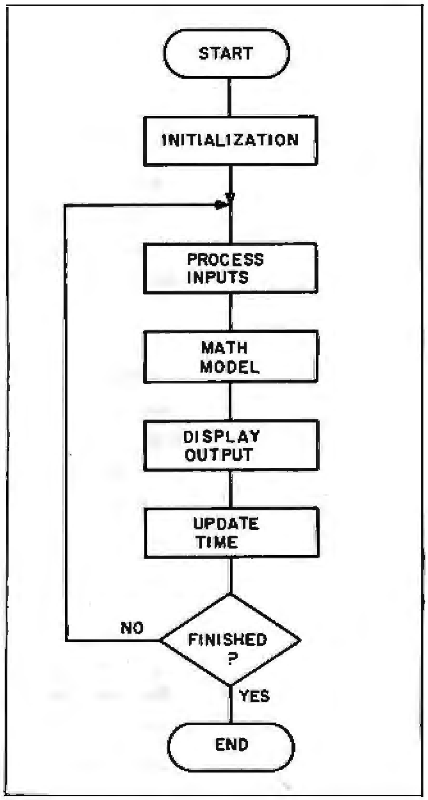

Figure 3: *A typical simulation-program flowchart.*

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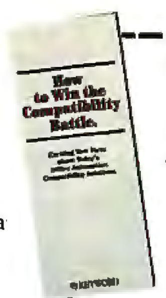

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situation that can be mathematically described in a cause-and-effect relationship can be simulated by a computer. Next, the program displays or prints an output. Then the time variable is incremented and, if the program is not terminated by some condition that exceeds its limits, the program repeats.

(continued)

Listing 1: *This program is written in* TRS-80 *Level* II BASIC *but can be adapted to any of the* BASIC *dialects.*

```
10 REM SCALE SERVO CONTROLLER
20 REM by Don Stauffer
30 CLEAR 200
40 REM  EDIT ASSIGNMENT STATEMENTS TO ALTER CONTROL CONSTANTS
50 PR=0   :  REM  PRINT CONTROL VARIABLE
60 TH=0   :  REM   SCALE BALANCE BEAM ANGLE
70 TM=0   :  REM  BEAM ANGLE DURING LAST ITERATION
80 W=0    :  REM   INITIAL WEIGHT IN PAN
90 JS=5   :  REM   BEAM MOMENT OF INERTIA
100 D=5   :  REM  DISTANCE FROM PIVOT TO WEIGHT OR SOLENOID
110 K=10  :  REM   SCALE FACTOR, SOLENOID CURRENT TO FORCE
120 K1= -0.4   : REM PROPORTIONAL SERVO CONSTANT
130 K2=0    :  REM RATE SERVO CONSTANT
140 K3=0    :  REM LAG SERVO CONSTANT
150 DT=0.2  :  REM TIME INCREMENT
160 T=0     :  REM INITIAL TIME
170 ST=0    :    REM STOP PARAMETER
180 REM  BEGIN SIMULATION LOOP
190 IF PR > 1.5 GOSUB 5000
200 REM CHECK FOR INPUT
210 GOSUB 1000
220 REM COMPUTE CONTROL FORCE
230 GOSUB 2000
240 REM COMPUTE MOTION
250 GOSUB 3000
260 REM DISPLAY AND PRINT OUTPUT
270 GOSUB 4000
280 REM UPDATE TIME
290 T=T+DT
300 IF ST<0.5 THEN 200
310 STOP
1000 'CHECK FOR INPUT
1010 IF PEEK(14400)=128 THEN GOTO 1010
1020 IF PEEK(14340)=8 THEN ST=1
1030 IF PEEK(14340)< >128 THEN RETURN
1040 PRINT@65," ";
1050 INPUT"CHANGE WEIGHT";W
1060 IF W<0 THEN W=0
1070 RETURN
2000 REM COMPUTE CONTROL CURRENT
2010 ER=TH
2020 IF ER< -10 THEN ER= -10 ELSE IF ER>10.0 ER=10.0
2030 I=K2*(TH-TM)/DT+K1*ER+K3*(ER+EM)
2040 EM=ER
2050 RETURN
3000 TM=TH
3010 J=JS+W*D[2
3020 F=K*I
3030 LC=F*D
3040 LW=W*D
3050 AA=(LC-LW)/J
3060 WD=WD+AA*DT
3070 TH=TH+WD*DT
```

(continued)

```
3080 IF TH< -10 THEN TH= -10 ELSE IF TH>10 THEN TH=10
3090 RETURN
4000 CLS
4010 PRINT"ACTUAL WEIGHT= ";W
4020 PRINT@384,"TIME","ANGLE","CURRENT","WEIGHT"
4030 PRINT@448,T,TH,I,F
4040 IF PR<0.5 THEN RETURN
4045 IF PR> 1.5 GOTO 4080
4050 LPRINT T,W
4060 LPRINT AA,WD,TH,F
4070 RETURN
4080 NF=T:NI=INT(NF): RX=NF-NI
4090 IF (RX<DT) THEN LPRINT CHR$(51); ELSE LPRINT CHR$(54);
4100 PP=10*F:IF PP<2 THEN PP=2
4110 IF PP> 134 THEN PP=134
4120 IF PP=134 THEN CH=74 ELSE CH=47
4130 NS=PP-2:IF NS<0 THEN NS=0
4135 FOR NZ=1 TO NS:LPRINT CHR$(88);:NEXT
4140 LPRINT SP$;CHR$(CH)
4150 RETURN
5000 LPRINT CHR$(27)CHR$(81):LPRINT CHR$(27)CHR$(84);"12"
5010 LPRINT CHR$(27)CHR$(35)
5020 FOR N=1 TO 135
5030 NF=N/10:NI=INT(NF):RX=NF-NI
5040 IF (RX<1E-2) THEN LRPINT CHR$(49);    ELSE LPRINT CHR$(53);
5050 NEXT N
5055 LPRINT CHR$(10)
5060 RETURN
```

The program shown in listing 1 follows this flowchart closely. The program is written in TRS-80 Level II BASIC, but I have attempted to use as few nonstandard instructions as possible. You can adapt this program to any of the BASIC dialects (see the text box "Program Changes" on page 153, for more information). Lines 50–170 set the physical constants' values and give initial values to variables. The stop variable ST (in line 170) is used to terminate the program upon command. The program must be edited to change the values of any of the constants except weight, which can be changed by the operator. PR is a variable printout control. PR = 0 results in no hard copy, PR = 1 gives you a tabular list of the variables shown on the screen, and PR = 2 gives a graphic trace of the indicated weight. Line 5000, referenced if PR > 1.5, is used to set up the scale of the printer and to print an axis.

Line 200 is where the main loop begins. Line 1000 looks for a user input. If you press the W key, the program stops and expects a new value for the weight on the pan. The S key and the space bar also have functions, which I'll describe later. The subroutine starting on line 2000 is the math model of the control computer block in figure 2. We will be able to understand this block better after we begin to play with the servo simulation. The subroutine that begins at line 3000 is also part of the math model and represents the physics of our scale. It represents Newton's second law of motion as applied to rotating systems. (The text box "Physics Math Model" on page 153 has more details about the mathematical model of our scale.) The force applied to the solenoid equals the current after it is multiplied by a scale factor (line 3020). Torque is equal to the product of a force (F) multiplied by a distance (D), so the torque in the beam is equal to the product of F multiplied by D (line 3030). Assume that the distance from the pivot to the weight is the same as that from the pivot to the solenoid, so line 3040 calculates the torque due to the weight. Therefore, line 3050 determines the angular acceleration by finding the net difference between the torque due to the weight and the torque due to the solenoid current, and then that net difference is divided by the moment of inertia. Lines 3050 and 3060 integrate the acceleration to angular velocity and angle.

The subroutine starting at line 4000 displays the output on the screen. The program displays elapsed time, the deflection angle, the solenoid current, and the indicated weight. For reference, the actual weight is also displayed in the upper left corner. If a hard copy is desired (PR equal to or greater than 1), the print routine continues. Lines 4050–4070 output the table, and the graphic output is begun by the command at line 4080. The table output routine slows down execution considerably, so don't use it unless you find an interesting case. If you don't want a hard copy, the subroutine returns to the main program. If you haven't set the stop variable, the program loops back to line 200 and continues.

The subroutine starting at line 5000 scales the characters per inch in both directions and draws an axis. In operation, the graph is drawn vertically down the paper. (The values given are those needed with a C. Itoh ProWriter.) Other printers will require different values in lines 5000 and 5010. Line 5000 puts the ProWriter in condensed (17 characters per inch) mode and sets the vertical feed to 12 lines per inch. You can set these values to any you like. Line 5010 puts the printer into the graphics mode. Be forewarned: The program does not take the printer out of the graphics mode. You have to do it manually.

You usually start the program with no weight on the pan (W = 0). Pressing the W key for about one second stops the problem and the computer will prompt you for the value of weight you want to add. The scale will work well with any weight less than 10 units. Other keys include the S key, which will stop the program (you can also hit the Break key) and the space bar, which freezes the operation for as long as you hold it down. You have to edit the program to alter the servo-control constants, the physical parameters of the scale, or the printout command. I recommend that you avoid printing anything until you have a setup you really want to document. The printer slows down the simulation, especially when you call for graphics. In fact, while the computer is executing the subroutine that does the scaling (line 5000), expect a lengthy pause. After several seconds the normal screen and simulation will appear.

SERVO THEORY

After typing in the program with the values given in listing 1, go ahead and run it to see that it works. Don't worry

(continued)

PROGRAM CHANGES

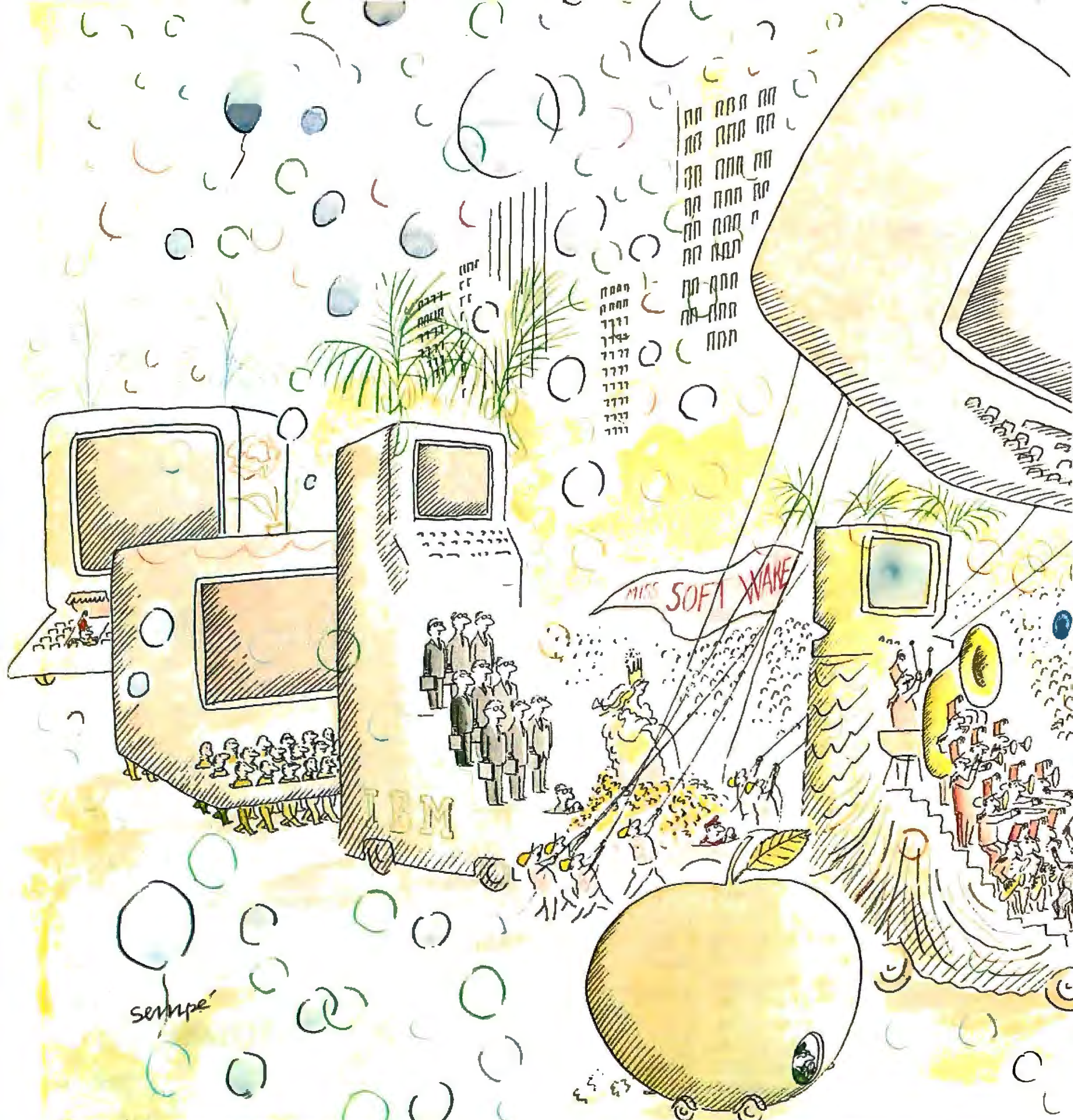
The BASIC I used in this program is Radio Shack Level II BASIC, but you can easily convert the program to other computers. I minimized commands unique to the Level II interpreter. The CLEAR command in line 30 clears for string space and is needed only for the graphic print option. The keyboard-scanning routine in lines 1010 to 1030 checks the keyboard for depressed keys. Using a normal INPUT statement would stop the program once every iteration, while we want the program to continue. The PEEKs look at the memory area of the memory-mapped TRS-80 keyboard. The Apple should use the same technique, although the memory locations will be different. Line 1010 looks for the space bar and freezes the program for as long as that key is depressed. Line 1020 looks for the S key. Line 1030 looks for the W key. For the Commodore 64 use the GET command.

The other main thing to watch for is the manner in which an output is sent to a line printer. If no printer is used, PR in line 50 will always be set to zero, and no changes are required. If a printer is used with another computer, however, modifications must be made. The TRS-80 merely uses the command LPRINT followed by the desired outputs, as in line 4050. For Apples, change all LPRINTs to PRINTs, precede each one with a PR#1, and follow it with a PR#0. For the Commodore 64, you must use the OPEN command before each output to the printer, followed by an OPEN 1,3 to return the output to the screen.

The other area of the program you may need to modify contains the graphics commands to printers other than the ProWriter. These parameters are discussed in the main text.

PHYSICS MATH MODEL

The code in lines 3000–3090 is a mathematical model of the physics of our scale. The scale operates according to Newton's second law of motion, but it is expressed in a form for angular motion, which may make it seem a little unfamiliar. Newton's second law is ordinarily expressed as: F=MA. For rotary or angular motion, however, it is expressed as: AA=L/J, where AA is the angular acceleration (degrees per second squared), L is the net torque (difference between the torques in opposite direction), and J is the moment of inertia. Moment of inertia is the resistance to a change in rotation and is the rotary equivalent of mass. The moment of inertia is a function of the beam's structure and of the weight added to the pan (line 3010). Torque equals force times distance. For our scale, we assume that the distance between the weight and the pivot is the same as the distance between the pivot and the point where the solenoid applies its force. Thus, line 3030 represents the torque generated by the solenoid, while 3040 represents the torque from the applied weight. Line 3050 calculates the angular acceleration. Line 3060 integrates the acceleration to find the angular velocity; 3070 integrates once more to find the angle. Line 3080 represents mechanical stops that prevent the beam from rotating more than 10 degrees in either direction.



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about making sense out of the simulation yet. Before we do any experiments, let's look at some elementary servo theory. Figure 4 shows the most simple form of servo controller. This is known among servo designers as a proportional control system. The controller merely takes the error signal ($Q_c - Q$) and multiplies it by a constant, known as the "gain constant." In our example, we want the angle of the scale to be zero. Thus, the commanded value of Q (Q_c) will always be zero, and our error is always equal to $-Q$, where Q is the scale's actual angle. The output signal to the actuator and, as mentioned previously, the restoring force on the scale are proportional to the error.

Now consider for a moment how you want your scale to act. Obviously the weight readout should be close to the actual weight in the pan. There are other desirable features, too. Beam balances seem to take forever to settle down and show whether they are indeed in balance. Electronic scales can also exhibit such oscillations, so we would like ours to settle down quickly. Additionally, if the scale comes to rest with the beam not level, there may be an inaccuracy. With these three criteria, let's run the program with the initial values from listing 1 and see how the scale performs.

As we start out, the scale is in balance and everything stays at rest with the scale at zero angle. Now press the W key until you see the prompt for weight. Type in a value, such as 5.0. This adds 5 ounces to the scale. The scale is now out of balance, and the beam swings to a negative angle. The control system senses this angular error and increases the solenoid current. This attracts the beam and slows it down. Now the current-generated force exceeds the weight, and the beam's angle moves back toward zero. When this happens, the solenoid shuts off the current and the cycle repeats. We have built a good oscillator. Our simulation will continue to oscillate like this forever. Figure 5 is a plot of a cycle of this condition. Stop the program now, as it is neither exciting nor instructive beyond this point. Pivot friction in an actual scale would eventually reduce these oscillations. However, it would take a long time and its effect would be small in a well-built scale. Consequently, I left friction out of my simulation model. Playing with the value of $K1$ will affect the period of the oscilla-

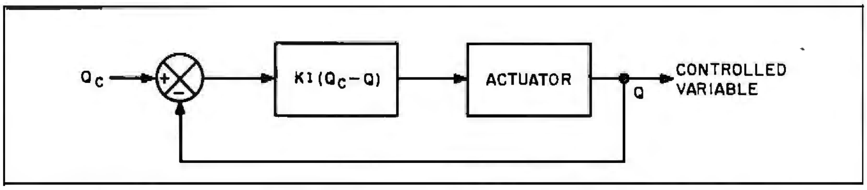

Figure 4: *In a proportional control system, the error between the actual and the commanded value is multiplied by a gain constant to drive the actuator.*

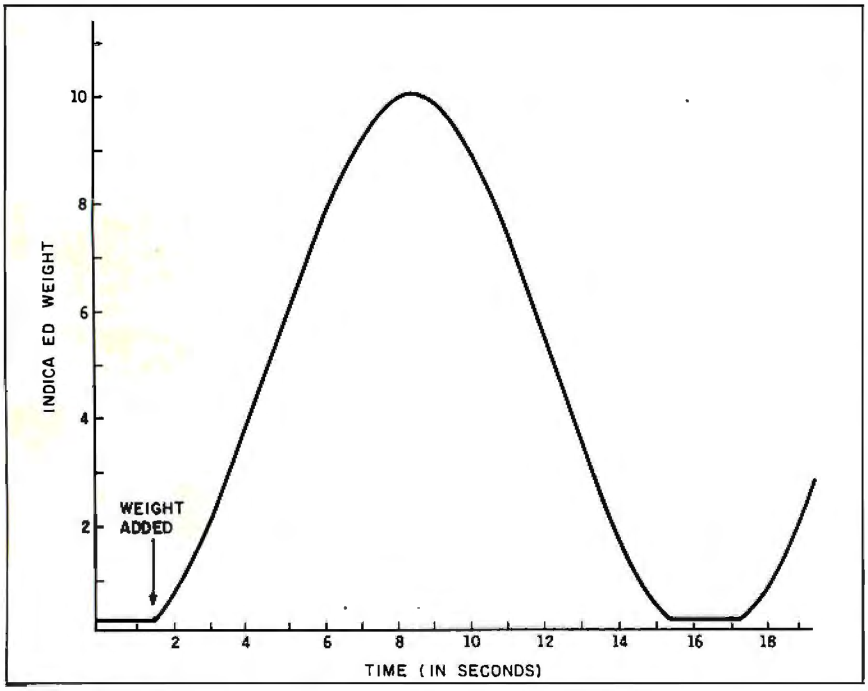

Figure 5: *Continuous oscillation is a common feature of a proportional control system with no damping.*

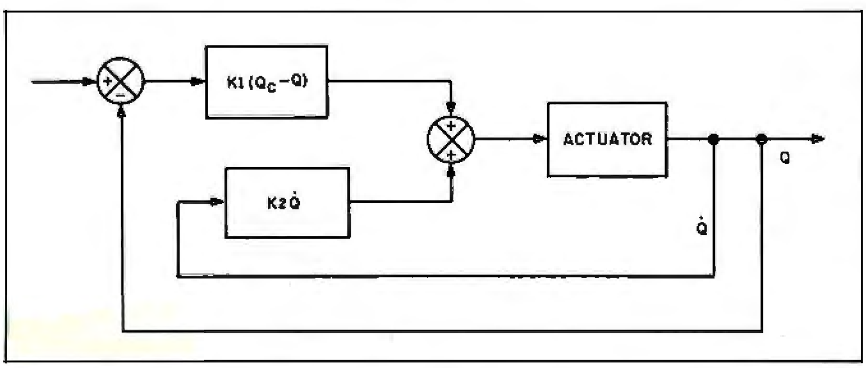

Figure 6: A *proportional-plus-rate system uses the output variable's rate of change as part of the control calculation.*

tion but won't eliminate it.

The way the servo designer eliminates eternal oscillation is to add "rate damping" to the system. Figure 6 shows a proportional-plus-rate system. The symbol Q with a dot over it (pronounced "Q dot") represents Q's rate of change over time. Again, Q is our controlled variable, the angle of the scale. In calculus, this is the time derivative. We add rate damping to our system by setting $K2$ to some nonzero value. Try a value of −4 in line 130 and run the program again. Figure 7 shows a typical result. Now we have reduced most of the oscillation, although a small amount of excess motion remains. The excess motion eventually stops, but the speed at which it stops is sluggish. The scale could almost be considered practical now. However, in addition to the sluggish response and the excess motion,

(continued)

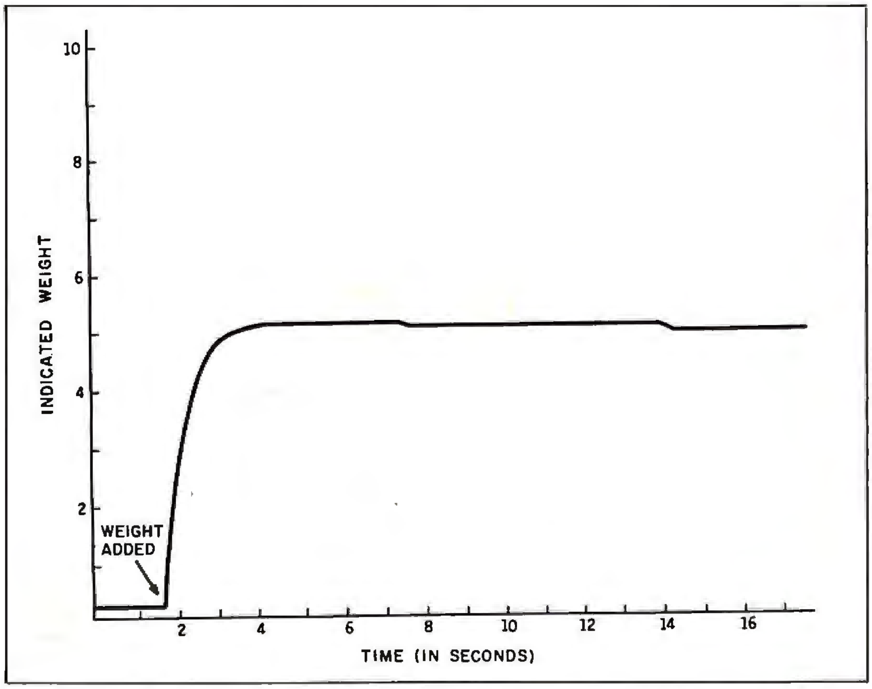

Figure 7: *The addition of rate-of-change feedback creates a damped oscillation.*

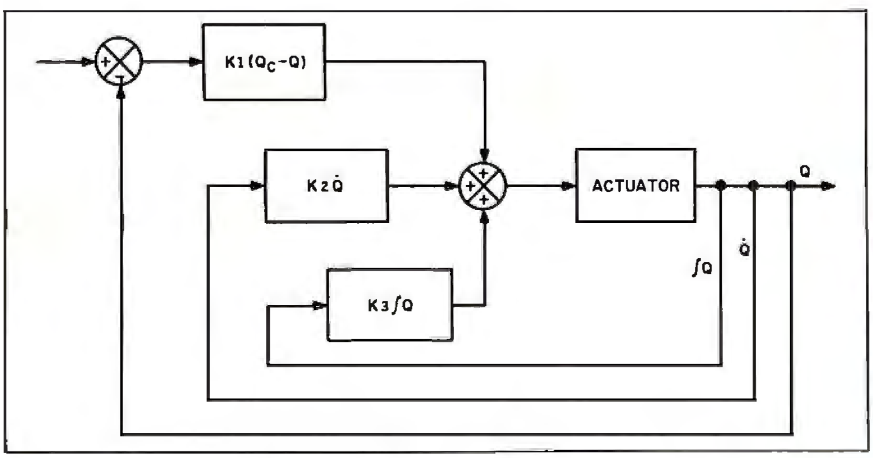

Figure 8: *The addition of a quantity proportional to the integral of the controlled quantity reduces error when the system reaches equilibrium.*

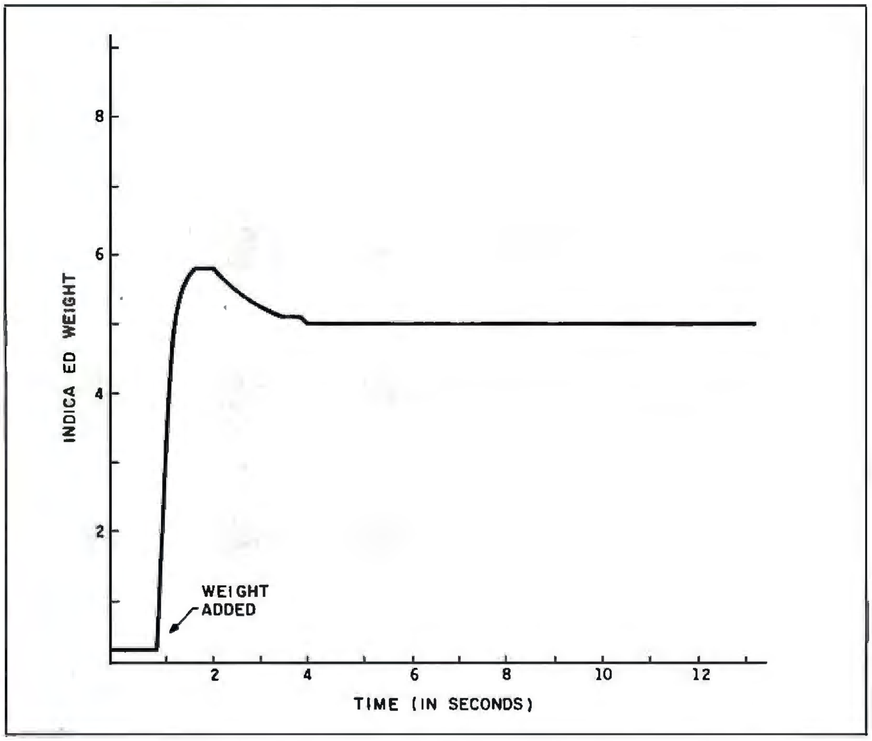

Figure 9: *The integral partially offsets the effect of rate damping so you get quicker response and some overshoot, which is quickly damped out. You can't see the reduction of the weight beam's angular error in this plot of indicated weight versus time, but including the integral Q increases the scale's accuracy.*

we have another problem. As the system approaches equilibrium, we still have an angle error of about 1 degree. This is not drastic, but we can do much better.

Specifically, we will add yet another block to the system (shown in figure 8) and create a proportional-plus-rate-plus-integral, or proportional-plus-rate-plus-lag, system. Although this is beginning to look like a formidable circuit, don't be dismayed. This is as complicated as it gets. We can create a proportional-plus-rate-plus-lag servo by changing $K3$ to a nonzero value. Try a -3 for $K3$ in line 140 and run the system again. We've speeded up the response and increased the excess motion. But as the system damps out, we see that a greatly reduced angle is obtained. Since an increase in $K2$ reduced the excess motion before, let's try increasing it again, this time to -8. Now that's more like it. Although there is still some excess motion, it quickly stops (see figure 9). The reading reaches equilibrium in a few seconds, and the angular error is less than one-tenth of a degree. You can improve your results even more by further refining $K2$ and $K3$. We have now designed a practical servo-controlled scale that is stable and becomes quiescent with reasonable speed. Play around with the system. As with any computer simulation, you can't hurt anything. If you want to see things really go awry, try putting in a value for any of the three servo constants with the opposite sign.

This simplified simulation illustrates much of the behavior of the typical servo system. You can easily modify the program to represent a speed-control servo (e.g., an automobile's cruise control). The professional engineer must still dabble in the realms of complex variables, nonlinear differential equations, and other forms of higher math, but simulations similar to this one are revolutionizing the design of servo systems. ■

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INTRODUCTION TO IMAGE PROCESSING

Image manipulation reveals hidden information

BY JEFFREY L. STAR

IMAGE PROCESSING, or I/P as it is often abbreviated, is a branch of computer graphics based on image data—the pieces that make up a picture. In essence, image processing is a special form of two-dimensional (and sometimes three-dimensional) signal processing. Scenes are developed from a camera-like sensor, either a conventional film-based system or a scanner, and manipulated so that they provide more information. I'd like to show just how common I/P is and describe some of its fundamentals.

Image processing is a powerful suite of techniques for uncovering information. Some of the techniques are comparable to photographic darkroom processes, but much more is involved. The principal idea behind image processing is to make an image more informative, or, in communications jargon, to extract more signal from the noise.

Commercial television has trouble displaying more than a dozen different gray levels. The human eye can perceive more levels of gray, but not many. If you need to be able to distinguish between shades of gray that are finer than you can see, you enter the realm where image processing can help. A black-and-white image-processing system can usually distinguish at least 32 gray shades.

Typically, computer systems treat images as arrays, or series of elements. The number of elements in an array determines the resolution of the image, and the number of bits available to any element of the array (or *word size*) determines the number of "colors" or gray-scale values each element can have. The smallest element of a picture corresponds to a single element of the data array. This element is called a *pixel*, an abbreviation for picture element. Popular choices for the number of pixels in an image are either based on powers of 2 (256 by 256, 512 by 512, or 1024 by 1024) or on hardware standards like the 525-line commercial television system.

The number of bits in a given pixel determines the number of unique gray values or colors available. Eight-bit pixels provide 256 different gray values in black and white or 256 unique colors. Most larger systems have 24-bit pixels—8 bits each for red, green, and blue—which translates into over 16 million unique colors. That many colors is more than one can display on a monitor, and certainly more than you can distinguish visually.

At least three standard systems are used to describe color. (See reference 2 for more background on color theory.) The *additive* system works by considering the amount of red, green, and blue light you would have to add together to create a specific color. Color television works precisely this way. If you take a close look at a color television or video monitor screen, you'll see triplets of colored dots. Each triplet contains a dot of each of the additive primary colors, red, green, and blue. This triplet represents the single pixel, the smallest element in the picture whose color you can specify. Similarly, I/P systems are almost always based on the red-green-blue additive system.

In contrast, when you're mixing paint, you mix the *subtractive* primary colors. The subtractive primary colors are cyan, magenta, and yellow.

Finally, human visual perception is often parameterized by hue, saturation, and intensity (or value). *Hue* is the simplest to understand; it is the "color" or dominant wavelength you see, for example, red versus green. *Saturation*, sometimes called purity, is easy to think of in terms of mixing white into a pure color. Red and pink are the same hue, but they differ in saturation—red is more saturated than pink. *Intensity* (or value) is the relativetive brightness of a color. When the relative brightness of a color. When you view a red wall with the sun shining brightly on it and then when the light is dim, the difference in "reds" appears only in intensity.

(continued)

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Photo 1a: *Color composite image of southern California by NASA Landsat Thermatic Mapper.*

Since all three of these systems are alternative ways of describing color, you might expect that you could freely convert (or "transform") between them, and you'd be right (see references 2 and 3). From here on, however, I'll be discussing the red-green-blue additive system.

IMAGING IN ACTION

My particular area of interest is image processing for satellite remote sensing. Several U.S. federal agencies, in particular NASA (National Aeronautics and Space Administration) and NOAA (National Oceanic and Atmospheric Administration), fly satellites with imaging sensors.

NASA's Landsat 5 is the most interesting such satellite now in operation. Landsat has two imaging systems: the Multispectral Scanner (MSS) and the Thematic Mapper (TM). Both are multiband imaging systems. Because of their fields of view and the satellite's orbital parameters, they cover the globe between latitudes 80 north and 80 south about every 18 days. Ground resolution for MSS is approximately 80 meters (that is, each pixel represents an area on the ground that is 80 meters on a side). For TM, ground resolution is approximately 30 meters. (Data from these sensors is available to the public from NASA. Ask for *The Landsat Tutorial Workbook: Basics of Satellite Remote Sensing*; see reference 6.)

Photo 1 comes from the NASA Landsat TM, showing a portion of southern California at the edge of the Salton Sea. The different colors correspond to rock type, and the San Andreas and associated faults run generally parallel to the shore. The image in photo 1a is a multiband color composite, produced as if several cameras with different filters were providing distinct information on the same scene. The image in photo 1b is pseudocolor processed (see explanation below). Photos 2a and 2b are from the Landsat MSS.

I/P SYSTEMS AND SOFTWARE

Systems for image processing range over almost all of the computer field—from Apples and IBM Personal Computers (PCs), through small minicomputers, to mainframe installations. While small PDP-11s have been the standard in the past, the Motorola 68000 microprocessor and DEC VAX systems seem to be the emerging standards. The following are a few of the commercially available systems.

ApplePIPS, for the Apple II with Apple DOS 3.3, and MicroPIPS, for the IBM PC with PC-DOS 2.0, are available from The Telesys Group Inc., Columbia, Maryland, at a cost of $495 each. These packages come with demonstration Landsat satellite data and are an excellent way to learn the rudiments of image processing. Classification (see definition below) and other higher mathematical functions are included in an advanced version of the software.

RIPS (Remote Image Processing System, Spectral Data Corp., Hauppauge, New York) is a Z80, S-100 bus 8-inch CP/M system with a 256- by 240- by 12-bit image memory. The base price is under $20,000 for the complete system. Software packages cover a broad range of applications. RIPS will process satellite data that the EROS Data Center (Sioux Falls, South Dakota) now supplies on 8-inch floppy disks. Upgrades include video input and a 9-track tape drive.

The IIS Model 75 (International Imaging Systems, Milpitas, California) and COMTAL/3M Vision One (COMTAL/3M, Altadena, California) are dedicated image-processing systems that include display memory, a video processor, a parallel interface to a computer, a track ball and function pad, digital-to-analog (D/A) converters, and a comprehensive software library. A typical small system as a peripheral to another computer might cost $50,000, and upgrades include a Motorola 68000 or DEC PDP-11 embedded microcomputer, with Winchester and 9-track magnetic-tape storage. These systems are typically used at universities and research agencies.

The only specialized hardware you must have for image processing is a display driver and a monitor, although when performance or image quality is important a great deal of specialized equipment is available. Among the components of display drivers are frame buffers, D/A converters, and lookup tables.

A *frame buffer* is the key to any image-processing system. This bank of memory stores the image data. Most medium-size systems use several banks of 512 by 512 elements; in I/P jargon, the rows of the frame-buffer matrix are the *lines* of the image, and the columns are the *samples* along each line. A typical choice for a color I/P system

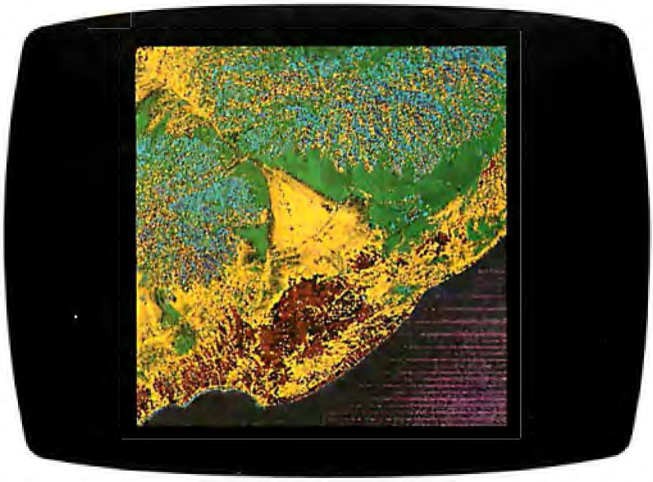

Photo 1b: *Pseudocolor processing highlights specific features of the image.*

is to have four memory banks or channels—one each for red, green, and blue, and a fourth for intermediate calculations and superposition of graphics and annotation.

Frame buffers and their associated control circuitry can get complicated. Some systems give you an option to segment memory on the fly. For example, a given system can have 128K bytes of image memory, and you could configure it as either 512 by 512 by 4 bits (16 colors), or 1024 by 1024 by 1 bit (black versus white), or 256 by 256 by 16 bits (64 kilocolors). Often, a system implements zoom and pan, which let you expand a smaller area in the image space to cover the entire display. You can accomplish zoom most easily by pixel replication; for any original pixel, the system displays a 2-pixel by 2-pixel square on the screen. This procedure provides a twofold magnification of any linear feature, and, of course, a fourfold reduction in the area displayed.

A *digital-to-analog converter* transforms the contents of the image memory into a form compatible with your monitor. The number of different intensity levels that a D/A converter can output is related to the number of bits it is designed to handle; the more bits, the more distinct colors or gray levels it can produce. Few systems use D/A converters with more than 8 bits of resolution. As mentioned earlier, for a full-color system this arrangement translates into 8 bits on each of three channels (red, green, and blue), a total of 24 bits of color information per pixel, or over 16 million unique colors. The outputs of the D/A converters are generally formatted to either a standard RS-170 composite video or, in higher-resolution systems, sent to the display via separate R, G, and B (red, green, and blue) cables.

A *lookup table* is an important part of an image-processing system and, like other lookup tables in the computer field, it is a table of stored data for reference purposes. The lookup table performs mapping between each unique input data value and some predefined output value. Applications include color or density mapping and calculations that must be performed rapidly. You could also use a lookup table to assign any particular value in image memory to any arbitrarily displayed color; this method of color determination is pseudocolor processing (more later). You could also use a lookup table to change the contrast range of a displayed image by setting up the table with a nonlinear transformation between input and output gray values; this adjustment of range can make the output intensities more distinct from one another or compensate for a nonlinear film emulsion or an electronic sensor response. In the same way, you could use the lookup tables, for example, to take square roots of the image values. This capability is particularly valuable if you are using the data in the image in a mathematical model or a statistical classification. You can then "recycle" the output of the lookup table back into a memory plane, which allows you to save enhanced images and manipulate them further.

Video processors are essentially array processors designed to work with the contents of frame buffers. They are dedicated computation units for performing certain routine operations on images, such as computing the ratio of two colors in an image. They permit relatively small computers and I/P systems to work in "real time," which is comparable to the time it takes to refresh an image on the screen (typically 1/30 second for a standard interlaced display, such as on a color television or microcomputer).

A *frame grabber* digitizes the output of a video camera and places the resulting image into memory. Video inputs are usually limited in terms of geometric accuracy and the number of available gray levels.

A *video film writer* is designed to produce color slides and prints with better resolution than a standard color CRT (cathode-ray tube). Again, on a color monitor a red, green, and blue dot make up a single pixel. The monitor's ability to display color depends on the limits of your eye's resolving power to merge the three color dots. Simply taking a photograph of a monitor works moderately well, but the quality is limited by the nature of the phosphor array (not much better than 1-millimeter resolution at best) and the curved screen.

Inside a video film writer are a black-and-white, high-resolution flat-screen monitor and three color filters. A single piece of film (color slide film or instant print film) is exposed to the monitor three times—first through the red filter, then the green, and finally the blue filter. This way, instead of the red, green, and blue dots being at a different place (as on a CRT), they are superimposed for each and every pixel. The business computer *(continued)*

graphics and computer-aided design/computer-aided manufacturing (CAD/CAM) uses for video film writers are numerous, with video film writers now available for under $4000. Some of the manufacturers include Celtic, Polaroid, Dunn, and Matrix.

If you want to turn an image into an array of numbers and you need more resolution and accuracy (or "spatial detail") than you can get from a video camera, you probably need an electromechanical scanner. The original image—transparency, film negative, or paper print—is mounted on a cylindrical carrier (similar to an old Edison cylinder phonograph). As the cylinder rotates, a photodetector scans along its axis and picks up image data. These scanners are generally large and expensive machines, but they have spatial resolution (in terms of pixel size) in the tens of micrometers.

The reverse process—turning digital data into a photograph—is performed by a device called a *film writer*. In this case, the cylinder holds a piece of film, which is exposed to a modulated light source (sometimes based on a laser in some commercial instruments). Such a device is capable of much higher resolution output than any monitor or video film writer; one manufacturer's specifications report a 25-micrometer raster over a 250-millimeter film negative. Negative and positive images and transparencies can be produced this way with high accuracy and geometric fidelity.

IMAGE-PROCESSING OPERATIONS

The principal operations involved in image processing are relatively simple. (Problems arise when you have large data sets. For example, the latest images from space derived from the Landsat Thematic Mapper satellite are from a piece of the earth's surface about 180 kilometers on a side and contain 300 megabytes of data.) A number of the key

(continued)

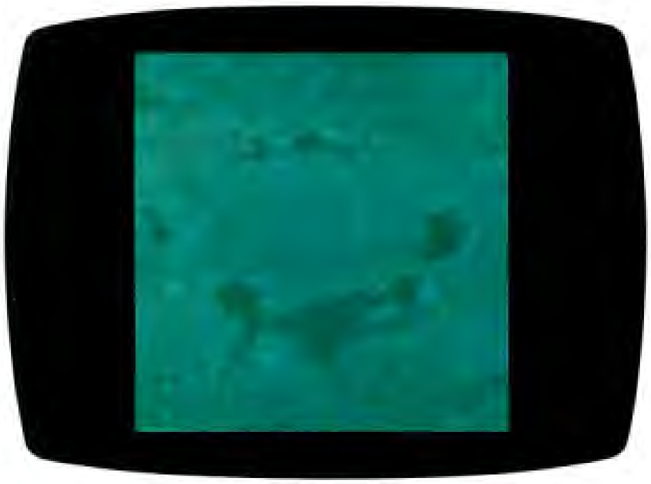

Photo 2a: *Raw Landsat satellite data.*

Photo 2b: *Landsat data contrast-enhanced.*

Photo 2c: *Upper portion is original data, lower portion has been rectified to a base map.*

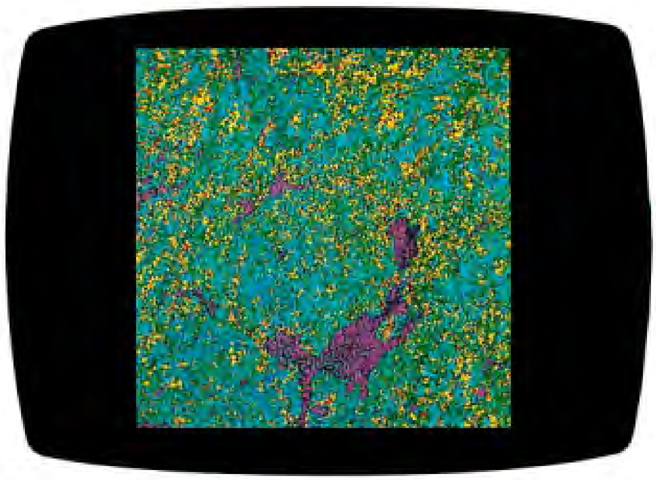

Photo 2d: *Pseudocolor-enhanced image.*

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image-manipulation functions are explained below.

Radiometric operations manipulate the intensity of the pixels in an image. For example, a given image may be washed out; all the pixel values are in a small range, and they are all very light. One type of radiometric operation, called *contrast stretching*, takes the darkest values in the image and forces their value to black, forces the lightest values to pure white, and linearly varies all the intermediate values. An example of contrast stretching is shown in photo 2, a series of images based on a test case in Sweden. Photo 2a shows the raw Landsat satellite data. In 2b, the image has been contrast-stretched so that the dark areas, representing water, show up better.

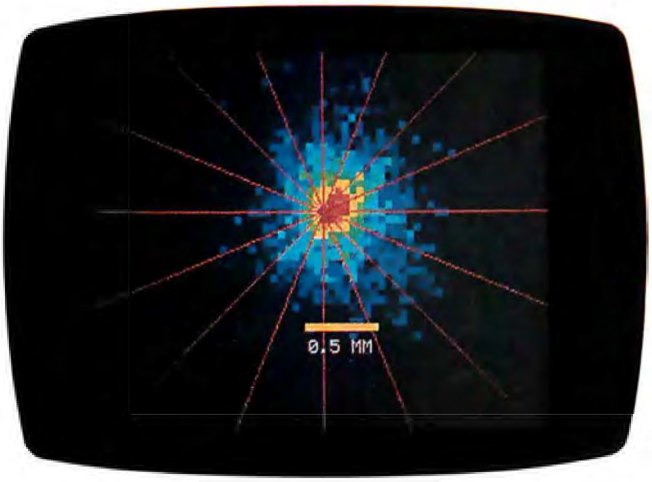

Photo 3: A *10-nanosecond x-ray pulse generated during the heating of a magnetically confined argon plasma. Red indicates the most intense x-ray emission and blue the least.* (Courtesy of COMTAL/3M *and* Sandia National Laboratories.)

Photo 4: A *neck x-ray image is shown on left. On the right is the same image enhanced by a spatial filtering operation.* (Courtesy of International Imaging Systems.)

Another radiometric operation is *density slicing*, where you display only those pixel values whose intensity is in some specified range. This operation is often used to highlight or classify objects in the image that have a characteristic brightness or color. Photo 3 illustrates a 10-nanosecond x-ray pulse during the heating of a magnetically confined argon plasma. In this image, red indicates the most intense x-ray emission and blue the least intense emission. The radial lines indicate the direction of the plasma motion prior to x-ray emission.

Sometimes color coding aids in the interpretation of the density-sliced image; for example, objects whose brightness is in a specified range are displayed in red. This process, known as *pseudocolor processing*, is shown in photos 1b, 2d, and 3.

Spatial operations are another family of manipulations that fall into several categories. One such category is *registration procedures*, which are used to take an image and force it to "overlay" another. For example, any map projection is a distortion of the earth's surface, and to superimpose an aerial photograph onto a map you need to "stretch" the photograph. (Imagine painting the photograph on a rubber sheet and then stretching the sheet until objects on the image overlay the same objects on the map.) Photo 2c shows the effect of a registration procedure. The upper portion is original data, and the lower portion has been rectified to a base map. Notice that features are both rotated and changed in shape; this is a typical application.

Another category of spatial operations is *filtering*, a term used in a signal-processing context. For those who are mathematically minded, think of a Fourier analysis, in this case, a two-dimensional Fourier transform. By isolating the high-frequency components in a scene (those that recur repeatedly), you can find edges, as shown in photo 4, a neck x-ray. The first view is the original x-ray, while the second has been enhanced by spatial filtering. The improvement in the ability to see structure is dramatic. Other smoothing operations remove high-frequency noise from an image in the same way that a filter on your stereo can reduce the sound of scratches and pops on an old record.

Spatial texture, the variation in pixel brightness in a small specified region, can be important in understanding an image. Texture is often calculated as the standard deviation of the nearest neighbors around a pixel, and this deviation can be displayed as an image itself.

Feature extraction and *classification*, also spatial operations, are powerful tools for image analysis. For example, if certain features in an image are a unique color or gray level, a simple statistical exercise is to "teach" the system to find the features. Unfortunately, feature extraction is almost never this easy. Pattern recognition is a complicated science itself and enters the realms of multivariate statistics, geometry, artificial intelligence, and radiative transfer theory. The end result of feature extraction is similar to photo 2d, where water is represented by the color purple and the regions that are peppered with yellow

(continued)

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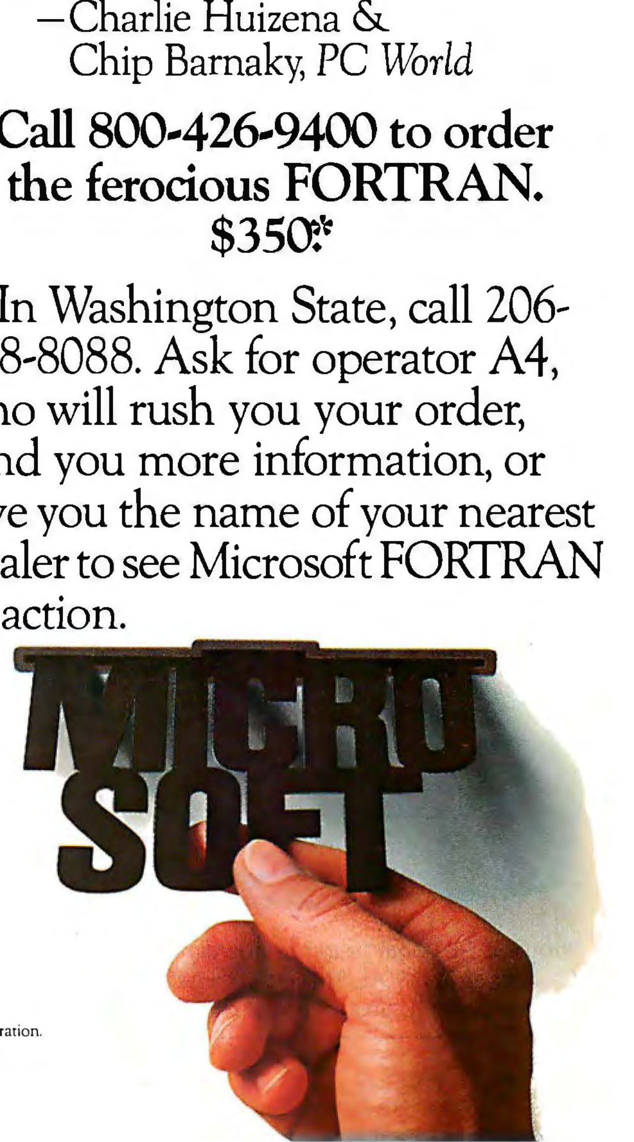

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correspond to known ground cover.

In the realm of *multiple-image operations*, another family of I/P manipulations, image processing can be considered three-dimensional; *x* and *y* are the rows and columns of the image, and *z* (the third dimension) is a spectral or time component. For example, you can have high-altitude color infrared images of agricultural crops taken at different times through the growing season. An image of a hydraulic system from both visible and infrared scanners can help detect overheating in the system by interpreting the infrared band as heat. In each case the data has a third dimension.

Data compression can be an important feature in an image-analysis system. At a theoretical level, the most efficient representation of a scene is to describe the location and orientation of the highest-level object description. ("High-level" is used here in the same way that BASIC is described as a high-level programming language as compared to assembly language. A high-level object description is "This is a house," as compared to "This is a square white object 25 feet by 25 feet in size.") This form of representation requires that you be able to distinguish all the objects in the scene, which is possible in only limited circumstances. On a more practical level, it is often possible to describe the image, using statistical techniques like principal-components analysis, or reduce the size of the data set with other techniques, such as run-length and difference encoding. Data compression becomes most important when image data must be transmitted or where large amounts of image data must be stored.

DOWN-TO-EARTH APPLICATIONS

Image processing is now being used in a number of disciplines. Medical people use image processing to construct pseudocolor images from CAT (computer-aided tomography) or PET (positron emission tomography) scanners. Photo 5 shows a series of images generated during a study of blood flow in a rabbit's heart.

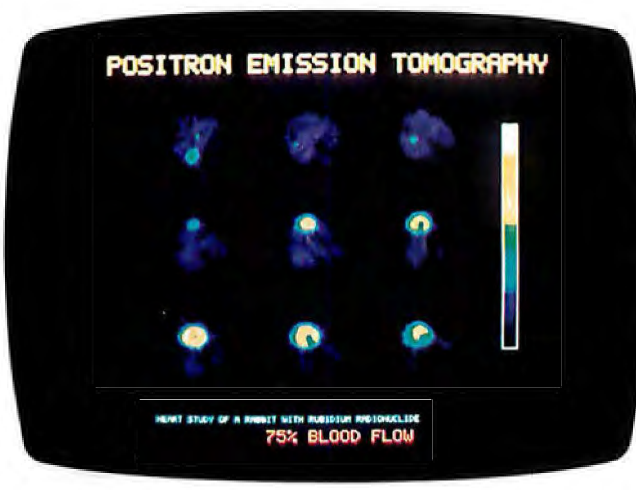

Photo 5: PET *scan images in a medical study of blood flow. (Courtesy of* COMTAL/3M *and the* Positron Diagnostic Research Center, University of Texas Health Science Center.)

As hardware prices drop while capabilities improve, image processing will be used more.

Art, advertising, and publishing people use pseudocolor and other techniques in the pursuit of more effective graphics. In the era of computer text editing, the idea of "cut and paste" is common; here, however, this approach includes full-color images and graphics. While straight graphics systems, in general, have difficulty with halftone illustrations and precise color balancing, an image-processing system can handle text, line art, and images in full color.

Structural engineers use I/P to examine weld x-rays for imperfections. Photographers can use I/P for a multitude of image enhancements that are either difficult or impossible in a conventional darkroom.

In each of these settings, people are interested in improving an image's ability to convey certain kinds of information. As hardware prices continue to drop while capabilities improve, image processing will become even more widely used. Courses in image processing are already available at many universities around the country, and in a remarkable range of subject areas; at the University of California, Santa Barbara, for example, I/P is taught in the geography department at levels ranging from beginning to advanced. ■

ACKNOWLEDGMENTS

I'd like to thank David Eckhardt *and* Earl Hajic, *University of California, Santa Barbara, for their help preparing this article, as well as* Robert Crippen *(University of California, Santa Barbara),* SATSCAN *(San Francisco, California),* COMTAL/3M *(Altadena, California), and* International Imaging Systems *(Milpitas, California) for providing data and images.*

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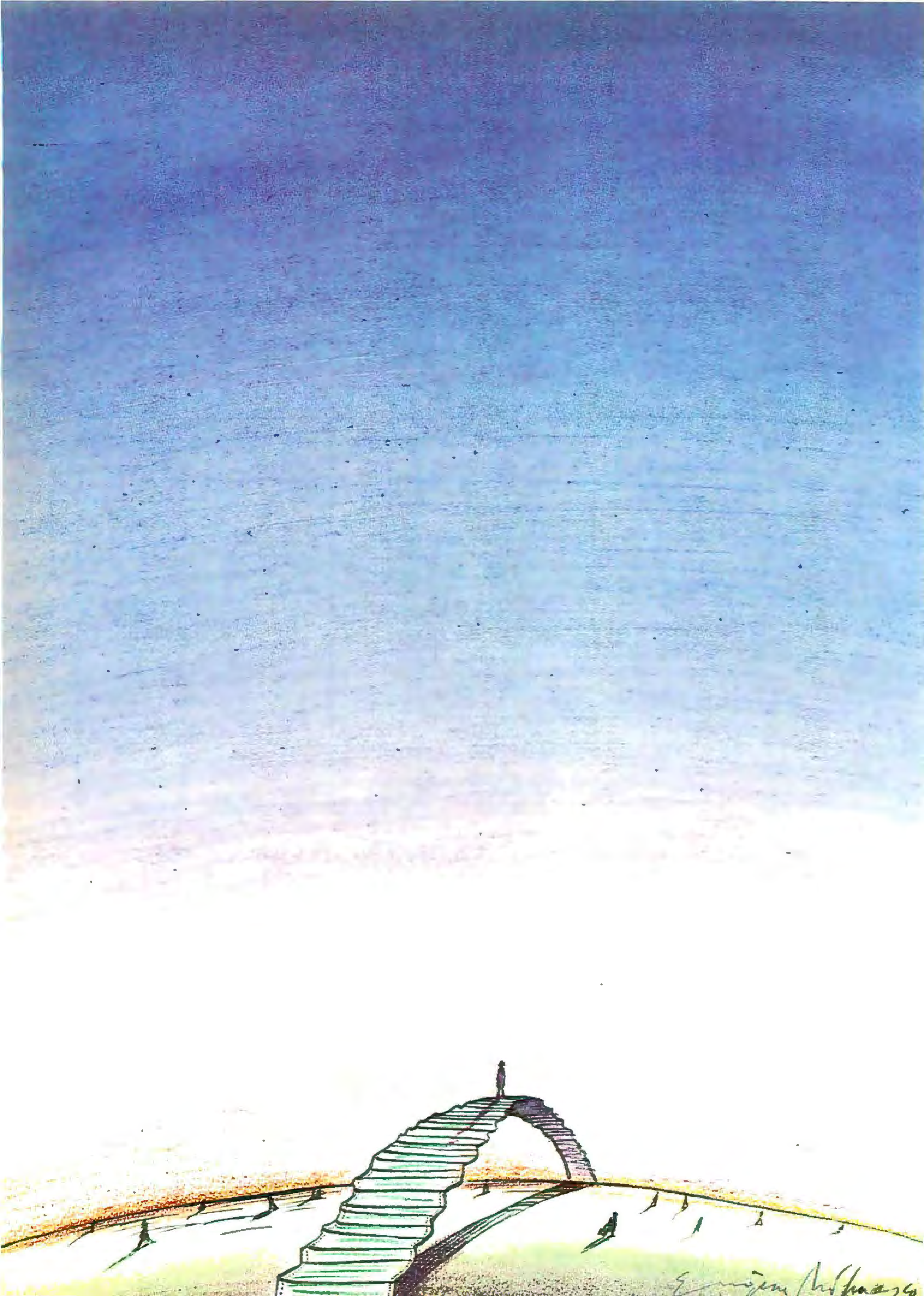

Sciences

WHEN I WAS ASKED to find articles under the umbrella of scientific computing, I realized that BYTE readers would probably best be served by articles focusing on the main aspects of microcomputer applications in science: development of tools of the trade, data acquisition, data analysis and reduction, and modeling of scientifically interesting systems or phenomena. This month's theme articles delve into those areas.

In "The Birth of a Computer" Dr. James H. Wilkinson, F. R. S., tells a fascinating story of the building of one of the earliest digital computers based on the designs of Alan Turing. Despite the 30-odd years since this work took place, the account is surprisingly fresh and relevant to today's use of computers in science.

The arithmetic underlying calculations is often ignored by users, regardless of their scientific background, yet it is important to know that the basis for these fundamental computer "tools" is sound. Richard Karpinski discusses one approach to learning about the arithmetic implemented on computers, the program Paranoia. This work, like so many others in the realm of scientific computation, owes much to the careful and detailed analyses performed and persistently reported by Professor William Kahan of Berkeley.

Data acquisition can be a difficult task involving expensive equipment. Some of the issues in the analog-to-digital conversion aspect of data acquisition are described by Dr. Lincoln Ford. For those with tight budgets, Kiyohisa Okamura and Kamyab Aghai-Tabriz present the hardware and software design of a Commodore 64–based system. To round out data acquisition, BYTE Technical Editor Tom Clune reviews the main avenues for interfacing experiments to computers.

Once the data is in the machine, it must be processed before it can be regarded as useful information. One technique for removing noise from data is Fourier smoothing, discussed by Eric Aubanel and Keith Oldham.

Having gained some understanding of a system, a scientist can attempt to model it—to generate or simulate the outcomes of experiments and "pictures" of what is going on. Earl J. Kirkland literally pictures molecules with an Apple Macintosh. Alan Curtis introduces the subject of modeling dynamic systems such as large-scale chemical or nuclear processes.

We have tried to strike a reasonable balance between depth and breadth in our coverage of scientific computing. In a field as large and sophisticated as this, the editorial choices made are never entirely satisfying. Nonetheless, we think that these articles present some fascinating glimpses into a complex domain.

—John C. Nash, Contributing Editor, Scientific Computing

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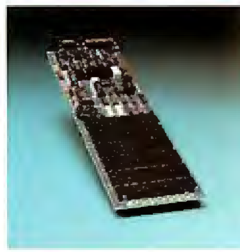

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THE BIRTH OF A COMPUTER

CONDUCTED BY JOHN C. NASH

An interview with James H. Wilkinson on the building of a computer designed by Alan Turing

The story of the construction of the first computers is both fascinating and instructive. Understanding the insights and decisions of computing's innovators may explain how the technology evolved to its present state and may illuminate the directions it might take in the future.

Among computing's innovators were Alan Turing (see page 65 for a review of a Turing biography) and the men he assembled to help him build a computer based on his Universal machine. Turing's team included James H. Wilkinson, a mathematician who had studied at Cambridge and worked for the British government as a ballistics engineer doing numerical analysis of explosives problems during World War II.

This interview was conducted for BYTE by Dr. John C. Nash and took place on July 13, 1984, at the Ninth Householder Gatlinburg Conference held at the University of Waterloo, Waterloo, Ontario, Canada.

BYTE: *Dr. Wilkinson, how did you become involved with Alan Turing and his computer?*

JHW: Shortly after the war, I discovered that a Mathematics Division was being set up at the National Physical Laboratory (NPL). I got in touch with E. T. Goodwin, who had been a colleague of mine at Cambridge in the Maths Lab. He was one of the first to join this new division. He invited me to have a chat with him at NPL in Bushy Park, Teddington, and there I met Turing, who I knew already by reputation as something of an eccentric. Turing and I had a long discussion, and I was very impressed with him. Presumably he must have been reasonably satisfied with me since he said if I came to NPL he would like me to work with him. I think that this offer and my friendship with Goodwin were the decisive factors. So in May '46, six and a half years after I joined the government service, I moved to NPL (as I thought then, temporarily) instead of going back to Cambridge University.

Turing had worked alone on the logical design of an electronic computer. When I arrived, he had presented his plans to what you might call a "review committee" at NPL. This consisted of a small group of Fellows from the Royal Society. The committee decided that Turing's ideas were basically sound, and they gave him a mandate to go ahead and recruit the appropriate staff.

Up to that time everything associated with the project had been done by Turing himself. He was a man with an original and inventive mind. His design had practically nothing in common with the group of computers which arose out of discussions at the Moore School of Electrical Engineering at the University of Pennsylvania. John W. Mauchly and J. Presper Eckert had already successfully completed the construction of the first electronic computer, the ENIAC (this was not a stored-program computer), and their influence was at its peak. When I went to NPL in May '46, Turing was working on what he called version 5 of [his] computer, though I never saw any documents relating to versions 1 to 4. Turing was not a great documenter, and no doubt the earlier versions were buried in the rubble on his desk.

Perhaps I should attempt to give some idea of the flavor of version 5, a typical Turingesque creation. It was

(continued)

Dr. John C. Nash (Nash Information Services, 1975 Bel Air Dr., Ottawa, Ontario, K2C 0X1, Canada) is an associate professor with the Faculty of Administration at the University of Ottawa, Canada. He is the author of two books on scientific computing and numerous journal articles.

a serial machine using mercury delay lines for storage, with a pulse repetition rate of what I still call a megacycle, being rather old-fashioned in such matters.

BYTE: *Define a megacycle.*
JHW: The basic pulse frequency was provided by a master clock which had a 1-megacycle pulse rate. It worked in binary, of course. That decision was taken early on and was regarded as irrevocable. The word length was 32 binary digits, which is rather better than 9 decimals.

BYTE: *They were fixed point?*
JHW: Yes. They were fixed point, but one of the earliest things that I did (at Turing's request) was to program a set of subroutines for doing floating-point arithmetic. These were later to become rather important in the history of NPL. Right from the start, Turing was impressed with the importance of speed. It is possibly not widely known that at that time most people weren't. For instance, Maurice Wilkes at Cambridge (who quite early became one of our principal competitors) took the view then that electronic computers were so fast that it was much more important to get one built than to make special efforts to increase its speed, and his views were generally shared. Turing took the opposite view, and most of the special features of his machine were designed to make it as fast as possible. There was merit in both views, but it was certainly true that the machines we were designing then were not nearly so fast as they appeared to be. However, Turing's obsession with speed certainly made for a very untidy machine. A great weakness of mercury delay lines is access time. In order to make them reasonably economic, it is necessary to store a number of words in each delay line. Clearly, if one stores consecutive instructions in consecutive positions in a delay line, one could perform only one instruction per major cycle, and indeed the early machines (other than ACE) that were based on mercury delays suffered from this weakness. |*Editor's note: ACE—for "automatic computing engine"—was the name given to Turing's machine by Mathematics Division head J. R. Womersley.*|

Photo 1: *English mathematician James H. Wilkinson, one of the builders and programmers of the early ACE computer.*

BYTE: *"Major cycle" meaning . . . ?*
JHW: "Major cycle" meaning the time of circulation of the main storage units, each of which held 32 words of 32 binary digits and hence had a circulation time of 1024 microseconds, i.e., approximately a millisecond. A conventional design would have meant that the maximum speed of operation was one instruction per millisecond.

BYTE: *Because, unlike a dynamic RAM, where you can get at any cell with one or two clock cycles, this had to use a thousand clock cycles.*
JHW: The other two early machines to work—EDSAC at Cambridge (which Wilkes built) and SEAC at the National Bureau of Standards (which Samuel Alexander built)—did, in fact, store consecutive instructions in consecutive positions, so that by the time one instruction had been executed the next one had been "missed," and one had to wait a full cycle for it to emerge. To avoid this, Turing stored consecutive instructions in such relative positions that the next instruction emerged just when the previous one was completed. Since different instructions took different times for their execution, consecutive instructions were irregularly spaced in the store. As you can well imagine, this made for what one would call "difficult" coding. I'm not sure that "difficult" is the right word. I would say such coding was tiresome or tedious. Also it made the design of automatic programming languages more laborious, while at the same time it made them more desirable. However, this feature of the machine turned out to be rather important; it meant we could do up to 16 instructions per major cycle, i.e., about 64 microseconds per instruction.

This practice later became known as "optimum coding" or "latency coding," but Turing never used that term. It was characteristic of him to see his machine as the basic one, all the others being out of step.

BYTE: *What was the ACE's total memory?*
JHW: Well, Turing envisioned a memory of 200 long delay lines, which would have given 6400 words.

BYTE: *About 24K bytes?*
JHW: Yes, and although that may sound rather small now, it was really very ambitious for that time. I am sure Turing would never have contemplated or supported the building of a smaller machine.

Shortly after I joined NPL, Turing moved on to version 6 and then rapidly to 7 and 8. Those were four-address code machines. |*Editor's note: A four-address machine had up to four address operands after an instruction, one of which would be to give the memory location of the next instruction.*|

The earlier machine, version 5, is hard to describe in these terms. But its successors performed instructions of the type A+B to C and selected the position D of the next instruction, which was necessary because they were not in consecutive positions.

BYTE: *A complete instruction would occupy one word?*
JHW: Yes, but it was a more powerful instruction than that on a conventional one-address code machine. Another striking difference in Turing's design was that he had a number of one-word delay lines and the arith-

(continued)

metic and logical operations were distributed among them. On a conventional one-address code machine the use of one accumulator leads to a tremendous bottleneck. One is always taking one number out of the accumulator to put in another. By having a number of one-word stores (delay lines), this is avoided. You see, this was all related to Turing's objective of making his computer faster.

BYTE: *When a word had an instruction, it would also have an address in it?*
JHW: Oh, yes.

BYTE: *So it wasn't like a modern microcomputer with instruction, operand, operand?*
JHW: No.

If Turing had stayed at NPL he would have gone for the full-scale computer with 200 delay lines, and quite frankly we had neither the facilities nor the experience to embark on such an ambitious project. It should be appreciated that the full-size computer was far larger than the one Wilkes was planning and eventually built as EDSAC.

Although I have used the term "optimum coding," most programs fell a good deal short of the optimum speed attainable. To achieve this would have been far too tedious. However, when it came to very important subroutines such as floating-point arithmetic, optimum speed was almost achieved. As I mentioned before, I produced the first set of floating-point routines, but when in 1947 Donald Davies, Mike Woodger, Gerald Alway, Billy Curtis, and John Norton joined the team, they all played a part in polishing them up.

BYTE: *This was all on paper?*
JHW: Naturally; we had no working computer. Because of the optimum coding, floating-point arithmetic (and other important routines such as double-length arithmetic) was much faster on Turing's machines than it was on its competitors. The speed of floating-point arithmetic turned out to be very important for me. When we finally built our computer, we dusted down our early routines and polished them up further. By the standards of the time they were very fast indeed, and this enabled me to get really extensive working experience with floating-point computation before it was practical elsewhere. I am sure this is why floating-point error analysis first made headway at NPL.

Turing continued with the logical design of machines, but after a while he began to get very dissatisfied. The policy had been adopted that the actual construction of the computer should be undertaken by some other government department such as the Ministry of Supply, where personnel experienced in pulse techniques as a result of working on radar were available.

I never liked that decision, but the director of NPL, Sir Charles Darwin (great-grandson of the great Charles Darwin), was not a very easy man to argue with. Remember, I was quite a junior member of the NPL staff at that time. But as I saw it, there were only two possibilities. Either the external group would be successful, in which case, if they had any imagination at all, they would take control of the computer themselves. Alternatively, they might fail. It seemed to me that we were in a no-win situation, and I couldn't understand why Turing accepted the proposal. This attempt to get the machine built outside continued very unsuccessfully, and Turing got more and more morose about it.

Finally, very belatedly, in 1947, Darwin agreed to set up a very small electronics group (not a division) at NPL. It was recruited mainly from people from other divisions of NPL, and inevitably most of the recruits were far from being experts in electronics, so they were going to have to learn on the job. A disaster struck almost immediately. The person who was put in charge of the team—a Dr. Thomas—is often criticized, but in my view rather unjustifiably. Thomas was much more interested in industrial electronics than in building a computer. I do not feel that this was unreasonable; it was not easy to have the imagination to foresee that computers were to become one of the most im-

(continued)

portant developments of the century. However, from our point of view Thomas's preferences were unfortunate. But worse was to come. Thomas and Turing had absolutely nothing in common and were scarcely capable of being civil to each other. So there we have the situation where the leaders of the two groups were completely incompatible.

This, naturally, made Turing even more unhappy, and he began to talk seriously of leaving. Finally, he left in 1948 and joined the group led by Freddy Williams and Tom Kilburn at Manchester. They were making rapid strides in the construction of a computer based on what became known as the "Williams-Kilburn store." Turing's decision was, in my opinion, an unfortunate one. He should have returned to Cambridge where he still held a fellowship at Kings.

I was left in charge of a team which consisted of six people including myself. We had virtually no contact with the electronics group, and at that stage Goodwin, who was in charge of the Desk Computing Section, had a long discussion with me. He said, "You know this enterprise looks now as though it's going to founder. Before you can be held responsible for its failure, would you not prefer to become a member of the Desk Computing Section?"

Well, I just couldn't accept that. By this time I was hooked on computers, so I said I would sweat it out and see what could be done.

Then a miracle occurred. Thomas left and went into industry where he had always belonged. The person who succeeded him, F. M. Colebrook, was an old radio engineer with very little knowledge of pulse techniques but a great fund of common sense. When he'd been in the post about two weeks, he came over to see me and he said, "You and I appear to be holding a very unhealthy baby." He went on to invite the four senior members of our group (Alway, Davies, Woodger, and myself) to join him in the Electronics Section on a semipermanent basis and attempt to achieve something together. This would be about May or June of 1948. Colebrook was a remarkable tactician, and soon we were all working rather well together. There were one or two uneasy weeks, but soon the animosity died down. E. Newman was in technical charge of the electronics group; he had worked on the H2S airborne radar system during the war and already knew quite a lot about pulse techniques. He and I got on remarkably well and that was a great help. In those days supplies were a problem, but fortunately one member of the electronics group, W. Wilson, a giant of a man, knew everybody in the supply world and was able to solve this problem satisfactorily. After we had spent a month or two building bits and pieces and generally finding our feet, Colebrook said, "Why don't we get together now and try to build a pilot machine, the success of which will demonstrate to the authorities that we are competent and therefore ensure the continuation of the enterprise." Then, in the light of success—we didn't hint at failure—we would go on and build the full-scale ACE.

Now it so happened that we had done a little experimental work in 1947 in the the Mathematics Division when Harry Huskey had spent a sabbatical year with us. At that time we had designed just such a miniature machine based on Turing's version 5. This enterprise had been stopped by Darwin when the Electronics Section was formed.

To a large extent we resurrected this machine, incorporating, of course, a substantial number of improvements. It was to be called the Pilot ACE and, effectively, it would be the smallest machine based on the logic of version 5, which would demonstrate the practicality of it.

BYTE: *How large a machine was the Pilot ACE?*

JHW: I suppose I was largely responsible for deciding on the size and scope of the machine, but any of the other three could by that time equally well have done so. In order to have some specific objective, I decided that

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it should be capable of solving fully automatically a set of 8 to 10 linear equations by Gauss elimination. This it would do in a matter of a second or two, very impressive for that time.

BYTE: *So you needed to store at least 150 numbers and the word width was 32 bits?*
JHW: In fact we decided to have 10 long delay lines, that is, 320 words. We started to design the chassis in late '48, some chassis being designed by the "mathematicians" and some by the "engineers." In the event, the mathematicians probably designed slightly more than half the chassis. I must emphasize that I am now talking about the detailed electronic design, not just the logical design. We put our newly won knowledge of electronics to immediate use.

We started to send our blueprints to the NPL workshop towards the end of that year. As each chassis arrived from the workshop, we put it into the main frame.

BYTE: *Literally a main frame?*
JHW: Yes, there really was a frame. We decided to use a plug-in assembly and planned to have spares of key chassis.

By the standards of the time it was an incredibly small machine physically, and yet it was in many regards more powerful than either EDSAC or SEAC. Direct comparisons are not really possible, but Pilot ACE was substantially faster on most problems, and it could solve some problems the other two couldn't.

BYTE: *And the clock cycle was still 1 megacycle?*
JHW: Yes, still 1 megacycle, a slightly tough decision. Wilkes had decided on 500 kilocycles. Certainly some of the problems we had would have been a lot easier at 500 kilocycles.

BYTE: *It is interesting that the Apple II is a 1-megacycle or 1-megahertz machine, by comparison. [Editor's note: This refers to the instruction rather than clock rate.]*
JHW: Yes, that's right.

The completed chassis would have started to arrive, I imagine, well through '49; I'm afraid progress was not documented. It so happened that the first chassis to arrive had been designed by Alway and myself, two of the mathematicians of the team, and naturally we put them into the main frame and got them working.

Then when the next chassis arrived—which Alway and I had not designed—we assisted in its installation because we already knew about the earlier chassis. Thus, without any conscious decision being made, Alway and I became the debuggers.

BYTE: *Weren't the chassis somewhat different from each group? Or were these different components?*
JHW: Of course, the various chassis had entirely different functions. Thus several were associated with the line counter, several with the logical control, and then there was one chassis for each delay line. (The latter were, of course, all identical.)

BYTE: *The line counter is . . . ?*
JHW: This was the section which counted the basic 32 pulses in a word time.

BYTE: *All this is now on one chip?*
JHW: Yes, of course, and much more. Our units were vast by today's standards in spite of being small by the standards of the contemporary design. Pilot ACE was also unique among the early computers in being extremely mobile. The main frame was on wheels and when the computer was finished, we wheeled it back to Mathematics Division without affecting its performance.

BYTE: *Was it power-hungry?*
JHW: It consumed somewhat less than 10 kilowatts, which was quite low. But we didn't have any forced cooling, and perhaps the construction was a little too compact for that. When we were assembling it, we were, of course, standing in front of it all day. It was like working in front of a 10-kilowatt fire, a rather trying experience.

BYTE: *Did you have much component trouble?*
JHW: Not really. Our main problem

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was with germanium diodes, which fortunately we didn't use on the same scale as SEAC. We used them for some gating requirements. Because our machine was so compact and didn't have forced cooling, the diodes were working at a temperature which was much higher than specified by the manufacturer.

BYTE: *So they would fail?*

JHW: Yes, there were some good diodes and some bad diodes. The bad diodes would fail after perhaps a week in the computer. A good diode, on the other hand, would go on almost indefinitely, so bad diodes were eventually weeded out.

Then came a key stage in the assembly of the computer. This was the day the first delay-line chassis was integrated. This was designed by Newman, and, as usual, he joined Alway and myself while it was installed, but from then on he stayed with us. The three of us worked well together and debugged the whole of the rest of the machine.

BYTE: *When did the first program run?*

JHW: On May the tenth, 1950. It is interesting that, unlike Wilkes, who had built everything he intended to have and then made it work, we added chassis by chassis as they were completed, and as soon as it was possible to do something (which was as soon as we had the control unit working, the adder and the subtracter, the logical operations and one long delay line), we tried it.

BYTE: *How would you feed the data in?*

JHW: Oh, at that point we fed the instructions in (in binary) from a set of 32 keys. When it worked on May the tenth, it could perform only the simplest of programs. In fact, our first program achieved the following: it took the binary number set up on the 32 keys, and every major cycle it added that number into the accumulator until it overflowed. Now, in addition to the 32 input keys we had a set of 32 output lights. When an overflow took place, the program put on the next light. So successive lights would come on at a speed which was directly related to the size of the number on the switches. Now this program, admittedly rather small, had to be fed in one instruction at a time, in binary, from the 32 keys. At the time the design of the delay lines needed improving; the amplifiers were somewhat unstable. So we kept feeding in the program, and it kept being forgotten before we could complete the input. So I said to Alway, "Let's try it four or five more times, and if it doesn't work, we'll call it a day and go home."

Well, we put it in about four times, and suddenly all the lights came on. This could have happened in any case, and it didn't guarantee the program was working. However, we made the input number smaller and the lights came on more slowly.

BYTE: *So the amplifiers had settled down?*
JHW: Yes. Then we doubled the number, and the lights came up twice as fast. We made the number three times as large and they came up three times as fast. On a binary machine that was quite convincing, so we said, "It must be working," and went home rejoicing. That program later became rather famous on the machine. It was known affectionately as "Successive Digits" or "Suck Digs."

Sometime before this, Teddy Bullard (later Sir Edward) had succeeded Darwin, and when he visited the Electronics Section (in late April 1950) he asked me how it was going. I replied that we should have something going in a week or two. Bullard was a very forthright chap, and he said with some scorn, "Come on, you can't pull the wool over my eyes. I've heard it's going very badly." (He had heard this, quite justifiably, via Harry Huskey.) I said, "You may well have heard this, and indeed it was true, but it's coming along nicely now, and in a week or two I confidently expect it to be working."

Naturally, when it did work, I tried to get in touch with him as I had promised to do. I tried to phone him. He wasn't there. Now the machine wasn't really very good at that stage

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and might stop working at any time. The director could not be traced, and I was pacing up and down, saying, "The bloody director is never here when you want him," when he stepped into the room via the window. His opening words were, "Here's the bloody director. I hear it's working."

I showed him this program, and he played with it and agreed that it was working. Then he turned to me with a grin and said, "It may be working, but the program's somewhat less than epoch-making," with which we had to agree, but it was very heartening for us.

We continued to add the chassis one by one, and by the end of June most of it was assembled. We didn't at that time have a multiplier, nor had we planned to have one, on Pilot ACE.

BYTE: *You would use successive addition?*
JHW: Yes; it was to be done by a subroutine, optimum coded so that it was not too slow. In fact, the optimum-coded version was about as fast as the automatic multiplier on EDSAC. So as soon as it began to do significant things, Bullard began to press us to have an Open [House] Day and to demonstrate it to the world. Well, I was a bit anxious about that because it wasn't really reliable enough. The amplifiers on the delay lines were still inclined to be unstable. However, Bullard was a very impetuous man, and he finally landed us with these "demonstration days."

BYTE: *When was that?*
JHW: It would have been November of 1950. By that time we could do a variety of significant things, but it was still not a very reliable machine.

One of the troubles we had at that time was with the power supply—not our power supplies but that of the Central Electricity Generating Board. For instance, in the evening when everyone arrived home and switched on electric fires, the voltage would drop suddenly, and that gave us problems.

BYTE: *Historically there was a coal shortage*

(continued)

at that time?

JHW: Yes. Such things added to our difficulties. We knew, too, that when SEAC had had its first demonstration—a little before us—it had been a fiasco, even though SEAC had, in general, been working reasonably well. During the whole of the time allotted to the press demonstration, it never once worked. You will find the early years abound with such bad-luck stories.

I must confess to having been pessimistic. We decided to have two popular programs for the daily press. For the first, they would give us a six-figure decimal number and the computer would tell them if it were a prime, and if not, output a factor.

For the second program, they would give us any date from the year 0 up to the year 9999 and it would output what day of the week it was. It covered both the Julian and Gregorian calendars and dealt with all leap years. In all, quite an amusing little program. Mike Woodger produced that program.

BYTE: *And where did he discover the technique?*

JHW: He worked it out for himself. Such programs are good fun, of course, but they leave one mercilessly exposed to the vulgar gaze. Someone puts in the current date, which is Wednesday, say, and the machine promptly says Thursday! So they're very much more dangerous. If you tell the press it's solving a partial differential equation, you can swear blind it's solving a partial differential equation and they would be hard put to prove it is not. Finally, we were to have one serious program; this traced skew rays through a set of lenses.

Well, we decided on this last program and announced it, only to find that we couldn't get the program to work. Two days before the press show it had still never worked, and we didn't know whether the program had a bug or whether it was due to computer malfunction. Then, just two days before the show, Alway and I accidentally found it was a minor machine fault which was not invoked at all in our other programs.

We got all three programs working then, just in time. The arrangement was that Bullard would entertain the popular press and I would give the demonstrations. The whole thing was to cover three days; one day with the popular press, one with the technical press, and a third day for VIPs including our competitors. Wilkes had his machine running in Cambridge and was justifiably proud of it. Williams and Kilburn from Manchester were also coming.

BYTE: *They had a machine too, didn't they?*

JHW: They had a little hookup at that

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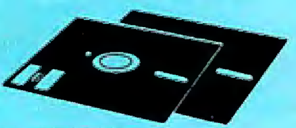

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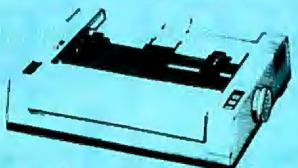

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time, but it could scarcely be called a computer. They hadn't built the Mark I by that time. Their little hookup was the first anywhere ever to run a stored program. It worked in 1947 and found the highest common factor of two numbers. This was, of course, a great deal smaller even than the Pilot ACE. However, it *was* an impressive "first" and I well remember being very heartened when I saw it working.

My point then, is that Open Day was doomed to be a failure. The plan for the first day was that Bullard was to entertain the press upstairs, while downstairs we made sure the computer was working. We were to receive a signal when Bullard was almost through. We did, and immediately the machine stopped working. We found out, almost at once, that it was a chassis associated with one of the delay lines. We plugged in a spare, but unfortunately we knew that the amplifier, as it warmed up, would become unstable: the amplifier would then need to be retuned and in 10 minutes all would be fine from then on.

So we were expecting to run into trouble almost as soon as the demonstration started. Well, the press arrived. They threw numbers at us and the computer factorized them like a charm. It was indefatigable!

We moved on to the "dates" program. It worked as it had never worked before: the day of Trafalgar, Waterloo, King George V's birthday.

We moved on to the ray tracing. It traced rays like a fiend; nothing could stop it. It continued in this vein from 10 till 1 o'clock. Then the press went away to lunch. We immediately looked at the output from the delay line, that is, the shape of the pulse coming out. It was the best output we'd ever seen!

The computer factorized numbers like a charm.

Further press representatives came in the afternoon; still a faultless performance.

The next day we had the technical press, and it was the same story. Never before had it worked for anything approaching this time period without a fault. The third day the VIPs came. Surely it would let us down now? Not a bit of it. Wilkes was there. I have always found him a very fair man, but naturally he was not prepared to give anything away. He didn't get a chance; it was perfect. It had already been decided that there would be a fourth day when it would

(continued)

Photo 2: A *hand-cranked desk calculator, like the one used by* Wilkinson *to perform numerical analysis during* World War II. *This machine was manufactured by* Brunsviga.

be put on show for the staff of NPL. This was a Saturday. The computer had a small fault before our audience arrived, but we soon put this right, and once again it performed flawlessly. The chances of such a performance must have been a million to one against.

On Monday we came in feeling rather jubilant. The computer was down, and it took us about a week to get it working again!

BYTE: *Today a lot of people are coming into computing with no background in calculation. Many of the machines they're using don't have the properties that ACE did, with double-precision accumulation of inner products. People have very little knowledge of this. How can these ideas be got across to them?*

JHW: It's a really difficult question, and I wouldn't claim to know the complete answer to it. Our experience with the Pilot ACE was really rather special. In order to get the most out of a machine with such a small store, user cooperation was essential on a scale which in many ways is not achieved even now. This gave one an intimacy with the machine; we were forced to look at the numbers and thereby achieved a deep understanding of what was going on. One can, of course, do this with modern computers; indeed the potential for doing it is actually greater, but one has to realize what it is one should be doing and why. For iterative methods we used acceleration techniques which were actually under the direct control of the operator. (For instance, when we were using the power method for the determination of the dominant eigenvector of a matrix, we could follow the progress of the vector on a cathode-ray tube screen. We had a cathode-ray display which showed the contents of any long delay line. We would look at the screen (which showed 32 components of the current vector), and we would see how fast it was converging. We would put a piece of paper over it, and we could say, for example, "It's gaining a binary digit every three iterations, so the ratio of the dominant to the subdominant eigenvalue must be about 2 to the power ⅓." We could then set up a shift of origin on the input keys that would give much faster convergence.) This work was commonly done by assistants who were in no sense qualified mathematicians, but they became very expert indeed. It is surprising how well they understood the battery of acceleration techniques available and how efficiently they used them. When later we went over to more automatic techniques, they complained we were "taking the guts out of their work." They really loved these early programs. The familiarity and intimacy gained with the computing process was fully comparable with that which one gets on a hand desk machine, where perforce you see every number. But on ACE that familiarity was gained quickly and painlessly. This experience was invaluable. Is there any way you can get it now? Of course there is, but one needs to know what is worth having and to have the incentive to output it.

BYTE: *I would say my own experience is that we are transferring large-machine, "faceless" programs down to the personal computers, where in fact one can go back to the ACE ideas.*

JHW: Yes. I agree. The potential is there, and it's much greater, really, than it was on ACE. But in my experience, many people who do computing are reluctant to look at numbers. At Stanford the general level of our students has been pretty high, but I would say their main weakness is in their inability to look at outputs and extract the meaningful information in them. In fact, somewhat to my surprise, they are generally less efficient at this than the assistants I used to have at NPL in the ACE days, in spite of having far superior mathematical qualifications. Most of those assistants had experience with desk computers and had learned to "look at numbers." The Pilot ACE forced them to continue with this habit.

I certainly do not want to suggest that the way to acquire this habit is to serve an apprenticeship on hand desk computers, but we have yet to learn how to instill the relevant knowledge. ■

FURTHER READING

This interview examines James H. Wilkinson's role in building the computer designed by Turing. For additional information on this subject, see Wilkinson's "Turing's Work at the National Physical Laboratory," in *A History of Computing in the Twentieth Century*, N. Metropolis, J. Howlett, and G. C. Rota, eds. (New York: Academic Press, 1980) and his articles on this topic in *The Radio and Electronic Engineer* (July 1975), plus a transcript of an oral history in *Pioneers of Computing*, C. Evans, ed. (London: Science Museum, 1975).

A LOW-COST DATA-ACQUISITION SYSTEM

BY KIYOHISA OKAMURA AND KAMYAB AGHAI-TABRIZ

A compromise between cost and quality, this system is adequate for many research projects

COMMERCIALLY AVAILABLE data-acquisition systems are quite expensive. A decent system may cost as much as or more than the entire annual equipment budget of an engineering department at a small educational institution like ours. Our solution to this problem was to design and build our own system. A reasonable compromise between price and quality, our system includes a Commodore 64 computer, a video display, a disk drive, and some miscellaneous hardware for about $800. It has only 8-bit data acquisition, but you can design a 12-bit system by using one and one-half I/O (input/output) ports (i.e., 12 bits) as the data-input pins. Furthermore, during breaks between experiments, our system can provide you with entertainment. Have you ever heard of a data-acquisition system you can play Pac-Man on?

HARDWARE

The circuit diagram to interface the real world to the Commodore 64 is shown in figure 1, and the corresponding hardware is shown in photo 1. For analog-to-digital (A/D) conversion, we use an 8-bit ADC0804. To multiplex the multichannel analog input signals, we use the multiplexer (MUX) chip 4051. The outputs are connected to data lines PB0–PB7 of Complex Interface Adapter 2 (CIA2) through the Commodore 64's User Port CN2. The input channel selection is done by the three bits PB0, PB1, and PB2 of CIA1, which are connected respectively to C(MSB), B, and A(LSB) of the 4051. For example, channel 0 is selected by CBA-000, channel 1 by CBA-001, and so on. This multiplexing arrangement can accept up to eight analog signals. However, our plotting software is limited to three channels. The graphic resolution decreases as the number of channels displayed on the screen increases. Handshaking between the ADC and CN2 can be done through a pair of connections: $\overline{\text{WR}}$(ADC) to $\overline{\text{PC2}}$(Commodore 64) and $\overline{\text{INT}}$(ADC) to $\overline{\text{FLAG}}$(Commodore 64). The latter is optional, and we don't use it in our software.

The analog signal to be connected to each input terminal of the MUX CD4051 in figure 1 should be properly conditioned, which involves amplifying and biasing the signal so that the voltage level is between 0 and +5 V, because +5 V is used as a voltage reference in the ADC. The signal should be made to come as close as possible to the full range of the ADC, without exceeding the full-range limit, for maximum resolution. Therefore, you may need an amplifier between each transducer and the MUX. In our case, since the output of each transducer was relatively large, we used an analog computer for signal conditioning. For a very small signal you can use a differential amplifier. According to figure 1, one of the two lead wires for the input signal is for return and should be grounded.

(continued)

Kiyohisa Okamura, an associate professor of mechanical engineering and director of the Applied High-Tech Laboratory at North Dakota State University (Fargo, ND 58105), holds a Ph.D. from Purdue University. He is also a technical consultant for U.S.–Japanese biomedical engineering and computer businesses. Kamyab Aghai-Tabriz is a graduate student of mechanical engineering at North Dakota State University.

The ADC converts analog input voltage to 8-bit binary data with 0 V corresponding to 00000000 and +5 V to 11111111. The computer shows only the decimal equivalent on the screen, that is, 0 to 255 for 0 to 5 V, respectively. Any value between these two extremes is proportionally converted. For example, a converted data 1 (decimal unity) corresponds to an analog input to 0.02 V (1 × 5/255). Similarly, a data value of 37 corresponds to 0.73 V (37 × 5/255), and so on. If you want to store or display the value of input directly expressed in voltage, all you have to do is divide the acquired data by 51 (255/5).

Using this method of conversion together with a manufacturer's calibration data sheet for a transducer, we can determine the correlation between the original physical quantity and the acquired data in the computer. Another method we often use is direct calibration.

The accuracy of the A/D conversion depends partly upon the accuracy and stability of the voltage supplied to REF/2 (pin 9). We used the reference voltage from the Commodore 64's 5-V power supply. Our measurement shows that this voltage is actually 4.98 V with a ripple component of less than 0.5 percent. It is quite stable and accurate enough for undergraduate experiments conducted in our laboratories. If you want greater accuracy, use a more reliable voltage reference for pin 9.

The serial data is output to pin M of CN2, which is connected to the coaxial cable as shown in figure 2. The other end of the cable is connected to the serial port of a receiving computer either directly or through a line driver/receiver, depending on the compatibility of the two computers' serial ports. For example, the Commodore 64 and TRS-80 we are using in our laboratories are not RS-232C–compatible. In the Commodore 64, binary state 1 corresponds to +5 V and binary 0 to 0 V at pin M. On the other hand, at the RS-232C terminal of the TRS-80, binary state 1 corresponds to 0 V and binary 0 to +12 V. Therefore, these two computers are incompatible in both voltage levels and polarity. This incompatibility can be resolved by line driver MC1488 as shown. If the receiving computer uses +12 V and −12 V with inverted polarity, you should connect point P to the receiving RS-232C. With noninverted polarity, use point Q instead.

We use a 500-foot coaxial cable to connect a Commodore 64 in one laboratory to a TRS-80 in another laboratory. We haven't noticed any voltage drop or noise at the receiving end.

SOFTWARE

[*Editor's note: The program for data acquisition is available for downloading via* BYTEnet *Listings. The telephone number is* (603) 924-9820.] The main portion of the program uses several assembly-language subroutines that are loaded in machine-language form via BASIC DATA statements. When you load the program, the menu in photo 2 appears. The menu and software are self-explanatory, so we'll only discuss the software briefly. When downloading the program, eliminate all state-

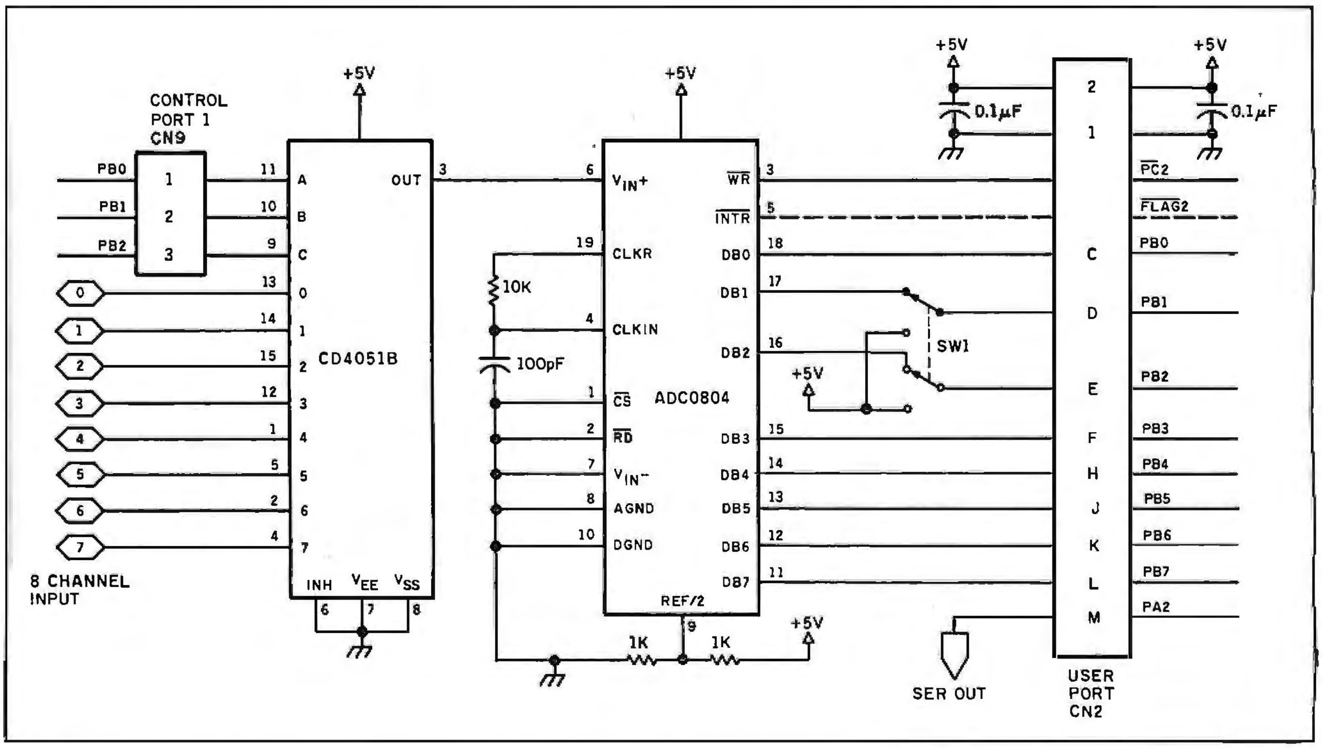

Figure 1: A *schematic for the* A/D *converter for the* Commodore 64 *data-acquisition system.*

ments headed with REM except for line 10, since they are strictly for comment and if typed in, they occupy too much space in RAM (random-access read/write memory).

When the main program is executed, all subroutines written in assembly language are poked into the appropriate locations as sequential data. Therefore, you should store the data (listings 2, 3, 4, and 5) as sequential files. Assign names (listing2, listing3, and so on) to these files. When the main program is executed, these programs will be poked into the locations shown in the first column of each listing.

A data-transmission subroutine is part of the main program. The transmission format is 2400 bps (bits per second), 7 data bits, 1 stop bit, and no parity check. This part of the program is also self-explanatory, but you have to remember to throw switch SW1 to the +5 V position when you use it. The screen displays the data as it is being transmitted from the Commodore 64. At the end of transmission, the screen displays an instruction: switch to ADC and press any key. You then throw SW1 back to the previous position so that the CIA is connected to the ADC.

The standard sampling rates of A/D conversion programmed in the main program are 1000, 500, and 100 samples per second; you can select the rate as part of the data-acquisition subroutine. In addition, you can set any sampling rate by yourself by adjusting parameters qq and ww in line 1110. This setting corresponds to the default value when the instruction for selecting the sampling rate is displayed on the screen. The maximum rate available is 4360 samples per second at ww = qq = 1. If you have three channels, this implies the sampling rate of 1453 samples/second for each channel. To lower the sampling rate, just increase qq and/or ww. These parameters are used in time-delay loops in the assembly program with parameter ww in the inner loop and parameter qq in the outer loop. Delay parameter ww has a greater effect on lowering the sampling rate than parameter qq does.

To calibrate the exact sampling rate, we used a square wave from a crystal oscillator as an input. Since the frequency of the crystal oscillator is quite accurately known, the sampling rate can therefore be determined.

(continued)

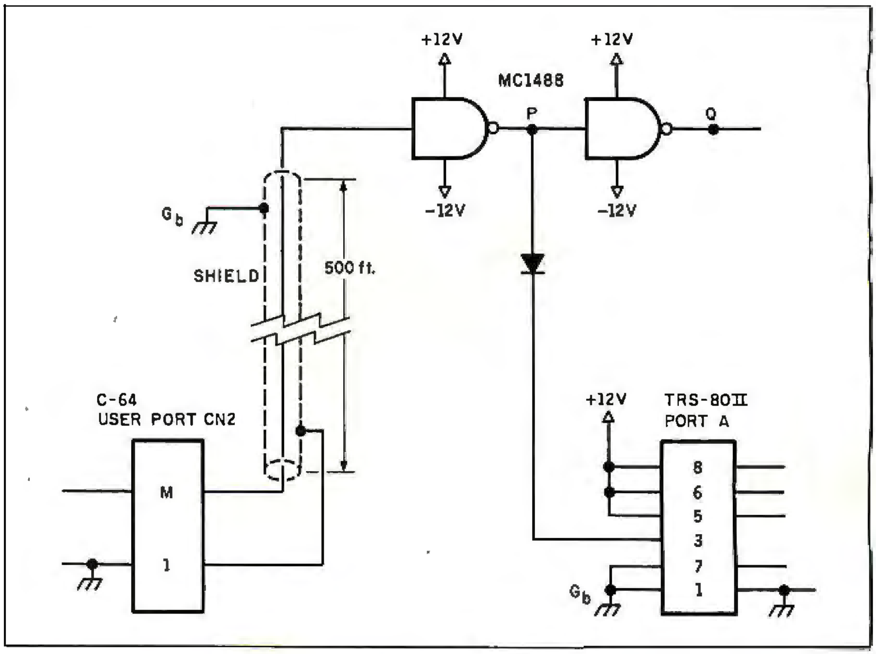

Figure 2: TTL *(transistor-transistor logic) to* RS-232C*-level conversion.*

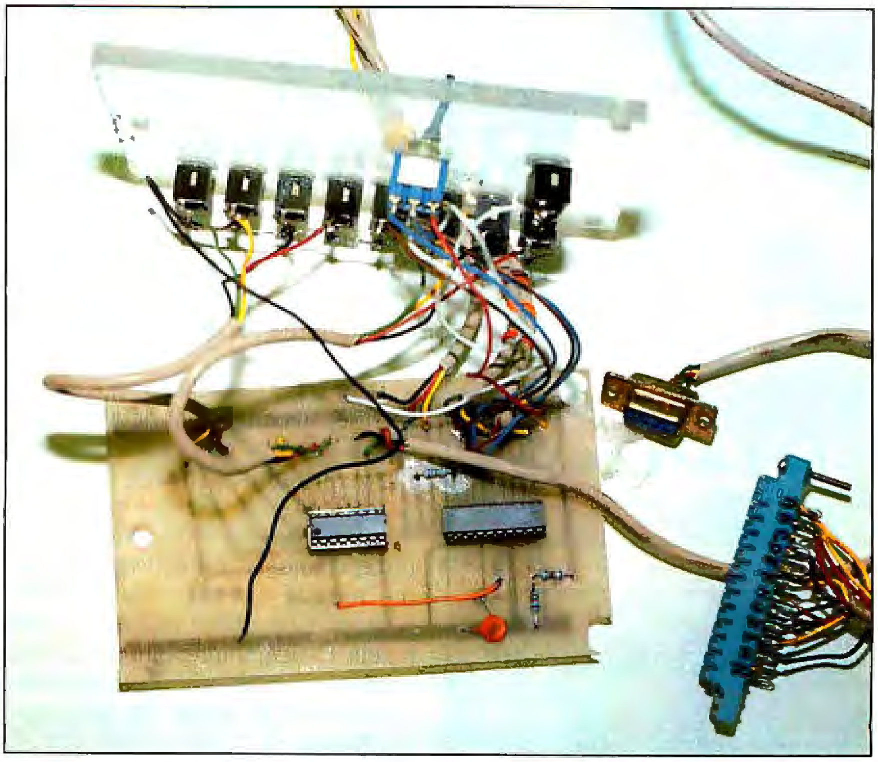

Photo 1: *The* A/D *converter.*

Photo 2: *The software menu for the data-acquisition system.*

The colors of screen background and data dots are determined by line 1470 in listing 1. You can change these colors by replacing the number 22 with another number. The number should be calculated as: 16 × (code number of dot color) + (code number of background color). In our example we used the white dots and a blue background. Hence, the number to be poked in is: $16 \times 1 + 6 = 22$. You can find the color codes in the Commodore 64 reference manual. You can also manipulate the color of the border in graphic display by changing the second number in line 1520.

When one channel of data is plotted on the screen, each data point is represented by one of 200 pixels in the vertical direction. The resolution represented by the error resulting from bit mapping is 0.5 percent. With three channels, the software divides the vertical axis into three sections: 66 (top), 67 (middle), and 67 (bottom) pixels. Hence, the resolution of each channel is 1.5 percent. As the number of channels increases, the resolution decreases.

The program stores data sequentially in RAM. In case of multiple channels (e.g., displacement x for channel 0, velocity v for channel 1, and acceleration a for channel 2) the data is stored in the following order: $x(1)$, $v(1)$, $a(1)$, $x(2)$, $v(2)$, $a(2)$, $x(3)$, . . . , where $x(1)$ and $x(2)$ are the first and the second bytes of data for x, and so on. They are stored sequentially in RAM with the starting address of 32769. The number of data points for each channel is 320 by default but can be changed. Since there are 320 pixels in the horizontal direction of the screen, 320 data points per channel is the maximum number of data points that can be displayed at one time.

CONCLUSION

We've found this system perfect for student use and adequate for some types of research. Though the system has many limitations, it is inexpensive and, above all, it's better than no system at all. ■

We would like to express our appreciation for the help Mr. William Welscher, a graduate student of agricultural engineering at North Dakota State University, gave us during the preparation of the manuscript of this article.

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FOURIER SMOOTHING

WITHOUT THE FAST FOURIER TRANSFORM

BY ERIC E. AUBANEL AND KEITH B. OLDHAM

An in-depth look at using the Fourier transform to remove noise from your data

IN THE SCIENTIFIC AND BUSINESS communities, gathering and analyzing data are very important activities. Data is often collected as a set of values of some variable (e.g., sales in business or current in electrochemistry) against some independent variable, most often time, at evenly spaced intervals. The data is then analyzed for the presence of significant trends. Sometimes these trends are difficult to discern because of the presence of noise or other short-duration perturbations in the data. You can attenuate the noise either by performing replicate experiments and signal averaging or by smoothing the data. The second approach is probably the less satisfactory of the two; it is commonly adopted, however, because the alternatives are more costly or time-consuming.

The three most common methods for smoothing data are moving-average, least-squares, and Fourier transformation. In the moving-average method, each data point is replaced by the average of itself and *n* neighboring points on either side of it. The advantage of this method is that it is very easy to program. The disadvantages include: the first and last *n* points are not smoothed to the same degree as the rest of the data set because they don't have *n* neighbors on each side of them; you must sample at a rate much faster than the fastest transient that you wish to study; and the method flattens the signal more than other smoothing methods.

The least-squares method identifies the line of the order you specify that minimizes the sum of the squares of distances between the data points and the calculated line. The advantages of this method are that it will permit you to easily generate statistical information on the goodness of fit, and it does not require that the data be collected at regular intervals. The disadvantages of the method are that it assumes that you know the basic form of the equation that the data satisfies, and the method is disproportionately biased by one or two very bad data points because it will twist the line of fit to spread the error over the entire data set.

Fourier transformation and inversion is probably the best method, since it lends itself naturally to identifying and eliminating noise. The reason for this is that noise is usually present at high frequencies, whereas the signal proper is usually at low frequencies. Fourier transformation produces the frequency spectrum. By eliminating the high-frequency portion of the spectrum and performing an inverse Fourier transform, you can obtain the original data without much of the noise—the "smoothed" data. The primary disadvantage of this method is that the data points must be collected at regular time intervals.

There are several reasons why Fourier smoothing is not practiced as often as other methods. Descriptions of Fourier transformation are often couched in unfamiliar jargon, though a few authors have succeeded in explaining Fourier transformation theory in simpler terms (see

(continued)

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references). A second reason is the common misconception that Fourier transformation and inversion are massive number-crunching operations that require large computers and cannot be implemented on the small personal computers that people are increasingly using for data collection and processing. Further, the success of the "fast Fourier transform" has spawned the belief that it is the only practical algorithm for transformation and inversion.

Before discussing the principles and operation of our BASIC subroutine for Fourier smoothing, let's look at the discrete Fourier transform, the removal of high frequencies, and the features of the fast Fourier transform. Our program does *not* execute fast Fourier transformation, though it does incorporate some of the same features. It is not especially fast when executed in a high-level programming language on a microcomputer, but it can achieve excellent smoothing in an acceptable length of time.

Discrete Fourier Transformation

A good explanation of the continuous and discrete transformations can be found in the article by Stanley and Peterson in the December 1978 issue of BYTE (reference 1). We will outline only some of the important features of the discrete Fourier transform.

Performing a discrete Fourier transform on a sequence of real valued data $x_0, x_1, \ldots, x_{N-1}$ produces two sets of real valued transforms:

(1)

$$R_k = \frac{1}{N} \sum_{j=0}^{N-1} x_j \cos\left(\frac{2\pi jk}{N}\right) \qquad k = 0,1,\ldots,N-1$$

(2)

$$I_k = \frac{-1}{N} \sum_{j=0}^{N-1} x_j \sin\left(\frac{2\pi jk}{N}\right) \qquad k = 0,1,\ldots,N-1$$

To regenerate the real valued data from the transforms, the following operation is performed:

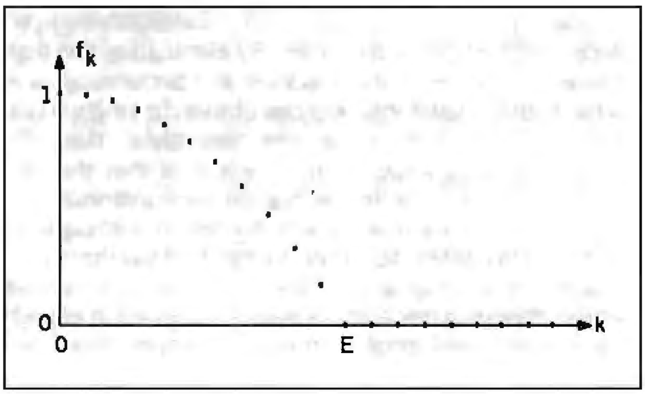

Figure 1: *When the digital filter function is incorporated into the FT algorithm, it eliminates all frequencies corresponding to $k \geq E$ from the discrete Fourier transform spectrum. Frequencies corresponding to $k < E$ are gradually attenuated.*

(3)

$$x_j = \sum_{k=0}^{N-1} R_k \cos\left(\frac{2\pi kj}{N}\right) - I_k \sin\left(\frac{2\pi kj}{N}\right)$$

$$j = 0,1,\ldots,N-1$$

The operation above is called Fourier inversion.

The information content of the original data is transferred, on Fourier transformation, into about the first half of the R_k, I_k numbers, i.e., those having $0 \leq k \leq \frac{N-1}{2}$ (if N is odd; $0 \leq k \leq \frac{N}{2}$ if N is even). The second half merely duplicates the first in magnitude: $R_{N-k} = R_k$, $I_{N-k} = -I_k$ (see Stanley and Peterson for a good illustration of this).

Removing High Frequencies

The procedure for removing high frequencies can be represented as a multiplication,

(4)

$$R_k \rightarrow f_k R_k; \quad I_k \rightarrow f_k I_k$$

by a function f_k (the so-called digital filter function). The simplest filter function is a rectangle, which would cut off the transforms for $k > E$. Such a sudden cutoff can lead to a false accentuation of frequencies corresponding to transform points in the vicinity of E. To avoid this you can use a quadratic filter function, which results in a gradual attenuation (see figure 1). The filter function we have incorporated into our algorithm is

(5)

$$f_k = \begin{cases} 1 - \left(\frac{k}{E}\right)^2 & k = 1, 2, 3, \ldots E-1 \\ 0 & k = E, E+1, \ldots \end{cases}$$

The smaller the value chosen for the integer E, the more denuded of high frequencies the subsequent invert will be; the closer E is to $\frac{N-1}{2}$ (or to $\frac{N}{2}$ if N is even), the less affected the regenerated signal will be.

Because there is no purpose in calculating those values of R_k and I_k that duplicate others or that will be replaced by zeros, the equations for Fourier transformation and inversion can be abbreviated to the following equations:

(6)

$$R_0 = \frac{1}{N} \sum_{j=0}^{N-1} x_j$$

(7)

$$R_k = \frac{x_0}{N} + \frac{1}{N} \sum_{j=1}^{N-1} x_j \cos\left(\frac{2\pi jk}{N}\right)$$

$$K = 1,2,\ldots,E-1$$

(continued)

(8)

$$I_k = \frac{-1}{N} \sum_{j=1}^{N-1} x_j \sin\left(\frac{2\pi jk}{N}\right)$$

$k = 1, 2, \ldots, E-1$

(9)

$$\tilde{x}_0 = R_0 + 2 \sum_{k=1}^{E-1} f_k R_k$$

(10)

$$\tilde{x}_j = R_0 + 2 \sum_{k=1}^{E-1} f_k R_k \cos\left(\frac{2\pi kj}{N}\right) - f_k I_k \sin\left(\frac{2\pi kj}{N}\right)$$

$j = 1, 2, \ldots, N-1$

where $\tilde{x}_j$ is the high-frequency-stripped analog of x_j. Note that R_0 is now expressed separately from R_k, as well as $\tilde{x}_0$ from $\tilde{x}_j$, and that $I_0 = 0$ because sin 0 = 0. The factor of two in equations 9 and 10 is present as a result of restricting E to be less than $\frac{N}{2}$ and by taking advantage of the symmetries ($R_{N-k} = R_k$, $I_{N-k} = -I_k$) already noted.

Though we used the word "abbreviated" to describe equations 6 through 10, their implementation still requires a lot of computation. Approximately 20*NE* multiplications or divisions and 4*NE* cosine or sine evaluations are needed to implement these equations straightforwardly. For example, if N=200 and E=20, about 16,000 trigonometric functions are needed, along with 80,000 multiplications. Some microcomputers take as long as 0.2 second to calculate a single trigonometric function and would spend almost an hour on this aspect of a Fourier program alone.

FAST FOURIER TRANSFORMS

To meet the problem of the large number of multiplications and other operations required to implement Fourier transformation and inversion straightforwardly, the fast Fourier transform (FFT) algorithm was invented. Books have been written on this topic, but here we can do no more than cite some of the features of the FFT.

The FFT has several advantages. (1) By using the properties of the sine and cosine functions, the number of needed sines and cosines is drastically reduced. (2) Similarly, the number of multiplications is drastically reduced, these, in effect, being replaced by additions. (3) The same routine, virtually unchanged, can be used for Fourier transformation and inversion. (4) No storage space is needed beyond that required for the initial data; the transforms simply "overwrite" the original numbers. (5) The total processing time is massively reduced, especially when N is large.

The disadvantages of the FFT algorithm, for our present purposes, are as follows. (1) To function efficiently, N is required to be a power of 2. (2) Even though far fewer are needed, the evaluation of sines and cosines may still be a bottleneck and therefore a memory-consuming "sine lookup table" must be incorporated into time-efficient FFT algorithms. (3) The algorithm is inherently "square," being designed to generate $2N$ outputs from $2N$ inputs; thus it cannot exploit the potential savings in the "rectangular" task of producing only E outputs from N inputs. (4) Because of the need to perform "bit inversions," programming in anything except machine language is not efficient.

To deal with situations in which the number of input data cannot be conveniently made a power of 2, the technique of "zero-filling" is often used. This inflates the number of points to be processed from N to the next higher power of 2—for example, from 200 to 256—with a consequential increase in storage and time requirements but without any benefit to our present task. On the contrary, because it may introduce a sharp discontinuity (see examples), zero-filling hinders smoothing.

For data-smoothing purposes, the disadvantages of the FFT often outweigh its advantages. This was the conclusion we reached after we had implemented a smoothing procedure that relied on a standard FFT routine. We therefore designed the algorithm that is the subject of this article. This new algorithm is not an FFT. It shares with the FFT the first two advantages cited above but does not share any of the disadvantages.

PRINCIPLES OF THE ALGORITHM

Notice that equations 7, 8, and 10 are all of the form

(11)

$$G = \sum_{m=1}^{M} U_m \cos\left(\frac{2\pi ml}{N}\right) + V_m \sin\left(\frac{2\pi ml}{N}\right)$$

when G, m, U_m, V_m, M, and l are appropriately interpreted. To evaluate expression 11 our algorithm uses the following principle: The sum is split into odd-m and even-m terms,

(12)

$$G = \sum_{m=1,3}^{M \text{ or } M-1} U_m \cos\left(\frac{2\pi(m+1)l}{N} - \frac{2\pi l}{N}\right) + V_m \sin\left(\frac{2\pi(m+1)l}{N} - \frac{2\pi l}{N}\right)$$

$$+ \sum_{m=2,4}^{M \text{ or } M-1} U_m \cos\left(\frac{2\pi ml}{N}\right) + V_m \sin\left(\frac{2\pi ml}{N}\right)$$

and the arguments of the trigonometric terms are modified in the odd-m moiety. Next, addition formulas are used to expand the modified functions and the m is then replaced by $2m-1$ in the first summation and by $2m$ in the second. After collection of terms, this leads to

(continued)

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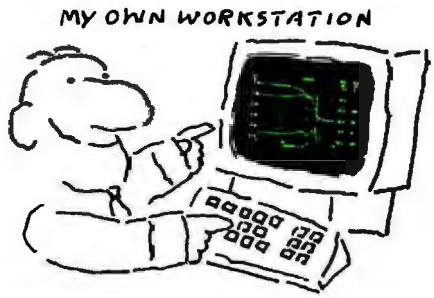
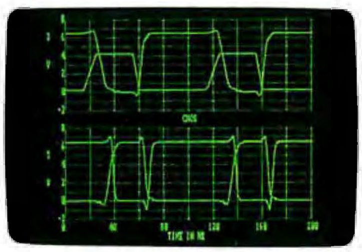
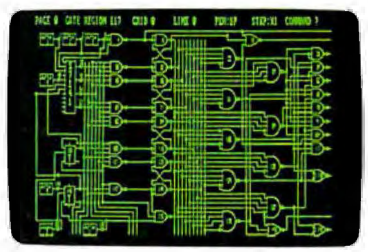




"Typical MICROCAP Transient Analysis"



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Listing 1: *The Microsoft* BASIC *version of the Fourier-smoothing algorithm.*

```
2 '**********************************************
4 '* FOURIER SMOOTHING WITHOUT THE FAST FOURIER
           TRANSFORM PROGRAM
6 '*     By Eric E. Aubanel and Keith B. Oldham
8 '**********************************************
10 CLS
12 INPUT "ENTER NUMBER OF DATA POINTS";N
14 REM LEAVING R AND I ARRAYS UNDIMENSIONED
   LIMITS VALID VALUES OF E TO <=10
16 N2=INT((N+1)/2+1):DIM X(N),X1(N),U(N2),V(N2)
18 FOR I=0 TO N-1
20      INPUT "ENTER DATAPOINT VALUE";X(I)
22      LPRINT "X(";I;") = ";X(I)
24 NEXT I
26 GOSUB 60
28 LPRINT "WHEN E = ";E;" THE SMOOTHED DATA
   VALUES ARE:"
30 FOR I=0 TO N-1
32      LPRINT "X(";I;") = ";X1(I)
34 NEXT I
36 INPUT "IF YOU WANT TO TRY A DIFFERENT E,
   ENTER 1 ELSE ENTER 0";MORE
38 IF MORE=1 THEN GOSUB 60 ELSE IF MORE<>0
   THEN 36 ELSE 42
40 GOTO 28
42 END
44 REM FOURIER ALGORITHM SUBROUTINE BEGINS
   AT LINE 60. LINE NUMBERS ARE THE SAME AS
   FOR THE HP VERSION OF THE SUBROUTINE
60 PI=3.141593
70 PRINT "NUMBER OF TRANSFORM POINTS
   TO BE KEPT";
80 INPUT E
90 IF E>INT((N+1)/2) THEN PRINT "E TOO LARGE"
   :GOTO 70
100 IF E<>INT(E) OR E<=1 THEN GOTO 70
110 IF E<=Q THEN 870
120 REM
130 IF Q<>0 THEN 330
240 'CALCULATE R(0)
250 G=0
260 FOR J=0 TO N-1
280      G=G+X(J)
290 NEXT J
300 R(0)=G/N
310 Q=1
320 REM
330 PRINT "WORKING ON R(K) TRANSFORM
    CALCULATIONS"
340 J2=INT((N-1)/2)
350 P1=INT(LOG(2*J2-1)/LOG(2))
360 FOR K=Q TO E-1
370      J1=J2
380      S=PI*K*2/N
390      C=COS(S):S=SIN(S)
400      FOR J=1 TO J1
410           L=2*J-1
420           U(J)=X(L)*C+X(L+1)
430           V(J)=X(L)*S
440      NEXT J
450      S=2*S*C:C=2*C*C-1
460      FOR P=1 TO P1
470           U(J1+1)=0:V(J1+1)=0
480           J1=INT((J1+1)/2)
490           FOR J=1 TO J1
500                L=2*J-1
510                U=U(L)*C-V(L)*S+U(L+1)
520                V(J)=U(L)*S+V(L)*C+V(L+1)
530                U(J)=U
540           NEXT J
550           S=2*S*C:C=2*C*C-1
560      NEXT P
570      R(K)=(X(0)+(U(1)*C+V(1)*S))/N
580 NEXT K
590 REM
600 PRINT "WORKING ON I(K) TRANSFORM
    CALCULATIONS"
610 FOR K=Q TO E-1
620      J1=J2
630      S=2*PI*K/N
640      C=COS(S):S=SIN(S)
650      FOR J=1 TO J1
660           L=2*J-1
670           U(J)=-(X(L)*S)
680           V(J)=X(L)*C+X(L+1)
690      NEXT J
700      S=2*S*C:C=2*C*C-1
710      FOR P=1 TO P1
720           U(J1+1)=0:V(J1+1)=0
730           J1=INT((J1+1)/2)
740           FOR J=1 TO J1
750                L=2*J-1
760                U=U(L)*C-V(L)*S+U(L+1)
770                V(J)=U(L)*S+V(L)*C+V(L+1)
780                U(J)=U
790           NEXT J
800           S=2*S*C:C=2*C*C-1
810      NEXT P
820      I(K)=-((U(1)*C+V(1)*S)/N)
830 NEXT K
840 REM
850 IF E>Q THEN Q=E
860 REM
870 PRINT "WORKING ON INVERSE TRANSFORM"
880 REM
890 'CALCULATE X1(0)
900 F1=0:F2=0
910 FOR K=1 TO E-1
920      T=R(K)
930      F1=F1+T
940      F2=F2+K*K*T
950 NEXT K
960 X1(0)=R(0)+2*(F1-F2*(1/E/E))
980 REM
990 P1=INT(LOG(2*E-3)/LOG(2))
1000 FOR J=1 TO N-1
1010      T2=E*E
1020      FOR K=1 TO E-1
1030           F=1-K*K/T2
1040           U(K)=R(K)*F:V(K)=-(I(K)*F)
1050      NEXT K
1060      K1=E-1
1070      S=2*PI*J/N
```

(continued)

```
1080        C=COS(S):S=SIN(S)
1090        FOR P=1 TO P1
1100              U(K1+1)=0:V(K1+1)=0
1110              K1=INT((K1+1)/2)
1120              FOR K=1 TO K1
1130                    L=2*K-1
1140                    U=U(L)*C-V(L)*S+U(L+1)
1150                    V(K)=U(L)*S+V(L)*C+V(L+1)
1160                    U(K)=U
1170              NEXT K
1180              S=2*S*C:C=2*C*C-1
1190        NEXT P
1200        X1(J)=R(0)+2*(U(1)*C+V(1)*S)
1220  NEXT J
1230  RETURN
```

Listing 2: *The straight-line procedure for eliminating the "end effect" can be* MERGEd *with listing 1 without modification. Note that this listing is not a stand-alone program.*

```
140 'STRAIGHT LINE CALCULATION
150 S1=0:S2=0
160 D=INT(N/10)
170 FOR J=0 TO D-1
180       S1=S1+X(J)
190       S2=S2+X(N-J-1)
200 NEXT J
210 X1=S1/D:X2=S2/D
220 M=(X2-X1)/(N-D)
230 B=(X1+X2)/2-M*N/2
270       X(J)=X(J)-M*J-B
970 X1(0)=X1(0)+B
1210      X1(J)=X1(J)+M*J+B
```

(13)

$$G = \sum_{m=1,2}^{\mathrm{Int}\frac{M+1}{2}} \left[U_{2m-1}c - V_{2m-1}s + U_{2m}\right] \cos\left(\frac{4\pi ml}{N}\right) + \left[U_{2m-1}s + V_{2m-1}c + V_m\right] \sin\left(\frac{4\pi ml}{N}\right)$$

where c and s are abbreviations for cos $(2\pi l/N)$ and sin $(2\pi l/N)$, respectively. If M is odd, equation 13 calls for the values of U_{M+1} and V_{M+1}, which were not present in equation 11; these terms are to be interpreted as zero.

A comparison of equations 11 and 13 shows that, at the expense of having to evaluate two new coefficients, we have condensed the number of summed terms by a factor of (almost or exactly, according to the parity of M) 2. A careful analysis shows that if such a condensation procedure is repeated P times, where P = $\mathrm{Int}\{\log_2(2M-1)\}$, then a single ($m$=1) term

(14)

$$G = \left[\text{newest U coefficient}\right] \cos\left(\frac{2^{P+1}\pi l}{N}\right) + \left[\text{newest } V \text{ coefficient}\right] \sin\left(\frac{2^{P+1}\pi l}{N}\right)$$

remains, from which G is easily calculable.

By adopting this P-fold condensation procedure, we have reduced the number of sines and cosines that each need to be evaluated from M to $P+1$, or from 198 to 9, for example. In fact, you can get away with evaluating only one sine and one cosine, since the arguments involved ($2\pi l/N$, $4\pi l/N$, $8\pi l/N$, . . . , $2^{P+1}\pi l/N$) form a sequence in which each is double the previous argument, allowing the duplication formulas $\sin 2\theta = 2\sin\theta\cos\theta$ and $\cos 2\theta = 2\cos^2\theta - 1$ to be used with advantage. It must be emphasized that our algorithm is for Fourier *smoothing* alone.

Operation of the Algorithm

[*Editor's note: The listings reprinted here are* Microsoft *versions of the authors'* HP *programs. The* HP *listings are available on the* FROMBYTE *file area of* BYTEnet Listings, (603) 924-9820, *under the names* FT.BAS *and* FTEXT.BAS.]

The data to be smoothed is entered into array $X(J)$, J = 0 to $N-1$, where N is the number of points. The number of iterations of the condensation procedure, Q, is initialized to zero. Lines 140 through 230, 270, 970, and 1210 have been omitted from the subroutine listing. These lines can be filled with a straight-line modification of the data, which we will discuss in the next section.

The degree of smoothing, E, must be an integer greater than 1 and less than $N/2$ (half the total number of points). The first transform calculated is R_0, followed by the evaluation of R_k and I_k for k = O to $E-1$ (see below). Then the first inverse transformed point $\tilde{X}_0$ is calculated, using the quadratic filter function and R_k. Finally, the rest of the inverse transforms $\tilde{X}_j$, for j = 1 to $N-1$, are calculated using R_k, I_k and the quadratic filter function. These inverse transforms consist of the smoothed data and are stored in array $X1(J)$, J = 0 to $N-1$.

After one pass through the subroutine, you may want to select a different degree of smoothing. To do so, you execute the subroutine again. Since many of the transforms will have been calculated previously (the number currently existing is Q), this second execution of the subroutine will require fewer transform calculations (or none if greater smoothing—i.e., a smaller E—is chosen).

Examples

Let's take a look at three types of applications of our algorithm: on scientific data, meteorological data, and annual agricultural statistics.

Our first example concerns electrochemical data acquired in this laboratory during studies of very low con-

(continued)

centrations of heavy metal in water. Because the signal is so small, it is contaminated with noise (see figure 2). Fourier smoothing the data eliminates the noise, leaving the signal proper. This illustrates the virtue of Fourier smoothing experimental data acquired electronically, since it can eliminate the high-frequency noise originating from the instrumentation. The peak height, which is proportional to the metal concentration, can be quantified easily from the smoothed curve.

Choosing the right degree of smoothing, by varying E, is a matter of trial and error. The effects of undersmoothing and oversmoothing are illustrated in figure 2. We obtained the best smoothing when $3 \leq E \leq 9$.

Consider a graph of daily maximum temperature readings for the period of January 1982 to June 1983, shown in figure 3. There is a clear seasonal variation, but there is also a great deal of scatter. This scatter is caused by short-term variations in the temperature due to changing weather conditions. To better examine the underlying seasonal variations, it would help to eliminate the short-duration fluctuations of temperature. A direct application of Fourier smoothing, however, produces the red line shown in figure 3, which is obviously not satisfactory. The smoothed curve does not match the data at the ends. The cause of this "end effect" is that some high frequencies not due to noise were eliminated in the smoothing process. The "genuine" high frequencies come from the discontinuity between the beginning and the end of the data. The discrete Fourier transform treats the data as periodic; that is, it assumes that the last points are followed by replicas of the initial points (see figure 4a). Thus the transform "perceives" a sudden jump between the end of one period and the beginning of the next. Sudden

(continued)

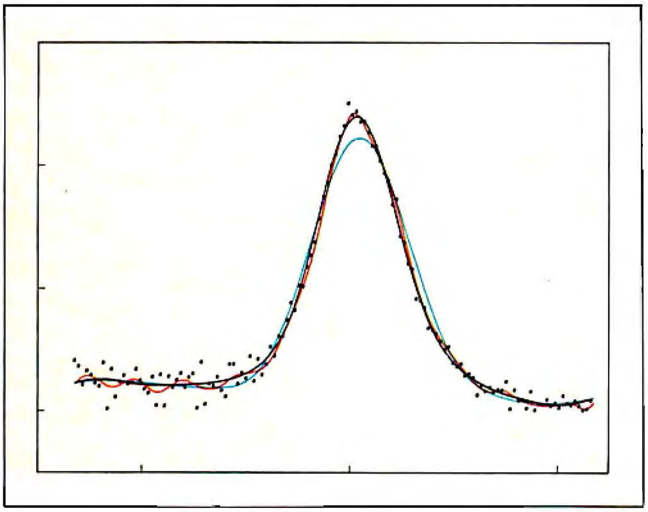

Figure 2: *An example of Fourier smoothing scientific data. The data represents a derivative neopolarogram at a static-mercury-drop electrode. The black line, showing proper smoothing, was obtained by* N = 72, E = 8. *In the red line, showing undersmoothing,* E = 20. *In the oversmoothed blue line* E = 4.

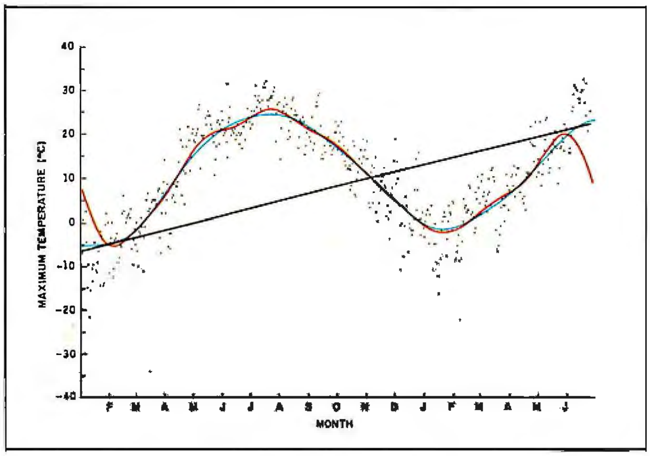

Figure 3: *Daily maximum temperatures at the Peterborough, Ontario, weather station from January 1982 through June 1983. The red line* (N = 546, E = 9) *provides an example of false smoothing due to an "end effect." To correct for this effect, subtract a straight line (black) joining the ends of the unsmoothed data. The resulting "normalized" smoothing is shown by the blue line* (E = 7).

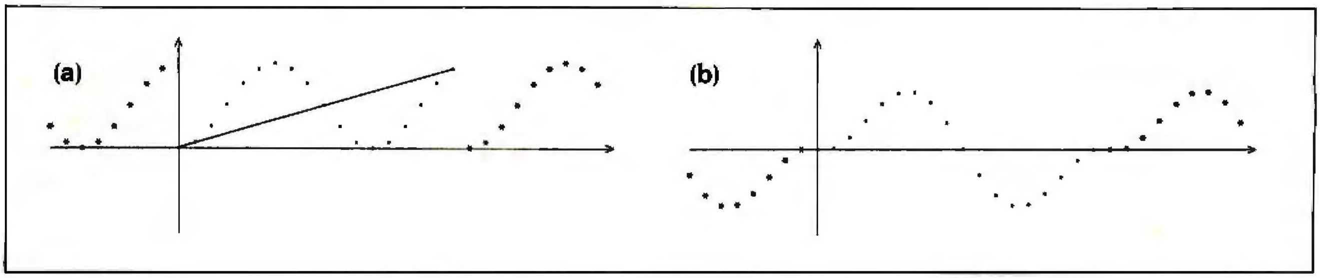

Figure 4: *An explanation of the "end effect," which results from the discrete Fourier transform treating the data as periodic (a). The sudden jumps between one period and the next produce "genuine" high frequencies (not associated with noise) in the transform spectrum. To eliminate the "end effect," subtract a straight line joining the ends from the data. The result of this operation is shown in (b). Notice that now the data begins and ends at the same ordinate value, which means that there are no sudden discontinuities from the transform's point of view.*

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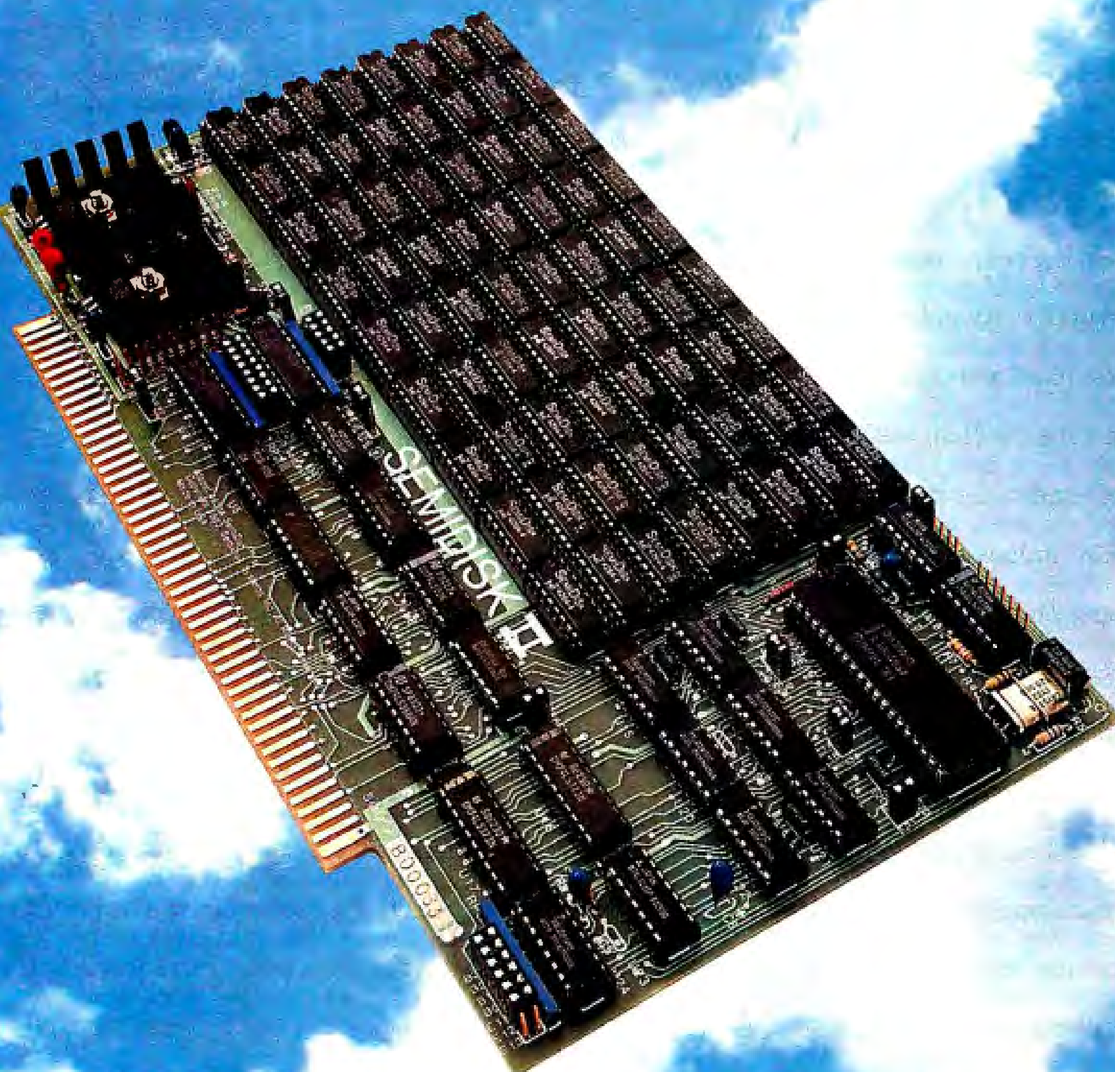

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jumps correspond to high frequencies, which in turn result in more high frequencies in the transform spectrum.

The solution to the problem of retaining genuine high frequencies from transformed data is to subtract a straight line joining the beginning and the end of the unsmoothed data. Initially we thought of subtracting a line joining the first and last points. However, since the unsmoothed data contains a lot of scatter, the straight line joining the end points would not necessarily match the beginning and end of the trend. We dealt with this problem by taking the first and last 10 percent of points, averaging each set, and joining the two resulting points. The procedure consists of subtracting the line from the unsmoothed data, smoothing the modified data, then adding the line on to the smoothed data. As mentioned before, the effect of subtracting the line is to eliminate end discontinuities (figure 4b). To include this procedure in the smoothing subroutine, you should merge the program steps shown in listing 2 with listing 1.

The result of treating the data in figure 3 with a straight line is shown as a blue line, which produces a much better fit. Note that a greater degree of smoothing is used here than in the "unnormalized" (red) line. Since we have now eliminated most "genuine" high frequencies, we can filter out more high frequencies.

Historical statistics can be found on such varied subjects as wheat production and the number of hospital beds. In many cases there is an upward trend, due to the increasing population and increasing costs. To examine a trend over a long period of time, you may want to smooth the data.

Our third case concerns wheat production in Canada from 1906 to 1974 (see figure 5). Here there is a great deal of noise, which makes it difficult to draw a definitive trend "by eye." The Fourier-smoothed curve shows an upward trend, as expected, but not in a straight line. This is important, because a straight-line fit might be an oversimplification for a particular analysis.

There are other, more subtle sources of high frequencies that will not be discussed but should be mentioned.

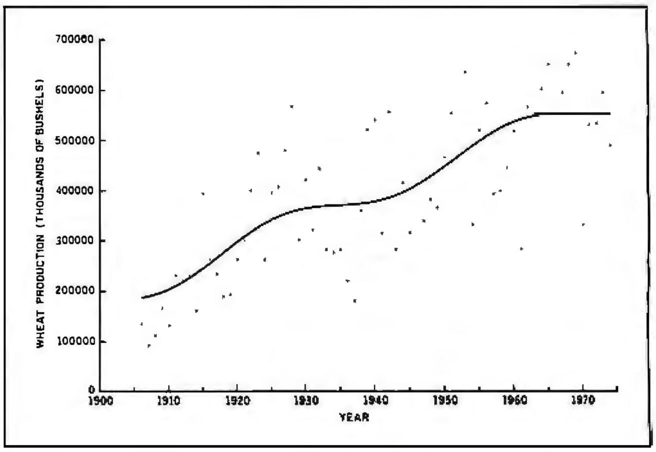

Figure 5: *Unsmoothed (dots) and smoothed (line) statistical data on wheat production in Canada from 1906 through 1974. The large amount of scatter makes it difficult to draw a straight curve through the data. Fourier smoothing accomplishes this quite well, given an appropriate choice of the degree of smoothing. Smoothing parameters:* N = 69, E = 3.

Sudden discontinuities other than the end type may occur in the data, and these may be treated by subtracting several straight lines where appropriate. You can also handle this problem by smoothing the continuous segments separately instead of treating the data as a whole. Another source of high frequencies is a sudden change in slope, which is more difficult to correct. Here it is necessary to subtract an appropriate curve that matches the portion of the data that changes slope abruptly. ■

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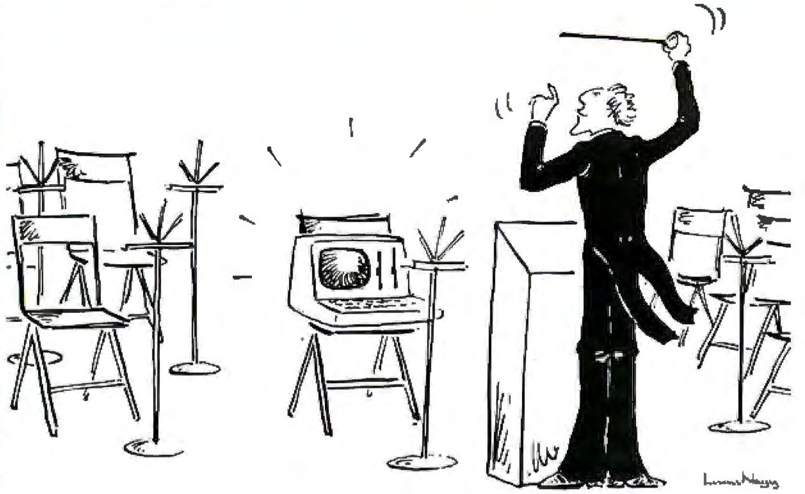

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SN74393N	14	1.49

74LS

Part No.	Pins	Price
74LS00	14	.29
74LS01	14	.29
74LS02	14	.29
74LS03	14	.29
74LS04	14	.35
74LS05	14	.35
74LS08	14	.35
74LS09	14	.35
74LS10	14	.35
74LS11	14	.35
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.35
74LS26	14	.29
74LS27	14	.35
74LS28	14	.35
74LS30	14	.29
74LS32	14	.39
74LS37	14	.35
74LS38	14	.39
74LS42	16	.49
74LS47	16	.89
74LS51	14	.29
74LS73	14	.39
74LS74	14	.39
74LS75	16	.45
74LS76	16	.39
74LS85	16	.89
74LS86	14	.39
74LS90	14	.55
74LS92	14	.55
74LS93	14	.59
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.45
74LS114	14	.39
74LS122	14	.49
74LS123	16	.79
74LS125	14	.59
74LS126	14	.59

Part No.	Pins	Price
74LS132	14	.65
74LS133	14	.59
74LS136	14	.39
74LS138	16	.59
74LS139	16	.59
74LS145	16	1.19
74LS147	16	1.95
74LS148	16	1.79
74LS151	16	.59
74LS153	16	.59
74LS154	24	1.49
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	.89
74LS166	16	.89
74LS168	16	1.19
74LS169	16	1.49
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.49
74LS190	16	.89
74LS191	16	.89
74LS192	16	.79
74LS193	16	.89
74LS194	16	.69
74LS195	16	.59
74LS196	14	.89
74LS197	14	.89
74LS221	16	1.09
74LS240	20	1.09
74LS241	20	.99
74LS243	14	1.09

Part No.	Pins	Price
74LS244	20	1.29
74LS245	20	1.49
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.49
74LS273	20	1.49
74LS279	16	.49
74LS280	14	1.95
74LS299	20	2.95
74LS322	20	3.95
74LS323	20	3.95
74LS347	16	.79
74LS353	16	1.09
74LS364	20	1.95
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.49
74LS393	14	1.19
74LS399	16	1.49
74LS490	16	1.95
74LS533	20	1.95
74LS540	20	1.49
74LS541	20	1.49
74LS640	20	2.19
74LS641	20	2.19
74LS644	20	2.19
74LS645	20	2.19
74LS670	16	1.49
74LS688	20	2.95
81LS95	20	1.49
81LS96	20	1.49
81LS97	20	1.49
81LS98	20	1.49

74S/PROMS*

Part No.	Pins	Price
74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.45
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S37	14	.99
74S38	14	.89
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S85	16	1.99
74S86	14	.55
74S112	16	.55
74S113	14	.55

Part No.	Pins	Price
74S114	14	.55
74S124	16	2.75
74S132	14	1.89
74S133	16	.45
74S135	16	.89
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.69
74S151	16	.89
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.29
74S169	16	4.29
74S174	16	1.09
74S175	16	1.09
74S188*	16	1.75
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	1.95

Part No.	Pins	Price
74S241	20	1.95
74S242	14	2.19
74S243	14	2.19
74S244	20	2.19
74S251	16	.99
74S253	16	.99
74S257	16	.99
74S258	16	.99
74S260	14	.79
74S273	20	2.39
74S280	14	1.89
74S287*	16	1.79
74S288*	16	1.79
74S299	20	5.95
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
74S471*	20	4.95
74S472*	20	4.95
74S473*	20	4.95
74S570*	16	2.95
74S571*	16	2.95
74S572*	18	4.95
74S573*	18	4.95

CA—LINEAR

Part No.	Pins	Price
CA3010H		1.09
CA3039H		1.25
CA3046N	14	.99
CA3059N	14	2.95
CA3060N	16	2.95
CA3065E	14	1.49
CA3080E	8	.99

Part No.	Pins	Price
CA3061N	16	1.15
CA3082N	16	1.15
CA3083N	16	1.15
CA3086N	14	.85
CA3089N	16	1.95
CA3096N	16	1.75

Part No.	Pins	Price
CA3130E	8	1.10
CA3140E	8	.85
CA3160H		1.79
CA3160E	8	1.49
CA3161E	16	1.79
CA3162E	16	6.95
CA3189E	16	2.70
CA3401N	14	.59

CD—CMOS

Part No.	Pins	Price
CD4001	14	.29
CD4002	14	.29
CD4006	14	.89
CD4007	14	.29
CD4008	16	.89
CD4009	16	.59
CD4010	16	.49
CD4011	14	.29
CD4012	14	.29
CD4013	14	.39
CD4014	16	.89
CD4015	16	.39
CD4016	14	.49
CD4017	16	.79
CD4018	16	.79
CD4019	16	.49
CD4020	16	.75
CD4021	16	.75
CD4022	16	.75
CD4023	14	.29
CD4024	14	.69
CD4025	14	.29
CD4026	16	1.59
CD4027	16	.45
CD4028	16	.69
CD4029	16	.79
CD4030	14	.39
CD4034	24	1.79
CD4035	16	.79
CD4040	16	.75

(More in Catalog)

Part No.	Pins	Price
CD4041	14	.69
CD4042	16	.69
CD4043	16	.79
CD4044	16	.79
CD4046	16	.89
CD4047	14	.89
CD4048	16	.59
CD4049	16	.39
CD4050	16	.39
CD4051	16	.79
CD4052	16	.89
CD4053	16	.79
CD4056	16	2.95
CD4059	24	3.95
CD4060	16	.89
CD4066	14	.45
CD4068	14	.39
CD4069	14	.35
CD4070	14	.29
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4077	14	.35
CD4078	14	.49
CD4081	14	.29
CD4093	14	.49
CD4094	16	1.95
CD4098	16	1.95
CD4099	16	1.89

Part No.	Pins	Price
CD4503	16	.69
CD4505	16	1.29
CD4507	14	1.19
CD4508	24	1.95
CD4510	16	.85
CD4511	16	.85
CD4512	16	.85
CD4514	24	1.49
CD4515	24	1.49
CD4516	16	.89
CD4518	16	.89
CD4519	16	.59
CD4520	16	.89
CD4526	16	1.19
CD4528	16	1.19
CD4529	16	1.69
CD4531	16	.89
CD4538	16	1.49
CD4541	14	1.49
CD4543	16	1.10
CD4562	14	6.95
CD4566	16	2.95
CD4583	16	2.49
CD4584	14	.59
CD4723	16	1.19
CD4724	16	1.19
MC14410	16	8.95
MC14411	24	11.95
MC14412	16	7.95
MC14433	24	17.95
MC14572	16	1.19

74F00 NEW

Part No.	Pins	Function	Price
74F00	14	Quad 2-Input NAND Gate	.69
74F02	14	Quad 2-Input NOR Gate	.75
74F04	14	Hex Inverter	.89
74F08	14	Quad 2-Input AND Gate	.75
74F10	14	Triple 3-Input NAND Gate	.75
74F32	14	Quad 2-Input OR Gate	.79
74F74	14	Dual D Flip-Flop	.85
74F86	14	Quad Exclusive OR Gate	1.15
74F109	16	Dual JK Positive Edge Flip-Flop	.95
74F138	16	Expandable 3/8 Decoder	1.69
74F157	16	Quad 2-Input Multiplexer	1.69
74F158	16	Quad 2-Input Multiplexer (Inv)	1.69
74F193	16	4-Bit Up/Down Binary Counter	5.29
74F240	20	Tri-State Octal Line Driver (Inverting)	3.75
74F244	20	Tri-State Octal Line Driver	3.49
74F257	16	Tri-State Quad 2-Input Multiplexer	1.79
74F373	20	Tri-State Octal Latch	4.80
74F374	20	Tri-State Octal D Flip-Flop	4.59

74ALS00

Part No.	Pins	Function	Price
74ALS00	14	Quad 2-Input NAND Gate	.59
74ALS02	14	Quad 2-Input NOR Gate	.59
74ALS04	14	Hex Inverter	.59
74ALS08	14	Quad 2-Input AND Gate	.59
74ALS10	14	Triple 3-Input NAND Gate	.59
74ALS30	14	8-Input NAND Gate	.59
74ALS32	14	Quad 2-Input OR Gate	.65
74ALS74	14	Dual D Flip-Flop	.79
74ALS109	16	Dual JK Pos. Edge Flip-Flop	.79
74ALS138	16	Expandable 3/8 Decoder	1.25
74ALS240	20	Tri-State Octal Line Driver (Inverting)	2.25
74ALS244	20	Tri-State Octal Line Driver	2.25
74ALS245	20	Octal Bus Transceiver (Non-Inv)	2.59
74ALS373	20	Tri-State Octal Latch	2.59
74ALS374	20	Tri-State Octal D Flip-Flop	2.59

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	Pins	Function	Price
D765AC	40	Floppy Disk Controller	19.95
03242	28	Addr. Multiplexer & Refresh Counter	7.95
TMS5501	40	Synchronous Data Interface (SRC)	14.95

Z80, Z80A, Z80B, Z8000 SERIES

Part No.	Pins	Function	Price
Z80	40	CPU (MK3880N) (780C) 2.5MHz	2.95
Z80-CTC	28	Counter Timer Circuit	3.49
Z80-DART	40	Dual Asynchronous Rec./Trans.	8.95
Z80-DMA	40	Direct Memory Access Circuit	12.49
Z80-P10	40	Parallel I/O Interface Controller	3.49
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.49
Z80-S10/1	40	Serial I/O (Lacks DTRB)	11.49
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	11.49
Z80-S10/9	40	Serial I/O	11.49
Z80A	40	CPU (MK3880N-4) (780C-1) 4MHz	3.49
Z80A-CTC	28	Counter Timer Circuit	4.49
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	17.95
Z80A-P10	40	Parallel I/O Interface Controller	3.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	11.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	11.95
Z80A-S10/9	40	Serial I/O	11.95
Z80B	40	CPU (MK3880N-6) 6MHz	8.95
Z80B-CTC	28	Counter Timer Circuit	11.95
Z80B-DART	40	Dual Asynchronous Rec./Trans.	10.95
Z80B-P10	40	Parallel I/O Interface Controller	10.95
Z8001B	48	CPU Segmented (10MHz)	79.95
Z8002B	40	CPU Non-Segmented (10MHz)	59.95

6500/6800/68000 SERIES

Part No.	Pins	Function	Price
6502	40	MPU with Clock (1MHz)	4.95
6502A	40	MPU with Clock (2MHz)	4.95
6502B	40	MPU with Clock (3MHz)	8.95
6520	40	Peripheral Inter. Adapter	3.95
6522	40	Peripheral Inter. Adapter	5.49
6551	28	Async. Comm. Interface Adapter	10.95
6800	40	MPU	2.95
6802CP	40	MPU with Clock and RAM	7.95
6809	40	CPU — 8-Bit (On-Chip Oscillator)	8.95
6809E	40	CPU — 8-Bit (External Clocking)	9.95
68B09E	40	CPU — 8-Bit (Ext. Clocking) 2MHz	14.95
68B10	24	128x8 Static RAM (2MHz)	5.95
6821	40	Peripheral Inter. Adapt. (MC6820)	2.95
68B21	40	Peripheral Interface Adapter (2MHz)	5.95
6845	40	CRT Controller (CRTC)	14.95
68B45	40	CRT Controller (CRTC) 2MHz	19.95
6850	24	Asynchronous Comm. Adapter	3.95
6860	24	0-600bps Digital MODEM	7.95
68000L8	64	MPU 16-Bit (8MHz)	39.95
68-488P	40	General Purpose Int. Adapter	9.95

8000/80000 SERIES

Part No.	Pins	Function	Price
8031	40	Control Oriented CPU w/RAM & I/O	14.95
8035	40	MPU — 8-Bit	5.95
8039	40	CPU—Sgl. Chip 8-Bit (128bts. RAM)	5.95
8040N-6	40	CPU (256 bytes RAM)	9.95
8060	40	CPU — 8-Bit NMOS	14.95
8073N	40	CPU w/Basic Micro Interpreter	29.95
8080A	40	CPU	3.95
8085A	40	CPU	4.95
8085A-2	40	CPU — 8-Bit N-Channel (5MHz)	11.95
8086-2	40	CPU 16-bit 8MHz	24.95
8087	40	Arithmetic Processor	189.95
8088	40	CPU 8/16-Bit	19.95
8155	40	HMOS RAM I/O Port-Timer	6.95
8156	40	RAM with I/O Port and Timer	8.95
8205	16	Hi Speed 1 out of 8 Binary Decoder	3.95
8212	24	8-Bit Input/Output (74S412)	2.95
8224	16	Clock Generator/Driver	2.95
8228	28	System Cont./Bus Driver (74S428)	4.95
8237-5	40	High Perf. Prog. DMA Cont. (5MHz)	19.95
8238	28	System Controller (74S438)	4.95
8243	24	I/O Expander for 48 Series	4.95
8250N	40	Async. Comm. Element	10.95
8251	28	Prog. Comm. I/O (USART)	4.95
8251A	28	Prog. Comm. Interface (USART)	7.95
8253	24	Prog. Interval Timer	6.95
8255	40	Prog. Peripheral I/O (PPI)	4.95
8255A-5	40	Prog. Peripheral I/O (PPI) 5MHz	7.95
8259	28	Prog. Interrupt Control	5.95
8272	40	Sgle/Dble Density Floppy Disk Cont.	19.95
8274	40	Multi-Protocol Serial Cont. (7201)	29.95
8279	40	Prog. Keyboard/Display Interface	6.95
8282	20	Octal Latch	8.95
8284	18	Clock Generator/Driver	6.95
8286	20	Octal Bus Transceiver	7.95
8287	20	Octal Bus Transceiver (Inverted)	7.95
8288	20	Bus Controller	19.95
8303	20	8-Bit Tri-State Bi-Directional Trans.	3.49
8304	20	8-Bit Bi-Directional Receiver	3.49
8310	20	Octal Latched Peripheral Driver	3.95
8741	40	8-Bit Univ. Peripheral Interface	29.95
8748	40	HMOS EPROM MPU	39.95
8749	40	MPU 8-Bit (EPROM Version of 8049)	39.95
8755	40	16K EPROM with I/O	39.95
80186-6	68	High Integration 16-Bit MPU	99.95
80188	68	High Integra. 16-Bit MPU (8-Bit Data Bus)	89.95

DISK CONTROLLERS

Part No.	Pins	Function	Price
INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv)	24.95
FD1793	40	Single/Double Density (True)	26.95
FD1795	40	Dual Density/Side Select (Inv.)	26.95
FD1797	40	Dual Density/Side Select (True)	29.95

SPECIAL FUNCTION

Part No.	Pins	Function	Price
DS0026CN	8	Dual MOS Clock Driver (5MHz)	1.95
INS2651	28	Communication Chip	7.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM5321N	16	TV Camera Sync. Generator	9.95
MM5424ON	24	Asynchronous Transmitter/Receiver	5.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	8.95
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	Pins	Function		Price
1103	18	1024x1	(300ns)	.99
4027	16	4096x1	(250ns)	1.49
4116N-2	16	16,384x1	(150ns)	1.39 — 8/10.95
4116N-3	16	16,384x1	(200ns)	1.15 — 8/8.95
4116N-4	16	16,384x1	(250ns)	.89 — 8/6.95
4164N-150	16	65,536x1	(150ns)	5.19 — 8/40.95
4164N-200	16	65,536x1	(200ns)	4.95 — 8/38.95
MM5261	18	1024x1	(300ns)	.35 — 8/1.95
MM5262	22	2048x1	(365ns)	.35 — 8/1.95
MM5270	18	4096x1	(250ns) MK4096	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
MM5298-3	16	8192x1	(200ns)	.59
41256-150	16	262,144x1	(150ns)	34.95
41256-200	16	262,144x1	(200ns)	31.95
48128	16	131,072x1	(200ns)	24.95

STATIC RAMS

Part No.	Pins	Function		Price
2101	22	256x4	(450ns) 8101	1.95
2102	16	1024x1	(350ns)	.89
2102-2L	16	1024x1	(250ns) L.P. (91L02)	1.49
2111	18	256x4	(450ns) 8111	2.49
2112	16	256x4	(450ns) MOS	2.49
2114N	18	1024x4	(450ns)	1.20 — 8/8.95
2114N L	18	1024x4	(450ns) L.P.	1.95 — 8/13.95
2114N-2	18	1024x4	(200ns)	1.39 — 8/10.95
2114N-2L	18	1024x4	(200ns) L.P.	1.69 — 8/13.49
2147HN	18	4096x1	(70ns)	4.49
2148HN	18	1024x4	(70ns)	4.95
TMS4045	18	1024x4	(450ns)	3.95
TMS40L47-45	20	1024x4	(450ns)	1.95
5101	22	256x4	(450ns) CMOS	3.95
MM5257	18	4096x1	(450ns) 4044	4.95
HM6116P-2	24	2048x8	(120ns) CMOS	7.95
HM6116LP-2	24	2048x8	(120ns) L.P. CMOS	8.95
HM6116P-3	24	2048x8	(150ns) CMOS	4.95
HM6116LP-3	24	2048x8	(150ns) L.P. CMOS	6.49
HM6116P-4	24	2048x8	(200ns) CMOS	4.75
HM6116LP-4	24	2048x8	(200ns) L.P. CMOS	5.49
HM6264P-12	28	8192x8	(120ns) CMOS	37.95
HM6264LP-12	28	8192x8	(120ns) L.P. CMOS	39.95
HM6264P-15	28	8192x8	(150ns) CMOS	34.95
HM6264LP-15	28	8192x8	(150ns) L.P. CMOS	37.95
27LS00	16	256x1	(80ns) L.P.	3.95
7489	16	16x4	(50ns) 3101	2.25
74C921	18	256x4	(250ns) CMOS	3.95
74C930	18	1024x1	(250ns) CMOS (6518)	5.95
74S189	16	16x4	(35ns) 93405	2.95
74S289	16	16x4	(35ns) 3101	2.95
82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25

PROMS/EPROMS

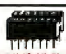
Part No.	Pins	Function		Price
1702A	24	256x8	(1µs)	3.95
2708	24	1024x8	(450ns)	3.95
TMS2516	24	2048x8	(450ns) 2716	4.95
TMS2532	24	4096x8	(450ns) MMC2532	5.49
TMS2564	28	8192x8	(450ns)	10.95
TMS2716	24	2048x8	(450ns) 3 voltage	7.95
2716	24	2048x8	(450ns)	3.95
27C16	24	2048x8	CMOS	14.95
2716-1	24	2048x8	(350ns)	5.49
2716Q-5	24	2048x8	(550ns)	3.79
2732	24	4096x8	(450ns)	4.95
2732A-20	24	4096x8	(200ns) 21V	11.49
2732A-25	24	4096x8	(250ns) 21V	7.19
2732A-45	24	4096x8	(450ns) 21V	6.49
27C32	24	4096x8	CMOS	19.95
27C32A-30	24	4096x8	(300ns) 21V (CMOS)	22.95
2764-20	28	8192x8	(200ns) 21V	14.95
2764-25	28	8192x8	(250ns) 21V	7.19
2764-45	28	8192x8	(450ns) 21V	6.49
27C64	28	8192x8	CMOS 21V	22.95
MCM68764	24	8192x8	(450ns) 21V	24.95
27128-25	28	16,384x8	(250ns) 128K Eprom 21V	21.95
27256-25	28	32,768x8	(250ns) 256K Eprom (14V)	99.95
74S188	16	32x8	PROM O.C. (6330-1)	1.75
74S287	16	256x4	PROM T.S. (6301-1)	1.79
74S288	16	32x8	PROM T.S. (6331-1)	1.79
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	4.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
74S476	18	1024x4	PROM T.S.	8.95
74S478	24	1024x8	PROM T.S.	9.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (82S137)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	2.95
82S129	16	256x4	PROM T.S. (27S21)	2.95
82S130	16	512x4	PROM O.C. (27S12)	3.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
82S191	24	2048x8	(80ns)	14.95
DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4	PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4	PROM T.S. (82S185)	9.95
DM87S191N	24	2048x8	PROM T.S. (82S191)	14.95

DATA ACQUISITION

Part No.	Pins	Function	Price
DC10		Mostek DC/DC Converter +5V to −9V	2.95
ADC0801	20	8-Bit A/D Converter (1/4LSB)	14.95
ADC0803	20	8-Bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-Bit A/D Converter (1LSB)	3.49
ADC0808	28	8-Bit A/D Conv. w/8-Channel Analog	8.95
ADC0809	28	8-Bit A/D Converter (8-Ch. Multi)	4.49
ADC0816	40	8-Bit A/D Conv. w/16-Channel Analog	14.95
ADC0817	40	8-Bit A/D Converter (16-Ch. Multi)	9.49
DAC0806	16	8-Bit D/A Converter (0.78% Lin)	1.95
DAC0807	16	8-Bit D/A Converter (MC1408-7)	1.49
DAC0808	16	8-Bit D/A Converter (MC1408-8)	2.25
DAC0830	20	8-Bit Up D/A Conv. (.05% Lin)	5.95
DAC0831	20	8-Bit Up D/A Conv. (.10% Lin)	4.49
DAC1000	24	10-Bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-Bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1020	18	10-Bit D/A Conv. (0.05% Lin.)	7.95
DAC1022	18	10-Bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-Bit D/A Conv. (0.20% Lin.)	6.95
DAC1230	20	12-Bit Up D/A Conv. (.05% Lin.)	14.95
DAC1231	20	12-Bit Up D/A Conv. (.10% Lin.)	13.95
AY-5-1013A	40	30K Baud UART (TR1602)	3.95

Low Profile (Tin) Sockets

Part No.	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
40 pin LP	.49	.46	.43



Soldertail (Gold) Standard

Part No.	1-9	10-99	100-up
8 pin SG	.39	.35	.29
14 pin SG	.49	.45	.39
16 pin SG	.55	.49	.45
18 pin SG	.65	.59	.51
20 pin SG	.75	.65	.59
22 pin SG	.79	.69	.65
24 pin SG	.79	.69	.65
28 pin SG	.95	.85	.75
36 pin SG	1.25	1.15	.99
40 pin SG	1.39	1.25	1.15

Wire Wrap Sockets (Gold) Level #3

Part No.	1-9	10-99	100-up
8 pin WW	.55	.49	.45
10 pin WW	.69	.65	.59
14 pin WW	.75	.69	.65
16 pin WW	.79	.72	.65
18 pin WW	.95	.85	.75
20 pin WW	1.19	1.09	.95
22 pin WW	1.29	1.19	1.05
24 pin WW	1.35	1.19	1.09
28 pin WW	1.69	1.55	1.39
36 pin WW	1.89	1.79	1.69
40 pin WW	2.29	1.95	1.79

Header Plugs (Gold)

Part No.	1-9	10-99	100-up
14 pin HP	.65	.59	.55
16 pin HP	.69	.65	.59
24 pin HP	1.15	.99	.89

Header Covers

Part No.	1-9	10-99	100-up
14 pin HC	.15	.13	.12
16 pin HC	.19	.17	.15
24 pin HC	.29	.25	.22

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Digitalker™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc.

The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. Female and children's voices can be synthesized. The vocabulary is chosen so that it is applicable to many products and markets.

The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two(2) Speech ROMs MM52164SSR1 and MM52164SSR2(24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

DT1050 Digitalker™ .... $34.95 ea.
MM54104 Processor Chip .... $14.95 ea.

DT1057 - Expands the DT1050 vocabulary from 137 to over 260 words. Includes 2 ROMs and specs.
Part No. DT1057 .... $24.95 ea.

INTERSIL

Part No.	Pins	Function	Price
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit	28	Stopwatch Chip, XTL (Evaluation Kit)	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	10.49
FE0202D	40	4 Digit LCD Display for 7106 & 7116	14.95
FE0203D		3½ Digit LCD Display for 7106 & 7116	14.95
7106EV/Kit	40	IC. Circuit Board. Display (Evaluation Kit)	46.95
7107CPL	40	3½ Digit A/D (LED Drive)	10.95
7107EV/Kit	40	IC. Circuit Board. Display (Evaluation Kit)	46.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD.	10.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	14.95
7205EV/Kit	24	Stopwatch Chip, XTL (Evaluation Kit)	16.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit	16	Tone Generator Chip, XTL (Evaluation Kit)	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit	14	Freq. Counter Chip, XTL (Evaluation Kit)	8.49
7215IPG	24	4 Func. CMOS Stopwatch CKT	16.95
7215EV/Kit	24	4 Func. Stopwatch Chip, XTL (Evaluation Kit)	19.49
7216AIJI	28	8 Digit Univ. Counter C.A.	31.49
7216DIPI	28	8 Digit Freq. Counter C.C.	21.49
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	9.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AEV/Kit	40	5 Function Counter Chip, XTL (Evaluation Kit)	99.95

30009 1983 INTERSIL Data Book (1356 p.) $9.95

74HC High Speed CMOS

Part No.	Pins	Price
74HC00	14	.59
74HC02	14	.59
74HC03	14	.89
74HC04	14	.59
74HCU04	14	.69
74HC08	14	.59
74HC10	14	.59
74HC11	14	.69
74HC14	14	.89
74HC20	14	.59
74HC27	14	.59
74HC30	14	.69
74HC32	14	.79
74HC42	16	1.09
74HC51	14	.89
74HC58	14	.89
74HC73	14	.79
74HC74	14	.79
74HC75	16	.99
74HC76	16	.79
74HC85	16	1.69
74HC86	14	.75
74HC107	14	.79
74HC109	16	.79
74HC112	16	.79
74HC123	16	2.29
74HC125	14	1.75
74HC132	14	1.29
74HC137	16	1.59
74HC138	16	1.19

Part No.	Pins	Price
74HC139	16	1.05
74HC147	16	1.29
74HC151	16	.99
74HC153	16	1.09
74HC154	24	2.65
74HC157	16	.99
74HC158	16	.99
74HC160	16	1.39
74HC161	16	1.39
74HC162	16	1.39
74HC163	16	1.39
74HC164	14	1.35
74HC165	16	2.15
74HC166	16	2.49
74HC173	16	1.29
74HC174	16	1.09
74HC175	16	1.09
74HC190	16	1.59
74HC191	16	1.59
74HC192	16	1.49
74HC193	16	1.49
74HC194	16	1.19
74HC195	16	1.19
74HC221	16	2.95
74HC237	16	1.49
74HC240	20	2.29
74HC241	20	2.29
74HC242	14	2.15
74HC243	14	2.15
74HC244	20	2.29

Part No.	Pins	Price
74HC245	20	2.59
74HC251	16	.99
74HC253	16	1.09
74HC257	16	.99
74HC259	16	1.69
74HC266	14	.89
74HC273	20	2.79
74HC280	14	4.59
74HC299	20	5.59
74HC366	16	2.59
74HC367	16	2.59
74HC373	20	2.69
74HC374	20	2.69
74HC390	16	1.59
74HC393	14	1.59
74HC533	20	2.69
74HC534	20	2.69
74HC595	16	3.19
74HC688	20	3.59
74HC4024	14	1.75
74HC4040	16	1.49
74HC4060	16	1.49
74HC4075	14	.59
74HC4078	14	.59
74HC4511	16	1.95
74HC4514	24	4.19
74HC4538	16	2.59
74HC4543	16	3.75

74HCU04 is unbuffered
All others are buffered

74C—C/MOS

Part No.	Pins	Price
74C00	14	.29
74C02	14	.35
74C04	14	.35
74C08	14	.35
74C10	14	.35
74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.19
74C48	16	1.79
74C73	14	.69
74C74	14	.59
74C85	16	1.39
74C86	14	.29
74C89	16	5.95
74C90	14	1.09
74C93	14	1.09
74C95	14	1.19

Part No.	Pins	Price
74C107	14	.79
74C151	16	2.19
74C154	24	3.25
74C157	16	1.75
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.29
74C165	16	1.29
74C173	16	.89
74C174	16	1.19
74C175	16	1.19
74C192	16	1.39
74C193	16	1.39
74C195	16	1.29
74C221	16	1.75

Part No.	Pins	Price
74C240	20	1.95
74C244	20	1.95
74C373	20	2.29
74C374	20	2.29
74C901	14	.59
74C902	14	.79
74C903	14	.59
74C906	14	.59
74C907	14	.89
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.69
80C97	16	.69

LINEAR

Part No.	Pins	Price
TL071CP	8	.79
TL072CP	8	1.09
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM109K		5.95
LM301CN	8	.39
LM302H		2.49
LM304H		1.95
LM305H		.99
LM307CN	8	.49
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.95
LM311CN	8	.59
LM312H		2.79
LM317T		1.19
LM317K		3.49
LM318CN	8	1.59
LM319N	14	1.49
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320K-24		1.35
LM320T-5		.85
LM320T-12		.85
LM320T-15		.85
LM320T-24		.85
LM322N	14	1.49
LM323K		4.95
LM324N	14	.59
LM329DZ		.65
LM331N	8	3.95
LM334Z		1.19
LM335Z		1.29
LM336Z		1.09
LM337MP		1.15
LM337T		1.89
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340K-24		1.35
LM340T-5		.75
LM340T-12		.75
LM340T-15		.75
LM340T-24		.75
LF347N	14	1.49
LM348N	14	.89
LM350K		4.79
LF351N	8	.59
LF353N	8	.89

Part No.	Pins	Price
LF355N	8	1.09
LF356N	8	1.09
LM358N	8	.59
LM359N	14	1.79
LM370N	14	4.95
LM373N	14	4.95
LM377N	14	1.95
LM380CN	8	1.09
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.49
LM384N	14	1.95
LM386N-3	8	.89
LM387N	8	1.39
LM389N	18	1.19
LM391N-80	16	1.19
LM392N	8	.59
LM393N	8	.45
LF398N	8	3.95
LM399H		5.95
LF412CN	8	1.95
TL494CN	16	2.79
TL496CP	8	1.59
NE531V	8	1.79
NE544N	14	1.95
NE550A	14	1.95
NE555V	8	.35
XR-L555	8	.69
LM556N	14	.79
NE558N	16	1.59
NE564N	16	1.95
LM565N	14	.99
LM566CN	8	1.49
LM567V	8	.99
NE570N	16	2.95
NE571N	16	2.49
NE592N	14	1.19
LM703CN	8	1.49
LM710N	14	.69
LM711N	14	.79
LM723N	14	.49
LM733N	14	.89
LM739N	14	1.95
LM741CN	8	.39

Part No.	Pins	Price
LM747N	14	.89
LM748N	8	.59
UA760HC		9.95
LM1456V	8	1.95
LM1458CN	8	.59
LM1488N	14	.69
LM1489N	14	.69
LM1496N	14	.99
LM1605CK		9.95
LM1800N	16	2.49
LM1871N	18	2.95
LM1872N	18	3.25
LM1877N-9	14	2.95
LM1889N	18	1.95
LM1896N	14	1.59
LM2002T		1.95
ULN2003A	16	1.49
XR2206	16	3.95
XR2207	14	2.49
XR2208	16	1.79
XR2211	14	2.95
LM2877P		1.95
LM2878P		2.95
LM2901N	14	.79
LM2902N	14	.89
LM2907N	14	2.49
LM2917N	8	1.95
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.89
LM3914N	18	2.39
LM3915N	18	2.39
LM3916N	18	2.39
RC4136N	14	1.25
RC4151NB	8	1.95
RC4195TK		5.95
LM4250CN	8	1.49
LM4500A	16	2.95
NE5532	8	1.69
NE5534	8	1.39
75MO5AH		1.29
ICL8038	14	3.95
LM13080N	8	1.19
LM13600N	16	1.19
76477	28	3.95

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30003 1982 Nat. Linear Data Book (1952pgs.) . $11.95

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RS232 ADAPTER FOR VIC-20 AND COMMODORE 64

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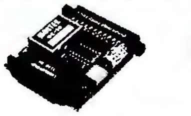

The JE232CM allows connection of standard serial RS232 printers, modems, etc. to your VIC-20 and C-64. A 4-pole switch allows the inversion of the 4 control lines. Complete installation and operation instructions included.

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Great Educating Tool!

JE520AP

JE520CM

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JE520AP	For Apple II, II+, and //e	$149.95

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Most of the popular Memory Boards (e.g. Quadram™ Expansion Boards) allow you to add an additional 64K, 128K, 192K or 256K. The IBM64K Kit will populate these boards in 64K byte increments. The Kit is simple to install—just insert the 9 - 64K RAM chips in the provided sockets and set the 2 groups of switches. Complete conversion documentation included.

IBM64K (Nine 200ns 64K RAMs). $43.95

IBM PC AT

Each kit comes complete with nine 128K dynamic RAMs and documentation for conversion.

IBM128K (Nine 200ns 128K RAMs). $199.95

APPLE //e

Extended 80-Column/64K RAM Card. Expands memory by 64K to give 128K when used with programs like VisiCalc™. Fully assembled and tested.

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Each Kit comes complete with eight MM5290 (UPD416/4116) 16K Dynamic RAMs and documentation for conversion. Model 1: 16K equipped with Expansion Interface can be expanded to 48K with 2 Kits. Model III: Can be expanded from 16K to 48K using 2 Kits. Each Kit will expand computer by 16K increments.

TRS-16K3 200ns (Model III). $8.95
TRS-16K4 250ns (Model 1). $6.95

TRS-80 MODEL IV & 4P

Easy to install Kit comes complete with 8 ea. 4164N-20 (200ns) 64K Dynamic RAMs and conversion documentation. Converts TRS-80 Model IV computers from 16K to 64K, Also expands Model 4P from 64K to 128K.

TRS-64K-2. . . . . $38.95
(Converts the Model IV from 16K to 64K or will expand the Model 4P from 64K to 128K)

TRS-64K2PAL (Model IV only). $59.95
(8 - 4164's with PAL Chip to expand from 64K to 128K)

TRS-80 COLOR AND COLOR II

Easy to install Kit comes complete with 8 each 4164N-20 (200ns) 64K Dynamic RAMs and documentation for conversion. Converts TRS-80 Color Computers with D, E, ET, F and NC circuit boards to 32K. Also converts TRS-80 Color Computer II to 64K. Flex DOS or OS-9 required to utilize full 64K RAM on all computers.

TRS-64K-2. . . . . $38.95

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DATASHIELD® Surge Protector

• Eliminates voltage spikes and EMI-RFI noise before it can damage your equipment or cause data loss • 6 month warranty • Power dissipation (100 microseconds): 1,000,000 watts • 6 sockets • 6 foot power cord • Normal line voltage indicator light • Brown out/black out reset switch

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The ProModem™ is a Bell 212A (300/1200 baud) intelligent stand-alone modem • Full featured expandable modem • Standard features include Auto Answer and Auto Dial, Help Commands, Programmable Intelligent Dialing, Touch Tone™ and Pulse Dialing & More • Hayes command set compatible plus an additional extended command set • Shown w/alphanumeric display option.

Part No.	Description	Price
PM1200	RS-232 Stand Alone Unit	$349.95
PM1200A	Apple II, II+ and //e Internal Unit	$369.95
PM1200B	IBM PC and Compatible Internal Unit	$269.95
PM1200BS	IBM PC & Comp. Int. Unit w/ProCom Software	$319.95
MAC PAC	Macintosh Package (Includes PM1200, Cable, & ProCom Software)	$399.95

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PM-COM	(ProCom Communication Software). Please specify Operating System.	$79.95
PM-OP	(Options Processor)	$79.95
PMO-16K	(Options Processor Memory — 16K)	$10.95
PMO-32K	(Options Processor Memory — 32K)	$20.95
PMO-64K	(Options Processor Memory — 64K)	$39.95
PM-ALP	(Alphanumeric Display)	$79.95
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Mitsumi 54-Key Unencoded All-Purpose Keyboard

• SPST keyswitches • 20 pin ribbon cable connection • Low profile keys • Features: cursor controls, control, caps (lock), function, enter and shift keys • Color (keycaps): grey • Wt: 1 lb. • Pinout included

KB54. . . . . $14.95

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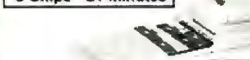

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JM08A	2708	25V	AMD, Motorola, Nat., Intel, TI	$14.95
JM16A	2716, TMS2516 (TI)	25V	Intel, Motorola, Nat., NEC, TI, AMD, Hitachi, Mostek	$14.95
JM16B	TMS2716 [illegible]	-5V, +5V, +12V	Motorola, TI	$14.95
JM32A	TMS2532	25V	Motorola, TI, Hitachi, OKI	$14.95
JM32B	2732	25V	AMD, Fujitsu, NEC, Hitachi, Intel, Mitsubishi, National	$14.95
JM32C	2732A	21V	Fujitsu, Intel	$14.95
JM64A	MCM68764, MCM68L764	21V	Motorola	$14.95
JM64B	2764	21V	Intel, Fairchild, OKI	$14.95
JM64C	TMS2564	25V	TI	$14.95

PARANOIA: A FLOATING-POINT BENCHMARK

BY RICHARD KARPINSKI

Test the quality of your software, not just its speed

FLOATING-POINT ARITHMETIC was created to make programming easier and programs faster. It is complicated so that your programs can be simple, but rough edges and pitfalls are common in floating-point systems.

The Paranoia benchmark was designed to find and notify you of those places where actual results are *not* good enough. It reports pitfalls discovered in a systematic checkout of the arithmetic used by the computer running it. Why Paranoia? *Webster's Ninth New Collegiate Dictionary* (Springfield, MA: Merriam-Webster Inc., 1983) provides the following as its second definition of paranoia: "a tendency on the part of an individual or group toward excessive or irrational suspiciousness and distrustfulness of others"—an apt description of this program, which looks for problems at every turn. This article looks into the workings of floating-point arithmetic to see why you need such quality tests and how they work.

LIFE WITHOUT FLOATING POINT

Remember those heavy mechanical calculators with 10 long rows of keys? If you wanted to use measurements in fractions rather than whole numbers, you could set the decimal point somewhere in the middle of the field. Numbers could grow or shrink on either side of it, but the point itself was really fixed. This is enough for many hand calculations where you need only 5 or 10 steps to get the final result. Fixed-point calculations like this are simple and match the pencil-and-paper methods we learned in grade school. They are easy to understand and use, and they work quite well almost all the time.

Almost is not enough, however. Even events that happen quite rarely require careful attention when you are designing a computer system. Because computers are so much faster than we are, a system that works correctly on 99.999 percent of its data can still fail once *every second*. With paper and pencil, if a few numbers don't fit within the limits you have chosen, you can write smaller or use another sheet of paper. Mechanical calculators and computers are not so flexible.

If you set up a calculator for numbers of the form *nnn,nnn.nnn,nnn*, for example, an intermediate result of 1 million is hopelessly damaged. There is no place to put the digit in the millions place. This problem is called overflow. There are calculators with 20 or 30 digits or even more, but you can't really solve the problem this way. Long calculations continually require you to copy an intermediate result from the calculator's dials back onto the keys in order to shift it to the left or the right to accommodate the overflow. The copying process is error-prone and tedious for those who do it. (Originally, these people were called "computers.")

Very small numbers in this format also suffer. Numbers smaller than 1

(continued)

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one-millionth are lost entirely. They *underflow* to zero. Even numbers as large as 1 one-thousandth lose most of their significant digits. Only 3 of the 12 digits of precision initially provided remain.

When overflow and underflow problems arise in hand calculations, and even in many computer applications that have tight constraints on hardware and timing, you can solve them by rescaling the numbers—multiplying or dividing them by 10, 100, or 1000—to bring the number back into view. Naturally, you must keep track of each scaling operation you perform so that you can readjust the final answer properly.

You must also check to see if this problem arises at every possible place, although such checking makes every program longer and more complicated. This high cost of being extra careful must be weighed against the fact that the unchecked version works most of the time. In fact, you may have tested the *unchecked* version with thousands of cases and consider it completely debugged.

In principle, if you know enough about the numbers that arise, you can build the rescaling shifts into your procedure so that they don't take any extra effort during the calculation itself. This can save up to two-thirds of the time that floating-point calculations take. John von Neumann, often called the father of computing, held the view that such a priori analysis was the proper approach. He saw no need for floating point. However, most programmers now agree that the analysis required is far too costly and error-prone to ignore floating-point hardware.

SCIENTIFIC NOTATION

As researchers and scientists have probed the further reaches of our world, they have developed scientific notation to express very large and very small numbers with equal precision. For example,

602,300,000,000,000

becomes 6.023×10^{14} while

0.000,000,000,000,006,624

becomes 6.624×10^{-15}. The precision or uncertainty figures for these numbers look very different until you express them in scientific notation: 5.0×10^{10} for the first versus 5.0×10^{-18} for the second.

When you consider imprecise numbers, it is easy to become confused between absolute uncertainty and relative uncertainty—relative to the size of the value involved. The relative uncertainty here is referred to as "half a unit-in-the-last-place" or "½ ulp." Since we want computers to cope quickly and precisely with a wide range of numbers, we adapt the

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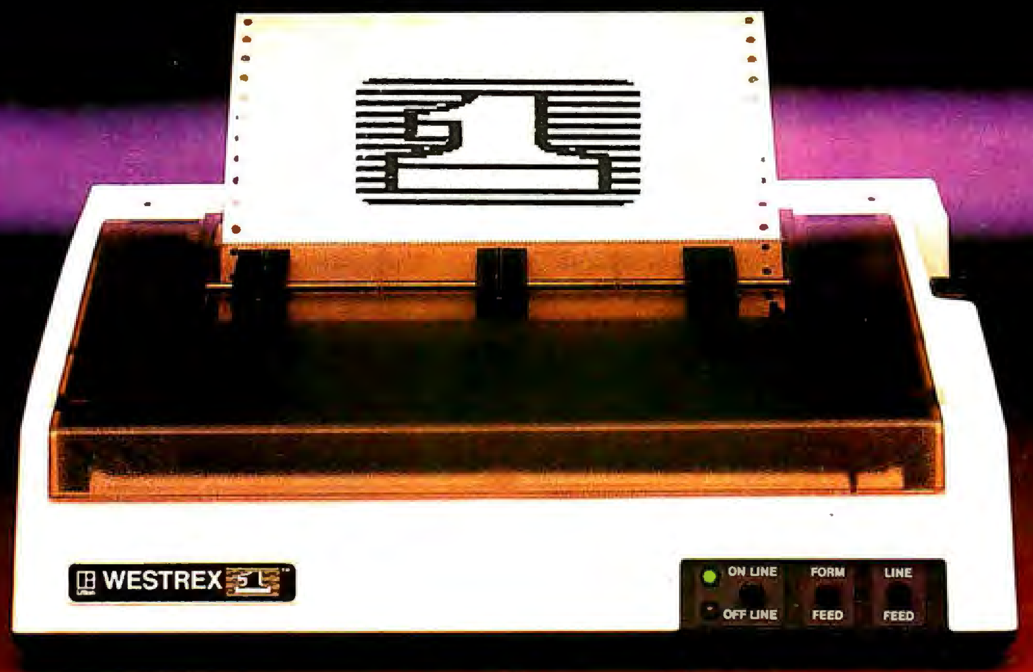
In a one-to-one comparison, Westrex-One.



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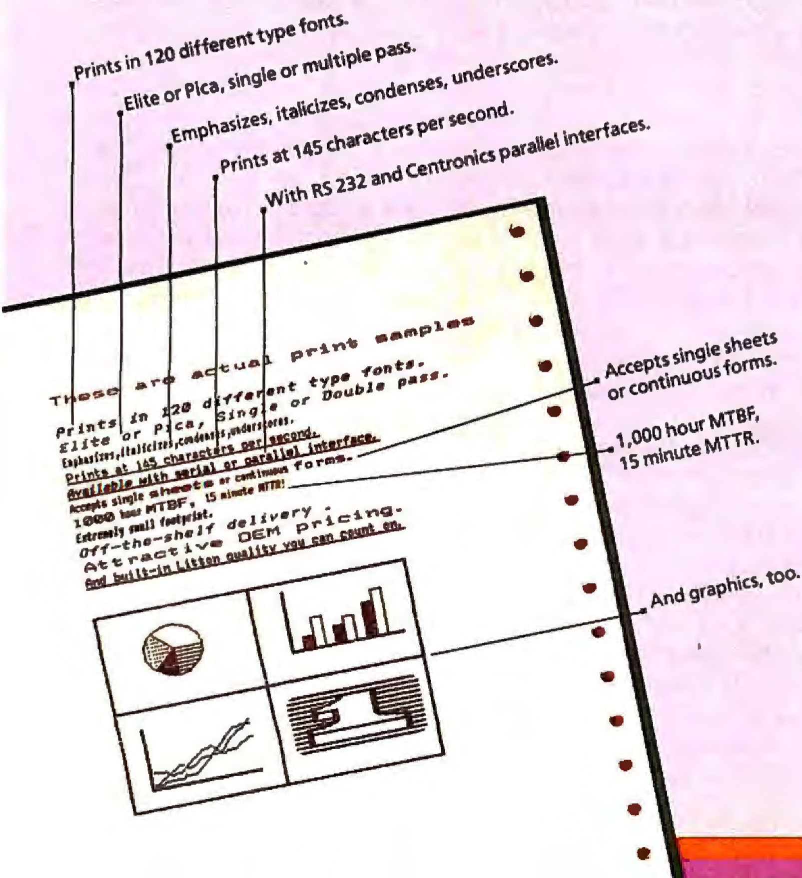

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scientific notation to the task. You don't need to store the "× 10" part because it doesn't change between various numbers, so you represent each number with a fractional significand and a whole-number exponent.

The rescaling hasn't gone away. The "exponent" is the variable in which rescaling operations note their adjustments. As you might expect, exponents are represented and used in different ways—each with its own particular problems—and each number is rescaled automatically after each operation to eliminate any leading zeros and to preserve the maximum number of significant digits.

We use decimal notation (radix 10) for numbers, but computers usually use binary notation (radix 2) to match their memory and logic-circuit components. In binary you can, for example, use a significand between ½ and 1, that is, between 1-over-the-radix and 1. Some computers use hexadecimal (radix 16) instead; their significands can lie between 1/16 and 1. Radix 2 packs the most range and precision into any given word (the number of bits devoted to representing a number). Radix 10 is also very useful because there are no errors *introduced* in moving ordinary decimal numbers into the computer. There are errors, but there are no *new* errors.

If your computer uses six decimal digits of precision, you have a pretty good idea of what happens to numbers like ⅓. However many digits you type, the most precise estimate you can ever get is 0.333,333. This contains a small error—only ⅓ ulp—but this error is inherently present for such fractions in any floating-point notation.

There are systems for maintaining rational numbers that avoid the problem of precision as long as possible, at a high cost in size and speed. They keep two whole numbers to represent a fraction—1 and 3 here—and save the division for later. Thus, if ⅓ is later multiplied by 3, the threes cancel and the answer is exactly 1. Unfortunately, in long calculations both of these numbers grow unreasonably large all too rapidly. Unless your need for high precision is very great, this method is uneconomical.

If you multiply 0.333,333 times 3, 0.999,999 is as close to 1 as you can get, given the round-off error of 1 ulp. Sometimes you can accept answers within several ulps of the best possible answer. In this case you must accept the 0.999,999 result if you're going to use floating point; but, even here, 0.999,998 is clearly unacceptable because we can do better.

ROUND OR CHOP?

Some computers offer you the choice of rounding off or chopping (truncating) the result of each calculation. Rounding off preserves an extra ½ ulp of precision in each step. If the numbers are all positive, rounding off avoids the systematic underestimating error that truncation introduces.

This is an important matter. For example, the *Wall Street Journal* reported on November 8, 1983 (page 37), that the Vancouver Stock Exchange maintains a stock index rather like the Dow Jones average. It began with a nominal value of 1,000.000 and was recalculated after each recorded transaction. At each stage, the value was calculated to five decimal places, but the last two were truncated.

The exchange found that after 22 months of operation, with about 2800 transactions per working day, the index had fallen to the 520 range while stock prices were reaching new highs. Investigation showed that all those lost fractions of thousandths of a point had mounted up to a major inaccuracy.

The solution the exchange planned was to round off instead of chop. If this was done in the usual way—01 to 49 round down, 50 to 99 round up—then a consistent error still remains. The error is only one percent as large as it was and tends to inflate rather than deflate the index, so the exchange might even consider it an advantage. This new error is that while 49 of the values round down and one stays the same, 50 of them round up.

The point is that even tiny errors, when they all go the same way, can

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do serious damage to numerical results. The Paranoia benchmark checks your arithmetic to see whether rounding is done correctly if at all.

GUARD DIGITS

Round-off errors are unavoidable. These errors are not mistakes in the process but the inevitable result of restricting the width of floating-point numbers. A carefully built arithmetic system can round meticulously whenever approximation is required. However, in order to round correctly, extra (guard) digits are needed temporarily in the course of ordinary calculations.

Guard digits reduce error. In a four-digit system you may need five or more digits to maintain accuracy until the result is rescaled. For example, 1.144×10^1 minus 8.336×10^0 really needs five digits. Without the extra digit this simple subtraction suffers an error of 4 to 6 ulps, a serious defect that makes numeric programming even more difficult and error-prone. To illustrate: *with* the guard digit, 11.44 minus 8.336 yields 03.104, which results in an answer after rescaling of 3.104×10^0; *without* the guard digit, 11.44 minus 8.33 (if truncated) yields 03.11 for a result of 3.110×10^0 and 11.44 minus 8.34 (if rounded off) yields 03.10 for a result of 3.100×10^0.

The need for guard digits becomes quite clear. What about your computer? Often the specific details of the arithmetic used on a given computer are known only to its designers. Yet they are important to programmers and other users who want to get good, precise, accurate answers.

Professor William Kahan at the University of California at Berkeley wrote Paranoia for just this reason. Paranoia checks many of the arithmetic details of your computer. For each aspect that is not handled in the best way, Paranoia reports what sort of difficulty will ensue from its use.

The full Paranoia program is some 700 lines of BASIC. Listings 1 and 2 show an extract sufficient to test for the use of a guard digit in addition and subtraction. If some part of the routine seems confusing, you may find it helpful to try a pencil-and-paper example with a four-digit system like the one above. These programs were simplified from the Pascal translation of Paranoia by B. A. Wichmann of the National Physical Laboratory in England. The full program guards itself against many (rare) problems that might possibly arise. Full Paranoia also rechecks critical calculations by a second method, just to be sure.

TEST YOUR CALCULATOR

You can use essentially the same guard-digit procedure to test your pocket calculator. Without checking for radix, etc., the results of two simple expressions will signal the

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IEEE ARITHMETIC AND PARANOIA AVAILABILITY

The IEEE has specified a particularly careful floating-point arithmetic intended to avoid the worst problems of the older arithmetics used on computers. One committee (p754) designed a very specific binary floating-point arithmetic with three sizes of numbers. A second working group (p854) relaxed some of those specifications to permit different sizes of numbers and different radixes to be used. These IEEE arithmetics are so good that Paranoia finds no fault with them at all.

An example of IEEE arithmetic is the way it avoids the problem of more numbers rounding up than down (50 versus 49): it rounds numbers ending in 50 up only half the time, i.e., when the previous digit is odd. The rest of the time, the numbers round down. For this reason, the normal IEEE rounding mode is called round-to-even.

The drafts of the IEEE specifications are highly technical and quite compact. The dozen or so pages require careful reading and often some deliberate studying to fully comprehend. Still, that task is rewarding to those who seek to achieve numerical results of the highest quality with their programs.

If you would like a copy of the IEEE p754 (binary) or p854 (binary and decimal) drafts, you may write to the author (IEEE p854 Mailings, U-76 UCSF, San Francisco, CA 94143). The full Paranoia test program will also be available, on floppy disk, for a distribution charge of $15. The author also has order forms for the disk. The floppy formats of the Paranoia disk will include at least the PC-DOS 9-sector 5¼-inch double-sided format. A page or two of documentation will help you run the program.

The second, corrected release of Paranoia in MS-BASIC should be available by this issue's cover date. Versions in FORTRAN and Pascal are also expected to be ready. Although the author of the Paranoia program, Professor William Kahan, is a key member of the IEEE Computer Society committees, the IEEE does not guarantee the program in any way.

If you request these test programs, you will be asked to assist Professor Kahan and Mr. Karpinski by reporting back the results you get when you use them. Please send us your results for any system that is either commercially available or interesting in its own right. You may copy the test program freely, maintaining its copyright notice, and pass it on to your friends. We would appreciate their results as well.

When you run Paranoia, you will get several pages of messages about the details of the arithmetic. So far results have been collected on more than six different BASIC systems, but some of these results are already obsolete. Perhaps you can help us to bring them up-to-date. We are especially interested in hearing about any errors you may discover in the tests themselves. We would also like to hear of any problems you have running or interpreting the tests, although we do not promise anything but our thanks in return.

A benchmark of this complexity may take years to reach its full value to the computing community. When enough arithmetics have been tested to make the results interesting, the authors will try to publish them.

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Listing 1: *A* Microsoft BASIC *program to test for the presence of a guard digit in subtraction. Note:* fpwidth *is the smallest number formed by multiplying one by the powers of the radix. It is calculated by successive multiplications, until the product when added to* 1.0 *no longer gives an exact result.* (Width *is a* Microsoft BASIC *reserved word and cannot be used as the variable name.*)

```
10 '       Guard — Test if add/subtract has a guard digit
20 '
30     One          =   1.0  '  Floating-point constants
40     Half         =   0.5
50     Zero         =   0.0
60     MinusOne     =  -1.0
70 '
80 ' variables:
90 '
100 ' Radix        Calculated floating-point radix
110 ' Precision    Significant digits in base Radix
120 '
130 '                        Precision
140 ' fpwidth        Radix             (or Radix ^ Precision)
150 ' Wide         First estimate of fpwidth
160 '
170 ' UlpOne       Unit in last place of just less than one
180 ' UlpRadix     Radix * UlpOne
190 '
200 ' OneMinus     One     - UlpOne     calculated with care
210 ' RadixMinus   Radix   - UlpRadix
220 '
230 ' s, t, u      Working variables
240 ' x, y, z
250 '
260 '
270 '     Find a Wide so big that adding one does not change it by one
280 '
290  Wide = One
300 '
310     Wide  = Wide + Wide ' Double it until it grows so large that
320     x     = Wide + One  '    Adding one does not change it or
330                         '    (with rounding) changes it by 2
340     y      = x     - Wide '     So the difference is zero or 2
350     z      = y     - One  '        And this becomes + / - one
360 '
370     IF ( MinusOne + ABS( z ) )    <     Zero   THEN 310
380 '
390 '
400 ' Find the radix (or number base) as the minimum increase in Wide
410 '     Remember that Wide is just large enough that the units place
420 '     is not represented, so a one in the last represented place
430 '     (the tens place, for decimal) is exactly the radix itself.
440 '     Try it by hand.
450 '
460     y = One
470 '
480      Radix = Wide  + y  ' No change on first addition
490      y     = y     + y  '    So double y
500      Radix = Radix - Wide '     Until some change happens
510 '
520      IF Radix = Zero THEN 480  '       The change is the radix
530 '
540    PRINT "Radix = "; Radix
550 '
560 '
```

```
570 ' Find the precision in Radix digits
580 '
590    Precision = Zero
600    fpwidth   = One
610 '
620       Precision = Precision + One     ' Count the digits
630       fpwidth   = fpwidth   * Radix '      And increase fpwidth
640       y         = fpwidth   + One     '          Until adding one
650 '
660       IF ( y - fpwidth) = One THEN 620 '                Is imprecise
670 '
680    PRINT "Precision = "; Precision
690 '
700    PRINT "fpwidth = "; fpwidth
710 '
720    UlpOne = One / fpwidth
730 '
740    PRINT "Closest relative separation found is UlpOne = "; UlpOne
750 '
760    OneMinus = ( Half - UlpOne ) + Half
770    UlpRadix = Radix * UlpOne
780 '
790    RadixMinus =   Radix                    - One
800    RadixMinus = ( RadixMinus - UlpRadix ) + One
810 '
820    x = One   - UlpOne
830    y = One   - OneMinus
840    z = One   - x
850 '
860    s = Radix - UlpRadix
870    t = Radix - RadixMinus
880    u = Radix - s
890 '
900    IF y = UlpOne THEN 920
910    GOTO 960
920    IF t = UlpRadix AND u = UlpRadix THEN 940
930    GOTO 960
940      PRINT "Add/subtract has a guard digit as it should."
950    GOTO 980
960      PRINT "Add/subtract lacks guard digit, cancellation obscured."
970 '
980    END ' Guard
```

Listing 2: *Pascal program to test for the presence of a guard digit in subtraction.*

```
program Guard;              { Test if add/subtract has a guard digit         }

const
  One        =  1.0;        { Floating-point constants                       }
  Half       =  0.5;
  Zero       =  0.0;
  MinusOne   = -1.0;

var
  Radix      : real;        { Calculated floating-point radix                }
  Precision  : real;        { Significant digits in base Radix               }

                            {        Precision                               }
  Width      : real;        { Radix                 (or Radix ^ Precision)   }
  Wide       : real;        { First estimate of Width                        }
```

(continued)

```
UlpOne      : real;    { Unit in last place of just less than one     }
UlpRadix    : real;    { Radix × UlpOne                               }

OneMinus    : real;    { One   - UlpOne        calculated with care   }
RadixMinus  : real;    { Radix - UlpRadix                             }

s, t, u     : real;    { Working variables                            }
x, y, z     : real;

begin {Guard}

  { Find a Wide so big that adding one does not change it by one.       }

  Wide := One;
  repeat

    Wide := Wide + Wide;         { Double it until it grows so large that  }
    x    := Wide + One;          {     Adding one does not change it or    }
                                 {     (with rounding) changes it by 2     }
    y    := x    - Wide;         {        So the difference is zero or 2   }
    z    := y    - One           {            And this becomes + / - one   }

    until ( MinusOne + abs( z ) )   >=    Zero;

  { Find the radix (or number base) as the minimum increase in Wide     }
  {     Remember that Wide is just large enough that the units place    }
  {     is not represented, so a one in the last represented place      }
  {     (the tens place, for decimal) is exactly the radix itself.      }
  {     Try it by hand.                                                 }

  y := One;
  repeat

    Radix := Wide  + y;          { No change on first addition             }
    y     := y     + y;          {      So double y                        }
    Radix := Radix - Wide        {          Until some change happens      }

    until Radix <> Zero;         {                The change is the radix! }

  writeln( 'Radix = ', Radix );

  { Find the precision in Radix digits                                  }

  Precision := Zero;
  Width     := One;
  repeat

    Precision := Precision + One;    { Count the digits                    }
    Width     := Width     * Radix;  {     And increase Width              }
    y         := Width     + One     {         Until adding one            }

    until ( y - Width ) <> One;      {              Is imprecise           }

  writeln( 'Precision = ', Precision );

  writeln( 'Width = ', Width );

  UlpOne := One / Width;

  writeln( 'Closest relative separation found is UlpOne = ', UlpOne );

  OneMinus := ( Half   - UlpOne ) + Half;
  UlpRadix :=   Radix * UlpOne;
```

(continued)

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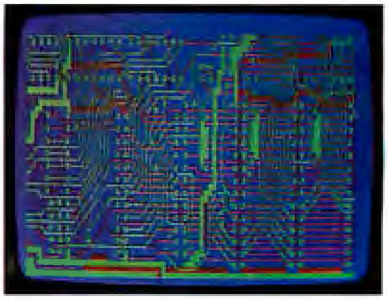

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```
RadixMinus :=   Radix                  - One;
RadixMinus := ( RadixMinus - UlpRadix ) + One;

x := One  - UlpOne;
y := One  - OneMinus;
z := One  - x;

s := Radix - UlpRadix;
t := Radix - RadixMinus;
u := Radix - s;

if (y = UlpOne) and (z = UlpOne) and
  (t = UlpRadix) and (u = UlpRadix)
then
   writeln( 'Add/subtract has a guard digit as it should.' )
else
   writeln( 'Add/subtract lacks guard digit, cancellation obscured.' )

end {Guard}.
```

presence or absence of a guard digit. If their results are equal, the guard digit is present. Otherwise, it is probably not. Those expressions are

1 – (9 / 27 * 3)

and

1/2 – (9 / 27 * 3) + 1/2

For four-function calculators without parentheses or memory, you can use

– 9 / 27 * 3 + 1

and

– 9 / 27 * 3 + .5 + .5

A smaller test in Pascal could be:

```
if (– 9 / 27 * 3 + 1 ) =
   (– 9 / 27 * 3 + .5 + .5 )
then writeln( 'Add/subtract has a
   guard digit.' )
else writeln( 'Add/subtract lacks
   guard digit.' )
```

CONCLUSION

Paranoia is an unusual benchmark: it tests the *quality* of your software, not just its speed. Most common computer arithmetics have a half-dozen or more flaws that Paranoia finds, reporting what kinds of calculations are harmed by them. Its use can be highly rewarding to those who seek to achieve very accurate, precise, numerical results from their programs. ■

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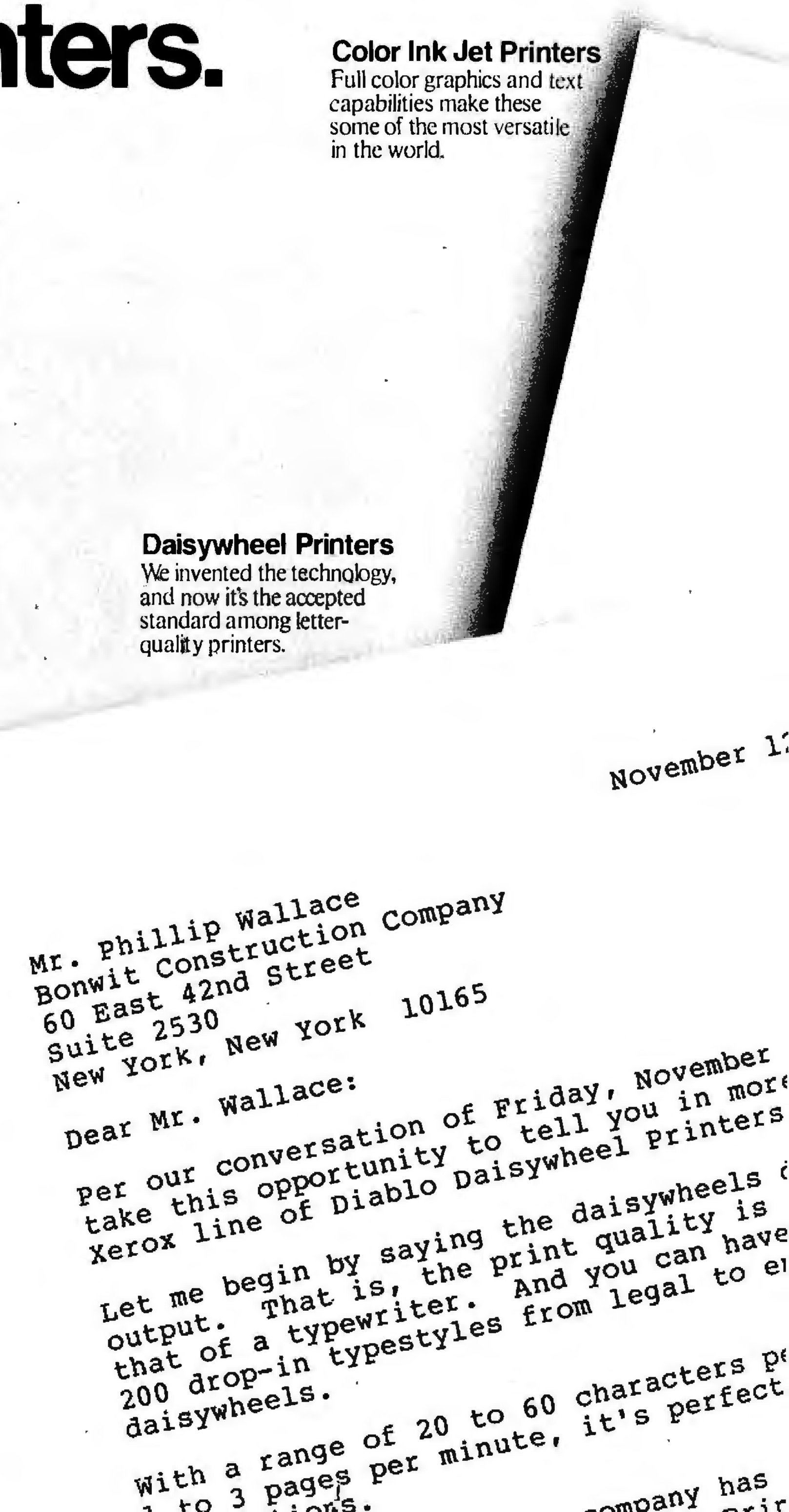

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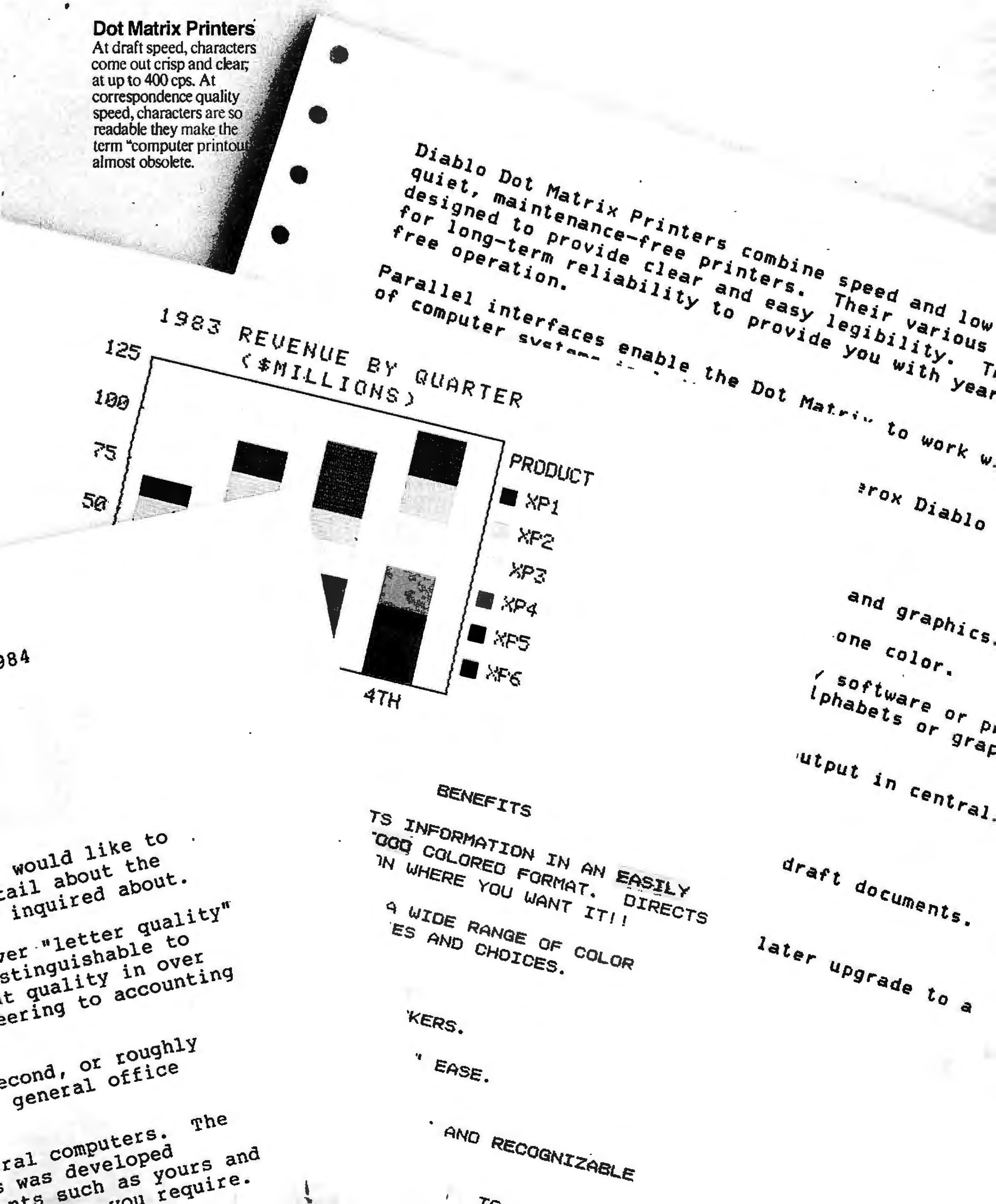

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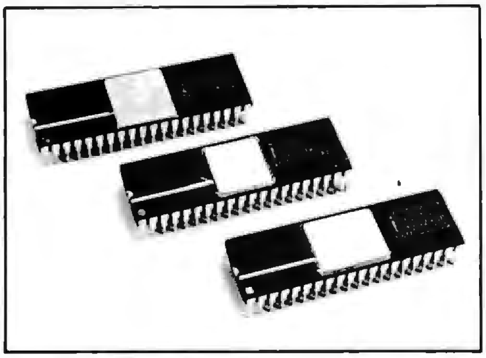

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MODELING MASS-ACTION KINETICS

BY ALAN CURTIS

In the future, microcomputers may have a substantial role in major scientific computations

AT THE UNITED KINGDOM Atomic Energy Research Establishment, Harwell, we have assembled scientific and technological applications of our FACSIMILE reaction-kinetics program. All can be run on one mainframe or another, but for the purposes of this article I have selected a few of those that now run on an IBM PC with 512K bytes of RAM (random-access read/write memory).

Like other simulation modelers such as DYNAMO, FACSIMILE facilitates the calculation of a set of differential equations that describe the continuous evolution of a system from a known initial configuration and then flexibly formats the output.

Simulation models solve problems repeatedly and carry out thorough statistical analyses to find the best fit among parameters. For such work, whether the microcomputer is practical depends on your point of view. A fairly large program that takes, say, three minutes on an IBM mainframe might well run all night on the PC, provided you use an 8087 math coprocessor; without it, running time would probably be about 10 times longer (this is a guess—we haven't checked it out).

Let's take a look at several examples of how simulation models can be used.

URANIUM FROM SEAWATER?

Seawater contains uranium, an extremely valuable fuel, at an extremely low concentration. Suppose we want to extract the uranium. The question is whether an economically viable extraction process exists. We might try pumping the seawater through an ion-exchange column, a tube tightly packed with minute spheres of a resin that preferentially absorbs uranium ions from solution and replaces them with ions of another metal. When sufficient water has been pumped through, the column is removed and cut up, and ordinary chemical means remove the uranium (now at high concentration in the resin) for further processing. Obviously the value of the recovered uranium must offset the costs of manufacturing the resin and the tubes, of the pumping power, and of the postprocessing to recover the uranium from the resin.

A feasibility study of the problem called for a simulation model because the rate coefficients for the absorption of uranium by the resin were not known. Experiments removed supposedly identical ion-exchange columns at different times, pumped different rates of seawater, and analyzed uranium contents at various points along the columns. Parameter-fitting options might have determined the best fit for these experimental results.

As it turned out, variations in properties, mainly the density of packing of the resin from one column to another, and even along the length of a single column, invalidated the model, which assumed a single uniform column. A more complicated

(continued)

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model might have involved some of the variability, but the experiments had shown that the whole process was not likely to be economical anyway.

Such negative results are not failures in scientific investigations. On the contrary, we understand far better the requirements for the simulation if we decide to pursue it again.

A modified model, now used for demonstration purposes, contains parameter values chosen to exhibit significant saturation. (There are other ways of solving the problem of modeling an ideal ion-exchange column if you know that saturation is negligible.)

To model the behavior of the column, we divided its length into 20 equal-size sections. One array of 20 variables represents the concentration of uranium in the seawater in each section, a second array represents the concentration in the resin, and a third array checks for saturation by monitoring available absorption sites in the resin. The simulation models the flow of seawater by passing material from one element of the array to the next at a rate reflecting the time it takes for the water to move the length of a section.

The first element receives material with the concentration in the incoming water; the last element sends material to a "waste" variable. The simulation of the exchange process between solution and resin uses modeling features for chemical reactions; a second-order reaction between corresponding elements of the first and third arrays represents absorption, and a first-order reaction represents the reverse process. The program runs on the IBM PC in about 550 seconds (compared with 2.5 seconds on the IBM 3081K), so that even a parameter-fitting run, which executes several dozen simulation runs, could be done overnight on the micro. It is fair to say that this investigation could have been done on the PC from the beginning.

The model provides three types of output: "snapshot" graphs, which show how the concentrations vary along the column at any time; "time-course" graphs, which illustrate how integrated quantities, such as the total uranium trapped in the resin, vary with time; and tables of numbers that give more accurate time histories of these integrated quantities. Figure 1 is a snapshot graph from this problem. By plotting the independent variable (distance along the column) along the y-axis and the dependent variables along the x-axis, a printer can plot graphs of any length. Points X represent the concentration of uranium in solution, multiplied by 100,000,000; points Y represent concentration in the resin, multiplied by 10,000; points S represent available sites, multiplied by 10,000.

```
PLOTTING PARAMETERS FOR GRAPH STREAM  2
INDEPENDENT VARIABLE :DIST        (PLOTTED VERTICALLY)
DEPENDENT VARIABLES (PLOTTED HORIZONTALLY):
X               SCALE  1.0000D-08   X
Y               SCALE  1.0000D-04   Y
S               SCALE  1.0000D-04   S
            0                         0.5                        1
            |----------|----------|----------|----------|----------|
  1.000D+00 |        Y |          |          |          | S       X|
            |          |          |          |          |          |
  3.000D+00 |        Y |          |          |          | S     X  |
            |          |          |          |          |          |
  5.000D+00 |--------Y-|----------|----------|----------|-S----X---|
            |          |          |          |          |          |
  7.000D+00 |        Y |          |          |          | S X      |
            |          |          |          |          |          |
  9.000D+00 |       Y  |          |          |          |  S       |
            |----------|----------|----------|----------|----------|
  1.100D+01 |       Y  |          |          |          | XS       |
            |          |          |          |          |          |
  1.300D+01 |       Y  |          |          |          |X S       |
            |          |          |          |          |          |
  1.500D+01 |-------Y--|----------|----------|---------X|--S-------|
            |          |          |          |          |          |
  1.700D+01 |       Y  |          |          |        X |  S       |
            |          |          |          |          |          |
  1.900D+01 |      Y   |          |          |       X  |   S      |
            |----------|----------|----------|----------|----------|
  2.100D+01 |      Y   |          |          |      X   |   S      |
            |          |          |          |          |          |
  2.300D+01 |      Y   |          |          |    X     |   S      |
            |          |          |          |          |          |
  2.500D+01 |------Y---|----------|----------|---X------|---S------|
            |          |          |          |          |          |
  2.700D+01 |      Y   |          |          |  X       |   S      |
            |          |          |          |          |          |
  2.900D+01 |    Y     |          |          | X        |    S     |
            |----------|----------|----------|----------|----------|
  3.100D+01 |    Y     |          |          |X         |    S     |
            |          |          |          |          |          |
  3.300D+01 |    Y     |          |          X          |    S     |
            |          |          |          |          |          |
  3.500D+01 |----Y-----|----------|---------X|----------|----S-----|
            |          |          |          |          |          |
  3.700D+01 |    Y     |          |        X |          |    S     |
            |          |          |          |          |          |
  3.900D+01 |    Y     |          |       X  |          |    S     |
            |----------|----------|----------|----------|----------|
```

Figure 1: A *snapshot graph from the ion-exchange-column problem.*

STARTING UP A CHEMICAL REACTOR

In a 1981 thesis for Imperial College, London, I. T. Cameron proposed this chemical-engineering problem. It is much simpler than the others described here, but in practice it had proved difficult to solve.

Initially a chemical reactor contains neutral gas. A pump starts to supply liquid feedstock through an inlet valve, compressing the gas and reducing the flow from the pump because of back pressure. A chemical reaction takes place in the vessel, and product mixed with unused feedstock, driven by the gas pressure and the liquid head, flows out through an outlet valve. In time the system reaches a steady state, but the main focus of the simulation is the start-up transient. Results of interest include the peak gas pressure and temperature (for vessel design) and the loss of unused feedstock and substandard product. The model includes the ef-

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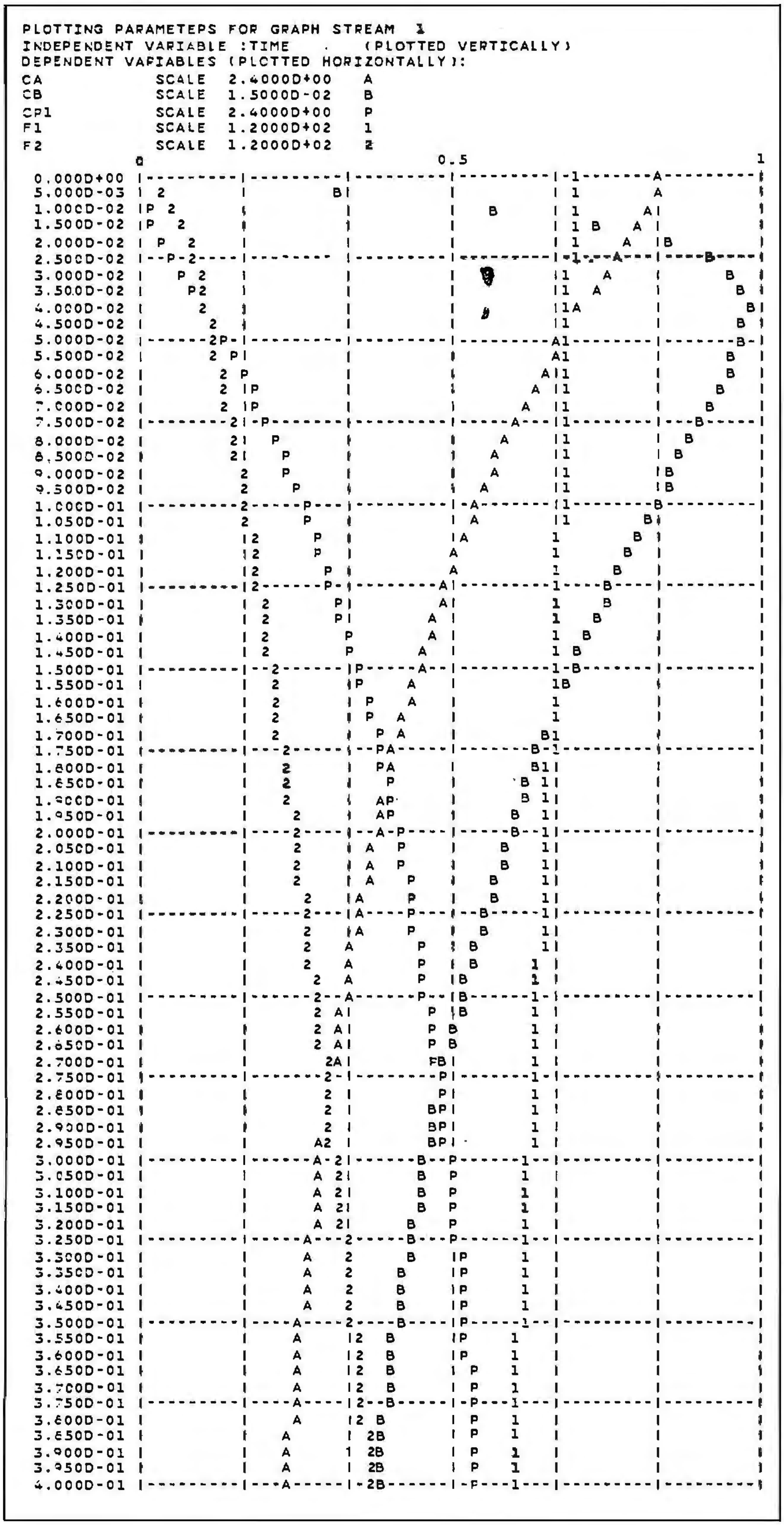

fect of pressure on inlet and outlet flow rates as well as the progress of the reaction, the depth of the liquid, and the thermodynamics of the gas.

Output consists of time-course graphs and tables of numbers. The graphical output (see figure 2) illustrates an interesting phenomenon that occurs fairly often. There is a long transient before the approach of the steady state, but the initial transient is very fast. To study the initial part effectively, it is necessary to plot many points at small time intervals. Graphs, therefore, have the independent variable (time in this case) plotted downward and the dependent variables plotted from left to right; thus (with continuous paper) there is no limit to the length of the plotted graph. However, if the PC screen displays the graph as it is produced, only about 25 lines are shown at a time, so a printer is essential.

DEATH OF A STAR

When a typical "main sequence" star has been burning and radiating energy away for a few billion years, it has transmuted all of its original lighter elements into carbon and oxygen and must enter a carbon-burning phase. During this time, the internal pressure needed to support the star's weight against its own gravitational attraction has required high density and temperature, which in turn make the star opaque to radiation.

According to Planck's law, the star radiates at a rate determined by its surface area and temperature. Therefore, when the star's lighter elements are exhausted and its energy from nuclear reactions becomes inadequate to support its weight, it starts to contract under gravity; this increases its internal temperature until it reaches about 1 billion degrees

(continued)

Figure 2: A *time-course graph from Cameron's reactor problem.* A = *concentration of feedstock;* B = *concentration of an intermediate (on larger scale);* P = *concentration of product;* 1 = *inlet flow rate;* 2 = *outlet flow rate.*

Generation of smog in urban areas is a complex phenomenon that involves numerous reactions among over 100 trace gases in the atmosphere.

Kelvin. This temperature is sufficient to cause carbon nuclei to begin fusing together to form heavier elements. This carbon-burning process supplies the necessary energy to make further gravitational contraction unnecessary.

If the star is an ordinary one—not too big—the temperature generates enough pressure to keep the star stable until the carbon is exhausted. The temperature and density do not rise further, and the carbon-burning phase takes place relatively slowly, in conditions of hydrostatic equilibrium. In a more massive star, however, the pressure is inadequate, contraction continues, the temperature and density continue to rise, and carbon burning proceeds explosively fast; the star becomes a supernova. In either case, the phase is extremely short in relation to the earlier leisurely history of the star; typical durations may be a week or two for an ordinary (less massive) star or about a second for a supernova.

Simulations have been successful for both the hydrostatic and the explosive carbon-burning phases. In both cases, the set of nuclear reactions is the same, but the rate coefficients depend on temperature and density, variables that vary with time in a way determined by the stellar dynamics. To model the hydrostatic version, temperature and density are kept constant and rate coefficients are computed only once, at the start of the run. For the supernova version, temperature and density are defined as functions of time, and the rate coefficients are frequently recalculated during the run.

The coding of the nuclear reactions, although they are numerous, is relatively easy because their structure is exactly that of chemical reactions. Protons, neutrons, neutrinos, alpha particles, and 36 heavier nuclides are simulated.

A run of the hydrostatic version takes about 8200 seconds (2.3 hours) on the PC, compared with about 25 seconds on the IBM 3081K. This is a larger speed ratio than average—about 330:1—but we may be able to improve the performance. The supernova version takes about 67 seconds on the 3081, so we expect it to take about 22,000 seconds (say, 6 hours) on the PC. Output consists of time-course graphs of the mass fractions of the various nuclides, plotted on logarithmic scales for time and for the mass fractions, and of tables giving numerical values for the mass fractions as functions of time. The graphs show clearly the stages at which the various nuclides are produced or used up; in many cases, this occurs in straight lines on the log-log plot, indicating mass fractions proportional to a (positive or negative) power of the time.

PHOTOCHEMICAL SMOG GENERATION

The generation of photochemical smog in urban areas is an extremely complex phenomenon that involves numerous reactions among well over 100 trace gases in the atmosphere. Important elementary steps in the process involve the breaking of chemical bonds when a molecule absorbs solar radiation; these steps switch off rapidly as sunset approaches and switch on equally fast

(continued)

at dawn. Rate coefficients also depend on smaller day/night variations such as temperature and water vapor content. Thus the behavior of the chemistry during the night is quite different from that during the day, and the switching processes are technically difficult for many differential-equation solvers to handle.

The model of this process is by far the largest and most complicated of those described here. The model involves a total of 300 reactions among 135 chemical species; the data occupies about 620 lines of code. The model also requires larger working arrays than the others, but it can be fitted into 470K bytes of RAM. Simulating 50 hours of real time (thus seeing how much greater the pollution is on the second day than the first) takes about 110 seconds on the IBM 3081K; we are not yet able to run it on the PC, but we might expect a speed ratio similar to that for the astrophysical problem. It is thus at the limit of practicability on the PC (at present) so far as running time is concerned, but it is interesting that the model would still run faster than real time. Simulation of the second 24 hours takes about one-third of the total time, and we would expect subsequent days to run at approximately this speed.

Output consists mainly of time-course graphs, which illustrate clearly the buildup, with afternoon peaks and nighttime troughs, in the concentrations of the important pollutants.

CONCLUSION

I have presented only a few of the many scientific and engineering applications that are practicable on a micro like the IBM PC with 512K bytes of RAM and an 8087 math coprocessor. I hope, nevertheless, that I have conveyed a feel for what I am sure has a very big future—the use of microcomputers for major scientific computation. ■

FOR FURTHER INFORMATION

For information on some specific microcomputer simulation modelers, contact:

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ACKNOWLEDGMENT

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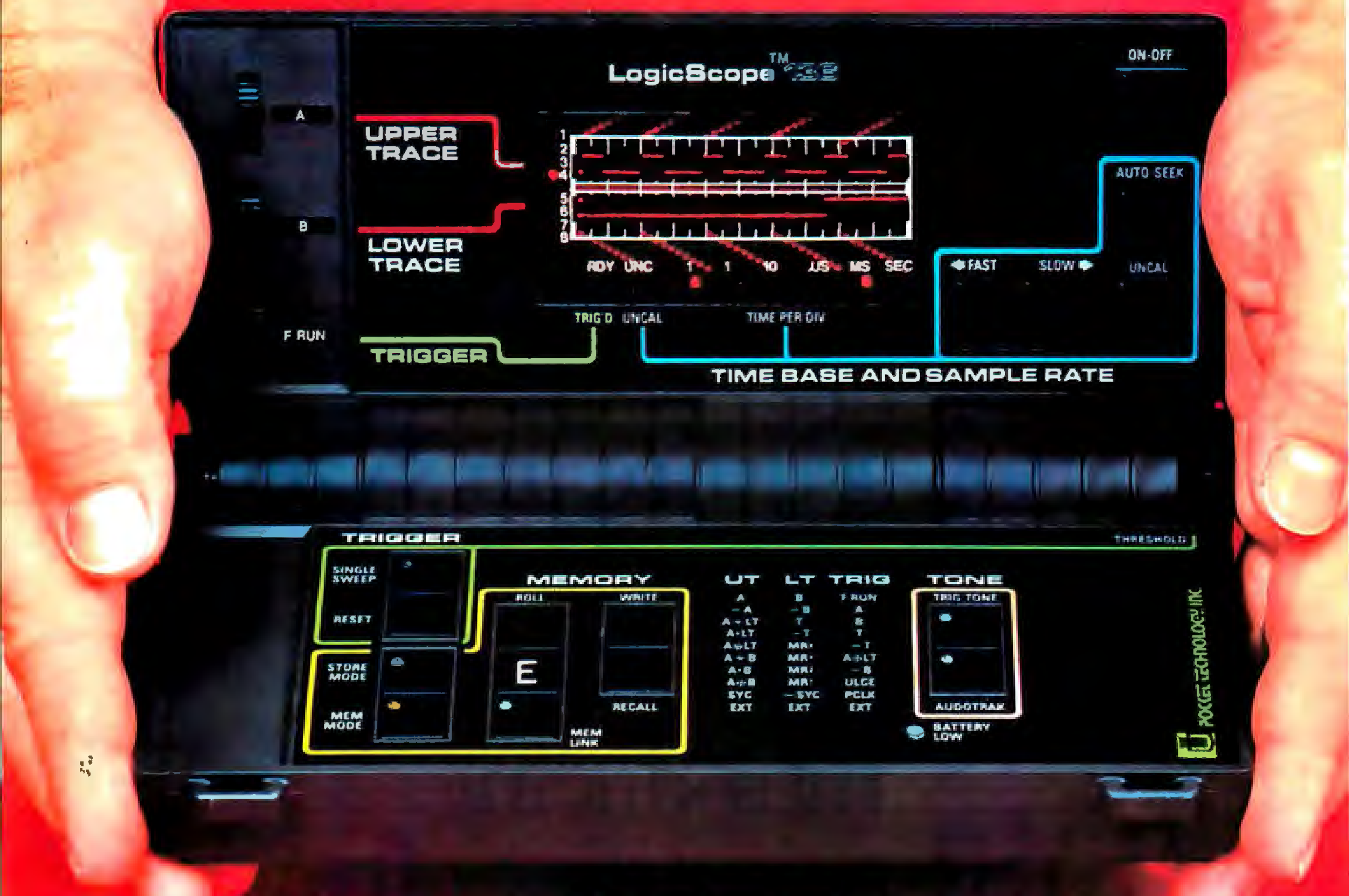

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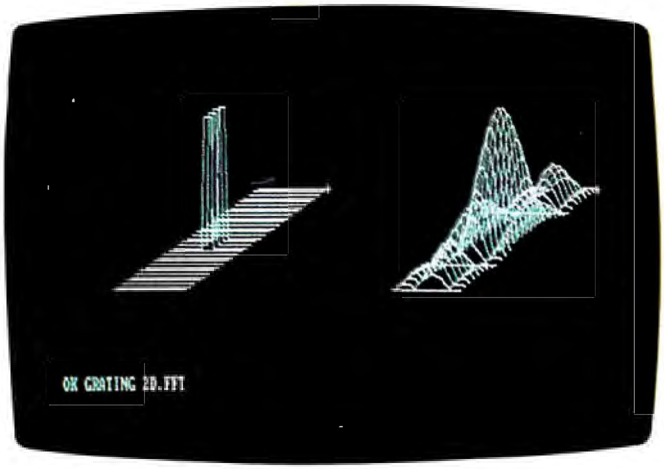
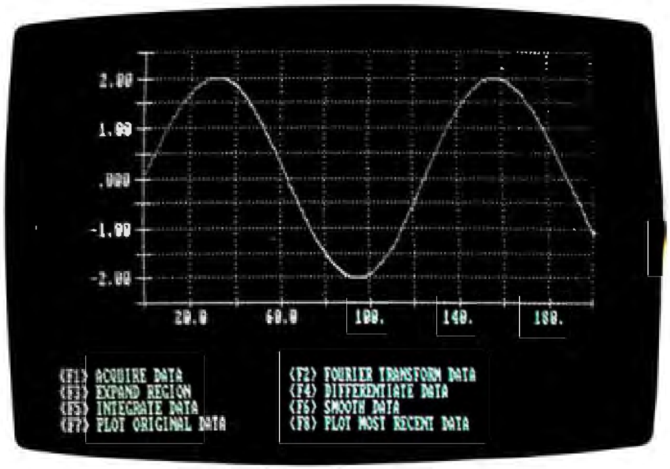


ASYST multiple windows permit side-by-side comparisons. The two-dimensional FFT routine, shown, is one of the many built-in functions.



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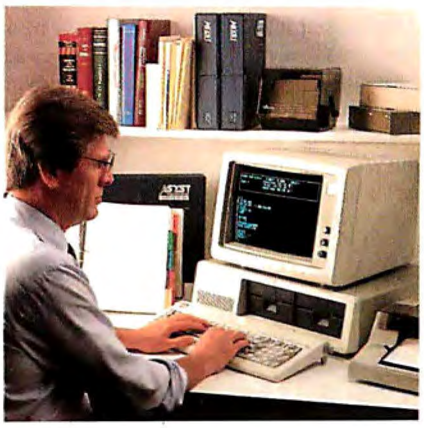

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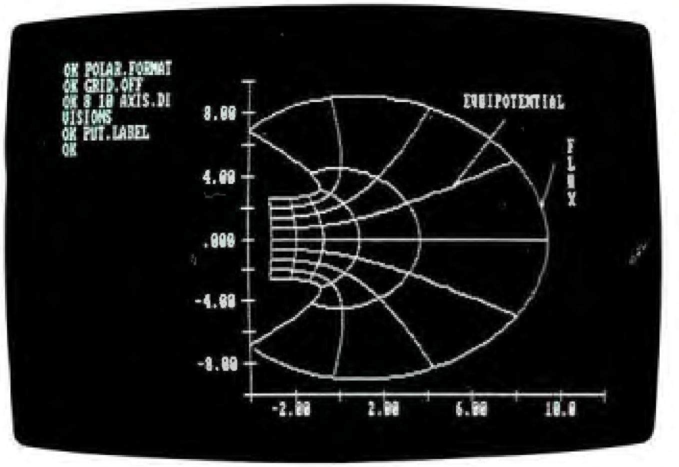

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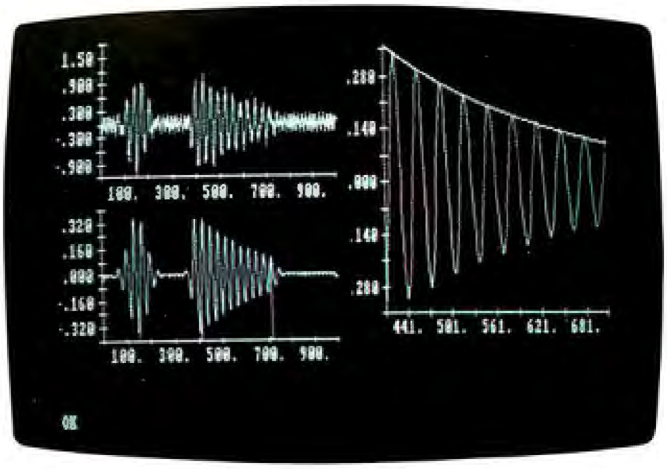

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VIEWING MOLECULES WITH THE MACINTOSH

BY EARL J. KIRKLAND

A BASIC *program provides* 3-D *images of complex molecules*

RESEARCHERS HAVE GAINED valuable insights into how molecules work by examining the basic physical structures of the molecules, which in part determine their functions. Scientists have learned, for example, that the physics of electronic conduction in a silicon crystal is influenced by the basic symmetries of the crystal.

The relative physical sizes and shapes of two molecules may also influence the rate at which they interact chemically (since, for two chemicals—i.e., atoms or molecules—to interact, they must first come into contact with each other). This is the case with a particular class of biochemical substances called enzymes, which are responsible for controlling the rate of biochemical activity without themselves being changed (i.e., they are biological catalysts). The size and shape of the enzyme molecule influences which other biochemical substances (molecules) may bind to it and hence be influenced by it.

We can gain some understanding of the basic functions of molecules by examining the size and shape of a given molecule, using either a real physical model or a computer-graphics representation of the molecule. References 1, 2, and 3 give some examples of graphic representations of molecular structure and their usefulness in understanding molecular function.

Molecules are far too small to be seen with optical microscopes, and electron microscopes are just becoming capable of directly imaging a few specialized types of molecules. Most of the molecular structures that we know today have been determined by X-ray diffraction studies of large crystals. A crystal can be thought of as a very large, single molecule composed of a small structure of a few atoms repeated many times. This repetitive nature allows researchers to analyze many identical molecules at one time and obtain a reasonable "signal-to-noise" ratio in the results.

Earl J. Kirkland (Cornell University, Ithaca, NY 14853) *holds a doctorate in applied physics and is a research associate at* Cornell's School of Applied and Engineering Physics. *His work involves computer image processing of electron micrographs.*

X-ray diffraction patterns cannot be directly interpreted but require a computer to digest the diffraction pattern. The computer outputs a sequence of numerical data describing the three-dimensional (3-D) positions of the atoms inside the molecule. This numerical data is rather difficult to understand without further reduction. Simple structures with only a few atoms may be intuitively visualized from the raw numerical data, but the more interesting or important structures often contain hundreds of atoms, each with its own numerical coordinate (x,y,z). Intuition is inadequate for complicated structures such as these.

Before the advent of computer graphics, researchers had to go through the elaborate process of building 3-D models of each molecule for futher study. Because this molecular-structure data is often generated by a computer, it is a practical alternative to also let the computer draw a 3-D perspective view of the molecule using computer graphics.

Computer graphics is a powerful

(continued)

tool for visualizing the structure of large molecules in three dimensions. Sophisticated (and expensive) computer hardware and software systems for displaying molecules and crystals in 3-D perspective are discussed in references 4 and 5.

The Apple Macintosh has enough resolution and speed to draw 3-D perspective views of relatively large molecules and to rotate them in space (not in real time but fast enough to be interactive). Although not as good as the more sophisticated systems (several of which are discussed in references 4 and 5), the Macintosh is certainly less expensive and can provide quite usable and educational results. MODEL3D, a program written in Microsoft Macintosh BASIC 1.0 and designed to run on the 128K-byte Mac, is capable of displaying up to 600 atoms in three dimensions, with hidden-surface removal, and azimuthal and polar rotations (these terms are defined below).

Molecules

For the purposes of this discussion, think of a molecule as a group of atoms that are bound together in a well-defined structure. Each molecule has a given number of one or more different types of atoms and each atom has a specific 3-D coordinate associated with it. A molecule may be as simple as two atoms or as complicated as the DNA molecule with its thousands of atoms. The atom-to-atom spacing varies from one molecule to the next and is determined by the chemistry and physics of the bonds. Typical atomic spacings are on the order of a few angstroms (1 angstrom $= 10^{-8}$ centimeters).

Each atom in the molecule or crystal has a further substructure consisting of a small nucleus of positive charge (protons and neutrons) surrounded by a larger, negatively charged electron cloud. The outer electrons in this cloud form the actual bond to the neighboring atoms. The radius of the atom (i.e., the electron-cloud radius) varies from one type of atom to the next. (Typically, atomic radii are on the order of 1 angstrom.) This atomic structure may be modeled graphically as a slightly fuzzy sphere whose radius is the radius of the electron cloud. The specific 3-D coordinate of the atom is associated with the center or nucleus of the atom. Therefore, to describe a whole molecule all you need is a list containing the 3-D coordinate and size of each atom in the molecule. This will be represented as the coordinates $(x,y,z)_i$ and atomic sizes (or radii) s_i, for $i = 1,2,3,\ldots,n$, where n is the total number of atoms in the molecule.

Rotation

Once you have the list of atomic coordinates inside the computer, you can rotate the atomic structure to any angle prior to viewing it. In three dimensions there are two possible independent rotations about a given center (or any other given point). They will be referred to as an azimuthal rotation (about the z-axis) and a polar rotation (about the x-axis). To azimuthally rotate the molecule about its center point $(x,y,z)_o$ through an angle ϕ, you must transform each atomic coordinate $(x,y,z)_i$ as:

$$x_i' = (x_i - x_o)\cos(\phi) + (y_i - y_o)\sin(\phi)$$

$$y_i' = -(x_i - x_o)\sin(\phi) + (y_i - y_o)\cos(\phi)$$

and to rotate through a polar angle θ, you must transform each atomic coordinate as:

$$y_i'' = y_i'\cos(\theta) + (z_i - z_o)\sin(\theta)$$

$$z_i' = -y_i'\sin(\theta) + (z_i - z_o)\cos(\theta)$$

The computer uses the new resulting rotated coordinates $(x',y'',z')_i$ to calculate the 3-D perspective view of the molecule. For convenience you may define the center of rotation $(x,y,z)_o$ to be halfway between the minimum and maximum extent of the molecule (along each axis).

3-D Perspective

To display a molecule in 3-D on a computer screen, the light coming from the two-dimensional CRT (cathode-ray tube) screen must be made to appear as if it comes from a three-dimensional object (i.e., the molecule). One way to do this is illustrated in figure 1 (see also references 4 and 6). The human observer is in the "viewing position" at a distance D from the CRT screen, which is illustrated as a two-dimen-

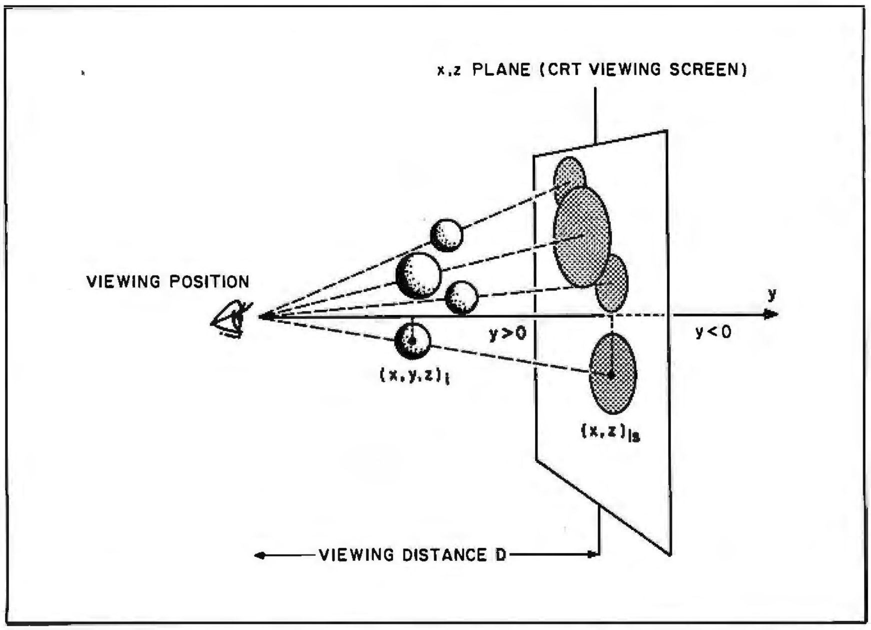

Figure 1: *A perspective view of a three-dimensional object as projected onto a two-dimensional* CRT *screen. The point* $(x,y,z)_i$ *represents the center of a* 3-D *sphere, and* $(x,z)_{is}$ *represents the projected screen coordinates.*

sional x,z plane, seen from the side. Projected on this "screen" is a 3-D molecule, of which one atom has the coordinates $(x,y,z)_i$.

We then trace several light rays from the viewing position through the three-dimensional-object points. The points where these rays intersect the CRT plane is where the object should be placed when drawn on the CRT screen. By comparing similar right triangles formed with the viewing position, the y-axis, and either the $(x,y,z)_i$ or $(x,z)_{is}$ points, we can calculate the screen coordinates as:

$$x_{is} = Dx_i / (D - y_i)$$

and

$$z_{is} = Dz_i / (D - y_i)$$

In practice, the leading multiplicative factor of D will be dropped because the screen coordinates will be rescaled later to fill the screen. The apparent size of each atom should also be scaled as above so that the atoms appear smaller as they get further away.

In realistic 3-D perspective, some atoms will be in back of other atoms and hence should not be visible. This is the so-called "hidden-surface problem." An easy, if crude, solution is to simply sort the atoms by depth and draw from the back forward, always overwriting each successive layer of atoms. When each successive atom is drawn it exactly overwrites the portion of the object that it would normally obscure. This is the approach I have used here.

THE PROGRAM

I have implemented the theory outlined above in MODEL3D (listing 1), a program written in Microsoft BASIC for the Macintosh. [*Editor's note: The source code for* MODEL3D *is available for downloading via* BYTE*net Listings. The number is* (603) 924-9820.] The program first asks for the name of the data file containing the atomic coordinates of the molecule you wish to draw. You can obtain this information from college-level chemistry or physics textbooks, or from the

(continued)

Listing 1: *The Source listing of* MODEL3D, *a Microsoft* BASIC 1.0 *program to draw* 3-D *perspective views of molecules.*

```
10  '     *** MODEL3D.BAS ***
20  ' Draw a 3D perspective view of a molecule with rotation
30  ' For private, noncommercial use only.
40  ' ©E. Kirkland   4-JUL-84, added printer distortion 9-SEP-84
50  '
60  ' NOTE: Remember to shrink command window to lower left
70  'hand corner so that the lower right side of screen is visible
80  '
90  DEFINT I-N:DEFSNG O-Z:DEFSNG A-G
100 DIM IE(4),IP(12),X(600),Y(600),Z(600),S(600)
110 '
120 ' Define shading bit patterns for sphere
130 IP(0)=&H4411:IP(1)=IP(0):IP(2)=IP(0):IP(3)=IP(0)
140 IP(4)=&H55AA:IP(5)=IP(4):IP(6)=IP(4):IP(7)=IP(4)
150 IP(8)=&HFFFF:IP(9)=IP(8):IP(10)=IP(8):IP(11)=IP(8)
160 '
170 '  Ask what to do
180 CLS:INPUT "Data file name : ",FILE$
190 INPUT "Azim., polar angles : ", PHI,THETA
200 INPUT "Viewing distance : ",VIEWD:INPUT "Size mag. : ",SMAG
210 INPUT "Type 1 for printer:",IPRINT
220 ' Printer distortion correction factor
230 IF IPRINT=1 THEN DISTORT=1.094 ELSE DISTORT=1!
240 TIM#=TIMER
250 PHI=PHI*3.14159/180!:THETA=THETA*3.14159/180!
260 CP=COS(PHI):SP=SIN(PHI):CT=COS(THETA):ST=SIN(THETA)
270 '
280 ' Read atomic coordinates from data file and scale
290 OPEN FILE$ FOR INPUT AS #1
300 XMIN=1E+25:XMAX= -XMIN:YMIN=XMIN:YMAX=XMAX
310 ZMIN=XMIN:ZMAX=XMAX:N=0
320 WHILE NOT EOF(1)
330 N=N+1
340 INPUT#1,X(N),Y(N),Z(N),S(N)
350 IF X(N)>XMAX THEN XMAX=X(N)
360 IF X(N)<XMIN THEN XMIN=X(N)
370 IF Y(N)>YMAX THEN YMAX=Y(N)
380 IF Y(N)<YMIN THEN YMIN=Y(N)
390 IF Z(N)>ZMAX THEN ZMAX=Z(N)
400 IF Z(N)<ZMIN THEN ZMIN=Z(N)
410 WEND
420 PRINT N "atomic coord."
430 XMIN=.5*(XMAX+XMIN):YMIN=.5*(YMIN+YMAX)
440 ZMIN=.5*(ZMIN+ZMAX):PRINT "Rotating..."
450 '
460 '  Rotate molecule around its center
470 FOR I=1 TO N
480 XA=X(I)-XMIN:YA=Y(I)-YMIN
490 X(I)=CP*XA+SP*YA:Y(I)= -SP*XA+CP*YA
500 YA=Y(I):ZA=Z(I)-ZMIN
510 Y(I)=CT*YA+ST*ZA:Z(I)= -ST*YA+CT*ZA
520 NEXT I:PRINT "Sorting..."
530 '
540 '  Sort by depth (shell sort)
550 IGAP=INT(CSNG(N)/2!)
560 WHILE IGAP>=1
570 FOR I=IGAP+1 TO N
580 FOR J=I- IGAP TO 1 STEP -IGAP
590 JG=J+IGAP
```

(continued)

```
600 IF Y(J)< =Y(JG) THEN GOTO 640
610 SWAP X(J),X(JG):SWAP Y(J),Y(JG)
620 SWAP Z(J),Z(JG):SWAP S(J),S(JG)
630 NEXT J
640 NEXT I
650 IGAP=INT(CSNG(IGAP)/2!)
660 WEND
670 '
680 '  For perspective projection and scale coordinates
690 SCALE= -1E+25:SMAX=SCALE
700 FOR I=1 TO N
710 YA=1!/(VIEWD-Y(I)):X(I)=X(I)*YA:Z(I)=Z(I)*YA:S(I)=S(I)*YA
720 IF SCALE<ABS(X(I)) THEN SCALE=ABS(X(I))
730 IF SCALE<ABS(Z(I)) THEN SCALE=ABS(Z(I))
740 IF SMAX<S(I) THEN SMAX=S(I)
750 NEXT I:SCALE=110!/(SCALE+.5*SMAX*SMAG)
760 SCALEX=SCALE*DISTORT
770 '
780 '  Plot shaded circles (emulating spheres)
790 FOR I=1 TO N
800 IX=FIX(X(I)*SCALEX+350!):IY=FIX(Z(I)*SCALE+130!)
810 IR=FIX(S(I)*SCALE*SMAG):IRX=IR*DISTORT
820 GOSUB 880
830 NEXT I
840 PRINT TIMER-TIM# " sec"
850 CLOSE#1:END
860 '
870 '  Sphere plotting subroutine using Quickdraw FILLOVAL
880 IE(0)=IY-IR:IE(1)=IX-IRX:IE(2)=IY+IR:IE(3)=IX+IRX
890 CALL FILLOVAL(VARPTR(IE(0)),VARPTR(IP(0)))
900 IR2=.8*IR:IRX2=.8*IRX
910 IE(0)=IY-IR2:IE(1)=IX-IRX2:IE(2)=IY+IR2:IE(3)=IX+IRX2
920 CALL FILLOVAL(VARPTR(IE(0)),VARPTR(IP(4)))
930 IR2=.65*IR:IRX2=.65*IRX
940 IE(0)=IY-IR2:IE(1)=IX-IRX2:IE(2)=IY+IR2:IE(3)=IX+IRX2
950 CALL FILLOVAL(VARPTR(IE(0)),VARPTR(IP(8)))
960 RETURN
```

crystallographic technical literature. Wyckoff's six-volume series (see reference 12) offers an encyclopedic tabulation of many molecular structures. [*You can also make up your own coordinates, following the format below, to experiment with the program.*]

Prepare the data file using MacWrite. As shown in the example in figure 2, each line of the file represents one atom in the molecule and has four numbers. The first three numbers of each line are the $(x,y,z)_i$ coordinates of the *i*th atom and the fourth number is the size or atomic radius of this atom. These numbers may be in any convenient set of units as long as all the numbers are in the same units. Note that MacWrite sometimes leaves several blank lines at the end of the file that must be deleted. You must also save the file as "text-only" instead of the default "entire-document."

Alternatively, if the molecule is a crystal, you can generate a data file containing the atomic coordinates for it by programming the rules for the repetitive structure of the crystal in a separate BASIC program, as I did for the crystal silicon (see below).

After asking you for the name of the data file, the program asks for the rotation angles (in degrees), the viewing distance (*D* in figure 1; in the same units as the atomic coordinates and sizes), the atomic-radius size magnifier (this can be used to expand or contract the apparent size of each displayed atom; to get the normal size from the input file, type 1), and finally,

(continued)

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```
0,0,0,.15
.5,.5,0,.15
.5,0,.5,.15
0,.5,.5,.15
.5,.5,1,.15
.5,1,.5,.15
1,.5,.5,.15
.25,.25,.25,.15
.25,.75,.75,.15
.75,.25,.75,.15
.75,.75,.25,.15
0,0,1,.15
0,1,0,.15
0,1,1,.15
1,0,0,.15
1,0,1,.15
1,1,0,.15
1,1,1,.15
```

Figure 2: A *sample data file showing the three-dimensional coordinates for one unit cell of silicon. This was generated by the program in listing* 2.

Listing 2: A *Microsoft* BASIC *program to generate the three-dimensional coordinates for a silicon lattice.*

```
10  '   ***SIGEN.BAS ***
20  ' Generate a Silicon lattice of Nx, Ny, Nz unit cells
30  'E. Kirkland 15-SEP-84
40  DEFINT I-N:DEFSNG A-G,O-Z
50  INPUT "Generate Nx,Ny,Nz Silicon unit cells : ",NX,NY,NZ
60  INPUT "Output file name : ",FILE$
70  OPEN FILE$ FOR OUTPUT AS #1:SIZE=.15
80  FOR IX=0 TO NX
90  FOR IY=0 TO NY
100 FOR IZ=0 TO NZ
110 WRITE#1,IX,IY,IZ,SIZE
120 IF (IX=NX) OR (IY=NY) OR (IZ=NZ) GOTO 230
130 WRITE#1,IX+.5,IY+.5,IZ,SIZE
140 WRITE#1,IX+.5,IY,IZ+.5,SIZE
150 WRITE#1,IX,IY+.5,IZ+.5,SIZE
160 WRITE#1,IX+.5,IY+.5,IZ+1,SIZE
170 WRITE#1,IX+.5,IY+1,IZ+.5,SIZE
180 WRITE#1,IX+1,IY+.5,IZ+.5,SIZE
190 WRITE#1,IX+.25,IY+.25,IZ+.25,SIZE
200 WRITE#1,IX+.25,IY+.75,IZ+.75,SIZE
210 WRITE#1,IX+.75,IY+.25,IZ+.75,SIZE
220 WRITE#1,IX+.75,IY+.75,IZ+.25,SIZE
230 NEXT IZ
240 NEXT IY
250 NEXT IX
260 CLOSE#1:END
```

A *circle appears elliptical printed with the Imagewriter.*

whether the drawing is to be printed. The Apple Imagewriter printer has a slightly different aspect ratio than the screen, so that a circle on the CRT screen appears slightly elliptical when printed. The program can apply a predistortion to the drawing (multiplying the *x* coordinate by 1.094) so that it will appear normal when you print it.

The program then reads from the data file until it encounters an "end-of-file" (EOF) condition (the total number of input lines determines the total number of atoms in the molecule). An "Input Past End" error indicates that the data file contains extra characters.

After reading in the atomic coordinates and size data, the program rotates them about the center point and sorts them by depth using the Shell sort method (see references 7, 8, and 9). The program then projects these new coordinates into the viewing screen coordinates with a 3-D perspective and scales them. If at this point the program signals, "Out of Memory," type CLEAR, 20000 and run the program again.

The final portion of the program draws a sphere at each of the projected atomic coordinates, from the back forward, to fulfill the hidden-surface requirements. The "sphere" is drawn using three QuickDraw FILL-OVAL calls with different shading patterns (see Appendix E of the Microsoft BASIC 1.0 manual). The first call draws a light-gray circle filling the whole atomic radius, the second draws a dark-gray circle with a slightly smaller radius, and the third draws a black circle with a still smaller radius. The net effect is a shaded circle that looks like a sphere. For a printout of the drawing, use the print-screen (Shift-Command-4) command.

(continued)

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Note that if two atoms are located at exactly the same depth (distance from the viewer), this program will arbitrarily draw one atom in front of the other. (Obviously this will make a difference only if the atoms are close enough to each other so that their radii overlap.) This problem will probably not be significant in most cases and may be easily overcome by

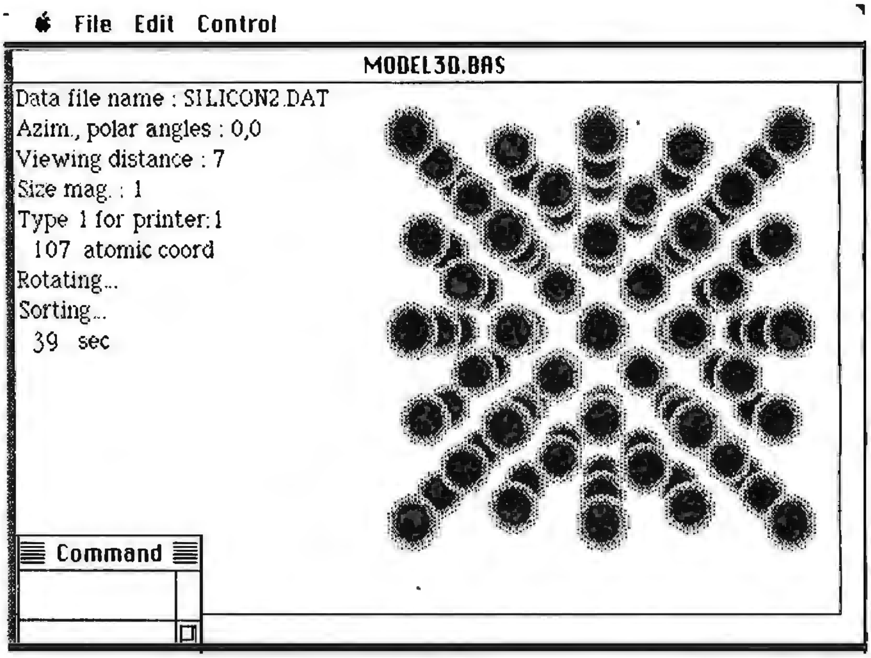

Figure 3: A 3-D *perspective view of 2- by 2- by 2-unit cells of a silicon lattice. The data file was generated by the program in listing 2.*

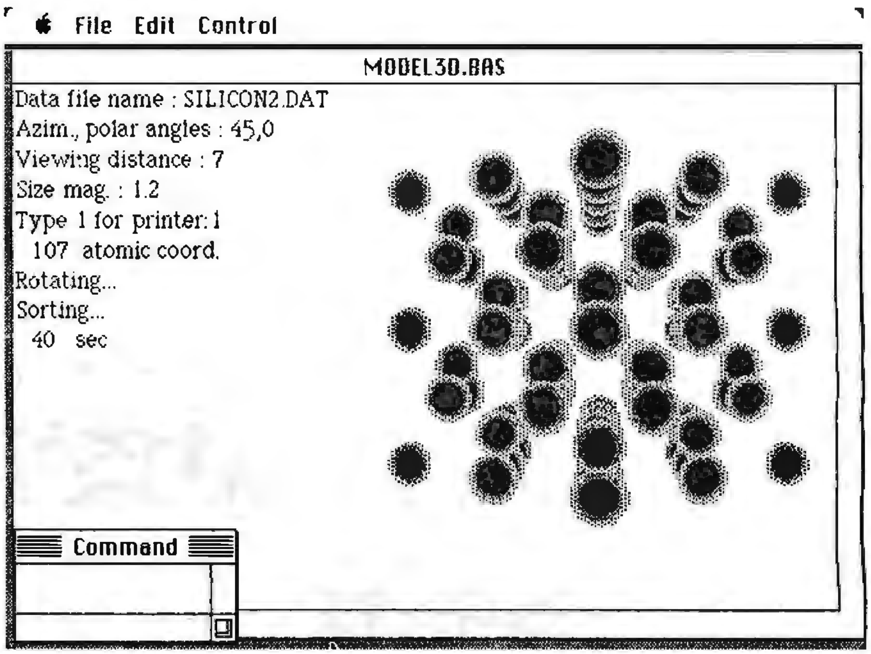

Figure 4: *Another 3-D perspective view of the 2- by 2- by 2-unit cell structure in figure 3.*

rotating the molecule so that one atom is slightly in front of (or behind) the other. A proper solution to this problem is beyond the scope of this exercise.

EXAMPLES

As I mentioned above, a crystal may be thought of as a single large molecule whose structure is a simple pattern repeated many times. Silicon forms a crystal structure with a basic repeat distance of 5.43 angstroms. It is composed of two interpenetrating face-centered cubic (fcc) lattices (see references 10 and 11), with one fcc lattice offset from the other by (¼,¼,¼) × 5.43 angstroms. There are roughly 6.25×10^{18} unit cells per cubic millimeter of silicon. Large crystals of silicon in this form (with suitable treatment) are commonly used to make the vast majority of integrated circuits in use today. For example, the Motorola 68000 processor used in the Macintosh is made out of a single crystal of silicon. Listing 2 shows SIGEN, a short Microsoft BASIC 1.0 program that generates a data file of the positions of the atoms in crystalline silicon. The data file in figure 2 was produced by SIGEN and contains the coordinates for one 1- by 1- by 1-unit cell of silicon. Figures 3 and 4 show computer-graphic representations of the crystal, with two slightly different orientations: the face of the cube (figure 3) and an edge of the cube (figure 4). Note the slight slope (like a roof of a house) visible in figure 4. The vertical edge in the center is nearer to the observer than the two outer edges on the left and right and hence appears larger (taller) than the outer edges in 3-D perspective. Note the characteristic symmetry of silicon that the graphic representation reveals.

Figure 5 is a computer-graphic representation of the aspirin molecule, whose structure is given in reference 12. The chemical formula for aspirin is $(HOOC)C_6H_4{-}OC(0)CH_3$. I have arbitrarily depicted the hydrogen atoms with a small radius to distinguish them from the other atoms in the molecule. The aspirin molecule has a large hexagonal carbon structure (benzene) on the bottom and clusters of carbon, hydrogen, and oxygen on the top.

CONCLUSIONS

Computer graphics offers a convenient way to visualize three-dimensional structures of molecules as an aid to understanding the behavior of the molecules. The Apple Macintosh computer is capable of displaying a graphic representation of fairly complex molecules. Although there are large computer systems that can produce better graphic representations, they are beyond the price range of most individuals. The Macintosh gives a spectacular performance in relation to its cost. Even though MODEL3D is written in interpreted BASIC, most of the actual graphics is done by the Macintosh ROM via the QuickDraw subroutine. Hence, the program runs relatively fast. These built-in graphics routines make the Macintosh very useful for this application. ■

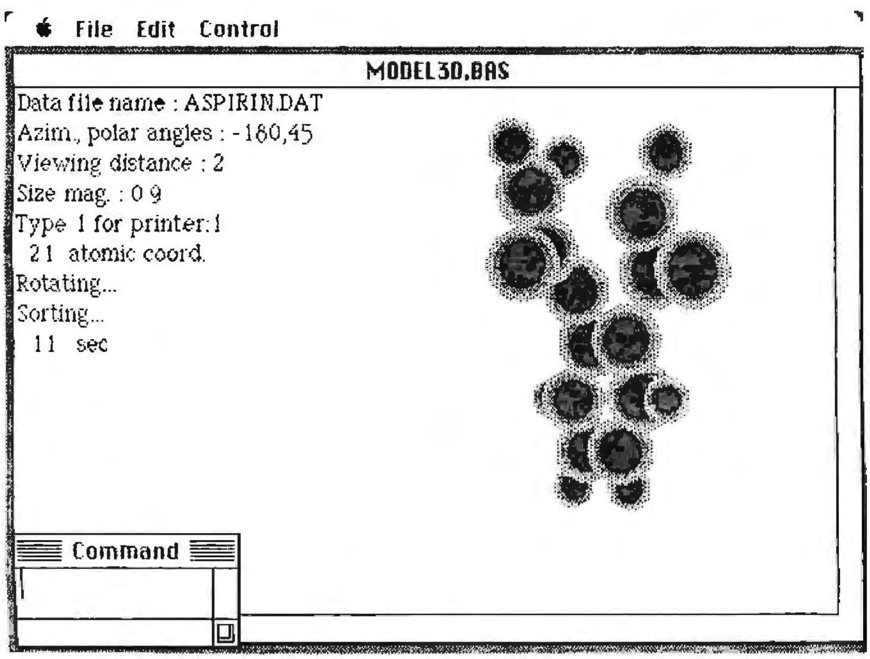

Figure 5: 3-D *perspective view of the aspirin molecule.*

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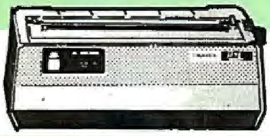

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LABORATORY INTERFACING

BY LINCOLN E. FORD, M.D.

A medical researcher examines the capabilities and limitations of an important laboratory device

ALMOST ALL LABORATORY computer applications can be described as one of the following functions: (1) control of experiments, including timing and synchronizing external events and setting external voltages; (2) data acquisition, usually through the digital conversion of analog electrical signals; (3) data storage; and (4) data analysis. While data storage and analysis make computers most appealing in the laboratory, these functions are common to most computer applications. The functions that make laboratory applications different from other computer uses are the first two, control of experiments and data acquisition. The following discussion is directed at these two areas. The two functions together require five distinct hardware components: analog-to-digital (A/D) converters, digital-to-analog (D/A) converters, digital input-output (I/O) ports, counters, and an accurate frequency generator. This discussion is developed from my experience with a hardware device that provides all five functions.

A/D CONVERSION

In a typical application, analog signals from some electronic device are sampled and converted to digital data at regular intervals. Usually sampling continues for some well-defined period. The sampling may progress at different speeds at different times. For example, it is frequently desirable to record high-speed events that occur within the setting of lower-speed events. To record both types of events with an analog recorder (an oscilloscope or chart recorder), it is usually necessary to make two recordings, one at a high speed and one at a low speed. Using a computer, it is relatively simple to record a single input at different speeds.

Analog-to-digital conversion is perhaps the most critical of laboratory applications because errors at this step will greatly distort the data. It is also frequently the function that most taxes the speed of the computer. Speed at this stage is sometimes limited by the A/D converters, but more often it is limited by software. Ultimately, the software is limited by the design of the computer, but more frequently it is limited by having to perform some other task concomitantly. One such task is the generation of control pulses during A/D sampling.

In many instances the initiation of an A/D recording must be synchronized with the experiment. Instead of having an external device initiate the A/D conversion sequence, it is tempting to have the computer control the experiment at the same time that it is collecting data. An additional advantage of this combined approach is that the data collection is very accurately synchronized to the experimental procedure. The difficulty with this approach is that it requires the computer to perform two tasks at once. This can call for some relatively sophisticated programming, particularly when high speeds are necessary.

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INTERFACE BOARDS

There are several commercially available devices that will perform at least four of the five functions required for

(continued)

the laboratory applications described above. Several of my colleagues and I bought the LabMaster board made by Tecmar because it provides all five functions and because it was the first one available. It also costs less than more recent devices. It consists of a motherboard that fits into the IBM PC and a daughterboard that houses the A/D converters outside the computer. This arrangement isolates the incoming analog signals from electrical interference inside the computer.

The Data Translation Company makes a similar board that has the capability of direct memory access not available on the LabMaster but does not have the Tecmar board's progammable counters. We preferred the Tecmar board in part because we wanted to put out logic pulses to control the experimental apparatus while collecting data with the A/D converter. The five programmable counters simplify this task because they operate independently of the central processing unit of the host computer. The counters can be programmed to begin counting the same frequency pulses that trigger the A/D conversions. When they have completed their count they toggle their external outputs without intervention from the computer. Thus, the logic pulses are synchronized exactly to data acquisition without interfering with the high-speed operation of the central processor.

When very high speeds are not required, the digital I/O port can be used for applications control. Although most commonly used as a single interface to other digital equipment, the individual channels in the port can be used separately to control different pieces of apparatus. In addition, these channels can be configured to accept logic pulses from the apparatus, thereby allowing a bidirectional interaction.

A final way of controlling experiments is to use the D/A converters to set voltage levels for external devices.

POSSIBLE IMPROVEMENTS

In spite of our general satisfaction with the Tecmar board, we found several areas that need improvement, both in the LabMaster and in the other devices that are available. As explained in John Mertus's letter to BYTE ("Data Collection with an IBM PC," October 1984, page 14), the absence of direct memory access on the Tecmar board severely limits this board in multitasking operations.

The cable connections could be greatly improved. Tecmar sells a set of cables for external connections to the board, but they are simply that—bare cables. Users must make their own interfaces. We have made an interface box with BNC connectors for each connection, and while we were at it, we put in some buffer chips to protect the digital I/O ports. Several other manufacturers supply slightly less primitive connections for their devices, but at best these consist of screw terminals for bare wires. I do not know of many laboratory scientists who relish the thought of bringing their signals out on bare wires. Any manufacturer who supplied a device with an interface having standard connectors such as BNCs and well-protected inputs would find a ready market.

There is one improvement related to signal processing that I would especially like to see. This is the addition of filters to the analog inputs of the A/D converters. It is well known that no information can be derived about the frequency components of a digitized signal that are greater than half the sampling frequency. Noise and oscillations in the signal that are faster than the sampling frequency at best decrease the signal-to-noise ratio. In many cases, faster signals introduce "aliasing," spurious low-frequency oscillations that result from sampling a high-frequency oscillation at systematically different parts of its period. Although filters generally introduce lags in electronic signals, the lags introduced by antialiasing filters are likely to cause far less signal distortion than will high-frequency oscillations. The antialiasing device should consist of a low-pass filter with a sharp cutoff frequency near the sampling frequency. The main argument against such a filter is that the sampling frequency varies widely, sometimes within the same record, so that the cutoff frequency must be made to vary in the same way. The solution to this problem is to use an integrator that averages the signal between sample intervals. A. F. Huxley and G. L. Reed recently described a clever circuit that performs this averaging (see "An Automatic Smoothing Circuit for Input to Digitizing Equipment," *Journal of Physiology*, volume 29?, 1979, page 11P). It is triggered by the same clock pulse that triggers the A/D conversions, so that its cutoff frequency always varies with the sampling frequency.

A major way in which A/D converters could be improved is by the use of separate converters for each input channel and the use of on-board data buffers. Most computer-controlled multichannel devices have a single A/D converter with a multiplexer that switches different channels into it. Only one channel is converted at a time, so that the samples in each channel are displaced in time relative to those in other channels. This time displacement can cause a systematic error when the data from one channel is plotted as a function of that in another. The samples from different channels can be brought into coincidence either by using separate A/D converters for each channel or by holding the signals from all channels in sample-and-hold circuits that are triggered when the first channel begins its conversion. The advantage of separate converters and on-board data buffers is that they increase the speed of operation while effecting the synchronization.

COMPUTER CONSIDERATIONS

Your choice of interface board has an effect on the size of the central processor and data bus needed. Most data is collected from 10-, 12-, or 16-bit A/D converters, so one A/D conversion will require a 2-byte word. In a machine with a 16-bit bus (a true 16-bit computer) entire words can be moved at once. In a smaller computer

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having an 8-bit bus, words must be moved in two sequential steps. This need to make two-step transfers greatly slows most of the computer's operation. Since most time-critical operations involve data transfers along the bus, this slowing occurs at a very vulnerable stage. Although a true 16-bit computer transfers data twice as fast as an 8-bit machine, it does not follow that a 32-bit computer would be still faster in handling integer data. Since integer data occurs in 2-byte words, increasing the bus size to 32 bits would not produce any increase in speed unless some way could be devised to move two words at once. The 16-bit machines available today are therefore as large as many operations require.

A question related to size is whether it is better to have several small, single-purpose computers or one large, multipurpose machine. My own preference is for the former. A major consideration is cost. In addition, the failure of a single computer in a group does not incapacitate the entire laboratory in the way that the failure of a single large computer does. Another advantage of a group of computers is that each can be dedicated to a single task. Even with the best multitasking arrangements, there will always be some time-critical operation that requires the uninterrupted use of the computer, forcing other users to wait. With multiple computers such interactive interruptions do not occur.

The main disadvantage of small computers is that they are slow. This disadvantage is usually more than offset by the ability to dedicate the machine to a specific task for an extended period.

THE IBM PC COMPROMISE

In spite of the negative considerations about the 8-bit bus, my colleagues and I bought several IBM PCs for use in the laboratory. We selected this computer rather than a true 16-bit machine because of its popularity. Many peripherals and programs are available for it, and we felt that it would not go out of production nearly as quickly as some of the other, less popular models.

We have found the PC to be as good as or better than expected in almost all areas except for one peculiarity: the absence of a limited interrupt or a software-controllable wait state. Once an A/D conversion is made, a flag consisting of one bit in a status register is set. The computer must then detect the flag and take the digital data from the converter. The PC can detect the flag in only two ways: polling the status register or generating a full interrupt. A full interrupt, together with its return, requires 83 clock cycles. This many cycles would take more than 20 microseconds (μs) just to detect the flag. Polling takes substantially less time. Using a polling routine, we have written sequential A/D sampling programs that operate at a rate of 22 μs per conversion. Over half that time is spent polling the status register. If a more rapid way of detecting the flag could be devised, this routine could operate at more than twice the speed. If the central processor could be put in a wait state immediately before each A/D conversion and be released by the "A/D done" flag, detection of the conversion would be virtually instantaneous. An otherwise-similar computer that had such a capability would be able to accept A/D conversions about every 10 μs.

SOFTWARE

Software is the most crucial part of any laboratory system. Clever programming can introduce great flexibility and compensate for many deficiencies in hardware. Poor programming can hobble even the best system. The time required to develop good programs should not be underestimated. Many of us have bought a piece of equipment that was physically capable of performing some desired task only to find that weeks of programming were required to make it work. For those of us who have had this experience, there is no stronger selling point for equipment than the concomitant availability of adequate programs to run it. ■

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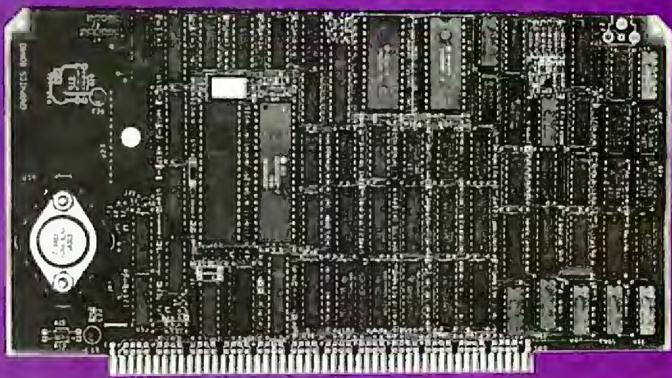

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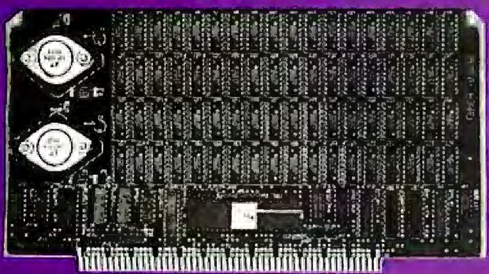

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INTERFACING FOR DATA ACQUISITION

BY THOMAS R. CLUNE

A comparison of three interfaces

THE USE OF MICROCOMPUTERS for data acquisition in the sciences is surprisingly limited. It is widely recognized that the need for such applications exists. But I discovered in my experience at Brandeis University that most researchers have either had bad experiences with data acquisition on minicomputers or simply don't feel that they have the time to learn what they would need to know to retool their labs. Nonetheless, the advantages of computerizing are so substantial that microcomputer-based data acquisition is slowly moving into the lab. In this article, I'll share some of my experience with different approaches to computerizing data acquisition. Since I find the IEEE-488 to be the most versatile option for laboratory data acquisition, I will devote a fair amount of time to explaining that interface. My hope is that my experience may ease the problems that you might encounter in computerizing your setup.

THE PROBLEM

There are three basic reasons why microcomputers are so important in the context of data acquisition. First, for a minicomputer or mainframe to be affordable, its use must be shared by more than one person, but in data acquisition it is crucial to have the computer's attention when the data is ready. Microcomputers make single-user systems affordable. Second, mainframe computers are generally not located in the laboratory. Thus, in any but very low speed data-acquisition contexts, there is a communications bottleneck created by the data transmission. Third, there is no common standard for interfacing with laboratory instruments on mainframes, so each laboratory setup presents substantial and individual problems of design and implementation that exacerbate the financial and logistical difficulties.

At least one other concern is fueling the drive toward computerization in the lab: The cost of turnkey instruments has become so high that most institutions are unable to afford the state-of-the-art equipment needed to conduct research. This is particularly irritating because most instruments in the sciences have essentially the same components. You end up paying over and over again for a built-in chart recorder, a waveform digitizer, a monochrometer, a photomultiplier, etc. And when the new generation of an instrument comes out with a broader dynamic range or some other improvement in one component, the entire turnkey instrument must be replaced. We simply can't afford to pay for research done that way any more. With the availability of microcomputers, we don't have to. We can tie chart recorders, waveform digitizers, and whatever else we need together into a dedicated instrument and recycle the components as the field or our research evolves.

Thomas R. Clune is a BYTE technical editor. Before coming to BYTE, he was the physical-chemistry lab coordinator at Brandeis University, where he taught data acquisition by microcomputer. He can be contacted at POB 372, Hancock, NH 03449.

A/D CONVERTERS

The least expensive way to automate a lab is with an analog-to-digital (A/D)

(continued)

The speed of a transient tracked by D/D equipment is not limited by the computer's throughput.

converter. There are, however, a number of limitations to this approach. First, an A/D converter samples only one voltage source at a time. Typically, an experiment requires correlating one reading to others for the same instant of time (e.g., pressure versus temperature at time *t*). If the time requirements are sufficiently lax, that is, if readings taken 10 or 20 microseconds apart can be treated as simultaneous, an A/D converter may be acceptable. But often this time lag is sufficient to make the data hopelessly imprecise. The second problem with A/D converters is that they are slow. The maximum sampling rate on most "high-speed" A/D converter boards is 100 kilohertz (kHz). Practically speaking, this means that you can't track a transient of greater than approximately 20 kHz. Much of scientific data acquisition now requires at least the ability to track a transient of a few megahertz. A third problem with A/D converters is that, because the boards are made to be inexpensive, their linearity is not very good. A 12-bit board may have an effective resolution of only 7 or 8 bits. Finally, A/D converters are very susceptible to noise in a lab. Commonly, the cabling will be either twisted-pair or ribbon cable—very good antennae. In a well-designed board, the cabling is simple coax, which may still not give the level of noise immunity required in a laboratory environment.

Nonetheless, an A/D converter is a good buy if it will do your task. My feeling is that the best use of an A/D converter is to connect it to the chart output of a stand-alone instrument. Instead of junking a high-quality analog instrument in the interests of modernizing, use the capabilities available in your lab now. One big advantage of this kind of setup is that you can use a very slow A/D converter. This is desirable for two reasons: first, a slow A/D converter will be better made than a comparably priced high-speed board, and second, since you will only need a 30-Hz-or-so A/D converter, most noise in the lab will be too fast for the A/D converter to respond to it. Further, your low-pass filter will be able to cut out line voltages, which are an inevitable source of noise in any lab.

D/D AND RS-232C

If an A/D converter won't meet your needs, you need stand-alone instruments that can transfer digital information to the computer via a digital-to-digital (D/D) interface. The first advantage of D/D over A/D is that data may be analyzed at high speed and the digital "snapshot" of the analysis stored in a buffer of a few kilobytes on the stand-alone instrument. The buffer data can then be downloaded to the computer at whatever speed the interface will support. That is, A/D conversion necessarily requires real-time analysis, whereas the speed of a transient that can be tracked by D/D equipment is not limited by the microcomputer's throughput. Of course, speed of data transfer is still important because it determines how quickly the instrument can repeat an analysis.

D/D interfaces come in two flavors: serial, which transfers information a bit at a time; and parallel, which transfers data a word (commonly one byte) at a time. The most common serial port is an RS-232C interface.

There is a lot to dislike about the RS-232C. First, it is not standard. There are two ends to an RS-232C interface: the DTE (data-terminal equipment) end and the DCE (data-communications equipment) end. Often the two instruments you want to hook together will both be configured as DTEs, so you will probably have to create a cable that matches your particular setup once you find out what it is. Second, the only handshaking provided is on the level of whole messages. The interface does not verify that data has been received before proceeding. It is very easy to lose data on this interface. Third, RS-232C is a notoriously noisy interface—perhaps no worse than an A/D converter, but that isn't saying much. Fourth, RS-232C is slow. Since it sends only one bit at a time, it has a built-in speed disadvantage over parallel interfaces. And interference is an increasing problem with increasing transmission rates (as is true of any system). Finally, RS-232C is able to connect only two devices together. Thus, coordination and control of multiple data sources requires more than one RS-232C port on the computer and makes for devilishly difficult software integration.

The strong points of RS-232C are twofold. First, it is capable of transmitting information over long distances by telephone. Second, it is the only interface available on some older instruments. If you have to use it, you learn to live with it. But you'll never learn to love it.

IEEE-488

The IEEE-488 is a byte-serial, bit-parallel interface that overcomes the problems of the interfaces outlined above. First, the interface is incredibly resistant to interference. For example, at the Brandeis University chemistry department, we used the interface in a pulsed-nitrogen-laser experiment and found that the data transmission was unaffected by noise in any environment where the computer itself was able to function. Figure 1 shows the physical layout of the cable that provides such excellent noise immunity.

The second virtue of IEEE-488 is that the interface has a bus structure. That is, you can interface up to 15 devices at a time using the same board. This structure simplifies process control and allows true simultaneous data acquisition, as we shall see presently.

(continued)

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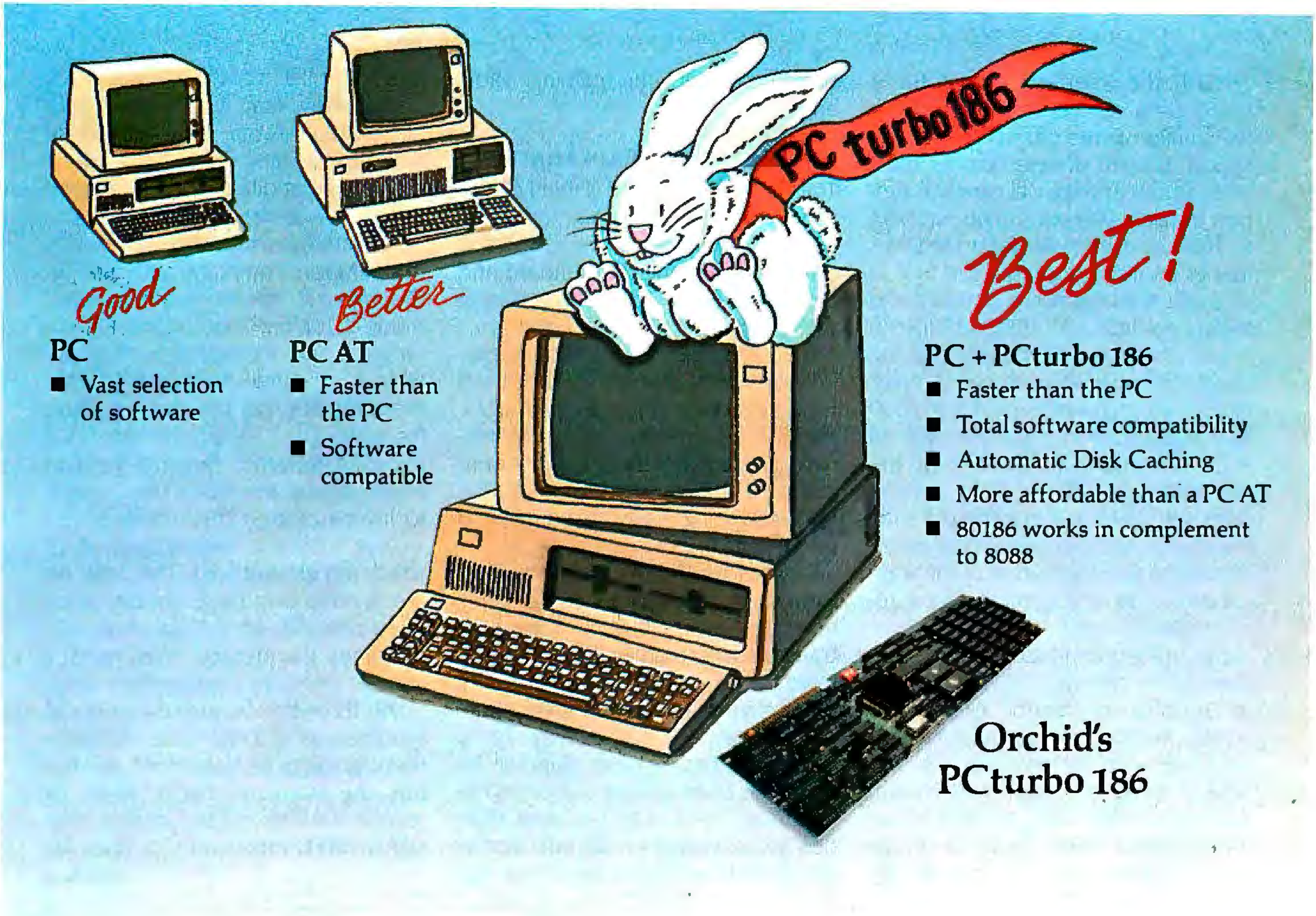

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Third, the interface is fast for a micro. Data can be transferred at up to 1 million bytes per second (using special tristate drivers on the lines) and without any special care will support transmission rates of about 250K to 300K bytes per second using DMA (direct memory access).

Fourth, the interface is standard and widely available. All IEEE-488 instruments are plug-compatible, and the interface is available on every major kind of laboratory device. Over 2000 devices are currently available with an IEEE-488 interface. Given that the standard was not set in its current form until 1978 and that there is a lag between specification and implementation, the rapid adoption of the standard gives an indication of how sorely needed it was.

The primary limitation of the standard is that the total cable length on an installation cannot exceed 20 meters without special (and expensive) repeaters. In practice, you will seldom need to exceed that length. And given that long cabling slows transmission rates and is more susceptible to noise, you generally do better to keep the cabling short anyway.

The Standard Explanation

The IEEE-488 standard is relatively involved because it accommodates a wide variety of uses. In the rest of this article, I'll examine the standard and then take a close look at a setup using the interface.

IEEE-488 began life as the General-Purpose Interface Bus (GPIB) of the Hewlett-Packard Corporation. In 1975, the IEEE adopted the GPIB as its standard. Some minor modifications were made to the standard in 1978, but IEEE-488 still goes by the name GPIB on HP products.

Devices on the interface may perform three kinds of functions. They may be talkers; that is, they may transmit data to other devices on the interface. Of course, there can be only one active talker at any given time. Alternatively, a device may be a listener—it may receive data or instructions from another device on the interface. There may be more than one active listener on the interface at any given time. And a device may act as a controller, a coordinator of which device may talk when and which devices may listen. Finally, a device may do nothing but stand by. A device may, at different times, assume any of the above functions.

The interface supports two modes of operation: command and data. As the name suggests, the command mode is for process control. For example, if one of the devices on the interface is a digital multimeter (DMM), the controller may program the DMM for reading DC voltages in the 3-volt full-scale deflection range. In the data mode, data is transferred from talker to listener(s) over the interface.

The interface has 24 lines, 8 of which are ground lines. The other 16 are divided into three groups: 8 bidirectional data lines, 3 data-byte control lines (handshake lines), and 5 general interface-management lines.

The three-line handshake protocol functions as follows: When information is going to be transferred over the bus, the listeners must be ready to receive the data. If they are not, they signal NRFD (not ready for data) by

(continued)

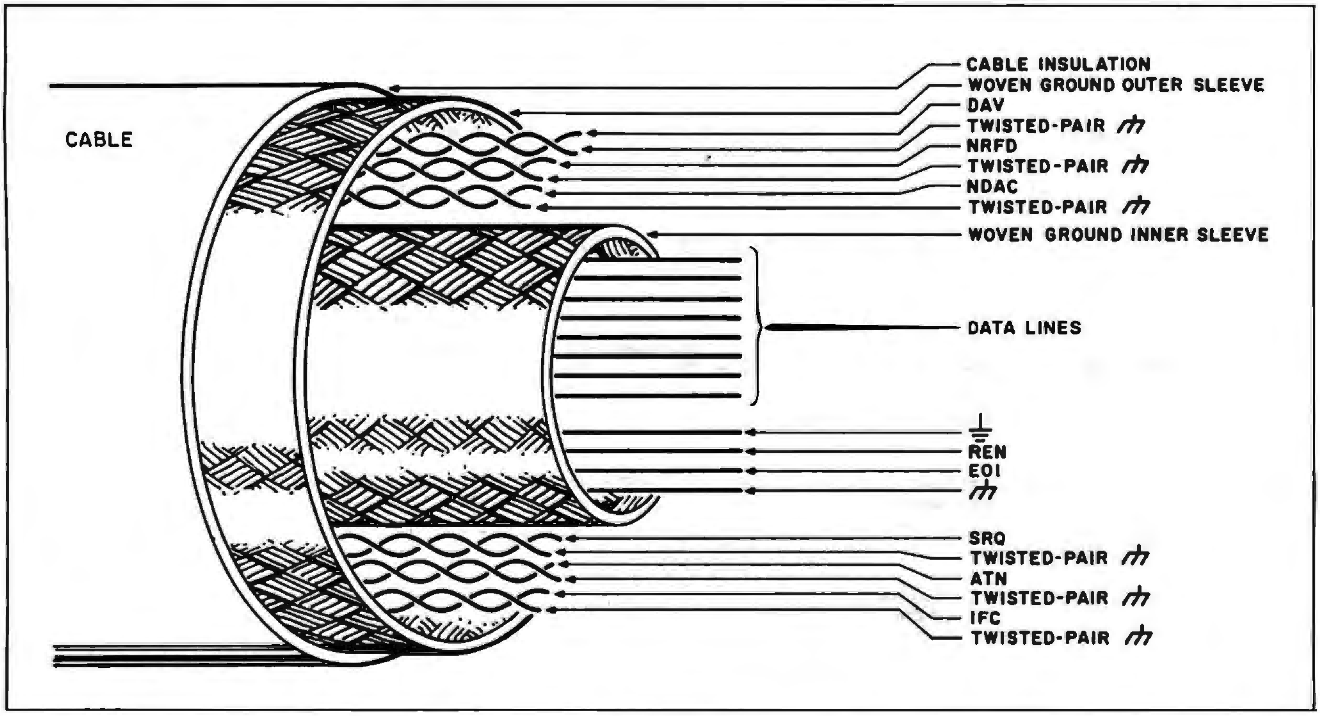

Figure 1: *Cutaway view of an IEEE-488 cable. Notice the large number of grounds for shielding.*

pulling the NRFD line low (low is defined as true by the IEEE-488 standard). The NRFD line has an open-collector design, so if any one listener is not ready, the line is kept low. When all the listeners are ready, the NRFD line goes high. If the talker is ready to transmit data, it sets the DAV (data valid) line low. The transition of the DAV line triggers the resetting of the NRFD line and the listeners pick up the latched byte of data. When each listener receives the data, it releases the NDAC (not data accepted) line, which is also open-collector. When all listeners have received the data, the NDAC line goes high, causing a reset of the DAV line, which in turn triggers the resetting of the NDAC line. This sequence, outlined in figure 2, is repeated for each byte in a transmission. It may not be immediately apparent why three lines are useful in this sequence. At first glance it appears that the DAV and NDAC line would accomplish everything necessary for the transmission of data. However, the NDAC line is released as soon as the IEEE-488 board of the listener has received the data. The information must still be downloaded from the IEEE-488 data register to, for example, the computer's main memory to be stored more permanently. By releasing the talker as soon as the data has been transferred, the talker becomes free to prepare the next byte for transmission at the same time that the listeners are "digesting" the last byte, so the rate of information transfer may be maximized. The NRFD line is thus necessary to prevent the possibility of a listener's data register being prematurely overwritten.

Since each byte of data transferred is a self-contained event on the interface, there must be some way of signaling the end of a data-transfer sequence. This may be done in two ways. The one I will mention here is to use one of the bus-management lines, the EOI (end or identify) line. When a talker sets this line, it signals that the data-transfer sequence is complete.

The "identify" in EOI applies to the controller's use of the line. If the interface is to be used for process control, there must be a way for the controller to monitor the "fitness for duty" of the various devices. One way it may do so is by conducting a parallel poll of the devices. If the controller asserts ATN (attention) and EOI, each device responds by using one data line to say whether or not it has any problems. If one does, the computer (the controller) can query that device further to determine the precise nature of the difficulty. The limitation of a parallel poll is that the controller must initiate the inquiry. IEEE-488 also provides for a serial poll, in which a device in trouble may alert the controller that all is not well by asserting SRQ (service request). The computer then can ask each device in turn what its status is to determine the source and nature of the problem.

ATN serves another, more general purpose as well. Any time the controller asserts ATN, it can change the function of a device from, say, talker to listener. When ATN is asserted, the board goes into the command mode. All subsequent information is control data. In general, control information will apply to only some of the available devices. How is the information restricted to only the appropriate devices' attention? Each instrument on the interface can be assigned a unique 5-bit address, generally by DIP (dual-inline package) switches on the backplane of the instrument. Valid addresses are numbers up to and including 30. When the computer wants to address its control data to a specific set of devices, it asserts ATN and outputs a list of the appropriate address numbers (notice that the same string of outputs would be treated as data were the board not in the command mode). Table 1 shows the protocols of the computer addressing for different functions. If a device is being told to listen to control information, an addressed command follows its address-to-listen call. Addressed control information defined by the IEEE-488 standard includes GTL (go to local), which releases a device from remote control; SDC (selected-device clear), which resets a device to its default setting; PPC (parallel-poll configure), which is used to assign a data line to a device for answering a parallel poll; GET (group-enable trigger), which initiates simultaneous data acquisition by each addressed device; and TCT (take control), which passes control of the bus management from the present controller to the specified device.

Two other kinds of multiline commands are shown in table 1. First is a secondary address. This is information after the primary address that configures a device for a particular kind of operation. This is one way that a DMM may be set for DC volts, for example. The primary address specifies the DMM device number, and the secondary address specifies the DC voltmeter function in the DMM. The significance of secondary addresses is not part of the standard. Each manufacturer decides whether

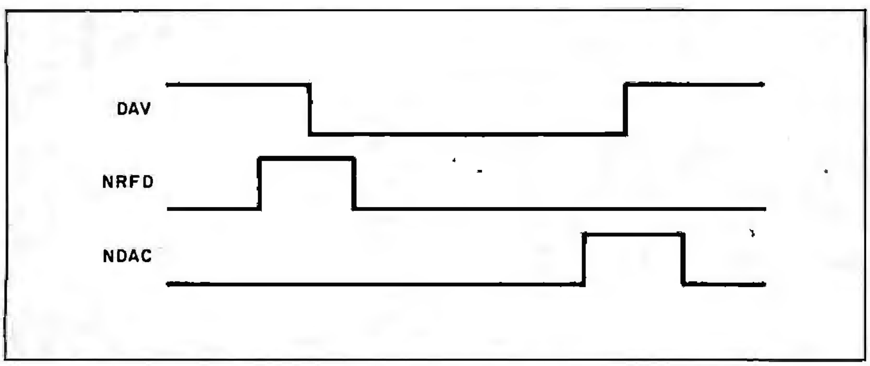

Figure 2: *The logic flow of the IEEE-488 handshake squence. Low is true.*

(continued)

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to use secondary addresses and, if so, what they will mean. The last kind of multiline command is a universal command. Reasonably enough, universal commands apply to all devices on the bus and are therefore not preceded by an address list. The universal commands defined by the standard include LLO (local lockout), which disables instrument front-panel control; DCL (device clear), which resets all devices to their factory-selected default states (this is the universal version of SDC); PPU (parallel-poll unconfigure), which deactivates parallel polling; SPE (serial-poll enable), which initiates a serial poll; and SPD (serial-poll disable), which terminates a serial poll.

The logical difference between the uniline commands and the multiline commands is that uniline commands are unconditioned. That is, they operate immediately instead of requiring that the bus be in command mode. The last two uniline bus-management lines illustrate the need for such immediacy. REN (remote enable) places a device under computer control. When a device is first going to be addressed by the computer, this provides the "warm boot" needed to get its attention. IFC (interface clear) is the "panic button." When the controller asserts IFC, the active talker must immediately relinquish control of the data lines to the computer. As you can see, the standard is rather involved. But it is not complete.

HPIB

The IEEE-488 standard ensures electrical compatibility among instruments, but it does not insure that two instruments will understand each other. The analogy has been drawn between IEEE-488 and the telephone system: You can call Rome on your telephone, but you may not understand what the person who answers the phone is saying. Similarly, the IEEE-488 standard does not specify the code that is to be used by instruments in transmitting data. Some instruments speak binary, some speak ASCII, etc. The Hewlett-Packard Corporation has developed a software standard for IEEE-488 data *that is not universally employed.* However, it is the most common format for data transfers on the bus. The protocol is called the Hewlett-Packard Interface Bus (HPIB). GPIB and HPIB are often used interchangeably, but strictly speaking GPIB is the IEEE-488 standard and HPIB is the conformance to HP's software protocol. HPIB specifies the following:

1. All information is transferred in ASCII code.
2. Information is transmitted "left to right"; that is, "C A T" is transmitted "67 65 84," not "84 65 67."

(continued)

Table 1: IEEE-488 *interface management command bit protocols. These apply only when the controller asserts* ATN. A=*address bit,* C=*command bit,* S=*secondary address bit,* N=*not used.*

Data Lines Bit 7 6 5 4 3 2 1 0	Significance
N 0 0 0 C C C C	addressed command
N 0 0 1 C C C C	universal command
N 0 1 A A A A A	address to listen
N 1 0 A A A A A	address to talk
N 1 1 S S S S S	secondary address


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The significance of a device's program data is determined by the manufacturer, not IEEE-488.

3. All sequences of data transmission end with ASCII 13 (a carriage return) and, optionally, ASCII 10 (a linefeed) instead of using the EOI line.

The advantage of the standard is that data can be fed directly to a printer to produce properly formatted output in continuous-data-collection applications. Of course, the biggest advantage of the standard is simply that it is a standard.

USING THE INTERFACE

So much for the standard. Now let's take a look at how to use it. Manufacturers of IEEE-488 interface boards provide interface drivers for you, so using the interface is easier than learning about the standard in the first place. Usually the interface driver is a set of assembly-language routines that you can call. In high-speed applictions you will want an assembly-language driver. But in the program I provide here (listing 1), I use an interpreted BASIC driver. The program is taken from a course in interfacing I taught at Brandeis University. It is used to calculate the lattice energy of solid argon from temperature and pressure data pairs. This is a low-speed application, with readings being taken every 30 seconds. Thus, an interpreted BASIC interface driver will provide adequate speed. A further benefit to me is that students can study the driver routines to understand how the interface works. Tecmar also makes an assembly version of its interface driver.

The equipment used in this experiment includes an IBM PC with 128K bytes of memory, a Tecmar IEEE-488 interface for the PC, two HP 3478A DMMs with IEEE-488 installed, a copper-constantan thermocouple wire, and a Barytron 220 pressure transducer. The program listing includes only the data-acquisition part of the program, and Tecmar's interface driver routine is not reprinted here. Before the experiment can be run, the DMMs must be set to their respective addresses (17 and 19) by DIP switches on the DMM backplanes.

The program is largely self-explanatory. I will limit my remarks on it to points that the listing may not make sufficiently clear. Notice the statement BD.ADDR%=&H310 in line 40. This initializes the beginning memory location of the 16-byte buffer used for communication between the IEEE-488 interface and the computer. MY.ADDR%=1 in line 60 declares that the computer's device address number will be 1. Both these variable names are specified by the driver software. Line 110 shows the way that the Tecmar driver routine is invoked. The routine begins at line 10000 and is merged with your application program. PARAM$ is the variable name for any parameter to be passed to the driver routine. In this case, the operation performed is initializing the IEEE board for controller operation. In line 130, ADTR is the mnemonic for asserting REN, to let the DMMs know that they are connected to and will be controlled by the computer. Line 150 contains the information to be output to the DMM that will monitor the pressure transducer. The significance of this data is determined by the DMM manufac-

(continued)

Listing 1: A *sample data-acquisition routine using the* IEEE-488 *interface.*

```
10      REM IEEE-488 PROGRAM FOR HEAT OF SUBLIMATION OF SOLID
            ARGON. PROGRAM SHOULD BE MERGED WITH TECMAR
            IEEE-488 SOFTWARE VER. 3.
20      REM PROGRAM BY THOMAS CLUNE, BRANDEIS UNIVERSITY
            CHEMISTRY DEPARTMENT
30      REM DMM #19 READS THE THERMOCOUPLE, DMM #17 READS THE
            PRESSURE TRANSDUCER.
            INITIALIZE IEEE-488 BUFFER LOCATION, DIMENSION ARRAYS
40 BD.ADDR% = &H310:DIM PRES(250):DIM TEMP(250)
50      REM SPECIFY COMPUTER DEVICE NUMBER, INITIALIZE DATA
            POINTER
60 MY.ADDR% = 1:DPT = 1
70      REM WAIT UNTIL READY TO BEGIN RUN.  PRESSURE READINGS
            MUST BE POSITIVE AND THERMAL EQUILIBRIUM MUST BE
            REACHED BEFORE THE RUN BEGINS.
80 CLS:PRINT "PRESS ANY KEY WHEN YOU ARE READY TO BEGIN YOUR
   RUN"
90 A$ = INKEY$:IF A$ = "" THEN 90
100     REM INITIALIZE BOARD WITH COMPUTER AS CONTROLLER
110 PARAM$ = "INIT.C/":GOSUB 10000
120     REM SET BOTH DMM'S FOR REMOTE CONTROL BY COMPUTER
130 PARAM$ = "ADTR/":GOSUB 10000
140     REM SET INTERRUPT REGISTERS OF DMM'S FOR SYNTAX ERROR
            AND FRONT PANEL SRQ.
150 DATA.STRING$ = "KM24D2PRESSURE"
160 PARAM$ = "WR.STR/17/14///":GOSUB 10000
170 DATA.STRING$ = "KM24D2TEMPERATURE"
180 PARAM$ = "WR.STR/19/17///":GOSUB 10000
190     REM ENTER DATA.STRING$ AND WRITE PROGRAMMING
            INFORMATION TO DMM #17. ADD <CR> FOR EOS.
200 CLS:INPUT "ENTER COMMAND STRING FOR PRES. DMM
    (#17)";DATA.STRING$
210 DATA.STRING$ = DATA.STRING$ + CHR$(13)
220     REM OUTPUT DATA.STRING$ TO DMM
230 PARAM$ = "WR.STR/17//13/EOS/":GOSUB 10000
```

(continued)

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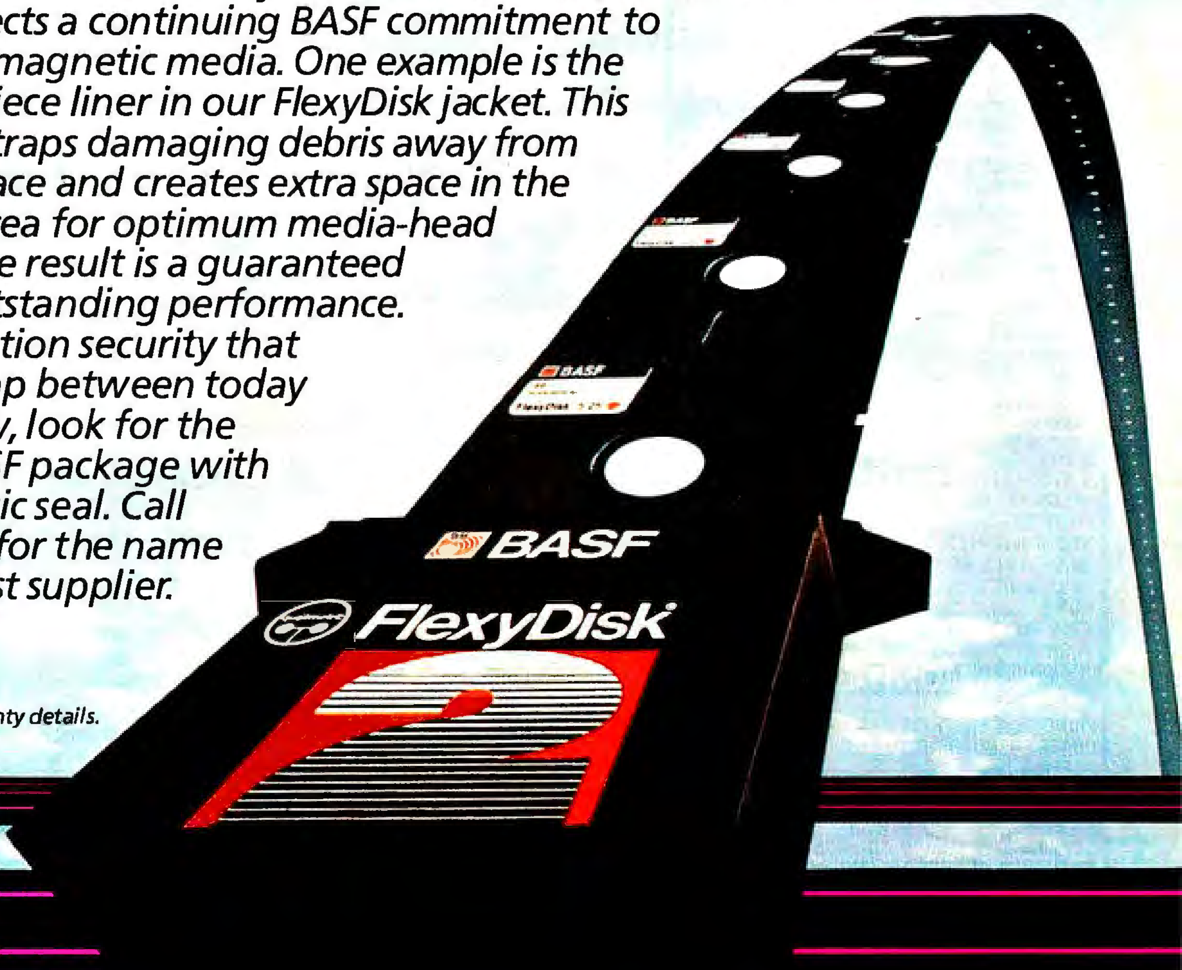

Inquiry 344

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INTERFACING

```
240       REM CHECK FOR SYNTAX ERROR IN DATA.STRING$.  IF YES, LOOP
               BACK TO REENTER DATA.STRING$
250 PARAM$="RBST/":GOSUB 10000
260 IF SRQ%=1 THEN PARAM$="SER.POLL/17/":GOSUB 10000:IF
    POLL.RESP% AND 4=4 THEN PRINT "SYNTAX ERROR IN
    COMMAND":SRQ%=0:GOTO 200
270       REM IF ERROR< >SYNTAX ERROR, LIST ERROR MESSAGE IN
               OCTAL AND END.
280 IF SRQ%=1 THEN PRINT "ERROR.  STATUS REGISTER (IN
    OCTAL)= ";OCT$(POLL.RESP%):END
290       REM ENTER DATA.STRING$ AND WRITE PROGRAMMING
               INFORMATION TO DMM #19. ADD <CR> FOR EOS.
300 INPUT "ENTER COMMAND STRING FOR TEMP. DMM
    (#19)";DATA.STRING$
310 DATA.STRING$=DATA.STRING$+CHR$(13)
320       REM OUTPUT DATA.STRING$ TO DMM
330 PARAM$="WR.STR/19//13/EOS/":GOSUB 10000
340       REM CHECK FOR SYNTAX ERROR IN DATA.STRING$.  IF YES, LOOP
               BACK TO REENTER DATA.STRING$
350 PARAM$="RBST/":GOSUB 10000
360       REM IF ERROR< >SYNTAX ERROR, LIST ERROR MESSAGE IN
               OCTAL AND END.
370 IF SRQ%=1 THEN PARAM$="SER.POLL/19/":GOSUB 10000:IF
    POLL.RESP% AND 4=4 THEN PRINT "SYNTAX ERROR IN
    COMMAND":SRQ%=0:GOTO 300
380 IF SRQ%=1 THEN PRINT "ERROR. STATUS REGISTER=(IN
    OCTAL) ";OCT$(POLL.RESP%):END
390       REM BEGINNING OF DATA-ACQUISION LOOP.  INITIATE A GROUP-
               EXECUTE TRIGGER TO RECORD THERMOCOUPLE AND
               PRESSURE TRANSDUCER READINGS SIMULTANEOUSLY.
400 PARAM$="GET/17,19/":GOSUB 10000
410       REM READ THE DMM VALUES INTO THE COMPUTER
420 PARAM$="RD.STR/17//10/EOS/":GOSUB 10000
430       REM STORE THE READING IN THE PRESSURE ARRAY.  1
               TORR=10mV, SO *100 MAKES V=PRES IN TORR.
440 PRES(DPT)=VAL(DATA.STRING$)*100
450       REM NOTE THAT THE LINE FEED IS USED TO SIGNAL THE END OF
               DATA INSTEAD OF THE LENGTH OF COUNT. LENGTH OF
               COUNT CAUSES AN ERROR CONDITION HERE WITH V.3
460 PARAM$="RD.STR/19//10/EOS/":GOSUB 10000
470       REM STORE THE READING IN THE TEMPERATURE ARRAY.  IF
               TEMP>77K GO TO CALCULATION ROUTINE
480 TEMP(DPT)=VAL(DATA.STRING$)*1000:IF TEMP(DPT)> -5.539 THEN 630
490       REM CHECK FOR FRONT PANEL SRQ.  IF YES, GO TO
               CALCULATION ROUTINE
500 PARAM$="RBST/":GOSUB 10000
510 IF SRQ%< >1 THEN 550
520 PARAM$="SER.POLL/17/":GOSUB 10000:IF POLL.RESP%< >0 THEN 630
530 PARAM$="SER.POLL/19/":GOSUB 10000:IF POLL.RESP%< >0 THEN 630
540       REM READ NEW TIME, CHECK ELAPSED TIME
550       REM TIME$ IS RESET TO 0 WHEN RBST CHECKS FOR TIMEOUT
               FAULTS
560 ENDCLK=VAL(RIGHT$(TIME$,2)):PRINT ENDCLK
570       REM IF AT LEAST 30 SEC HAVE ELAPSED, GET NEW READING
580 IF ENDCLK<30 THEN 560
590       REM CHECK FOR END OF ARRAY.  IF YES, JUMP TO CALCULATION
               ROUTINE. OTHERWISE INCREMENT DPT AND COLLECT NEXT
               POINT
600 IF DPT>249 THEN 630
610 DPT=DPT+1:GOTO 400
620       REM PRINT DATA AND DO SEMILOG REGRESSION GOES HERE.
               ROUTINE DELETED FOR BYTE ARTICLE. FULL ROUTINE
               AVAILABLE FROM AUTHOR.
```

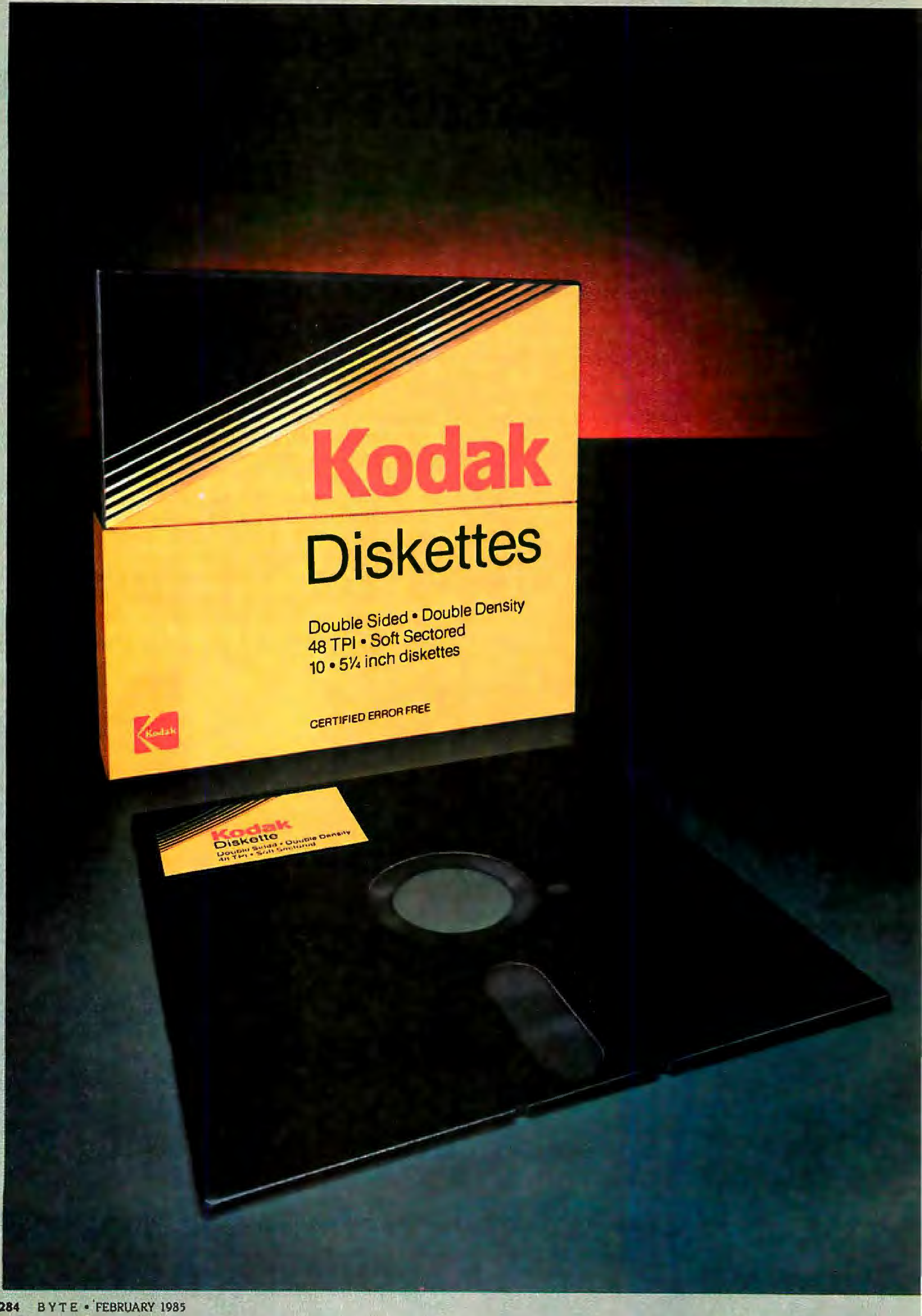
(continued)

The cost of adding an IEEE-488 interface is nominal and the added flexibility is not available from any other source.

turer and is not a part of the IEEE-488 standard. This data is used to program the 3478A instead of secondary addresses, which the HP does not support. The significance of the string to the DMM is as follows: K = "clear the maskable interrupt register," M24 = "set a new mask to generate an SRQ if programming data sent to the DMM has a syntax error or if the front-panel SRQ button is pushed," and D2PRESSURE = "display the word 'PRESSURE' on the DMM's display panel." Since the pressure-monitoring DMM and the temperature-monitoring DMM look exactly the same, this prompt ensures that the instrument is connected to the right transducer. Line 160 has the programming string output to the correct DMM. Field 2 of WR.STR specifies the device number (17) of the appropriate DMM and field 3 says to transmit 14 characters. That is, the end of sequence (EOS) is identified by simply counting the number of characters transmitted. At the end of 14 characters, the computer will UNLISTEN the DMM to terminate transmission. Line 200 has the operator input the programming information that will specify the functions that the pressure-monitoring DMM will use. Since the number of characters in the command string will vary with what options the operator selects, we don't use a character count to signal EOS here. Rather, in line 210 we tack a <CR> code onto the end of the data and in line 230 specify that the transmission to the DMM should continue until "13" (the carriage-return code in ASCII) is encountered. Since each operator enters the programming information on each experimental run, we want to verify that the DMM string does not contain any typographical mistakes. Therefore, we read the IEEE-bus status (line 250) and see whether an SRQ flag has been set (line 260). Remember that the DMM was programmed in line 160 to generate an SRQ on a syntax error. If an SRQ has been sent, we examine the status register of the DMM (260 also) to make sure that the SRQ was caused by a syntax error and, if so, have the operator reenter valid programming information for the DMM. Note that the SRQ does not automatically interrupt the central processing unit. It only sets a flag on the IEEE bus. If we want to ignore it, all devices that are still able to function properly can carry on with their business as usual. If we want an SRQ to automaticaly interrupt the computer, we can tie the SRQ line to an IRQ line.

Now let's skip to line 400. This initiates a group-enable trigger for both DMMs (numbers 17 and 19). Thus, our pressure and temperature data readings are triggered at the same time and are truly simultaneous. In line 420, we read the pressure DMM data into the pressure array PRES. Character 10, a linefeed, is used as an EOS by the DMM and is so declared in line 420. Lines 500 through 530 check to see if an SRQ was sent by any device and, if so, conducts a serial poll. This is done because the program allows the experimenter to interrupt the experiment at any time by pressing a front-panel button on either DMM. The program will then treat the data collected up to that time as the complete data set and begin the data analysis routine. If there was no SRQ, the program waits 30 seconds, checks to make sure that the data arrays are not about to overflow, and then takes another data reading.

The program presented above is a very simple routine. However, even this basic level of process control is very difficult to achieve on interfaces other than the IEEE-488. If you have a choice, you should begin reshaping your lab to support IEEE-488 interfacing. As you replace outdated or broken equipment, the cost of adding an IEEE-488 interface is nominal and the added flexibility is not available from any other source. ■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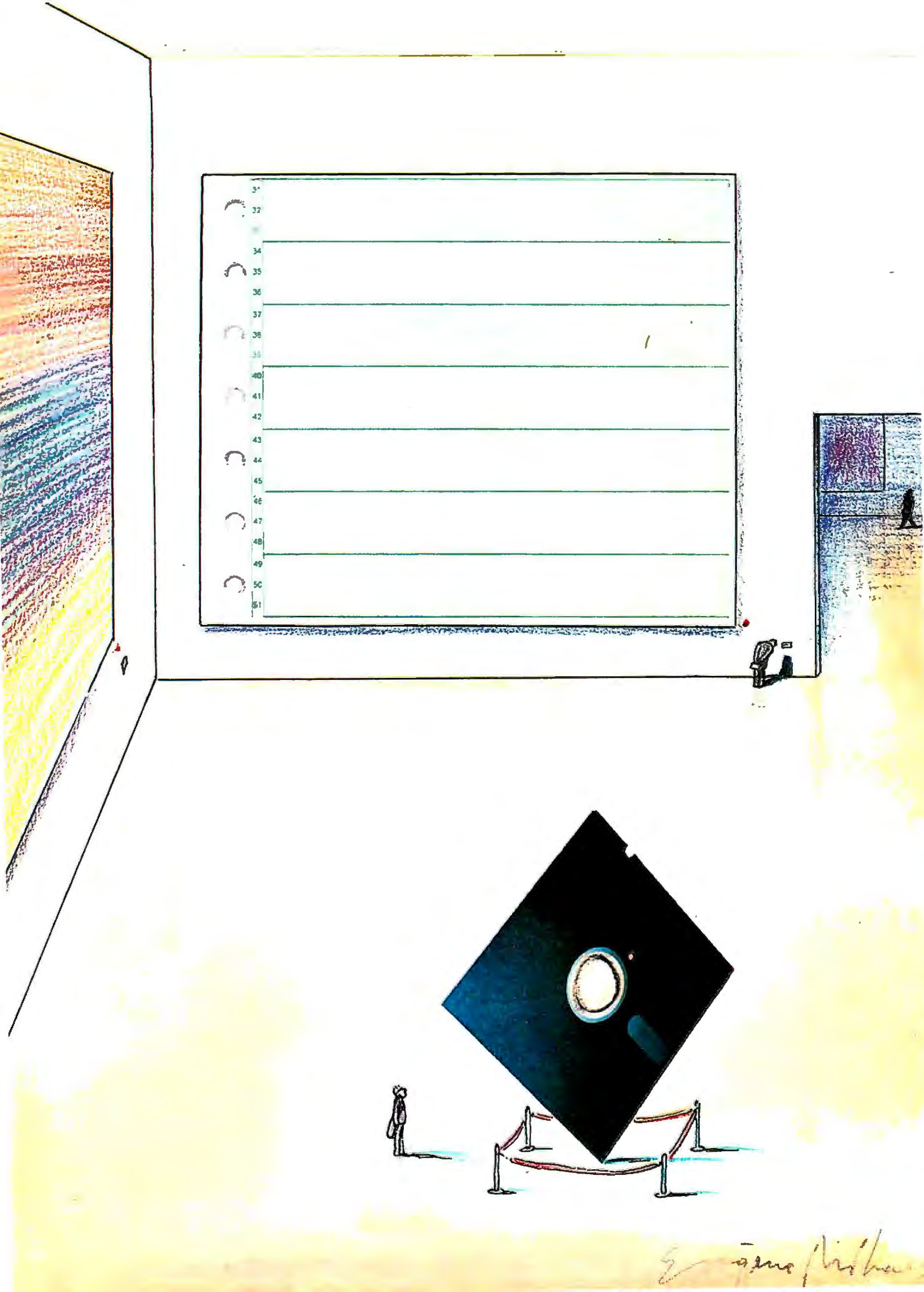

Reviews

EVEN WITH ITS MULTIPLE-KEYSTROKE FUNCTIONS and non-mnemonic commands, WordStar has retained its reputation as a powerful and popular word processor. Now some of the people who developed WordStar have gotten together and written a package designed to capitalize on WordStar's strengths while addressing its weaknesses. Called NewWord, this program from NewStar Software has strengths and weaknesses of its own. In our first review this month, John Heilborn and Nanci Reel take a close look at whether it fails or succeeds in its objectives.

Next, Mark Welch gives us his investigations of Janus/Ada. A nonstandard subset of Ada for MS-DOS and CP/M-80, Janus/Ada lacks a lot of features that give Ada its special character and utility. On the other hand, its fundamental structure is that of Ada's, and it can give you a definite head start in your attempts to pick up a new and complex programming language.

The Geneva PX-8 is Epson's lap-size computer. These small machines look now to be a permanent feature of the microcomputing landscape. The PX-8's credentials are impressive: a CMOS Z80, 96K bytes of two kinds of memory, an 8 by 80 LCD, and a comprehensive list of bundled software for less (just less) than $1000. Still, what we've seen for some time are systems that do very similar things with their major difference being price. How well can one of these briefcase computers help you work? Rich Malloy has taken a hard look at the PX-8. His review this month shows you what you can expect.

When confronted with a choice between two products designed to do the same thing, do you ever find yourself asking why one costs more than 10 times as much as the other—and is it worth it? A case in point is demonstrated in this month's review of "Two Modula-2 Compilers for the IBM PC." Both are adaptations of the original Swiss compiler and neither is a trivial implementation. Why then does one cost $40 and the other $495? Is the more expensive product necessarily the better product? While not primarily a comparison on a cost basis, Kevin Bowyer's review provides good evidence about what each compiler can do.

Another comparative review is offered by Wayne Rash Jr. in his look at MCI Mail and EasyLink. In theory, electronic-mail services have a lot to recommend them. Why haven't they caught on as well as their advance billing a few years ago would lead us to expect? Both of these packages are full services, and each has been heavily promoted. Do you want one to call your own? If so, do you want either of these? Good questions. Mr. Rash provides some good answers.

Closing out this month's review section, Mark Welch provides a straightforward look at a straightforward product. Mannesmann Tally's latest printer, the MT160, has a variety of print modes, speeds, configuration capabilities, and programmable features. Mark Welch details the MT 160 and gives you as good an idea as anyone could about what this machine will and won't do.

—Glenn Hartwig, Technical Editor, Reviews

R·E·V·I·E·W·E·R'S N·O·T·E·B·O·O·K

Two software packages for laboratory data acquisition tie in with this month's theme, computing in the sciences. Up for future review are Labtech Notebook, from Laboratory Technologies Corp., 328 Broadway, Cambridge, MA 02139, (617) 497-1010; and Asyst, from Macmillan Software Co., 866 Third Ave., New York, NY 10022, (212) 702-3241. Also slated for closer scrutiny in upcoming issues is the software provided by various A/D (analog-to-digital) board manufacturers. Those companies include Tecmar, 6225 Cochran Rd., Cleveland, OH 44139, (216) 349-0600, maker of the Labmaster board; and Data Translation, 100 Locke Dr., Marlboro, MA 01752, (617) 481-3700. While the A/D board makers seem to concentrate on producing driver software, the two packages first mentioned are integrated data-acquisition and data-analysis software.

Beginning with hardware requirements, there are key differences between the two main packages. The Labtech Notebook (which Data Translation also markets, under the name DT Notebook) *can* use the Intel 8087 math coprocessor chip; the Asyst package *requires* it.

There are other differences between the two. Asyst supports complex number types, while Labtech Notebook does not. Asyst includes a wide variety of statistical-analysis options, while Labtech Notebook is more limited. Asyst includes routines to calculate polynomials, to operate on vectors and matrices (including matrix inversions), to determine the eigenvalues and eigenvectors of a matrix, to fit data to curves using least-squares approximations and multilinear regression, and to do fast Fourier transforms (including two-dimensional forward and inverse transforms). Labtech Notebook lacks these sophisticated mathematical functions. Arguing on behalf of Labtech Notebook is its ability to continuously stream input data to disk up to the limit of mass-storage space. Additionally, Labtech Notebook (written in FORTH-like MAGIC/L) is menu-driven and easy to use, while Asyst is a FORTH extension and requires the use of FORTH syntax, making it more difficult for some people to use. Finally, Labtech Notebook supports a wider variety of A/D boards. Both packages, however, support curve fitting.

Labtech Notebook uses Lotus 1-2-3 or similar products to do its graphing (except for real-time graphing, which is built in) and requires a spreadsheet or user-written program to perform data analysis. What is good about this is that the data files are written in comma-delimited ASCII (American Standard Code for Information Interchange), which could be transported to most other software packages that include a user-written analysis routine. What is not so good is that we don't know many scientists who can so easily write good graphing routines that they actually want to spend time doing it. Further, Lotus 1-2-3 has been characterized as inappropriate for creating sophisticated analysis programs. You'll need to take a serious look at this Labtech Notebook/Lotus 1-2-3 interdependency if you're considering it for your application. Right now, being tied into Lotus's graphing capabilities strikes a number of people around here as providing less functionality than needed for serious laboratory data analysis.

Nor is Asyst a likely "white knight" for the scientist. True, it has everything you could want except continuous data acquisition, but it is so hard to use that some of the company's own demonstrators seemed to have learned their presentations by rote. At a recent demonstration in Washington, DC, they wouldn't vary the input data at the suggestion of the audience.

Neither of these packages is cheap. Asyst comes in three separate modules and is priced at $1695 when all three are bundled together. The first module contains the system/graphics/statistics routines, is required to run the other two modules, and costs $795. The second module handles data analysis and costs $495. The third takes care of data acquisition and sets you back another $495.

Labtech Notebook is a single package and is less expensive in strictly relative terms—$795. The catch is that you have to provide your own Lotus 1-2-3.

Reporters are slowly realizing that system crackers cannot magically break into any computer. They are more likely invited in by poorly designed security measures. One of the devices that has arisen from this purported problem is the call-back modem, a device that allows access only from a group of specially selected phone numbers. And the first to arrive here at BYTE is the GTX-100 secure modem, from Lockheed-GETEX, 86 South Cobb Dr., Marietta, GA 30063. This modem, which sells for about $1000, can be set up so that nobody can call in to the system directly. You merely give it a password and the modem will then call you back after referring to a list of phone numbers in its memory. Unfortunately, the modem is not completely compatible with the Hayes modem, so some software may not work with it, but it seems to be a pretty interesting idea.

—Glenn Hartwig, Technical Editor, Reviews

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Inquiry 133

S·O·F·T·W·A·R·E R·E·V·I·E·W

NewWord

A WordStar clone with significant improvements

BY JOHN HEILBORN AND NANCI REEL

WordStar, the archetypal word processor, is a versatile text-manipulating tool, but it can be difficult to master. NewWord, developed by NewStar Software, retains the strengths that have made WordStar popular while addressing most of WordStar's shortcomings.

NewWord, available for the IBM PC, PC-compatibles, and CP/M-80 systems, is priced at $249. Functionally, NewWord is similar to WordStar—it was, in fact, designed by some of the same people—but it is not merely a WordStar clone. And although it is not perfect, NewWord offers some significant advantages over WordStar.

WordStar's delete commands (Control-G, Control-T, Control-Y) are permanently destructive; when you delete something, it's gone forever. If you change your mind (or if you erase accidentally), you need to retype. To make matters worse, Control-Y (delete line) is right next to Control-T (delete word), so you can easily delete an entire line by mistake.

NewWord has an undo command (Control-U) and an "unerase" buffer. This command will usually undo whatever the last command did. For example, it will unerase a block that you erased with the command Control-KY. You can set the size of the unerase buffer during installation. Its original setting is 255 characters, or about 10 words.

When you request a document to edit, WordStar does not check to make sure that you typed the name correctly. If you misspell a document name, WordStar assumes that you want to create a new document. You have to abandon your misspelled file with Control-KQ. On the other hand, NewWord looks for the document and asks for verification if the entered name does not match a file in the disk directory. This eliminates abandoning empty files inadvertently created when you try to retrieve an existing document for editing.

When WordStar saves a file during editing (Control-KS), the cursor returns to the top of the document, not to where you were editing. You must then use Control-QP to move the cursor back. NewWord returns the cursor to your editing location without extra keystrokes.

PRINT FEATURES

In general, WordStar displays a document on the screen that looks exactly the way the printed page will look. Unfortunately, it also displays the control commands that you have to insert before and after text to turn boldface, underline, and other print features on and off. WordStar does have a special command that hides these commands, but it prevents you from seeing the control codes. You might forget where they are or leave out a trailing command and, for example, italicize the remainder of your document.

NewWord can display special print options such as boldface, underline, and strikeover on the screen if your terminal supports this capability. And NewWord's search function recognizes these embedded print control characters. For example, you can find all the boldfaced words and change them to underlined words; with WordStar, you have to conduct such a search visually without program support.

Another feature WordStar lacks is the ability to print more than one copy of a document at a time unless you buy the MailMerge program at extra cost. NewWord, however, includes the option of printing multiple copies of a document via a selection from the print menu. Also, you do not need an extra program to create form letters and perform other merge-printing tasks. NewWord has a merge-print function with features and commands similar to MicroPro's MailMerge, and advanced features such as conditional merge-print commands.

RULERS AND HEADERS

WordStar has other shortcomings that might be visible only to advanced users. For

(continued)

John Heilborn (POB 20102, Castro Valley, CA 94546) is president of ThinkWorks Inc., and Nanci Reel (6700 Southwest 105th St., Suite 200, Beaverton, OR 97005) is a technical writer for Teneron Corporation.

AT A GLANCE

Name
NewWord

Type
Word-processing software

Manufacturer
NewStar Software Inc.
1601 Oak Park Blvd.
Pleasant Hill, CA 94523
(415) 932-2278

Price
$249

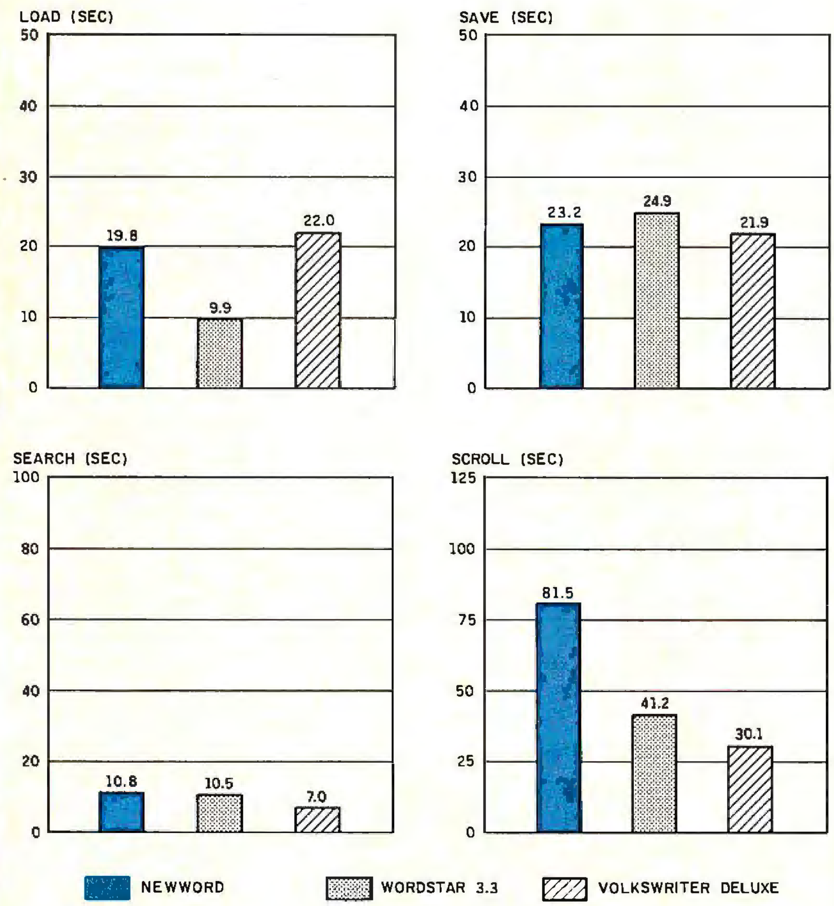
Format
5¼-inch floppy disk, PC-DOS (MS-DOS) and CP/M

Language
8080 machine language or 8086/8088 machine language

Computer
MS-DOS– and CP/M-80–based microcomputers

Documentation
420-page manual, *Read Me First* (23 pages), Pocket Reference flyer, and disk tutorial

Audience
Business and home users of microcomputer word-processing software who require advanced features



Document Load measures how long it takes each word processor to load a standard 4000-word document from disk. Document Save measures how long it takes to save the document to disk. Search measures the time it takes to find the last word in the document. Scroll measures how long it takes to scroll through the document manually.

example, in WordStar a "ruler" indicates left and right margins and tab stops. If you use several rulers within a document, you must embed each ruler in the text of your document. Each time you edit a document with several rulers, you must use a special command to turn on the new rulers as you encounter them.

NewWord allows more flexible use of multiple rulers. When you edit, NewWord automatically changes the ruler line every time it encounters a new ruler (when moving either forward or backward through a file). The command Control-OO inserts a copy of the current ruler into your text, and the factory setting lets you use up to six rulers per file, although you can increase the number during installation.

NewWord also lets you use up to three lines in page headings and footings, where WordStar limits you to single lines.

PRINTER INSTALLATION

WordStar operates with a wide variety of printers but usually does not take advantage of their most sophisticated capabilities, such as proportional spacing (with microjustification) and italics, without assembly-language patches to the printer drivers. Also, if you have more than one printer hooked up to your system (for example, a dot-matrix printer for drafts and a letter-quality printer for final copies), you need to customize a WordStar disk for each printer and load the appropriate one.

NewWord lets you attach more than one printer to your computer and select the right one when you are ready to print. NewWord accomplishes this with multiple printer drivers, including dot-matrix, letter-quality, and electronic typewriter drivers, which are available as overlays. This package uses the advanced capabilities of the printers supported, including microjustification, variable character width and line height, and alternate pitches on the same line.

OTHER FEATURES

NewWord's IBM PC version (with DOS 2.0 or higher) protects a document when you use the opening menu's C command. You cannot edit or delete a protected document.

NewWord also lets you find a particular page using Control-QP.

The Control-T command (delete word) works differently in NewWord than in WordStar. WordStar treats a punctuation mark as part of a word; if you use Control-T to delete the word "end." the trailing period is deleted with the word. NewWord deletes the word but not the period.

A minor difference between NewWord and WordStar is that NewWord's left-arrow key is a destructive backspace (WordStar's is nondestructive).

Finally, in NewWord you can set the right margin to 255 (WordStar's limit is 240). The wider margin is not significant for most applications, but it might be important in yours.

DISADVANTAGES

You have to give up some WordStar features for NewWord's improvements. For example, you can't print a document while editing (Control-KP). This is NewWord's most serious flaw. Even when you use a print spooler, printing a long document requires a fair amount of time before the program accepts additional input.

You can change logged disks while editing, but NewWord can't turn on the file directory (Control-KF in WordStar), so you can't see what's on your disk. For a way around this, issue the command Control-KJ (delete file). NewWord will display the directory of the currently logged disk and prompt you for the name of the file to delete. You can check the directory of the currently logged disk and cancel the command with Control-U; NewWord won't delete anything.

The R command, which temporarily returns you to DOS and runs a program, is missing from NewWord, and NewStar Software has no plans to add it to NewWord's vocabulary. If you want to format a blank disk from within NewWord, you're out of luck.

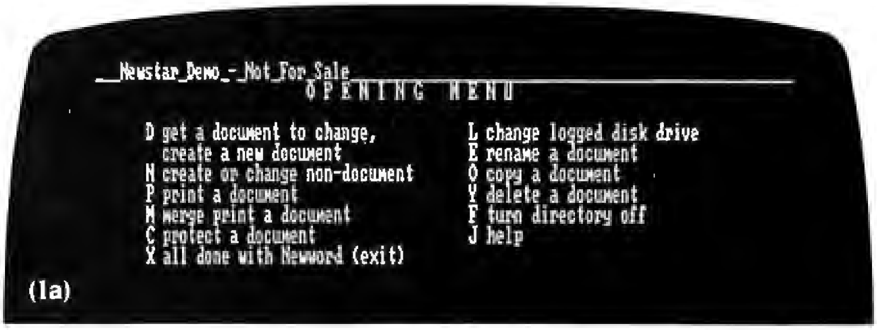
Another missing command is WordStar's "repeat this key" (Control-Q Control-Q*). Also, NewWord doesn't separate program messages and text clearly, which often makes the screen display confusing.

USING NEWWORD

Like WordStar, NewWord uses a multiple-menu-oriented command structure, but because NewWord's menus are less cluttered, they are easier to read (see photo 1).

When you begin program execution, NewWord presents an opening

(continued)



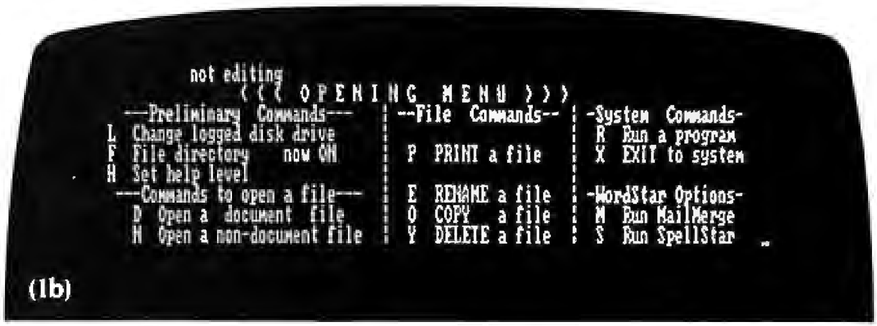
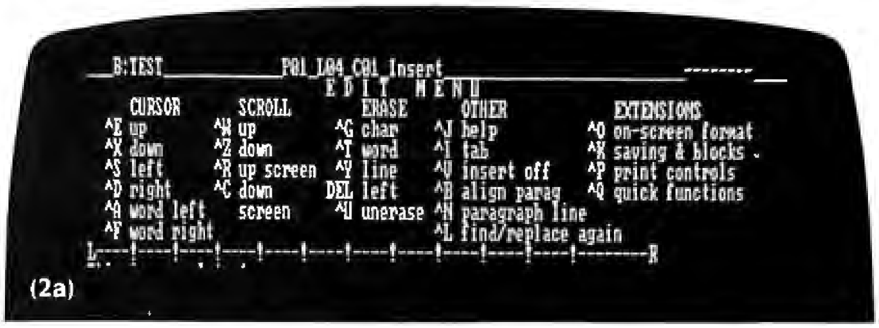


Photo 1: (*a*) *NewWord's opening menu compared with* (*b*) *WordStar's no-file menu.*



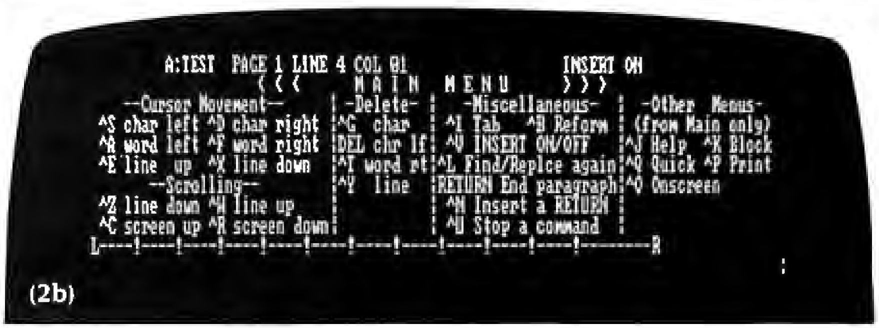


Photo 2: (*a*) *NewWord's edit menu compared with* (*b*) *WordStar's main menu.*

menu (older versions of WordStar call this a no-file menu). You select one of the activities listed by typing a single character.

If you select D or N, you enter edit mode (see photo 2). Once you are in the edit mode, the edit menu (called the main menu in WordStar) appears on the screen. From this menu, you access commands by pressing the Control key and entering a character. The four commands labeled EXTENSIONS (Control-O, Control-K, Control-P, and Control-Q) are for submenus. Pressing these commands calls submenus that let you select the third character required for each command sequence. If you are familiar with NewWord, you can enter the commands without waiting for the submenus.

Fortunately, NewWord can read and edit WordStar files without conversion or translation. The program can also use some of the same auxiliary programs; for example, we use the same print spooler we use with WordStar.

PERFORMANCE

We tested NewWord version 1.29, which is available for the IBM PC and compatibles (we used a PC, PCjr, and Compaq) and for CP/M-80 systems (we used a Morrow MD-11). Some improved versions are available: version 1.40 for the IBM PC and compatibles is slightly faster than 1.29 and contains some minor program changes, and version 2.0 for CP/M-80 systems contains the column block-move feature, which NewStar reports will be available soon (two to three weeks) for IBM PC users. [*Editor's note: We used NewWord version 1.43 to perform our benchmark tests.*]

Unlike WordStar, NewWord uses no overlays except the printer driver. In cases where WordStar must load an overlay to perform a function, NewWord's performance is faster. Overall though, we judge WordStar to be faster than NewWord on the IBM PC and compatibles and slightly slower on the CP/M computers. See table 1 for data on the IBM PC, and John Heilborn's article "The Morrow MD-11" (September 1984 BYTE, page 325) for benchmarks using CP/M systems (in table 2, page 334).

INSTALLATION

The NewWord installation procedure is long (13 pages of step-by-step instructions) and critical, because the custom installation procedure is also the copy-protection scheme. Prior to this installation (called "unlocking") the software won't run on any computer. In order to unlock the software, you have to call a special 800 number maintained by NewStar. After unlocking, the software runs only on the machine on which it was installed.

The unlocking procedure is described in *Read Me First*, a 13-step instruction guide accompanying NewWord. The steps are clearly stated and even an inexperienced novice could follow the guidelines.

To customize NewWord to fit your own needs, NewStar has included a utility called NWINSTAL, a customization program. Like NewWord, NWINSTAL is menu-driven. Some users will need to use the utility to install special terminals and printers (the default terminal is a TeleVideo 925). The program is easy to use and well documented; the menus are comprehensive but not intimidating. NewWord's many customization options are described in the manual's Nuts and Bolts section. The organization of this section could use work (and there are several typographical errors) but, in general, the guidelines for using NWINSTAL are clear.

NewWord includes another utility program called NWCOLOR that lets you customize the screen display for a color monitor. You can select any one of eight colors for the foreground and background of text display, as well as high intensity (boldface), blinking, and blinking boldface mode for the foreground. You can display text in seven different ways and change any or all of them. NWCOLOR makes it easy to play with possibilities.

DOCUMENTATION

NewWord's documentation includes a 420-page manual divided into three major sections: Do It Yourself, a tutorial that is organized into 12 sections, each covering important word-processing tasks; Nuts and Bolts, a customization guide; and NewWord Encyclopedia, a reference manual. The manual was written for the CP/M version and has not been updated for the MS-DOS version, so it does not include the information required to make full use of some of NewWord's enhancements (such as built-in special printer drivers and programmable function keys).

NewWord also includes the aforementioned *Read Me First*, a disk tutorial for word-processing novices, a Pocket Reference flyer, and a Do-It-Yourself supplement that describes conditional merge-print dot commands.

CONCLUSIONS

NewWord has some features WordStar users have longed for (such as sophisticated yet flexible printer control and the undo command, which reverses whatever you just did). However, NewWord is not perfect. It can be slower than WordStar and it doesn't have some of the capabilities you might be dependent on if you've used WordStar more than casually. But at $249, NewWord is useful enough so that the lack of a few features is tolerable. ■

Table 1: *A comparison of benchmarks for NewWord, WordStar, and Volkswriter Deluxe.*

Benchmark	NewWord 1.43	WordStar 3.3	Volkswriter Deluxe
Document Load	19.76	9.9	22.0
Document Save	23.17	24.9	21.9
Search	10.75	10.5	7.0
Scroll	1:21.45	41.2	30.1

Janus/Ada

A useful nonstandard tool for learning Ada

BY MARK J. WELCH

Ada is the U.S. Department of Defense's "Language of the Future." Although the DOD ordered that all defense contractors use Ada beginning this year, a lack of available, proven compilers has delayed its wide use. Whether or not you agree with the DOD that Ada is the best language, it will soon be the language of preference for government work. The DOD hopes that using a single standardized language will reduce maintenance costs for software.

Microcomputer owners seeking to learn Ada will likely feel a sense of despair, since the compilers available for microcomputers are either partial implementations or nonstandard subsets of the full Ada language.

RR Software's Janus/Ada (version 1.4.7) is a nonstandard subset of Ada for MS-DOS and CP/M-80. Janus lacks most of the features that distinguish Ada from other high-level languages, and it includes a number of nonstandard features.

However, Janus is a useful tool for learning about a complex programming language; those who have tried realize how hard it is to learn any programming language by reading even the best books or magazines. For a written overview of Ada, see Sabina H. Saib's two-part tutorial, "An Ada Language Primer," in June 1984 BYTE, page 131, and July 1984, page 139.

I used the MS-DOS version of Janus for the IBM PC. I am not an experienced Ada programmer; most Janus/Ada buyers will probably be in the same situation.

Ada was originally designed for real-time applications like guiding missiles or processing radar data. I don't have access to guided missiles and Janus doesn't implement Ada's concurrent tasking, so I wrote sample programs exercising Ada's usefulness as a general-purpose language. Since Janus doesn't have built-in graphics libraries, I wrote a simple text-based adventure game.

I had written a similar adventure game in BASIC in about 10 hours. Programming the game in Janus/Ada took quite a bit longer, perhaps due to my lack of experience. However, the resulting code was more structured and easier to understand and update later.

I am familiar with Pascal, the language Ada most resembles. Pascal programmers should have an easier time learning Ada than those experienced in other, less structured languages. A warning, though: the similarity between the languages is also confusing. I was often slow to locate an error because the illegal Janus/Ada line resembled valid Pascal code.

Included with the compiler are several sample Janus/Ada programs translated from Pascal. While none of the programs are noteworthy, they show how some functions are implemented.

After compiling several of the included packages, I wrote a simple program of my own to print a message, read a line of text, and echo it. It took four hours and a phone call to RR Software before I could compile the program.

JANUS IS NOT ADA

Janus is not an entirely accurate subset of Ada. The problem I battled for hours involved parameter calls. Standard Ada lets you call any function or procedure that assumes default parameter values by invoking its name. Janus—like an earlier version of Ada—requires that you add an empty set of parentheses so the use of default parameters is explicitly stated.

Because Janus doesn't use standard Ada strings, it does not have a simple way to read in a string with the valid Ada procedure:

```
get(word);
```

or

```
get_line(word);
```

Instead, Janus excludes strings from the get procedure. You must use the get_line function instead of the get procedure. This

(continued)

Mark J. Welch is a BYTE staff writer. He can be contacted at POB 372, Hancock, NH 03449.

AT A GLANCE

Name
Janus/Ada Compiler

Type
Ada programming language subset compiler

Manufacturer
RR Software Inc.
2718 Dryden Dr.
POB 1512
Madison, WI 53701
(608) 244-6436

Price
$300 for CP/M-80 (not reviewed)
$500 for MS-DOS
$700 for MS-DOS with tools disk

Format
Three 5¼-inch double-sided floppy disks (compiler, linker, and tools)

Documentation
237-page loose-leaf manual in three-ring binder

Audience
Applications software developers, Ada programmers, aspiring Ada programmers

makes any program that uses I/O (input/output) nonstandard Ada. To read a string, you must call the get_line function:

```
word := get_line();
```

Note the required parentheses.

To make finished code look more like standard Ada, I created simple procedures to hide these nonstandard calls; if you compile such a program with a more complete Ada compiler, you need to change only these procedures.

Janus's nonstandard array handling also creates problems. You can create patches to cover some missing features, but some of Ada's elegance is lost. For example, the valid Ada array assignment:

```
y(1..10) := x(1..10);
```

will copy each element of x(i) into the corresponding y(i) element. This won't work in Janus because Janus doesn't implement array or string "slicing." That is, it cannot access groups of array elements. If x and y are non-string arrays, the following replaces the above code:

```
for i in 1..10 loop
  y(i) := x(i);
end loop; -- for i
```

If x and y are strings, the job is tougher. An appendix to the manual explains several nonstandard substring functions and procedures. To do exactly the same as the original, I'd have to use:

```
y := extract(y,11,length(y));
insert(y,extract(x,1,10),1);
```

where the first line removes the first 10 characters of y and the second inserts the first 10 characters of x into the beginning of y. Somehow this lacks the simple elegance of the valid Ada array assignment.

SEPARATE COMPILATION

Any Ada or Janus code can easily be bundled off in a separate segment and separately compiled. By doing this, several programmers can develop code independently, each knowing only the names and parameters of the subprograms the others are developing. Any changes made to the subprograms later will require only that dependent segments be recompiled and the program relinked with a minimum of debugging.

THE COMPILER

The compiler makes four separate passes; I've only experienced errors on the first three. Much information is echoed to the screen, most of it useless to the typical user; during each pass of the source or intermediate code, screen symbols show that the compiler is working.

When the compiler finds an error, it displays the guilty line and the line preceding it along with the line number; it points out the error and displays a fairly helpful error message.

Run-time errors are more confusing. When an error occurs during run time, the system merely displays the error message and line number. Since my text editor isn't line-oriented, I had to count lines to find the error—not an easy task when the error is in line 675.

Each compilation takes from two to five minutes, depending on the length of the file and on whether the file being compiled is merely a specification or includes executable code. Long files can be broken into segments for separate compilation; this is helpful when a single procedure must be recompiled many times during debugging. After all segments are compiled, you can link the main program and generate a .COM file. Like most compilers, Janus/Ada generates .COM files that are longer than the source code because library subprograms are linked into the file as well.

BENCHMARK PERFORMANCE

Janus/Ada is not an optimized compiler, nor does it optimize the code it generates. This is forgivable given its price and the speed with which it was brought to market. Still, it needs substantial performance improvements before I would use it for commercial software development.

The Sieve program in Ada compiled in 184.7 seconds, linked in 15.1 seconds, and ran in 29.4 seconds. Most, if not all, other language compilers on the IBM PC generate faster code more quickly. (RR Software includes with the compiler a version of the Sieve program translated from Pascal to Ada that is different from the BYTE Ada Sieve benchmark.)

The floating-point benchmark (listing 1) compiled in 184 seconds, linked in 15.8 seconds, and ran in 2.6 seconds. In this case, execution time was faster than the speed of several C compilers, although compilation speed was slow by comparison. Note that an 8087 coprocessor was used and that Janus can use floating-point numbers on the IBM PC only if it is equipped with this math coprocessor; no provision is made for floating-point arithmetic in software.

A benchmark that computes Fibonacci numbers wouldn't run when translated because Janus/Ada doesn't support 16-bit unsigned integers; they cause a run-time error when the highest value is computed. When rewritten to use Janus's long_integer type, a stack/heap overflow occurs because Janus uses only 64K bytes of memory for data. (It uses another 64K bytes for code.) The Quicksort and IOfile programs used in benchmarking compilers also use long integers but were not benchmarked.

Janus's long_integer type was not easy to figure out, even after several calls to RR Software. The manual notes that long_integer is a standard type, but in fact you must use a separate library package called LONGOPS. Copies of the library packages are included on disk, a fact I discovered only after calling the company several times.

Janus long_integers can't be manipulated like integers, since they're essentially user-defined types; addition or type conversion has to be done using one of the functions in LONGOPS. As a result, a program using long_integers in Janus looks radically different from one using integers in a more standard compiler. Listing 2 shows the Fibonacci program in standard Ada; an overflow error is generated because the 24th Fibonacci number is a 16-bit unsigned number and Janus supports only 15-bit unsigned or 16-bit signed integers. Listing 3 shows the program converted to use the type long_integer in Janus; a heap overflow occurs because of the deep recursion and large data space required.

DOCUMENTATION

The Janus/Ada manual follows the format of Ada's military standard reference manual: each section mimics the reference manual and discusses any differences between Janus and Ada. The manual warns that it is not a complete guide and suggests that you have a copy of the Ada reference manual and an Ada textbook.

The Janus manual refers to the Ada reference manual of 1980, which is no longer accurate; changes were made during the ANSI (American National Standards Institute) review process,

(continued)

Listing 1: *The floating-point benchmark program translated from the C version.*

```
package body floatbch is
  const1 : constant float := 3.141597E0;
  const2 : constant float := 1.7839032E4;
  count  : constant integer := 1000;
  a, b, c : float;
  i: integer;
begin -- float main program body
  a := const1;
  b := const2;
  for i in 1..count loop
    c := a * b;
    c := c / a;
    c := a * b;
    c := c / a;
    c := a * b;
    c := c / a;
    c := a * b;
    c := c / a;
    c := a * b;
    c := c / a;
    c := a * b;
    c := c / a;
    c := a * b;
    c := c / a;
  end loop; -- for i
  put ("Done"); new_line;
end floatbch;
```

Listing 2: *The Fibonacci benchmark program in the standard Ada language translated from the C version as printed in BYTE, June 1984, page 307.*

```
package body fibo is
  ntimes : constant integer := 10; -- # of times to compute fibonacci value
  number : constant integer := 24; -- biggest we can compute in 16 bits
  value  : integer;
  i      : integer;
  ----------
  function fib(x: in integer) return integer is
  begin
    if x > 2 then
      return (fib(x - 1) + fib(x - 2));
    else
      return 1;
    end if;
  end; -- function fib
  ----------
begin -- fibo
  put(ntimes);
  put(" iterations: ");
  new_line;
  for i in 1..ntimes loop
    value := fib(number);
  end loop; -- for i
  put("fibonacci(");
  put(number);
  put(") = ");
  put(value);
  new_line;
end; -- fibo
```

Listing 3: *The Fibonacci benchmark program translated from* C (BYTE, *June* 1984, *page* 307) *into Janus/Ada using the necessary* long__integer *type.*

```
with longops;
package body fibo is
  use longops;
  ntimes : constant integer := 10; -- # of times to compute fibonacci value
  number: constant long__integer := lint(24); -- biggest we can compute
                                             -- in 16 bits
  one    : constant long__integer := lint(1);
  two    : constant long__integer := lint(2);
  value  : long__integer;
  i      : long__integer;
  ----------
  function fib(x: in long__integer) return long__integer is
  begin
    if Lgt(x,two) then
      return Ladd(fib(Lsub(x,one)),fib(Lsub(x,two)));
    else
      return one;
    end if;
  end; -- function fib
  ----------
begin -- fibo
  put(ntimes);
  put(" iterations: ");
  new__line;
  for i in 1..ntimes loop
    value := fib(number);
  end loop; -- for i
  put ("fibonacci(");
  put (L__to__Int(number));
  put (") = ");
  put (L__to__Int(value));
  new__line;
end; -- fibo
```

Table 1: *A partial list of unimplemented or nonstandard features of Janus/Ada.*

Item	Purpose/Difference
Slices	Allows references to sections of arrays or strings Example: *a(1..5)*
Strings	Not Ada standard (dynamic length)
Named/default parameters	Allows default input parameters or named parameters in subprogram call Examples: *attack(enemy => sam, weapon => knife);* *attack(enemy => fred);* *procedure attack (enemy: IN person := dave; weapon: IN tools := gun);*
Tasks	Ada's multitasking facilities
Exceptions	Exception/error-handling facilities
Generics	Subprograms can be easily redefined for new data types Example: *procedure EXCHANGE (u,v: in out ELEM) is* *t: ELEM;* *begin* *t := u; u := v; v := t;* *end EXCHANGE;* *procedure swap is new EXCHANGE (character);* *procedure swap is new EXCHANGE(ELEM => integer);*

You need to rewrite Janus programs to run on an Ada compiler.

and the true Ada is now reflected in the reference manual of January 1983. (Like its manual, Janus conforms to the earlier version of Ada.)

A fairly complete index is included in the manual, but some items are omitted. When I tried to learn about string-handling routines, for example, I found that section 15—which includes the list of string functions—was not in the index under "string."

As noted above, the manual says that long__integer is a standard type, although it isn't. RR Software admits that the manual (version 3.2) is behind the compiler.

SUMMARY

The Ada Joint Program Office (AJPO) insists that any partial implementation of Ada be so marked and all missing features be clearly identified. RR Software includes a list of implemented and unimplemented features in its brochure and its documentation. Some of the most significant missing features are listed in table 1.

While missing Ada features make experience with Janus less helpful to programmers, its nonstandard implementations of other features can be downright confusing. String and file handling are nonstandard, which means that you will need to rewrite almost all Janus programs in order to run them on a valid Ada compiler.

RR Software expected the next version of Janus/Ada to be available in the fall of 1984 and said that many extensions and changes would be made to the compiler. The new version might be available by the time you read this article.

While Janus is not a true implementation and lacks many of Ada's features, it is a useful, inexpensive tool for those wishing to learn the language before true Ada compilers are available for microcomputers. ■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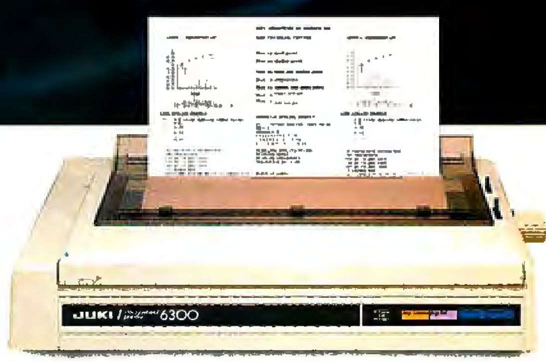
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B/2

S·Y·S·T·E·M R·E·V·I·E·W

The Epson Geneva PX-8

Epson strikes back

BY RICH MALLOY

The Epson Geneva PX-8 (see photo 1) has a low-power CMOS (complementary metal-oxide semiconductor) version of the Z80 processor, 64K bytes of CMOS memory, 32K bytes of permanent ROM (read-only memory), an 8-line by 80-character LCD (liquid-crystal display), a rechargeable battery, a full-size keyboard, and a microcassette drive. In addition, the PX-8 comes with a full complement of software: the CP/M operating system (version 2.2), WordStar, CalcStar, BASIC, a scheduling program, and a communications program. This package ($995), in combination with a healthy supply of expansion hardware, makes the PX-8 a good second computer, especially for people with CP/M systems.

HARDWARE

At five pounds and with physical dimensions just slightly larger than a heavily packed three-ring binder, the PX-8 is quite at home in a briefcase. With its LCD folded tightly and a plastic cover over its keyboard, it is fairly well protected for the ordeals of the road. There is even a large plastic handle that slides out near the keyboard. When you want to use it, the cover quickly slides off and the display unfolds to the desired angle, revealing a speaker and microcassette drive.

On the rear panel of the PX-8 are several ports: an RS-232C DIN (Deutsche Institut für Normung, the German standards organization) connector, a serial DIN connector (for an optional floppy-disk drive), a connector for a bar-code reader, an external speaker connector, and a 50-pin expansion connector covered by a plastic strip. The power switch is conveniently placed on the right side of the unit.

DISPLAY

The size of the Geneva's LCD is acceptable, but it is a little hard to read (see photo 2). You can adjust the display to whatever angle gives you the least glare and the most contrast, and you can adjust the screen contrast further by sliding a switch that's below the screen.

The PX-8 can display 8 lines of 80 characters each. (The characters are composed on a 5- by 7-pixel matrix inside a 6- by 8-pixel matrix.) However, lowercase letters such as *g* and *y* do not have descenders, and you can't display in reverse video (i.e., light character on dark background). The characters are much smaller and thinner than those on the TRS-80 Model 100, and the screen is slower, but the Epson does display twice as many characters.

The screen displays all 96 standard ASCII (American Standard Code for Information Interchange) characters plus 32 common graphics symbols (codes 128–159 decimal), which are compatible with *some* Epson printers but not with the IBM-compatible ones. Character sets are available for France, Germany, U.K., Denmark, Sweden, Italy, Spain, and Norway.

The PX-8's keyboard is similar to but better than the HX-20's (see photo 3). It has four cursor keys above the Return key and a Help key plus five function keys in the upper left. And there are indicators for caps-lock and num-lock features.

MEMORY

The PX-8 uses a low-power CMOS version of the Z80 microprocessor with a clock rate of 2.45 MHz. In tests with BASIC and CalcStar, it appeared slower than most other office computers at calculating. The PX-8 also uses two slave processors. A 6303 controls access to the display, the external disk drive, and the application ROM chips, among other things. A 7508 works with the system clock and keyboard and controls the Geneva's alarm features.

The Geneva comes with 64K bytes of CMOS memory that is always *on*: even if the main battery fails, a small backup battery keeps the memory chips powered on for a week or so until you can recharge it. The only event that should clear memory is if

Rich Malloy is a senior technical editor for BYTE. *He can be contacted at* BYTE, *43rd Floor, 1221 Avenue of the Americas, New York, NY 10020.*

you press a special hidden reset button on the bottom of the machine and do a cold reboot. You can set part of the memory up as a RAM disk with a size of 2K to 24K bytes.

The operating system is held in 32K bytes of ROM. When you turn on the system, it replaces (bank-switches) the lower 32K bytes of RAM (random-access read/write memory) with this ROM. When you run an application, the system bank-switches the RAM back into this location. The net result is a virtual 96K-byte machine.

The machine has two sockets for ROM chips hidden under a panel on the bottom of the computer. The software bundled with the PX-8 comes on four 32K-byte ROM chips: one each for CP/M system utilities, WordStar, BASIC, and a combination of CalcStar and a scheduling program. Only two of these chips can be resident in the machine at one time.

Epson has done a good job of implementing a microcassette drive in the Geneva. Even though it looks and acts like a tape drive, the operating system sees it as a disk drive, albeit a slow one. It even has its own directory and drive specification (H:). However, it has some quirks. To save time, the system doesn't write the directory onto the cassette until you tell it that you are going to remove the tape. If you forget to tell the system, some data stored on the cassette will be lost.

A 60-minute cassette (30 minutes per side) stores up to 12 files and up to 60K bytes per side.

You can also use the microcassette drive much like a regular audio-tape drive. Under certain conditions, the programmable function keys can simulate the control keys on a cassette tape player. You can even use it to listen to your audio cassettes, but the volume is very low.

The PX-8 is powered by an internal nicad (nickel-cadmium) battery, which can supply full power for about 15 hours. (Use of the microcassette drive or serial port shortens this time.) You can recharge the battery with a small transformer that plugs into any power outlet. A full recharge takes about 8 hours, longer if you use the machine during the process.

INTERFACES

The Geneva has a number of interfaces for external peripherals. The most useful is probably the RS-232C serial port configured as a round eight-pin DIN jack. It has pins for all the most commonly used signals—GND, TD, RD, RTS, CTS, DSR, DTR, DCD, and FG (frame ground)—and a maximum speed of 19,200 bps (bits per second). You can use two protocols: SI/SO (shift in/shift out), which can transmit a full 256 characters over a 7-bit communications link, and XON/XOFF.

To use the RS-232C port you need to purchase a DIN/DB-25 converter cable (approximately $25). Although we didn't test a large number of serial devices, we found the Geneva worked well with an Epson acoustic modem and with an IBM Personal Computer (PC) using a null modem adapter.

(continued)

Photo 1: *The Epson Geneva PX-8 computer, shown with optional battery-powered 3½-inch floppy-disk drive. Note the internal microcassette drive located between the keyboard and the display.*

The PX-8 has another similar connector labeled serial, which you can use to connect an external disk drive (at 38,400 bps) or a serial printer (at 4800 bps). It also has three other ports: an external speaker jack (in addition to the internal speaker), an analog input jack (which connects to an internal analog-to-digital (A/D) converter, 0–2 volts, 6 bits of resolution), and a connector for a bar-code reader.

One interface noticeably absent is a parallel printer interface. Another desirable connection would be for a full-size 80- by 24-character display.

The PF-10 portable 3½-inch disk drive (see photo 1) is available for $599. Powered by an internal battery, it is rechargeable by the same transformer that recharges the Geneva. The disk drive can store about 320K bytes on a 3½-inch microfloppy disk and connects to the PX-8 with a short cable through the serial port. You can connect two disk drives in daisy-chain fashion. The data-transmission rate is 38,400 bps, slower than the parallel connections most disk drives use. When you purchase the disk drive, you also get the following familiar CP/M utilities: FORMAT, DISKCOPY, ED, DDT, ASM, LOAD, and DUMP.

EXPANSION

The Geneva has some other interesting accessories. All are wedge-shaped modules that attach to the bottom of the computer and connect through the 50-pin expansion bus. These modules add little to the size and weight of the unit and elevate the keyboard to a comfortable typing angle.

The first of these are memory-expansion modules (see photo 4), which come in two flavors: 60K bytes ($329) and 120K bytes ($460). Since the Z80 microprocessor can address only the basic 64K bytes of memory, the second and third 60K-byte segments are set up as a RAM drive.

A second add-on module is a direct-connect, 300-bps modem ($180). A third module combines that modem with 60K bytes of memory for $360. We did not test either of these modules.

These expansion units all connect through the 50-pin expansion-bus connector on the back of the computer. This connector was not designed for easy access, but once you attach an accessory you probably won't have to touch it again.

SOFTWARE

The Geneva comes equipped with 128K bytes of software on ROM chips—four 32K-byte chips. The first one contains the BASIC interpreter; the second, some CP/M utilities; the third, Portable WordStar; and the fourth, a combination of Portable Calc (CalcStar) and Portable Scheduler. Only two of these chips can be present in the system at one time (see photo 5).

The Geneva's operating system has some interesting features. First, it all resides on yet another ROM chip,

(continued)

Photo 2: *The display of the Epson PX-8. Under certain lighting conditions this 80-character by 8-line display can be difficult to read.*

Photo 3: *The keyboard of the Epson PX-8. In this picture the display is folded down over the microcassette drive. Note the second Control key to the right of the space bar and the caps-lock, num-lock, and insert-mode indicators above the zero key.*

AT A GLANCE

Name
Geneva PX-8

Manufacturer
Epson America
2780 Lomita Blvd.
Torrance, CA 90505
(213) 539-9140

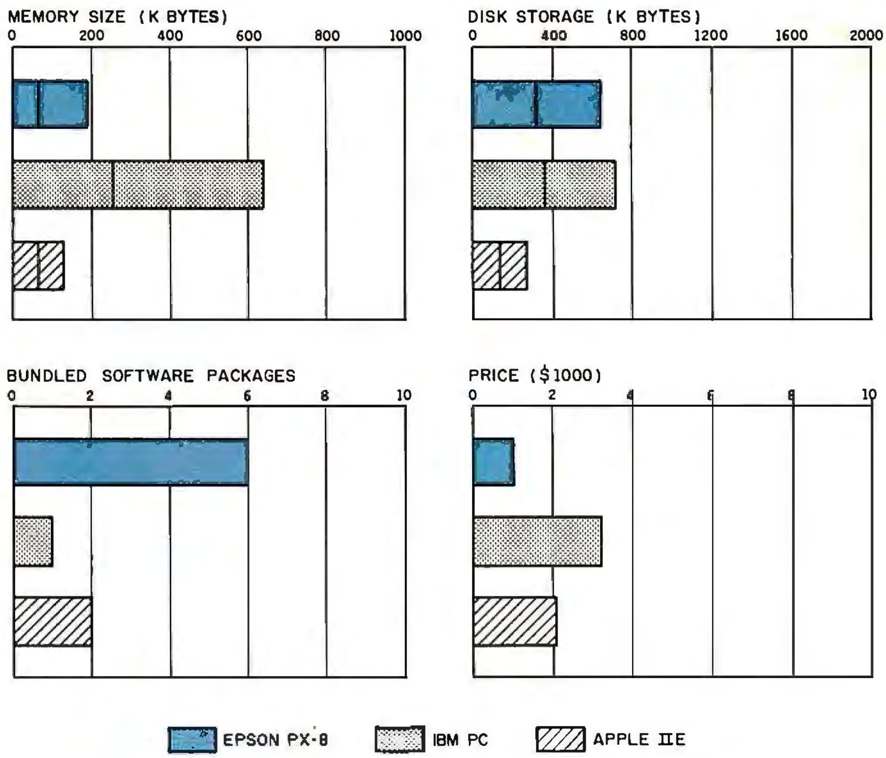
Size
11.7 by 8.5 by 1.9 inches
(29.7 by 21.6 by 4.8 cm),
5.1 pounds (2.3 kg)

Components
Display: 80-character by 8-line LCD, 480- by 64-pixel graphics
Keyboard: 72 keys, 4 cursor keys, 5 programmable function keys
Processor: Z80-compatible, low-power CMOS version, 2.45-MHz clock speed
Memory: 64K RAM; 6K RAM for display; 32K ROM (system); 64K ROM (applications)
Power: Nicad battery rated at 15 hours, small transformer/recharger
Options: 320K, 3½-inch disk drive ($599); 60K memory expansion ($329); 120K memory expansion ($460); 300-bps, direct-connect modem ($180); combination 60K memory plus modem ($360)

Software
CP/M 2.2, BASIC (Microsoft), Portable WordStar, Portable Calc, Portable Scheduler, TERM (communications)

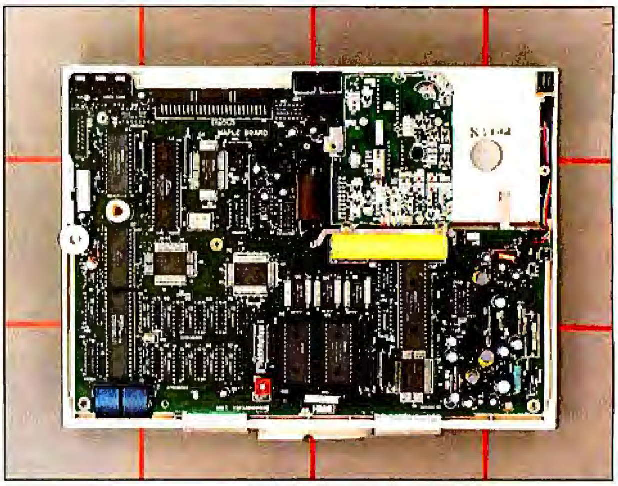
Documentation
Five manuals

Price
$995

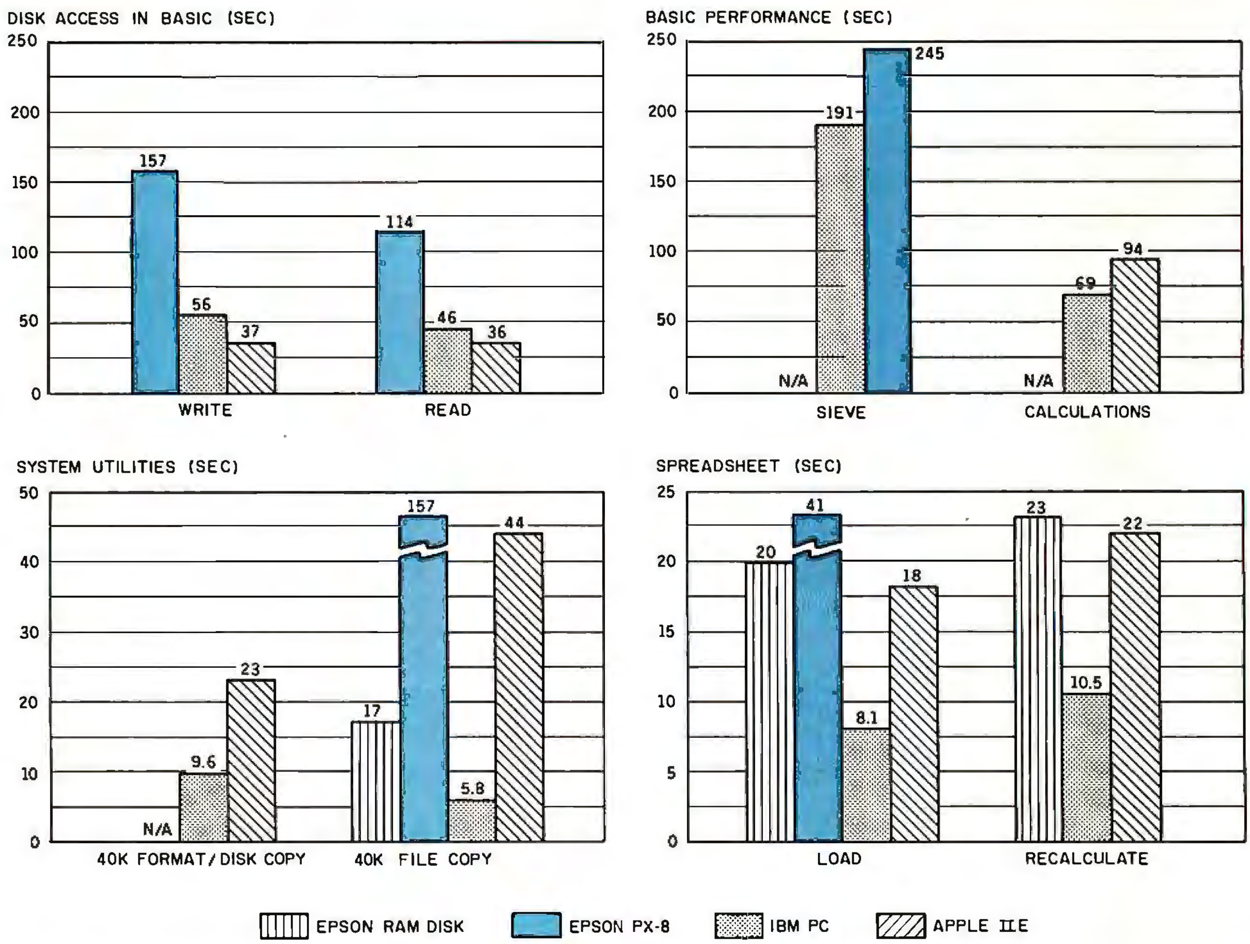


The Memory Size graph shows the standard and optional memory available for the computers under comparison. The graph of Disk Storage capacity shows the highest capacity of one and two floppy-disk drives for each system. The Bundled Software Packages graph shows the number of software packages included with each system. The Price graph shows the list price of a system with two high-capacity floppy-disk drives; a monochrome monitor; graphics and color-display capability; a printer port and a serial port; 256K bytes of memory (64K for 8-bit systems); and the standard operating system and standard BASIC interpreter for each system. Note that the price of the Epson does not include a disk drive.

The rear panel reveals (among other things) a speaker jack, an expansion bus, and an RS-232C port.



A look inside the PX-8 shows the processor chips (left) and the ROM chips (lower center).



The graphs for Disk Access in BASIC show how long it takes to write a 64K-byte sequential text file to a blank floppy disk and how long it takes to read this file. (For the program listings see June 1984 BYTE, page 327, and October 1984, page 33.) The Sieve column shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. Note that the Epson could not run the Sieve test because of insufficient available memory. The Calculations column shows how long it takes to do 10,000 multiplication and division operations using single-precision numbers. The System Utilities graph shows how long it takes to format and copy a disk (adjusted time for 40K bytes of disk data). The file-copy test involved copying a file from one part of a floppy disk to another. The Spreadsheet graph shows how long the computers take to load and recalculate a 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. The spreadsheet programs used were Portable Calc for the Epson and Microsoft Multiplan for the others. The tests for the Apple IIe were done with the ProDOS operating system. The IIe Multiplan test was done with DOS 3.3, the IBM with PC-DOS 2.0.

which is permanently installed in the system. Second, when you turn the machine on for the first time, the system asks you how much memory you want in your RAM disk—from 2K to 24K bytes. Thereafter when you turn on the system, you see a menu of all the files on a particular drive. (By *drive* I refer to any device: a disk, a RAM drive, a microcassette tape. The operating system treats them all alike.) You then move the cursor to the program or document you want and press the Enter key. This loads the selected program into RAM and executes it.

If you press Control-Help, you see the System Display, which includes information on various operating-system parameters. The display contains the date and time, the size of the RAM disk, whether or not a password is in effect, which drives are listed on the menu, and which data files are linked to which programs.

The password feature on this machine is pretty secure. If you set a password, the machine won't do anything until you give it the correct one. The only way around it is to do a cold reboot and lose all your data.

You can turn the menu on or off and choose which drives are to be listed on the menu and in which order.

The System Display also lets you control the cassette drive manually. The function keys become like the controls on a tape recorder.

In practice, the menu is quite useful, but sometimes it gets in the way. For example, it is hard to enter a command such as STAT A:*.*—how many files are on the A drive and how large are they. To do this you must leave the menu by hitting Escape. Fortunately, you can turn the menu on or off.

The most significant piece of software in the Geneva is the ROM-based version of WordStar. Despite its small size, this version seems to contain most of the features of the larger version. The only features lacking are certain printing capabilities.

The spreadsheet supplied with the PX-8 is Portable Calc, a ROM-based version of CalcStar. Portable Calc performed our standard recalculation

(continued)

Table 1: *Word-processing benchmarks for* Portable WordStar *on the* Epson Geneva PX-8 *(times in seconds). In many tests the Epson with a* RAM *disk performs as fast or faster than a floppy-disk-based* IBM PC. *There are two glaring exceptions, however: the scroll test and any test involving the Epson's floppy disk. All tests were done using a standard* BYTE 4000-*word test file* (21K *bytes). The* RAM *disk used was a* 128K-*byte external memory-expansion module. The data for the* IBM PC *was obtained using an* IBM PC *with* WordStar *version* 3.3, DOS 2.0, *two floppy-disk drives, and a monochrome monitor and adapter.*

	Geneva PX-8		IBM PC
	RAM disk	Floppy disk	
Load text file	8.3	17.3	9.9
Save text file	15.6	80.0	24.2
Search	12.5	37.6	10.5
Scroll	287.0	n.a.	41.2

Photo 4: *The optional memory-expansion module for the* Epson PX-8, *shown ready to attach to the bottom of the computer.*

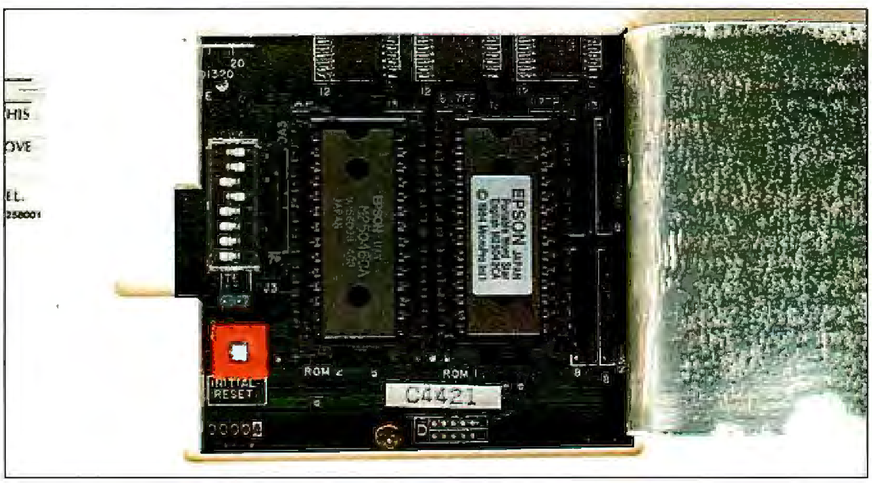


Photo 5: *The sockets for the Epson's* ROM *chips are hidden in a special compartment on the bottom of the machine. A soft metallic sheet minimizes radio-frequency interference in the surrounding environment.*

test as fast as Multiplan did on the Apple IIe, and it was much faster than the CalcStar version that comes with the 16-bit Sanyo MBC 550.

Portable Scheduler runs rings around the SCHED program on the Radio Shack Model 100 and approaches the usefulness of the scheduler features on the HP 75 portable. You can set an alarm, and you can have the computer remind you of a series of appointments.

BASIC AND CP/M

The BASIC interpreter on the Geneva takes up about 32K bytes of memory, compared to about 16K bytes used by the Model 100's BASIC. The Geneva version lets you do quite a few more things; for example, you can access the alarm features directly from BASIC. It also includes AUTO (automatic line numbering) and WHILE ... WEND. Both BASICs were created by Microsoft, and they are fairly compatible.

In terms of performance, the Geneva's BASIC does not compare well with desktop-machine versions. The results of our single-precision calculation test were significantly slower on the Epson than on the IBM PC and the Apple IIe. Also, we could not get our Sieve of Eratosthenes test to run. Of course, anything that involved disk accesses was significantly slower.

Finally, we come to the utility programs of CP/M version 2.2, such as copy files (PIP), check disk or RAM-drive status (STAT), and perform several different programs in sequence (SUBMIT). To these programs Epson has added a configuration utility and two communications programs.

TERM is a general-purpose program for communicating with other computers via phone or direct connection. It doesn't support automatic dialing or logging on, but it is quite easy to use. FILINK is for file transfer to and from an Epson QX-10. We didn't test this program.

The practicality of these application programs is somewhat limited by the fact that only two ROM chips can be present in the PX-8 at one time. If, however, you have one of the optional memory-expansion modules, you can load some of the more useful utilities into the RAM drive, then remove the CP/M utility chip and use that socket for another ROM chip.

One advantage of owning a CP/M system is that you potentially have a wide selection of available software. The Geneva display and keyboard emulate a Soroc IQ-120 terminal, and, theoretically, the Epson can run any CP/M software that is compatible with the Soroc. In actuality, the Geneva doesn't support features such as high-intensity or inverse-video characters, and although it has a virtual screen of 24 lines, its physical screen has only 8. According to Bob Diaz of Epson, most of the simple CP/M utility programs such as DU and CATALOG run on the Geneva. More complex CP/M programs, such as PeachText, will run but with some minor problems. And CP/M programs customized for a particular terminal or computer probably won't run at all.

DOCUMENTATION

The documentation for the Geneva and its software is, on the whole, good. The manuals are typeset, well written, accurate, and practically devoid of typographical errors. I was particularly impressed with the easy-to-read Portable WordStar manual, which included a reference card and stick-on labels for certain keys.

The main manual lists the entry addresses and functions of all the BIOS (basic input/output system) and BDOS (basic disk operating system) routines of the Geneva's version of CP/M.

SUMMARY

After the disappointment of the Epson HX-20, the Geneva PX-8 represents a giant improvement. It is, at this time, the most powerful 8-bit portable available. And its price of $995 makes it fairly affordable. With the CP/M 2.2 operating system, the Geneva is an ideal second computer for CP/M system owners. It is also a good second computer for people who use WordStar on a desktop system. ■

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Two Modula-2 Compilers for the IBM PC

A great buy is pitted against a professional system

BY KEVIN BOWYER

Kevin Bowyer is on the faculty of Computer Science and Engineering at the University of South Florida in Tampa. He was previously on the faculty of the Swiss Federal Institute of Technology in Zürich. He received his Ph.D. in Computer Science from Duke University. Among several books he has written are An Introduction to Modula-2 *(Reston Publishing, available early 1985, co-authored with Warren Jones of the University of Alabama at Birmingham) and* Pascal for the IBM PC *(Robert J. Brady Co.).*

Two Modula-2 compilers are available for the IBM PC and run under PC-DOS. Both are adaptations of the original Modula-2 compiler developed at the ETH (Federal Institute of Technology, Zürich, Switzerland) to run on the Lilith personal workstation. One is the Modula Research Institute (MRI) Modula-2 compiler, version 1.35, available for $40 from the Modula Research Institute in Provo, Utah. The other is the Logitech Modula-2/86 compiler, version 1.0, available for $495 from Logitech Inc. in Redwood City, California. The one other Modula-2 compiler for the IBM PC is marketed by Volition Systems of Del Mar, California. However, this compiler runs under the UCSD p-System and so is not directly comparable to the two I discuss here. [*Editor's note: A PC-DOS version of this compiler has recently become available.*]

The MRI and Logitech compilers have many similarities traceable to their common ancestor. The essential difference between them is that the MRI compiler generates M-code, the machine language developed at ETH for the Lilith workstations, whereas the Logitech compiler generates 8088 machine language. The noticeable differences in compilation and program execution speed are a result of this difference.

REQUIRED RESOURCES

The Logitech compiler requires an IBM PC equipped with an 8087 numeric coprocessor chip, two double-sided disk drives, and at least 170K bytes of RAM (random-access read/write memory) in addition to whatever space the operating system uses. It runs under PC-DOS 1.1 or 2.0. A practical minimum for using the Logitech Modula-2 compiler with PC-DOS 2.0 is 256K bytes of memory. The MRI compiler might function on a system of two single-sided disk drives and 128K bytes of RAM, but a practical minimum is two double-sided drives and 196K bytes of RAM.

I did all the testing for this comparison on a PC XT with 256K bytes of RAM. Judging by the number of disk accesses made by either system, enough extra internal memory to create an "electronic disk" would greatly increase speed.

EASE OF USE

Both the MRI and Logitech systems require some care in setting up the original configuration. You have to decide where to put the many files that make up either system, and your CONFIG.SYS file at the root level of the file system must have certain options. All this is well described in the documentation and should present no problem.

Neither the MRI nor the Logitech compiler runs directly from PC-DOS. Nor do they produce standard EXE or COM format files, so the programs created with the compilers cannot be executed directly from PC-DOS. The MRI system runs its own "shell," or command interpreter, on top of PC-DOS. The compiler and any programs that you write are run from this shell. The Logitech system is similar. While it doesn't have a shell that stays resident on top of PC-DOS, it does have a "run-time system" that you have to invoke for running the compiler or programs created with the compiler.

Since neither the Logitech nor MRI system includes a text editor, you must use your own (or EDLIN) to prepare a standard PC-DOS text file that contains the program's source code. Assume that you have already prepared a source program in the file SAMPLE.MOD. You can start up the MRI shell with the command **interp**. The MRI shell then displays the copyright notice and an asterisk prompt. You can now run the compiler by entering the command **modula**. You can run the resulting compiled program by entering its name. When you want to leave the MRI shell, you type Control-C.

In the case of the Logitech system, you invoke the compiler from PC-DOS with the command **m2 comp**. The m2 is the name of the Logitech run-time system, so any Logitech program running under PC-DOS

(continued)

must be prefaced with m2 at run time.

Both systems will then prompt you for the source file and give almost exactly the same messages as the compiler progresses:

```
  source file sample.mod
p1
  InOut: C:InOut.SYM
p2
p3
p4
  end compilation
```

The sameness of the messages reflects the origin of both compilers—the Modula-2 compiler developed at ETH. The four-pass structure of the compilers is a carryover from the original Lilith compiler, which was ported from a PDP-11 Modula-2 compiler that had to run in a small address space.

Unlike the MRI system, the output of the Logitech compiler must undergo a separate link step before it can be executed. The linker collects all the separately compiled parts of the program and groups them into a single load file. The m2 command executes this load file.

The MRI interpreter takes rather long to load into memory: about 10 seconds on a hard-disk system, more with a floppy-disk system. This can be annoying if you have to leave and reenter the interpreter to use an editor for correcting errors in your program. For this reason, the MRI shell incorporates an "escape to DOS" feature. You can enter an exclamation point to start up a copy of the PC-DOS command interpreter (COMMAND.COM) on top of the MRI shell. Then you can edit your program and return to the MRI system with the exit command.

The escape-to-DOS feature works quite well and is much faster than the alternative most of the time. However, if you change directories while in DOS and forget to change back before returning to the MRI shell, things get hopelessly confused and you have to reboot the system. If you want to use the escape-to-DOS feature and have the MRI software in a subdirectory of the file system, you need to place a copy of COMMAND.COM in the same directory as the MRI software.

SPEED

After running lots of small test programs, I am convinced that Logitech's compiler is substantially slower than the one from MRI. However, the Logitech compiler can produce programs that execute much faster than those produced with the MRI compiler. A program that does nothing but write "Hello, World!" to the display (listing 1) compiles in a little less than 40 seconds with the MRI compiler and about 65 seconds under the Logitech system. This does not include time for the link step required by the Logitech system, which takes another minute or so.

An equivalent IBM PC-DOS Pascal program could be compiled and linked in under 30 seconds—even though it involves entering three separate commands to PC-DOS (PAS1, PAS2, and LINK). Neither Modula-2 system could be called speedy as far as compile time is concerned.

If program execution speed is what you are after, Logitech's compile time might be worth waiting for. The Logitech compiler can produce programs that are many times faster than those produced by the MRI system. Another trivial example program (listing 2), using nested loops and integer arithmetic, takes about 20 seconds for the MRI system to compile and something over 60 seconds to execute. The Logitech system takes 55 seconds to compile the same program, again not counting the required link step. (The link step would be quick here because there are no IMPORTs from separately compiled modules.) However,

Listing 1: *"Hello, World!" program.*

```
MODULE sample;
FROM InOut IMPORT WriteString;
BEGIN
  WriteString("Hello, World!");
END sample.
```

Listing 2: *Nothing to the nearest integer program.*

```
MODULE sample;
VAR i, j, sum: INTEGER;
BEGIN
  sum := 0;
  FOR i := 1 TO 1000 DO
    FOR j := 100 TO 1 BY -1 DO
      sum := sum + (i-j) + (j-i);
    END;
  END;
END sample.
```

Listing 3: *Extended-precision nothing program.*

```
MODULE sample;
VAR x, y: ARRAY[1..100] OF REAL;
    sum: REAL;
VAR i, j: INTEGER;
BEGIN
  FOR i := 1 TO 100 DO  (* initialize *)
    x[i] := FLOAT(i);  y[i] := FLOAT(i);  END;
  sum := 0.0;
  FOR i := 1 TO 100 DO
    FOR j := i TO 100 DO
      sum := sum + x[j]*y[j] - y[j]*x[j];
      sum := sum / FLOAT(i);
    END;
  END;
END sample.
```

the Logitech program executes in about 8 seconds—which is less than one-sixth the time of the MRI program.

Both systems compile this second example more quickly than the first one, even though the executable part is more complex. This is because the first example imports a procedure from a separate module. Nearly any useful Modula-2 program will import procedures from at least one module, if for no other reason than to do input/output (I/O). Importing objects from separate modules takes time because the compiler must read the definition of the module and check it against the IMPORT clause.

For one more comparison on compiler and execution speed, I ran the Sieve of Eratosthenes prime-number generator used as a benchmark in previous BYTE articles (see reference 1). The Logitech compiler took about 65 seconds to process the program, 25 seconds to link, and about 17 seconds to execute. The MRI compiler took about 55 seconds to process the program and nearly 3 minutes to execute it. (The definition of "execution time" here is the same as that used in the article referenced above: the time between seeing the messages from the two output statements in the benchmark program.)

Real Numbers

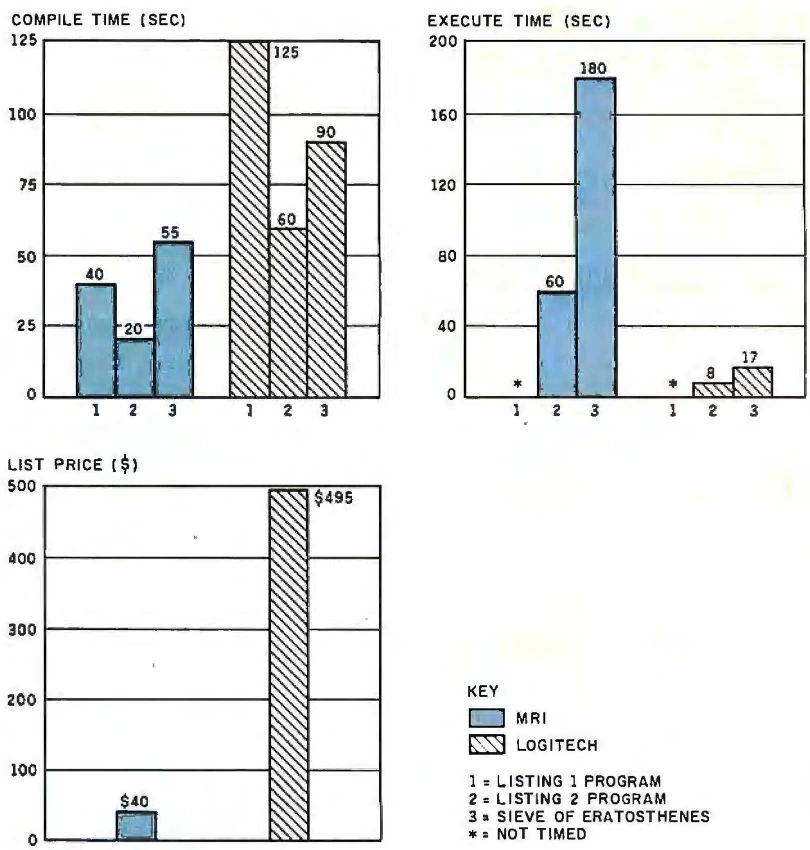
The MRI and Logitech compilers are similar in how they represent all the standard data types except real. The MRI system implements real values as 32-bit quantities, and arithmetic operations on these values are performed in software. The Logitech system uses 64-bit real numbers and can generate code for the 8087 numeric coprocessor. For a PC with the 8087 installed, this can be a great advantage. Consider the program in listing 3.

The MRI compiler took just under 30 seconds to compile this program, and the resulting program took about 25 seconds to execute. The Logitech compiler took just over 50 seconds to compile the program, but the resulting program executed in about 3 sec-

(continued)

AT A GLANCE

Name MRI Modula-2 Compiler	**Name** Logitech Modula-2/86
Vendor Modula Research Institute 950 North University Ave. Provo, UT 84604 (801) 375-7402	**Vendor** Logitech Inc. 805 Veterans Blvd. Redwood City, CA 94063 (415) 365-9852
Computer IBM PC or compatible	**Computer** IBM PC or compatible
Price $40 plus $2.50 shipping and handling	**Price** $495
Audience Anyone who wants a good, inexpensive introduction to Modula-2 on the PC	**Audience** Anyone who wants to develop software using Modula-2 and the 8087 numeric coprocessor chip; the 8087 is required with Modula-2/86



Note that the Logitech compiler requires an 8087 coprocessor and the MRI compiler does not support the 8087, so execution times do not involve commensurable hardware. Compile times for the Logitech compiler include link times. The Logitech compiles to 8088 machine code, while the MRI compiles to M-code and operates as an M-code-to-8088 interpreter at run time.

onds on a PC XT equipped with the 8087 numeric coprocessor.

Compiler Directives

Compiler directives in Modula-2 are specified much the same as in Pascal. The directive letter and setting are given inside a comment. The Logitech compiler has three directives:

(*$R+*) code generation for subrange and type checking
(*$T+*) index testing (arrays, case statements)
(*$S+*) stack overflow

The directives can be turned off by using a minus sign instead of a plus sign, or an equal sign can be used to change the setting back to the previous value.

Directives work the same way in the MRI system, but only the first two of the three options above are available. Both systems also allow several possible options on the command line that invokes the compiler. Among these are a listing file and prompting for the names of symbol files.

Language Extensions

Both compilers claim to accept the same Modula-2 language as defined by the Modula-2 report (see reference 2). However, the Logitech system has the advantage of some extra PC-specific routines available in the System module. Technically, these don't count as extensions to the language, but most users will think of them that way. Among the extensions are routines to read and set the values of 8088 registers; enable, disable, and initiate interrupts; read and write to the 8088 I/O ports; and generate a call to the DOS system interrupt.

The MRI System module contains only procedures defined in the Modula-2 report. It might be easier to write processor and operating-system-specific programs with Logitech Modula-2.

To test whether these compilers might be useful to owners of PC-compatibles, I checked them out on a Compaq portable equipped with two floppy-disk drives and 256K bytes of memory. Both compilers ran several small examples properly. Both also seemed painfully slow—with all the file I/O, a hard-disk drive is almost a necessity for using one of these compilers.

Summary

The compilation/execution speed comparisons between the two compilers are not surprising. The MRI system compiles programs into M-code, which was designed with the goal of efficient Modula-2 compilation. Given this background, it makes sense that the MRI compiler is faster than the Logitech compiler. But the MRI programs pay for this advantage with their slower execution. The MRI software executes programs by interpreting the compiled M-code, but the Logitech programs' 8088 machine code doesn't need interpretation.

If you just want to learn Modula-2 and write some programs for your own use, the MRI software is probably for you. You will appreciate the faster compile time with small programs, in which execution speed probably depends on user input anyway. And the MRI software is much cheaper.

On the other hand, if you want to write software to distribute or sell, the Logitech system is probably right for you. This is especially true if Logitech comes out with a linker to produce COM or EXE format files.

If you are one of the relatively few PC owners who operates the UCSD p-System, you should look into the Modula-2 compiler available from Volition Systems. However, better compilers are likely to become available at any time, from these companies as well as others. Professor Wirth and Jurg Gutknecht of ETH have created a fast one-pass Modula-2 compiler for the Lilith; a compiler for the IBM PC derived from this one is likely to show up in the future. ■

REFERENCES

1. Gilbreath, Jim, and Gary Gilbreath. "Eratosthenes Revisited: Once More through the Sieve." BYTE, January 1983, page 283.
2. Wirth, Niklaus. *Programming in Modula-2*. Springer-Verlag, 1982.

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A/D Input	RS-170 (CCIRR), 6-bits at 5MHz
Frame Grab	1/30 (1/25) second per field
LUT's	8, 64 × 8 input; 4, 256 × 12 output
D/A Output	64 colors × 64 intensities, R-G-B; 64 grey levels, monochrome
Frame Memory	256 × 256 × 8 (2-bits for graphic overlays)

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Inquiry 44

E-Mail for the Masses

MCI Mail and Western Union's EasyLink

BY WAYNE RASH JR.

Two giants of the telecommunications industry have started electronic mail services. MCI Telecommunications Corporation's MCI Mail and Western Union Telegraph Company's EasyLink offer the services to individual consumers and businesses. Both services are heavily advertised, and both promise to open the world of easy and inexpensive instant communications to nearly anyone. Only one fully delivers on this promise.

MCI MAIL

MCI Mail is part of the same corporation that provides MCI telephone communications. MCI has expanded its operations to include electronic mail, billing itself as the "nation's new postal system." You can access MCI Mail with a local phone call in 64 cities around the country and with a toll-free number to its Washington, DC, headquarters. You can use these numbers with your computer to transmit letters and documents to other MCI Mail subscribers in the U.S. and Canada or to Telex addresses anywhere in the world. If your recipient does not have access to MCI Mail or Telex, you can have a paper copy of the communication mailed or delivered. As of January 1, 1985, MCI Mail service was available in 41 countries.

MCI Mail's hard-copy communications are prepared using a laser printer at 18 locations in the U.S. Courier delivery is available within four hours in some locations, and overnight courier delivery is available in most major metropolitan areas. Delivery by mail usually takes two business days. Because they are prepared on a laser printer, the MCI letters look like they were done on a letter-quality printer and then photocopied. You can have your letterhead and signature placed on file with MCI so they can appear on your letters. Otherwise, the MCI Mail letterhead will appear on the first page of your letter.

You can log on to MCI Mail with either a 300- or 1200-bps (bit per second) modem. After you enter your user name and password, you will read some announcements and get a couple of news headlines before the main menu appears. Every function of MCI Mail is menu operated, and the service has extensive help files for every function. You can use the built-in text editor to prepare your document, or you can transmit a document you have already prepared. Once you finish, you can edit the document or reformat it before sending it. There is no limit to the length of the document you can send, but longer documents cost more.

You can read incoming messages or refer to messages you sent out earlier. MCI Mail also offers you access to Dow Jones News/Retrieval or lets you order discount merchandise from on-line advertisers.

EASYLINK

Western Union apparently designed EasyLink for experienced users who already understand how the system works. You can access EasyLink with either a 300- or 1200-bps modem. You will find no descriptive prompts or menus to lead you through the system. You log on at the ID? prompt by giving a terminal description, your ID number, your user name, and your password. You enter these on a single line, separated by spaces and a period. You will not see what you are typing if you are operating in full duplex.

Once you gain access to EasyLink, the cryptic PTS prompt greets you. You can find out what your options are by using the on-line help facility or by reading the package's *User Guide* or quick-reference guide. Essentially, your choices are: send one of several types of messages, read messages waiting for you, or use the help facility. An information database called FYI is also available to EasyLink subscribers, but not from within EasyLink.

EasyLink gives you a wide variety of ways to send a communication to others. You can send a message directly to another sub-

(continued)

Wayne Rash Jr. is a member of the professional staff of American Management Systems Inc. (Federal Consulting Group, 5th Floor, 1925 North Lynn St., Arlington, VA 22209). He consults with the federal government in areas concerning microcomputers.

scriber's mailbox, just as you can with MCI Mail, and you can have a message mailed to a nonsubscriber using what Western Union calls a "computer letter." Computer letters are mailed from Western Union's facility in the Washington, DC, area, which means that delivery can take a while for some sections of the country. Unlike MCI's laser-printed letters, the EasyLink computer letter is printed on what appears to be a Teletype printer using only uppercase letters.

Like MCI Mail, EasyLink lets you send messages to Telex addresses and gives you a Telex address for replies. Since you are using Western Union, you can use EasyLink to send telegrams, mailgrams, and cablegrams. Western Union also has an arrangement with the U.S. Postal Service that lets you send messages through the E-COM system, although the long-term existence of that service is questionable.

Using MCI Mail

Working with MCI Mail, especially for the inexperienced, casual, or infrequent user, is a pleasant experience. About the only information you have to remember is your password. As you enter the system, every possible command is listed for you (see photo 1). The help files are extensive and detailed, and you can specify the command or function for which you need help. Since the on-line time on MCI Mail is free, you don't feel the need to rush the process unless you're using the 15-cents-per-minute 800 number.

Creating a message is easy. Following the directions on the main menu, you type the word CREATE and enter the text editor. The next prompt asks for the addressee. After you type in the name, MCI Mail checks to see whether it matches the name of a subscriber. If one or more names match, you are shown a list of names and asked to pick the proper one. If the person you want is on the list, you choose him; otherwise, you will be asked to enter his address so the message can be mailed. You can name any number of addressees since the TO: prompt will appear until you enter a blank line. You will be prompted to enter the mailing address of the recipient and the subject of the message. Then MCI Mail prompts you to enter the text of the message.

The basic rate for an MCI Mail message is $1 for an "MCI ounce" transmitted electronically. An ounce equals 7500 characters. Short messages of 500 characters or less cost 45 cents. The cost for the first ounce is $2 if the letter is mailed. In areas where courier service is available, you can have a letter hand-delivered overnight for $8 and within four hours for $30. In each case the cost for an additional ounce is $1, although for courier delivery the second ounce is free. If you are sending to a Telex address, the ounce is quite a bit less, about 400 characters, due to a limit set by Telex. International rates are higher than domestic rates, but still within reason. MCI gives you a Telex number so your correspondents can answer you by Telex. If you use the toll-free number, you are charged an extra 15 cents per minute.

Once you complete your message, you can read it. If you want to make changes, an MCI editing mode has its own menus, prompts, and help files. You can also see what your document will look like when it's printed, complete with spaces reserved for the letterhead and the page breaks. You can use the edit mode to reformat the letter. Once you are satisfied, you tell MCI to send your document by typing SEND followed by any optional delivery methods. Once you send the message, a copy is placed in your Out box for a day or two. This makes it easy to refer to messages later.

Checking for messages is also easy; MCI Mail tells you that your In box has a message. You might also be told that an unfinished draft is on your desk, in the event that you terminated an earlier session for some reason before sending a message. This is one of the nice features of MCI Mail. Once you start creating a message, it stays in the MCI system. If your computer or phone goes dead or your modem explodes, the draft of your message

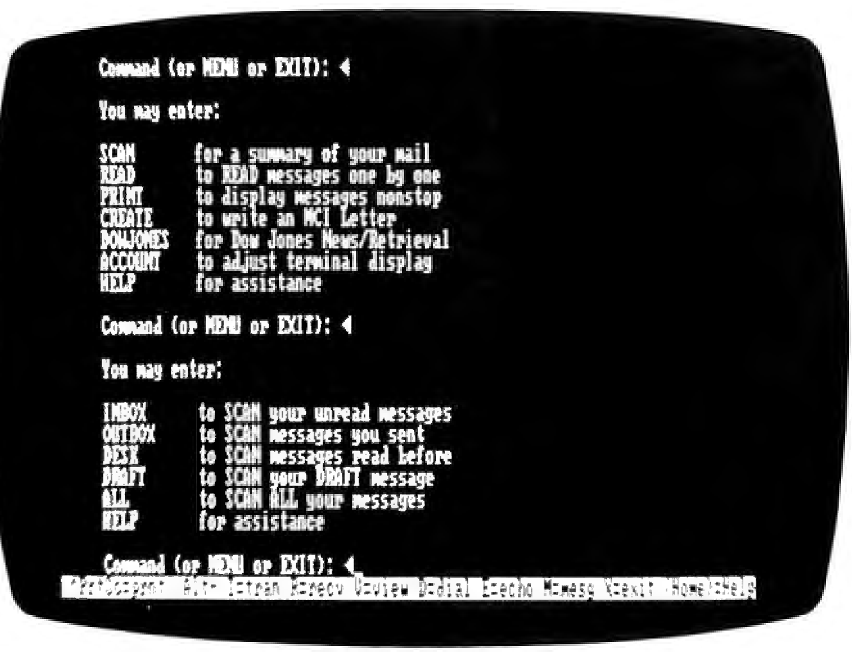


Photo 1: *Entry-level and Scan menus for* MCI *Mail. Your correspondence is organized like an office desk. The* In *box holds incoming messages, the* Out *box holds copies of messages sent, the desk holds copies of messages received, and the draft folder contains a message written but not sent.*

will be waiting when you return.

As I mentioned earlier, you can do a lot besides send and receive messages. MCI Mail has an advertising section where you can order anything from gifts and travel services to fanfold paper and floppy disks. You also have access to Dow Jones News/Retrieval at regular Dow Jones rates. Off-peak rates are 20 cents a minute for 300-bps connections or 40 cents for 1200-bps service. Incidentally, Dow Jones customers also have access to MCI Mail as part of their subscription.

USING EASYLINK

My first impression of EasyLink is that it isn't very easy. As I've already discussed, logging on to the system is complicated and tedious.

Logging on wouldn't be such a problem if you were given the necessary information to enter. For example, the terminal ID is necessary if you are using a personal computer and a modem, since EasyLink's default mode does not seem to work with that type of equipment. The terminal codes are listed in Appendix E in the *User Guide*, but the differences between the 24 terminal codes aren't explained. Many users will have little luck deciphering them. The first time I used EasyLink it took me four tries to log on.

Once you get past the log-on sequence, you are faced with the PTS prompt (see photo 2). At this point you have to enter a slash followed by a command. Since EasyLink has no menu, you will have to look up all the commands in the documentation or read the on-line help file. If you don't have a local-access phone number, looking at the help file is going to cost you 15 cents per minute. Fortunately, Western Union has over 400 local-access phone numbers in the U.S.

Since the charges for EasyLink are based on the actual connect time, you will save yourself money if you prepare your messages ahead of time and transmit them to EasyLink. You can also save money if you minimize use of the on-line help by using the manual instead.

You are also charged by the minute for the time it takes you to send messages. The normal charge for a 1200-bps connection is 45 cents per minute. If you like to compose on line or if your modem program can't transmit easily, this can run into money. You can save 40 percent by calling during off-peak hours (12:01 a.m. to 7 a.m. local time).

EasyLink has a number of charges besides the connect time. For example, a computer letter costs you $1.25 for the first page and 40 cents for each additional page. A three-page letter that costs you $2 to send on MCI Mail will cost you $3.30 on EasyLink, assuming the total connect time was two minutes, the time required to send the document was one minute, and you called using the EasyLink toll-free number. Using a local-access number would reduce the cost by 45 cents.

Sending messages to other EasyLink subscribers is less expensive. The basic charge is only 45 cents per minute for 1200-bps service, plus 15 cents per address. A short message could go out for less than the equivalent message on MCI Mail, but a longer one could cost somewhat more. If you have to use the WATS line to call EasyLink, your costs are almost certain to be higher.

If you are a low-volume user of electronic mail, EasyLink will be a substantially more expensive service. Even though it has no sign-up fee, EasyLink has a $25-per-month minimum charge. Depending on the type of electronic mail you use, you might have to send one piece of mail per day just to break even.

DOCUMENTATION

EasyLink definitely has the more complete and attractive documentation. When you sign up for EasyLink, Western Union sends you a bookshelf-size binder. Sections of the book are marked by tab dividers, and the pages are attractively typeset and easy to read. This is an advantage because you're probably going to spend lots of time reading this manual.

A disadvantage is that the manual is not well organized. The process of calling EasyLink, logging on, creating

(continued)

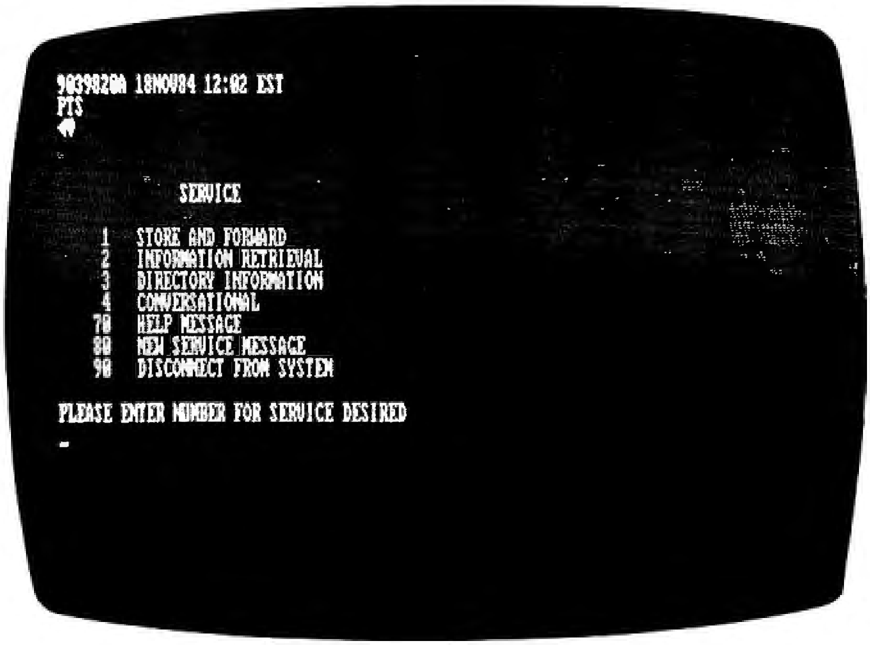


Photo 2: *Entry-level prompt and help menu for EasyLink. You enter commands by typing a slash and a command word, such as* /SCAN *to list all messages,* /READ *to read a message, or* /HELP *for the help files.*

AT A GLANCE

Name
EasyLink

Service Supplier
Western Union Telegraph Company
One Lake St.
Upper Saddle River, NJ 07458
(800) 336-3797 ext. 908

Requirements
Personal computer, modem, and telecommunications software, or dedicated communications terminal

Special Features
Messages can also be sent via Telex, telegrams, cablegrams, mailgrams, and through the U.S. Postal Service E-COM system

Optional Software
EasyLink Instant Mail Manager program ($95) requires IBM PC or compatible computer with one disk drive, 256K bytes of RAM, and asynchronous communications modem

Price
Minimum monthly charge: $25
EasyLink mailbox message (maximum 200,000 characters):
30 cents/minute (300 bps)
45 cents/minute (1200 bps)
EasyLink to Telex (maximum 200,000 characters):
43 cents/minute (300 and 1200 bps)
Mailgram message overnight letter (maximum 15,000 characters):
First page (2700 characters) $3
Each additional page (3500 characters) 75 cents
Computer letter service (maximum 25,000 characters):
First page (2700 characters) $1.25
Each additional page (3500 characters) 35 cents

Name
MCI Mail

Service Supplier
MCI Telecommunications Corporation
1900 M St. NW
Washington, DC 20036
(800) 424-6677

Requirements
Personal computer, modem, and telecommunications software, or dedicated communications terminal

Special Features
Messages can also be sent via Telex, via mail delivery, or via overnight or four-hour hand delivery

Optional Software
MCI Mail Access program ($49.95) requires IBM PC or compatible computer with one disk drive, 256K bytes of RAM, and asynchronous communications modem

Price

Instant letter	
500 characters or less	$0.45
7500 characters	$1
MCI letter (mail delivery)	$2
Overnight letter	$8
Four-hour letter	$30
Each additional 7500 characters	$1
Annual mailbox fee	$18

and sending a message, and getting off again requires a great deal of flipping through the manual. All the time you're looking up what to do next, the connect charges are mounting if you're calling on the WATS line or are in the midst of creating a message. [*Editor's note:* EasyLink *has since issued a new* User Manual Release 1.3 *that appears to be rewritten and better organized.*]

The MCI Mail manuals are shorter, less fancy, and paper-bound. They include the *Welcome Kit and Service Guide*, which gives an overview of the service, contains some basic information on performing routine functions, and explains the services available; and the *Basic User's Guide*, which gives detailed information on the use of MCI Mail. The manuals skip some of the functions of MCI Mail (for example, sending a Telex message).

The manuals are much less important for the routine use of MCI Mail, however, since the menus lead you through most functions quite well. The help files are also excellent and do not have a connect charge.

CUSTOMER SUPPORT

I had occasion to call customer support at MCI Mail twice, and at Western Union three times. The personnel at MCI Mail were helpful and familiar with the service. I received accurate, complete answers to both questions. Unfortunately, MCI Mail customer support is not open on weekends.

Western Union's customer service is nearly a total contrast. The customer-service lines are open on weekends, but they might as well be closed. Regardless of the time I called, the support representatives showed little familiarity with EasyLink. Once I was told that no one knew anything about it, but that the representatives were trying to learn. In another case, the representative had never heard of a computer letter and could offer no information on how to send one or on how long it would take to deliver.

CONCLUSIONS

Both EasyLink and MCI Mail offer communications packages to make

(continued)

EasyLink is slow in sending printed material and can be "user-hostile."

using their services easier. I have not had the opportunity to test them, but the information I have about them indicates that they are functionally equivalent. Both systems run on the IBM PC or close compatibles, and both make logging on and sending messages almost automatic. I would consider such a package essential for the use of EasyLink.

I found the difference between these two services to be substantial. MCI Mail was easy to use and fairly inexpensive for the low-volume user, and it presented a much more attractive product when messages were delivered on paper. Overnight or four-hour delivery of printed material can be critically important in some circumstances.

On the other hand, EasyLink was anything but easy. For the low-volume user it can be very expensive, and a printed computer letter is not particularly attractive. In addition, EasyLink is slow in sending printed material and can be "user-hostile" in the process. Twice I tried to send myself a computer letter in order to compare delivery time and appearance. The first try was canceled two days after I sent it because a line was too long. The second try took eight days to arrive. I should add that Western Union has plans to implement two-hour and overnight courier delivery in 1985.

EasyLink might be easy if you have the communications software sold by Western Union, and it might be relatively inexpensive if you send large volumes of electronic mail. This is especially true if you need the ability to send telegrams or use the Postal Service's E-COM system. Otherwise, MCI Mail appears to be the electronic mail service of choice. ■

Mannesmann Tally MT 160

An adaptable dot-matrix printer

BY MARK J. WELCH

Mannesmann Tally's MT 160 is a small, high-speed, dot-matrix printer. You can configure the printer using front-panel buttons and a printer-generated menu. The printer features high-speed, draft-quality printing; a slower correspondence-quality mode; and a wide range of character sets and printing formats.

The MT 160 is compact—considerably more compact than, for example, Epson's MX-80—but surprisingly heavy at 18 pounds. It includes both serial and parallel interfaces, so it can be connected to virtually any computer.

Mannesmann Tally advertises the MT 160 as printing at 160 characters per second (cps) in draft-quality mode, or 40 cps in correspondence-quality mode. In actual use, the MT 160 is faster in draft mode than the Epson FX-80, also advertised as a 160-cps printer. In its higher-quality correspondence mode, however, the MT 160 slows down severely, lagging behind the FX-80.

A wide variety of print modes are supported by the MT 160, including underlining, emphasized (bold), superscript, and subscript (see figure 1). In draft-quality mode it can print 5, 6, 8.3, 10, 12, 16.7, and 20 characters per inch (cpi). In correspondence-quality mode, it can print 10 or 12.5 cpi or proportional spacing.

In draft mode, the MT 160 prints characters in a 7- by 9-dot matrix. Uppercase characters use the top 7 by 7 matrix, with lowercase descenders using the bottom of the matrix. In correspondence mode characters look almost like typewriter quality. A line is printed in two passes. The paper is advanced a fraction of a line between passes, so characters are printed in a 7 by 18 matrix. In emphasized mode, characters are again printed twice; the second impression is slightly offset to the side. When the correspondence and emphasized modes are combined, it's almost impossible to distinguish any dots.

The printer can be reconfigured to recognize control codes used for other printers. This is especially helpful since very little software supports the MT 160's standard control codes. WordStar text and Lotus 1-2-3 graphs were printed accurately by the MT 160 using this mode. Mannesmann Tally also offers a configuration program for Lotus 1-2-3.

The MT 160 doesn't support italic characters even when Epson control codes are used. The lack of italics is a serious handicap, although emphasized characters or underlining could be used instead.

PROGRAMMABLE FEATURES

One of the most convenient features of the MT 160 is that configuration details can be selected using the front-panel buttons and printed menus, so no DIP (dual-inline package) switches or jumpers are involved in configuring the printer for your computer (see listing 1). The current configuration is stored when the printer is turned off.

Many of the print features available through software control can be set as default parameters (see listing 2). Any of the seven character sets available can be chosen. If the printer is usually used for printing documents in another language, a European or other character set can be selected as the default. Likewise, form-length, print-format, and communications parameters can be reset.

To reconfigure the printer for my serial interface, for example, I simply pressed the Yes and No buttons to activate the menu, answered Yes to the CHANGE COMM CONFIG? prompt, and again to SERIAL prompt. While responding to prompts, I had to press No quite a few times, but this is far simpler than removing the cover to move jumpers and reset DIP switches.

There are six control buttons on the front panel of the MT 160. The on-line, form-feed, line-feed, and test buttons do what you'd expect. Two additional buttons labeled Yes and No allow you to answer the questions

(continued)

Mark Welch is a BYTE staff writer. He can be contacted at POB 372, Hancock, NH 03449.

You'll have to go out of your way to build a special cable to hook the MT 160

in the reconfiguration mode and also combine with other buttons for special functions. For example, pressing the Yes and the line-feed buttons causes the printer to toggle from correspondence to draft mode.

I dislike loud, nonstop fault alarms, so I appreciate that the MT 160 makes no noise when a fault occurs. A red light indicates a problem. While this is better than the endless whine some printers produce when the paper runs out, I wish it would give a little beep so I'd know something was wrong right away.

The MT 160 is not a standard serial printer. Its RS-232C connector uses pins 11 and 19 to send a busy signal, something most computers don't expect. As a result, you'll almost certainly have to buy or build a special cable to connect the MT 160 to your computer. For my older CP/M system, I switched pins 19 and 20. For the IBM Personal Computer (PC), Mannesmann Tally's service department says pin 5 must be swapped with either pin 11 or 19. Since the MT 160 is configured as data-terminal equipment (DTE), IBM PC users will also have to swap the connections to pins 2 and 3 (printer cables are readily available that way). The use of pins 11 and 19 was a surprise to me. You'll have to go out of your way to hook up the MT 160 to your system by either paying a premium to have a cable built your way or spending the extra time building your own.

Another problem I often find with printers is that the paper feeding out can feed right back into the printer. You'd almost have to work at it to get that to happen with the MT 160.

Power and interface cables often seem to need the same path as the paper. The MT 160's power cable has a right-angle connector at the printer end and feeds though a slot in the back of the left side of the printer, so there's no interference with the paper feed.

The parallel and serial connectors, however, feed straight out through the path the paper needs when it feeds from below. This problem was aggravated when, rather than rewire the printer cable, I used an adapter that also extended the printer's serial port. The right side of the paper dragged against this adapter and tore several times; there seems to be no solution except to wire a new cable especially for the MT 160. The parallel port is closer to the center of the back of the printer, so the cable would have to be routed underneath the printer.

There's never been a standard printer ribbon and Mannesmann Tally hasn't tried to change that. When my first ribbon faded, I tried to buy a replacement at several local computer stores. No one at any of the stores had seen this kind of ribbon before and delivery estimates ranged from two days to two weeks. The ribbons cost about $13 each—well above an average price for other types. If you buy an MT 160, you should probably

(continued)

This is regular draft-quality ou
This is the double-pass 'corresp mode.
This i emphasized mode.
This is emphasized corr espo
This is 10 cpi printing.
This is 12 cpi pr g.
This is 16.7 cpi printi
This is 20 cpi printing.
This is doub
This is double-w 8. cpi printing
This is double-width 1 cpi printing.
This 12.5 pi correspo ce-q
This is proportional corres
This s underli text.

Figure 1: *Print samples from the Mannesmann Tally MT 160 printer.*

AT A GLANCE

Name
MT 160

Manufacturer
Mannesmann Tally
8301 South 180th St.
Kent, WA 98032
(206) 251-5500

Type
High-speed, 80-column dot-matrix printer

Size
14¼ by 9¾ by 6¼ inches

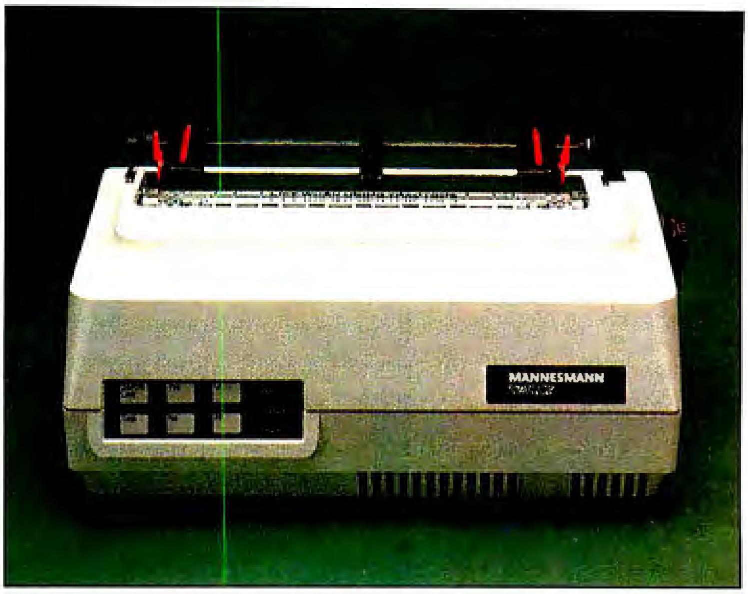
Weight
18 pounds

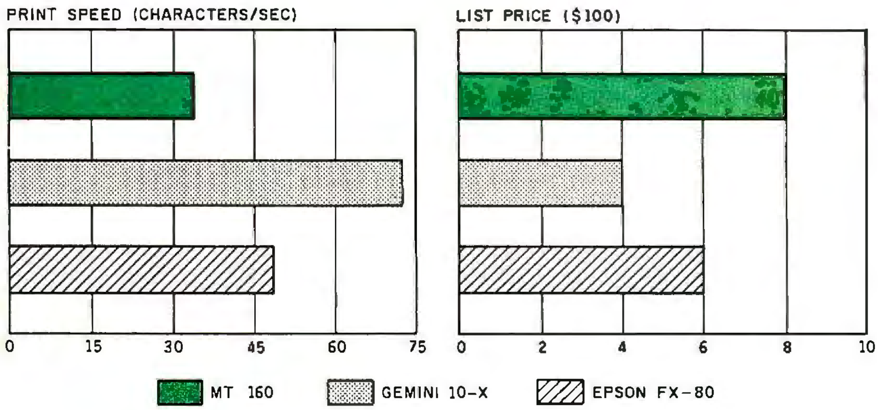
Equipment Needed
Computer with parallel or serial interface, cable

Features
Six front-panel buttons; reprogrammable configuration; high-speed draft quality or slower correspondence quality; international character sets; graphics

Documentation
Operator's manual, 64 pages

Price
$798





This is the Mannesmann Tally MT-160 printe
This is the Epson FX-80, draft mode. This
This is the Star Gemini-10X This is the St

The output from the Mannesmann Tally MT 160 dot-matrix printer in draft mode is compared with the Epson FX-80 and the Star Micronics Gemini 10-X, both in draft mode. The pitch for all printers is 10 cpi. The print speeds were determined by dividing 3000 characters (50 lines of 60 As each) by the time required to produce the output. (See "The Art of Benchmarking Printers" by Sergio Mello-Grand, February 1984 BYTE, page 193.) Prices shown are list.

Listing 1: *An example of the interactive way of changing the configuration of the MT 160 printer. The printer prints out a short question to which you might respond by pressing either a Yes or No button on the printer's control panel.*

```
RESTORE DEFAULTS ?                      NO
CHANGE FORM LENGTH ?                    NO
CHANGE PRINT FORMAT ?                   YES
        CHANGE LPI ?                    NO
        CHANGE CPI ?                    YES
                10 ?                    NO
                12 ?                    NO
                16 ?                    NO
                20 ?                    NO
                CORR.QUAL. 10 ?         NO
                CORR.QUAL. 12 ?         YES
        CR IMPLIES LF ?                 NO
        LF AT FULL LINE ?               YES
        POPC ?                          NO
CHANGE CHAR SET ?                       YES
        USA ?                           NO
        UK ?                            NO
        NOR/DAN ?                       NO
        SWE/FIN ?                       NO
        GER ?                           NO
        FREN ?                          NO
        SPAN ?                          YES
SLASH ZERO ?                            NO
CHANGE AUX CODE SET ?                   YES
        NONE ?                          NO
        E CODES ?                       NO
        D CODES ?                       YES
CHANGE COMM CONFIG ?                    YES
        CHANGE BUFFER SIZE ?            NO
        PARALLEL ?                      NO
        SERIAL ?                        YES
        CHANGE BAUD ?                   YES
                9600 ?                  NO
                4800 ?                  NO
                2400 ?                  YES
        CHANGE NO. DATA BITS ?          NO
        CHANGE NO. STOP BITS ?          NO
        CHANGE PARITY ?                 NO
        CHANGE BUSY ?                   NO
        CHANGE COMM PROTOCOL ?          NO
END OF MENU
```

Listing 2: *The current status of the printer can be printed out by pressing the No button.*

```
FORM LENGTH         11 INCH
LPI                 6
CPI                 CORR. QUAL.
CR IMPLIES LF       NO
LF AT FULL LINE     YES
POPC                NO
LF IMPLIES CR       NO
CHAR SET            SPAN
SLASH ZERO          NO
AUX CODE SET        D CODES
BUFFER SIZE         MAX
INTERFACE TYPE      SERIAL
BAUD                2400
NO. DATA BITS       8
NO. STOP BITS       1
PARITY              NONE
BUSY                LOW
PROTOCOL            NONE
```

buy spare ribbons and reorder when you install the last one.

Documentation

I've never seen a printer manual that I liked. I found myself flipping through the MT 160 manual hunting for simple details I wish were included in a one-page appendix. To its credit, the manual does include a careful description of most (not all) of the configuration menu, as well as brief explanations for each print command with examples in BASIC.

However, the explanations were too short, while the four-page control-code appendix was too long to be useful as a quick-reference guide. Several control-code commands weren't explained enough and left me wondering exactly what they did.

I'm not sure a novice would understand the MT 160 manual, but anyone who has used another printer should be able to figure it out fairly quickly. There is enough information in both manuals for a programmer to use most of the printer's features, though some experimenting may be necessary.

Mannesmann Tally doesn't have a toll-free number, but I called the company several times while configuring the printer and looking for a new ribbon. Each time I was put through to the service department quickly, and the person I spoke with answered my questions competently.

Conclusions

The Mannesmann Tally MT 160 is a fast, high-quality, dot-matrix printer, but its price led me to expect more. Particularly irritating was the lack of italic characters, the unusual serial cable configuration, and the nonstandard printer ribbon. Even though the printer is well designed, small and quiet, I had problems using an adapter with the serial port.

This machine is probably not as suited for the home user as some other printers, notably the Epson FX-80. However, its speed, print quality, and diverse print modes might make it appropriate for office use. ■

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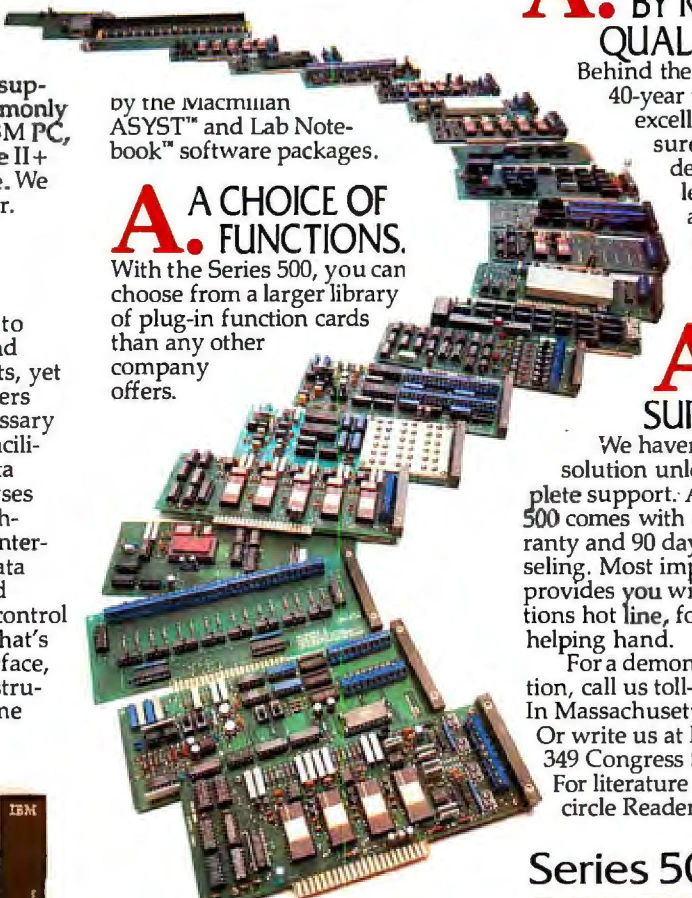

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Inquiry 304

SAGE II AND IV

I was pleased to see the review by Allen Munro of the Sage II and Sage IV in your July 1984 issue (page 235). I agree with the author's conclusion that the Sages are fast, powerful, and reliable machines. I've owned a Sage IV for almost a year now and I'm extremely pleased with it. Not one single glitch so far.

After getting used to the power and speed of the Sage it's hard to imagine going back to a slower machine. The amount of Sage software in terms of operating systems, languages, utilities, and applications may cover the broadest range in the industry. (How many computers offer 10 operating systems and languages such as Ada and APL?) I do have some problems with Mr. Munro's review, however. I find several misleading and simply incorrect items.

First, the graphs are terribly misleading. The price graph states that the comparison is for systems with "two high-capacity floppy-disk drives," yet the Sage line lists the Sage IV at $7300, which includes a hard disk. By the way, the price shown for the IBM PC XT is considerably lower than we've paid for that machine.

The spreadsheet comparison reaches the point of being ridiculous. The graph is labeled "Multiplan." Yet we read in the fine print that the Sage run was actually on Timberline, a p-System spreadsheet with many more bells and whistles than Multiplan that is consequently much slower. This is NOT a benchmark.

The BASIC calculation comparison is not valid. Even though the Sage's power is shown to be an advantage here, the comparison is still against the Sage. The procedure states that the calculation test involved 10,000 multiplication and division operations. Later, in the fine print, we find that the Sage runs were using 64-bit real arithmetic.

There are also minor discrepancies in the system standard configurations. For instance, both the II and IV come equipped with the IEEE-488 interface as standard equipment, not just the IV. Also, the picture of the computer shown in "At a Glance" is a Sage II, not a Sage IV. True, Sage did try for a short time to market all machines as the IV, but soon returned to the II/IV separation. As many Sage ads as you've run, I'm sure you could have obtained the right pictures.

Incidentally, Mr. Munro failed to note some of the more exotic standard features of the Sage, such as the fact that its multiuser capacity is not operating-system-dependent, which means that different operating systems with multiusers on each can operate simultaneously. Or that multiusers can be assigned to the same terminal, thus producing concurrency with any operating system.

I'm a professional engineer with over 20 years of experience in the computer arena. I currently direct a large staff of scientific programmers using everything from PCs, HPs, 3033s, and 3081s up to the CRAY-1. I'm convinced that the Sage is by far the best computer value in today's market. It outperforms many upper-end "business oriented" machines, including several minicomputers, at a fraction of the price.

BILL BRUMMETT
Dhahran, Saudi Arabia

We thank Mr. Brummett for noting an error in our Sage review. The prices listed for the Sage II/IV on the "At a Glance" page were incorrect. The prices were listed as $3200 and $7300. The prices for the BYTE standard configuration (including terminal, two drives, and BASIC) should have been $4790 and $8190. The price of the IBM PC, not the XT, was given in the graph and was labeled as such.

For our Spreadsheet test we usually use Multiplan. For the Sage, we used the only spreadsheet available, Timberline. The purpose of our spreadsheet test is to determine how fast a given system/software combination can perform a given task. In this case, the Sage/Timberline combination is twice as slow as the IBM PC/Multiplan combination. Incidentally, bells and whistles do not always slow down a program: for example, Lotus 1-2-3 runs three times faster than Multiplan on the IBM PC.

As for the BASIC calculation test, again we wanted to time how long it took a given system to do a given task. Most calculations only require seven significant digits. If a system cannot efficiently support this type of arithmetic, then in this test that system is penalized slightly and justifiably.

Finally, there was what looked to be a discrepancy in the photograph of the Sage. The machine in the picture, which we received directly from Sage, was configured as a Sage II but was marked as a Sage IV. We were aware of the discrepancy at the time, but we can only photograph what we receive. We do not change or alter products to put them in a better light. We are, however, glad to hear that Sage is now labeling their products more logically.

—Rich Malloy
Senior Technical Editor

SANYO MBC 550

Bill Sudbrink was generally fair in his review of the Sanyo MBC 550 (August 1984, page 270). However, there were obvious errors in the article that do a disservice to an excellent product. To begin with, the comparison of execution time between the IBM and Apple running Multiplan to the Sanyo running CalcStar was misleading and irresponsible. Only the fine print at the bottom of the page explained the untruth of the spreadsheet (Multiplan) caption. The fine print further stated that "Sanyo BASIC apparently cannot access other disk drives." This is incorrect. The author apparently was not aware that the catch here is that the drive specifier *must* be in uppercase, such as LOAD "B:filename". Granted, the documentation did not point this out, and I agree that it was an unfortunate oversight.

James G. Droppo Jr. feels that the Sanyo BASIC screen editor is limited in comparison to the IBM Personal Computer (PC) BASIC screen editor (see "The Double-Drive MBC-555," August 1984, page 278). Maybe so. However, I find it much more convenient than that which comes with some of the PC-compatibles. The Sanyo's feature of being able to suspend and resume scrolling during a list is super. Entering changes during program debugging is also far superior. I can make

(continued)

changes all over the screen, then with one touch of the Break key I can be assured that every change has, in fact, been entered into the program. Try that in IBM's BASICA!

After having used a Columbia professionally and a Sanyo recreationally on a daily basis for several months, I find that I prefer to use the Sanyo, if possible, because of its superior keyboard arrangement, its large Return key, a better key "feel," its handy reset switch, and the dedicated asterisk key.

ORRIN B. ISEMINGER
Colton, WA

REVISING THE SIEVE

Mark Bridger's article, "Four Logos for the IBM PC" (August 1984, page 287), includes two benchmark programs using the Sieve of Eratosthenes—one iterative and one recursive. They execute in about the same amount of time but differ in how many primes can be discovered before stack space is gone. IBM Logo used the stack space best but it could not get all the primes through 1500 using the recursive version in the review.

In the November 1984 BYTE (page 356), Ian MacMillan of Logo Computer Systems Inc. gives a revision of the recursive version that finds all primes through 1500 on a 128K-byte IBM PC. MacMillan's program runs about as fast as the other two; its main feature is efficient use of tail recursion.

The version in listing 1 uses Logo's property lists to increase simplicity. It might not use stack space as efficiently, but it seems to execute on a 128K-byte IBM PC.

It also seems to execute faster. For example, the Zenith Z-150 takes over 35 minutes for the primes through 1500 using MacMillan's version but only 15 minutes for the version in listing 1.

FURMAN SMITH
Montgomery, AL

Listing 1: *Revised recursive version of the Sieve program.*

```
TO SIMPLE.SIEVE :LIMIT
MAKE "PRIME 2
CARRY.ON
END

TO CARRY.ON
IF :PRIME > :LIMIT (TONE 300 3 STOP)
PRINT :PRIME
MAKE "FOOT.PRINT :PRIME
CROSS.OUT
MAKE "PRIME PRIME.AFTER :PRIME
CARRY.ON
END

TO CROSS.OUT
IF :FOOT.PRINT > :LIMIT (STOP)
MAKE "FOOT.PRINT :FOOT.PRINT + :PRIME
PPROP :FOOT.PRINT "? "N
CROSS.OUT
END

TO PRIME.AFTER :NUMBER
MAKE "NUMBER :NUMBER + 1
IF NOT GPROP :NUMBER "? = "N (OUTPUT :NUMBER)
OUTPUT PRIME.AFTER :NUMBER
END
```

PEACHTEXT 5000

In the September 1984 Review Feedback (page 355), A. Stanbury reported problems with the PROP ON and PROP OFF commands for PeachText 5000. We had similar problems, and after about two months of talking to our dealer I was allowed to talk directly to people at Peachtree. They told me about the following patch that corrected the problem.

Use the Debug (under PC-DOS 2.0) utility to patch the PRINT.PGM portion of PeachText. When you are done the screen should look like the following:

```
DEBUG PRINT.PGM
-E3558
091B:3558   A0.F6 0D.06 08.FC 34.07
            80.01 A2.75 0D.0C 08.A0
091B:3560   F6.0D 06.08 FC.34 07.80
            01.A2 74.0D 04.08 FF.
-W
-Q
```

Refer to the Debug instructions for the correct interpretation of this information.

To make the superscript and subscript function work, it is absolutely essential to use one of the printers listed on the configuration menu. Unfortunately, there is no way to customize the printer driver to accommodate printers other than those listed. I hope this helps.

JOHN SONEWALD
Rolla, MO

I am writing in regard to the letter in Review Feedback from A. Stanbury (September 1984, page 355).

I have been using PeachText and its predecessor, the MagicWand, for more than six years and have yet to find anything I like better. By comparison, WordStar with its voluminous help messages, disk-intensive editing, and complicated commands is not worth the trouble. Stanbury complains that proportional spacing, character spreading, and sub- and superscript don't work with PeachText. It is stated clearly and often in the manual that these functions will only work with printers (such as the NEC Spinwriter) equipped to handle them.

The only complaint I have with PeachText 5000 is that it is not integrated, but it does the job and the price is right. The Heath H-110 (Zenith Z-100 clone) is also a best buy. It does everything better than the IBM.

ROD HALLEN
Medan, Indonesia

LEADING EDGE PC

Jeffrey Mazur did a good job in the review of the Leading Edge PC (September 1984, page 312). However, I want to bring up a couple of points.

First, the fan was not correctly designed. It draws air from inside the system unit and expels it out the back. This air is drawn through such convenient openings as the disk-drive doors. This results in dust deposits on the inside of the disk drive and other boards.

The second item concerns the Leading Edge word processor, which is excellent. However, the program came with very few printer drivers. After all, many users own

Okidatas and the newer Epsons. What caused my concern was that my MX-80 (type 3) is capable of solid underlining, italics, and super- and subscripting, but the word processor does not support these features. My dealer told me that Leading Edge will provide additional printer drivers in the future.

I feel that I have made the right decision in buying the Leading Edge PC. The only alternative is an IBM PC; if purchased locally with similar software, it would cost almost $14,000.

RAMESH INDHEWAT
Bangkok, Thailand

LEADING EDGE WORD PROCESSING

The software review entitled "Leading Edge and MultiMate" (November 1984, page 287) is strewn with bias and inaccuracies. Our documentation is being rewritten, the latest 1.2 version of the software has increased speed, and at no point in time could it be considered inefficient. If during the reviewing process the reviewer had called us to find out something about the future of our package, that could have been reported.

We are, if anything, faster than MultiMate in just about everything and give WordStar a run for the money in almost all categories. We also provide easy-to-use and easy-to-learn word processing that we feel is leagues ahead of WordStar. How does the reviewer know that "Programs like MultiMate and Leading Edge might be easy to teach because they are designed for correspondence and short reports, projects that require few commands"? Both Leading Edge and MultiMate have many similarities to the Wang word processor. Surely the reviewer doesn't intend us to believe that the original Wang word processor was designed solely for short reports and correspondence.

Finally, this is the only reviewer to date who did not like Leading Edge Word Processing or see it as a great value for the money. It is not wrong to be different or to state opposing points of view, as long as one has done the research correctly, thoroughly, and fairly. In comparing our 1.1 version with the current version of MultiMate and WordStar, the author has done a grave disservice to BYTE's readers.

J. B. ROYAL
Senior Vice President
Word Processing R&D
Leading Edge Products Inc.
Canton, MA

SPIRIT 80

I was pleased to see Mark Welch's review of the Mannesmann Tally Spirit 80 printer, (November 1984, page 335). I agree with your conclusions that it represents a fine combination of improved print quality and lower price.

I've experienced the occasional paper jamming that Welch mentioned, but only when I tried to print from the top of a cut sheet of paper. What seems to happen is that the paper is hampered as it first goes through the paper bail rollers and jams either against them or against the removable cover. The remedy is to have about a half-inch of paper past the print head when starting printing or a full sheet if beginning precisely at the top of the form is essential. If an adjustment of the top of the form is desirable you can ask the printer to pause at the end of the first page. Using these procedures, I've had no jamming.

Two points Welch does not mention might be of importance to some users. The cassette ribbons used by the Spirit 80 are specific to it and list for about $12, though I've found them for $7 at a discount house. Second, the replaceable print head is rated at 30 million characters, significantly less than some other dot-matrix printers; for medium use, I still consider it adequate (at 1.6K bytes per page, that represents about 19,000 double-spaced pages).

CHRISTOPHER CONLY
Seattle, WA

SANYO CUSTOMER SUPPORT

I would like to share Harvey J. Coopersmith's complaint in Review Feedback (November 1984, page 357) about Sanyo's poor response to owner's problems. I bought the Sanyo 1250 and had difficulty booting up the CalcStar program.

I forwarded to Sanyo the error messages, original disks, warranty, and original purchase receipt with instructions written in large letters to return the receipt for my income tax records. Sanyo returned the original disks with a scribbled note stating

(continued)

that its testing equipment found no problems. The booting problem remained, and Sanyo offered no explanations for the error messages. Moreover, the company did not return the warranty or the original purchase receipt as I requested. Fortunately, I resolved the booting problem by PIPping the components of CalcStar between the two disks.

MAXIM W. MIKULAK
Nesconset, NY

GIFFORD UPDATE

Since my recent review ("Gifford's MP/M 8-16," January, page 305) Gifford Computer Systems (2446 Verna Court, San Leandro, CA 94577, (415) 895-0798) has started shipping MC-DOS, the multiuser concurrent disk operating system. This operating system is one of the first implementations of Digital Research Inc.'s Concurrent CP/M 3.1 to be available for non-IBM hardware. MC-DOS resembles MP/M 8-16 at the user-interface level, so the user who is already familiar with the older Gifford offering needs little training. Upgrades include a simple update guide for converting from MP/M 8-16 to MC-DOS.

MC-DOS has several advantages, including increased speed. Concurrent CP/M is basically an outgrowth of MP/M-86 and uses disk buffering, directory buffering, hashing, etc., to allow faster operation. The M-Drive/H 512K-byte board is no longer used as a disk emulator but serves as a large hard-disk buffer. A utility locks any files into this buffer, so they are unaffected by the LRU (least recently used) technique of buffer flushing. This provides an MC-DOS user with the advantages of a large buffer and a solid-state disk emulator.

Gifford incorporated local-area networking into its new operating system. Optional Arcnet hardware is available for Gifford's S-100 systems and IBM PCs, and all appropriate utilities in the MC-DOS package have been modified.

Also new from Gifford is the Macrotech MI-286 dual-processor board, now supported and shipped in most Gifford systems. This board was designed as a plug-compatible replacement for the CompuPro 8085/8088 board. It comes in its standard configuration with a 6-MHz 80286, an 8-MHz Z80H, and a socket for an optional 5.33-MHz 80287 numeric processor. Operating in an 8086-compatible mode, the MI-286 offers as much as two-and-a-half times more throughput under ideal circumstances.

MC-DOS lists for $695, and you must order it for a specific hardware configuration. MP/M 8-16 is listed in the price guide for $1345. The networking software and a single board cost $895. A networking package for the IBM PC XT and compatibles is available. Passive hubs (connecting up to four nodes, 200-foot maximum) are $95, while an active hub (eight nodes, 2000-foot maximum) is $795. The Macrotech MI-286 processor board with the standard Gifford two-year replacement warranty is $1595, and the 80287 numeric processor is $650.

CHARLES H. STROM
New York, NY

THE COMPAQ DESKPRO

I noticed with interest in the November 1984 Reviewer's Notebook (page 261) that you have been using a Compaq DeskPro. The DeskPro is not compatible with the 384K-byte Quadram Quadboards; I have tried three in my DeskPro and each makes the screen go into outer space when the machine tries to switch resolutions on the monochrome monitor. Compaq claims on the telephone that this board is compatible with the machine, and people at Quadram have discussed it for the past six weeks or so, but I think it is clear that the board is not usable with this computer. Dealing with Quadram about this has soured me on them as a source of peripherals for IBM-type machines—their support is weak.

A couple of additional points: Compaq's documentation is helpful in setting up the machine, but it doesn't include much technical information (like a memory map), and Compaq's customer-support telephone number will only answer real questions from dealers, not end users.

GEORGE CAREY
Marietta, GA

REVIEW FEEDBACK is a new column of readers' letters. We welcome responses that support or challenge BYTE reviews. Send letters to Review Feedback, BYTE Publications, POB 372, Hancock, NH 03449. Name and address must be on all letters. ▮

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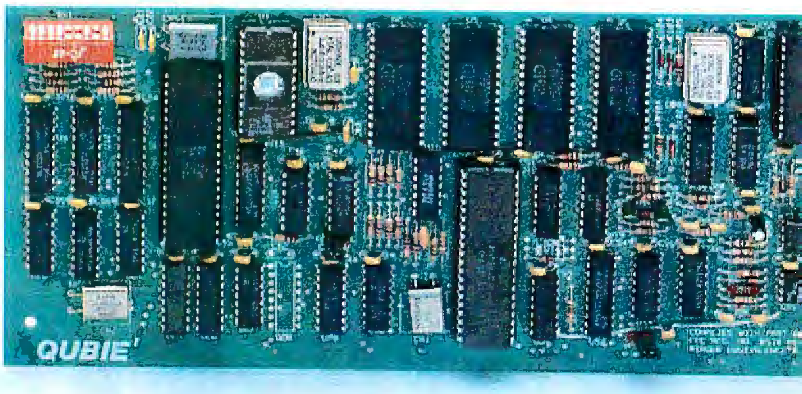

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TROUBLES HAVE WE ALL, and this month Jerry Pournelle mentions some space problems at Chaos Manor, talks about the problem of choosing computer books, and still finds time to look at some interesting goodies.

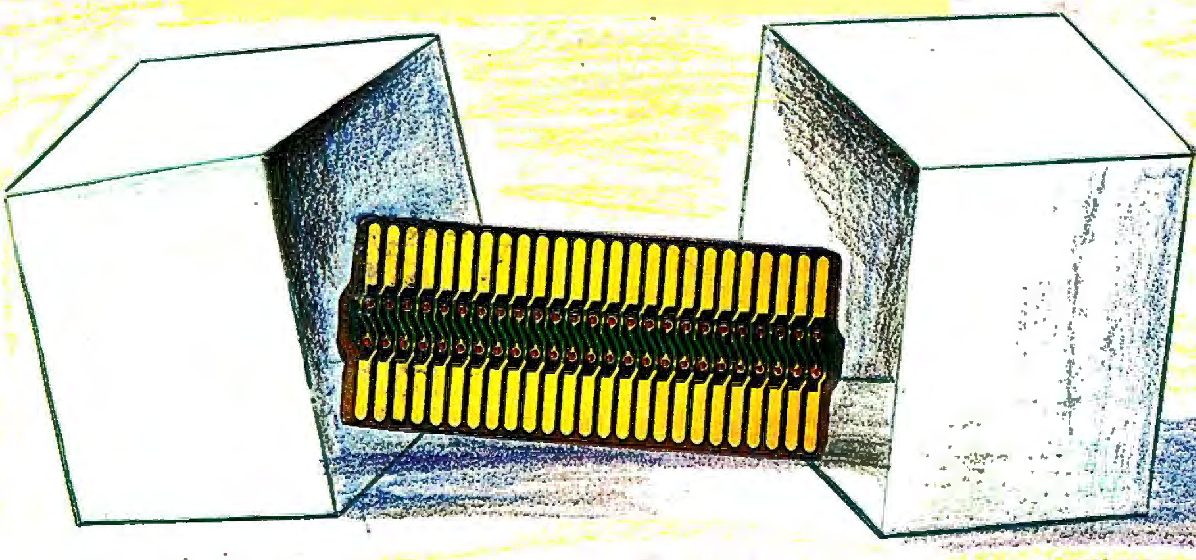
In BYTE Japan, columnist Bill Raike's trip to the 1984 Data Show provides some information on disk-drive storage technology and laser printers.

From California, BYTE West Coast looks at a high-resolution digitizer for the Mac, some new workstations, and the windowing game.

Dick Pountain, our U.K. contributing editor, appears to have found the system that he's always wanted—and this time it's affordable.

We introduce a new column this month—Computers and Law. Attorneys Robert Greene Sterne and Perry J. Saidman begin with the legal issues of copying software.

Also this month, Steve Ciarcia again finds time to answer readers' questions about his projects in Circuit Cellar Feedback.



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Troubles

BY JERRY POURNELLE

Jerry Pournelle holds a doctorate in psychology and is a science-fiction writer who also earns a comfortable living writing about computers present and future.

I have problems. My office, its extension, the back room, and indeed my whole house are filled with software, books, computers, and computer components.

I've foreseen the crisis. We have plans for rebuilding Chaos Manor, adding a large new library, office, and workshop as a second story. If I can get that up, I'll last awhile longer. Alas, my *real* problem is with the city of Los Angeles, which has taken nearly a year to process my application to let me build that second story. If I have any friends in the appropriate departments—it's a yard variance I need, to let me build out even with the existing office extension—HELP!

BOOKS AHOY

I've just sent in the final version of my *Adventures in Microland* (Baen Books, spring 1985). Like *The Users Guide to Small Computers* (Baen Books, 1984), it's a collection of my BYTE and *Popular Computing* columns with considerable updating. I don't *change* the columns, but I do add information and comments to make them up-to-the-minute timely. Indeed, *Adventures* will contain columns that haven't been published as I write this.

After I finished the book I called my publisher, Jim Baen; what he told me is very disturbing.

It also gives me a problem. I want to enlist your help in what I think is a cause important to all of us. So far, so good, but I'm hardly a disinterested party.

THE BOOK EXPLOSION

The problem is real: there's been an enormous explosion of computer books. *Publishers Weekly* estimated the total 1985 sales of computer books to be comparable to *fiction*. However, there are so many computer books that no one of them does very well. Moreover, many of those books are pure schlock. Many publishers, seeing the rapid expansion of the computer-book category, simply flooded the market with books regardless of their quality. Quick in, quick profit, quick out. The result is that the field will soon be awash in dreck; and by a kind of Gresham's law, the bad books drive out the good ones. Publishers who take their time, bringing out carefully edited books of high quality—publishers like Que—are already being forced out, leaving the field to the schlockmeisters and hypesters.

The problem is curable but complicated. What's happening is that book buyers—the book-chain and book-distributor officials charged with actually ordering the books—do not know the difference between the good and the bad. How could they? A year ago these same people were buying romances. Romances are down, computer books are up, so their assignments changed. They didn't read the romances they used to buy, and they aren't reading the computer books they buy now.

My books sell fine once they get to the bookstores—but the only reason they get to the store in the first place is that the salespeople remember me as a science-fiction writer. Frank Herbert wrote a computer book. So did Pournelle. Neither the book buyers nor the publisher's sales force ever heard of this column, or indeed of BYTE magazine; magazine sales are handled by entirely different people. Since buyers don't know the difference between good and bad computer books, they order "some of each." If the salespeople insist that a particular book is hot, the buyer may order twice as many of that one; still not enough to make any sales.

THE REMEDY

The only cure for this is consumer organization, and the only relevant organized consumer groups I know of are the enthusiasts and hobbyists. The largest block of those are BYTE readers. There was a time when we enthusiasts *were* the computer revolution. We're still the largest organized part of it. We're also the people who lose the most

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if computer-book publishing is abandoned to drecksters and schlockmeisters. We *need* good books.

It's time for us to do something about the situation. If we don't, no one will.

Several things must happen. First, most of us are accustomed to buying computer books in specialty stores. That's not the way to influence what's published. The impact is made in regular bookstores, and particularly in the big book chains: which means that if you don't see the computer books you want at your local B. Dalton and Waldenbooks, say something to the manager. Better yet, put in a special order. The only way the book buyers will know which are the best computer books is for store managers to tell them—and the only information source the managers have is *us*. Most of their customers don't know a good computer book from a bad one. The average computer-book buyer is so used to being ripped off that yet another overhyped horror isn't even noticed.

It isn't enough to praise the good books. You must also condemn the bad. Now do understand what I mean by a bad book. I'm not talking about books that I disagree with or say "bad things," as for example the silly books that try to claim that computers are bad for poor people. I am thoroughly uninterested in censorship of ideas. No; by "bad books" I mean those that are poorly edited, filled with typos and misspelled words, crammed with jargon; books with neither index nor analytical table of contents; books written so poorly that you don't know whether or not you disagree with the authors because you can't understand what they said. Books with programs that can't possibly run. Books filled with obsolete materials.

There are plenty of such books, and if you discover that a particular publisher seems to bring out a lot of them—you won't have any trouble finding them if you look on the shelves of your local B. Dalton—then take them to the bookstore manager. Show her why these are bad books. Make sure she notices which publisher put them out.

There's another odd phenomenon: newcomers to the computer field are desperate for books, so much so that they pay little attention to price. It's strange: but a book will sell about as well at $19.95 as it does at $9.95. Publishers notice this sort of thing. If it keeps up, pretty soon there aren't going to be any low-cost books. Incidentally, my own Pournelle Users Guide books, including both *The Users Guide to Small Computers* and *Adventures in Microland*, sell for $9.95. They'd sell for even less if there were the slightest evidence that lowering the price would sell significantly more books.

If a certain publishing line consistently puts out overpriced schlock, complain loudly and often. If you find a publisher who consistently puts out good books at decent prices, tell your store manager that.

Baen tells me that he can make five times the profit publishing science fiction—quality science fiction—than computer books. It's true for me, too: my advances for computer books are a pretty small fraction of what I can get for science fiction. So far, the love of the field—I really *like* writing about little computers—keeps me putting out the books, while hope that the market will settle into something reasonable keeps quality outfits like Baen Books publishing them, but it's a strain. The real computer enthusiasts, led by BYTE readers, could make things a lot easier for the good guys.

SemiDisk

Speaking of good guys, SemiDisk Systems of Beaverton, Oregon, continues to develop a high-quality line of RAM-disk products for S-100 machines, IBM PCs and PClones, and the Epson QX-10. They've now got SemiDisk boards with up to 2 megabytes on board, and I believe their costs are now the lowest per megabyte in the industry. A RAM (random-access read/write memory) disk, for those few who tuned in late, is a method of fooling your computer into believing that a block of memory is a *very* fast disk; indeed, the computer can't tell the difference. In CP/M systems, we generally designate the RAM disk as M: (for memory drive); once installed, you use it as you would any other disk drive, copying files to and from it (use COPY in MS-DOS and PIP in CP/M), renaming files, erasing them, marking them read-only, etc.

The time saved can be quite significant. For instance, my accounting system begins with a journal, which is a report, in chronological order, of every financial transaction: income from my agent, or BYTE, or speaking engagements; travel expenses, computer supplies, salaries to my assistants, etc. From time to time, these must be posted into the general ledger. Since the files are quite large, each page of my ledger is a random-access disk file. There are about 200 ledger pages, and each month's journal has a couple of hundred entries.

Due to sloth, I seldom post all these until year's end. That can take *time*. With 8-inch floppy disks, it takes about three hours. With my CompuPro (Quantum) hard disk, it takes about 50 minutes. With a RAM disk, it takes just under 11 minutes to do a year's posting. Now true: in my CompuPro system I'm using a CompuPro M-Drive/H RAM disk; but we've done speed comparisons between SemiDisk's S-100 boards and the CompuPro, and they're nearly identical. We've had a SemiDisk board running in Helen, Alex's CCS S-100 computer, for nearly three years with no problems at all.

Except for power failures, RAM disks are much more reliable than physical disk drives. There are no moving parts and no door latches to break (Barry Workman reports that he's still doing a brisk business in Tandon drive-door latches). There's no maintenance and no problems with disks lunched by cats, tobacco, or stray magnetic fields. SemiDisk makes a battery backup unit; you can plug it into the wall, so that if you turn off your computer, the memory stored on SemiDisk doesn't go away; and if there is a power failure, the files are protected for up to six hours.

That six-hour limit does bother me

somewhat, but in actual fact the longest power failure we've endured in 20 years here at Chaos Manor was only about four hours, and it happened in the middle of the night. In fact, that data on my RAM disks is safer than the rest of what I'm doing since, although I've intended to get one for years, I blush to confess I am not using an uninterruptible power supply. I intend to get one Real Soon Now.

As I said above, SemiDisk makes RAM-disk boards for the Epson QX-10; they've done that for years, and therein lies a tale.

VALDOCS COMES FORTH AGAIN

The Epson QX-10 story is very odd. Back in mid-1982 Chris Rutkowski, president of Rising Star Industries, secretly showed the upcoming Epson computer to a number of writers. Rutkowski had been heavily involved in marketing the Epson printers (he once told me that he had made them the success they were) and was given a contract to develop unique software for the QX-10; he seemed to be involved with marketing the QX-10 at that time.

The Epson QX-10 was yet another Z80 in a market flooded with new Z80 machines, but it did have some special features. First, it had a bit-mapped screen, meaning that it was capable of better graphics than almost anything then on the market. Second, it could hook into an Epson dot-matrix printer, so that the on-screen graphics could be translated into hard copy.

Third, the QX-10 would come out with Rutkowski's own keyboard design, which he called the HASCI; the acronym stood for human applications standard computer interface. Rutkowski predicted a great future for that design; so great that he was going to license it and charge 50 cents a copy, the money to go to a research institute that would improve human/machine interface designs. The HASCI keyboard had a good feel and was intended for newcomers; Rutkowski

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tried to make it like a typewriter by, for example, putting the Escape key well off to one side and labeling it "Margin Release." There were some other special-function keys with labels like "Edit" and "Copy" and "Delete Line."

The QX-10's really big feature, though, was to be the integrated software known as Valdocs; this was going to be so wonderful that Epson would stop the IBM flood, save the Z80 computer, and, while they were at it, wipe out CP/M. Epson pinned so many hopes on Valdocs that the company didn't even have a CP/M version of the machine. Valdocs ran under TP/M, which is a kind of CP/M workalike different enough from CP/M that CP/M hackers have real problems with it.

More: the whole Valdocs/TP/M software package was developed in STOIC, which is an offshoot of FORTH. The machine itself used a hardware bus developed by Epson America and employed by no one else. The result was that there were essentially no independent software or hardware developers interested in the Epson QX-10.

Freezing out independent developers has been the formula for financial disaster for every computer company that has tried it so far. Epson was going to bring it off, though, because of Chris Rutkowski, Rising Star Industries, and Valdocs. Valdocs would do everything. It made charts, wrote documents, kept track of files, made file indexes, took care of communications, did calculations, and kept track of calendars: in other words, at least what Borland's Sidekick plus WordStar does on the IBM PC and other 16-bit machines. Rutkowski had promised a salable version of Valdocs by the end of 1982. Epson America believed him and began a big advertising campaign.

Alas, Valdocs wasn't ready in January of 1983. The first versions were sent to test sites. I got one. I really wanted it to succeed, but it was a disaster. Valdocs was slow, sent without documents, easy to learn but

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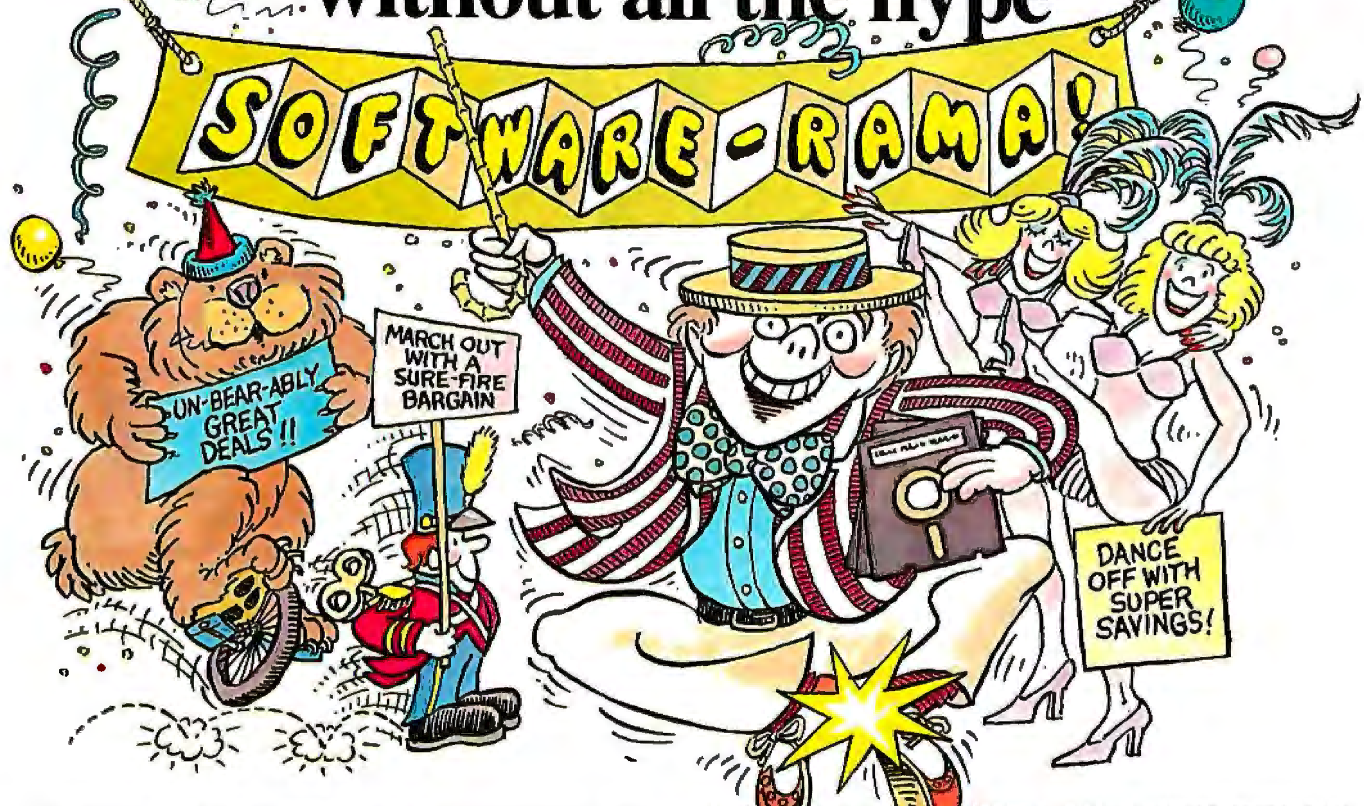

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hard to use, and quite capable of losing your files without warning. It could take up to a full minute simply to erase an unwanted file, and it took about 15 minutes to use Valdocs to create a one-paragraph letter. As to TP/M, the only documentation was some photocopied sheets so dim that I couldn't read them in strong light with a powerful glass; and it blew up if you tried to use standard CP/M utilities such as SWEEP.

Over the course of 1983, version after version of Valdocs (and, I suppose, of TP/M) emerged from Rising Star. All were improvements, but none were very good. In the September 1983 BYTE (Valdocs Revisited, page 480), Rutkowski promised that Valdocs 2.0 would fix everything and that it would be available *soon* (italics his). My answer was that I hoped he was right, but I didn't believe it; in my view, Valdocs was too ambitious for the Z80 chip. To do what Rutkowski wanted his software to do, you'd need a great deal more memory (8-bit computer chips such as the Z80 can address only 64K bytes of memory directly; to have access to more requires kludges).

One Possible Fix

There was, though, one obvious improvement that could be made to Valdocs: a RAM disk could probably take the software well past tolerable. The Epson used a very conservative—and slow—disk-control system, and Valdocs is heavily dependent on disk operations, making it painful; but with a RAM disk it might become a pleasure to use.

Apparently the people at SemiDisk thought so. In any event, they developed a SemiDisk for the Epson QX-10. In the meantime, Epson had brought out a CP/M version of the QX-10. The CP/M Epson was a nice little machine, well made and handsome, but not particularly distinguished among Z80 machines except for its extremely nice screen and graphics. The SemiDisk worked splendidly with the CP/M Epson—but of course that wasn't the system that needed the RAM disk. Alas, they never did get the software to connect up the SemiDisk to Valdocs.

I don't blame them, understand. Working with an operating system written in FORTH and intended to ape CP/M is my idea of purgatory. The fact remains that even with plenty of cooperation from Rising Star, they never were able to tie SemiDisk to Valdocs; so we were never able to see whether the speed improvements would make Valdocs tolerable.

A RAM disk would certainly have helped Valdocs. The trouble is that it's not *really* an integrated software package. It's not even callable on demand. It's only a set of chained programs.

That is: when you invoke Sidekick on your IBM PC, the program is *already* in memory and so is your own work in progress. Whatever you were doing stays where it was, while Sidekick operates with its own section of the PC's memory cells. If Sidekick needs to call in a file from disk—such as the calendar or the help file—it does it, but it still hasn't disturbed what you were doing. The result is that when you exit Sidekick, you're right back where you were when you brought it in.

Valdocs doesn't work that way. When you change functions in Valdocs, it must first save your current work to disk, then bring the new job in off the disk. When you return to your previous work, that process is reversed. Disk operations are slow. Five-inch floppies are *very* slow. If Valdocs could have been hooked up with a good RAM disk, the slowest and worst part would be speeded by a factor of at least 10, and Valdocs might have been tolerable. Alas, that didn't happen.

Real Soon Now

In October 1984 Rutkowski announced the imminent release of Valdocs 2.0 in a big press conference. Computer writers who were present—I didn't go; it was in the Bay Area and I live in Hollywood—had mixed reactions. The BYTE staff wasn't very impressed, especially when they were told that certain features promised for 2.0 would be implemented in "the next version."

Valdocs 2.0 was developed with a new language: according to Rising Star, a greatly improved version of FORTH. It will employ a new operating system, TP/M 3. It was developed under a radical new organizational structure: many programmers, working individually in locations from New Hampshire to Hollywood, linked by electronic mail, each working on a small part of the system. I wasn't told whether the documents were developed that way; perhaps it doesn't matter, since Rutkowski once told me that he didn't consider documents necessary anyway. The program ought to teach itself.

The people at SemiDisk have been told by Rising Star that the software drivers for using a SemiDisk RAM disk with Valdocs 2.0 and TP/M 3 are "already written and installed directly into the operating system." Moreover, they actually have a copy of TP/M; they do not have Valdocs.

My advice to QX-10 owners is not to hold your breath. The Valdocs 2.0 release date is said to be January of 1985. At the moment (December 12, 1984), the software technicians inside Epson America do not have copies of Valdocs 2.0.

Valdocs was a valiant effort. In my judgment, it was doomed from the beginning: 8-bit machinery just isn't powerful enough for what Valdocs attempted even if you don't further handicap it by trying to do it in FORTH. It's a kind of moot question anyway, now that the 16-bit integrated software packages are beginning to deliver what Valdocs promised.

I've never understood the people at Epson America. They had everything going for them, but somehow they hitched themselves irrevocably to Rising Star and Rutkowski's obsession with proving that you can write good, fast, compact, usable software in FORTH. Epson's loyalty to Rising Star is touching. I guess they can afford it.

More Orchids

Last month I reviewed Orchid Technology's PCturbo 186 board ("Orchids to You," page 363), which speeds up your IBM PC something wonderful. We've been running it for nearly two months now: no glitches, no problems, and it's fast, FAST, **FAST**.

The Orchid board uses its own on-board memory, allowing the original memory in your PC to become one or more RAM disks. Last month there was a problem: the Orchid manuals weren't clear enough on how to install the RAM disks.

That's been fixed. Orchid now has an Options program that runs fine and lets you configure your PC in a number of ways, allocating memory to I/O (input/output) buffers, RAM disks, etc. The version sent to me still had documentation problems; but after my phone call to get Orchid's people to walk me through it, they once more rewrote the instructions, and I don't think you'll have trouble with them now.

I'm very impressed with the Orchid PCturbo 186.

So That's It ...

I've often wondered why there's no hardware reset key on the IBM PC. (There isn't one on the PC AT either.) The lack of such a key can be pretty serious, as for instance when your machine locks up and won't listen to the keyboard at all, and you have to turn it off to get it going again. This is not good for hard disks. It isn't particularly good for power supplies, either.

Deep Blue, my source inside IBM, has told me why there's no hardware reset: Microsoft didn't want IBM to put one on. It seems that if you can reset the machine it's easier to pirate software. IBM, for reasons not known to my source, went along with this nonsense. It didn't even put a hardware reset on the AT.

Of course, all the IBM people at Boca Raton use an expensive hardware addition called PC Trace that contains, among other things, a hardware reset. That's a pretty costly way out.

Fortunately, there's a less expensive remedy. Security Microsystems, the manufacturer of Quickon, the nifty little switch that lets you dispense with the PC's memory test on power-on, now makes PC Reset, a combination gadget that will disable the memory test and also do a hardware reset. There's a version for the PC and another for the PC XT; so far none for the AT, although I wouldn't be surprised if one is in the works.

I've had Security's memory-disabler in Lucy Van Pelt, our fussbudget PC, for eight or nine months now with no problems. When we were installing the reset switch, we brought up the

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PC with the memory test. We'd forgotten how long that takes: 90 seconds, if you have your system chock-full of memory. That's a long time.

We've just put in the reset switch system. It works: push the button and it forces reset. To install it, you have to cut one power wire; Security Microsystems thoughtfully includes a gizmo to reconnect the wire if you ever decide to remove the switch. The kit also includes an IC (integrated circuit) puller. Interestingly enough, it works with the PCturbo 186 board installed; I don't know whether or not it forces the 186 to reset. That board has its own hardware reset button on the back, and if I ever lock up the 186, I'll probably use both reset buttons just to be sure.

With an S-100 system, the contents of a RAM disk will survive a reset; at least they do with my CompuPro, which won't reformat a RAM disk that's already formatted. Alas, the Orchid PCturbo 186 RAM-disk files do not survive resetting the PC, whether that's done by the Security Microsystems button or by Ctrl-Alt-Del. I suspect that's a function of the Orchid Software, but it may be inherent in the way Security Microsystems forces system reset.

The Security Microsystems reset comes out the back of the machine to a big button reminiscent of the pickle switch on the old Norden bombsight. The company has thoughtfully included some sticky-back Velcro so that you can attach the button to the side of your PC at any convenient place. Alas, the Orchid PCturbo 186 button remains on the back where it's hard to get at.

Anyway, you can now have hardware reset for your PC; gee, if this keeps up, the machine will have most of the features the Altair did.

PC AT Rumors

Knowledgeable sources are ordering their PC AT for delivery in six to nine months; it seems there are some hairy power-supply problems on many of the ATs recently delivered. This comes from a company that orders IBM PC equipment by the pallet load.

Deep Blue tells me there are about 80,000 PC ATs sitting in warehouses waiting for Intel to deliver 80286 chips. The production yields on those chips are *much* lower than expected. There's also some concern that the power supplies in many of those warehoused machines will have to be replaced or at least reworked. By the time you read this, you can be sure that IBM will have done something about the problem. Big Blue does not intend to ship equipment that frustrates users.

I've further information on the AT: according to a friend in an independent laboratory, the AT is set up for

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Boot Framework, and you've created the Framework desktop.

Ctrl C 0 **Press the Ctrl and C keys together, then press the 0 key.** An outline appears on the screen.

↵ **Type** Outline **(or any title you like) and press the Return key.** The outline is titled.

\+ **Press the grey + key.** You move to heading 1.0.

↵ **Type** Main Point 1 **then press the Return key.** Heading 1.0 is titled.

↓ **Press the (down) arrow key.** You've moved to subhead 1.1.

Ctrl C E **Press the Ctrl and C keys together, then the E key.** A new heading is inserted under 1.1.

Ctrl + **Press Ctrl and the grey + key.** A subhead is added to the heading you just created. (Under any of these heads or subheads, you can be writing text, creating spreadsheets, generating graphics, etc.)

Ctrl C S **Press the Ctrl and C keys together, then the S key.** A spreadsheet frame is created as the second subhead.

F9 **Press the F9 key.** There's the spreadsheet you created, full screen.

F9 **Press F9 again.** Back to the outline.

Ctrl D C **Press the Ctrl and D keys together, then the C key.** Your desktop is cleaned up.

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multiprocessing—there are signals on the extra bus for it. (The "extra bus" is another strip of connectors that make the AT's bus 16 bits wide.) The extra bus seems to run all of the current PC cards just fine but also will run "wider" cards.

Another thing: the AT's crystal is socketed, just as if IBM were planning for faster 80286s already.

SYNCHRONICITY

Talking with Jim Baen reminds me that he has a new software line. It includes a number of games, many based on the works of authors he's published—the most notable is Fred Saberhagen's Berserker series, and of course I'll finish the game based on Niven and Pournelle's *Inferno* Real Soon Now. I've mentioned Baen's Magic Keyboard several times before.

There's also The Electric Dragon.

The *I Ching* or *Book of Changes* has been around a long time; Confucius thought it was old at the time of Christ. It is supposed to have been composed about the time of the Trojan War. Scholars including Confucius and Jung have thought it worth a great deal of study. Many science-fiction readers first heard of it through the late Philip K. Dick's masterful *The Man in the High Castle*, which, according to Dick, was largely written through the aid of the oracle.

One uses the *I Ching* by tossing joss sticks to generate random numbers. The theory is that all events in the universe are connected, and thus the study of any event will lead to understanding of events (and total situations) existing simultaneously; and thus the total pattern of the universe will be brought to bear on the fall of the yarrow stalks.

You can also generate the *I Ching* hexagrams by tossing coins; Chinese coins were supposed to be preferable, but I used to use silver dollars. Whatever method you use generates a hexagram of six lines. Each possible hexagram has a name and considerable text concerning it. Study of that text is supposed to give you sage advice on what to do at this particular moment.

Modern science, particularly the general theory of relativity, holds that the concept of simultaneity is meaningless; and it isn't necessary to believe in the theory of the *I Ching* to be fascinated with it. You can also believe that its author was a very astute judge of human nature and wrote a number of mind-concentrating passages designed to focus an individual's powers of thought.

In any event, the standard way to consult the *I Ching* involves hand washing, lighting incense, taking the book down from a high shelf, and unwrapping it from its silk cover with great respect; laying it on a south-facing table in the middle of the room; and, after suitably composing one's mind, tossing the yarrow stalks in a precisely defined manner.

With The Electric Dragon you merely put a floppy disk into an IBM PC and type ICHING <return>. The system will prompt you from there. The manual tells you that you may, *if* you like, treat your floppy disk with the proper reverence, place your computer facing south on a table in the middle of the room, and use incense. Somehow it's not quite the same.

However, the program does all that the yarrow stalks could do. Instead of tossing the sticks (or coins), you press any key whenever you feel that the time is propitious; this generates one line of the six-line *I Ching* hexagram. Lines are either yin or yang and can be either fixed or moving; if any of the lines is a "moving line" (the odds are good that at least one will be), you have actually generated two hexagrams, and their meaning, modified by the meaning of the moving line or lines, must also be considered. The odds for generating each kind of line (as generated by tossing yarrow stalks) are easily calculated; one supposes that The Electric Dragon program duplicates those odds as closely as possible.

The manual was written by Steve Rasnic Tem. I've not read a lot of his poetry, but I have twice included poems by Tem in anthologies I've edited. The *I Ching* implemented in the

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OPEN SYSTEMS • 430 OAK GROVE, MINNEAPOLIS, MN 55403 • A **UCCEL** Company program is the 1950 Richard Wilhelm translation rendered into English by Cary F. Baynes from Princeton University Press. I'm no authority on versions of the *I Ching*; I assume this is a good one mostly because I've known Jim Baen a long time, and he's always pretty careful to do things right—and I also know he's been intrigued by the *I Ching* for many years. Certainly the messages read poetically—and enigmatically—enough.

The Electric Dragon program contains what amounts to a log book. You can type in your question, and after receiving an answer from the oracle, type in a comment; after which you can save the whole thing. The file is time- and date-stamped, so that it can become a kind of diary of your problems and your thoughts about them. Alas, I've found no way to make hard copy to paste into my regular log book.

You can also review previous sessions or study an individual hexagram.

If you've ever wondered about the *I Ching*, this is a reasonably painless way to consult it. At worst, it's an expensive electronic log book.

SMALL DISKS!

Everyone has moved to 5¼-inch disks; everyone, that is, except me. Eight-inch disks are still the main workhorses here at Chaos Manor. The CompuPro 8-inch double-sided format holds 1.1 megabytes per disk: that's 180,000 English words, more than enough for a novel. I can copy all that in about two minutes flat. It's easy to keep *lots* of backup copies. Eight-inch drives are much faster than 5¼ and significantly more reliable; I almost never get "retry" errors on the 8-inch drives, and there's at least one a week with 5¼.

However, most software now comes on the small disks, and it's a pain to have to get Peter to use the Disk Maker I to transfer it over to 8-inch format so that I can get it into the Golem, my big CompuPro 8/16 system. For some time now I've been promised small disks for the Golem; when the CompuPro hard disk arrived, it had a blank spot with a piece of yellow stick-on saying "5¼ drive goes here"; but nothing happened.

Last week that got fixed. CompuPro sent down a big box that contained a new power supply and two Mitsubishi 96-tpi (tracks per inch) 5¼-inch drives. There was also a CompuPro Disk One-A controller that will handle both the 5¼-inch and 8-inch drives.

We took the hard disk out of the old box and put it in the new; the old power-supply box went back up to Hayward, where CompuPro intends to take it apart to see how it has held up under nearly a year of intense use. Then Tony Pietsch came over to set things up. In the course of the installation, we discovered one mode of board failure that the CompuPro quality-assurance people hadn't tested for. A quick phone call took care of that; they've now changed their test procedure.

One of the main reasons I get so much attention from the people at CompuPro is that nearly everything they put out gets set up and used here before it gets to the public; and I often find problems that did not show up in other tests, precisely because I do not "test" equipment and software. I use it; and since we do almost everything here, from writing books to running accounting software to writing programs, it gets "tested" a great deal more thoroughly than most test sites can manage.

I generally find some problems. That's why I have more than one computer, including one I don't touch; when we get a problem with the experimental system, I leave it alone until Tony can look at it. He finds the problem, consults with CompuPro, and they modify the design, change software, or do what it takes to make things work properly.

The result can be impressive. Take the Golem as an example. He's often torn apart and filled with experimental equipment. We work him *hard*. Yet he hasn't been off duty for two weeks cumulatively in the more than two years we've had him.

Anyway, the board glitch was fixed, as was a minor software problem; and I can now run my 5¼-inch drives as well as 8-inch. They run under Tony's Newmedia program. Newmedia tells your system that any one of about 40 different disk formats (he's adding to them all the time) is *native*. Once that's done, you can read, write to, and *format* 5¼-inch disks in the format you chose. Possible formats include both 48- and 96-tpi, IBM, Epson, Kaypro, and a whole bunch of others.

Changing native formats with Newmedia takes about 30 seconds, after which you can use COPY or PIP to move files to the new format from the hard disk, 8-inch drive, or RAM disk. Like all of Tony's recent programs, it contains its own instructions: type NEWMEDIA ? <return> and it tells you all you want to know about using it. Newmedia with the CompuPro Disk One-A is going to save Peter and the Disk Maker I a lot of work. Incidentally, all of Tony Pietsch's software uses that convention: type the program name, space, and a question mark and the program explains itself. Nifty.

Tony also brought the new very fast Copy and Format programs that cut disk-copy time in about half.

My system was installed by Tony; but CompuPro has been working on making its stuff easier to get running, and installation of the new BIOS (basic input/output system) software can now be accomplished by running a single Submit file, which assembles the BIOS (you get the source code) and does the system installation. Pournelle's law still obtains though: if you don't know what you're doing, deal with people who do. In CompuPro's case, that translates to "work with Systems Centers unless you're pretty familiar with S-100 bus systems."

THAT VIDEO BOARD AND THE SPUZ

Tony also brought over a copy of the new CompuPro PC-compatible S-100 video board. Alas, he couldn't leave it; as of now there are only five of them in existence. CompuPro is making more next week, and I ought to have mine Real Soon Now. I can hard-

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ly wait. When I get that in, we'll change my 8/16 over to Concurrent DOS, replacing the CompuPro 8/16 processor board with the new 80286 microprocessor and one or more SPUZes.

SPUZ is CompuPro's code name for a concurrent Z80 board, which is already running in test sites, including at Tony's house. Once Tony is happy, it's my turn. I'm eager to get at it: When it's all done, there will be no more Switch! and Swap programs; if the machine's fed a Z80 program, it will run that simultaneously with 16-bit 80286 programs. Bill Godbout says it's like having a box full of computers; turn 'em loose and let 'em all play together, each one running at its own speed.

CompuPro also has a new version of Shirley, otherwise known as the CompuPro 10 multiuser system. The new one will fly with Concurrent DOS. Owners of the older machines will be able to upgrade through local Systems Centers.

UNIX?

I've not changed my views on UNIX: on Mondays and Wednesdays I'm convinced it's going to sweep through the computer world like wildfire and be the unifying influence we all need. After all, Digital Research is supposed to be working on ways to make Concurrent DOS run under UNIX; and since PC-DOS runs under Concurrent DOS, that will go a long way toward integrating the micro world into one happy family.

On Tuesdays and Thursdays I recall that UNIX is enormous, too big and too slow, changes all the time, and generally requires a UNIX wizard to maintain; there's no way it's going to be popular outside large computer establishments. Give vanilla UNIX to business users and hear the screams of agony.

For those interested, though, these rumors out of CompuPro: the European branch of the firm has shipped a beta-test version of UNIX for the 68000 chip to CompuPro Canada. This is supposed to be the full Berkeley UNIX *plus* System V. CompuPro also has UNIX System V for the 80286 chip. It shouldn't take the company all that long to bring UNIX into the United States.

Flowcharts

Mrs. Pournelle is doing a book plus computer program that will allow any child with access to a computer to learn to read. She can do that because she has for years been the reading teacher of last resort for the Los Angeles County juvenile justice system. Her students are teenage illiterates in a lockup. They mostly come with pound after pound of psychological mumbo jumbo that "proves" the kid can't possibly learn to read; it wasn't the school system's fault.

She ignores that junk and teaches the kids to read. She hasn't failed yet.

Now she's doing a book on methods. With the book will come a computer program. Alex and I are working on it. Her contract specifies that part of the advance will be paid when we turn in a flowchart of the computer program. By coincidence, we got that contract the same day that Flow Charting, a program by Patton and Patton, arrived.

This looks as if it would be an easy system for producing flowcharts; heaven knows I'd like to use something like that, because modifying and redrawing flowcharts is one of the more boring ways to spend time.

Alas, Flow Charting is copy-protected. The manual says a backup copy of the program is provided, but there's none in my package.

I'm not about to waste my time designing flowcharts that can then be accessed only by use of an off-brand disk that I can't make backups of. For that matter, I don't much like using programs I can't put on a RAM disk. Looks as if Flow Charting goes off into the same corner as the other stuff I'll get to when things are slack.

Free Filer

One of Peter Flynn's jobs is compiling the Items Discussed box. This can be a pretty tedious job. He has recent-

(continued)

ly found an excellent CP/M program that makes it considerably easier.

Free Filer from Telion Software was designed to work with WordStar files, but it works fine with WRITE text files, too. Free Filer is a "free form information retrieval system" that will let you keep card files, search through them on single or multiple keys, and make sorted files of the kind you see in the Items Discussed box.

His example: suppose you had the following card entries:

—Cats
furry, sneaky, warm, smart, small, edible (although eating them is not socially acceptable), semidomesticated, cheap to expensive

—Sheep
wooly, medium-sized, warm, edible, domesticated, expensive

—Toads
small, wet, cold, beautiful [it's Peter's file, not mine], inedible [as far as I'm concerned], cheap

Free Filer could be used to search for all animals that are small (toads and cats) or warm and expensive (cats and sheep) or cheap and edible (cats). Each time a record is found that contains the word or words searched for, it is displayed by itself on the screen. You then have the option to print it or add it to the search file.

There are a number of ways to sort your data once you retrieve it.

The program is not copy-protected and indeed urges you to make a backup copy before using it. It can be run from within WordStar as an information utility to generate specialized files that can then be included in the text you're working on.

The instructions are simple, in English, and easy to use. There are plenty of examples. Free Filer is one of those wonderful little general-purpose text utilities that simplify life with computers.

Recommended.

WINDING DOWN

Tony just called. He's got a CompuPro 80286 board and SPUZ intended for me; first they go into his system for checkout. COMDEX is coming up in two weeks; just after that I ought to have the new stuff aboard.

I could say the book of the month was mine; certainly that was the book I put the most time and effort into. However, the real book of the month is *The World of Digital Typesetting* by John W. Seybold (1984; Seybold Publications, POB 644, Media, PA 19063; no price shown). This book will tell you a *lot* about typesetting equipment, software, and interfaces. It is *not* complete. There's more to the story; but this is a good introduction and history. Like Skillin and Gay's *Words Into Print*, Seybold's book belongs on the reference shelf of any serious professional writer. It's not easy reading, but it's stuff that professional wordsmiths had better know.

There hasn't been enough time for games, so there is no game of the month. However, I have been promoted to Vice Admiral in the Cygnus Star Fleet I game.

We've ordered 512K-byte upgrades for our Macintosh computers, but they haven't come yet. Our dealer says Real Soon Now.

Finally, I just got a call from AT&T, and it looks as if I'm going to get one of the UNIX-running 3B2 systems to play with; hopefully, in a couple of months I'll know what to think about UNIX on Fridays and weekends. ■

ITEMS DISCUSSED

COMPUPRO DISK ONE-A (5¼) . . $695
Not A
UNIX 68000 . . . . Not A ble
CompuPro
3506 Breakwater Court

FLOW CHARTING $167
Patton and Pattor
340 L npark Circle
San J CA 95136
(408) 5044

FREE FILER . . . . Not A ble
Telion Software
POB 1464
La Mirada, CA 90637-1464

. . . . $6694
IBM Entry Systems Division
POB 1328
Boca Raton, FL 33432
4700

PC RESET PACKAGE (includes Quickon) $89.95
icrosystems Consultants
lace, Suite 102
Staten Island, NY 10304
(212) 667-1019

PCTURBO 186
K bytes $1095
256K bytes $1245
Orchid Technology
47790 Westinghouse Dr.
Fremont, CA 94539
(4) 490-8586

SEMIDISK (for the Epson QX-10)
512K bytes $799
megabytes $2499
SemiDisk Systems
POB GG
Beaverton, OR 97075
(503) 642-3100

THE ELECTRIC DRAGON . . disk $34.95
Baen Enterprises
8 West 36th St.
New York,
(212) 947-8244

VALDOCS 2.0 . . . . less than $50
Rising Star Industries
24050 Madison St., Suite 113
Torrance, CA 90505
(213) 378-9861

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Corvus Problems

Dear Jerry,

I was very interested to see your comments on the Corvus hard disk. We've been using one for almost two years. Our experience has been frustrating, different enough from yours, and, I hope, relevant to enough people that you might decide to look into it further.

After researching hard disks for several months, our ultimate reason for going with Corvus was that the finance company we use for our computer deals said it was the only brand it wanted to finance because it was the only one with a reasonable service record. After five firmware and hardware crashes, I wish I knew then what I know now.

More distressing than having to baby the beast has been the response of Corvus itself. Our first crash was due to a bug in Corvus's firmware. I got on the phone with Corvus's technical people, who told me they knew about the problem and how to fix it. The strange part was that they also told me they hadn't bothered to notify dealers or users about the problem. Corvus has also failed to answer my letters asking to buy documentation (including a manual for multiusers, which an insert in the original users manual two years ago promised would be mailed to me Real Soon Now).

Among our other problems was a burned-out main drive bearing, which, luckily, failed just before the warranty ran out. There was one service technician in all of Colorado who seemed to know something about the drive, but his shop went under, and the new local Corvus contact told me they're not interested in spending much time with them unless we're ready to spend big bucks on more hardware. They did tell us all our problems were because the Rev B was a lousy product, and if we'd just junk it and buy all the latest Corvus stuff, our problems would go away.

My computer responsibilities are with a small business, using Apples and wanting to get bigger. But it's the old story of having to live with an investment after so many bucks went into it. We'd like to get a real network in here and more disk space, but I'm sure not going to trust Omninet after our experiences with our first Corvus product. I've done a fair amount of documentation myself, have the thing interfaced with ProDOS now, and managed to get around some of the limits Corvus built into the thing when it implemented it under DOS 3.3.

I thought you might be interested. I enjoy reading you, even when I disagree with you.

Glenn Holliday
Denver, CO

Alas, Rev B was a dog, as was Rev A. Corvus has got most of its problems fixed now, or so I am told. The one we have is scheduled for a pack of revisions; I'll do a full report when it's done.

I do wish Corvus well. The company has some good troops and good ideas, and its people are trying hard: unlike most of their competitors, they're trying to network everything, *not just the biggies. We hear good things about their networks.*—Jerry

NEC PC-8201A

Dear Jerry,

Recently I purchased an NEC PC-8201A lap-size portable computer, partly because you had nice things to say about it and partly because I couldn't resist the sale price. In general, I've been quite pleased with it (although I'll need to add more memory before I'll be really happy). I also own a Kaypro 2, and I have been using Mycroft Labs' MITE communications package along with the Telcom program in the NEC to transmit text files between the two. However, according to the way I read the NEC manuals, it should be possible to use the NEC SAVE **<*filename*>** as COM: command to transmit files from the NEC through the RS-232C port to the Kaypro. This feature would be potentially useful in saving BASIC programs from the NEC to the Kaypro's disk drives. The useful feature is that the NEC tries to convert a BASIC file (.BA) from internal format to ASCII format as it transmits. Thus, using the SAVE command would prevent you from having to first save a BASIC program in ASCII format on the NEC and then calling up Telcom to send it to the Kaypro.

Unfortunately, the SAVE command does not work very well in my setup. I have both computers set to agree on communications protocol and whatnot, but when I save a text file to the RS-232C port on the NEC, the Kaypro gets only about half a screen and then gets hung up. When I try this procedure with a .BA file, the same thing happens, but the Kaypro drops a few characters as well (notably line numbers). This seems to happen regardless of how low I set the transmission rate. I was wondering if you have tried the NEC SAVE command to send things out the communications port to a Kaypro or other computer.

The NEC Telcom program has worked fine for my setup (as long as one is aware that because of the Kaypro's software screen scrolling, any communication that echoes to the screen has to be no faster than 1200 bps for the scrolling to keep up and no characters to be lost). At any rate, I would like to hear about any experience you have had with the SAVE command. Thanks.

Mark E. Cornell
Tucson, AZ

I've never used the SAVE *command. Indeed, I only use Percy, my NEC PC-8201A, as a lapboard typewriter when I'm on aircraft. When I get to my hotel, I use Telcom and the* PIP *command to send the resulting text to Adeline, my Otrona Attache; or when I get home, I use Telcom to send the text to my CompuPro 8/16. Both work perfectly at 9600 bps.*

I've tried this with the Kaypro 10 and it all works fine at 9600 bps; just don't *echo to the screen. Use* PIP *to collect the files onto the Kaypro. Alas, I think you have no choice but to save your programs in ASCII and use Telcom.*

I still like Percy a lot. So does Mrs. Pournelle.—Jerry

Copy Protection

Dear Jerry,

I can empathize with your gripes about copy-protected source disks. I had such a

(continued)

utility disk self-destruct on me six months ago. I have no children or animals underfoot and am reasonably fastidious about disk care. Even with the best-laid plans, part of the copy-protection scheme is an (usually abortive) attempt to reformat the disk. Fair enough, except when the switch on your drive slips slightly and the underside of the write-protect flap caves in just enough, leaving you with a rather expensive blank disk. In defense of the manufacturer, the program is very reasonably priced, does exactly what it claims, and one backup disk is available to registered owners at a reduced price. I was still rather miffed at having my disk destroyed through no real fault of my own.

The distributor was no help (buy the backup—but what if *that* one goes?). I began snooping around in my DOS and discovered the nature of the copy protection, where certain information is returned to the DOS buffers with certain types of read errors. I then wrote a couple of utilities to read and write these irregular formats track by track. I now have backups for my own use that in a better world I should have had in the first place. I'm no real pirating threat, since I don't know anyone who can use this program who doesn't have it already (an essential part of my system is no longer manufactured), yet these copies are not entirely on the up-and-up (maybe one, since I paid for one). Serial numbers are a good idea, but the numbers on this package are not hidden very well even though the code itself is gibberish.

I don't know if an equitable and sensible solution is on the horizon. Just look at what a mess "fair use" turned out to be when certain publishers decided to play hardball with photocopying. Inflating software costs to anticipate piracy could easily price some packages out of the market. Improved copy protection is just more of a challenge in the escalating war of copy-protection/subversion schemes. I agree that cheap, reliable software usually isn't worth trying to steal, but I don't think we'll be flooded with exemplars anytime soon.

LAWRENCE L. CRAWFORD
Philadelphia, PA

Another good letter on copy protection. The issue is not going away.—Jerry

THE USERS STRIKE BACK

Dear Jerry,

The time has come for the computer users of the world to unite and to make the following declaration to the software suppliers of the world.

Dear Software Supplier/Copy Protector:

I understand that you perceive the unauthorized and illegal copying of your software to be a huge and critical problem. There are many people who criticize your position and logic, but that is neither here nor there. To you, this copying is seen as a problem, and I doubt that any arguments or evidence will change your mind. So I am not writing you about piracy, its economic effects, or any of this. Instead, I ask you to consider for a moment the forgotten person in this debate, the ordinary user.

The means you have chosen to solve this problem of illegal copying, copy protection, are completely inappropriate from the viewpoint of the user of your software. You should be able to recognize this without long and tedious argument; you should be able to recognize that you owe everything to the user, that you owe to the user the duty of utmost care, that you are a trustee of the user's information needs. You should, in short, be able to recognize the tremendous responsibility you have toward the user.

But you don't. Instead, you treat the user with the utmost contempt and disrespect. You deliver unintelligible manuals, full of jargon and convoluted syntax, when you should be trying desperately to communicate clearly. You disclaim all legal responsibility for the correctness of your software; you spend millions in advertising and then refuse to even commit yourself to the proper working of your product.

But you show your greatest contempt by instituting copy-protection schemes, which create new dangers for those who have so foolishly placed their trust in your ability to help them. No copy-protection scheme will ever help any user, and usually the scheme will only serve to injure and frustrate the user. Are the concepts of pride and professionalism really so foreign to you?

Maybe you are protected by these schemes; but they serve me poorly. Can't you see that your duty is to me, your customer, instead of to your perception of your own injury? You can't balance the perceived cost to yourself against the injury to me and then say your interest is the greater and should prevail; you are morally responsible to consider and protect my own information welfare, and I demand that you attend to this duty.

Maybe your product is truly wonderful, but I am not interested in any copy-protected software, no matter how wonderful. I can see that your only interest is what you can get from me and not what you can do for me. So I will avoid your product. I will not buy it, so you will not have my money. More important, I will not use it, so you will not have my trust and respect; for these are what I give when I use a piece of software. Needless to say, I will not waste my time trying to copy a piece of software that I am committed not to use. I will advise everyone I know to do the same. I will choose my software vendors as I do my friends, my physician, and my attorney. And I will hold you in the same contempt as you, perhaps unknowingly, hold me.

Should you learn to temper your greed with wisdom, let me know. I'm always ready to make a new friend.

Sincerely,
Software User

Boycott is the only effective answer to this problem. The vendors will somehow have to be coerced into being fair and reasonable, since they have no inclination to take this step on their own.

EDMUND B. BURKE
Atlanta, GA

Maybe yours is the only way. Alas, computer users are not all that well organized. Still, a few thousand such letters. . .—Jerry

A FANTASY?

Dear Jerry,

A while back, I was part of a commercial programming effort. The question of copy protection came up. We came to the following conclusions:—

If customers cannot back it up, then:
- We would have to maintain full customer records; We would have a higher number of disks returned because the disk needed very accurate drive-speed adjustment; It would involve another entire job/position/department; It would have to be a nonprofit endeavor.

All locks can be picked:
- The only people we had to stop could copy and sell it anyway; If they give away only one to three copies, we still have a large number of paying clients (free advertising, too!).

We would either have to:
- Write the lock ourselves (time=$); Hire someone to write it (ditto); Pay

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a higher duplication cost.

We would find ourselves with a large custom-programming job:

Patches to fit/use all printers; Patches for all 80-column (Apple) cards; Patches for several disk operating systems.

The market would be more than halved because it would not fit many specific systems (hardware).

The market would be reduced further because it could not fit into a menu-driven, userproof, black box with many functions.

It would please the programmer because no one would see the faults. But then he had already been paid.

I would not have bought it because I think programs should be unlocked; people lend/borrow your books don't they?

At this point we ended the discussion and sold it unprotected.

WILLIAM M. REED
New Orleans, LA

I wish all the publishers would come to the same conclusion.—Jerry

ETHICS

Dear Jerry,

Re your September 1984 column on Tom Tcimpidis and his RCBS being busted at the behest of one of Ma Bell's offspring:

Of course, it's always the little guy who gets hung out to dry. This same sort of stuff must certainly go on (even if only on a one-on-one basis) via CompuServe and The Source. Can you imagine how many lawyers the *Reader's Digest*, Control Data Corp., and H & R Block would have barring the doorway if a phone company tried to impound the computers at *their* two subsidiaries?

You seemed to think that your supermarket analogy was a bit off-the-wall, but if you've ever read the tortured logic and mind-boggling conclusions that some judges hand down every day, you wouldn't be *quite* so quick to dismiss the idea. Some more hypothetical cases:

The *Washington Post* runs a car dealer's ad. I respond, get bait-and-switched, and buy a lemon from him. Can I impound the *Post* presses? What if the *Post* had received previous complaints about the dealer? Even if the *Post* later yanked the ad, the damage is done. It seems to me that the argument for joint tort-feasance is just as strong here as it is in Tcimpidis's case.

If I get ripped off by a con-artist advertisement, can I have the magazine's Second Class Postage permit yanked?

Suppose you print in your column (notice how we're getting closer and closer to home?) my casual comment to you that "the Bytecrunch-99 computer stinks," along with my name and address. Some irate Bytecrunch-99 owner firebombs my house. Can I send your local sheriff over to impound your 32 computers?

As a "reader service," I print your phone number in our Eagle users group newsletter, with the suggestion that you can be reached between the hours of 2–4 a.m. PST. Is your unpublished phone number "owned" by you and/or Ma Bell?

Regarding your comments (same column) that electronic bulletin boards publish ways to defeat copy-protection schemes—there's an obvious connection here to the Tcimpidis case. If Tcimpidis is guilty of some crime, then what do we do about those who publish these other hacker goodies? Or are they safe because they only published ways to defeat copy-protection schemes and not the proprietary information itself?

How ethical is it to hit a buyer for one or two weeks' take-home pay for a copy-protected program? While awaiting a replacement for the program disk you accidentally trashed, you make the next VISA payment on a worthless disk and loose-leaf binder, the project deadline has come and gone, and you've lost bucks, grades, or a job. What are the ethics of arrogant licensing agreements, hyped product descriptions with product disclaimers packed inside the box, refusal to fix bugs, user nonsupport, and other problems you've talked about?

Yes, I read program reviews by the bucketful. My eyes glaze over and skip to the next product review as soon as they encounter the phrase "copy-protected." I absolutely refuse to buy copy-protected programs. But let's be realistic—what percentage of home computer software produced today gets a thorough magazine review so you can be forewarned? And how many interested buyers are going to dig up, say, a March 1983 BYTE to see what you said about their intended purchase? What makes it really bad is that fighting a battle against copy-protected programs can be heartbreaking when you have to pass up an otherwise luscious piece of software. There's got to be a better way.

JOHN MAZOR
Clinton, MD

Yeah. I get so coldly furious about the Tcimpidis situation that I'm tempted to cry havoc. One thing I note that Pacific Telephone has done: by acting as its people have, they've opened what ought to have been a closed ethical debate, thus causing a lot of bright kids to seriously consider becoming phone phreaks.

It is statistically improbable that the forbidden phone codes have not been sent through The Source and CompuServe; equal justice demands that Ma Bell try to confiscate their equipment. Perhaps they're not so eager to take on the Reader's Digest?

As to copy protection: I don't know the answer. One of my readers counsels me to "let loose the demons"; that is, any copy-protection scheme can be defeated, usually by a program called a "demon" that sits in high memory, watches what the copy-protection scheme does, and then begins to do it. My reader wants me to publish the source and installation procedures for various demons.

A number of them are already available on computer bulletin boards. I'm thinking what to do.—Jerry

THE TRUTH ABOUT ALEX

Dear Jerry,

A friend of mine and his wife are taking a systems course at UCSD. As part of this course they develop software in C on the UNIX system there. While browsing through the system after a long night of programming, my friend's wife came across an adventure game. As any self-respecting hacker would do, she began playing the game. At the end of the game, after being killed several times, the program listed the top ten players. It turns out your son has more talents besides the business end of computer systems. His name was at the *top* of the list.

ANDREW H. BUSHNELL
San Diego, CA

So that's what he's doing down there! I understand the game was Rogue. Alas. —Jerry ■

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バイト

Disks and Printers

Important peripherals from the 1984 Data Show

BY WILLIAM M. RAIKE

William M. Raike, who holds a Ph.D. in applied mathematics from Northwestern University, has taught operations research and computer science in Austin, Texas, and Monterey, California. He holds a patent on a voice scrambler and was formerly an officer of Cryptext Corporation in the United States. In 1980, he went to Japan looking for 64K-bit RAMs. He has been there ever since as a technical translator and a software developer.

The 1984 Data Show was held from September 26 to 29 at the International Trade Center Exhibition Site at Harumi, near the Tokyo waterfront. The fastest way to get there is by ferryboat; a pleasant 5-minute ride replaces the usual 15-minute taxi or bus trip through some of the least impressive neighborhoods in Tokyo. In this case, the boat trip was one of the more interesting events of the afternoon; the show itself was only so-so in terms of noteworthy new computer products. The most important exhibits at this show were peripheral devices, especially optical disks and laser printers.

One of the high points of the show was Hitachi's OC-301 optical-disk cartridge system, which looks like a practical solution to on-line storage requirements for large databases. You can put 2.6 gigabytes on one double-sided disk and still have room left over. The disks look like ordinary videodiscs. While a disk spins at 600 rpm (revolutions per minute) within its cartridge, microscopic pits are laser-scanned to read the data. Data can also be written in random-access mode to any track and any sector on the disk.

According to Hitachi, the maximum data-transfer rate is 440K bits per second; this limitation is apparently due to the drive itself, since the built-in controller/formatter is capable of more than twice that rate. The disk is organized into over 40,000 tracks per side (both single- and double-sided cartridges are available), but the average seek time is only 200 milliseconds. That means that it takes less than ¼ second, on the average, to access any part of a 2.6-gigabyte disk, and a single controller can handle up to four disks. No information about prices of either the cartridges or the optical-disk drive was available during the show, but the system is now available to OEMs (original equipment manufacturers). It will probably be adopted first by minicomputer vendors, but the supermicro market won't be far behind.

Hitachi floppy-disk drives were featured earlier in BYTE Japan (see "Show Time," September 1984, page 407) when I reported on the 9.6-megabyte 8-inch floppy-disk drive that was announced at the Tokyo Microcomputer Show. After that announcement, it seemed almost anticlimactic when Hitachi displayed its 6.5-megabyte 5¼-inch FDD541 floppy-disk drive at this Data Show. Even though the new DK 512 (see photo 1), a 171-megabyte 5-inch hard-disk drive, was displayed right next to it, the new floppy-disk drive stole the show: its data-transfer rate is 3 million bits per second. That's more than twice as fast as the transfer rates of most hard-disk drives and means really fast access, even for big files. Right now the FDD541 (and the DK 512) are available to OEMs, but it won't be long until we see consumer products that use them.

For people who want something in between the sizes of the new optical-disk and floppy-disk systems, Hitachi also displayed a compact 8-inch hard-disk drive. The DK 815 holds 525 megabytes unformatted (435 megabytes formatted), and two of them will fit into a standard 19-inch equipment rack.

Printers were very much in the spotlight at the show, among them laser printers by Canon, Fuji Xerox, Konica, and TEC. (TEC printers are marketed in the U.S. by the C. Itoh trading company.) All four laser printers have similar characteristics: they print with very high resolution (typically about 300 dots per inch), offer a large variety of character fonts with sharp, magazine-quality printing, and have printing speeds in the 8- to 10-page-per-minute range. All are tabletop machines. Some models have RS-232C serial interfaces, while others require a special video interface. Although no prices were available as of this writing, it looks as if laser printers will eventually become standard for high-quality word-processing and office applications.

Laser printers use the same principle as an electrostatic copying machine. A drum

(continued)

Conventional printers are getting better and cheaper.

coated with a material like selenium is given a static charge. When light (in this case, laser light) touches the drum, the drum material becomes conductive and the charge leaks away from the area exposed to light. A dark powder (the toner) charged with the same polarity is then applied to the drum; since like charges repel, the toner adheres only to the parts of the drum that were exposed to the light. The laser beam itself is extremely narrow and is bounced off a multifaceted (typically 8 or 12 facets) spinning mirror, so that the beam sweeps across the surface of the drum as the mirror spins. Regulation of the mirror-rotation speed is simplified because the beam can be synchronized using a simple photodetector arrangement. The beam is simply turned on and off to form the desired image, much the same as the electron gun in a cathode-ray-tube screen. No "vertical deflection" of the beam is necessary because of the rotation of the selenium drum.

The Casio LCD (liquid-crystal display) shutter printer I mentioned in last month's BYTE Japan ("The New and the Old," page 429), the LCS-2400, uses a similar principle, except that the laser and the scanning mechanism are replaced by a simpler combination of a light source and a liquid-crystal shutter to expose the image on the drum. Casio has announced a Japanese price for the printer equivalent to $1650.

Conventional printers, both the dot-matrix type and the daisy-wheel type, are getting better and cheaper. A number of 18-dot and 24-dot near-letter-quality (or better) printers have been on the market for some time, at prices ranging from $800 to $1000, for both Japanese-language word-processing and graphics applications. Now TEC has introduced the M1570, which prints kanji characters using a 24-dot font and letter-quality alphanumeric characters using an 18-dot font. In draft mode it produces near letter-quality printing at 200 characters per second (cps) and has a four-color ribbon so that it can produce graphics and/or characters in any of seven colors.

Citizen, better known for its electronic wristwatches, is a newcomer to the computer peripheral-equipment market. Citizen's new MSP-10K printer (see photo 2) is an 18-dot, 21-cps kanji printer and near letter-quality alphanumeric printer that prints in draft mode at 160 cps. It will retail for about $520.

Two low-speed, relatively low-cost daisy-wheel printers are worth mentioning. C. Itoh is selling its Y-10 daisy-wheel printer, which weighs only 17 pounds, at a list price of only about $525. It has a cassette-interface feature that lets you change between serial and parallel interfaces; you swap print wheels using a "slide-in-and-snap" loading method. The other printer is an original-equipment model that's sold here in Japan as the Aurora 650. You can buy one for only about $360, discounted, which is just about the best deal I've seen. It uses a film-type ribbon cartridge and prints clearly and evenly at 13 cps. It includes built-in parallel and RS-232C serial interfaces.

New Toshiba MSX Computer Can Communicate

In the December 1984 BYTE Japan I discussed the MSX computer phenomenon. MSX is the name of a set of standards, developed by Microsoft Corporation, for low-cost computers based on Z80 or equivalent microprocessors that have Microsoft BASIC in ROM (read-only memory). About two dozen models of MSX computers are available in Japan from all the major Japanese computer manufacturers. Until now they have been sold almost exclusively for playing video games. Prices generally range from about $200, or even less, up to about $400 for models with 64K bytes of RAM (random-access read/write memory). In addition to built-in sound generators and joystick interfaces, MSX machines all have one or more slots that can accept standardized RAM/ROM cartridges. Hundreds of game cartridges are available; most sell for about $10 to $20.

There is little MSX software for any purpose other than entertainment, and with the computer-game market quickly becoming saturated, the MSX phenomenon here has been more of a curiosity than a force for steady growth.

All of that may change soon, however. I had a chance to try out Toshiba's newest MSX machine, the HX-22, the other day. Due to be released in about a week, it's a 64K-byte computer that has a list price of only about $360, is supplied with useful Japanese-language word-processing software, and includes a standard RS-232C serial interface and terminal software. A 500K-byte 3½-inch floppy-disk drive is optional, supported by the MSX-DOS operating system. (See the December 1984 BYTE Japan, "Hand-held Computers and MSX Standards," page 365.) The standard display is only 40 characters wide, but an inexpensive 80-column adapter will be available soon.

The HX-22's serial interface, which can operate at speeds up to 19,200 bits per second, may cause major changes in the low-priced computer market in Japan. Until now, personal computer users here have lagged behind their American counterparts in terms of communication services like bulletin boards, conferencing systems, and wide-ranging information services like The Source and CompuServe. Although The Source is available in Japan, there aren't yet any widely available analogous Japanese services. My guess is that the introduction of the HX-22 (and its inevitable competitors) will be a powerful stimulus for people to start developing them. Also, because the HX-22 includes a sizable Japanese-language (kanji) character set in ROM, the road is now open for developing information and communication services in the Japanese language, which is an absolute necessity for acceptance of this kind of technology by the Japenese general public.

The market for MSX machines is fiercely competitive, and other major producers like Sony, Canon, Pioneer, and Mitsubishi are certain to introduce their own versions of MSX machines with communications and kanji display capabilities; prices in the $275

(continued)

Photo 1: *The 6.5-megabyte floppy-disk drive from* Hitachi.

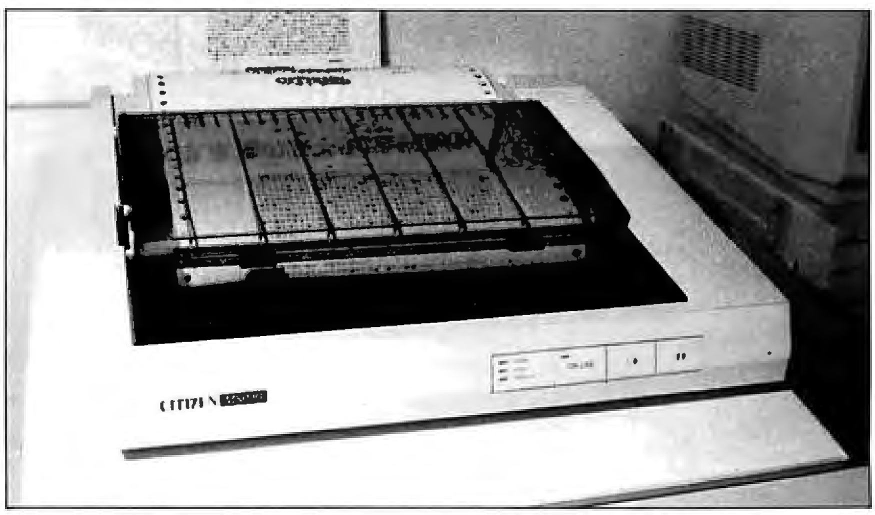

Photo 2: *An inexpensive (about* $520) 18-*dot kanji printer from* Citizen.

to $300 range wouldn't surprise me at all. Toshiba claims it has no plans yet to market the HX-22 in the U.S. because of the lack of an appropriate distribution system, but those kinds of plans have a way of changing quickly when the company perceives a demand.

INNOVATIONS

Especially in the last few years, integrated-circuit designs have been moving more and more toward CMOS (complementary metal-oxide semiconductor) technology. The biggest advantage CMOS has to offer is its very low power consumption. Although the speeds of CMOS integrated circuits have been increasing, they generally can't match the speeds obtainable with the older bipolar technology. Hitachi has just announced that it has come up with a way to combine both bipolar and CMOS elements on the same chip and claims that a gate array based on the new process has a gate delay, or operating speed, of only 0.8 nanosecond. That's comparable to the fastest ECL (emitter-coupled logic) chips. Its power consumption is only about 0.15 milliwatt per gate, similar to CMOS.

Optical-disk technology is moving fast, too. Sony has just developed a magneto-optical-disk system for delivery to the Japanese international telephone company this month. The significance of the Sony development is that the disks are erasable, in contrast to other optical-disk systems like the one Hitachi introduced at the Data Show. The capacity of the disk is 1 gigabyte, and a single controller can handle up to four disk drives. No information about the speed of the new system was available, and so far Sony hasn't announced that it will market the system commercially.

COMING UP

Next month I'll cover the IBM JX, WordStar 2000, the new Toshiba 1-megabit RAM chip, and the growing popularity of UNIX in Japan, and I'll compare the Japanese PC-9801F3 personal computer with the NEC APC-III. ■

B·Y·T·E W·E·S·T C·O·A·S·T

What Next?

Thunderscan, the ins and outs of the windowing game, new workstations, and more

BY JOHN MARKOFF, PHILLIP ROBINSON, AND EZRA SHAPIRO

Apple Computer's president, John Sculley, has a habit of publicly referring to Macintosh graphics as "super graphics." However, although the Mac may be impressive when compared to the Apple II and the IBM PC, we've always been a little irritated by the super-graphics claim. Shouldn't the superlatives be reserved for the new generation of personal computers with 1024- by 1024-pixel (picture element) bit-mapped screens and hardware coprocessing support for animation and other sophisticated graphics operations? By those standards, the Mac seems primitive indeed.

Yet, over the course of the past few months, as new applications have been introduced, the Macintosh has proven to be consistently surprising in the quality of its graphics. Despite its relatively low number of pixels, the Macintosh display is crisp, partly because of its small screen size.

THUNDERSCAN

Recently, a demonstration given to us by Macintosh designer Andy Hertzfeld and Tom Petrie of Thunderware provided convincing evidence that if Macintosh graphics aren't "super," they're at least a clear step above anything else currently available in that price range.

Thunderware, previously known as a manufacturer of clocks for the Apple II and III, drew a lot of attention when its new Macintosh product, Thunderscan, was introduced at this year's National Computer Conference. Thunderscan is a high-resolution digitizer that enables the Macintosh to capture and later reprocess virtually any image that can be rolled under the platen of the Apple Imagewriter dot-matrix printer. The process is deceptively simple. Thunderscan consists of a palm-size optical sensor that snaps into the Imagewriter in place of the ribbon cartridge. When a document or picture is rolled through the printer, software written by Hertzfeld controls the sensor as it slides back and forth over an image.

Petrie says that Thunderware is sensitive about discussing the exact nature of the scanning technology used in the device. However, he will say that the scanner is able to extract analog information from the image and transmit it to one of the Macintosh serial ports without having to use traditional A/D (analog-to-digital) conversion techniques.

It's an intriguing process. For example, it's possible to increase the resolution of the image being scanned by increasing the scanning rate. The result of the proprietary technology is a low-cost scanning device (initially $229) that permits the Macintosh to store and manipulate images with a resolution in excess of 200 dots per inch.

According to Petrie, there are a number of difficulties in getting graphics images into the Macintosh. The greatest problem is that high-resolution graphic images require a relatively large bit map. Until now, the only way of stuffing this information into the Mac has been to use a video camera, and video cameras are relatively high cost and low resolution. (At the same time, it should be noted that cameras have the advantage of being fast. Because essentially only one row of pixels is scanned at a time, it takes Thunderscan as long as 15 minutes to digitize an entire 8½- by 11-inch document.)

Once Thunderscan has transmitted an image to the Macintosh, software designed by programmer Hertzfeld (who has left Apple and is now working on his own) can do a remarkable job of enhancing or manipulating it. Not only can you rescale images, you can also alter brightness and contrast to create halftones or high-contrast images (see figure 1). Additionally, the Thunderscan software contains a number of graphics tools familiar to those who have used the MacPaint program on the Mac. There is also a special "express" option that lets you go directly to MacPaint to further enhance an image.

The Thunderscan software operates on a

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bit map that is stored in the Macintosh RAM (random-access read/write memory). The bit map has a size limit of 48K bytes on the 128K-byte machine. This is just about a full page at 72 dots per inch. On the 512K-byte Macintosh, a bit map as large as 300K bytes can be stored. With this amount of information you can store a full 8½- by 11-inch document at up to a 300 percent magnification. You can use this expanded storage space for image enlargement or to extract gray-scale information on up to 64 levels of intensity. On the 128K-byte Macintosh, both the magnification and the halftoning features are available, but only for smaller regions of a scanned document (a document can be scaled four times linearly, yielding a magnification of up to 16 times by area).

To use the equipment, first select a page-map option from the scanner's menu. From within the page-map screen you can choose to scan the area of your original by changing the size of a selection rectangle. The system prompts you with warning messages if the area you select is either too large to store gray-scale information or too large to scan. This feature also lets you scan just a portion of a larger document to make certain that you have gray scale and magnification set correctly.

After you've completed the scanning phase, you can play with the image in memory. You can work with a document in the same way you use MacPaint, with a special image window. But Hertzfeld has added a series of features to the Thunderscan software that give it functions that MacPaint doesn't have. You can use a special hand icon to move large documents around in the image window (unlike the first release of MacPaint, which stored image information outside of memory on disk, Thunderscan allows the document to slide freely).

You also can use the hand icon to impart inertia. For example, if you push the mouse in one direction, the image will continue to slide after you have stopped, much like a piece of paper slides along a table. In addition to being intuitive, this feature lets you move slowly or quickly around an image.

Other MacPaint icon tools, such as the pencil, FatBits, and cutting and pasting, as well as inversion (changing black pixels to white pixels and vice versa), are also available within Thunderscan.

Documents created by Thunderscan can be saved in one of two formats. One is a special MacPaint format yielding a 720- by 756-pixel document with 1 bit of information per pixel. The second is a less-restricted scan format that permits multiple bits of information to be stored for each pixel.

The range of possibilities that Thunderscan creates is fascinating. For example, Hertzfeld thinks that it might put an end to the burgeoning market for Macintosh predrawn images because you can copy virtually any image into the Macintosh memory.

A future project for Hertzfeld is a Macintosh desk accessory (a small program that runs in the background under the Mac operating system) that will permit Thunderscan to send scanning information out through the Macintosh modem port while you work in another program. This would convert the Macintosh into a low-cost (and multitasking) digital-facsimile machine. Hertzfeld is also working on a protocol that would enable the Macintosh to print software code in a format that could be scanned using Thunderscan. Paper would then be the medium for software distribution. Hertzfeld believes that he could get close to 40K bytes per sheet of paper.

MORE DELAYS FOR MICROSOFT WINDOWS

In early October 1984, Microsoft Corporation announced that it was postponing the introduction of its long-awaited Windows software-integration package until June 1985. Leo Nikora, Windows product-marketing manager at Microsoft, said that the company was undertaking "a major redesign," in part because Windows' code cur-

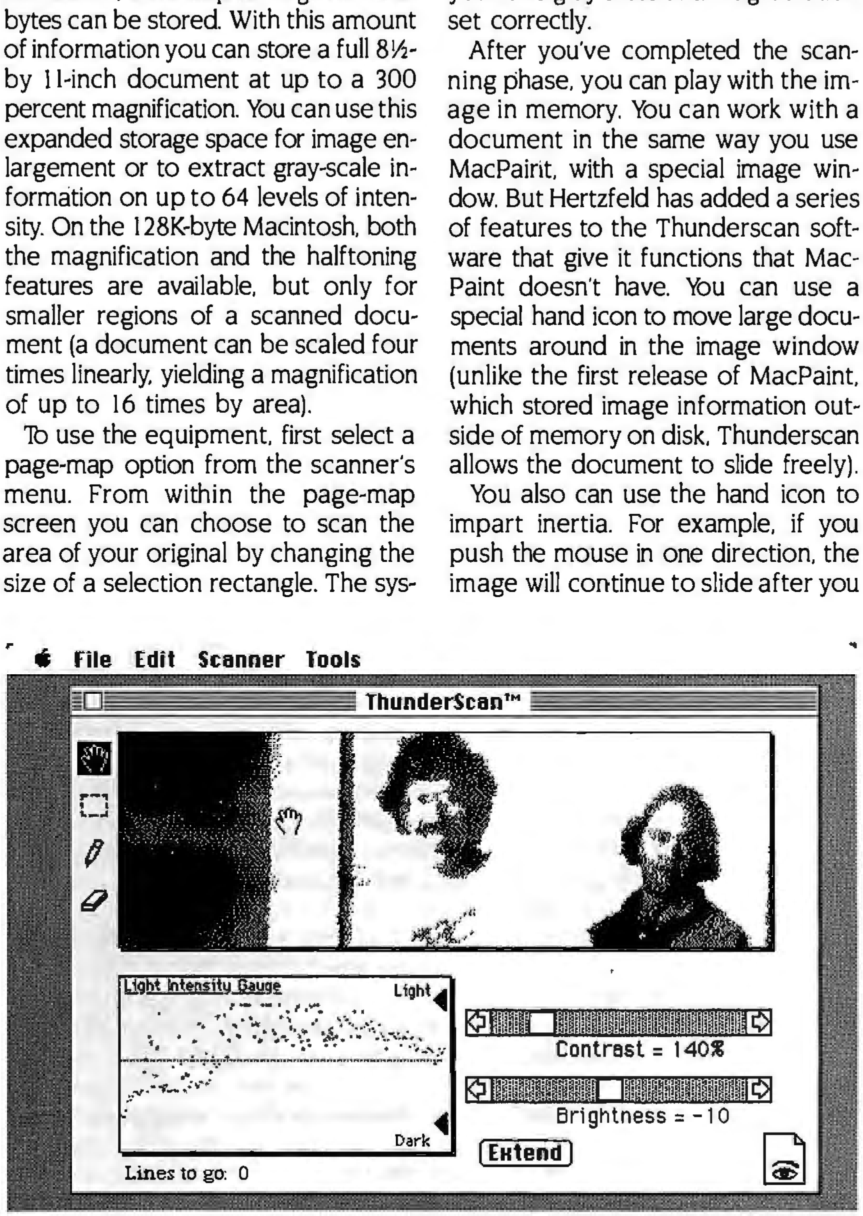

Figure 1: *A scan dump. As Thunderscan scans a document, the image appears on the screen display. It can be adjusted dynamically by resetting the contrast and brightness gauges on the display. As each line is scanned, a scattergram of the scan appears on the Light Intensity Gauge. In the lower left corner a message reports on the progress of the scanner. After the bit map of the image has been transferred to the Macintosh RAM it can be edited with several MacPaint-style tools that are displayed as icons in the upper left corner of the screen. The image also can be displayed in a larger window accessible from the menu bar.*

rently takes up too much space and also because several functions are not running fast enough.

As recently as this spring, Microsoft was hoping to achieve a minimum recommended system size of 192K bytes. The most current technical information available on Windows states that Windows together with the operating system occupies 156K bytes of memory; thus the currently recommended 256K bytes leaves only about 100K bytes for applications software—not much by today's standards.

Nikora said that almost all of Windows is now written in the C language and that Microsoft plans to rewrite as much as half of the program in 8088 assembly language. Apparently Microsoft is happy with the window-management functions of the program but feels that text management is inadequate. Nikora said that Microsoft expects a twofold increase in text performance after the code is rewritten, although he feels that the performance of the product is already satisfactory on the IBM PC AT.

Microsoft is clearly worried that its decision to delay Windows will lead to a negative attitude in the marketplace. "We have to be careful that Microsoft doesn't get the reputation of giving up in the face of TopView," claims Nikora, referring to IBM's entry in the window-management fray.

He also maintains that Microsoft's decision to delay the product introduction hasn't led to mass desertions on the part of companies developing applications software for Windows. On the contrary, he said that there was a general feeling of relief that they were being given more time to get their applications ready for market.

Microsoft is also looking for a way to differentiate Windows from TopView, and the company appears to have found one because the current version of TopView is designed for a character-based display. This will, at least temporarily, be a selling point for Windows, which functions only in a bit-mapped environment.

Will Windows face the same fate that befell Visi On? Nikora says that he is certain that it won't—his evidence is the fact that a number of the manufacturers of IBM PC-compatible computers appear to have a sizable stake in the success of Windows. Still, Microsoft is starting over again after investing more than a year in attempting to develop a user interface for the IBM PC.

Convergent's Fast NGEN

Although criticism of the IBM PC AT hasn't been nearly as fevered as that leveled at the PCjr, there are some doubters emerging. Why, some experts have asked, does the 80286 microprocessor in the PC AT have an artificially lowered clock speed? And why is the bus speed even slower than the bus speed for the IBM PC? A number of companies are already comparing their systems to the PC AT to demonstrate their systems' performance.

Several companies are already comparing their systems to the PC AT to demonstrate their systems' performance.

Convergent Technologies Inc., a Santa Clara, California, company is selling its NGEN "modular" workstation based on the Intel 80186 microprocessor to a variety of OEM suppliers. Last year the NGEN got off to a slow start because of the scarcity of the 80186, but now Convergent claims to have shipped 50,000 systems.

The NGEN is built around a collec-

(continued)

The NGEN is a quick machine, and it has an "X-Bus" that allows 16-bit DMA transfers at speeds up to 4 megabytes per second.

tion of components; a separate video display and keyboard connect to a shoebox-size central processor. A variety of add-ons such as RAM, floppy- and fixed-disk drives, and graphics components can be simply plugged into the processor module to expand the system. Convergent Technologies' own multitasking multiprogrammed operating system (CTOS) permits users to run MS-DOS, CP/M-86, and Convergent's own flavor of UNIX System V called Distrix.

It's a quick machine; the 80186 runs at 8 MHz, and it comes equipped with 120-nanosecond RAM. The NGEN has a proprietary "X-Bus" that allows 16-bit DMA (direct memory access) transfers at speeds up to 4 megabytes per second.

To show off the performance of the NGEN, Convergent sets it next to an IBM PC AT and then has both systems recalculate a series of Fibonacci numbers in 2400 cells of a Multiplan spreadsheet. It takes the NGEN 4.9 seconds to recalculate the series while the PC AT finishes it in 11.8 seconds. This performance comparison may not be entirely fair, given that Multiplan on the NGEN has been ported to run under CTOS and in the process its performance has been considerably improved. However, the demonstration gives ample evidence that it won't be hard to improve on the performance of the PC AT.

Explosive Compatibles

Tandem Computers Inc. has a new workstation and some associated software aimed at the IBM PC crowd. Tandem is known for its NonStop systems, such as the new TXP 32-bit, transaction-processing computer. Parallel processors and special software protects these systems from breakdowns, which endears Tandem computers to on-line users such as airlines and banks.

The new Dynamite 654x family of workstations provides the same features as the 653x family of on-line terminals but adds both 3270 emulation and personal computer features. The Dynamite is built around the 8086 and can, it is claimed, run most IBM PC software.

The two Dynamite workstations (which will be built in Austin, Texas) differ in mass-storage capacity and price. The 6541 has two 360K-byte floppy-disk drives and costs $2995. The 6546 has one 360K-byte floppy-disk drive and a 10-megabyte hard-disk drive and will cost $3995.

Both the 6541 and the 6546 have 12-inch green screens (for both text and graphics) and 256K bytes of RAM. The current options include bit-mapped graphics and memory expansion to 640K bytes of RAM. The Dynamite terminals interface directly with Tandem's 5540 and 5541 printers.

Dynamite terminals come with MS-DOS and GW-BASIC. The new Tandem software includes IXF and PCformat. IXF (and associated information exchange facilities) can transfer data from files on a Tandem NonStop system to a Dynamite workstation. PCformat converts such files into MS-DOS-compatible files.

Is Dynamite just another "compatible"? Tandem says it isn't because, while the Dynamite can run most IBM PC software, it isn't supposed to be an IBM PC competitor; it's designed

(continued)

COMPANIES MENTIONED

CONVERGENT TECHNOLOGIES INC.
2500 Augustine Dr.
Santa Clara, CA 95051
(408) 727-8830

INTEL CORPORATION
151 Blue Ravine Rd.
Folsom, CA 95630
(916) 351-8080

MICROSOFT CORPORATION
10700 Northup Way
Bellevue, WA 98004
(206) 828-8080

TANDEM COMPUTERS INC.
19333 Vallco Parkway
Cupertino, CA 95014
(800) 482-6336

THUNDERWARE
19 Orinda Way, Suite G
Orinda, CA 94563
(415) 254-6581

specifically to work with Tandem's bigger transaction machines.

REMEMBER BUBBLES?

Intel's Non-Volatile Memory Division—one of the few companies still in the bubble-memory game—has a couple of new removable bubble-memory cassette kits: the BCK-10 and the BCK-12. Both provide a 1-megabit cassette. The BCK-12 prototype kit costs $495 and has a limited temperature range (10 to 55 degrees Celsius). The BCK-10 production kit costs $605 and can survive a greater range of temperatures (0 to 65 degrees Celsius). The kits include the necessary support chips for the bubble memories and an SBC-258 board interface with a ribbon-cable output so you can just hook the kit up and start writing software. Intel is proud of the simplicity of these kits; they use only six support chips where earlier bubble systems required many more.

The Intel facility in Folsom, California, is getting a new fabrication line to make 4-megabit bubble chips; the standard 1-megabit chips will now probably be phased out in 1985 or 1986. Moving from 4 to 16 megabits on a chip (by shrinking the loops) will be difficult and should take several years—the 4-megabit chips already depend on the advanced, expensive technique of X-ray lithography.

Bubble memories aren't found in many personal computers; the expense just can't be justified for routine applications. Some portables—the Grid and the Sharp—do use bubbles, which allow mass-storage with low power use. A few add-on boards have appeared (such as the Helix board for the IBM PC) that exploit the nonvolatility of the bubble chips. While both the Grid and the Helix products use Intel bubbles, the Sharp portable uses Japanese bubble chips. If fabrication costs can be brought down to a reasonable level, bubbles could be the storage device of the future, though early hopes have long since faded.

A BLUE NOTE

Rolm—the telecommunications equipment maker—has frequently been used as an example of the Silicon Valley workstyle because it offers such employee benefits as flextime, sabbaticals, and a multimillion-dollar recreation center. Two senior IBM officials appeared at Rolm to quell speculation that the famous workstyle would be threatened by the IBM buyout. Said one of the officials, "Contrary to what the press has said, we're not here to drain the pool." ■

Realizing a Dream

The Whitechapel Computer Works MG-1 personal workstation

BY DICK POUNTAIN

In previous columns I've documented some of the activity in British low-cost home computer design. Don't run away with the idea that we can *only* make home computers, though. This month I've been looking at a 32-bit graphics workstation that provides power roughly equivalent to a VAX 11/750 at a starting price of £5500.

The machine is called the Whitechapel Computer Works MG-1 (see photo 1), and it is the first product from this start-up company (let's call them WCW from now on). WCW was founded in April 1983 by Managing Director Timothy Eccles (a physicist turned computer engineer who has worked at Bell Laboratories, Logica, and Rank Xerox) and Technical Director Bob Newman (a computer science lecturer at Queen Mary College in London). The company is located in a new complex called Whitechapel Technology Centre, which was created with assistance from the city council to attract high-technology industries back into the deindustrialized center of London; it seems to be working. Design of the MG-1 was begun in August 1983 and carried through to production in barely a year, with the first units shipped in September of 1984.

PERSONAL WORKSTATIONS

For several years I've permitted myself the occasional daydream about what my (realizable) dream computer might be. It goes something like this: a 68000 or 16032 (this was before National Semiconductor decided that 32016 sounded sexier) processor in a desktop box, a "clean" architecture with lots of memory and straightforward in-memory bit-mapped graphics (but very high resolution), an on-board Winchester drive, and above all, hardware assistance for raster-graphics operations. In other words, my dream computer would be a personal computer (à la Apple II) fed with anabolic steroids, or alternatively, the Xerox Alto at a personal computer price. I kept watching, but it didn't quite happen. The Sage (now Stride) looked interesting, but what's this—a serial terminal? The Corvus Concept showed us that even a 68000 runs out of steam if asked to run the screen as well as crunching numbers, but the Lisa and Macintosh continue to try.

The MG-1 fits the bill exactly except that it isn't quite in my price range. It isn't meant to be, of course. WCW has single-mindedly targetted it at the CAD/CAM (computer-aided design/computer-aided manufacturing) personal workstation market, competing with machines like Sun, Apollo, and Perq, which typically cost over four times as much as the MG-1. These dedicated minicomputers are called "personal workstations" because only one person uses the machine at a time (i.e., they're not multiuser), but at upwards of £20,000 all but the richest firms would require several designers or engineers to share one machine on a rota.

Bob Newman, principal designer of the MG-1, reasoned that if he adopted personal computer rather than minicomputer design techniques (no multiboard bit-slice processors, no demountable hard-disk packs, no industrial fans), a colossal price reduction should be possible. He reasoned thus at the same time that VLSI (very-large-scale integration) technology had made it possible. Viewed this way, the MG-1 is the first truly personal workstation; not only will it fit on a desk, but it's priced so that firms can afford one per person: it costs about the same as a full-spec IBM Personal Computer (PC) XT and less than a PC AT.

SPECIFICATIONS

The MG-1 is driven by the NS32016 32-bit virtual-memory processor chip, running at 8 MHz, and mounted along with all the other integrated-circuit (IC) components on a single personal-computer-style system board. An eight-layer board is used to give simpler routing for the conductors. This board is held in a desktop casing with a footprint slightly larger than that of an IBM

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PC; the works are cooled by a single miniature silent fan.

The 32016 is complemented by its support chips, the 32082 memory manager and the 32081 floating-point processor, though the former is still suffering from bugs, and WCW currently has it on a piggyback board that contains its own hardware fixes. Standard memory is 512K bytes, expandable in 512K-byte chunks up to 8 megabytes. At least 100K bytes of this memory is devoted to the bit-mapped black-and-white display that has a resolution of 1000 by 800 pixels. A 17-inch (landscape format) monitor with a display width of 150 characters is included, and it can depict an A4 document page, albeit slightly reduced to fit the height. Mass storage is provided by a single 800K-byte floppy-disk drive and a choice of a 10-, 22-, or 45-megabyte Winchester drive built into the case.

Peripheral expansion is catered to by the bold step of adopting the IBM PC bus. The MG-1 internal expansion unit has three IBM expansion slots and IBM cards will work (with the proviso that suitable drivers have to be written). Communication is via a built-in Ethernet interface for networking MG-1s to share the expensive laser printers or plotters necessary to print on the high-resolution screen. An RS-232C port enables a local draft-quality printer or modem to be attached.

The operating system is Genix, a Berkeley 4.1 UNIX customized by WCW to support the MG-1's graphics abilities, for which optimized C, FORTRAN, and Pascal compilers are offered.

Raster Graphics

A CAD/CAM workstation has very specific requirements (which I believe are, in the main, also the requirements for future personal computers). It is by definition an interactive system that dictates very fast response times even for the most complex operations.

It must be capable of very-high-resolution graphics. In a low-cost machine this has to be achieved by using a direct refresh bit-mapped screen. Personal computer users are quite familiar with bit-mapped graphics; it's the rule rather than the exception. However, in the CAD/CAM business it isn't yet the rule, but one technique among many; random-scan vector displays still are in use, and where a raster display *is* used it frequently has a dedicated frame buffer separate from main memory.

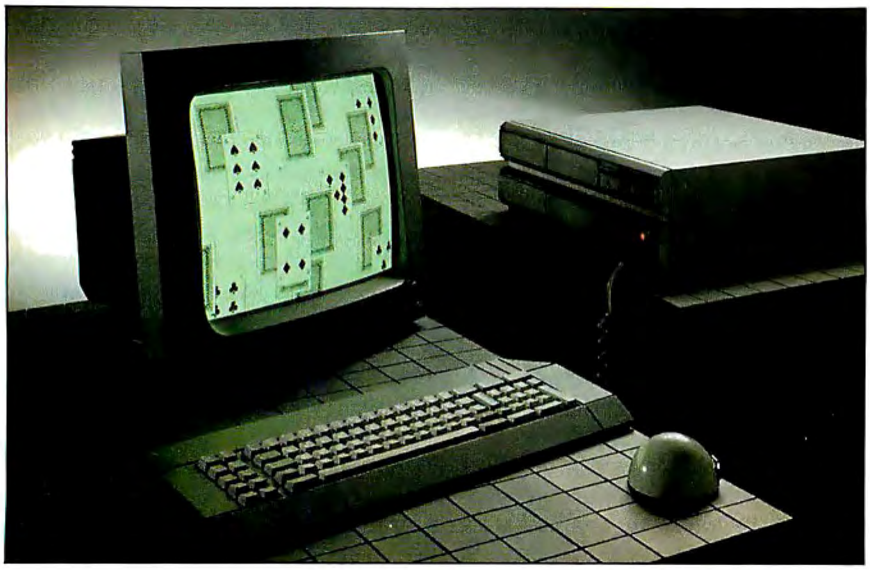

Photo 1: *The Whitchapel Computer Works* MG-1 *uses the National Semiconductor* 32016 32-*bit virtual-memory processor chip.*

WCW decided that the bit-map data should be in main memory (just like an Apple II or IBM PC) so that multiple screen buffers could be utilized; animation then can be achieved by building one screen while another is being displayed. The other advantage of having the bit map in main memory is that it simplifies the use of *RasterOps* as the primitive graphics operations.

RasterOp (called BitBlt, for Bit Block Transfer, at Xerox PARC [Palo Alto Research Center]) is a fast algorithm for doing bit-mapped graphics. Anyone who has written a BASIC program to draw a circle knows that it takes a long time to move that circle (by redrawing it again somewhere else); the computation of which points to plot is wastefully repeated every time the circle is drawn. RasterOp, in a nutshell, says "don't redraw the circle, move the bits that make up the first circle." Rectangular areas of the screen data (called "rasters") are directly moved about in the bit map using raster block-move operations (RasterOp). Unlike, for instance, simple Z80 block moves, with RasterOp you can do Boolean operations (AND,OR,XOR) between the destination and source rasters so you can get effects like overlapping transparent backgrounds or use mask rasters to clip shapes. Much of the theory and practice of this kind of graphics was worked out at Xerox PARC in the 1970s (by the Smalltalk people, among others), and it lives today in the Lisa and Mac. (For more information on Smalltalk, see the August 1981 BYTE.)

Display systems based on RasterOp tend to be homogeneous; there is no distinction between "text" and "graphics." All text characters are handled as rasters, and this is what makes the plethora of different type styles possible on the Macintosh. Because of this total reliance, the efficiency of RasterOp becomes critical.

There are two computation problems when using RasterOp; what to do if a raster (which is defined in *bit* coordinates) doesn't lie nicely on byte or word boundaries, and how to find the actual memory addresses of the lines in a raster (don't forget that successive lines in a rectangle on the physical screen aren't contiguous in memory). The amount of computation involved can bring even the most powerful of the new microprocessors to its knees if it has to do the computation every time it wants to write a character or scroll the screen in addition to all its other duties.

Having decided on a 1000 by 800 screen (the minimum for a serious CAD display), WCW was committed to a 100K-byte bit map. It's often necessary to treat the whole screen as a raster (e.g., when scrolling) so you have to be able to deal with single graphic objects of up to 100K bytes in size. The main design question has now answered itself. A 32K-bit processor is necessary to efficiently manipulate objects larger than 64K bytes. When writing a program on the MG-1 in C, for example, you can pass the whole screen as a single array.

WCW then decided to provide a separate video processor to handle RasterOps; this unit performs the shifts to align rasters to word boundaries, masking, and Boolean operations. It also calculates the addresses of rasters and feeds them to the microprocessor. The 32016 isn't loaded with any of these chores.

By employing some tricky design techniques, including a 64K-bit-wide memory bus, WCW has managed to attain a flickerless 60-MHz screen-refresh rate using industry-standard 150-nanosecond memory chips. The total memory bandwidth available is 200 MHz, giving sufficient leeway for the 32016 to access memory with effectively no wait states.

The 32016's demand-paged virtual memory means that the data for a single screen might be scattered all over physical memory in different pages. Rather than waste time reorganizing these fragments into a contiguous 100K-byte block, the video controller maintains a page map so that it always knows where its images are stored.

The result of all these design decisions is spectacularly fast graphics operation combined with easy programming in high-level languages. Rasters can be created and processed anywhere in main memory and then moved onto the screen. As many screens as memory allows can be held in memory simultaneously, and with virtual memory, "memory allows" has a broad meaning. The MG-1 employs a two-level paging system similar to that on the VAX.

At a somewhat higher level, WCW has implemented the GKS (Graphical Kernel System) graphics standard, which is more suitable for CAD/CAM

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applications programmers than are the raw raster-graphics primitives.

I/O Hardware

The adoption of virtual-memory UNIX together with the constraints imposed by the high-performance display places extraordinary demands on the hard-disk subsystem.

Again Newman broke away from minicomputer design practices and went for a solution taken from the personal computer domain: a central DMA (direct memory access) controller rather than complex multiple buses. The single-chip DMA controller can load consecutive blocks to any page in memory and works fast enough to do without buffering; there is a direct path from memory to the Winchester disk. In one rotation of the disk a whole track can be loaded, shotgun fashion, into a scattered selection of pages. Apart from performance and cost benefits, this scheme has the virtue of providing DMA service for any IBM expansion cards fitted to the expansion bus.

The Ethernet controller can't be as simple because Ethernet requires devices to receive its packets of information without warning and at very high speed. With Ethernet, buffering was found to be necessary under operating system control using a second DMA device.

Operating System

Having decided upon the 32016, WCW was faced with the crucial choice of an operating system. UNIX turned out to be the only commercially widespread operating system that could support 32-bit virtual memory and had a reasonable software base. The fact that UNIX was designed for timeshared multiuser systems and has no support for graphics didn't help.

National Semiconductor already had Genix, based on UNIX System II with the BSD (Berkeley Software Distribution) extensions, available for the 32016. WCW had to do considerable work to get satisfactory performance in a single-user, interactive, graphics-based application quite unlike that for which it was designed.

One of the biggest problems with UNIX is its poor response time to interrupts. Like most modern workstations, the MG-1 uses a mouse for cursor control and a mouse works by sending interrupts to the operating system to say that it's moved. If UNIX is busy elsewhere, cursor movement will start to lag noticeably behind mouse movement, thus destroying the visual illusion upon which mouse control is based. It's like driving a car with a flexible rubber steering wheel. Newman, typically, went for a hardware solution. The cursor is *not* represented in the main bit map as on most other systems. Instead another coprocessor is employed to read the mouse position continuously, and the 64-pixel cursor is produced in a small separate memory, then video-mixed with the main display. UNIX and the main processor are only interrupted when some action is to be taken, i.e., a mouse button has been pressed. This same coprocessor handles the "soft" keyboard too, which makes it earn its keep.

Another problem arises with the windowing system, for which UNIX's process communication system is not ideal. WCW is working on the window manager and has decided to treat it as a user program rather than an extension to the UNIX kernel. This will permit experienced users to modify it if they wish.

One of the great dangers with UNIX is system corruption on shutdown; you can't simply switch off the power on a UNIX system as you can with CP/M or MS-DOS and expect it to come back up unscathed. Huge amounts of housekeeping and reshuffling need to be done before UNIX can be put to sleep. Because personal computer users are used to a more cavalier attitude toward their machines, WCW took a leaf out of Lisa's book and provided a soft power switch. When you hit the "power-off" button, power is not disconnected immediately; instead an orderly UNIX shutdown is initiated while you are on your way down the stairs to catch your bus.

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Commodore 64 Benchmark (Sieve of Eratosthenes)	PROMAL	BASIC	COMAL	FORTH	PASCAL	
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Object Code Size (bytes)	128	255	329	181	415	
Program Load Time (secs.)	3.2	3.8	6.3	11.2	23.5	
Compile Time (secs.)	8.5	—	—	3.9	108	

As the benchmark results in the table show, PROMAL is much faster than any language tested. From 70% to 2000% faster! And it generates the most compact object code. The PROMAL compiler is so fast that it can compile a 100-line source program in 10 seconds or less. And, not only is it fast in compile and run time, it also reduces programming development time.

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Hardware solutions are becoming cheaper than writing software.

Other little goodies include a battery-backed real-time clock/calendar and CMOS (complementary metal-oxide semiconductor) RAM (random-access read/write memory) area for holding system information to assist service engineers in maintenance and fault tracing.

SOFTWARE

WCW does not intend to become a supplier of CAD/CAM software. The sort of client they are aiming the MG-1 at will typically have some existing software system or will have a specification for such a system and the capability to write it. WCW will provide an operating system with graphics support (included in the machine's price), the GKS Kernel, a window manager, and three high-quality compilers for Pascal, C, and, in recognition of its huge existing software base, FORTRAN.

THE FUTURE

There's no point in pretending that the MG-1 is a personal computer in its present form. It's an extremely powerful and cost-effective tool for engineers, designers, and possibly artificial-intelligence researchers, but it requires a plotter or a laser printer to provide proper hard-copy output (hence the Ethernet). A serial dot-matrix printer could only produce text output for program listings.

As a personal computer user I am interested in the MG-1 because the design decisions embodied in it are relevant to the next generation of personal computers. In particular, Bob Newman's philosophy of "do it in hardware where you can" is at odds with current thinking in certain large corporations, where a reliance on software solutions seems to be based on highly optimistic estimates of the power of the new microprocessors. Besides, we are entering an epoch in which hardware solutions are becoming cheaper than writing software.

At the moment, the Macintosh is by far the cheapest personal computer using advanced raster graphics. Could the functionality of an MG-1 be had for the price of a Macintosh? The 32016 chip set is still terrifyingly expensive and constitutes a significant fraction of the hardware costs, but this factor should ease in coming years as the various 32-bit chips get into volume manufacture. Similarly, the price of 256K-bit memory parts and of Winchester disks is steadily falling. Custom gate arrays could do away with most of the discrete logic used in the MG-1. Perhaps most significant, though, is the new generation of graphics coprocessor chips that are on the way; for example INMOS's G213 Graphics Controller promises BitBlt at 8 million pixels per second. Laser printers are tumbling in price (witness the Canon), or perhaps one of the more potent dot-matrix printers like the Epson LQ-1500 could be persuaded, like Apple's Imagewriter, to perform as a fast graphics device.

Speculation aside, a most exciting prospect arises because the MG-1 possesses sufficient brawn to support the Xerox Smalltalk language system. Newman is enthusiastic about Smalltalk and sees it as a possible development, though the marketing people are not yet convinced that a real demand exists. Tektronix announced the HS 4404 Artificial Intelligence System with Smalltalk-80 at $14,950—the cheapest Smalltalk system so far (see What's New, October 1984 BYTE, page 39). You won't need a spreadsheet to work that out; an MG-1 should do it for about half that price with a laser printer thrown in. This would at least put Smalltalk into the hands of educational institutions, but it remains well beyond private pockets. More's the pity.

WCW should have a subsidiary in the U.S. in operation by the time this column is printed. Contact Whitechapel in the U.K. at 75 Whitechapel Rd., London E1, England. BYTE hopes to review the MG-1 in a future issue. ■

Photographed at Gulfstream Aerospace, Savannah, GA.

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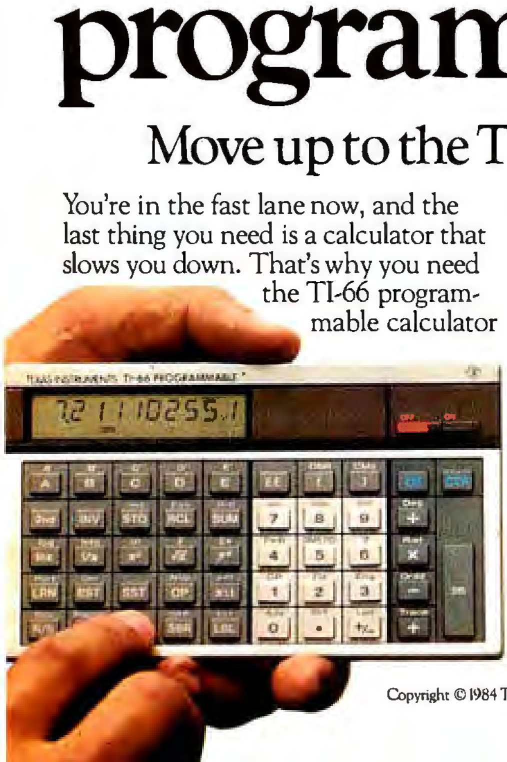

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Copying Mass-Marketed Software

Both sides of the Lotus lawsuits

BY ROBERT GREENE STERNE AND PERRY J. SAIDMAN

This is the first of our columns on computers and law, and a few words are in order. As contributing editors, we will examine state-of-the-art computer-law issues. Since the law lags behind the technology and the technology is evolving at a rapid rate, legal systems everywhere are being confronted with such novel legal questions as legal protection of application and operating-system software, user rights against vendors for defective hardware and software, ownership rights in microcomputer technology created by independent contractors, and the right to publish protected software in user magazines. The resolution of such questions will shape the microcomputer industry in the years ahead. In our columns, we will address a given computer-law issue, present the arguments and legal precedents, if any, on either side, and let you decide which is more persuasive. This, we hope, will foster an awareness of computer-law issues.

THE LOTUS LAWSUITS

Lotus Development Corporation has started the next round in the legal prizefight between software vendors and users of mass-marketed software packages. In the winter of 1983/84, Lotus filed a lawsuit against Rixon, a maker of modems and multiplexers in Silver Spring, Maryland, alleging that Rixon personnel have made more than 10 unauthorized copies of Lotus 1-2-3 and associated documentation. The suit was quickly settled. According to the trade press, Rixon agreed to a permanent injunction against unauthorized copying and paid Lotus an undisclosed sum of money. The suit received widespread publicity and sent shock waves through corporate America.

Flush with victory, Lotus filed suit in July 1984 against Health Group Inc. (HGI). Lotus alleged that HGI had made several unauthorized copies of the Lotus 1-2-3 disks and delivered them to its hospitals and nursing homes in the southeastern United States. The suit was settled by consent decree in September 1984, a little more than two months after it was initiated. As Rixon did, HGI agreed to a permanent injunction against unauthorized copying and paid Lotus an undisclosed sum of money. This suit also has received widespread publicity.

These two lawsuits appear to be the beginning of a wave of such suits by software vendors against institutional users—manufacturers, service organizations, governmental bodies, schools—whose personnel are making unauthorized copies of mass-marketed software packages. This activity seems to be enormous and growing. Depending on whom you talk to, estimates range from 1 to 20 unauthorized copies for each *authorized* copy. These unauthorized copies represent an enormous amount of money: estimates place it in the hundreds of millions of dollars.

Top executives at several large software houses have indicated to us that they are seriously thinking of following Lotus's lead. We also know from discussions with top lawyers at several large companies and governmental agencies that a massive cleanup campaign is afoot as organizations silently trash their unauthorized copies.

LEGAL ISSUES INVOLVED

All this has started a spirited, and often very heated, debate between vendors and users. Vendors see this as a market-correcting mechanism for keeping institutional users "honest." Many users grudgingly agree but wonder if the vendors might not be biting the hand that feeds them. A vocal group of users vehemently disagrees with the vendors and charges that this is nothing more than an attempt to intimidate users into paying inflated license fees. The users warn that the upshot of this will be a loss of creativity and freedom as big business tightens its grip on the microcomputer market.

In its suit against HGI, Lotus alleged six

(continued)

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Lotus claimed maximum statutory damages of $50,000 for each unauthorized copy plus court costs.

legal theories (called counts) to support the legal remedies sought, including a permanent injunction against unauthorized copying, compensatory money damages, lost profits, statutory money damages, attorneys' fees, and court costs. If the Lotus Development Corporation had been awarded relief on all counts in the amounts alleged in the complaint, HGI would have been out more than 2 million dollars.

Count one alleged that HGI had willfully infringed the Lotus copyrights on Lotus 1-2-3. Lotus stated that it owned two copyright registrations—TX 1-233-501 and TX 1-233-502—in the Lotus 1-2-3 packages, which include the user's manual and the software disks. It stated that the two registrations had effective dates prior to the date on which infringement began. This was important, since Lotus could not receive statutory damages or attorneys' fees for any infringement that occurred before the effective date of the copyright registrations. Lotus also stated that all lawful copies of Lotus 1-2-3 had carried a proper copyright notice. It alleged that since the infringement was willful, it was entitled to attorneys' fees and statutory damages of $50,000 for "each act of infringement" (i.e., *each* unauthorized copy!) in addition to a permanent injunction and court costs.

Court decisions have been handed down that find that application software is entitled to copyright protection and that verbatim copying constitutes copyright infringement unless it is authorized by agreement or by law. Further, the Copyright Office routinely grants copyright registrations for application software that is in compliance with the registration requirements. What is of great significance in count one is that Lotus alleged that it was entitled to statutory damages in the maximum of $50,000 for each unauthorized copy. Section 504(c) of the Copyright Act of 1976 states that the copyright owner may receive instead of actual damages and profits "an award of statutory damages for all infringements involved in the action, with respect to any one work. . . ." Statutory damages range from $100 to $50,000 depending on whether the infringement is innocent or willful. While the court has considerable latitude in the actual dollar amount, many legal experts argue that the language of Section 504 and its legislative history do not permit the court to multiply the statutory-damage dollar amount by the number of unauthorized copies. There do not appear to be any legal decisions that have addressed this precise issue.

The resolution of the statutory-damage issue will have far-reaching practical effects. If Lotus were correct in its interpretation and if the court agreed that it should receive the maximum $50,000 for each infringing copy, then Lotus would have received 1 million dollars for 10 unauthorized copies of Lotus 1-2-3 (multiplied by two since there were two copyright registrations). If Lotus were *incorrect* in its interpretation, then it would have received $50,000 for the 10 unauthorized copies. Compare these two amounts to $4950, which is calculated by multiplying the 10 unauthorized copies by $495 (the suggested retail price for Lotus 1-2-3). Under the 1909 Copyright Act, the current law's predecessor, some court decisions multiplied "in lieu" damages (similar to statutory damages) by the number of infringements of a single work. Fine lines were drawn as to the number of infringements. For example, one factor was whether the unauthorized copies were made all at once or over a space of time. Essentially, courts were finding ways to justify the multiplication approach in situations where a large number of unauthorized copies had been made of a single work and they felt that only one statutory amount was insufficient.

Supporters of the Lotus interpretation argue that the multiplication is proper since it fulfills the intent behind statutory damages, which is to provide adequate relief to the copyright owner. They point out that it is form over substance if multiplication is allowed when unauthorized copies are made over time and not allowed if they are made all at once. They maintain that the court should have discretion both with the dollar amount of the statutory damage and with the number of times it is awarded.

Detractors of the Lotus interpretation go straight to the language of Section 504. They see no ambiguity and argue that only one amount of statutory damages can be awarded for all infringements of a single work. They note that the legislative history of Section 504 supports this interpretation. They see the availability of actual damages and profits as the mechanism to compensate the copyright owner where there have been many unauthorized copies of a single work. Any other approach, they argue, would allow the copyright owner to effectively obtain punitive damages, which are unavailable under the copyright law.

Count two alleged that HGI committed willful trademark infringement since the unauthorized copies contained the Lotus and 1-2-3 trademarks. As pointed out in our article "Trademarking Software Packages" (March 1984 BYTE, page 393), trademarks often offer the most effective way to protect mass-marketed software packages. It is interesting to see that Lotus thought enough of its trademark rights to allege that it was entitled to not less than 1 million dollars for their infringement. It has been well documented that Lotus has spent millions of dollars advertising and promoting Lotus 1-2-3. It makes good business sense that Lotus would try to protect this investment by vigorously enforcing its rights in its trademarks and goodwill.

Count three is of interest because Lotus alleged that HGI violated the terms of the license agreement that accompanied the lawful copy of Lotus 1-2-3. This is the so-called *shrink-wrap* license, which you find under the clear wrapper that encases Lotus 1-2-3 before you first open it. The whole issue of shrink-wrap licenses was debated at the BYTE Computer Show in San Francisco in September 1984. (Tapes of the software piracy session (SS1) can be purchased for $8 from Professional Cassette Center, 180 East California Blvd., Pasadena, CA 91105, (818) 796-0200.)

Lotus alleged that the unauthorized copies breached the provision of the shrink-wrap license that states that the user "may not . . . make copies of the User's Manual or the 1-2-3 system disk. . . ." Vendors argue that the shrink-wrap license becomes binding on the user when the software package is opened and not returned and that contractual provisions against copying are valid. Users take the opposite view. First, they argue that a shrink-wrap license is not binding because the user never has accepted it. They also argue that even if there has been acceptance, the copying provisions are invalid because they are in conflict with the copying provisions contained in Section 117 of the 1980 Software Amendments to the 1976 Copyright Act. Section 117 states that "it is not an infringement for the owner of a copy of a computer program to make or authorize the making of another copy or adaptation of that computer program provided: (1) that such a new copy or adaptation is created as an essential step in the utilization of the computer program in conjunction with the machine and that it is used in no other manner, or (2) that such new copy or adaptation is for archival purposes only and that all archival copies are destroyed in the event that continued possession of the computer program should cease to be rightful."

Users argue that, when it is read literally, the Lotus copying prohibition is in conflict with Section 117 and thus is invalid due to preemption under Section 301 of the copyright law. Essentially, preemption means that the federal copyright law will take precedence over any state law that is in direct conflict with it.

It would seem that Lotus is picking and choosing its targets carefully.

Count four alleged that HGI unjustly enriched itself by making and using the unauthorized copies. Count five alleged that HGI committed fraud and misrepresentation. And, finally, count six alleged that HGI violated the Tennessee Consumer Protection Act. Each of these counts may have been viable, but the real teeth of the Lotus action were in counts one to three.

Why Settle?

Lotus has been able to settle both of these suits to its satisfaction outside of court. Thus, we have no way of knowing whether a court would find one or more of the alleged legal theories valid. Cynics would argue that Lotus and other vendors will only bring lawsuits in situations with a high probability of settlement. In other words, they are deliberately avoiding a legal test of these legal theories.

There is definite merit to the argument that Lotus is picking and choosing its targets carefully. This is exactly what Apple did when it successfully went after copiers of its operating-system software. This approach was also employed by Bally, Atari, and other electronic-game manufacturers. Copyright owners have learned to be very careful in bringing lawsuits involving new computer-law theories. An unfavorable decision, even if later overruled, can have a major impact on that theory of computer law for years. A loss also generates adverse publicity for the vendor, which makes settlements in other situations more difficult to obtain.

How Do They Find Out?

We were interested in learning how vendors find out about institutional

(continued)

Users argue that the root of the problem lies in inflated prices of software.

copying. It seems that vendors are as creative in this regard as users are in making unauthorized copies. They appear to have two major avenues of information. The first involves vendor software support. The actual user of an unauthorized copy will call the vendor's support number for assistance. In helping the user, the vendor begins to realize that the copy is unauthorized. It may sound crazy, but this is exactly what happened in the Rixon situation.

The other avenue is employees. It is understandable that disgruntled former employees often inform on their former employer as a way of getting revenge. Vendors meet with such people, and if their stories check out, a legal action may result. Even more interesting is the present employee who is having pangs of conscience. Management is asking him to make unauthorized copies, and he feels that it is wrong.

The unauthorized copies occur for many different reasons: a supervisor may have it done to keep within budget; a purchasing agent may make the procurement process so cumbersome that unauthorized copying is the path of least resistance; or a corporate attitude may evolve that condones and even applauds unauthorized copying. Vendor lawyers told us that this is one of the major areas of reform that the suits are intended to achieve.

In the Final Analysis

Users argue that much of the unauthorized copying would not be taking place if vendors had more enlightened marketing policies. They think that it is absurd that they have to pay such a high price for the *n*th copy of the same software package. Some vendors are responding to this argument by implementing site licenses that allow multiple copies to be obtained at discounted prices. This seems to make economic sense for vendors due to the economy of scale that is present.

Some users argue that the root of the problem lies in the inflated prices of software, whether in single or multiple copies. They contend that copying, whether by institutions or individuals for their own use, would come down in direct proportion to a reduction in price. It is a kind of supply-side economic theory.

Vendors see things quite the opposite. They argue that high prices are due to the lost sales caused by the unauthorized copying. Contrary to the myth of exorbitant profits, they point to the shakeout in the microcomputer software industry as proof positive that they cannot afford to shave their profits any more than they have. They point out that creating a commercially successful software package today requires a team of specialists—designers, programmers, technical writers, marketing specialists, and administrative personnel—and big development and marketing budgets. Gone are the days of shoestring success stories such as Electric Pencil. They constantly come back to the fact that the financial community no longer is in awe of the software industry and demands significant returns for its software investments.

Where Does This Leave Us?

There is no doubt that the Lotus suits are having a major impact on institutional users. As time goes on, a greater percentage of mass-marketed software will be used by institutional users as microcomputers find their way onto desks and workstations throughout the country. Lotus and others intend to make sure that *authorized* software is used with these machines. Sooner or later, one of these users will actually be sued and will fight back. That first court case will have an impact that will cause the impact of Lotus's two out-of-court settlements to pale by comparison. ■

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Conducted by Steve Ciarcia

Term-Mite for Visually Impaired

Dear Steve,

I am looking into the possibility of assembling a word-processing system for someone who is visually impaired and can read only oversize type. My thought is to couple a terminal with oversize characters to a machine like the Morrow Micro Decision, which works with an external terminal. Could your Term-Mite ST Smart Terminal be configured with a character grid of 12 lines by 40 columns of double-height and double-width characters? Do you know of any other terminals that produce oversize characters?

I would greatly appreciate an answer to these questions and any other suggestions you have regarding computing for the visually impaired.

Steven Ebstein
Cambridge, MA

The Term-Mite ST Smart Terminal (described in January and February 1984) has attributes to allow double-height and double-width characters. It is therefore possible to create the 12-line by 40-column display you desire.

Several terminals on the market that feature double-height/double-width character sizes include the Ergo 301 from Micro-Term Inc., 1314 Hanley Industrial Court, St. Louis, MO 63144, (314) 968-8151; the ET80 from Tec Inc., 2727 North Fairview Ave., Tucson, AZ 85705, (602) 792-2230; and the TeleVideo 970 from TeleVideo Systems Inc., 1170 Morse Ave., Sunnyvale, CA 94086, (408) 745-7760.

Many graphics terminals are available that allow custom programming of character sizes, but they are considerably more expensive (several thousands of dollars). If double-size characters are not adequate, either a terminal of this type or a dedicated computer with graphics capability will be needed.—Steve

Line Protection

Dear Steve,

After reading your December 1983 article, I decided to install some MOVs (metal-oxide varistors) in my power strips for my computer systems. When I purchased my computer, I bought a General Electric Spike Protector from the hardware store (for $19.95—and I thought radio tubes had the highest markup in the electronics industry). I can see that this is identical to the Radio Shack model pictured in your article. However, I realized that this would not afford me the full protection you recommended.

I decided, after reading your article, to take it apart to see what it contained. I found a GE V170LA10A MOV connected in series with a Microtemp 4168A1 temperature-cutoff device. How does this device function in this circuit?

My local electronics-supply store does not carry GE parts but had the RCA equivalents. I decided upon the SK53, which is equivalent to the GE V130LA20A. This is because I have several items plugged into my power strip, and I didn't want to take the chance of underprotecting it. The SK (and the ECG) catalogs list temperature devices, but I did not know which one to get nor how to install it (one for each MOV?), so I left them out for now. I would like to know if I need to install these cutoffs and how I should go about it.

I would also like to know how to build my own power strip that would filter out line noise, because my Apple IIe causes my wireless telephone to go crazy whenever graphics or flashing text is being displayed on the screen. I don't believe that the interference is RF-transmitted because the phone is two rooms away. Also, the phone is in its cradle at the time and is supposed to be immune to outside transmissions. Would a line filter help in this instance? The Radio Shack filter, part number 273-100, doesn't seem to be available any more—none of the stores in my area have it.

I look forward to your excellent articles every month, and although some are above me (I'm an audio/video expert), I still enjoy reading them. Keep warm up there in Connecticut and keep the articles coming!

Robert M. Deano
New Orleans, LA

MOVs usually fail by shorting. The temperature-cutoff device in series with the MOV is designed to open in the event of an MOV failure. A fuse will serve the same purpose and should be installed in series with the MOV.

In either case, the protection device should function before the MOV casing ruptures. If you are in an area where lightning strikes are not too frequent, the SK53 or GE V130LA20A MOVs are suitable. Use a "slow-blow" series fuse rated at no more than 15 A.

Before applying line filters to your Apple IIe, be sure that the cause of radiation is not ungrounded leads to your monitor or disk drives. Often, these leads can act as an antenna and radiate spurious signals.

Several manufacturers supply power-line filters that are suitable for your applications. They include

Corcom Inc.
1600 Winchester Rd.
Libertyville, IL 60048
(312) 680-7400
Type 5VK1 or 5VK3

Cornell-Dubilier Electronics
150 Avenue L
Newark, NJ 07105
(201) 589-7500
Type APF511L

Delta Electronics Industry USA
1355 Yosemite Way
Hayward, CA 94545
(415) 785-5231
Type 05DBAG5

Potter Company
POB 337
Wesson, MS 39191
(601) 643-2215
Type 600A5

These filters are equivalent to the Radio Shack part number 273-100. Write the manufacturers for additional information and the address of your nearest supplier.
—Steve

Speech Synthesis

Dear Steve,

I thoroughly enjoyed your article "Build a Third-Generation Phonetic Speech Syn-

(continued)

thesizer" in the March 1984 issue. I would like to bring attention to two comments in the article. On page 36, you said: "Most text-to-speech routines don't let you modify the rule tables or expand the number of exceptions." My company, Spectrum Projects, markets a voice synthesizer for the Radio Shack Color Computer; it costs $69.95 and includes in its text-to-speech software a word manager that lets you construct and edit custom dictionaries. It also prints the phonemes of a word, which lets you try different spellings to get better pronunciation and then have hard-copy printouts to review before adding the words to the dictionary. Finally, the product pronounces each alphanumeric key as it is pressed—an aid for the visually impaired.

On page 40, you said: "I haven't mentioned many uses for speech synthesis, but I'm sure you have a few ideas for what you could do with a speech synthesizer." Spectrum Projects also markets a program called Termtalk that allows the visually impaired to communicate using low-cost equipment ($159 for a 16K-byte Color Computer II, $69 for the Spectrum Voice Pak, and $39 for Termtalk). A blind customer of mine is thrilled that he can now get stock quotes from Dow Jones using my products.

BOB ROSEN
Spectrum Projects
93-15 86th Dr.
Woodhaven, NY 11421

Thank you very much for your letter and the data on your Voice Pak speech synthesizer and related software. The product sounds quite impressive, especially the price!

The ability to modify the rules of speech is an excellent feature that enables greater accuracy in pronunciation. The Sweet Talker speech-synthesis algorithm is a proprietary package and lacks that feature.

Your software is very comprehensive and allows the Voice Pak to be used in an integrated fashion. Termtalk is especially useful for the visually impaired.

Thanks again for the information. It's nice to see others promoting speech-synthesis applications.—Steve

NOT JUST FOR IBM

Dear Steve,

I have a new Columbia 1600-4. This desktop model is considered to be an IBM PC-compatible computer. Would the Trump Card work in it?

I also have a North Star Horizon, about four years old, on which I run BASIC programs—some under North Star DOS and some such as WordStar under CP/M. The Horizon has a Z80-A chip, and I am wondering whether the Zilog Z8001 can run Z80 programs. In other words, is the 8000 or 8001 upward-compatible with the Z80 instruction set, and does it constitute what could be considered part of a family of chips with the 8001 simply being more advanced, powerful, and able to handle 16 bits?

WOLCOTT TOLL
Newtown, CT

The Z8001 does not have the same instruction set as the Z80 and is not directly compatible with your Z80 programs. The Trump Card does, however, have a CP/M 2.2 software emulator that will run Z80 programs like WordStar, SuperCalc, and Multiplan. To use your Z80 programs, they must first be transferred to a PC-DOS or MS-DOS disk and given a filename extension of .CMD to differentiate them from 8088 .COM files. This can be accomplished in several ways. The easiest way to transfer your files is to connect the RS-232C ports on your computers and use communication software to send and receive the files.

The Trump Card should be compatible with your Columbia 1600-4, but if you have any questions contact Sweet Micro Systems, 50 Freeway Dr., Cranston, RI 02910, (401) 461-0530.—Steve

TEMPERATURE OVER POWER LINES

Dear Steve,

I read your article "Build a Power-Line Carrier-Current Modem" in the August 1983 issue. I'd like to build a data-collection network that would send temperature information over 120-V power lines to a host computer for storage. The temperature sensors would send information only when requested to do so by the host. In what form is the information best sent and which is cheapest?

NASSER AUDATALA
Cleveland, OH

Most low-cost serial-communication systems use ASCII characters to transmit information. These systems require a method of generating the ASCII character and converting it to serial data on the transmitting end and a method of receiving the serial data on the receiving end and converting it to some useful format. Computers and dumb terminals are typically used to send and receive the information in these systems.

However, in a data-collection system of the type that you indicate, data transfer can be handled in a much simpler manner. The temperature data can be acquired and converted to a frequency proportional to the temperature using a VCO (voltage-controlled oscillator). I presented a temperature-conversion circuit of this type in my article "Build a Computerized Weather Station" in the February 1982 issue. With this type of system, the computer on the receiving end needs only to determine the frequency and compare it to a calibration table to determine the remote temperature.—Steve

TRUMP CARD FOR S-100 BUS

Dear Steve,

I am an engineer forced into retirement by a heart condition several years ago. However, I have been interested in electronics since about 1927 when my father got involved in that field, and it has been a hobby of mine ever since. I took several night courses at our technical school in digital electronics and computers. I invested in a Heathkit H-100, which is the 8085/8088 hybrid using the S-100 bus. I purchased a couple of 8-inch double-sided double-density MPI drives and did all my own interfacing.

Adapting your Trump Card looks rather challenging, as I would have to wire-wrap the board for the S-100 bus. This would not deter me, but before I start I would like to know whether there would be a lot of program adaptation required to use the software that you offer with this system. Is the BASIC compiler suitable for Microsoft BASIC or, as Heath/Zenith terms its version, ZBASIC? I am not familiar with the version that IBM supplies (BASICA), and my concern is whether the compiler is specific to the IBM version or if it is general purpose. Would you venture to say how the Z8001 would compare in execution speed on mathematical programs compared to the 8087 coprocessor?

E. G. HRDLICKA
Edmonton, Alberta, Canada

With your background in interfacing, you should have little trouble in converting the Trump Card circuit to operate on the H-100 bus, and it should be an interesting project.

The software-initializing routine called

LDSYS and the device driver used by PC-DOS will probably have to be modified to run on your system. The documentation that accompanies the software does not describe these routines in any great detail, and this may be a problem area depending on your programming skills. You will also need a 5¼-inch disk drive that can read PC-DOS or MS-DOS disks, since this is the only format for which you will be able to find available software.

I am not familiar with ZBASIC syntax, but if it is close to MBASIC, written by Microsoft for standard CP/M machines, it will be highly compatible with BASICA, since MBASIC is practically a subset of BASICA.

The Trump Card will have a higher throughput in most applications than the 8088/8087 combination. This is because the 8087 is used only to perform numeric computations, which usually comprise only a small part of most BASIC programs. The advantages of the 8087 will be noted in programs that predominantly do number crunching.—Steve

TRUMP CARD AND CP/M-80

Dear Steve,

I currently have an IBM PC and a Xerox 820 printer. With the arrival of your Trump Card, I'd like to consolidate as much software as possible in the IBM. Question: How good is the CP/M-80 emulator accompanying your Trump Card? Also, is there a list of commercial CP/M-80 programs that can run under it? Can it handle all BDOS function calls? Thank you for any information you have.

JOHN M. ALLRED
FPO Miami, FL

The CP/M-80 emulator used with the Trump Card can run many programs written for a standard CP/M 2.2 environment. Typical programs that have been tested on the Trump Card are WordStar, SuperCalc, and Multiplan.

Since the CP/M-80 emulator is really a Z8001 program that interprets Z80 code and emulates it on the Z8001, the performance of the interpreted programs suffers a little in speed of execution. This reduction may or may not be noticeable to you, depending on how fast your own CP/M system is running.

The emulator handles 28 of the 37 CP/M 2.2 function calls. The function calls not supported are 3 Reader Input, 4 Punch Output, 7 Get I/O Byte, 8 Set I/O Byte, 27 Get Alloc Addr, 28 Write Protect, 30 File Attributes, 31 Disk Param Addr, and 32 User Codes. In addition, the standard CP/M BIOS calls dealing with the disk, the reader, and the punch are not supported by the emulator.—Steve ■

Over the years I have presented many different projects in BYTE. I know many of you have built them and are making use of them in many ways.

I am interested in hearing from any of you telling me what you've done with these projects or how you may have been influenced by the basic ideas. Write me at Circuit Cellar Feedback, POB 582, Glastonbury, CT 06033 and fill me in on your applications. All letters and photographs become the property of Steve Ciarcia and cannot be returned.

8086 and Z-8000 XASM includes Source Code Translators

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8086/88 ASM			$ 99.50	$ 99.50	
8086/88 XASM	$199.50	$750.00			$199.50
80186 XASM *new*	199.50	750.00	199.50	199.50	199.50
32000 (all) XASM *new*	299.50	750.00	299.50	299.50	299.50
68000,08,10XASM *new*	199.50	750.00	199.50	199.50	199.50
Z-8000™ ASM		750.00			299.50
Z-8000 XASM	199.50		199.50	199.50	
Z-80 ASM	49.50				
Z-80 XASM		500.00	99.50	99.50	99.50
Z-8 XASM	99.50	500.00	99.50	99.50	99.50
6301(CMOS) *new*	99.50	500.00	99.50	99.50	99.50
6500/11 XASM *new*	99.50	500.00	99.50	99.50	99.50
6502 XASM	99.50	500.00	99.50	99.50	99.50
65CO2(CMOS) XASM *new*	99.50	500.00	99.50	99.50	99.50
6800,2,8 XASM	99.50	500.00	99.50	99.50	99.50
6801,03 XASM	99.50	500.00	99.50	99.50	99.50
6804 XASM *new*	99.50	500.00	99.50	99.50	99.50
6805 XASM	99.50	500.00	99.50	99.50	99.50
6809 XASM	99.50	500.00	99.50	99.50	99.50
8748 XASM	99.50	500.00	99.50	99.50	99.50
8051 XASM	199.50	750.00	199.50	199.50	199.50
8080 XASM	99.50	500.00	99.50	99.50	99.50
8085 XASM	99.50	500.00	99.50	99.50	99.50
8096 XASM *new*	199.50	750.00	199.50	199.50	199.50
1802 XASM	99.50	500.00	99.50	99.50	99.50
F8/3870 XASM	99.50	500.00	99.50	99.50	99.50
COPS400 XASM	99.50	500.00	99.50	99.50	99.50
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SIMULTANEOUS EQUATIONS WITH LOTUS 1-2-3

BY JAN-HENRIK JOHANSSON

An example from macroeconomics

SPREADSHEETS ARE amazingly useful in a number of applications. In this article, I will show how macroeconomic models can be formulated as simple spreadsheet programs as long as they can be defined using just linear simultaneous equations. I will then go on to show how to solve such equations numerically using standard spreadsheet commands.

My inspiration for this article came after reading an article by Patrick E. McGuire (see reference 3). He published a simple BASIC program that solved simultaneous equations analytically, and he therefore seemed to have solved the problem I was interested in. But programming everything in BASIC from now on seemed to me to be a step backward. Was there a more general approach? I will illustrate a different method by using only the familiar spreadsheet Lotus 1-2-3. I will use it to solve systems of simultaneous linear equations through iteration (successive recalculations) rather than through successive transformations of the equations. The technique demonstrated here is in fact quite general and can also be applied to other spreadsheets and to many other types of models.

A FAMOUS MACROECONOMIC MODEL

Before describing the solution technique in detail, let me describe the problem. An area where systems of simultaneous equations (even very large ones) have become an essential vehicle for formulating and analyzing relationships is macroeconomics. Macroeconomic models describe global economic behavior of nations and groups of nations. Many models with hundreds of equations have been developed in efforts to analyze and project the economic performance of, for example, the United States. One of the first economists to develop major macroeconomic models for the U.S., using simultaneous equations as his analytical tool, was Professor Lawrence Klein of the Wharton School of the University of Pennsylvania. His classic model of the U.S. consists of a set of 20 simultaneous equations. The work was done in the early 1950s (see reference 2).

As our example, I am using an earlier and slightly simpler version known as "Klein's model I" (see reference 1), which I will formulate and run in Lotus 1-2-3. I will then show how to solve this model through iteration, using nothing but standard Lotus 1-2-3 commands. The example is important because it represents a type of application where the need to solve simultaneous equations efficiently has continued to be a key technical problem for economists around the world. However, you do not need to be an economist to understand the technique itself. I will ignore the economics and concentrate instead on demonstrating a general method—expecting the method to be applicable to other problems as well. On the

(continued)

Jan-Henrik Johansson (11123 Saffold Way, Reston, VA 22090) is a manager in the World Bank. He is interested in the use of microcomputers for development in the third world. The views and interpretations in this article are those of the author and should not be attributed to the World Bank, its affiliate organizations, or to any individual acting on their behalf.

other hand, if you want to know more about macroeconomic models, reference 4 is a good book. All the models described there can be handled by the techniques described in this article.

I will first define the model by using standard college algebra and then verify that the equations are circular. The circularity is what makes this example interesting. I will then translate the equations into an equivalent set of spreadsheet formulas. Table 1 shows the equations in algebraic form. This version of the model has six equations, each defining an economic variable in terms of some other economic variables. The equations for $C(t)$, $I(t)$, and $W(t)$ have previously been estimated from historical data using regression. The equations for $YR(t)$, $Y(t)$, and $K(t)$ are identity relationships. To see the circularity, notice that $I(t)$ is defined in terms of $K(t)$ and that $K(t)$ is defined in terms of $K(t-1)$ and $I(t)$—the variable we started with. The equations are therefore circular. If we take a closer look, we will find other circularities in the set of equations as well.

But there is more: not only is this set of equations circular, it is also recursive. That is, the solution to the set of equations for a particular time period depends on the solution of the same equations for preceding time periods. In this particular model, only one preceding time period is needed (referring to, for example, $K(t-1)$). However, it is quite common that one has to go back in time more than one time period to define the model. Of course, the recursion must stop at some point in the past. Therefore, instead of a reference to an earlier period, we need an initial numeric value to start the process.

One last point regarding the algebraic formulation of the model: the equations make use of three variables that have no equations. They are $G(t)$, $W'(t)$, and $P(t)$. These variables are input data. In fact, they are constants, although they vary from one year to the next. These three input variables are said to be exogenous (external to the model), while the six variables computed by the model are endogenous (internal to the model). We now have a model and a nomenclature to describe it. Let's now translate it to Lotus 1-2-3.

The reformulation of the equations in table 1 as a spreadsheet is straightforward; table 2 displays the formulas in columns B, C, and D of the spreadsheet. The spreadsheet formulas are in fact almost identical to the ones in table 1, except that we have reserved extra rows for the exogenous variables $G(t)$, $W'(t)$, and $P(t)$ as well as for the time period $YR(t)$. No typical spreadsheet coordinates are shown because I have named every cell in column D by the name of the corresponding variable. If a formula references a cell that has a name, Lotus 1-2-3 automatically replaces the normal coordinate notation by the name

(continued)

Table 1: *Klein's model I.*

Behavioral equations:	
Consumption function	C(t) = B0 + B1*P(t) + B2*(W + W')(t) + B3*P(t − 1) + u1
Investment function	I(t) = B4 + B5*P(t) + B6*P(t − 1) + B7*K(t − 1) + u2
Demand for labor	W(t) = B8 + B9*(Y + T − W')(t) + B10*(Y + T − W')(t − 1) + B11*t + u3
Identities:	
Taxes	T(t) = C(t) + I(t) + G(t) − Y(t)
Income after tax	Y(t) = W'(t) + W(t) + P(t)
Capital stock	K(t) = K(t − 1) + I(t)
Exogenous data:	Government expenditure (G), Government wage bill (W') and Profits (P) Regression coefficients: B0 − B11. Stochastic disturbances: u1, u2, and u3.

of the cell. This makes the formulas more readable and is a practical necessity for bigger models. As a special trick, I have given names like $K(-1)$ to the cells in column C (corresponding to period 1).

The net result is that Lotus 1-2-3 displays all formulas in a notation that is familiar to economists and almost identical to that of table 1. We thus have six equations with six unknowns for each period. Because formulas for subsequent periods are structurally identical to the ones in column D, it is sufficient to list only one column in order to display the logic of the model. But to *solve* the model, we must explicitly repeat the formulas in column D for each time period we are interested in.

Because the formulas for different periods reference each other, a solution to the model must satisfy all formulas for all periods at the same time. In fact, if we wrote down an algebraic formulation of this model in a nonrecursive form, the total number of equations would equal the number of equations (six) for each period times the number of time periods minus four initialized values for the first time period. Solving the model for, let us say, 24 periods therefore amounts to solving a system of linear equations with 140 unknowns. The lesson is that our rather simple spreadsheet example has revealed considerable underlying complexity and a respectable computational problem. Considering recursion and circularity, how do we go about calculating the solution?

GAUSS-SEIDEL

A common method used to solve complex systems of linear equations is the Gauss-Seidel iterative method, which roughly goes like this: take an arbitrary value (often 0) and use it to initialize one or several of the unknowns in order to break all circularities in the system of equations. Now compute the rest of the unknowns through simple substitution. Obviously, what we have now is not a solution because at least one unknown has been given an arbitrary value. Because of the circular nature of the equations, however, we can now compute this variable from the other variables we just computed. In so doing, we will get a better initial value to use in a second round with the other unknowns. Now repeat the process a number of times. During each iteration the values tend to change less and less. After a certain number of iterations, they do not change any more. The process has converged, and the values are stable. We have reached the solution.

Solving equations through iterations is not something one would like to do by hand, but a computer can do it, and Lotus 1-2-3 does it quite nicely. The traditional Gauss-Seidel method may sometimes require many iterations to converge and may therefore be quite slow, even on a computer. It is not unusual if 40 to 100 iterations are needed before a solution is found. The better we are at guessing the initial values, the fewer iterations we need for convergence. In particular, if we already have solved the equations once and we then introduce a slight change to the exogenous data or to the equations, the old solution is likely to be a good first guess. Taking it as our set of initial values (instead of arbitrary numbers), we will need fewer iterations to reach a new solution.

A spreadsheet gives us the opportunity to take advantage of this fact, because spreadsheets like Lotus 1-2-3 always store the results of the last computation (the last solution) with the formulas. When using a spreadsheet, we will always start the iterations from an approximation that is probably close to the solution. The only exception to this rule is the first time we enter the formulas. By going in small steps from solution to solution, we can explore the performance of our model in a way that is fast because we have reduced the total number of computations needed.

Fortunately, this process matches well with the way people actually use models. For example, we may be interested in how sensitive exports are to small changes in exchange rates or import tariffs. Or we may want to see

(continued)

Table 2: *A formulation of Klein 1 in Lotus 1-2-3. The exogenous variables* G *and* W′ *have been given a 5 percent and 3 percent annual growth rate, respectively. Use of the information in this table is explained in the text box.*

Column B	Column C	Column D
B1: YR =	C1: 1	D1: +YR(−1)+1
B2:	C2:	D2:
B3: C =	C3: 1.5	D3: −2.0+0.2*P+0.55*(W+W′)+0.26*P(−1)
B4: I =	C4: 3.0	D4: +1.0+0.78*P−0.05*P(−1)−0.02*K(−1)
B5: G =	C5: 5.0	D5: +G(−1)*1.05
B6:	C6:	D6:
B7: W =	C7: 3.0	D7: −1.0+0.24*(Y+T−W′)+0.2*(Y(−1)+T(−1)−W′(−1))+0.1*YR
B8: W′ =	C8: 1.0	D8: +W′(−1)*1.03
B9: P =	C9: 3.0	D9: 3
B10:	C10:	D10:
B11: T =	C11:	D11: +C+I+G−Y
B12: Y =	C12:	D12: +W+W′+P
B13: K =	C13: 5.0	D13: +K(−1)+I

Table 3: *The solution to Klein I for 10 time periods using the data from table 2.*

Klein's model I	YR =	1	2	3	4	5	6	7	8	9	10
Consumption	C =	1.500	1.620	1.784	1.937	2.094	2.256	2.423	2.596	2.775	2.961
Investment	I =	3.000	3.090	3.028	2.968	2.908	2.850	2.793	2.737	2.683	2.629
Government expenditure	G =	5.000	5.250	5.513	5.788	6.078	6.381	6.700	7.036	7.387	7.757
Private wage bill	W =	3.000	3.043	3.309	3.557	3.809	4.070	4.339	4.618	4.907	5.206
Government wage bill	W ' =	1.000	1.030	1.061	1.093	1.126	1.159	1.194	1.230	1.267	1.305
Profits	P =	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
Taxes	T =	2.500	2.887	2.954	3.044	3.145	3.259	3.384	3.521	3.672	3.836
Income after tax	Y =	7.000	7.073	7.370	7.649	7.935	8.229	8.533	8.848	9.173	9.510
Capital stock	K =	5.000	8.090	11.118	14.086	16.994	19.844	22.637	25.375	28.057	30.686

Regression coefficients:

-C-		-I-		-W-	
B0 =	−2.000	B4 =	1.000	B8 =	−1.000
B1 =	0.200	B5 =	0.780	B9 =	0.240
B2 =	0.550	B6 =	−0.050	B10 =	0.200
B3 =	0.260	B7 =	−0.020	B11 =	0.100

what happens to the model when it is exposed to a shock, such as quadrupling the oil price or barring all sales of grain to the Soviet Union.

THE REAL THING: 9000 UNKNOWNS

Experimenting with Klein's model I shows that when changing exogenous variables we need only 3 to 9 iterations to reach a new solution from an old one. Of course, a drastic change of exogenous variables may require more iterations. For 24 years, one iteration takes less than 7 seconds on my Compaq. With an average of 5 iterations required to reach the solution, the microcomputer has solved a system of simultaneous equations that has 140 unknowns in about half a minute. A printout showing the results for the first 10 years can be found in table 3.

I have experimented with very large models with up to 450 endogenous and 100 exogenous variables covering a time span of 20 years. Such a system has almost 9000 unknowns! One complete iteration still takes only about 22 seconds, and only 4 to 10 iterations are required for convergence. This is fully adequate for practical work with realistic models and makes our simple spreadsheet approach surprisingly competitive when compared even to large mainframe software packages specifically designed to solve macroeconomic models. What we have seen is a synergism. Iteration is an easy and slow method to solve equations. But because a spreadsheet by default makes a smart guess, we see a drastic improvement in efficiency, allowing us to attack much tougher problems than before.

However, a problem relates to finding a new solution to the system of equations. In the case of a small model, like Klein's model I, there is no question whether the model has converged or not. We can simply look at the screen and see what happens when we give a calculation command. When nothing happens, we are done. However, it will not take long before we have a model that does not fit on

KLEIN'S MODEL I IN LOTUS 1-2-3

This is a complete step-by-step example of how to build and execute the model. First, you set up the worksheet. When entering the model, use the data in table 2.

1. Type in the variable names in cells B1 to B13.
2. Type in the initial values in cells C1 to C13.
3. Using the variable name in column B and the Lotus /RNC command, name all the corresponding cells C1 to C13 as lagged variables (i.e., "*YR*(−1)," "*C*(−1)," etc.) and name all cells D1 to D13 simply with the variable names (i.e., "*YR*," "*C*," etc.).
4. Format the range C3..D13 to display three decimals.
5. Now enter the model equations into cells D1 to D13. Because cell names have been created earlier, equations can now be entered exactly as they are.
6. Copy the range D1..D13 all the way to column H. Also, copy D11 and D12 to C11 and C12, respectively. This extends the model to six annual periods.
7. Hit the Calc key (F9) several times and watch the values for year six in column H. If the model has been entered correctly, you will see the worksheet converge.
8. To run further simulations, change some of the initial values. Convergence control is still manual.

Automatic convergence control is next. We will use wages in year six (cell H7) to check for convergence.

9. Type the formula +H7 into cell A1. This will cause Lotus 1-2-3 to start every new iteration by copying the result of the preceding iteration to A1. The value of H7 is then recomputed. The difference between A1 and H7 is a measure of how close we are to a solution.
10. Using /RNC, give the cell A15 the name "\S" and enter the test for convergence: '/XI@ABS(A1−H7)>0.001~{CALC}/XG\S~. Translated into English, this macro says: *if the absolute value of the difference between two iterations for wages in year six is greater than a certain tolerance* (0.001), *recompute the spreadsheet and reevaluate the macro again; otherwise, you have found the solution.* That is, if the condition is not met, Lotus 1-2-3 will loop over the macro and continue recomputing the worksheet until changes are smaller than the tolerance.
11. To ensure that the value of A1 is computed before H7, i.e., that the value of the old iteration is stored, type /WGRC.

You are now ready to run a simulation. The macro we just created will automatically control the iteration process for you.

12. Change the initial value of some variable, for example, change G in C5 from 5.0 to 3.0.
13. Now execute our macro by typing ALT-S. We will see the model converging and then stop automatically when the solution is reached.

the screen. What we need is some kind of convergence-control mechanism. The ideal is that Lotus 1-2-3 keeps iterating until the biggest change in any value is smaller than some predefined (small) constant. Some other spreadsheets (Multiplan, for example) have convergence control built in, which is a real plus. The step-by-step example in the text box ("Klein's Model I in Lotus 1-2-3") contains a simple test for convergence written in the macro language of Lotus 1-2-3. The one-line macro illustrates the impressive power of the macro facility of Lotus 1-2-3. ■

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THE APPLE WORDSTAR BOOK, Jerry Mar. Glenview, IL: Scott, Foresman and Co., 1984; 288 pages, 19 by 22.8 cm, spiral-bound, ISBN 0-673-15992-2, $11.95.

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AUTOMATA, LANGUAGES AND PROGRAMMING, Jan Parendaens, ed. Lecture Notes in Computer Science #172. New York: Springer-Verlag, 1984; 536 pages, 16.5 by 24.3 cm, softcover, ISBN 0-387-13345-3, $22.

BASIC FUN FOR THE COMMODORE 64 BEGINNER, Arthur Denzau, Kent Forrest, and Robert Parks. Englewood Cliffs, NJ: Prentice-Hall, 1984; 256 pages, 17.5 by 23.3 cm, softcover, ISBN 0-13-061441-6, $19.95. Includes floppy disk.

A BASIC PRIMER FOR THE IBM PERSONAL COMPUTER: PROGRAMMING BUSINESS APPLICATIONS, Donald B. Trivette. Glenview, IL: Scott, Foresman and Co., 1984; 208 pages, 19.5 by 23 cm, softcover, ISBN 0-673-15997-3, $18.95.

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A BUYER'S GUIDE TO MICROCOMPUTER BUSINESS SOFTWARE, Amanda C. Hixson. Reading, MA: Addison-Wesley, 1984; 304 pages, 18 by 23.3 cm, softcover, ISBN 0-201-11065-2, $19.95.

CLU REFERENCE MANUAL, B. Liskov, R. Atkinson, T. Bloom, E. Moss, J. C. Schaffert, R. Scheifler, and A. Snyder. New York: Springer-Verlag, 1981; 200 pages, 15.5 by 23.5 cm, softcover, ISBN 0-387-91253-3, $14.95.

CAREERS IN COMPUTERS, Texe W. Marrs. New York: Simon & Schuster, 1984; 160 pages, 15.5 by 23.5 cm, softcover, ISBN 0-671-50221-2, $8.95.

THE COMMODORE 64 SOFTWARE BUYER'S GUIDE, Gary Phillips, Terry Silveria, and Sanjiva K. Nath. Bowie, MD: Brady Communications Co., 1984; 494 pages, 17.8 by 23.3 cm, softcover, ISBN 0-89303-382-0, $16.95.

THE COMMODORE 64 SURVIVAL MANUAL, Winn L. Rosch. New York: Bantam Books, 1984; 256 pages, 15.3 by 22.8 cm, softcover, ISBN 0-553-34127-8, $9.95.

COMPAQ USER'S HANDBOOK, Weber Systems Inc. staff. New York: Ballantine Books, 1984; 352 pages, 14 by 21.5 cm, softcover, ISBN 0-345-31841-2, $9.95.

THE COMPLETE SOFTWARE MARKETPLACE, 1984–85, Roger Hoffman. New York: Warner Books, 1984; 256 pages, 20.5 by 23.3 cm, softcover, ISBN 0-446-38024-5, $17.95.

THE COMPUTER ALPHABET BOOK, Elizabeth S. Wall. New York: Avon Books, 1984; 64 pages, 13 by 19 cm, softcover, ISBN 0-380-87106-8, $2.25.

COMPUTER BASED NATIONAL INFORMATION SYSTEMS, Stephen J. Andriole, ed. New York: Petrocelli Books, 1984; 176 pages, 20 by 26 cm, hardcover, ISBN 0-89433-255-4, $24.95.

THE COMPUTER COOKBOOK, William Bates. New York:

(continued)

THIS IS A LIST of books recently received at BYTE Publications. The list is not meant to be exhaustive; its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

BOOKS RECEIVED

Doubleday and Co., 1984; 416 pages, 20.8 by 27.8 cm, softcover, ISBN 0-385-19291-6, $14.95.

COMPUTER CRAZINESS, Paul Somerson and Stephen Manes. New York: Scholastic, 1984; 176 pages, 20.3 by 27.5 cm, softcover, ISBN 0-590-33175-2, $4.95.

COMPUTER KEYBOARDING FOR CHILDREN, Edward B. Fry. New York: Teachers College, Columbia University, 1984; 28 pages, 21.5 by 28 cm, spiral-bound, ISBN 0-8077-2754-7, $8.95.

COMPUTER MONSTERS, Stephen Manes and Paul Somerson. New York: Scholastic, 1984; 176 pages, 20.3 by 27.5 cm, softcover, ISBN 0-590-33177-9, $4.95.

COMPUTER OLYMPICS, Stephen Manes and Paul Somerson. New York: Scholastic, 1984; 174 pages, 20.3 by 27.5 cm, softcover, ISBN 0-590-33176-0, $4.95.

COMPUTER PROGRAMS FOR THE KITCHEN, Terence F. Dicker. Blue Ridge Summit, PA: Tab Books, 1984; 256 pages, 18.8 by 23.3 cm, softcover, ISBN 0-8306-1707-8, $13.50.

COMPUTER SPACE ADVENTURES, Paul Somerson and Stephen Manes. New York: Scholastic, 1984; 176 pages, 20.3 by 27.5 cm, softcover, ISBN 0-590-33178-7, $4.95.

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THE FREE SOFTWARE HANDBOOK, 1984–1985 CP/M EDITION, Patricia Hatcher and Blake Van Meter. Plano, TX: PeopleTalk Associates, 1984; 368 pages, 14 by 21.5 cm, softcover, ISBN 0-915907-07-0, $17.95.

AT HOME WITH BASIC, Henry Mullish and Dov Kruger. New York: Simon & Schuster, 1984; 272 pages, 14.8 by 21.3 cm, spiral-bound, ISBN 0-671-49861-4, $12.95.

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INSIDE COMMODORE DOS, Richard Immers and Gerald G. Neufeld. Chatsworth, CA: Datamost, 1984; 512 pages, 17.8 by 25.3 cm, softcover, ISBN 0-88190-366-3, $19.95.

INSTANT WORDSTAR FOR THE KAYPRO, Robert Wolenik. Reston, VA: Reston Publishing, 1984; 144 pages, 15 by 22.8 cm, softcover, ISBN 0-8359-3090-4, $15.95.

INVITATION TO MVS: LOGIC & DEBUGGING, Harry Katzan Jr. and Davis Tharayil. New York: Petrocelli Books, 1984; 256 pages, 16 by 24 cm, hardcover, ISBN 0-89433-081-0, $29.95.

JOB CONTROL LANGUAGE, 2nd ed., Ruth Ashley and Judi N. Fernandez. New York: John Wiley & Sons, 1984; 168 pages, 17 by 25.3 cm, softcover, ISBN 0-471-79983-1, $12.95.

THE JOY OF COMPUTER CHESS, David Levy. Englewood Cliffs, NJ: Prentice-Hall, 1984; 144 pages, 13.5 by 21.5 cm, softcover, ISBN 0-13-511619-8, $7.95.

KIDS & COMPUTERS: ADVANCED PROGRAMMING HANDBOOK, Eugene Galanter. New York: Perigee Books, 1984; 224 pages, 17.5 by 23.5 cm, softcover, ISBN 0-399-50976-3, $7.95.

LET'S LEARN BASIC: A KIDS' INTRODUCTION TO BASIC PROGRAMMING ON THE APPLE II SERIES, Ben Shneiderman. Boston, MA: Little, Brown and Co., 1984; 208 pages, 19 by 23.5 cm, softcover, ISBN 0-316-78721-3, $8.95.

LET'S LEARN BASIC: A KIDS' INTRODUCTION TO BASIC PROGRAMMING ON THE ATARI HOME COMPUTERS, Ben Shneiderman. Boston, MA: Little, Brown and Co., 1984; 208 pages, 19 by 23.5 cm, softcover, ISBN 0-316-78722-1, $8.95.

LOTUS 1-2-3 FOR MARKETING AND SALES, Michael V. Laric and Ronald Stiff. Englewood Cliffs, NJ: Prentice-Hall, 1984; 240 pages, 17.8 by 23.5 cm, softcover, ISBN 0-13-540899-7, $14.95.

MACHINE INTELLIGENCE 10, INTELLIGENT SYSTEMS: PRACTICE AND PERSPECTIVE, J. E. Hayes, D. Michie, and Y-H Pao, eds. New York: John Wiley & Sons, 1982; 582 pages, 15.8 by 25 cm, softcover, ISBN 0-470-27323-2, $109.95.

MANAGING YOUR BUSINESS WITH MULTIPLAN, Ruth K. Witkin. Bellevue, WA: Microsoft Press, 1984; 430 pages, 18.8 by 23.3 cm, softcover, ISBN 0-914845-06-3, $17.95.

MICROCOMPUTERS GO TO SCHOOL, Stanton Leggett, ed. Chicago, IL: Teach 'em, 1984; 248 pages, 13.5 by 21.5 cm, softcover, ISBN 0-931028-53-1, $16.95.

LE MICROPROCESSEUR 16 BITS 8086/8088, Alain-Bernard Fontaine. Paris, France: Masson, 1984; 238 pages, 16 by 23.8 cm, softcover, ISBN 2-225-80313-7, 108 francs.

MICROPROCESSORS IN INDUSTRY, Michael F. Hordeski. New York: Van Nostrand Reinhold, 1984; 542 pages, 16 by 23.5 cm, hardcover, ISBN 0-442-23207-1, $49.50.

MINUTE MANUAL FOR PFS: FILE/REPORT/GRAPH/WRITE, Jeffery Lesho and Jim Pirisino. Columbia, MD: MinuteWare, 1984; 184 pages, 13.5 by 21.5 cm, softcover, ISBN 0-913131-03-2, $12.95.

A MODEL-MANAGEMENT FRAMEWORK FOR MATHEMATICAL PROGRAMMING, Kenneth H. Palmer. New York: John Wiley & Sons, 1984; 416 pages, 17 by 24 cm, hardcover, ISBN 0-471-80472-X, $42.50.

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MORE COLOR COMPUTER APPLICATIONS, John P. Grillo and J. D. Robertson. New York: John Wiley & Sons, 1984; 176 pages, 17 by 25.3 cm, softcover, ISBN 0-471-80767-2, $39.90. Includes floppy disk.

MULTIPLAN FOR MARKETING AND SALES, Michael V. Laric. Englewood Cliffs, NJ: Prentice-Hall, 1984; 320 pages, 17.8 by 23.3 cm, softcover, ISBN 0-13-605080-8, $14.95.

MULTIPLAN: HOME AND OFFICE COMPANION, Elna Tymes and Peter Antoniak. Berkeley, CA: Osborne/McGraw-Hill, 1984; 246 pages, 20.5 by 27.5 cm, softcover, ISBN 0-88134-133-9, $15.95.

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THE OSBORNE/MCGRAW-HILL BUSINESS SYSTEM BUYER'S GUIDE, 2nd ed. Adam Osborne, Steve Cook, and Gail Todd. Berkeley, CA: Osborne/McGraw-Hill, 1984; 182 pages, 16.3 by 23.3 cm, softcover, ISBN 0-88134-125-8, $10.95.

PEAS STRUCTURAL ANALYSIS SERIES: APPLE II OR IIE VERSION, Practical Engineering Applications Software (PEAS). New York: John Wiley & Sons, 1984; 88 pages, 14.8 by 22.8 cm, softcover, ISBN 0-471-80290-5, $30. Includes floppy disk.

PERSONAL FINANCE PROGRAMS FOR HOME COMPUTERS, William S. Hodges and Neal A. Novak. Boston, MA: Little, Brown and Co., 1984; 192 pages, 21.5 by 27.8 cm, softcover, ISBN 0-316-36788-5, $14.50.

THE POWER OF: APPLEWORKS, Robert E. Williams. Englewood Cliffs, NJ: Prentice-Hall, 1984; 240 pages, 21 by 27.5 cm, softcover, ISBN 0-13-688045-2, $19.95.

POWER UP! KIDS' GUIDE TO THE COMMODORE 64, Marty DeJonghe and Caroline Earhart. Berkeley, CA: Sybex, 1984; 204 pages, 18 by 22.8 cm, spiral-bound, ISBN 0-89588-188-8, $14.95.

A PRACTICAL GUIDE TO THE APPLE IIC, Peter C. Weiglin and Joyce Conklin. Reading, MA: Addison-Wesley, 1984; 176 pages, 18.8 by 23.5 cm, softcover, ISBN 0-201-09660-9, $12.95.

PRESENTATION GRAPHICS ON THE APPLE MACINTOSH, Steve Lambert. Bellevue, WA: Microsoft Press, 1984; 288 pages, 18.8 by 23.3 cm, softcover, ISBN 0-914845-11-X, $18.95.

PROBOTS AND PEOPLE: THE AGE OF THE PERSONAL ROBOT, Timothy O. Knight. New York: McGraw-Hill, 1984; 144 pages, 13.5 by 20.3 cm, softcover, ISBN 0-07-035106-6, $9.95.

PROGRAMMABLE ASSEMBLY, W. B. Heginbotham, ed. New York: Springer-Verlag, 1984; 368 pages, 16 by 24 cm, hardcover, ISBN 0-387-13479-4, $43.

PROGRAMMING APPLE BASIC, John J. DiElsi, Elaine S. Grossman, John P. Tucciarone. New York: Holt, Rinehart and Winston, 1984; 464 pages, 17.8 by 23.3 cm, softcover, ISBN 0-03-063733-3, $18.45.

PROGRAMMING IN C ON THE IBM PC, Bryan J. Cummings and Lawrence Pollack. Englewood Cliffs, NJ: Prentice-Hall, 1984; 208 pages, 15.3 by 22.8 cm, softcover, ISBN 0-13-729351-8, $14.95.

SHOULD I BUY A HOME COMPUTER? A GUIDE WITH CHECKLISTS, Lincoln Hallen. Princeton, NJ: Petrocelli Books, 1984;

104 pages, 14 by 20.8, softcover, ISBN 0-89433-257-0, $8.95.

Small-Time Operator: The Computer Edition, Bernard Kamoroff. South Bend, IN: and books, 1984; 306 pages, 21 by 27 cm, spiral-bound, ISBN 0-89708-117-X, $19.95.

Software Defect Removal, Robert Dunn. New York: McGraw-Hill, 1984; 352 pages, 15.5 by 23 cm, hardcover, ISBN 0-07-018313-9, $29.95.

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The Software Marketplace: Where To Sell What You Program, Suzan D. Prince. New York: McGraw-Hill, 1984; 220 pages, 16 by 23 cm, softcover, ISBN 0-07-050859-3, $16.95.

Structure and Interpretation of Computer Programs, Harold Abelson and Gerald Jay Sussman with Julie Sussman. Cambridge, MA: MIT Press, 1985; 564 pages, 16 by 23.5 cm, hardcover, ISBN 0-262-01077-1, $30.

Structured Programming with Basic for the Acorn Computer, Roy Atherton. New York: John Wiley & Sons, 1984; 208 pages, 17 by 25.5 cm, softcover, ISBN 0-471-80600-5, $15.95.

TI Logo, Harold Abelson. New York: McGraw-Hill, 1984; 256 pages, 18 by 23.5 cm, softcover, ISBN 0-07-038459-2, $17.95.

Take It with You: The Complete Guide to Portable Business Computing, Richard M. Grelewicz. New York: John Wiley & Sons, 1984; 264 pages, 15 by 22.8 cm, softcover, ISBN 0-471-88198-8, $14.95.

The Time-Life Step-by-Step Guide to the Commodore 64, the editors of *Time-Life*. New York: Random House, 1984; 102 pages, 21 by 24 cm, hardcover, ISBN 0-394-72515-8, $12.95.

The Time-Life Step-by-Step Guide to the IBM PC, the editors of *Time-Life*. New York: Random House, 1984; 102 pages, 21 by 24 cm, hardcover, ISBN 0-394-72521-2, $12.95.

The Time-Life Step-by-Step Guide to the IBM PCjr, the editors of *Time-Life*. New York: Random House, 1984; 102 pages, 21 by 24 cm, hardcover, ISBN 0-394-72519-0, $12.95.

La Transportabilité du Logiciel, Olivier Lecarme and Mireille Pellissier. Paris, France: Masson, 1984; 264 pages, 16 by 24 cm, softcover, ISBN 2-225-80223-8, 140 francs.

Turtlesteps: An Introduction to Apple Logo and Terrapin Logo, Pamela Sharp. Bowie, MD: Brady Communications Co., 1984; 210 pages, 17.8 by 23.3 cm, softcover, ISBN 0-89303-906-3, $14.95.

Using the IBM Personal Computer: EasyWriter, Ada W. Finifter. New York: Holt, Rinehart and Winston, 1984; 318 pages, 17.8 by 23.5 cm, softcover, ISBN 0-03-063736-8, $18.45.

VIC 20 Computer Graphics Toolbox, Russell L. Schnapp and Irvin G. Stafford. Englewood Cliffs, NJ: Prentice-Hall, 1984; 192 pages, 17.8 by 23.3 cm, softcover, ISBN 0-13-941998-5, $14.95.

Word Processing with Your Adam, Barbara Spear. Blue Ridge Summit, PA: Tab Books, 1984; 160 pages, 18.5 by 23.5 cm, softcover, ISBN 0-8306-1766-3, $9.25. ■

INTRODUCING
Interface Technologies' Modula-2 Software Development System

The computer press is hailing Modula-2 as "the next standard in programming languages." Modula-2 combines the strengths of Pascal with the features that made C so popular, like independent compilation and direct hardware control.

But until today, no company offered a Modula-2 system that made the development of software fast, easy and efficient. Now, though, there's a new tool at your disposal.

The fast, powerful tool for programmers

The breakthrough is here: Interface Technologies' new Modula-2 Software Development System for the IBM® PC, XT, AT and compatible computers to give programmers the same quantum leap in productivity spreadsheets and word processors gave to end-users. It can reduce monotonous wait time, will dramatically increase speed, help stop thoughtless mistakes, and free you to become more creative in virtually all of your programming efforts.

How to speed input and eliminate 30% of errors

Thirty percent of programming mistakes are syntax errors and simple typos in the program structure. Our "syntax-directed" Modula-2 editor does away with these time-consuming headaches once and for all.

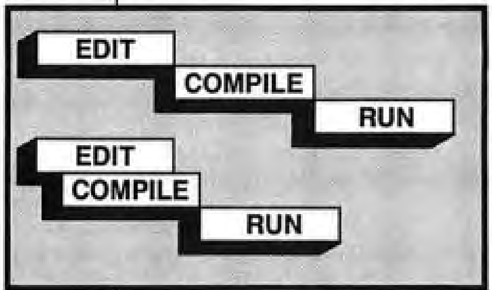
Enter complete statements with one keystroke.

It speeds input by cutting manual typing as much as 90%, letting you enter statements with a single keystroke. For example, if you type a capital "I" to begin a line, the editor completes the logical "IF THEN" statement automatically, so you can concentrate on what you want to program, rather than concentrate on what you're typing.

The editor locks out errors, finishing statements and procedures in perfect accord with the standardized rules of Modula-2. It also indents and formats your text automatically, making programs easy to read and maintain, an important feature on big projects.

And if you leave an undefined variable or data type, the editor detects the mistake and gives you the option of on-line "help" to correct it. No other programming text editor offers you so much innovation at any price.

How to turn "wait time" into "work time"



It not only has a faster compiler, it also saves time by compiling while you edit.

The vast majority of programming time is spent waiting, and the biggest slowdown is most often with compilers.

THE ANATOMY OF A

Our compiler turns wait time to work time with a new innovation that lets you compile in the "background."

With background compilation, your program is automatically compiled into object code line by line as you work, every minute you spend writing or editing a Modula-2 program!

When you're finished editing, all that's left for the compiler is a quick mopping up job that generates optimized native code in a single pass.

How quick is "quick"?

Thanks to background compilation and the fact that the compiler itself is so fast, Interface Technologies' compiler turns 100 lines of typical Modula-2 text into optimized machine code in *under five seconds*.

Plus the Interface compiler produces compact code with execution speed superior to that produced by any other Modula-2 compiler on the market.

How to do two things at once

Along with the background compiler and syntax-directed editor, which can save you hours every day and make you more productive, Interface Technologies' Software Development System gives your monitor windows so you can refer to one file while you edit another simultaneously, saving you even more time.

Work with multiple files faster, easier in windows.

Concurrent editing of two or more files is especially useful when doing programming work that's intended for separate compilation, and Interface Technologies has the only Modula-2 system on the market that provides you with this helpful benefit for developing software.

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One of the advantages of Modula-2 is that it lets you build large, reliable programs quickly, by linking together many smaller "building-block" modules.

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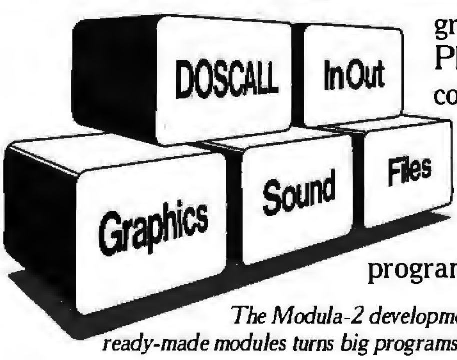

The Modula-2 development system's toolkit of ready-made modules turns big programs into smaller projects.

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BENCHMARKING UNIX SYSTEMS

Thanks to David F. Hinnant's excellent article, "Benchmarking UNIX Systems" (August 1984, page 132), I feel I gained an awareness of the limitations and advantages of the different UNIX/machine combinations. The results are a great reference guide. However, I was a little surprised by the lack of a System V version (the standard-to-be one), which motivated me to run all the benchmark programs specified in the article on an NCR Tower (an M68000-based computer) under UNIX System V. Table 1 shows my findings. For the tests I used 2 megabytes of RAM and one 30-megabyte hard disk.

The values obtained fall about midway between systems 6 and 7 when plotted on the graph in figure 1 on page 408.

I was rather pleased with these results, since my Tower was, according to Hinnant's tables, among the top seven most powerful systems. I hope this small extension of Mr. Hinnant's work will be very useful to all System V users, because this version is intended to standardize the UNIX world.

MARIO DESCALZI
Columbia, SC

Table 1: NCR *Tower performance using* UNIX *benchmarks discussed in* "*Benchmarking* UNIX *Systems*."

	real	user	sys
1. Pipe	6.1	0.0	2.8
2. System Call	13.8	0.5	13.2
3. Function Call	1.7	1.6	0.0
4. Sieve	4.5	4.3	0.1
5a. Disk Write	3.4	0.0	1.3
5b. Disk Read	8.8	0.0	2.0
6. Shell	9.1	0.4	2.2
7. Loop	13.4	12.8	0.1

Number of Concurrent Processes

1	2	3	4	5	6
9.8	16.0	22.2	35.3	44.2	52.2

A CALL FOR STANDARDS

In a computer system, dates can be kept in many different ways. If "DD" represents day, "MM" month, and "YY" the year, let me define the British way as "MMDDYY," the French way as "DDMMYY," and the standard international way as "YYMMDD." Despite its universality and advantages for sorting, the last one is not used by MS-DOS, dBASE, or Quickcode (to name just a few).

Let me ask both software and hardware developers to stick to international standards. Let me further suggest that they keep dates as numeric values (taking advantage of most keyboards' numeric locking feature) and automatically enforce month and day values smaller than 13 and 32, respectively. Zeros could be allowed for month and day when their values are unknown.

PAUL-ANDRE DESJARDINS
Rabat, Morocco

ENHANCING PERFECT WRITER

In the August 1984 BYTE, Barry D. Smith wrote about reconfiguring Kaypro's keypad for use with Perfect Writer ("Reconfiguring Perfect Writer Commands," page 22).

To anyone using Perfect Writer on a Kaypro, I recommend the inexpensive enhancements available from Plu*Perfect Systems (Box 1494, Idyllwild, CA 92349). While running the word-processing program, keys can be defined, files printed or erased, disks changed, and the directory accessed. Key definitions also can be saved and automatically loaded. The swap file can be increased in size up to an entire disk.

Plu*Perfect recommends erasing Perfect Writer's menu to provide space on the disk for key definitions and other files. Everything that can be done through the menu can be done more quickly at the system level.

Documentation and user support is excellent. I have been using the enhancements for nearly a year and wouldn't do without them.

JAMES SWANSON
McBride, British Columbia, Canada

SUBSCRIBER'S LAMENT

My letter is one of caution to other readers of computer magazines. My experience with computers and the computer-magazine industry goes back only about four years, and in this period of time I have subscribed to at least eight different publications, most of which are good sources of information and education, especially yours. But something less than professional is happening within this industry.

In the past six months I have had the unfortunate experience of being a subscriber to two publications that just quit sending out their magazines: *CLOAD* and *Computer User*. A third magazine that quit publishing (*Basic Computing*) did have the professional integrity to transfer its subscriptions to another magazine.

Maybe I have been a victim of a freak set of circumstances, but I don't think so. I believe this is the trend of the future. I hope not, but there doesn't seem to be much a consumer can do once the magazine has your money. It's obvious that bad management is ever present even in the computer-magazine industry.

STEVE HERMES
Bloomington, IL

FORTH CONFERENCE

The fifth Rochester FORTH Conference will be held at the University of Rochester, Rochester, New York, June 12–15, 1985. Sponsored by the Institute for Applied FORTH Research Inc., the focus of the conference will be on software engineering and software management.

There is a call for papers on the following topics:

- software engineering and software management practices
- FORTH applications, including, but not limited to: real-time, business, medical, space-based, laboratory and personal systems; and FORTH microchip applications
- FORTH technology, including finite-state machines, metacompilers, FORTH implementations, control structures, and hybrid hardware/software systems

Papers may be presented in either platform or poster sessions. Please submit a 200-word abstract by March 30, 1985. Papers must be received by April 30, 1985, and are limited to a maximum of four single-spaced, camera-ready pages. Longer papers may be presented at the conference but should be submitted to the refereed *Journal of FORTH Application and Research*.

Abstracts and papers should be sent to the conference chairman: Lawrence P. Forsley, Laboratory for Last Energetics, 250 East River Rd., Rochester, NY 14623. For more information, call or write Ms. Maria Gress, Institute for Applied FORTH Research, 70 Elmwood Ave., Rochester, NY 14611, (716) 235-0168.

ADDING A HARD DISK

In Roy M. Matney's excellent article, "Adding a Hard Disk" (October 1984, page 203), he reiterated a common misunderstanding about my software product, The Norton Utilities. I would like to explain what my programs can and cannot do, and why.

As many of your readers know, my Norton Utility programs provide file recovery (UnErase) and disk exploration (DiskLook) features for the IBM PC family. However, in the past they have not worked on most unconventional disks: RAM disks, quad-density disks, JFORMAT 10-sector disks, or any hard disk that wasn't in one strict format.

Many people—including Mr. Matney—have assumed that this was because my programs worked "below the BIOS." Actually not. All disk operations were done through conventional PC BIOS services. My programs did not work on more disk formats for a much worse reason: simply because I had coded these programs rather rigidly on the framework of five standard IBM disk formats. It was a lack of flexibility in my programming that restricted their use from wide application.

I am happy to say that I have mended my ways. Version 3 of my Utilities does all of its disk work completely at the DOS level (a full level higher than the BIOS) and is carefully written to adjust to any reasonable disk format. The version 3 programs run beautifully on RAM disks, partitioned hard disks, the PC AT's 1.2-megabyte high-capacity disk, quad-density micro disks (such as those in the Data General/One), and many others.

Version 3 of the Norton Utilities is in beta test as I write this and is planned to be released to the public in mid-December 1984. Owners of old versions can upgrade for a $25 charge.

For those who are interested, here is a summary of what's new in version 3: the programs automatically adjust to the format of the disk they are working with; the programs are virtually DOS-generic, so that they would work on nearly any MS-DOS computer; a new set of disk-management services, dubbed the "hard disk helpers," has been added; overall, the character of these programs has been shifted toward the needs of nonexpert computer users: the programs are easier to understand and use and have features with broader appeal. I'm not leaving the experts unsatisfied, though: my beta-testers, experts all, have been giving version 3 lots of applause.

PETER NORTON
Santa Monica, CA

I enjoyed Roy Matney's informative article, "Adding a Hard Disk," on hard-disk upgrades. However, it is incorrect to say that the Norton Utilities will not work with our controller. The Norton program is expecting 305 DOS cylinders, no more, no less. Our system gives you more than that. By using FDISK.COM to reduce the number of DOS cylinders to 305, the Norton Utilities will perform as expected.

CHRIS TIPTON
Director of Technical Support
Maynard Electronics
Casselberry, FL

CLUSTER ANALYSIS

Rob Spencer's article, "Cluster Analysis" (September 1984, page 129), is a jewel. In the midst of all the recent articles on structuring BASIC by executing subroutines

(continued)

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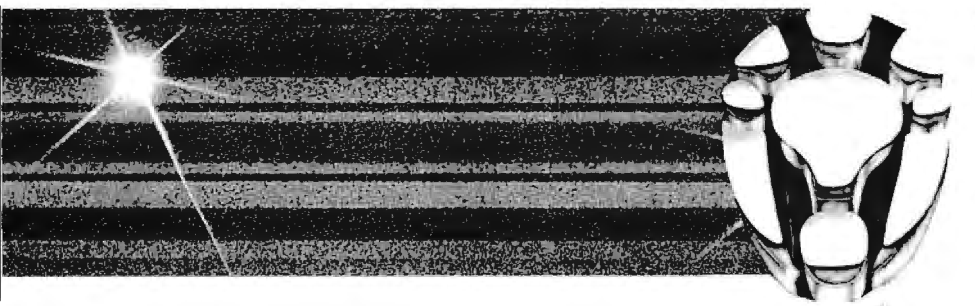

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each time anything is to be accomplished, his program succeeds in accomplishing its task simply and clearly with only one GOTO and only four GOSUB instructions in the body of the program, plus the two recursive GOSUB instructions in each subroutine. Only five line numbers are referenced in the entire program.

The problem with the "structured BASIC" proponents is that in general they want us to write BASIC programs as if they were really Pascal. Let's face it: It may be proper German to put a verb at the end of a sentence, but in English that is bad grammar. The goal is to write clear programs. What purpose would have been served by inserting in Mr. Spencer's program lines such as:

```
31 GOSUB 40 ' initialize
32 GOSUB 140 ' get data, do basic stats
33 GOSUB 240 ' do means
```

The goal is to write clearly with the tools given us, not to emulate one language from within another.

W. HOWARD CORNELSEN JR.
Houston, TX

The September issue was outstanding. Two programs presented in it—"Cluster Analysis" by Rob Spencer and "Fractals" by Peter R. Sørensen—give the micro owner a wonderful opportunity to use a program running on a computer as a way of understanding important phenomena. This aspect of computer literacy is not often stressed, and articles such as these serve such a purpose.

BENJAMIN W. WHITE
Tiburon, CA

DATABASE TYPES

Every once in a while BYTE carries an article that really makes me sit up and take notice. I wish that I had seen Rich Krajewski's article, "Database Types" (October 1984, page 137), a couple of years ago.

I had need of a database program to run on my Commodore 64 but really had no way to know which program to buy. Actually, none that I read about sounded right for me. So I wrote my own. Now, as I am in the middle of revising my program, I discover in your October issue that I have a "free-format database." Too bad I didn't know what to look for before. But, actually, I'm not sure that there was, or is, such a program for the Commodore 64.

I teach at Southern Arkansas University–El Dorado. Each year I need to select an outstanding student from science and math to be honored at graduation. And I need to select students for nomination to "Who's Who." Frequently, I hear from a student who would like me to write a letter of recommendation. With my Database program, I can print out my records for all students that got an A for any particular semester, and in any particular course if needed. Or I can print out all the information that I have on a particular student.

Recently, I have been computerizing my card file. When finished, I will be able to call up all references to databases, or to dot-matrix printers, or on using solar energy to heat pools.

If any reader of BYTE would be interested in trying "Database" on his Commodore 64, send me a disk and a check for $5. I'll return a copy of the program and documentation.

JACK RYAN
Rte. 5, Box 244
El Dorado, AR 71730

I have been searching for databases that will fulfill my own requirements as well as requirements for clients over the past several months and found your articles very helpful. There was, however, one change to your coverage that other "searchers" might find helpful. Savvy, by Excalibur, now runs on MS-DOS as well as on its own operating system. It requires MS-DOS version 2.0 or later. With this enhancement, I have found it to be an unbeatable value for most applications. It is easy to use, complete, powerful, and very well supported. Its documentation is excellent, a real rarity in the marketplace—and in the industry.

WARREN S. NAKISHER
Falls Church, VA

WHAT'S "FRIENDLY"?

I wonder if you have any idea how overused and undefined the word "friendly" is when used to describe a computer system? I have found that every user community has a different idea about that, and even the same users will feel differently about it with use.

I believe we should be simply talking to our users rather than trying to define friendly within the computer community. This kind of action requires that we get hardware and operating systems that are as flexible as possible and that we write applications to react to the needs of the users. This is hard to do when writing for a large unknown user, and perhaps this is the reason most software is deemed unfriendly.

I think the most unfriendly operating system is UNIX, but I really like that system, and many users will call it friendly because it is flexible and permits the programmer to write friendly applications. I would be interested to hear comments on this.

JOHN L. BEAL
Phoenix, AZ

PSEUDORANDOM NUMBERS

Your article by Charles A. Whitney entitled "Generating and Testing Pseudorandom Numbers" (October 1984, page 128) is a good tutorial on examining the periodicity of pseudorandom sequences used in Monte Carlo and other simulation techniques. To this end, I would like to contribute the two-line program below for IBM PC DOS 2.0 to further demonstrate the inherent periodicity of the BASICA RND (and other) pseudorandom functions.

```
10 RANDOMIZE TIMER: KEY OFF:
   SCREEN 1: CLS
20 X=320*RND: Y=200*RND:
   C=4*RND: PSET (X, Y), C: GOTO 20
```

The program is intended to graphically demonstrate periodicity as spatial/color banding. Such banding indicates a clear recurrence of pseudorandom triplets repeatedly formed for X, Y, and color.

Other than an interesting star-like twinkling effect, this graphical technique has considerable value in visually inspecting both the periodicity and distribution (uniform, Gaussian, etc.) of other pseudorandom sequences.

H. J. SOMMER III
University Park, PA

THE ORIGIN OF "FOO.BAR"

I have been working with computers for 26 years, and I *still* don't know the origin of the words "FOO" and "BAR" which appear in just about every language manual I've read.

Are they Ada Lovelace's boyfriend's middle names? Or perhaps they are magic words from an early adventure game. (They never work for me.)

Someone out there must know.

PETER SMITH
Kenmore, Australia

We believe "FOO.BAR" started out as "FUBAR," an unofficial military acronym for Fouled Up Beyond All Recognition. Perhaps often used as a test filename, FUBAR may have been altered to FOOBAR when a large computer manufacturer's file specification required six characters. We're curious too. ■

ADD-INS

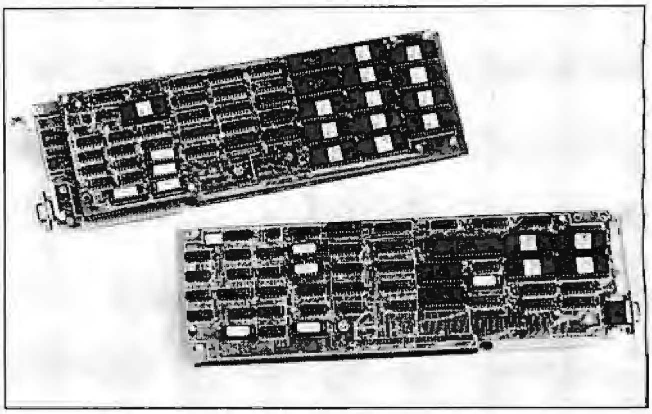
PC Chinese Software Bridge

The CCC-PC Chinese Character Generator Card from Multitech Industrial Corporation lets you run Chinese applications software on your IBM 5550 and IBM PC. This card plugs into an IBM expansion slot and gives you the ability to display and print out Chinese characters.

The CCC-PC card stores Chinese characters in a 2-byte international code using a technique known as the Dragon Coding Method. This method is said to reduce 17,000 characters to 24 alphabet-like symbols. The CCC-PC supports the method in two modes: one for beginners and the other for experienced Chinese encoders.

Other input/output methods on the CCC-PC include telegraphics, lightning, national phonetic alphabet, and internal code dictionary.

The CCC-PC supports IBM-compatible TTL-input monochrome monitors with a 40-character by 25-line display for Chinese characters and an 80 by 25 format for ASCII characters. The resolution uses a 16- by 16-dot character cell.



The CCC-PC is available to original equipment manufacturers and end users. Contact Mr. William Lu, Multitech Industrial Corp., 266 Sung Chiang Rd., Taipei, Taiwan, Republic of China; tel: (02) 551-1101; Telex: 19162 MULTIIC.
Inquiry 615.

IBM PC Color-Graphics Board for S-100

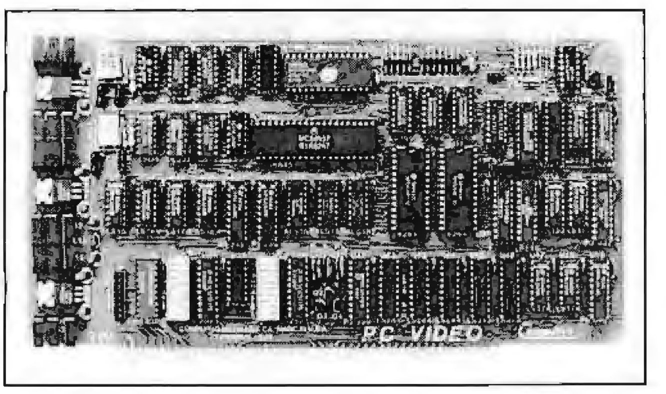
An IBM PC-compatible color-graphics display board for S-100 bus systems is available from CompuPro. The PC Video Board runs under CompuPro's Concurrent DOS 8-16 with Digital Research's IBM PC-compatibility module, and it works with Digital Research's GSX graphics software.

Built around the Motorola 6845 video-display controller, this board can be programmed to produce an assortment of timing characteristics for a variety of color and monochrome monitors. It features 16K bytes of static CMOS RAM, 24-bit memory addressing, 16-bit addressing for I/O ports, and variable wait states, which provide independent access to up to eight boards.

In its color mode, the board permits graphics screens of 160 (horizontal) by 200 pixels (vertical) in 16 colors using an alphanumeric 4- by 2-dot character box, 320 by 200 pixels in four colors, or 640 by 200 pixels in one color plus black.

The alphanumeric screen uses an 80 or 40 by 25 format and an 8- by 8-dot cell with a 7- by 7-dot character within the box. A 256-character ROM generates uppercase and lowercase characters with single-line descenders. Direct-drive outputs include horizontal sync, vertical sync, RGB TTL, and half- and full-intensity.

In its monochrome mode, the PC Video Board produces a graphics screen with a 320 or 640 by 200 resolution. Its alphanumeric screen in this mode has the same column and line sizes as in the color mode but uses a 9- by 14-dot character cell with a 8- by 12-dot character. The 256-character ROM generates character sizes in upper- and lowercases with fully formed descenders and such character attributes as underline, blanking, and reverse video. Direct-drive outputs include horizontal sync, vertical sync, video dots, and half- and full-intensity.



The PC Video Board is $495. Contact CompuPro, 3506 Breakwater Court, Hayward, CA 94545, (415) 786-0909.
Inquiry 616.

2K Programmable Microcontroller

The MC-1Z is a 3- by 4-inch microcontroller with 2K bytes of RAM and 40 fully programmable I/O lines. Its resident programming language is Integer BASIC, making the MC-1Z suitable for such applications as instrumentation and process control.

This board is built around a Zilog 8671 microprocessor. It can be upgraded to 16K bytes of RAM, or it may be equipped with a 4K- or 8K-byte EPROM. Standard equipment includes a clock/calendar, two timer/counters, six interrupts, and an EPROM receptacle. With more cabling, the MC-1Z can be linked to an RS-232C terminal for applications programming. Its data rates range from 110 to 19,200 bps.

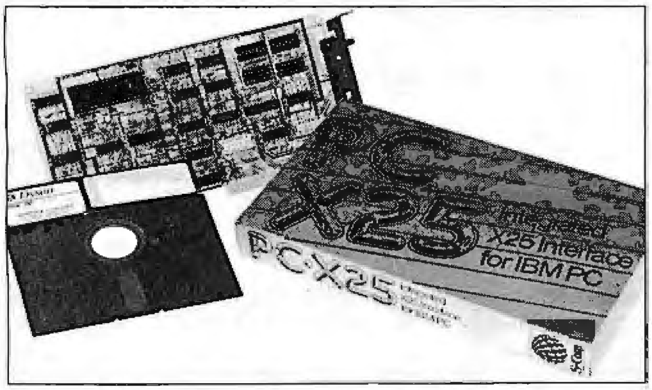
The MC-1Z comes with complete hardware and software manuals. Prices begin at less than $200. Contact Basicon Inc., 11895 Northwest Cornell Rd., Portland, OR 97229, (503) 626-1012.
Inquiry 617.

(continued)

ADD-INS

X.25 Interface for PC

The PC-X25 is an X.25 communications interface for the IBM Personal Computer. A plug-in board, the PC-X25 comes with supporting software that provides a menu-driven environment for accessing network services, exchanging messages, and transmitting files. Data transmission rates range up to 19,200 bps.



The PC-X25 has received PTT approval in the United Kingdom, France, Holland, Japan, and Switzerland. The manufacturer claims that approval is imminent in the United States as well as the rest of Europe and Australasia.

The single-license charge is £1000. Contact S-Com Computer Systems Engineers Inc., Tower House, High St., Aylesbury, Buckinghamshire, HP20 1SQ, England; tel: (0296) 32023; Telex: 837520 ADTRAV G.
Inquiry 618.

Apple IIe Video Card

Checkmate Technology has announced the MultiView 80/160 Card, a video card that displays from 80 to 160 characters per line on a 12-MHz monitor. The MultiView 80/160's seven screen sizes are 80 characters by 24 lines, 80 by 32, 80 by 48, 96 by 24, 132 by 24, 132 by 30, and 160 by 24. Screens longer than 24 lines require a monitor with a long-persistence phosphor. The user can view each screen size in wide-angle mode for easier reading.

The MultiView 80/160 also adds up to five prompt lines to the standard screen display. The card uses an 8 by 9 matrix with true descenders to create a letter-quality character set. Characters can be displayed as bold, inverse, normal, or underlined. You can reverse-scroll up to 4096 characters.

The MultiView 80/160 installs in the Apple IIe's slot 3. It lets you use the 64K bytes of memory of an extended 80-column card in the auxiliary slot. Through MultiView, you can access the extra 64K bytes by using BASIC commands. The card is compatible with CP/M, Apple Pascal, DOS 3.3, and ProDOS.

MultiView is priced at $349.95. Contact Checkmate Technology Inc., 509 South Rockford Dr., Tempe, AZ 85281-3021, (602) 966-5802.
Inquiry 619.

Multifunction Card for Apple IIe

AST Research's Multi-I/O board for the Apple IIe offers a serial printer port, a communications serial port, and a ProDOS-compatible clock/calendar with battery backup. It also includes an on-disk tutorial program, clock read/set, text-file listing, graphics dump, phone dialer, modem or remote-terminal print, and screen time-display utilities package.

The price for the complete package is $235. Contact AST Research Inc., 2121 Alton Ave., Irvine, CA 92714, (714) 476-3868.
Inquiry 620.

Greeting Card Security

The Greeting Card prevents unauthorized use of your Apple II, II+, or IIe. This single card has a 2K-byte nonvolatile memory that holds a security program that gives your Apple password protection. It can be used for posting short messages, and it can hold up to eight assembly-language programs, which can be set to run when the Apple is booted up.

The Greeting Card requires 48K bytes of RAM and a disk drive. The price is $69.95. Contact Birchem Computer Products, 5728 Thames Way, Carmichael, CA 95608, (916) 489-7542.
Inquiry 621.

A/D Cards

Action Instruments offers a line of plug-in, IBM PC-compatible analog and digital I/O cards for industrial process and laboratory applications.

The ACIP-AI04 accepts 4 analog inputs, transmits 2 analog outputs, and provides 12 channels of configurable digital I/O, all with 12-bit resolution. The AICP-AI016, also with 12-bit resolution, accepts 16 single-ended or 8 fully differential inputs. The AICP-AI08 handles 8 single-ended, ±5-volt inputs and provides 7 channels of digital I/O.

Both the AICP-RTD15 and the -TC15 are designed for temperature applications. Each accepts up to 15 input channels and provides 500-volt input-to-expansion bus signal isolation.

The AICP-SG4 enables the IBM PC to monitor and control force, strain, and pressure applications. A general-purpose, low-level analog card, the SG4 provides 8 outputs and sources its own excitation voltages for direct connection to load cells, strain gauges, and pressure transducers. Also standard are front-end filtering and individual on-board channel alarm set points.

The AICP-DIM32 has 32 input channels, and the -DOM32 has 32 output channels. Both are designed for interfacing multiple digital signals to the IBM PC and can connect with industrial, isolated high-level I/O racks. They provide positive or negative true TTL-compatible logic levels.

Prices range from $250 for the AICP-DIM32 to $1295 for the thermocouple, RTD, and strain-gauge cards. Contact Action Instruments Inc., 8601 Aero Dr., San Diego, CA 92123, (619) 279-5726.
Inquiry 622.

PERIPHERALS

Omninet for the Mac

Corvus Systems' Omninet local-area network can connect up to 63 Macintoshes at distances up to 4000 feet and run at 0.7 megabits per second. This card is built into the computer interface cable; you plug the cable into the modem port of the Mac.

The connections for Omninet are $200. Disk drive costs depend on amount of memory: $1795 for 5 megabytes, $2495 for 10 megabytes, $3495 for 16 megabytes, and $4995 for 45 megabytes. Contact Corvus Systems Inc., 2100 Corvus Dr., San Jose, CA 95124, (408) 559-7000.
Inquiry 623.

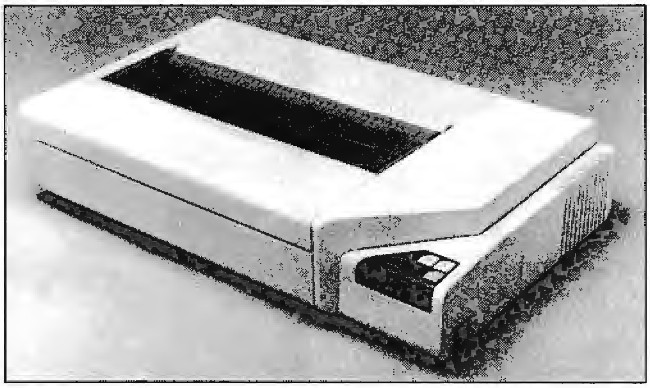
High-Speed Printer

The OT-700 dot-matrix printer from Output Technology uses an advanced print-head technique to reach a maximum speed of 700 characters per second. It also features correspondence-quality printing at 350 cps and dot-addressable graphics capability in two modes: 50 by 69 dots per inch for high speed or 100 by 69 dpi for high resolution.

Centronics parallel and RS-232C serial interfaces and a 4K-byte buffer are standard. You use menu-driven program commands to configure the OT-700. Numerous character sets, including foreign languages, are offered.

The printer has 136-column carriage width, and paper feeds from the front or bottom of the case. The control panel features membrane switches and LED indicator lights.

The OT-700 sells for $1595. Contact Output Technology Corp., Suite 205, 606 110th Ave. NE, Bellevue, WA 98004, (206) 453-9794.
Inquiry 624.



Multiuser Hard Disk for the IBM

A multiuser, 38-megabyte hard-disk drive for the IBM PC or PC XT is available from Adcomp. Up to 16 microcomputers can access the system, which includes a removable 6-megabyte disk drive for backup. Its modular design lets you expand it to use more computers and up to 100 megabytes of memory.

Adcomp also offers ready-made file administration for multiuser applications. One computer supervises the access administration for the others while it remains functional as a workstation.

The hard-disk system costs $3995. Contact Adcomp Datensysteme GmbH, Olgastrasse 15, D—8000 Munich 19; tel: 011 (49) 89-129-80-45; Telex: 52 16 271.
Inquiry 625.

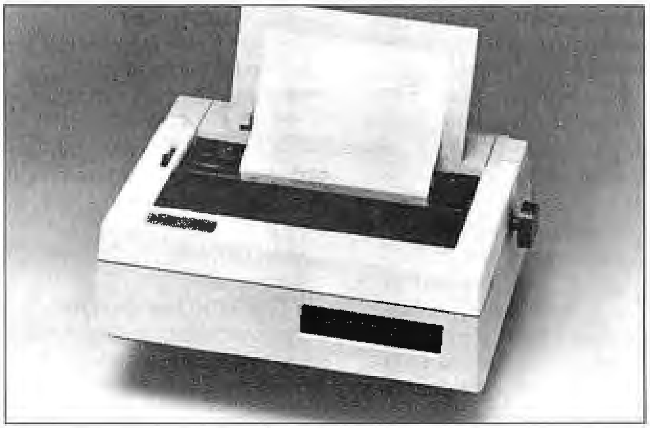
Graphics and Letter-Quality Print

Star Micronics has announced the Star SB-10, a letter-quality, dot-matrix printer. The Star SB-10 produces text at two speed and quality settings: letter quality at 60 cps and draft quality at 120 cps. It also can combine letter-quality text with graphics.

The printer's character fonts include pica, elite, condensed, proportional, expanded, emphasized, and double-strike. It has a standard Centronics parallel interface plus optional serial (RS-232C) and GPIB (IEEE-488) interfaces. Some of the Star SB-10's features are continuous underline, vertical and horizontal programmable tabs, self-test, left and right margin set, and bit-image column scan.

The Star SB-10 is $995. For details, contact Star Micronics Inc., 200 Park Ave., New York, NY 10166, (212) 986-6770.
Inquiry 626.

(continued)



NEW SYSTEMS

Passport Comes with Hard Disk

Anderson Jacobson's AJ Passport/PHD desktop computer gives you both floppy- and hard-disk storage. The system behind the storage has 256K bytes of dynamic RAM, on-board color, graphics, and five expansion bus slots. An MS-DOS 2.11-compatible operating system, TeleDOS controls operations.

Based around Intel's 8088 microprocessor, the Passport/PHD comes with an asynchronous RS-232C serial communications port, a parallel Centronics-type printer port, a single internal IBM PC-format bus slot, and RGB and composite-video connections. It has fifteen data rates, ranging from 50 to 9600 bps.

The slimline 5¼-inch floppy-disk drive provides 360K bytes of formatted storage, and the 3½-inch hard disk offers 10 megabytes. The floppy-disk transfer rate is 250K bits per second. The hard disk offers a 5-megabit per second transfer rate.

The Passport/PHD has a 12-inch amber display with a nonglare surface that tilts and swivels. Graphics capabilities are supported by 16K bytes of dedicated memory. The monochrome display resolution is 640 by 200 pixels. The color resolution is 320 by 300 pixels.

The IBM PC-style keyboard features 83 keys, with a numeric pad and 10 programmable function keys.

The Passport/PHD is $4095, which includes integrated word-processing, spreadsheet, and database-management programs. Contact Anderson Jacobson, 521 Charcot Ave., San Jose, CA 95131, (408) 945-9030. **Inquiry 627.**

A Wyse Line of IBM PC-Compatibles

Wyse Technology has unveiled a line of IBM PC-compatible computers.

The WYSEpc Model WY-1100-1 is an entry-level system. It comes with a pair of 360K-byte double-density floppy-disk drives, 256K bytes of RAM, two serial ports, and a parallel printer port. A 14-inch tilt-and-swivel monochrome display and a 101-key keyboard are standard. Two expansion slots provide room for IBM PC-compatible options.

The IBM PC XT-compatible Model 1100-2 comes with a 10-megabyte Winchester hard-disk drive and one floppy-disk unit.

Both units are shipped with MS-DOS 2.11 and GW-BASIC and are offered with a color graphics option. Other options include 256K bytes of RAM, a real-time clock/calendar, battery backup, and an expansion chassis with four IBM PC-compatible slots.

The Model 1100-1 is $1995, while the Model 1100-2 is $3495. The color graphics option is $500. Contact Wyse Technology, 3040 North First St., San Jose, CA 95134, (408) 946-3075. **Inquiry 628.**

Datapoint Announces 32-bit Computer

The Datapoint 3200, a 32-bit computer has a UNIX-like operating system known as UNOS. The 3200 can serve as a stand-alone system and as a member of Datapoint's ARC intelligent local-network system.

UNOS, which is said to optimize 68000 performance, provides such file-management capabilities as multitasking, device-independent I/O, dynamic file allocation, I/O redirection, and hierarchical directory structure.

Software options for the 3200 include C, RM/COBOL, and a business programming language. Ace Microsystem's LEX word processor and Microsoft's Multiplan are supported.

The 3200 has dual 68000 microprocessors. One 68000 has a 4K-byte cache memory for application processing at a 12.5-MHz clock rate. The second 68000 organizes I/O.

Presently, two models are available with a variety of options, including up to 8 megabytes of RAM, three types of terminals, three different printers, and a 2780/3780 communications adapter. The 3200 can support 28 Datapoint terminals.

An entry-level 3200 comes with 1 megabyte of RAM, cache memory, and four serial ports. A 1-megabyte 8-inch floppy disk and a 32-megabyte hard disk provide mass storage. The base system price is $15,430 through Datapoint's ISO and end-user direct-sales force. UNOS is $1000, and a network adapter is $2500. For more information, contact Datapoint Corp., 9725 Datapoint Dr., San Antonio, TX 78284, (800) 334-1122. **Inquiry 629.**

SOFTWARE • APPLE

Musical Macintosh

Even if you can't read a note of music, you can use MusicWorks to create and perform music on a Macintosh. MacroMind, developer of the software, claims the program enables anyone to compose and edit simple melodies or fully orchestrated symphonies. The compositions can then be played back with as many as four voices simultaneously over an eight-octave range, and you can assign each voice any one of eight musical instruments. You can vary the tempo, intensity, timbre, and meter.

MusicWorks features two composing options. In the first method, you place notes and rests on a conventional staff. In the second method, you place boxes on a matrix grid that resembles the keys of a piano. The program automatically updates the composition in standard notation and can print scores for one instrument or for an ensemble.

The program comes with sample songs that you can edit and rearrange. The manual includes an introduction to the basics of music.

MusicWorks for the Apple Macintosh costs $79.95 and is being marketed by Hayden Software Company Inc., 600 Suffolk St., Lowell, MA 01854, (617) 937-0200.
Inquiry 630.

MacManage Projects

A project-management tool for the Macintosh, MacProject enables you to draw a schedule on the screen and enter beginning dates, required completion dates, resources, and fixed and variable cost data for each task. MacProject then calculates the start and finish dates.

The program features "what-if" analytical capability that lets you instantly recalculate dates, resources, and expenses when variables are introduced into a project. You can cut and paste sections of projects into other project schedules or into files created with MacWrite. You can also transfer cost data to Multiplan for further analysis. Schedules, resources, and tasks can be represented in tables.

MacProject can accommodate up to 200 jobs on the 128K-byte Macintosh and up to 2000 jobs on the Lisa 2 or the 512K-byte Macintosh. Available from authorized Apple dealers, the package has a suggested retail price of $125. Contact Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014, (408) 996-1010.
Inquiry 631.

High-Level Language

Based on the FORTH language model, SkyForth 1.3 is a development system for the Apple II series. According to the vendor, SkyForth can execute 10 iterations of the Sieve of Eratosthenes benchmark in 139 seconds and alphabetize 2000 five-character names in 5.2 seconds.

The language, including its source-code editor, resides in the upper 16K bytes of the computer. Since the editor/compiler is always resident, you can write, compile, and test programs quickly. SkyForth reads and writes its programs as continuous Apple DOS 3.3 files. You can save finished programs and overlays as object code.

The developer features a full assembler, utility and debugging routines, and a turnkey, run-time package. SkyForth's kernel includes words to handle floating-point math, 32-bit integers, memory moves, sorts, list structures, and windowed graphics.

A single-user license costs $99. Contact Tosch Information Management, Dept. S, 16025 10th Ave. SW, Seattle, WA 98166, (206) 246-3839.
Inquiry 632.

Introduction to CAD

With CADAPPLE—Entry Level, you can learn and apply the fundamentals of computer-aided design (CAD). The program features menus and single-stroke operation, built-in error recovery, and floating-point internal calculations.

The package provides lines, arcs, circles, rectangles, ellipses, polygons, and text. You can select grid spacing and divisions in both *x* and *y* axes independently, in "real world" coordinates, and change them at any time. You can input with a keyboard, joystick, mouse, or KoalaPad. Any distance can be dimensioned automatically. You can scale objects or groups of objects independently, rotate them to any degree, or delete (or undelete) them. Windowing functions let you zoom in and out of a drawing or pan across it. Drawings are done on a plotter.

CADAPPLE—Entry Level costs $495 and runs on an Apple II or II+ with 64K bytes of memory and on an Apple IIc or IIe. Contact T & W Systems Inc., Suite 106, 7372 Prince Dr., Huntington Beach, CA 92647, (714) 847-9960.
Inquiry 633.

System Helps You Search Information Databases

Searchware has developed a software system that enables an Apple computer to access and search information databases. The system emphasizes a knowledge of the subject you are investigating rather than familiarity with the search procedures of each database.

According to the company, you don't need to know the syntax of search commands. The program asks you to identify key words in the subject of interest; the search strategy is then developed off line, which can reduce search-time charges. When the strategy is complete, the computer automatically dials the phone number of the database, logs on, transmits the search strategy, records the results of the search either on paper or on floppy disk, and then logs off and disconnects.

You can search at three levels. The first level takes care of commands, syntax, and logic. At the second level, the software develops and transmits the search commands, but you create the logic. The third level lets you search on line.

Searchware bills monthly for search-time charges. There is no minimum monthly charge.

The company is offering an automated demonstration program for $15. No modem is required to run this program. Complete software packages start at $290. A version for the IBM PC is also available. Contact Searchware Inc., Suite E, 22458 Ventura Blvd., Woodland Hills, CA 91364, (818) 992-4325.
Inquiry 634.

(continued)

SOFTWARE • CP/M/MS-DOS

WordStar Commands Placed on Function Keys

Keys Please! with Instant Install gives WordStar users the convenience of single-keystroke operation. This enhancement package, published by Precision Software Products, places all 140 WordStar commands onto function keys and automatically activates all WordStar's printer capabilities, including condensed, bold, and italics. Commands are grouped by function, and an on-screen command summary line eliminates the need for rote memorization of key combinations.

Hardware modifications or optional boards are not required. Keys Please! with Instant Install runs on CP/M 2.2, CP/M-80, CP/M 3.0, TurboDOS, CDOS, and Cromix systems with 56K bytes of RAM. It also works with MS-DOS and PC-DOS version 1.x or 2.x computers with 128K bytes of RAM. Two disk drives are required. A variety of printers are supported. The suggested list price is $69.95. For more information, contact Precision Software Products, Suite 204, 360 17th St., Oakland, CA 94612, (415) 839-5780.
Inquiry 635.

Hard-Disk Backup Traps Errors in CP/M-86

BackRest 2.0 is a hard-disk drive backup program for such operating systems as CP/M-86, MS-DOS, and MP/M. When used with CP/M-86, BackRest will trap hard system errors, even though that operating system does not support error trapping.

BackRest can interrupt a backup at any time to perform a priority task or to format additional floppy disks. After the interruption, it can resume the backup procedure from where it left off. It locks out bad sectors on the hard disk, and it supports backups to most file-oriented tape devices. Standard features include optional restoration to an alternate drive, automatic restoration, the ability to split large files over several floppy disks, backup of sparse files, and local-area network support.

Other DOSes supported include PC-DOS, Concurrent CP/M, CP/M 2.2, CP/M Plus, MP/M-86, and TurboDOS. The suggested retail price is $180. Contact Stok Software Inc., 17 West 17th St., New York, NY 10011, (212) 243-1444.
Inquiry 636.

Product Generation Utility Eases Rebuilding Process

Lattice has announced the availability of an automated product generation utility for MS-DOS. Called LMK, this product functions like a UNIX MAKE facility. LMK is designed to facilitate the making of alterations in a variety of source files. It eliminates the manual reconstruction of a product's source files. Its scope in constructing software, documentation, or file systems is limitless.

Here's what LMK does: Once you have specified the relationships between various pieces of a system, such as source modules, object modules, or chapters of a manuscript, in a "dependency file," you can invoke a single LMK command to automatically rebuild the system. LMK's actions can be any executable command, such as invoking a batch text editor to make replacements in a number of files, applying a file comparator to new and old files, updating a database, or running utilities.

Minimum system requirements are 320K bytes of floppy-disk capacity, 128K bytes of RAM, and MS-DOS 2.0 or 3.0. It runs on computers based on 8086, 8088, 80186, or 80286 microprocessors. The suggested retail price for LMK with full documentation is $195. For further information, contact Lattice Inc., POB 3072, Glen Ellyn, IL 60138, (312) 858-7950.
Inquiry 637.

Software Connections Supports Networks 1.0

Software Connections has announced a line of network applications software that works with Microsoft's Networks 1.0 network-operating system extension. Products available include a relational database-management system, a relational database-applications development tool, and a store-and-forward electronic-mail file-transfer system.

Contact Software Connections, 2041 Mission College Blvd., Santa Clara, CA 95054, (408) 988-0300.
Inquiry 638.

Integrated Package Grows with You

TymIV is an integrated software package that can be expanded as your needs increase. The basic package, known as Anthology, comes with word-processing, spreadsheet analysis, and database-management capabilities. For more sophisticated data management, there's Six, a universal database package that lets you save, recall, and edit large quantities of information and print standard or custom-designed reports, forms, and labels.

At the heart of this package is a native C code master program called Execu/Bus. Execu/Bus serves as a common environment by generating uniform commands and screen presentations for all applications. These commands control the start-up and completion of a task as well as provide an interface for data swapping among applications. Operating system utilities can be accessed through Execu/Bus. Utility functions include file backup and copy; rename, delete, and print file; and display directory. A common help facility supports all applications.

Presently, the manufacturer has 18 vertical and horizontal applications in the TymIV series, including financial application templates, plotting software, banking packages, and communications. The TymIV series runs on MS-DOS, PC-DOS, and UNIX System V systems. Anthology is $495, and the suggested price for Six is $395. Specialized applications range from $195 to $1500. For details, contact InfoTym, TymIV Marketing, 20705 Valley Green Dr., Cupertino, CA 95014, (408) 446-7406.
Inquiry 639.

SOFTWARE • IBM PC

Equation Processor

Equate is an equation processor for the IBM PC and compatibles using DOS 1.1 through 2.1.

It lets you enter up to 799 equations anywhere on screen in standard algebraic notation. A full-screen text editor facilitates equation and explanatory-text entry, and an interactive Constants Window gives you more than 400 physical constants and measurement conversions to insert into equations. Equations or other constants can be added to the window.

Equate evaluates your equations, prompts for undefined variables, and produces 16-bit (double-precision) results at the press of a function key. A forms feature helps you devise application worksheets that prompt for data or arrange results into tables. Data cells can be sited at any spot on screen; rows or columns are not mandatory.

Equations, results, and tables can be stored as worksheets. Worksheets may be printed or transferred to a word processor that accepts ASCII files.

The General Worksheet Series Disk 1 comes with Equate. It provides worksheets for solving simultaneous equations and for calculating standard deviation, variance, and the area and moments of inertia for principal shapes.

Equate comes with an evaluation version that's good for 30 uses. The master disk and related materials can be returned to the manufacturer within 30 days for a full refund. Equate is $195. Contact Banyan Systems Corp., 5632 East Third St., Tucson, AZ 85711, (602) 745-8086.

Inquiry 640.

Soft Winchester: Inexpensive, Alternative Hard Disk

The BYSO Soft Winchester program from Levien Instrument Company stores your most frequently used data in RAM so that you can access it quickly. The manufacturer says that with Soft Winchester such programs as WordStar and dBASE II will load or sort hundreds of times faster than from a floppy.

Soft Winchester lets you use 1440K bytes of data. If you have data that cannot be accessed from RAM or disk, it prompts you for the disk with the data. It automatically backs up your data to disk, and, once loaded, its operation is transparent. A simple key combination lets you use new 1440K-byte sets of data.

The BYSO Soft Winchester runs on 128K-byte IBM Personal Computers, including the PCjr, and true IBM compatibles. A monochrome or graphics adapter is required. It costs $60. For more information, contact Levien Instrument Co., POB 31, McDowell, VA 24458, (703) 396-3345.

Inquiry 641.

FORTRAN and UNIX for AT

Unisource Software Corporation has introduced a UNIX-based FORTRAN-77 compiler for the IBM PC XT and PC AT. In a related development, the Massachusetts-based publisher and distributor of UNIX software also announced an implementation of UNIX for the IBM PC AT.

The FORTRAN compiler runs under VENIX on such machines as the IBMs, AT&T 6300, Compaq Plus, Eagle Turbo, MAD 1, and DEC Professional 350. It costs $395.

Its UNIX operating system, claims Unisource, is the first licensed implementation of AT&T UNIX for the the IBM PC AT. This version is delivered with a System V UNIX license. A full implementation for one or two users retails for $875. For up to eight users, it's $1075.

For further information, contact Unisource Software Corp., 71 Bent St., Cambridge, MA 02141, (617) 491-1264.

Inquiry 642.

IBM Fits the Curves

A curve-fitting program for the IBM PC, Curve Fitter-PC is available directly from Interactive Microware.

Curve Fitter-PC fits curves to experimental or business data. Curve types include polynomial, cubic spline, or Stineman interpolation methods. If you want, least-squares fitting can produce the standard curve using a polynomial (degree 1 to 6), geometric, or exponential least-squares method. Any or all fitting models can be used to select the best fit.

Some statistical measures of the accuracy of the fitted curve provided are standard error of estimates and percent deviation for calculated versus observed values.

Features include curve-fitting demonstrations, high-resolution (i.e., 320 by 200) graphics, choice of plotting symbols on the same graph for distinguishing multiple superimposed curves, the ability to enter data as *x,y* pairs or as values at fixed intervals, and four text-label locations. Working files can be saved and transferred to programs that accept ASCII data.

Minimum requirements are 128K bytes of RAM, color graphics board, a disk drive, and PC-DOS 1.1, 2.0, or 2.1. The manual alone is $15; the complete package is $95. Contact Interactive Microware Inc., POB 139, State College, PA 16804-0139, (814) 238-8294.

Inquiry 643.

WHERE DO NEW PRODUCT ITEMS COME FROM?
The new products listed in this section of BYTE are chosen from the thousands of press releases, letters, and telephone calls we receive each month from manufacturers, distributors, designers, and readers. The basic criteria for selection for publication are: (a) does a product match our readers' interests? and (b) is it new or is it simply a reintroduction of an old item? Because of the volume of submissions we must sort through every month, the items we publish are based on vendors' statements and are not individually verified. If you want your product to be considered for publication (at no charge), send full information about it, including its price and an address and telephone number where a reader can get further information, to New Products Editor, BYTE, POB 372, Hancock, NH 03449.

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6500

6502	$4.50	6504	$6.75	6522	$6.75
6502A	6.90	6507	9.75	6532	9.50
6502B	9.50	6520	4.25	6551	11.50

8035	$5.75	8214	$3.75	8259	$6.75
8039	5.75	8216	1.95	8271	69.95
8080A	3.95	8224	2.20	8275	26.95
8085A	4.90	8226	1.95	8279	8.75
80C85A	9.95	8228	3.40	8282	6.25
8086	24.50	8237	14.75	8283	6.25
8087	169.95	8237-5	18.95	8284	5.50
8088	29.50	8238	4.25	8286	6.45
8089	88.95	8243	3.95	8287	6.45
8155	6.75	8250	10.50	8288	14.95
8156	6.75	8251	4.25	8289	44.95
8185	26.95	8251A	6.95	8292	12.95
8202	23.95	8253	6.75	8741	27.95
8203	37.95	8255	4.25	8748	24.50
8205	3.25	8255A	4.95	8749	24.50
8212	1.95	8257	5.75	8755A	34.95

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	2.5MHz	"A" 4.0MHz	"B" 6.0MHz
Z80-CPU	3.75	4.35	9.60
Z80-CTC	3.75	4.75	12.25
Z80-DART	—	9.50	17.95
Z80-DMA	12.95	11.95	17.95
Z80-PIO	3.75	4.25	12.50
Z80-SIO/0	11.25	12.25	—
Z80-SIO/1	11.95	12.75	—
Z80-SIO/2	11.95	12.75	36.95
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2N2219A	.45	TIP31A	2/1.25
2N2905	.45	TIP32A	2/1.25
2N2907	.25	1N4148	25/1.00
2N3055	.69	1N751	5/1.00
2N3565	4/1.00	1N4002	12/1.00
2N3638	4/1.00	1N4004	10/1.00
2N3772	1.89		

MCT-2	$.59	4N33	$.89
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MCA-255	1.69	4N38	.98
4N26	.65	TIL117	.79
4N27	.65	SPX33	.29
4N28	.69		

	1-99	100
Jumbo Red	$.09	$.08
Jumbo Green	.17	.15
Jumbo Yellow	.17	.15
Mini Size Red	.10	.09
Mini Size Green	.19	.18
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	1-99	100
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S-100 WW	4.75	4.10
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24 Pin WW/3L	1.25	1.17
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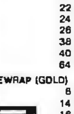

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LM310CN	1.65	LM723H	.75	CA3023	2.75
LM311CN	.62	LM733	.98	CA3039	1.25
LM312H	1.75	LM739	1.85	CA3048	1.25
LM318CN	1.45	LM741CN	.33	CA3059	2.85
LM318H	1.55	LM741H	.40	CA3060	2.85
LM319N	1.19	LM741N	.29	CA3065	1.69
LM320(see VRs)		LM747	.85	CA3080	1.10
LM324N	.55	LM748	.55	CA3081	1.60
LM339N	.95	LM1014	1.15	CA3082	1.60
LM340(see VRs)		LM1303	1.90	CA3083	1.55
LM348N	.95	LM1310	1.45	CA308	.80
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LM376N	3.75	LM1414	1.55	CA3160	1.49
LM377N	1.90	LM1558H	2.99	LM13060	1.25
LM380CN	.85	LM1800	2.35	LM13600	1.45
LM380N	1.05	LM1812	8.10	LM13700	1.45
LM381N	1.59	LM1830	3.40	LF347	2.19
LM382N	1.35	LM1871	5.45	LF351	.80
LM383N	1.95	LM1872	5.45	LF353	.99
LM384N	1.75	LM1877	3.20	LF355	1.10
LM386N	.89	LM1889	1.90	LF356	1.10
LM387N	1.29	LM1896	1.70	LF357	1.39
LM389N	1.15	ULN2001	1.95	TL071CP	.79
LM392N	.69	ULN2003	1.49	TL072CP	1.35
LM723N	.48	XR2206	3.75	TL074CN	1.90
LM723H	.55	XR2207	2.90	TL081CP	.59
NE531	2.85	XR2208	2.40	TL084CN	1.90
NE555	.35	XR2211	3.75	TL494	4.10
NE556	.65	LM2877P	2.00	TL496	1.65
NE558	1.49	LM2878P	2.25	TL497	3.20
NE561	23.50	LM2900	.83	MC3423	1.49
NE564	2.85	LM2901	.99	MC3453	4.95
LM565	.95	LM2907	2.45	MC3456	1.29
LM566	1.45	LM2917	2.85	MC3459	3.75
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- 78MG/79MG.......1.49
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7400

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7402	.19	7448	.68	74126	.44	74179	1.34
7403	.19	7450	.19	74128	.49	74180	.75
7404	.19	7451	.19	74132	.45	74181	1.75
7405	.23	7453	.19	74136	.75	74182	1.15
7406	.49	7454	.19	74141	.65	74184	2.25
7407	.49	7459	.25	74142	2.95	74185	2.25
7408	.24	7460	.37	74143	3.70	74190	.67
7409	.19	7470	.29	74144	2.95	74191	.67
7410	.19	7472	.29	74145	.59	74192	.67
7411	.24	7473	.33	74147	1.49	74193	.67
7412	.38	7474	.34	74148	1.19	74194	.67
7413	.34	7475	.38	74150	1.09	74195	.67
7414	.49	7476	.34	74151	.55	74196	.75
7416	.49	7479	4.60	74152	.67	74197	.88
7417	.49	7480	.69	74153	.53	74198	1.15
7420	.19	7482	.95	74154	1.19	74199	1.15
7421	.35	7483	.45	74155	.69	74221	1.19
7422	.45	7485	.55	74156	.59	74251	.75
7423	.58	7486	.35	74157	.59	74273	1.65
7425	.29	7489	1.95	74158	1.65	74276	1.89
7426	.29	7490	.35	74159	1.58	74279	.75
7427	.25	7491	.65	74160	.79	74283	1.40
7428	.55	7492	.45	74161	.69	74284	2.90
7430	.18	7493	.35	74162	.69	74285	2.90
7432	.29	7494	.65	74163	.69	74290	1.49
7437	.25	7495	.50	74164	.69	74298	1.49
7438	.29	7496	.69	74165	.69	74365	.55
7439	.58	7497	2.70	74166	.85	74366	.55
7440	.19	74100	1.50	74167	2.75	74367	.55
7441	.79	74107	.24	74170	1.25	74368	.55
7442	.45	74109	.37	74172	4.75	74390	1.45
7443	1.15	74116	1.45	74173	.69	74393	1.33
7444	1.15	74121	.29	74174	.69	74490	2.25
7445	.88	74122	.44	74175	.69		

74LS00	$.28	74LS113	$.38	74LS247	$.74
74LS01	.25	74LS114	.39	74LS248	.98
74LS02	.25	74LS122	.45	74LS249	.98
74LS03	.25	74LS123	.95	74LS251	.59
74LS04	.33	74LS124	2.75	74LS253	.59
74LS05	.25	74LS125	.49	74LS257	.59
74LS08	.27	74LS126	.49	74LS258	.59
74LS09	.28	74LS132	.59	74LS259	2.95
74LS10	.25	74LS136	.39	74LS260	.59
74LS11	.33	74LS138	.59	74LS261	2.49
74LS12	.33	74LS139	.59	74LS268	.55
74LS13	.39	74LS145	1.19	74LS273	1.45
74LS14	.59	74LS148	1.38	74LS275	3.29
74LS15	.33	74LS151	.55	74LS279	.59
74LS20	.28	74LS153	.55	74LS283	.68
74LS21	.29	74LS154	1.49	74LS290	.88
74LS22	.29	74LS155	.69	74LS293	.78
74LS26	.29	74LS156	.69	74LS295	.98
74LS27	.29	74LS157	.69	74LS298	.88
74LS28	.29	74LS158	.69	74LS324	1.75
74LS30	.25	74LS160	.69	74LS347	1.95
74LS32	.33	74LS161	.69	74LS348	1.95
74LS33	.53	74LS162	.89	74LS352	1.25
74LS37	.35	74LS163	.89	74LS353	1.25
74LS38	.39	74LS164	.69	74LS363	1.29
74LS40	.25	74LS165	.90	74LS365	.48
74LS42	.44	74LS166	1.90	74LS366	.46
74LS47	.74	74LS168	1.15	74LS367	.45
74LS48	.74	74LS169	1.15	74LS368	.45
74LS51	.25	74LS170	1.40	74LS373	1.39
74LS54	.29	74LS173	.87	74LS374	1.33
74LS55	.29	74LS174	.67	74LS375	.89
74LS73	.39	74LS175	.67	74LS377	1.38
74LS74	.34	74LS181	1.95	74LS385	1.95
74LS75	.39	74LS190	.65	74LS386	.45
74LS76	.39	74LS191	.85	74LS390	1.15
74LS78	.39	74LS192	.78	74LS393	1.15
74LS83	.59	74LS193	.78	74LS395	1.15
74LS85	.69	74LS194	.69	74LS399	1.47
74LS86	.39	74LS195	.69	74LS424	2.95
74LS90	.54	74LS196	.79	74LS668	1.75
74LS92	.54	74LS197	.79	74LS670	2.29
74LS93	.54	74LS221	.89	81LS95	1.45
74LS95	.75	74LS240	.95	81LS96	1.45
74LS96	.89	74LS242	.95	81LS97	1.45
74LS107	.39	74LS243	.95	81LS98	1.45
74LS109	.39	74LS244	1.25	25LS2521	2.65
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4010	.39	4037	1.95	4073	.28	4514	1.16
4011	.24	4040	.75	4075	.28	4515	1.79
4012	.24	4041	.75	4076	.75	4516	1.19
4013	.35	4042	.65	4077	.35	4518	.65
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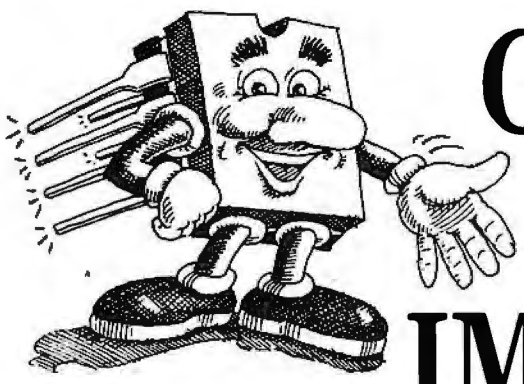

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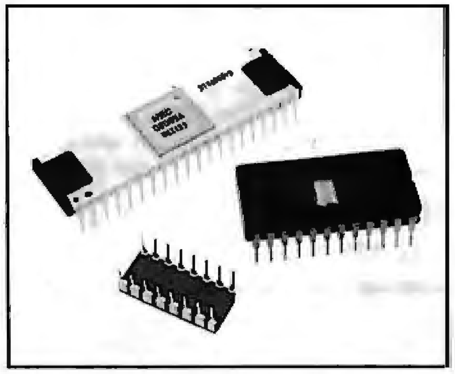

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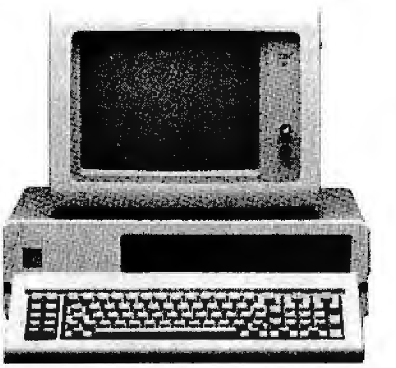

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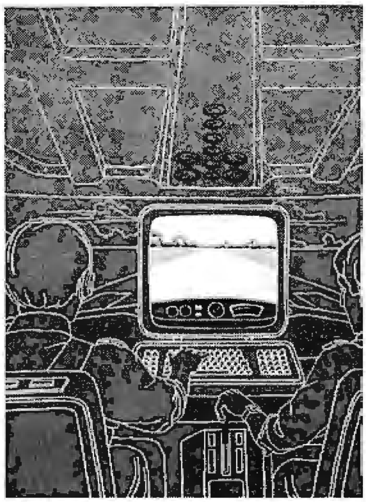

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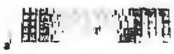

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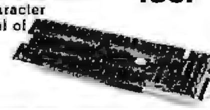

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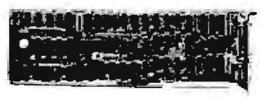

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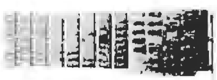

FC-930 RS232/Parallel Printer Port Card

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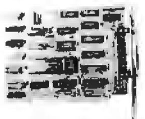

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- One RS-232C Port, One Clock Calendar, Battery Back-up

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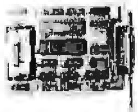

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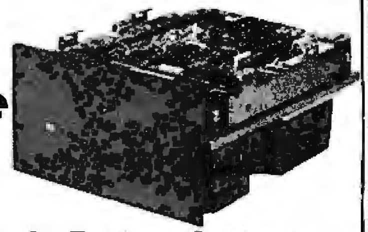

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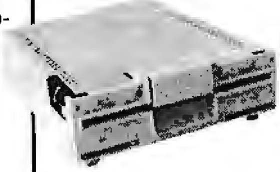

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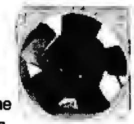

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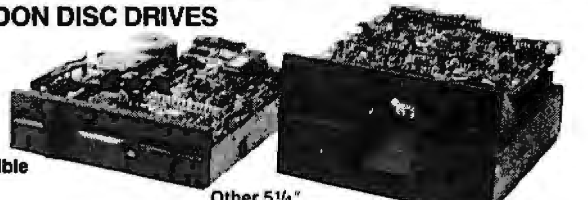

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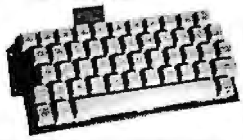

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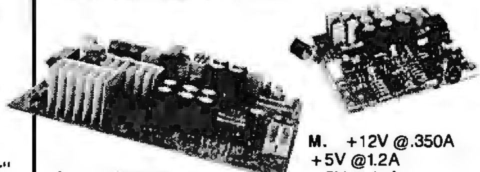

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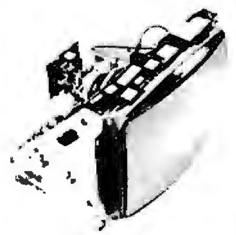

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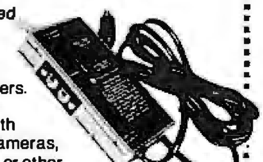

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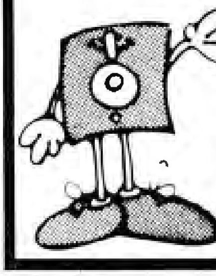

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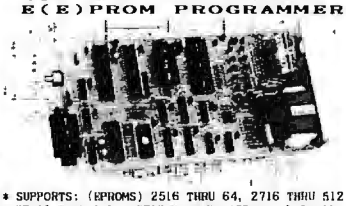

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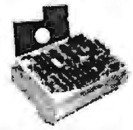

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DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.95
UPD411	4096 x 1 (300ns)	1.95
MM5280	4096 x 1 (300ns)	1.95
MK4108	8192 x 1 (200ns)	1.90
MM5298	8192 x 1 (250ns)	1.80
4116-200	16384 x 1 (200ns)	.79
4116-150	16384 x 1 (150ns)	1.20
2118	16384 x 1 (150ns) (5v)	4.90
4164-250	65536 x 1 (250ns)	2.99
4164-200	65536 x 1 (200ns) (5v)	3.33
4164-150	65536 x 1 (150ns) (5v)	3.99
41256	(200ns)	29.95
41256	(150ns)	39.95

5V = Single 5 Volt Supply

EPROMS

1702	256 x 8 (1us)	4.45
2708	1024 x 8 (450ns)	2.49
2758	1024 x 8 (450ns) (5v)	5.90
2716	2048 x 8 (450ns) (5v)	2.95
2716-1	2048 x 8 (350ns) (5v)	5.90
TMS2516	2048 x 8 (450ns) (5v)	5.45
TMS2716	2048 x 8 (450ns)	6.95
TMS2532	4096 x 8 (450ns) (5v)	5.90
2732	4096 x 8 (450ns) (5v)	4.45
2732-250	4096 x 8 (250ns) (5v)	8.90
2732-200	4096 x 8 (200ns) (5V)	10.95
2764	8192 x 8 (450ns) (5v)	6.45
2764-250	8192 x 8 (250ns) (5v)	7.45
2764-200	8192 x 1 (200ns) (5v)	16.45
TMS2564	8192 x 8 (450ns) (5v)	12.95
2732A	(350ns)	4.45
MC68766	8192 x 8 (450ns)(5v) (24 pin)	29.95
27128	16384 x 8 (250ns) (5v)	24.95

5v = Single 5 Volt Supply

74LS00

74LS00	.23	74LS125	.48	74LS260	.58
74LS01	.24	74LS126	.48	74LS266	.54
74LS02	.24	74LS132	.58	74LS273	1.45
74LS03	.24	74LS133	.58	74LS275	3.30
74LS04	.23	74LS136	.38	74LS279	.48
74LS05	.24	74LS137	.98	74LS280	1.95
74LS08	.27	74LS138	.54	74LS283	.68
74LS09	.28	74LS139	.54	74LS290	.88
74LS10	.24	74LS145	1.15	74LS293	.88
74LS11	.34	74LS147	2.45	74LS295	.98
74LS12	.34	74LS148	1.30	74LS298	.88
74LS13	.44	74LS151	.54	74LS299	1.70
74LS14	.58	74LS153	.54	74LS323	3.45
74LS15	.34	74LS154	1.85	74LS324	1.70
74LS20	.24	74LS155	.88	74LS352	1.25
74LS21	.28	74LS156	.88	74LS353	1.25
74LS22	.24	74LS157	.84	74LS363	1.30
74LS26	.28	74LS158	.58	74LS364	1.90
74LS27	.28	74LS160	.88	74LS365	.48
74LS28	.34	74LS161	.84	74LS366	.48
74LS30	.24	74LS162	.88	74LS367	.44
74LS32	.28	74LS163	.84	74LS368	.44
74LS33	.54	74LS164	.88	74LS373	1.35
74LS37	.34	74LS165	.94	74LS374	1.35
74LS38	.34	74LS166	1.90	74LS377	1.35
74LS40	.24	74LS168	1.70	74LS378	1.13
74LS42	.48	74LS169	1.70	74LS379	1.30
74LS47	.74	74LS170	1.45	74LS385	1.85
74LS48	.74	74LS173	.88	74LS386	.44
74LS49	.74	74LS174	.54	74LS390	1.15
74LS51	.24	74LS175	.54	74LS393	1.15
74LS54	.28	74LS181	2.10	74LS395	1.15
74LS55	.28	74LS189	8.90	74LS399	1.45
74LS63	1.20	74LS190	.88	74LS424	2.90
74LS73	.38	74LS191	.88	74LS447	.38
74LS74	.34	74LS192	.78	74LS490	1.90
74LS75	.38	74LS193	.78	74LS624	3.95
74LS76	.38	74LS194	.88	74LS640	2.15
74LS78	.48	74LS195	.88	74LS645	2.15
74LS83	.59	74LS196	.78	74LS668	1.85
74LS85	.88	74LS197	.78	74LS669	1.85
74LS86	.38	74LS221	.88	74LS670	1.45
74LS90	.54	74LS240	.94	74LS674	9.60
74LS91	.88	74LS241	.98	74LS682	3.15
74LS92	.54	74LS242	.98	74LS683	3.15
74LS93	.54	74LS243	.98	74LS684	3.15
74LS95	.74	74LS244	1.25	74LS685	3.15
74LS96	.88	74LS245	1.45	74LS688	2.35
74LS107	.38	74LS247	.74	74LS689	3.15
74LS109	.38	74LS248	.98	74LS783	23.95
74LS112	.38	74LS249	.68	81LS95	1.45
74LS113	.38	74LS251	.58	81LS96	1.45
74LS114	.38	74LS253	.58	81LS97	1.45
74LS122	.44	74LS257	.58	81LS98	1.45
74LS123	.78	74LS258	.58	25LS2521	2.75
74LS124	2.85	74LS259	2.70	25LS2569	4.20

CRT CONTROLLERS

6845	11.95
7220	38.95
CRT 5027	18.95
CRT 5037	28.95
TMS 9918A	36.95
HD 46505sp	11.95

DISC CONTROLLERS

1771	14.95	2797	54.95
1791	21.95	6843	33.95
1793	25.95	8272	18.95
1795	21.95	UPD765	18.95
1797	21.95	MB8876	23.95
2791	49.95	MB8877	25.95
2793	49.95	1691	6.95
2795	54.95	2143	6.95

1984 – THE IC MASTER –

Your ticket to fast and easy IC selections

$ 89.95

6500

1 MHZ		2 MHZ	
6502	4.90	6502A	6.90
6504	6.90	6522A	9.90
6505	8.90	6532A	10.95
6507	9.90	6545A	26.95
6520	4.30	6551A	10.95
6522	6.90	**3 MHZ**	
6532	9.90	6502B	8.95
6545	21.50		
6551	10.85		

6800

68000	45.95	6860	6.95
6800	2.75	6862	10.95
6802	7.90	6875	6.90
6808	12.90	6880	2.20
6809E	13.95	6883	21.95
6809	10.95	68047	23.95
6810	2.90	68488	18.95
6820	4.30		
6821	2.75	**1 MHZ**	
6828	13.95	68B00	9.95
6840	11.95	68B02	21.25
6843	33.95	68B09E	28.95
6844	24.95	68B09	28.95
6845	11.95	68B10	6.90
6847	10.95	68B21	6.90
6850	3.20	68B45	18.95
6852	4.95	68B50	5.90

MICROPROCESSORS

8000

8031	5.75	8088	25.95
8035	5.90	8089	59.95
8039	5.75	8155	6.90
INS-8060	16.95	8155-2	7.90
INS-8073	45.95	8156	6.90
8080	3.90	8185	28.95
8085	4.75	8185-2	38.95
8085A-2	10.95	8741	19.95
8086	23.95	8748	35.95
8087	159.95	8755	23.95

8200

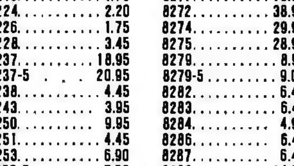
8202	23.95	8255-5	5.20
8203	38.95	8257	7.90
8205	3.45	8257-5	8.90
8212	1.75	8259	6.85
8214	3.80	8259-5	7.45
8216	1.70	8271	75.00
8224	2.20	8272	38.95
8226	1.75	8274	29.95
8228	3.45	8275	28.95
8237	18.95	8279	8.90
8237-5	20.95	8279-5	9.00
8238	4.45	8282	6.45
8243	3.95	8283	6.45
8250	9.95	8284	4.95
8251	4.45	8286	6.45
8253	6.90	8287	6.45
8253-5	7.90	8288	24.00
8255	4.45	8289	13.95
		8292	16.95

Z-80

2.5 MHZ		4.0 MHZ	
Z80-CPU	2.95	Z80A-CPU	3.95
Z80-CTC	2.95	Z80A-CTC	3.95
Z80-DART	8.95	Z80A-DART	8.95
Z80-DMA	11.95	Z80A-DMA	8.95
Z80-PIO	2.95	Z80A-PIO	3.95
Z80-SIO/0	10.95	Z80A-SIO/0	11.95
Z80-SIO/1	10.95	Z80A-SIO/1	11.95
Z80-SIO/2	10.95	Z80A-SIO/2	11.95
Z80-SIO/9	10.95	Z80A-SIO/9	11.95

6.0 MHZ		ZILOG	
Z80B-CPU	8.95	Z6132	33.95
Z80B-CTC	8.95	Z8671	38.95
Z80B-PIO	8.95		
Z80B-DART	12.95		

MEMORY EXPANSION KIT



4164 200ns 9 for $29.97

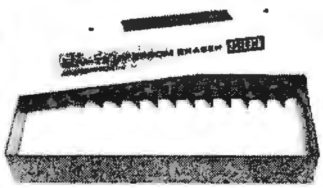
Low Cost EPROM – PROGRAMMER –

The "Shooter" $395.00

- 32K bits upgradable to 128K memory
- Built-in Serial RS-232 Port
- Program & verify 2718 thru 27256
- Intelligent, fast programming
- Up/download Hex, Binary, ASCII etc.
- Serial RS-232 interface compatible

UV ERASERS

QUV-T8/1 $49.95
ECONOMY Model



- Erases 8 EPROMS in 20 minutes
- Plastic Enclosure

QUV-T8/2T $97.50
INDUSTRIAL Model
- Tray Action, • UV Indicator
- 80-minute adjustable timer
- Steel enclosure • Safety switch
- Erase 15 EPROMS in 20 minutes

QUV-T8/2N $68.95
(No Timer)

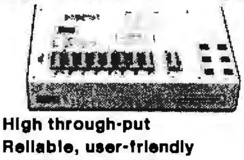
LUV-1 $149.95
PRODUCTION Model

QUV-T8/2 $124.95
FAST Industrial Model

ST-8 $195.00
8-Tray Storage Cabinet

GANG PROGRAMMER

GANGPRO-8™ $995.00



- High through-put
- Reliable, user-friendly
- Intelligent algorithm
- Program and verify 2718 thru 27256
- Stand alone (RS-232 option $185)

OTHER PRODUCTS:

PROMPRO-8 $689.00
64K Version
- Powerful EPROM/Micro development programmer
- Keypad simulation
- 256K memory buffer option available

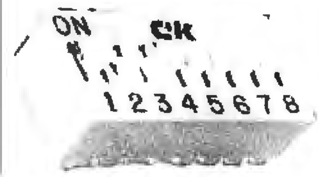
PROMPRO-7 $489.00
- 32K non-expandable unit
- Built-in 8748, 8749 programming

PALPRO-2 $1895.00
Stand-alone RS-232 Unit
- Programs 20 and 24 series PALs

PALPRO-1 $995.00
Programs 20-pin PALs

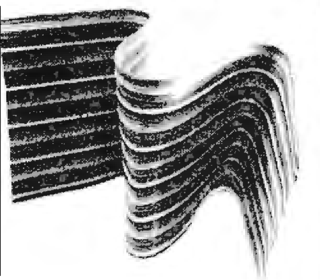
LOGICAL DEVICES, INC. LOGICAL

DIP SWITCHES



4 POSITION	.79
5 POSITION	.85
6 POSITION	.85
7 POSITION	.89
8 POSITION	.89

RIBBON CABLE



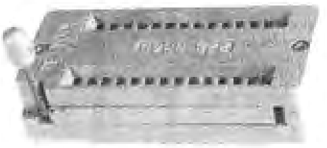
CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10"
10	.45	4.30	.78	7.20
16	.50	4.70	.95	8.70
20	.60	5.60	1.15	10.90
25	.70	6.50	1.22	11.50
26	.70	6.60	1.27	11.50
34	.93	8.50	1.55	14.40
40	1.27	11.50	1.82	16.70
50	1.28	12.00	2.40	21.90

IC SOCKETS
(1 to 99)

8 pin ST	.12	8 pin WW	.58
14 pin ST	.14	14 pin WW	.68
16 pin ST	.16	16 pin WW	.68
18 pin ST	.19	18 pin WW	.98
20 pin ST	.28	20 pin WW	1.04
22 pin ST	.29	22 pin WW	1.34
24 pin ST	.29	24 pin Ww	1.44
28 pin ST	.39	28 pin WW	1.64
40 pin ST	.48	40 pin WW	1.94

ST = Soldertail WW = Wirewrap

ZIF SOCKETS



14 pin ZIF	5.45
16 pin ZIF	5.45
24 pin ZIF	7.45
28 pin ZIF	8.45
40 pin ZIF	10.45

ZIF = TEXTOOL (Zero Insertion Force)

VOLTAGE REGULATORS

7805T	.74	7905T	.84
78M05C	.34	7908T	.84
7808T	.74	7912T	.84
7812T	.74	7915T	.84
7815T	.74	7924T	.84
7824T	.74	7905K	1.44
7805K	1.34	7912K	1.44
7812K	1.34	7915K	1.44
7815K	1.34	7924K	1.44
7824K	1.34	79L05	.78
78L05	.68	79L12	.78
78L12	.68	79L15	.78
78L15	.68	LM323K	4.90
78H05K	9.90	UA78S40	1.90
78H12K	9.90		

C,T = TO-220 K = TO-3
L = TO-92

CRYSTALS

1.0000 MHz	3.69	8.0000 MHz	2.69
1.8432 MHz	3.69	10.0000 MHz	2.69
2.0000 MHz	2.69	10.7386 MHz	2.69
2.0972 MHz	2.69	12.0000 MHz	2.69
2.4676 MHz	2.69	14.3182 MHz	2.69
3.2768 MHz	2.69	15.0000 MHz	2.69
3.6796 MHz	2.69	16.0000 MHz	2.69
4.0000 MHz	2.69	17.4300 MHz	2.69
4.1943 MHz	2.69	18.0000 MHz	2.69
4.9160 MHz	2.69	18.4320 MHz	2.69
5.0000 MHz	2.69	19.6608 MHz	2.69
5.0688 MHz	2.69	20.0000 MHz	2.69
5.1850 MHz	2.69	22.1184 MHz	2.69
5.2429 MHz	2.69	32.0000 MHz	2.69
5.7143 MHz	2.69	36.0000 MHz	2.69
6.0000 MHz	2.69	48.0000 MHz	2.69
6.1440 MHz	2.69	49.4350 MHz	2.69
6.4000 MHz	2.69	49.8900 MHz	2.69
6.5536 MHz	2.69		

32.768 KHz...... 1.69

CRYSTAL CLOCK OSCILLATORS

PART NO.	FREQUENCY	PRICE
1.000	1.0000 MHz	6.99
1.843	1.8432 MHz	6.99
2.000	2.0000 MHz	6.99
4.000	4.0000 MHz	6.99
8.000	8.0000 MHz	6.99
10.000	10.0000 MHz	6.99
16.000	16.0000 MHz	6.99
18.432	18.4320 MHz	6.99
19.660	19.6608 MHz	6.99
20.000	20.0000 MHz	6.99
32.000	32.0000 MHz	6.99

EDGECARD CONECTORS

S-100 ST	3.85	50-pin ST	4.85
S-100 WW	4.85	44-pin ST	2.85
72-pin ST	6.85	44-pinWW	4.85
72-pinWW	7.85		

RESISTORS

¼ WATT 5% CARBON FILM
ALL STANDARD VALUES
FROM 1 OHM - 10 MEG OHM

50 PCS	1.25
100 PCS	2.00
1,000 PCS	15.00

LED LAMPS

	1-99	100+
Jumbo RED	.09	.08
Jumbo GREEN	.16	.14
Jumbo YELLOW	.16	.14

INTERFACE CHIPS

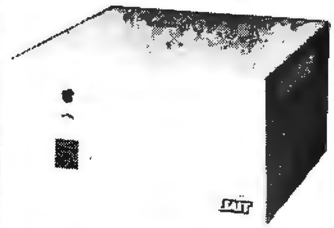
8T26	1.64	8T98	.88
88T26	1.64	DM8131	2.90
8T95	.88	DP8304	2.24
8T96	.88	DS8835	1.94
8T97	.88	DS8836	.98

— TRANSISTORS —

2N918	.49	2N3663	.39	2N4402	.24
MPS918	.24	2N3866	.39	2N4403	.24
2N2102	.74	PN3565	.24	2N4857	.99
2N2218	.49	MPS3638	.24	PN4916	.24
2N2218A	.49	MPS3640	.24	2N5086	.24
2N2219	.49	PN3643	.24	PN5129	.24
2N2219A	.49	PN3644	.24	PN5139	.24
2N2222	.24	MPS3704	.14	2N5209	.24
PN2222	.09	MPS3706	.14	2N6028	.34
MPS2369	.24	2N3772	1.60	2N6043	1.70
2N2484	.24	2N3903	.24	2N6045	1.70
2N2905	.49	2N3904	.09	MPS-A05	.24
2N2907	.24	2N3906	.09	MPS-A06	.24
PN2907	1.20	2N4122	.24	MPS-A55	.24
2N3055	.78	2N4123	.24	TIP29	.64
3055T	.68	2N4249	.24	TIP31	.74
2N3393	.29	2N4304	.74	TIP32	.78
2N3414	.24	2N4401	.24		

SAFT Power Products:

STANDBY POWER — SUPPLIES —

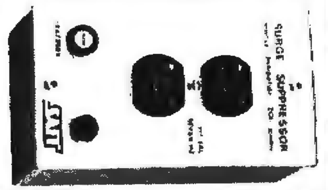


Protect your computer and its precious data from black-outs or brownouts. Turns on if the power goes off at the wall outlet!

SPS0200VA/117V **$499.00**

SPS0400VA/117V **$699.00**

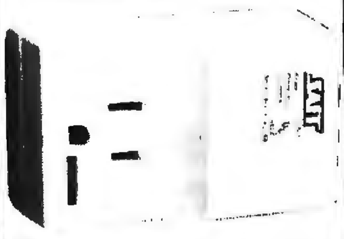
SURGE - SUPPRESSOR -



STOPS lightening bolts or other high energy line surges from damaging your computer's sensitive components.

SURGE SUPPRESSOR **$149.00**

- EMI/RFI FILTER -



Eliminates line noise caused by office equipment, printers, flourescent lights, switches, etc.

INTERFERENCE FILTER **$49.95**

LINE - CONDITIONER -

Isolation transformer is harmonic compensating to hold line voltage steady, regulated; also suppresses pulses and line noise.

LINE CONDITIONER **$395.00**

ORDER TOLL FREE

(800) 538-8800

(CALIFORNIA RESIDENTS)

(800) 848-8008

VISA MasterCard

DIP CONNECTORS

DESCRIPTION	ORDER BY	8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	HRTxxST	.94	.94	.94	1.59	1.79	1.79	1.89	2.39	2.89
COMPONENT CARRIERS (DIP HEADERS)	ICCxx	.60	.70	.80	.95	1.15	1.15	1.26	1.40	2.00
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	—	1.35	1.55	—	—	—	2.40	—	4.05

(NO. of CONTACTS: 8–40)

ORDER EXAMPLE: A 14-pin High Rel. ST socket would be HRT 14 ST

D-SUBMINIATURE

DESCRIPTION		ORDER BY	9	15	25	37	50
SOLDER	MALE	DPxxP	1.98	2.59	2.40	4.70	5.96
CUP	FEMALE	DBxxS	2.56	3.53	3.15	7.01	9.14
RT. ANGLE	MALE	DBxxPR	1.55	2.10	2.90	4.73	—
PC. SOLDER	FEMALE	DBxxSR	2.08	2.93	4.32	6.09	—
IDC	MALE	IDPxxP	3.27	4.60	6.13	9.12	—
RIBBON CABLE	FEMALE	IDBxxS	3.59	5.03	6.74	9.98	—
HOODS	BLACK	HOOD-B	—	—	1.15	—	—
	GREY	HOOD	1.50	1.50	1.15	2.85	3.40

(NO. of CONTACTS: 9–50)

ORDER EXAMPLE: A 5-pin Male Solder Cup would be MALE DP 25 P

IDC CONNECTORS

DESCRIPTION	ORDER BY	10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.77	1.19	1.58	2.10	2.48	3.14
RT. ANGLE SOLDER HEADER	IDHxxSR	.80	1.25	1.66	2.21	2.62	3.29
WW HEADER	IDHxxW	1.76	2.88	3.74	4.40	5.18	6.53
RT. ANGLE WW HEADER	IDHxxWR	1.95	3.18	4.12	4.35	4.70	7.20
RIBBON HEADER SOCKET	IDSxx	1.05	1.76	2.33	3.05	3.63	4.55
RIBBON HEADER	IDMxx	—	5.40	8.15	6.90	7.40	8.40
RIBBON EDGE CARD	IDExx	2.15	2.26	2.55	3.15	3.70	4.64

(NO. of CONTACTS: 10–50)

ORDER EXAMPLE: A 20-pin WW Header would be IDH 20 W.

Continental U.S.
800-421-5500

Inside California
800-262-1710

For Technical Inquires
or Customer Service call:
213-973-7707

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Printers

OKIDATA
Prices Slashed
*FREE IBM ROMS

160 CPS. Correspondence Quality	LIST	JADE
Okidata 92 parallel	$599	$389.95*
Okidata 93 parallel FREE tractor!	$995	$599.95*
2K serial board	$120	$99.95
IBM PC ROMS for 92	$59	$49.95
IBM PC ROMS for 93	$69	$59.95
Extra 82/93 Ribbon	$9.95	$4.95
82/92 tractor	$89	$54.95

120 CPS & 200 CPS OKIDATAS	LIST	JADE
Okidata 82 120 CPS	$499	$299.95
Okidata 83 120 CPS	$775	$569.95*
Okidata 84 parallel 200 CPS	$1395	$799.95*
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Allows your computer to run either of two printers standard parallel switch box.

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Little Board with CP/M	$400	$349.95
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190K Disk drive	$249	$99.95
350K Disk drive	$399	$149.95

EPSON PRINTERS
New Plus Series in Stock!

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EPSON RX-100F/T	SAVE	$250.00
EPSON JX-80F/T	SAVE	$200.00
EPSON FX-80F/T	SAVE	$200.00
EPSON FX-100F/T	SAVE	$300.00
EPSON LQ-1500	SAVE	$300.00
EPSON/COMREX 420 CPS	SAVE	$500.00
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FX-80 Tractor	$59	$39.95
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Tractor for F-10	$250	$199.95
New Comrex CR-IIE	$599	$439.95
Tractor for CR-II	$120	$99.95
Keyboard for CR-II	$199	$179.95
Sheet feeder for CR-II	$259	$199.95
Juki 6100 18 CPS	$599	$449.95
Tractor for 6100	$149	$124.95
NEC 3550 33 CPS	$2250	$1399.95
Tractor for 3550	$265	$229.95

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8K parallel in serial out	$199	$169.95
32K parallel in serial out	$260	$199.95
8K serial in serial out	$199	$169.95
32K serial in serial out	$260	$199.95

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Practical Peripherals

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5151	$299	$199.95
5152	$329	CALL

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	LIST	
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Quadmeg-AT 2 MEG	$3995	$3195.00
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Quad 2 MEG w/512K	$1195	$995.00
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IBM PC XT 256K with 2 Drives	3499	Call	Call
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IBM PC-33 256K RAM, 2 ea 360K FD, Color Bd. Monitor, KB $2049
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Amdek 300A .... $149 ea.
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22 MB	$1349	$1529
33 MB	$1769	$1889

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- Back-up in 8 min.

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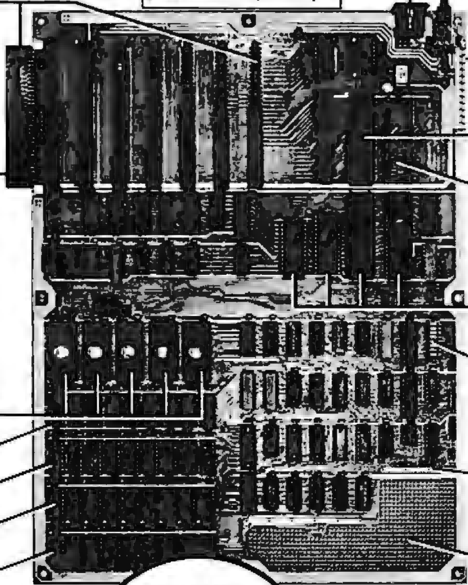

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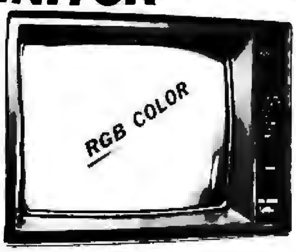
NEC RGB COLOR MONITOR $259



The NEC JC-1401D is a 13" medium/high resolution RGB monitor suitable for use with the Sanyo MBC-550/555 or the IBM/PC. The monitor features a resolution of 400 dots by 240 lines. Colors available are Red, Green, Blue, Yellow, Cyan, Magenta, Black and White. These monitors are currently being used in applications far more critical than microcomputers.
The NEC monitor carries the Litton-Monroe label and was originally scheduled for use in their "Office of the Future" equipment. A change in Monroe's marketing strategy has made these units excess inventory which were sold to California Digital. We are offering these prime "new" RGB monitors at a fraction of their original cost. Sanyo compatible NEC-1401/S; IBM/P/C Computer compatible NEC-1401/PC

TELETYPE MODEL 40

$795

$395

The Teletype peripherals are continuous heavy duty communication equipment that have recently come off lease from a Cado Computer customer. It is seldom that California Digital becomes involved in the marketing of USED products but we felt that these peripherals represented such an exceptional value that we had to offer this equipment to our customers.

The full character chain printer is capable of printing text in excess of 300 lines per minute. This printer, long used in high speed mini-computer applications, will provide the small business user with good quality multi-part printouts at speeds that can not be attained by dot matrix printers.
This unit also has a four channel vertical forms feed controller that allows for quick change of various form lenghts. The Teletype Model 40 printer has a proprietary serial Teletype SSI interface and DIP switches are provided for setting baud rates to 9600. The printer requires special support software when connecting directly to a mainframe, call for technical support.

The Model 40 CRT terminal has a RS-232 and current loop serial interface as well as a printer port that supports the Model 40 printer. This terminal features block mode, full screen editing as well as DC1/DC3 select capabilities.

All Teletype equipment is fully inspected by our engineering department before shipment. These peripherals are shipped freight collect by truck.

Teletype Printer $795 • Model 40 CRT Terminal $395
• Both printer and terminal $1065 •

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BMC 12A green phosphor 15 MHz composit video	BMC-12A	7895
BMC 12 high resolution, 20MHz	BMC-12EN	119 00
Amdek 300G 12 green phosphor	AMK-300G	128 95
Amdek 300A 12 amber phos hi-resolution	AMK-300A	138 95
Amdek 310A designed for IBM/PC amber	AMK-310A	15895
Zenith ZVM122 Amber Phosphor 12 40/80 column switch	ZTH-122	89 95
Zenith ZVM123 green phosphor 12 40/80 column switch	ZTH-Z123	8995
NEC JB1201 green phosphor 18 MHz composit video	NEC-JB1201	15900
NEC JB1260 commercial grade composit	NEC-JB1260	119 00
Conrac 9 open frame requires horz sync & 12v supply	CON-BW9	5900

COLOR

NEC JC1401D Medium/High 13 RGB	NEC-1401/X	259[illegible]
BMC AU9191U Color composit video with sound	BMC-9191	23
BMC 9191M RGB designed for use with the IBM computer	BMC-9191M	37
NEC JC1203DM RGB color monitor	NEC-1203	69
NEC JC1215 color composit	NEC-JC1215	339.00
Zenith ZVM135 RGB & composite suitable for IBM PC	ZTH-Z135	47500
Amdek Color I, 13 composit video	AMK-100	299 00
Amdek Color II, 13 RGB hi-resolution	AMK-200	419 95
Amdek Color III RGB medium resolution	AMK-300	35995
Princeton HX-12 RGB IBM/PC compatible	PRN-HX12	478.95

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Star Gemini-15X, 100 char/sec 15" paper	STR-G15X	365 00
Star Gemini Della 10, 160 Char/sec	STR-D10	399 00
Star Coex 80FT friction & tractor	VST-C80FT	179.00
Toshiba P1351, 192 char/sec letter quality	TOS-1351	1495 00
Okidata 82A serial & parallel 9½ paper	OKI-82A	32900
Okidata 92A parallel interface, 160 char/sec	OKI-92A	39900
Okidata 83A & parallel 15 paper	OKI-83A	5[illegible]
Okidata 84A & parallel 15" paper	OKI-84A	9[illegible]
EpsonRX-8010" 120 Char/sec.	EPS-RX80	2[illegible]
Epson FX80, 10 160 char./sec with graphtrax	EPS-FX80	4[illegible]
Epson FX 100 15 160 char/sec with graphtrax	EPS-FX100	6[illegible]
Epson LQ1500, 15" corespondence quality	EPS-LQ1500	11[illegible]
Epson JX80 Color printer	EPS-JX80	5[illegible]
Anadex 9501B high speed with graphics	ADX-9501B	10[illegible]
Anadex 9620B 200 char/sec par'l & serial	ADX-9620B	1129 00
Prowriter 8510 parallel 9½ paper	PRO-8510P	35900
Prowriter II, parallel 15 paper, graphics	PRO-2P	68900
Dataproducts B-600-3, band printer 600 LPM	DPS-B600	698500
Printronix P300 high speed printer 300 lines per minute	PTX-P300	399500
Printronix P600 ultra high speed 600 lines per minute	PTX-P600	57[illegible]

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NEC7730 55 char/sec, par'l interface	NEC-7730	179500
NEC3550 popular printer designed for the IBM/PC	NEC-3550	159900
NEC2050 designed for IBM/PC 20 char/sec par'l	NEC-2050	995.00
Silver Reed EXP500, 14 char/sec. par'l interface	SRD-EXP500	45900
Silver Reed EXP550 17 Char/sec par'l interface	SRD-EXP550	659 00
Diablo 630 40 char/sec, serial	DBL-630	176500
Diablo 620, proportional spacing, horz. & vert tab 20 cps.	DBL-620	775 00
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Brother HR1A serial interface	BTH-HR1S	695.00
Starwriter F10 serial, 40 char/sec	PRO-F10S	1125 00
Starwriter F10 parallel, 40 char/sec.	PRO-F10P	1125.00
Comrex CR2, 5k buffer, proportional spacing, par'l	CRX-CR2P	49500

TERMINALS

Freedom 100, split screen, detatchable keyboard	LIB-F100	495 00
Oume 102 green phosphor terminal	OUM-102	539.00
Ampex Dialogue 125 green screen.	APX-D125G	675 00
Ampex Dialouge 175 amber screen, two page, func. keys	APX-D175A	719 00
Wyse50, 14" green phosphor	WYS-50	595 00
Wyse 300, Eight color display, split screen	WYS-300	115900
Zenith29 terminal, VT52 compatible detatchable keyboard.	ZTH-Z29	76500
Televideo 910 Plus, block mode	TVI-910P	575.00
Televideo 925, detatchable keyboard, 22 function keys	TVI-925	759.00
Televideo 950, graphic char .split screen, 22 func	TVI-950	950.00
Televideo970, 14" green, 132 column, European	TVI-970	1095 00

EAGLE $895

unit provides two 5 1/4" drives for a combined storage capacity of 780 K/Byte. The computer contains a 4Mhz Z-80A, DMA disk interface, two RS-232C serial ports, Centronics printer interface, along with an auxillary parallel port.
Software included consists of ULTRACALC electronic spread sheet, SPELLBINDER word processor, CBASIC2, CP/M 2.2, and an exclusive Eagle menu driven utility package.
These units are all "factory new" and are being offered far below their suggested price of $2495. This is your opportunity to purchase a complete CP/M system for only $895

PROMETHEUS ProModem 1200

300/1200 baud modem. This Hayes compatible modem features completely unattended operation, auto answer/auto dial and even includes "redial number when busy". Internal diagnostics makes the Promodem 1200 an easy modem to install. Help commands, real time clock and internal speaker add to the ease of use of this unit.

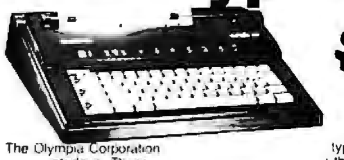
An optional processor accessory allows battery back up, extra memory space for storing additional phone numbers, messages received, and can act as a transfer buffer when exchanging programs.

The Alphanumeric display option allows messages saved to be displayed when they were received, diagnostic test results, numbers ... the directory, as well as modem status.

MODEMS

CTS212AH 1200 baud autodial	CTS-212AH	31900
Signalman Mark 12, 1200 baud, Hayes compatible	SGL-MK12	25900
Signalman Mark 1, direct connect with terminal cable	SGL-MK1	7500
Hayes Smart Modem 1200 baud, auto answer autodial	HYS-212AD	479.00
Hayes 1200B for use with the IBM/PC, 1200 baud	HYS-1200B	429 00
Hayes Smartmodem 300 baud only, autoanswer, auto dial	HYS-103AD	229.00
Hayes Micromodem II, 103 Apple direct connect	HYS-MM2	279 00
Hayes Chronograph, time & date	HYS-CHR232	199 00
Prometheus 1200 super features	PRM-P1200	33[illegible]
Prometheus 1200B internal PC	PRM-P1200B	27[illegible]
Team 1200 Hayes Compatible	TEM-SM1200	22[illegible]
U.S. Robotics 212A 300/1200 baud, auto dial/answer	USR-212A	43[illegible]
U.S. Robotics Password 300/1200 baud	USR-PW212	389 00
Penril 300/1200 industrial quality	PEN-12AD	595 00
Universal Data 103LP, line power, answer & originate	UDS-103LP	169 00
Universal Data 202, 1200 baud, half duplex only	UDS-202LP	219 00
Universal Data 212LP, full 1200 baud duplex, line power	UDS-212LP	359 00
Novation J Cat, direct connect, auto answer	NOV-JCAT	115 00

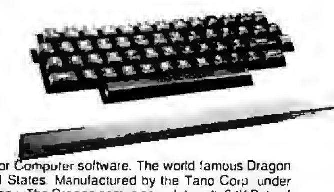
OLYMPIA Computer Printer Typewriter



$339

The Olympia Corporation typewriters with built in Centronics interface. These the ideal answer to your personal correspondence needs.
The Compact 2 prints at 14 characters per second and is priced at $459 OLY-C2. The Orbit XP, pictured above, prints at 10 characters per second and is priced at only $339 OLY-XP1. Both machines are equiped with 2 K/byte printer buffers and a lift off correction key.

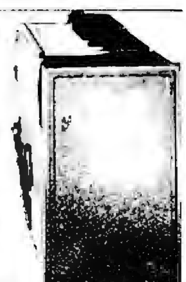
Sellout DRAGON



'157

Compatible with most Radio Shack Color Computer software. The world famous Dragon computer is now available in the United States. Manufactured by the Tano Corp. under license of the British Broadcasting Company. The Dragon comes complete with 64K Byte of memory, serial modem port along with a Centronics printer interface. This unique microcomputer features Motorola's advanced 6809E microprocessor and comes standard with

Shugart 604 WINCHESTER $159



These 6.7 Megabyte drives are new units recently released by the Shugart division of Xerox.
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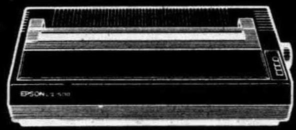

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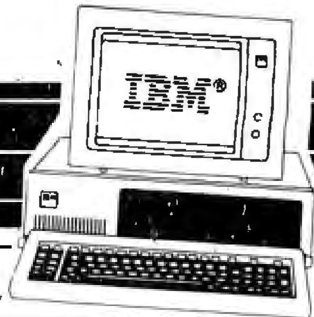

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Kaypro4	Call
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PC 256K, 1 Drive	1399
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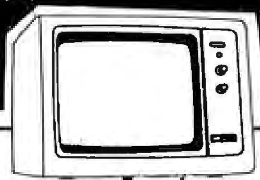

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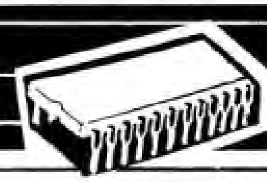
Inquiry 52

IBM & APPLE ACCY'S



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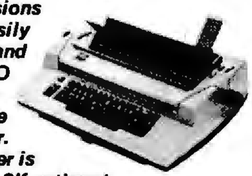

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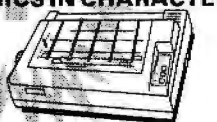

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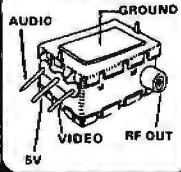

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22	50V	.05	680	50V	.05
25	50V	.05	820	50V	.05
27	50V	.05	.001µf	50V	.05
33	50V	.05	.0015	50V	.05
47	50V	.05	.0022	50V	.05
56	50V	.05	.005	50V	.05
68	50V	.05	.01	50V	.07
82	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10

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10	50V	.16	10	50V	.16
47	35V	.18	22	16V	.14
100	16V	.18	47	50V	.20
220	35V	.20	100	15V	.20
470	25V	.30	100	35V	.25
2200	16V	.60	220	25V	.30
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MINI GREEN	T1	.18	.15
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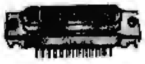
IDB37S

DB37S



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RIBBON HEADER	IDMxx	—	5.50	6.25	7.00	7.50	8.50
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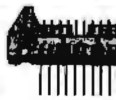
ORDERING INSTUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED. EXAMPLE: A 10 PIN RIGHT ANGLE HOLDER STYLE WOULD BE IDH10SR



IDH20WR

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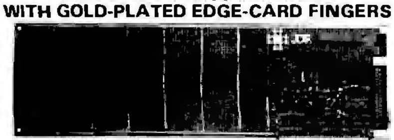
IBM PC PROTOTYPE CARD WITH DECODING CIRCUITRY $29.95

WIRE WRAP PROTOTYPE CARDS

FR-4 EPOXY GLASS LAMINATE WITH GOLD-PLATED EDGE-CARD FINGERS



IBM-PR2

IBM

BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

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IBM-PR2	AS ABOVE WITH DECODING CIRCUITRY	$29.95

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P100-2	HORIZONTAL BUS	$21.80
P100-3	VERTICAL BUS	$21.80
P100-4	SINGLE FOIL PADS PER HOLE	$22.75

APPLE

P500-1	BARE - NO FOIL PADS	$15.15
P500-3	HORIZONTAL BUS	$22.75
P500-4	SINGLE FOIL PADS PER HOLE	$21.80
7060-45	FOR APPLE IIe AUX SLOT	$30.00

GENERAL PURPOSE

22/44 PIN EDGE-CARD (.156" SPACING)

P441-1	BARE - NO FOIL PADS 4.5" x 6.0"	$9.45
P441-3	VERTICAL BUS 4.5" x 6.0"	$13.95
P441-4	SINGLE FOIL PADS 4.5" x 6.0"	$14.20
P442-1	BARE - NO FOIL PADS 4.5" x 9.0"	$10.40
P442-3	VERTICAL BUS 4.5" x 9.0"	$14.20
P442-4	SINGLE FOIL PADS 4.5" x 9.0"	$13.50

36/72 PIN EDGE-CARD (.1" SPACING)

P721-1	BARE - NO FOIL PADS 4.5" x 6.0"	$9.45
P721-3	VERTICAL BUS 4.5" x 6.0"	$13.25
P721-4	SINGLE FOIL PADS 4.5" x 6.0"	$14.20
P722-1	BARE - NO FOIL PADS 4.5" x 9.0"	$10.40
P722-3	VERTICAL BUS 4.5" x 9.0"	$14.20
P722-4	SINGLE FOIL PADS 4.5" x 9.0"	$15.15

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P45x85	4.5" x 8.5"	$6.20
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IBM	$45.00
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FD200-8 BY SIEMENS, SHUGART 851 EQUIV. DS/DD 10/$185.00 ea. $$195.00

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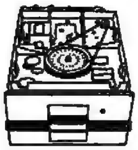
TEAC FD-55B



TANDON TM100-2

PLEASE INCLUDE SUFFICENT AMOUNT FOR SHIPPING ON ABOVE ITEMS

DISK DRIVE CABINETS

CABINET #1 $29.95
- Fits one full height 5¼" disk drive
- Color matches Apple

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8" DISK DRIVE CABINETS ALSO AVAILABLE-PLEASE CALL

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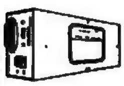
PS-IBM $175.00
- FOR IBM PC-XT COMPATIBLE
- 130 WATTS
- -5V @ 15A, +12V @ 4.2A -5V @ .5A, -12V @ .5A
- ONE YEAR WARRANTY



PS-A $49.95
- USE TO POWER APPLE TYPE SYSTEMS
- +5V @ 4A, +12V @ 2.5A -5V @ .5A, -12V @ .5A
- APPLE POWER CONNECTOR

PS-3 $39.95
- AS USED IN APPLE III
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- 15.5" x 4.5" x 2", .884 LBS.

PS-ASTEC $19.95
- CAN POWER TWO 5¼" FDDS
- +5V @ 2.5A, +12V @ 2A -12V @ .1A
- +5V @ 5A IF +12V IS NOT USED
- 6.3" x 4.0" x 1.9"

OK INDUSTRIES

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- ONE PIECE METAL CONSTRUCTION
- EASILY EXTRACTS 8-24 PIN DEVICES
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EX-1

EX-2 IC EXTRACTION TOOL

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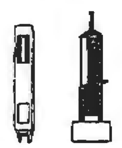
INS-1416	for 14-16 pin IC's	$5.15
MOS-1416	for 14-16 pin IC's	$10.92
MOS-2428	for 24-28 pin IC's	$10.92
MOS-40	for 40 pin IC's	$12.43

MOS series insertion tools have metal constuction and include grounding lug for CMOS applications.



INS-1416 INS-2428

BW-630 WIRE WRAP GUN

- BATTERY POWERED-USES 2 NI-CAD C CELLS(NOT INCLUDED)
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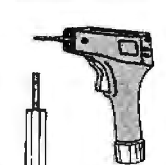
- ANTI-OVERWRAP DEVICE $41.55



BW-630

WSU-30 WIRE WRAP TOOLS

- WRAPS, STRIPS, AND UNWRAPS
- WSU-30M WRAPS AN EXTRA TURN OF INSULATION

WSU-30 $8.84 / WSU-30M $10.14

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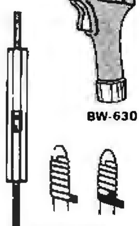
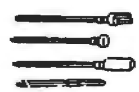
WWT-2	SINGLE SIDED	25/$4.25
WWT-3	IC SOCKET	25/$7.06
WWT-4	DOUBLE SIDED	25/2.80
INS-1	INSERTION TOOL	$3.64



WSU-30/30M

WIRE DISPENSER

- WITH 50' ROLL OF WIRE
- BUILT IN PLUNGER CUTS WIRE
- BUILT IN STRIPPER STRIPES 1"
- REFILLABLE



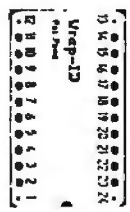
WD-30 $6.50 WD-30TRI $9.50
Specify Blue, white, Yellow or Red — With 50' of each: Red, Blue and White

SOCKET-WRAP I.D.™

- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON PLASTIC; SUCH AS IC #

PINS	PART#	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)



WIRE WRAP WIRE

PRECUT AND STRIPPED

Note: 1 inch of insulation is stripped on each end. A 3.5" wire has only 1.5" of insulation.

LENGTH (INCHES)	QUANTITY 100	500	1000
2.5	1.60	4.70	8.20
3	1.60	4.70	8.20
3.5	1.65	5.00	8.90
4	1.75	5.40	9.60
4.5	1.80	5.75	10.30
5	1.85	6.10	11.00
5.5	1.90	6.50	11.75
6	2.00	6.85	12.50
6.5	2.30	7.80	14.30
7	2.40	8.20	15.05
7.5	2.50	8.55	15.85
8	2.60	8.95	16.60
8.5	2.65	9.30	17.40
9	2.70	9.80	18.15
9.5	2.80	10.00	18.95
10	2.90	10.50	19.70

PRECUT ASSORTMENT IN ASSORTED COLORS $27.50

100ea: 5.5", 6", 6.5", 7"
250ea: 2.5", 4.5", 5"
500ea: .3", 3.5", 4"

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100 feet	$4.30	250 feet	$7.25
500 feet	$13.25	1000 feet	$21.95

Please specify color: Blue, Black, Yellow or Red

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AA CELLS	QTY. 2	$11.71
C CELLS	QTY. 2	$13.21
D CELLS	QTY. 2	$13.21
9 VOLT	QTY. 1	$13.21

BATTERIES ONLY

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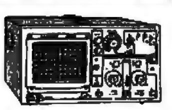
AA CELLS	PKG. 1	$3.03 ea.
C CELLS	PKG. 1	$3.78 ea.
D CELLS	PKG. 1	$3.78 ea.
9 VOLT	PKG. 1	$7.57 ea.

20 MHz DUAL TRACE OSCILLOSCOPE FROM RAMSEY ELECTRONICS



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$399.95 WITH PROBES

FULL ONE YEAR WARRANTY

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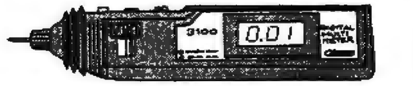

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- ONLY 1¼" x 6¼" x ¾"
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- .1 OHM-20 MEG OHMS
- WEIGHS ONLY 2.3 OUNCES
- LOW PARTS COUNT-CUSTOM 80 PIN LSI INSURES RELIABILITY
- INCLUDES MANUAL, BATTERIES, SOFT CASE, 2 PROBE TIPS, AND ALLIGATOR CLIP

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Inquiry 164

U·N·C·L·A·S·S·I·F·I·E·D A·D·S

NEEDED: Information on or public-domain software for Commodore 64 to develop educational and social skills of mentally handicapped adults. Also, we will share the programs we have developed. Mrs. M. Worsman, Pennine House, 39 Well St., Bradford, West Yorkshire BD1 5RE, England.

WANTED: Information on computers/hardware to videotape high-resolution/double high-resolution drawings and animation without flickering. Want equipment to transform signal to NTSC or computer with such capability (now using an Apple IIe and Add Wor board that does not generate true NTSC output). Marianne Unger, 1313 Good St., Reading, PA 19602.

NEEDED: Tax-deductible donation of computers (Apple II, IBM PC, or compatible), monitors, and printers for Appalachian students in biology and pre-medicine. Shipping will be paid. Dr. H. W. Elmore, Department of Biology, Marshall University, Huntington, WV 25701, (304) 696-3638 or 696-3148.

WANTED: Donation of a Macintosh or Apple IIe to be used by Miss Pantipa Isaramongkolpant, Multiple Cropping Project, Faculty of Agriculture, Chiangmai University, Thailand 50002. For shipping fee and arrangements, call John Dennis (Department of Rural Sociology, Cornell University, Ithaca, NY 14850) at (607) 256-3159.

WANTED: Tax-exempt, nonprofit organization working with teenagers seeks donation of personal computer equipment for word processing. Fully tax-deductible. Will pay shipping. Especially interested in letter-quality printer. Northwest Indiana Youth for Christ, POB 537, Valparaiso, IN 46383.

WANTED: Private elementary school seeks to purchase Apple II+ at low cost or receive as donation. Dr. Peter Hulick, James River Day School, 5039 Boonsboro Rd., Lynchburg, VA 24503.

NEEDED: Boy Scout Troop #397 seeks tax-deductible donation of Apple II, IBM PC, Kaypro, or compatible. Troop #397, 243 42nd St., Copiague, NY 11726.

WANTED: Educational institution seeks tax-deductible donations of microcomputer, disk drives, monitor, and printer. Cardozo Computer Users' Group, Cardozo School of Law, 55 Fifth Ave., New York, NY 10003.

WANTED: Nonprofit publisher of *Education Week* newspaper needs PC and Apple computers and peripherals of all types in exchange for tax benefit and printed recognition. Janice Lopez, *Education Week*, 1255 Twenty-third St. NW, Washington, DC 20036, (202) 466-5190.

NEEDED: Nonprofit state college art department with computer graphics skills needs graphics equipment to update curriculum and improve student employment profile. Anything will do: CPUs, RGB monitors, video input, printers, disk drives, plotters, graphics tablets, and video film recorder. Desmond McLean, Art Department, Memorial Hall, Glassboro State College, Glassboro, NJ 08028, (609) 863-7366/7081.

WANTED: Charitable nonprofit organization seeks donation of computers, peripherals, printers, monitors, terminals, disk drives, memory expansion, etc. Certified tax-deductible receipts furnished. Will pay reasonable shipping. Holdeman International, POB 329, West Point, MS 39773.

WANTED: Tax-exempt, nonprofit educational organization seeks donation of microcomputers and peripherals. Donation is tax-deductible; will provide receipts and pay reasonable shipping. Baton Rouge Astronomical Society, 11683 Flamingo Dr., Baton Rouge, LA 70814.

WANTED: Information on an available cut-sheet feeder that accommodates 11-inch-wide paper and fits a Brother HR-35 printer. Michael L. Cook, 3318 Wimberg Ave., Evansville, IN 47712.

FOR SALE: BYTE, September 1975 through December 1984. 112 consecutive issues. Best offer for all. R. F. Nichol, 25747 Date St., San Bernardino, CA 92404, (714) 862-1252.

WANTED: Documentation for Motorola Experimenter II 6800 board. Schematic for Burroughs EA2300 10-column calculator. Correspondence with hackers using Tano Dragon, APF M-1, or TS1000. B. R. Pogue, POB 111, Thatcher, AZ 85552.

FOR SALE: HP 86 computer, HP interface bus 82937A, HP dual-disk drives 250K each, and HP 82913A monitor: $2500 or trade for Apple IIe. Rick Crowsey, 9599 Southeast Valley Court, Hobe Sound, FL 33455, (305) 840-1633 or 546-8560.

WANTED: Religion department at private Lutheran college seeks donation of Apple IIe, TRS-80 Model III, or any comparable model with disk drive. Shannon Jung, Department of Religion, Concordia College, Moorhead, MN 56560, (218) 299-3435.

FOR SALE: BYTE, July 1976 (volume 1, number 11) through December 1982, marked but complete: $190 includes UPS shipping in U.S. Jerry Nelson, 3 Hill Rd., St. James, NY 11780, (516) 862-9351.

FOR SALE: Lobo MAX-80 (128K, serial ports, runs eight 5-inch/8-inch hard-disk drives, clock, 5-MHz Z80, function/numeric keypad, RAM drive) with two Shugart 160K drives, books, and original documentation: $1250. Stewart Dean, POB 120, Lake Hill, NY 12448, (914) 679-7637.

FOR SALE: BYTE, September 1975 through present in good condition. Missing May 1980 and January 1982. $250 includes shipping. D. M. Wyckoff, 5419 Mariposa Ave., Citrus Heights, CA 95610, (916) 967-6790 home, (916) 322-7484 work.

FOR SALE: New Radio Shack Model 16B with two disk drives, printer, hard-disk drive, and modem. Haas Honda, Route 1, Box 7, Marietta, OH 45750, (614) 374-4044.

FOR SALE: Magnavox Odyssey 1, the original video-game machine. Excellent condition: make an offer. William Blair, 909 East Emerson, Morton, IL 61550, (309) 266-7032.

FOR SALE: MS-DOS/CP/M-86 S-100 system, 12 slots, 8088/8087/8089 CPUs, 128K CMOS RAM, 64K low-power RAM (all static), battery-backed-up clock, two serial and two parallel ports, Jade bus probe, kludge card, two 8-inch DS/DD drives, one 5¼-inch SS/DD drive, ADM-2A CRT: $2450. Flexible; must sell. Dan Pritchard, 4721 Bali Court, Albuquerque, NM 87111.

WANTED: Other Olivetti M20 owners to share ideas and information. Kurt Moeller, POB 193, Chico, CA 95927, (916) 893-0887.

FOR SALE: TI 59 programmable calculator with PC-100C thermal printer, includes over a dozen magnetic cards and two rolls of printer paper: $100. Ed Cundy, Lyme Rd., Hanover, NH 03755, (603) 643-5004 evenings.

NEEDED: Correspondent who has knowledge of the KORG SAS-20 music keyboard's operating system. Looking for help in interfacing with computer and programming new ROM packs. Bill Tomlinson, 1038 West Mill St., Kewanee, IL 61443.

NEEDED: Victor 9000 owner wants to exchange ideas with other Victor users. Philippe Ciraud-Lanoue, 18 Bd de Perpigna, 17200 Royan, France.

WANTED: Back issues of BYTE, June through September 1982 and August 1983 through May 1984. Will pay $15 and postage. W. Michael Yearick, 305 July Lane #285, Copperas Cove, TX 76522.

WANTED: CompuPro system. Other multiuser systems considered. Alan Born, POB 272, Tiburon, CA 94920, (415) 924-6352.

FOR SALE: TRS-80 Model I, like-new condition, 5¼- and 8-inch disks, parallel and RS-232C ports. Passport 300/1200-bps auto-answer auto-dial modem, brand new: $325. Anadex 9501 graphics printer: $800. Joe Ruby, 6641 Northwest 22 Court, Margate, FL 33063, (305) 972-6641.

WANTED: Eagle PC II user wants to join/form support group to share information, advice. Prefer NYC area, but eager to correspond with Eagle users anywhere. M. C. Scarino, 55B Brighton #10 Court, Brooklyn, NY 11235, (718) 646-6988.

FOR SALE: Heath H-89 Z80 computer with 64K memory, Z-37 double-density floppy-disk controller with two SS/DD disk drives, full documentation. Excellent condition: $1450. Mike Ulis, 337 Cody Rd., San Dimas, CA 91773, (714) 592-3133 after 5 p.m.

WANTED: Schematics, service manuals, or other information on the GCE Vectrex video-game unit and the prototype Vectrex computer add-on unit. Want to contact anyone interested in interfacing the Vectrex to other computer hardware. Dennis Lo, 1862 East Broadway, Vancouver, BC V5T 1Y1, Canada.

NEEDED: Information on TI 99/4A, circuit diagrams, and hardware. Roy Antaw, 47 Park Ave., Ashfield, New South Wales 2131, Australia.

FOR SALE: Columbia MPC, 384K, two disks, color-graphics board, monochrome monitor, Gemini-10X printer, 1200-bps modem, and more. Will telephone support first month: $3500 for everything. Richard Platkin, 222 3rd St., Troy, NY 12180, (518) 271-7449.

FOR SALE: S-100 static memory boards. CompuPro: two RAM IV (16K) and one RAM IIa (8K). All 4 MHz, used but in excellent working condition: $100 for 16K and $75 for 8K or offer. Also, Industrial Micro-systems: two 8K at 2 MHz (use 2102s): $50 each or offer. Arnold Cohen, 41-34 52nd St., Apt. 3L, Woodside, NY 11377, (212) 446-0399.

FOR SALE: Centronics printer Model 779, parallel interface, friction feed: $500. Anderson-Jacobson IBM Selectric keyboard/printer terminal, serial interface (to 1200 bps): $600. Both work well. Manuals included; prices negotiable. Jeffrey Katz, 160 West 87th St., New York, NY 10024, (212) 873-6717.

FOR SALE: Level II ROM set with instructions: $100. Disk-drive upgrade for Model III or 4, less drives: $225. Frank Weatherford, Route 12, Hidaway Hill #36, Gray, TN 37615.

FOR SALE: Ohio Scientific timesharing system with 104K, 80-megabyte hard disk, two 8-inch floppy-disk drives: $8000. Also, extra boards to reconfigure system to support extra users/peripherals. Dana Humfleet, 665 East Dublin-Granville #300, Columbus, OH 43229, (614) 436-9510.

FOR SALE: HP 85 with 7470 plotter, HPIB interface, RS-232C serial port and ROM drawer, 16K expansion module. All manuals included: best offer. Dave Fiske, 8139 Van Noord, North Hollywood, CA 91605, (818) 848-4429 days, (818) 989-2070 evenings.

FOR SALE: Zenith Z-90 computer with 64K, Z-37 disk drive, warranty: make offer. Scott Kudika, 237 Main St., New Kensington, PA 15068, (412) 282-4756.

WANTED: Schematic diagram for Digital Equipment Corp. LA-30P DECwriter. Elwood Jackson, 34 Havelock Dr., Rochester, NY 14615, (716) 621-3266 or 682-4308.

FOR SALE: BYTE, September 1975 through July 1984. Complete set except July and September 1983 issues. Best offer over $300 plus shipping. Thomas Aulicino, 2014 59th St., Brooklyn, NY 11204.

WANTED: Manuals or hardware helpful in interfacing an old Kennedy 3110 nine-track 800-bpi, 25-ips bare Magtape deck to an H11 (Q-bus) or DEC PDP-11 Unibus system. A. DuRea, 101 Indian Lane, Oak Ridge, TN 37830, (615) 483-0784.

FOR SALE: S-100 computer, motherboard mounted inside ADDS Regent 25 terminal. 4-MHz Z80 CPU, two serial and three parallel ports, 64K RAM, 8-inch and 5¼-inch DD controller. Two Shugart 8-inch SS/DD drives. Used by church camp for three years: $2000 or best offer. D. Golowka, 6510 Lindley Ave., Reseda, CA 91335, (818) 705-6631.

WANTED: Will pay good price for used Apple disk drives, memory cards, modems, and other equipment. Would like to trade tips and techniques useful on an Apple II+ or IIe. Jared Edis, POB 1772, Summerland, BC V0H 1Z0 Canada, (604) 494-9934.

FOR SALE: Fortune 32:16 small-business computer; console plus two terminals. Expandable to 12 users, 20-megabyte hard disk, 512K (also expandable), new June 1983, moderate use: $15,000. Epson MX-100 dot-matrix printer: $500. D. F. S., POB 9687, Colorado Springs, CO 80909, (303) 471-4633.

FOR SALE: Hazeltine 1500 terminal, 80 by 24 lines, upper/lowercase, well-designed keyboard, dust cover, excellent condition: $250 or best offer. Christopher Pettus, 10920 Palms Blvd. #110, Los Angeles, CA 90034, (213) 202-8925. ■

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