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the small systems journal

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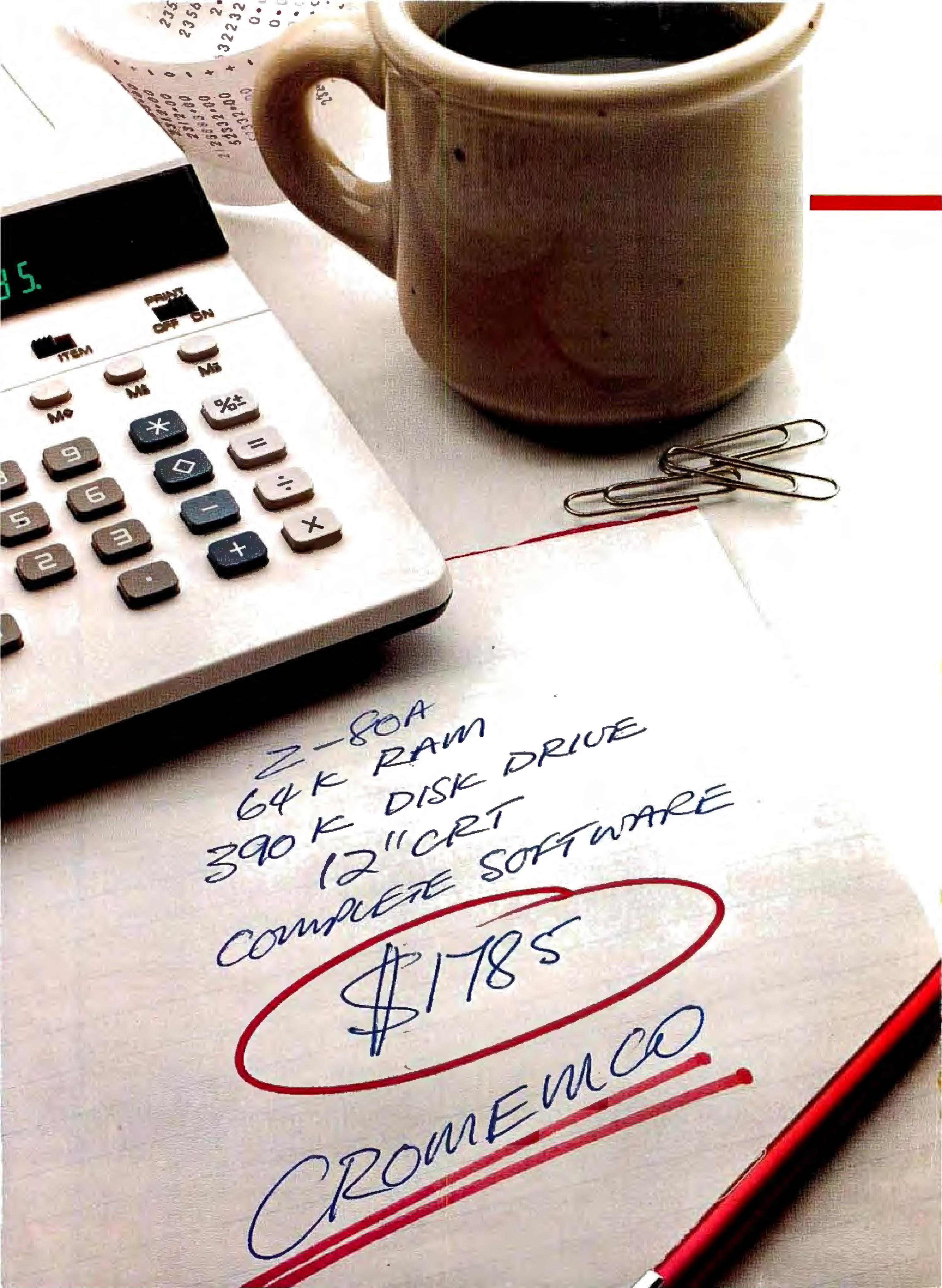
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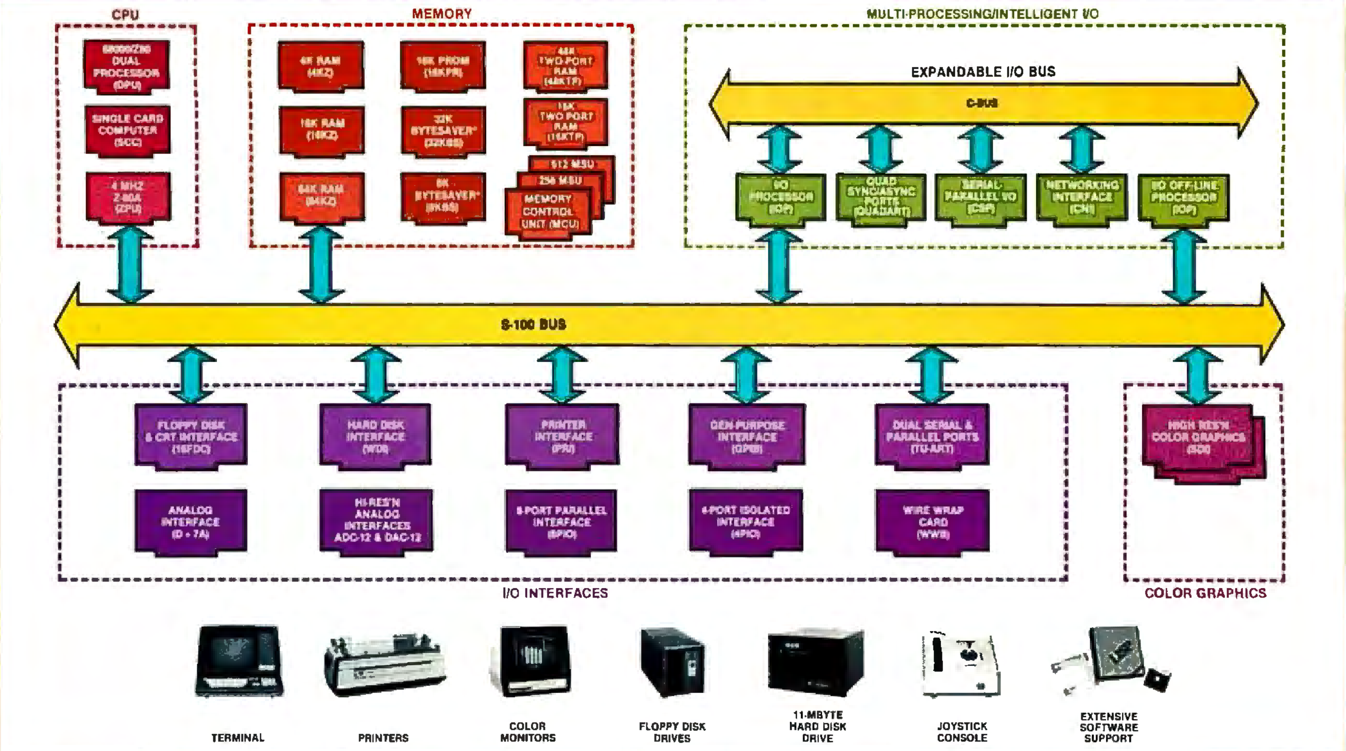


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# In The Queue

BYTE Volume 8, Number 3 March 1983

## Features

**26 Build the ECM-103, an Originate/Answer Modem** by Steve Ciarcia / The Texas Instruments TMS99532 forms the heart of a Bell-103-compatible modem.

**34 The Enhanced VIC-20, Part 2: Adding a 3K-Byte Memory Board** by Joel Swank / Supplement the VIC-20's standard 5K bytes of RAM and eliminate those annoying "out-of-memory" messages.

**44 A User's View of COMDEX** by Jerry Pournelle / An impressionistic report of one of the largest gatherings of computer dealers and manufacturers.

**56 The Promise of Perpendicular Magnetic Recording** by Clark E. Johnson Jr. / As the Japanese seem to have realized already, PMR represents the next level of recording technology.

**68 New Developments in Floppy Disks** by Tom Moran / New advances in floppy-disk-drive technology spurs intense competition.

**86 Optical-Memory Media** by Edward Rothchild / Some background on how optical disks work, who makes them, and how much data they can hold.

**110 Will Removable Hard Disks Replace the Floppy?** by Larry Sarisky / Improved data-storage technologies may eventually eliminate floppy disks.

**122 The Winchester Odyssey, From Manufacturer to User** by Jim Toreson / A look at drives, OEMs, and the cost of doing business.

**130 Building a Hard-Disk Interface for an S-100 Bus System, Part 1: Introduction** by Andrew C. Cruce and Scott A. Alexander / The first in a series of articles on interfacing a Winchester disk drive to an S-100 bus CP/M microcomputer.

**152 NAPLPS: A New Standard for Text and Graphics, Part 2: Basic Features** by Jim Fleming / How to encode text and simple graphics elements in a standard and efficient manner.

**218 User's Column: Sage in Bloom, Zeke II, CBIOS Traps, Language Debate Continues** by Jerry Pournelle / The consummate computer user tackles his new writing machine.

**262 A Faster Binary Search** by Dr. L. E. Larson / An important technique results in faster-running applications programs and shorter response times.

**295 Data Collection with a Microcomputer** by Dr. Mahlon G. Kelly / Using a TRS-80 Model I for environmental research saves time and money.

**310 Build This Memory, Part 1: How to Construct a Low-Cost Memory with 4116 Memory Devices** by Cameron Spitzer / Take advantage of the low price of the 4116-type memory.

**331 A Peek into the IBM PC** by Tim Field / An assembly-language program enables an Epson printer to display all 256 characters used by the IBM PC.

**389 Keywords in a Fuzzy Context** by Thomas A. Smith / CBASIC programs for bibliographic search tell you the degree to which various articles meet your requirements.

**418 ROTERP: An Interpretive Language for Robot Control** by Gary Liming / High-level languages may help bridge the gap between artificial intelligence and the home experimenter's robot.

**436 Using SOUND Arguments for High-Precision RTTY** by Scott Persson / How to generate radioteletype audio frequencies from an Atari 800.

**453 Binary-Format Number Storage on the Apple II Disk** by David Eyes / A machine-language routine to read and write binary data to a text file.

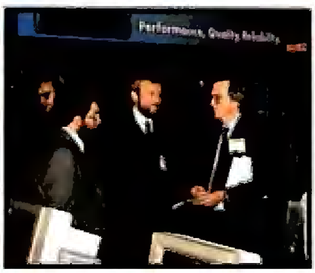
## Reviews

**190** MP/M II by Stephen Schmitt
**247, 248, 251** BYTE Game Grid: Project Nebula by Keith Carlson; **Legionnaire** by Gregg Williams; Omega Race for the VIC-20 by Stanley J. Wszola
**256** Quickcode by Adam B. Green
**282** Hayes's Stack Smartmodem by Norman C. McEntire

## Nucleus

**6** Editorial: The Software Revolution: Where Will We Store All Those Programs?
**14** Letters
**22** BYTE's Bugs
**307, 450** Programming Quickies: Add Dimensions to Your BASIC; Computing Telescope Parameters with the OSI Superboard II
**380, 462** System Notes: Circles and Ellipses on the Apple II; Adding a Trace to North Star BASIC
**474** Event Queue
**478, 486** BYTE's Bits
**484** Software Received
**487** Ask BYTE
**490** Books Received
**491** Clubs and Newsletters
**492** BYTELINES
**497** What's New?
**557** Unclassified Ads
**558** BOMB, BOMB Results
**559** Reader Service

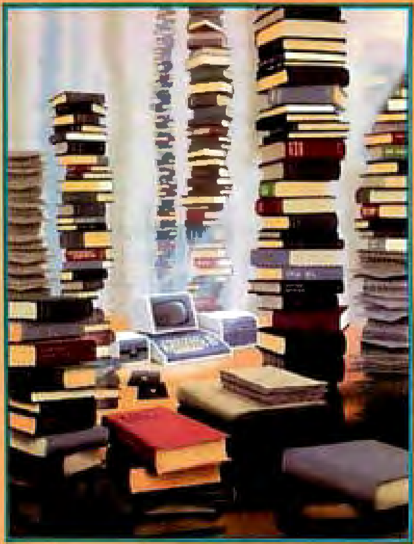
Page 26



Page 44


Page 152

Page 247



# In This Issue

Sophisticated new operating systems and multitasking software promise to alter significantly the way we use personal computers. Because of the large memory requirements of the new software, we're sure to see changes for the better in the nature of external storage devices. New technologies for mass storage will become even more critical as the software revolution continues to escalate. As Robert Tinney's cover suggests, personal computers will need a large quantity of high-speed mass storage to hold all the software and other data that we'll generate. Our theme articles address the latest developments in mass storage. Clark E. Johnson Jr. discusses "The Promise of Perpendicular Magnetic Recording," Tom Moran looks at "New Developments in Floppy Disks," Edward Rothchild writes about "Optical-Memory Media," Larry Sarisky explores the question "Will Removable Hard Disks Replace the Floppy?" Jim Toreson concentrates on "The Winchester Odyssey," and in the first of a three-part series Andrew C. Cruce and Scott A. Alexander discuss "Building a Hard-Disk Interface for an S-100 Bus System." Plus we have part 2 of "NAPLPS, A New Standard for Text and Graphics," the second installment in the VIC-20 series, "Adding a 3K-Byte Memory Board," a review of MP/M II from Digital Research, and BYTE's Game Grid. Steve Ciarcia tells you how to "Build the ECM-103, an Originate/Answer Modem," and more.

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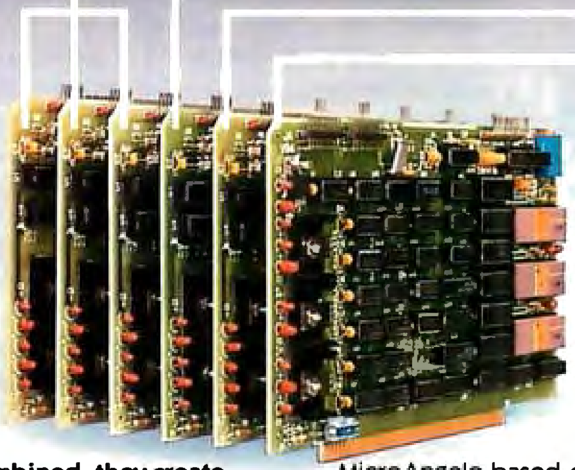

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## Editorial

# The Software Revolution

## Where Will We Store All Those Programs?

*Phil Lemmons, West Coast Editor*

Two advances in hardware—the 16-bit microprocessor with its great memory-addressing range and the 64K-bit dynamic RAM (random-access, read/write memory)—have paved the way for a software revolution. The Lisa software from Apple, and soon the Visi On operating environment from Visicorp and a new generation of software from Microsoft, will transform the way we use computers and the way we think about our jobs. But just as hardware advances made possible a revolution in software, the exciting new software demands an improvement in hardware, specifically, in mass storage. The memory-intensive operating systems and integrated applications programs that are emerging today will make unprecedented demands on the mass storage of personal computers. Not only will personal computers need a lot of mass storage to run the new software effectively, they will also need high-speed mass storage that is faster than today's floppy disks.

You might think that the current low prices of RAM would reduce the need for speed in mass storage. The computer could read the operating system and applications program from floppy disk into RAM once, at the beginning of a session, and thereafter execution would proceed at the lightning speed of RAM itself. But consider how *big* the new operating systems and applications programs will be. Even if new personal computers have 256K bytes of RAM, they will not be able to accommodate at one time both a desktop-manager operating system and more than one sophisticated applications program. The resident portion of Lisa's operating system approaches a quarter of a megabyte, and its sophisticated applications programs are almost as large. Even though Lisa has a half megabyte of RAM as standard equipment, the operating system has to use virtual memory. Virtual memory means treating part of mass storage as if it is part of RAM. Since a major limiting factor in the speed of software that uses virtual memory is the speed of input/output of mass-storage devices, systems like Lisa will require high-speed mass storage for effective operation. Otherwise we will see computer users tapping their feet while waiting for their expensive personal computers to read in the next chunk of beautiful software.


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## Hard Disks for the Masses?

The point of this argument is not to debunk the new software. On the contrary: the revolution in software can extend the power of computing to millions of people as well as making life more enjoyable for current microcomputer users. If the software revolution is to make microcomputing a true mass phenomenon, however, there must first be a reduction in the price of high-speed mass-storage hardware. Lower prices for Winchester hard disks would be an ideal solution. Making hard disks standard equipment on 16-bit computers would help bring down the cost of the disk drive somewhat. And because hard disks operate up to 20 times faster than floppy disks, the delays required to read in software would cease to be a problem. In the office, hard disks will no doubt be the standard answer to the new software's need for high-speed mass storage.

But hard disks are likely to remain too expensive to become standard equipment outside the office. Prices have plunged in the last three years, but hard-disk systems still cost at least $1500. More often the prices are closer to $2500. (See "The Winchester Odyssey," page 122, about why hard disks that cost $600 in quantity at the factory cost much more by the time they're integrated into hard-disk systems.) The mechanics required to rotate the disk at very high speed while the magnetic head floats microns above the disk are not simple and the manufacturing process cannot get much less expensive.

The only remaining area for significant cost savings in hard disks is the controller. Several companies are reducing Winchester controllers to single chips or small chip sets. Western Digital Corporation has a series of Winchester controller boards based on its own LSI (large-scale-integration) chips. The Western Digital WD1001 board cost $245 last year. The WD1002 cost $195 at the end of 1982. The company plans to introduce the WD1003 at $175 this summer, and the WD1004 at $150 in the fall. In other words, Western Digital's advances can squeeze about $100 out of the cost of hard-disk systems by the end of the year.

National Semiconductor will introduce a four-chip Winchester-disk controller this summer. The DP8464 disk pulse detector, the DP8460 MFM data separator, the DP8462 MFM data encoder, and the DP8466 disk data controller together make up a sophisticated, high-performance controller capable of handling multiuser and multitasking operations. Single-user systems will not require the entire chip set; in fact, the National Semiconductor chips needed for a hard-disk controller in a typical personal computer will cost less than $100.

Adaptec, a start-up firm (1625 McCarthy Blvd., Milpitas, CA 95035), also is offering its own Winchester controller chip set and boards based on the chips. Adaptec's products are based on five chips in the ACS-500 series. The complete chip set required for high-performance, multiuser and multitasking systems costs $190 in quantity. The Adaptec product of most interest to personal computer users is the single-chip controller called the Winchester Controller Chip. This chip costs only $75 in large quantities. NEC, too, has announced a single-chip Winchester controller at less than $100.

As with the Western Digital boards, these other LSI controllers will reduce Winchester prices for single-user systems by about $100. That is a significant saving, but even a saving of $200 would probably not induce manufacturers of personal computers to make Winchester disks standard equipment. Replacing one floppy disk with a Winchester disk would add at least $1000 to a computer's list price, and probably more. Manufacturers seem reluctant to raise list prices that much. And yet, keeping the hard disk optional prevents the kind of volume savings that would come with making the hard disk standard equipment. Thus, hard disks remain more expensive than they really have to be and add $1500 to $2500 to system costs.

If hard disks will remain too expensive to host the software revolution in personal computers, where will we put the friendly new operating systems and applications programs?

## Solving a Read-Only Problem

Businesses and individuals who need to write and read large amounts of data at high speed will have no choice but to use hard disks. But we don't need to write and rewrite the new operating systems and applications programs; we only need to read them into RAM time and again every day and to update them on disk every few months. Most people's requirements for writing data are not so great as to require hard disks. Few of us generate enough data each day to overflow an ordinary floppy, much less the new high-capacity floppies (see "New Developments in Floppy Disks," page 68).

Is an inexpensive form of ROM (read-only memory) on the horizon? NEC's new 1-megabit semiconductor ROMs are remarkable bargains at something more than $40 per megabit, but the real requirements of the new operating systems and a set of applications programs may approach a megabyte. That would require more than $320 worth of ROMs. Moreover, software updates and bug-fixes would pose major problems. Software houses, computer manufacturers, and computer dealers could not be expected to swallow the cost of replacing the ROMs. Erasable and reprogrammable ROMs and the equipment needed to program them would be prohibitively expensive.

## The Laser Card from Drexler

Fortunately, a new form of read-only mass storage, the Drexon Laser Card (from Drexler Technology Corp., 2557 Charleston Rd., Mountain View, CA 94043) is just coming to market (see photo 1). The size of a credit card, the Laser Card has a storage capacity of 2 megabytes. With 1 megabit or 125K bytes prerecorded, Laser Cards

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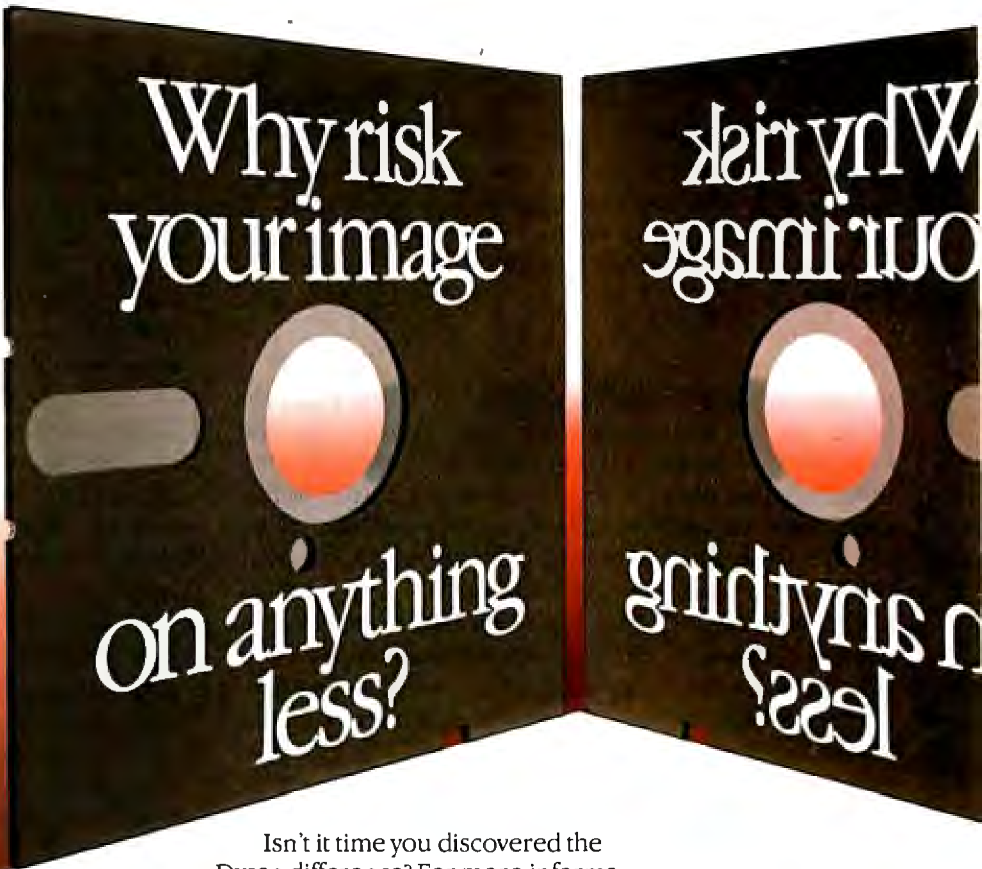



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**Photo 1:** *The Drexon Laser Card. This card can store 2 million bytes of data. The small object resting on the card's recording stripe is the semiconductor diode laser required to write data on the stripe. Either a diode laser or a photodetector array can read the data.*

will cost about $1.50 each; with the full 2 megabytes encoded, the cost will remain less than $6. At that price, the Laser Card will be less expensive to distribute than today's floppy disks. It will not present a barrier to frequent software updates. Indeed, software houses will be able to distribute updates in the same mass mailings that banks use to distribute new credit cards.

The name Laser Card is somewhat frightening because lasers are expensive. But lasers are required only to write data on these cards; an array of inexpensive photodetectors can read the data. In fact, the equipment required to read data from a Laser Card at a rate of 125K bytes per second will cost less than $100. The read rate has no intrinsic limit. To increase the rate to that of hard disks, manufacturers can just add more of the inexpensive photodetectors to the array. The cost of laser writing equipment, estimated at about $500, will not deter computer manufacturers or software houses. For very high-volume high-speed writing operations, such as printing 100,000 Laser Card copies of a piece of software, photolithographic processes will be more economical than lasers.

New peripheral technology usually requires expensive redesign of existing equipment, but the Laser Card seems to escape that problem. The reading equipment is compact and will not require significant changes in the housings of today's personal computers. The most conspicuous sign of the Laser Card's presence, in fact, will be a slot in the side or the front of the computer. The size of the slot is like that found on automatic teller machines.

The Laser Card has another feature that will appeal to software houses and program authors: every vendor can encode optical data at a different level of reflectivity. For this and other reasons, software piracy will be more difficult with Laser Cards than it is with magnetic storage.

One of the features that will appeal most to manufacturers and computer users is that Laser Cards do not wear out as floppy disks do; in fact, Laser Cards show no signs of wear at all. Futhermore, Drexon coatings—the recording material used on the Laser Cards—are resistant to damage from bending and are invulnerable to magnetic hazards. (For more information about the Laser Card and the nature of its recording medium, see "Optical Memory Media," page 86.) The reading equipment itself is expected to require much less maintenance than a floppy-disk drive does.

To encourage use of the Laser Card, Drexler is licensing the technology needed to read and write the cards. For a one-time fee, companies can purchase information on read/write equipment design, gain the use of patents for read/write equipment without paying royalties, and acquire the right to distribute Laser Cards to end users. Toshiba is the first announced licensee. Others may be announced by the cover date of this issue. Drexler intends to be the principal supplier of the cards but will license a second manufacturer. Drexler is now capable of making 100,000 cards per day.

The Laser Card has many possible applications besides the one that now looks most important: serving as the read-only medium for large operating systems and applications programs that comprise the software revolution. Dictionaries and other large reference books could be encoded compactly, especially when the Laser Card's capacity goes up to 10 megabytes, as Drexler expects. The compactness and reliability of the card and the reading equipment also seem to suit the Laser Card ideally for use in portable computers. When computer users leave their home or office, they will not have to leave behind the software to which they're sure to become addicted. With all the software in a Laser Card, the need for read/write/rewrite data storage in the portable computer may be reduced to a single microfloppy disk or bubble-memory cartridge. While Laser Cards will find many uses in the office, they are likely to coexist there with hard disks and floppy disks. The read/write capabilities of magnetic storage will remain indispensable for most business applications.

The coming availability of inexpensive 10-megabyte read-only mass storage, in the form of the Laser Card, will no doubt broaden the application of the microcomputer in ways unforeseen. One of the delights of watching the microcomputer industry is that each round of progress feeds on the next in a combination of synergism and serendipity. Just as 16-bit microprocessors and 64K-bit (8 of these chips make up 64K bytes) RAMs made possible today's software revolution, and the software revolution demands new mass-storage technology and finds the Laser Card ready, so this new mass-storage technology will feed the software revolution. What software will this new technology make possible? What new hardware will that new software demand? Something is bound to turn up. ■

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# Letters

## Misleading Advertising

I read with great interest an advertisement for the AMI II++ Computer, manufactured by Apollo Computer Company of Taiwan and distributed by Oriental Investments Limited of Switzerland (November 1982 BYTE, page 332). The computer is advertised as being "Apple II Plus Compatible" and appears nearly identical in its physical characteristics to the Apple II. The terms of sale for the computer, which is offered at an enormous price reduction over the usual discounted cost of an Apple II, require prepayment by money order or by certified check.

Because of recent articles concerning the potential infringement of copyrights owned by Apple, I contacted the U.S. Customs Service in Washington [(202) 566-5765] to inquire on the legality of importing the AMI II++. I was told that all Apple II "look-alikes," specifically including those manufactured by Apollo Company, will be seized by Customs upon import.

In my opinion your magazine has done a great disservice to your readers in carrying the ad for the AMI II++ Computer. I hope that not many of your readers have responded to this alluring ad and sent in their prepayments only to have their purchased equipment impounded at the border.

**Richard L. Merriam**
**7 Thoreau Rd.**
**Lexington, MA 02173**

*As is true of most publications, BYTE periodically receives complaints from one advertiser (or individual) about the activities of another advertiser. As is also true of all magazines, it is quite impossible for us to act as judge and jury and arbitrate commercial disputes between advertisers. In addition to other problems, the cost of the technical and legal expertise that we would have to hire would put our magazine out of the price range of most of our readers and advertisers alike.*

*Is there nothing, then, that a magazine like BYTE can or should do? Of course there is. Every advertisement from a new advertiser is reviewed both by an editor and a publisher in an attempt to spot problems and potential reader rip-offs before they occur. While this is not foolproof, we are pleased that we have headed off several problems before they found their way into print.*

*The other step we can take is to adhere rigorously to the rulings of government tribunals or agencies, who, after all, are the appropriate ones to respond to disputes between advertisers. Unfortunately, unless the prevailing advertiser or the tribunal itself thinks to inform us of a ruling, there is no automatic way we receive this information. Thus, it was somewhat fortuitous that we received a copy of a Customs Department Newsletter mentioning the importation ban against some Apple II "look-alikes." As soon as we received that notice, the ad in question was removed from all issues not yet printed. . . .* **Gordon R. Williamson**

## Language Flexibility

Jerry Pournelle's exposure of the high priests of computer software is long overdue (see "User's Column," October 1982 BYTE, page 254).

Since the microcomputer revolution began, these high priests have stood by their "cure-all" languages and have had a put-down attitude toward us poor slobs using "nonstructured" code (anything with a GOTO statement). Fact is, it's easier to defend a familiar language than to tread on unfamiliar territory by trying to learn another.

Let's get with it, gang! Every language on the market has its share of strengths and weaknesses. Just as a wood craftsman requires a variety of special tools to do the job right, the professional programmer needs to understand which software "tools" are available to get the job done. There is no "best" programming language, but given any particular problem, there are several languages that will do the job quite well.

The software engineer needs to be able to select which language is suitable for the task at hand. That might involve breaking down a project into modules written in BASIC, FORTRAN, COBOL, and assembly language to capitalize on the strong points of each language. I admire Digital Research, Microsoft, and others for taking steps in this direction to allow the programmer to "link" modules written in different languages into a single program.

The hardware side of the computer revolution is leaps and bounds ahead of, and being held back by, the software development side. It's high time that we move software development from the mystical black art of the '60s into the rapidly changing environment of the '80s. The high priest stuck holding onto ALGOL/Pascal/FORTRAN/whatever as the cure-all language will be much like the electrical engineer of the '50s left holding a vacuum tube.

**Robert S. Walden, President**
**XL Computer Products**
**POB 805**
**Mesa, AZ 85202**

## Almost a Tinkerer's Dream

I just had to write and compliment you on the November 1982 BYTE. I am an electrical engineer and a hardware hacker from way back, and I was about ready to let my subscription to BYTE lapse. While hardware hackers are a dying breed, I had begun to think that we were entirely forgotten. I realize that there aren't many left, but there are probably more of us than there are disabled microcomputer users (see the September 1982 BYTE on "Computers and the Disabled") or artist microcomputer users (July 1982 BYTE, "Computers in the Arts and Sciences") or even microcomputer users that program in Logo (August 1982 BYTE, "Logo"). While these are probably worthy causes to devote an issue of BYTE to, it seemed that the tinkerers were entirely left out. And then came the November 1982 issue. While not quite a tinkerer's dream, it is in the general direction of one. Steve Ciarcia's "Build the Circuit Cellar MPX-16 Computer System, Part 2" (page 78), Phil Lemmons's informative article "Victor Victorious: The Victor 9000 Computer" (page 216), a vector-graphics construction article (Billy Garrett's "Microvec: The Other Type of Video Display," page 508), and even Phil Lemmons's "An Interview with Chuck Peddle" (page 256) were all interesting. No long, boring articles about why this DBMS (database management system) is better than that (for a *home* computer?), no articles on a language that needs five full-time programmers and a mainframe computer to maintain it, and no one telling me to rush right out and plunk down $4000 for the latest do-every-thing-but-change-the-baby gizmo.

While I am not advising that you change the editorial direction of BYTE, I

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am glad to see some articles of interest to people other than full-time data processing managers or game addicts. And besides, the November issue did not have one mention (that I could find) that "the uses of a computer are limited only by your imagination." If I ever see that trite, overworked, meaningless phrase in print again, I think that I will go into a homicidal rage.

Oh yes, tell Jerry Pournelle that I enjoy his "User's Column." And his books are okay, too.

Stuart Ball
1101 Dover St. NE
Cedar Rapids, IA 52402

## For the Record

In the November 1982 BYTE, an erroneous reference was made in Peter Sørensen's article "Tronic Imagery" (page 48).

On page 56 (in the paragraph continuing from page 55), Michael Fremer, music and sound design supervisor for *Tron*, was referred to as the sound effects creator.

As the actual sound effects creator for *Tron*, I would like this point clarified.

Frank Serafine
Serafine FX
1861 South Bundy Dr.
West Los Angeles, CA 90025

## What Did He Say?

BYTE magazine is used by a cross-section of people representing many different levels of involvement with the applications of computers. To serve and to maintain its readership, the magazine offers access to knowledge and access to tools.

While access to knowledge is also catered to by the book market, access to tools is provided almost exclusively by periodical publications of this type, some with self-serving and others with public-serving interests. In this context, the word tool can be taken in its global meaning of "what is instrumental in the realization of something."

The more useful BYTE magazine becomes at providing both types of access, the more likely it is to become itself a tool and be used as such by its readers. Of all needs presented to the editors of the magazine by the readers, the key demand will always be for more usefulness, hence for more useful access. End of loop.

The editor's job: define "access."

The reader's job: define "useful."

I am right now working on my own list of wishes. Readers, to your pens!

Laurent Dube
Green Island
POB 3670
Prince Rupert, British Columbia
Canada V8J 3W8

## The Myth of Computer Literacy

Yes, computer literacy is really a myth. There is no such thing. Many articles have been written decrying the lack of computer literacy in our society. Thousands of books and junior college courses have been devoted to this subject, but it really doesn't exist. Why not? Because computers are not literate. In fact, computer operators need not be literate either (although knowing how to read is advantageous).

Like telephones, computers are machines and are quite easy to operate. You just turn them on and follow the instructions as they appear on the screen. You don't hear about telephone literacy. Computers are the same thing. No problem.

A properly functioning computer with user-friendly software is a pleasure. Where we get into trouble is when we have software or hardware that malfunctions. Just like the early telephones, which had a lot of hardware and software problems, computers (still in their evolutionary infancy) have often given us interesting moments. As time goes on, this will straighten out and become a rare annoyance, as is now the case with the telephone.

So why all the baloney about computer literacy? It is due to the desire of our news and education industries to increase their power. The news media tell us we are dumb, stupid, and will fall behind or lose a job if we are computer illiterate. This makes many people nervous and they buy more books, papers, and magazines in an effort to catch up. Educational institutions, suffering from the exit of all those baby-boom people, need more bodies to maintain income and justify their share of tax revenues.

Certainly we need programmers and systems analysts who must be well trained in computer technology, just as all telephone repairmen and installers must be trained for their trade. But for the rest of us consumers, all we do is turn the computer on and use it, just like the telephone, and that requires very little "literacy."

What we really need is to be digital-watch literate. I have a 45-function, $29 wrist watch with 4 buttons and I cannot make it stop beeping. . . .

E. J. Neiburger DDS
Dental Computer Newsletter
1000 North Ave.
Waukegan, IL 60085

## An Ounce of Preventive Maintenance

We second Mr. Brady's motion (November 1982 BYTE, "Letters," page 19) requesting more BYTE articles concerning maintenance and repair.

Computers may sometimes be astonishing in their capabilities but they're still machines, and machines break—some more frequently than others and some more mysteriously.

Of course, thorough and regular maintenance can help cut down on the number of breakdowns, but when the machine does go on the blink there's no reason why it can't be up and running quickly. To ensure a minimum of downtime, every computer owner should establish a relationship with a reliable and efficient maintenance organization before any repairs are needed.

In the world of microcomputers, the most likely and most reliable source of service is the computer distributor or dealer. In short, the person you buy it from. It is naive to expect prompt service from hardware makers. They are in the business of manufacturing, not servicing, microcomputers.

So it behooves the microcomputer buyer to compare service capabilities as well as prices when shopping for a system. In fact, service should be a more crucial factor than price in the decision because the few dollars saved by buying from a mail-order house with no maintenance service will cost you dearly as time goes by and equipment fails.

In order to evaluate the maintenance capabilities of computer dealers and to make sure you'll get prompt service if and when you need it, make sure they meet the following criteria.

**Proximity:** Common sense tells you that you'll get better service from a company close by than one far away. Also keep in mind that shipping charges are usually the responsibility of the customer.

**Longevity:** We've been living in the age of computers long enough that you needn't deal with a company that doesn't have a substantial track record. (For instance, Tristar has been in business over 10 years.) Unless there's something very special about the company, don't deal with a brand-new business. The computer industry has seen too many casualties, and one thing you want is a company that will be around tomorrow.

**Legitimacy:** It's easy to get into the computer business today. Deal with a *real* business, not an answering service. Ask for references.

**Adequate stock of replacement parts:** Ask if the company has an inventory of replacement parts. Having the necessary parts on hand can mean the difference between hours and weeks of downtime.

**Tools and space for in-house repair:** In order to provide good maintenance, adequate money must be allotted for a repair shop and sophisticated tools. Make sure that your dealer has done so.

**Trained people:** Any reputable manufacturer runs training sessions to teach people how to repair their equipment. Make sure one of your dealer's employees has gone to that school.

Computer downtime means money and inconvenience and sometimes even hardship for anyone whose computer operations are essential. For those reasons, all computer owners should be well versed in their equipment's proper care and feeding and should have a top-notch maintenance organization on call to fix things if they start going bad.

Pete Morley
Tristar Data Systems
Cherry Hill Industrial Center
2 Keystone Ave.
Cherry Hill, NJ 08003



## Victor Club

Phil Lemmons's article "Victor Victorious: The Victor 9000 Computer" (November 1982 BYTE, page 216) was indeed impressive.

The Andrews Group is heavily involved in the development end of CAD/CAM (computer-aided design/computer-aided management) software for the Victor 9000 coupled with Houston Instrument plotters and digitizers.

Over the last six months of development work we have had tremendous support from the Victor Software Group in Chicago. We feel at this point, however, there should be some central point for information exchange for the Victor.

To this end we have set up the Victor User's Club and for the present time we will use the offices of the Andrews Group and its facilities.

The club will be for the free exchange of information and will publish a monthly newsletter pertaining to new developments and software ideas. The yearly fee is $35, which will cover publishing and mailing expenses.

Mark W. Andrews
The Andrews Group
310 SW 2nd St.
Fort Lauderdale, FL 33312





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|---|---|
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| List Price | $7495.00 |

| ALTOS™ ACS 8000-10 | |
|---|---|
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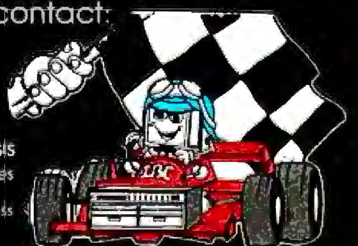

## The Real Bottleneck

I take exception to a term which I fear is becoming widely accepted. I have recently seen it in BYTE and other publications. This term is *Von Neumann bottleneck*.

The term is used because the concept of the stored program computer as we know it today is largely due to the work of John Von Neumann (1903-1957) in the early '40s and because in this concept instructions are fetched and executed in a strictly linear fashion.

I disagree with the popular use of the phrase for several reasons. First, in his innovative work this genius broke the bottleneck of the day, which was the common narrowmindedness that thought of computers in terms of single-use or hard-to-modify dedicated systems.

Second, the term contains the pejorative connotation that if it were not for Von Neumann this bottleneck would not exist today. It certainly would because it is related to hardware technology more than to anything else.

Third, if Von Neumann had lived longer, the state of computer theory would most likely be far more advanced than it is. Doubtless his theoretical contributions would have gone well beyond the advances in hardware that we have seen over the years, particularly in regard to the capability of true multi- and parallel-processing. So if there is a Von Neumann bottleneck, it is in the loss that the world of mathematics and computers suffered in his early death.

The contributions Von Neumann made to mathematics are well known, from the founding of the theory of games, with its wide-reaching applications in areas like weather research and economics, to his work in set theory and theoretical physics and his work in the logical design of electronic computers and a general theory of automata. These contributions, along with the many anecdotes still told today about the intellectual powers of the man, attest to his true genius in many areas of mathematics and computing theory. I strongly protest the use of the term I have been discussing—it is a manifest injustice to connect the name Von Neumann with this pseudo-problem.

In a constructive vein, may I make two suggestions. First, that this phenomenon be more aptly named. Terms like *uniprocessing bottleneck*, *linear-processng bottleneck* or *sequential-processing bottleneck* come to mind, but I will not presume to coin the definitive phrase here.

Second, may I suggest the following definition of the term *Von Neumann bottleneck*: the fact that more than 95 percent of all people have less than 5 percent of the ability of John Von Neumann.

**Philip Mahler**
**Instructor of Mathematics**
**Middlesex Community College**
**Springs Rd.**
**Bedford, MA 01730**

## The Meaning of Oppression

Just to set the record straight: I am the source of the "RESIST THE DRAFT" message that Dr. Kallend discovered assembled into Apple Logo (see the December 1982 BYTE "Letters" column, page 18). Neither Apple Computer Inc. (which dis-

tributes the product) nor Logo Computer Systems (which manufactures it) knew of its inclusion.

Dr. Kallend sees "an early start on 1984" in the dissemination of the message (which he regards as subversive) "into so many of our schools." This view is astonishingly upside down. In the nightmare world of George Orwell's novel *1984*, the expression of "subversive" ideas was all but wiped out; thus was obedience to government authority assured. It's hard to imagine a clearer antithesis to the type of oppression depicted in *1984* than encouraging defiance of the draft, in schools and elsewhere. Dr. Kallend seems to be telling us that resistance is oppression.

**Gary L. Drescher**
**NE43-743**
**Massachusetts Institute of Technology**
**Cambridge, MA 02139**

## A Language Is Born

November 1982 saw continued discussion of the QWERTY versus Dvorak keyboards in the "Letters" section of BYTE (page 16). I am a touch-typist, and although I did not relish the prospect of learning to type all over again, the benefits from Dvorak's "simpler keyboard" intrigued me.

As with many microcomputers, the keyboard on my Osborne is not redefinable. This meant that I couldn't implement Dvorak's layout without first replacing my ROM. However, I found a solution: rather than redefining the keyboard into Dvorak's structure, I chose to redefine the alphabet. If the word to be typed is "letter" I mentally encode it and type the "Dvorak-English" word "pokkdo." "Dear Sir" becomes "Hdao :so" and "Having a wonderful time." equates to the seemingly nonsensical "Ja.gly a ,slhdotfp kgmdq."

I find that I have sufficient time to think of (or read) what I wish to type, convert its spelling into Dvorak-English, and still retain the speed of a true Dvorak keyboard. The one problem, that other people cannot read my text until it is decrypted, does not significantly subtract from the value I have gained. However, it is my intention to seek the removal of even this irritation. Dvorak-English as a second language, perhaps taught alongside French and Spanish in public schools, would do the trick.

**Chris Rudek**
**5975 Newman Court, #4**
**Sacramento, CA 95819**

## Warranty Pirates

I thoroughly enjoy Jerry Pournelle's articles and find them informative and entertaining. However, I would like to take a good-natured poke at one of his commentaries in the November 1982 BYTE "User's Column" (page 394) regarding the warranty and license information included with the Soft-Link evaluation copy of Colortrol that Mr. Pournelle considered reviewing.

If Mr. Pournelle will reread the warranty and license information that he signed when he began running CP/M on his system, he will find that Soft-Link, as many other software vendors have done, has merely used wording similar to that used by Digital Research. These vendors apparently feel there's no point in arguing with success. Digital Research has a successful software package, has not been sued out of business, and has successfully sued against pirates, while other software companies have difficulty coming up with anything else as simple and as protective. In other words, most software houses have "pirated" Digital Research's warranty and license format, probably for good reason, and Soft-Link shouldn't be taken to task for doing the same.

Actually, most software houses are willing to be less restrictive in practice, but with suits being brought for almost any reason, valid and otherwise, and with such suits being expensive to defend, with little or no compensation for the winning defense, software houses will probably continue to use similar wording in warranties and licenses, if for no other reason than to avoid attorney fees rather than responsibility.

**R. David Otten, Owner/President**
**Signature Software Systems Inc.**
**5602 Stouder Place NW**
**Pickerington, OH 43147** ■

# BYTE's Bugs

## MARC This Correction

In the textbox on the MARC operating system that accompanied Christopher O. Kern's article "Microshell and Unica: Unix-Style Enhancements for CP/M," an incorrect telephone number was listed for Vortex Technology. (See the December 1982 BYTE, page 206.) The correct number is (213) 645-7200.■

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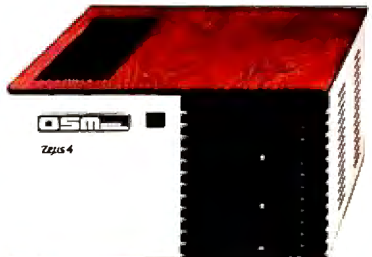


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# MICROBUFFER FREES COMPUTERS.

Circle 350 on inquiry card.

# Build the ECM-103, an Originate/Answer Modem

*The Texas Instruments TMS99532 component forms the heart of a Bell-103-compatible modem.*

Steve Ciarcia
POB 582
Glastonbury, CT 06033

Back in the August 1980 BYTE, I presented an article on how to build an originate-only modem for under $50 (see reference 2). It must have been the right project at the right time; I know that several thousand of you ordered the kit version. Since then, however, technology has advanced. The degree of functionality that took about a hundred components and a fair amount of construction complexity in 1980 can now be obtained with less effort and can offer even better performance. The limited originate-only design from 2½ years ago may not be adequate for all applications. I believe a new design is warranted.

This month's project is the construction of a reliable and versatile 300-bps (bit-per-second) data-communication device called the Circuit Cellar ECM-103 modem (see photo 1). It requires no calibration or critical adjustments, uses only 30 components, and operates in both originate and answer modes. I think you'll be intrigued with its simplicity.



Let's begin with a quick review of modems and data-communication techniques.

## What Is a Modem?

The word *modem* is a contraction of the two words *modulator* and *demodulator*. The modem converts digital signals from the computer into analog signals, which can be transmitted via a telephone line. Various techniques can be employed in this conversion.

Modems are generally categorized by the speed at which they transmit data. The data-transmission rates are properly expressed in bits per second (bps), although you often hear the term *baud* used. Strictly speaking, "baud" measures the number of transitions in state of the communication link, rather than the amount of data represented by these transitions. A single change of state may in some cases represent multiple data bits, and therefore the data rate may not equal the baud rate. The difference can be important.

Modems are commonly divided into four categories, based on their speed of transmission. The low-speed modems are those operating at speeds from 0 to 600 bps. The medium-speed modems operate from 1200 to 2400 bps. From about 3600 bps to around 16,000 bps are a group of modems generally called high-speed, but still higher in speed are the wide-band modems, which work at speeds from 19,200 bps on up.

The higher the data rate, the greater the price of the modem. Most low-speed (300-bps) modems are generally under $200, while most 1200-bps units are in the $700 to $1000 range. Low- and medium-speed modems generally use voice-grade telephone lines, but the higher-speed units require dedicated communication-grade lines. And as the speed of data communication increases, the techniques required to ensure error-free reception become, by necessity, more sophisticated.

## How Modems Work

The process of translating digital information into a form that can be sent through telephone lines is called *modulation*. Current practices include several techniques.

Low-speed modems generally employ a technique called *frequency-shift keying* (FSK), which uses two distinct

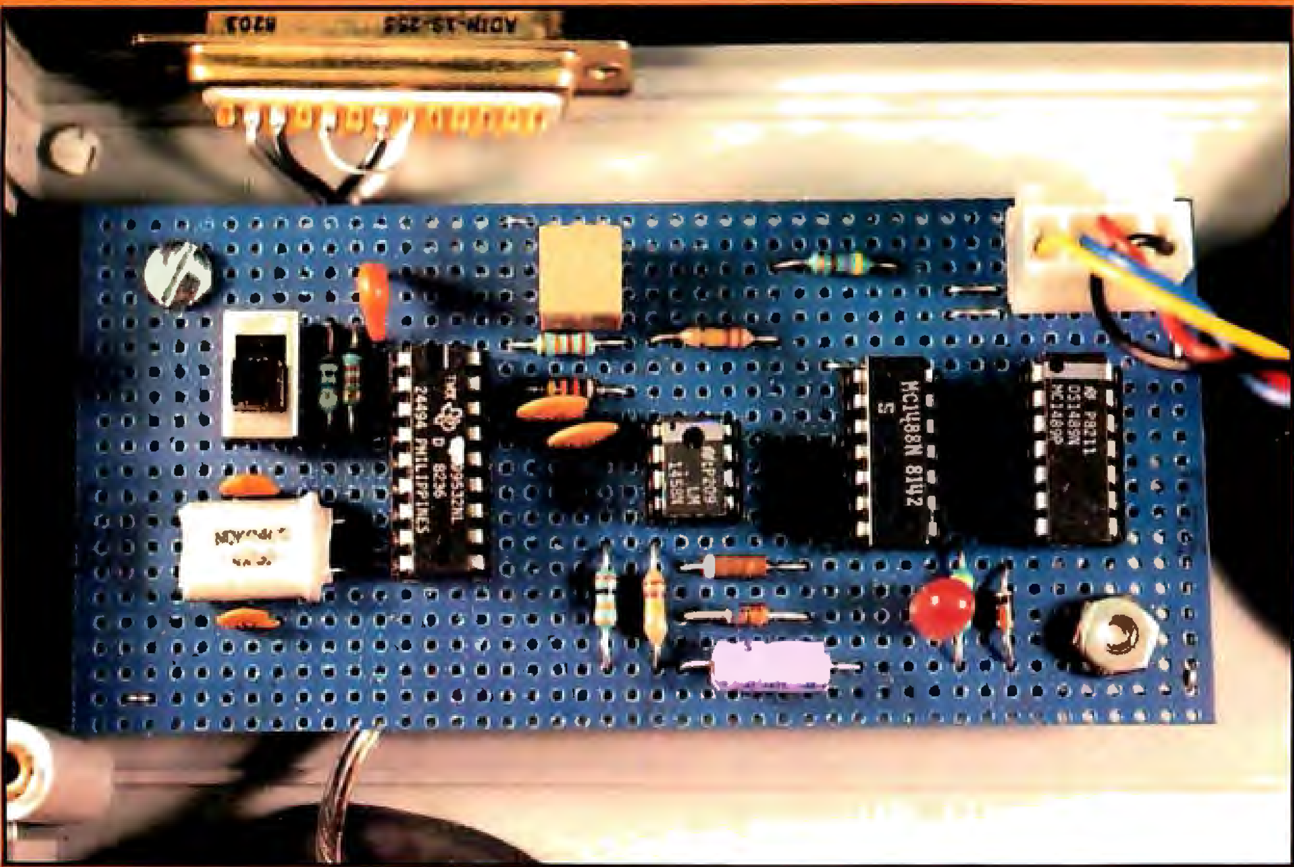

**Photo 1:** *Prototype of the Circuit Cellar ECM-103 300-bps modem. The TMS99532 is the chip on the left next to the crystal. The circuit can be directly attached to the telephone lines through a DAA or acoustically coupled through the coupler shown in photo 3.*

tones of different frequency to represent logic 1 and 0. Data is sent by the modem's alternately transmitting the two frequencies (i.e., shifting the frequency of its transmitted carrier tone). The amount of information that can be sent using FSK in a given interval of time is limited by the frequency bandwidth of the telephone line: a transmitted data bit must consist of at least the number of cycles of a 1 or 0 tone required for the receiver to recognize it, and the number of cycles of the transmitted tone taking place in a time interval is the same thing as its frequency. The frequencies used cannot exceed the capability of the line.

Higher-speed modems use more complex and sophisticated transmission techniques, all of which to some extent modulate not only the frequencies of the tones but their phase, and possibly amplitude, as well. These *phase-shift keying* (PSK) methods permit more compact data encoding, with more information transmitted in less time, by making a single change in the state of the physical communication link communicate more than one data bit. (In such a technique, the data rate differs from the baud rate; see reference 1.)

The most popular variation of PSK is called *quadrature amplitude modulation*, or QAM. Widely used in 1200-bps modems, QAM employs both amplitude and phase modulation to encode 2 bits of data in every state transition (see reference 4).

The chief drawback of any PSK technique is the sophistication required in the decoding mechanism of the receiving modem, which must sort out the information-bearing phase and amplitude variations in the received signal from the meaningless phase and amplitude distortions induced in the signal by the communication link.

Because this article is about building a low-speed modem, I'll save the discussion of these more sophisticated encoding techniques for a more appropriate time in the future.

## How an FSK Modem Works

In computer communication via modems, one of the two modems involved is called the *originating* modem because the communication link is established beginning with it. The other modem is called the *answering* modem. In the archetypal case, the originating modem is associated with a video-display terminal, and the answering modem is connected to a remote host computer.

In frequency-shift-keyed communication, a modem is said to operate in either originate or answer mode. Each of these modes has its own unique set

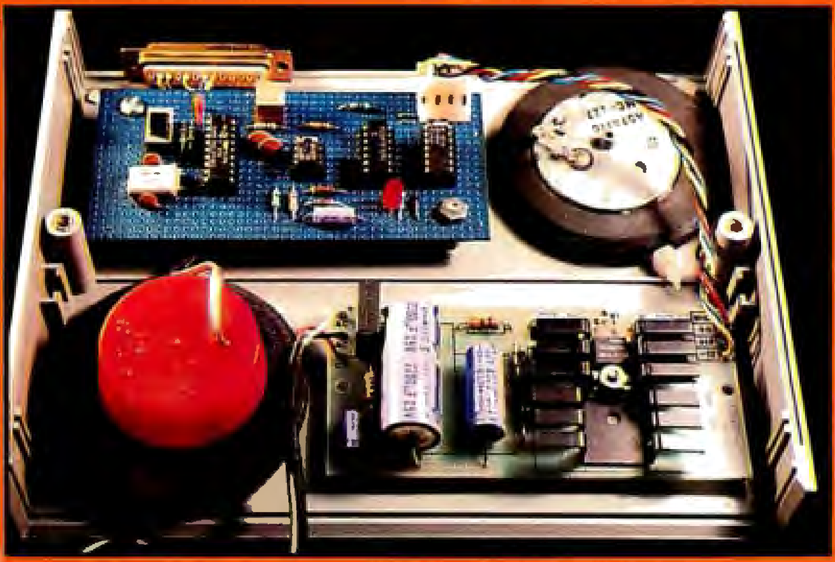

**Photo 2:** *Inside view of prototype modem. Box contains modem circuit (upper left), coupler, and power supply (lower right).*

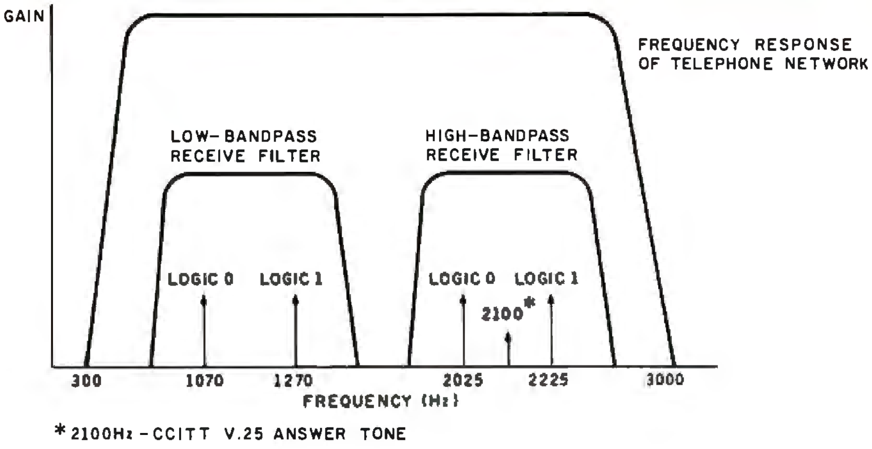


**Figure 1:** *Frequency spectrum used by low-speed Bell-103-compatible modems for data communication over voice-grade telephone lines. For full-duplex operation, two distinct passbands are used, one for data passing in each direction. The modulation technique used is phase-continuous frequency-shift keying.*

of tone frequencies to indicate 1 and 0. (From the previous discussion of FSK, you will recall that the transmission of one tone at a given frequency signifies a logic 1 and that a tone at a certain other frequency signifies a logic 0.) Use of two sets of tones allows *full-duplex* communication, in which information moves in both directions at once over a single pair of wires.

The modem operating in originate mode transmits using the originate set of tones (1070 Hz for a 0 and 1270 Hz for a 1). The modem operating in answer mode transmits using the answer tones (2025 Hz for a 0 and 2225 Hz for a 1). In receiving, each modem listens for the tones being used by the other modem. The logic-1 frequency is sometimes called the *mark* tone, and the logic-0 frequency is then called the *space* tone. Figure 1 shows the telephone-line passband and the relationship of the two sets of tones.

Almost universally, if you are dialing a large computer network, your terminal is considered the originating terminal, and therefore your modem need only operate in originate mode. A modem that can do only this is called an "originate-only" modem. If you wish your equipment to be able to answer calls from an originate-mode modem, you need a modem capable of operating in answer mode.

If the other party is willing and able to establish the link but still use answer frequencies, you could receive calls on an originate-only modem. (The choice of which modem uses which mode is arbitrary as long as they don't both try to use the same

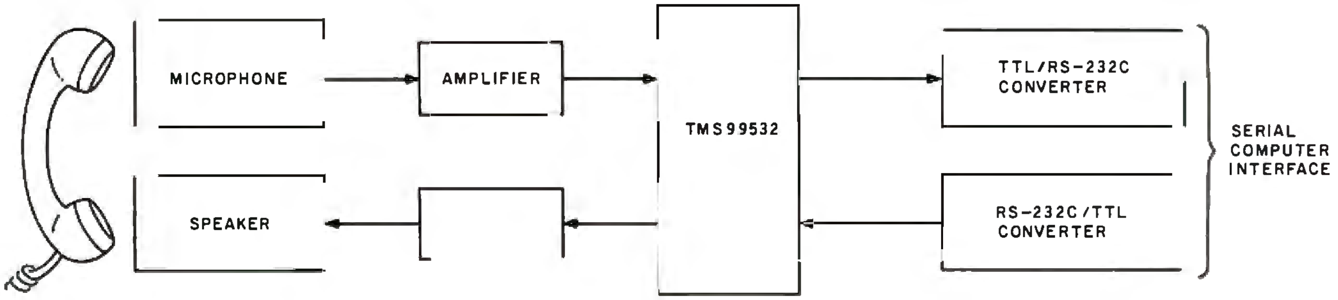


**Figure 2:** *Block diagram of the Circuit Cellar ECM-103 modem, which is designed around the Texas Instruments TMS99532 integrated circuit.*

mode.) So owning an originate-only modem doesn't put you at a major disadvantage, but a unit that can operate in both modes, an *originate/answer modem*, is more flexible. The ECM-103 presented for construction here is such an originate/answer modem.

## Design of the ECM-103

The Circuit Cellar ECM-103 300-bps modem is built around the Texas Instruments TMS99532 FSK modem chip, which allows the modem to achieve a new plateau of elegance and reliability. The ECM-103 uses significantly fewer components than most modems presently available and is simple enough for the casual hobbyist to assemble (see photo 2). I've arranged for The Micromint to produce a kit for building the ECM-103.

Completely crystal-controlled, the ECM-103 requires no calibration or adjustments. Although designed for acoustical coupling to a telephone handset, the modem also lends itself to direct telephone-line connection through an FCC- (Federal Communications Commission-) registered protective circuit, a so-called DAA (data-access arrangement). A 600-ohm matching transformer for connection to the DAA is available in the parts list. The ECM-103 is connected to its associated computer or video terminal (its data-terminal equipment) through an RS-232C-compatible interface.

Figure 2 is a block diagram of the ECM-103. The distinctive modem functions are all contained in the TMS99532; the other parts of the circuit serve to interface the TMS99532 to either the acoustic coupler or the computer.

Figure 3 is the schematic diagram of the ECM-103. The four integrated circuits in the modem work as follows. IC1 is the TMS99532. Component IC2 (an MC1458) is a dual operational amplifier (op amp). One half of it amplifies the signals received from the microphone next to the handset's earpiece, while the other half amplifies the FSK output from the TMS99532 to drive a speaker under the telephone mouthpiece. IC3 (an MC1488) and IC4 (an MC1489) serve chiefly as level-shifters to convert the digital circuitry's TTL (transistor-transistor logic) voltages to the ±12-V (volt) levels required for RS-232C communication. One section of IC3 is used to drive the carrier-detect LED (light-emitting diode). Switch SW1 selects the answer or originate operating mode.

| Number | Type | +5 V | GND | −12 V | +12 V | −5 V |
|---|---|---|---|---|---|---|
| IC1 | TMS99532 | 5 | 18 | | 14 | 11 |
| IC2 | MC1458 | | | 4 | 8 | |
| IC3 | MC1488 | 14 | 7 | | | |
| IC4 | MC1489 | | 7 | 1 | 14 | |

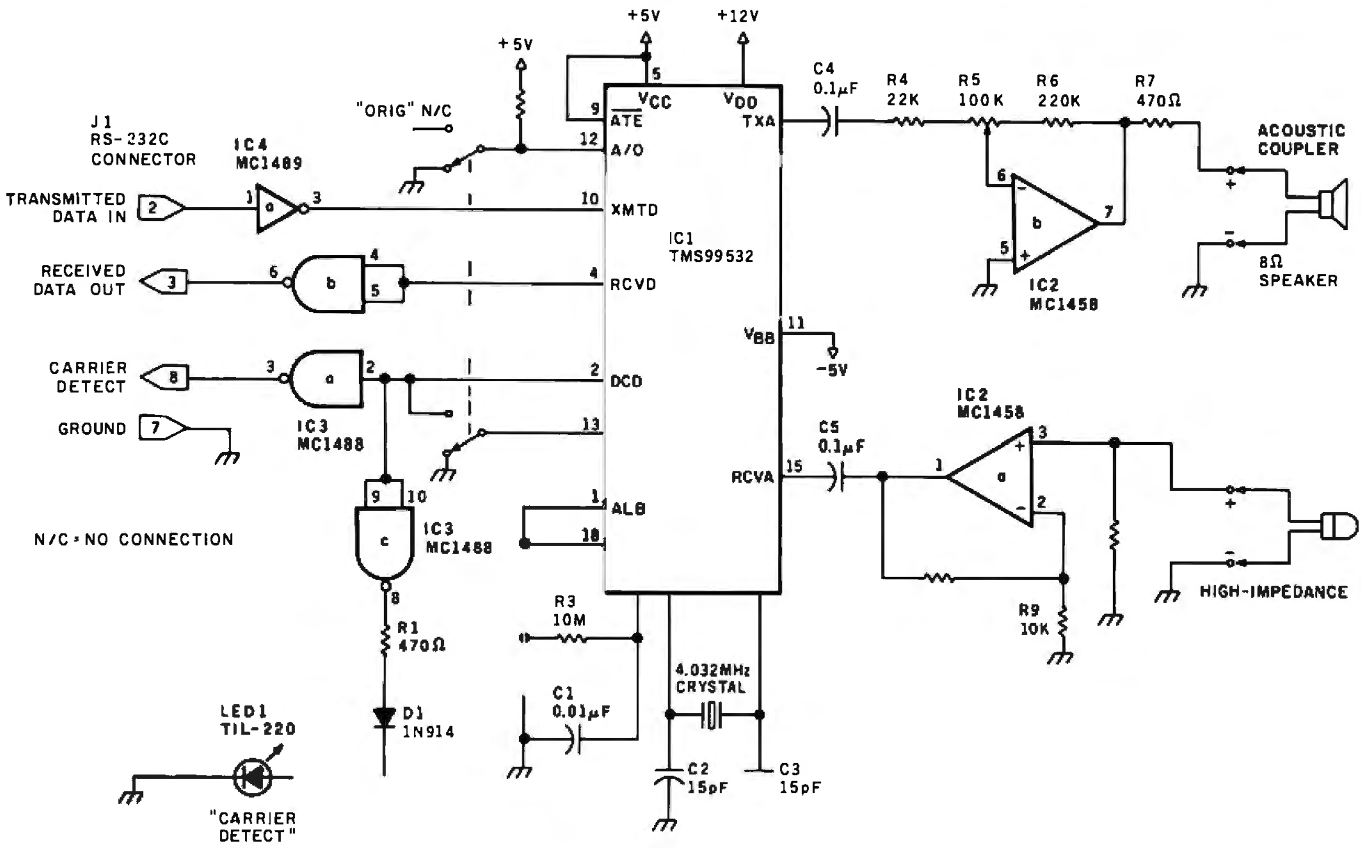


**Figure 3:** *Schematic diagram of the ECM-103. Four voltages are required to power the unit; no power-supply components are shown in this figure.*

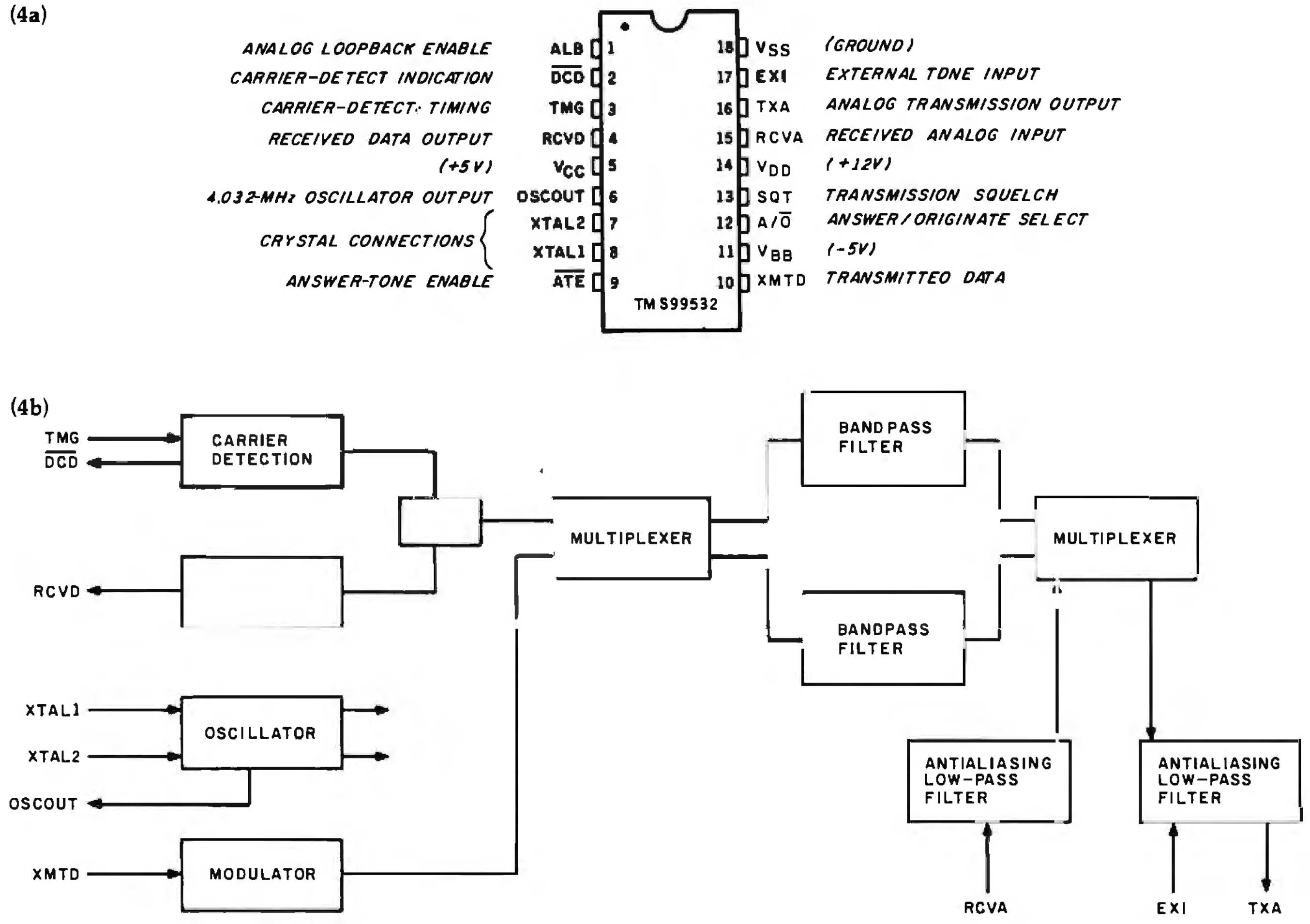


**Figure 4:** *Pinout specification (a) and functional block diagram (b) of the TMS99532 modem chip.*

Not shown in the schematic is the four-voltage power supply. The TMS99532 requires three voltages: +5 V, −5 V, and +12 V, while an additional −12-V supply is required by the MC1458 and MC1488. An external three-voltage power supply can be used if an onboard voltage converter (−12 V to −5 V) is installed in the modem. (This approach was taken in the kit version, which requires the input of only +5 V, +12 V, and −12 V for operation.)

Figure 4 shows a pinout specification and block diagram of the TMS99532 modem chip. The LSI (large-scale integration) NMOS (negative-channel metal-oxide semiconductor) technology of the TMS99532 enables it to contain all the necessary modulation, demodulation, and filtering circuitry required to form the heart of a modem. Its use eliminates many standard discrete components, reducing the size and increasing the reliability of modem designs.

The transmit FSK-modulator section is *phase-continuous*, that is, the phase of the transmitted signal remains constant during a frequency shift. The mark (logic 1) and space (logic 0) frequencies are derived from the clock circuit. Whether the answer or originate frequencies are transmitted is determined by the logic level on the A/$\overline{O}$ select line (pin 12). The frequency shifting of the output is controlled by the data arriving through the XMTD line (pin 10). The modulator's output, bandpass-filtered to eliminate noise, makes its way to the outside world via the TXA line (pin 16).

**The TMS99532 uses a 4.032-MHz crystal to generate the four reference frequencies used by the digital filters.**

The demodulator includes two stages of filtration: two primary antialiasing filters, each of which feeds two secondary narrow-bandpass digital filters centered on the particular mark and space frequencies. One primary filter is centered on 1170 Hz (to pass received originate-mode tones) and the other on 2125 Hz (allowing answer-mode tones to pass).

The TMS99532 uses a 4.032-MHz crystal to generate the four reference frequencies (both sets of mark and space tones) used by the digital filters. In either operating mode, one set is used to sample the analog input signals (from the chip's RCVA input, pin 15) through a switched capacitor-filter network, while the other set generates the carrier signals in the transmit modulator.

In the receiving process, the outputs of the digital mark and space filters are full-wave rectified and their levels are compared. If the signal coming from the mark filter is greater in amplitude than the space filter's amplitude, the received data is interpreted as a logic 1 (or vice versa). The input from the microphone is attached to the RCVA input (pin 15), and the demodulated data comes out on the RCVD output line (pin 4).

The TMS99532 has a carrier-detect function that allows separate time-out intervals for acquisition and loss of signal. For a valid carrier-detect signal to be generated, the TMS99532 must receive a mark signal of detectible amplitude during the interval selected as the carrier-detect turn-on time. After a mark-state carrier has been detected, the signal must fall below the carrier-detect turn-off threshold for a predetermined turn-off interval before the Data Carrier Detect output (pin 2) indicates loss of signal. The turn-on and turn-off times are preset by the connection of a resistor/capacitor combination to the TMG input (pin 3). In designing the ECM-103, I chose a 10-megohm resistor and a 0.01-microfarad capacitor to provide a turn-on carrier-detect interval of approximately 75 ms (milliseconds) and a turn-off time of approximately 25 ms.

**Photo 3:** *Acoustic modem components. Consists of a high impedance ceramic microphone, 8-ohm speaker, and 2 rubber cushions. Because it makes no physical connection to the telephone line, no FCC certification is required.*

## Acoustic-Coupler Interface

The easiest and simplest way of making the physical connection from the ECM-103 modem to the telephone line is to use an *acoustic coupler*. This apparatus is in essence just a speaker and a microphone that "talk" through a standard telephone handset. While direct connection to the telephone lines has technical advantages, acoustic coupling is convenient and does not require FCC approval.

Construction of a serviceable acoustic coupler is really quite simple; I described the process with detailed photographs in my previous modem article (reference 2). You need only common, easy-to-find materials and a modicum of dexterity to assemble the device.

If you prefer the professional look in your projects and want to guarantee top performance, I recommend the acoustic-coupler kit available from The Micromint. It uses rubber cushions specially designed for a tight fit on the telephone handset and a

**A 300-bps modem can neatly serve most needs for everyday data communication.**

ceramic microphone specifically designed for use in modems (see photos 3 and 4). Interestingly enough, as I was working on the ECM-103, the folks at The Micromint informed me that they had received a large order for acoustic-coupler parts from Texas Instruments itself, where someone was apparently also prototyping a number of TMS99532 projects.

## In Conclusion

Today, the need for one computer to be able to talk to other computers is apparent without much explanation. The proliferation of automatic bulletin-board systems, timesharing services, and business data services dependent upon data communication has touched most computer users.

For the average casual computer user or experimenter, a 300-bps Bell-103-compatible modem is generally adequate and is considered standard equipment. The prices of 1200-bps units are still very high, but I expect that they will eventually come down, and as a consequence more people will begin to use 1200-bps modems. (As soon as it becomes cost-effective,

Photo 4: *Finished modem prototype.*

there will be a Circuit Cellar project to build a 1200-bps modem.) But for now, a 300-bps modem can neatly serve most needs for everyday data communication.

The ECM-103 uses the latest LSI technology and is a considerable improvement over previous designs. Because it is crystal-controlled and uses no external filtering or frequency-setpoint components, it offers substantially improved performance and long-term reliability. The TMS99532 is a relatively new chip and as such is very expensive. Because of this, I have limited the complexity of the ECM-103 so that even with the other components it is still economical to build.

## Next Month:

*After you've built the modem, you'll need to connect it to your computer or terminal. In April, we'll look at a "break-out box," a diagnostic aid for making RS-232C connections work.* ■

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

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3. Parsons, Ronald G. "An Answer/Originate Modem." June 1980 BYTE, page 24.
4. Skjellum, Anthony, and Richard S. Shuford. Letter and Reply: "In Search of Faster Modems." June 1982 BYTE, page 42.


**Editor's Note:** *Steve often refers to previous Circuit Cellar articles as reference material for each month's current article. Most of the past articles are available in reprint books from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08520.*

Ciarcia's Circuit Cellar, Volume I *contains the articles that appeared in BYTE from September 1977 through November 1978.* Ciarcia's Circuit Cellar, Volume II *contains the articles from December 1978 through June 1980.* Ciarcia's Circuit Cellar, Volume III *contains the articles that were published from July 1980 through December 1981.*

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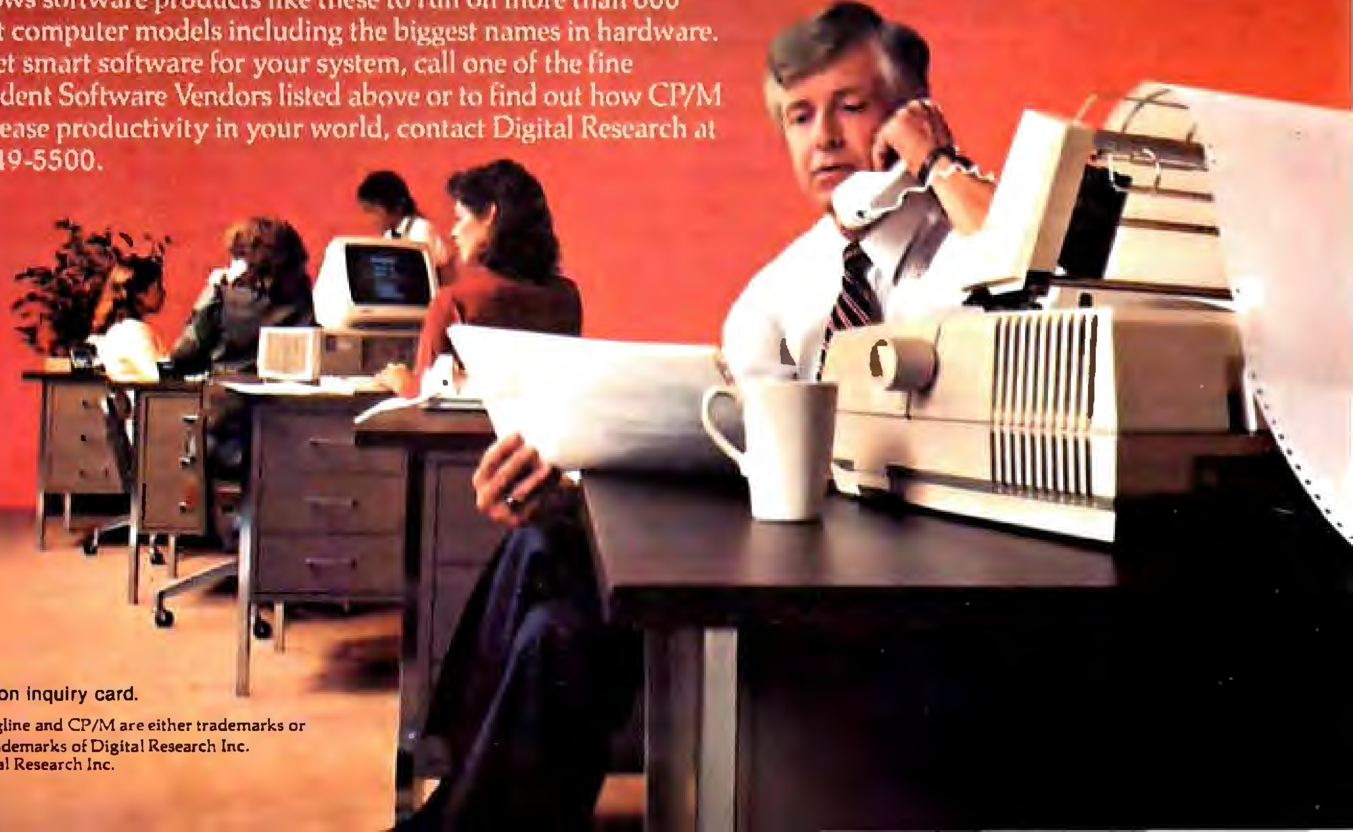

Circle 148 on inquiry card.

# The Enhanced VIC-20
## Part 2: Adding a 3K-Byte Memory Board

Joel Swank
12550 SW Colony #3
Beaverton, OR 97005

OUT OF MEMORY is one of the most annoying error messages you can get. It usually happens just when you've almost finished writing that essential program. This article, the second in the Enhanced VIC-20 series, will show you how to prevent this problem by adding more memory to your microcomputer.

Essentially, the addition of memory fills a "gap" in the VIC's memory. The memory circuit is relatively simple, but building the board demands a certain amount of experience with electronic components.

As supplied by Commodore, the VIC-20 comes with 5K bytes of programmable RAM (random-access read/write memory) which is logically divided into two sections. One kilobyte (four pages) is located at the low end of the VIC memory space spanning addresses 0–1023 ($0–$3FF hexadecimal). This block of memory is used by the VIC control program (called the KERNAL) and is not available to BASIC programs. The 6502 microprocessor, which controls the VIC, requires that page zero (0–255 or $0–$FF) be used for direct-page machine instructions and that page one (256–511 or $100–$1FF) be used for the hardware stack. The KERNAL program uses pages two and three (512–1023 or $200–$3FF) to store such important VIC data as vectors, current color, and the screen buffer location. The keyboard input buffer and the tape buffer are also located there. Almost all of the first 1K bytes of memory are dedicated to some use.

The other 4K bytes of memory on the standard VIC are located at 4096–8191 ($1000–$1FFF). This RAM, which is used to hold the BASIC program and variables and the screen buffer, has a special use. It can be accessed by the 6560 video interface chip (hence VIC). The 6560 is the integrated circuit (IC) in the VIC that creates the color images that are sent to the screen. Special circuitry allows both the microprocessor and the video interface chip to access this 4K-byte block of RAM. It is the only RAM in the system that can contain the screen buffer and alternate character sets. This block of RAM must occupy a 4K-byte boundary. That's why it's located at 4096 ($1000) instead of 1024 ($400), leaving a 3K-byte gap in RAM at 1024–4095 ($400–$FFF). Filling this memory gap with RAM will expand the VIC's memory to 8K bytes. Commodore offers two memory cartridges that fill this gap: the 3K-byte Memory Expander and the Super Expander.

The KERNAL program checks for the presence of RAM at 1024 ($400) during power-up initialization. If RAM is present, it is used by BASIC. BASIC will then display the message 6655 BYTES FREE instead of the normal 3583 BYTES FREE. That makes available 3072 more bytes for BASIC programs and variables. It also moves the start of BASIC to 1024 ($400), which frees the RAM in the special video block for use with special characters and lets you use full high-resolution graphics. (See the VIC users manual for information on high-resolution graphics.) The VIC LOAD command automatically relocates BASIC programs when they are loaded, so any programs you save on a 5K-byte VIC will also work on an 8K-byte VIC.

### Design

A 3K-byte RAM board must be connected to the VIC via the expansion connector slot in the right rear of the case. Inside this slot is a standard 44-pin card-edge connector with contacts on 0.156-inch centers. This connector will accept a standard industry card-edge plug. Commodore cartridges consist of a printed circuit (PC) board to which a plastic case is bolted. The case helps to guide the edge of the PC board into the connector. You can also insert a board without a case if you carefully align the board and the connector.

**Editor's Note**

*The VIC-20 is one of the new breed of low-cost computers that offer a surprising amount of computing power for the money. But its low cost also means that it lacks some of the features we've come to take for granted. In this series of articles, author Joel Swank will "enhance" the VIC-20 and in so doing increase the utility of this very interesting computer. . .S.J.W.*

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| 5 | CD3 | E | CA3 |
| 6 | CD4 | F | CA4 |
| 7 | CD5 | H | CA5 |
| 8 | CD6 | J | CA6 |
| 9 | CD7 | K | CA7 |
| 10 | $\overline{\text{BLK1}}$ | L | CA8 |
| 11 | $\overline{\text{BLK2}}$ | M | CA9 |
| 12 | $\overline{\text{BLK3}}$ | N | CA10 |
| 13 | $\overline{\text{BLK5}}$ | P | CA11 |
| 14 | $\overline{\text{RAM1}}$ | R | CA12 |
| 15 | $\overline{\text{RAM2}}$ | S | CA13 |
| 16 | $\overline{\text{RAM3}}$ | T | $\overline{\text{I/O2}}$ |
| 17 | VR/W | U | $\overline{\text{I/O3}}$ |
| 18 | CR/W | V | S02 |
| 19 | $\overline{\text{IRQ}}$ | W | $\overline{\text{NMI}}$ |
| 20 | NC | X | $\overline{\text{RESET}}$ |
| 21 | +5VDC | Y | NC |
| 22 | GND | Z | GND |

**Table 1:** *VIC expansion-bus pin assignments using the nomenclature in the VIC users manual.*

VIC Expansion-bus Select Lines

| Signal | Space | Addresses | Intended Use |
|---|---|---|---|
| $\overline{\text{BLK1}}$ | 8K | \$2000–\$3FFF | RAM EXPANSION |
| $\overline{\text{BLK2}}$ | 8K | \$4000–\$5FFF | RAM EXPANSION |
| $\overline{\text{BLK3}}$ | 8K | \$6000–\$7FFF | RAM EXPANSION |
| $\overline{\text{BLK5}}$ | 8K | \$A000–\$BFFF | ROM CARTRIDGE |
| $\overline{\text{RAM1}}$ | 1K | \$400–\$7FF | RAM EXPANSION |
| $\overline{\text{RAM2}}$ | 1K | \$800–\$BFF | RAM EXPANSION |
| $\overline{\text{RAM3}}$ | 1K | \$C00–\$FFF | RAM EXPANSION |
| $\overline{\text{I/O2}}$ | 1K | \$9800–\$9BFF | I/O EXPANSION |
| $\overline{\text{I/O3}}$ | 1K | \$9C00–\$9FFF | I/O EXPANSION |

**Table 2:** *VIC expansion-bus external select lines, their address ranges and intended use.*

Page 150 of the VIC users manual shows the signals on each pin of this connector. Table 1 lists the pin numbers and their signals. The 6502 microprocessor uses these signals, which are collectively called a bus, to communicate with all parts of the system. The memory-expansion port is not the entire 6502 bus because the two high-order address lines are missing. But all standard 6502 control and data lines are present, along with nine select lines. A select line exists for each unused block of the VIC address space. Table 2 shows the select lines and their corresponding address ranges. (Note that there is an error on page 150 of the users manual. The two select lines I/O2 and I/O3 (pins T and U), like all the other select lines, are negative logic signals. They should be shown with a line or bar over them.)

Figure 1 shows the schematic for a 3K-byte RAM board that will plug into the VIC expansion bus. Implementing a 3K-byte RAM board is very simple because no external decoding of the address lines is needed. The VIC provides a select line for each 1K bytes of RAM in the range 1024–4095 (\$400–\$FFF).

I chose 2114 static RAM ICs for my board, the same parts used for VIC's 5K bytes of memory. Each 2114 contains 4K bits organized as 1K of half bytes or nybbles. Each 1K bytes of RAM require a pair of 2114s. One 2114 contains the high-order nybble of each byte, and the other contains the low-order nybble. Six 2114s are needed for 3K bytes of RAM. Each pair is selected by one of the RAM select lines.

## Construction

Although the logic of the 3K-byte board is simple, constructing it is more complicated. The pin numbers shown in both the VIC users manual and table 1 do not use the standard industry nomenclature for the 44-pin card-edge connector. It's actually a mirror image of the industry standard. If you buy a plugboard or a connector whose pins are marked, they won't match the VIC pin numbers. (I almost wired my board wrong before I realized that.) I guess Commodore used this numbering scheme to be consistent with the rest of the connectors on the back of the VIC. Table 3 lists the VIC pin assignments in standard nomenclature.

The dimensions of the expansion-interface slot also present a problem. A PC board plugged into the VIC expansion connector has only 1/8-inch clearance below and 5/8-inch clearance above the edges of the slot. This clearance is no problem if you're using an etched printed-circuit board, but most people who build their own boards use one of the wire-wrapping methods of construction. Wire wrapping requires space below the board for wrap posts and wires.

To work around the physical constraints, I built my board upside-down. That is, I built the board so that it would plug into the VIC with the components facing down and the wire-wrap pins facing up. To make the scheme work, I had to leave the first 2½ inches of the board bare, which brings all components and wiring outside the VIC case (see photo 1). The 5/8-inch clearance above leaves room to install wires to bring the signals out to the components. It looks a little strange, but it works well. It also means you have to use a third pin-assignment nomenclature. Table 4 shows the VIC upside-down bus pin assignments.

Once you have the pin assignment nomenclature down, constructing the board is fairly straightforward. I have used Vector Electronic Company's Slit-N-Wrap

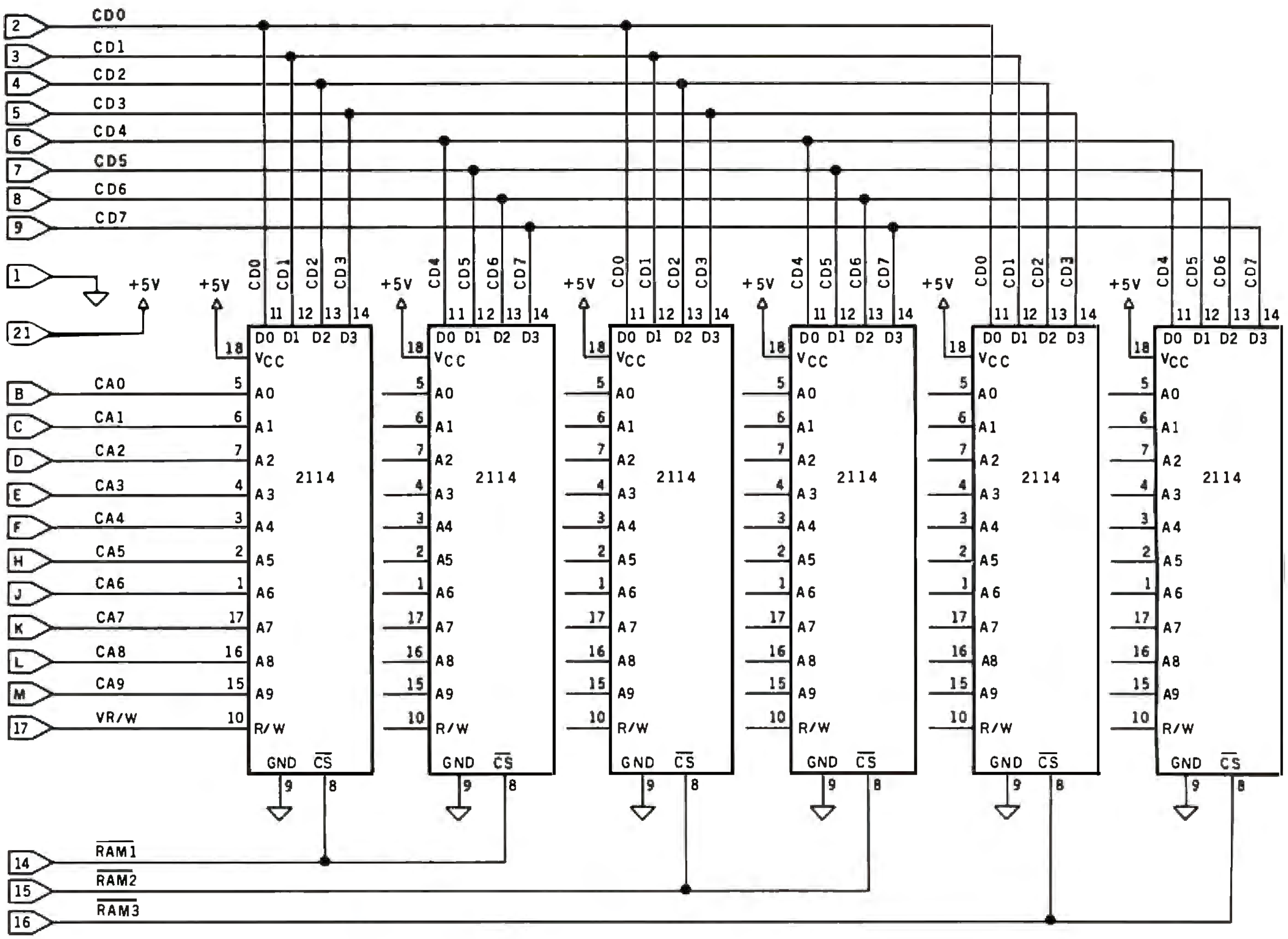


**Figure 1:** *Schematic diagram of the VIC 3K-byte RAM board. The connector numbers on the left match the VIC expansion-bus pinouts shown in both table 1 and the users manual.*

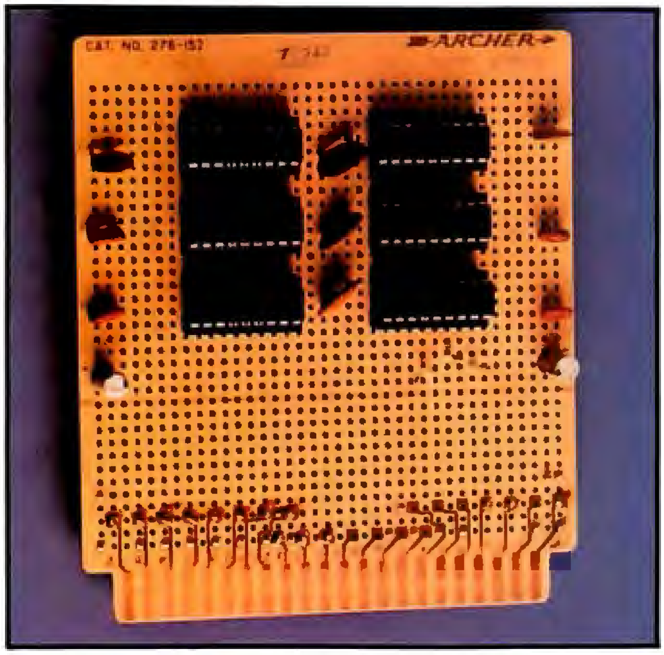

**Photo 1:** *A 3K-byte RAM board for the VIC-20 computer. This view shows the component side of the board and the parts layout. The circuit wiring, done with wirewrap technique, is on the opposite side.*

method of construction for years with good results. Standard wire wrapping or the newer Just Wrap method from OK Machine and Tool Corp. should also produce good results. A variety of distributors sell wire-wrap sockets and individual wrap posts. I wrap all connections except the power and ground connections. For those I use point-to-point soldering so that I can use heavier gauge wire than the 28-gauge required for the Slit-N-Wrap method. It's a good policy to put a 10-$\mu$F electrolytic capacitor across the power and ground lines near the edge connector and to put a 0.1-$\mu$F ceramic-disk bypass capacitor next to each IC on the board from the power-supply line to ground. Whichever construction method and pin nomenclature you use, it's a good idea to mark the board and the VIC so that you never insert the board backward.

## Testing

When you plug the 3K-byte RAM board into the VIC and turn it on, you should see the message 6655 BYTES FREE. If you don't, there's an error on the board. The VIC does a memory test at power-up. If it detects an error, it fills the screen with a random pattern of characters and colors and refuses further communication. Even if you get the proper message, you can't be sure that the


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VIC Expansion-bus Standard Nomenclature

| Pin # | Use | Pin # | Use |
|---|---|---|---|
| 1 | GND | A | GND |
| 2 | +5VDC | B | NC |
| 3 | NC | C | $\overline{\text{RESET}}$ |
| 4 | $\overline{\text{IRQ}}$ | D | $\overline{\text{NMI}}$ |
| 5 | CR/W | E | S02 |
| 6 | VR/W | F | $\overline{\text{I/O3}}$ |
| 7 | $\overline{\text{RAM3}}$ | H | $\overline{\text{I/O2}}$ |
| 8 | $\overline{\text{RAM2}}$ | J | CA13 |
| 9 | $\overline{\text{RAM1}}$ | K | CA12 |
| 10 | $\overline{\text{BLK5}}$ | L | CA11 |
| 11 | $\overline{\text{BLK3}}$ | M | CA10 |
| 12 | $\overline{\text{BLK2}}$ | N | CA9 |
| 13 | $\overline{\text{BLK1}}$ | P | CA8 |
| 14 | CD7 | R | CA7 |
| 15 | CD6 | S | CA6 |
| 16 | CD5 | T | CA5 |
| 17 | CD4 | U | CA4 |
| 18 | CD3 | V | CA3 |
| 19 | CD2 | W | CA2 |
| 20 | CD1 | X | CA1 |
| 21 | CD0 | Y | CA0 |
| 22 | GND | Z | GND |

**Table 3:** *VIC expansion-bus pin assignments using standard industry nomenclature. Most numbered plugboards use this nomenclature.*

VIC Expansion-bus Upside-down Nomenclature

| Pin # | Use | Pin # | Use |
|---|---|---|---|
| 1 | GND | A | GND |
| 2 | CA0 | B | CD0 |
| 3 | CA1 | C | CD1 |
| 4 | CA2 | D | CD2 |
| 5 | CA3 | E | CD3 |
| 6 | CA4 | F | CD4 |
| 7 | CA5 | H | CD5 |
| 8 | CA6 | J | CD6 |
| 9 | CA7 | K | CD7 |
| 10 | CA8 | L | $\overline{\text{BLK1}}$ |
| 11 | CA9 | M | $\overline{\text{BLK2}}$ |
| 12 | CA10 | N | $\overline{\text{BLK3}}$ |
| 13 | CA11 | P | $\overline{\text{BLK5}}$ |
| 14 | CA12 | R | $\overline{\text{RAM1}}$ |
| 15 | CA13 | S | $\overline{\text{RAM2}}$ |
| 16 | $\overline{\text{I/O2}}$ | T | $\overline{\text{RAM3}}$ |
| 17 | $\overline{\text{I/O3}}$ | U | VR/W |
| 18 | S02 | V | CR/W |
| 19 | $\overline{\text{NMI}}$ | W | $\overline{\text{IRQ}}$ |
| 20 | $\overline{\text{RESET}}$ | X | NC |
| 21 | NC | Y | +5VDC |
| 22 | GND | Z | GND |

**Table 4:** *VIC expansion-bus pin assignments using upside-down nomenclature. This is how the signals would appear on a standard numbered board when they are inserted upside-down into the VIC.*

memory is working properly because the VIC's memory test is not thorough.

The next step is to load and run a BASIC program to see if it works. If it does, there's a good chance that the memory is okay. If you have any problems, there are a few things you should check. Look for broken wires and poor solder joints. Check all connections for proper pin numbers. Be sure not to pull wires tight across adjacent pins. Wrap posts have sharp corners that can pierce insulation. Try reseating the ICs in their sockets. As a last resort, try replacing the ICs one at a time, with spares you know to be good.

The most difficult part of expanding the VIC was figuring out the pin-assignment nomenclature and how to work around the board's physical limitations. After solving those problems, I was able to add 3K bytes of RAM for about $30 in parts and four hours of construction time.■


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# A User's View of COMDEX

## The Industry Begins to Mature

Jerry Pournelle
c/o BYTE Publications
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COMDEX is a big show put on mostly by manufacturers for dealers, and dealers definitely ought to attend. Users are another matter. COMDEX isn't set up for users, and paradoxically, there's too much to see. The most recent COMDEX, held in December in Las Vegas, had over a thousand exhibits and more than 40,000 attendees.

For all that, COMDEX is important. It's here that suppliers convince dealers they should handle their hardware and software products. Because everyone wants to be first with new technology, a lot of new developments are announced and shown at COMDEX. Some are the products of mature technologies, some are prototypes, and some are half-baked schemes that aren't going anywhere. For computer journalists, COMDEX is a good place to pick up background material.

My first impression of COMDEX was lines. Lines for taxis at the airport; a long and inexplicable check-in line at the Imperial Palace hotel; a line for a taxi to the Convention Center; long lines for badges; and long lines for taxis to get back to my hotel when the day was nearly over. As working press I didn't have to stand in the badge line, but that was the only one I missed.

My second feeling was dismay: there's no way to cover a thousand exhibits in three days, nor is it much easier to characterize an entire industry in a few sentences. (The *Computer Dealer*, a show newspaper published daily, ran to 168 pages!) Consequently this report will be highly personal. I saw as much as I could. I've consulted experts when possible. Still, there's much I missed, and if I've overlooked something significant, I can only apologize.

One more warning: this is a show report. It is, therefore, much more impressionistic than my User's Column. I can describe what I saw, and what I thought about it; but I am not making recommendations and won't until I can use some of this new stuff.

I can remember when the microcomputer industry consisted of little more than MITS kits and some homebrew machines; one had to be a determined hobbyist, or at least have a pioneer spirit, to become involved in "this crazy new game" back then. Now there are hundreds of computers and thousands of programs. As the market expands, vendors hope to sell to less sophisticated users. Thus have grown up the "system packagers," who combine hardware, software, and "teaching aids." I saw evidence of advances in hardware, software, and materials designed to show beginners how to use the stuff.

### Hardware

The most significant hardware I saw was the Syquest "removable media Winchester." This is a 100-mm hard-disk drive that comes in a package half the height of a thin 5¼-inch floppy disk and has a removable disk cartridge called the Q-Pak. Each cartridge holds 5 megabytes formatted. The drives have the same pinouts, timing, etc. as a standard 5¼-inch Winchester and work with standard Winchester controllers, power supplies, and interfaces.

The Syquest drives sell for $800 each; the Q-Paks are $50. A few systems at the show already made use of Syquests; these typically sold a two-drive system with power supply and controller for $2500, about half again what you pay for a pair of 8-inch double-sided double-density floppies. Tecmar is offering a single-drive sys-

**About the Author**
*Jerry Pournelle is a former aerospace engineer and current science-fiction writer who loves to play with computers.*

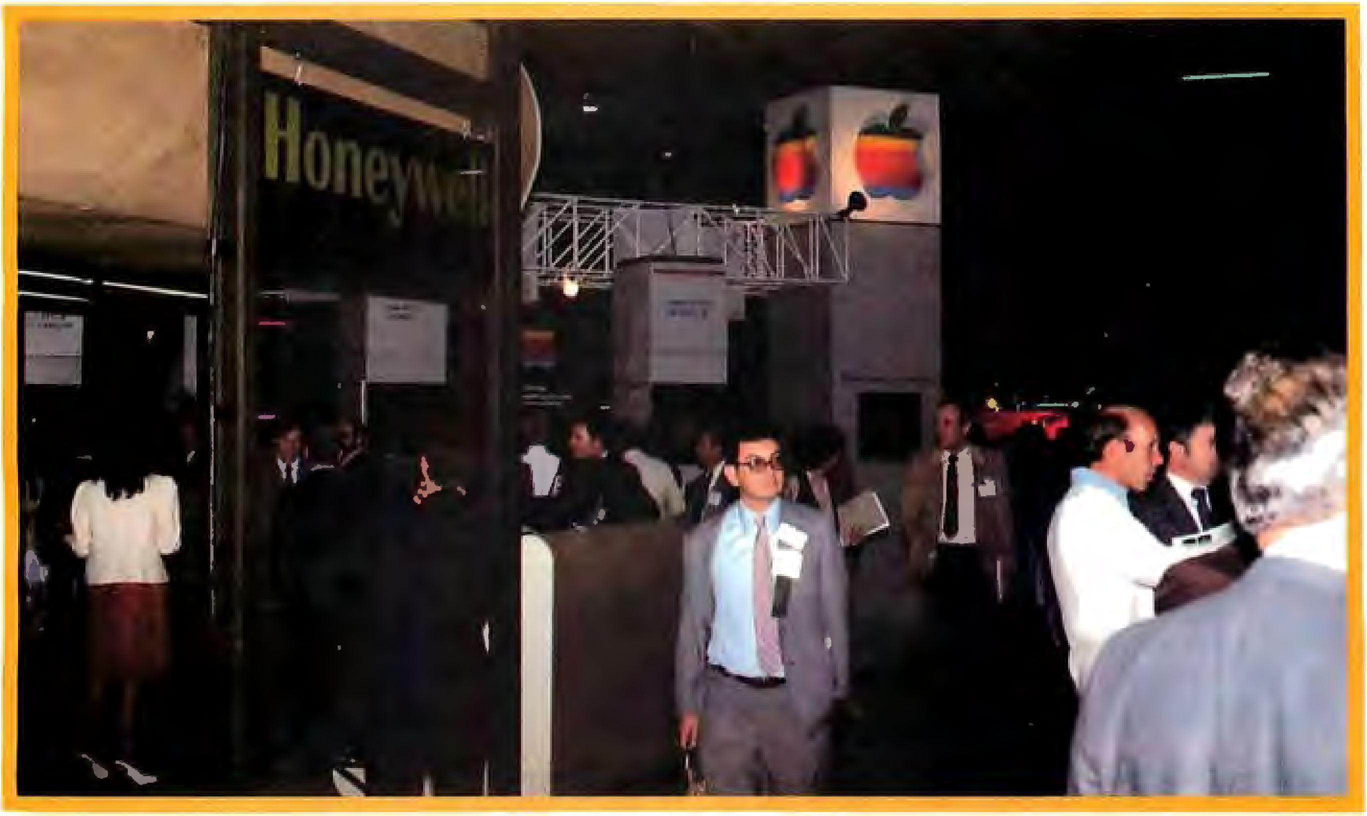


**Photo 1:** *Neighbors at COMDEX Honeywell and Apple Computer.*


**Photo 2:** *A sight we all thought we'd never see. A "foreigner" at the IBM display booth. IBM now makes equipment that can be used by Apple computers.*


**Photo 3:** *COMDEX is a wonderful place to meet people (left to right): Compupro President Mark Garetz; Tony Pietsch of Proteus Engineering (who builds and maintains all my computers); and BYTE's West Coast Editor Phil Lemmons.*

tem with controller for the IBM Personal Computer for $1795.

The second significant trend in disk technology was to microfloppy disks. Tandon, Tabor, Shugart, Sony, and others were pushing these "shirt-pocket" disks. I saw two sizes, 3¼ and 3½ inches; each has vocal defenders. I'm told, however, that a number of major manufacturers are getting together to try to agree on a standard size and format, and I hope they do.

A third trend in disk technology is the "enormous minifloppy." I saw several demonstrations of 2-megabyte double-sided double-density 5¼-inch floppy disks.

Add to this the incremental developments in the standard nonremovable Winchester hard disks—up to 40 megabytes formatted on a drive that costs no more than a 5-megabyte drive cost a year or two ago—and you can see that system designers have some decisions to make. Bill Godbout of Compupro went about looking at all the new disk systems in hopes of getting some clues as to what the future standards will be. So did George Morrow of Morrow Designs, and I'm sure they weren't alone.

I don't know what conclusions they came to. I can offer the opinion of Tony Pietsch of Proteus Engineering, the computer engineer who developed my system and who tries very hard to stay current with the state of the art.

"Flat prediction," Tony said. "Within two years, both 8-inch and 5¼-inch disk systems will be obsolete and after that they'll rapidly die out. I don't know exactly what will replace them, but it will be a combination of hard disks and shirt-pocket floppies."

Tony thinks the Syquest removable Winchester is an excellent idea, but he'd prefer to see the technology develop a bit before recommending the system to end users. Bill Godbout had the same view. Compupro will test the concept thoroughly before incorporating it into systems. The company is also working with shirt-pocket disks, and it has multimegabyte 5¼-inch systems working.

The explosion in computer technology continues. Some companies, like Altos, are moving to erase the distinction between the "big" minicomputer and the microcomputer. Altos President David Jackson is proud of his new single-board machines that offer all the power of a DEC PDP-11 for well under $20,000. Meanwhile, Compupro's Bill Godbout showed a whole line of expandable S-100 equipment, including a working processor board based on the 68000 chip, another built on the 8086 with optional "math chip" aboard, and two prototypes based, respectively, on the National Semiconductor 16-bit external, 32-bit internal 16032, and Intel's iAPX 286.

Tony Pietsch put it this way: "The 16032 is going to be a *big* machine. The internal chip architecture makes it equivalent in power to the IBM System 360 or 370. For that matter, it will be trivial to get it working like a LISP Machine." The IBM 370 is, as Tony says, big; the LISP Machine was developed at the Massachusetts Institute of Technology, primarily by Marvin Minsky, and is very important in artificial-intelligence studies. It looks as if machines equivalent to both will be available at S-100 prices within a year.

We also have the 68000 machines. Fortune was out in force. So was Sage. Both had working systems and an expanding line of software.

The 8088 chips were not neglected either. Eagle Computers, with an IBM Personal Computer work-alike, attracted a lot of attention. My favorite of those, though, is the Zenith Z-100, which has an S-100 bus and runs PC programs without making you endure the PC's maldesigned keyboard.

There was also the Basis, a European machine (but which features an American-style keyboard) that has both a 6502 chip and a Z80. I was much impressed by the Basis, and I'd advise anyone contemplating an Apple acquisition to look it over first.

And on, and on. . .

## Portables

There are so many portable machines now that I can't keep track of them. It seems a new one springs up every week, and all the manufacturers of portables are trying to build dealer and repair networks to service them.

There are flat-screen systems based on liquid-crystal displays, portable versions of the IBM Personal Computer, machines with plastic cases and machines with metal cases, machines with tiny screens and machines with larger screens. Not only can't I keep up with them, I can't even list them all.

Meanwhile, the "old" portables continue to improve. There's new software for the Kaypro. There's a new carrying case, a very nice new screen display, and new software for the Otrona. The Osborne 1 has both double-density disks and an 80-character screen as an option. As well it has the most impressive package of software and "learning tools" I've seen for any entry-level computer.

A few of the new ones I saw: the Hyperion, a somewhat portable IBM PC work-alike; the Zorba, a Z80-based machine that looks a bit like someone crossed the Osborne with the Kaypro and kept many of the best features of both; and Teleram's new true portable, which uses a liquid-crystal display and can run for several hours on its batteries.

Anyone looking for a computer ought to look seriously at the portables.

## Software

The exciting news in software is a new language by Niklaus Wirth, the creator of Pascal. The language is called Modula 2 and was first implemented on the Apple; we now have it for our Sage 68000 computer. Modula 2, from Volition Systems (POB 1236, Del Mar, CA 92014) has many similarities to Pascal, and Volition Systems says that with its learning package a Pascal programmer can learn Modula 2 in a few days.

As implied by the name, Modula 2 is a modular language; each module is a collection of declarations that can be put together to make very structured and readable programs. I'm much looking forward to playing with it on our Sage.

Another interesting development came from Peachtree Software: it has developed a voice synthesizer that takes considerably less memory (or disk space) to store significant messages, and it sounds human, complete with inflections and emphases. Peachtree is using it to develop human-machine interfaces; this could become very significant.

The other big news was Digital Research's GSX graphics-support package, Visi On from Visicorp, and Lotus's 1-2-3. These three companies all had dealers clustered at their booths. Unfortunately, I ran out of time and had no chance to see them.

In addition to the new software, there were a lot of hefty improvements. A score of companies have database management programs; everyone wants to cut into the dBASE II sales. Altos President David Jackson told me he saw at least six database management programs that Altos wants to evaluate, and I noticed that Bill Godbout's people were collecting information too.

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Spreadsheet programs were also popular. Sorcim announced a number of improvements in Supercalc, as well as a new programming editor. There must have been 20 other spreadsheets and derivatives. Every one of them claims one or another unique feature, and without thorough tests and reviews there's no way I can tell them apart.

There's now software for almost any "standard" machine and operating system. CP/M and the 8-bit Z80 and 8085 are still the most commonly written for, but their popularity is being strongly challenged by the IBM Personal Computer and its work-alikes. Because CP/M-86 is just coming out in a final and usable form—I saw it running only at Godbout's Compupro booth, although doubtless other exhibitors had it going—it's a bit early to tell how it will fare in competition with MS-DOS.

## Package Deals

A lot of "business computers" are available. Some come from original manufacturers, but many are systems put together from other people's machines. Typically, there's a package deal of software and hardware, along with introductory materials and manuals.

Some of these packages are pretty good; but it is my impression that the best hardware has not yet got together with the best software, and neither has been put into a package with the best introductory and teaching materials combined with an extensive dealer and service network. This doesn't mean that there aren't some pretty good packages available.

The Altos line, for example, is quite good. It has reasonable to excellent software, decent introductory manuals, reliable and handsome hardware, and support from a very good dealer network. The Altos can be configured to work with Ethernet and other communications networks. On the other hand, the Altos is a single-board computer. It's not easily expanded or upgraded. What you buy is what you'll have for a while, unless you trade it in on an entire new system. For many buyers that's good enough.

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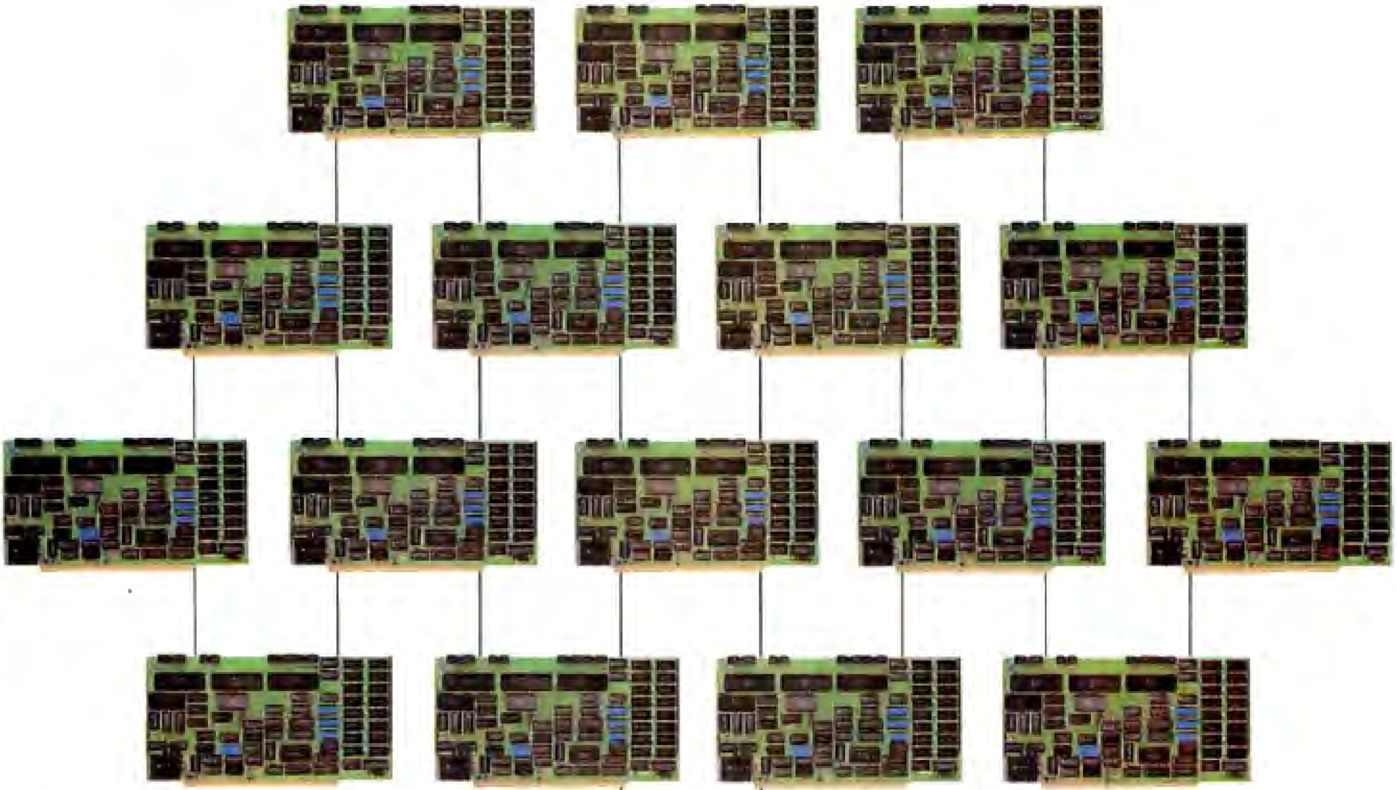

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The Altos is the top end of the microcomputer line, and total package costs tend to be high (although low compared to the minicomputers the Altos can replace). At the low end, the Osborne 1 is an excellent total package. I'm impressed with both the software and the introductory materials that come with the machine; I'm even more impressed with the dealer and service network that Osborne has built.

I didn't see any other total packages as impressive as those; but that was at COMDEX. I also saw hardware firms out looking at packaging. Compupro, Otrona, Zenith, Non-Linear Systems (Kaypro), Altos, and Morrow Designs were all buying rights to software, hiring writers, and building up their dealer networks. (I'm sure many others were also; these are the ones I talked to myself.)

### The Bottom Line

Tony Pietsch, who knows what to look for, thought the most significant thing about this year's COMDEX was that of a dozen new terminals and small computers, just about every one of them offers ANSI-Standard X-3.64-1979. That, he explains, is standard ASCII, which specifies how computers ought to communicate with each other and what the control characters ought to mean. This is what the big boys in mini- and mainframe computers conform to.

This trend is significant because it means that the microcomputer industry is moving that much closer to maturity. We now have microcomputers that can hook into the communications networks used by the very large business systems, and that trend is strengthened by the adoption of ANSI (American National Standards Institute) standards for communications. Microcomputers cost only a fraction of what the business community usually expects to pay. We've established a trend toward decent software at reasonable prices. New and better manuals, instructional materials, and training systems are being developed all the time.

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Of the several new mass-storage technologies that promise greatly increased data densities, perpendicular magnetic recording is the one most likely to enjoy early widespread use. Perpendicular-magnetic-recording technology, even in its infancy, promises a tenfold improvement over conventional recording.

The key to the new method lies in magnetizing the tape or disk surface material at right angles, i.e., at angles perpendicular to the surface. In contrast, conventional longitudinal recording creates magnetized zones along the surface. With perpendicular recording, higher recording densities now squeeze the width rather than the length of these magnetized regions.

## Conventional Recording

The digital 1s and 0s of a computer's binary language are recorded by magnetizing discrete regions of the magnetic material, usually an oxide of iron, that coats the surface of a recording tape or disk. You can think of each computer bit (1 or 0) as a tiny permanent magnet within this magnetizable surface layer.

In conventional recording technology, the tiny permanent magnets representing digital 1s might be recorded north-pole-first along the length of the recording track, while digital 0s would be recorded south-pole-first along the same track. Because the playback heads can detect only transitions, the process of reading the recorded data actually involves detecting the change in polarity: a north-to-south transition may be arbitrarily defined as a digital 1, and a south-to-north change will then become a digital 0. The magnetized zones lie lengthwise, or end to end, along the recording track in conventional longitudinal recording.

A nine-track digital tape recorder will encode 1s and 0s in nine parallel rows or tracks along the length of the tape, with each track containing up to 6250 magnetic changes (called flux changes) per inch. The most advanced magnetic memories can record the equivalent of 15,000 "tiny permanent magnets" per inch of recording track. Winchester disk memories, using the most advanced head-positioning mechanisms, create up to 1000 circular recording tracks per inch of disk radius. Such advanced Winchester memories have storage capacities as high as $1.6 \times 10^9$ bits per disk.

## The Limiting Factor

What limits recording density and therefore memory capacity? That is, what sets a ceiling on the number of tiny permanent magnets that can be created in each inch of the recording medium's magnetic coating? What are the sources of data-reading error that prohibit an indefinite increase in magnets-per-inch recording density? Computer memories must sustain error-free operation in the region of 1 bit in $10^{12}$ bits. Otherwise, computer systems would provide unexpected payroll bonuses and guide astronauts to Hoboken instead of the moon.

The stronger the recording equipment can make each tiny magnet that it creates in the medium's magnetic layer, the more accurately the equipment's read head will determine whether a magnet represents a 1 or a 0. Memory-system designers try to create circumstances that will sustain magnet strength as recording density (bits per inch) increases.

From basic research on magnetism, it has long been understood that a permanent magnet should be long and thin; its length should be several times greater than its thickness. If for some reason a magnet must be shortened, then the magnet's thickness must be proportionately reduced in

**About the Author**

*Clark E. Johnson Jr. is the president of Vertimag Systems Corporation, a company that was formed specifically to commercialize perpendicular magnetic recording. He began his involvement with magnetic-recording research and development with the 3M Company in the 1950s.*

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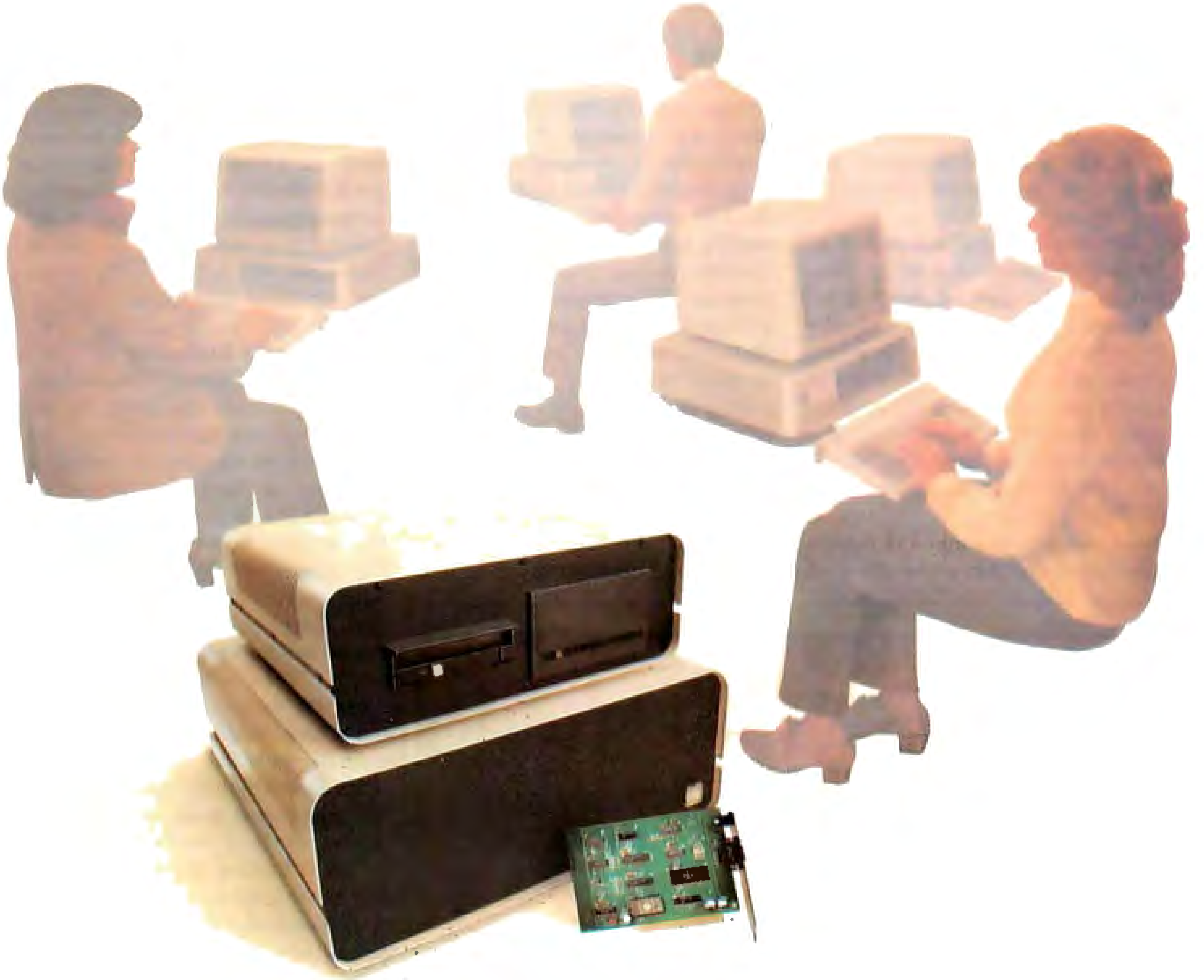

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order to maintain the magnet's strength. This need to make the magnet long relative to its "waistline" dimension stems from the self-demagnetization properties of all permanent magnets. The north and south poles tend to neutralize each other, with a net reduction in the magnet's overall effectiveness and resulting external field. Keeping the poles far apart and the ratio of length to thickness high reduces this self-demagnetization effect. The length-to-thickness ratio suffers as longitudinal recording's data density increases.

An examination of the factors determining the dimensions of these longitudinally recorded magnets will show why increased density adversely affects the magnet's length-to-thickness ratio. Because they are recorded end to end along the magnetic track, their length must decrease as recording density rises. One dimension of the "waistline" is fixed, being set by the thickness of the tape or disk's magnetic coating. The other is determined by the across-the-track width of the recording head.

Therefore, to maximize the magnet's length-to-width ratio, recording-head designers strive to produce very narrow tracks, while manufacturers of tape and disk media offer products with remarkably thin magnetic layers. Both endeavors are aimed at creating magnetized regions with very narrow waistlines so that the reduced magnet length at high densities still preserves a reasonable length-to-thickness ratio.

At densities above 15,000 magnets per inch, however, even these tactics reach a point of diminishing returns. Thinner coatings mean less magnetic material, hence weaker electrical output signals. Recording experts suggest that conventional longitudinal-recording technology has already pushed lineal recording density close to its ultimate ceiling. The only dimension left open to improvement in raising memory capacity within this technology is the number of tracks per inch. Currently, the most advanced head-positioning servomechanism can advance the head in increments of only 1/1000 of an inch, producing 1000 tracks per inch of disk diameter. It should ultimately be possible, however, to record 10,000 magnetic zones per inch and, therefore, something approaching 10,000 tracks per inch. That would yield a tenfold gain in memory capacity without need for further gains in along-the-track recording density. Improved head-positioning mechanisms will doubtlessly raise the tracks-per-inch figure in the years ahead but perpendicular recording affords the possibility of major gains not only in tracks per inch but especially in bits per inch along each track.

### Perpendicular Recording

Since conventional longitudinal-recording technology leads to increased self-demagnetization of the tiny recorded magnets as density is increased, is there some alternative approach that sidesteps the problem? The obvious way is to reorient the tiny magnets within the magnetizable layer on each disk or tape, so that their length-to-thickness ratio no longer deteriorates at higher densities. While conventional recording reduces the length dimension of the end-to-end magnets, perpendicular recording puts the squeeze on width rather than length at higher densities. The magnetized zones are turned 90 degrees, so that instead of lying along the tape's surface, the length dimension of the zone now stands vertically, perpendicular to the surface of the disk or tape. You might say that the magnets are recorded "into" the magnetic material rather than along it. Magnet length is now determined by the depth of the layer of magnetic material. One of the width dimensions is still set by recording-track width and the other by bits per inch along the track.

Consequently, raising the recording density no longer worsens the demagnetizing effect. In fact, the opposite is true. Because the recorded magnetic zones are perpendicular to the disk or tape surface, higher densities now squeeze their waistline dimensions, rather than their length. The length-to-thickness ratio steadily





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| Technology | Versatility | Lineal Density | Areal Density |
|---|---|---|---|
| longitudinal recording | read and write | 15,000 flux reversals per inch | $165 \times 10^6$ flux reversals per square inch |
| perpendicular recording | read and write | 100,000 flux reversals per inch | $10^{10}$ flux reversals per square inch |
| laser (optical) recording | read only | 25,000 impressions per inch | $6.25 \times 10^8$ impressions per square inch |
| 64K-bit RAM | read and write | NA | $10^6$ bits per square inch |

**Table 1:** *A comparison of the theoretical performance of four memory technologies. Perpendicular magnetics offers both read and write capabilities and the highest areal densities. The 64K-bit RAM is, of course, volatile and is included here only to put the density of the other technologies in perspective.*

improves as recording density is raised, and we have a condition, rare in science, in which pushing technology to higher limits actually enhances the phenomenon being pushed.

Even though perpendicular-recording technology has yet to emerge from the research laboratory, scientists confidently predict that densities of 100,000 bits per inch will rapidly be realized in commercial hardware. Indeed, some experiments already suggest that a 440,000-bit-per-inch density will be possible. Further improvements will be made in the years ahead, with an ultimate limit set by phenomena—perhaps at the atomic level—totally different from the self-demagnetization that limits the density attainable with longitudinal-recording technology.

## Areal Comparison with Other Technologies

Recording media and technologies are best compared on the basis of bits per square inch rather than bits per inch. This is because you can increase memory capacity by raising both recording density and the number of recording tracks. Thus, areal comparisons take both sources of improvement into account. On this basis, perpendicular recording offers close to an immediate hundredfold improvement, at $10^{10}$ ($100,000 \times 100,000$) bits per square inch, over longitudinal recording's $10^8$ ($10,000 \times 10,000$) bits per square inch. True, these figures represent recording densities that may be attainable in the future rather than what can be achieved with today's hardware, but they provide a useful basis for comparison.

## Laser Recording

Laser memory techniques enjoy a "good press," probably owing to their space-age novelty. There are physical limitations, however, to the potential data densities achieved by laser technology. Diffraction phenomena limit physical dimensions to about 1 micron when visible light is used. (The same limitation crops up in geometries of semiconductor layout.) Because 1 micron is 1 millionth of a meter, and a meter is roughly 40 inches, this limiting resolution works out to $40/10^6$. At best, therefore, based on visible-light wavelengths, laser recording can achieve a maximum density of $10^6/40$ or 25,000 bits per inch. That compares to 100,000 magnets per inch for perpendicular recording, which also has no comparable fundamental barrier to much higher densities. In terms of areal density, laser technology might attain a maximum of $25,000 \times 25,000$ or $6.25 \times 10^9$ bits per square inch.

## 64K-bit RAM

The uses of RAM (random-access read/write memory) are, of course, different from those of nonvolatile memory devices such as floppy disks. It is worth noting, however, that the theoretical data density of perpendicular magnetic recording exceeds the density of today's RAM. A 64K-bit RAM chip measures about one-quarter inch on each side. Therefore, it would be theoretically feasible to produce 16 such 64K-bit RAMs from a square inch of silicon. Thus, using the same hypothetical areal basis for comparison, the memory chip offers a density of $16 \times 64,000$ or $1024 \times 10^6$ bits per square inch, much lower than laser or magnetic technology.

Table 1 presents a brief comparison of the performance of four recording technologies as to versatility, lineal density, and areal density.

## The Problem of Media for Perpendicular Recording

The limiting factor in the development of perpendicular recording technology has been finding a magnetic material that lends itself to this recording process. Today's answer is an alloy of chromium and cobalt, which is placed on the recording medium's surface in the form of hexagonal crystals that can support magnetization perpendicularly. In other words, the CrCo crystal's magnetizable axis lies at right angles to the medium surface and parallel to its crystallographic "C" axis.

The process of depositing the CrCo crystals is very sophisticated, involving the same sputtering techniques that are used in manufacturing semiconductor integrated circuits. (Using sputtering techniques, manufacturers coat a surface by putting it in a vacuum chamber that has a cathode consisting of the substance to be used as a coating. When the cathode is bombarded by positive ions, atoms of the coating substance are transferred uniformly to the surface being coated.) This sputtering technology needs to be modified in order to deal with the requirement to coat acres of substrate rapidly and economically and realize reproducible results. While these techniques are being developed and undoubtedly will be commercialized, such mass production equipment and techniques do not exist at the moment. It will probably be a year to 18 months before production equipment becomes available to fabricate media in commerical quantities. The development of perpendic-


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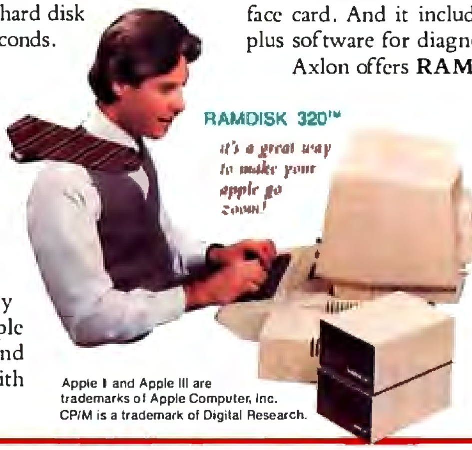


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ular-recording technology may be media-limited for as many as 10 years due to cost.

The first floppy disks for perpendicular recording will probably cost about $20 each, compared with $5 to $10 for conventional disks. In the future, fresh materials and fresh processes for placing the material on the medium will cut costs. These fresh approaches should lead to an economical way to place the CrCo alloy, or some alternative material, on recording tape as well as disk.

## Hardware and Applications

Floppy disks are expected to be the first commercial memory products to exploit the new perpendicular recording technology. They will offer 3 to 5 times the capacity of today's longitudinal floppy-disk systems and will be priced 30 to 70 percent higher. Later designs will push down the cost per bit even more. Vertimag Systems Corporation has demonstrated a prototype floppy-disk system that operates at 36,000 flux reversals per inch and provides 5 megabytes of total storage capacity. The system will eventually sell for around $500, with production expected to begin in 1984.

Following the market acceptance of floppy-disk memories based on perpendicular recording, a number of manufacturers are likely to launch hard-disk data-storage systems that challenge present Winchester systems. Because the Winchester disk is sealed in a clean-air environment, it lends itself to the meticulous mechanical engineering necessary to increase the number of tracks per inch and also to the control of the "flying height" of the head relative to the magnetic recording surface.

The potent combination of more tracks and perpendicular recording's tenfold increase in bits per track will give designers the headroom to continue product evolution through the rest of this century. To date, 5¼-inch Winchesters can accommodate more than 10 megabytes per disk. Memory designers have doubled capacity every two to three years for the past 25 years, and perpendicular recording provides the technological advance that can be expected to maintain this rate of progress for many years to come.

## Digital Audio/Video Market

Current techniques for the digital recording of music consume memory capacity at a prodigious rate, and digital video applications consume recording surface area in amounts that are orders of magnitude greater than audio. This may serve as an incentive to put perpendicular recording to work in the digital audio/video market.

Digital-recording techniques first convert what the microphone "hears" into the binary language of computers. This is done by taking many instantaneous samples of the microphone's electrical output signal and converting these samples into their digital equivalents. It is these samples, which provide a digital replica of the original music, that are recorded for future playback.

To preserve music fidelity, it is necessary to take many "instantaneous" samples. Typically, the microphone's electrical output is sampled approximately 50,000 times per second. Moreover, because music spans a very wide range of loudness, from the nearly inaudible to the deafening, each of the 50,000 samples must be represented by a sizable digital word to accommodate the full dynamic range. The music industry has chosen to include 16 bits to allow a 64,000 : 1 range of loudness as the standard word "size" for music digitizing. Consequently, each of the samples taken 50,000 times per second produces 16 bits of digital information to be recorded for subsequent playback.

Any magnetic memory systems designed to handle digital audio applications must therefore accept data at the rate of 800,000 bits per second (50,000 × 16 = 800,000 bits per second). A conventional longitudinal-recording system capable of a 10,000-bit-per-inch recording density would therefore consume 80 (800,000/10,000) inches of tape per second. Perpendicular recording, at the prom-

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ised 100,000 bits per inch, would cut this profligate use of tape down to 8 inches per second. Future digital-signal manipulation and compression will probably condense the amount of music data that must be recorded to preserve music fidelity. For example, it might be possible to develop techniques for recording only the *changes* in the music rather than, for example, continuing to record all data for notes that persist unchanged for substantial fractions of a second. Why record all 800,000 bits of data for a soprano who sustains the same note for an entire second? Such digital trickery, coupled with perpendicular recording's storage density, should put true digital music in the home in much less than a decade.

### The Future Development of Perpendicular Recording

The new perpendicular-recording technology is being developed mainly by an alliance of Japanese industry and universities. In America, only the Magnetics Research Laboratory at the University of Minnesota operates at the forefront of this new science.

Reports from Japan provide evidence of perpendicular recording at 440,000 bits per inch. At this early stage of research, such density is probably accompanied by error rates that would be prohibitive in commercial applications. However, digital music recording is less critical in regard to data error, so such densities would represent another major step toward commercialization of digital audio systems. At a 440,000-bit-per-inch density, tape consumption for digital music would drop to around 2 inches per second. If the data can be distributed over several parallel tape tracks, tape consumption will be reduced even further.

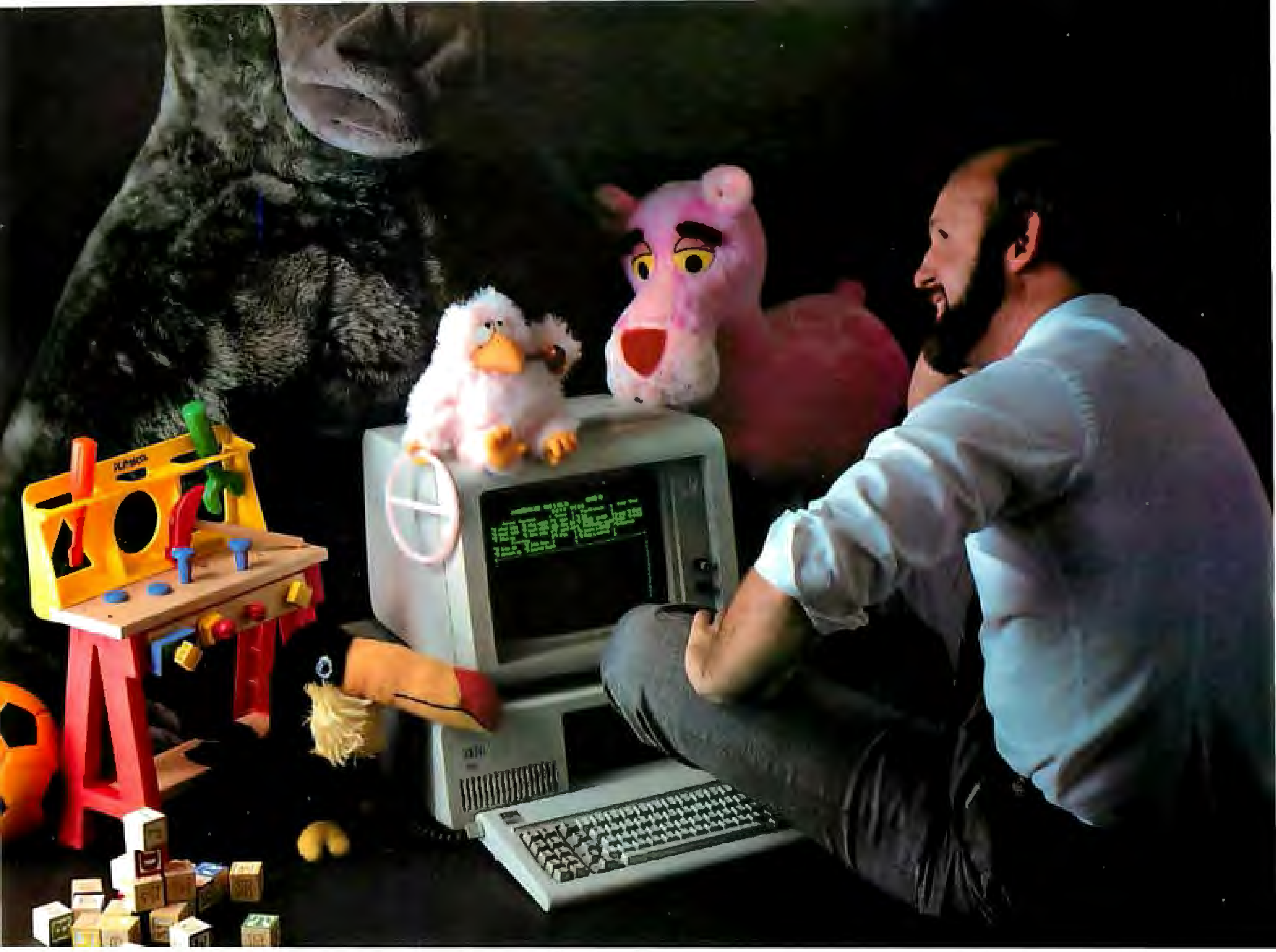
The Japanese have a massive effort going on in perpendicular recording. On March 11 and 12, 1982, in Sendai, Japan, the first International Symposium on Perpendicular Recording was sponsored by Tohoku University and organized by the inventor of perpendicular recording, Professor Iwasaki. Some 320 people attended, and 23 papers were given at this meeting. Twenty of the papers were by Japanese authors; three by U.S. authors, all of them with Vertimag Systems Corporation. Only seven non-Japanese people participated: three from Vertimag and four from the rest of the world.

Virtually every well-known Japanese electronics company is working on perpendicular recording. We estimate that at least 400 researchers are working in Japanese universities and companies on perpendicular recording technology. The companies include, but certainly are not limited to, Hitachi, Toshiba, Fujitsu, Nippon Electric Company (NEC), NTT, Sony, Matsushita, and a number of smaller companies. The recent Toshiba announcement of a 3½-inch perpendicularly oriented floppy-disk system is a case in point. While this product is still two years or so from production, it represents Japan's level of achievement in this area.

Initially, the Japanese activity will probably be aimed at the consumer electronics industry because the Japanese dominate this area.

Ironically, many of the research managers of the Japanese companies were graduate students and postgraduate fellows under Professor Jack Judy, director of the Magnetics Research Laboratory at the University of Minnesota and one of Vertimag's founders. These graduate students, whose tuition and expenses were completely paid by their companies, are now the leaders of the Japanese technical thrust in perpendicular recording. This certainly does not speak well of the ability and awareness of American industrial management.

Once a medium is available and the technology of perpendicular recording is well understood and disseminated, there will be an urgent movement toward perpendicular-recording-based data-storage systems. Since "smaller is better," we may expect to see a continuing movement toward smaller drives, even more compact than the new 3¼- and 3½-inch drives, perhaps down to something as tiny as a 1-inch floppy-disk system. ■



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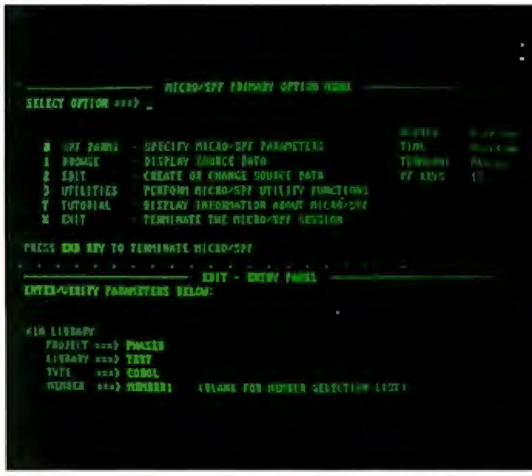


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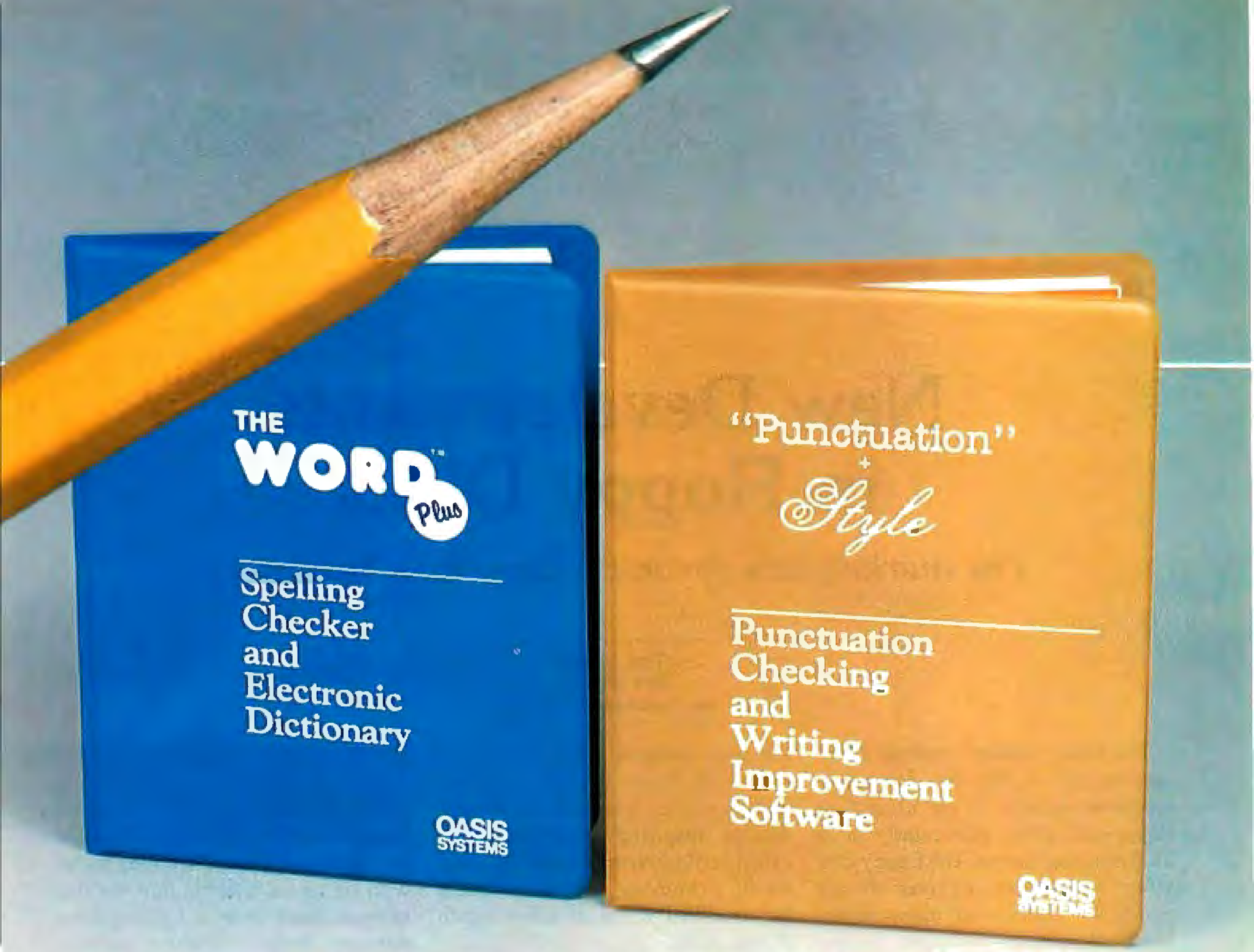
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# New Developments in Floppy Disks

*The marketplace for microfloppies is heating up.*

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The most popular method of recording and storing data for microcomputer systems is the ubiquitous floppy-disk drive, particularly in its 5¼-inch incarnation. The floppy disk offers inexpensive archival storage and is the medium for many widely available software packages. To survive in this large and robust market, manufacturers of floppy-disk drives are constantly trying to improve the price, capacity, size, and performance of their products.

Some companies are pursuing new technologies while others are relying on enhancements of proven methods. Those who are working with new technologies feel that their innovative methods are necessary to maintain the constant increase of data storage capacity that has occurred up to now. Proven methods appeal to companies that feel that advances can be made without the risks inherent in using less well known procedures.

Three different technologies that are most likely to influence floppy-disk products for computer systems and electronic typewriters are perpendicular magnetic recording (also called vertical recording, or VR), Bernoulli technology, and the exciting but muddied world of sub-5¼-inch floppy disks.

Perpendicular magnetic recording (PMR) is expected to increase the storage capacity of disk drives by re-aligning the magnetic material on the disk surface to achieve a higher density of bits per inch on a disk. Bernoulli technology is a noncontact method of recording data in which the read/write head flies in close proximity to the surface of the disk. This, in combination with other techniques, enables a floppy disk rotating at 1500 rpm (revolutions per minute) to perform very much like a Winchester hard-disk drive.

**About the Author**
*Tom Moran is a freelance technical writer living in San Francisco. He has written several articles for* Electronics *magazine.*

## "Aflopalypse" Now

The term "three-ring circus" doesn't adequately describe the efforts on the part of manufacturers to make smaller floppy-disk drives for lighter, more portable systems (see photo 1). A number of companies are now making or are about to make 3-inch, 3¼-inch, and at least three different, incompatible 3½-inch floppy-disk-drive systems. The situation is like a tag-team wrestling match with six teams jumping into the ring at once. Each team is fighting for a different design. Alliances between the teams have been made and broken. However, everyone in the contest is striving for the same objective—to have a product with the prestigious and lucrative title of "Industry Standard" for the sub-5¼-inch market.

Previously, every disk-drive standard has ultimately been decided by the marketplace and never by a committee. The advantage of being the first drive maker to ship significant quantities of a sub-5¼-inch floppy disk belongs to Sony, which makes a drive called the OA-D30V that stores 437K bytes on a 3½-inch metal hub disk within a hard plastic cartridge. But an alliance of 19 companies has gone before the ANSI (American National Standards Institute) X3B8 Committee advocating substantially different specifications from those of the Sony microfloppy disk. The


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1117 Venice Boulevard Los Angeles CA 90015 (213) 298-1297 Telex: 194561 LSA loosely knit alliance, referring to itself as the Microfloppy Standards Committee, includes media makers Verbatim Corporation, BASF Systems Corporation, Xidex, Brown Disc, Memorex, and Dennison Kybe Corporation, and drive makers Shugart Associates Inc., Micro Peripherals Inc. (MPI), Olivetti Peripheral Equipment, Luctor Corporation, and the Remex Division of the Ex-Cell-O Corporation.

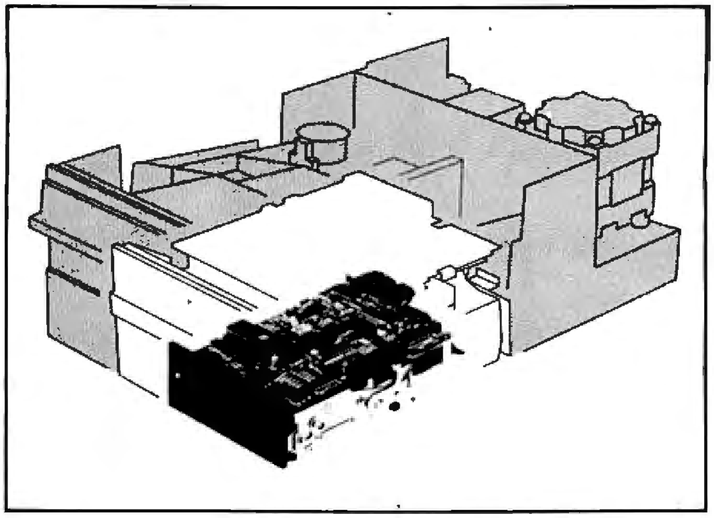

**Photo 1:** *"The Incredible Shrinking Floppy-Disk Drive." The Tandon TM35 3½-inch microfloppy-disk drive is shown in comparison with standard and half-height 8- and 5¼-inch drives. Although occupying far less volume, the microfloppy has seven-eighths of the data storage capacity of the 5¼-inch drives and more than one-half of the capacity of the 8-inch drives.*

The Microfloppy Standards Committee invited Sony and the 3-inch-drive advocates, Hitachi, Matsushita, and Maxell Corporation of America, to make technical presentations to the committee, which they did. General agreement was reached on the need for a floppy-disk drive with disks small enough to fit into a shirt pocket. Everyone attending the meeting also thought that a hard shell would be preferable to the standard vinyl floppy-disk jacket. However, the Hitachi/Matsushita/Maxell group thought that the drive should be as small as possible, while the Microfloppy Standards Committee preferred not to push the technology, opting instead for the larger 3½-inch standard it considers more reliable.

Amdek Corporation of Elk Grove Village, Illinois, is marketing the Hitachi/Matsushita/Maxell-type drive. Amdek is offering two of the 3-inch drives as a unit with a total unformatted capacity of 1 megabyte. The unit is compatible with the 5¼-inch industry-standard format and became available for end users in December 1982. The suggested retail price of the Amdisk-3 Micro-Floppy-disk Cartridge system is $799 for the two-drive unit and cables if an additional controller card is not required. Presently Amdek expects to have controller cards for the Apple II and III and IBM PC.

Micro Peripherals Inc. introduced its model 301F 3-inch design at COMDEX. It was the first American firm to manufacture and market a 3-inch drive and endorse the Hitachi/Matsushita/Maxell standard. Its drive has a capacity of 250K (unformatted) bytes per side with a "flippy" feature enabling both sides to be used for data storage. The drive features a band-type head positioner to achieve a 3-ms (millisecond) track-to-track seek time and uses standard 5¼-inch specifications such as 300-rpm rotation, 40 tps, 100 tpi, and a 250K-bit-per-second transfer rate. Disks are provided by Maxell, TDK, and others.

**Sony and the Microfloppy Standards Committee disagreed on many points, including the preferred disk rotation rate.**

Sony and the Microfloppy Standards Committee disagreed on many particulars. The most important is the committee's wish to make 3½-inch drives that are plug-compatible with standard 5¼-inch drives so that designers can use standard controllers and users can run standard software, thus keeping redesign costs to a minimum.

Sony stuck by its 600-rpm disk-rotation rate, while the committee chose 300 rpm. Sony's argument for the faster rotation is that, on smaller drives, the innermost tracks pass under the read/write head too slowly and the data-transfer rate is impaired. The committee says that the slower rotation it proposes will keep the data rate compatible with 5¼-inch drives and that the high speed Sony advocates would generate too much heat, causing reliability problems due to expansion and contraction of the disks during use. Again for reasons of compatibility with extant 5¼-inch drives, the committee opted to widen the read/write window to allow more tracks without greater track density, recommending 40 or 80 tracks per side (tps) on either one or both sides of the disk. Currently, the highest capacity in this format would be 1 megabyte of unformatted storage.

Most of the physical dimensions of the standard suggested by the Microfloppy Standards Committee are the same as those of the Sony drive. However, the medium used by Sony is nominally 580 oersteds, 100 microinches thick, while the committee's standard would use a medium of 650 oersteds, 40 to 50 microinches thick. [**Editor's note:** *An oersted is a unit of magnetic resistance used to quantify the performance of magnetic media.*] Members of the committee say that Sony's medium is unique, but a number of companies, including some that are not members of the committee, are developing new media similar to that specified by the committee. Although the committee agrees with Sony's use of hard-shell cases for the media, it wants to add further protection in the form of an automatic shutter that will open the

head-access window when the disk is inserted into the drive and close it when the disk is removed.

The major backers of the Microfloppy Standards Committee are Shugart and Verbatim, which expect to have limited production quantities of drives and media available early in the third quarter of 1983. Industry analysts believe that 4 million sub-5¼-inch drives will be produced by all manufacturers in 1983. According to Malcolm Northrup, president of Verbatim, in a few years shipments of all sub-5¼-inch systems may grow as large as 151 million units.

Two years from now Toshiba Corporation of Tokyo expects to be in production of its recently announced PMR 3½-inch 3-megabyte floppy-disk drive. Although a lot of development is left to be done, the company clearly hopes to get a jump on competitors by announcing its new technology now. The drive's hard plastic cartridge with autoshutter contains a 75-micron-thick polyester disk that is sputter-coated on both sides with a 0.5-micron layer of cobalt chromium. The cartridge is 90 by 92 by 3 mm. The recording density will be 50,000 bits per inch (bpi) at 144 tracks per inch (tpi) compared to 5500 bpi at 48 tpi for conventional longitudinal data recording. This is 7 or 8 times the density of most longitudinal recording. The entire drive measures only 100 by 130 by 40 mm.

In the 3¼-inch corner, two dropouts from the Microfloppy Standards Committee who submitted their own proposal to the X3B8 committee, drive-maker Tabor and disk-maker Dysan, have recently been joined by Seagate Technology, which will become a second source for Tabor drives.

Tabor calls its 3¼-inch floppy-disk drive the Model TC 500 Drivette and says it's the first in a family of drives with different capacities. The single-sided drive uses a soft vinyl jacket and records in either FM or MFM (frequency modulation or modified frequency modulation) on 80 tracks at a density of 140 tpi. When recording is in FM, the bit density is 4625 bpi, and when in MFM, it is 9250 bpi. Data transfer is 250K bits per second

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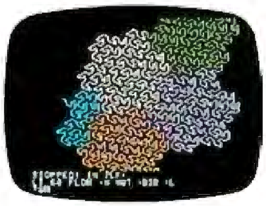

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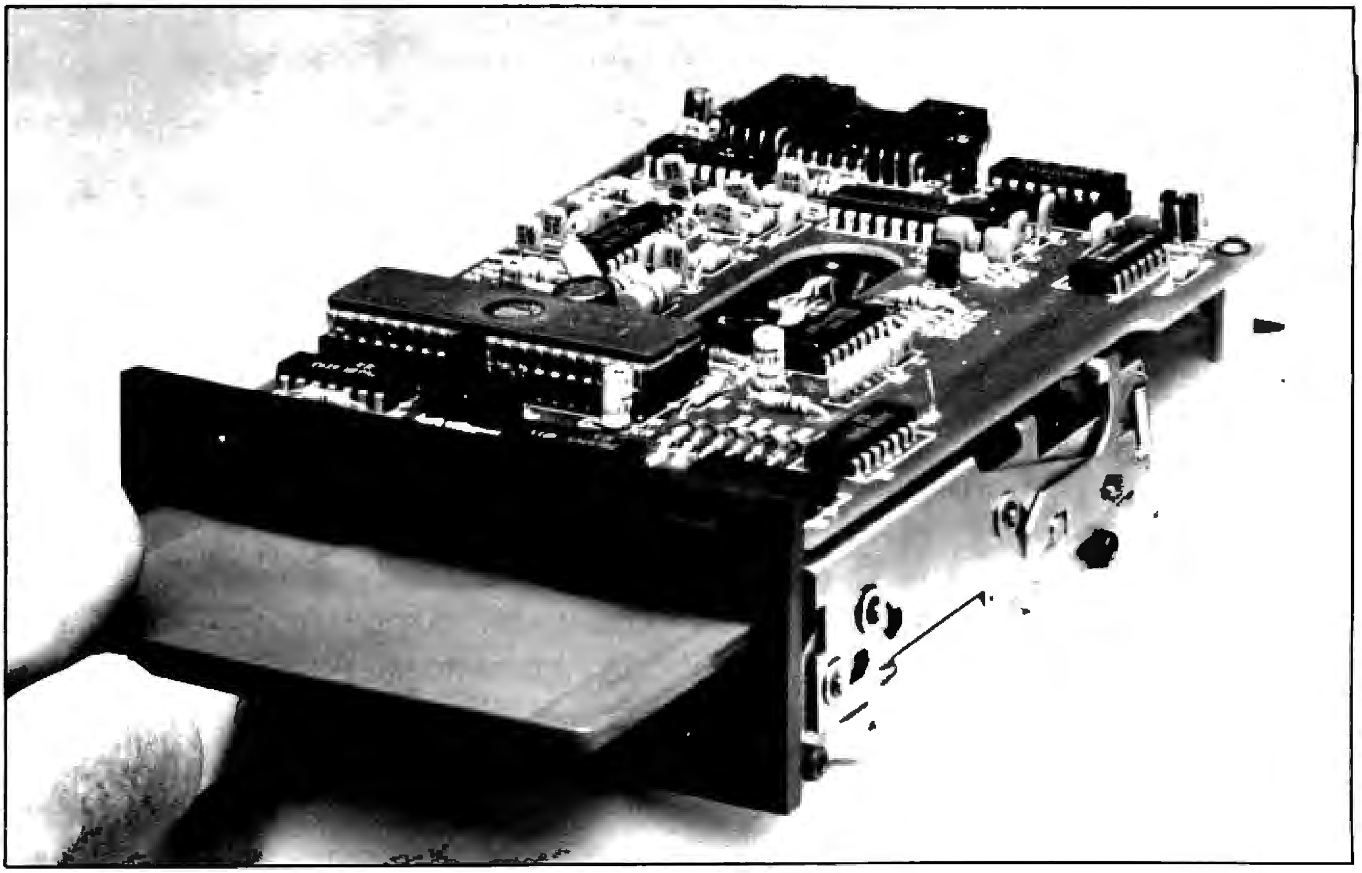

**Photo 2:** *The Tandon TM35-2 microfloppy-disk drive, which is compatible with standard 5¼-inch drive controllers, has a rigid cartridge enclosing the magnetic medium.*

(FM). The 1.625- by 4- by 5.5-inch drive weighs 1.6 pounds and records 250K bytes (unformatted) per disk in FM and 500K bytes in MFM. The company, started in January 1982, is based in Westford, Massachusetts. Some units were in early evaluation in December, and volume production started in January of this year.

According to Tabor, Seagate had previously agreed to make drives in the Sony format but decided not to when Sony would let it assemble only Sony components instead of making complete drives. Another problem was that Seagate thought that double-sided versions of the Sony drive would be unstable. However, Sony can take some comfort from a $30-million contract with Hewlett-Packard for drives to be integrated into HP's systems. Hewlett-Packard has indicated that it chose the Sony system because it is already in production and that HP will support the Sony system as the standard.

Another disk-drive manufacturer, Tandon Corporation, has recently introduced its TM35 Microline 3½-inch microfloppy in two models (see photo 2). The TM35-2 is compatible with the standard 5¼-inch interface, and the TM35-4 is compatible with the Sony OA-D30V microfloppy's interface, software, and disks, but it records data on both sides of its disk. Both models of the TM35 store 875K bytes using both sides of the disk. The TM35-4 has an average access time of 70 ms, and the TM35-2, 100 ms. The devices measure 1⅝ by 4 by 6½ inches. The TM35-4 records 7610 bpi at 135 tpi and 70 tps, while the TM35-2 records 3617/7610 bpi, 135 tpi, and 40 tps. The two models have an onboard Intel 8084 microprocessor to control spindle speed and head positioning, and a brushless direct-drive DC motor. Tandon is using the Sony-type disks for the drives and says that an automatic shutter is available for the rigid cartridge.

Tandon says that it's not hedging bets, just providing products for different markets. According to Tandon representative Al Erickson, Sony and Hewlett-Packard will be putting Sony-type drives into instruments and new office equipment that have nothing to do with the 5¼-inch-drive market. Tandon expects there will be more than one market and more than one application for both of these drive forms. In fact, Tandon withdrew from the standards committee because president Jugi Tandon felt that market acceptance will determine the standard as it has done before. The company planned to deliver evaluation units in the first quarter of 1983 with high-volume production following later in the year. In large OEM (original-equipment-manufacturer) quantities, the TM35s will cost $200 to $250 each.

Many companies don't seem terribly worried about the eventual outcome in the sub-5¼-inch market. Most express confidence that the standards they are backing will do well and add that, even if the market goes against them, it won't take them more than six months to a year to retool to meet the new demand.

Even if the magnetic dust clears up tomorrow and one microfloppy-drive format emerges victorious, it will still

have an inherent problem. The standard microfloppy-to-be may well be compatible with 5¼-inch controllers and software, but incompatibility between the 3½-inch microfloppies and 5¼-inch floppy disks will be axiomatic.

### Perpendicular Magnetic Recording

Although a lot of room still exists to increase track densities and thus capacity, the limitations of conventional recording techniques are beginning to be reached, and perpendicular, or vertical, magnetic recording seems a likely next step (see also "The Promise of Perpendicular Magnetic Recording" by Clark E. Johnson Jr., page 56). In media in use now, the magnetic particles are laid end to end along the direction of the media's tracks. PMR "stacks" the magnets side by side vertically. This not only increases the number of bits that can be stored in the same space, it reduces the self-demagnetizing effect, which lessens as the length-to-thickness ratio of a magnet decreases. One way to keep a favorable length-to-thickness ratio is to decrease the thickness of the medium by developing a thin-film disk. Unfortunately, although thin-film disks have been used in well-functioning prototypes many times, no one has been able to produce them economically and reliably in large quantities. In the words of one industry observer, "thin-film media have been just around the corner for nine years, and they're still not here. Something tells me they never will be."

Because PMR records the bits "into" the medium rather than along it, the length is determined by the thickness of the substrate. And, as density increases along the track, the length-to-thickness ratio is actually improved, so that the self-demagnetizing effect approaches zero. However, this does not mean that there are no problems with this technology. In the past, prominent industry analysts have expressed skepticism about the possibility of recording vertically, saying that recording takes place not vertically or horizontally but somewhere in between. In fact, the greatest need in working with PMR is to find a medium substrate that can be vertically oriented in a consistent pattern on the disk's surface.

The best substrate candidate so far seems to be cobalt chromium, which can be deposited in hexagonal crystals on the disk's surface under carefully controlled conditions. The best method found so far for coating disks is *vacuum sputtering*, which, although slow, has been extensively perfected by the semiconductor industry, which uses sputtering to coat silicon wafers.

Vertimag Systems Corporation of Minneapolis, Minnesota, expects to start production of a 5¼-inch floppy-disk drive using PMR in 1984. Already demonstrated in prototype, its system will provide 5 megabytes of storage in a form compatible with the SA400 standard from Shugart. In fact, the drive will use Shugart's me-





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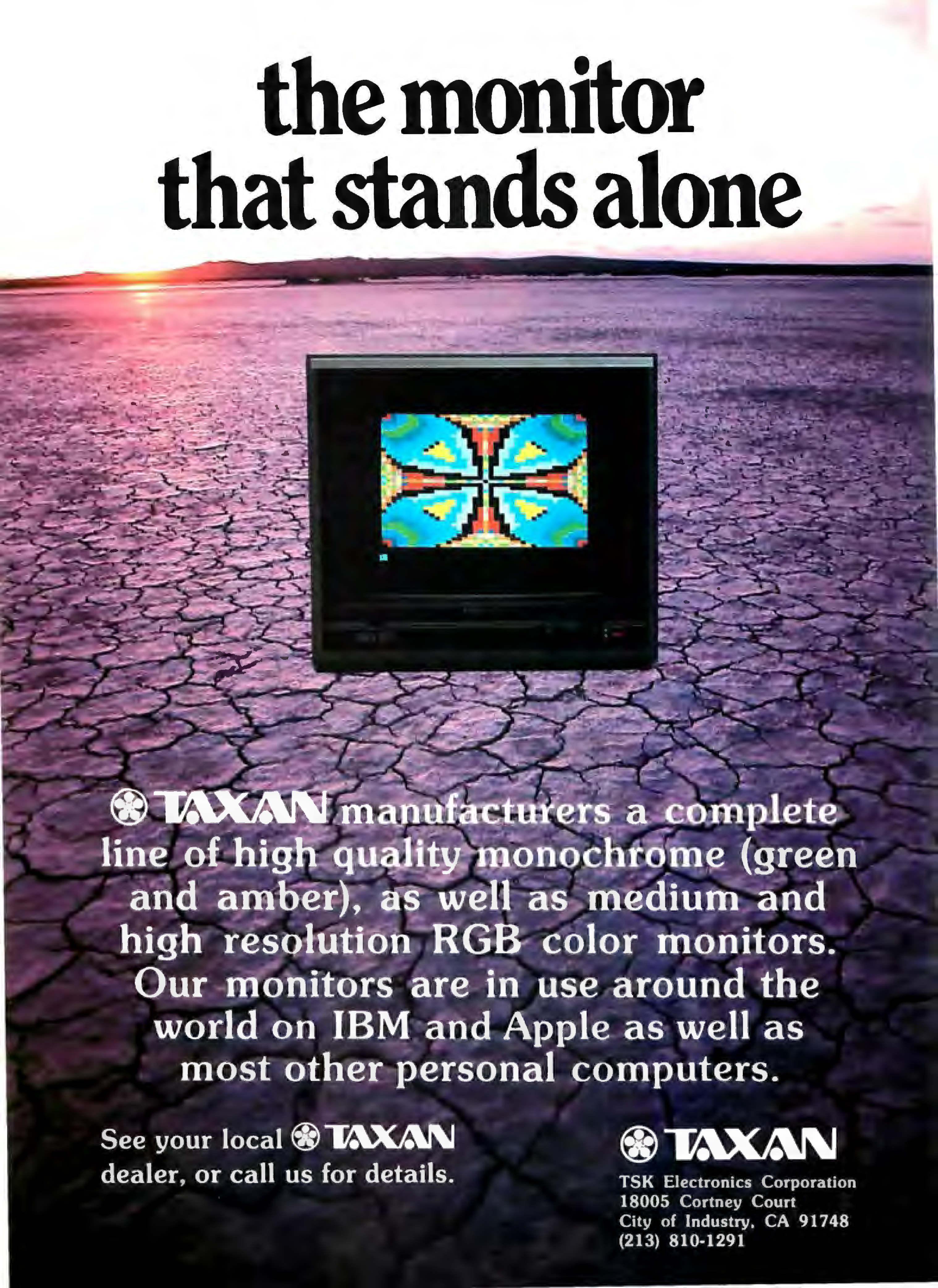
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chanical components and Vertimag's own cobalt-chromium-sputtered disks. Data will be stored at 96 tpi, and up to 36,000 bpi will be recorded on the inner tracks using a form of MFM. According to Clark E. Johnson Jr., president of Vertimag, the drive will have a data transfer rate of 1.7 megabits per second and will sell for less than $500 in OEM quantities.

## Flying with Bernoulli Technology

Another company that's using innovative techniques is Iomega Corporation of Ogden, Utah, which is making a 10-megabyte 8-inch floppy-disk drive, the Alpha 10, using Bernoulli technology. With this technique, founded on principles discovered 200 years ago by Swiss physicist Daniel Bernoulli, the head "flies" less than 10 microinches above the surface of the medium. The drive uses a large flat surface called the Bernoulli plate that is positioned 0.005 inch from the disk, which spins at 1500 rpm. The spinning of the disk creates an airflow moving from the middle of the disk radially outward to its circumference. This lowers the air pressure and pulls the medium evenly toward the Bernoulli plate. A hole in the plate allows the medium to be accessed by the read/write head, which is hydrodynamically mounted. The airflow ensures that the disk is reliably positioned and that it does not touch the plate. This noncontact arrangement means less wear and greater reliability than is normally found, for example, in Winchester hard-disk drives. In fact, Iomega says that its 8-inch floppy disk has reliability advantages over Winchesters because the design of the head assembly causes contaminants to be flushed out of the system away from the read/write area and because the airflow cushion damps shock and vibration of the disk and read/write head configuration, resulting in less chance of head crashes. Because the head and disk are brought together by the Bernoulli effect, not by springs, any shock to the system will act to decouple them, thus avoiding a collision and resulting in a soft data error instead of a catastrophic failure. When the passing contaminant has cleared the area, the head and disk recouple.

Because the system's compliance is in the disk itself, no gimbal arrangement is necessary for the arm and read/write head. In fact, the drive has only two moving parts, the rotary head actuator and the spindle motor.

The Alpha 10 has a closed-loop embedded servomechanism in each track, allowing 300 tpi recording. The present bit density is 24,000 bpi using run-length-limited code, and Iomega is looking closely at the possibility of increasing that with PMR. Data is transferred at 1.13 megabytes per second. Production of the Alpha 10 started in September 1982. Meanwhile, Iomega is working on a 5¼-inch drive called the Beta 5 that uses the same technology. The new drive will store 5 megabytes of formatted data, and the disk will rotate at 1964 rpm. The Beta 5 will use 434 tpi and 17,000 bpi and have a standard (Winchester) data-transfer rate of 5 megabits per second. Iomega says that the Bournelli technology translates well to a smaller size because smaller disks are easier to stabilize. Both the 5¼-inch drive and the Alpha 10 use the industry-standard disk interface.

Although Iomega is currently the only manufacturer shipping Bernoulli drives, the company believes Bernoulli technology is the way of the future because of its inherent advantages of a cheap medium, Winchester-like performance and capacity, and extreme simplicity of design. Second sources of the Alpha 10 are expected to be announced soon, and Iomega says that IBM and others are working on similar systems.

## High Capacity with Proven Technology

Drivetec Inc., of San Jose, California, founded by Herb Thompson, one of the founders of Shugart Associates, is a company that believes in fine-tuning proven technology. The year-old company's first product, announced in November 1982, is called the Drivetec 320 Superminifloppy and offers 3.33 megabytes of unformatted storage in a half-height

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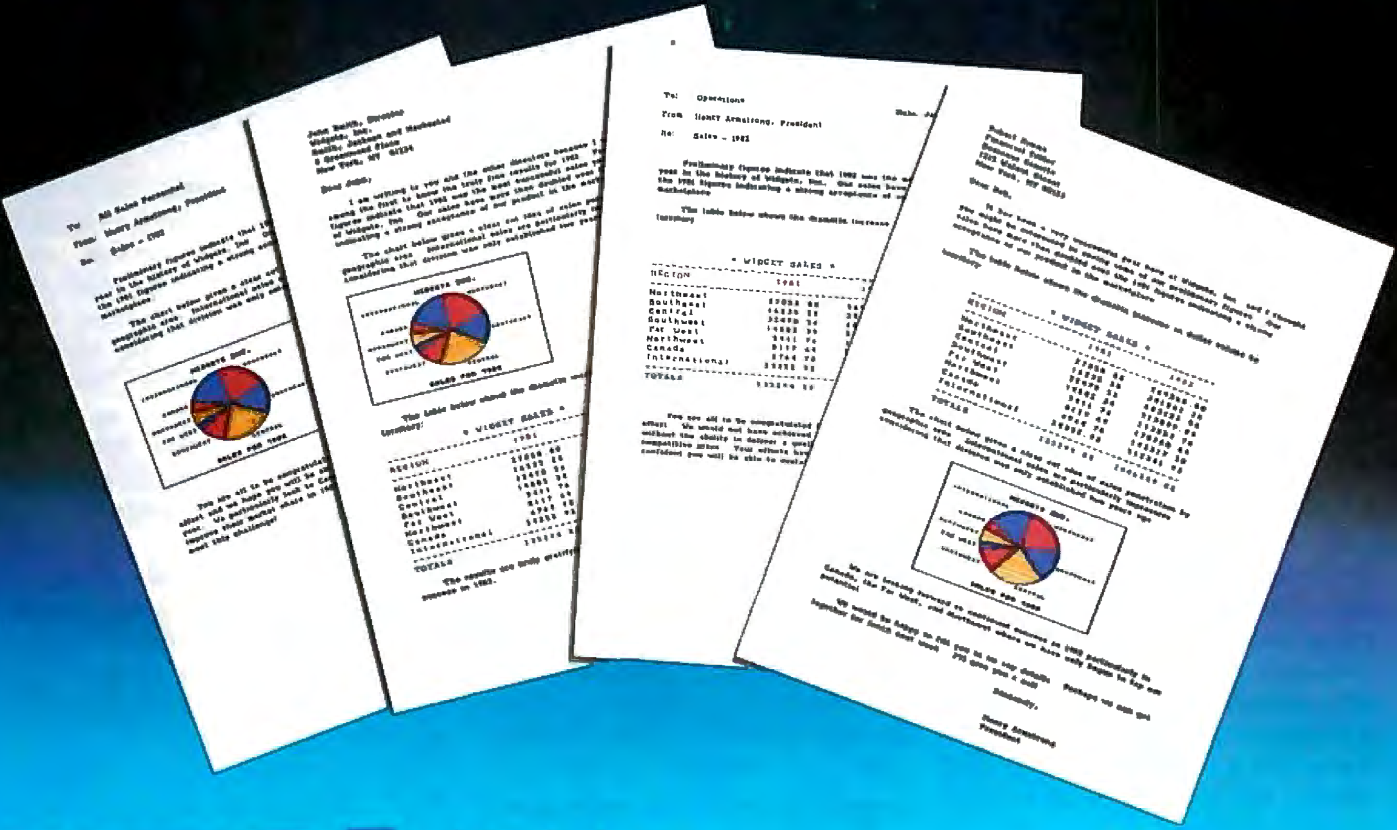

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5¼-inch drive. The Drivetec 320 has a proprietary track-following embedded servo system that allows recording of 192 tpi, and its linear recording density is approximately 9908 bpi (see photo 3). A two-stepper system uses one stepper for large head movements and another for fine adjustments, so that the two recording heads can be moved in 200-microinch increments. The medium is a special preformatted 50-microinch-thick oxide coating on a platter that allows much higher bit densities and track densities than conventional 100-microinch-thick media. The drive has an onboard microprocessor, a brushless DC motor, and buffered track seek and is designed to be downward compatible with 48-tpi disks. Data is transferred at 500K bits per second.

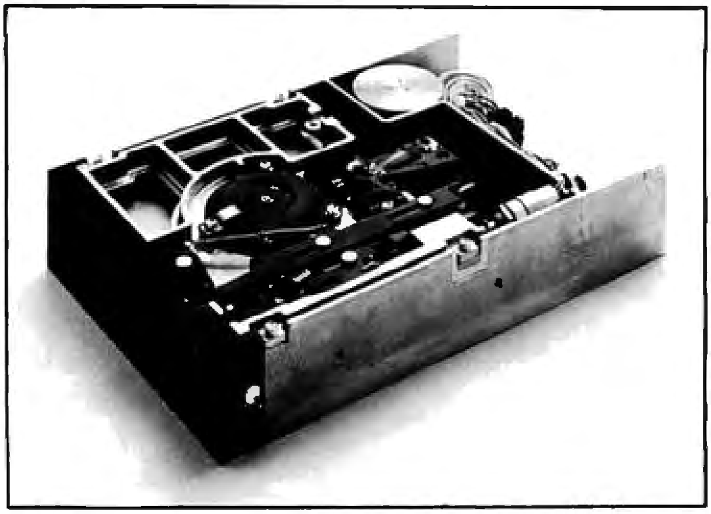

**Photo 3:** *Drivetec 320 Superminifloppy. Based on established technology, the Drivetec offers 3 megabytes of storage in a half-height 5¼-inch drive.*

Drivetec expects to ship evaluation units in the first quarter of 1983, with manufacturing start-up scheduled for the second quarter. The Drivetec 320 will cost less than $325 each in OEM quantities of 1000.

Drivetec's Herb Thompson believes that long-term trends will be the fine tuning of established technologies. "I built the first floppy disk at IBM in 1967," he says, "and it really hasn't changed a bit since then, except that performance has dramatically increased. It still has a long way to go, of course, but I don't want to argue with success. Why should I go off and start up with thin-film heads and exotic media when the chances of failure are so high?" Thompson goes on to say that PMR is another buzzword like thin-film heads and bubble memories. "I wouldn't hold my breath waiting for vertical recording because it requires thin-film heads and they're not cost-effective and I don't see them becoming so." He also doesn't think that cobalt chromium substrates will be the medium of the future unless there's a major breakthrough. "I saw plated media 20 years ago; IBM's done a huge amount of research on them and threw them out. I wouldn't risk my company on anything less than proven technology."

### Half-Height Floppy Disks

Tandon, Shugart, and Qume are now offering half-height 5¼-inch floppy-disk drives, the form that is the most serious threat to microfloppies in the portable, low-cost, and small-computer-systems markets. Shugart is producing two models, the SA455 and the SA465. The SA455 uses 48 tpi and stores 250K or 500K bytes, while the SA465 has a 500K-byte single-density and 1-megabyte double-density capacity with 96 tpi (all unformatted). Both double-sided drives are compatible with the standard floppy-disk interface and, like other half-height drives, use brushless direct-drive DC motors that reduce the size of the drives by eliminating belts, pulleys, and bearings used with AC motors. Evaluation-model shipping was due in the fourth quarter of 1982, with volume production to follow in the first quarter of 1983. In quantities of 5000, the SA455 is priced at $160 and the SA465 at $195. Average access time is about 94 ms, and data-transfer rate is 125K or 250K bits per second depending on whether single or dual density is used.

**Specially formulated disks from Verbatim Corporation will be used by Apple Computer and Amlyn in new drives.**

Tandon's half-height 5¼-inch drive is offered in two versions, one costing $100, and the other, a mechanism-only version, is $50 in very large OEM quantities. The TM50 uses double-density single-sided recording and 48 tpi to store 250K bytes in a 5.75- by 1.625- by 8-inch package. Average access time is 267 ms.

Qume's half-height 5¼-inch drive offering is the Qumetrak 142, a double-sided 48-tpi drive that stores 500K bytes unformatted. Its average access time is 175 ms. High-volume OEM prices are expected to be less than $150 each.

NEC has introduced a half-height 8-inch floppy-disk drive, the FD 1165, with storage capacity of 1.6 megabytes using double density and both sides of the disk. The FD 1165 is priced at $525 each for quantities of 100; in quantities of 300 the cost is $395 each.

### Super Disks

Specially formulated disks from Verbatim Corporation will be used in new drives from Apple Computer and Amlyn. The disks will have a 50-microinch coating of cobalt-impregnated gamma iron oxide with a magnetic resistance of 625 oersteds instead of the standard 300 oersteds and will have a 17-year warranty. Apple will use the disks in two new full-sized drives, the Apple Unifile and the Apple Duofile. The Unifile will store 871K bytes formatted on 62.5 tpi at 10,000 bpi. The Duofile will contain 1.7 megabytes formatted. The Apple drives are designed

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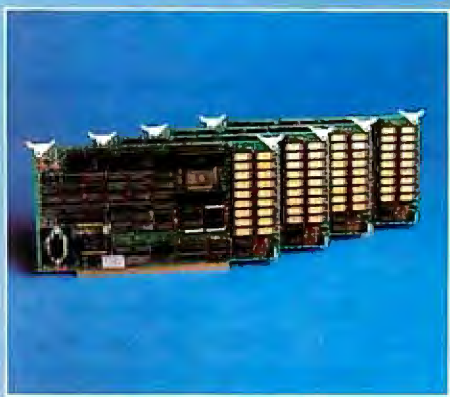

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### Multicartridge Drives

The Amlyn drive belongs to the multicartridge drive category. It uses five-disk Mini Pack cartridges, each storing 1.6 megabytes of unformatted data on one side using 170 tpi at 9500 bpi and 154 tracks. The unformatted capacity of each cartridge will be 8 megabytes, and the user will be able to remove one or all of the five 5¼-inch disks at will.

Another drive that uses multiple disks is the Mega-Mate, made by Mega-Data Computer Products Inc. of Overland Park, Kansas. The Mega-Mate contains an interchangeable 40-disk magazine that stores 5 formatted megabytes on one side of all the disks. The magazine can be reversed to provide an additional 5-megabyte capacity. The drive itself is priced at $695, and additional magazines are $70.

### Conclusion

The current revolution in data-storage technology poses an interesting problem for end users. On one hand, the size reduction and increased storage of the new microfloppies offers several advantages to small-computer-system designers. Drives could be incorporated into a handier, less conspicuous area on a computer. Two microfloppies could, for example, be placed underneath a standard-sized keyboard.

On the other hand, with the proliferation of different formats and data-storage technologies, end users could find themselves stuck with an orphan disk-drive system. And the subsequent lack of inexpensive media and support could become very expensive.

Although microfloppies and improved data-storage technologies will have their market, there is a simpler method for increasing the transportability and convenience of existing 5¼-inch floppy disks. Just have all the shirt makers agree upon a standard 5½-inch pocket. ■

## BYTE's Bugs

### Gremlins Gobble Up-Arrows

It looks like gremlins have struck once again. This time they invaded the program listing in "High-Speed Pascal Text File I/O" by K. Brook Richan and James S. Rosenvall (January 1983 BYTE, page 454). The program listing for FASTIODEMO (listing 1) should have up-arrows in several places but, unfortunately, doesn't. Anyone interested in obtaining a copy of the corrected listing may do so by sending a legal-size self-addressed envelope with $0.37 U.S. postage to:

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# Optical-Memory Media

*How optical disks work, who makes them, and how much data they can hold.*

Edward Rothchild
Optical Memory Newsletter
POB 14817,
San Francisco, CA 94114

Laser videodisks and players have been commercially available for over five years, but the commercial use of this technology for storage of digital data has been delayed. Although building optical mass-storage drives is not a trivial exercise, perfecting and fabricating the optical media has proved to be an even more difficult task. Nevertheless, it appears likely that a variety of American, European, and Japanese firms will present prototype optical-memory systems and media at computer and micrographics trade shows this spring, with "beta testing" (initial user tests) occurring by year-end. Commercial availability finally seems to be at hand.

I'll now try to describe the composition and performance characteristics of the various types of nonerasable optical-memory media that will most likely be used with the first-generation optical drives, and I'll indicate possible directions in which the industry can be expected to move as the second-generation drives and erasable media are introduced toward the end of the 1980s.

## Lack of Disk Standards

Just as a wide variety of magnetic disk drives and media have been designed for different applications, performance characteristics, and price, so, too, a wide range of optical drives and media will eventually be available. Unfortunately, the optical-recording community has made little movement to agree on standards for the infant industry. Recent meetings have not even been able to agree on the size of the center hole in the disk, let alone the disk's composition, diameter, thickness, or performance. Every manufacturer is trying to position its product to become the de facto standard.

Disks are being made now in 12- and 14-inch diameters, with 8-, 5¼-, 3-, and possibly 2-inch disks likely in the near future for use in small computers. Media for both the current least-capacity and greatest-capacity systems are rectangular cards or slides, and some firms are offering experimental optical reel-to-reel tapes and cassettes for a variety of applications, large and small.

The most important reasons for the delay in introduction of optical recording technology are problems with the stability, archivability (shelf life), data integrity, and producibility of the media themselves. No one knows for sure just which material or combination of materials will gain acceptance in the marketplace. Many major computer companies planning to introduce optical media are hedging their bets by developing several different types.

## Starting an Industry

No one wants the optical-memory industry to suffer the embarrassing fiasco (and lawsuits) experienced by those firms trying to commercialize video tape for document storage and retrieval in the 1960s. Before any significant part of the computer-user community can be expected to transfer existing records or store new data on a new medium, that medium must be reliable and widely perceived to be so.

The first generation of optical mass-storage devices will be based almost exclusively on lasers writing data by distorting thin metal films. In some systems, the laser burns holes in

**About the Author**
*Edward S. Rothchild is a consultant and publisher of the* Optical Memory Newsletter Including Interactive Videodisks.

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the thin metal film; this process is called ablation. In other processes being developed by 3M Company and France's Thomson-CSF, bubbles or blisters are raised by lasers. In still others, a phase change in the index of reflectivity is created without either ablating or blistering the thin metal film's surface.

Regardless of which technique is used, the pattern of holes, bubbles, or marks in the medium surface causes the read-back laser beam to be deflected at specific intervals, thus reproducing the original binary bit pattern. The size or position of the hole, blister, or mark relative to its neighbors may also be used to encode binary information onto the medium.

### Tellurium-Based Media

To date, over 70 percent of the research into materials for optical-memory media has concentrated on a rare nonmetallic element, tellurium, which resembles sulfur and selenium in chemical properties. Although tellurium is sometimes found native in white crystals, it is usually found alloyed with other elements. The chief reason for this is that pure tellurium oxidizes rapidly when in contact with moisture. Tellurium is somewhat toxic (and gives workers in contact with it a bad case of body odor). Researchers, nevertheless, have concentrated on finding ways to prevent tellurium from oxidizing, such as by overcoating it, encapsulating it, building bilayered, trilayered, or Philips' Air-Sandwich structures, or alloying it with more stable elements such as selenium or arsenic.

Tellurium has been favored primarily because of its low melting point (450°C) and high sensitivity. However, much optical-media research in recent years has concentrated on finding viable alternatives to tellurium. Among these are silver halide and gold/platinum alloys. Tellurium has its champions as well as detractors; most systems to be commercially tested this year will use tellurium or one of these alternatives. Firms that already have or are planning to show tellurium-based optical-media products in 1983 include Control Data Corporation (CDC), Fujitsu, Hitachi, Matsushita, Omex, Philips, RCA, Storage Technology, Toshiba, and Xerox.

### Japanese Optical-Memory Media

Japanese-developed media lean heavily toward tellurium alloys, including tellurium suboxide, tellurium/carbon alloy, and tellurium/copper alloy. Toshiba and 3M have been showing Toshiba's DF-2100 (tellurium/carbon alloy medium) document-storage system at computer and micrographics shows for over a year. Toshiba claims a 40-year archival life for its medium.

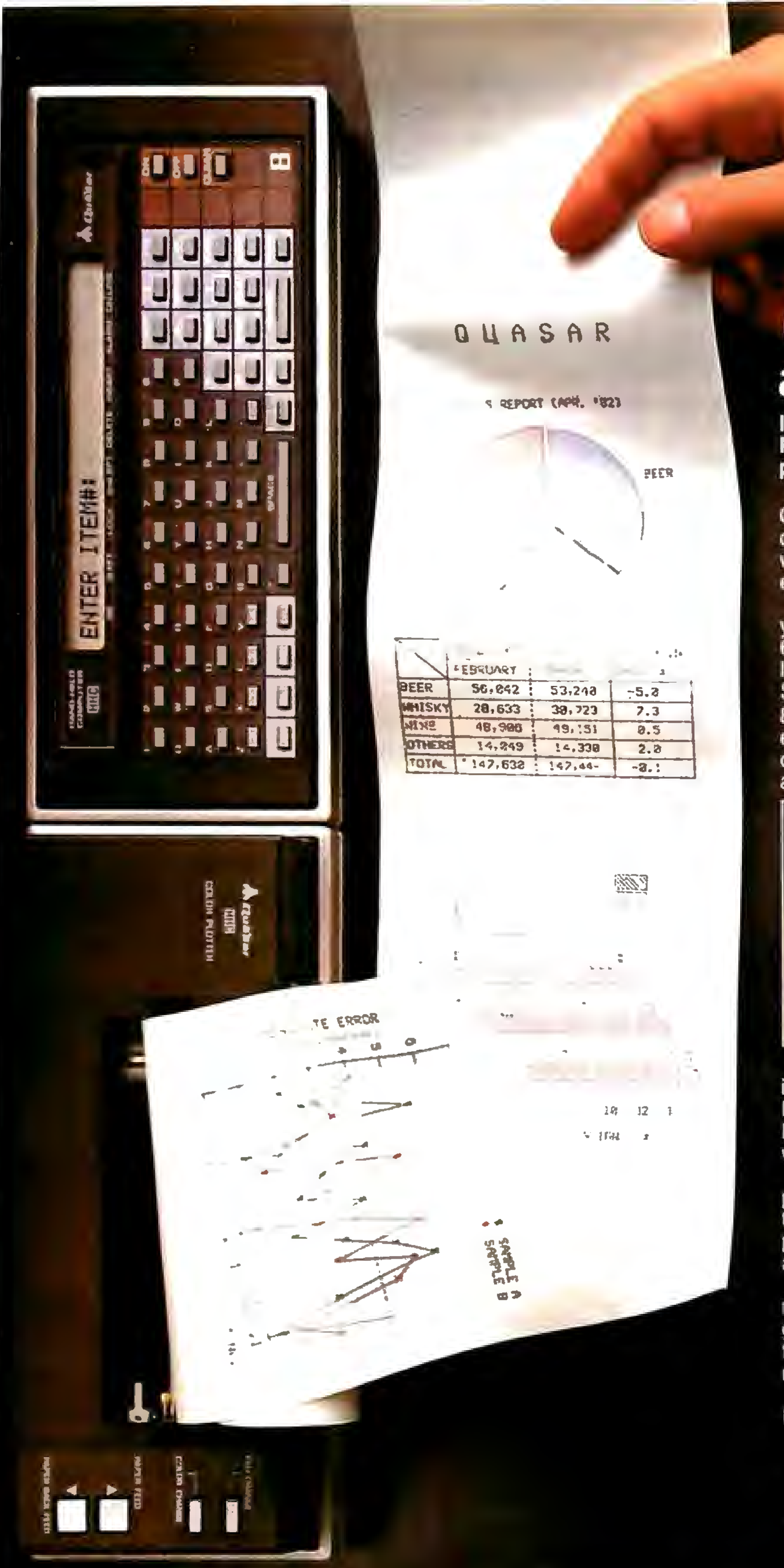
Matsushita, under the Panasonic label, has been showing prototype DRAW (direct-read-after-write) still-frame analog video recorders using diode lasers; they are able to store 15,000 images on one side of an 8-inch tellurium suboxide disk. Digital DRAW recorders are expected from Matsushita shortly, and Fujitsu is expected to use a tellurium/copper alloy in its high-end optical recording medium.

### Other Media

Gold/platinum alloy optical media are being developed by the French firm Thomson-CSF in cooperation with the Optimem project in Xerox's Shugart Division. Silver halide is the metal used in the only optical medium now commercially available, Drexler Technology Corporation's Drexon. Kodak is quite far along in development of a polymer/dye binder optical medium that uses no thin metal film.

### Desired Characteristics

Regardless of the materials used, optical media should have the following general characteristics: long-term archival storage ability, high absorptivity at the recording wavelength, low writing energy, low manufacturing cost, high signal-to-noise ratio, good hole- (or bubble- or mark-) forming characteristics, low thermal

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### Erasable Reusable Media

Originally, optical media's lack of erasability was considered by many to be a shortcoming. However, more recent thought has recognized that for most applications it is not desirable that optical media be erasable. This is because optical media will occupy a different place in the memory hierarchy than most magnetic media and will be preferred for archival and massive data-collection jobs where there is more need to preserve the information than to erase and update it.

Because optical media typically contain up to 100 times the storage capacity of the same size magnetic media, they provide storage at a small fraction of the cost per user-byte for magnetic media. Optical media in systems to be shown this year range in capacity from 1¼ to 4 gigabytes (a gigabyte is 1024 megabytes). Being able to erase and reuse an optical disk is not an economic consideration as it is with more expensive magnetic disks. Far more important than erasability is the convenience of removing optical disks and their much longer life in an archive; one need not rerecord optical disks every two to three years.

### Erasable vs. Nonerasable Media

With the luxury of so much storage space available, many computer scientists feel that rather than erase data on optical disks, it is preferable merely to put a disabling code in each obsolete data sector with a pointer to updated information. Thus, if an audit trail must be done to find out how an answer was constructed, the original data will not have been obliterated.

Nevertheless, erasability would definitely be desirable in some applications, and research organizations around the world are increasing their efforts to identify the best techniques for achieving erasable and reusable optical media. Laboratory experiments have offered encouraging results, and commercial availability can be expected around 1986, at which time optical media can be expected to seriously affect magnetic media sales. Until then, optical media will complement rather than compete with magnetic media. The storage media most likely to be hurt by optical media in the near term are reel-to-reel magnetic tape and microfiche for archival data and document storage.

A variety of approaches to erasability are being tested in laboratories. Dr. Alan Bell, now with IBM's Research Laboratories in San Jose, California, described the state-of-the-art thinking on the subject in the March/April 1982 issue of *Optical Memory Newsletter*, and he concluded that recent developments in the U.S. and Japan in magneto-optic materials using encapsulated trilayer structures now look more promising for erasability than they did in the 1970s when phase changes were caused by using amorphous semiconductors that recorded at one





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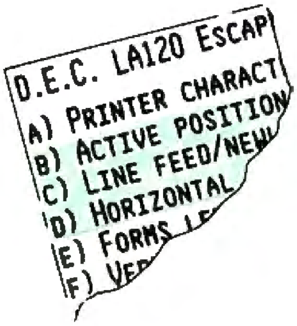


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temperature and erased at another.

Robert McFarlane of North American Philips Laboratories predicts that reversible media are three to five years away; magneto-optics will probably be developed first, especially by Matsushita and Hitachi in Japan, and phase-change erasable techniques will be less likely. Philips has published very little about its reversible-media research.

This, however, is not the unanimous view; Edward LaBudde, general manager of Burroughs' optical recording program, sees amorphous-to-crystalline phase transition as the most promising technique. Despite heavy work in magneto-optics by the Japanese as well as Xerox and IBM, LaBudde doubts that the contrast and signal-to-noise ratio will be sufficient for most applications. Burroughs is not concentrating much effort on reversible media now. Compared with the problems in perfecting erasable media, developing nonerasable media seems trivial.

## Error Rates

Corrected BERs (bit error rates) satisfactory to both the mainframe computer and micrographics industries seem to have been attained within the past year. However, it is necessary to link discussion of the BER with each application, taking into account the seriousness of an error versus the cost of correcting it. Although magnetic media for mainframe data applications have corrected (or "hard") BERs of 1 in $10^{13}$, not all magnetic media require it; floppy disks typically have a corrected BER of 1 in $10^9$. For document-storage applications, where images rather than digital data are recorded, a corrected BER of 1 in $10^6$ is more than adequate. An error in that range will show up as a tiny black speck on a high-resolution image.

Typically the "raw" (uncorrected) BER of optical media is 1 in $10^6$. New techniques in EDAC (error detection and correction) codes bring the uncorrected user BER up to 1 in $10^{13}$ but require from 10 to 50 percent of the disk's total capacity to do so. The most dramatic breakthrough in EDAC is from Storage Technology Corporation (STC), which claims corrected BER of 1 in $10^{13}$ with overhead of only 20 to 30 percent of the disk's capacity while leaving users with a 4-gigabyte capacity on one side of a 14-inch tellurium-based multilayer disk.

## Data Transfer Rates

Burroughs and STC are developing 14-inch disks for high-end, sophisticated mainframe applications, but not all optical memory systems will be used with mainframes. Most optical-memory drives and media will be sought by the mid-range and low-end of the market for use with minicomputers and microcomputers for both digital data and office automation applications. The capacity of the first-generation disks will typically be 1 to 2 gigabytes; the disks and drives will be much less ex-

pensive than the high-capacity, high-performance systems designed for mainframe environments. Burroughs' medium will handle transfer rates of 12 million bps (bits per second); STC's will handle 24 million bps. The medium being jointly developed by Control Data and Philips for mid-range office automation jobs handles 5 million bps.

### Optical Media Costs

What will optical media cost? Most manufacturers predict that within a year 1- to 2-gigabyte disks will sell to end users for about $150; 2- to 4-gigabyte disks will cost $200 to $300 initially. STC foresees a cost of $100 to $150 for its 4-gigabyte disk by 1985. By the end of the decade, when yields should make it possible to build millions of disks annually, most optical-media developers see user costs dropping to $15 for a nonerasable disk.

Assuming that high yields have been achieved, STC spokesmen feel that by 1990 the cost of putting down a bit on optical media will have dropped to the equivalent of putting a bit down on paper, or around 15 cents per megabyte.

A market-research study offered for sale by Rothchild Consultants predicts that in 1986 erasable media would cost a premium of 50 percent over nonerasable disks, dropping to a 25 percent premium by 1990, when they should capture 40 percent of the optical-disk market.

### Ease of Handling

Ease of handling is one of the strongest arguments in favor of optical disks over magnetic media. Although most optical-media developers now favor encapsulating their disks in protective overcoats or cartridges, all optical media are removable from the drive, unlike most high-capacity magnetic disks. Furthermore, the optical disks are much less susceptible to being damaged by heat or humidity, and neither fingerprints nor magnetic fields can affect optical disks.

Their ease of handling makes it possible to develop automatic disk-changing mechanisms (similar to jukeboxes) for optical disks. The

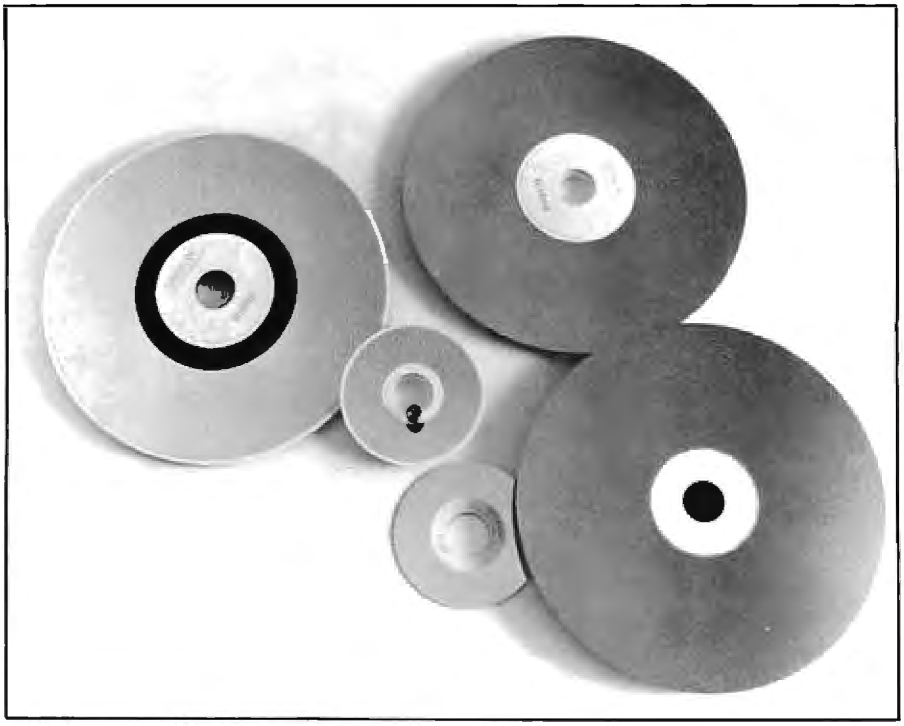

**Photo 1:** *The Drexon family of optical disks. Disks are available in 12-inch and 4.7-inch sizes, with or without the clear protective cover plate. Near the center of one of the smaller disks is a semiconductor-diode laser used for recording and reading optical disks. The larger disks have a capacity of 1250 megabytes per side, while the 4.7-inch disks can store 200 megabytes per side. Disks are recorded with 0.8-micron to 1.0-micron holes burned into their reflective surface. (Photo by Victor Budnik.)*

most ambitious design is one STC has for a 500-disk IBM-compatible device which, with 4-gigabyte capacity per disk, gives users online access in seconds to 2 terabytes (2 million megabytes)!

## Drexler's Drexon Medium

The first company to offer optical recording media on a commercial basis is Drexler Technology Corporation of Mountain View, California. One of the world's largest suppliers of photomasks and chemicals used in the fabrication of semiconductors, Drexler has patented a technique whereby spherical (reflective) and filamentary (absorptive) particles of silver halide are embedded in a colloidal polymer matrix ("gelatin") to form the recording medium.

Tradenamed Drexon II, the medium is a double-layer configuration of a crust containing silver halide particles and an insulating underlayer devoid of the metal. A diode laser heats the medium so that the silver halide particles absorb the laser energy. As the temperature rises to about 200°C, the polymer film melts and creates spots of low reflectivity in a field of high reflectivity.

An increasing variety of disk sizes is being offered. Photo 1 shows 12-inch (30 cm) and 4.7-inch (12 cm) Drexon disks with and without clear protective overcoats. Also shown is a semiconductor-diode laser used for writing and reading data. Using 0.8- to 1.0-micron-wide holes, 12-inch Drexon disks hold 1.25 gigabytes per side, whereas 4.7-inch disks contain 200 megabytes per side. Although holes as small as 0.4 micron have been recorded, Drexler recommends 0.7-micron pits.

Drexler has avoided two problems associated with using silver halide for optical DRAW media: processing and graininess. Usually graininess results in intrinsic noise because the particle size prevents obtaining the sharp-edged pit definition needed in high-density optical recording.

Furthermore, because the laser melts the gelatin rather than the silver, lower-powered compact diode lasers can be used, rather than the

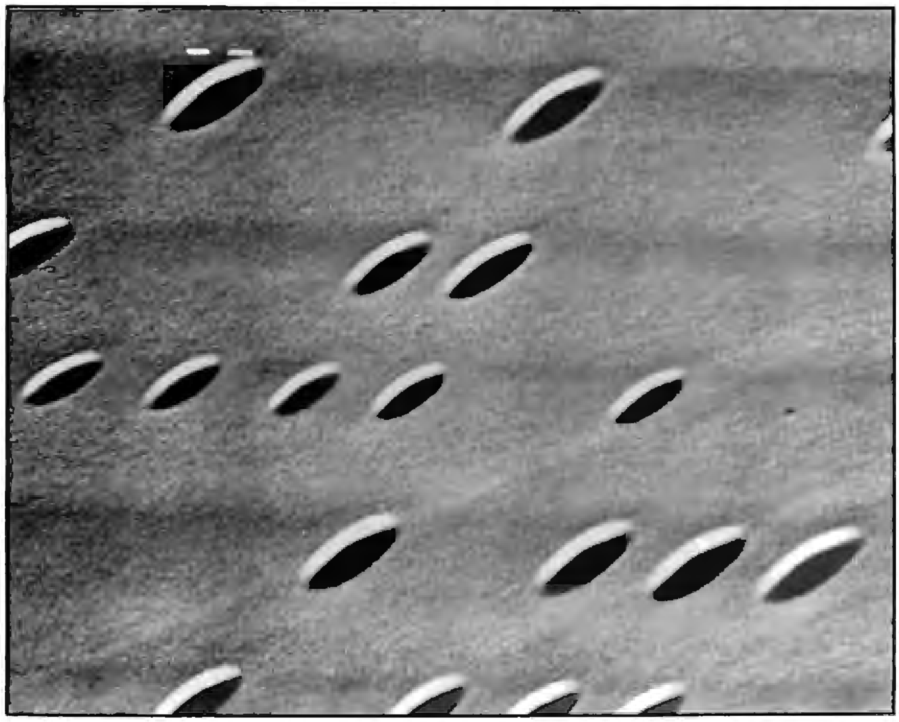

**Photo 2:** *Recorded surface of Drexon II material as photographed by a scanning electron microscope at 2500-power magnification. The holes vary in size between 3 and 5 microns and were recorded with a 3-mW laser pulsed for a duration of 75, 150, and 300 microseconds. Holes recorded in Drexon II are well defined and have lipless rims because the material shrinks when heated. These characteristics improve the signal-to-noise ratio and permit data to be encoded by varying hole lengths and spacings.*


**Photo 3:** *A common credit card could use the Drexon laser-recorded stripe. The stripe on the back of this card has a capacity of 1.6 million bits and is not susceptible to erasure by stray magnetic fields. A card this size completely covered on both sides could store 40 million bits. (Photo by Victor Budnik.)*

bulkier gas lasers. When production of 12-inch disks reaches 100,000 annually, Drexler expects the cost to drop to about $40 each.

On Drexon II disks the laser records a unit of data as a well-defined hole with a lipless rim, which Drexler says improves the signal-to-noise ratio and permits data encoding by varying the hole lengths and spacings between holes. The laser shrinks the gelatin in the medium, leaving the lipless rims, rather than throwing up craters around the pit as happens in other ablative techniques. The scanning electron microscope photo at 2500-power magnification (photo 2) shows 3-micron and 5-micron holes recorded at 3 milliwatts (mW) of laser power for a duration of 75, 150, and 300 microseconds.

In addition to disks, Drexler is now offering its medium in reel-to-reel optical tape, cassettes, and cards. The Drexon Laser Card has attracted considerable attention for its ability to deliver high-density storage in a conveniently small and inexpensive package the size of a credit card. Photo 3 shows a bank credit card with a stripe of Drexon instead of the typical magnetic stripe on the back. Using 10-micron holes, the stripe yields 200K bytes. If both sides of the card were fully covered by Drexon recorded with 5-micron holes, storage capacity would be 5 megabytes. The card has interested manufacturers worldwide for a variety of applications.

SRI International is developing four types of equipment for Drexler to demonstrate Laser Card technology to potential licensees: a microbar reader for security access applications, a spot reader for read-only software applications, a read/write machine for spots useful as an output device, and a debit card machine. Recently, Toshiba took the first license to use Laser Card equipment, probably for personal computer applications. Drexler estimates that a Laser Card small-computer database-entry device containing 3 megabits would cost $2. Drexler expects to soon have other licensees for its technology.

## The Philips Air-Sandwich

Philips began research on optical-

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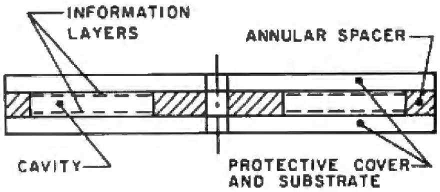


**Figure 1:** *Cross section of the Philips Air-Sandwich disk. The cavity is 20 mm thick and is filled with very clean air; each of the plastic substrates is 1.1 mm thick, while the thin-film tellurium recording surface is 300 angstroms thick (an angstrom is one 10-billionth of a meter).*

storage media in Holland in 1972 and since 1975 has been aiming its products at mid-range applications in both office automation and digital data processing.

North American Philips manufactures a 12-inch double-sided disk. A unique feature of Philips' media is the Air-Sandwich, shown in cross section in figure 1, which functions as a miniature clean room. The 20-millimeter (mm) cavity holds very clean air. The substrate is 1.1 mm thick, and the tellurium-alloy recording layer is 300 angstroms, for a total disk thickness of 2.5 mm.

It's possible to burn 0.7-micron holes in Air-Sandwich disks, as shown magnified about 40,000 times by a scanning electron microscope in photo 4. Track pitch is 2 microns, capacity is 1¼ gigabytes per surface, for a total of $2 \times 10^{10}$ bits per disk. Errors are corrected to 1 in $10^9$ bits, with 40 to 50 percent overhead for formatting and error detection and correction. The disk can provide a corrected BER of 1 in $10^{12}$ at the expense of capacity. Raw BER is 1 in $10^6$.

North American Philips uses plastic substrates, whereas N.V. Philips in Holland uses glass for its version of the Air-Sandwich. Philips and Control Data Corporation, in a joint venture for development of disks and drives, will probably use plastic substrates, even though the Dutch prefer the more expensive glass approach. A North American Philips spokesman indicated that both versions may be produced until the market selects one or the other. A CDC spokesman thinks that glass substrates will be used on the first disks. Even though the plastic transpires water, the tellurium alloy will still allow archival life of 10 years according to accelerated life tests.

North American Philips has developed a cartridge that is necessary only for very high density recording requiring holes smaller than 0.7 micron; the cartridge will not be used with lower-density, lower-cost Air-Sandwich applications. For high-density optical recording, the fundamental limit in capacity is the resolution of the medium itself. Philips thinks that 0.3 or 0.4 micron represents the smallest recordable hole, which will be very ragged, making

**Photo 4:** *Recorded surface of a Philips Air-Sandwich optical disk. In this photo, taken by a scanning electron microscope, the 0.7-micron holes are magnified 40,000 times. The Philips disk has a capacity of 1.25 gigabytes per side. See figure 1 for a cross section of the Air-Sandwich disk.*



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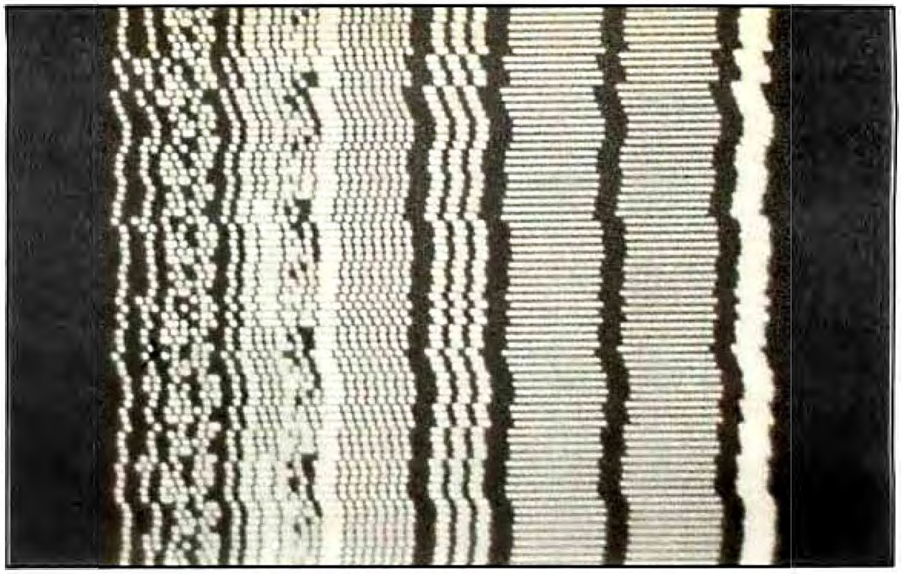

**Photo 5:** *Recorded surface of a Burroughs Corporation optical disk. This photo was taken by an optical microscope at 800-power magnification and clearly shows the tracks of 0.6-micron holes. Capacity of the 14-inch disk is 2 gigabytes per side.*

retrieval without errors very difficult. Capacities of $10^{12}$ bits per disk will require 14-inch disks.

Philips writes on its disks with diode lasers, generally in spiral patterns, and may possibly use Hitachi diode lasers for writing up to 5 million bps, but the disks are read with helium/neon gas lasers. Transfer rates over 5 million bps will require selected diode lasers, which are not yet widely available, or argon gas lasers. Reading requires about 2 mW of power. N.V. Philips in Holland finds that diode lasers that both read and write at 2 million bps are sufficient for office automation applications. North American Philips disks are not pregrooved, whereas the Dutch disks are, simplifying the recording process but lowering capacity.

### Burroughs' Process

The Burroughs medium operates differently from the ablative hole-burning technique used by Philips and Drexler and the bubble-raising technique of 3M and Thomson-CSF. In the Burroughs system, laser power heats up the metal-film surface and causes an irreversible phase change of the index of refraction and the extinction coefficient ($n$ and $k$, respectively). The refractive index is described by a complex number. The real part ($n$) describes the velocity of light going through the material and the imaginary part ($k$) describes the rate of absorption. Metals have very high $k$ because light is absorbed very rapidly, as opposed to glass, which has a low $k$.

Although Burroughs' medium employes $n$ and $k$ phase change, it is not the standard crystal-to-amorphous reaction. Thus the film does not move very much, as in ablative techniques, and is compatible with a contact overcoat approach because no rims are created around the pits. It also requires much lower laser power. Using off-the-shelf helium/neon lasers, track pitch is 1.7 microns and average spot size is 0.6 micron. Most of the testing has been with 10- to 15-mW incident laser write power with 42-nanosecond (ns) exposure times. Medium threshold is described as 4 mW to 6 mW, with demonstrated read power of under 1 mW. Photo 5, taken with an optical microscope at 800-power magnification, shows data, track, and sector information written on the Burroughs medium.

The trilayer medium, with 2-gigabyte capacity, is manufactured from a standard 14-inch Winchester-disk platter spin-coated with plastic to smooth its surface. The subsequent layers, composed of an aluminum (or other metal) reflector, dielectric spacer, and absorber layer, together are a few thousand angstroms thick. The overcoat is 0.007-inch, thick

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enough to keep dust particles out of focus and thin enough to control the thickness tolerances. This medium contains no tellurium, but Burroughs has not divulged the materials used. The disk will be factory formatted with address and sector information and will contain 600 sectors per track.

Burroughs is designing a high-performance disk with a signal-to-noise ratio of 30 decibels for broadband applications able to be transported across the country and rugged enough to be washed in case of severe contamination. To prevent that necessity, the 0.125-inch-thick disk will be encased in a 15-inch-square, 0.5-inch-thick cartridge (not hermetically sealed).

Edward LaBudde of Burroughs believes that this medium can achieve 1 in $10^{12}$ corrected BER after a projected 10-year lifetime. The raw BER is 1 in $10^6$; 50 percent of the total 4-gigabyte disk capacity is used for error detection and correction, formatting, and addressing. However, Burroughs says its approach is capable of producing *no* uncorrectable errors when the disk is new.

## Kodak's Approach

Kodak started developing a polymer/dye binder bilayer medium using two laser wavelengths, whereby colored dyes in a plastic material over a reflective material are written on in the infrared part of the spectrum (800 to 850 nanometers) and read in the red part (633 nanometers). The medium can now be both written and read in the infrared for system designers wishing to keep to a single laser wavelength, but Kodak recommends a two-wavelength approach. Capacity on two-wavelength-approach Kodak disks is 5.6 gigabytes per 12-inch disk side. Data can be written at 3 million bps with a 0.8-micron pit length and 1.67-micron pitch.

## Packing Densities

How dense will the packing on optical disks become by the end of the century? Burroughs is already working near the diffraction limit and believes that packing density will probably not increase significantly until electron-beam or other exotic technologies are commercialized. Packing density is not the primary emphasis at Burroughs. The price/performance ratio and reliability are more important when compared with magnetic technologies.

STC foresees the possibility to increase optical-disk packing density to 1 trillion bytes per square inch by the year 2000 by recording in various colors and using filters to read just the desired data. Other researchers go even further, estimating the possibility of building disks containing $10^{21}$ bits.

## Future Materials

Although I have indicated that almost all first-generation media will employ thin metal films in the recording layer, some industry researchers say that polymer/dye binders offer advantages in ease and cost of manufacture over thin metal films and may become the preferred material before the end of this decade. This view has raised strong controversy, however. Dr. Bell of IBM points out that polymer/dye binders have advantages and disadvantages when compared with thin metal films, adding that the issue is complex and it is not yet clear that polymer/dye binders will be the wave of the future.

Edward LaBudde of Burroughs says that polymer/dye binders will not be the trend; thin-film will remain the preferred medium until something better comes along. Thin-film technology is widespread and will invite many people to work on its problems. The enormous capital investment necessary to develop a totally new medium like polymer/dye binders may be outweighed by the sheer numbers of people involved in "mainstream" media.

In addition, LaBudde sees no inherent advantage to dye-based optical disks and believes thin metal films should be cheaper to make, even in a small operation, than polymer/dye binders because the latter require a much heavier outlay for capital equipment, such as a web


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press, than thin-film. This point, however, is not universally agreed upon. Once this equipment is amortized, polymers do indeed offer a cheaper method of putting down a data-storage medium and easier production techniques, and unlike tellurium, the most commonly encountered thin-metal medium, they are nontoxic.

The main champions of the polymer/dye binder medium are Kodak and other major film producers, who can take advantage of already installed web coating equipment used to process Kodacolor and similar films; the same machinery can be used to make optical disks to keep the equipment running at full capacity. The web coating process, however, employs a flexible substrate rather than the rigid substrate used on other optical disks, leading some experts to speculate that polymer-based media might eventually find their way onto the market late in the decade as the low-cost 3- to 5-inch optical floppy disks predicted by many observers.

A wide variety of other potential optical-media materials are being reported on at scientific conferences. Some of the more exotic include diazo, photochromics, amorphous semiconductors, spectral-hole burning in crystals, surface texturing, copper sulfate in glass, and frequency domain storage.

### Copper Sulfate in Glass: Archival Master Disks?

Copper sulfate in glass, researched at Xerox's Advanced Development Laboratory in El Segundo, California, has implications for both optical disks and videodisks. The process yields a disk that should be absolutely archival, perhaps lasting thousands of years. The technique involves using copper ion-exchanged glass, which is simple and cheap to produce.

An optically absorbing region is formed extending up to 8 microns into the Pyrex 7740 glass surface, forming a monolithic structure. The glass is immersed in molten copper salt at 550°C for between 15 seconds and 6 hours. The sodium out-diffuses and the copper in-diffuses. Focused laser light causes localized perturbations on the surface, appearing as raised hemispherical bumps, rather than hollow bubbles. A density of $10^8$ bumps per centimeter squared has been achieved.

Although the bump-forming mechanism is not understood, the medium has great promise to be used as an optical disk or videodisk master because no encapsulation is needed for the bumps. However, a 150-mW argon laser is needed, calling for about 10 times the laser power required with other media. Writing is at 488 nanometers, with reading done either with an argon laser with reduced power, or a helium/neon laser.

**OHSq has strong optical absorption extending into the infrared.**

### IBM Studies Hydroxy Squarylium

IBM is looking at many different materials for optical media. Some of the more promising research the firm has disclosed relates to organic dyes. One of the most interesting of these is hydroxy squarylium (OHSq), which has a melting point of 360°C, compared to tellurium's 450°C, but requires 60 percent higher laser power for writing and reading than tellurium.

OHSq appeals to researchers because it has strong optical absorption extending into the infrared, excellent thermal and optical stability, and can be either solvent coated or evaporated in preparing disks, offering substantial cost savings. OHSq disks were subjected to 10 million readouts before a 10 percent degradation in data occurred, more than adequate stability for digital data storage applications.

### Cryogenic Frequency Domain Storage

An even more esoteric optical-media research project at IBM concerns the frequency-domain-storage approach, the most important feature of which is that up to 1000 data bits can be stored in frequency space at each spatial location, so that a fixed media/scanning read/write spot system can yield extremely high data rates and packing densities. Despite the lack of threshold exhibited by photochemical hole-burning materials, IBM reports that up to 10 million read cycles were possible on relatively low-sensitivity media while maintaining a signal-to-noise ratio of 10 to 1. The technique provides for reversible media but requires that the system be kept at cryogenic temperatures: 4 kelvins, close to absolute zero.

### Surface Texturing

Bell Laboratories has done considerable work using reactive ion etching to microscopically texture the surface of optical media to produce submicron-sized columns and cones. Although they have formed textured surfaces in metals, semiconductors, and insulators, germanium and silicon have produced the best results. The textured surface is not reflective. When hit with 10 mW of laser power, the structures are melted away, leaving a spot 100 times as reflective as before. The technique produces no debris or rims around the recorded spots. Bell Labs finds the technique much more stable and permanent than systems using tellurium, and it may be possible to use the disk as a master to replicate copies.

### Looking Ahead

Where is all this leading? Little about the composition of optical media will matter to most users; the media, along with system hardware and software, will have to be transparent to the user in order to gain wide acceptance. Research is moving quite rapidly in the optical-media field, and only time will tell if this most promising technology will catch on with the computing public, or whether it will be cast aside as some other promising technologies have been in the recent past. Fortunately, most of us dedicated to informing the industry and public about developments in optical recording technology believe predictions are realistic that by 1990, most digital and image data will be stored on low-cost, removable, high-density optical media. ■


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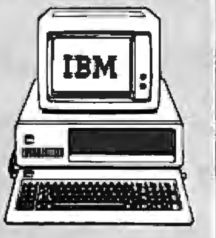

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# Will Removable Hard Disks Replace the Floppy?

*Improved data-storage technologies may eventually eliminate floppy disks.*

Larry Sarisky
Syquest Technology
47923 Warm Springs Blvd.
Fremont, CA 94539

The floppy-disk drive has been the method of choice for data storage for several years now. But like all de facto standards, its dominance is being challenged, in this case by the development of a new storage medium—the removable hard-disk cartridge.

The cartridge appears to offer all the advantages of the floppy disk as well as increased storage capacity and access speed. But before describing this new method of data storage, let's take a look at how and why floppy disks were developed.

When IBM introduced the System/360 computers, their low-level microcode programs were stored in read-only memory (ROM). By the time the IBM 370 was developed, however, semiconductor technology had advanced so far that microcode storage could be implemented in semiconductor memory. This memory was volatile, so a microcode loading-and-storage device was necessary. Magnetic tape was considered, but the need for loading diagnostic programs as well as microcode presented a problem. So in 1973, IBM developed a cheap disk and drive that provided the random-access speed needed for diagnostic-program loading. This low-cost, flexible disk gave IBM an economical random-access program-loading device. And once such a device was available, it was easy to add a write capability for data storage. Semiconductor technology and the IBM 370 had set the stage for the floppy disk, the data-storage medium that helped launch the small-computer revolution.

**Newer microprocessors can make use of virtual storage only with the faster access speeds offered by hard disks.**

The revolution, however, was spearheaded not by IBM but by independent manufacturers of floppy disks such as Shugart Associates and Memorex, who saw the value of low-cost, random-access storage for smaller computers. By 1975, 27 independent suppliers were producing 8-inch floppy-disk drives.

The new medium for storage offered potent advantages. As

**About the Author**
*Larry Sarisky is the vice-president of sales and marketing for Syquest Technology. He has more than 12 years' experience in marketing data-storage products.*

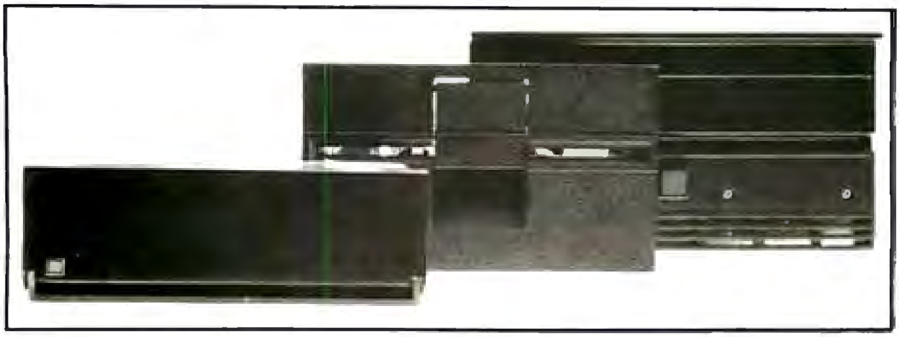

**Photo 1:** *A size comparison of the 3.9-inch removable hard-disk cartridge drive with standard 5¼- and 8-inch floppy-disk drives. The cartridge drive is 1.625 by 4.8 by 8 inches.*

*Business Week* reported in a May 17, 1976, article, "Each standard disk (floppy) has the data-storage capacity of 3000 punched cards. The disks are also reusable, easier to store and mail, and inexpensive." The article also predicted that "a new market segment is opening up thanks to the development of the cheapest of computers—the microprocessor or computer-on-a-chip."

As these prophetic words were written, Shugart Associates was developing a lower-cost 5¼-inch flexible-disk drive. It was this drive that signaled the decline of cassette tape. The 5¼-inch floppy-disk drives and media cost less than comparable cassette-based storage. They offered an average access time of about half a second compared to the cassette's 20 seconds. And their error rate was two orders of magnitude better than that of cassettes.

### The Winchester Disk

While lower-cost 5¼-inch floppy disks gained most of the attention in 1976, Memorex saw another IBM-developed storage technology that could be used in small computers. Its Model 601 hard disk was the first small Winchester system to be available from a source other than IBM. By protecting the read/write heads and disk platters in a sealed environment, the Winchester could deliver higher data-storage capacities, faster access, and greater reliability at a lower cost per byte. While the 601's disk diameter was a hefty 14 inches, successive Winchester-technology disk drives reduced it to 8 inches and then 5¼ inches.

The history of disk storage has been a tale of increasing compactness. The first 14-inch Winchester-type drives paralleled established storage-module devices. The 8-inch Winchester followed the 8-inch floppy disk. The 5¼-inch drive was compatible in size with its corresponding floppy disk. And, finally, the 3.9-inch hard-disk cartridge (see photo 1) parallels the newer "microfloppies."

### The Need for Better Disks

The development of 16-bit processors, more complex operating systems, and multiuser, multitasking configurations has increased the need for hard-disk capacity, reliability, and speed. Newer processors can make use of virtual storage only with the faster access speeds of hard disks. Operating systems such as Unix have a large assortment of utilities that won't fit on a floppy. To perform multiple tasks for multiple users, systems required the capacity and access speed available only from hard disks.

Microcomputer applications are becoming far more sophisticated. A business accounting system can require a box of 10 floppy disks. A high-resolution digitizing camera may need more than a megabyte of data storage for a single picture. Database-management systems, computer graphics, English-language-based programming, extensive menus, and broad-based application packages all require faster access to a larger amount of data than a single floppy disk can hold.

**If a fixed disk crashes, it can be replaced only by a factory technician.**

### The Limitations of Fixed Disks

While fixed-disk Winchester drives are suitable for many applications, they present severe integration problems for smaller computer systems that now use one or two 5¼-inch floppy-disk drives. The 14-inch drive is simply too big and too heavy to be integrated into many existing systems. It also requires a more sophisticated interface and both AC and DC power-supply voltages.

The smaller 5¼- and 8-inch Winchester drives have proved to be more practical for small systems, but they are no panacea. Although they're smaller than the 14-inch drives, they still may be too large for some systems. Why? Because most systems have required both removable and fixed media. If the current system has been designed for one or two 5¼-inch floppy disks, there may not be room to add a fixed-disk drive.

The user must also worry about the possibility of a fixed-disk failure. If the fixed disk crashes, it can be replaced only by a trained technician. Even worse, data may be lost forever. For this reason, most users back up important programs and files on floppy disks or tape. Unfortunately, the floppy disk is often inadequate for backup. Small Winchester drives have capacities that range from 5 to 80 megabytes. Backing up that much storage on floppy disks is inconvenient and slow. And although tape can be used for backup, it lacks the random access, reliability, and serviceability of disk storage.

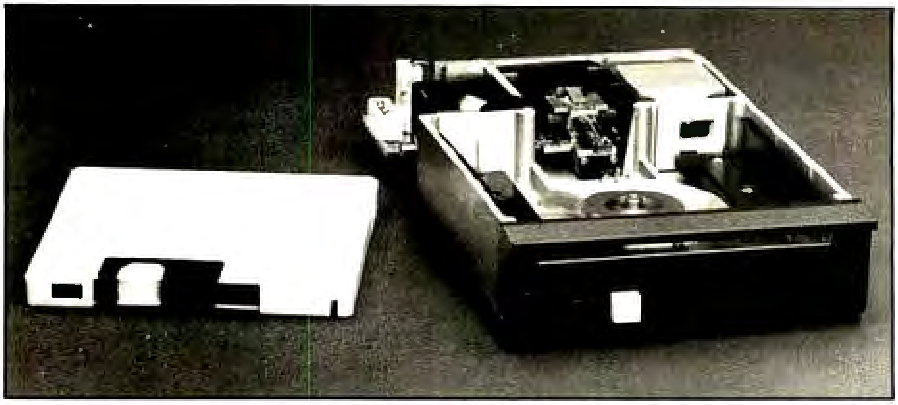

**Photo 2:** *Syquest Technology SQ-306 removable-cartridge hard-disk drive. The cartridge (shown at left) is inserted into the drive unit, shown with its top cover and drive door removed.*

In spite of these limitations, small hard-disk drives have become the hottest products in data storage. Almost every computer manufacturer now offers Winchester hard-disk storage, as either a standard system component or an option. Why, then, are floppy disks still needed? Because, until recently, they enjoyed two critical advantages over hard disks: they were removable and cheap.

## The Hard-Disk Cartridge

Floppy disks can no longer inherently claim those advantages over hard disks, following the development of a new generation of removable, pocket-sized hard-disk cartridges and drives such as the Syquest SQ-306. Cartridges can be replaced when they're full, and, like floppy disks, they can be transported from one computer to another (see photo 2). [**Editor's Note:** *The Syquest removable-cartridge hard-disk drive is not a Winchester drive because the read/write heads are not permanently sealed with the disk, as is the case in true Winchester technology . . .* **R. S. S.**]

But not all hard-disk cartridges can compete with the floppy disk. Cartridge drives are now available in three sizes: 3.9, 5¼, and 8 inches. All three sizes share the same basic technology, but their prices differ significantly. Eight-inch cartridge drives cost $1500 or more. The smaller 5¼-inch drives cost more than $1000. The still smaller 3.9-inch drives cost less than $800. Smaller cartridges also cost less. The 8-inch cartridge can cost more than $100, the 5¼-inch about $50, and the 3.9-inch about $35.

Although all three sizes are gaining acceptance, many industry analysts believe that only the 3.9-inch hard-disk cartridge is inexpensive enough to compete with floppy-disk drives and media. The drive costs only slightly more than a floppy-disk drive. The cost of a cartridge is comparable to the cost of a box of 10 floppy disks.

This comparison is even more favorable in terms of cost per byte because the hard-disk cartridge supplies far more capacity per unit. While floppy disks can hold up to 1 megabyte of storage before formatting, the 3.9-inch hard disk has an unformatted capacity of 6.38 megabytes. Not only does it carry from 6 to 15 times more data than a floppy disk, it carries it more safely, sealed in a protective cartridge.

While floppy-disk technology has matured and offers few opportunities for enhancement, small hard disks are at the beginning of their product-technology cycle and will have their data storage capacity increased again and again. The cost per megabyte of storage is dropping rapidly.

Like audio- and video-tape cassettes, hard-disk cartridges will be available in a variety of capacities. Syquest, for example, is already developing a cartridge, compatible in size with existing cartridges, that will double capacity to 12.76 megabytes.

Regardless of capacity, these cartridges deliver better performance than floppy disks. Their average access time is 75 milliseconds, or from 1.5 to 3 times faster than floppy disks. The data-transfer rate is even more impressive. In one second, the cartridge drive can transfer 5 megabits, compared to the 5¼-inch disk's ¼ of a megabit. That's 20 times faster.

Cartridge models provide better interchangeability between drives than floppy disks. The cartridge is designed to provide for a minimum of 10,000 insertion/removal cycles (see figure 1). A closed-loop embedded digital servomechanism ensures cartridge interchangeability while allowing variable sectoring. The embedded servo information is recorded on the disk and provides the sector-mark signals and timing information for all read/write operations.

The digital servo system locks the read/write heads over the centerline of the appropriate recording track. More practical than conventional track-following systems, the digital servo leaves both surfaces free for data and provides flexibility in sector formatting. This enables system builders to define the number of bytes per sector to match any format requirement.

The digital servo, helped by on-board microprocessor control and a microstepping head positioner, also speeds data access and improves accuracy. The microstepping positioner steps in increments of 0.9 degrees rather than the conventional 1.8 degrees. The drive's microprocessor reads servo information, corrects for track alignment, and adjusts the stepper within 100 microinches, all at 60 times a second.

The 3.9-inch disk drives mount almost anywhere—under a keyboard or in a terminal. Two hard-disk drives can occupy one conventional 5¼-inch floppy space. The drives are

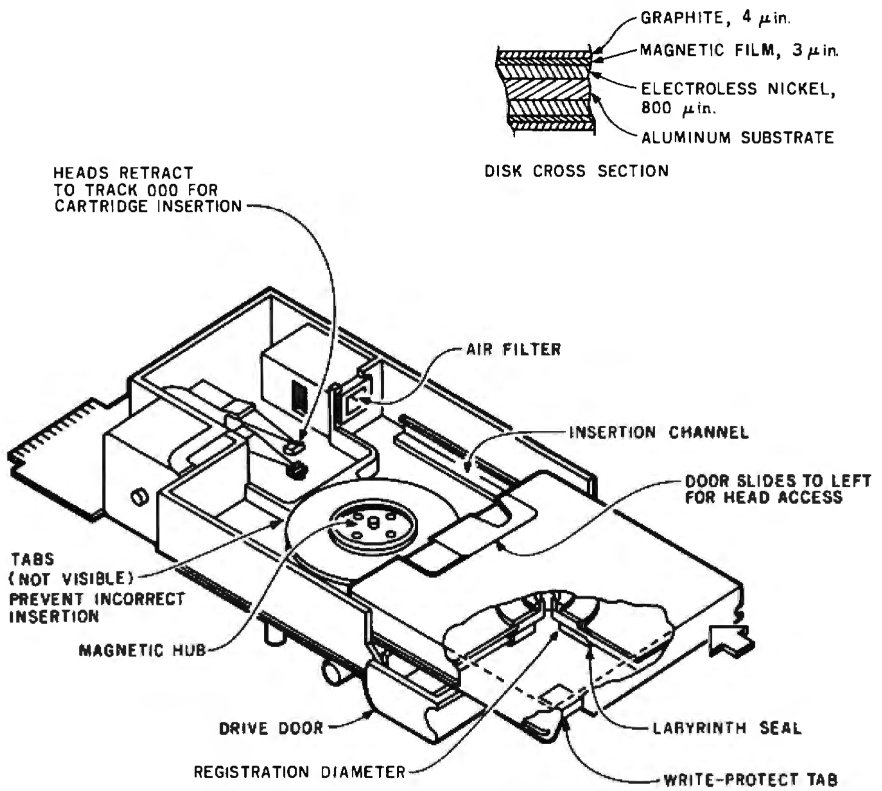


**Figure 1:** *As a cartridge is inserted into the hard-disk drive, the cartridge door slides open to allow access to the read/write heads, which were previously retracted to track 000. The disk is seated onto the drive spindle by a metal scroll on the cartridge (not visible in the figure) and then secured by a magnetic hub. Tabs on the drive base ensure that the cartridge is inserted correctly and that the cartridge door is open. A cross section of the hard disk illustrates the layers of materials on the disk (not drawn to scale).*

only 1.625 inches high, 4.8 inches wide, and 8 inches deep. Their rugged design enables them to be used in portable systems.

## Easy Integration

The 3.9-inch cartridge has the same pinouts, timing, data-transfer rates, and track/sector formatting as industry-standard 5¼-inch fixed-disk Winchester drives. This compatibility allows the use of standard Winchester controllers and interfacing procedures, as well as standard 5¼-inch floppy-disk DC power supplies.

## Convenience

Convenience of use is an important factor in the success of the cartridge. The 3.9-inch cartridge is a more convenient size than 8-inch floppy disks or larger cartridges. Just under 4 inches in length and width and less than ½ inch high, it fits in a coat pocket, purse, or briefcase. Its "unbendable" case is easy to handle and safer to mail.

Perhaps more important is the convenience of direct access to more data. The user can retrieve data from a larger online database without inserting and removing many floppy disks. This is especially important in such applications as accounting, inventory control, database searches, and so on.

**The thin-film-plating technique used on 3.9-inch hard disks eliminates the need for an initial purge cycle, which with conventional disks can take several minutes.**

## Thin-Film Plating

The 3.9-inch hard-disk cartridge can store more data more reliably and in less room because it uses thin-film plating for the magnetic data-recording layer. While conventional Winchester technology must seal the disks away from dust, smoke, and other contaminants, the cartridge's graphite-coated thin-film metallic alloy needs less protection. This thin-film plating, with a lubricating coating that shields against dirt, allows denser packing of data and protects the disk from "head crashes."

This plating also eliminates the need for an initializing purge cycle. Users do not have to suffer the inconvenience of long waits before beginning operation. (With conventional hard disks, filtered air is first blown over the surface of the disk to remove any possible contaminants. This purge cycle can take several minutes.) The thin-film recording medium provides greater data density, a more consistent recording surface, better magnetic resolution, less susceptibility to contamination, and greater durability than the conventional ferric-oxide recording medium.

Let's take a closer look at these advantages. Thin-film technology increases data density. It increases storage capacity beyond the current limitations of the standard Winchester or floppy disk. While the conventional medium at 20 to 30 microinches of thickness has a maximum density of only 8000 flux reversals per inch, thin film is an order of magnitude thinner and can store more than 20,000 flux reversals per inch. This means simply that thin film can increase data density by 2.5 times. Thin film maintains a more consistent recording surface. The conventional medium is limited by its uneven thickness and a soft surface that can be damaged in the event of a head crash.

Thin film offers higher resolution Expressed as a percentage, the typical disk recording medium has a resolution of 65 percent. In contrast, the metal-film medium has a resolution of 80 percent. (Resolution is defined as the read-back voltage ratio of a signal recorded at twice the normal

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recording frequency versus the normal recording-frequency signal.)

Thin film is more durable. Durability, expressed in terms of sensitivity to head impact, is another critical factor. Soft oxide coatings are no match for a read/write head. When a head crashes (contacts the disk's surface), oxide particles are dislodged. These particles can lead to still more crashes or surface damage.

Although it's not as hard as a read/write head, metal film is 1000 times harder than an oxide layer. This greater degree of hardness is measured by the Mohs test, which scales degrees of hardness from 1 to 10. Each increasing degree on the scale represents an order of magnitude increase. A typical read/write head has a Mohs number of 7. The conventional medium has a Mohs number of 2.0 to 2.5. Metal film has a hardness of 5.0 to 5.5.

Thin film is less susceptible to contamination. With the conventional medium, dust particles are attracted and captured by the fluid lubricant used over the ferric-oxide layer. This presents operating problems, especially for oxide media used in Winchester-type disk drives with low-flying heads. In such drives, a purge cycle of one to two minutes is required.

Some manufacturers of thin-film disks add a layer of graphite, quartz, or sapphire above the metal magnetic layer. Depending on the loading force of the heads used with the disk drive, the protective layer can range between 0.025 micron and 0.1 micron. (The heavier the loading force, the thicker the protective layer.) Microdisk of Fremont, California, a sister company to Syquest, adds a 0.1-micron graphite overcoat. The dry lubricant affords extra protection against head crashes and seals the metal substrate to prevent corrosion.

## Summary

Floppy disks and drives still cost less than their nonflexible cartridge counterparts, but the cost per byte is comparable. The removable-cartridge user gains online access to more data, faster access speed, greater drive reliability, and better data integrity. These advantages will become even more affordable as hard-disk technology and volume production improve. Users who buy a single cartridge rather than a box of floppy disks will get more for their money. They will have the best of both worlds—the high capacity, performance, and reliability of a fixed rigid disk as well as the removability and low cost of a floppy disk.

The 3.9-inch hard-disk cartridge with thin-film plating offers the floppy-disk user a better storage medium at a competitive price. I predict that just as the floppy disk replaced the punched card and the cassette, so will the cartridge replace the floppy. The cartridge's better cost/performance ratio and convenience for the user will make the floppy disk obsolete. ■

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# The Winchester Odyssey

## From Manufacturer to User

*A look at drives, OEMs, and the cost of doing business.*

**Jim Toreson**
**Xebec**
**432 Lakeside Dr.**
**Sunnyvale, CA 94086**

Looking at the advertisements for 5¼-inch Winchester drives, the first thing you notice is the substantial difference between the original equipment manufacturer (OEM) prices and the retail prices. What happens to a 5-megabyte drive between the manufacturer's shipping dock and the display floor to cause a price increase from $600 to $3000?

Perhaps the primary reason for the price difference is that the drives advertised for the OEMs are by no means complete and ready to use. It's no accident of advertising photography that you see the drive's interior workings in beautiful detail. The photographer was not hindered by a cabinet or controller board because neither of those items is part of the deal at this stage. Another missing item is the power supply. Before you can use this drive, the OEM must make these additions. The controller poses a particularly difficult problem for the OEM because the original Winchester design omits the data separator, and therefore each OEM must tackle that job.

The high-speed data transfer in Winchesters requires a data separator, which takes the data stored on disk in one-channel modified frequency modulation (MFM) code and separates it into the clock and data channels that the host computer uses in non-return-to-zero code (NRZ). (See the text box on page 126 for a description of the process.) The design of the separator becomes a complex task because of the number of different drives and operating systems in existence. This challenge to the OEM's creativity translates into considerable expense.

Even after the controller, power supply, cables, and cabinet become part of the product, the OEM still has hurdles to overcome before the drive appears on your desk. Meeting the UL (Underwriters Laboratory) and FCC (Federal Communications Commission) testing requirements calls for additional work. The OEM also provides operating-system software, documentation, and customer support after the sale. After determining the cost of each of these steps, the OEM adds a sales markup to the total and you now have a $3000 drive.

Many of these same expenses apply to OEMs who simply act as wholesalers for another manufacturer's drives. They must test and therefore pay for an entire system. To the resulting overhead OEMs then add their general and administrative costs and their own markup when calculating a drive's final price. They send the drives to a distributor, who also adds a markup. If we examine the details of this process by looking at an OEM in action, the reasons for the price difference are more apparent.

Xebec of Sunnyvale, California, produces two Winchester drives, the Xebec/Apple kit and the UP-9705 Universal Winchester Mass Storage Subsystem. Both drives are functionally identical and use a single-board large-scale integration (LSI) controller with automatic error detection and correction, a universal command set, onboard sector buffer, Shugart Associates Standard Interface (SASI), and a data transfer rate of 1 megabyte per second. The company charges $1299 for the Xebec/Apple kit and $1995 for the UP-9705. As I explain

**About the Author**

*Jim Toreson is the president, chairman of the board, and chief executive officer of Xebec, a manufacturer of disk-drive controllers.*

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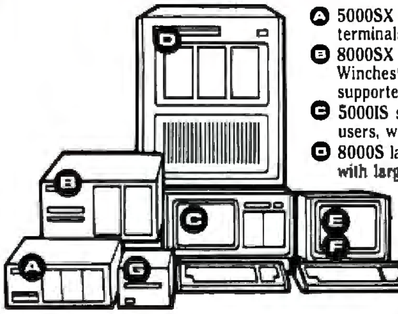


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the differences in these two products, you'll see how OEMs charge back for their costs.

Xebec calls the UP-9705 "universal" because its design incorporates host adapter cards to allow you to operate it with a variety of microcomputers. (For an overview of the link between drive and computer, see "Building a Hard-Disk Interface for an S-100 Bus System" by Andrew C. Cruce and Scott A. Alexander on page 130 of this issue.) Currently these include products from Apple and IBM, along with S-100 bus, Multibus, and Q-bus compatible computers. The advantage of this approach is that it lets the OEM or dealer supply drives for a variety of computers simply by stocking a sufficient number of these universal drives and the adapter cards for each system. The advantage for the user is that once a Winchester system is bought, it can be made compatible with several systems just by purchasing adapter cards. The design can save money for both the dealer and the user in the long run.

To provide this flexibility, Xebec buys each type of computer and hires a programmer already familiar with that computer's operating system to design the adapter card. The completion of the design and the ensuing production of the card does not mean an end to the company's use of the system and the programmer. To keep pace with software corrections and enhancements, Xebec retains both.

The central concept of the Xebec/Apple kit is to reduce the expenses of software support. Although the components in the two drives are identical, Xebec offers this kit with only an Apple II adapter card supporting DOS, CP/M, or Pascal. This difference saves the company and the end user money.

One expense common to both drives occurs during inspection for hard and soft errors at the OEM's facility. Because the bit error rate (or BER, a function of the average number of bits transferred before an error occurs) is a crucial test, drives must be thoroughly use-tested before the company passes them. The drives must average 1 bit error or less for every million bits transferred, and it is apparent that checking this with a statistical sample large enough to ensure validity would be very time consuming. For example, at 5 megabytes per second, such a sample would require nearly three hours of continuous read time for just one data track, not including seek and head-settling time. At that rate, complete testing of a typical drive would take more than 1600 hours or nearly 70 days. Xebec, however, uses *phase margin analysis* to reduce the testing time to under two minutes on one data track and to 48 hours on the entire drive (see the text box on page 128 for a description). This analysis system reduces the company's overhead for this stage of the process, and the cost to the end user is also somewhat less than it would be if the drives were tested conventionally.

In terms of packaging, the Xebec/Apple kit and the UP-9705 differ greatly. The latter uses a compact, custom-made 115-volt/230-volt power supply, FCC- and UL-approved shielded connectors, and a custom-designed cabinet. Not only are the materials costly, but these drives are fully assembled. The kit, on the other hand, has a power supply (same voltage, but not custom-made), cables, a crude cabinet that is packed in a box with the drive, controller, adapter card, accompanying software, and some instructions for assembly. Not only does the company avoid paying wages to an assembler, it also saves money in completely bypassing FCC and UL testing. Certification by these agencies is not possible and therefore not necessary for any device shipped in component parts. The cost of testing, engineering, and producing the additional shielded cables, connectors, and sheet-metal parts required for FCC and UL certification adds considerably to the price you pay for a packaged subsystem.

The biggest difference between the package and the kit is the company's definition of support for each. The end user pays less for the kit because it is shipped directly from the factory and thus avoids the entire distri-

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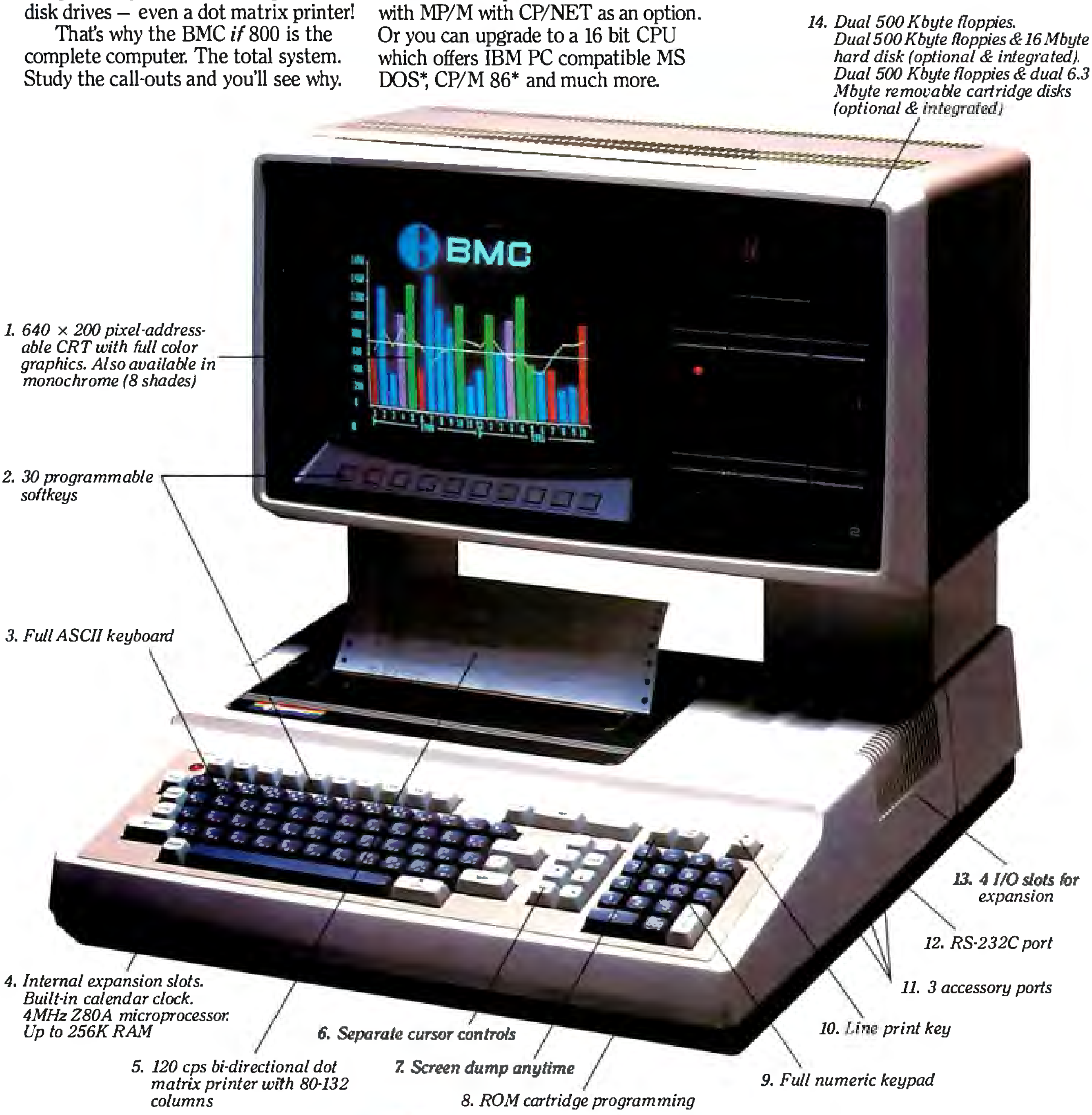


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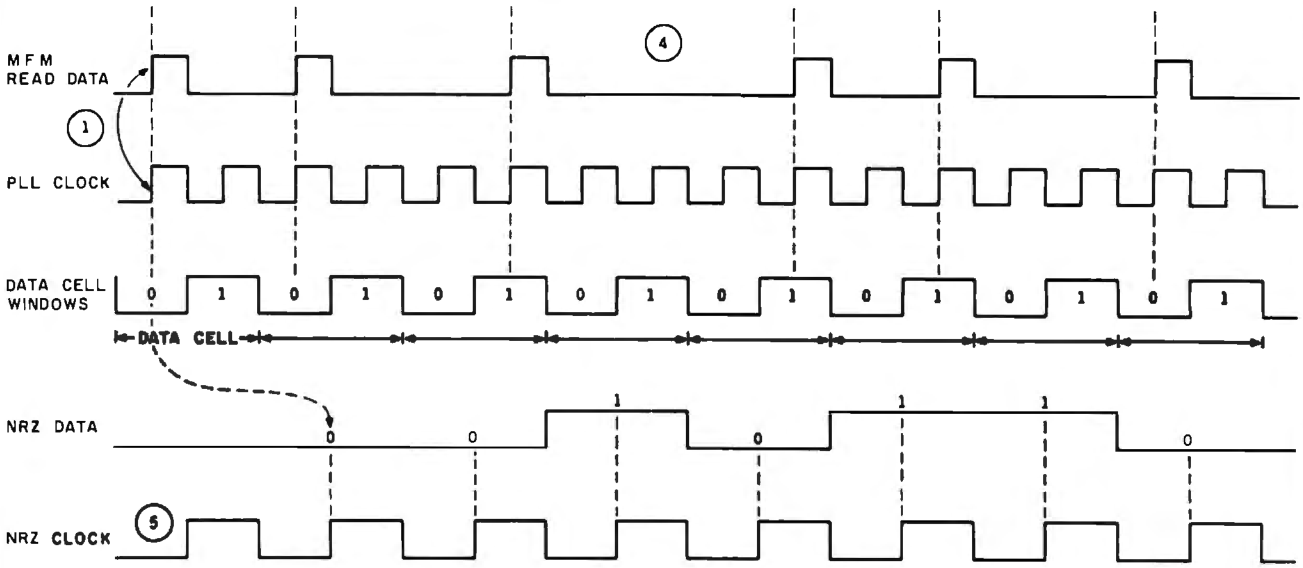


1. MFM read data is phase locked to the PLL clock. The rising edge of data is in phase with the rising edge of clock.
2. The PLL clock generates the data window.
3. If the MFM data pulse occurs in the zero half of the data cell, the NRZ data is zero (0). If the MFM data pulse occurs in the one half of the data cell, the NRZ data is one (1).
4. If no MFM data pulse occurs, the NRZ data is zero.
5. The NRZ clock is a constant-frequency clock generated from the PLL clock. On the rising edge of the NRZ clock, the state of the NRZ data line determines if the data bit is a one or a zero.
6. The NRZ data line changes states only on the trailing edge of the NRZ clock.

**Figure 1:** *Typical MFM-to-NRZ data recovery. For further information refer to chapter 5 of* Computer Storage Systems and Technology *by Richard E. Matick (Wiley-Interscience, 1977).*

## The Data Separator: A Necessary Expense

*When 5¼-inch Winchester disk drive manufacturers decided to omit the data separator from their devices, the responsibility for that important piece of design fell to the designers of controllers. Let's now take a look at the role of the data separator in hard-disk data storage.*

*Bit-shifting during data separation can seriously affect the read/write accuracy or bit error rate (BER) of a Winchester drive that has been integrated with its controller. When data is magnetically stored on the recording surface of the drive, it is translated from the host computer's non-return-to-zero (NRZ) code into modified frequency modulation (MFM) code. The data separator compresses the two channels of information that make up the NRZ code, data and clock, into one channel encoding both. This process is necessary because a magnetic disk stores data as a series of bar magnets along individual tracks in the substrate, thus leaving only a data channel available.*

*When data is transferred from the disk back to the host computer, the read/write head reads transitions from one magnetic polarity to another. This series of pulses must be separated into the original data and clock channels. The clock is a series of cells with a square voltage peak, found before and after the window area. This area is where the read/write head measures data voltage to determine if the bit is a one or a zero. It is understandably difficult to match the two channels perfectly against each other at five million cycles per second. However, this is exactly what must be done if the data is to be read. (See figure 1.)*

*Because floppy disks transfer data at a much lower rate, a much larger amount of time is available to transfer each bit. With the increase in time comes an increase in the size of the window, and thus the system has a greater margin for error. Then consider what happens when the entire cell gets down to the 200-nanosecond range, as is the case with Winchester drives. The slightest mismatch of the two channels means that the bits literally go out the data window and the data is unreadable.*

*The Xebec controller solves this problem by using a* phase-locked loop *(PLL) system that locks onto the MFM data pulses and recovers the bit timing from the disk by first picking off the data transitions and converting them into a voltage. Then a voltage controller oscillator uses that voltage to generate a clock frequency that directly correlates to the data transfer rate. Because the clock is customized to fit the data, variations in the speed of movement of the data can be accommodated.*

*It should be obvious from this brief account that the design of the data separator is no small task, and for this reason it contributes considerably to the end cost of a disk drive subsystem.*

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| Detached Keyboard | YES | NO | YES | NO | NO |
| N-Key Rollover | YES | NO | YES | NO | NO |
| Audible Key Click | YES | YES | NO | NO | NO |
| Menu Set-Up Mode | YES | NO | NO | NO | NO |
| Status Line | YES | NO | NO | NO | NO |
| Full 5 Attribute Selection | YES | NO | NO | NO | YES |
| Smooth Scroll | YES | NO | NO | NO | NO |
| Line Drawing Character Set | YES | NO | NO | NO | NO |
| Block Mode | YES | YES | NO | NO | YES |
| Insert/Delete Line | YES | YES | NO | NO | YES |
| Bi-Directional Aux Port | YES | YES | NO | YES | NO |
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butor/dealer network and its markups. The kit comes with a standard 90-day warranty, and the user must return defective drives to the factory, where they are repaired and returned within 30 days. With the package, the user can opt for a maintenance contract that provides a replacement drive within 24 hours if a drive needs repair. Additionally, the buyer of the UP-9705 can take advantage of company-provided training, full documentation, manuals, and a phone service for questions. Direct sales staff and after-sale support are two other services that Xebec provides for the packaged system.

To keep the expenses of the kit to a minimum, Xebec is experimenting with a variety of low-cost support activities. A newsletter will provide kit owners with a place to exchange information, ideas, and solutions to problems. Company representatives will attend Apple trade shows not to answer questions but to encourage kit owners to form users' groups. Where the kit is concerned, Xebec's goal is to avoid answering questions on the phone, debugging applications programs, and holding the hands of inexperienced users. If the company can avoid providing that support, the kit remains a less costly alternative for hobbyists and others who eschew the frills.

As you can see, the cost of providing the end user with a functioning drive is a factor of the cost incurred by the OEM. In our case, we have chosen to provide our customers with two options: a bare-bones kit with little in the way of after-sale support, and an assembled and tested package with several support services included. Which product the user buys will depend on his needs. The price difference is substantial but is an accurate reflection of the differences in our costs for producing the two systems. ■

**Testing the Bit Error Rate**

*The difficulty facing anyone who wants to test a Winchester drive is that the bit error rate (BER) is so low that it is hard to determine what a valid statistical sample size should be. Xebec uses a technique called* phase margin analysis *to handle this problem.*

*The size of the data window and the position of the data in the window are important factors in the BER. Phase margin analysis artificially reduces the width of the data window and then counts the number of bits that fall outside this boundary. With this approach, the BER climbs enough to make analysis of the drive's reliability easier and faster. The increased BER gives us a sample of significant events statistically large enough to make accurate predictions about the drive's reliability.*

*By using this method, we measure both actual errors and near misses. We don't attempt to predict the BER from analog measurements of signal-to-noise ratio or from maximum peak shift. Our experience shows that the artificially high BERs correlate reliably with actual BERs when the drive is in actual operation. By using this system, we also reduce the time needed to test a Winchester disk subsystem from 70 days to 48 hours.*

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# Building a Hard-Disk Interface for an S-100 Bus System

## Part 1: Introduction

*How a Winchester disk drive and disk controller work, and what is needed to connect them to the S-100 bus and the CP/M operating system.*


Andrew C. Cruce and Scott A. Alexander
ASC Associates Inc.
POB 615
Lexington Park, MD 20653


The development and availability of inexpensive, high-performance Winchester-technology disk drives offers us the opportunity to vastly expand the capability of microprocessor-based systems. The fact that these disk systems are both inexpensive and intrinsically highly reliable makes them extremely attractive as add-on devices for existing systems. Over the past several months we at ASC Associates have designed and constructed 5¼-inch Winchester disk subsystems for several microprocessor systems. In this and two subsequent articles we will describe in detail all the hardware and software necessary to integrate a standard, commercially available Winchester disk with an existing S-100-bus, CP/M-based computer system.

**In terms of speed increase, a hard disk is to a floppy disk roughly what a floppy disk is to a cassette tape.**

This month we'll review the general background information required to understand the following articles. Next month we'll explain the design steps required to interface the disk hardware with the system. In part 3 we will cover the software necessary to make CP/M aware that the disk is on the system, and we will describe the initial integration and debugging process. We intend that at the conclusion of this series you will have sufficient background information to be able to construct and integrate the disk system described in these articles with an S-100, CP/M-based computer system.

### Why a Winchester?

The first question you might ask is why go to all the trouble of putting a Winchester disk on a microprocessor system in the first place. The answer is twofold: increased storage capacity and speed. Current state-of-the-art 5¼-inch floppy-disk-drive systems are limited to about 1 megabyte of storage per drive. The smallest Winchester systems, 5¼-inch drives, can today store over 10 megabytes per drive, and these storage capacities are only the beginning. The development of newer-technology thin-film read/write heads is expected to increase capacity by factors of four and more

**About the Authors**

*Andrew Cruce has a Ph.D. in Aeronautical Engineering and has recently received an S.M. degree in management as a Sloan Fellow at MIT. Scott Alexander has an M.S. in Electrical Engineering. Both have extensive design and implementation experience with small computers and are full partners in the firm of ASC Associates, which markets the hardware described in this series of articles.*

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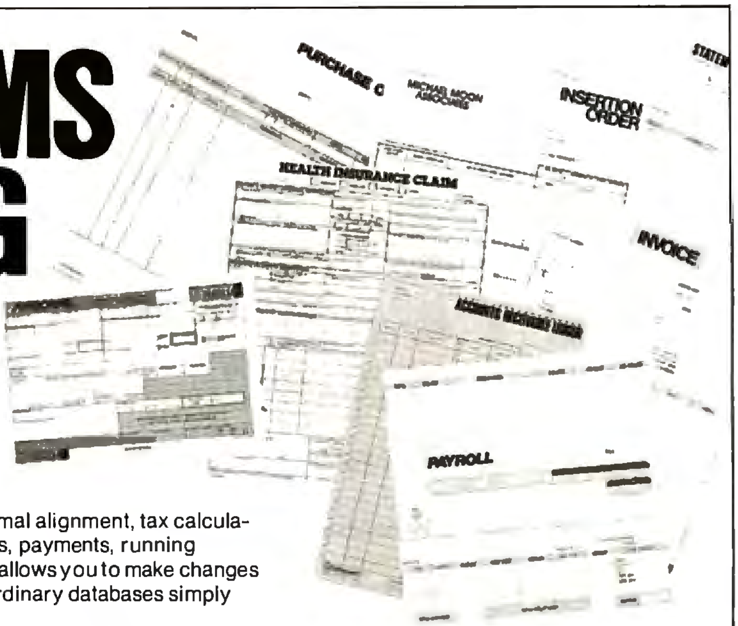


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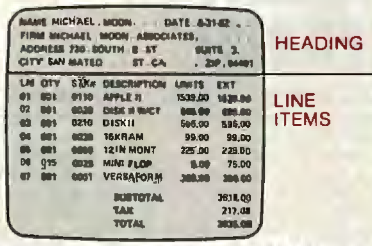


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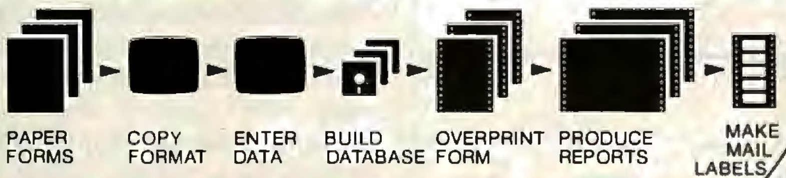


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in the next several years.

The other advantage of a Winchester disk drive is its rapid operation. In terms of speed, a hard disk is to a floppy disk roughly what a floppy disk is to a cassette tape. For a Winchester disk system, maximum seek times (maximum time to find data on the disk) are on the order of 150 to 200 milliseconds (ms) rather than the several seconds associated with many floppy-disk systems. Also, once the data is located, it is transferred at 5 million bits per second, which is much faster than existing floppy-disk systems. At these rates a Winchester system can access data anywhere on the disk and load 64K bytes of information in under 1 second. The low access times, high data-transfer rates, and large storage capacities of Winchester drives allow us to realize the full processing power that is inherent in current microprocessor systems. Winchester drives open new vistas for such applications as large inventory systems, database management systems, and data analysis applications.

## What Is a Winchester?

The term Winchester comes not from an inventor's name, but from the code name IBM assigned to the development of the Model 3340 disk memory, which was introduced in 1973. The industry as a whole has borrowed the Winchester name and now generally uses it to describe any disk drive using similar technology. The key element of the Winchester technology is that the head-to-disk assembly (HDA) is sealed from outside air and the disk is generally nonremovable.

In some ways, the Winchester technology is similar to conventional hard-disk drives. As with conventional hard disks, the read/write head floats over the recording medium on an air cushion that keeps the head from contacting the disk. In the case of the Winchester, however, the sealed and extremely clean environment of the HDA permits the disk designer to "fly" the read/write head closer to the disk surface. In typical removable-media hard-disk systems, the read/write head flies 60 to 70 microinches above the disk surface. The limitation on the distance the head flies above the disk is based on the minimum distance the head can fly safely above the disk and not risk contact with dust or any other contaminant on the disk. Any contact of this type causes the head to stop flying and crash on the disk surface. Such a crash normally ruins the read/write head and the surface of the disk medium, results in a complete loss of data, and necessitates an expensive repair job. Sealing the HDA in a Winchester drive provides a substantially cleaner environment than that of removable-media disks and allows the designer to fly the head about 20 microinches over the disk surface. This lower head altitude provides higher magnetic flux densities at the recording surface and thus higher recording densities on the disk.

During read/write/seek operations, the Winchester head flies above the surface of the disk on an air bearing, supported by carefully balanced aerodynamic forces. As the disk starts or stops, the head takes off or lands in a silicone-lubricated landing area. When the disk is not spinning, the head rests on and actually contacts the landing zone on the disk.

Winchester drives have a number of advantages over conventional hard-disk drives. First, they are very low cost both in absolute terms and in terms of cost per bit of storage capacity. In addition, the sealed environment of the HDA produces extremely high reliability with MBTF (mean time between failure) figures quoted in excess of 8000 hours. Winchester disk drives also require no preventive maintenance such as changing air filters or cleaning and aligning heads. This is of particular importance to owners of small, inexpensive computer systems who wish to have the capability associated with removable-media hard disks without the attendant maintenance hassles and expense. The primary disadvantage comes from the fact that the storage medium (the actual disk platter) is not removable. This prevents us from backing up data files in the conven-

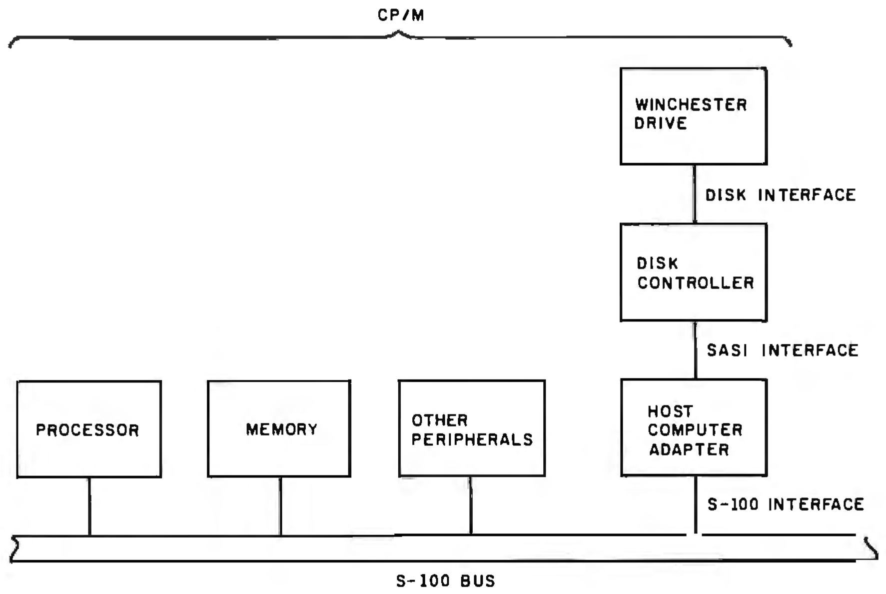


**Figure 1:** *A block diagram showing how a Winchester disk drive can be interfaced with an S-100-bus computer system.*

tional way (that is, by making and storing an exact copy of the disk to be backed up). However, this problem can be overcome in systems that have a floppy disk in addition to the Winchester drive. If you are willing to take the trouble, important files can be periodically backed up on floppy disks and saved in the event that a Winchester disk malfunctions. This may not be as convenient as standard backup procedures, but it can provide a large measure of data security.

## Which Winchester?

During the design process of our system we first had to decide which of the available Winchester disk systems we should use. Currently, Winchester disks are available from a variety of manufacturers with disk platters in different sizes, the most common being 14-, 8-, and 5¼-inch diameters. We evaluated these three options by examining the requirements of a typical microcomputer user. As storage densities have gone up, the 14-inch systems have grown to the point where they can store a staggering amount of data at a relatively low cost. Currently, 14-inch systems have storage capacities in the multiple hundreds of megabytes. Although this leads to a very attractive cost per bit of storage capacity, it also leads to a relatively high absolute cost for microprocessor applications. In our opinion this level of capacity far exceeds the requirements of the typical microcomputer user. To a certain extent, the same logic also applies to the 8-inch drive systems. They are too big and too expensive for the highly price-sensitive microcomputer market. As a result, we homed in on the more recently available 5¼-inch drives as the best alternative. They are relatively inexpensive and are currently available in models that can store over 10 megabytes of data. Additionally, expected technology improvements in the near future will increase this storage capacity to over 40 megabytes. Thus the 5¼-inch format will not only satisfy most of today's requirements but also will provide a large potential for growth.

In addition to price and storage capacity there are a number of other features of the 5¼-inch drives that make them particularly attractive. One asset is a standardized drive interface that allows complete flexibility in switching from one manufacturer's drive to another in a completed system. This also allows companies to build standardized controller boards, which greatly ease the system integration problem. The major advantages of the 5¼-inch Winchester drive for microprocessor system applications are:

1. low cost
2. large storage capacity
3. rapid access time
4. high reliability
5. no need for preventive maintenance
6. common interfaces
7. small and compact size
8. low power requirements and low heat generation
9. availability from multiple vendors with standard interfaces

## The Interface Problem

The block diagram in figure 1 presents a common approach to interfacing a Winchester disk with an existing computer system. The existing system contains a microprocessor, memory, and one or more peripherals that are all running under control of the CP/M operating system. All this hardware is plugged into and communicates via the S-100 bus. To add the Winchester system, the designer must provide an HCA (host computer adapter) that allows communication between the existing system bus and the disk controller. In addition, there must be a disk controller that accepts commands from the system via the HCA and in turn commands the Winchester disk to perform the desired functions. Finally, the designer must add software to the CP/M system to receive disk I/O (input/output) requests from application programs, such as "read a file" or "write a file," and translate these requests into commands for the HCA.

Now we'll discuss each of the elements in the Winchester system in more detail, concentrating on the operation of each element as well as the interfaces between the various elements.

## The Disk and Disk Interface

A Winchester disk is similar to any other disk system in terms of operation and organization. The disk can be considered to be composed of concentric tracks of recorded information. Each track is further subdivided into sectors. A typical 5¼-inch Winchester drive system may contain upwards of 40,000 individual sectors,


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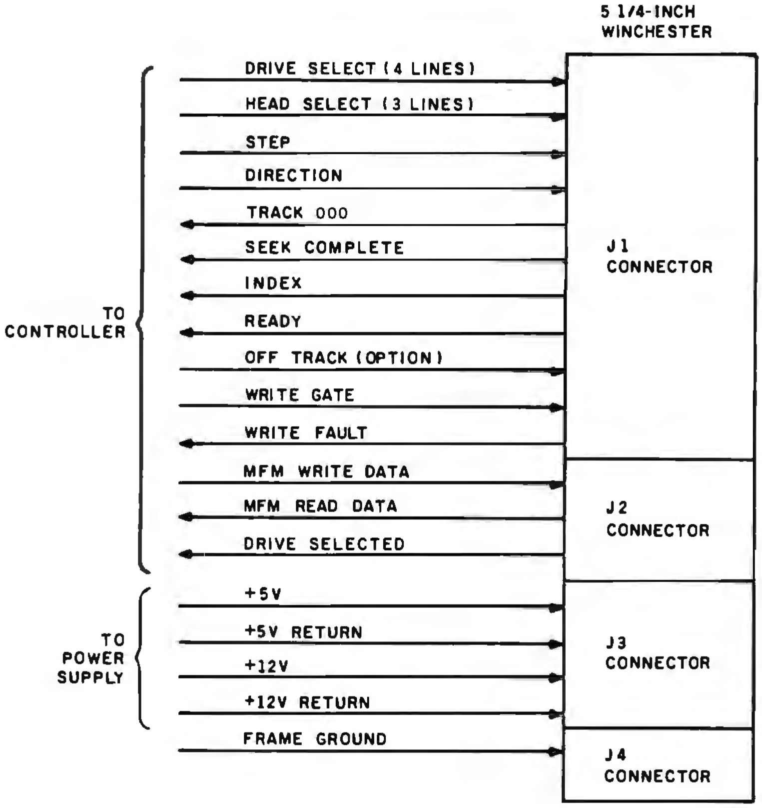


**Figure 2:** *The standard 5¼-inch Winchester disk-drive interface.*

each containing its own sector address information and data-storage space. As the following discussion will show, the operation of a Winchester disk is very similar to that of a standard floppy disk. The major difference is the speed of operation and the amount of data that a Winchester can hold. The speed of operation also requires that we use a dedicated hardware disk controller rather than have the controller functions performed by software as in a floppy-disk system.

Figure 2 illustrates the standard 5¼-inch Winchester disk drive interface, which connects the disk drive to the disk controller. Signals in this interface are of three basic types. The first type provides power required for disk operation, in this case +12 and +5 volts DC. Signals of the second type are data signals that transfer data between the disk and the controller. The data is transmitted serially at a 5-megabit-per-second rate in MFM (modified frequency modulation) format. The last type of signals are signals for control purposes that

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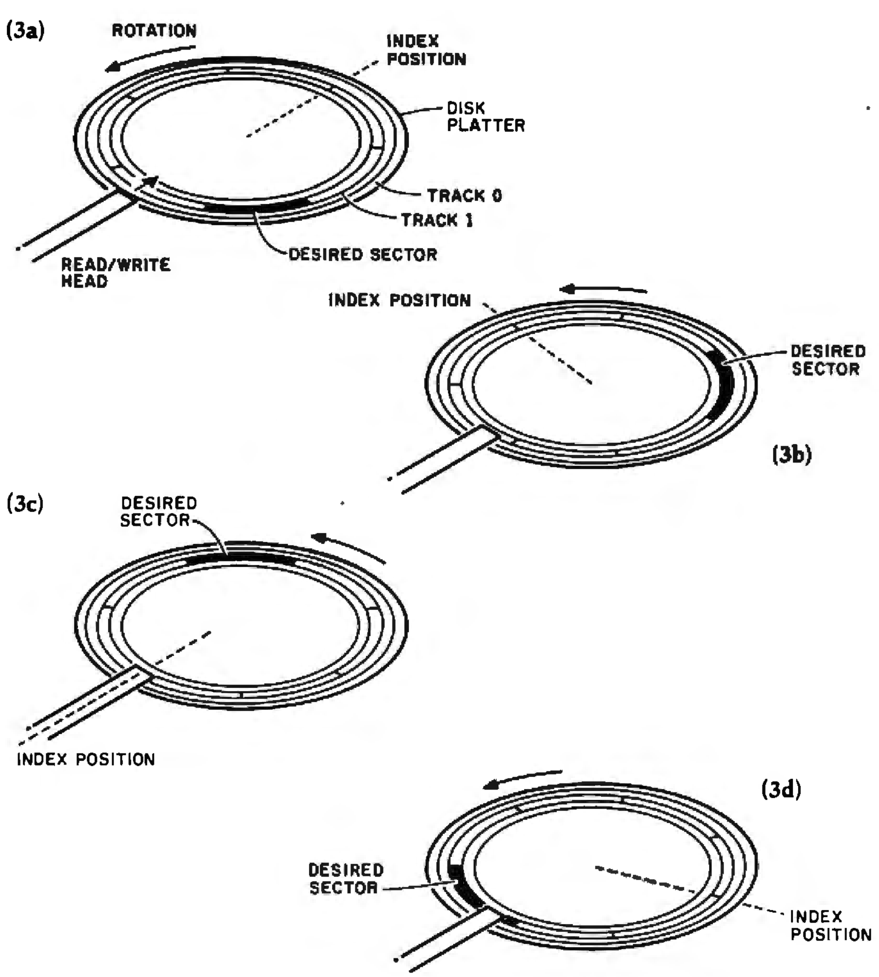


**Figure 3:** *Reading a sector on a hard disk. In figure 3a the read/write head moves to the proper track. In 3b the read/write head is positioned and waiting for the index pulse. When the index position passes under the read/write head (3c), the disk controller starts reading the first sector on the selected track and continues to read until the desired sector is reached. In figure 3d the desired sector is under the read/write head and the controller begins transferring data.*

allow selection of a particular drive, stepping of the read/write head in the selected drive, and control of other primitive disk functions.

Probably the easiest way to understand disk operation is to go through the steps involved in seeking and reading data on a particular sector of the disk. In our case, these are the functions performed by the controller. As the first step in the process, the controller moves the read/write head to the track containing the desired segment by sending control signals to the disk drive. When the read/write head is on the proper track, the controller then waits for a specific portion of the disk called the index position to pass under the head. This index position provides orientation information which identifies the start of a track. The controller then begins reading the serial data coming from the disk, looking at the sector-address information for each sector until it locates the address indicating the desired sector. The data immediately following this address is then captured and the read is completed. This sequence of events is shown diagrammatically in figure 3.

A disk-write operation is performed similarly. The same sequence of events occurs until the controller locates the proper sector. At this point, instead of reading data from the disk, the controller sends new data to the disk for recording.

The final point to be covered is how the sector-address information is put on the disk in the first place. This process is called formatting. When a disk is formatted, the controller starts on track 0 and, following the index position, writes the sector-address information for the first sector on the disk. It then fills the data area following the first address with nulls or other characters to reserve the data space for future use. As soon as it has filled the area, the controller begins the process over again for the next sector, writing the sector-address information and then reserving the data area. This process continues until all the sectors on the first track of the disk are formatted. The controller then steps the read/write head to the next track and repeats the process until it has formatted all the sectors on all the tracks.

Formatting is typically performed only once because creating the sector addresses and reserving the data areas would destroy any previously stored information on the disk. When formatting, we generally have to define the size of the data area associated with each sector. The size of this area affects the total number of sectors on the disk and thus the fraction of the available disk space that the sector-address information occupies. Typically, these data areas are set up to hold either 256 or 512 bytes of information, although special applications could require different allocations for optimum storage efficiency. For our case we will restrict consideration to the 256- or 512-byte cases.

Because of the need for formatting (i.e., placing sector-address information on the disk) manufacturers quote two storage-capacity measures for disk systems. The unformatted number refers to the total amount of data that can be stored on the disk. The formatted number refers to the total amount of data space that is available on the disk after it has been formatted. In general, the latter measure is of more importance to disk users.

## The Controller and Controller Interfaces

Working backward from the disk drive toward the S-100 bus, the next device in the disk-drive subsystem is the disk controller. We just discussed



text continued on page 142

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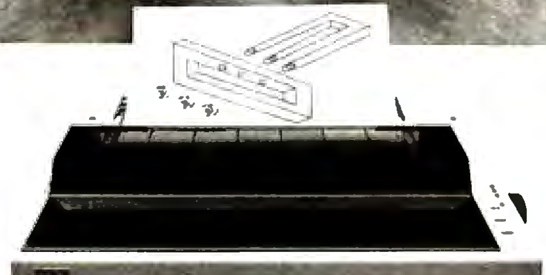

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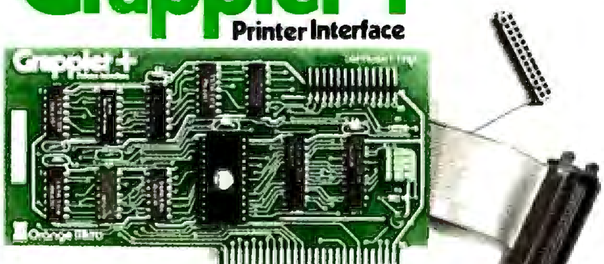

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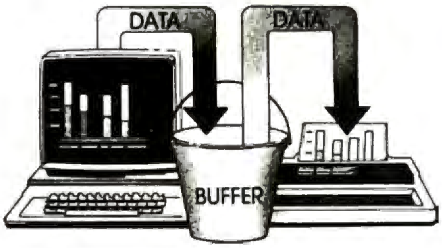


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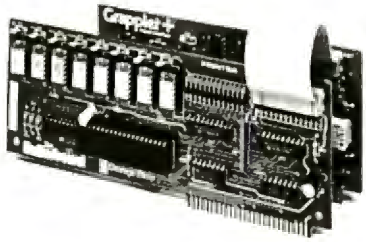

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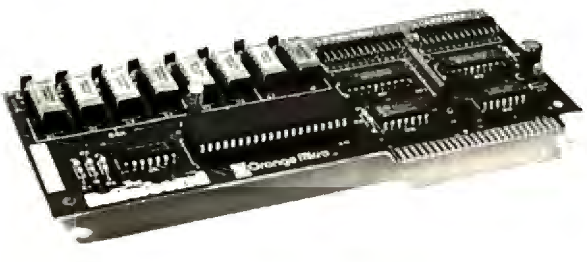

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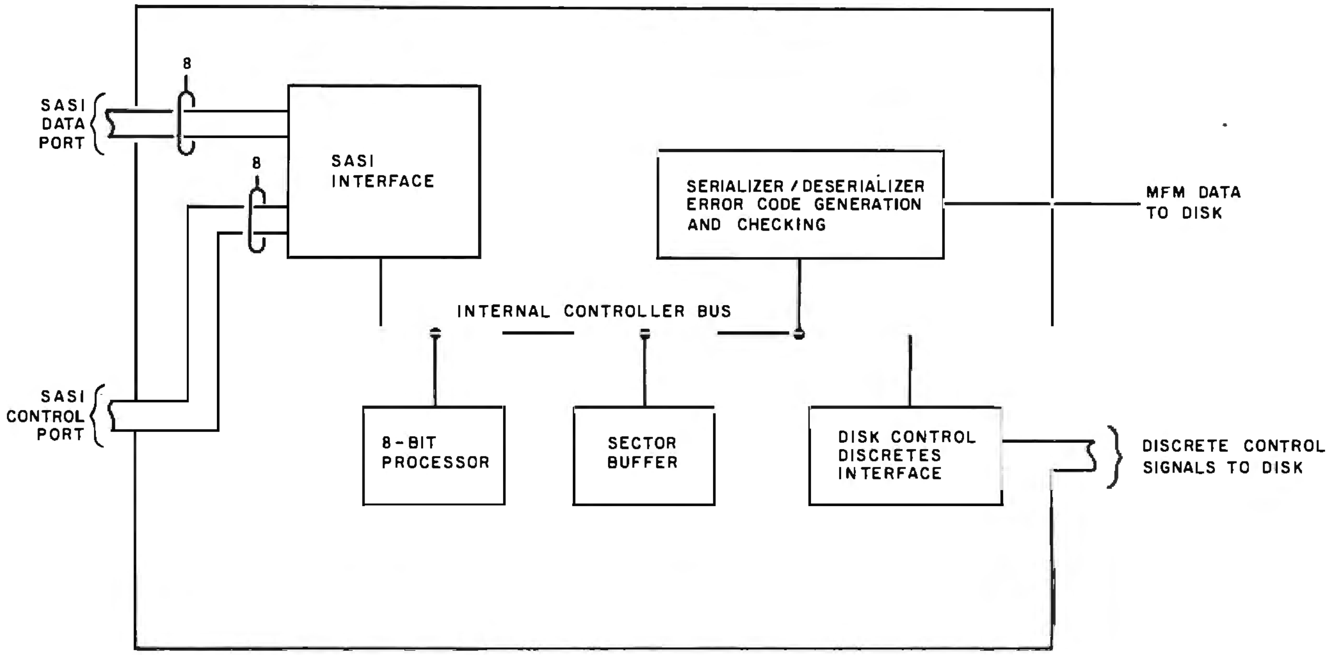


**Figure 4:** *A block diagram of the disk controller.*

the signals that the controller uses to access particular sectors on the disk. Now we'll discuss how these signals are generated and, in general, how a controller operates.

The controllers we will address are characteristically known as "smart" controllers. This means that they have some internal processing capability and use this capability to perform many of the interfacing chores with the disk without intervention from the host computer. The speed of the Winchester disk drive necessitates a dedicated controller to effectively handle all disk control and timing. Figure 4 presents a conceptual block diagram of this type of controller. The disk-drive interface, which we have already discussed, is on the right, and the interface to the HCA is on the left. A common interface between the controller and the HCA is based on that developed by Shugart Associates, known as the Shugart Associates System Interface (SASI). As shown, the SASI consists of two 8-bit connections. One set of 8 bits is for data and the other is for control signals. The control signals are split, with 5 bits used for controller-to-HCA signals and 3 bits for HCA-to-controller signals.

Internally, the controller is a bus-structured device with an 8-bit processor, a sector buffer, a serializer/deserializer, the disk interface, and the SASI interface connected to the internal bus. Again, the easiest way to understand the operation of the controller is to go through a typical sequence of operations. In this case, the controller will perform a read operation from a particular sector of the disk. The process starts when the host computer, using the HCA, generates a Select signal on the SASI interface. This alerts the controller that a command sequence will be coming in over the 8-bit data port. Through a series of handshakes, a command sequence consisting of 6 bytes of data is passed through the data port of the SASI. These 6 bytes contain the command to be executed by the controller—in this case, read data—and the sector address of the data to be read.

With this information, the controller begins to execute the requested command using its internal processor. It sends commands to the disk to move the read/write head to the track that contains the desired sector. Once the head arrives at the right track, it waits for the index pulse and then starts reading the data coming from the disk to find the appropriate sector. The 8-bit processor reads the data from the disk after it has gone through the serializer/deserializer. The deserializer portion of this device receives the MFM data directly from the disk, performs error checking and error correction on the data, and then passes the data to the 8-bit processor (via the internal controller bus) in parallel byte format. Once the controller locates the desired sector, it transfers the data from the disk into the sector buffer. This buffer is essentially a RAM (random-access read/write memory) chip that is used to store the information retrieved from the disk until it is requested by the host processor. The controller informs the host system, through the SASI port, when it has completed the data transfer. At this point the host can read the retrieved data out of the controller and take any appropriate action with it.

A write operation is performed in a similar manner. In this case, the host sends the Select command and the 6-byte command sequence to the controller that tells it to write data to a particular sector. The host then sends the controller the data to be written into the particular sector. The controller accepts this data and places it in the sector buffer. It then initiates the series of actions to find the sector to which the data is to be written. When the controller locates this sec-

tor, it passes the data from the sector buffer through the serializer, which adds error detection and correction bits to the data, and then sends the result to the disk in serial MFM form.

In addition to the read and write functions, a smart controller can perform a number of other functions, including formatting the disk, reformatting a particular track on a disk, and a variety of built-in test and loopback test functions. These functions are initiated exactly like the read and write functions but with a different set of commands passed to the controller.

### The Host Computer Adapter

The last piece of hardware required to complete the Winchester system interface is the host computer adapter (HCA). As figure 1 indicates, this adapter allows communication between the host computer S-100 bus and the SASI on the controller. A number of options are available in designing an HCA, but basically they boil down to the degree of intelligence that is to be incorporated into the HCA. In more simple designs, the HCA consists of only a couple of output ports on the S-100 bus with the proper address-decode logic. In this case, the two output ports on the S-100 bus correspond to the two 8-bit ports of the SASI interface, and the HCA is essentially a buffer device. The disk-driver software then manipulates these two ports to perform any required function exactly as if the controller were part of the system.

More complex designs would allow the HCA to perform some of the functions that would be performed by the host computer in the simpler design. Again, an example will best illustrate the process. Assume that a host system wishes to transfer a sector of 256 bytes from the host system to the disk. In the case of the simple HCA design, the driver software would be informed by the operating system of this required transfer and then would send the proper commands to the controller to initiate the transfer process. In addition, the driver software would sequentially fetch each of the 256 bytes of data to be transferred from the host memory and pass it through the SASI data port to the controller.

An alternate, more complex design of the HCA would eliminate much of this processing burden from the host system's processor. If the HCA were given DMA (direct memory access) capability, all the host processor would have to do would be to tell the HCA what sector to read or write to, where in host memory the data transfer was to begin, and how many bytes of data to transfer. The HCA would then take over the entire process of fetching the data from host memory and passing it to the controller and would simply inform the host processor when the process was complete.

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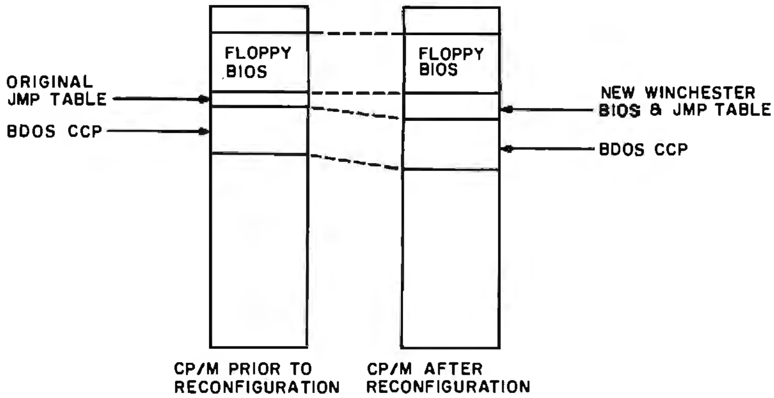


**Figure 5:** *A block diagram showing how the BIOS for the Winchester disk drive is inserted into the CP/M operating system.*

system, we considered this trade-off carefully. In next month's article on the hardware design, we will go through these trade-offs in detail and describe what system we chose and the reason for that choice.

### Variations

Up to now, we have described a general Winchester interface system that consists of a drive, a controller, and an HCA. Any given system must contain all these components. However, there is considerable latitude in how these components are packaged. One common packaging strategy is to put the controller and HCA functions on the same board. In this configuration, a single board plugs into the S-100 bus and a ribbon cable connects this board to the disk. In another strategy, the HCA is plugged into the S-100 bus and a ribbon cable connects the HCA to the controller and another ribbon cable connects the controller to the disk. This second configuration is likely to be more common because it allows builders of controllers to build one controller card that is applicable to many systems. In fact, as you will see next month, this is the configuration we chose.

In the previous discussions, we have not mentioned the possibility of adding multiple Winchester drives to a system. This is certainly possible and can be done with very little design effort. In most cases, the incremental cost of the second drive amounts to only the cost of the drive itself and the interconnection hardware. We will cover this option in detail next month when we discuss the specifics of the hardware implementation we chose and the particular controller hardware.

### Operating System Considerations

The final step in integrating a Winchester disk into an existing S-100 CP/M-based system is to somehow make the CP/M operating system aware that the disk is part of the system. This is done by expanding the existing CP/M BIOS (basic input/output system) to include the new disk. The existing BIOS contains all the software necessary to run the current peripherals on the system. The modification we need would keep these existing routines and add the necessary routines to communicate with the new Winchester disk drive. The simplified memory map of CP/M both before and after the required modification, presented in figure 5, shows how this can be done. At the top of the existing BIOS is a jump table that points to the various primitive disk functions for an existing system. These functions include set track, set sector, select disk, read sector, write sector, etc. In order to add these functions for the new disk, the CP/M system is moved using the MOVECPM utility, and a new jump table is installed that points to the new disk routines. This new code, in addition to performing the required

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disk functions, keeps track of which disk is selected. If the Winchester is the selected disk, then these new routines perform any requested functions. On the other hand, if another disk or peripheral is selected, say the existing floppy disk, then the commands are passed directly to the old BIOS routines for that system. In this way, with a minimum of difficulty, the disk primitive routines for the new disk can be included in the CP/M system. We will cover the details of the BIOS routines for the Winchester system as well as the procedures for reconfiguring the existing system in part 3.

**Summary**

So far we have covered, in a general way, all the components required to interface a Winchester disk with an existing S-100, CP/M-based system. You should now have a fairly complete understanding of what a Winchester disk is, how it operates, and what some of the differences are between Winchester disks. In addition, you should now have a general grasp of the 5¼-inch drive interface, the Shugart Associates Standard Interface, the functions of a smart controller, and the host computer adapter. In parts 2 and 3 we will cover a specific example of the interfacing process in detail, using commercially available equipment: next month we will describe the hardware including the HCA, the controller, and a disk power supply; and in the final article we will describe the software aspects of writing new BIOS routines for CP/M and reconfiguring the system to include the new Winchester disk drive.

These articles will cover only the details of interfacing with S-100 CP/M-based systems. For interfacing with other computers and operating systems, however, the procedure is much the same. First, an HCA must be designed to allow communication between the host computer and the disk controller. Then the equivalent of the CP/M BIOS must be found in the operating system used, and new code must be generated to include the Winchester disk system. Depending on the availability of documentation on the hardware and operating system, this may or may not be an easy task. Hopefully, this series will provide a reference point from which to proceed. ■

*The Winchester disk drive subsystem described in this series of articles is available as a completely assembled unit from ASC Associates of Lexington Park, Maryland. In addition to the S-100 version discussed, versions are also available for TRS-80 and Apple computers. The disk-drive systems for these computers use the same drive and controller hardware as the S-100 version but use a different host computer adapter and interface software. Until a nationwide dealer distribution network is established, these systems will be available by mail order for $1995. To order or obtain further information, write to ASC Associates Inc., POB 615, Lexington Park, MD 20653, or phone (301) 863-6784.*

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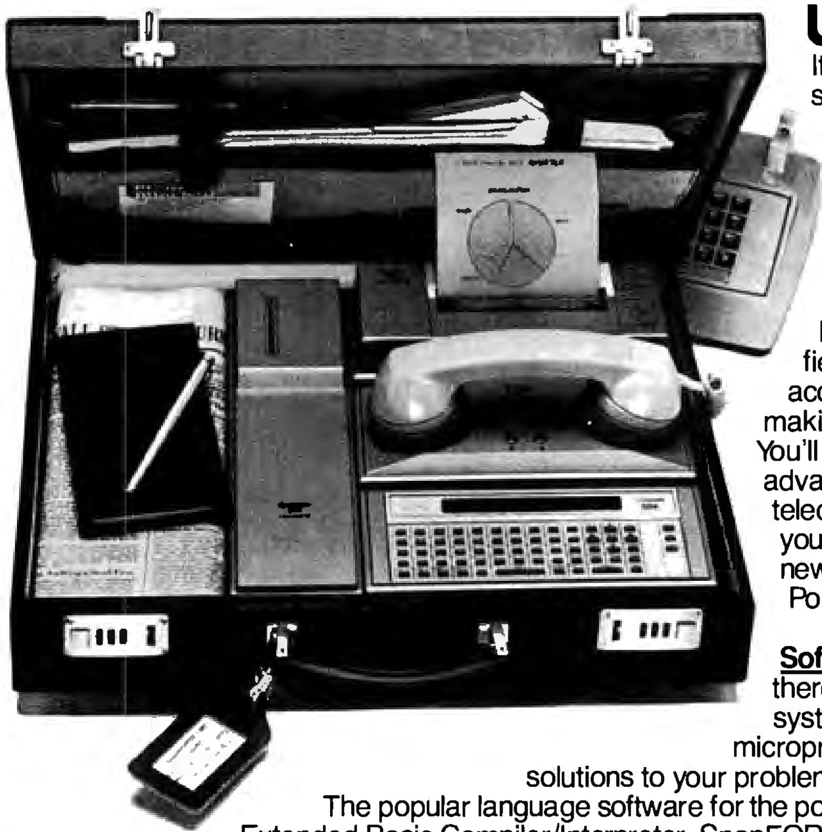

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Last month in part 1 of this series we introduced the North American Presentation-Level-Protocol Syntax (NAPLPS, or "nap-lips"), which is an ASCII-like standard that can be used to facilitate the interchange of both textual and graphical information. The graphical information is encoded in a very portable and resolution-independent form, which can be displayed on a large number of suitably equipped display terminals, printers, or plotters.

This month the basic features and specific coding formats of NAPLPS are introduced. The emphasis will be on the set of Picture-Description Instructions (PDIs), around which most of the important features of NAPLPS revolve.

### A Picture Is Worth 284 Bytes

The easiest way to explain the detailed coding formats of NAPLPS is to use the simple picture (or frame) shown in figure 1 (on page 164), which illustrates many of the basic NAPLPS features. Listing 1 (pages 154-163) is an annotated version of the NAPLPS codes used to produce this picture. As you can see, although the annotated listing is quite long, the actual coding consists of only 284 bytes.

For the sake of simplicity, this picture was created using the 7-bit form of NAPLPS. As you may remember from last month, NAPLPS can use either 7 or 8 bits. If we had used the 8-bit form, the coding would be even shorter.

### Op Codes and Operands

As can be seen in listing 1, a Picture-Description Instruction usually consists of an op code and an operand. The op code specifies a particular function; the optional operand(s) specify the data needed by the function. Figure 2 (on page 166) illustrates the general op code/operand structure used in NAPLPS.

In NAPLPS it is very easy to distinguish between the op codes and the operands. As can be seen, bit 6 is a 0 for an op code and a 1 for an operand. This distinction allows us to have variable-length operands, as long as each operand byte has bit 6 set to a 1. Another nice feature is that if the PDIs are presented in octal form as in listing 1, it is easy to distinguish the operands from the op codes. Octal codes with a first digit of 0 (e.g., 045) are op codes, while a first digit of 1 (e.g., 154) indicates an operand.

Bit 5 will always be a 1 for an op code. This distinguishes op codes from the standard control codes in the C0 set. The lower 5 bits of an op-code byte are used to indicate the particular function. These 5 bits accommodate 32 op codes, which are shown in figure 3. Most of these op codes will be covered in this article.

The operand bytes shown in figure 3 all have bit 6 set to 1. The lower 6 bits (bits 0 through 5) are thus available to encode data, the format of which is dependent on the op code preceding the data.

The 6 bits available in each operand byte can be formatted in a variety of ways. Figure 4 illustrates the four standard operand-encoding formats used in NAPLPS.

The *fixed* format for operand encoding is the simplest and most flexible. (Isn't it interesting that something "fixed" can be "flexible"?) Fixed-format operands are used for small bit fields (6 bits or less) and often contain a few suboperands. For example, in the Text op code (see figure 7), a fixed operand is used to encode the Text Rotation (2 bits: 0, 90, 180, or 270 degrees), Character Path (2 bits: Right, Left, Up, or Down), and Character Spacing (2 bits: 1, 1.25, 1.5, or Proportional). The fixed-format operands are used in most of the

*Text continued on page 164*

**About the Author**
*Jim Fleming was a member of the original small group of engineers at Bell Laboratories who developed PLP (Presentation-Level Protocol). PLP was later standardized as NAPLPS by the ANSI X3L2.1 committee. He is now an independent consultant specializing in interactive computing systems.*

**Listing 1:** *An annotated listing of NAPLPS codes used to produce the designs in figure 1. Note that each byte is given in its octal form. This makes it easy to distinguish op codes (first digit = 0) from operands (first digit = 1). Coordinates are described in terms of both their fractional form and their equivalent form for a 256 by 256 screen. For example, in lines 11–13 the coordinates (0.375,0.25) are equivalent to (96,64) on a 256 by 256 grid. The notation (dx,dy) refers to coordinates relative to the present drawing point.*

```
Byte  Octal Symbolic
No.   Form   Form     Description
--------------------------------------------------------------------
        .
        .        Get ready for graphics (7 Bit Mode)
        .
  1    016       SO        Select G1 (PDI Graphics)
        .
        .        Set color to BLUE
        .
  2    074       SET       Set Color
  3    111       BLU       X100B00B
        .
        .        Draw the sky by clearing
        .        the screen to the current color (BLUE)
        .
  4    040       RES       Reset
  5    120                 Clear screen to current color
        .
        .        Change color to GREEN
        .        for the grass
        .
  6    074       SET       Set Color
  7    144       GRN       X1G00G00
        .
        .        Make sure polygons are not highlighted
        .        or textured
        .
  8    043       TEX       Texture
  9    100                 Solid areas, lines and no highlight
        .
        .        Draw the grass
        .
 10    067       SPF       Set Polygon Filled
 11    111                 }
 12    140                 } - (x,y) = (.375,.25) => (96,64)
 13    100                 }
        .
 14    110                 }
 15    140                 } - (dx,dy) = (+.375,+.0) => (+96,+0)
 16    100                 }
        .
 17    110                 }
 18    102                 } - (dx,dy) = (+.25,+.0625) => (+64,+16)
 19    100                 }
        .
 20    106                 }
 21    106                 } - (dx,dy) = (+.0,-.3125) => (+0,-80)
 22    100                 }
        .
 23    140                 }
 24    100                 } - (dx,dy) = (-1.0,+.0) => (-256,+0)
 25    100                 }
        .

 26    100                 }
 27    106                 } - (dx,dy) = (+.0,+.21484375) => (+0,+55)
 28    107                 }
        .
 29    100                 }
```

*Listing 1 continued on page 156*

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Circle 152 on inquiry card.

*Listing 1 continued:*

```
30   152             ) - (dx,dy) = (+.171875,+.0625) => (+44,+16)
31   140             )
      .
      .     Change to RED
      .
32   074    SET      Set Color
33   122    RED      X1OR0OR0
      .
      .     Make sure highlighting is on
      .
34   043    TEX      Texture
35   104
      .
      .     Draw the house
      .
36   044    SPA      Point Set Absolute
37   110             )
38   127             ) - (x,y) = (.3125,.234375) => (80,60)
39   104             )
      .
40   061    REF      Rectangle Filled
41   100             )
42   174             ) - (dx,dy) = (+.21875,+.125) => (+56,+32)
43   100             )
      .
      .     Draw the roof
      .
44   045    SPR      Point Set Relative
45   170             )
46   104             ) - (dx,dy) = (-.234375,+.125) => (-60,+32)
47   140             )
      .
48   074    SET      Set Color
49   100    BLK
      .
50   065    POF      Polygon Filled
51   100             )
52   141             ) - (dx,dy) = (+.125,+.05859375) => (+32,+15)
53   107             )
      .
54   107             )
55   146             ) - (dx,dy) = (+.125,-.0625) => (+32,-16)
56   101             )
      .
      .     Label the "House"
      .
57   045    SPR      Point Set Relative
58   107             )
59   125             ) - (dx,dy) = (+.078125,-.078125) => (+20,-20)
60   144             )
      .
61   017    SI       Select G0 (ASCII Text)
      .
      .     "House"
      .
62   110    H
63   157    o
64   165    u
65   163    s
66   145    e
      .
      .     Back to graphics
      .
67   016    SO       Select G1 (PDI Graphics)
      .
      .     Set color to CYAN (Light Blue)
      .
68   074    SET      Set Color
69   155    CYN      X1G0BG0B
      .
      .     Label "BIRDS" before drawing them
```

*Listing 1 continued on page 159*

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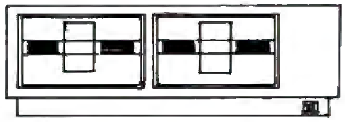

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Circle 22 on inquiry card.

*Listing 1 continued:*

```
         .
 70    044     SPA     Point Set Absolute
 71    102             }
 72    150             } - (x,y) = (.15625,.52734375) => (40,135)
 73    107             }
         .
 74    017     SI      Select G0 (ASCII Text)
         .
         .     "BIRDS"
         .
 75    102     B
 76    111     I
 77    122     R
 78    104     D
 79    123     S
         .
         .     Back to Graphics
         .
 80    016     SO      Select G1 (PDI Graphics)
         .
         .     Draw bird with black wing tips
         .
 81    057     SAF     Set Arc Filled
 82    101             }
 83    167             } - (x,y) = (.1953125,.46875) => (50,120)
 84    120             }
         .
 85    107             }
 86    107             } - (dx,dy) = (+.015625,-.015625) => (+4,-4)
 87    144             }
         .
 88    107             }
 89    107             } - (dx,dy) = (+.0078125,-.015625) => (+2,-4)
 90    124             }
         .
 91    055     ARF     Arc Filled
 92    100             }
 93    100             } - (dx,dy) = (+.0078125,+.015625) => (+2,+4)
 94    124             }
         .
 95    100             }
 96    100             } - (dx,dy) = (+.0234375,+.0234375) => (+6,+6)
 97    166             }
         .
         .     Draw bird without black wing tips
         .
 98    043     TEX     Texture
 99    100
         .
100    045     SPR     Point Set Relative
101    100             }
102    111             } - (dx,dy) = (+.03515625,+.0390625) => (+9,+10)
103    112             }
         .
104    055     ARF     Arc Filled
105    107             }
106    107             } - (dx,dy) = (+.015625,-.015625) => (+4,-4)
107    144             }
         .
108    107             }
109    107             } - (dx,dy) = (+.0078125,-.015625) => (+2,-4)
110    124             }
         .
111    055     ARF     Arc Filled
112    100             }
113    100             } - (dx,dy) = (+.0078125,+.015625) => (+2,+4)
114    124             }
         .
115    100             }
116    100             } - (dx,dy) = (+.0234375,+.0234375) => (+6,+6)
117    166             }
```

*Listing 1 continued on page 161*

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Circle 120 on inquiry card.

*Listing 1 continued:*

```
         .
         .      Draw Cloud
         .
118     044     SPA     Point Set Absolute
119     122             }
120     160             } - (x,y) = (.6875,.5) => (176,128)
         .
121     074     SET     Set Color
122     177     WHT     X1GRBGRB
         .
123     055     ARF     Arc Filled
124     170             }
125     170             } - (dx,dy) = (-.015625,+.0234375) => (-4,+6)
126     146             }
         .
127     100             }
128     110             } - (dx,dy) = (+.04296875,+.01171875) => (+11,+3)
129     133             }
         .
130     055     ARF     Arc Filled
131     100             }
132     110             } - (dx,dy) = (+.03125,+.02734375) => (+8,+7)
133     107             }
         .
134     107             }
135     107             } - (dx,dy) = (+.0234375,-.01171875) => (+6,-3)
136     165             }
         .
137     055     ARF     Arc Filled
138     100             }
139     121             } - (dx,dy) = (+.06640625,+.03515625) => (+17,+9)
140     111             }
         .
141     107             }
142     105             } - (dx,dy) = (+0.0,-.078125) => (+0,-20)
143     104             }
         .
144     055     ARF     Arc Filled
145     177             }
146     157             } - (dx,dy) = (-.08203125,-.01953125) => (-21,-5)
147     133             }
         .
148     170             }
149     150             } - (dx,dy) = (-.06640625,+.01171875) => (-17,+3)
150     173             }
         .
151     065     POF     Polygon Filled
152     100             }
153     101             } - (dx,dy) = (+.02734375,+.03515625) => (+7,+9)
154     171             }
         .
155     100             }
156     110             } - (dx,dy) = (+.0546875,+.015625) => (+14,+4)
157     164             }
         .
158     107             }
159     126             } - (dx,dy) = (+.06640625,-.04296875) => (+17,-11)
160     115             }
         .
         .      Label "CLOUD"
         .
161     045     SPR     Point Set Relative
162     170             }
163     142             } - (dx,dy) = (-.1171875,+.078125) => (-30,+20)
164     124             }
         .
165     017     SI      Select GO (ASCII Text)
         .
         .      "CLOUD"
         .
166     103     C
167     114     L
```

*Listing 1 continued on page 162*

*Listing 1 continued:*

```
168   117    O
169   125    U
170   104    D
       .
       .     Back again
       .
171   016    SO      Select G1 (PDI Graphics)
       .
       .     Set color to CYAN again for the rain
       .
172   074    SET     Set Color
173   155            X1G0BG0B
       .
       .     Draw Rain using various textured lines
       .
174   045    SPR     Point Set Relative
175   107            }
176   104            } - (dx,dy) = (+.01953125,-.1171875) => (+5,-30)
177   152            }
       .
178   043    TEX     Texture
179   102            }
       .
180   051    LIR     Line Relative
181   177            }
182   165            } - (dx,dy) = (-.0390625,-.078125) => (-10,-20)
183   164            }
       .
184   045    SPR     Point Set Relative
185   100            }
186   122            } - (dx,dy) = (+.078125,+.0703125) => (+20,+18)
187   142            }
       .
188   043    TEX     Texture
189   101            }
       .
190   051    LIR     Line Relative
191   177            }
192   165            } - (dx,dy) = (-.0390625,-.078125) => (-10,-20)
193   164            }
       .
194   043    TEX     Texture
195   100            }
       .
196   045    SPR     Point Set Relative
197   100            }
198   122            } - (dx,dy) = (+.078125,+.08984375) => (+20,+23)
199   147            }
       .
200   051    LIR     Line Relative
201   177            }
202   165            } - (dx,dy) = (-.0390625,-.078125) => (-10,-20)
203   164            }
       .
204   045    SPR     Point Set Relative
205   100            }
206   122            } - (dx,dy) = (+.078125,+.0625) => (+20,+16)
207   140            }
       .
       .     Label the "RAIN" vertically
       .
208   042    TXT     Text
209   114            Char Path Down
       .
210   017    SI      Select G0 (ASCII Text)
       .
       .     "RAIN"
       .
211   122    R
212   101    A
213   111    I
214   116    N
       .
       .     Back to Graphics
       .
```

*Listing 1 continued:*

```
215   016     SO      Select G1 (PDI Graphics)
       .
       .      Reset to normal text
       .
216   042     TXT     Text
217   100             Char Path Right
       .
       .      Set color to BLACK
       .      (actually transparent)
       .
218   074     SET     Set Color
219   100     TRN     X1000000
       .
       .      Draw the road
       .
220   044     SPA     Point Set Absolute
221   100             }
222   100             } - (x,y) = (0.0,0.0) => (0,0)
223   100             }
       .
224   065     POF     Polygon Filled
225   120             }
226   106             } - (dx,dy) = (+.5,+.1953125) => (+128,+50)
227   102             }
       .
228   100             }
229   121             } - (dx,dy) = (+.078125,+.0546875) => (+20,+14)
230   146             }
       .
231   100             }
232   120             } - (dx,dy) = (+.078125,+.0) => (+20,+0)
233   140             }
       .
234   177             }
235   155             } - (dx,dy) = (-.0703125,-.0703125) => (-18,-18)
236   166             }
       .
237   167             }
238   142             } - (dx,dy) = (-.3515625,-.1796875) => (-90,-46)
239   162             }
       .
       .      Label the "ROAD"
       .
240   044     SPA     Point Set Absolute
241   120             }
242   102             } - (x,y) = (.5,.078125) => (128,20)
243   104             }
       .
244   017     SI      Select G0 (ASCII Text)
       .
       .      "ROAD"
       .
245   122     R
246   117     O
247   101     A
248   104     D
       .
249   016     SO      Select G1 (PDI Graphics)
       .
       .      Change Size of text
       .
250   042     TXT     Text
251   100             }
252   100             }
253   100             }
254   112             } - (dx,dy) = (+.046875,+.078125) => (+12,+20)
255   144             }
       .
       .      Draw BLACK "Figure 1"
       .      as base for drop shadow
       .
256   044     SPA     Point Set Absolute
257   112             }
258   105             } - (x,y) = (.25,.6859375) => (64,175)
259   107             }
```

*Listing 1 continued on page 164*

*Listing 1 continued:*

```
                 .
260     017      SI       Select GO (ASCII Text)
                 .
                 .        "Figure 1"
                 .
261     106      F
262     151      i
263     147      g
264     165      u
265     162      r
266     145      e
267     040      space
268     061      1
                 .
                 .        Finish drop shadowing with yellow over black
                 .
269     0 6      SO       Select G1 (PDI Graphics)
                 .
270     074      SET      Set Color
271     166      YEL      X1GROGRO
                 .
272     044      SPA      Point Set Absolute
273     102               }
274     176               } - (x,y) = (.24609375,.6875) => (63,176)
275     170               }
                 .
276     0 7      SI       Select GO (ASCII Text)
                 .
                 .        "Figure 1"
                 .
277     106      F
278     151      i
279     147      g
280     165      u
281     162      r
282     145      e
283     040      space
284     061      1
                 .
                 .        The end
                 .
                 .              Text is still large and
                 .              YELLOW is the current color
                 .
```

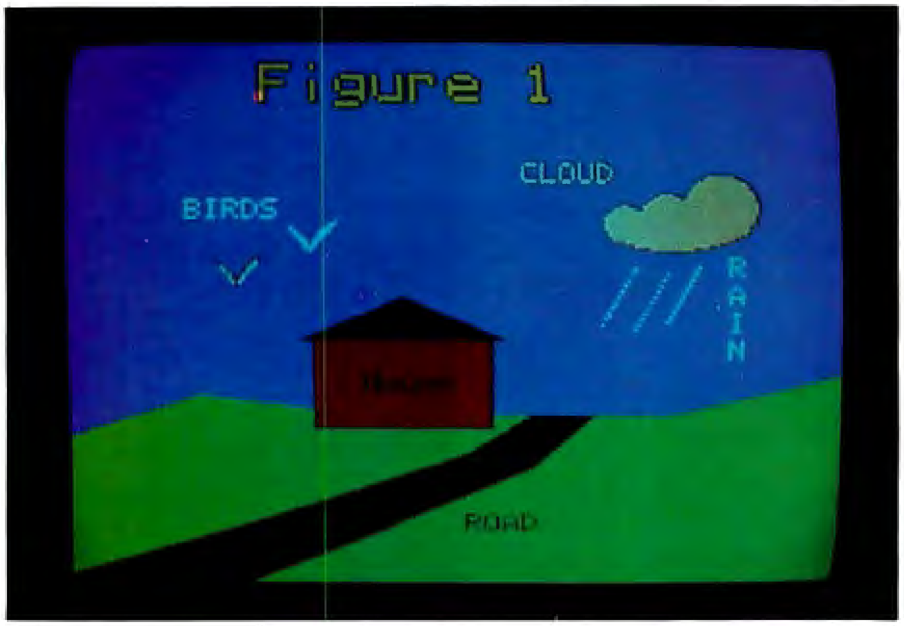



**Figure 1:** *A simple picture produced by the NAPLPS codes in listing 1. (Photo courtesy of the Unir Corporation.)*

*Text continued from page 152:*
"control-oriented" NAPLPS functions.

The *single-value* format is used when a common integer is needed. This format is used when specifying color indexes and blink rates (in tenths of a second). The single-value format is encoded using 1 to 4 bytes, each containing 6 bits of data. In the default mode, 1 byte is used, thus allowing numbers in the range 0 to 63 to be encoded. In the maximum mode (4 bytes or 24 bits), numbers from 0 to 16,777,215 can be specified.

The most common format in NAPLPS is the *multivalue* operand. The multivalue-operand format has two coordinate forms and a color form, as shown in figure 4.

The coordinate forms are used to encode $(x,y)$ or $(x,y,z)$ coordinate locations in the unit screen. In the two-dimensional mode, each 6-bit operand contains 3 bits of $x$ and 3 bits of $y$. Multivalue operands are normally encoded in 3 bytes. Therefore, 9 bits of resolution are encoded for each coordinate. The 9 bits allow for a sign bit and 8 data bits, which results in coordinates suitable for a 256 by 256 resolution display.

NAPLPS supports multivalue operands up to 8 bytes. The 8 bytes each contain 6 data bits. Therefore, 48 bits are available to be split between the coordinates. In two-dimensional mode the 24 bits available for each coordinate can support displays with a resolution of 8 million by 8 million points! This exceeds the resolution of most media, including a page in this magazine.

The multivalue-operand format is also used for color specification. Various amounts of green, red, and blue are specified using this multibyte format. Each 6-bit data item contains 2 bits of each color. The colors are interlaced as shown in figure 4, with green being first and thus least likely to be truncated. This takes advantage of the fact that the human eye is more responsive to green than it is to red and blue.

The 8-byte multivalue-operand format will again yield 48 bits of color information that results in 280,000,000,000,000 colors. With the maximum display resolution and the

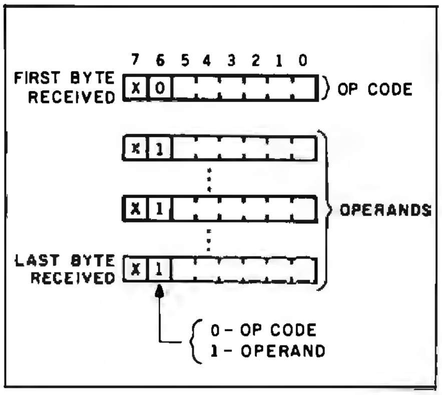



**Figure 2:** *The general structure for op codes and operands of the Picture-Description Instructions (PDIs) in NAPLPS.*

maximum color resolution, NAPLPS can support displays with $2^{96}$ bits of display memory! At today's memory prices, such a display would cost $750 billion billion billion dollars. (No wonder semiconductor companies are interested in NAPLPS.)

The final operand format is the *string* operand. This format is used when a long string of bits is needed that may require hundreds or thousands of bytes to encode. This format is used when sending high-resolution pictures and for encoding compressed chain-coded images. These techniques will be discussed in part 3 of this series.

The operand/op code encoding structure of NAPLPS allows a variety of formats and subformats. Many of the op codes contain one or more of the operand types. For example, the Text op code, which will be described in detail later on, is followed by two fixed-format operands and a multivalue operand. The total number of operand bytes for this op code is variable, but the first 2 bytes will always be interpreted as fixed-format bytes and the remaining bytes will be considered as part of a multivalue format. Because of the variable-length nature of the operand encoding in NAPLPS, operands can be truncated and/or omitted with a consistent result dependent on the op code active at the time.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | b6 | 0 | 0 | 1 | 1 | 1 | 1 |
| | | | | b5 | 1 | 1 | 0 | 0 | 1 | 1 |
| | | | | b4 | 0 | 1 | 0 | 1 | 0 | 1 |
| b3 | b2 | b1 | b0 | | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 0 | 0 | 0 | 0 | RESET | RECT (OUTLINED) | | | | |
| 0 | 0 | 0 | 1 | 1 | DOMAIN | RECT (FILLED) | | | | |
| 0 | 0 | 1 | 0 | 2 | TEXT | SET & RECT (OUTLINED) | | | | |
| 0 | 0 | 1 | 1 | 3 | TEXTURE | SET & RECT (FILLED) | | | | |
| 0 | 1 | 0 | 0 | 4 | POINT SET (ABS) | POLY (OUTLINED) | | | | |
| 0 | 1 | 0 | 1 | 5 | POINT SET (REL) | POLY (FILLED) | | | | |
| 0 | 1 | 1 | 0 | 6 | POINT (ABS) | SET POLY (OUTLINED) | NUMERIC DATA | | | |
| 0 | 1 | 1 | 1 | 7 | POINT (REL) | SET & POLY (FILLED) | | | | |
| 1 | 0 | 0 | 0 | 8 | LINE (ABS) | FIELD | | | | |
| 1 | 0 | 0 | 1 | 9 | LINE (REL) | INCR POINT | | | | |
| 1 | 0 | 1 | 0 | 10 | SET & LINE (ABS) | INCR LINE | | | | |
| 1 | 0 | 1 | 1 | 11 | SET & LINE (REL) | INCR POLY (FILLED) | | | | |
| 1 | 1 | 0 | 0 | 12 | ARC (OUTLINED) | SET COLOR | | | | |
| 1 | 1 | 0 | 1 | 13 | ARC (FILLED) | WAIT | | | | |
| 1 | 1 | 1 | 0 | 14 | SET & ARC (OUTLINED) | SELECT COLOR | | | | |
| 1 | 1 | 1 | 1 | 15 | SET & ARC (FILLED) | BLINK | | | | |

**Figure 3:** *The complete set of Picture-Description Instruction op codes in NAPLPS.*

## Picture-Description Instructions

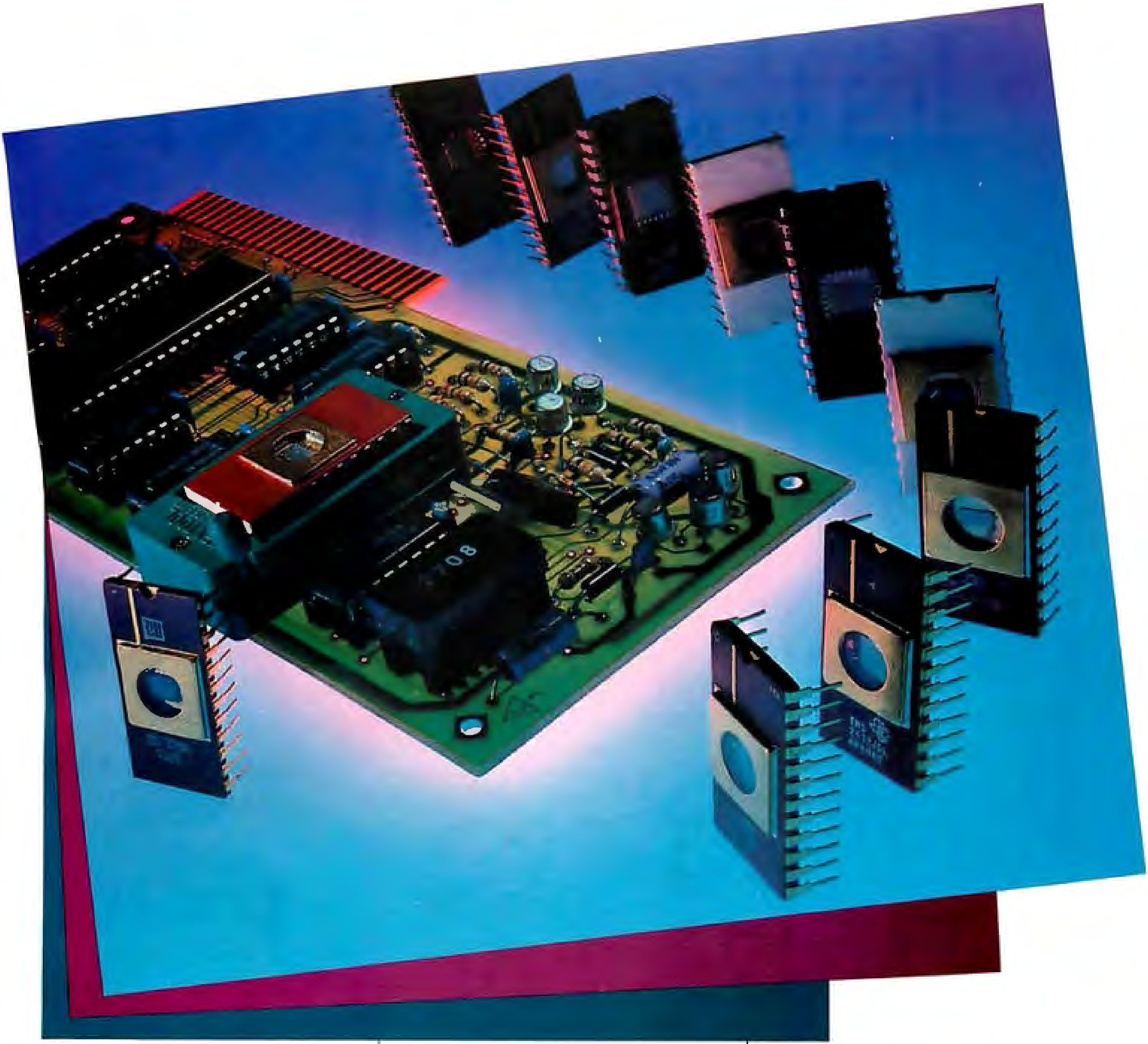
The Picture-Description Instructions (PDIs) are used to encode graphics images in NAPLPS. Codes from the PDI G-set and the ASCII-like text set can be intermixed on the same frame. Most of the common PDIs have been used to encode the image in figure 1. These PDIs are described here with references to the coding in listing 1.

## Reset

The Reset PDI is illustrated in figure 5. It is used to clear the screen



*text continued on page 170*



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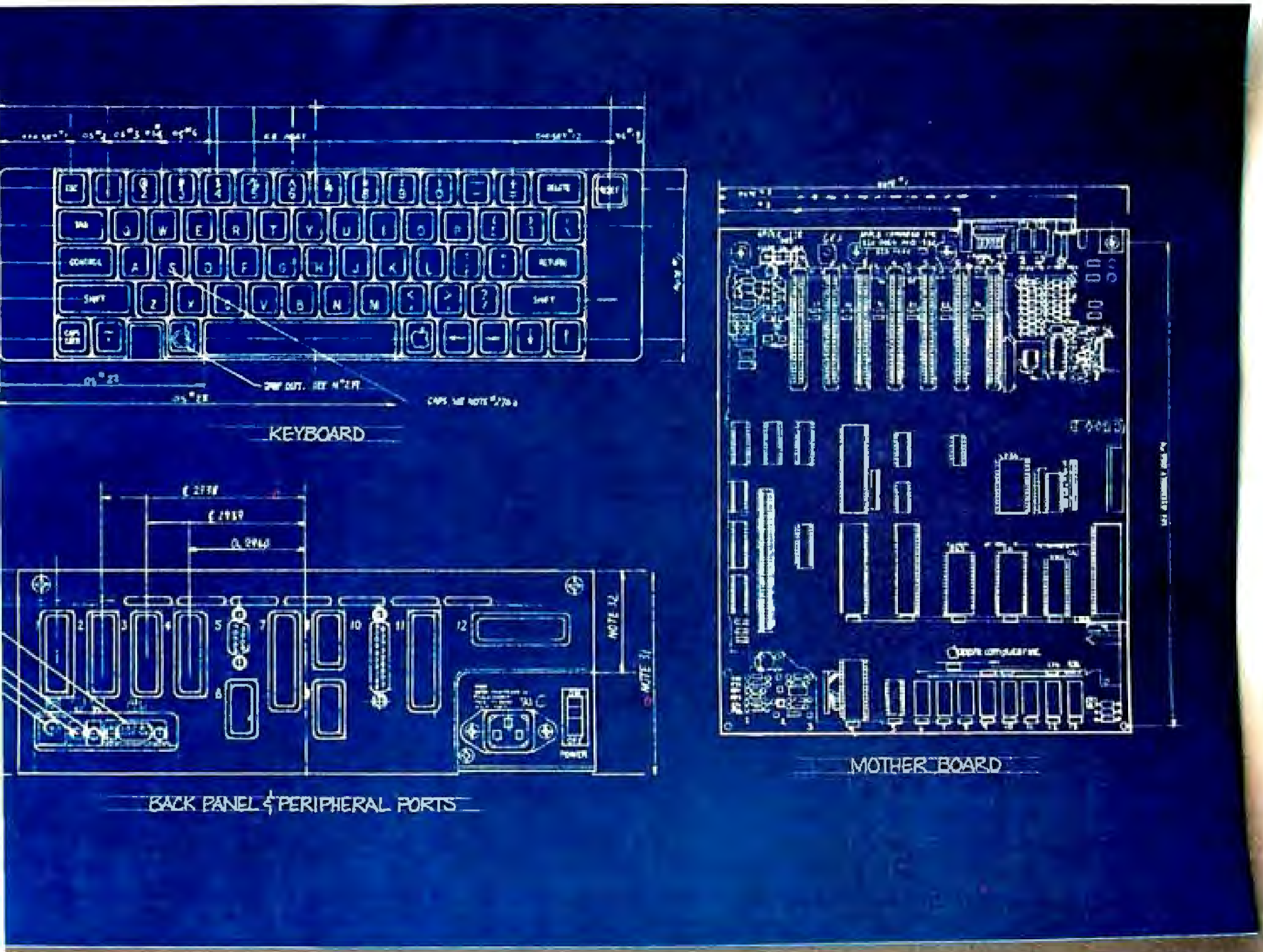


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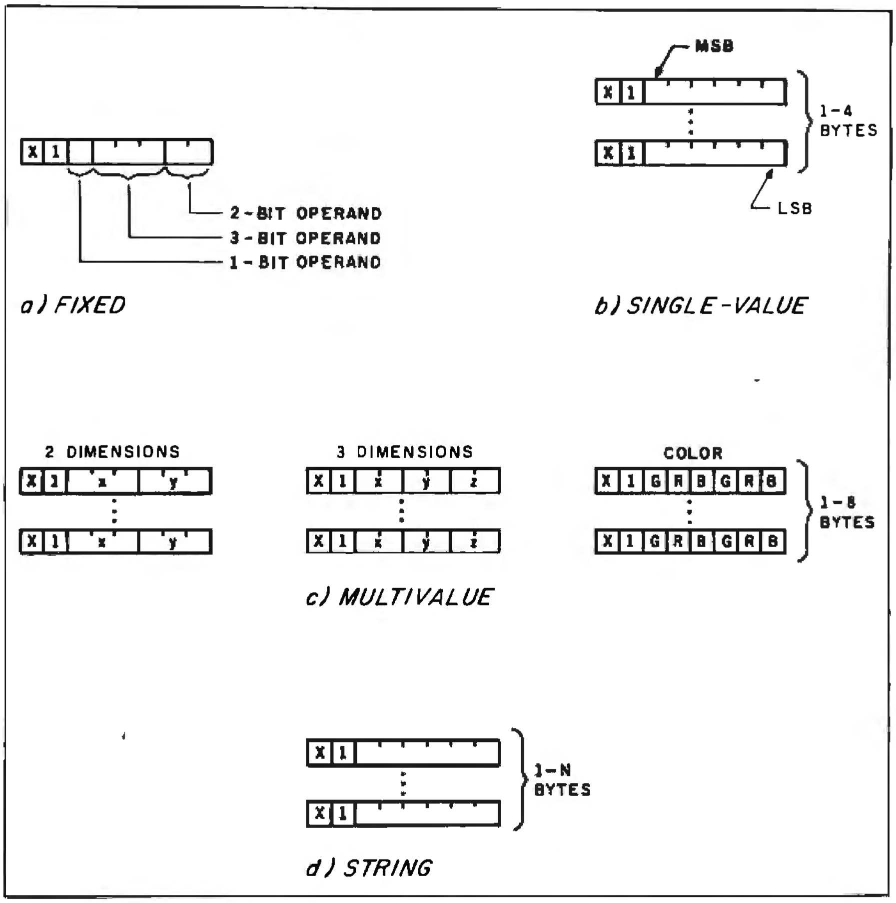


**Figure 4:** *The various formats for the operands of the PDIs in NAPLPS.*

RESET

| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| OP CODE (2/0) | X | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| OPERAND (SEE BELOW) | X | 1 | B | B | B | C | C | D |
| OPERAND (SEE BELOW) | X | 1 | R | M | X | U | F | T |

| B B B | Color |
|---|---|
| 0 0 0 | No action |
| 0 0 1 | Physical display area to nominal black |
| 0 1 0 | Physical display area to current drawing color |
| 0 1 1 | Border area to nominal black |
| 1 0 0 | Border area to current drawing color |
| 1 0 1 | Physical display area and border area to current drawing color |
| 1 1 0 | Physical display area to current drawing color and border area to nominal black |
| 1 1 1 | Physical display area and border area to nominal black |

| C C | Color mode |
|---|---|
| 0 0 | No action |
| 0 1 | Select color mode 0, set color map to default colors, and set the in-use drawing color to white |
| 1 0 | Select color mode 1 and set color map to default colors. If this is executed while in color mode 0, it has the same effect as "11." |
| 1 1 | Select color mode 1, set color map to default colors, and set the in-use drawing color to white |

| Miscellaneous | Resets |
|---|---|
| D | Domain |
| T | Text |
| F | Blink |
| U | Unprotected (User) Fields |
| X | Texture |
| M | Macro PDIs |
| R | DRCS |

**Figure 5:** *The operand structure for the Reset instruction.*

and initialize various attributes. Two fixed-format operand bytes contain nine suboperands. The second operand byte can be omitted when those operations are not needed. If both operand bytes are omitted, a complete Reset is performed.

The screen is cleared based on the value in bits 4 to 6 of the first operand byte. The eight combinations are shown in figure 5. In the example frame (line 4), the screen is cleared once to establish the blue sky. The fixed-format operand (octal 120 at line 5) indicates that the screen should be cleared to the current in-use color (in this case, blue). Note that the second fixed-format operand byte is omitted. The op code at line 6 indicates that the previous operation and op code have ended.

## Domain

The Domain PDI is used primarily to control the size of data operands for subsequent PDIs. As shown in figure 6, the Domain PDI is made up of a fixed-format operand followed by a multibyte operand. The fixed-format operand controls the size of single-value operands and multivalue operands as well as the dimensionality of coordinates.

The multivalue operand is used to control the size of the logical drawing point.

## Text

The Text PDI controls attributes related to text and "text-like" symbols. As discussed in part 1, text symbols are unique in the sense that they are rectangular templates that contain a figure. When a text symbol is requested, the proper template is positioned at the current drawing point, the template is scaled as specified by the text size, and the drawing is performed.

Figure 7 illustrates the Text PDI and operands. Two fixed-format operand bytes contain six suboperands. Each of the suboperands has four possible values. As can be seen, these suboperands control attributes such as rotation, spacing, and cursor style.

The multivalue operand following the two fixed-format operands is used to specify the size and orientation of the text template. The size is expressed in terms of relative coordinates, which we will indicate by the notation $(dx,dy)$. This is to distinguish relative coordinates from absolute coordinates $(x,y)$ that refer

DOMAIN

| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| OP CODE (2/1) | X | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| OPERAND (see below) | X | 1 | D | M | M | M | S | S |
| LOGICAL PEL SIZE | X | 1 | | | | | | |
| ⋮ | | | | | | | | |
| | X | 1 | | | | | | |
| | | | dx | | | dy | | |

| D | Dimensionality |
|---|---|
| 0 | two-dimensional |
| 1 | three-dimensional |

| M M M | Length of Multivalue Operands (Bytes) |
|---|---|
| 0 0 0 | 1 |
| 0 0 1 | 2 |
| 0 1 0 | 3 (default) |
| 0 1 1 | 4 |
| 1 0 0 | 5 |
| 1 0 1 | 6 |
| 1 1 0 | 7 |
| 1 1 1 | 8 |

| S S | Length of Single-Value Operands (Bytes) |
|---|---|
| 0 0 | 1 (default) |
| 0 1 | 2 |
| 1 0 | 3 |
| 1 1 | 4 |

**Figure 6:** *The operand structure for the Domain instruction. The Logical Pel Size can be thought of as the size of the drawing pen.*

TEXT

| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| OP CODE (2/2) | X | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| OPERAND (see below) | X | 1 | I | I | P | P | R | R |
| OPERAND (see below) | X | 1 | C | C | M | M | S | S |
| CHARACTER FIELD SIZE | X | 1 | | | | | | |
| ⋮ | | | | | | | | |
| | X | 1 | | | | | | |
| | | | dx | | | dy | | |

| I I | Intercharacter Spacing |
|---|---|
| 0 0 | 1 (default value) |
| 0 1 | 1.25 |
| 1 0 | 1.5 |
| 1 1 | Proportional spacing |

| P P | Character Path |
|---|---|
| 0 0 | Right (default) |
| 0 1 | Left |
| 1 0 | Up |
| 1 1 | Down |

| R R | Rotation |
|---|---|
| 0 0 | 0 (default) |
| 0 1 | 90 |
| 1 0 | 180 |
| 1 1 | 270 |

| C C | Cursor Style |
|---|---|
| 0 0 | Underscore (default) |
| 0 1 | Block |
| 1 0 | Cross-hair |
| 1 1 | Custom |

| M M | Move Attribute |
|---|---|
| 0 0 | Move together (default) |
| 0 1 | Cursor leads |
| 1 0 | Drawing point leads |
| 1 1 | Moving independently |

| S S | Interrow Spacing |
|---|---|
| 0 0 | 1 (default) |
| 0 1 | 1.25 |
| 1 0 | 1.5 |
| 1 1 | 2 |

**Figure 7:** *The operand structure for the Text instruction.*

TEXTURE

| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| OP CODE (2/3) | X | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| OPERAND (see below) | X | 1 | P | P | P | H | L | L |
| MASK SIZE | X | 1 | | | | | | |
| ⋮ | | | | | | | | |
| | X | 1 | | | | | | |
| | | | dx | | | dy | | |

| P P P | Texture Pattern |
|---|---|
| 0 0 0 | Solid (default pattern) |
| 0 0 1 | Vertical hatching |
| 0 1 0 | Horizontal hatching |
| 0 1 1 | Vertical and horizontal crosshatching |
| 1 0 0 | Mask A |
| 1 0 1 | Mask B |
| 1 1 0 | Mask C |
| 1 1 1 | Mask D |

| H | Highlight |
|---|---|
| 0 | Off |
| 1 | On |

| L L | Line Texture |
|---|---|
| 0 0 | Solid (default) |
| 0 1 | Dotted |
| 1 0 | Dashed |
| 1 1 | Dotted-dashed |

**Figure 8:** *The operand structure for the Texture instruction.*

to specific points on the unit screen.

In the example frame, text is used to label the objects as well as the entire figure. Most of the text is encoded in the standard manner and therefore no Text PDI is needed. The first Text PDI appears in line 208 and is used to change the Character Path from left-to-right to down. This allows the word "RAIN" (lines 211–214) to be sent without repositioning the drawing point.

Note that the second fixed-format operand and the multivalue size operand are omitted because only the Character Path is being changed. Also note that because the Character Path is being changed, the other two suboperands in that byte (Intercharacter Spacing and Rotation) have to be restated or "refreshed." It is assumed that the NAPLPS code generator will always have knowledge of the current settings of these suboperands so that such a refresh is easy to do.

The Text PDI is used again in lines 250–255. The size of the text is changed to label the figure. The Character Path is also set to left-to-right. The (*dx,dy*) of (+0.046875, +0.078125) results in a character twice as big in both dimensions as the default characters. If you want to find out how many of these characters could fit on a line, you could divide 1.0 by 0.046875, which results in 21.3 characters per line.

It should be noted that no other Text PDIs appear after the one in line 250. At the end of the frame, the text size is still large. When the next frame is sent, the text size should be changed back to its default state. This is typically done with a global Reset at the beginning of the frame.

## Texture

The Texture PDI applies to the texturing of filled areas and lines (see figure 8). Line texturing can be set so that dotted, dashed, or dotted-dashed lines will be drawn instead of the nor-

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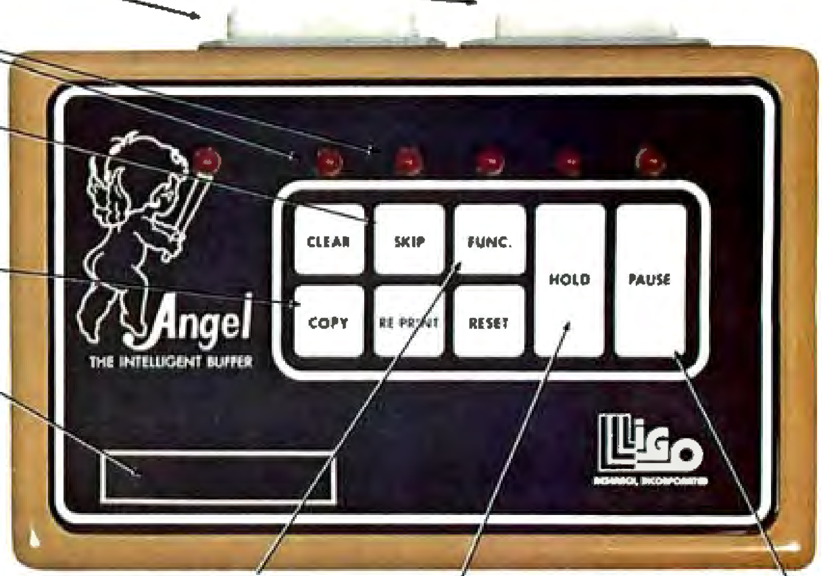


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| B | | ? | N/A | 19.2K | ? |
| | Yes | * | | * | * |
| el-Serial | Y | * | | * | * |
| | Yes | * | Y | * | * |
| | Yes | Y | | Y | Yes |
| Copy | Yes | Yes | | Yes | |
| | Yes | Y | | Yes | Y |
| | Y | | | Y | |
| Page Skip | Yes | | | | |
| Page Reprint | Yes | | | | |
| Copy | Yes | ? | No | | |
| f-Diagnostics | Yes | ? | ? | | |
| | Yes | No | No | | |

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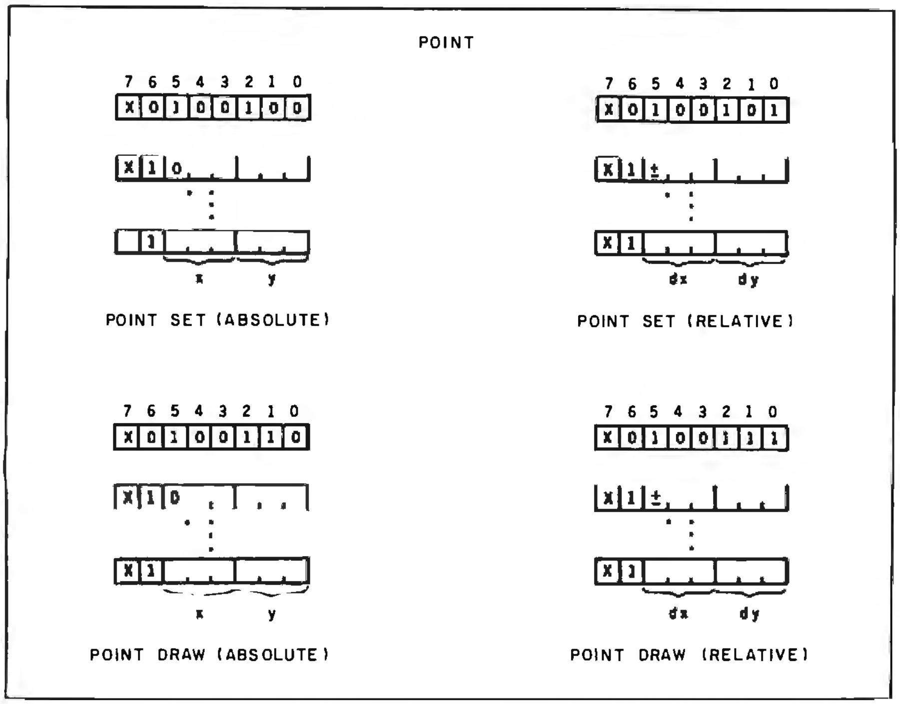



**Figure 9:** *The Point instructions in NAPLPS. Point Set merely moves the "drawing point" to the desired position. Point Draw actually draws a point at that position. Coordinates can be either absolute (x,y) or relative (dx,dy). The first bit of each coordinate is a sign bit. The remaining bits are encoded as fixed-point binary numbers, with the "binary point" assumed to be just to the right of the sign bit.*

mal solid line. A variety of area textures can be selected so that large objects can have recognizable interiors. The area textures can be chosen from a "stock" set of patterns or "programmable" patterns can be used.

A "cartoon-like" highlighting feature is included. When enabled, filled areas are highlighted (usually in black) to accent the edges. This is especially useful in low-resolution video-display systems that have trouble making rapid color changes.

The Texture PDI is used several times in the example frame (lines 8, 34, 98, 178, 188, and 194). The highlighting is turned off for the grass and on for the house. The highlighting is also used on the left bird to add a little diversity. The line textures are demonstrated in creating the rain (lines 171–203).

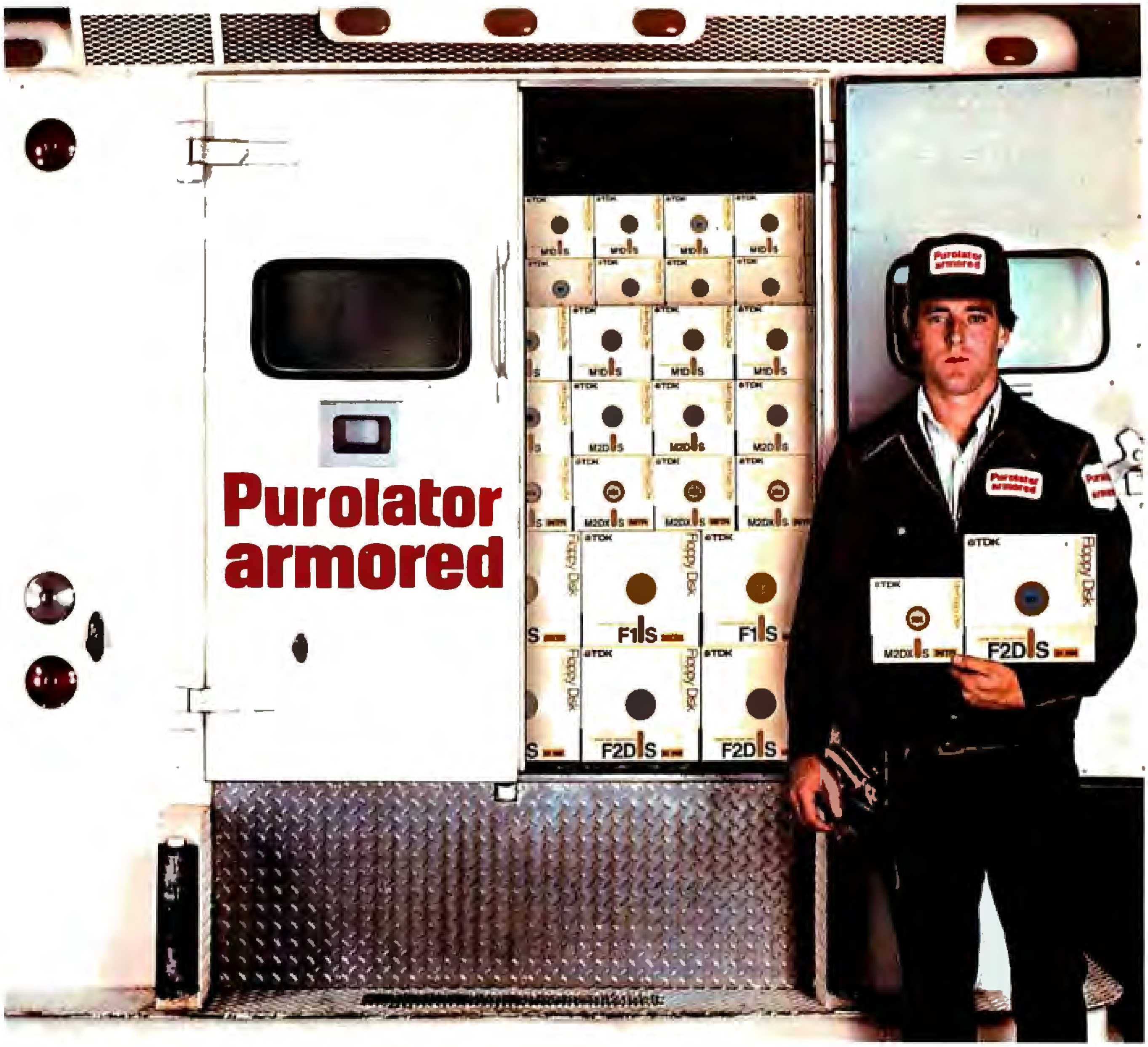
### Outlined Drawings

The majority of drawings are created using the basic primitives *Point, Line, Arc, Rectangle,* and *Polygon*. All these primitives are supported in NAPLPS with each one having several forms.

### Points

Points can be drawn on the unit screen in a variety of ways. As shown in figure 9, four Point PDIs are provided. Two of these commands are used to actually draw points (Point Draw), while the other two merely position the drawing point prior to drawing text or graphics (Point Set). The coordinates for both Point Draw and Point Set can be expressed in either absolute or relative terms.

At this point (no pun intended), it is probably useful to distinguish between the drawing point and the cursor. The drawing point is the imaginary pen point or brush tip that is used to draw graphics on the screen. The cursor is the typical block or underscore that marks the position where the next text entry will be made. The drawing point and cursor usually "track" each other, but this is not required. In other words, the cur-

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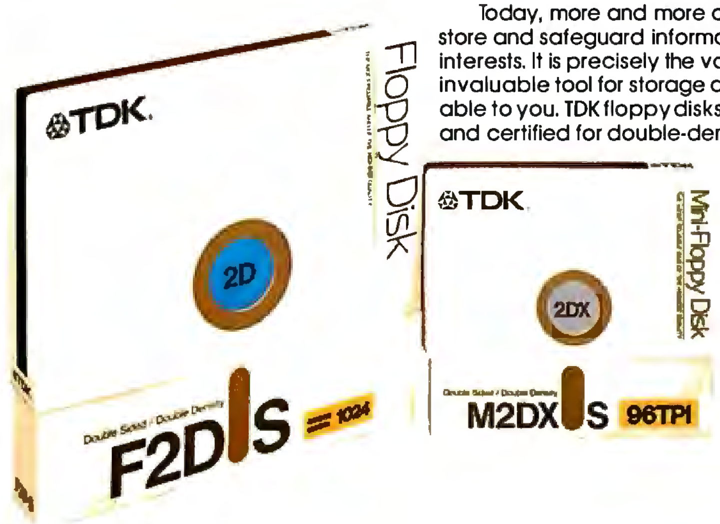


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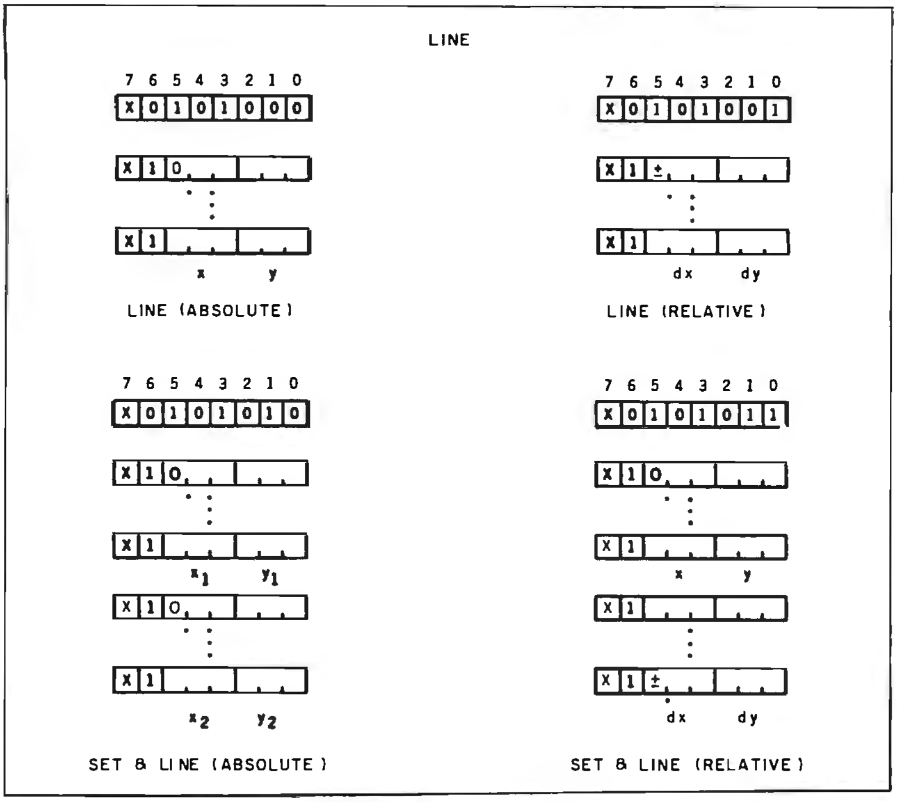


**Figure 10:** *The Line instructions. The Set & Line instructions move the drawing point to a new position and draw a line from that position. The Line instructions draw a line from the present drawing point.*

sor can be positioned on the screen and the drawing point can be moved independently.

The example frame uses the "Set" forms of the Point PDIs, but not the "Draw" forms. Line 36 is an example of a Set Point Absolute op code. This op code is used to position the drawing point to a specific place on the screen regardless of where the drawing point is currently located. This is in preparation for drawing the house.

Line 44 is an example of a Set Point Relative op code. This op code is followed by a $(dx,dy)$ operand that specifies a distance to move from the current position. This move is made in preparation for drawing the roof. Note that the relative form of the op code is useful because the roof should always be "tied" to the house. If a specific (absolute) screen coordinate had been specified, the roof would be fixed at a certain location. In this example, if the initial coordinate (lines 37–39) is changed, the roof will move with the house.

## Lines

Lines are used in almost every graphics display. Four forms of the Line PDI are provided, as shown in figure 10. The major difference in the four op codes is that two of them draw a line from the present drawing point and the other two draw from a new set point. Also, two of the op codes involve relative positions and two involve absolute positions.

Lines are used to create the rain in the example frame. The relative form of the Line PDIs is used in lines 180, 190, and 200. As mentioned, the lines are drawn using the current texture setting.

## Arcs

The Arc PDIs are extremely powerful, but may be confusing to the casual observer. Most people can eventually be convinced that only one circular arc can be drawn through three points if two of the points are known to form the endpoints. In NAPLPS the three points on the arc are specified rather than the center and radius. The three points are specified just like other points in the unit screen.

text continued on page 180

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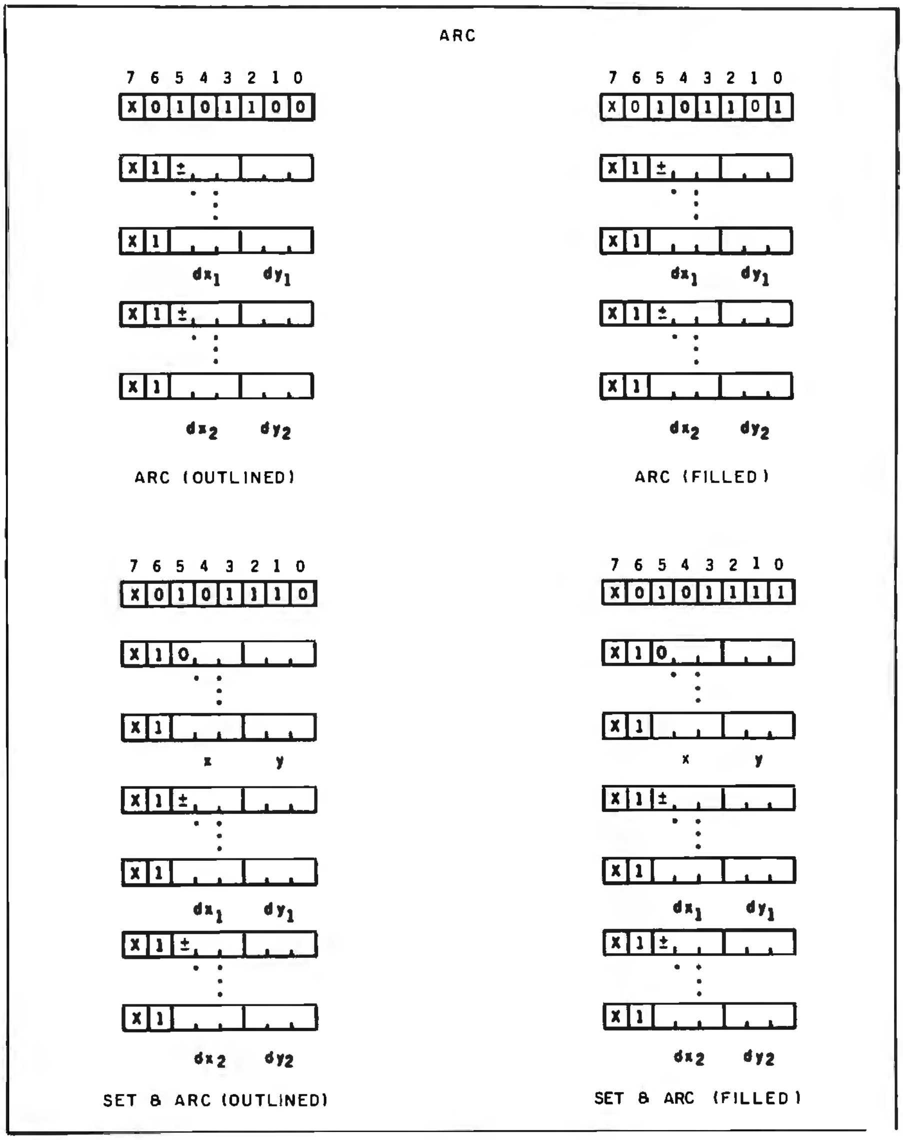


**Figure 11:** *The Arc instructions.*

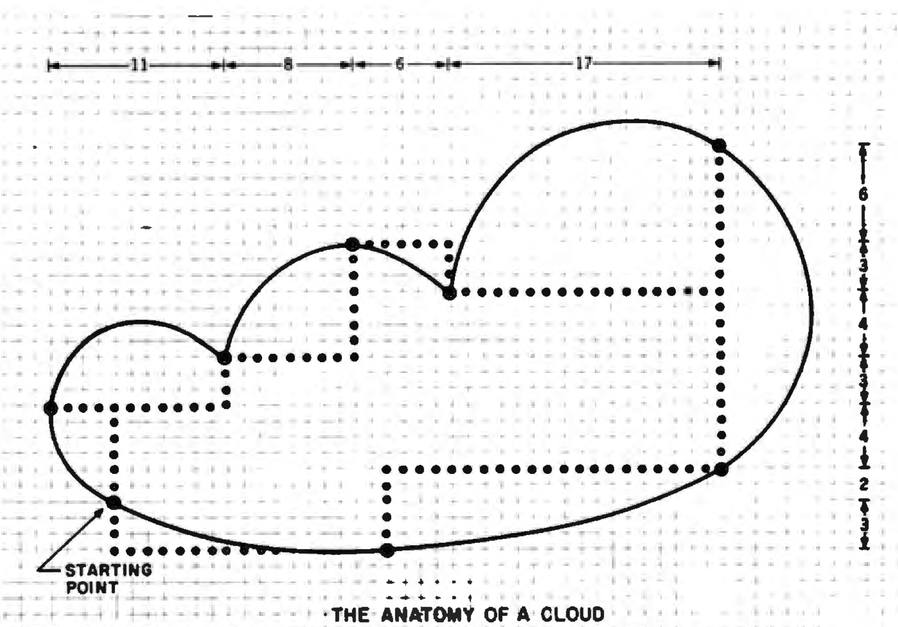


**Figure 12:** *A diagram showing how the cloud in figure 1 was constructed from four filled arcs and a filled polygon.*

Four forms of the Arc PDIs are included in NAPLPS, as shown in figure 11. Two of the forms allow arcs to be filled so that solid areas with curved edges can be created.

Arcs are used in the example frame to create the birds and the cloud. As shown in figure 12, the cloud is made up of four arcs and a polygon. The area between each arc and a line (or chord) connecting the endpoints of the arc is filled by the Arc (Filled) command. The Polygon (Filled) command fills the middle area.

Circles are a subset of the more general arc. If only two points are specified (instead of three), those points are assumed to form endpoints of a diameter of a circle. Circles can also be encoded using three points in the normal arc format, but the starting and ending points must be equal for a circle to be drawn.

A "hook" has been provided in NAPLPS so that it might eventually support complex curves or *splines*. These curves cannot be described by using simple arcs of circles. But if more than three points are specified for an arc, it should be possible to draw a smooth curve connecting the points. Until algorithms are developed that can efficiently draw a spline, lines can be used to connect the points.

## Rectangles

Both filled and outlined rectangles are supported by NAPLPS. The four forms of the Rectangle PDI are shown in figure 13. Rectangles are described by specifying the opposite corner in terms of relative $(dx,dy)$ coordinates. Negative values for $dx$ or $dy$ can be used to produce rectangles in various directions from the current drawing point.

One difference that should be noted with Rectangles is the final destination of the drawing point. Most drawing commands cause the drawing point to be left at the last point involved in the figure. In the case of the Rectangle, only the $x$ coordinate is modified so that the drawing point moves horizontally. This allows for histograms or bar charts to be generated in an efficient manner.

A Rectangle is used to generate the


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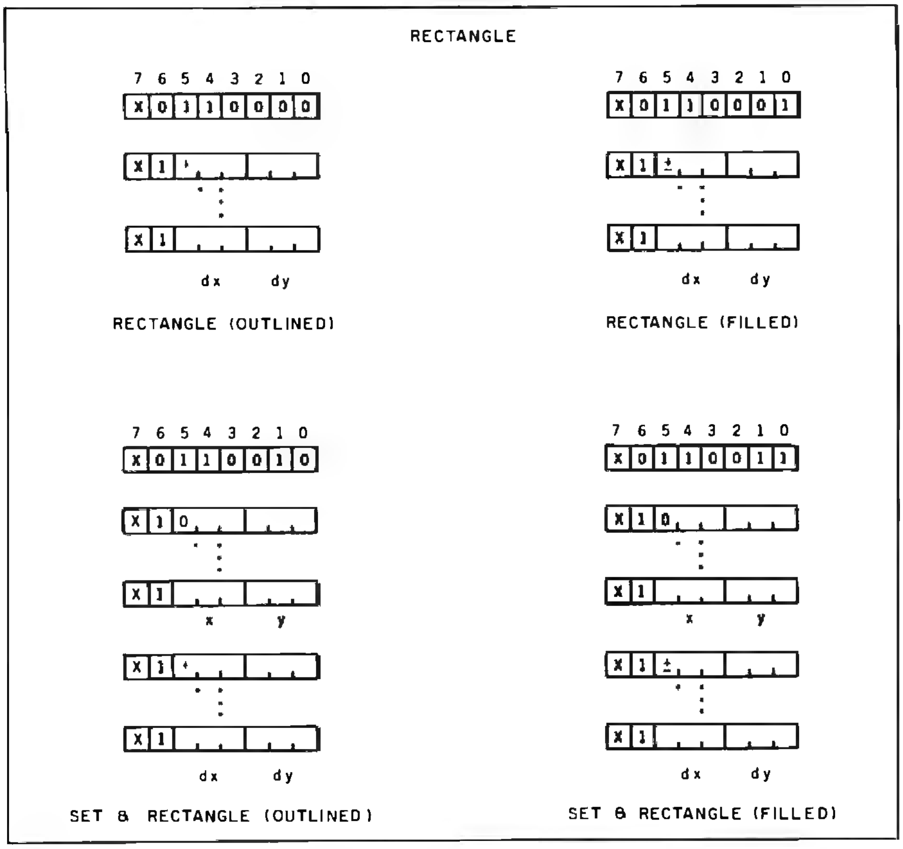



**Figure 13:** *The Rectangle instructions. Note that only one point is required to define a rectangle.*

house in the example frame. The op code at line 40 could have been a Set Rectangle Filled with the data from lines 37–39 moved into the operation. This would eliminate the need for the Point Set Absolute op code at line 36. Both encodings would yield the same result.

## Polygons

The irregular Polygon is a very useful feature in NAPLPS. Many objects can be broken down into multisided irregular objects. These objects can be encoded using the endpoints of the lines forming the sides.

Four forms of the Polygon op code are available, as shown in figure 14. The outlined polygons do not offer much more than an efficient way to send a lot of lines. It should be noted that the last line in a polygon is not explicitly sent. The polygon is automatically "closed" by an edge connecting the last point sent and the starting point.

The filled polygons offer the ability to define an entire object disregarding

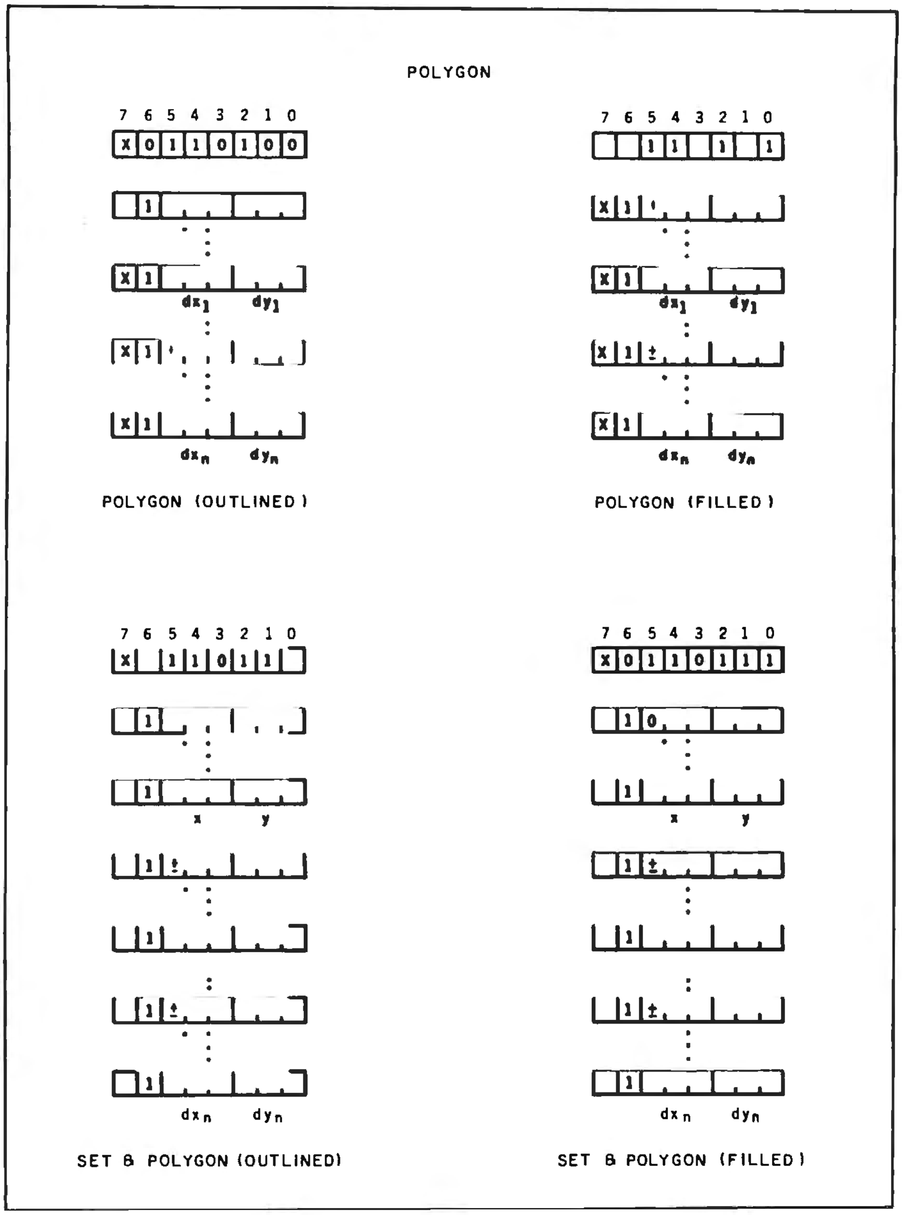



**Figure 14:** *The Polygon instructions. Any number of points can be used to define the polygon.*

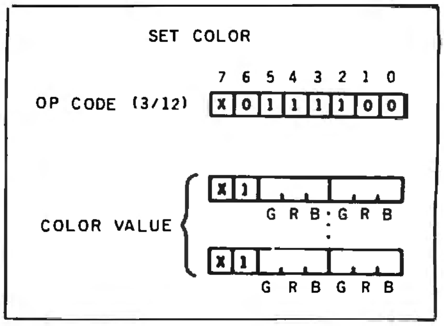



**Figure 15:** *The Set Color instruction. This instruction defines the color with which all succeeding characters or graphics designs will be drawn.*

what may be "under" the object. Pictures can be built up in the same manner that kids create pictures using construction paper.

In the example frame, the largest polygon is the grass (lines 10–31). When the house is drawn on top of the grass, a piece of the polygon is covered. Likewise, when the road is drawn (lines 220–239), more of the grass is covered. If the grass had been drawn last, part of the house and the entire road would not be seen.

The polygon that is used to fill the center of the cloud (lines 151–160) can be derived directly from the arcs that surround it. As shown in figure 12, the *(dx,dy)* values for the polygon end up being the sum of the *(dx,dy)* values for the three points that describe the arc.

## Other PDIs

Several other PDIs are available in NAPLPS. Some of them allow compressed encoding of high-resolution images and detailed line drawings. PDIs are included that allow "logical" areas on the screen to be specified for user input. Timed waits and blinking capabilities are also part of NAPLPS, but will not be discussed here.

## Color Control

Color control in NAPLPS ranges from primitive, static color definitions to exotic color mapping and animation. Here I shall describe only the primitive color-control capabilities of NAPLPS.

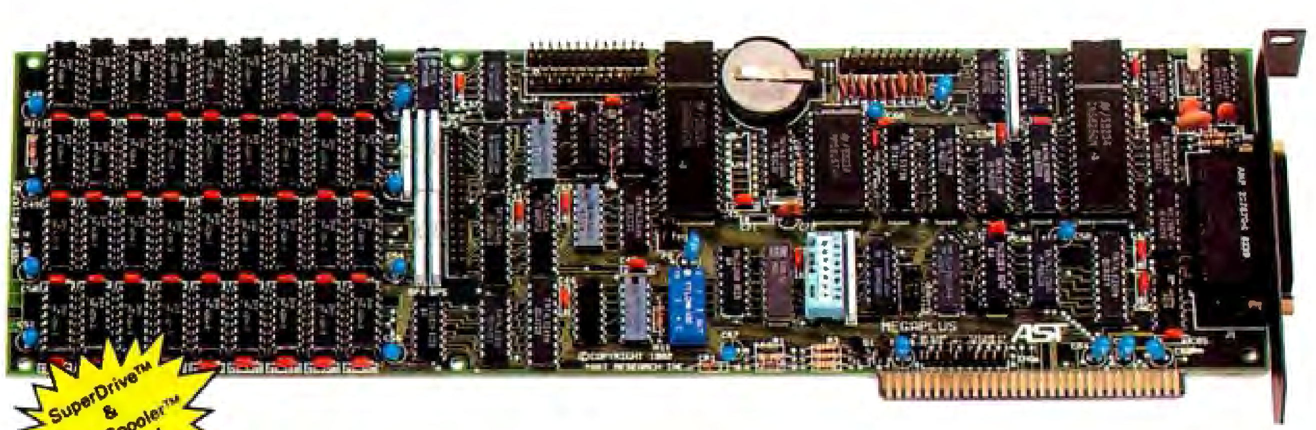
The basic color-control capability of NAPLPS allows a color to be expressed as relative amounts of red, green, and blue. The "resolution" of the color specification can vary just as with coordinates (see figure 15). A display device is expected to display the "closest" color that is available.

For simple display devices, 4 to 6 bits of color specification are usually sufficient to select every available color (unless color maps are available). These color-specification bits are usually encoded in a truncated multivalued-operand byte. The first color specification in the sample frame appears in lines 2 and 3. The Set Color PDI is an op code and is followed by a data byte that specifies three units of blue, zero units of red, and zero units of green. The resulting color of the sky is a "very blue" blue.

When a color is specified, it becomes the "current in-use color." Anything drawn after the Set Color will be drawn in the new color. Note that after the sky is created, the green grass color is specified in lines 6 and 7. If this was not there, the grass would be drawn in blue and would not be visible.

## Changing Character Sets

If you have been carefully decoding the information in listing 1, you have

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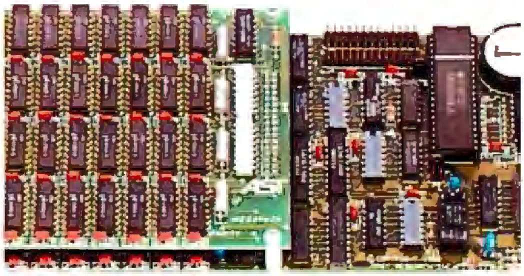

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The disk emulation software creates "disk drives" in memory which access your programs at the speed of RAM memory. The print spooler allows the memory to accept data as fast as the computer can send it and frees your computer for more productive work. Some manufacturers sell hardware printer buffers that do only this for hundreds of dollars. SuperSpooler™ eliminates the need for these slot robbing products.

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probably come across a few SO and SI codes (octal 016 and 017). These codes are used to indicate a change in the character sets or G-sets that are to be used. In the 7-bit mode of NAPLPS, only one character set can be used at a time. The SO code specifies that the set of PDIs should be used, and the SI code specifies that the Text character set should be used.

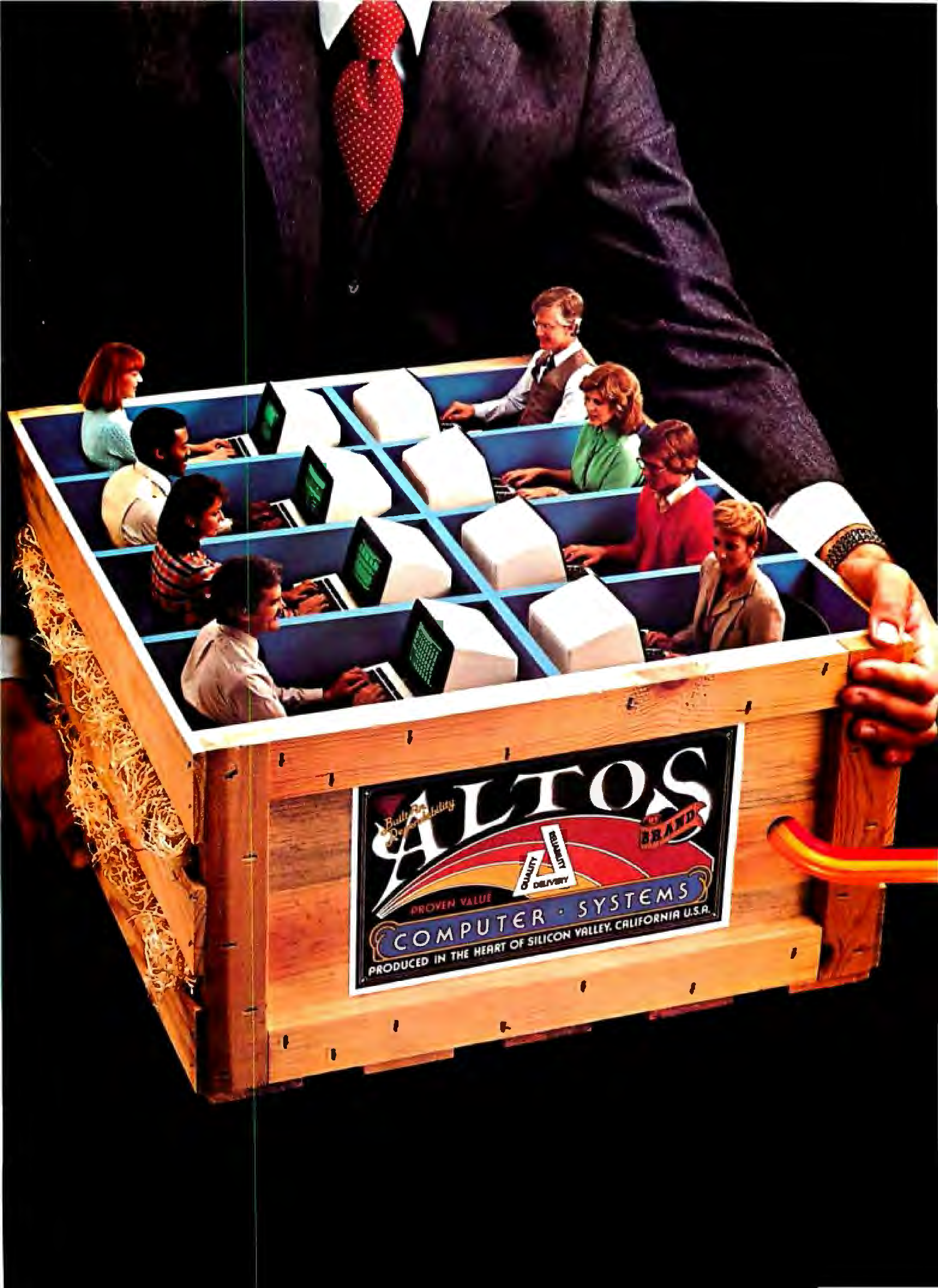
You have also probably noticed that the high-order bit of all the codes has not been used. The reason for this of course is that we have been using the 7-bit mode of NAPLPS. If the 8-bit mode were desired, a simple conversion can be made. Each time an SO is found it should be removed, and all bytes following that code should have their high bit set to 1. When an SI is encountered, it should also be removed and the bytes that follow should have a high bit equal to 0. The result would be that all graphics-related codes would be in the form 1XXXXXXX. All text-related codes would have the form 0XXXXXXX.

In the 8-bit mode of NAPLPS, the 14 SI and SO bytes could be removed, which would allow the figure to be stored in only 270 bytes. This may not seem like a big savings, but for large national databases with thousands of frames, every byte counts. There would also be a payoff in transmission time. At 30 characters per second, those 14 bytes might represent almost ½ second, which adds up as a user interacts with a system.

### Next Month

In part 3 of this series, I will cover some of the more advanced topics in NAPLPS, including Incremental Lines, Macros, Dynamically Redefinable Character Sets, and Fields.

This series of articles should give the reader a very good overview of this coding system. But as was mentioned last month, anyone seriously interested in working with NAPLPS should obtain a copy of the complete specifications for $18 from X3 Secretariat, CBEMA, 311 First St., NW, Washington, DC 20001, (202) 737-8888. ■



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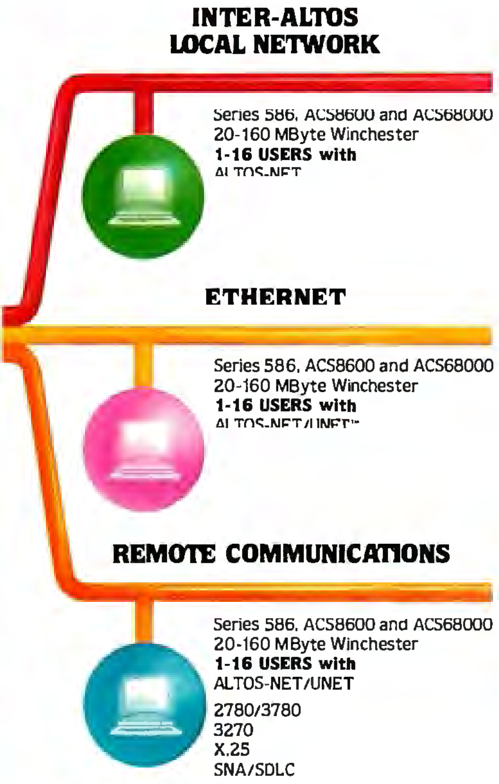


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# MP/M II

## The Multiuser, Multiprogramming Version of CP/M

Stephen Schmitt
2892 Sandhill Rd.
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MP/M II, the revised version of the Multiprogramming Monitor for Microcomputers from Digital Research, is a powerful combination of valuable operating-system features that could become a dominant force in the advanced microcomputer market.

The operating system offers you significant advantages over conventional single-user, single-job systems: it makes more effective use of improved microprocessor technology, has a broader scope of applications, offers better programming and development facilities, and will even increase throughput for your system. The operating system supports real-time processing, timesharing, multiprogramming, and multitasking. MP/M II even provides capabilities for memory management, interrupt handling, extended file operations, system security, and sequential process management that are usually found only on larger systems.

Compatibility with CP/M software is assured because CP/M file structures, system calls, and command processing are all supported by MP/M II. All programming languages and software tools for CP/M should run on MP/M with little or no modification. Thus the available repertoire of CP/M applications and the large number of high-level languages that CP/M supports should provide MP/M II with a substantial supply of software.

Systems other than MP/M II are competing for prominence in the expanding microcomputer field. Unix or Unix-like systems and Oasis-16 from Phase One Systems are among its chief competitors. Currently, however, no clear consensus exists in the market for rating the various systems. In fact, many leading computer manufacturers are offering several operating systems as options to lure customers.

In this review, I will describe the MP/M II system and its operation, outline an application of the system, and analyze its feasibility for general microcomputer operation. Some of the concepts I'll touch on require a rudimentary background in operating-system fundamentals and a general knowledge of CP/M and related software. I've included a list of reference materials that will acquaint you with any unfamiliar subjects.

### Overview

Briefly, MP/M II can be described as a multiple-user version of CP/M with enhanced processing capabilities. Each terminal presents its user with a CP/M-like environment that can manage more than one task at a time. The timesharing capability of MP/M II makes it seem as if the system is running several programs at once, thus allowing more than one user to operate the microcomputer at a time. This ability to run programs concurrently improves performance by using system resources more efficiently. Programs waiting for slow I/O (input/output) devices such as printers do not consume central processor processing time. Unlike some other timesharing systems, MP/M permits all active processes to reside in memory and thus a large amount of disk swapping is avoided. All this is handled by a real-time kernel program in MP/M II that supervises timesharing, handles requests as they happen, sets priorities for resource allocation, and coordinates the layered interrupt structure.

MP/M uses a simple file-system design that allows the user to access a broad class of mass-storage devices. The user also has access to very large RAM (random-access read/write memory) areas, even in 8-bit pro-

**About the Author**
*Stephen Schmitt has worked for Hewlett-Packard and taught at Michigan Technological University. He is now doing a review of a version of the Ada programming language for microcomputers.*

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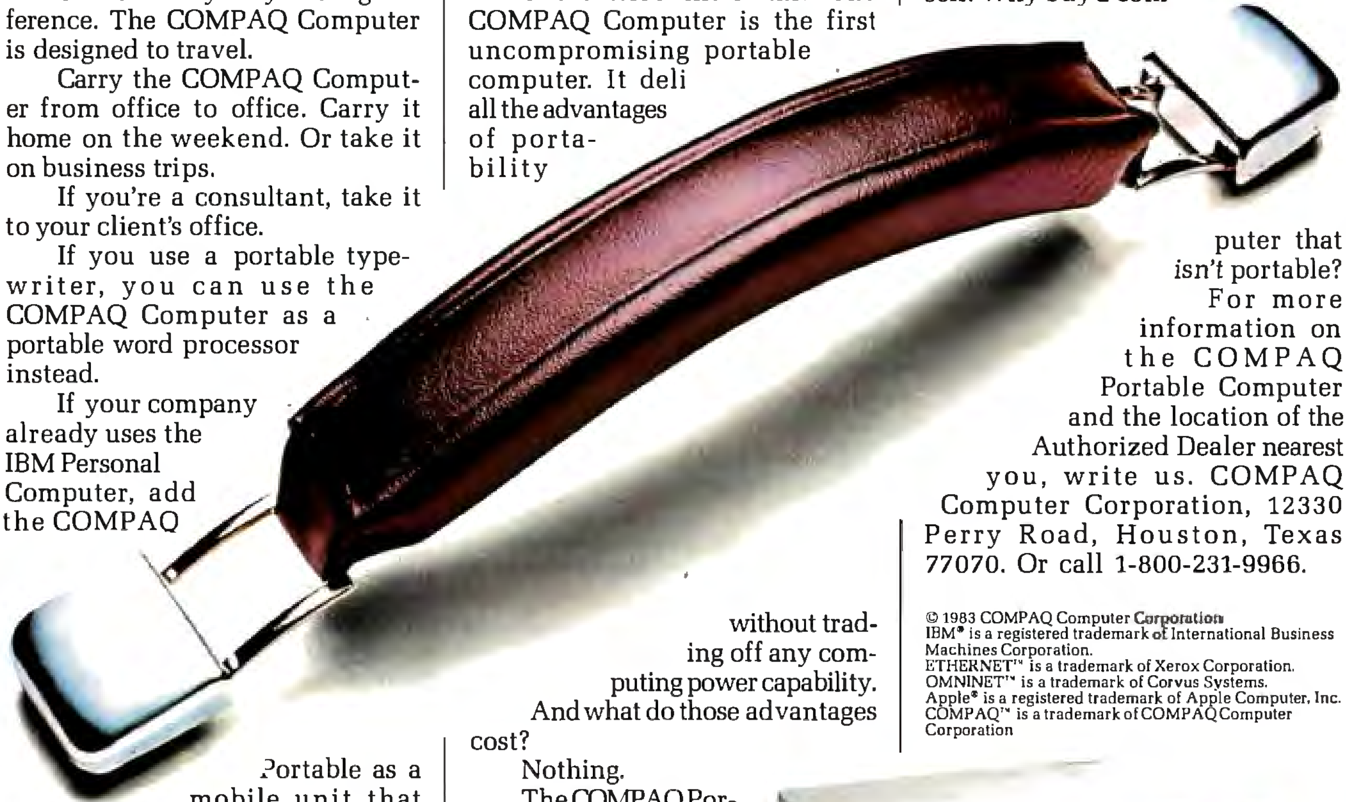

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cessor systems. File improvements such as separate user file areas, security options, and time-stamping features extend the standard CP/M file structure.

Fortunately, all enhancements of MP/M over CP/M are totally transparent to CP/M application software. Potential applications for MP/M II include office automation, real-time process control, advanced personal computers, information management, and software-development systems.

## Two Versions

MP/M II is currently available for two popular microprocessor families: the 8080 family and the 8086 family. The 8086 version, MP/M-86, differs in memory management, code file structure, and its ability to support shared-code segments. Fortunately, these variations seldom affect user software. You can run the same program written in a high-level language such as CBASIC on both systems easily. Digital Research also supports programming tools for transporting assembly code from 8080 to 8086 machines. To avoid confusion, I will discuss only the 8080 version of MP/M II in this article.

| Feature | Purpose |
|---|---|
| Multitasking | Several processes (tasks) can be executed concurrently. Any console can initiate multiple tasks. Each task is memory resident. |
| Task Priority | Tasks are assigned a ranking factor to ensure that critical tasks receive processor time. |
| Queuing System | Process communication<br>Synchronization<br>Mutual exclusion |
| Interrupts and Timing | Real-time control<br>System clock<br>Program scheduling<br>Timesharing<br>I/O device handling<br>Delay and timing functions |
| Network Capability | Compatible with CP/NET (local area network). Enables resource sharing with other microcomputers. |
| Multiple-Console Environment | 16 terminals or other character I/O devices can be simultaneously supported. |
| Multiple Printers | Spooling and access to several printers is now possible. Printers can vary in type and speed (maximum printers: 16). |
| Reentrant Code | Shared code allowed. Only one copy of code segment necessary for multiple invocations of a process. (MP/M-86: user programs and RSPs. MP/M-80: RSPs only.) |
| Memory Management | Memory-management technique is dependent upon microprocessor family. Memory protection is also supported (hardware-dependent).<br>8080 family:<br>Bank-switching system<br>400K bytes total physical memory limit<br>Maximum number of banks: 8<br>8086 family:<br>Partition model technique<br>Automatic allocation/deallocation<br>Memory fragmentation recovery algorithm<br>1 megabyte total physical memory limit |
| File Password Protection | File locking to prevent unwanted concurrent access<br>Shared-access methods for multiple users<br>Security |
| Time Stamping | File creation or updating and accessing data are maintained to enhance file management. |
| Record Locking and Sharing | Individual records can be exclusively owned or shared in file-processing applications. |
| Increased Mass Storage | A maximum of 16 logical disk drives with a total capacity of 8 gigabytes of online storage. (Maximum file size: 32 megabytes. Maximum drive size: 512 megabytes.) |

**Table 1:** *A summary of the features of MP/M II. These capabilities greatly expand the power of the standard CP/M 2.2 operating system.*

## Features

The multitasking aspects of MP/M II significantly enrich the basic CP/M operating-system model, even though the user interface and the function of software utilities are virtually identical to CP/M. Extensions can be divided into three subject areas: process management, resource sharing, and file-system improvements. Table 1 summarizes these additional capabilities.

The command structure and system-entry points of MP/M II are a superset of those for CP/M. Old commands are virtually unchanged. This upward compatibility with CP/M was a prime objective in the design of MP/M. Also, many of the objections raised against CP/M and previous versions of MP/M have been addressed by MP/M II. Some rough spots still remain, however.

## System Design and Operation

MP/M II is organized using a hierarchical approach. Figure 1 details the basic structure of the system and shows the relationships of the various system components. The layered structure permits successive levels of increasingly sophisticated functions. A component of one layer is logically dependent upon one or more underlying layer components. For instance, the user interface employs the TMP (terminal message process) to relay console data and the CLI (command line interpreter) to process user requests. TMP receives data from the console queues, which are in turn supplied with character input by a physical handler in the XIOS (extended input/output system). Access across more than one layer is permitted (e.g., direct XIOS calls) but not recommended.

MP/M II is also divided into modules, and the layers do not always correspond to these modules. They are grouped according to function and are distributed as separate software components. Briefly, the system modules are as follows:

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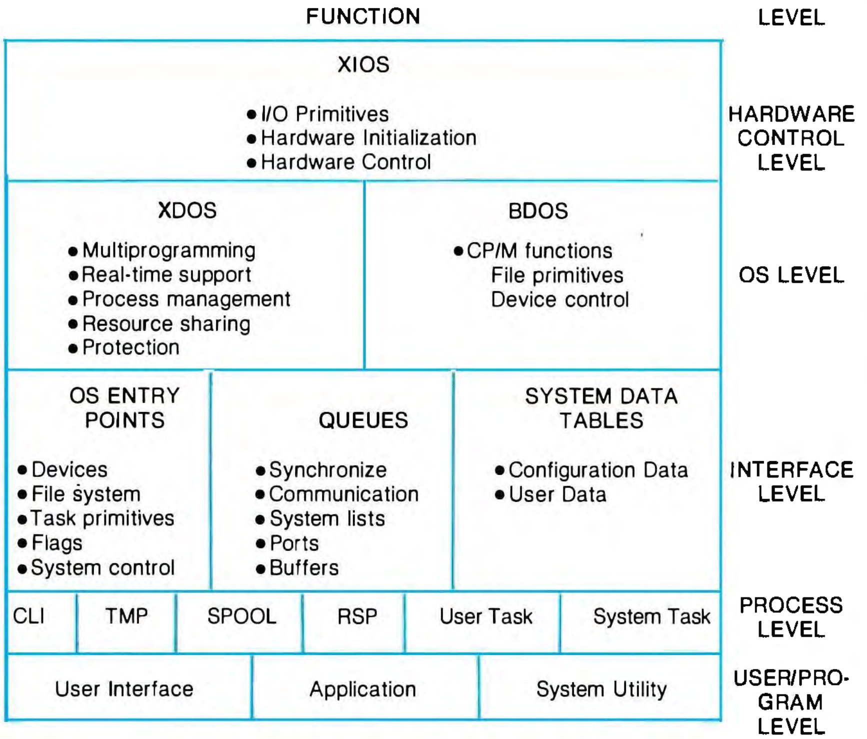


**Figure 1:** *A logical representation of the MP/M II system. Functional capabilities are divided into successive layers of increasing sophistication.*

## At a Glance

**Name**
MP/M II (8080)
MP/M-86 (8086)

**Type**
Microcomputer operating system

**Version**
2.1 (May 1982)

**Manufacturer**
Digital Research Inc.
POB 579
Pacific Grove, CA 93950
(408) 649-3896

**Price**
MP/M II: $450
MP/M-86: $650

**Format**
CP/M single-density 8-inch floppy disk; 5¼-inch floppy-disk versions also available

**Language**
Digital Research PL/I and 8080 or 8086 assembler

**Computer**
8080-, Z80-, 8085-, 8086-, or 8088-based system with a minimum of 32K bytes of RAM

**Documentation**
5 softbound books (8½ by 11 inches): Users Guide, 176 pages; Programmer's Guide, 226 pages; System Guide, 161 pages; Link-80 Manual (for linker program, 8080 family only); RMAC Language Manual (for 8080 family)

**Audience**
Operating-system enthusiasts, CP/M users, microcomputer OEMs (original equipment manufacturers), hobbyists

BDOS (basic disk operating system) is an upward-compatible version of the single-user CP/M BDOS. It supports standard CP/M BDOS calls and adds extensions for multiple console and printer support. File-system enhancements are also included.

XDOS (extended disk operating system) contains the real-time program nucleus that monitors processes and manages system resources. This module supports the multiprogramming and memory-management capabilities of MP/M II. Included with it are the TMP and CLI for processing console input. The XDOS also contains other functions accessible by user programs.

XIOS, like the CP/M BIOS, provides the low-level hardware-dependent routines. This part of MP/M II must be customized for every computer system. By encapsulating the system-dependent functions, MP/M II can be hosted by various hardware implementations. Functions include console drivers, printer drivers, mass-storage primitives, hardware-initialization code, physical interrupt handlers, memory-management primitives (e.g., bank select), timing, and other I/O routines.

System Data Tables is a group of miscellaneous data tables containing global system parameters, information sets pertaining to each user, system stacks, active file lists, and system queues.

RSP (resident system program) and OS (operating system) processes include code, data, and process descriptors for system tasks. OS processes are differentiated from RSPs in that they must be included with MP/M II and are not system options.

System Parameter Area is a common memory area for communication between executing programs and the operating system. It occupies low memory (0–100 hexadecimal) and is compatible with the CP/M memory organization.

Memory layout plays a key role in the analysis of MP/M II's operation and programming. Figure 2 shows how memory is organized. Bank switching increases effective system memory capacity. The total physical memory is divided into blocks termed banks (usually 48K bytes). The system can switch a portion of the logical address space from one physical bank to another. Thus, even though the 8080 family of central processors can address only 64K bytes directly, multiple memory banks can be placed into the logical 64K-byte address space, thus increasing memory size and multiprogramming capabilities. Part of the operating system is stored in a portion of memory that's always active (i.e., never switched).

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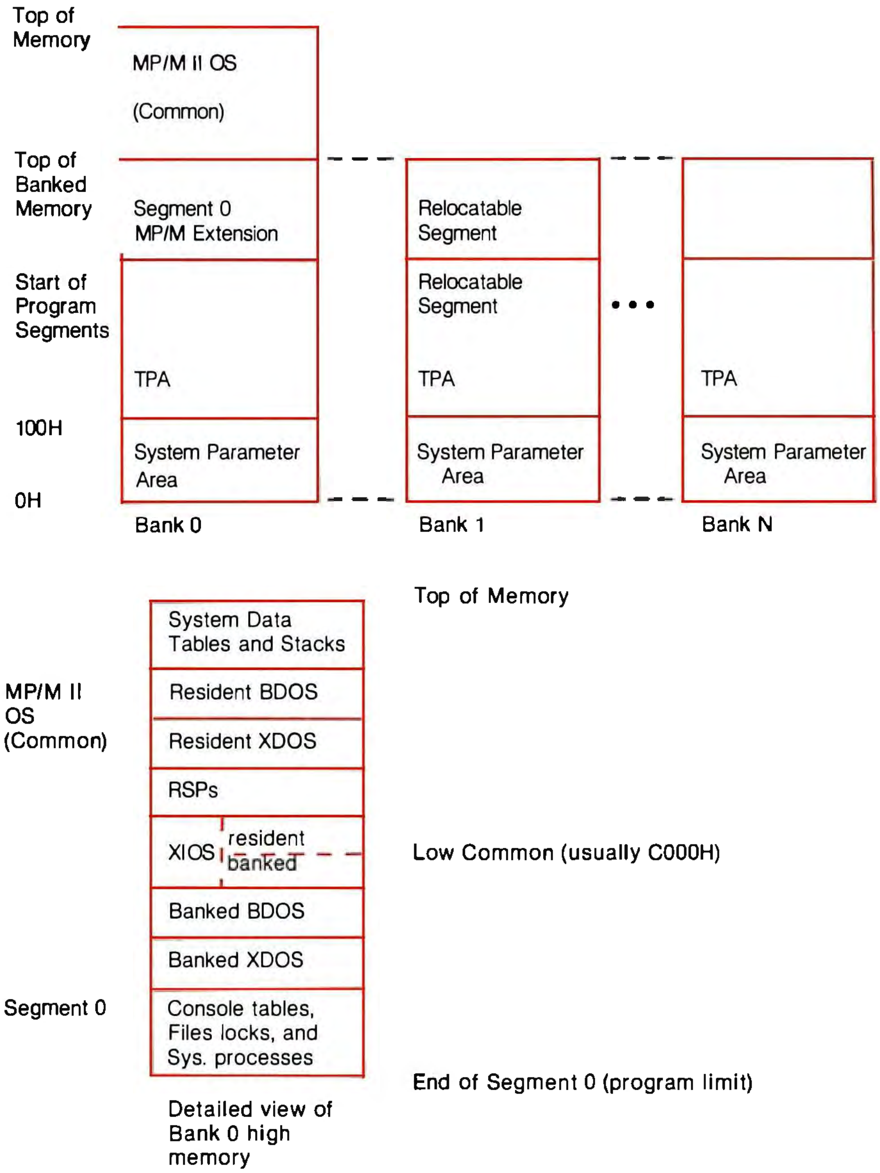


**Figure 2:** *(Top) MP/M II memory organization for the 8080 family of microprocessors. Note the flexibility for partitioning banks into segments. Transient-program area (TPA) segments are for CP/M programs. (Bottom) This figure details both the common segment that includes the MP/M II OS and segment 0. Note that in MP/M systems without memory banking, the banked versions of XIOS, BDOS, and XDOS are not required, which saves memory space.*

memory banks with memory segments. Memory segments are partitions of memory where program code can be loaded. A memory bank may have several segments. Transient programs must be loaded into segments for execution. For example, CP/M COM files must be loaded into the transient-program area (TPA) in low memory. Page-relocatable programs (PRLs) can run in any partition.

The common area, which is used by all banks, is located in the upper part of logical memory and contains the operating-system software. Segment 0 is a special partition reserved for system modules and RSPs. The division between the common area and segment 0 defines the top of banked memory. In banked MP/M II systems, XDOS, BDOS, and XIOS are broken into common modules and segment 0 modules. Buffers, queues, process descriptors, and operating-system entry points must be kept in the common area. File functions and higher-level operations that are accessed through system entry points can reside in segment 0 and need not occupy the logical address space of each bank. Memory management is done automatically. Programs are assigned to segments using a best-fit policy.

## Operation

Operating MP/M II is straightforward, especially if you have a good understanding of the fundamentals of CP/M (see references on CP/M). MP/M II can be loaded by a boot routine from mass storage or it can be initiated by executing a special CP/M utility. Once the system is initialized, every terminal console displays a sign-on message and the standard system prompt. The console works very much like a single-user CP/M system. The system prompt differs from CP/M in its inclusion of a user number identifier; for example, "0A>" where 0 is the user number and A is the default drive. User numbers identify the file area associated with each console.

As in CP/M, a command is nothing more than an order to load and execute a user-written or system-supplied program file. The uniform strategy achieves both simplicity and flexibility (i.e., you can define your own commands or change the names of system utilities supplied with MP/M II).

## Installation and System Generation

MP/M II software is designed for adaptation to a broad range of microcomputer hardware environments. Hardware independence with MP/M II is attempted through a fourfold strategy:

- MP/M II is written in a transportable high-level language.
- Hardware-dependent functions are encapsulated in a user-defined interface module (XIOS).
- Mass-storage functions are table-driven to simplify mapping physical disk systems to MP/M II's logical file system.
- A system-generation utility is provided to allow the user to specify the operating environment structure.

The majority of MP/M II is written in a PL/I dialect. In order to imple-

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ment MP/M on the different microprocessor systems, the designers had to modify the PL/I compiler so that it could emit specific machine codes.

Central to the portability strategy is the hardware-interface module XIOS. The module is a superset of the functions defined for CP/M's BIOS (basic input/output system). Operations found in the XIOS include interfaces to printers, disk systems, terminals, and other system-specific devices. Physical interrupt handlers, system timers, and memory-management functions are also defined.

The peripherals attached to MP/M II can be serviced via two methods: interrupts and polling. Polling is provided for low-speed I/O, debugging, and multiple-device processing for systems that lack interrupt facilities.

The XIOS is either written by a manufacturer distributing MP/M II with its computer system or it can be customized by an end user. Digital Research provides you with a skeleton XIOS module along with sample implementations for a few systems (e.g., Altos Computer Systems). The documentation for generating XIOS routines is clear and specific. XIOS is composed of approximately 25 functions and usually requires 5K to 6K bytes of code including buffer space.

Attributes of the mass-storage system easily map onto the logical file structure by use of parameter tables, which are called Disk Definition Tables. These tables define the characteristics of a particular disk system. Generation of the tables is done automatically by an MP/M utility. Disk systems ranging from simple floppy disks to the new Winchester-technology disks are effectively supported. Digital Research also supplies a disk blocking/deblocking procedure for increasing mass-storage performance. Blocking, a technique designed to improve access properties, allows a portion of disk storage to reside in main memory.

Integration of MP/M II software into a custom operating system is performed by the system-generation utility GENSYS. The system-generation process consists of (1) specifying system options, (2) collecting optional and required code segments into a single code file, and (3) layout of memory segments. Customizing the operating system enables you to fine-tune system performance, better match applications, and increase the software's overall flexibility.

The SYSGEN utility is simple, small, and easy to understand. It provides the minimum set of options necessary for flexible system design but doesn't bog down programmers with extraneous specifications. For the most part, the generation process facilitates the integration of host-computer hardware with the MP/M II operating-system software.

I found that developing MP/M II XIOS and configuring the software for my specific needs were not too difficult. Most problems resulted from misunderstanding hardware operation. The documentation on developing XIOS occupies an entire manual. The material should be carefully covered to minimize problems. I recommend implementing CP/M as the first step in creating an MP/M II system. Without CP/M, the generation procedure is not well documented and requires more effort.

### Programming

Programming MP/M II software is a more difficult task than that for CP/M. In addition to the extra system functions offered by MP/M II, the multitasking features add an order of complexity. But with this extra sophistication you get a more powerful tool, and more work is possible per unit of computing equipment with shared access.

### Processes and Data Structures

A *process* is an active program segment ready for execution in memory. MP/M II controls processes through a data structure termed a process descriptor. Process descriptors contain such information as process name, priority, status, device associations, file environment, and links to other processes in system queues. Process descriptors are created at the

*Text continued on page 202*



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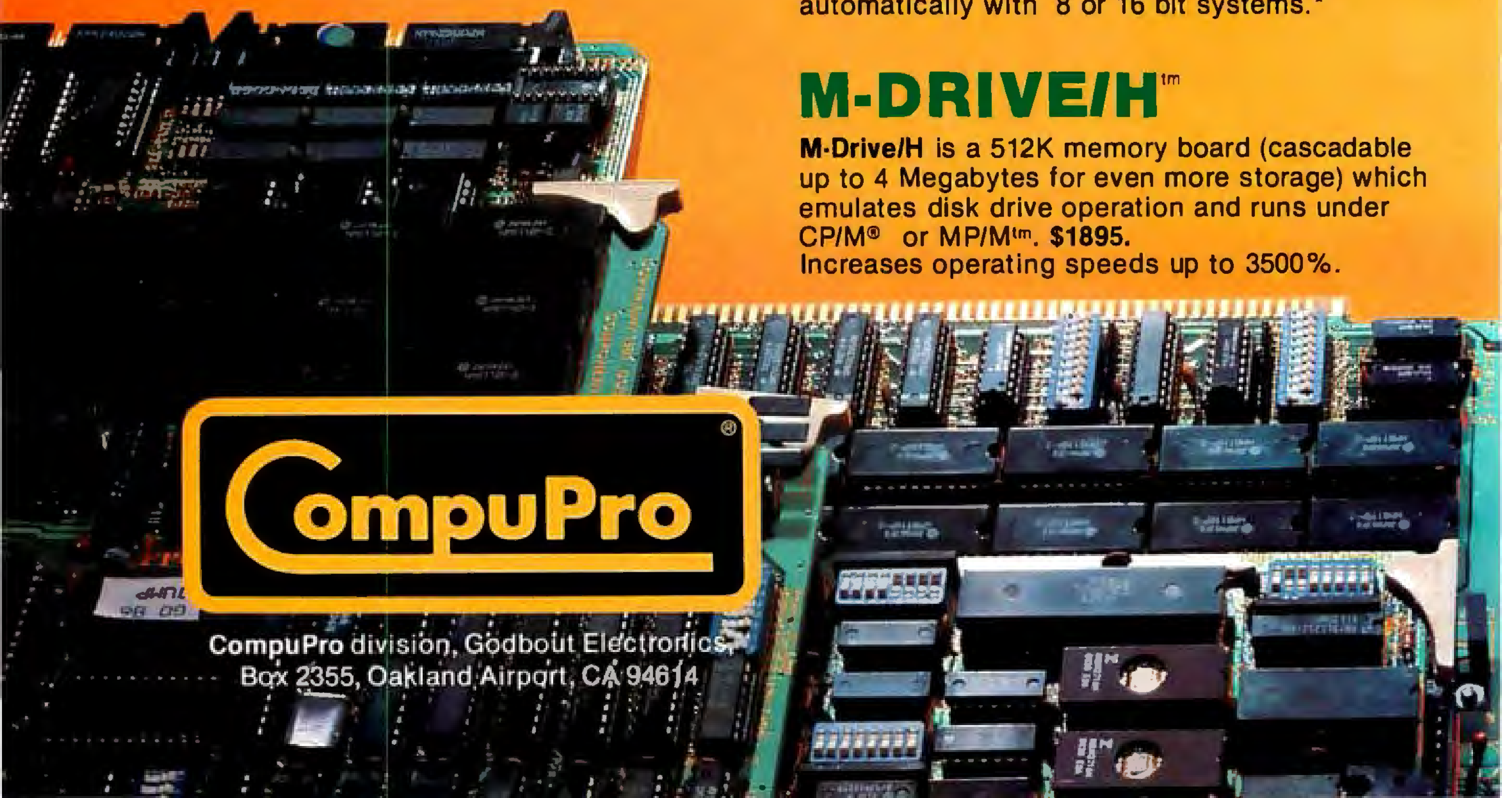

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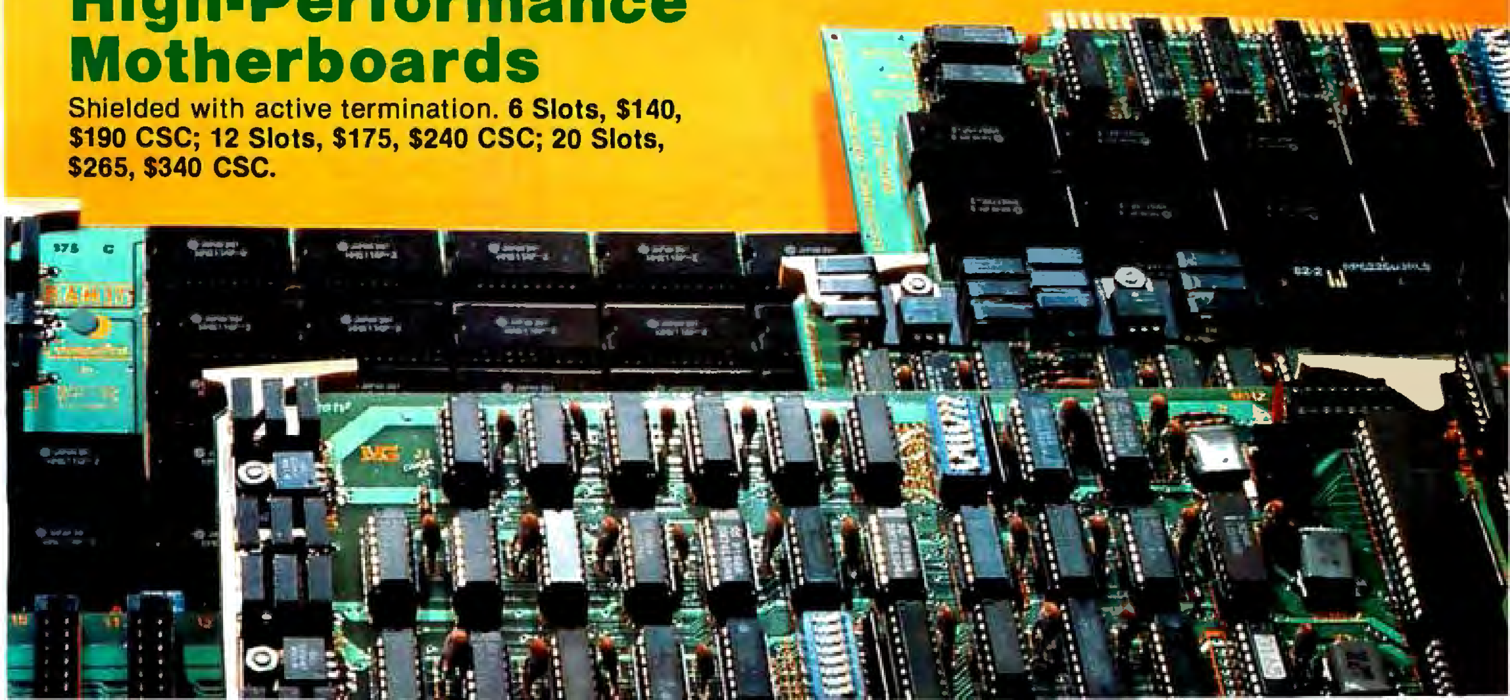

time the program is invoked by a system command.

MP/M II supervises the execution and resource allocation for various tasks in its role as a task coordinator. Task scheduling is done on a priority basis. Each task has an associated static priority. The scheduling algorithm selects the task with the highest priority as the one to execute next. In case of a tie, tasks are scheduled using a "round-robin" technique. Tasks with the same priority receive an equal share of the central-processor resource. Timesharing is facilitated by the fact that most CP/M and MP/M programs are assigned equal priorities. MP/M II permits 256 priority levels.

Queues and queue management play an important role in the design and function of the operating system. The basic function of the queue is to support the multitasking environment. A first-in, first-out pipeline transports data safely between processes. And queue data structures are maintained by the system. These act as "message files." Like files, they can be created, purged, opened, closed, read, or written.

Three types of queues are defined for MP/M II: mutual-exclusion queues, circular queues, and linked-list queues. With a mutual-exclusion queue, a process has sole rights to the associated resource. For example, listing to a printer requires a printer mutual-exclusion queue. When a process is writing to the printer, it owns the resource and blocks interference from other programs. This prevents undesirable accidents such as intermixing two source listings. The other two queue types perform the same function but differ in physical representation. Circular queues, which store messages in array structures, are employed when message size is between 0 and 2 bytes. Linked-list queues support messages longer than 2 bytes but have a considerably slower access time. Circular and linked queues are used for passing data between processes. Data messages can range from simple console-device character transmissions to sophisticated synchronization information between real-time tasks.

### The File System

MP/M II's file system is an extensively enhanced revision of the file system used by CP/M and old versions of MP/M. Changes to the file structure are completely upward compatible. Mass storage is organized as a collection of logical drives. A drive may be a single mass-storage device like a floppy disk or a component of a large mass-storage peripheral. The system supports up to 16 drives that are identified as devices "A" through "P." Each drive is divided into two areas: a directory region and a data region. Files are grouped into 16 user areas in the directory. Files registered under a particular user number are usually accessible only by a user with the matching system user number. Data space for deleted files is automatically recovered, thereby eliminating the need for user packing.

Specifying a file in a command line differs from the CP/M convention in that a password may have to be included:

[*drive:*]*filename*[.*type*][;*password*]

where *drive* = A-P, *type* has a maximum of 3 characters, and *filename* and *password* have a maximum of 8 characters. If a file is password protected, it can be referenced only with the proper password or with the default-system password. MP/M II supports three levels of protection: read protection, write protection, and deletion protection. Password protection can be turned on or off for the entire system.

Another file-protection measure permits you to open files in either a locked or a shared mode. A locked file can be accessed by only one process at a time. Shared files can be referenced by several processes simultaneously. Files opened in the shared mode can have records of the file locked to an individual program. Record locking is an important attribute for many applications. For example, database systems often re-

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| File System Extensions | System Control |
|---|---|
| Record locking | Multiple-printer control |
| File locking/Shared access | Access console via terminal/message process (TMP) |
| Error-processing level | Access RSP (resident system program) |
| Password management | Send CLI (command line interpreter) a command line |
| Parse MP/M II file name | Access system data table |
| Access disk label | |
| **System Clock Interface** | **Process Management** |
| Set time and date | Run highest-priority task |
| Return time and date | Terminate task |
| Delay program | Create task |
| Schedule program | Set task priority level |
| **Queue Operations** | **Memory Management** |
| Read/Write to queue (conditional/unconditional) | Request memory segment |
| Create, Purge, and Open | Free memory segment |
| | Request CP/M transient-program area (TPA) segment |

**Table 2:** *MP/M II BDOS functions not found in CP/M. Programmers can access a powerful set of new system functions.*

quire this capability. Files can also be designated "read-only"; thus several programs can read the file but cannot update the contents.

Time stamping attaches additional information to file-directory entries by indicating the times when a file was created (or updated) and last accessed. Even disk drives can have labels showing time stamp, name, and status information. This is a very important feature designed to give better support for business applications and software-maintenance procedures.

These additions to the CP/M file definition scheme have significantly improved file processing. A broad range of information-management applications are now feasible with these enhancements. But although both sequential and random-file I/O are present, the lack of ISAM (indexed sequential-access method), VSAM (virtual storage-access method), B-tree, or other direct-access methods is a notable weak link in the file system.

## The User Environment and Command Structure

As mentioned earlier, the formats for MP/M commands are almost identical to those for CP/M commands. The only differences are the new MP/M commands that were not supported in CP/M.

For the most part, commands are simple and easy to use. One drawback of the command structure, however, is that you can't put multiple commands on a single input line. The MP/M II command-batching facility (SUBMIT) is also relatively primitive. Batching is a mechanism for processing groups of commands in a data file. The SUBMIT utility lacks such convenient features as parameter input, data prompting, or conditional command execution.

Like CP/M, MP/M II monitors special-character keyboard input. These control-character commands are used for line editing and device I/O management. MP/M II defines an additional character command: "D." This command detaches the currently executing process from the console or reattaches detached programs waiting to communicate with the console device. When you detach all of your programs, the console returns to the system command input state.

System error messages have been extended and improved over previous versions of the operating system. More information is given and several new classes of errors are reported. System function call errors give you more detail. Command entry errors provide supplementary information relating to new system features. However, I still find the error-reporting system shallow and incomplete. A more uniform approach to handling the several error sources should be adopted. Error messages need to be more meaningful and explanatory. A help facility for users would aid in error understanding and improve the overall quality of the user interface. Though the simple nature of the user interface is a big plus, MP/M II is often difficult for nontechnical people to comprehend.

## System Functions

A collection of system entry points enables your programs to access a powerful set of primitives. Under CP/M, programs could make use of BDOS functions that primarily dealt with device I/O and file management. In MP/M II, system interface routines have been added to exploit multitasking capabilities and extensions to the file system. These new routines are defined in table 2.

## System Utilities

System utilities directly interact with the system or provide access to system functions. Utilities can be subdivided into four groups: programming aids, system-generation programs, a file manager, and system interface routines. Because utilities are nothing more than file-resident programs, they can be modified or replaced in accordance with application requirements. Some programs correspond to the transient or built-in commands of CP/M. Table 3 lists M/PM utilities and briefly outlines their functions.

## Multitasking

A real-time multitasking kernel located in the XDOS module manages program execution. Multitasking enables you to support many active tasks simultaneously. Although tasks may seem to operate in parallel, only one process really uses the central processor at a given time. The operating system maintains a list of

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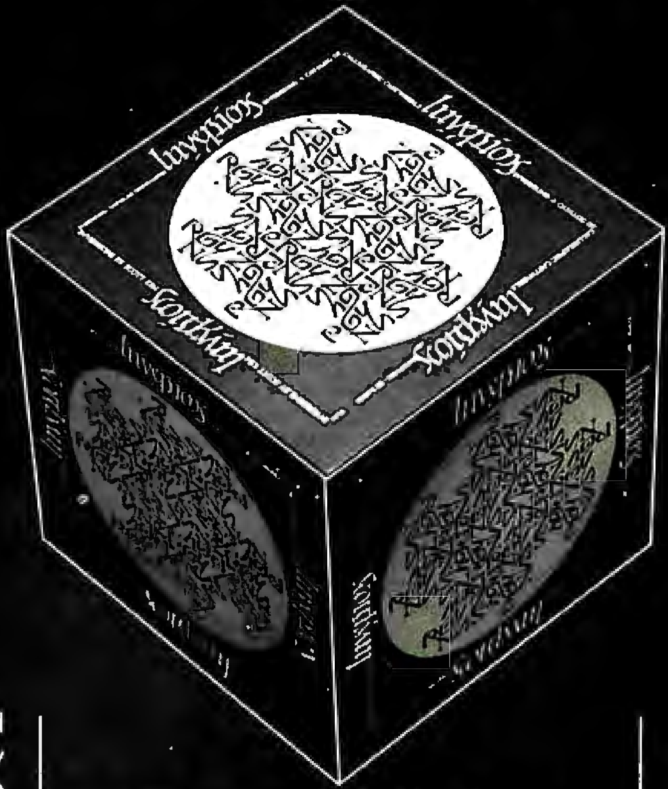


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| Utility Name | Application Group | New for MP/M? | Description |
|---|---|---|---|
| ABORT | Interface | Yes | Aborts process specified in command line. I suggest this utility be designated as an RSP to ensure that it can run when all memory segments are in use. |
| ATTACH | Interface | Yes | Binds a process to the console at which it was started. Console I/O to the process is again permitted. |
| ASM | Programming | No | Central-processor assembler. |
| CONSOLE | Interface | Yes | Lists console number of terminal. |
| DDT | Programming | No | CP/M interactive debugging program. |
| DIR | File | No | Displays disk directory information. Lists only CP/M-compatible data. |
| DSKRESET | Interface | No | Reinitializes disk drives. |
| DUMP | File | No | Displays contents of specified file in hexadecimal format. |
| ED | Programming and File | No | Line-oriented text editor. |
| ERA | File | No | Erases file entry from directory. |
| ERAQ | File | Yes | Same as ERA except that it prompts you for confirmation before erasing. Some systems rename ERAQ to ERA to provide users with more protection. |
| GENHEX | File | No | Changes .COM file to .HEX file. |
| GENMOD | File | Yes | Converts .HEX file to .PRL format. .HEX file must be 2 concatenated. .HEX files offset by 100 hexadecimal. |
| GENSYS | Generation | Yes | Performs MP/M II system generation. |
| LIB | Programming | Yes | Creates library files from set of relocatable files (.REL). |
| LINK | Programming | Yes | Linkage editor for binding .REL files. |
| LOAD | File | No | Creates .COM file from .HEX file. |
| MPMLDR | Generation | Yes | Loads MP/M II operating system and starts execution. |
| MPMSTAT | Interface | Yes | Displays up-to-date status of system environment. |
| PIP | File | No | File/device data-transfer routine. |
| PRINTER | Interface | Yes | Displays or selects active printer for console. |
| PRLCOM | File | Yes | Converts .PRL file to .COM format. |
| RDT | Programming | Yes | Memory segment relocatable version of DDT. |
| REN | File | No | Changes file name. |
| RMAC | Programming | Yes | Relocatable macro assembler for central processor. |
| SCHED | Interface | Yes | Schedules a program to start execution at a specific time and date. |
| SDIR | File | Yes | Extended file/directory information-list utility. Allows you to view time stamps, file attributes, etc., across multiple drives. |
| SET | File | Yes | Sets file options. |
| SHOW | File | No | Displays disk-drive status and protection levels. |
| SPOOL | File | Yes | Primitive file-spooling program. CP/M also has a spooling utility. |
| STAT | File | No | CP/M-compatible utility used to display or modify disk/file status. |
| STOPSPL | File | No | Terminates active spooling. |
| SUBMIT | Interface | No | Command-batching facility. |
| TOD | Interface | Yes | Sets/displays current time and date. Valid only for systems with clock. |
| TYPE | File | No | Displays file contents in ASCII format. |
| USER | Interface | No | Sets/displays active user number. |
| XREF | Programming | Yes | RMAC cross-reference listing program. |

**Table 3:** *System utility programs supplied with MP/M II.*

active processes, each of which may be in one of several states—ready-to-run, waiting on resource, terminated, waiting for flag (logical interrupt), and so on. The number of memory partitions limits how many programs can run concurrently. Although idle programs are not swapped to disk to free up memory, that doesn't limit the number of tasks that can be performed because several tasks can reside in a single program.

In terms of speed, Digital Research claims that a single-console MP/M II system compares in performance to CP/M 2.2. The overhead required for dispatching ranges from 7 to 15 percent. When multiple tasks are running, dispatching overhead may increase. I/O-bound processes are not degraded severely unless they are competing for the same resources. Priority and timesharing ensure fair distribution of the central-processor resource.

## Resource Sharing

Resource sharing is realized through MP/M II's queue system. Devices that must be used exclusively by a given task—printers or the mass-storage system, for instance—are accessed via a mutual-exclusion queue. Printing requests require sequential processing, and disk access is provided to only one program at a time. Even systems incorporating multiple-disk controllers handle file requests sequentially. Reentrant RSPs such as the command line interpreter (CLI) are also obtained via queue operations. The CLI services those routines that have placed a message in its associated queue, CLIQ (command line interpreter queue).

Memory is allocated based on the list of memory partitions specified during system generation. Processes hold memory resources until they terminate or are aborted. The central processor is shared through a specialized queue, the process-ready list, which enables you to set the priorities of each task element. Deadlock detection and prevention measures are not fully supported by the operating system.

*Text continued on page 210*


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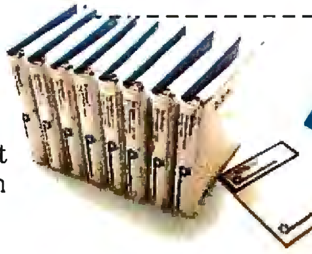

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| 8086 | Intel | 16 |
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| M68000 | Motorola | 16 |
| iAPX-432 | Intel | 32 |

**Table 4:** *Central processors supported by MP/M II.*

## Application Example: Modem Service Routine

You are probably wondering at this point how all the new features and options can be applied to real programming situations. I'll sketch a simple real-life application that will highlight the capabilities of MP/M II. This program is only qualitatively described, but it offers you an insight into system programming and operation. Specifically, this example defines a program that handles modem access to an MP/M system.

A handy computer-system feature is the capability to call the computer from a remote terminal by telephone. Instead of having primitive I/O routines handle the operation in the XIOS, you might prefer to use an RSP that monitors an auto-answer modem and initiates communication. The process should perform the following functions: answering the phone, initializing communication handshaking (e.g., setting the DTR for the RS-232C serial port), checking for access authorization, recording the event in a log, finishing up, and waiting for the next call. The design process for such a program would be as follows:

- Write the program as an RSP. MP/M II will put the program in the ready list and begin its execution at system start-up.
- Add an interrupt handler to detect the asynchronous event of the call. Assume the serial port has the ability to cause an interrupt when the call comes in. The handler may be in the XIOS or RSP depending on hardware flexibility for adding interrupt code. The handler's sole function is to set a system flag.
- The RSP suspends itself while waiting for the call flag to be set. When set, the process is activated. The process should have a priority higher than normal application programs so that the call will not be missed during periods of high activity.
- Once activated, the RSP should clear the call flag. It then establishes communication with the modem by attaching the console representing the modem port. Once the communication link is set, the process sends a message to the console and waits for the password. The RSP may loop until a correct password is entered or terminate if an illegal ID code is entered.
- When the process accepts the user, it can send a log-in message to a queue attached to an accounting program or write a message in a file. The program releases (detaches) the console so that the TMP associated with the console can start normal MP/M II interaction with the modem terminal.

Perhaps programs such as the above will become available as MP/M utilities.

## Hardware Specifications

MP/M II's design is relatively independent of the underlying computer hardware organization. Of course, the concept has practical limitations, but the MP/M II system has to date been implemented on a fairly large set of microprocessors (see table 4). And Digital Research is expanding the number of processors MP/M supports, with much emphasis being placed on 16- and 32-bit microprocessors. Memory systems can range from simple structures to virtual schema, banking, and page-mapped systems. Indeed, the new Zilog Z108 chip, a Z80-compatible microprocessor with on-chip memory management, would be an ideal MP/M environment. The mass-storage system is also quite flexible. Several mass-storage technologies with varying access properties are adaptable to the MP/M II file interface. Of course, terminals, printers, and other character I/O devices are necessary components of a complete system.

## Internal Hardware

The minimal memory requirement for MP/M II is 32K bytes of RAM. Many valuable CP/M programs need a larger memory space than this, however, so I recommend at least 56K to 64K bytes. Banked or register-mapped memory that allows a physical address space greater than 64K is also highly recommended, especially in a multiuser environment. A good rule of thumb is 32K per extra user, but the more memory you have, the better.

Two other hardware components are critical for MP/M II systems: a clock/timer circuit and communications-interface hardware. Timer circuits are used for tracking time of day and generating interrupts for timesharing. The suggested "tick frequency" is between 50 Hz and 100 Hz. A Zilog CTC chip exemplifies a good selection for this application because of its adjustable frequency and interrupt-generating capabilities. Both serial and parallel I/O chips are valuable system components. Serial communications are necessary for terminals, printers, tape systems, EPROM programmers, and many other serial devices. Parallel ports can be used for Centronics interface printers and digital signal processing. In addition to these system peripherals, you might allocate a few extra ports for expansion and occasional communication functions.

Although a general interrupt system offers the best system performance, MP/M II can operate without interrupts by using a polling mechanism. But if a polling mechanism is used, system throughput declines and user programs must make dispatch requests to share resources. The type of interrupt schema is not critical because the operating system translates real interrupts into logical interrupts or flags.

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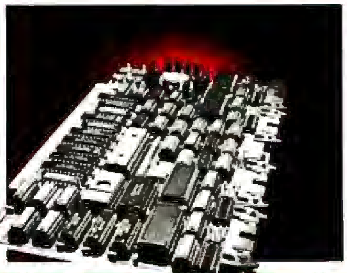

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## Mass-Storage Requirements

A variety of disk systems can be employed, ranging from 5¼-inch floppy disks to high-capacity hard disks. Also included are RAM memories that simulate high-speed drives. Because hardware-dependent functions are isolated in the XIOS and configurable attribute tables are used, customizing is easy. I suggest that any mass-storage system include an IBM 3740-compatible (8-inch) floppy system because it's the most popular software distribution format. For systems with several users, a hard-disk system is best. File bottlenecks usually result if floppy-based systems are accessed by too many people at the same time. Many disk systems are available for MP/M II applications. Most offer the necessary software for generating XIOS disk functions.

## Other Peripherals

Systems may have an assortment of associated peripherals. Video-display terminals are expected for console devices. "Dumb terminals" with minimal cursor features are adequate for most program environments. Other serial devices such as teletypes, card readers, paper-tape punches, and so on can be connected as specialized console devices.

MP/M II does not directly support a magnetic-tape backup system, but tape systems controlled by an application program or integrated with some of the newer Winchester disks are common alternatives. Other equipment such as graphics terminals, modems, synchronous communication interfaces, and plotters must be operated via custom-written utilities.

## Evaluation

Digital Research operating-systems software has been a dominant force in the microprocessor industry. With MP/M II, Digital Research hopes to solidify its position in the 8-bit market and set the trend for 16-bit microcomputers.

The goal for the MP/M II designers was to extend the CP/M model to a multiuser environment without losing compatibility with CP/M. The system is simple, easy to understand, and consistent. Real-time processing adds a valuable programming dimension. Hardware independence is another important attribute. Table-driven disk logic, the encapsulation of hardware-dependent functions, and good supporting documentation are all effective solutions to a complex problem. The well-defined set of operating-system interface functions is complete and plays an essential role in software portability. And MP/M II's queue system is excellent. Coordination of multiple resources is efficiently handled in a single logical mechanism. The queue model is simple, but it effectively supports process interaction without sacrificing performance. The resulting system is neither awkward nor superficial.

The file-system design and user interface are vital aspects of any operating system. In MP/M II, the file structure is an improved version of that of CP/M. The additional descriptive information, protection, and file-sharing attributes that are provided are very useful. However, a hierarchical structure similar to Unix would vastly improve the organization of file information. And file-access methods for data processing are notably absent. As for the user interface, it is simple and understandable. Error processing is good, but it could be much better. A help utility, input correction, and multiple command lines are necessary improvements.

### Documentation

Documentation for MP/M II departs from the old standard for microprocessor literature; it is clear, concise, and informative. The manuals are well organized and make it easy for you to locate key ideas. Numerous examples and a straightforward format help you to understand difficult concepts. Three manuals are included: a Users Guide, a Programmer's Guide, and a System Guide. Each contains a separate summary, table of contents, index, and (except for the System Guide) glossary. Print quality is only fair. I found few errors and typographical mistakes.

Each manual addresses a different MP/M II user audience: the general applications user, the system programmer, and the system manager or architect. The Users Guide describes program operation and the user interface, the Programmer's Guide explains system structure and programming guidelines, and the System Guide outlines procedures to customize MP/M II for your own hardware. In addition to these three system manuals, documentation for the linker program (LINK) and the relocatable macro assembler (RMAC) also comes with the MP/M package.

**Although MP/M II systems can support up to 16 consoles, 6 to 8 active users is probably a more realistic number.**

### Performance

System performance under load is reasonable because of low system overhead and faster microcomputer components. MP/M II's efficiency can be attributed to its compact code size (15K bytes) and a manageable system-function set. A single-user MP/M II system is 7 percent faster than a CP/M 2.2 system. Unlike CP/M, MP/M II does not reload part of the operating system after command calls, so it saves disk-access time.

A major bottleneck with multiple-user MP/M II is the mass-storage system. To maintain file integrity, only one task at a time can access the file system. Thus high disk I/O activity substantially degrades performance, especially if requests come two or three at a time. Because of the disk-intensive nature of program development and business applications, a hard disk is advisable for systems with more than two users. Floppy systems are too slow to handle the traffic involved in loading commands, running word processors, compiling several programs, and so on. A blocking/deblocking algorithm can improve disk response; however, the size of available main memory is reduced by the size of the disk buffer that would be involved.

If there are a large number of users, a few concessions must be made. As the number of terminals increases, data-transmission rates decrease and buffering methods become necessary. Slow data-transmission rates could be improved by a more sophisticated spooling system. Although MP/M II systems can support up to 16 consoles, 6 to 8 active users is probably a more realistic number.

### Scope

Multitasking real-time control and process management are necessary for most industrial and scientific computing jobs. Monitoring a home, controlling a small plant operation, or simple robotics are potential MP/M II applications. The interrupt facility in conjunction with queue operations facilitates the handling of asynchronous processing and ordering of priority requests. The small overhead imposed by the operating system makes real-time programming feasible.

Several MP/M II features will help those users who are involved in program development. The file-stamping option, for example, is a useful concept for keeping track of an evolving source code. A large set of applications can be conveniently addressed by the large selection of programming languages available for CP/M. In particular, some language processors like Pascal/MT+ support a program-development system similar in concept to the Ada run-time environment. Companies making CP/M compilers are modifying their systems to incorporate the novel features of MP/M II (e.g., record locking and shared access). Word processors, file utilities, and debuggers streamline the programming process. For large programs, MP/M II supports chaining of programs. Overlay linkers are also available for CP/M-compatible software. Well-defined system functions and a small operating-system "nucleus" form a flexible base for building complex programs.

MP/M II would also make a viable office-automation system. CP/M database systems, word processing, accounting programs, inventory systems, and so on are offered by a variety of software firms. Multiple-user capability coupled with CP/M information and planning software provide the necessary features. The ability to support networking further enhances MP/M II's position in this market.

## Conclusions

MP/M II offers features and processing power comparable to many large computer operating systems. Three of these features—multitasking, real-time programming, and networking—address a class of useful applications that range from efficient multiple-device control to full-scale distributed processing. Task management and communication is effectively handled with the queuing system. The user interface and enhanced file system make it much easier to use general-application programs.

The operating system is well designed, but it lacks some features that are necessary for some commercial requirements. File-system organization and access methods are not adequate for information management. Also, although security, user accounting, and man-machine interfacing are significant issues in a business data-processing environment, MP/M II, like other microprocessor operating systems, does not fully address them.

Several operating systems that have been designed for the latest microcomputer technology have impressive capabilities. Whether the MP/M II operating system is the best of these is debatable. I do not intend to make such a claim. Instead, I would point out two critical factors by which to judge microprocessor operating systems: hardware independence and the availability of software applications. A universal operating system must provide a standard interface, independent of a computer's word size and components. More important, an extensive software base is mandatory for a useful system. MP/M II is founded on these premises and should prove to be a leading microprocessor operating system. ■


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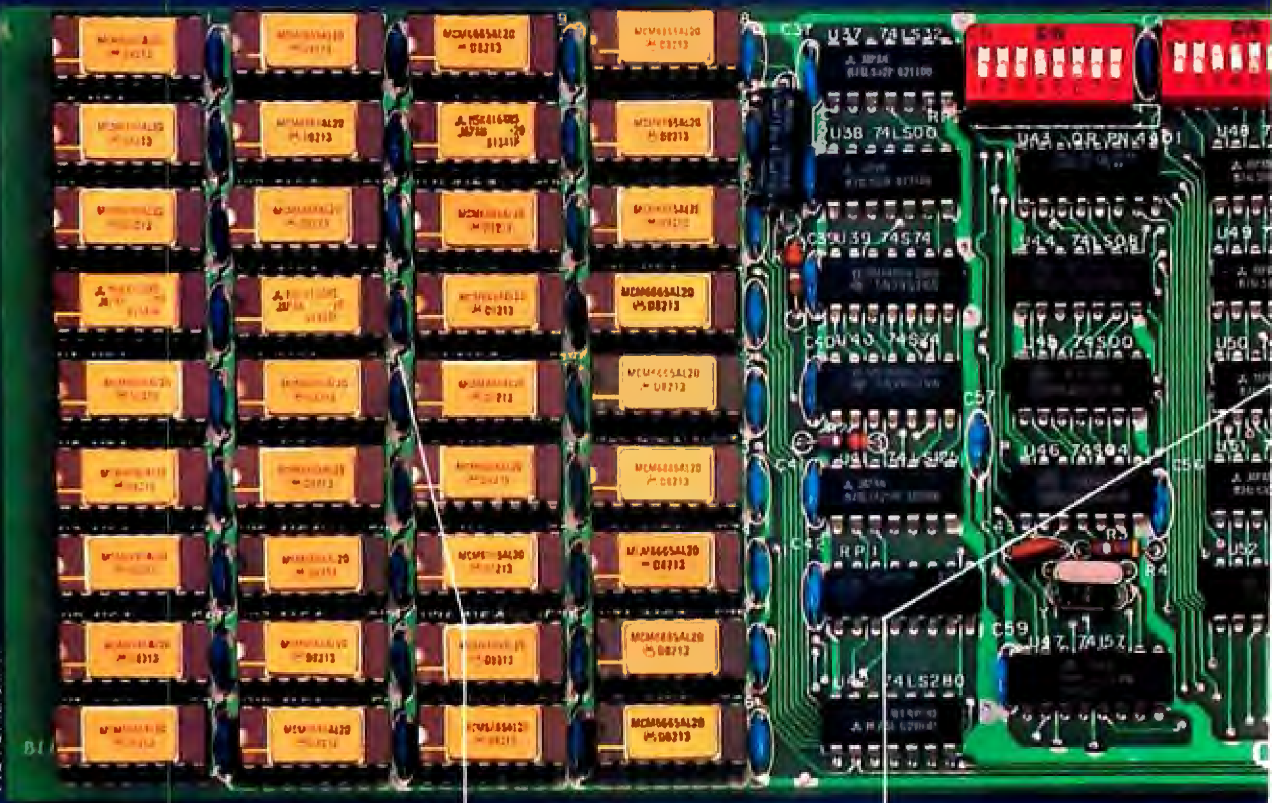

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# Sage in Bloom, Zeke II, CBIOS Traps, Language Debate Continues

*The consummate computer user tackles his new writing machine, and other tales from Chaos Manor.*

Jerry Pournelle
c/o BYTE Publications
POB 372
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I have three pages of notes on what I should write about this month, and if I finish the list I'll double BYTE's already amazing thickness—and still not be caught up with either hardware developments or the flood of useful software that's pouring out for microcomputers. There was a time when I could pretend to be, if not familiar with, at least *aware* of nearly everything going on in the microcomputer world. No longer. I hear about many developments, for which I thank my numerous correspondents, but there's no way anyone can keep up with the explosion.

Meanwhile, we have two new systems at Chaos Manor: a new writing machine and a Sage II that runs UCSD Pascal for the fastest time yet in my benchmark.

I can't keep up, but what the hell, it can't hurt to try . . .

## The Sage in Bloom

I first saw the Sage 68000-based machine at the 1982 West Coast Computer Faire. Then at Wescon/Mini/Micro I saw another and got to talking with Sage's president, Rod Coleman.

About a week ago our Sage arrived. I'll be writing a lot about it as time goes on.

My first impression is that I love it. The Sage is a working machine. Mine has a half megabyte of memory (some of which can be configured to be run as "RAM disk," that is, as a memory simulation of a disk, exactly like the Compupro M-Drive or Semidisk Systems' Semidisk). It has two double-sided double-density 5¼-inch disk drives; those disk drives, I must confess, are part of the reason I'm changing my mind about small disks, because we've been working the dickens out of the Sage and we haven't had a disk glitch (or any other kind of glitch for that matter).

It's a handsome machine. It is also quite small; the whole thing—disk drives, power supply, computer, and all—takes up considerably less space than one of the Compupro boxes, and in fact is smaller than the Televideo 925 terminal that came with the Sage.

The Sage can be that small in part because it uses what's known as a switching power supply rather than the brute-force transformer, rectifier, and filter system in the Compupro. Switching power supplies rectify the 110-volt AC immediately, then they use electronic switching to eliminate the bulky low-frequency transformers of conventional power supplies. They are a lot more efficient than the old-fashioned kind; they're also trickier to design and use.

While the Sage is really lovely hardware, there is a small problem: the operating system is UCSD Pascal.

For many that's not a bug, it's a feature. Heaven knows, UCSD Pascal has its champions, including my friend Carl Helmers, the founding editor of BYTE. The UCSD system (now marketed by Softech Microsystems) is a completely integrated

package containing the Pascal compiler, a text editor, disk-file system, and a bunch of utilities to format and copy disks and such like. One nice feature of the system is that when you try to compile a Pascal program, as the compiler finds your errors, it shows them to you in the editor; you can fix them on the spot and go on, or wait to see more. This takes a lot of the sting out of Pascal.

The system is *fast*, too. It compiles Pascal programs with lightning speed. The programs are compiled to the UCSD Pascal p-code, which is an intermediate code that must be interpreted at run-time. It is not machine code, but the 68000 chip is so fast that this turns out not to be a handicap either.

My 20 by 20 matrix benchmark program (see the October 1982 BYTE) ran in 8.9 seconds on the Sage; the best time on the 8085/8088 dual processor was 19.2 seconds when compiled by Pascal MT+ (which compiles to *machine* language).

That's fast.

The other drawback to the Sage is that the documents assume you know more than I do. Not a *lot* more; just more. Fortunately, there's a brief cookbook example of how to make copies of disks; I was able to back up the Sage operating system before trying to experiment, which is just as well. However, after that admirable step-by-step tutorial on formatting and duplicating disks, the documents lapse off into "documentese," with few to no examples and a nonlogical order of presentation.

Rod Coleman tells me that by the time you read this the Sage will probably have other operating systems, including some kind of CP/M. I hope so. Meanwhile, you can get from Softech a program called Xenofile that will translate CP/M text files into the UCSD format, so you can salvage ASCII (American National Standard Code for Information Interchange) files from your CP/M system for use on the Sage if you like. Probably the most useful thing you can bring over would be Pascal *source* programs.

Last-minute addition: if you get a Sage, get *Introduction to the UCSD p-System* by Charles W. Grant and Jon Butah. Published by Sybex, it contains a really detailed tutorial introduction. I wish I'd had the book when I first got the Sage; it would have saved a *lot* of time. Given that book, you can get a fairly good understanding of the UCSD system in a reasonable time. You may not *like* the system, but at least you'll know how to use it. Flash: the Grant and Butah book now comes standard with the Sage computer.

We've sent the Sage off to a mad programmer associate of Alex's; he's putting it through strenuous tests, as well as writing considerable software for it. Much more on the Sage in later columns.

### Alas, Poor Ezekial

We sent Ezekial, my old friend who happened to be a Cromemco Z-2, off to the organ banks; he has officially become spare parts for Larry Niven's machine. Like the wonderful one-horse shay, everything went at once. The final problem was the disk system. Zeke used old iCOM disks, the kind that had Percom drives with the controller on two boards in the box with the drives and their power supply; and they became unreliable. Spare parts are unobtainable: although those drives were the very best available when we got them, they're now from the Dark Ages. To update them would cost more than new Compupros, and they'd still be slow with very limited storage.

Zeke's bus is too slow, and his old Industrial Micro Systems memory uses too much power. The bottom line, alas, is that it just wasn't worth fixing him up. Nor Singh swears he's going to get him running so that I can donate him to the Los Angeles Science Fantasy Society. The LASFS already owns Altair, the first Niven machine. (That's a little embarrassing, because Altair Niven was officially accepted as a *member* of the club.)

There's another possibility. Dan MacLean's widow donated Alice, Dan's old IMSAI, to the LASFS, and Nor Singh has been hired to get Alice running for the club; it may be that

Zeke and Alice (who shamelessly carried on a long-distance affair for years) may yet be united into a single working entity . . .

### Zeke II

Ezekial has departed, but I have consolation: as Nor Singh arrived to remove Zeke, Tony Pietsch delivered Zeke II, which is a state-of-the-art writing machine. That, of course, is the point of all this. I get lots of letters asking my recommendation for "the ideal word processor." My answer usually is, "That depends." However, I've seen nothing better than Zeke II for creative writing.

First: my "ideal" writing system is a computer, not a dedicated word processor. True, some excellent dedicated word processors are on the market, and it's a lot easier to learn to use them than it is to learn to write with a full microcomputer. However, in my judgment, the saving is illusory: it doesn't take *that* much longer to learn to use a real computer; and then you can tap the power of the software explosion. Most dedicated word processors leave you at the mercy of one company: you get only the software it thinks you should have. Consequently, I recommend CP/M systems.

Second, iron is expensive but silicon is cheap: new computer boards are invented all the time. Get a good S-100 bus system and you can take advantage of the dozens—perhaps hundreds—of firms developing new capabilities for it.

Third, deal with reliable companies with a good track record.

In keeping with these views, Zeke II consists of a Compupro S-100 bus and power supply. My friend Bill Grieb continues to swear by the Integrand box that has bus, power supply, disk power supply, and disk drives all built into a handsome wood-grain cabinet—and perhaps he's right. I can only say that the Compupro box has never disappointed me. It's built like a Mack truck, with .2 *farads* (none of this microfarad stuff!) of power filtration. The only disadvantage is that it's *big*, but I don't mind that. The large size helps keep the components cool.

Inside the box is a Compupro 6-MHz Z80 central processing unit, 64K bytes of memory (Compupro RAM-17), an Interfacer 4, and the Compupro Disk-1 disk controller. That drives a pair of Compupro 8-inch double-sided double-density drives at 1.2 megabytes per disk. The Interfacer 4 plus the new CBIOS (customized basic input/output system—the thing that tells CP/M about your particular hardware) written by Tony Pietsch allows a number of ways to talk to the system. Tony's CBIOS is now available from Compupro.

The CBIOS allows you to use either 5¼- or 8-inch disks. The Compupro controller supports either. It does not run both at once; if you want both on the same system, you will need two different controllers. That, however, is no problem: the Compupro box and CBIOS can handle the situation, so that you can transfer files from 8-inch to 5¼-inch and vice versa.

Some disk controllers will run both



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8- and 5¼-inch disk drives; I once asked Bill Godbout why his wouldn't.

"I don't make Muntz TVs, either," he told me.

Interpreted that means that it's tricky enough running at the speeds his direct-memory-access (I'll explain DMA below) systems use without trying to play games. Bill Godbout once told me, "If the error rate is measurable, it's too high." His stuff is designed to that philosophy.

I still prefer 8-inch disk drives, although not as adamantly as I did last year. The 5¼-inch systems are getting more reliable, and running double sided and double density they hold quite a bit of information. I do not believe the small disks are as reliable as the 8-inch, but many people for whom I have respect say they're reliable enough, so my preference is probably pure prejudice; unfortunate, but there it is.

I can also hang a normal terminal on the system, and indeed the same Televideo 950 that drives the Compupro 8085/8088 dual processor can run Zeke II. That, however, is not the normal mode, because we've set up Zeke II mostly as a writing machine. When he's powered up, he comes up in WRITE, my text editor; and when he's in WRITE mode, he talks to me through an Ithaca IA-1100 memory-mapped video board. (Memory-mapped video displays directly what's in a segment of memory; I tried to explain it in the November 1982 BYTE.)

Tony has modified the Ithaca board to be "write-only memory"; that is, you can't read the board's memory, you see only what's displayed on the monitor screen. The board is addressed to the top 1K bytes of memory, and thus overlaps the RAM-17, but they can't interfere with each other.

We took the video chips out of Ezekial and put them in the Ithaca board, so that the display on my big Hitachi 15-inch screen is identical to the old Zeke. I continue to use 16 lines of 64 characters to avoid eyestrain. Also, I'm used to it: after all, a standard manuscript has 60-character lines. A page is usually 25 or 26 lines, so I don't see a whole page at once; but I've noticed an unexpected benefit. Having only 16 lines on a screen tends to make me shorten my (usually too long) paragraphs.

We wanted to put in a 24 by 80 "write-only memory" board, but we couldn't find one that would work at 6 MHz and had a nice (i.e., stable, legible, etc.) display; if anyone knows of such a beast for the S-100 system, I'd appreciate the information.

Another really nice thing about Zeke II is the keyboard, which comes from an Archive computer. The Archive, incidentally, is the machine Dr. Arthur C. Clarke settled on. His is named Archie. He got an Archive in part because he could get service for it in Sri Lanka. I'm sure, though, that he fell in love with the keyboard, and if I had to buy an Archive to get this keyboard I probably would. As it happens, Tony was able to obtain three or four of them.

The Archive has great key feel, a good nonelectronic "click," and a really nice (Selectric-style) key

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layout. The entire ASCII character set is on board along with arrows on the left side and a numeric key pad on the right.

There aren't any extraneous keys in odd places; and a lot of special-purpose keys are put up where you can get at them without their being in the way. The special-purpose keys are really nice in that they make characters with the eighth bit set, so that we can make use of not only the entire range of control characters, but also more than a dozen additional one-stroke commands.

The Archive comes with a printed strip that translates the special-function keys into Wordstar commands, and I suppose the Archive machine itself takes advantage of those. Because I don't use Wordstar, I had some work to do. Figuring out how to make good use of those keys was instructive; more below.

The bottom line is that callous as it may seem, I don't really miss Zeke. This new keyboard is fast and convenient, and the Compupro disk drives are so much faster than the old iCOMs that I find myself saving my text far more often. Scrolling is smooth and lightning quick.

I do hope that Nor Singh can make Zeke work again; he's still better than half the junk I see out on the market, and it would be nice if others could get some good from him. Meanwhile, Zeke II is as close to being the "ideal" writing machine as I've ever worked with.

There are a few possible improvements. For one, there's no hard disk; but that's merely a matter of time. Tony has one and is refurbishing the software right now. A hard disk isn't strictly necessary anyway; with a DMA disk controller and double-density disks, saving your text doesn't take very long; and for a writing machine, safety is the number one goal, meaning that you want the machine to make it easy to save early and often. (That's one major advantage of the MIT EMACS full-screen editor and its descendants: it can be set to automagically save text even if you don't think of it.)

DMA and high density speed up floppy-disk operations something wonderful. Direct memory access is literally just that: the disk controller has an on-board microprocessor that can get at your system's memory without going through the regular processor; that lets it do a faster job of getting stuff from memory and putting it on disk or vice versa.

Whether or not there's a hard disk, the ideal writing machine will need fast and reliable floppies. I don't feel really safe until my text is saved on a disk and the disk has been removed from the machine.

**What do you do if you have several serial output devices but only one RS-232C output port? Enter the T-Switch.**

A second limitation to Zeke II is there's no RAM disk, i.e., memory that's set up like a disk for fast access. RAM disks are nice for checking spelling (as well as compiling and other computer operations). Of course, if you have a hard disk you might not want a RAM disk too.

I do have Semidisk on my dual-processor machine, and that would work fine in Zeke II; but Compupro has announced that it's coming out with an M-Drive that will work with the Z80, and since almost everything else in Zeke II is Compupro, I thought I'd wait for Compupro's system. More on M-Drive and Semidisk below.

Finally, the Z80 makes for a vanilla system; more advanced stuff is available. We have here an experimental board from Compupro that runs at 12 MHz. That's *fast!* However, for a writing machine you don't really need that much speed, and the Z80 chip has been around long enough to have a track record. Zeke II is as near the state of the art as I'd now recommend for a system devoted mostly to text handling.

### Terminal Switching

For a while it looked as if I'd be up to my clavicle in keyboards. Although it's possible to make Zeke II run with the 16 by 64 screen as his normal console (as well as when he's running the text editor), there are good reasons to want a 24 by 80 screen when you do programming. At the same time, I have the Televideo 950 nearby because that machine does nearly all our development work and is also useful for checking spelling and the like.

I sure didn't want a second terminal for Zeke II, so I solved the problem with a T-Switch from Inmac. I suppose that requires a bit of explanation.

Computers talk to the outside world in two basic ways: serial and parallel.

Parallel communication sends all the data bits of a single character at the same time. Parallel communication is inherently faster than serial; but it requires many wires (in an 8-bit machine at least 10 and generally many more). Parallel, which is often electrically noisy, is usually more subject to errors induced by stray radio noise.

As an example, MacLean used parallel ports to connect his keyboard to Alice the IMSAI, and when he began he used a flat ribbon cable. He got a lot of extraneous garbage into his computer. Eventually he converted to a round shielded cable and *most* of the errors vanished.

Centronics printers and other such devices generally use parallel communication. The distance they can be from the computer is limited—15 feet maximum.

With serial communication the bits are sent one after another; an 8-bit character thus takes at least 10 times as long to send in serial as it would in parallel. (That's not strictly true, but we'll ignore the fine details.)

Your computer has I/O (input/output) ports built in as part of its basic structure. Those ports are parallel ports; it takes special hardware to convert from parallel to serial. Serial signals can be sent farther, however, with less noise and interference. Most letter-quality printers, like the Diablo, and all telephone or modem communications use the serial method.

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| IBM-PC Compatible Expansions Slots Beyond Professional Configuration[1] | 8 Slots | 0 | ? |
| Resident Floppy Disk Storage | Dual 320K (std) | Dual 160K (Opt)<br>Dual 320K (Opt) | ? |
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| MP/M 86 | Yes | — | ? |
| OASIS-16 | Yes | — | ? |
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| Z-80 CP/M-80 Board | Yes | — | ? |
| Cache Buffer Hard Disk | Yes | — | ? |
| Time/Calendar Board | Yes | — | ? |
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| 8" Floppy Disk System | Yes | — | ? |
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| Tape Cartridge System | Yes | — | ? |

[1] For comparison purposes, typical professional configurations consist of 16-Bit 8088 Processor, 128K RAM with Parity, Dual 320K 5-inch Floppies, DMA and Interrupt Controller, Dual RS-232 Serial Ports, Centronics Parallel Port and Dumb Computer Terminal or Equivalent.

[2] Columbia Data Products also supports CP/M 80® with an optionally available Z-80 CP/M Expansion Board.

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There's more than one serial system, but by far the most popular in the microcomputer world is called RS-232C. In theory there's an RS-232C standard; in practice that's *almost* true but not quite. However, it's true enough for T-Switches to work.

Suppose you have several serial output devices—say a printer and a modem for communications—and only one RS-232C output port on your computer. Enter the T-Switch, which lets you connect both to the port and switch between them. Obviously only one is active at any given time. It's true you could accomplish the same result by physically plugging and unplugging cables, but that's hard on the cables as well as darned inconvenient.

I'd only seen the T-Switch in advertisements, but it seemed a good idea; meanwhile, Inmac sent me a catalog of its equipment for microcomputers. I've ordered stuff from Inmac before; although its equipment is high-priced, its service is speedy and reliable. Anyway, I bought a T-Switch, and the result is that the Televideo 950 can run both Zeke II and the dual-processor machine. Actually, things are better than that: Tony has ingeniously set up the BIOS so that even after exiting from WRITE the Archive keyboard is active. Therefore, I can run Zeke II on the Televideo 950 terminal but continue to type on my splendid Archive board.

I love it.

### Changing the CBIOS

The CP/M operating system has to be told about your hardware. That's done through a beast known as the CBIOS. CP/M, as modified by the CBIOS, resides on tracks 0 and 1 of your floppy disk and is read in when the system is powered up. This is known as "cold booting" the system. Once CP/M is in memory, it can read in other files.

In the early days you couldn't do many fancy tricks with the CP/M CBIOS because there just wasn't room for a big program on two disk tracks. Now, however, with double-sided double-density disk systems, there's acres of space, and, if you have the source code to your CBIOS, there are all kinds of nifty things you might want to do. Tony does a lot of them in the CBIOS he put together for the Compupro systems.

In my case, I wanted to make use of those special keys on the Archive keyboard.

The usual microcomputer accepts only 7-bit characters from the keyboard. This is no problem because few keyboards can do anything with the eighth bit. As a practical matter, then, we are limited to 128 ($2^7$) unique characters in our communications with machines. Of these, the first 31, plus character 127 (delete), are reserved as "control" characters. These include Control-H, which is backspace; Control-M, which is carriage return; and others, as well as the less familiar ones like Control-backslash.

Most microcomputers do not display control characters; they've been programmed to treat them as orders to be executed rather than something to show to the operator. Thus, character 7, Control-G, rings the bell, but it doesn't print anything.

Some programs, particularly text editors for word processing, have a lot of commands. You might want to move the cursor around; jump to the end of the text; save the text; display helpful information; delete words, lines, and characters; and such like. The problem, then, is how to communicate your wishes to the computer.

If you want to be really elegant about it, you can put extra keys on the keyboard and label them "Delete Word" or "Find" or whatever. This is fine for the first 32 commands; then what do you do? Each special key has to send *something*, and if you want to use the entire ASCII character set including curly braces and squiggle and such like, then you're stuck. After you run out of control characters, you can't have just one keystroke per command.

Various programs use different ways around this. Some go to "com-

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mand modes" and use ordinary letters (K for kill and such like) while in the special mode. Electric Pencil did this: one control command put you in a special disk-operations command table, another into a print command table. WRITE follows this precedent, as does Select.

Others use "escape sequences": the computer intercepts the special character Control-], called "Escape," and interprets the next thing it sees as a command.

Wordstar does *both*: that is, you go Escape, then K, and you are in a special command block. Perfect Writer and the various EMACS-like editors do the same.

One problem with all this is that as the number of commands increases they get harder to remember. Worse, though, it's distracting for creative writers, and many (including me) don't like it. Indeed, I like multistroke *text* commands (as opposed to disk and print operations) so little that I'd rather not have them than use Wordstar and its relatives. I'll admit, however, that if there were dedicated keys that accomplished the results quickly, I'd opt for more editing commands than I have at present. Obviously, then, what's needed is a way to send many more unique commands from the keyboard.

One way to do that is to have programmable keys that send sequences. The Otrona Attache computer does something like that. You can program the Televideo 950 to do it. Tony has a version of WRITE that works with the Heath/Zenith Z-19 terminal and makes use of the escape-sequence arrow and other special-function keys.

Another way is to make a keyboard that sets the eighth bit. If you could do that, you'd have up to 128 additional "control characters."

The Archive keyboard has a number of special keys that set the eighth bit. However, because CP/M wasn't designed to support 8-bit characters, the CBIOS in nearly every CP/M system resets that bit to 0 before the program ever gets a chance to see it. Tony's CBIOS was no exception, but with a difference: he left a place in the source code where you can intercept what's coming from the console and do whatever you like with it.

Now the version of WRITE that I have doesn't accept eighth-bit commands, so even if my BIOS would pass them through I couldn't use them. On the other hand, I want to use the arrows, the Home key, the Delete Word key, and such like; they're easier to remember than control characters.

The permanent solution to that problem is to change my editor so that it accepts eighth-bit characters; that's being done. Meanwhile, a temporary solution is to intercept those special characters and interpret them. That is: the normal command to move the cursor up in WRITE is Control-W. The up-arrow key on the Archive keyboard makes the equivalent of Control-K but with the eighth bit set (decimal 139, or hexadecimal 8B). I need something that sees that hexadecimal 8B, intercepts it, and sends character number 23 (hexadecimal 17), which is Control-W, to the text editor. That will cause the editor to lift the cursor one line when I hit the up-arrow key.

That can be done. The interception takes place between the keyboard and CP/M as part of the Get Console Input routine that's programmed into the CBIOS. It requires assembly-language programming, something I haven't done in a year or so, but it was all very easy: compare the incoming character with 128 (which is delete plus one); if there's a carry, meaning that the character is smaller than 128, continue as before. If there's no carry, meaning that the incoming character is 128 or larger, go to a special table, look up what I've got, see what I want sent instead of that, put it in the A register, and once again go on as before.

You then have to assemble this with CP/M's RMAC (relocatable code macro assembler), patch it into the BIOS, and use the CP/M SYSGEN function to put the new version onto tracks 0 and 1 of the WRITE system master disk. After that, any time I do a cold boot with that disk in the A drive, the interpreter is operating.

Obviously there can be more than one of these interpreter systems. For example, Micropro's Wordmaster, which we use for programming, wants Control-K as the up-cursor command. It was a trivial job to change the table in the CBIOS and have a new Wordmaster system master. Cold boot that, and the up-arrow key sends a Control-K. Of course, I have to remember not only to change system master disks, but to reset the computer when I change from using WRITE to using Wordmaster. The CP/M "warm boot" command (Control-C) won't do the job; warm booting causes CP/M to refresh its disk directories, but it doesn't read in the system track again.

I realize this is complex. It's important for several reasons. First, unless you buy your system—CP/M—from an outfit that gives you the *source code* to your CBIOS, you won't be able to do anything like that; and while there's no temptation to play about like that when you first get a machine, it's surprising how quickly the urge can come upon you. After all, I swore to Tony and my mad friend that I would never, never be interested in understanding operating systems and all that arcane stuff that goes on inside the machine . . .

Second, it shows just how complicated things can be just to get some convenient features. This is the appeal of the dedicated word processor: they've set up all this for you and put the dedicated keys on the console. All you have to do is read the labels. I agree that's tempting, too. The problems come after you've learned your system and you want to do things that weren't designed into the dedicated machine.

Third, there's a way out: fully reprogrammable keyboards. I'm told that the IBM keyboard is that way, which is why Jim Baen's Magic Keyboard program can reassign the various misplaced keys. I'm also told that the new Lobo Max-80's keyboard is completely under software control, so much so that it has to read in an assignment file when it does a cold boot. The Otrona Attache keyboard is much like that as well. Alas, neither IBM nor Otrona has given us the software and documentation to allow complete reassignment of keys. I don't know whether Lobo intends to or not.

I wish everyone would, though. Then we could have truly customized text-editor programs.

### M or N?

Mucking about with the CBIOS gave me the opportunity to check the timing on both the M-Drive and N-Drive. As most of you know, these are two similar schemes for fooling your computer into thinking that a big block of memory is a disk; programs read and write on the "memory disk" rather than an actual disk device. This is very fast. Unless you have a battery backup, it is also very temporary.

My Compupro 8085/8088 dual processor has both M-Drive (several of the new Compupro superfast RAM-21 boards) and N-Drive (Semidisk). Both have advantages: the M-Drive memory is available as regular memory when I run the machine as an 8088 (for instance with CP/M-86), but M-Drive can work only with the dual processor and a direct-memory-access disk controller. The Semidisk memory is not available for any purpose other than as a pseudodisk, but Semidisk will work with any S-100 bus machine (and versions are available for the IBM Personal Computer and the TRS-80 Model II also).

Whatever their relative advantages, they're nearly equal on speed. I used the RMAC assembler to assemble my CBIOS on M-Drive, then on N-Drive. The source code is 72K bytes long. Much of it is comments; Tony believes in well-annotated code. Still in all, it's a big enough job for a fair test. To make sure there were lots of disk operations, I had the assembler write both .PRN (printing) file and .SYM (symbol tables) onto the logged disk. The .PRN file is well over 100K bytes long.

It assembled in one minute and nine seconds on M-Drive and one minute and eleven seconds on N-Drive. This is as near to equal as makes no never mind. For comparison I then did the same job on the B-Drive. That took 2:49, more than twice as long.

M-Drive and N-Drive are also about equal in speed when used for spelling checking. I now have a new version of The Word Plus that runs fine with either M-Drive or N-Drive; and because of the pseudodisk speeds, it's practical to use The Word's Lookup feature routinely. Lookup is a search through the dictionary for words similar to your misspelling; with normal disks, the computer's search takes about as long as it would for me to look up the word in *Words Most Often Misspelled*, but it's really nice with pseudodisks.

**Now I have been accused of being a "typical academic snob."**

### More Benchmarks

My "Benchmark of Sorts" as reported in the October 1982 BYTE must have been reasonably popular; at least it drew a lot of mail, almost all favorable. The program fills two 20 by 20 matrices, multiplies them, and sums all the elements in the answer, using REAL variables. (Someone wrote to tell me I needn't have used reals, because integers would do. Of course that's true, but the point of the benchmark was to test ability to handle real numbers.)

John Aro of Caspar, Wyoming, used the matrix benchmark programs on a North Star Horizon Z80A (4 MHz); for the 20 by 20 matrices, he got two minutes and eight seconds (2:08) with North Star BASIC and 1:52 with FPBASIC; 1:10 with JRT (p-code) Pascal; 2:01 with CBASIC; and 0:24.6 with CB-80. These times seem reasonably comparable to those I got.

Using FORTRAN, Harold Conrad of Taber, Alberta, Canada, got a time of 39.3 seconds for the 20 by 20 case on a 2-MHz 8080A. This is again comparable but slightly faster than the MT+ time obtained on my 8085.

Another letter was from Professor Roger Kirchner of Carleton College in Northfield, Minnesota (where the James and Dalton boys came to grief). Professor Kirchner ran my benchmark program on his TI-99, using the TI-99/4A p-code Pascal compiler.

His time for the 20 by 20 was 75.7 seconds. By comparison, Pascal M, which also uses p-code, did the same program in 59 seconds on my Compupro dual processor. (And see above, 8.9 seconds for the Sage 68000.)

Professor Kirchner, incidentally, argues in favor of Logo as the beginner's language of choice.

### More Things My Postman Brings Me

This column generates a lot of mail. Most is favorable. I brood too much about the unfavorable mail, but there's not much to be done about that tendency; I don't know any writer who doesn't ignore 30 good letters to worry excessively about one poison-pen epistle.

Sometimes, though, I just don't know what to do, as for example with the pair of letters I got concerning Edsger Dijkstra's "unpleasant truths" (see the October 1982 BYTE). Professor Edward O'Connell Jr. of the Psychology Department of Syracuse University tells me "BASIC is indeed brain damaging," and I was far too unkind to Professor Dijkstra, who was essentially correct in his observations.

Meanwhile, John S. Harbaugh of the Diebold Company says he's been programming for 23 years, and that "Mr. Pournell [sic] and Professor Dijkstra are typical academic snobs"; he takes me to task for being too partial to Pascal and insufficiently appreciative of BASIC.

In fairness to Mr. Harbaugh, it looks as if he'd read the quotes from Dijkstra and skimmed so fast he thought I agreed with them.

Professor O'Connell's letter is another matter. I was going to let it go, but I've just read it again, and it needs a reply.

He says, "I have been in the field since 1959, through FORTRAN, IPL-V, COBOL, GATE, PL/I, BASIC, APL, and Pascal. The only one of the list that I have found teachable is


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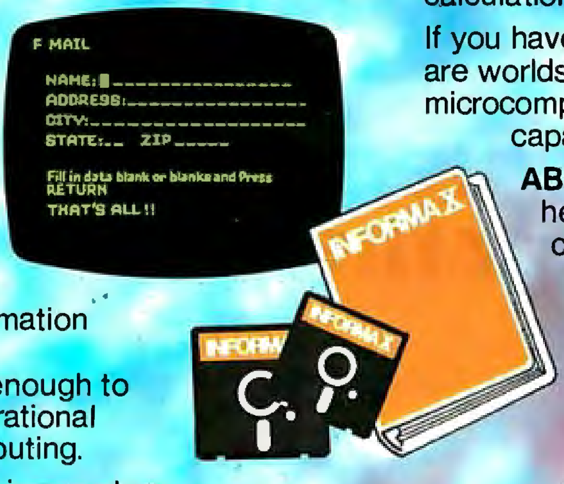


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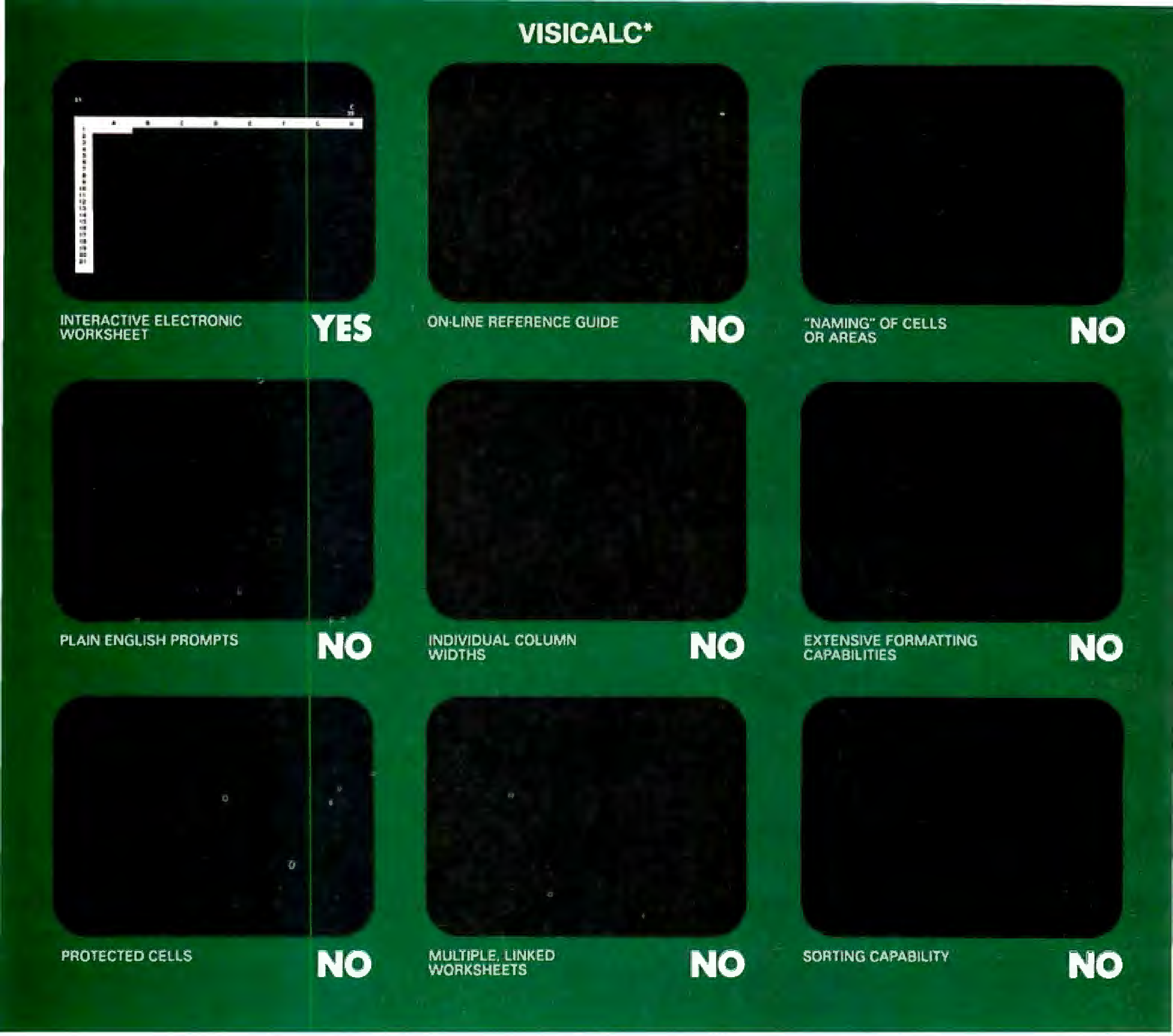


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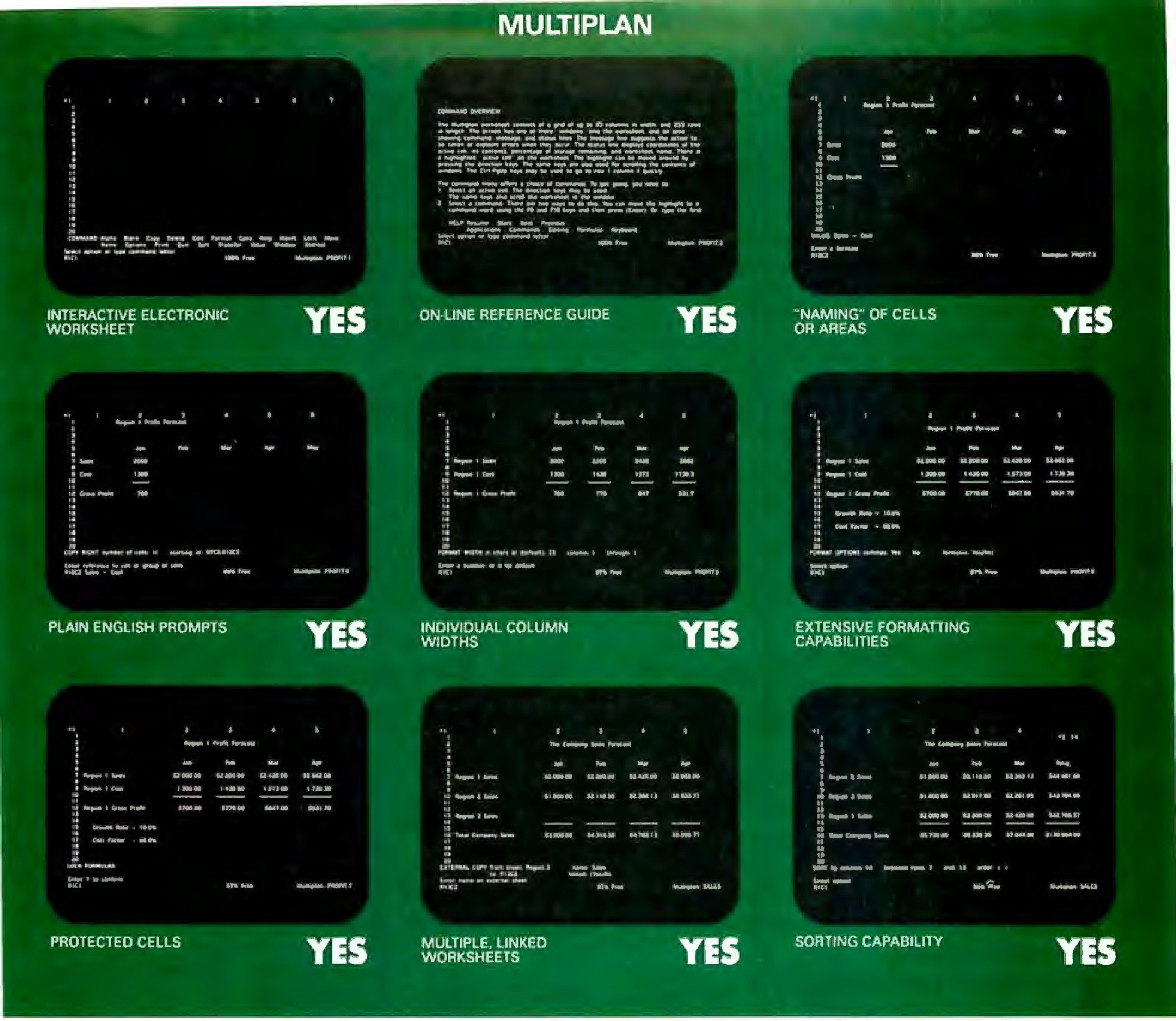


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Pascal. . . . Diddling about with BASIC as a first language leads to infantile fixations. Pascal can be taught, is logical, and demands very little more than BASIC initially. (By the way, how many times do you want to write single-statement programs of the form 'PRINT 2*2'?)"

Now what is one to make of all this? According to Professor O'Connell's letter, he has been teaching for 18 years that which cannot be taught; for I doubt seriously that he has long been teaching Pascal. Has he really been taking money under false pretenses? FORTRAN and COBOL are not my favorite languages, but ye gods, useful computer programs didn't start with Pascal!

It's certainly possible to rationally debate what is the best introductory teaching language. It's even possible that there is no "best" for all ages; that BASIC or Logo is "best" for young children, while older students might better start with Pascal or even LISP. One thing I am certain of is that letters that inform me that I am "infantile, naive, biased, and ignorant" are not likely to change my views, and I'd have thought a professor of psychology would realize that.

He does say my columns are "always interesting" and that he likes my reviews of equipment and software.

### The Language Debate Continues

Mr. Paul A. Sand in defense of Pascal says, "Pascal is primarily useful for composing large programs. Its advantages don't usually show up in benchmarks and tutorial texts. A good analogy is one I heard from an employee of Apple Computer: it is very impractical to use a Boeing 747 to run to the corner grocery store; it's equally impractical to walk from New Hampshire to California. Similarly, it is impractical to use Pascal for small programs, and BASIC—any version—is often hopelessly underpowered for larger programs."

I agree with this except for the final sentence, which is ambiguous. If he is saying that *no* version of BASIC is useful for large programs, I think he may be wrong.

### SPP to the Rescue!

One of my major dislikes of Pascal as it is normally implemented on microcomputers—I have no experience with it on big machines, and anyway that's irrelevant since I'm writing for "the Small Systems Journal"—is that Pascal tries to make me think like a computer. Indeed, Mike Lehman put it very well in the manual to his Speed Programming Package:

> The Speed Programming Package helps the user to remove all "dumb" errors prior to compilation. One of the limits to productivity is the human frustration threshold. One must experience first-hand reaching the end of a four thousand line source compilation only to find that a semicolon (or period) was missing to fully understand the situation. One must then re-edit and recompile only to find that it may still be wrong, leading to only more and more frustration. This tends to lead programmers to become extremely careful and spend much time simulating the compiler in their heads to save time when the computer should be able to make the production of programs easier, not harder.

That is precisely the point I have been trying to make about Pascal: that the implementations I have worked with seem well designed to drive you to either think like a computer or go quite mad. Perhaps Professor O'Connell and Mr. Nelson and my other detractors never leave out semicolons. Perhaps they are correct when they condescendingly tell me that if I had enough experience I wouldn't make syntax errors; but perhaps they are not. Mike Lehman has far more experience than I do; after all, he wrote the Pascal MT+ compiler, first in UCSD Pascal, then in MT+ itself.

I don't want to have to think like a computer. I want the computer to compute, leaving me to get my own work done. I don't much care whether my programs meet some outside criterion of "elegance" or even "efficiency." ("After all," as Carl Helmers says, "if you define 'efficient' as 'using least memory,' then the old one-letter BASIC variables were efficient. . . .") I do care that my programs are easy to work on at periodic

EXTRA EXTRA

# S-100 World News

MACROTECH International Corporation 22133 Cohasset Street, Canoga Park, California 91303 • 213-887-5737

# Megabyte S-100 Memory Here Now

## Major breakthrough made by Macrotech International Corporation

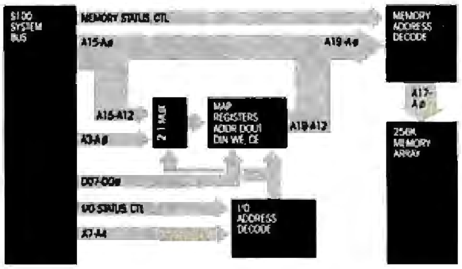
CANOGA PARK (MI)-January 20, 1983-Mike Pelkey, president of Macrotech International Corporation, today announced a major technological breakthrough in S-100 dynamic memory board density. A full megabyte of high speed dynamic ram is contained on a single standard size S-100 multilayer P.C. board. The product, dubbed 'Max' meets all IEEE/696 mechanical and electrical specifications and byte parity generation/checking is included as a standard feature. Max supports IEEE/696 24-bit addressing (selectable at any 128K boundary), 8/16 data transfer protocol, phantom line operation, and the same ultra low noise bus signal filtering provided on Macrotech's popular high performance 256K dynamic memory board.

Max is in production now and shipping at the all-time low cost per bit list price of $1,983 in unit quantity.

Bruce Kimmel, Macrotech's sales manager reports that customers are being served on a "first-in, first-out" basis and warns that due to a high incidence of graphics and similar memory-intensive applications, along with an unwillingness in the trade to pay exorbitant prices for memory, backlogs may occur for Max which could delay shipments against some late orders. With the improbability of second sourcing for some time, interested parties are urged to get orders in as soon as possible. Bruce can be contacted at 22133 Cohasset Street, Canoga Park, California 91303, or reached by telephone at (213) 887-5737.

## M³ Family Growing

Another product recently introduced by Macrotech is soaring to the top of the best-seller list. The Multiuser II is a 128 kbyte 70ns CMOS static ram memory board that is unquestionably without peer in the S-100 marketplace. It's a 6-layer board with blazing speed, 8/16 data transfer protocol, and ultra-low power external battery support. The same M³ memory mapped addressing architecture so in demand with system software professionals is now standard in the new Multiuser II. M³ was first developed by Macrotech for the popular Multiuser I 256K dynamic ram board to meet the demanding requirements of today's sophisticated systems.

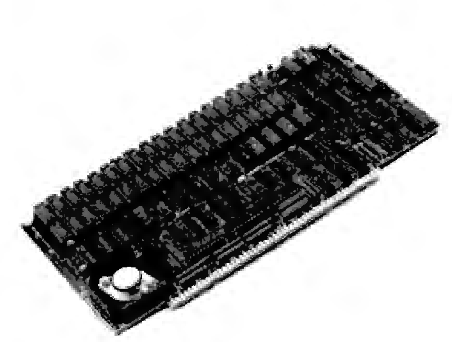



Macrotech's advanced memory mapping scheme allows each 4K block of the 16 bit (64K) logical addresses to be dynamically translated to any 4K block of the physical memory. Global memory can be configured to any size and located anywhere in the logical address space. All remaining memory can be addressed through the remaining logical address space by simply reloading the mapping registers to address the desired physical memory blocks. This scheme permits unlimited use of all on-board physical memory.

## Virtual Disk Flexibility Cited

CANOGA PARK-January 20, 1983-Macrotech reports their Multiuser I and Multiuser II S-100 ram memory boards can be used as both system memory and "virtual disk" storage in eight or sixteen-bit applications. Addressing flexibility is the key. The Multiuser M³ memory mapped addressing is guaranteed to allow memory partitioning to fit the exact requirements of your system without ever wasting a single byte.

Today's trend in operating systems appears to include extended memory capabilities to allow for the recent technological advances in semiconductor memory. A close look at Digital Research's new CP/M 3™ for example, would lead you to believe that it was especially created to fit Macrotech's family of Multiuser memory boards. (It wasn't, but try to find one that fits better.)



*Where it all started: pictured is the popular Multiuser I, Macrotech's first product. This widely used board provides 256 Kbytes of dynamic ram with 4K page memory mapping (called M³), 8/16 bit operation, 24 bit addressing and byte parity checking.*

## *MACROTECH Announces Distribution Expansion*

CANOGA PARK-January 20, 1983-Macrotech is now establishing domestic and international dealer/representative networks. The California based firm is expanding it's customer support through these channels and invites inquiries. Volume users and retailers should contact the company for details.

Macrotech's marketing director Bob Ryle states, "IEEE/696 has made S-100 legitimate. It is rapidly gaining acceptance due to its inherently superior speed characteristics." Ryle attributes the growing demand for Macrotech memories to Macrotech's strict adherence to the IEEE standard. Circle 253 on inquiry card.

intervals.

Let me praise Lehman's Speed Programming Package. When Mike first sent me Pascal MT+, he sent along the SPP; but alas, he sent no documents for it, and I was never able to use it. Every now and again I got puzzled letters from readers who were using SPP, and who didn't understand some of my frustrations with Pascal. Why didn't I use SPP?

Meanwhile, Digital Research was redoing the SPP documents, and they'd send them along Real Soon Now. Eventually they came.

Put simply, SPP is indispensable. It's not wonderful. It could stand some improvements. Even so, it's vital that if you program in Pascal MT+, you must get SPP.

SPP is a whole package of programming aids, including both editing and syntax-checking functions. As Paul Sand put it in his thoughtful letter, many of Pascal's deficiencies are disadvantages of compilers rather than interpreters; compilers are notoriously unfriendly. With SPP, though, some of those deficiencies are remedied.

SPP contains a screen-oriented editor somewhat similar to Wordmaster. Some changes have been made to the Wordmaster command structure and not all have been well chosen; I particularly miss Wordmaster's little "QP" buffer, and I can't understand why Lehman made some of his other changes. No matter. You can always use Wordmaster to create most of your program, then go to SPP for the final touches; or, more likely, you can simply get used to SPP's quirks.

Incidentally, I'm writing an SPP editor CBIOS to enable my Archive keyboard to work directly on SPP's editor.

The SPP editor has some of the features of the UCSD Pascal editor. It aids in indentation, for one thing. There's also a "pretty print" reshuffler: once your program has been created, SPP will automagically reformat it with levels of indentations. That by itself shows you many of your horrible mistakes, such as missing END statements.

Finally, from within SPP you can do syntax checking. That goes *fast* on the M-Drive; and when a syntax error is detected, SPP puts you automatically in the text editor, with the cursor where the compiler thinks the error was. (The UCSD editor on the Sage 68000 system does this also.)

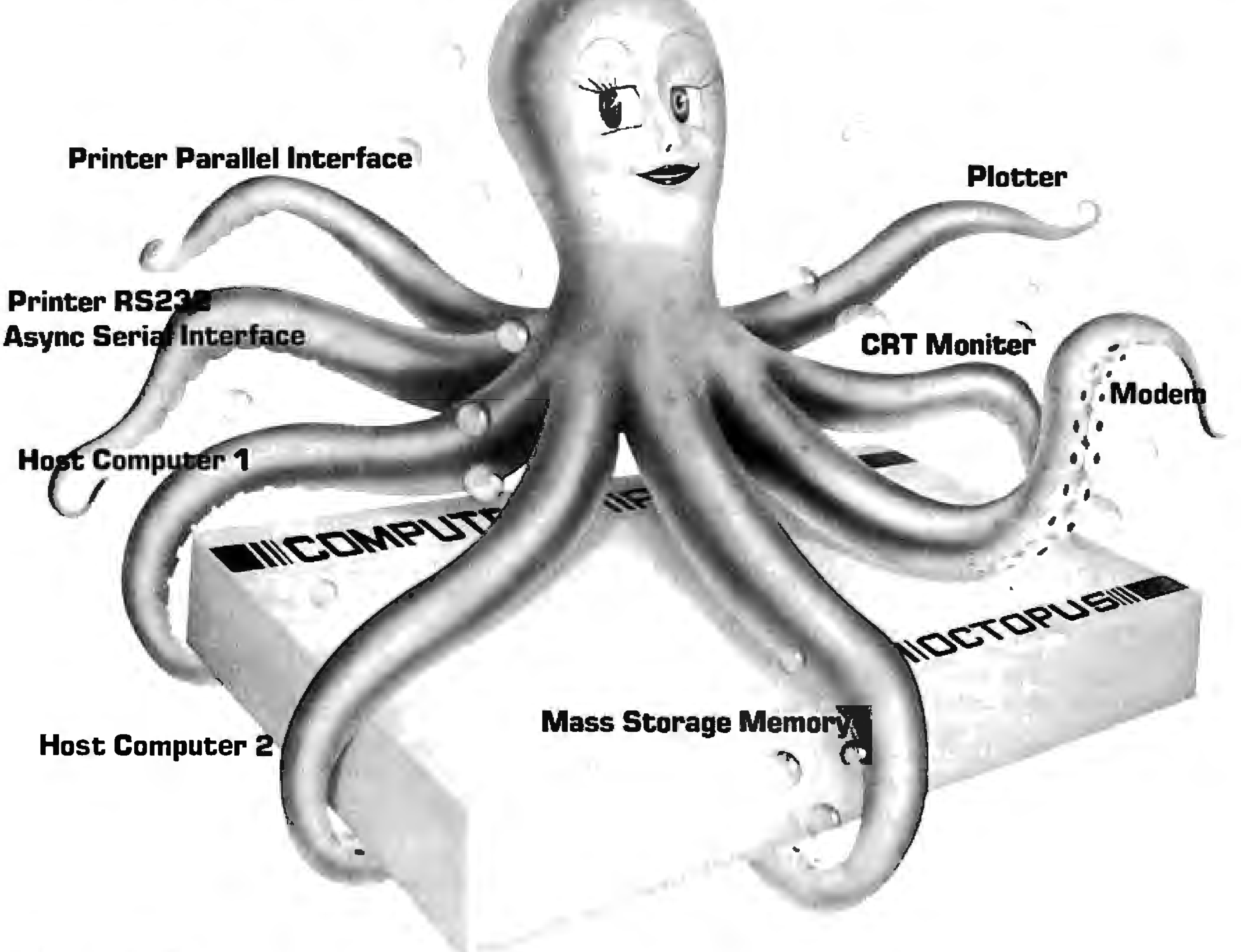
There are more valuable features to SPP. It will check the spelling of your variables. If it finds a variable used precisely once, that's a pretty good candidate for a spelling error. It will log source-code modifications. It will even run special procedures you write yourself.

In other words, I'm wild about SPP, and I think it's high time that *everyone* selling Pascal get busy to provide something similar; the effect on the national blood pressure will be dramatic.

### Database the Easy Way

If I'm after a quick and easy way to store data, I generally use my own

# OCTOPUS

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More complex data storage and retrieval requires more sophisticated programs. One such I've long recommended is dBASE II. (I have several rivals of dBASE II here, and I hope some time to try them; the problem is that between MDB and dBASE II there's been no *need* for anything else.)

The only real problem with dBASE II is the documentation; getting started with it from scratch can be a frustrating experience. It's not an impossible task; a number of friends, some of whom have zero experience with computers, have taken dBASE II and created really sophisticated record-keeping structures with it with no help from anyone. Still, the introductory documents have not been its strongest point.

Comes now Fox & Geller with its Quickcode program; and a good part of the problem of getting started with dBASE II is solved. The Quickcode programs and book will help you get set up with dBASE II and get you through the transition from "I just want to do my Christmas card list" to generating sophisticated accounting programs.

It works by "screens"; that is, you can use Quickcode to set up the structure of the database, one screen per record; after that, you enter data into the database by filling in the blanks, a screen at a time. Anyone starting out to learn to use dBASE II can save a good bit of time and frustration by getting the Fox & Geller Quickcode as well. Quickcode would also be useful for anyone using dBASE II as a programming language. (Many do; it's possible to write some very sophisticated programs in dBASE II.)

## Keyboard Companion

One day there appeared via UPS five boxes, each about two feet long by half that high and wide. The only clue as to what they contained were the words "Keyboard Companion." When we opened them, we found several copies of a device with that name. Each was slightly different. One was designed for use with a TRS-80, another for an Apple, the others for more general systems.

The Keyboard Companion is a combination copyholder and tilted table. It consists of some metal box-like structures to elevate your monitor screen and an attractive nonmagnetic black Bakelite board with an aluminum edge holder at the bottom. A plastic line guide/paper holder fits onto one edge. The board attaches to your screen via Velcro strips; the bottom edge can rest on your keyboard or alternatively on the table that holds the keyboard. The result is that you've a table between the keyboard and the monitor screen for notebooks, program copy, notepaper, or anything else you might want to be looking at while using the keyboard.

Our Keyboard Companions sat unopened for months. Then Barry Workman took the TRS-80 away, and one of the students remembered we had a Companion for it and sent that along. Later we got the Apple, and out came another. They worked out very well; so well that I fished out yet another Companion and set it up as part of Zeke II's system. The Companion has proven to be a very useful addition to the system, and I am beginning to wonder how I got along without it for so long.

When you're designing your computer setup, it couldn't hurt to look into the Keyboard Companion line; this might be just what you're looking for. They come in 16- and 20-inch widths, with screen holders designed for most popular monitors.

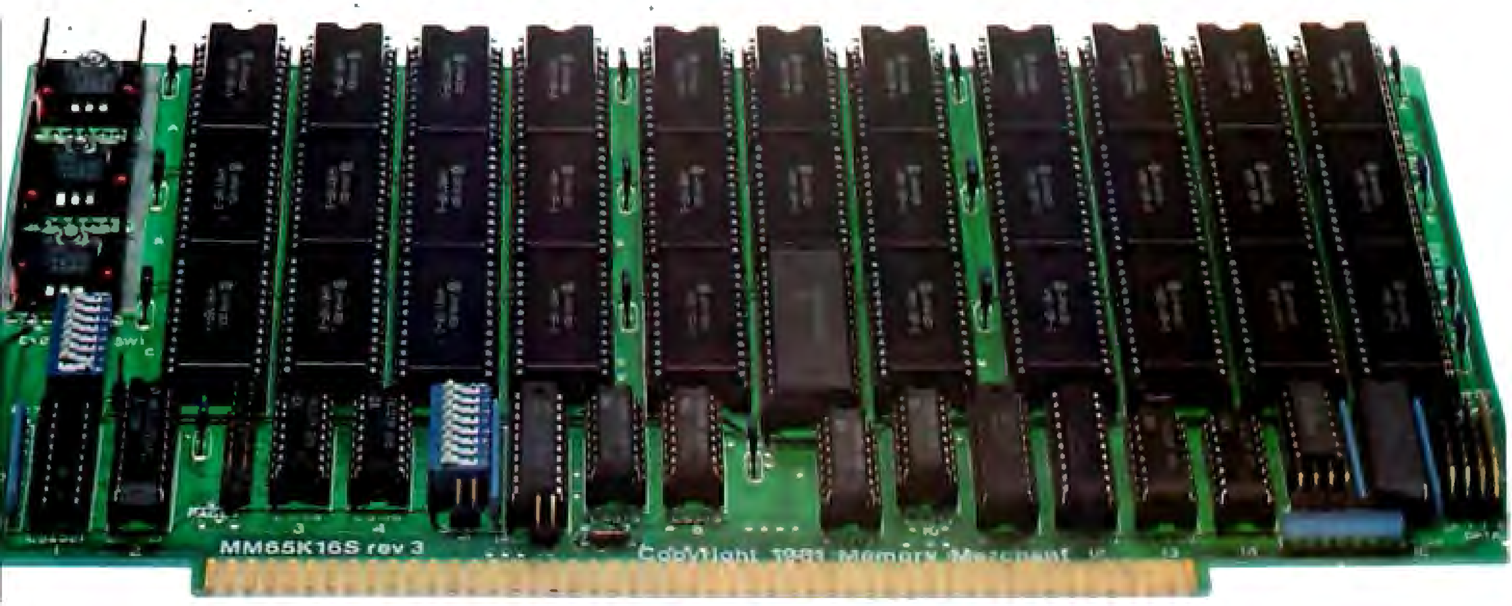
## New Operating Systems

As I write this, they're arranging to get me a test copy of CP/M 3.0. I've just finished speaking with my colleague Mark Dahmke, who already has it; Mark likes it a lot. It has a number of attractive features—including no more Control-C every time you change disks. More on that next month.

I'm also eagerly waiting for Tony to finish work on the CBIOS for CPM-86 to run on the Compupro

*Text continued on page 242*

# 64K STATIC RAM MEMORY

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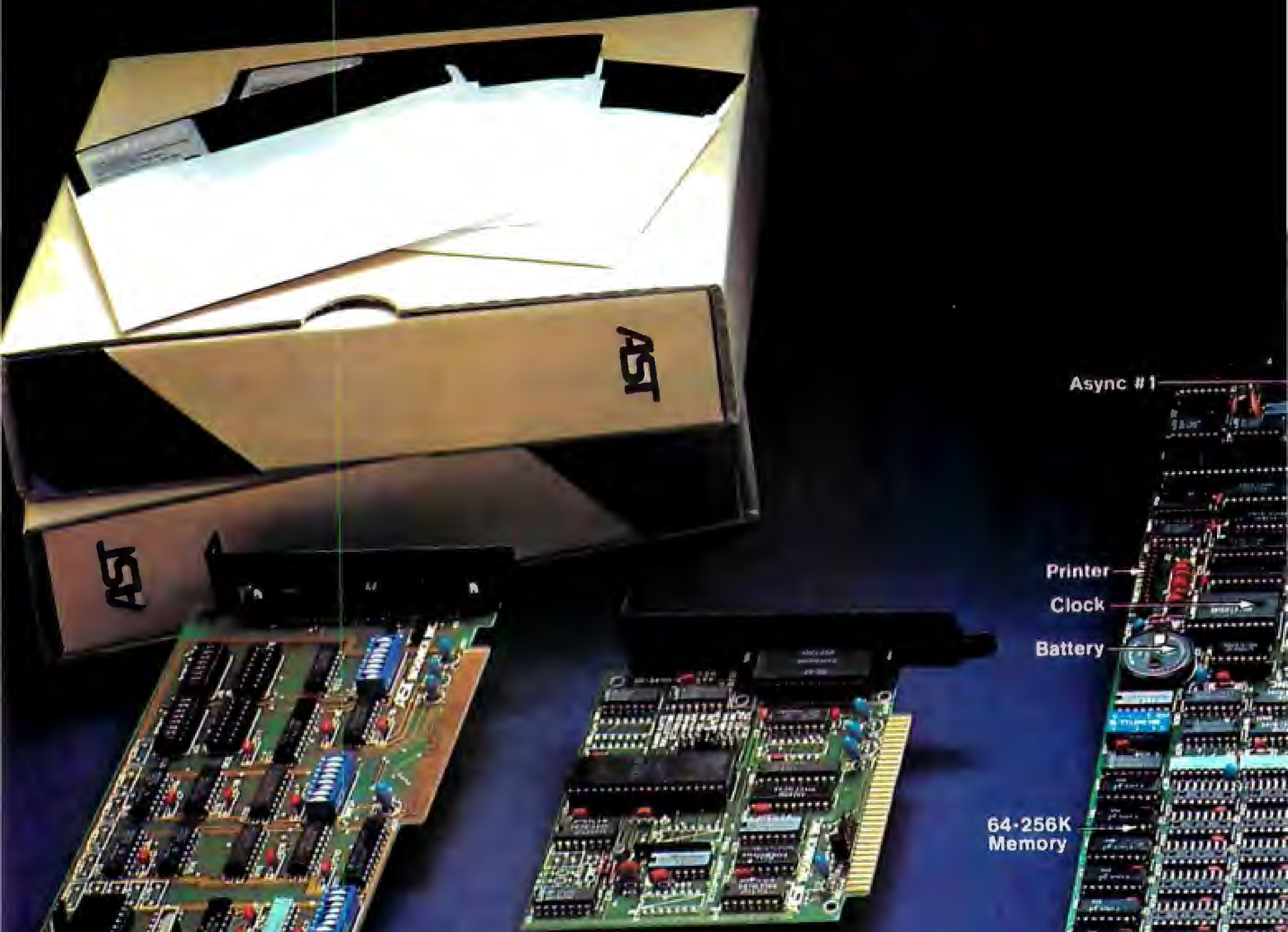
# Number One Add-On

## Communications

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manual $147
automatic $395

## Book Reviewed

**Introduction to the UCSD p-System** by Charles W. Grant and Jon Butah, Berkeley, CA: Sybex, 1982, 300 pages, (415) 848-8233
$14.95 ($1.50 handling)

dual processor. CP/M-86 will enable the Compupro to run a number of programs that run on the IBM Personal Computer. On that score, Mark Dahmke has it running and says, "CP/M-86 makes the IBM PC a usable machine." I thought that a bit extreme; after all, a lot of people think the IBM PC is usable now. I'd probably have one if I hadn't become so furious over that horrid "European-standard" keyboard.

Mark agreed he'd probably overstated the case but added, "Going from MS-DOS to CP/M-86 is very much like going from TRS-DOS to CP/M. Once you've done it, you can never understand how you put up with the old system." I'll have to take his word for it, but not for long; one day I will get a PC, either by getting the right kind of S-100 video output

board for the Compupro; or by getting a Heath/Zenith Z-100, which seems to be a complete PC workalike; or by getting the PC itself and installing Jim Baen's Magic Keyboard reprogrammer. I have too many friends who are too happy with the PC for me to be a holdout forever.

Getting the PC won't solve my real problem, which was rather succinctly put by Professor Ben Singer of the University of Western Ontario. Professor Singer writes, "I am still looking for a metaprogram—one thing that you turn on—a giant file cum program that you can write with, retrieve, make notes, rewrite, find old things, but without menus, without leaving disks and programs and all of that."

I know precisely what he means: I'm looking for that program too. Right now we have text editors, databases, calculator programs, filecard programs, scratchnote programs, things to hold telephone numbers, spelling programs, etc., but they don't really work together. A few, like Wordstar with Spellstar and Datastar, try to work together, but they aren't really what we're looking for.

A possible approach is multitasking. I've never thought highly of multiuser operating systems for microcomputers; the computers are cheap enough that I think the goal ought to be one user, one processor. However, that doesn't mean the processor can't be doing more than one thing at a time. After all, while it's waiting for me to type in more text, it can be checking the spelling of the text I've already written or doing something useful like that. In theory, that would be fine; in practice, I suspect it would have side effects sufficiently distracting that I'd never use the capability.

On the other hand, I would greatly *love* to be able to access a desk calculator, retrieve telephone numbers and disk catalog information, see my calendar, and make log entries right from within my text editor without having to save my text and load a new program. I've even made notes on what I'd like such a program (or operating system) to do, and I've given it the name Executive Secretary. I'm told it wouldn't be all that difficult to write; that I can add some memory, and with a little hard work Executive Secretary can be made to run.

I'll believe it when I see it. That may not be as long as I think. Tony has a whole mess of stuff from Compupro and has been making mysterious noises about new upgrades to the operating system; while I keep hearing rumors of similar activities elsewhere in computerland. After all, Compupro already has its MPM-8/16 multitasking multiuser system, and although it's not quite what I want it's a step in the right direction. My own bet is that by the time the West Coast Computer Faire comes along in 1984 someone will have my Executive Secretary. I sure hope so.

## Pascal Prime Project

The Pascal Prime Project mentioned last time continues. This is an attempt to get major compiler writers and publishers to agree on a set of "standard" extensions that fix Pascal's major defects. Carl Helmers will become chairman of the actual meeting to be held during the West Coast Computer Faire. We've heard from nearly all the major compiler writers and publishers, and they'll be there. Just how much agreement we'll get on Pascal extensions is still more guesswork than knowledge, but most of the compiler people seem anxious to cooperate.

Meanwhile, I've got a copy of Niklaus Wirth's report on Modula-2, his candidate for the language to remedy Pascal's defects and take its place. I haven't had a chance to study the book yet, but I don't think there's a Modula-2 compiler running on any system I'm likely to have; until I can run Modula-2, then, I'll continue to work on fixing Pascal. Last-minute flash: we now have Modula-2 working on the Sage. I like it a lot.

The Pascal Prime meeting will be open to the public; the structure will be a panel discussion of the invited participants, after which we'll take suggestions and questions from the floor. Since we don't have a lot of time, and we do hope to get some agreement on required Pascal extensions, we hope the questions and comments can be both relevant and short. And this column has gone on long enough. Next month, I hope, we can look at some equipment using 8087 "math" chips, plus lots more on the Sage and the new Lobo Max-80, and perhaps the new Epson QX-10 machine.■

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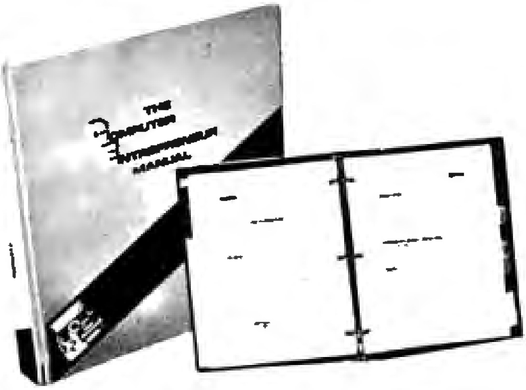

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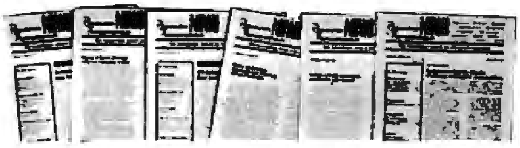

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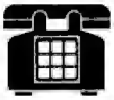

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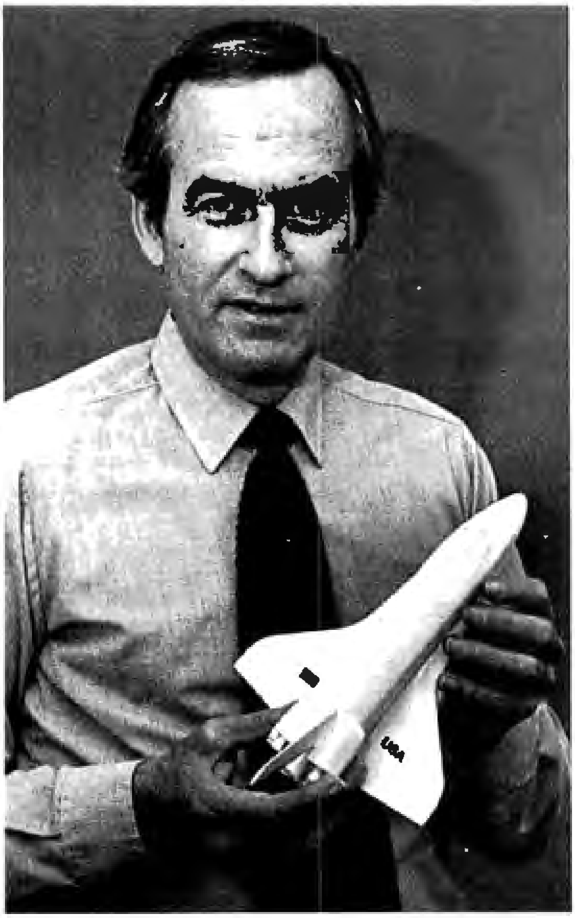

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# Project Nebula

Keith Carlson
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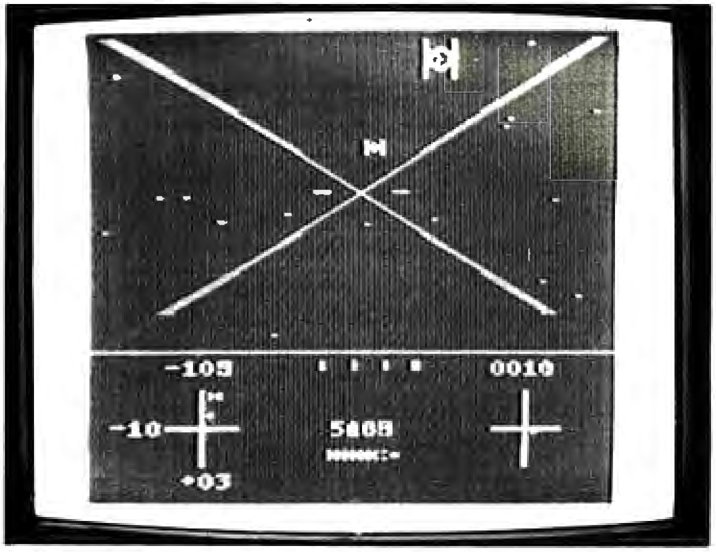



**Photo 1:** *The forward view from your scout vessel is shown in the upper section of the screen. Two Zykon craft have dodged one of your energy bolts (diagonal lines converging in center). At the bottom are your instruments showing direction, energy units, and score.*

In light of the enormous popularity of video games, it's not unusual that imitations of the most popular ones should spring up. After all, consumers spend $10 billion a year on video arcades, and manufacturers want a slice of the pie. So naturally I expected Project Nebula to be Radio Shack's version of Atari's blockbuster, Star Raiders. Not so. The two games have similarities, but after a thorough investigation I found that Project Nebula's differences in terms of rules and play make it a true original.

Actually, Project Nebula for the TRS-80 Color Computer includes four games. Each game offers you 10 levels that increase in difficulty. Target practice is the first game, and you'll need it. The joystick control is sluggish and difficult to use in the beginning, and practice will help you get comfortable using it. Whether the unusual feel of the joystick was intentional or not, it detracts from the game. Target practice will also introduce you to the short-range sensors (both front and rear views) in the lower corners of the screen. In my initial experience with this practice, I discovered one of Project Nebula's most interesting aspects: the program maintains depth of field. In other words, if you have two enemy ships in your sights, you can only shoot the one in front. The second ship becomes vulnerable only when it is closer to you than the leftover debris from the enemy you just exploded. And the best part is that you gain all of this wonderful experience under the most ideal conditions; you can shoot the Zykons, but they can't shoot back!

Once you master the joysticks and the range sensors, you're ready for game two. It, too, is target practice, but with a big difference: now the Zykons are shooting at you. But don't fret too much; your ship is still safe. When you get a direct hit from an enemy bolt, the screen briefly fills with red @ signs, and the game continues. During this game, your other joystick is activated and it controls the forward speed of your craft. That feature isn't particularly useful in the first two games, but it becomes quite significant in subsequent games when you have to dock and refuel.

In the third game, you apply what you've been practicing. Now you have an entire quadrant to patrol, and with a press of the Z key, you view a multicolored map. To travel between sectors, you choose a sector and, by press-

### At a Glance

**Name**
Project Nebula

**Type**
Game

**Manufacturer**
Tandy Corporation
1 Tandy Plaza
Fort Worth, TX 76102

**Price**
$39.95

**Author**
Robert Arnstein

**Format**
ROM cartridge

**Language**
6809 machine language

**Computer Needed**
TRS-80 Color Computer
(any configuration)

**Additional Equipment**
Two joysticks

**Documentation**
8-page manual

**Audience**
Arcade game players and
Star Wars fans

ing the H key, off you go into "hyperspace." When you move in hyperspace from one sector to another, the graphics resemble those in *Star Wars.* You will travel in hyperspace often. Every time the Zykons zap your ship, you lose energy units. To refuel, you must travel to a sector with a base, dock your ship, and get recharged.

Docking can be tricky. If you forget to reduce your speed at the right time, you will overshoot the base. You must set the ship's horizontal and vertical directions within a certain range, increase your speed until the base is in sight, and then decrease your speed to a specified point. When you are close enough to the base, you will receive a new power pack. Instructions for this procedure are included with the game, and with a little practice docking almost becomes easy.

The fourth and final game of the series pulls out all of the stops. Not only do you lose energy units when your ship is hit, but the accumulated hits begin to take their toll on your vessel. The type and level of damage the hits inflict remains unpredictable. You must remember to check the damage status report, which is displayed to the right of the quadrant map. When it's time for repairs, you must travel to a base.

At this point, finding a base can present quite a challenge. If your long-range sensors are damaged, you'll still be able to display the quadrant map, but the sectors will be randomly filled, making it impossible for you to tell which sector contains what; in my opinion, false information is more frustrating than no information at all. If you didn't memorize which sector has your home base, your only recourse is to conduct a costly sector-by-sector search, consuming large amounts of time and fuel. Trying to use damaged warp engines lands you in a random sector, no matter where you want to go. I find this more maddening than nonfunctional warp engines.

A few relatively minor things about Project Nebula bother me. Its terrible sound effects grated on my nerves and detracted from my ability to enjoy the game. As soon as I turned off the white noise, I had a much better time. Another quibble concerns the strategy for winning. If you're cautious, it's practically impossible to lose. An inexhaustible supply of bases for fuel and repair keep you from serious trouble, provided you memorize the location of your base. My last objection concerns the ending of the game. When you manage to eliminate every last Zykon, all you get is a mere congratulations. A rating based on the number of times you refueled combined with your score would be more gratifying. These problems, however, are trivial compared to Project Nebula's overall enjoyability. ■

# Legionnaire

Gregg Williams
Senior Editor

I have always had an extreme dislike for any game that reminds me of a legal contract. I've never liked war games for that reason. The rules always have the length, clarity, conciseness, and type size of the average insurance policy. I have also never been able to deal with war game maps (which are often the size of movie posters) and the number of playing pieces (anywhere from fifty to hundreds of units); I much prefer the playability of simple game mechanisms to complex ones. Because of all this, I've never been comfortable with war games, even though I've spent considerable hours playing them.

Avalon Hill's Legionnaire changes all that. The name of the game is misleading (for most people, it conjures up images of American Legion veterans trying to get to the Saturday night banquet alive) and the cover art is poor, but those are the only flaws in the presentation of an otherwise perfect solitaire game.

Legionnaire is the most recent game by Atari's Chris Crawford, easily the most innovative and talented person working on the Atari 400/800 computer today. Though his previous game, Eastern Front, solves many of the problems of war games, it retains several features that don't suit me—only one scenario with over 50 pieces on each side, a playing time of several hours, and a complexity that intimidates rather than challenges me. (Dyed-in-the-wool war gamers don't have these problems with the game, but I'm sure many feel as I do. I'm happy to report that Chris is working on an enhanced version of Eastern Front that has, among other things, various levels of complexity.)

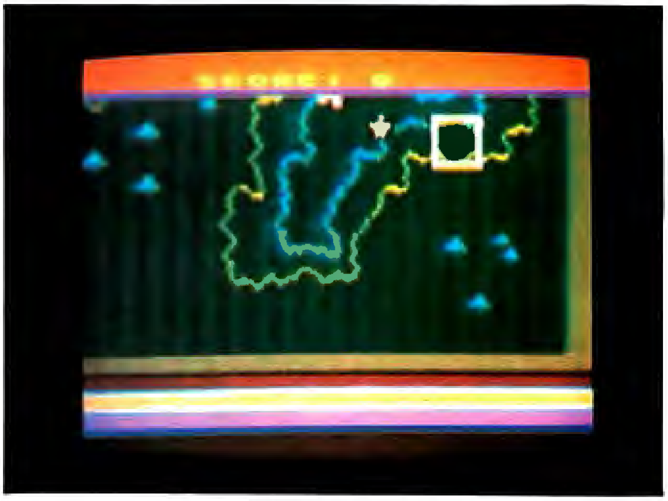
Legionnaire is Crawford's latest war game, and many of its features improve on Eastern Front. For example, you can play games of varying complexity and length (the shortest is perhaps 10 minutes), you command between one and ten units, the computer automatically takes care of the enormous amount of calculation and record-keeping that conventional war games require, and—best of all—the game takes place in real time.

In Legionnaire, you are Caesar, and you command a force of between one and nine Roman legions. You play on a scrolling topographical map several screens high and wide (see photo 1), and your task is to defeat two barbarian tribes (played by the computer) that are challenging your power. When the game starts, you are asked how many legions you want to play with. You can choose a force of between one and ten legions, the first of which represents Caesar. (As the number of units you possess increases, you receive successively weaker units; the game is easier with smaller forces. Choose five units the first time you play.) You then choose one of twelve barbarian infantry tribes (listed in order of increasing strength and skill) and one of twelve barbarian cavalry tribes. Because each tribe is the same size as your force, you are always outnumbered by two to one. Your force and the two barbarian groups are placed randomly on the map, and the game is ready to begin.

When you press the Start button on the Atari keyboard, the barbarian units begin to move toward you. This is a very unsettling sight, especially compared with Eastern Front, in which you had conventional game turns and combat takes place only when you are ready. Not so in Legionnaire—the game is in real time and you have no time to spare. You use the joystick and a hollow-square cursor to give each unit up to eight orders, and each unit begins moving as soon as you have finished. The amount of time you need to execute these orders depends on the type of unit, its current characteristics, and the terrain; of course, cavalry units are faster than infantry units, but infantry units are stronger and harder to destroy. In general, units move once every 4 to 30 seconds, which gives you an idea of the pace of the game. The Caesar

(1a)

(1b)



(1c)

**Photo 1a–c:** *Legionnaire in action. In this sequence, the cursor (yellow box) moves to the top edge of the screen (1a and 1b). When it needs to move further up, the background scrolls down (1c). You can see this by noting the locations of Caesar (the eagle-shaped pink unit) in each photo.*

### At a Glance

**Name**
Legionnaire

**Type**
Arcade-style real-time military-strategy game

**Manufacturer**
Avalon Hill Microcomputer Games Inc.
4517 Harford Rd.
Baltimore, MD 21214

**Price**
$35

**Computer**
Atari 400 or 800 with cassette recorder, joysticks, and 16K bytes of memory

**Author**
Chris Crawford

**Language**
6502 machine language

**Documentation**
A 20-page manual with game instructions, strategy, an analysis of Roman and barbarian units, and some relevant history

**Audience**
Game players

unit is both strong and fast, but it has a special liability: if you lose it, you lose the game. When enemy units are adjacent and trying to occupy the same square, they begin to fight each other. Depending on the circumstances, a unit may retreat and/or lose men and swords; if it loses all of its swords, the unit dies and is removed from play.

The current status of each unit is indicated by the number of unwounded men in that unit and a number that reflects their combat strength at the moment due to fatigue and circumstances. In addition, the behavior of each Roman legion and each barbarian tribe is influenced by its overall temperament, which is described in the rulebook for Legionnaire. Such subtle information is of interest to only the experienced Legionnaire player, but it can mean the difference between defeat and victory when you are playing against the toughest opponents.

Of course, there is a lot of strategy to Legionnaire. Beginners should take the Roman troops to the top of the nearest hill and wait for the attack; that way the tired barbarians will have to walk uphill to attack rested Romans. You should also keep the cavalry units from being "pinned"; they should be free to execute a flank (side) or rear attack. See "More Legionnaire Tactics" for more information; you may want to play the game for a while before reading this box.

## Conclusions

Legionnaire is a wonderful game that, for me, combines the graphics and movement of arcade games with the depth of strategy games. It also performs the valuable service of making the war game accessible to people who don't like the complexity and tedium of paper-and-cardboard war games. I also like the large number of gradations (in both playing time and skill level) it offers; Legionnaire has 1,440 variations (10 troop sizes times 12 cavalry opponents times 12 infantry opponents). Looking up combat results in a table (the procedure in most war games) has always struck me as a method of combat resolution that gives the players too much information on how combat is decided; seeing only the results of a battle, in real time, gives me a better simulation of war-making. Legionnaire has taught me more about military strategy and tactics than all the war games I've played to date.

Avalon Hill should be congratulated on such a strong game that extends its leadership in the war-gaming field to the microcomputer arena. I only wish that Avalon Hill had given Chris Crawford more prominent credit—if they don't know it by now, Chris's name sells games, and Legionnaire is just one example why. ■

### More Legionnaire Tactics

- *One tactic for winning Legionnaire is to send one of your cavalry units toward the slower barbarian infantry units. If you are careful, you can get the infantry units to chase your cavalry, thus drawing them away from your main group. The remaining units (mostly infantry) can usually overcome the isolated barbarian cavalry; once that's done, use your cavalry to draw the barbarian infantry back to your main group. It will take some practice to use this tactic successfully.*
- *If you simply can't give your orders fast enough during a fierce battle, an undocumented feature of this game is to hit the Option key once (hitting it twice ends the game with your surrender). The game pauses (as with the Select key), but here you can give your units orders. Hit the Start key to continue the game. This is, strictly speaking, cheating, and it should be used only when necessary. However, the Huns (the most powerful barbarian cavalry) are impossible to beat, I'm told, so any method of winning is permitted here.*

# Omega Race for the VIC-20

Stanley J. Wszola
Technical Editor

It isn't easy converting a well-known arcade game to the smaller screen and coarser graphics of a microcomputer. Invariably, the microcomputer display doesn't look as nice and the game's action isn't as fast as the arcade version. So I was pleasantly surprised when I saw Omega Race for the first time. The version for the Commodore VIC-20 is fast paced, has colorful graphics, and features good sound effects.

The game is relatively unchanged from the original Bally Midway version. At the start you are shown the race course, a rectangular-shaped field with a smaller rectangle in its middle. The smaller rectangle displays the number of ships you have left, your current score, and the previous high score. Populating the larger rectangle are a number of space mines and android-controlled ships. Each ship or mine is worth a certain number of points (see table 1). The object of the game is to maneuver your ship around the large rectangle and destroy the various space mines and android ships in your path.

The course is bounded on all sides by energy fields. If any ship hits the fields, it will bounce off like a billiard ball. The behavior of the ships can be used to your advantage in maneuvering around the course.

There are three varieties of android ships, each with its own behavior. The Death ships look and act like whirling dervishes as they careen around the course laying mines, firing wildly, and attempting to crash into your ship. They are the most dangerous of all because their seemingly random behavior makes them difficult to destroy. The Command ships, which move at a slower pace, are more deliberate in their firing and mine laying. They can be outgunned and outmaneuvered. The Droid ships are slower still, so they present a tempting target.

All the ships share one interesting characteristic: they can evolve into more advanced ships. A Droid ship can turn into a Command ship and a Command ship can become a Death ship. This metamorphosis usually occurs at the most inconvenient moment.

All of the action on the screen is accompanied by appropriate sound effects. The sounds of laser fire, exploding ships, and the victory fanfare at the end of a successful session add an interesting dimension to the game and reinforce its similarity to the arcade version.

| Object | Point Value |
|---|---|
| Photon Mine | 350 |
| Vapor Mine | 500 |
| Droid Ship | 1000 |
| Command Ship | 1500 |
| Death Ship | 2500 |

5000 bonus points are awarded for each Droid force you destroy. You receive an additional ship for each 40,000 points you score.

**Table 1:** *Point values for mines and android ships.*

### At a Glance

**Name**
Omega Race

**Type**
One-player arcade-style game

**Manufacturer**
Commodore Business Machines Inc.
487 Devon Park Dr.
Wayne, PA 19087
(215) 687-9750

**Price**
$39.95

**Format**
Plug-in ROM cartridge

**Language**
6502 assembly language

**Computer Needed**
Commodore VIC-20 with game paddle or joystick

**Documentation**
A one-page instruction sheet

**Audience**
Arcade-game players of all ages

## Game Controls

You can control your ship by means of a game paddle or joystick. Using the joystick, you can fire your ship's engines by pushing forward. Pushing the stick right or left turns the ship clockwise or counterclockwise, respectively. The button will fire your laser cannon. If you use

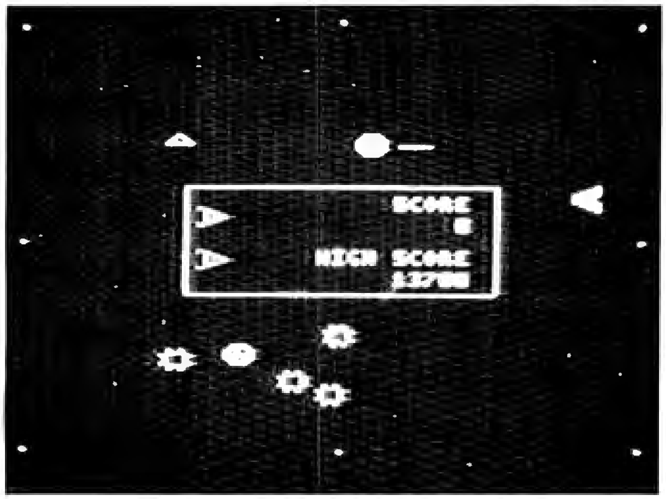



**Photo 1:** *An Omega Race game display. The game is played on a course bounded on all sides by energy fields. Your ship, at the left of the course, must destroy the Droid ships, the circular objects, and the mines (the single and double triangles).*

| Key | Function |
|---|---|
| F1 | Starts game, joystick, 3 ships |
| F2 | Starts game, joystick, 5 ships |
| F3 | Starts game, paddle, 3 ships |
| F4 | Starts game, paddle, 5 ships |
| F5 | Selects screen color, 8 choices |
| F7 | Selects ship color, 8 choices |

**Table 2:** *Game controls. The special function keys are used to select the various game options.*

a paddle, continuously holding down the Fire button will fire your engines. Rotating the paddle turns the ship left or right. Tapping the Fire button fires your laser.

The special function keys on the VIC-20 are used to select various game options (see table 2). You can select the background color, ship color, your choice of paddle or joystick, and the number of ships per turn.

### Game Strategy

The fact that your ship will bounce off the energy fields surrounding the course can be used to your advantage. A good strategy is to position your ship at one end of the course. Point the ship straight up or down and fire your engines. The ship will bounce off the energy field at the top and bottom of the course. You can then pivot your ship to fire down the long axis of the course as you slowly drift from top to bottom. This gives you a clear shot at the approaching Droid ships, yet you can still duck around the corner of the small rectangle for cover.

In evaluating the game, I used a number of different brands of joysticks and paddles. I found that the joysticks worked best and that the Atari type was the most responsive. That's because the game is very sensitive to user commands. The Atari joystick had just the right feel, whereas other more responsive joysticks caused overcontrol problems.

I did develop one foolhardy method for increasing my score: letting the Droid ships evolve into Command ships, which are worth more points. However, this strategy could backfire because the Command ships also evolve into Death ships, which are much harder to hit.

It's hard to adequately describe Omega Race in words alone. Essentially a visual game, it demands concentration, fast reflexes, and a lot of body English. The use of the special function keys to select screen color, ship color, and choice of paddles or joystick is well thought out. This feature lets you modify the game according to your taste. Overall, Omega Race is a fun game that retains all the best characteristics of the arcade version. ■

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# Quickcode

## *Help arrives for users of dBASE II..*

Adam B. Green
Softwarebanc Inc.
661 Massachusetts Ave.
Arlington, MA 02174

Imagine sitting in front of your computer and saying, "One accounts receivable program please—and hold the invoicing." Well, the state of the art in software hasn't reached quite that point yet, but a new breed of program generators is certainly working in that direction. One of these program generators is Quickcode from Fox & Geller, which generates programs to be used with dBASE II, the popular database program from Ashton-Tate.

Incorporating a database, query language, report writer, and full programming language into one package, dBASE II is an application-development program. It is used to perform information-processing tasks ranging from simple mailing lists to full accounting systems. The dBASE II language handles most of the "dirty work" of programming, such as disk-file and screen-handling operations. But even though it simplifies the job of writing custom programs, you need a general knowledge of programming techniques and syntax to make full use of the package.

Quickcode was developed to help two types of dBASE II users: businesspeople who lack the required programming background and consultants under pressure to produce programs in as short a time as possible. A Quickcode user with little computer background can describe a standard application, such as an inventory system, and Quickcode will produce a complete set of menu-driven programs in the dBASE II programming language. These programs are clearly written, well documented, and easily modified. More knowledgeable users can incorporate parts of these programs into their own applications. And the programs that are created do not require Quickcode to be present when they are running. If changes are required, Quickcode can be used to generate slightly different versions of the same programs.

I will analyze Quickcode with three criteria in mind: how easy it is for the user to describe the desired application, the length of computer time required for programs to be generated, and the quality of the generated programs. The limitations of Quickcode will also be discussed.

### Describing the Application

How can a computer understand your billing problems when the salesperson who sold it to you couldn't? The answer is by using a special program. Some programmers call this the *human interface*, and it can be the most challenging aspect of writing a program generator.

One commonly used technique is to engage the user in a long, tedious series of questions and answers. Quickcode takes an alternate approach of letting the user fill in screens and, in effect, "paint a picture" of the application.

The first step is to use the Quickcode editor, which is similar to a limited word processor, to create a data-entry form. This *screen mask* is used for adding, displaying, and editing the data in generated programs. If you don't find the editor powerful enough, a word processor such as Wordstar can be used to create the screen mask. This

**About the Author**

*Adam B. Green has written a book on dBASE II and teaches dBASE II classes around the country. Softwarebanc is a mail-order software company that specializes in business software.*

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## At a Glance

**Name**
Quickcode

**Type**
Program generator for the dBASE II database language

**Manufacturer**
Fox & Geller
POB 1053
Teaneck, NJ 07666
(201) 837-0142

**Price**
$295

**Format**
5- or 8-inch floppy disk; can use hard disk for storage

**Operating System**
CP/M 2.2, MP/M, Turbodos

**Computer System**
8080, 8085, or Z80 computer with 48K bytes of usable RAM, a 24 by 80 cursor-addressable terminal, 180K bytes of disk storage, and the dBASE II database program

**Documentation**
137 pages, perfect bound

**Audience**
Users of dBASE II who need to produce programs quickly and those without any programming knowledge

can then be saved on a disk file in a nondocument mode (e.g., by using the "N" command in Wordstar), which can later be accessed by Quickcode to create the data-entry form.

All variables that will be used in the data-entry form (e.g., name and address in a mailing list) are defined in a second Quickcode screen. In this screen, the user describes each variable in terms of the following attributes: type of variable, length, default value, minimum value, and maximum value. The user can designate an error message to be displayed if data is entered outside the minimum and maximum range. It is also possible to specify which variables are to be kept in a dBASE II index file.

A third screen is used to specify which of the 12 possible types of programs are to be created (see table 1). The dBASE II language encourages the use of small, single-function modules, in keeping with the philosophy of structured programming. Quickcode follows this practice and creates a separate module for each major application function, as listed in table 1.

These three screens allow the user with little or no programming experience to describe an application and actually "see" how the finished programs will appear. The primary disadvantage is that Quickcode makes certain assumptions on several factors, such as the type of menus to be used and the overall structure of the application system.

### Generating the Code

This is an area in which Quickcode is far superior to other program generators. The user simply presses the Escape key, and Quickcode is off and running. For example, if the user wants to create one of every possible type of module, up to 34K bytes of dBASE II programs are written in less than two minutes, and an empty database file can be created at the same time. On my double-




Programs:

| | |
|---|---|
| ADD | Add records to a data file |
| CMD | Main menu program for entire system |
| ED | Edit an existing record |
| FAU | Store default values into data-entry variables |
| GET | Search for a record by index value |
| GO | Create index files for the database |
| IO | Format information for the data-entry screen |
| LBL | Print mailing labels from the data file |
| OUT | Format information for printing a single data record |
| RPT | Run reports created with dBASE II report writer |
| VAL | Perform validation of data entered in ADD |
| WS | Transfer dBASE II data into Wordstar/Mailmerge format |

Data Files:

| | |
|---|---|
| DBF | Database file for storing information |
| NDX | Index file for rapid retrieval and organizing data |

**Table 1:** *A list of the various types of program modules that can be generated by Quickcode in the dBASE II programming language.*

density 8-inch floppy disks, the generation step is actually performed in less time than it takes the CP/M utility program PIP to copy the same amount of code from one disk to another. Of course, this time might vary depending on the hardware used.

The speed of Quickcode should have a noticeable effect on the entire program-development process. The cycle of writing, testing, and modifying programs becomes a matter of hours rather than days. If you don't like a particular screen—or want to add another variable—simply start up Quickcode, and within minutes a new version of the system is created.

## The Quality of the Programs

While program quality is often a matter of personal taste, some objective measurements are available. The factors considered in this review are modularity, standard use of variable names, internal documentation, and performance.

Because Quickcode writes all its code as small modules, the user can maintain control over the finished product by specifying which of these "building blocks" should be created. A nonprogrammer could generate a set of modules for a completely menu-driven application system, while a consultant might prefer to generate only a few functions and manually code the rest. To encourage the latter practice among professional programmers, Fox & Geller does not require any licensing fee for resale of its generated code.

To ensure compatibility among all these modules, Quickcode uses standard naming conventions for its variables. This allows modules created for separate applications to be "hooked" together. For example, an inventory system might be added to an accounts receivable system created several months before. Use of standard naming conventions also simplifies the task of integrating Quickcode modules with handwritten code.

The task of including internal documentation in programs is the bane of all programmers. This mechanical task has now been taken over by Quickcode. The programs it writes all contain detailed comments in English, which not only eases the job of modifying the generated code, but also assists the less-experienced user in learning the dBASE II language.

Evaluating the performance of any written material often becomes the personal judgment of an individual's style. Two conflicting styles of programming are in common practice. One style involves the use of all possible tricks and shortcuts in a language in order to optimize the speed of the running programs. Advocates of this method (often C and FORTH programmers) call it *tight programming*. Critics often refer to it as *write-only code*, because of the difficulty in reading it at a later date. Quickcode takes the opposite approach and generates clean, standard code. The resulting programs could run faster if shortcuts were taken, and some programmers might prefer to modify the code to take advantage of a personal speedup technique. I prefer a slow program that I can later enhance, instead of a fast but cryptic mess.

One area of performance where Quickcode clearly shines is in the elimination of programming bugs. A great deal of programming time is usually spent tracking down and removing these pesky critters. Because the code is being generated from prewritten text stored within the Quickcode program, syntax errors and improper use of commands are eliminated.

Overall, I would say that the quality of the programs produced by Quickcode is equal to that of a very methodical programmer with more than one year's experience with dBASE II.

### Documentation

The 130-page manual that accompanies Quickcode is fairly easy to follow. A preliminary tutorial section is designed for overly anxious users who need their applications finished two weeks before buying the product. This is followed by detailed instructions on each section of the program.

Although there is a table of contents, the manual lacks an index. I hope that Fox & Geller finds the time to add one, even though it might seem to fly in the face of tradition.

The manual also needs more detailed application examples. Although the basic operation of Quickcode is clearly described, a sample inventory or accounts payable system would be helpful.

### Limitations

While I am obviously pleased with most aspects of Quickcode, it has some limitations that should be made clear. A major weakness is the inability to create programs that access more than one data file. Also, some Fox & Geller advertisements claim that a complete accounting system could be "knocked out in a weekend." Typically, accounting systems consist of several modules that share data files. For example, a receivable module must be able to access the files of an inventory module. And although adequate inventory and receivable systems could be written with Quickcode, the necessary integration of the two systems would require a fair amount of programming knowledge. The other major weakness is the lack of any sophisticated report-writing facilities. I hope that Fox & Geller will be able to address these limitations in a later version.

### Conclusions

Quickcode is a well-written, easy-to-use program generator for the dBASE II programming language, which allows the user to describe an application by simply filling in screens.

A large amount of code (more than 30K bytes) can be generated in less than two minutes. The code produced is modular, easily modified, and runs at an acceptable speed.

The manual included with the program is clearly written, but lacks an index and sufficient application examples. The limitations of Quickcode include the inability to access more than one data file and a weakness in the report-writing functions.

The major audiences for Quickcode are dBASE II users with little programming background and programmers who need to produce large amounts of standard code quickly. ■

# A Faster Binary Search

*An important technique results in faster-running applications programs and shorter response times.*

Dr. L. E. Larson
General Technology Division
IBM Corporation
Endicott, NY 13760

Most applications of computer processing involve searching data tables of one form or another. The process is used in compilers, language interpreters, command processors, assemblers, database processors, and word processors. The regularity with which table searching is used makes the choice of searching techniques vital. A reduction in search time usually results in faster-running applications programs and shorter response times.

Although many techniques exist for searching tables in storage and on external media, the three principal ones are linear, series, and binary. The linear search examines each item, starting with the first, and proceeds sequentially. The series search, based on a mathematical series such as the power series or the Fibonacci series, works by subdividing the table of data in accordance with successive smaller numbers in the series. The binary search divides the table of data into two parts, rejecting one part and repeating the process on the other part until the item in question is found. ("Hashing" can be used to search by address calculation, but it sometimes yields the same key for more than one different field, which often reduces it to one of the three principal techniques.)

A discussion of a method of enhancing the binary search would not be complete without some background on the binary search itself. The binary search is appropriate for tables whose entries are in some order. Based on the concept of dividing a large problem into smaller parts, this technique involves dividing a list into two parts of equal size. None of the entries in one part meets the search criteria value (low), while an entry in the other part does meet that value (not low). The binary search divides the not-low part again, and the process of division continues until only one entry remains. The remaining entry, of course, matches the search item.

Usually, the midpoint of a table is computed by dividing the sum of the left and right indexes by two. Initial-

## Glossary

**Field:** *a part of a record that holds a particular kind of data. Examples: name field, telephone number field, social-security number field, and zip code field.*

**Hash duplication:** *the replacement of more than one unique original key by the same key after hashing. Example: in hashing by division, two different numbers divided by the same divisor may yield different quotients but the same remainder, hence the same key.*

**Hashing:** *transforming a key field into a more compact and more easily manipulated form to increase the speed of sorting or searching. Example: if the social-security number is the original key field, a new key might be calculated by dividing the social-security number in each record by 10,000 and using the remainder as the new key.*

**Key:** *the field of a record that is compared to a test value in order to identify or locate a record. Example: if records are searched for a name, the name field is the key.*

**Record:** *a group of related data items that is treated as a unit; when there is more than one record, each record contains the same type of item at corresponding positions. Example: a record might contain someone's name, telephone number, social-security number, and zip code.*

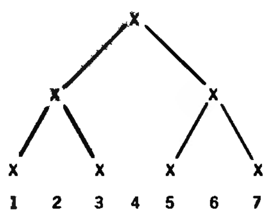


**Figure 1:** *A search tree representing the binary-search process. The search begins at the top with the root node and proceeds down the tree to the leaf or terminal nodes. This process continues until the search argument is found or the table is exhausted.*

ly, the left and right indexes are the two extremes of the table. Comparing the search argument to the table entry at the midpoint determines whether the right or left index is replaced. The process continues until the matching entry is found or the table has been reduced to an empty state.

In the quest for enhancement, many different techniques exist for analyzing the process time of an algorithm. In searching, for example, the usual technique is to examine the number of comparisons required to locate an item in a table. Because my enhancement of the binary-search algorithm involves moving a portion of the midpoint-calculation code after a comparison is made, the analysis that I will present focuses on the number of comparisons and the number of required iterations of the midpoint-calculation code.

The binary-search process I devised is a traversal of an implicitly defined binary-search tree that is a complete binary tree as well. Like all traversals, it begins with the root node and proceeds down the tree to the leaf or terminal node. Figure 1 shows a representation of the search process as a search tree.

In the binary-search process, if it takes one unit of time to locate the third element in a table of seven entries, then the computation time necessary to locate the third entry does not double until the table is expanded to 31 entries. In other words, the binary search resembles a logarithmic pattern despite the use of the division process. It is this logarithmic performance that has led to the false conclusion that little can be done to improve the binary search.

A long-standing rule of thumb about random access to data files is that 80 percent of the activity is concerned with only 20 percent of the file. The implication is that after a data argument has been seen, the probability of seeing it on the next request is 3.25 times that for the total random case.

Files and tables share an important characteristic: both can be viewed as linear-ordered representations of the records to be inspected and retrieved. Extending the 80/20 rule to tables, then, suggests a means for improving the performance of a binary search.

## Analysis of Enhancement

Figure 2 shows the implicit tree used for the enhanced-search process. In this example, a prior search returned the eighth entry of the table (P represents the node returned by a

*Text continued on page 268*


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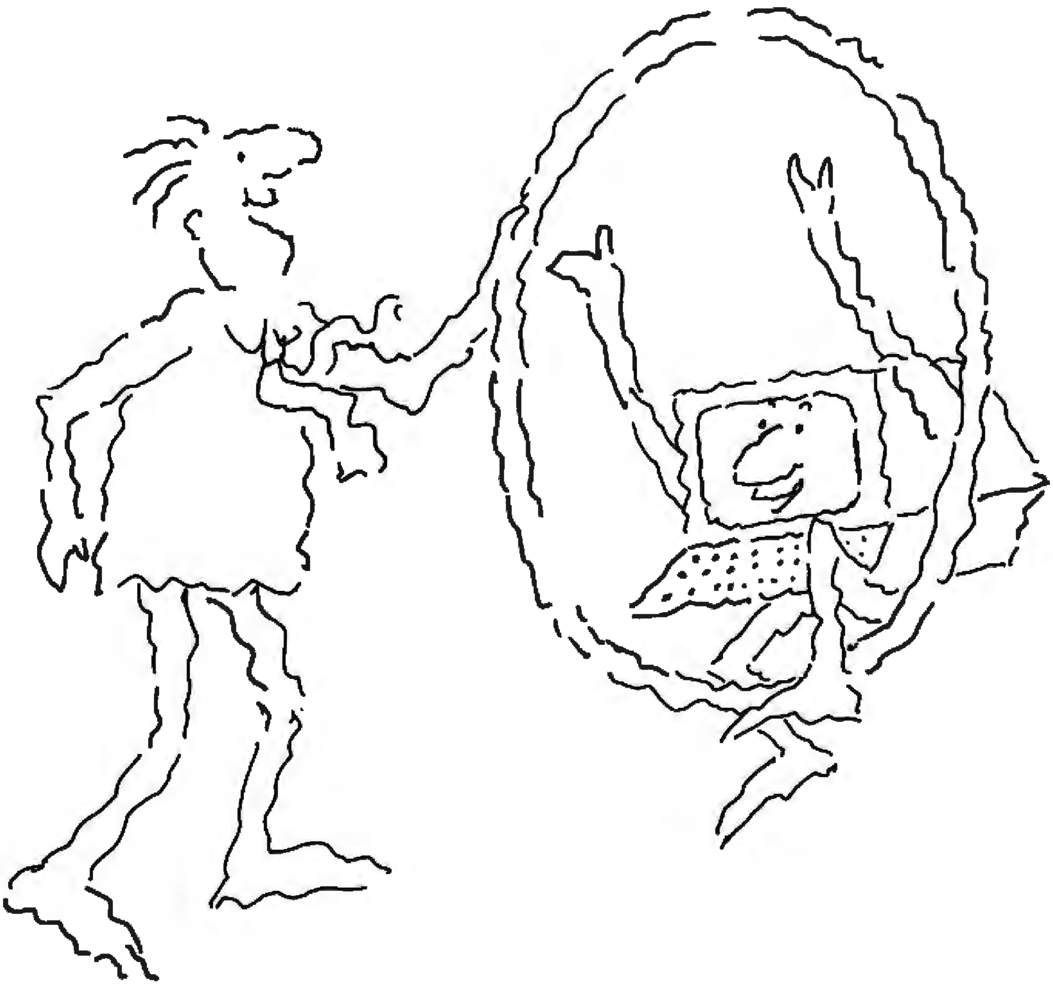

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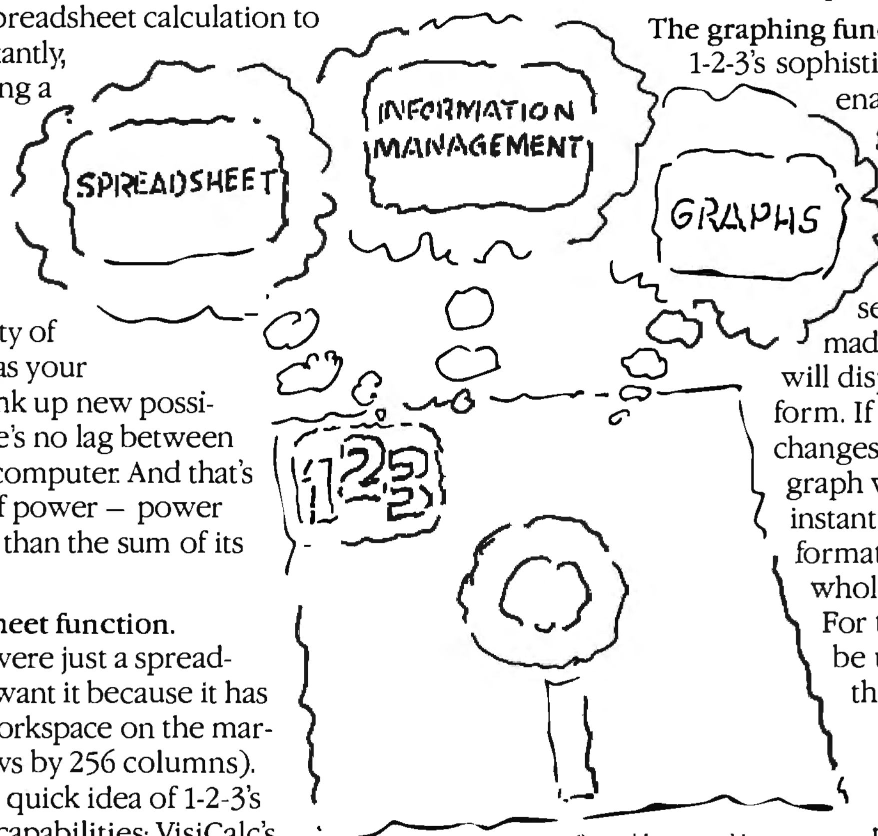


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**The spreadsheet function.**

If 1-2-3 were just a spreadsheet, you'd want it because it has the largest workspace on the market (2048 rows by 256 columns). To give you a quick idea of 1-2-3's spreadsheet capabilities: VisiCalc's spreadsheet for the IBM PC offers 15 arithmetic, logical and relational operators, 28 functions and 32 spreadsheet-related commands. 1-2-3 has 15 operators, 41 functions and 66 commands. And if you include data base and graphing commands, it actually has 110!

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**The information management function.**

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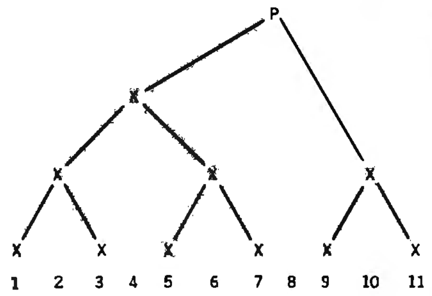


**Figure 2:** *A search tree for the enhanced binary search representing a table of 11 elements. A prior search returned the element shown as node P. The subtrees branching down from P represent the search paths to be followed after comparing the search argument with P. Although the complete search tree extends to a depth of 4, the enhanced binary search has two trees to consider: the tree shown on the left has a depth of 3, and the one on the right has a depth of 2. The reduction in depth indicates a reduction in the number of iterations required by the search.*

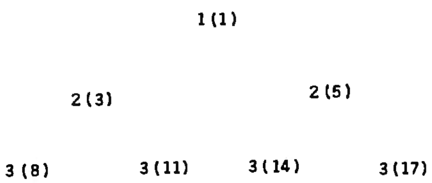


**Figure 3:** *A search tree showing the accumulated weight of iterations required to inspect every element in a binary search of seven elements. Numbers preceding parentheses identify the depth; numbers within parentheses show the cumulative inspections. If each of the seven elements is equally likely to match the search argument, the binary search would require an average of 2.43 inspections to find the match.*

| | Comparisons by Element | | | | Iterations by Element | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Case 1 | 1 | 3 | 2 | 3 | 0 | 2 | 1 | 2 |
| Case 2 | 2 | 1 | 2 | 3 | 1 | 0 | 1 | 2 |
| Case 3 | 2 | 3 | 1 | 2 | 1 | 2 | 0 | 1 |
| Case 4 | 3 | 2 | 3 | 1 | 2 | 1 | 2 | 0 |

**Table 1:** *The number of possible comparisons and possible required iterations of the midpoint-calculation code for an enhanced binary search of a table of four elements.*

| Table Entry | Subtables Left | Subtables Right | Subtable Weight Left | Subtable Weight Right |
|---|---|---|---|---|
| 1 | 0 | 7 | 0 | 17 |
| 2 | 1 | 6 | 1 | 14 |
| 3 | 2 | 5 | 3 | 11 |
| 4 | 3 | 4 | 5 | 8 |
| 5 | 4 | 3 | 8 | 5 |
| 6 | 5 | 2 | 11 | 3 |
| 7 | 6 | 1 | 14 | 1 |
| 8 | 7 | 0 | 17 | 0 |

**Table 2:** *A summary of the possible cases for an enhanced binary search of a table of eight elements. Assuming that the entry in the left-hand column matches the search argument, the next two columns indicate the number of subtables to the left and right of the entry. The two right-hand columns show the subtable weights, which reflect the number of iterations necessary to find the search argument in each case.*

prior search). The subtrees to either side represent the search path used as a result of the first comparison. Although the table's 11 elements require a complete binary-search tree to a depth of 4, the enhanced search has two trees to consider, one to a depth of 2 and the other to a depth of 3. The resulting change in depth of the search tree translates to a reduction in the number of iterations required by the search.

Figure 3 illustrates the depth of each node in a full binary-search tree and the total number of accesses required to inspect every node in the tree. A binary search of a table of seven elements would require an average of 2.43 (17/7) accesses if the likelihood for all cases were equal.

Table 1 illustrates all of the possible cases for a table of four elements. The left half of the table shows the number of comparisons required for each element in each configuration. The right half of the table shows the number of iterations through the midpoint-calculation code if the comparison is moved to the beginning of the loop and the previous search information is used. The average number of comparisons in the example shown is 2.13 (34/16), but the number of iterations is 1.13 (18/16). Traditional implementations would have required 2.00 iterations of the comparison code and the midpoint-calculation code.

Table 2 summarizes the possible cases for a table of eight elements and the number of table interrogations required to inspect every entry in every subtable for every case. The subtable "weights" reflect the number of iterations required in each case. If the weights are added and the equal-likelihood assumption is applied, the result is an average of 2.84 table accesses and 1.84 iterations.

For a full binary tree of depth $D$, there are $2^{(D-1)}$ nodes at that depth. In general, at depth $K$ there are $2^{(K-1)}$ nodes at the level of $K$ in the tree. When the tree is full (meaning all nodes are present at a level), the average number of comparisons ($C$) to locate a node, assuming equal likelihood, is the sum of the levels for each node divided by the number of nodes. Thus

$$C = \sum_{I=1}^{D} \frac{I(2^{I-1})}{2^{D-1}}$$

To extend to the case for the complete, but not full, binary tree, the average becomes

$$C = \sum_{I=1}^{D} \frac{I(2^{I-1})+R(D+1)}{N}$$

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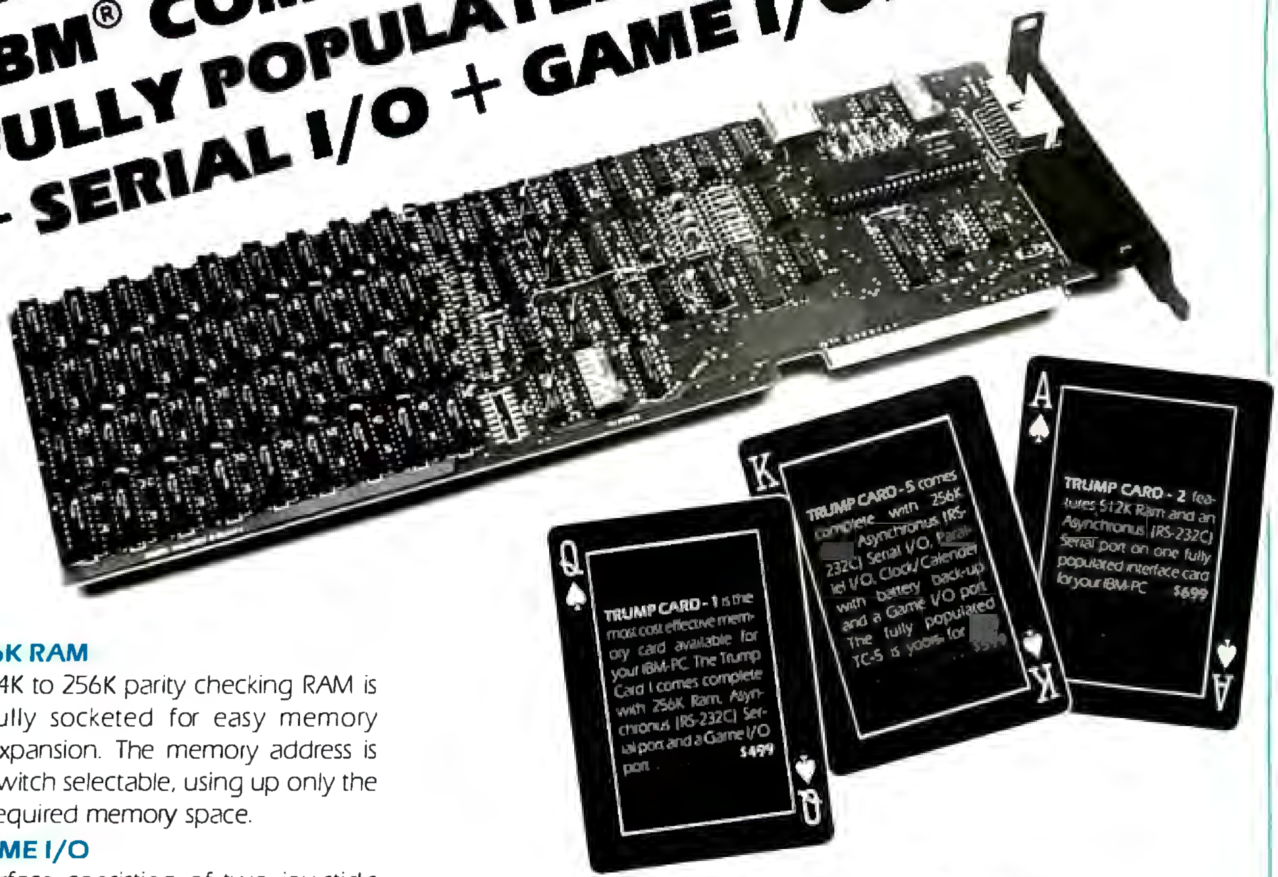


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where $N$ is the number of nodes in the tree satisfying the relation

$$N = 2^D + R-1$$

The solution for the general case becomes

$$C = \frac{(D-1)(2^D)+R(D+1)}{N}$$

Although the formulas imply a method to calculate the average number of comparisons as a function of $N$ by solving for $D$ and $R$, the round-off errors in the calculations of LOG(2,$N$) produce incorrect results. Thus the best way to calculate the average number of comparisons is through an iterative process that determines the depth of the complete tree and adds the remaining weights.

When information from a prior search is available, you compute the average number of comparisons by examining each possible case, computing the sum, and dividing by the number of cases. Because the table has $N$ elements, the number of cases is $N$. For each case in which the equal-likelihood assumption applies, there is a probability that the argument is equal to a prior argument ($1/N$) and not equal ($(N-1)/N$). Because the subtable weights represent the number of comparisons for the nodes in the subtables, you can simply divide the sum by the number of cases ($N-1$). If $K$ is set to

$$K = \sum_{i=1}^{N-1} \textit{subtable weight}_i$$

the result after simplification is

$$C = 1 + \frac{2K}{N^2}$$

The number of iterations of the midpoint-calculation code is

$$I = \frac{2K}{N^2}$$

The above derivations apply to the case of equal likelihood; however, it is possible to have the case of never-equal likelihood. Changing the probabilities for the never-equal case produces

$$C_{NEVER} = 1 + \frac{2K}{N(N-1)}$$

The number of iterations of the midpoint-calculation code is

$$I_{NEVER} = \frac{2K}{N(N-1)}$$

A general formula relating the probability of a match with a prior search argument ($M$) and the size of the table ($N$) is

$$C = 1 + \frac{2K(1-M)}{N(N-1)}$$

and the number of iterations becomes

$$I = \frac{2K(1-M)}{N(N-1)}$$

The possibility of the 80/20 rule applying in an example requires that we compute the probability of the occurrence of a duplicate argument. The rule divides the members of the table into two sets: high activity (H) and low activity (L). A duplicate occurrence can exist only if the prior and current arguments are members of the same set. If $X$ represents the prior argument and $Y$ the current argument, the probability of duplication can be computed by

$$P(X=Y)=A \cdot B \cdot C+D \cdot E \cdot F$$

where

$A=P(X=Y|X,Y \text{ in } H)=1/(0.2N)$
$B=P(X \text{ in } H)=0.8$
$C=P(Y \text{ in } H)=0.8$
$D=P(X=Y|X,Y \text{ in } L)=1/(0.8N)$
$E=P(X \text{ in } L)=0.2$

and

$$F=P(Y \text{ in } L)=0.2$$

The resulting simplifications produce

$$P(X=Y)=3.25/N$$

and

$$P(X \neq Y)=(N-3.25)/N$$

Thus

$$C_{RULE} = 1 + \frac{2K(N-3.25)}{N^2(N-1)}$$

As before, the number of iterations of the midpoint-calculation code is

$$I_{RULE} = \frac{2K(N-3.25)}{N^2(N-1)}$$

The results of these equations are shown in table 3, which compares a pure binary search for tables of dif-

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TEXAS INSTRUMENTS



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| Table Size | Binary Search | Enhanced Search Equal Likelihood | Never Equal | 80/20 Rule |
|---|---|---|---|---|
| 1.00 | 1.00 | 0.00 | 0.00 | 0.00 |
| 2.00 | 1.50 | 0.50 | 1.00 | 0.00 |
| 3.00 | 1.67 | 0.89 | 1.33 | 0.00 |
| 4.00 | 2.00 | 1.13 | 1.50 | 0.28 |
| 5.00 | 2.20 | 1.36 | 1.70 | 0.60 |
| 6.00 | 2.33 | 1.56 | 1.87 | 0.86 |
| 7.00 | 2.43 | 1.71 | 2.00 | 1.07 |
| 8.00 | 2.63 | 1.84 | 2.11 | 1.25 |
| 9.00 | 2.78 | 1.98 | 2.22 | 1.42 |
| 10.00 | 2.90 | 2.10 | 2.33 | 1.58 |
| 30.00 | 4.13 | 3.44 | 3.56 | 3.18 |
| 50.00 | 4.86 | 4.12 | 4.20 | 3.93 |
| 100.00 | 5.80 | 5.06 | 5.11 | 4.95 |
| 300.00 | 7.33 | 6.59 | 6.61 | 6.54 |
| 500.00 | 8.00 | 7.32 | 7.34 | 7.29 |
| 1000.00 | 8.99 | 8.31 | 8.32 | 8.30 |
| 5000.00 | 11.36 | 10.62 | 10.62 | 10.62 |
| 10000.00 | 12.36 | 11.62 | 11.62 | 11.62 |

**Table 3:** *A comparison of the binary search and the enhanced binary search. The average number of iterations of the midpoint-calculation code that are required to find the search argument are given for different sizes of the table being searched. For the enhanced binary search, the number of iterations is given for three different assumptions about the table being searched: (1) that each element in the table is equally likely to match the search argument, (2) that no two elements in the table are equally likely to match the search argument, and (3) that after a data argument has been seen, the probability of seeing it again after the next iteration is 3.25 times greater than the probability for the random case (the 80/20 rule).*

ferent sizes to the enhanced binary search in the cases of equal likelihood, never-equal likelihood, and the 80/20 rule.

While a binary search can be implemented in many ways, traditional implementations require the initialization of local variables (five PL/I statements) followed by a loop composed of the midpoint calculation (five PL/I statements) and a comparison of the search argument with an entry in the table (three PL/I statements). The enhanced search is similar in structure, but its midpoint calculation follows the comparison. If the processor that executes the searches requires one instruction cycle per PL/I style statement, the binary-search time (BT) can be expressed as

$$BT = 5 + 8C$$

and the enhanced-search time (ET) can be expressed as

$$ET = 5 + 3C + 5I = 8 + 8I$$

in which C represents the number of comparisons and I represents the number of iterations needed to satisfy the search.

If in the two preceding equations we substitute the number of comparisons and the number of iterations indicated in table 3, a comparison of the data indicates that the enhanced search is usually better than a pure binary search. If the tables contain approximately 300 entries and an equal likelihood applies, the enhanced search results in an advantage of approximately 6 percent. A higher probability of duplication increases the reduction-in-time advantage of the enhanced search. If your processor takes a long time to perform a divide or shift, the advantage approaches 10 percent.

## A Description of the Process

We can express the process for the improved binary search in several ways. Table 4 is an example of a decision table that represents a looping process. The first row of entries

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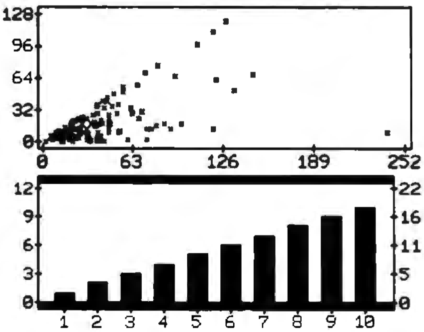


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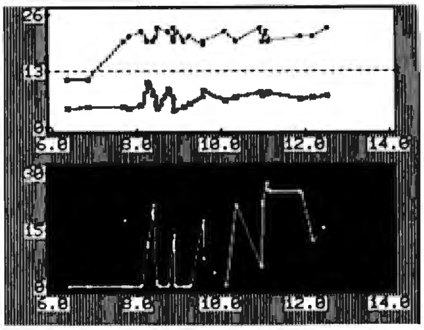

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| | Stub | Decision Rules 1 | 2 | 3 | 4 | 5 | 6 | Columns |
|---|---|---|---|---|---|---|---|---|
| Tests to be performed | M = 0 | Y | N | N | N | N | N | Test results that select a column |
| | ARG> = TABARG(M) | - | Y | Y | Y | N | N | |
| | ARG = TABARG(M) | - | Y | N | N | - | - | |
| | L<R | - | - | Y | N | Y | N | |
| Data trans-formations | L = M + 1 | | | 1 | | | | Actions to be selected |
| | R = M | | | | | 1 | | |
| | M = (L + R)/2 | 1 | | 2 | | 2 | | |
| | M = 0 | | | | 1 | | 1 | |
| When and how loop terminated | RETURN(M) | | X | | X | | X | Loop termination criteria |
| | /* LOOP */ | X | | X | | X | | |
| Initial steps required | SEARCH: PROCEDURE(ARG,TABARG,LEFT,RIGHT,M) RETURNS(FIXED) | | | | | | | |
| | DCL (ARG,TABARG(*),LEFT,RIGHT,L,R,M)FIXED | | | | | | | |
| | L = LEFT | | | | | | | |
| | R = RIGHT | | | | | | | |
| Instructions for terminating execution | /* NO SPECIAL TERMINATIONS */ | | | | | | | |
| | END | | | | | | | |

**Table 4:** *A decision table for the enhanced binary search specifying the various actions to be performed under various combinations of conditions. The labels shown in the gray areas are external to the decision table. The decision table itself is divided both horizontally and vertically. The upper part is called the "condition" portion; the lower part, shaded in blue, is the "action" portion. The left portion of the table, called the "stub," identifies the tests to be performed and the actions to be taken (in this case, data transformations). The right portion is divided into six columns, each of which expresses a decision rule. The first row of each column shows the condition under which a decision rule applies, and the lower rows show the actions to be performed if those conditions are true. For example, if M is not equal to 0, we must select one of columns 2 through 6. Moreover, if ARG is greater than or equal to TABARG(M), we can narrow our choice to columns 2 through 4. If L is also less than R, then all columns except the third are ruled out. Therefore that column expresses the relevant decision rule. Looking down that column to its action portion, you can see that two actions are selected: L is to be set equal to M + 1, and M is to be set equal to (L + R)/2. All the statements in the stub are from the PL/I program shown in listing 1. The variables represent the following: ARG, the search argument (the value being searched for); TABARG, the function argument (the value at the current midpoint address); M, the midpoint address; L, the left (or low) extreme address; R, the right (or high) extreme address.*

describes the tests that have to be performed for the process to work correctly. The next row indicates the various data transformations that will be applied. The third specifies when and how the loop will be terminated. The fourth row describes the initial steps that are required, and the fifth row provides instructions for terminating the execution process. The YN-column entries specify the results of the condition tests that must be satisfied to select a column. The numbers in the column identify the actions to be selected and their sequence. The X values select the loop-termination criteria. The decision table presents, in an abstract manner, all of the information that is required for a program without requiring a unique implementation.

The programming language used in the decision-table stubs is PL/I, but converting the statements to APL, Pascal, BASIC, or machine codes would not be difficult.

A brief description of the enhanced binary-search process provides an understanding of the procedure that is employed when the searching process uses the prior search results and completes the search using the reduced implicit-search tree. For the

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following situations we will assume that the table is an ascending linear list in an array data structure. The calling sequence takes for granted a call parameter that contains the prior index returned for a prior search of the entries in the table. The prior index value returned is initialized to 0 if there is no prior search data available and then updated by the searching process:

- If the current index is 0, the midpoint address is recalculated for the next iteration and the process continues.
- If the search argument is not less than the function argument and the low address is less than the high address, the low address is replaced with the midpoint-plus-one entry. The midpoint address is recalculated for the next iteration.
- If the search argument is equal to the function argument in the table, the current midpoint is the value returned to the calling program.
- If the search argument is less than the function argument in the table and the low address is less than the high address, then the high address is replaced with the midpoint address. The midpoint address is recalculated for the next iteration.
- If no entry is found, the current midpoint is set to 0.
- The current midpoint is the value returned to the calling program when all iterations have been completed.

The decision table (table 4) illustrates how to use the enhanced-search process. One of the many possible implementations is illustrated in listing 1.

**Listing 1:** *A PL/I procedure that carries out an enhanced binary search. The first line identifies the procedure and its variables and states that it will return a fixed value. The second line declares the variables so the computer can arrange appropriate storage for the kind of values that each variable can assume. ARG represents the search argument (the value being searched for); TABARG, the function argument (the value at the current midpoint address); M, the midpoint address; L, the left (or low) extreme address; and R, the right (or high) extreme address. The procedure works by repeatedly setting the value of one of the extremes (R or L) to the previous midpoint value and then calculating a new midpoint by adding the extremes and dividing by two. Statements between "/*" and "*/" are comments.*

```
SEARCH: PROCEDURE(ARG,TABARG,LEFT,RIGHT,M)RETURNS(FIXED);
DCL (ARG,TABARG(*),LEFT,RIGHT,L,R,M)FIXED;
L=LEFT;
R=RIGHT;
ENHANCE='0'B;
DO WHILE (ENHANCE='0'B);
  IF M=0 THEN
    DO;
      M=(L+R)/2;
      /* LOOP */;
    END;
  ELSE
    DO;
      IF ARG>=TABARG(M) THEN
        DO;
          IF ARG=TABARG(M) THEN
            DO;
              RETURN(M);
            END;
          ELSE
            DO;
              IF L<R THEN
                DO;
                  L=M+1;
                  M=(L+R)/2;
                  /* LOOP */;
                END;
              ELSE
                DO;
                  M=0;
                  RETURN(M);
                END;
            END;
        END;
      ELSE
        DO;
          IF L<R THEN
            DO;
              R=M;
              M=(L+R)/2;
              /* LOOP */;
            END;
          ELSE
            DO;
              M=0;
              RETURN(M);
            END;
        END;
    END;
END;
/* NO SPECIAL TERMINATIONS */;
END;
```

## Conclusion

It is clearly possible to improve the binary search by examining a table entry before doing any computation. The time-saving advantage of this technique ranges from 2 to 30 percent depending on the size of the table and the computing system you use. For tables containing approximately 300 entries, there is a 5 to 10 percent advantage if the probability of a match ranges from 0 (never equal) to 3.25/300 (the 80/20 rule). ■


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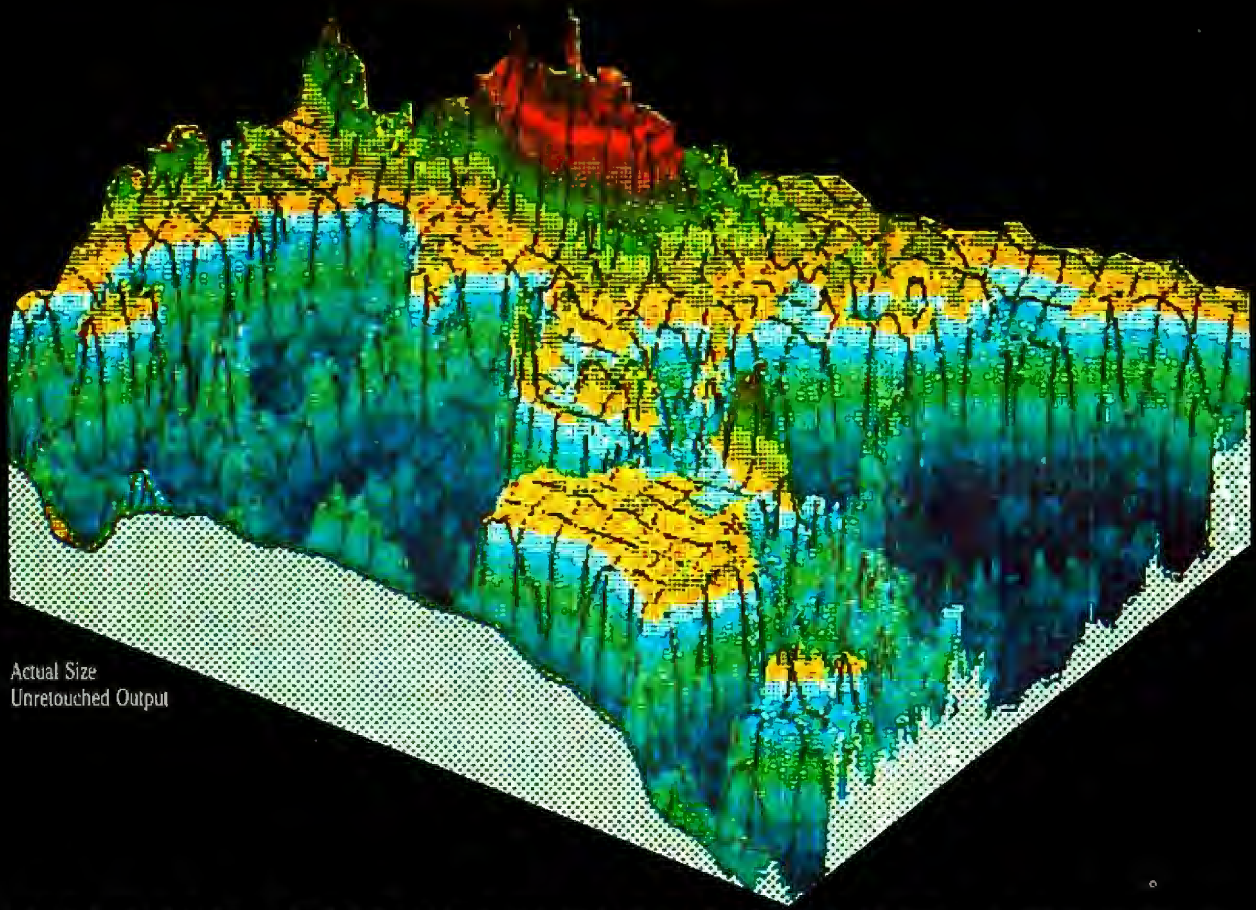

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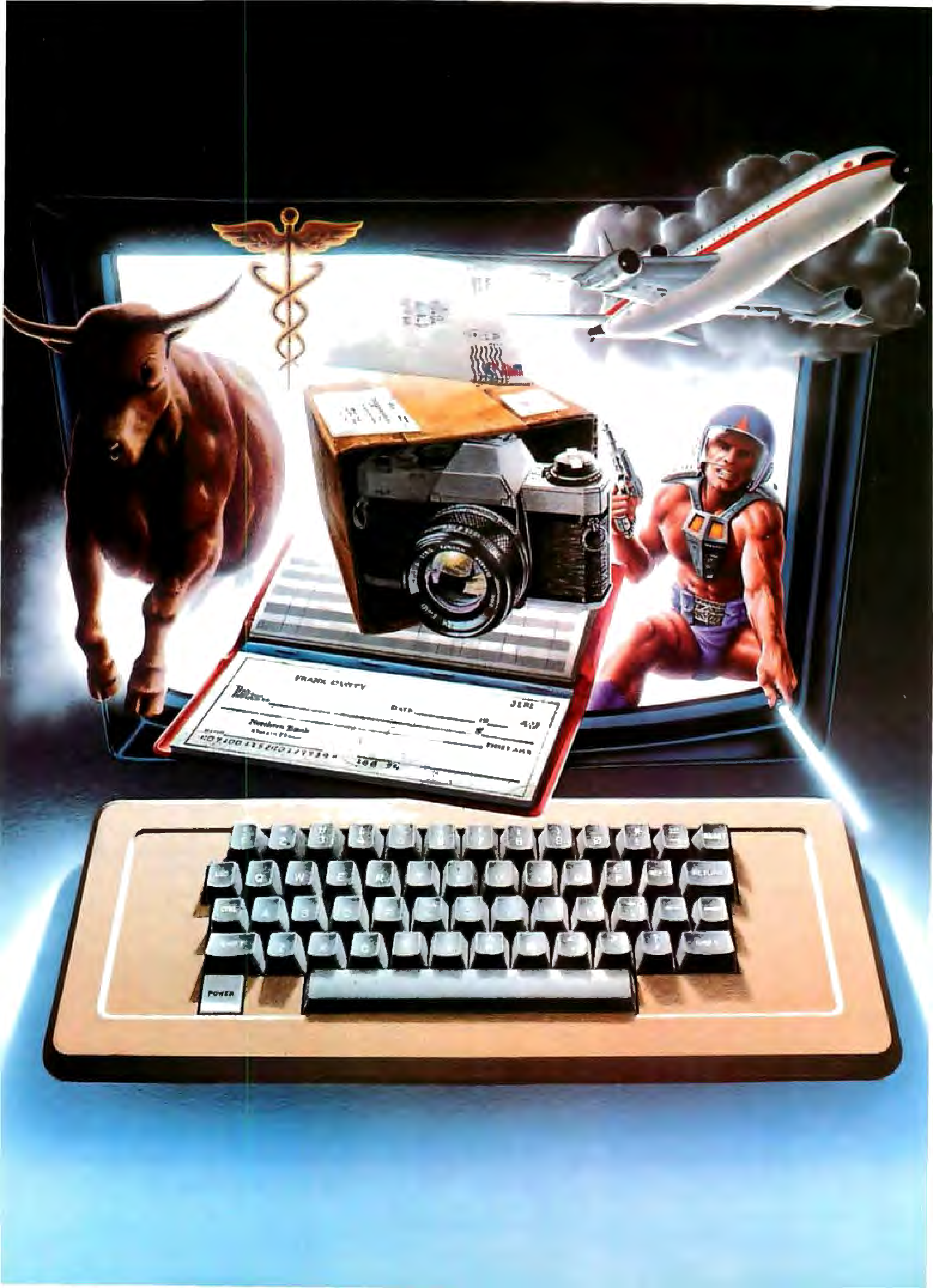

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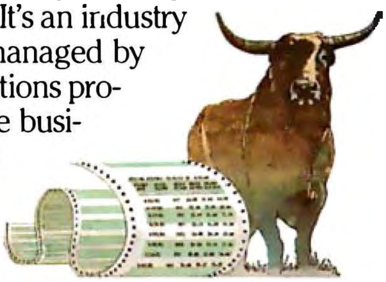

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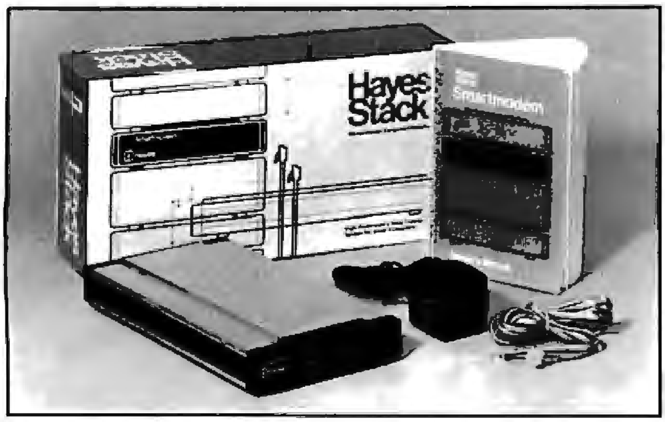


**Photo 1:** *The Smartmodem package includes the modem, a modular telephone cable, an AC line adapter, and an excellent manual. (Photo by Ed Crabtree.)*

### At a Glance

**Name**
Hayes Stack Smartmodem 300 or Smartmodem 1200

**Use**
Communication over normal (voice) telephone lines

**Manufacturer**
Hayes Microcomputer Products Inc.
5835 Peachtree Corners E.
Norcross, GA 30092
(404) 449-8791

**Price**
Smartmodem 300 $289
Smartmodem 1200 $699

**Dimensions**
1.5 inches high by 5.5 inches wide by 9.6 inches long

**Features**
0 to 300 bps and 1200 bps direct-connect; accepts ASCII command strings

**Hardware needed**
RS-232C port and RS-232C cable

I have always admired the Hayes Microcomputer Products' Micromodem II, available as a plug-in board for Apple II computers. The Micromodem II has ideal features: it can run at 300 bps (bits per second), can be connected directly to the telephone line, performs auto-dial and auto-answer functions, has excellent documentation, and is reasonably priced. Because I own a TRS-80 Model I, however, I had to sit back and hope that Hayes would develop a general-purpose modem for use with RS-232C interfaces.

My hopes came true when Hayes announced its Stack Smartmodem. Advertisements claimed that it contained all the desirable features mentioned above, including a unique feature that allowed the use of ASCII (American National Standard Code for Information Interchange) character strings to program the device. What's more, it was available in two versions: a 300-bps Bell 103-compatible unit and one that is also 1200-bps Bell 212A compatible. With my spirits high, I rushed to the computer store and purchased the 300-bps model. I have not been disappointed.

### First Impressions

The package contains the Smartmodem, a modular telephone cable, an AC line adapter, and the owner's manual. These items are shown in photo 1.

The Smartmodem is attractively styled. Its dimensions of 1.5 by 5.5 by 9.6 inches ensure that it takes up little space. The design is such that either a regular telephone or another Hayes Stack product—such as the Hayes Chronograph clock/calendar—can be placed on top of it. With a color scheme of gray and black, the Smartmodem blends with almost any environment.

| Symbol | Name | Use |
|---|---|---|
| AA | Auto Answer | When illuminated, signals that the Smartmodem is in auto answer mode. When the telephone rings, the AA LED blinks at the rate of the ringing signal. When this indicator is off, the Smartmodem does not automatically answer. |
| CD | Carrier Detect | Illuminates when the Smartmodem detects a carrier from a distant modem. |
| OH | Off Hook | If the "phone" is off-hook, this LED illuminates. The LED is always on when the Smartmodem is using the telephone line. |
| RD | Receive Data | This LED blinks while sending data or command results from the Smartmodem to the RS-232C port. |
| SD | Send Data | Blinks while data or commands are sent from the terminal to the Smartmodem. |
| TR | Terminal Ready | Indicates the status of the RS-232C signal DTR (data terminal ready), pin 20 of the RS-232C connector. As shipped from the factory, the DTR signal is ignored and TR is always illuminated; setting configuration switch S1 in the "up" position forces the Smartmodem to monitor the DTR signal. |
| MR | Modem Ready | Indicates the Smartmodem is turned on. |

**Table 1:** *Summary of the Smartmodem's status indicators.*

As shown in photo 2a, the front of the Smartmodem contains seven LED (light-emitting diode) status indicators. From left to right, they are: AA (auto-answer mode), CD (carrier detect), OH (off hook), RD (receive data), SD (send data), TR (terminal ready), and MR (modem ready). The LEDs allow the operator to visually monitor the operating status of the Smartmodem. The operation of each LED is explained in table 1.

Also at the front, behind the front cover, are eight *configuration switches* that determine the power-up setting for some of the Smartmodem's operating parameters. These switches are explained in table 2. Most of the switch settings can be changed under software control.

Photo 2b shows the back panel. From left to right are the power switch, power connector (for the AC line adapter), RS-232C connector (for connection to your computer system via a user-supplied RS-232C cable), telephone connector (for one end of the modular telephone cable), and the volume-control knob.

The Smartmodem's RS-232C connector is wired for connection to DTE (data terminal equipment), which

 

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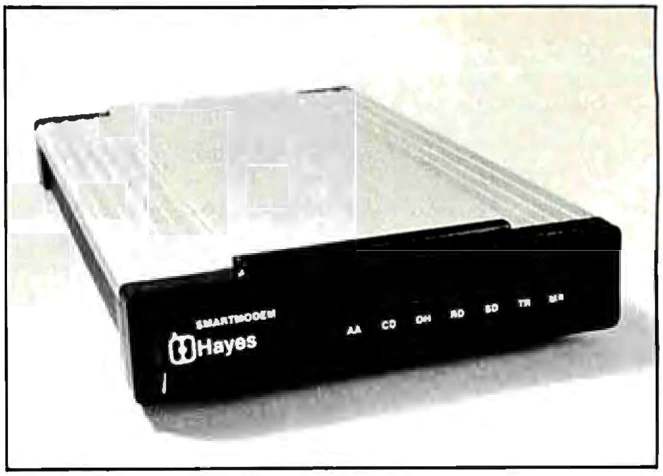
| Switch | Down | Up |
|---|---|---|
| S1 | Ignores the RS-232C DTR signal. | Monitors the RS-232C DTR signal. |
| S2 | Responds with number result codes. | Responds with ASCII character-string result codes. |
| S3 | Sends result codes to the terminal. | Does not send result codes to the terminal. |
| S4 | Does not echo command characters to the terminal. | Echoes command characters to the terminal. |
| S5 | Does not automatically answer the telephone. | Automatically answers the telephone. |
| S6 | Does not monitor the RS-232C CD (carrier detect) signal. | Monitors the RS-232C CD signal. |
| S7 | For use with RJ12 and RJ13 telephone jacks. | For use with RJ11 telephone jacks. |
| S8 | Not used. | |

**Table 2:** *Summary of the Smartmodem's configuration switches. Boldfaced entries are default settings as shipped from the factory. All functions can be changed under software control.*

(2a)




(2b)


**Photo 2:** *Front and rear views of the Smartmodem. In photo 2a, the seven LED status indicators are visible; photo 2b shows the power control, power connector, and RS-232C connector.*



works with 99 percent of terminals and RS-232C interfaces; a slight wiring change allows the use of this modem with DCE (data communications equipment). The volume-control knob allows you to adjust the volume level of the audio monitor.

The power connector is U. L. (Underwriters' Laboratories) listed at 120 volts (V) AC, 60 Hz, with a 13.5-V AC output. The supplied telephone cable is normally connected to an RJ11 modular telephone jack. Changing the setting of configuration switch 7, however, allows the use of either an RJ12 or RJ13 telephone jack.

Documentation for the Smartmodem consists of a single owner's manual with fine-quality print. In addition, it is a spiral-bound manual; this makes it easy to use while sitting at the computer.

## Installing the Smartmodem

Connection of the Smartmodem is easy. Connect the AC line adapter, the telephone cable, and an RS-232C cable to their appropriate connectors. In my case, the RS-232C cable connects the Smartmodem to the expansion interface of a TRS-80 Model I. The expansion interface

| ASCII Command String | Use |
|---|---|
| A | :Answer the telephone immediately. |
| A/ | :Redial the last number. |
| Cn | :Enable/Disable the transmitter carrier. |
| , | :Pause for a given amount of time. |
| Ds | :Dial a number. |
| Fn | :Set half or full duplex. |
| Hn | :Enable or disable switch hook. |
| Mn | :Enable or disable the audio monitor. |
| O | :Return to the "on-line" state. |
| P | :Enable pulse dial. |
| Qn | :Enable or disable the return of result codes. |
| R | :Enter answer mode after dialing a number. |
| Sr? | :Read the value of register Sr. |
| Sr = n | :Assign the value n to register Sr. |
| ; | :Return to command state after dialing a number. |
| T | :Enable tone dialing. |
| Vn | :Select method of sending result codes. |
| Z | :Perform a software reset. |

**Table 3:** *Summary of the Smartmodem's commands.*

contains the standard TRS-80 RS-232C board. After the connections are made, the Smartmodem is ready for use.

### Use of the Smartmodem

As stated earlier, the Smartmodem can be used with any RS-232C interface. I use the standard TRS-80 setup with the TERM program. TERM is a Z80 machine-language program that transforms the Model I into a "dumb" terminal.

Once the connections are correct and TERM is executing, two LEDs on the Smartmodem will light: MR (modem ready) and TR (terminal ready). Proper operation is assured by typing the following:

<enter>
AT <enter>

(The AT stands for attention.) If all is well, the Smartmodem will respond with the ASCII string OK and will be ready to accept a command.

The procedure just described demonstrates the most unique feature of the Smartmodem: you can immediately communicate with it without writing any special software! Because this modem accepts ASCII strings as commands, you can sit at your computer or terminal and issue one command after another. The Smartmodem takes each command and executes it. After each command, it responds by sending back one of five possible ASCII strings: OK, CONNECT, RING, NO CARRIER, or ERROR.

A brief description of the commands is given in table 3. To see how easy it is to operate the Smartmodem, let's try some examples. Suppose you want to use the auto-dial feature. To dial the number 960-1700, simply type

AT D T 960-1700 <enter>

for tone dialers, or

AT D P 960-1700 <enter>

for pulse dialers. After you press <enter>, the Smartmodem proceeds to dial the number. After dialing, it waits for the other end to answer. When the other end answers, it detects the carrier and sends the ASCII string CONNECT back to the terminal. If the telephone is not answered or if no carrier is detected, the Smartmodem sends back the ASCII string NO CONNECT.

The audio monitor is useful when dialing a number. Under normal operation, the audio monitor is enabled in the off-hook condition. This allows you to monitor the dial tone, ringing, busy tone, and carrier tone. After detecting the carrier, the Smartmodem normally disables the audio monitor; however, the monitor can be enabled or disabled by sending the M command

AT M*x* <enter>

where *x* is 0, which means speaker is off; *x* is 1, which means speaker off until carrier detect; or *x* is 2, which means speaker always on.

Suppose you want the Smartmodem to answer the telephone on the fourth ring. The ASCII command string is

AT S0=4 <enter>



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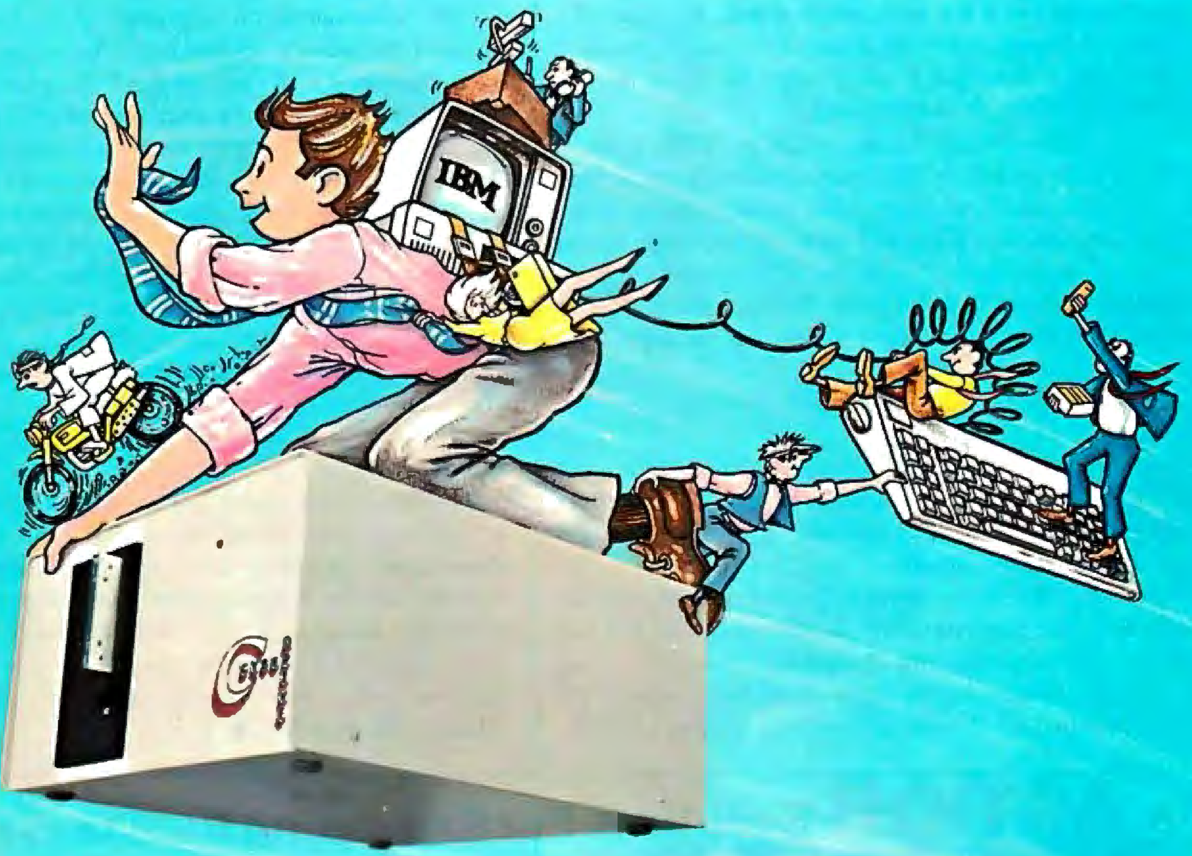


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This command results in the enabling of the AA (auto-answer-mode) LED. When the telephone rings, the AA LED blinks *off* at the rate of the ring. In addition, each ring sends the string RING to the terminal. On the fourth ring, the Smartmodem answers the telephone and enables the carrier signal. If the other modem does not respond in a given amount of time (the amount of time is programmable), the Smartmodem hangs up and sends the NO CONNECT string to the terminal.

Many other commands are available. Table 3 shows commands to set half or full duplex, to answer or to hang up, to redial, and to set the various status registers. In addition, you can mix pulse and tone dialing, allowing use of the Smartmodem in certain PBX (private-branch-exchange) systems that use pulse dialing; after pulse dialing the PBX access code, tone dialing can be used:

AT D P9, T960-1700 <enter>

There is no explicit command for switching between 300 and 1200 bps; the Smartmodem recognizes the speed from your initial command and adjusts itself accordingly, even in auto-answer mode.

Even with the many commands and options that are available, the Smartmodem is simple—even fun—to operate. The beginner can immediately control it using the simple commands; the experienced programmer will enjoy learning all the commands and options. Finally, programmers will find that the high-level commands available will simplify their applications programming tasks.

## Documentation

The documentation consists of a single owner's manual, but what a manual it is! The manual is extremely well organized and easy to read. You can immediately use the Smartmodem by reading just the first few chapters. Indeed, you will probably get the modem operating 15 minutes after taking it out of the box! The first few chapters contain installation and command guidelines, while the later chapters contain in-depth information on commands and configuration switches. Also, the appendixes contain information such as RS-232C connections, telephone information, an ASCII code table, a block diagram, a quick reference card, and a warranty card (two-year warranty).

## Conclusions

The Hayes Smartmodem is an excellent buy. It is nicely styled, has very good documentation, and provides dependable operation. Also, the ASCII-string programmability of the Smartmodem gives easy control of its numerous features. If you are in the market for an RS-232C-compatible modem, certainly give the Hayes Smartmodem consideration. After all, "smart" beats "dumb" any day. . . .■

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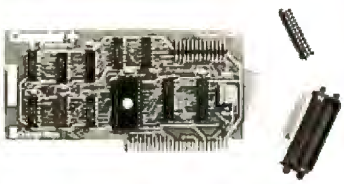

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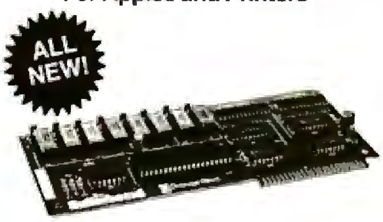


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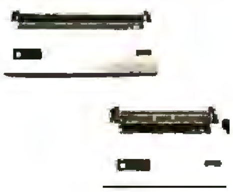

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# Data Collection with a Microcomputer

*Using a TRS-80 Model I for environmental research saves time and money.*

Dr. Mahlon G. Kelly
Department of Environmental Sciences
University of Virginia
Charlottesville, VA 22903

A friend of mine who lives on the edge of a small lake spends every day watching the seasons change, studying the weather, and observing the effects of the creatures in the lake. My friend is particularly fascinated by the chemical, biological, and physical processes going on in the little pond, and like Thoreau beside Walden the fellow resides in a small cabin and has little contact with outsiders. Much to my advantage as a limnologist (a biologist who studies lakes), my friend has almost infinite patience as an observer and commentator and asks only for a continuous supply of electrical power and reliable maintenance for the various sensors, probes, and transducers that monitor the lake. My friend, as you may have guessed by now, is not a person but an old TRS-80 Model I. My colleagues and I have found this inexpensive computer very useful for scientific research.

As a limnologist, I am interested in the conditions that control the rate of growth of the microscopic algae (phytoplankton) that are suspended in lake water. The variables that influence their growth include light, physical mixing of the water (which is related to the temperature variation with depth in the water column), and available nutrients such as nitrate and phosphate.

**Photo 1:** *The tower supports such meteorological sensors as anemometers and radiometers, and the raft supports such sensors in the lake water as oxygen and temperature probes. Signal-conditioning amplifiers are housed in the white box on the raft, and special equipment can be set up on the raft as well.*

The release of oxygen and the uptake of carbon by photosynthesis reveal the algae's rate of growth. By measuring the change of oxygen and inorganic carbon concentrations in the water, we can estimate the rate of photosynthesis. We can then relate that rate to various environmental factors if we have measurements of light, temperature distribution, wind velocity, air temperature, relative humidity, and precipitation. But manually measuring and logging all of these variables is time consuming and produces only infrequent estimates of photosynthesis. If we could study daily variation by collecting data at least every half hour and collect that data day after day for periods of weeks, months, and seasons, we could produce a very sophisticated analysis of the factors that regulate the ecological quality of a lake.

All of these variables can be measured by probes, sensors, and other transducers whose output can be converted to a voltage. In the past, we recorded the voltages on digital tape with a data logger. Then we fed the tape to a large computer to get actual values for light intensity, temperature, oxygen concentration, and so on, from which it calculated the rate of photosynthesis. The catch is that data loggers are expensive and data processing is tedious.

**About the Author**

*Dr. Kelly, an associate professor of environmental science at the University of Virginia, is involved in research into the character of lakes.*

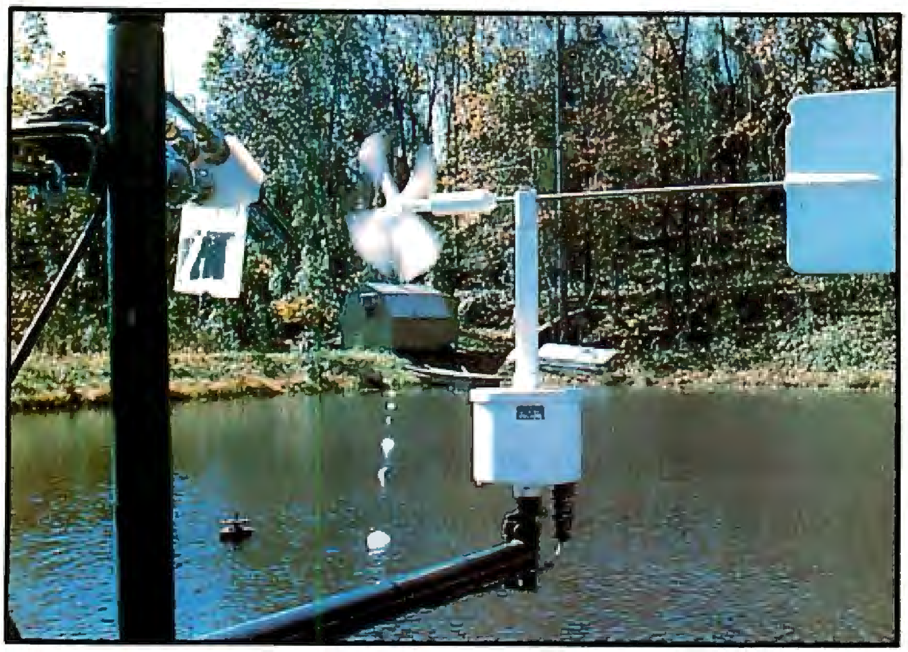

Photo 2: *The buoys leading to shore support the wires that send analog signals to the cabin. The wire for transmitting the signals would have been the most expensive item of the whole installation if we had not bought it as military surplus.*

*The TRS-80 is housed in the hut along with other equipment for studying the lake. The hut is heated and air-conditioned because the graduate students operating the equipment argued that the TRS-80 couldn't withstand a wide temperature range. Personally, I think the students are more temperature sensitive than the TRS-80 is.*

That's where my friend the TRS-80 comes in. Our department has a 16K-byte Model I that includes an interface with an analog-to-digital (A/D) converter, a multiplexer, and a clock. The interface feeds 48 channels of data into the computer's bus and from there into memory. The A/D converter cost about $450 in parts and the TRS-80 about $650, making a total of $1100 for hardware. The least expensive data logger available would have cost more than $3000, and a specially designed data-logging computer to do the same job as the TRS-80 would have cost more than $10,000. Granted, a more expensive computer would have had additional capabilities, but we didn't need them. And we certainly didn't need the additional expense.

## The Data-Acquisition Problem

Figure 1 shows the general data flow we needed for our research. This sort of data flow is common in many science and engineering applications: data is collected from a variety of sensors, recorded, and processed, then the results are displayed and stored.

In the past, monitoring data from the field, which is common in meteorological and water-quality work, usually involved a "dumb" data logger. Figure 2 shows such a data flow. In this instance, the data is converted to raw digital values that are stored at some fixed-time interval on magnetic tape. Tapes from the field recorder are then carried to the lab and processed through a tape-to-tape converter that makes standard 7- or 9-track tapes compatible with a mainframe computer. Then we carry these tapes to the computer, where the values are converted from voltages and transferred to hard disk.

**A specially designed data-logging computer to do the same job would have cost more than $10,000.**

The data can be examined on a video display using an editor to eliminate obviously bad values. (Bad values are the result of anything from birds perching on anemometers to fishermen anchoring their boats on top of light sensors.) Once corrected, the voltage values are then usually stored on magnetic tape. The voltages are averaged using an appropriate scheme to remove spurious noise and then converted to true values, such as temperature, which are stored as another disk file and saved on tape. Then that file is processed to convert the data into the information needed for the research. In our case, rates of change of oxygen concentration are converted to photosynthetic rates, which are expressed as the rate of release of oxygen by plants in the water. These results are output to tape and printed.

This scheme has several disadvantages. The most obvious drawback is that the operator can't monitor what a dumb logger is doing. And data loggers (even dumb ones) are expensive. Moreover, it takes time and money to transfer tapes from the field to the lab and then to the computer, to pick up output (tapes and printout) from the computer, and so on. And, of course, processing time and disk storage on a mainframe computer are expensive. We needed to make at least five trips to and from a computer center and five program runs on the mainframe for the scheme shown in figure 2.

## Enter the Microcomputer

Figure 3 shows the same data flow mediated by two TRS-80 microcomputers. An A/D converter still processes the voltage signals, but now they go directly to the memory in the microcomputer. The signals are then converted to voltages (in floating-point form), the values are averaged by whatever scheme is appropriate, and the results are recorded on an inexpensive cassette tape.

The advantages of this method are clear. The operator can monitor what's happening on a video screen, and the voltages can be converted to preliminary true values. Out-of-range values can also be recognized and eliminated. Several steps usually done by a mainframe computer are now done in real time by the TRS-80 located in the field. After a few days, the tape is removed and taken to another TRS-80 in the lab, where the data is transferred to disk. The data is then checked and changed with a text editor (we use Scripsit), and the voltages are converted to real data values. Archival data is stored on a 5¼-inch floppy disk, which is much cheaper than a magnetic tape.

At this point there are two options for further data analysis. One is to do simple data analysis using the TRS-80 in the lab. For example, if we only need averages of various parameters every six hours, they can be calculated, stored on disk, and printed out by the TRS-80. Usually, however, the necessary calculations would take too much time and memory, and the mainframe computer would better suit the task. Fortunately, several communications programs are available for the TRS-80 that enable disk files to be sent over the phone to other computers. Our files are sent to the university's computer for further processing, and results are returned to the TRS-80, where they are stored on disk and printed.

By using the communications programs, we eliminated all of the trips to the computer center, cut the mainframe programs down to one, completely eliminated reel-to-reel data conversion, and made the system easier to use. The special hardware and software we needed to accomplish our task are described below.

## The Hardware

The A/D unit, designed by Jim Demas of the University of Virginia Chemistry Department, uses an interface from HUH Electronics (a company since acquired by California Computer Systems) to convert signals from the 40-line TRS-80 bus to an S-100 bus. The HUH interface has three cards: a multiplexer, an A/D card, and a Wameco RTC-1 clock board. Once the clock board is programmed by the TRS-80, it controls the multiplexer sampling and data transmission to the TRS-80. The multiplexer board, also designed by a faculty member, uses six Analog Devices chips (AD7507s), each of which controls eight input

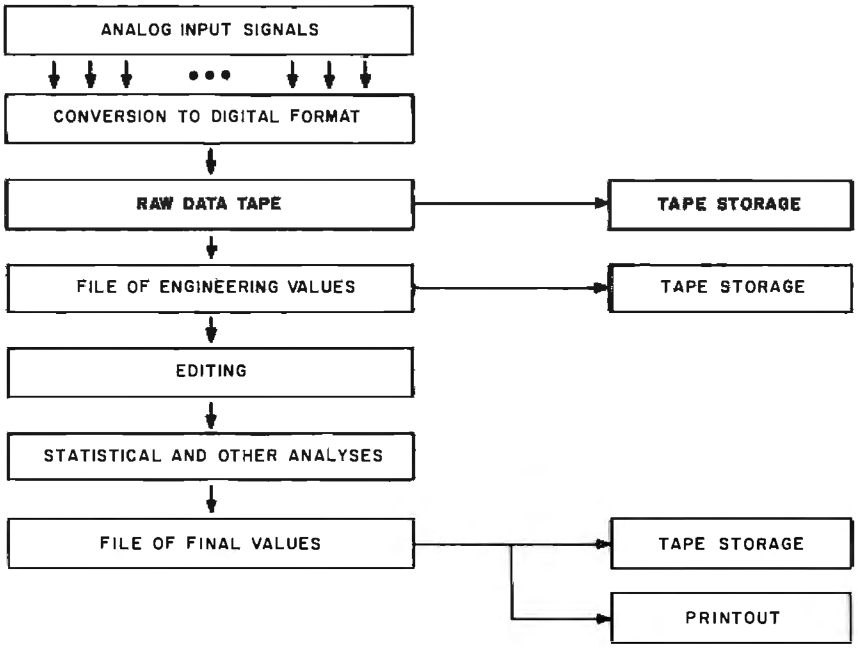


**Figure 1:** *The data flow used in our research.*

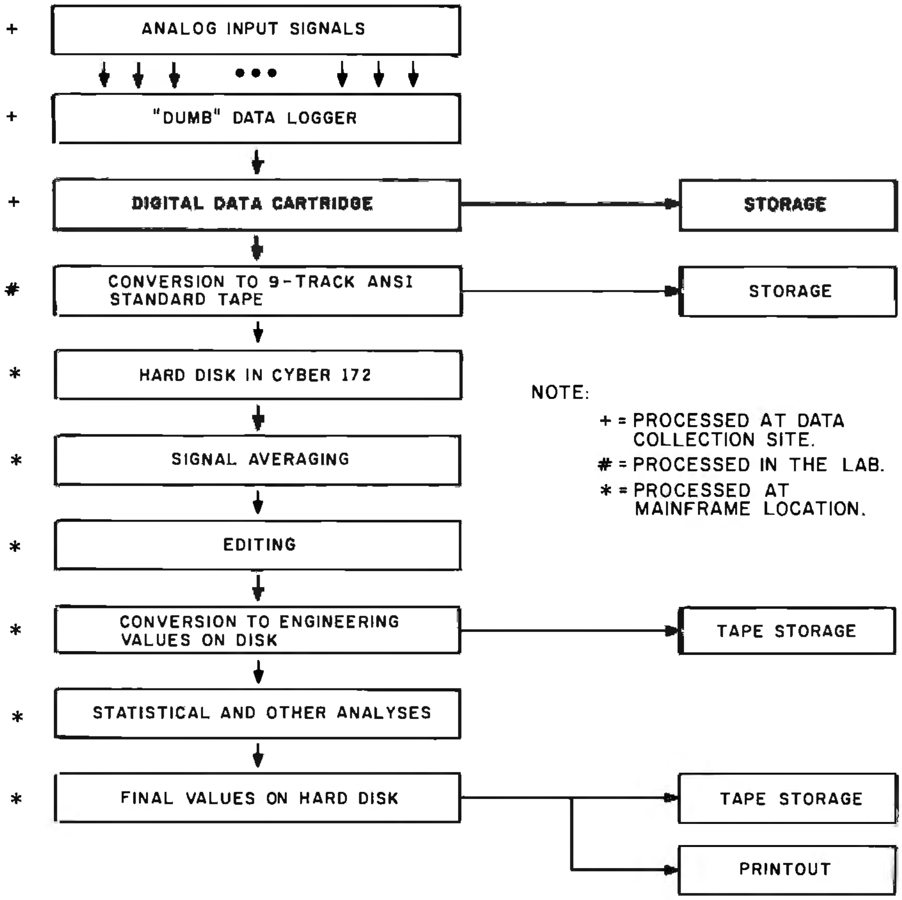


**Figure 2:** *A typical scientific data flow using a data logger.*

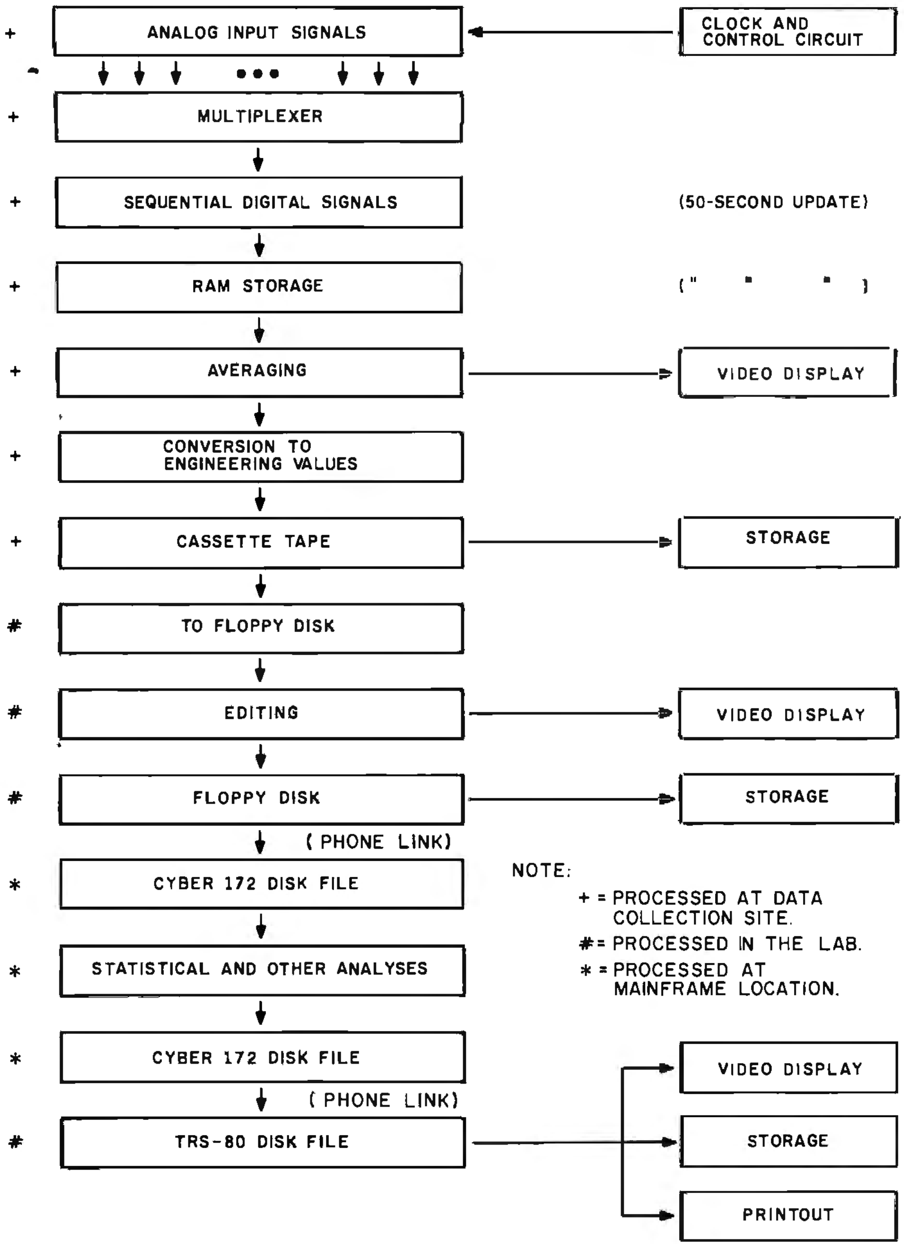


**Figure 3:** *A typical scientific data flow using two microcomputers.*

signals. The input signals go to an ICL 7109, 12-bit A/D converter chip and from there via the HUH converter as parallel input into the TRS-80 bus. The input ranges from −4 to +4 volts (adjustable with a trimpot) with a resolution and accuracy of more than 1 millivolt. Each of the 48 channels can be examined at an interval of less than 10 ms (milliseconds), although we sample only at 50-second intervals. The sampling interval can be programmed by the TRS-80.

## Data-Acquisition Software

Output from each channel is stored in 2 bytes of high memory and refreshed at every sampling interval. The sampling is interrupt-driven. Another 2 bytes are used to store output from the clock, which is recorded as "elapsed time since start." The software is a simple 154-line BASIC program that includes two machine-language programs that are put into a specific high-memory location.

The first program, which uses 36 bytes, initializes and sets up the clock board. The second, which uses 154 bytes, is a driver that receives the inputs and places them in their memory locations. Those locations are then read by the BASIC program and the contents are converted into a millivolt value that is stored as an array variable. We use an $x$ by $y$ matrix for the input variables where $x$ is the number of channels and $y$ is the number of samples taken in the interval between outputs to the tape recorder. Thus, using a 5-minute recording interval and 15 channels, data is stored in a 15 by 6 array (5 channels with 50-second sampling results in 6 inputs per channel).

Normally we average the inputs for 5 minutes before recording, then convert the averages of the input voltages to actual variable values (e.g., oxygen concentration in milligrams per liter or temperature in degrees Celsius). The time is also read from memory and recorded as decimal hours. We could process the inputs further by examining, for example, rates of change of the values. That would require only the addition of subroutines to the BASIC program.

When the data is recorded to tape it is also placed in memory in an $x$ by 48 matrix; here, $x$ is the number of input channels. This matrix may be examined at any time by the operator, so if records are made every half hour, the previous 24 hours of data can be reviewed on the screen. Other information can be stored at the time of recording for future review by the operator.

## Using the System

The operator needs to know little more about the computer than how to turn it on and load the program from tape; the program is self-prompting. First it asks for a header message that will be recorded on tape and will describe the particulars of the experiment. Another prompt asks how many channels are being used, what the sampling interval should be, how often the data should be recorded and what the averaging period should be, what the start time is, and what variables are being input on

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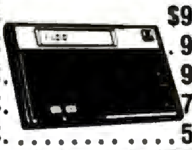

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particular channels. It also asks for certain calibration constants. Alternately, the operator can choose to record input voltages directly, leaving conversion for later processing. While the program is running, the operator can press certain keys to do such things as display the time, review past data, allow another message to be recorded, or stop the run.

Initially, recording data to tape posed a problem, because numerical data takes a lot of tape space. Our solution was to convert each value to a string, concatenate the strings (with the time added on at the end), and record the single resulting string. This procedure makes it possible for one side of a 90-minute cassette to hold enough data for about 10 days. You may find the procedure useful if you want to store a lot of data on tape.

### Processing the Data

Getting the data to the computer and then onto tape is only half the problem. The tape must be read and the data processed further, and in some cases we have to send it to the university's Cyber-173 computer for very detailed and time-consuming analysis. This additional work requires the use of a more sophisticated TRS-80 that has three double-density disk drives, a fast printer (Centronics 102A), 48K bytes of memory, and a modem. This TRS-80 is used as a text editor and teaching device as well as a smart terminal for our large computer.

Two programs do all of the work with the field data. The first one reads the tape and makes an image on disk while (at the option of the operator) it sends a copy to the printer. Once the printout has been examined, any errors can be corrected using Scripsit. As a result, editing and modifying the data is very easy.

The second program reads the disk image of the data and decomposes each data string into actual values. It also does any further conversion that is necessary. For example, if values were stored as voltages, the program will calculate true values. In the data string, a space is used as a value delimiter, and the string must be

examined character by character. This process would be insufferably slow in interpreted BASIC, but using Microsoft's compiler speeds up the process. For example, it takes about 15 seconds to decompose and manipulate a single string record in interpreted BASIC, while 30 may be done in a minute using the compiled program.

The output is sent to a second disk file, to the printer, and to the screen. The disk file may also be modified by Scripsit if necessary. The entire process for 5 days of 15 channels of data takes from one to two hours, depending on how much editing you must do. Because the TRS-80 is not always reliable when it comes to writing and reading from tape, some records are garbage. The second program detects garbage and dubs in interpolated values (we can get away with this because we are collecting more data than we really need). By using one of the commercially available units that improve tape read/write reliability, the garbage could be largely eliminated.

The data must still be sent to the university's Cyber-173 computer. This is easily accomplished by using any of the communications programs designed for uploading and downloading programs from computer bulletin boards, The Source, and so on. We use Lance Micklus's ST80-III. We load the data file into a memory buffer, dial the Cyber's user number, log on, and send the buffer to the CDC at 300 bits per second. The data is then stored on a disk at the Cyber, where we can do whatever analyses we like.

### Similar Applications

We also use a TRS-80 for logging data in an analytical chemistry lab. It's connected to a spectrophotometer, an automated titrator, and an autoanalyzer to calculate chemical concentrations and other information. In fact, this TRS-80 has replaced many of the functions of a $40,000 LSI-11. We had been sending the chemical data over wires to a central LSI that serviced several labs, but using the TRS-80 for the same purpose was actually cheaper than buying and installing the cables to transmit the data. And it was more convenient.

### Microcomputer As Data Logger

We chose the TRS-80 for its low cost and the plethora of software available for it. Having a low-cost field unit is very important to us. Last summer our installation was hit by lightning; traces were actually vaporized on the boards and the TRS-80 was ruined. Even after we replaced it, our total expenditure was much less than the price of one data logger.

The software advantages are even more important. Using Scripsit to edit data files gives us flexibility that is not possible with the university's large computer, and ST80-III gives us data-transmission flexibility not available with most systems. I suppose we could have written software to do the same thing for another system, but that would have taken time away from the research itself.

### Saving Time and Money

I think my TRS-80 is a good example of how useful small microcomputers can be to a scientist for operations previously done by much more expensive equipment. The TRS-80 in the chemistry lab pretty well eliminated a much larger minicomputer, and our TRS-80 completely eliminated a data-logging system that had been in use for six years. As a result, our charges from the university's computer center have decreased by about 30 percent during the past year, and I would guess that the hours spent on data processing have been cut in half. Field work that required two technicians is now done by one, and more quickly as well.

Data collection, once a nuisance, is now much more fun. Perhaps most important is that we can now spot and correct problems in the field without bringing data tapes back to the lab to be processed. ■

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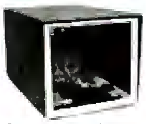

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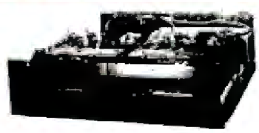

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# Add Dimensions to Your BASIC

Timothy G. Corrigan
4232 North Mulligan
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If you have an application that requires more dimensions than your BASIC supports, or if you are an assembly-language wizard with a multidimension application, then have no fear. There is an easy solution to your problem.

Listing 1 contains a program that uses an array with one dimension as if it had two dimensions. Line 130 defines the function used to calculate the single index value using two variables. Lines 140 and 150 define the maximum values for the two dimensions. The rest of the program builds a simple multiplication table. To alter the size of this two-dimensional array, just change the XM and YM values. You will also have to change the number of elements in the A array.

Listing 2 contains a program that uses an array with one dimension as if it had three dimensions. The programs in listings 1 and 2 are very similar. The difference in listing 2 occurs in line 130, which determines the function that calculates the index value. To change the function from two dimensions to three, a set of parentheses is placed around the function used for two dimensions. This value is then multiplied by the maximum value for the third dimension, and the third-dimension variable is added. The procedure can be repeated to give you an unlimited number of dimensions in your arrays. For example, the function for an array with four dimensions is

$$I = ((X*YM + Y)*ZM + Z)*TM + T$$

This addressing scheme will also allow you to create and randomly process disk arrays. Instead of using the calculated index as an array index, it may be used as the record number when reading or writing to a disk file.

Listing 3 contains an assembly-language routine that will calculate the index value for any multidimensional array. The routine is written in IBM 360/370 assembler code. (The IBM 370 has 16 general-purpose registers. The registers all appear in the listing as "Rn".) Register 2 points to a series of 2-byte data items that define the array. Register 3 points to another series of 2-byte data areas that specify the values of the variables (i.e., the X, Y, and Z values from the BASIC programs) that will be used to calculate the index value. Register 4 is used as an index register. The rest of the program is explained in the BASIC-like comments. ■

**Listing 1:** *This simple BASIC program builds a multiplication table using an array with only one dimension. A PRINT statement can be added at line 195 to print the values of I, X, and Y.*

```
100 REM
110 REM ACCESS SINGLE DIMENSION ARRAY WITH TWO INDICES
120 REM
130 DEF I=X*YM+Y       :REM DEFINE INDEX CALCULATION FUNCTION
140 XM=9               :REM X DIM HAS 10 ELEMENTS 0-9
150 YM=4               :REM Y DIM HAS  5 ELEMENTS 0-5
160 DIM A(49)          :REM ARRAY HAS 10*5 ELEMENTS 0-49
170 FOR X=0 TO XM      :REM INIT X LOOP
180 FOR Y=0 TO YM      :REM INIT Y LOOP
190 A(I)=X*Y           :REM BUILD A MULTIPLICATION TABLE
200 NEXT Y             :REM LOOP FOR ALL Y VALUES
210 NEXT X             :REM LOOP FOR ALL X VALUES
220 END                :REM END OF PROGRAM
```

**Listing 2:** *A BASIC program that builds a three-dimensional table for the function X * Y + Z using an array with only one dimension. A PRINT statement can be added at line 215 to print the values of I, X, Y, and Z.*

```
100 REM
110 REM ACCESS SINGLE DIMENSION ARRAY WITH THREE INDICES
120 REM
130 DEF I=(X*YM+Y)*ZM+Z      :REM DEFINE INDEX CALCULATION FUNCTION
140 XM=7                     :REM X DIM HAS  8 ELEMENTS 0-7
150 YM=9                     :REM Y DIM HAS 10 ELEMENTS 0-9
160 ZM=9                     :REM Z DIM HAS 10 ELEMENTS 0-9
170 DIM A(799)               :REM ARRAY HAS 8*10*10 ELEMENTS 0-799
180 FOR X=0 TO XM            :REM INIT X LOOP
190 FOR Y=0 TO YM            :REM INIT Y LOOP
200 FOR Z=0 TO ZM            :REM INIT Z LOOP
210 A(I)=X*Y+Z               :REM BUILD A TABLE FOR X*Y+Z FUNCTION
220 NEXT Z                   :REM LOOP FOR ALL Z VALUES
230 NEXT Y                   :REM LOOP FOR ALL Y VALUES
240 NEXT X                   :REM LOOP FOR ALL X VALUES
250 END                      :REM END OF PROGRAM
```

**Listing 3:** *This IBM System 360/370 assembly-language, general-purpose program performs the same array index calculation used in the two BASIC programs, and it can be used with any size array. The routine requires one input area that describes the size of the array (the array control information) and another input area that indicates which element you wish to address (the requesting values). The output of this routine is the index or byte displacement of the element you have asked for. This value should be added to the beginning address of the array.*

```
                                 *         INPUT...
                                 *
                                 *         R2 = POINTER TO FOLLOWING ARRAY CONTROL INFO
                                 *         2 BYTE ELEMENT LENGTH
                                 *         2 BYTE # ARRAY DIMENSIONS
                                 *         2 BYTE MAX VALUE FOR DIMENSION 1
                                 *         2 BYTE MAX VALUE FOR DIMENSION 2
                                 *         *                              *
                                 *         *                              *
                                 *         2 BYTE MAX VALUE FOR DIMENSION N
                                 *
                                 *         R3 = POINTER TO FOLLOWING PARM LIST
                                 *         2 BYTE REQUESTING VALUE FOR DIMENSION 1
                                 *         2 BYTE REQUESTING VALUE FOR DIMENSION 2
                                 *         *                                      *
                                 *         *                                      *
                                 *         2 BYTE REQUESTING VALUE FOR DIMENSION N
                                 *
                                 *
                                 *         OUTPUT...
                                 *
                                 *         R1 = INDEX VALUE INTO ARRAY
                                 *
                                 *
0000 4862 0002                             LH    R6,2(R2)       R6 = # DIMENSIONS
0004 8960 0001                             SLL   R6,1           R6 = R6 * 2
0008 1B44                                  SR    R4,R4          R4 = 0
000A 1B55                                  SR    R5,R5          R5 = 0
000C 4814 3000                   ARRLOOP   LH    R1,0(R4,R3)    R1 = VALUE FROM PARM LIST
0010 1A15                                  AR    R1,R5          R1 = R1 + R5
0012 4140 4002                             LA    R4,2(,R4)      R4 = R4 + 2
0016 1964                                  CR    R6,R4          IF R6 = R4 THEN
0018 4780 F026                             BE    ARRDONE        GOTO ARRDONE, ELSE
001C 4C14 2004                             MH    R1,4(R4,R2)    R1 = R1 * MAX FOR DIM N+1
0020 1851                                  LR    R5,R1          R5 = R1
0022 47F0 F00C                             B     ARRLOOP        GOTO ARRLOOP
0026 4C12 0000                   ARRDONE   MH    R1,0(R2)       R1 = R1 * ELEMENT LENGTH
002A 07FE                                  BR    R14            RETURN
```

# Build This Memory, Part 1

*How to construct a low-cost memory board with dynamic devices.*

**Cameron Spitzer**
**3369 Vanderbilt Way**
**Santa Clara, CA 95051**

Many personal computer experimenters want a lot of inexpensive memory to expand their computers. I'll explain how I built a 64K-byte memory card for my S-100 machine for less than $200, using the 4116 memory device. I'll also explain how the board works. This inexpensive circuit has been reliable for me and, if you build it carefully, will satisfy your memory needs for years.

I limited the parts list to items I could buy from mail-order "hobby" dealers. The circuit was designed for easy expansion later on, as your needs grow. It will take few changes to switch to 4164s, if you wish. Plenty of room is left on the card (see photo 1a and b) for adding simple accessories like write protection, overlaid pages, interrupt on a write or address violation, or whatever you like.

The integrated circuits (ICs) most often used in S-100 memory systems are 2114L, 4K by 1-bit MOS (metal-oxide semiconductor) static devices, but the best-selling ICs are 4116 16K by 1-bit dynamic devices. Both are made by the same process, using n-channel metal-oxide silicon transistors, but each takes a different circuit-design strategy (table 1 contrasts the two types of circuits). The static version costs about five times as much per bit of storage as the dynamic and will occupy twice the space in your system. On the other hand, statics require far simpler support circuitry.

**The circuit was designed for easy expansion later, as your needs grow.**

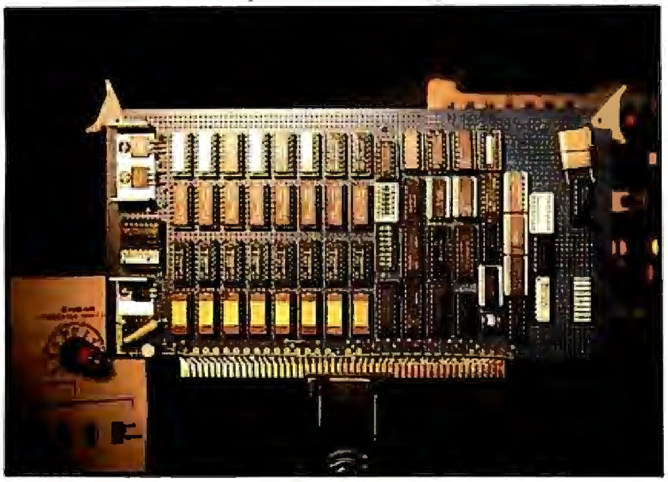
I chose the S-100 bus for my machine because it's the most widely supported modular computer. Every computer accessory you can name is probably available for the S-100. The bus first appeared in early 1975, and the IEEE (Institute of Electrical and Electronics Engineers) has established it as a standard. For many years there were no standard signal definitions, pin numbers, or timing relationships, so there are several mutually incompatible variations of the bus. I'll describe two: the IEEE-696 specification and the simplified Z80 version. For years S-100 owners have had to examine each product for compatibility with their own bus versions, and I've approached the problem by showing jumper-selectable interface circuits for both versions.

## S-100 Signals

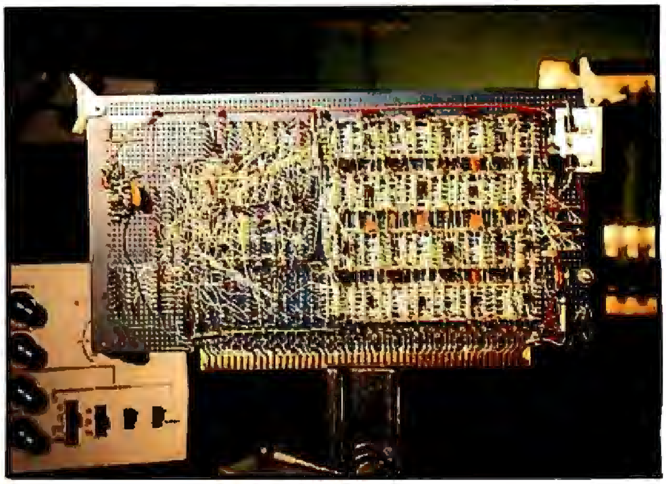
First I'll describe the Z80 version of the S-100 bus, by giving a description of the signal on each pin used by my memory card. The status, or cycle-request, bus consists of four lines that request bus cycles: sMEMR, MWRT, sIN, and sOUT. Figure 1 shows how the Z80 processor board in my system generates these. The other lines are mostly power and buffered Z80 signals.

A +8-volt (V) power supply is used to power the TTL (transistor-transistor logic) devices. A +16-V power supply powers the dynamic memory devices. The Z80 also requires a −16-V power supply. (The supplies are regulated on the card, so

(1a)



(1b)



**Photos 1a and 1b:** *The wire-wrapped prototype memory board. Photo 1a shows the general layout used to minimize wire lengths. At left are the power supply and the bus terminations. Photo 1b is the back of the board. S-100 lines are blue, and the power-supply lines are solid AWG 18 copper. To avoid loops, all grounds are connected at the S-100 ground pin only.*

these voltages can be slightly higher.)

Sixteen address lines specify an address, which must be valid when a cycle is requested. The card places fetched data on eight DIN (data-input) lines and receives data to be written over eight DOUT (data-output) lines. (You may use the same eight wires for these two functions, if your other cards allow it.)

The signal on line sMEMR rises when the address is stable and the bus wants data from memory. It falls when the bus has sampled the data.

When MWRT rises and when address and data are stable, the memory should store data. It falls at least 200 nanoseconds (ns) later.

The line pRDY is an input to the processor that any card may pull low. The signal on line pRDY indicates to the processor to slow down. The memory card pulls pRDY low whenever the memory card may not be ready for the processor to proceed. In normal operation, the memory doesn't make the processor wait, but if cycle requests are piling up, pRDY can prevent the (disastrous) loss of a cycle.

Those are all the signals I really need, but two others will improve the performance of the memory in a system. M1 indicates there will be an idle period of at least 400 ns after the current cycle is done. The memory board performs an internal cycle during that period. $\overline{\text{PHANTOM}}$, when low, turns off the buffer that drives DIN. It

| | 2114 (1K by 4-bit) static | 4116 (16K by 1-bit) dynamic |
|---|---|---|
| Number of devices for 64K bytes | 128 | 32 |
| Price of 16K bytes (memory devices only) | $64 | $12 |
| Number of support devices required for S-100 interface | 5 to 10 | 20 to 30 |
| Cost of 64K-byte S-100 board | $350 (two cards) | $180 (do-it-yourself) |
| Power required for 64K bytes | 50 W | 10 W |
| Ease of interface design | very easy | difficult |

**Table 1:** *A comparison of the most common static and dynamic memories.*

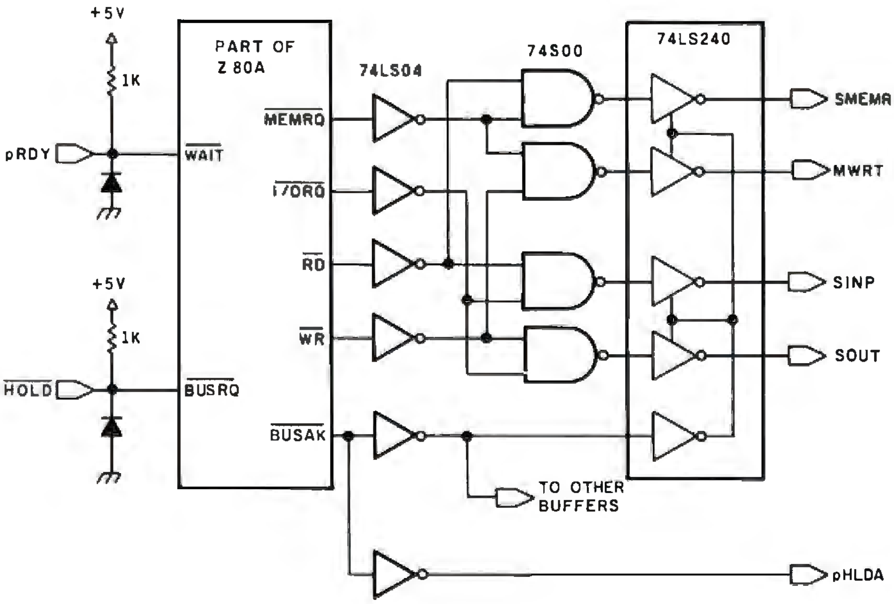



**Figure 1:** *Developing S-100 bus signals from a Z80 microprocessor.*

allows you to map other devices inside an enabled 8K-byte block of memory. Usually these other devices are ROM (read-only memory), and they are required to pull down $\overline{\text{PHANTOM}}$ while they drive the DIN lines.

Those are all the signals necessary to operate a high-performance (2-million-bytes-per-second) memory on the S-100 bus, Z80 version.

The 8080 version of the bus, which is described in the IEEE-696 specification (see reference 4), is more complex. The lines sMEMR and MWRT contain nonsense most of the time because the 8080 does not synchronize its status lines with its bus cycle requests. The original S-100 machine (the MITS Altair) didn't provide any correction of this nonlatched status on its processor board, and the processor instead produced a pulse (pSYNC and Φ1) to operate a latch on each of the other boards. Since no new machines are being built using the Intel 8080 microprocessor, I've shown the status latch as an option for users of the older equipment. This latch is required to meet the IEEE specification. Three extra signals, pSTVAL (also called Φ1), pSYNC, and pDBIN, are necessary. When pSTVAL goes low, status may be valid, and when pSYNC is high, pSTVAL is meaningful. The logical AND function is used to combine these two signals. Because sMEMR can't be used to gate data onto DIN, pDBIN is used instead. The line pDBIN is also active when the processor reads an I/O (input/output) port. Sometimes, analogous lines are used to synchronize a write (pWR or sWO), but they are redundant with MWRT.

To complete the introduction, I'll describe some of the things that may happen on the bus and that a memory must ignore.

To achieve synchronization, many peripherals hold up the processor until they have data. These devices may hold pRDY low for a long time, while a disk rotates, or a printer prints, or a glacier approaches the sea. While pRDY is low, the bus is idle, but at the same time, memory needs the bus signals in order to retain data. The card doesn't depend on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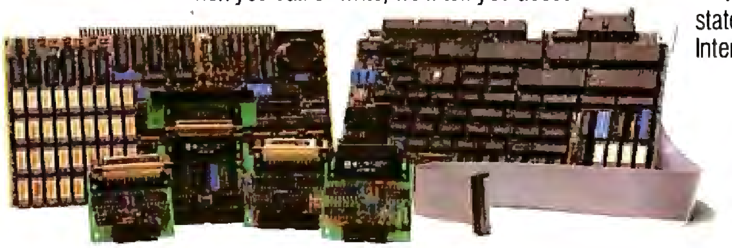

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Circle 222 on inquiry card.

1733 South Douglass Road, Suite E Anaheim, California 92806 (714) 978-9758 Telex: 678401-TAB-IRIN bus activity for refreshing data, and I've held pRDY (also called WAIT) low for 72 hours with no data loss.

Other peripherals work so fast they have to take control of the bus and use the memory themselves via DMA (direct memory access). In the Z80 version of the bus, there may be spikes (brief pulses) on the active-high signals MWRT and sMEMR when a transfer of control takes place. The memory must, therefore, ignore pulses of less than 100-ns duration on these lines. Extra sMEMR signals are all right, but an extra MWRT is a disaster. I've filtered MWRT to reject such pulses.

Finally, many older machines use hardware front panels, on which the operator reads and writes with push buttons. To read memory at human speed, the output data must stay valid as long as sMEMR stays high. I've used an output latch that holds data until the next cycle. Some designs I've seen do not latch the data indefinitely, and they may not work with a bus controller as slow as a push button.

Now that I've sketched the problem of using the S-100 bus, I'll summarize the requirements of the 4116 dynamic memory device and show how to build and use the card.

### 4116 Makes Demands

To understand how the board works, you must first know what the bus provides and what the 4116 requires. I'll only abstract the 4116 specification sheet, so you should send for one if you want all the details (see table 2).

For $48 you can fill this card with 4116s and your directly addressable Z80 memory space with thirty-two 16-pin DIPs (dual-inline packages). Each stores 16,384 bits as charges in a grid of 0.03-picofarad (pF) capacitors. Because the charges leak away, the cells must be refreshed (read into a latch and rewritten) at least 500 times per second. Any memory-access cycle refreshes 128 bits, so that they will last for another 2 milliseconds (ms). But that complication aside, the inputs are practically TTL-compatible, and the DC (direct current) power drawn is very small. Current is drawn by 4116s in RF (radio-frequency) pulses, with a small DC bias added.

| Vendor | Vendor's number for 4116 |
|---|---|
| Advanced Micro Devices<br>901 Thomson Place<br>Sunnyvale, CA 94086<br>(408) 732-2400 | Am9016E |
| Hitachi America Ltd.<br>707 West Algonquin Rd.<br>Arlington Heights, IL 60005<br>(312) 593-7660 | HM4716A |
| Intel Corporation<br>3065 Bowers Ave.<br>Santa Clara, CA 95051<br>(408) 734-8102 | 2116 |
| ITT Semiconductors<br>470 Broadway<br>Lawrence, MA 01841<br>(617) 688-1881 | ITT 4116 |
| Mostek Corporation<br>1215 West Crosby Rd.<br>Carrollton, TX 75006<br>(214) 323-6000 | MK 4116 |
| NEC Electronics U.S.A. Inc.<br>Microcomputer Division<br>One Natick Executive Park<br>Natick, MA 01760<br>(617) 655-8833 | μPD416 |
| Texas Instruments<br>Semiconductor Group<br>POB 225012<br>Mail Stop 308<br>Dallas, TX 75265<br>(214) 238-6611 | TMS4116 |
| Toshiba America<br>2151 Michelson Dr.<br>Suite 190<br>Irvine, CA 92715<br>(714) 955-1155 | TMM416 |
| Zilog Inc.<br>315 Dell Ave.<br>Campbell, CA 95008<br>(408) 370-8000 | Z-6116 |

**Table 2:** *Vendors that can supply specification sheets for 4116-type memories. If you send a self-addressed 9- by 12-inch envelope with 50 cents in stamps, you will usually receive a data sheet by return mail.*

The memory circuits can perform six kinds of cycles, but I use just the simplest three: read, write, and refresh-only. You could think of the general memory cycle as a string of five clock periods, as shown in figure 2a and b. The common 4116 with an access time of 200 ns would have periods of 67 ns.

A memory-access cycle begins with the falling edge of $\overline{RAS}$ (Row Address Strobe), which makes the device sample 7 bits of an address. This portion of the address controls which row of memory cells inside the device will be refreshed. As soon as the second 7-bit address value on the address pins is valid, $\overline{CAS}$ (Column Address Strobe) may go low. $\overline{CAS}$'s falling edge makes the 4116 sample its address, write-enable, and data-input pins. The other inputs must remain stable until the beginning of the third clock period. WR (write) can alter the data any time $\overline{CAS}$ is low.

If $\overline{CAS}$ stays high (inactive), a $\overline{RAS}$-only refresh occurs; the row of bits is rewritten, so they are recharged for another 2 ms. $\overline{RAS}$ must be low long enough for the refresh to work, an interval that coincides with the ICs' advertised access time (200 ns).

After the third clock period, output data is ready, and you may let $\overline{RAS}$ and $\overline{CAS}$ rise. The output data becomes invalid when $\overline{CAS}$ rises. After $\overline{RAS}$ rises, the 4116 must be left alone for two more clock periods. The whole cycle takes 375 ns. You may stretch any of the clock periods out to 5 microseconds (μs) or so, but each row must be refreshed every 2 ms. Figure 2b shows a cycle in time, drawn to scale.

The 4116s require little DC (the whole card takes half an amp at +12 V, running full tilt with a 4-MHz Z80), but they "drink" RF energy. The supply current is drawn in a burst after each strobe edge (when $\overline{RAS}$ or $\overline{CAS}$ changes). Capacitors must be mounted near each memory device for quick action. The +12-V supply operates the circuitry of the 4116 and must be less than 10 percent noise. The −5-V supply keeps internal diodes cut off. A word of warning: it must be more reliable than the other supplies. The presence of a +12 voltage without a −5 voltage will damage the memory with the very next strobe. The +5-V supply is used only by the memory to generate a logic 1 and thus makes far less noise.

All the signal inputs of a single 4116 may be driven by LS (low-power Schottky) TTL levels. Unfortu-

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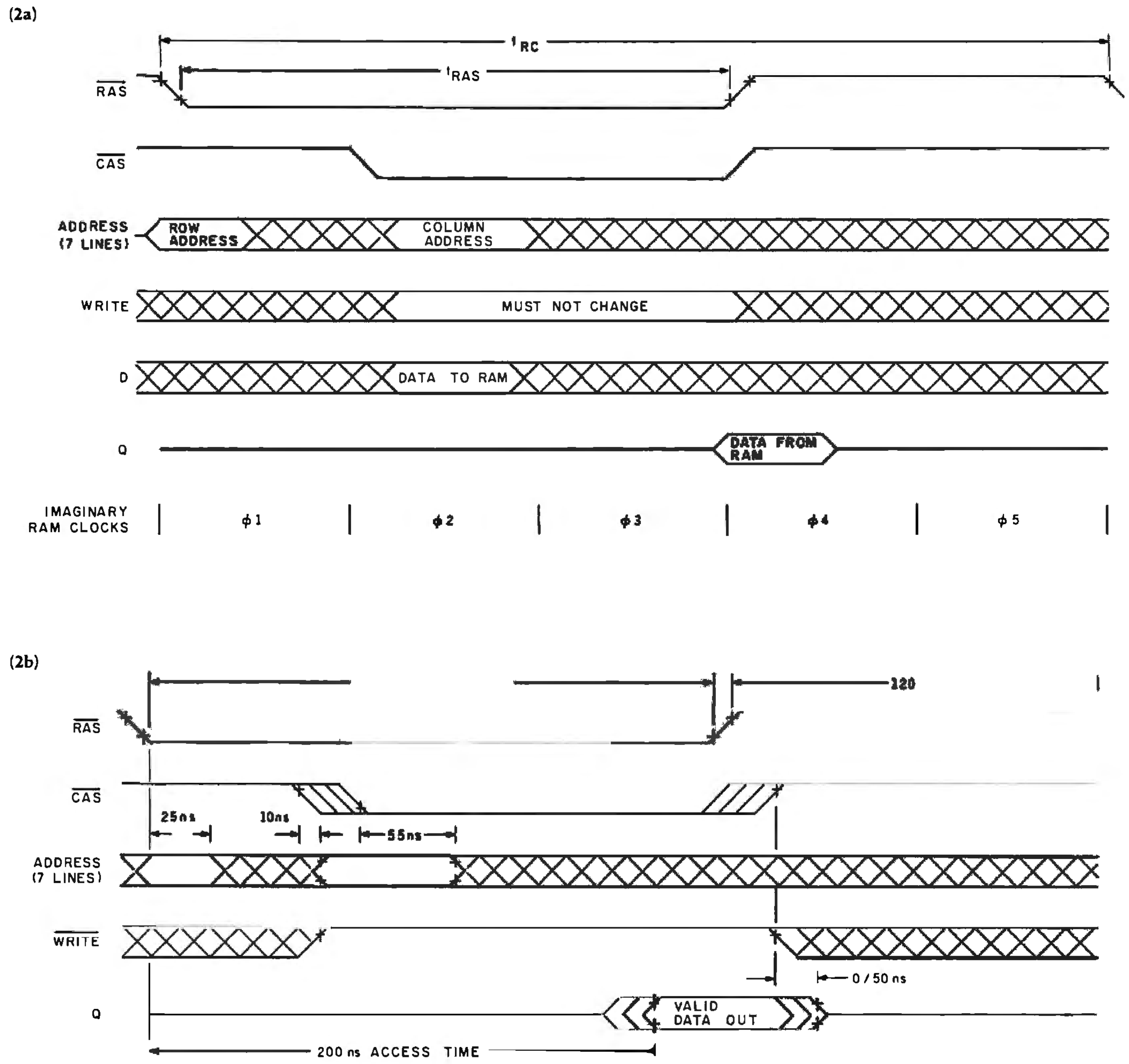
Circle 15 on inquiry card.




**Figures 2a and 2b:** *Timing relationships of the 4116-type dynamic memory. Figure 2a shows how the cycle time of the memory can be considered as five imaginary periods. In this figure, $t_{RAS}$ is the advertised access time. Figure 2b is a read cycle drawn to scale. Valid data may terminate from 0 ns to 50 ns after the trailing edge of $\overline{WRITE}$.*

nately, when you tie 32 MOS inputs together in a grid, it works like a long piece of cable. When a fast pulse like $\overline{RAS}$ or $\overline{CAS}$ hits the open end of a cable, it bounces back, upside down. Since a −3-V pulse may destroy the data in a 4116 and the bouncing reflections wreck the timing, any line to eight or more MOS inputs must be terminated to absorb falling edges. Clamping diodes and pullup resistors are used. Series resistors at the source work by slowing the fall time of the pulses. For more about transmission-line effects, see the references.

Now you see how these popular devices got their reputation for interface complexity: they deserve it!

## Support Circuitry

Now that the 4116s and the bus are less mysterious, you can follow the block diagram (figure 3) and the schematic diagram (figure 4) to understand how the board works. The functions of the support devices are given in table 3.

The power supplies that regulate the voltages applied to the TTL and the memories deserve special attention. Diodes ensure that the last supply to quit after power is removed will be −5 V. They also protect the memories if the −16-V supply fails. Three separate grids of heavy wire (one for each supply) and thirty-two

"... GOOD MORNING, ... I'M YOUR SUBSTITUTE TEACHER MRS. MALONE, FILLING IN FOR YOUR COMPUTER WHICH IS BEING REPROGRAMMED. DONT EXPECT ME TO GENERATE GRAPHICS, PLOT, PRINT OUT OR SOLVE COMPLICATED MATH FUNCTIONS, ... I'M ONLY HERE FOR ONE DAY..."

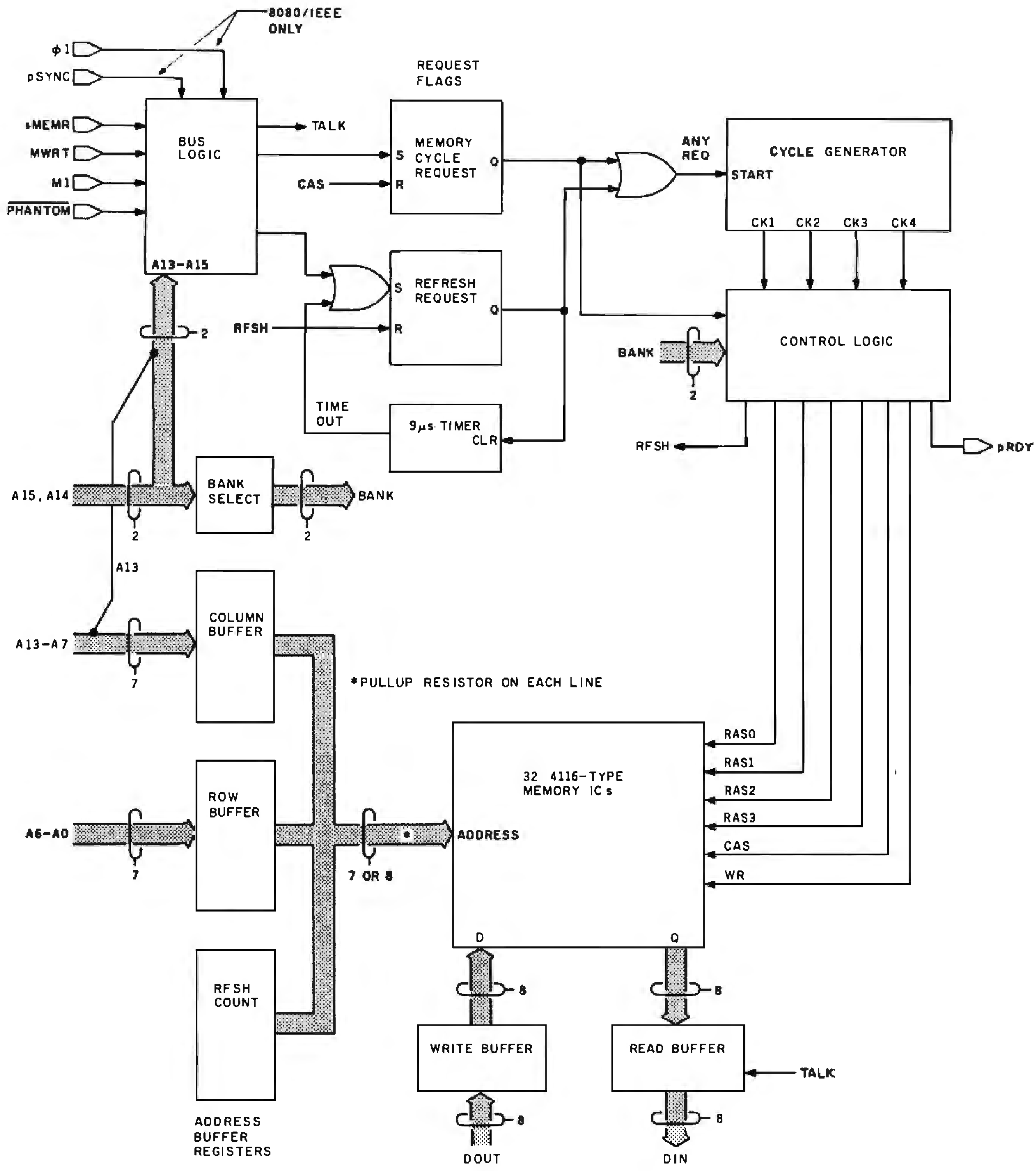



**Figure 3:** *A block diagram of the 64K-byte dynamic memory board.*

0.1-microfarad (μF) ceramic capacitors prevent the memories from injecting more than a volt of noise onto the supplies. Such noise would keep the sense amplifiers in the memory devices from working reliably.

Inputs from the bus are translated into refresh-cycle requests by the block labeled Bus Logic in figure 3 (see figure 4, page 320, for the specific TTL involved) and into $\overline{\text{TALK}}$, the signal that enables the output buffer (labeled Read Buffer in figure 3, IC24 in figure 4, page 323). Using the top three address bits, IC33 (see figure 4, page 321), a multiplexer selects one of the eight jumpers at J1 to see if the 8K-byte block addressed is enabled and generates the signal MADDR. For IEEE-696 versions of the board, status of the bus is latched (see figure 4, page 320) to ward off extra cycles and MWRT is filtered to reject noise. The resulting status signals (Z80MEMR and

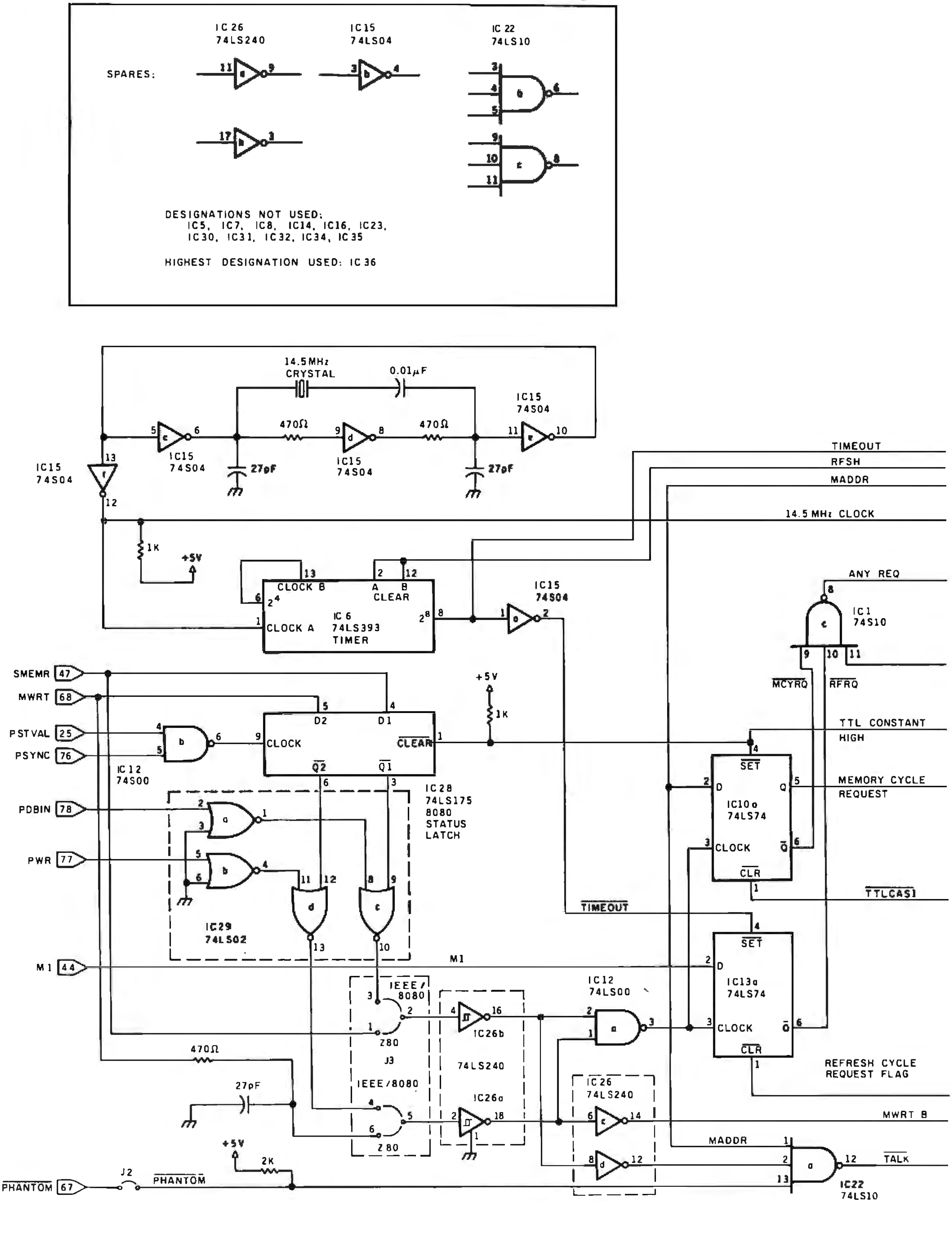
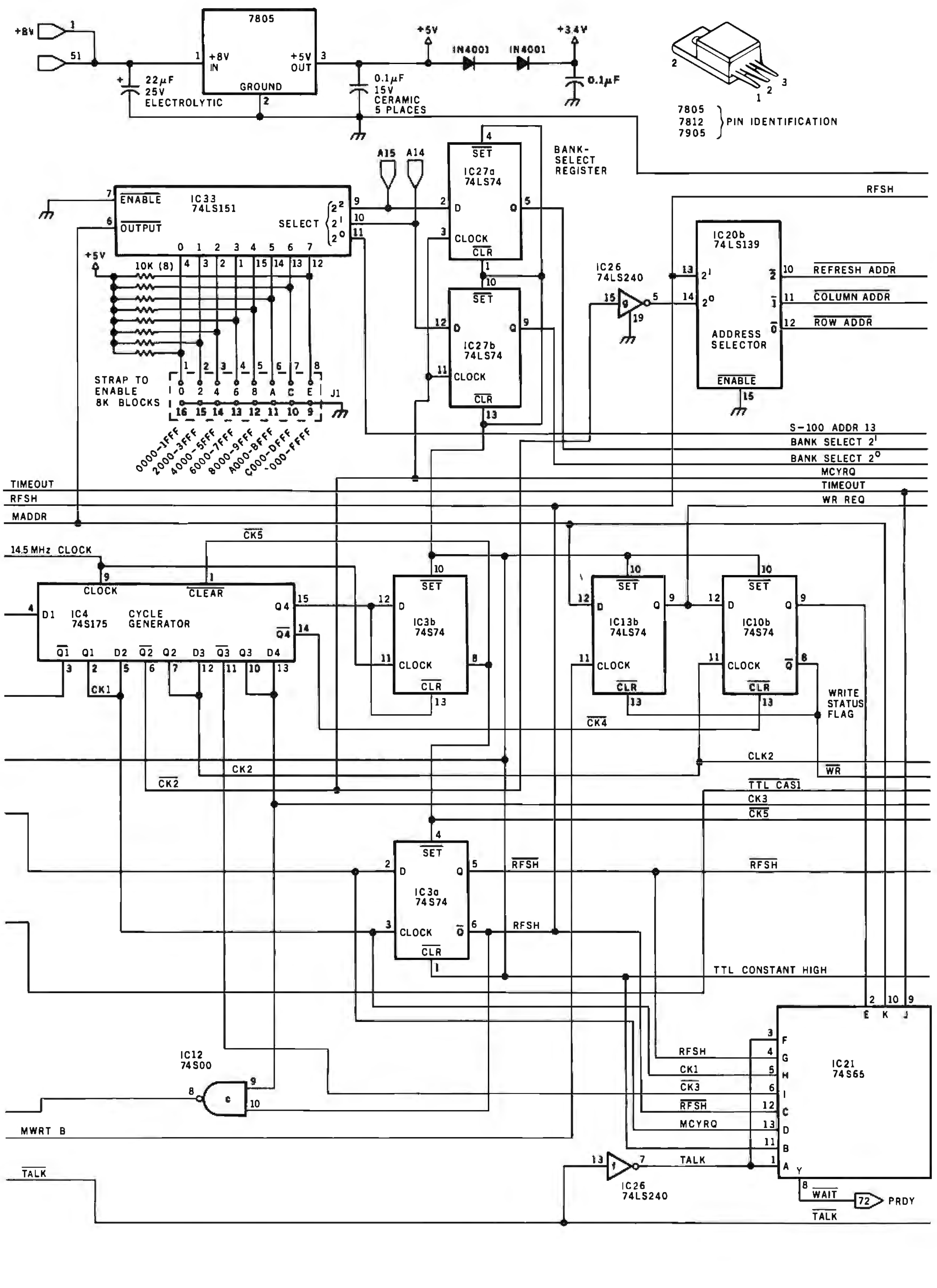



**Figure 4:** *A schematic diagram of the 64K-byte dynamic memory board (continued on page 322).*



+8V
7805
+8V IN
+5V OUT
GROUND
22μF 25V ELECTROLYTIC
0.1μF 15V CERAMIC 5 PLACES
+5V
IN4001
IN4001
+3.4V
0.1μF
7805
7812
7905
PIN IDENTIFICATION
A15
A14
IC27a 74LS74
SET
CLOCK
CLR
BANK-SELECT REGISTER
IC33 74LS151
ENABLE
OUTPUT
SELECT
10K (8)
+5V
STRAP TO ENABLE 8K BLOCKS
J1
0000-1FFF
2000-3FFF
4000-5FFF
6000-7FFF
8000-9FFF
A000-BFFF
C000-DFFF
-000-FFFF
IC27b 74LS74
IC26 74LS240
IC20b 74LS139
ADDRESS SELECTOR
RFSH
REFRESH ADDR
COLUMN ADDR
ROW ADDR
S-100 ADDR 13
BANK SELECT 2¹
BANK SELECT 2⁰
MCYRQ
TIMEOUT
WR REQ
RFSH
MADDR
14.5 MHz CLOCK
CK5
IC4 74S175
CYCLE GENERATOR
CLOCK
CLEAR
CK1
CK2
IC3b 74S74
IC13b 74LS74
IC10b 74S74
WRITE STATUS FLAG
CK4
CLK2
WR
TTL CAS1
CK3
IC3a 74S74
TTL CONSTANT HIGH
IC12 74S00
IC21 74S65
CK1
MCYRQ
TALK
IC26 74LS240
WAIT
PRDY
MWRT B

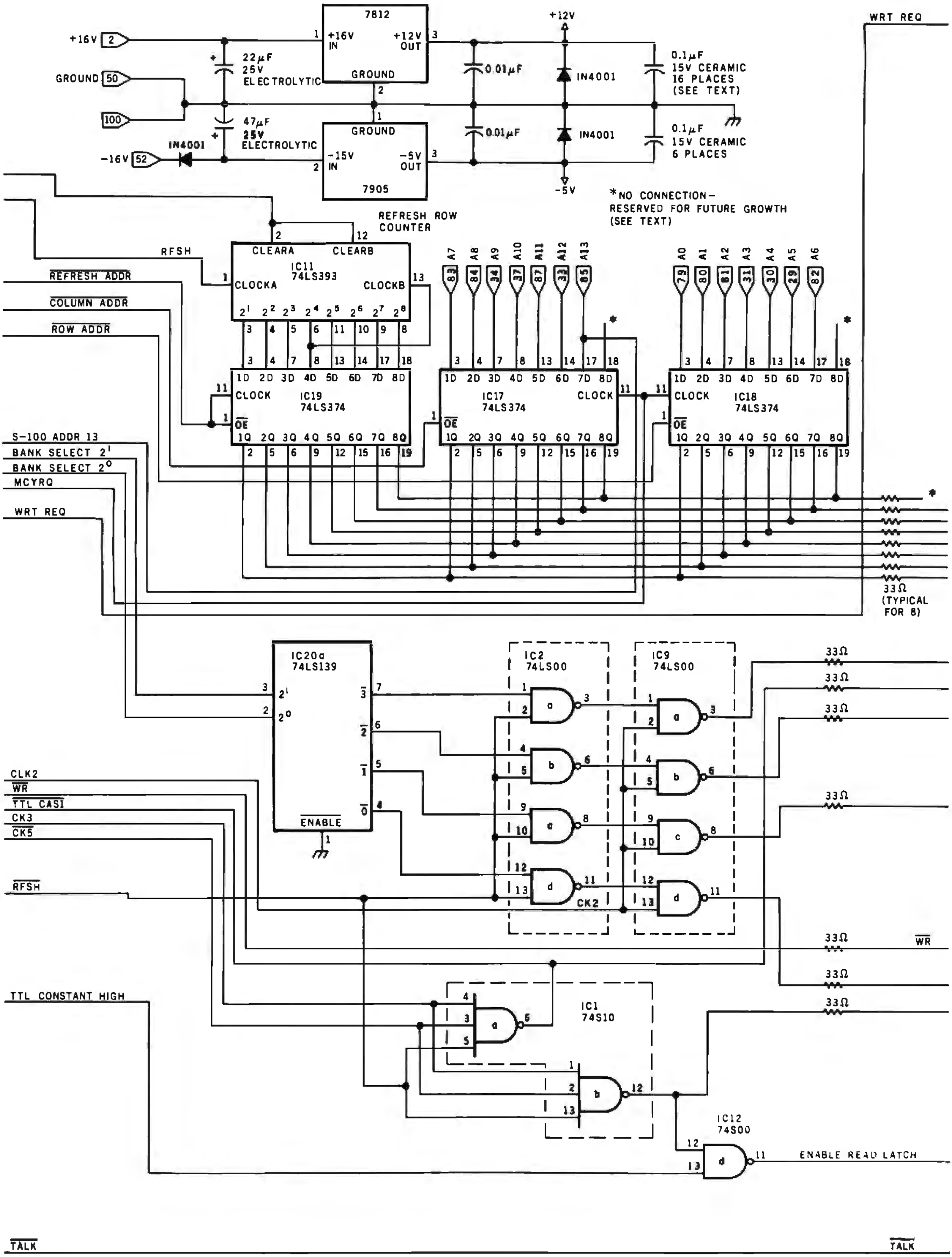
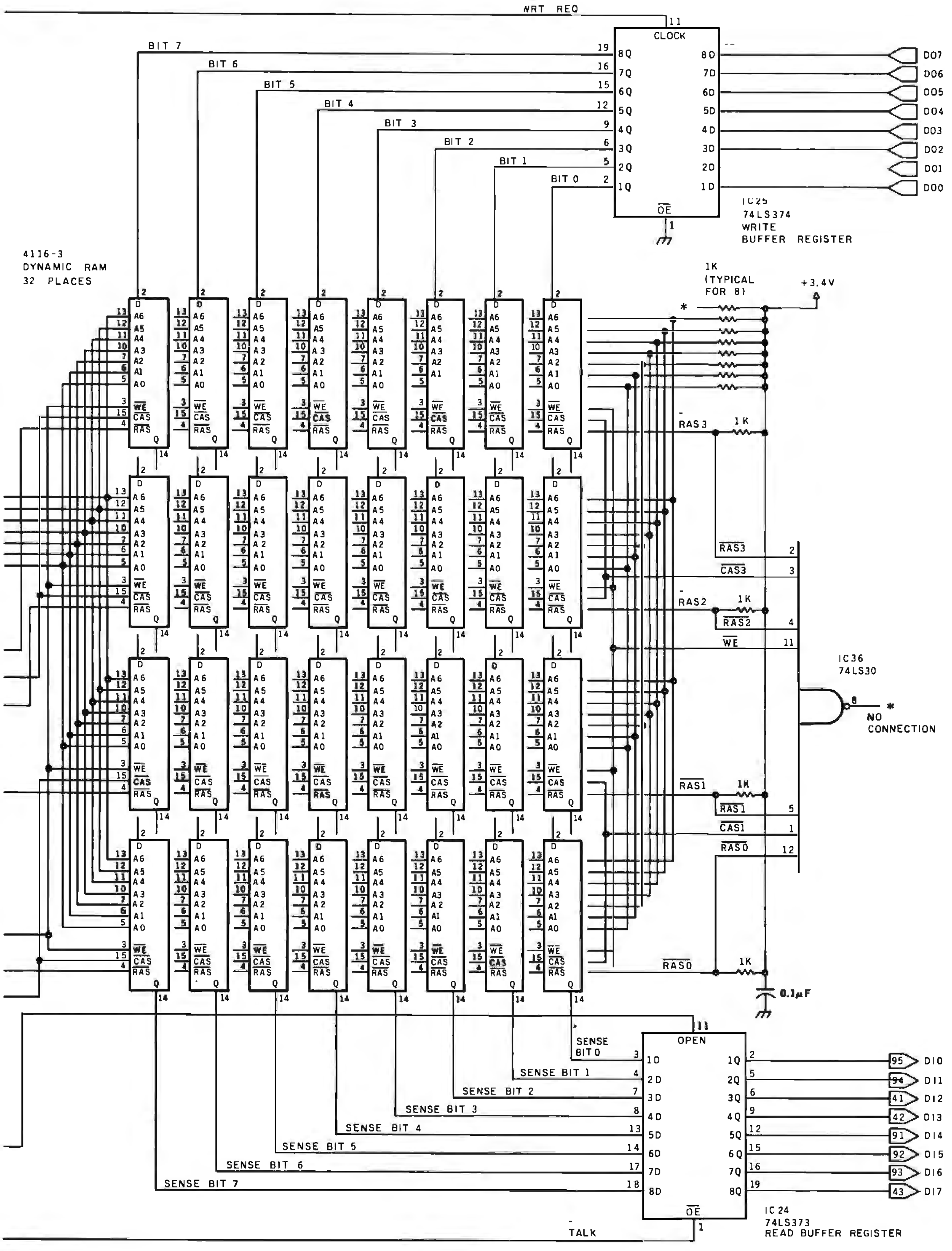



**Figure 4 (continued from page 321):** *A schematic diagram of the 64K-byte dynamic memory board.*


WRT REQ
CLOCK
BIT 7
BIT 6
BIT 5
BIT 4
BIT 3
BIT 2
BIT 1
BIT 0
DO7
DO6
DO5
DO4
DO3
DO2
DO1
DO0
IC25
74LS374
WRITE
BUFFER REGISTER
4116-3
DYNAMIC RAM
32 PLACES
1K
(TYPICAL
FOR 8)
+3.4V
RAS3
CAS3
RAS2
WE
IC36
74LS30
NO
CONNECTION
RAS1
CAS1
RAS0
0.1μF
OPEN
SENSE
BIT 0
SENSE BIT 1
SENSE BIT 2
SENSE BIT 3
SENSE BIT 4
SENSE BIT 5
SENSE BIT 6
SENSE BIT 7
DI0
DI1
DI2
DI3
DI4
DI5
DI6
DI7
TALK
IC 24
74LS373
READ BUFFER REGISTER

| Unit | Type | Function |
|---|---|---|
| 1 | 74S10 | $\overline{CAS}$ gate, $\overline{TALK}$ gate |
| 2 | 74LS00 | $\overline{RAS}$ enable |
| 3 | 74S74 | CK5, MEM/RFSH arbitration and status flag |
| 4 | 74S175 | Cycle generator |
| 6 | 74LS393 | Refresh timer |
| 9 | 74S00 | $\overline{RAS}$ gates |
| 10 | 74S74 | Memory request, write status flags |
| 11 | 74LS393 | Refresh row counter |
| 12 | 74S00 | "Glue" |
| 13 | 74LS74 | Write, refresh request flags |
| 15 | 74S04 | Clock |
| 17 | 74LS374 | Column address buffer register |
| 18 | 74LS374 | Row address buffer register |
| 19 | 74LS373 | Refresh address buffer register |
| 20 | 74LS139 | Bank, cycle interval decoder |
| 21 | 74S65 | $\overline{WAIT}$ |
| 24 | 74LS373 | Read data buffer register |
| 25 | 74LS374 | Write data buffer register |
| 26 | 74LS240 | Line receiver, inverters |
| 27 | 74LS74 | Bank select buffer register |
| 28 | 74LS74 | Status latch (8080, IEEE only) |
| 29 | 74LS02 | Status gate (8080, IEEE only) |
| 33 | 74LS151 | Memory address decoder |
| 36 | 74LS30 | Clamping diodes |
| — | 4116 | Dynamic memories |
| — | 7805 | Logic supply |
| | 7812 | RAM power supply |
| | 7905 | RAM substrate bias supply |

**Table 3:** *Functions of the various integrated circuits used on the memory board.*

Z80MWRT) are used to trigger the three request flags MCYRQ, MWRT B, and $\overline{RFRQ}$. $\overline{TALK}$ comes true when $\overline{PHANTOM}$ is false, MADDR is true, and Z80MEMR is true. $\overline{TALK}$ turns on the output bus driver.

Each of the three request flags indicates that some memory cycle is pending, and each is cleared when its cycle is accomplished. MCYRQ demands a memory-access cycle, either read or write. MCYRQ triggers all the incoming-address buffers (labeled Column Buffer and Row Buffer in figure 3; IC17 and IC18 in figure 4, page 322; and IC27 in figure 4, page 321) so that the bus need not remain stable until the end of an access cycle. MWRT B means the pending memory cycle is a write. It triggers the input-data buffer (labeled Write Buffer in figure 3, IC25 in figure 4, page 323) for the same reason. $\overline{RFRQ}$ means it's time to refresh a row in every memory on the board. $\overline{RFRQ}$ may be due to an op-code fetch or the 9-$\mu$s timer running out. (A careful examination of the timing of a 4-MHz Z80 PUSH

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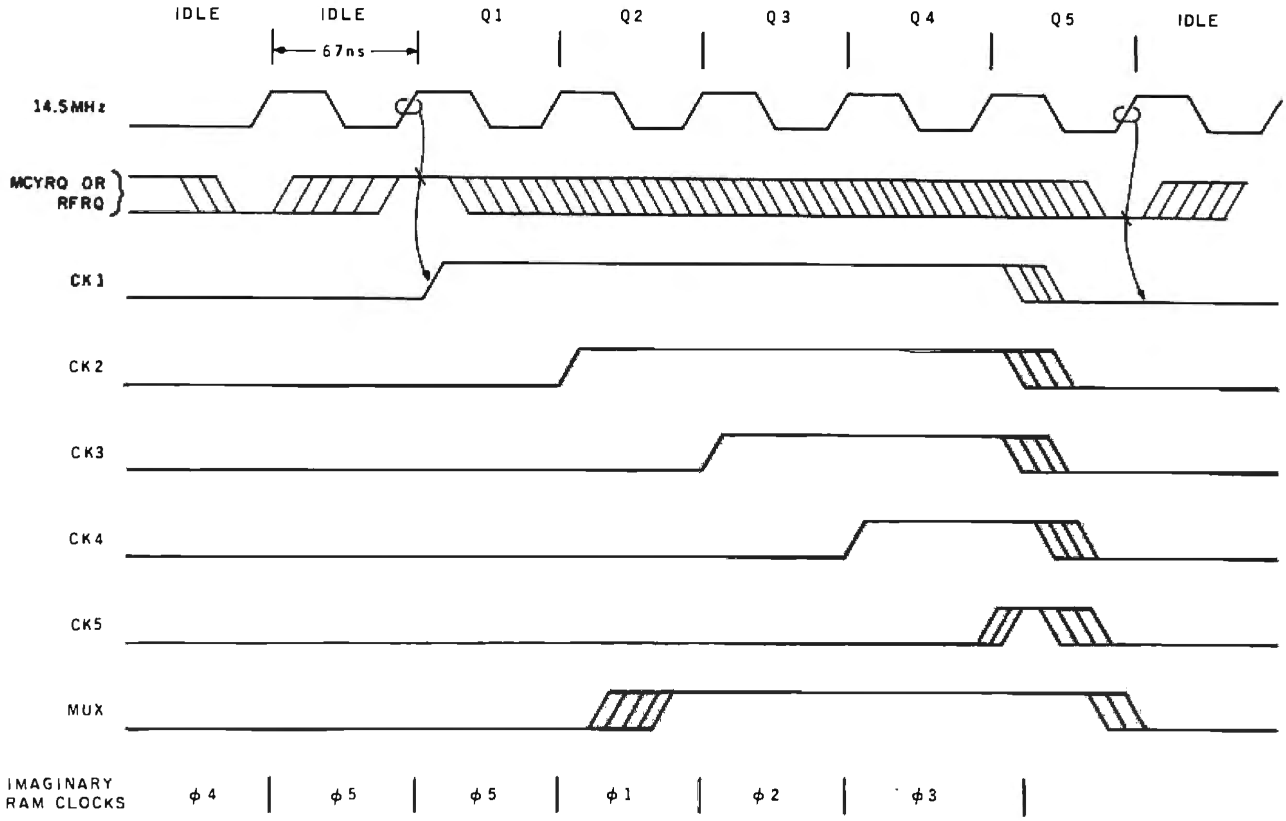
(5a)




**Figures 5a and 5b:** *Timing of signals generated on the board, as they relate to the imaginary five-period cycle. In figure 5a, the cycle begins on the leading edge of the 14.5-MHz clock while either MCYRQ (the cycle request signal) or RFRQ (the refresh request signal) are true. The fifth imaginary period is a forced idle period. Figure 5b shows an idealized read cycle.*

instruction will reveal why you *must* latch incoming address and data; in the worst case, the column address disappears from the bus just before the memories are finished sampling it.)

The 9-$\mu$s timer (IC6 in figure 4, page 320) starts running when a refresh cycle happens. After 9 $\mu$s without another $\overline{\text{RF}}$ it asserts $\overline{\text{TIMEOUT}}$ and sets an $\overline{\text{RFRQ}}$ itself. If there are op-code fetches more often than that, $\overline{\text{TIMEOUT}}$ stays inactive. In case a fast DMA transfer should "lock out" refreshes for a while, a 9-$\mu$s interval gives nearly twice as many refreshes as the memories require. It also lets you use a clock as slow as 8 MHz on this board without changing the circuit.

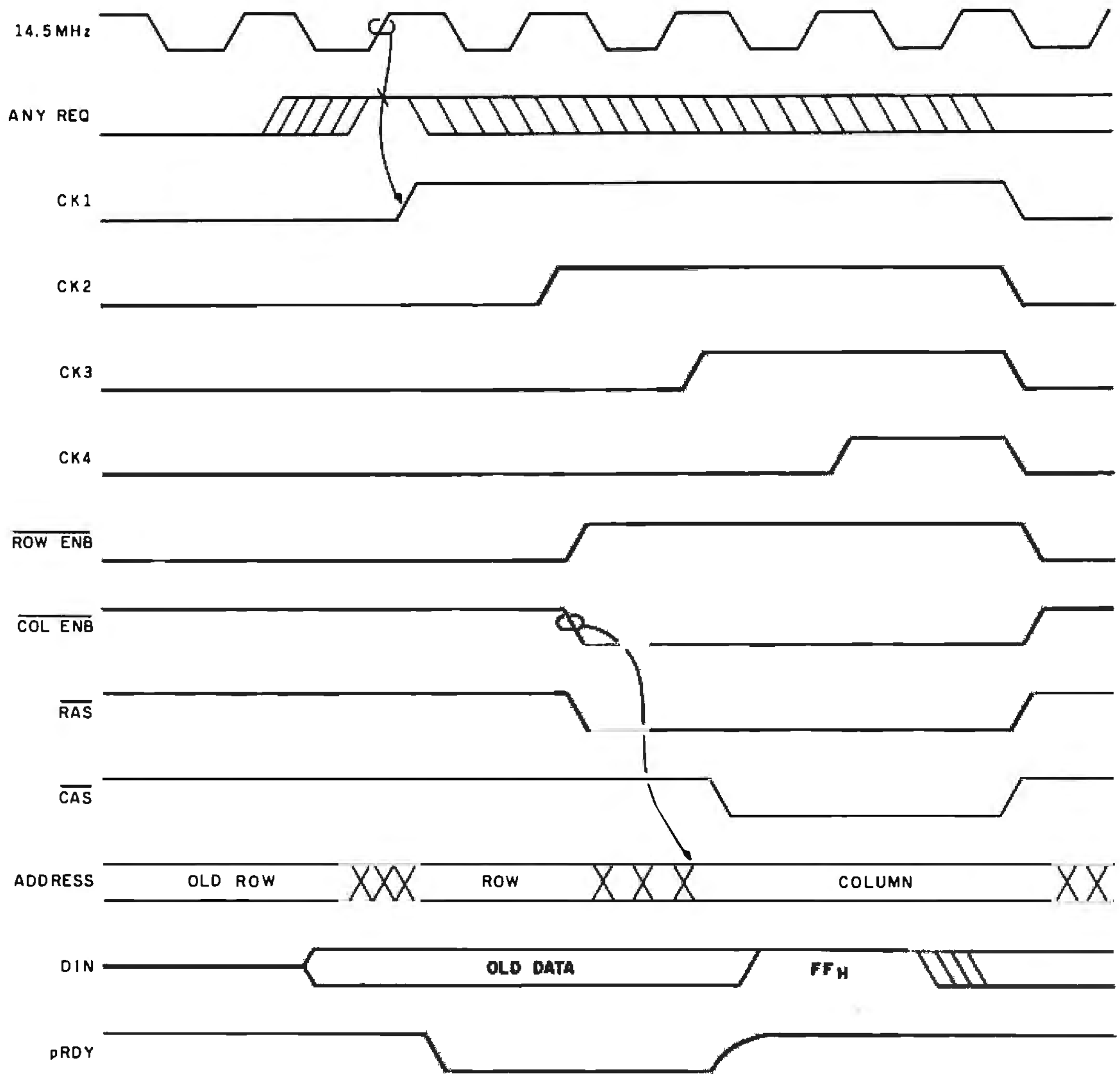
The cycle generator (IC4 of figure 4, page 321) is a shift register that fills with 1s as each cycle progresses (a "half-Johnson counter"). Figures 5a and b show the cycle generator's timing relationships. On every 14.5-MHz clock pulse, it samples ANY REQ and stores a 1 immediately if there's a request. On the fifth clock pulse, IC4 is reset by the 1 as it is shifted to $\overline{\text{CK5}}$, and the generator is ready to cycle again. The connection from $\overline{\text{CK1}}$ to the input of the cycle generator via IC1 ensures that no cycle can be aborted once it starts. $\overline{\text{CK5}}$ stretches the last phase of the cycle a little and gives a rest of at least one clock period between cycles (see figures 5a and b).

When CK1 rises, the cycle in progress may be either memory access or refresh. If the cycle is refresh, RFSH (pin 6 of IC3, figure 4, page 321) is true, and there will be no $\overline{\text{CAS}}$. All four $\overline{\text{RAS}}$ lines (figure 4, page 323) will be active. RFSH is shown in photo 2. Thus, memory accesses have priority if a refresh request and a memory access occur simultaneously.

On the next phase (CK2 rises), the write-status flag $\overline{\text{WR}}$ (see IC10 of figure 4, page 321) is triggered, and it tells the memories whether to read or write. The memories ignore this signal during refreshes because they can't write without $\overline{\text{CAS}}$.

IC11 (figure 4, page 322) counts the rows being refreshed after each refresh cycle. There are three address buffer registers: row (IC18), column (IC17), and refresh row (IC19). IC19 is used only for its three-state outputs, but it simplifies the wiring by matching the output pins of the other registers. The decoder (IC20) selects the address the memories will need next, and its propagation delay (and that of the registers) guarantees the hold time of the row address (i.e., the row address will not begin to change until 25 ns after $\overline{\text{RAS}}$ has fallen). I designed the path to allow for eight address bits to encourage users to switch to the denser 4164 memories later. The lines that end in stars on the schematic are left dangling, for now, but you should mount all the

(5b)




resistors anyway.

Because the bus won't wait once it begins a write, data is latched into the board. A refresh might be in progress when the write begins, and the data would be gone by the time the memories were ready for it if you did not include the latch (IC25 in figure 4, page 323). IC25 also isolates the bus from the long, reflection-prone lines to the memories. One commercial board I've seen omits the input buffer, hooking the memory inputs to the bus with 18 inches of printed-circuit board trace.

Data is latched coming out of the memories, too. The transparent latch, IC24, puts the data on the bus as soon as it's ready and holds it there until $\overline{\text{TALK}}$ goes away. This action makes it possible to read the board with very flexible timing, including push-button front panels, long waits, or very slow bus controllers.

The address strobes, $\overline{\text{RAS0}}$ through $\overline{\text{RAS3}}$ and $\overline{\text{CAS}}$ (see photo 3), are each gated by phases of the crystal-controlled clock. $\overline{\text{RAS}}$ is used in decoding the bank address, but all four banks receive $\overline{\text{RAS}}$ simultaneously during refresh. $\overline{\text{CAS}}$ isn't decoded because it appears only during a memory cycle. The LSTTL gate at the far end of each strobe line is used only for its input diodes, to limit the reflected pulses to a safe level.

The clock (most of IC15, figure 4, page 320) is a ring oscillator. With no crystal installed, a pulse chases itself around the ring at about 22 MHz. The crystal limits the frequency to 14.5 MHz, and the free speed of the ring limits the crystal (or it would try to run at 29 MHz). The ring has no stable logic state, so the oscillator always starts. This circuit gave me more trouble than anything else on the board but less trouble than the other two oscillators I tried first (two inverters and an Intel 8224). Do not substitute smaller capacitors, or you'll get 29 MHz, and your memory probably won't work. The 1K-byte pullup resistor and the fourth inverter improve the waveform at its rising edge, so that IC3 and IC4 (figure 4, page 321) are triggered *simultaneously*, as they must be.

The wait gate, IC21, decodes the various conditions that mean the processor is outrunning the memory. It makes the processor wait if:

1. an op code isn't ready; or
2. an ordinary read isn't almost ready (look very carefully at the refer-

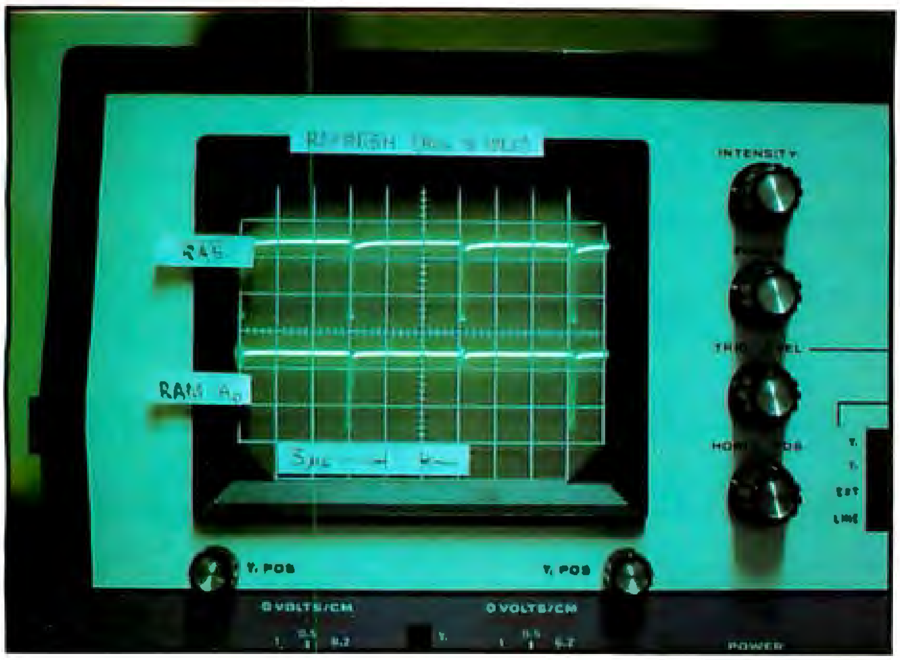



**Photo 2:** *A demonstration of the refresh timer while the bus is idle. With pRDY grounded, address line 0 is shown alternating as the refresh address is incremented.*

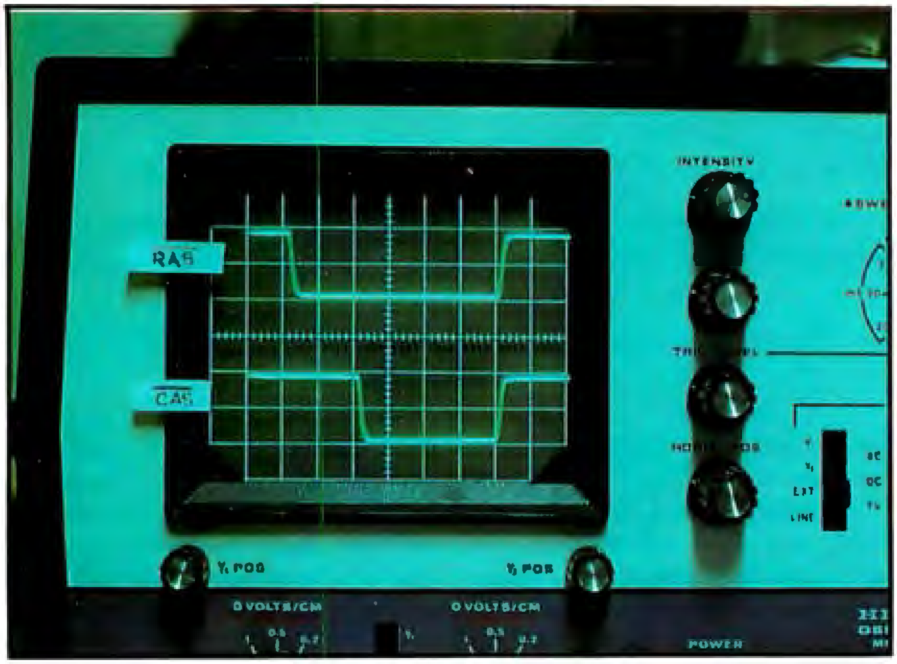



**Photo 3:** *The multiplexed address strobes. With the memory card's clock set at 4 MHz and the processor running at 2 MHz, $\overline{RAS}$ and $\overline{CAS}$ are clear and well defined (the oscilloscope is being triggered by the rising edge of CK1).*

ences and notice that both versions of the memory board sample pRDY earlier during an ordinary read than during an op-code fetch); or

3. a write is still under way, and the bus begins a read; or
4. the timer runs out, and the processor is looking our way.

Number 4 isn't that important, but it limits the occurrence of the others. The interaction between processor and cycle generator is probabilistic and hard to observe. I'd rather make an extra wait than skip a cycle. If you use Schottky devices everywhere I have specified, you'll very seldom get wait states at 4 MHz.

## Next Month

Once the general operation of the board is understood, all that remains is to order the parts and proceed with construction. Of course, the cost advantage of this build-it-yourself project may be completely negated if proper construction techniques are not followed. In the conclusion of this article next month, I will detail the proper building procedures and attempt to smooth out some of the rough spots that experimenters may run into. Remember, if you build the circuit carefully, you will have a dependable memory board that will serve you for years. If you rush, or buy "untested" parts, you may end up with an expensive puzzle, or even fireworks. ■

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### Acknowledgments

*Jim Cooley, Ben Slade, Les Newcastle, and Ed Criscuolo tested the new board in their S-100 machines. Thanks to their courage, I can claim the card works in systems with SD Sales' 2-MHz computers and in the Netronics Explorer 85. It also works in my system with a Z80 running anywhere between 125 kHz and 4 MHz.*

*The good people of Litton Systems' Amecom Division, especially Jay Lancaster and Jim Cooley, put up with me while they taught me the basics of digital electronics. Jay helped with the photography. I thank you all.*

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# A Peek into the IBM PC

## Expanding the Printer Character Set

*An assembly-language program enables an Epson printer to display all 256 characters used by the IBM Personal Computer.*

**Tim Field**
**95 South El Monte**
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The IBM Personal Computer is a top-notch product that has attracted a great deal of enthusiastic support, as evidenced by the large number of hardware and software products that have been developed for it. The basic system already seems to have set the standard by which all new personal and small-business machines are being compared.

But while the Personal Computer was being designed, IBM was faced with numerous hardware and software trade-offs. IBM wanted to get the system on the market as quickly as possible, and some desirable features were omitted in order to speed up the development cycle. Thankfully, IBM put a great deal of emphasis on making the computer as flexible as possible and then published all the technical reference material about the computer that anyone could desire.

The documentation and flexibility allow the system to be easily adapted to many different uses. Also, many of the faults found by critics of the system can be easily fixed. It is one of these faults that I set out to correct.

One of the trade-offs that IBM made in speeding the Personal Computer to the marketplace was in deciding not to manufacture its own printer. Instead, IBM made an arrangement with Epson to use the MX-80 dot-matrix printer and slap on the IBM logo. By doing this, IBM saved a great deal of effort and began with a proven product.

The Epson MX-80 is a high-quality, inexpensive, dot-matrix printer with a plethora of features. The one feature that it does not have, however, is the capability to print the full IBM character set. Both the monochrome and color graphics-display options for the IBM PC provide the user with 256 characters to display. Within that set are many characters that are not normally available and that are useful for authors, mathematicians, scientists, and so on. But the Epson (IBM) printer can provide a hard-copy output of only 96 of these 256 characters.

In this article, I present a program called PR-256 that will correct this deficiency. This program requires an Epson MX-100 printer, or an Epson MX-80 with the Graftrax graphics option, to run properly. The IBM printer, because it is almost identical to the MX-80, can also be equipped with the Graftrax chip. Given one of these printers and PR-256, all 256 characters of the IBM PC are available to be printed out (see listing 1).

Unfortunately, Epson's new Graftrax-Plus graphics chip, which allows some additional capabilities including italic typefonts, is not compatible with PR-256 as it is now written. A revised version of PR-256, however, that will be compatible with this new chip should be available by the time this article appears in print. This new program will work with printers having either graphics chip. The present program listed in this article, however, will work only with the older Graftrax chip.

### Overview of PR-256

PR-256 is designed to operate as if the user had installed extra hardware in the printer. But no additional hardware other than the Graftrax graphics capability is necessary! Once the user has set up the program as described in this article, PR-256 will automatically

**About the Author**
*Tim Field has just completed his master's degree in computer science at Purdue University. His experience also includes a few years working at DEC. He is presently at work on a series of articles about the IBM PC.*

**Listing 1:** *A printout of the full IBM Personal Computer character set as produced by the program PR-256.*

| ASCII VALUE | CHARACTER | ASCII VALUE | CHARACTER | ASCII VALUE | CHARACTER | ASCII VALUE | CHARACTER |
|---|---|---|---|---|---|---|---|
| 0 | | 64 | @ | 128 | Ç | 192 | └ |
| 1 | ☺ | 65 | A | 129 | ü | 193 | ┴ |
| 2 | ☻ | 66 | B | 130 | é | 194 | ┬ |
| 3 | ♥ | 67 | C | 131 | â | 195 | ├ |
| 4 | ♦ | 68 | D | 132 | ä | 196 | ─ |
| 5 | ♣ | 69 | E | 133 | à | 197 | ┼ |
| 6 | ♠ | 70 | F | 134 | å | 198 | ╞ |
| 7 | • | 71 | G | 135 | ç | 199 | ╟ |
| 8 | ◘ | 72 | H | 136 | ê | 200 | ╚ |
| 9 | ○ | 73 | I | 137 | ë | 201 | ╔ |
| 10 | ◙ | 74 | J | 138 | è | 202 | ╩ |
| 11 | ♂ | 75 | K | 139 | ï | 203 | ╦ |
| 12 | ♀ | 76 | L | 140 | î | 204 | ╠ |
| 13 | ♪ | 77 | M | 141 | ì | 205 | ═ |
| 14 | ♫ | 78 | N | 142 | Ä | 206 | ╬ |
| 15 | ☼ | 79 | O | 143 | Å | 207 | ╧ |
| 16 | ► | 80 | P | 144 | É | 208 | ╨ |
| 17 | ◄ | 81 | Q | 145 | æ | 209 | ╤ |
| 18 | ↕ | 82 | R | 146 | Æ | 210 | ╥ |
| 19 | ‼ | 83 | S | 147 | ô | 211 | ╙ |
| 20 | ¶ | 84 | T | 148 | ö | 212 | ╘ |
| 21 | § | 85 | U | 149 | ò | 213 | ╒ |
| 22 | ▬ | 86 | V | 150 | û | 214 | ╓ |
| 23 | ↨ | 87 | W | 151 | ù | 215 | ╫ |
| 24 | ↑ | 88 | X | 152 | ÿ | 216 | ╪ |
| 25 | ↓ | 89 | Y | 153 | Ö | 217 | ┘ |
| 26 | → | 90 | Z | 154 | Ü | 218 | ┌ |
| 27 | ← | 91 | [ | 155 | ¢ | 219 | █ |
| 28 | ∟ | 92 | \ | 156 | £ | 220 | ▄ |
| 29 | ↔ | 93 | ] | 157 | ¥ | 221 | ▌ |
| 30 | ▲ | 94 | ^ | 158 | ₧ | 222 | ▐ |
| 31 | ▼ | 95 | _ | 159 | ƒ | 223 | ▀ |
| 32 | | 96 | ` | 160 | á | 224 | α |
| 33 | ! | 97 | a | 161 | í | 225 | ß |
| 34 | " | 98 | b | 162 | ó | 226 | Γ |
| 35 | # | 99 | c | 163 | ú | 227 | π |
| 36 | $ | 100 | d | 164 | ñ | 228 | Σ |
| 37 | % | 101 | e | 165 | Ñ | 229 | σ |
| 38 | & | 102 | f | 166 | ª | 230 | µ |
| 39 | ' | 103 | g | 167 | º | 231 | τ |
| 40 | ( | 104 | h | 168 | ¿ | 232 | Φ |
| 41 | ) | 105 | i | 169 | ⌐ | 233 | Θ |
| 42 | * | 106 | j | 170 | ¬ | 234 | Ω |
| 43 | + | 107 | k | 171 | ½ | 235 | δ |
| 44 | , | 108 | l | 172 | ¼ | 236 | ∞ |
| 45 | - | 109 | m | 173 | ¡ | 237 | φ |
| 46 | . | 110 | n | 174 | « | 238 | ε |
| 47 | / | 111 | o | 175 | » | 239 | ∩ |
| 48 | 0 | 112 | p | 176 | ░ | 240 | ≡ |
| 49 | 1 | 113 | q | 177 | ▒ | 241 | ± |
| 50 | 2 | 114 | r | 178 | ▓ | 242 | ≥ |
| 51 | 3 | 115 | s | 179 | │ | 243 | ≤ |
| 52 | 4 | 116 | t | 180 | ┤ | 244 | ⌠ |
| 53 | 5 | 117 | u | 181 | ╡ | 245 | ⌡ |
| 54 | 6 | 118 | v | 182 | ╢ | 246 | ÷ |
| 55 | 7 | 119 | w | 183 | ╖ | 247 | ≈ |
| 56 | 8 | 120 | x | 184 | ╕ | 248 | ° |
| 57 | 9 | 121 | y | 185 | ╣ | 249 | ∙ |
| 58 | : | 122 | z | 186 | ║ | 250 | · |
| 59 | ; | 123 | { | 187 | ╗ | 251 | √ |
| 60 | < | 124 | \| | 188 | ╝ | 252 | ⁿ |
| 61 | = | 125 | } | 189 | ╜ | 253 | ² |
| 62 | > | 126 | ~ | 190 | ╛ | 254 | ■ |
| 63 | ? | 127 | ⌂ | 191 | ┐ | 255 | |

load into the IBM system whenever power is turned on and will reside in memory until power is turned off.

Whenever a user program sends any characters to the Epson to be printed, PR-256 will wake up and cause the appropriate characters to be printed out. Whether you are running a BASIC program, a Pascal program, an assembly-language program, or even executing a Print Screen function, PR-256 will automatically step in and cause the proper characters to be printed. PR-256 operates with a minimum of user intervention. Generally, once it has been set up as described below, the user need not even know that it is there.

PR-256 is an assembly-language program requiring the IBM Macro Assembler to assemble and link. It requires just over 2K bytes of RAM (random-access read/write memory). It will load up in the lowest available area of memory automatically and will not affect DOS (disk operating system) operation. If your IBM has 64K bytes or less of RAM, PR-256 will take away from the amount of memory available to BASIC. But if you have more than 64K bytes, you will rarely (if ever) miss the memory occupied by PR-256. In that case, PR-256 will probably be stored outside of the 64K bytes that are used for BASIC.

For the remainder of this article I will be talking about PR-256 in detail. In order to understand how the program works within the IBM system, I must first discuss three different areas relating to the program interface. The first topic is the interrupt structure of the 8088 microprocessor and how the IBM BIOS (basic input/output system) software uses this structure. Second, we will look at interfacing with DOS to set up PR-256. Finally, we will deal with the MX-100. (I will use the term MX-100 throughout the article to signify both the Epson MX-100 and either the IBM printer or the MX-80 with the graphics option.)

After covering these peripheral topics (no pun intended), I shall delve into the inner workings of PR-256.

## 8088 Interrupt Structure

The interrupt structure of the 8088 microprocessor is really the tie that binds the IBM system together. It is analogous to the human spinal column in its function. Essentially, the system of hardware and software interrupts provides the mechanisms that are necessary to coordinate the various operations of the computer.

An interrupt is an input into the processor that causes the current sequence of operations to be momentarily broken and some special action to be taken. Generally, these have been hardware mechanisms that simply allow the execution flow of a processor to be temporarily "interrupted" so that some pressing matter can be attended to by the processor. Interrupts for microprocessors have been used primarily by hardware designers. An interrupt was signaled by "pulling" a pin on the microprocessor chip low (or high). This allowed various off-chip functions to be monitored and controlled by the processor.

Intel designed into the 8088 a very flexible interrupt structure that the IBM computer puts to good use. Intel gave us 256 interrupts with which to work. And these are accessible through both hardware and software. Intel set aside some 32 of the 256 interrupts for predefined use (e.g., "Divide by Zero," "Nonmaskable Interrupt," etc.). But the remaining 224 interrupts are available to the system designer for software use.

To invoke these software interrupts, the 8088 has a special INT instruction in its repertoire. In

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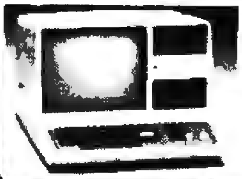

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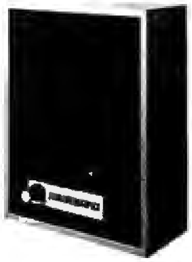

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assembly-level code, this instruction is followed by a 1-byte *interrupt value*. The value of that byte determines which of 256 interrupts the processor should invoke.

In order for these interrupts to be used or *serviced*, the user must provide an interrupt-service routine for each of the possible interrupts that may occur. When the 8088 processes an INT call, its hardware looks at the second byte (with the interrupt value in it) and determines where the appropriate interrupt-handling routine is to be found. To accomplish this, Intel has reserved the memory locations from 0 to 1023 for interrupt use. This area of memory is called the *interrupt vector table*.

These 1024 bytes of memory are partitioned off into 4 bytes per interrupt type (i.e., 256 interrupt types × 4 = 1024 bytes). The 8088 hardware takes the interrupt value, multiplies it by 4, and accesses the 4-byte area reserved for this interrupt. In these 4 bytes, the 8088 expects to find the address of the appropriate interrupt-service routine.

The address is stored in these 4 bytes in standard 8088 format. That is, the first 2 bytes of the 4-byte section must contain the program-counter address (IP register) for the interrupt-service routine, and the second 2 bytes must hold the new Code Segment register (CS register) address. From these two values, the 20-bit service-routine address is determined and processor execution continues at that location.

All this work is done automatically by the 8088 hardware. Therefore, if you have previously set up the table of interrupt vectors (the 0 to 1023 bytes containing the service-routine addresses) and you execute an INT instruction, the next instruction that will occur is at the start of the service routine. This call is very similar to a normal subroutine call in that the CS and IP registers are saved on the system stack at the time of the INT call. In addition, for interrupts, the Flag register is also saved on the stack. After the interrupt routine has executed, an IRET (Interrupt Return) command restores the proper IP, CS, and Flag registers, and returns control to the instruction following the INT call.

At this point you are probably saying, "So what! What do I care about all of this?" The vital point is that the designers of the IBM system made extensive use of this setup. Virtually all interaction between processes in the IBM are performed via interrupt calls.

When BASIC executes a FILES instruction to get a listing of the system disk, it sets up certain parameters in the 8088 internal registers and issues an appropriate interrupt to perform the requested function. Likewise, when DOS is requested to list the directory of a disk, it executes the same interrupt request as BASIC did. In either case, when the interrupt returns, the directory of the disk has been read and printed to the screen.

IBM provides the assembly-language programmer many utilities through the use of the interrupt structure. In its *Technical Reference Manual*, IBM states that "access to the BIOS function is through the 8088 software interrupts. Each BIOS entry point is available through its own interrupt, which can be found in the (supplied) interrupt vector listing."

The BIOS routines are basically a group of utilities available to the user. Through BIOS, you can perform disk, cassette, video, keyboard, printer, and communications I/O operations in a standardized manner. Other system services available include time-of-day and memory-size determination. IBM states, "the goal is to provide an operational interface to the system and relieve the programmer from concern over hardware device characteristics."

The extensive use of the interrupt structure gives us users of the IBM system another big benefit in addition to easy access to various utilities. Whereas the actual BIOS code resides in ROM (read-only memory), the interrupt vector table (remember, the memory locations 0 to 1023 reserved for interrupt addresses) is in RAM. These addresses are initialized by the IBM bootstrap routine on each system reset or power-on. This means that the user can change the interrupt-service addresses stored in this table after the system initialization process has finished.

How can we put this knowledge to good use? Well, there are many possibilities. For example, suppose that we want to read and store data to a cassette using a different format than that defined by IBM. (Perhaps we would like to be able to read a format used by some other system.)

The format is determined in software, and because all processes that access the cassette will use the CASSETTE_IO routine supplied in the BIOS, we simply need to overlay or replace IBM's routine with one of our own. As we have just seen, replacing the address in the interrupt vector table of a BIOS routine with the address of our own routine is effectively the same as replacing the whole routine with our own.

In order to accomplish this, we must do several things. First, we must determine the input and output parameters specified in IBM's BIOS cassette routine. In its *Technical Reference Manual*, IBM provides a complete listing (with excellent comments) of the 8K-byte BIOS.

Looking over the BIOS listing for the CASSETTE_IO routine, we can set up the appropriate interface with all calling routines. We can then rewrite the BIOS routine, making sure that all parameter inputs and outputs are the same as for the IBM version. We can then load our routine into RAM, change the interrupt-vector-table entry for the cassette routine so that it addresses our routine, and tell DOS to keep our program in RAM. From then on, as long as the system is not reset, any call from BASIC to save data or programs to cassette, or read from cassette, goes through our routine rather than IBM's. We have managed to replace the ROM version with our own.

The preceding example is exactly the method used by PR-256 to expand the character set on the MX-100 to the full 256 characters defined by the IBM computer. Whenever the IBM is powered on or reset, the program is automatically loaded into RAM and the BIOS PRINTER_IO routine is virtually overlaid by changing the



*Text continued on page 338*

interrupt-vector-table address to address the new program. Because all output to the printer will probably be routed through the BIOS PRINTER_IO routine, the new program has full control over each character that is sent to be printed.

## DOS Notes

In this section, I will discuss some basic principles of DOS that we will need to use in order for PR-256 to work correctly. DOS, the disk operating system for the IBM computer, is a collection of programs that interface the user to the system. For an in-depth discussion of DOS, IBM's *DOS Manual* provides all the necessary details, especially in the appendixes.

PR-256 must handle three interfaces to DOS. First, we would like DOS to automatically load the print program when the system is initially turned on or reset. Second, we need DOS to give the initialization code of PR-256 control to set up the printing program for execution. Third, during the initialization of PR-256, we need to tell DOS that the area in memory that the program occupies should not be overlaid during system operation. In order to understand how this is all accomplished, a short discussion of the inner workings of DOS is in order.

Let's begin by looking at an overview of what DOS must do when the system is initially powered on (or reset). DOS begins by executing a series of initialization routines that check the equipment status of the system (i.e., how much memory is installed, how many drives, what type of monitor, etc.). This check is followed by an initialization of any attached devices, setting up the interrupt vector table, and an assortment of other jobs that are necessary to get the system ready for operation.

After the initialization phase is completed, DOS loads a file from the system disk called COMMAND.COM. (A system disk is the one that has the proper files on it to permit you to load and start up DOS.) If you look at any of your system disks, you will find a file by that name. It is the code in this file that acts as a *command processor*. Essentially, all communication with DOS will be handled by COMMAND.

When COMMAND is executed, it does various and assorted tasks before issuing the first user prompt. One of these first tasks is to check for a file called AUTOEXEC.BAT on the system disk. This is a special file. The extension ".BAT" indicates that the file is a batch file, which means that its contents are read and executed as if a user were typing at a keyboard. Thus, if you include a line that says DIR in a batch file, a directory of the currently selected disk will be displayed on the screen just as if you had typed in the DIR command at the keyboard.

The "AUTOEXEC" portion of the name indicates that this is a file that is to be automatically executed whenever the system is started. With this facility, the user can cause programs or DOS commands to be executed immediately every time the system is started. If the file is not present, COMMAND continues on. If the file exists, however, COMMAND loads and processes the file as a normal batch file. The AUTOEXEC file is set up by the user. We will use this feature to load and initialize PR-256 every time the system is started.

After COMMAND finishes its initial tasks, it prompts the user with the familiar A> and then looks to the keyboard for user input.

Let us take a closer look at how we can use AUTOEXEC. PR-256 needs to be loaded into RAM and then must do a little setup before it is ready to operate. Because PR-256 exists on the disk as an assembled and linked machine program, all that is required of AUTOEXEC is to request "PR-256." COMMAND will see this as it processes AUTOEXEC and will go to the default drive, where it will find the file called PR-256, load it, and initiate execution of the file.

It appears that loading PR-256 and initializing it are fairly simple to do using DOS. However, we would like to return to DOS after PR-256 initialization is finished. To accomplish this, we must work through a special area of memory called a Program Segment Prefix buffer or PSP. The PSP is a special data structure that COMMAND builds for any process before it loads and starts up that process. This is simply 256 bytes of RAM set aside for various communication protocols with DOS. For example, if you have a program that needs to do some disk I/O, portions of the PSP are set up to permit DOS to do the actual I/O transfers.

We need concern ourselves with the PSP for only two things. First, we need to realize that it is there. When DOS loads in PR-256, it will set up a PSP in the lowest available RAM space and will then load PR-256 in the RAM area immediately following the PSP. Thus, our program actually grows by 256 bytes in order to make room for the PSP.

The second reason is as follows: When DOS loads in a program and gives it control to execute, DOS expects to gain control back eventually. And it has to have a standard way to get this control. DOS expects the user program to issue a special interrupt call when it is ready for DOS to regain control of the system.

Three different interrupts may be used to start up DOS again. An INT 20H is the normal way to exit from a program. An INT 27H is an "End but stay resident" command. This is what we shall use. It tells DOS that the program is to remain in the system and that DOS should take care not to move some other program on top of this one. The third interrupt is a special INT 21H that we will not be concerned with here.

IBM warns in the *DOS Manual* that "every program must ensure that the CS register contains the segment address of its Program Segment Prefix control block prior to issuing INT 20H (or INT 27H or INT 21H)." This is necessary because DOS saves certain state values and other information in the PSP and, for proper termination of the program, must access these.

Now this is a tricky problem. When DOS sets up the PSP and loads in the program, it sets the CS register to the "paragraph" at the start of the program, not the start of the PSP. (A paragraph in this context refers to the 16-byte "granularity" or increment that the CS register is able to address in the 8088.) When the program finishes execution and issues the INT 27H to return control to DOS, it must somehow move the correct value into the CS register.

Thankfully, COMMAND gives us an easy way out. When the PSP is initially built, COMMAND places an INT 20H instruction into the first 2 bytes of the PSP. In order for PR-256's initialization routine to return control to DOS, the user program can issue a jump instruction to the first byte of the PSP. We can construct the jump in such a way that it will replace the CS register with the proper segment address for the PSP. The resulting INT call has the proper CS value and DOS comes back online.

The astute reader will have noticed that the PSP contains an INT 20H command and we need an INT 27H executed. We simply alter this instruction during initialization of PR-256 and everything works great.

### PR-256 Initialization

We have two fundamentally different tasks for PR-256 to do. First, it must set up the interrupt vector table and return to DOS control. This task has to be done only once, when the program is initially given control by COMMAND. This is called the initialization process or phase. The second task is to intercept all output data heading toward the printer and process it to effectively give the user the 256-character set desired. This is the run-time process.

We have already discussed how to interface with DOS on system reset. I will now describe the complete initialization process of PR-256. If you look at the PR-256 listing, you will notice that the first code encountered is the initialization code. It consists simply of a call to an initialization subroutine and a return. It is within this subroutine that the initial tasks are done. I could have just as easily put this code in the main program rather than make it a subroutine, but let me explain why I did not.

When PR-256 returns control to DOS after initialization via the INT 27H command, DOS expects the internal register DX to point to the last memory address plus one, after which it is okay for DOS to overlay. Because we execute the initialization code only once, we can let DOS overlay that portion of PR-256 and we will miss nothing. Thus, by making the initialization code a subroutine, I was able to place it after all the run-time code. I could then set the DX to point to the last address of run-time code on the INT 27H call. The space occupied by the initialization subroutine is now available to DOS. This saves us a little more RAM for other uses.

The initialization routine does several things. First, it simply changes the INT 20H command in the PSP to an INT 27H. Then it replaces the interrupt vector address for INT 17H with the start of the PR-256 run-time code, saves the old vector address (for reasons discussed later), and sets up a return to DOS to keep the run-time code resident. After DOS regains control, PR-256 just lies in hiding in the system. It is invoked by any process that wishes to send a character to a printer.

### Printer Notes

So far I have discussed the 8088 interrupt structure and IBM DOS interface as far as they affect PR-256. In this section, I will present a quick overview of the Epson MX-100 and MX-80 (with graphics option) printers. Again, all references to the MX-100 are also valid for the MX-80 or IBM printer with the required Graftrax graphics option.

The Epson MX-100 printer is a dot-matrix printer loaded with features. In its normal operating mode, the MX-100 can print the standard ASCII (American National Standard Code for Information Interchange) character set. This includes the entire uppercase and lowercase alphabet, the numerals, and other standard characters in the 96-character set. In addition, the MX-100 offers a small set of "international" characters. These are subdivided into characters associated with various countries: France, Germany, England, Denmark, Sweden, Italy, and Spain. A total of 37 additional unique characters are available using these different international modes.

Finally, the MX-100 provides the user the capability of a *bit-image* mode. To understand how this works, let's look at the Epson print head. It consists of nine "needles" or "wires" stacked vertically very close together. Each wire can be caused to impact with the ribbon by the electronics in the printer. The stack of wires moves horizontally to the left or right. By causing specific wires to impact with the ribbon as the head moves along the width of the paper, the printer produces dots that form the shape of a character.

By placing the printer in the bit-image mode, the user can gain direct access to the top eight of the nine wires. A single byte sent from the computer to the MX-100 in bit-image mode will cause a single column of dot wires to act and the print head to move one column to the right. Because a byte consists of 8 bits, each bit controls one wire. The most significant bit (bit 7) activates the uppermost wire. Bit 0 activates the lowest wire. If a bit is "1," the print wire prints a dot. A "0" does not print.

Sending a stream of bytes in the bit-image mode results in a pattern being printed across the page. When putting the printer in bit-image mode (as discussed below), the user must supply a count of the number of columns to be printed. After that many columns are received, the printer leaves the bit-image mode and returns to whatever mode it was previously in.

How do we change modes in the MX-100? The user sends some non-printing ASCII code or escape sequence to the printer. The processor in the MX-100 interprets it and then acts accordingly. An escape sequence is a multibyte command string that begins with an ESC character

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| Line graphics | No | No | No | No | No | Yes | No | Yes |
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| Character/line editing | Partial | No | No | Yes | No | Yes | Yes | Yes |
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| Control Code | Hexadecimal | Decimal | Function |
|---|---|---|---|
| NUL | 00 | 0 | NULL. Ends tab setting. Follows ESC B and ESC C. |
| BEL | 07 | 7 | BELL. Sounds buzzer for about 1 second. |
| BS | 08 | 8 | Backspace. Cancels a last character input. |
| HT | 09 | 9 | Horizontal Tabulation. |
| LF | 0A | 10 | Linefeed. |
| VT | 0B | 11 | Vertical Tabulation. |
| FF | 0C | 12 | Form Feed. Advances paper to next Top of Form. |
| CR | 0D | 13 | Carriage Return. |
| SO | 0E | 14 | Shift Out. Turns on the enlarged-character printing mode. |
| SI | 0F | 15 | Shift In. Turns on the condensed-character printing mode. |
| DC1 | 11 | 17 | Device Control 1. Selects printer. Ready to receive data. |
| DC2 | 12 | 18 | Device Control 2. Turns off the condensed-character printing mode. |
| DC3 | 13 | 19 | Device Control 3. Deselects printer. Not ready to receive data. |
| DC4 | 14 | 20 | Device Control 4. Turns off the enlarged-character printing mode. |
| ESC | 1B | 27 | Escape. ASCII code for Escape. Precedes numbers and alphabets. |
| ESC 0 | 30 | 48 | Sets a line spacing to eight lines per inch. |
| ESC 2 | 32 | 50 | Sets a line spacing to six lines per inch. |
| ESC 8 | 38 | 56 | Deselects paper end detector. |
| ESC 9 | 39 | 57 | Selects paper end detector. |
| ESC A | 41 | 65 | Sets a line spacing between a range from $1/72$ inch to $85/72$ inch. |
| ESC B | 42 | 66 | Sets VT up to eight positions. |
| ESC C | 43 | 67 | Sets form length up to 127 lines or 22 inches. |
| ESC D | 44 | 68 | Sets HT up to 12 positions. |
| ESC E | 45 | 69 | Turns on the emphasized-character printing mode. |
| ESC F | 46 | 70 | Turns off the emphasized-character printing mode. |
| ESC K | 4B | 75 | Turns on the normal-density bit-image mode. |
| ESC L | 4C | 76 | Turns on the dual-density bit-image mode. |
| ESC N | 4E | 78 | Sets skip-over perforation. |
| ESC O | 4F | 79 | Releases skip-over perforation. |
| ESC Q | 51 | 81 | Sets a column length. |
| ESC R | 52 | 82 | Selects an international character set from among eight languages. |

**Table 1:** *Control codes for the Epson MX-100 printer (or the Epson MX-80 with graphics capability).*

(decimal 27 in ASCII) and is followed by a defined sequence of bytes. The printer's processor parses in the whole sequence of bytes and performs a mode change in response.

For example, to tell the printer to turn on normal bit-density mode, the user program sends the ASCII character 27 (Escape character) followed by a K. The K will not be printed. It merely tells the printer that the escape sequence is selecting the normal bit-image mode. For a summary of the control codes and escape sequences used by the MX-100, see table 1.

As many different modes are available (i.e., normal-density bit-image, dual-density bit-image, condensed-character, enlarged-character, normal-character, etc.), many different escape sequences will be accepted by the printer. Epson decided not to be modular and has designated some mode selectors to be set using other nonprinting ASCII characters rather than have all mode selection be done via escape sequences.

Several standard ASCII printer commands are used by the Epson. These include Bell (ASCII 7), Backspace (ASCII 8), Carriage Return (ASCII 13), Linefeed (ASCII 10), and so on. As I will discuss below, these special characters present some big problems for PR-256.

To summarize, the MX-100 simply looks to the computer for ASCII sequences. Most of the bytes that the printer receives are associated with some character in the ASCII set, which is then printed.

Some ASCII codes and sequences of codes are reserved by the MX-100 to allow the user to change modes of the printer. Thus, from BASIC at the IBM terminal, the user can send (using LPRINT) the proper commands to move the printer from enlarged-character mode to bit-image mode and then to normal print mode. This gives the user considerable power from software. It is just this power that PR-256 uses to enlarge the MX-100 character set to the full 256 characters used by the IBM system.

## How PR-256 Works

I have now discussed the three major components that are necessary for understanding the PR-256 program. These are the 8088 interrupt structure (and its ties with the IBM BIOS routines), the DOS interfacing required to load and initialize PR-256 at system start-up, and the MX-100 modes of operation. The remainder of this article is devoted to using this knowledge to see exactly how PR-256 operates. Numerous subtle touches are contained throughout PR-256, which I will explain as we proceed.

First, let's look at how a process running on the IBM Personal Computer normally prints out text. Any routine that wishes to print out characters to a printer attached to the IBM PC will use the BIOS PRINTER_IO routine. The operation of this routine is very straightforward. The calling process will make one call to PRINTER_IO for each character to be printed out.

The calling process must first move the character to be printed into the AL internal register of the 8088, clear the AH register, and indicate the printer number in the DX register. (Note: the IBM can be attached to as many as three parallel port printers at one time, and the user must specify which of the three printers the current character is to be directed to.)

After setting these registers up, the

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process executes an INT 17H interrupt request. This causes the BIOS print routine (PRINTER_IO) to send out the character to the printer. When it is done, the BIOS print routine executes an IRET instruction to return control to the calling process.

Instead of causing a character to be printed out, we can also use PRINTER_IO to initialize any of the printers or to check the current status of a printer. This is accomplished by placing a 1 or 2, respectively, into the AH register and executing an INT 17H call.

All programs that output data through the parallel port to a printer are supposed to use this method. IBM's BASIC, DOS, the Print Screen function, Micropro's Wordstar, and so on, all comply with this standard method. Thus, if I wish to replace the PRINTER_IO routine with my own, I had better be sure that, for any given input, PR-256 (the program scheduled to replace PRINTER_IO) will react in the same manner as PRINTER_IO would.

With this understanding of PRINTER_IO, I can outline PR-256 operation. Whenever a process executes an INT 17H instruction, PR-256 will receive control of the system. The input to the routine is identical to the PRINTER_IO routine. If PR-256 sees that a character is to be printed out, it does some processing of the character (which will be described in a moment) and takes an appropriate action that results in the IBM-defined character being printed out on the MX-100.

If the input to PR-256 indicates that a printer initialization or a status check is being requested, the requested function is carried out and the results returned to the calling process. That is all there is to PR-256. Everything else is implementation detail. Of course, the implementation details are extremely important and will be fully explored now.

### Using the PRINTER_IO Routine

One of the tenets of good programming practice is that a programmer should not constantly be reinventing the wheel. If other programmers have already done the work that you need, see if you can use their results. In the case of PR-256, it made sense to make as much use as possible of the 114-byte PRINTER_IO subroutine that IBM supplied in the BIOS.

After processing a character, PR-256 at some point must interact with the printer. Most of the time, the printer output from PR-256 will be the same as that from the PRINTER_IO routine. PR-256 simply provides some front-end work or preprocessing of certain characters. Thus, I decided early on that PR-256 would do whatever processing was required for a given character, but would use the PRINTER_IO code to do the actual data transmission to the printers.

In order to do this, the PR-256 initialization code must save the 4-byte address of PRINTER_IO that was originally stored in the interrupt vector table. This saved address is later used by the main PR-256 process as a subroutine address for doing actual printer I/O.

Note that instead of having PR-256 bother to look up and save the PRINTER_IO address every time the system was initialized, I could have coded the address into the program as a constant. This would have saved a little code and storage space. However, this would have made PR-256 more susceptible to failure if IBM made future changes in its BIOS chip.

If IBM updates its BIOS routine in some later version of the Personal Computer, the base address of PRINTER_IO could be changed. This would not affect any code using PRINTER_IO, because DOS would be updated to initialize the interrupt vector table to the correct address. But if PR-256 had the original address for PRINTER_IO coded in as a constant, it would not work on the new version. By always getting the address from the vector table, PR-256 is sure to have the correct address.

Another item worthy of note is the way in which PR-256 calls the PRINTER_IO routine. This routine was designed to execute as an interrupt-service routine and returns to the calling process via an IRET instruction. PR-256, however, cannot call PRINTER_IO as an interrupt,

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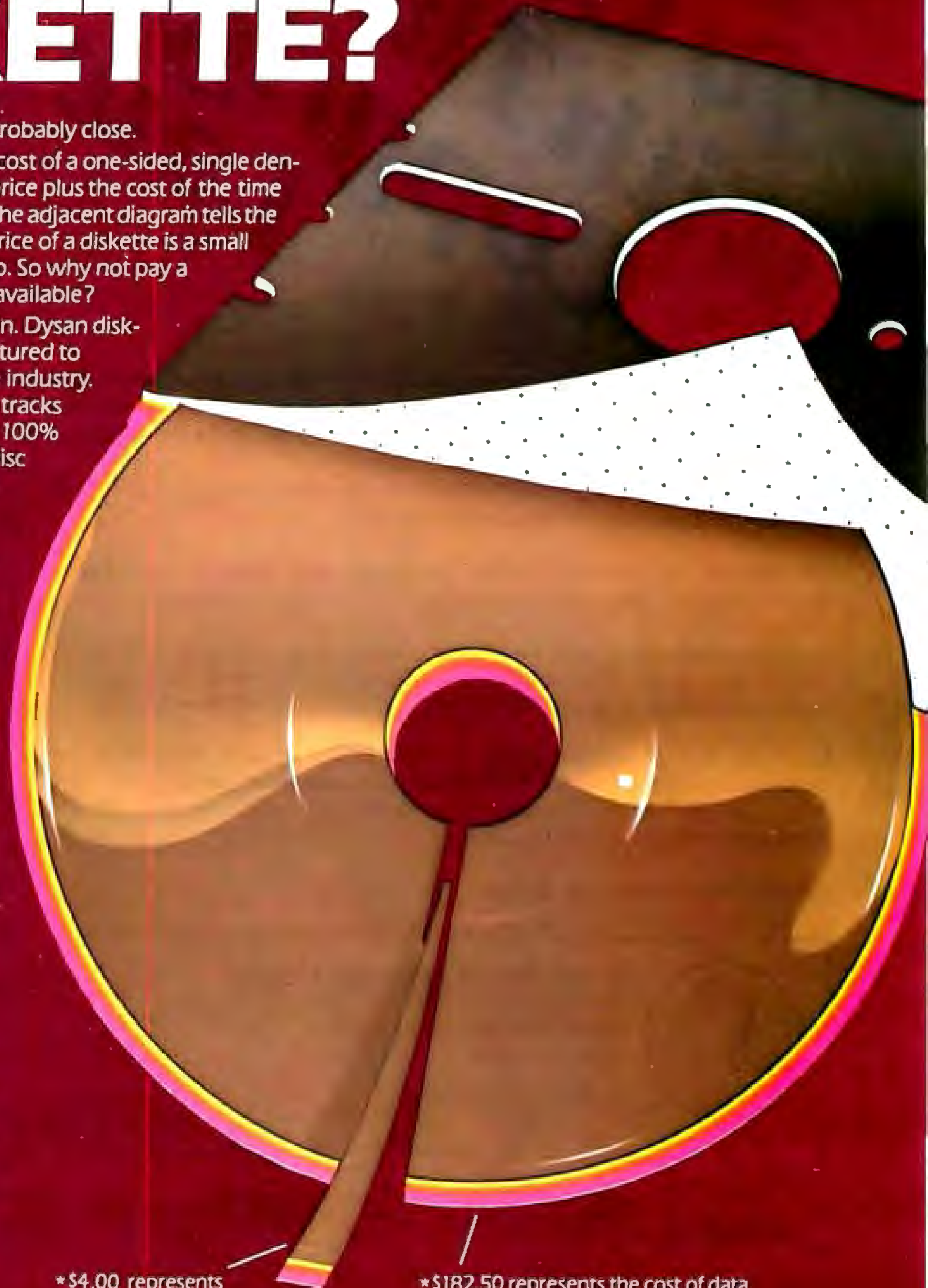

*$4.00 represents Dysan's suggested retail price for a one-sided, single density 8" diskette, packaged ten to a box. Minimum total cost of ownership = $186.50

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because it has already changed the interrupt vector table when it removed the address for PRINTER_IO.

If we look at the difference between an interrupt-service subroutine call and a standard 8088 subroutine call, we see that for a subroutine call the hardware pushes the CS and IP registers onto the system stack, while for an interrupt call it additionally pushes the Flag register onto the stack. Thus, on return from a normal call, the hardware will expect to pop off two values on a normal call, but will expect three values for an interrupt call.

If we can just keep the system stack straight across the call to PRINTER_IO, we can use it as a normal subroutine. The solution is simple. The 8088 hardware, on an interrupt call, pushes the Flag register onto the stack before CS and IP. This is great. All we have to do then is manually push the Flag register onto the stack ourselves (via a PUSHF instruction). Then we can call the PRINTER_IO routine as a normal subroutine. Upon execution completion, PRINTER_IO does an IRET that will pop off the proper sequence of words and leave the stack in good shape.

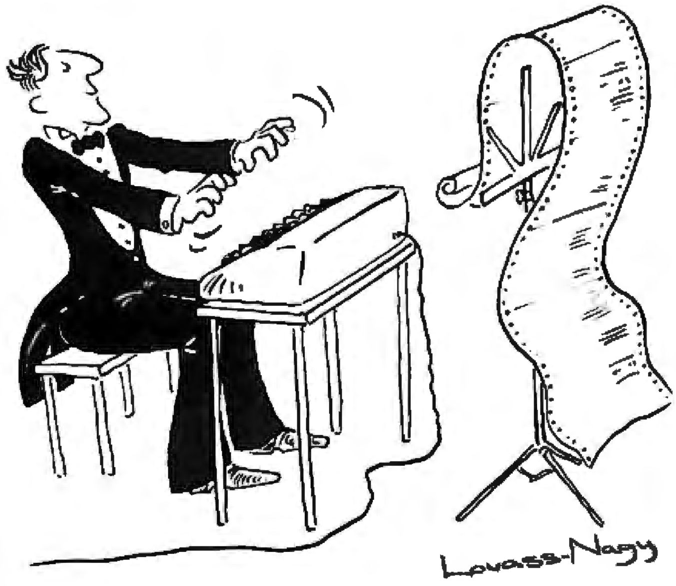
The last benefit that we get from using PRINTER_IO as a subroutine of PR-256 is that PR-256 does not need to be concerned with initialization of status checking of the printer. If PR-256 receives a request for either of these services, it immediately calls PRINTER_IO and then returns the results it receives.

## Character-Set Definition

Let's now look at the character set of the IBM computer versus that of the Epson MX-100. A close comparison study breaks the 256 characters into five categories that PR-256 must handle in different ways. I have designated these categories as *Common, International, Graphics, Extended,* and *Control.* The following text describes each category and discusses the effect each had on the PR-256 design.

## Common Characters

The first character category covers

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the Common characters. The characters of this type are the 95 characters (ASCII codes 32 to 126) that are common to both the IBM and the Epson. These are the printing characters defined by the ASCII standard except for ASCII 127, for which IBM uses a different character.

Once again, following the maxim of not reinventing the wheel, I designed PR-256 to spot any Common characters and send them on to the MX-100 as they are. They are printed using the Epson character set.

It is important that we look at how these different character types affect the performance of the MX-100. By separating Common characters out and using the Epson character set to print them, we see that PR-256 will exhibit virtually no difference in the throughput of normal text printing. The small amount of processing that PR-256 must do in order to determine that the current character is Common and then send it out to the printer is negligible compared to the speed of mechanical movement of the printer. Thus for normal text printing, PR-256 will not noticeably affect the printing speed of the Epson.

Another benefit of using the standard Epson set for Common characters is that it permits the use of all the character printing modes offered by the MX-100. Thus, for Common characters, the user can print condensed, normal, or enlarged characters. These may be emphasized or normal. All the MX-100 modes available are accessible to users through PR-256.

### International Characters

The second character category in PR-256 includes most of the 37 unique extra characters in the seven international sets available on the Epson. Of these, 30 are also part of the IBM character set. To use these, PR-256 must map the IBM codes for an International character onto the specific international set in the Epson and the code that the Epson designates for that character.

PR-256 uses a bit map to determine if the current character is an International type. The bit map is a structure of bits stored in the program such that each bit is associated with a specific ASCII code. The value of the bit identifies whether the associated character is International (if the bit is 0) or not (if the bit is 1). PR-256 uses the value of the character sent with the calling routine as an index into the bit map (identified as BITTYP in the PR-256 listing) and determines whether that character is indeed International or not.

When an International character is identified, PR-256 does a table lookup to get the Epson international set to be used and the ASCII code that the MX-100 expects for the character. PR-256 then sends a sequence of commands to the MX-100.

PR-256 first sends an escape sequence (ESC "R") followed by the desired international-set designation (0 to 7) to put the Epson in the proper mode. Next, it sends the correct 8-bit code to print out the character. Finally, it sends out the escape sequence to place the Epson back into the international-set mode that it had previously been in.

In order to reset the international set to what it had previously been in, PR-256 must "remember" the last set that the MX-100 was placed in. How it does this is discussed later in the article. But it should be noted here that, in order to allow the user to access all the Epson capabilities, PR-256 must remember the latest international set selected by the user.

To the user, the printing of an International character looks like the character was part of the Epson's normal character set. The user program simply sent PR-256 a single value and the result was that the desired character was printed out. The user does not need to know that PR-256 actually sent a total of 7 bytes of data to the printer.

The effect of the International characters on performance is minimal. Even though PR-256 sent the MX-100 7 bytes of data, 6 of them were control codes used by the printer's processor. Only one caused the slow (as measured by computer speeds) mechanical action of printing a character.

### Graphics Characters

The third classification of characters covers the Graphics characters. On the IBM PC, these characters have code values of 0 to 31, 127 to 178, and 224 to 255 (minus the International characters that are scattered throughout). These characters are not defined at all by the MX-100 and must be printed out via the MX-100 bit-image mode. When PR-256 spots a Graphics character to be printed, it takes the appropriate action to place the printer into the bit-image mode. It then sends the MX-100 a stream of bytes defining the columns of dots that will make up the character form. The Epson prints these out and then returns from the bit-image mode to its previous state.

One of the major decisions that I had to make in designing PR-256 was what size and density to make the Graphics characters. Should they be the same size as Epson's condensed, normal, or enlarged characters? Should they be emphasized or not? I could not duplicate all the MX-100 modes because it would have made PR-256 prohibitively large.

I finally decided that all Graphics characters would be the same size and density as Epson's normal-size emphasized characters. I believe that this was the best compromise. This way, they fit in comfortably with standard-size nonemphasized characters, but if you wish to print in the higher-quality emphasized mode, all the Graphics characters would fit in perfectly.

You should understand that if you place the Epson in a different mode—say the enlarged-character mode, and print out Common, International, and Graphics characters intermixed—the Common and International characters will be enlarged in size, but the Graphics ones will remain the normal size.

Having decided on using normal-size, emphasized Graphics characters, I had to analyze how Epson defines these. The MX-100 uses 12 columns to print out its normal-size emphasized characters. The first column is blank, followed by nine columns of character bits and two more blank columns. The blank columns are character separators. PR-256 follows the same strategy.

PR-256 uses the dual-density bit-image mode of the Epson to send out 12 columns of data per Graphics character. It sends out one blank column followed by nine data columns followed by two blank columns. The data columns are accessed through a lookup table to give PR-256 the correct values to define the desired character. After receiving the 12 data bytes from PR-256, the MX-100 prints them out and returns to the mode it was previously in.

The user program is completely ignorant of what has occurred. It simply sends a single character value to be printed out. The result it sees is that the character has indeed been printed. The fact that PR-256 has sent 16 bytes of data to the MX-100 (4 setup bytes and 12 printing bytes) is hidden.

What is not hidden is the degradation of printing speed. Printing of Graphics characters is slower than Common and International characters. The speed is still more than sufficient to remain practical though.

### Extended Characters

The fourth character type is the Extended type, which includes IBM character values 179 to 223. These are the drawing characters that are used to create nice connecting tables and borders. They are physically larger than the other characters defined by IBM. Extended characters are designed to connect to each other both in vertical and horizontal directions.

PR-256 handles Extended characters in much the same manner as it does Graphics characters. It simply extends the 9 data bytes of the Graphics character to cover the full 12 columns of dots allocated to each character. Thus, when printing out an Extended character, PR-256 looks at the first of the 9 data bytes for that character and prints it twice. Instead of printing a single blank column, it has extended the data column one to the left. After printing the 9 data bytes as in the Graphics mode, PR-256 retains the last byte and prints it out twice more, in place of the two blank columns printed by the Graphics mode.

By extending the character to the left and to the right, a string of Extended characters will connect in the horizontal direction exactly as they do on the IBM monitor. Unfortunately, for several reasons, it is not a simple matter to extend the characters in the vertical direction. Thus, the Extended characters are not guaranteed to connect vertically. It depends on how much space is inserted between lines. For examples of the Extended characters, see listing 2.

### Control Characters

The final category of characters known to PR-256 covers Control characters. These include the ASCII characters 0, 7 to 20, and 27. These characters, reserved by the MX-100 to change modes of the MX-100, do things like Carriage Return, Linefeed, Backspace, Tabulation, and so on.

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**Listing 2:** *Some examples of how certain graphics characters (the Extended characters) can connect together vertically using PR-256. In (2a) the printer was set at six lines per inch. The vertical lines of the box show large gaps. In (2b) the printer was set at eight lines per inch. In (2c) the printer was set at nine lines per inch. Here the characters connect together vertically and allow us to create some interesting patterns. In (2d) PR-256 is used to print out a mathematical formula. Note that the integral sign was made by vertically connecting two "hook" characters.*

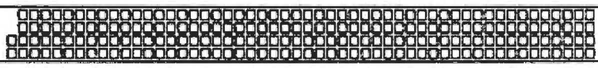
**(2a)**

```
When the printer is set to print at 6 lines per inch, the
EXTENDED characters do not connect too well vertically.
```

**(2b)**

```
EXTENDED is not bad when the printer is set at 8 lines per inch
```

**(2c)**



```
If we send an ESC 'A' sequence with a parameter value 8,
then the EXTENDED characters do connect vertically.  The
escape sequence sets a line spacing of 8/72 of an inch.
This works okay as long as we insert blank lines between
each line of text.
```

**(2d)**

$$V = \lim_{\|\Delta\| \to 0} \sum_{i=1}^{n} \pi([f(\beta_i)]^2 - [g(\beta_i)]^2)\,\Delta_i x$$

$$= \pi \int_{-1}^{2} ([f(x)]^2 - [g(x)]^2)\,dx$$

Deciding how to handle these characters was the real headache of the PR-256 design. Indeed, these characters are difficult to display, let alone print out. In BASIC, the only way to display these characters is to use a POKE command to place them into display memory.

The problem for PR-256 is that it cannot guess what the user is trying to do. When it receives an ASCII 13 character as input (Carriage Return Control character), it must decide whether the user means to execute a carriage return on the printer or print out the musical note sign that is defined by the IBM character set as value 13. It is desirable to offer the user either possibility.

The solution is to allow several different options and force the user to make the decision. In PR-256, the user has three different modes for handling these Control characters. It is vital that the different modes be understood by the user.

The first mode is the "Pass-em thru" mode, which is the default mode for PR-256. In this mode, whenever a control code is spotted by PR-256, it simply sends that character on to the MX-100. Thus, the Control character is assumed to be a control code that the printer is to receive.

The second mode is the "Print it out" mode. This assumes that any control code is to be interpreted as a printing character rather than an MX-100 control code. In this mode, PR-256 will treat the character as a standard Graphics character and print out its IBM-defined form.

The third mode is a compromise. It is the "Print all but CR & LF" mode. Notice that in the second mode, there is no way for the user program to tell the Epson to move on to the next line on the paper. In that mode, if PR-256 receives a CR character, the output will be the musical note being printed to the paper on the printer. In order to permit CR and LF printer actions, this third mode is allowed. The only valid Control characters recognized by this mode are CR (ASCII 13) and LF (ASCII 10). These are sent on to the printer. Any other Control characters are interpreted as Graphics characters and printed out as such.

So how do you go about changing control modes in PR-256? The user program must physically change the contents of a memory location within PR-256 code. The address of PR-256 must be obtained from the interrupt vector table, and the offset into PR-256 is dependent on the printer number you wish to change. (Remember, PR-256 can work with up to three printers. If you have only a single printer attached to the system, it should be set up as printer #0.) The offset into PR-256 is 12 bytes for printer 0, 18 bytes for printer 1, or 24 bytes for printer 2. The mode values are:

| Mode Type | Value |
|---|---|
| "Pass-em thru" | 0 |
| "Print it out" | 1 |
| "Print all but CR & LF" | 2 |

A sample BASIC subroutine to change these modes is presented in listing 3. The patch routine in listing 4 allows you to change the default of PR-256 to some mode other than "Pass-em thru."

A word of caution is in store at this point. If PR-256 is in the default mode of "Pass-em thru" and the user performs a Print Screen function of the BASIC screen, a problem may occur. The problem stems from the display of the function keys that BASIC puts on the screen for the user.

If you enter BASIC and look at the display of the function keys, you will notice that on the second function-key display, after the letters "RUN," is a back arrow that IBM uses to indicate a carriage return. The ASCII code for this character is 27, the same as the Escape control code used by the Epson. When PR-256 is asked to print out this back arrow (for example, when you want to print out a page of BASIC commands), PR-256 checks its internal mode. If it is in the "Pass-em thru" mode, it will interpret this character as a Control character and send it on to the Epson rather than print out the Graphics version of the back arrow. This results in the MX-100



*Text continued on page 356*

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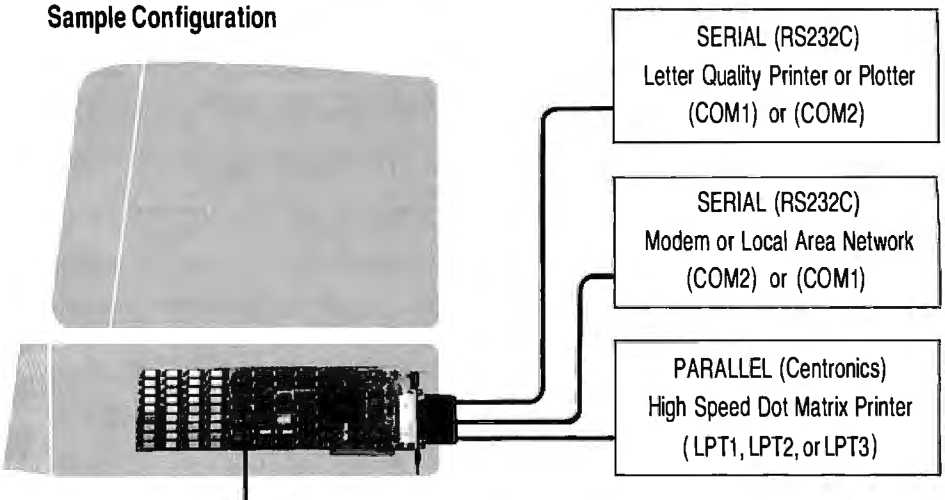


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**Comparison Chart**

| | 2 Serial ports standard | 1 Parallel port standard | I/O ports "ready-to-go"* | Electronic Disk | Print Spooler | Default Printer Toggle | Clock Calendar | Mfg. supplied cable/connectors** for all communications | Uses only 1 slot |
|---|---|---|---|---|---|---|---|---|---|
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| SEATTLE RAM+™ | | | | | | | | | NA |
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*all I/O ports factory-wired to all necessary connectors — no user modification required
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**Manual:** Illustrated 26 page manual in IBM PC owner's manual format

**Warranty:** One (1) full year on all parts and labor (second year extended warranty available)



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**Listing 3:** *A BASIC subroutine to change the printer mode.*

```
1000 ' PRINTER_MODE - this subroutine will set the printer mode in PR256.
1010 '
1020 '     INPUTS:    PRNUMB - printer number (0, 1, 2)
1030 '                PRMODE - printer mode (0 - "Pass-em thru"
1040 '                                       1 - "Print it out"
1045 '                                       2 - "Print all but CR & LF")
1050 '     OUTPUTS:   DEF SEG value is changed
1060 '
1070 DEF SEG = 0    'FIRST GET ADDRESS TO PR256 FROM INTERRUPT VECTOR TABLE
1080 INTVECT = &H17*4 'OFFSET INTO INTERRUPT TABLE
1090 TMPSEG = PEEK(INTVECT+3)*256 + PEEK(INTVECT+2)
1100 DEF SEG = TMPSEG:POKE (12+6*PRNUMB),PRMODE:RETURN
```

**Listing 4:** *A BASIC program called PATCH256. This will allow the user to have both Epson graphics printers and nongraphics printers on the same system.*

```
10 ' PATCH256 by Tim Field  June 13, 1982
20 '      This program will patch various printer configurations into
30 '      PR256 code.  This permits the user to have both Epson graphics
40 '      printers and non-graphics printers used properly on the same
50 '      system.  It also patches in the default CONTROL code mode.
60 CLS : KEY OFF : BASEADDR = 525
70 PRINT:PRINT:INPUT "Name of file containing PR256 program <PR256.EXE>";PGM$
80 IF LEN(PGM$) = 0 THEN PGM$ = "PR256.EXE"
90 IF ((INSTR(PGM$,".EXE")=0) AND (INSTR(PGM$,".exe")=0)) THEN PGM$=PGM$+".EXE"
100 OPEN PGM$ FOR INPUT AS 1:CLOSE 1
110 OPEN PGM$ AS 1 LEN = 1:FIELD 1,1 AS VALUE$
120 PRINT:INPUT "Which printer do you want to update (0,1,2)";PRNUMB
130 IF ((PRNUMB<0) OR (PRNUMB>2)) THEN PRINT "Invalid printer number":GOTO 120
140 PNMB = BASEADDR+(PRNUMB*6)
150 PRINT "Does printer";PRNUMB;
160 INPUT "contain Epson bit image capability (Y/N)";YN$
170 IF YN$="N" OR YN$="n" THEN GOTO 400
180 IF YN$<>"Y" AND YN$<>"y" THEN GOTO 150
190 ' If the printer selected has the bit image capability, we need to set
200 ' up the CONTROL character mode used by PR256.
210 CLS:PRINT:PRINT:PRINT
220 PRINT "PR256 has three different methods for handling control characters:"
230 PRINT:PRINT
240 PRINT "     1. 'Pass-em thru' - This mode sends any CONTROL character"
250 PRINT "           on to the printer as a control character.  This mode"
260 PRINT "           allows full user access to all Epson modes and functions."
270 PRINT
280 PRINT "     2. 'Print it out' - This mode interprets any CONTROL character"
290 PRINT "           as a printing character. It allows no control codes to be"
300 PRINT "           sent to the Epson."
310 PRINT
320 PRINT "     3. 'Print all but CR & LF' - This mode sees only ASCII 13 and"
330 PRINT "           ASCII 10 (carriage return and line feed) as valid CONTROL"
340 PRINT "           codes.  All other CONTROL characters are assumed to be"
350 PRINT "           printing characters."
360 PRINT:PRINT:PRINT
370 PRINT "What mode should printer";PRNUMB;:INPUT "be set into (1,2,3)";PRMODE
380 IF PRMODE<1 OR PRMODE>3 THEN GOTO 370
390 GET 1,PNMB:LSET VALUE$=CHR$(PRMODE-1):PUT 1,PNMB
400 IF YN$="Y" OR YN$="y" THEN YNVAL = 0 ELSE YNVAL = 1
410 GET 1,PNMB+1:LSET VALUE$=CHR$(YNVAL):PUT 1,PNMB+1
420 PRINT:INPUT "Any more configurations (Y/N)";YN$
430 IF YN$="Y" OR YN$="y" THEN GOTO 120
440 CLOSE 1:SYSTEM
```

entering an undesirable state.

You can get around this problem in two ways. Either you can put the printer in the "Print all but CR & LF" mode (in which case the PR-256 will print out the back arrow as desired) or you can turn off the function-key display (issue a BASIC KEY OFF statement) before printing the screen. The first method prevents you from changing any MX-100 modes while in the "Print all but CR & LF" mode. The second method removes the function-key display from view momentarily.

BASIC also presents a small problem in the "Print it out" mode. Whenever BASIC is asked to use LPRINT to print an ASCII character 13, it assumes that the user is sending the printer a carriage return command. BASIC always tacks on a linefeed (ASCII 10) following the sending of the ASCII 13 character. In "Print it out" mode, this means two characters will be printed for each LPRINT CHR$(13) command issued.

IBM's BASIC version 1.1 provides a way to get around this problem via a "random" printing mode. A printer "opened" in random printing mode suppresses the automatic linefeed after a carriage return. To set the printer into random mode, issue an 'OPEN "LPT1:" AS #1: WIDTH #1, 255.' Now the character 13 can be printed using a 'PRINT 1, CHR$(13)' command.

## PR-256 Internal Modes

If you look through the PR-256 listing (listing 5), you may notice a bunch of funny internal modes that are turned on and off. These include:

| | |
|---|---|
| FULL_INSTR | GRAF_PRINTER |
| PREV_ESC | BIT_GRAF |
| FST_BITG | SEC_BITG |
| NEW_INTL | ESC_SINGLE |
| ESC_NULL | ESC_C |

These are modes that are used to respond properly to various Epson printer modes specified by user programs.

FULL_INSTR mode is the three-way mode discussed above concerning how PR-256 handles Control characters. The three modes available in FULL_INSTR are the "Pass-em thru," "Print it out," and "Print all but CR & LF" modes.

GRAF_PRINTER mode is set by the user to tell PR-256 that the printer is not an Epson graphics printer. Because the IBM computer allows multiple printers to be attached at one time, it is reasonable to expect a business setup that would include a letter-quality printer attached to one port and an Epson dot-matrix printer on another port. The GRAF_PRINTER mode is defaulted to assume that all printers attached are the proper graphics type.

To allow the user full flexibility for setting up PR-256 in the desired configuration, I have included PATCH256, a patch program found in listing 4. A patch program simply prompts the user for configuration settings for a program and then probes into and updates the object code on the disk to reflect these settings. Anytime you change the printer configuration of your system, you can rerun PATCH256 (making sure that the disk containing PR-256 is not write protected) to reflect the new setup.

The PREV_ESC mode is set by PR-256 anytime an ESC Control character (ASCII 27) is received. (Remember that ASCII 27 is considered as a Control character only when PR-256 is in the "Pass-em thru" mode.) When the ESC character is sent to the printer, it acts as a wake-

Circle 454 on inquiry card.



Circle 455 on inquiry card.

up signal to the printer. It tells the MX-100, "Hey you, the next character you receive is going to change some operational mode."

The printer does not print out a character upon receipt of an ESC character; rather it enters an "Escape sequence receiving" mode. The next character or characters will be interpreted as Control characters and used to change some operational characteristic of the MX-100. The remaining modes mentioned above reflect different actions that PR-256 must take in response to some of these different escape sequences.

PR-256 must make sure that it distinguishes between a code sent to the Epson as an escape sequence or as a normal printing character. If the character is part of an escape sequence, PR-256 must not do any processing with that character. For example, if the code normally refers to a Graphics character, PR-256 had better not try sending 12 data bytes to the printer instead of the character value.

This means that PR-256 must retain a certain amount of knowledge of which characters have been received by any given printer. Because PR-256 will get only one character at a call, it must have the ability to store the knowledge that certain escape sequences are in the process of being sent to the printer.

PR-256 sets the PREV_ESC mode whenever it spots an ESC Control character. On the next call to print out a character, PR-256 will examine the character to determine what type of escape sequence is being sent. Depending on the particular escape sequence, different courses of action must be taken.

The ESC_SINGLE, ESC_NULL, and ESC_C modes are set by PR-256 for certain escape sequences to indicate how many more Control characters to expect. These modes do not require any action from PR-256 other than transmitting the proper number of control bytes to the printer.

ESC_SINGLE tells PR-256 to expect one more control byte. This mode is the result of ESC "A," ESC "Q," and ESC "N" sequences received by PR-256. These all send some sort of parameter byte that PR-256 is to send directly to the MX-100.

ESC_NULL tells PR-256 to send all bytes to the printer as Control characters until a NUL character (ASCII 0) is seen. The transmission of the NUL will put PR-256 back into normal printing mode. This mode is entered from ESC "D" and ESC "B" sequences.

ESC_C is set when an ESC "C" sequence is sent through PR-256. This indicates that one more byte will be a control byte unless that additional byte is equal to 0. If it is equal to 0, PR-256 should expect an additional byte after that.

The BIT_GRAF, FST_BITG, and SEC_BITG modes are related. When PR-256 receives an ESC "K" or ESC "L" sequence, it knows that the user is setting the printer into one of two bit-image modes. This escape sequence specifies that the user also send a 2-byte count of the number of byte values that the Epson is to interpret as bit-image codes. FST_BITG and SEC_BITG are used to tell PR-256 to expect the 2 consecutive bytes that form the count.

When the user puts the MX-100 into bit-image mode, all the characters sent to the printer in that mode are to be sent directly to the printer by PR-256. In other words, a code that normally refers to a Graphics character is not to be processed as such; instead, the given code should be relayed to the printer. This means that PR-256 must determine the number of characters that will be sent to the printer in the bit-image mode. PR-256 does this and then decrements the count for every character received until the count hits 0. At that point, the printer and PR-256 both revert back to normal printing modes.

The last mode is the NEW_INTL mode. This is set whenever PR-256 receives an ESC "R" sequence. This signals PR-256 that the printer is be-

ing set into a new international-character-set mode. PR-256 must intercept the mode being sent and store it for its own use. We can see the need for this if we recall how PR-256 prints out International character types.

Remember that PR-256 will temporarily change the printer's international set to print out characters in the International group. After the printing, PR-256 will restore the printer's set to what it had been previously. Thus, using the NEW__INTL mode, PR-256 can intercept and save the mode being sent and then send the mode to the MX-100.

## Conclusion

As a conclusion, I will quickly mention the steps involved in setting up PR-256 to run with your system. First, you must type in, assemble, and link the program as found in listing 5. Next, you must set up AUTOEXEC.BAT to load in PR-256 on system start-up.

The AUTOEXEC.BAT file can be set up using an editor (like EDLIN supplied with DOS) or, because the file is very short, using the DOS copy command. To use the copy command, you must be under DOS control. Simply type in "COPY CON: AUTOEXEC.BAT<ENTER>". This tells DOS to copy from the console (keyboard) into the AUTOEXEC.BAT file. You will not get any prompt back after the <ENTER> key is hit. Now, type "PR-256<ENTER>" followed by "DATE<ENTER>". End the copy session by pressing the F6 function key. DOS will save your keyboard entries into the new AUTOEXEC.BAT file and return with the normal prompt.

The next time you start up the IBM with this disk in the default drive, DOS will load PR-256 and prompt you for the current date. That is all there is to setting up PR-256.

It will be necessary for you to put copies of PR-256.EXE and the AUTOEXEC.BAT files on any system disk that you intend to boot off of. If for some reason you do not want DOS to load PR-256 for some system start-up, simply press CTRL-BREAK after you hear the power-on beep. This prevents DOS from processing the contents of AUTOEXEC.BAT.

Good luck and good printing. ■

*For those readers interested in obtaining a running version of PR-256, I have arranged to make it available for purchase. The disk contains the PR-256 source listing, the assembled and linked (ready-to-run) object code, the patch program discussed in the article, and a sample BASIC program using the different modes of PR-256. The program is fully revised to work with both Graftrax-Plus and Graftrax printers. The cost of this disk is $25. A program called NUCHAR, available for $10 extra, allows you to customize as many as 128 of PR-256's printing characters. User's manuals are included with each order. Please include $1.50 for shipping in the U.S., Canada, and Mexico ($5 elsewhere) plus sales tax in California. Send orders to Field Computer Products, 909 North San Antonio Rd., Los Altos, CA 94022, (415) 949-3457. Visa and Mastercard accepted.*

**Listing 5:** *The complete assembly-code listing of PR-256. Note that this program works only with Epson printers equipped with the Graftrax graphics option, not with the newer Graftrax-Plus option.*

```
                                PAGE
                                PAGE 64,132
                                TITLE PR256 - IBM CHAR SET FOR MX100 by Tim Field


                                ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
                                ;
                                ;   PR256...Copyright by Tim Field, 1982
                                ;
                                ;  IBM CHARACTER SET - This program resides on the IBM personal
                                ;    computer.  All 256 of the characters used by the IBM will
                                ;    be available to be printed out using the MX100 or MX80 with
                                ;    graphics option.  The non-standard characters are printed
                                ;    automatically by any process or program executing the IBM
                                ;    interrupt #17H (normal print routine in BIOS).
                                ;
                                ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;




                                ;;;;;;;;;;;;;;;;;;;;;;;
                                ;
                                ;  DEFINE CONSTANTS USED BY PROGRAM
                                ;
                                ;;;;;;;;;;;;;;;;;;;;;;;


        = 005C                     INTADDR    EQU  017H * 4       ; Address to interrupt vector addr
        = 0027                     NEWINT     EQU  027H           ; DOS interrupt code for "End but stay resident"
        = 001B                     ESC_CHAR   EQU  1BH            ; ASCII escape character
        = 0000                     NUL        EQU  0              ; ASCII NUL character

                                  ;
                                  ; Define mask bytes used to turn on and off SYS_MODE for each printer
                                  ;
        = 00FE                     MASK$BIT_GRAF   EQU  11111110B ; Printer in bit-graphics mode
        = 00FD                     MASK$SEC_BITG   EQU  11111101B ; Next char is 2nd graf char count
        = 00FB                     MASK$FST_BITG   EQU  11111011B ; Next char is 1st graf char count
        = 00F7                     MASK$NEW_INTL   EQU  11110111B ; Next char international char defn
        = 00EF                     MASK$ESC_SING   EQU  11101111B ; Expect one more control char
        = 00DF                     MASK$ESC_NULL   EQU  11011111B ; Expect control chars until NUL found
        = 00BF                     MASK$ESC_C      EQU  10111111B ; One more control char if non-zero, else 2 more
        = 007F                     MASK$PREV_ESC   EQU  01111111B ; Next char is escape defn char

                                  ;
                                  ; Define structure used to hold each of the three (possibly existing)
                                  ; printers.
                                  ;
                                   PRINTERS STRUC
        0000  00                        SYS_MODE      DB   0   ; Stores bits pertaining to current printer mode
        0001  0000                      GRAF_CNT      DW   0   ; 16 bit count of graphics chars...for bit-graf mode
        0003  00                        FULL_INSTR    DB   0   ; <0 : CR/LF mode, >0 : No control codes, =0 : normal
        0004  00                        GRAF_PRINTER  DB   0   ; =0:Printer has Epson graphics, <>0:No
        0005  00                        INTLSET       DB   0   ; 0-7 value of current international set for Epson
        0006                       PRINTERS ENDS



                                ;;;;;;;;;;;;;;;;;;;;;;
                                ;
                                ;  Define a temporary stack.  Required for initialization
                                ;  of program only.
                                ;
                                ;;;;;;;;;;;;;;;;;;;;;;

        0000                    STACK SEGMENT PARA STACK
        0000      0A [               DB   10 DUP('STACK   ')
                        53 54 41 43
                        4B 20 20 20
                                 ]

        0050                    STACK ENDS
```

*Listing 5 continued on page 362*


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Listing 5 continued:

```
                          ;!!!!!!!!!!!!!!!!!!!!
                          ;
                          ; Start code area''
                          ;
                          ;!!!!!!!!!!!!!!!!!!!!

0000                      CODE SEGMENT
                          ASSUME CS:CODE,DS:CODE,SS:STACK,ES:NOTHING

0000                      PR256 PROC FAR
                               ;
                               ; Initialization code...used only once, on system startup
                               ;
0000  E8 0783 R                CALL INIT_CODE              ; Call initialization routine
0003  CB                       RET                         ; Return from initialization

                          ;!!!!!!!!!!!!!!!!!!!!!
                          ;
                          ; Define storage areas here
                          ;
                          ;!!!!!!!!!!!!!!!!!!!!!

0004  0000 0000                DWORD_ADDR DW 0,0           ; Save address to 8135 print routine here
0008  09                       TMPBYTE    DB 9             ; A multiplicand
0009  00                       PR1        PRINTERS  <>     ; Set aside area for three printers
000A  0000
000C  00
000D  00
000E  00

000F  00                       PR2        PRINTERS  <>     ;
0010  0000
0012  00
0013  00
0014  00

0015  00                       PR3        PRINTERS  <>     ;
0016  0000
0018  00
0019  00
001A  00


                          ;!!!!!!!!!!!!!!!!!!!!!
                          ;
                          ;  Start of actual print runtime code
                          ;
                          ;!!!!!!!!!!!!!!!!!!!!!


001B                      START_UP:     ; Start of actual print routine

001B  1E                       PUSH DS                     ; Save segment register
001C  56                       PUSH SI                     ;
001D  53                       PUSH BX                     ;
001E  51                       PUSH CX                     ;
001F  52                       PUSH DX                     ;
0020  50                       PUSH AX                     ;
0021  8C CB                    MOV  BX,CS                  ;
0023  8E DB                    MOV  DS,BX                  ;
0025  80 FC 00                 CMP  AH,0                   ; Is this to print out a char?
0028  74 06                    JE   PCHAR                  ; Br if yes
002A  E8 01D4 R                CALL PR2BYTE                ; Otherwise, just print char
002D  E9 01C5 R                JMP  DONE                   ;    and exit

0030                      PCHAR:

0030  BB 0009 R                MOV  BX,OFFSET PR1          ; Now get offset to printer structure
0033  80 FA 00                 CMP  DL,0                   ; DX contains 0,1,2 for printer number
0036  74 0B                    JE   T1                     ; Br if printer 0
0038  83 C3 05                 ADD  BX,5                   ; Move to next printer area
003B  80 FA 01                 CMP  DL,1                   ; Is it printer 1?
003E  74 03                    JE   T1                     ; Br if yes
0040  83 C3 05                 ADD  BX,5                   ; Offset to printer 2 structure

0043                      T1:

0043  80 7F 04 00              CMP  GRAF_PRINTER[BX],0     ; Are we talking to a printer with Epson graphics?
0047  75 0E                    JNE  MORE$TO$COME           ; Send out char if not graphics printer
0049  8A 2F                    MOV  CH,SYS_MODE[BX]        ; Get system mode bits
004B  D0 DD                    RCR  CH,1                   ; BIT_GRAF_MODE?
004D  73 0A                    JNC  NOT$BIT$MODE           ; Br if not
                               ;
                               ; We are in bit-graphics mode...decrement mode count and send character
                               ; as is to printer.
                               ;
004F  FF 4F 01                 DEC  GRAF_CNT[BX]           ; Decrement count of graphics chars left
0052  75 03                    JNZ  MORE$TO$COME           ; Are we done with graphics mode?
0054  80 27 FE                 AND  SYS_MODE[BX],MASK$BIT_GRAF   ; If yes, clear bit to indicate done

0057                      MORE$TO$COME:

0057  EB 6F                    JMP  SHORT SENDCHAR         ; Send out bit-graf mode character

0059                      NOT$BIT$MODE:

0059  80 7F 03 01              CMP  FULL_INSTR[BX],1       ; Are we in "Full Instr Set" mode?
005D  74 0A                    JE   TO$CHKCHAR             ; Br if yes...no "control char" check
005F  7C 0B                    JL   NORM_MODE              ; Br if in normal mode
                               ;
                               ; If reach here, we are in CR/LF mode.  The only "printer action"
                               ; codes expected in this mode are CR (ASCII 13) and LF (ASCII 10).
                               ; All other ASCII values are interpreted as characters to be printed.
                               ;
0061  3C 0D                    CMP  AL,13                  ; Is Carriage Return char?
0063  74 63                    JE   SENDCHAR               ; Send to printer if yes
0065  3C 0A                    CMP  AL,10                  ; Is Line Feed char?
0067  74 5F                    JE   SENDCHAR               ; Send to printer if yes

0069                      TO$CHKCHAR:

0069  E9 0123 R                JMP  CHKCHAR                ; Else print character from character set

006C                      NORM_MODE:

006C  D0 DD                    RCR  CH,1                   ; SEC_BITG_CNT?
006E  73 11                    JNC  NOT$SEC                ; Br if no
                               ;
                               ; If reach here, the current character is the second count value for
                               ; the bit-graphics mode.  It is the high-order byte and must be added
                               ; to the low order byte which was the previous character.
                               ;
0070  88 47 02                 MOV  (FULL_INSTR-1)[BX],AL  ; Save Graf Cnt
0073  80 27 F0                 AND  SYS_MODE[BX],MASK$SEC_BITG   ; Turn off SEC_BITG_CNT bit
0076  83 7F 01 00              CMP  GRAF_CNT[BX],0         ; Is count equal zero?
007A  7E 4C                    JLE  SENDCHAR               ; If yes, don't set Bit-graf mode
007C  80 0F 01                 OR   SYS_MODE[BX],NOT MASK$BIT_GRAF; Indicate in Bit-graf mode
007F  EB 47                    JMP  SHORT SENDCHAR         ; Send out count character

0081                      NOT$SEC:

0081  D0 DD                    RCR  CH,1                   ; FST_BITG_CNT?
0083  73 0B                    JNC  NOT$FST                ; Br if not
                               ;
                               ; If this bit is set, it indicates that the last character printed out
                               ; was "Start Bit Graphics mode" indication.  The current character is
                               ; to be used as the low order byte of the count of bit-graphics characters
                               ; to be sent.  The next character expected is the high-order byte for the
                               ; count.
                               ;
0085  80 27 FB                 AND  SYS_MODE[BX],MASK$FST_BITG   ; Turn off FST_BITG_CNT bit
```

Listing 5 continued on page 366

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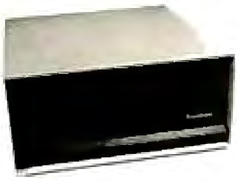

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*Listing 5 continued:*

```
0088  80 0F 02         OR   SYS_MODE[BX],NOT MASK$SEC_BITG; Turn on SEC_BITG_CNT bit
0088  89 47 01         MOV  GRAF_CNT[BX],AX               ; Save low order count
008E  EB 38            JMP  SHORT SENDCHAR                ; Send count to printer

0090              NOT$FST:

0090  D0 DD            RCR  CH,1                          ; NEW_INTL?
0092  73 10            JNC  NOT$INTL                      ; Br if not
                       ;
                       ; If this bit is set, it indicates that we previously saw request for a
                       ; new "International" character set to be used.  The current byte is
                       ; expected to be a value from 0 to 7 indicating the set to be used.  If
                       ; an error is found, no set change is accomplished.
                       ;
0094  3C 00            CMP  AL,0                          ; Is current char less than 0?
0096  7C 07            JL   NOT$VALID                     ; Br if yes
0098  3C 07            CMP  AL,7                          ; Is it greater than 7?
009A  7F 03            JG   NOT$VALID                     ; Br if yes
                       ;
                       ; If reach here, have valid set...update in memory
                       ;
009C  88 47 05         MOV  INTLSET[BX],AL                |

009F              NOT$VALID:

009F  80 27 F7         AND  SYS_MODE[BX],MASK$NEW_INTL    ; Clear NEW_INTL bit
00A2  EB 24            JMP  SHORT SENDCHAR                ; Send out value to printer

00A4              NOT$INTL:

00A4  D0 DD            RCR  CH,1                          ; ESC_SINGLE mode?
00A6  73 05            JNC  NOT$ESC_SING                  ; Br if not
00A8  80 27 EF         AND  SYS_MODE[BX],MASK$ESC_SING    ; Turn off ESC_SINGLE mode
00AB  EB 1B            JMP  SHORT SENDCHAR                ; Send char to printer

00AD              NOT$ESC_SING:

00AD  D0 DD            RCR  CH,1                          ; ESC_NULL mode?
00AF  73 09            JNC  NOT$ESC_NULL                  ; Br if not
00B1  3C 00            CMP  AL,NUL                        ; Is this a NUL character?
00B3  75 13            JNE  SENDCHAR                      ; If not, print out character
00B5  80 27 DF         AND  SYS_MODE[BX],MASK$ESC_NULL    ; Otherwise, turn off ESC_NULL mode first
00B8  EB 0E            JMP  SHORT SENDCHAR                ;

00BA              NOT$ESC_NULL:

00BA  D0 DD            RCR  CH,1                          ; ESC_C mode?
00BC  73 10            JNC  NOT$ESC_C                     ; Br if not
00BE  3C 00            CMP  AL,NUL                        ; Is character NUL?
00C0  75 03            JNE  NOT$NUL                       ; Skip next if not
00C2  80 0F 10         OR   SYS_MODE[BX],NOT MASK$ESC_SING ; Expect one more control char

00C5              NOT$NUL:

00C5  80 27 BF         AND  SYS_MODE[BX],MASK$ESC_C       ; Turn off ESC_C mode

00C8              SENDCHAR:             ; Print out current character and return

00C8  E8 01CE R        CALL PRBYTE                        ; Call print routine
00CB  E9 01C5 R        JMP  DONE                          ; Go to end

00CE              NOT$ESC_C:

00CE  D0 DD            RCR  CH,1                          ; PREV_ESC mode?
00D0  73 40            JNC  NOT$ESC                       ; Br if not
                       ;
                       ; If PREV_ESC bit is set, it indicates that the last character seen by
                       ; this printer was an "Escape" code.  We will now look and see if it is
                       ; a control code that we need to remember.  These are:
                       ;
                       ;       ESC "L" - Puts printer in dual density bit graphics mode
                       ;       ESC *K- - Puts printer in single density bit graphics mode
                       ;       ESC "R" - Selects an International character set in printer
                       ;
                       ;
                       ; In addition to the codes that we need to remember, we have some
                       ; codes which set a temporary mode.  These temporary modes are:
                       ;
                       ;    "ESC_SINGLE"  : Expect one more control code.  This is to be
                       ;                    sent to the printer.
                       ;    "ESC_NULL"    : Expect control codes to continue until a NUL
                       ;                    character (ASCII 0) is received.
                       ;    "ESC_C"       : Expect one more control code.  If that code is
                       ;                    an ASCII 0, expect one more after that.
                       ;
                       ; The escape sequences which set these modes are:
                       ;
                       ;    ESC "A" - ESC_SINGLE mode
                       ;    ESC "D" - ESC_NULL mode
                       ;    ESC "Q" - ESC_SINGLE mode
                       ;    ESC "B" - ESC_NULL mode
                       ;    ESC "C" - ESC_C mode
                       ;    ESC "N" - ESC_SINGLE mode
                       ;
00D2  80 27 7F         AND  SYS_MODE[BX],MASK$PREV_ESC    ; Turn off PREV_ESC mode bit
00D5  3C 4C            CMP  AL,'L'                        ; CTRL-L?
00D7  74 04            JE   SET$BIT_GRAF                  ; Br if yes
00D9  3C 4B            CMP  AL,'K'                        ; CTRL-K?
00DB  75 05            JNE  ARND$BIT_GRAF                 ; Br if not

00DD              SET$BIT_GRAF:

00DD  80 0F 04         OR   SYS_MODE[BX],NOT MASK$FST_BITG; Indicate that next char is FST_BITG_CNT
00E0  EB E6            JMP  SHORT SENDCHAR                ; Done, send out

00E2              ARND$BIT_GRAF:

00E2  3C 52            CMP  AL,'R'                        ; CTRL-R?
00E4  75 05            JNE  NOT$INT                       ; Br if not
00E6  80 0F 08         OR   SYS_MODE[BX],NOT MASK$NEW_INTL; Indicate next char is NEW_INTL bit
00E9  EB DD            JMP  SHORT SENDCHAR                ; Send out character

00EB              NOT$INT:

00EB  3C 41            CMP  AL,'A'                        ; ESC A?
00ED  74 08            JE   DO$ESC_SINGLE                 ; br if yes
00EF  3C 51            CMP  AL,'Q'                        ; ESC Q?
00F1  74 04            JE   DO$ESC_SINGLE                 ; Br if yes
00F3  3C 4E            CMP  AL,'N'                        ; ESC N?
00F5  75 05            JNE  NOT$SINGLE                    ; Br if not ESC_SINGLE mode

00F7              DO$ESC_SINGLE:                          ; Set ESC_SINGLE mode

00F7  80 0F 10         OR   SYS_MODE[BX],NOT MASK$ESC_SING;
00FA  EB CC            JMP  SHORT SENDCHAR                ; Print out char

00FC              NOT$SINGLE:           ; Check for ESC_NUL mode now

00FC  3C 44            CMP  AL,'D'                        ; ESC D?
00FE  74 04            JE   DO$ESC_NULL                   ; Br if yes
0100  3C 42            CMP  AL,'B'                        ; ESC B?
0102  75 05            JNE  NOT$NULL                      ; Br if not ESC_NULL mode

0104              DO$ESC_NULL:          ; Set ESC_NULL mode

0104  80 0F 20         OR   SYS_MODE[BX],NOT MASK$ESC_NULL ;
0107  EB BF            JMP  SHORT SENDCHAR                 ; Print out char

0109              NOT$NULL:             ; Check for ESC_C mode now

0109  3C 43            CMP  AL,'C'                        ; ESC C?
010B  75 03            JNE  NOT$ESCC                      ; Br if not
010D  80 0F 40         OR   SYS_MODE[BX],NOT MASK$ESC_C   ; Set ESC_C mode bit
```

*Listing 5 continued on page 368*


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*Listing 5 continued:*

```
0110                 NOT$ESCC:             ; Do not care what type of char this is...print it

0110  EB B6              JMP  SHORT SENDCHAR


0112                 NOT$ESC:              ; Previous character was not an ESCAPE control char
                         ;
                         ; Is this an ESCAPE code?
                         ;
0112  3C 1B              CMP  AL,ESC_CHAR                    ;
0114  75 05              JNE  NESC                           ; Br if not
0116  80 0F 80           OR   SYS_MODE[BX],NOT MASK$PREV_ESC; Set escape found bit
0119  EB AD              JMP  SHORT SENDCHAR                 ; Send out character

011B                 NESC:

                         ;
                         ; See if we have any standard control codes...ASCII 7 - 20
                         ;
011B  3C 07              CMP  AL,07H                         ; Is character less than 7?
011D  7C 04              JL   CHKCHAR                        ; Br if yes, not control code
011F  3C 14              CMP  AL,14H                         ; Is character greater than 14H?
0121  7E A5              JLE  SENDCHAR                       ; If not, is a control code...print it

0123                 CHKCHAR:
                         ;
                         ; Here we check to see if the character to be printed is in the range
                         ; of 20H to 7EH (ASCII value of the character to be printed.) If in
                         ; that range, use standard Epson character set. Otherwise, we have
                         ; a special character to print.
                         ;
0123  B4 00              MOV  AH,0                           ; Make sure nothing is in upper byte
0125  3D 0020            CMP  AX,20H                         ; Is character less than 20H?
0128  7C 07              JL   BIT$CHAR                       ; Br if yes, special character
012A  3D 007E            CMP  AX,7EH                         ;
012D  7E 99              JLE  SENDCHAR                       ; Not a special character, just print it
012F  2C 5F              SUB  AL,7EH-20H+1                   ; Subtract non-special character set out

0131                 BIT$CHAR:



                         ;
                         ; See if current character is part of the Epson's international character
                         ; set.  (If its offset into BITTYP array is 0, international.
                         ;
0131  53                 PUSH BX                             ; Save offset to storage area
0132  50                 PUSH AX                             ; Save current character
0133  8B D8              MOV  BX,AX                          ;
0135  B1 03              MOV  CL,3                           ; Shift count
0137  D2 EB              SHR  BL,CL                          ; Shift lower three bits from AL
0139  8A AF 079E R       MOV  CH,BITTYP[BX]                  ; Get byte containing type bit
013D  D2 E3              SHL  BL,CL                          ; Move AL back to original position
                         ; Note: we have now lost the lower three bits from AL.
013F  F7 DB              NEG  BX                             ; Take two's complement of BL
0141  02 D8              ADD  BL,AL                          ; Add original contents of AL to negated
                                                             ;   value to get right three bits
0143  FE C3              INC  BL                             ; This is now our index to type bit
0145  8A C8              MOV  CL,BL                          ; Let's use value as shift count
0147  F6 26 0008 R       MUL  TMPBYTE                        ; Offset into array
014B  8B F0              MOV  SI,AX                          ; Set index into array
014D  58                 POP  AX                             ; Once again, get original char
014E  D2 E5              SHL  CH,CL                          ; Recall CH holds bit-type byte
0150  72 3B              JC   DO$BIT_GRAF                    ; Carry now is type of the char
                         ;
                         ;  Well, we see that the bit type was 0, so we are to specify a character
                         ;  from the Epson international character set.  To determine which, we
                         ;  expect the first byte in BITVAL array to tell us which international
                         ;  set to use and the second byte to tell us the character to print.
                         ;
0152  8A AC 01F5 R       MOV  CH,BITVAL[SI]                  ; Get character set
0156  38 6F 05           CMP  INTLSET[BX],CH                 ; Is this the set we are now using?
0159  75 08              JNE  NEW$INTSET                     ; Br if not
015B  5B                 POP  BX                             ; Keep stack clean
015C  8A B4 01F6 R       MOV  AL,BITVAL[SI][1]               ; If yes, just send out character
0160  E9 00C8 R          JMP  SENDCHAR                       ;

0163                 NEW$INTSET:           ; Must temporarily set up new international set

0163  B0 1B              MOV  AL,ESC_CHAR                    ; Print out "Esc" char
0165  E8 01CE R          CALL PRBYTE                         ;
0168  B0 52              MOV  AL,'R'                         ; Send out new international signal
016A  E8 01CE R          CALL PRBYTE                         ;
016D  8A C5              MOV  AL,CH                          ; Print out character set to use
016F  E8 01CE R          CALL PRBYTE                         ;
0172  8A B4 01F6 R       MOV  AL,BITVAL[SI][1]               ; Get intl character to print
0176  E8 01CE R          CALL PRBYTE                         ;
0179  B0 1B              MOV  AL,ESC_CHAR                    ; Now restore original character set
017B  E8 01CE R          CALL PRBYTE                         ;
017E  B0 52              MOV  AL,'R'                         ;
0180  E8 01CE R          CALL PRBYTE                         ;
0183  5B                 POP  BX                             ; Restore address to store area
0184  8A 47 05           MOV  AL,INTLSET[BX]                 ; Set type
0187  E8 01CE R          CALL PRBYTE                         ;
018A  E9 39 90           JMP  DONE                           ; We are done so exit program

018D                 DO$BIT_GRAF:          ; Special bit-graphics mode

018D  5B                 POP  BX                             ; Restore to keep stack straight
018E  50                 PUSH AX                             ; Save current character for indexing
018F  B0 1B              MOV  AL,ESC_CHAR                    ; Put printer in dual density bit mode
0191  E8 01CE R          CALL PRBYTE                         ;
0194  B0 4C              MOV  AL,'L'                         ;
0196  E8 01CE R          CALL PRBYTE                         ;
0199  B0 0C              MOV  AL,12                          ; Each graphics character consists of
019B  E8 01CE R          CALL PRBYTE                         ;   exactly 9 columns of bits followed
019E  B0 00              MOV  AL,0                           ;   by 3 blank columns (12 columns total)
01A0  E8 01CE R          CALL PRBYTE                         ;
01A3  58                 POP  AX
01A4  3D 0054            CMP  AX,0B3H-(7EH-20H+1)            ; See if in extended set
01A7  7C 0F              JL   NON_EXTND                      ; Br if not
01A9  3D 0081            CMP  AX,0E0H-(7EH-20H+1)            ;
01AC  7D 0A              JGE  NON_EXTND                      ;
                         ;
                         ; The character is in the "extended" set. (ASCII 176 to 223)
                         ;
01AE  8A B4 01F5 R       MOV  AL,BITVAL[SI]                  ; Pre-extend first column
01B2  E8 01E4 R          CALL PR9BYTS                        ; Print out character
01B5  E9 08 90           JMP  AROUND                         ; Move around non-extended set

01B8                 NON_EXTND:      ; Character is non-extended

01B8  B0 00              MOV  AL,0                           ; First column is blank
01BA  E8 01E4 R          CALL PR9BYTS                        ; Print out character
01BD  B0 00              MOV  AL,0                           ; Last two columns are blank

01BF                 AROUND:

01BF  E8 01CE R          CALL PRBYTE                         ; Print out last two columns
01C2  E8 01CE R          CALL PRBYTE                         ;

01C5                 DONE:           ; Exit program

01C5  5A                 POP  DX                             ; Restore AL without disturb AH
01C6  8A C2              MOV  AL,DL                          ;
01C8  5A                 POP  DX                             ; Restore registers
01C9  59                 POP  CX                             ;
01CA  5B                 POP  BX                             ;
01CB  5E                 POP  SI
01CC  1F                 POP  DS
01CD  CF                 IRET                                ; Return from interrupt

01CE                 PR256 ENDP      ; Done with main routine !!!
```

*Listing 5 continued on page 370*


Over thirty years of down-to-earth experience as a precision parts manufacturer has enabled Star to produce the Gemini series of dot matrix printers—a stellar combination of printer quality, flexibility, and reliability. And for a list price of nearly 25% less than the best selling competitor.

The Gemini 10 has a 10" carriage and the Gemini 15 a 15½" carriage. Plus, the Gemini 15 has the added capability of a bottom paper feed. In both models, Gemini quality means a print speed of 100 cps, high-resolution bit image and block graphics, and extra fast forms feed.

Gemini's flexibility is embodied in its diverse specialized printing capabilities such as super/sub script, underlining, backspacing, double strike mode and emphasized print mode. Another extraordinary standard feature is a 2.3K buffer. An additional 4K is optional. That's twice the memory of leading, comparable printers. And Gemini is compatible with most software packages that support the leading printers.

Gemini reliability is more than just a promise. It's as concrete as a 180 day warranty (90 days for ribbon and print head), a mean time between failure rate of 5 million lines, a print head life of over 100 million characters, and a 100% duty cycle that allows the Gemini to print continuously. Plus, prompt, nationwide service is readily available.

So if you're looking for an incredibly high-quality, low-cost printer that's out of this world, look to the manufacturer with its feet on the ground—Star and the Gemini 10, Gemini 15 dot matrix printers.

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*Listing 5 continued:*

```

                                ;$$$$$$$$$$$$$$$$$$$$$$$$$
                                ;
                                ;     PRBYTE - Clears current value of AH and prints out character in AL
                                ;
                                ;$$$$$$$$$$$$$$$$$$$$$$$$$

 01CE                           PRBYTE PROC NEAR

 01CE  B4 00                        MOV  AH,0                     ; Clear out for printing w/BIOS
 01D0  E8 01D4 R                    CALL PR2BYTE                  ; Do actual printout of char
 01D3  C3                           RET                           ; Done

 01D4                           PRBYTE ENDP



                                ;$$$$$$$$$$$$$$$$$$$$$$$$
                                ;
                                ;     PR2BYTE - Calls IBM's BIOS print routine to print out contents of AX
                                ;
                                ;$$$$$$$$$$$$$$$$$$$$$$$$

 01D4                           PR2BYTE PROC NEAR

 01D4  1E                           PUSH DS
 01D5  56                           PUSH SI
 01D6  9C                           PUSHF                         ; IBM print proc expects interrupt call
 01D7  BE ---- R                    MOV  SI,SEG DWORD_ADDR        ; Get segment to ROM code
 01DA  8E DE                        MOV  DS,SI                    ;
 01DC  BE 0004 R                    MOV  SI,OFFSET DWORD_ADDR     ; Get address to ROM code for print
 01DF  FF 1C                        CALL DWORD PTR [SI]           ; Call print routine
 01E1  5E                           POP  SI
 01E2  1F                           POP  DS
 01E3  C3                           RET                           ; Return

 01E4                           PR2BYTE ENDP




                                ;$$$$$$$$$$$$$$$$$$$$$$$$
                                ;
                                ;     PR9BYTS - Prints out a graphics character using BITVAL table below.
                                ;               On entry, AL contains byte value of first column to be printed.
                                ;               Next nine columns of character are fetched from indexing thru
                                ;               SI (which must be initialized by calling routine) into the
                                ;               BITVAL table.
                                ;
                                ;$$$$$$$$$$$$$$$$$$$$$$$$

 01E4                           PR9BYTS PROC NEAR

 01E4  E8 01CE R                    CALL PRBYTE                   ; Print out first column
 01E7  B9 0009                      MOV  CX,9                     ; Loop through 9 columns

 01EA                           LOOP$SEND:

 01EA  8A 84 01F5 R                 MOV  AL,BITVAL[SI]            ; Get next column to print
 01EE  E8 01CE R                    CALL PRBYTE                   ; Print it out
 01F1  46                           INC  SI                       ; Move to next column
 01F2  E2 F6                        LOOP LOOP$SEND                ; Loop until done
 01F4  C3                           RET                           ; Done, return

 01F5                           PR9BYTS ENDP



                                ;$$$$$$$$$$$$$$$$$$$$$$$$$
                                ;
                                ; Define characters...9 bytes per character
                                ;
                                ;$$$$$$$$$$$$$$$$$$$$$$$$

 0010                           .RADIX 16    ; All values are in hexadecimal

 01F5  00 00 00 00 00 00        BITVAL  DB  000,000,000,000,000,000,000,000,000    ; 0 (Decimal ASCII)
       00 00 00
 01FE  3C 42 89 A5 85 A5                DB  03C,042,089,0A5,085,0A5,089,042,03C    ; 1
       89 42 3C
 0207  3C 7E 93 9B FB 9B                DB  03C,07E,093,9BH,0FBH,9BH,93,07E,03C    ; 2
       93 7E 3C
 0210  60 F0 F8 7C 7E 7C                DB  060,0F0,0F8,07C,07E,07C,0F8,0F0,060    ; 3
       F8 F0 60
 0219  00 10 38 7C FE 7C                DB  000,010,038,07C,0FE,07C,038,010,000    ; 4
       38 10 00
 0222  10 38 38 D0 EE D0                DB  010,038,038,0D0,0EE,0D0,038,038,010    ; 5
       38 38 10
 022B  00 00 30 72 FE 72                DB  000,000,030,072,0FE,072,030,000,000    ; 6
       30 00 00
 0234  00 00 30 78 78 78                DB  000,000,030,078,078,078,030,000,000    ; 7
       30 00 00
 023D  FF FF CF 87 87 87                DB  0FF,0FF,0CF,087,087,087,0CF,0FF,0FF    ; 8
       CF FF FF
 0246  00 18 24 42 42 42                DB  000,018,024,042,042,042,024,018,000    ; 9
       24 18 00
 024F  FF E7 DB BD BD BD                DB  0FF,0E7,0DBH,0BDH,0BDH,0BDH,0DBH,0E7,0FF ; 10
       DB E7 FF
 0258  00 0C 12 12 12 B2                DB  000,00C,012,012,012,0B2,0CC,0E0,000    ; 11
       CC E0 00
 0261  00 00 64 94 9F 94                DB  000,000,064,094,09F,094,064,000,000    ; 12
       64 00 00
 026A  00 06 06 FE A0 A0                DB  000,006,006,0FE,0A0,0A0,0A0,0E0,000    ; 13
       A0 E0 00
 0273  06 06 FE A0 A0 A0                DB  006,006,0FE,0A0,0A0,0A0,0AC,0AC,0FC    ; 14
       AC AC FC
 027C  54 10 38 28 EE 28                DB  054,010,038,028,0EE,028,038,010,054    ; 15
       38 10 54
 0285  00 FE 7C 7C 38 38                DB  000,0FE,07C,07C,038,038,010,010,000    ; 16
       10 10 00
 028E  00 10 10 38 38 7C                DB  000,010,010,038,038,07C,07C,0FE,000    ; 17
       7C FE 00
 0297  00 00 28 6C FE 6C                DB  000,000,028,06C,0FE,06C,028,000,000    ; 18
       28 00 00
 02A0  00 F2 F2 00 00 00                DB  000,0F2,0F2,000,000,000,0F2,0F2,000    ; 19
       F2 F2 00
 02A9  60 90 90 FE 80 80                DB  060,090,090,0FE,080,080,0FE,080,080    ; 20
       FE 80 80
 02B2  01 5D 00 00 00 00                DB  001,5DH,000,000,000,000,000,000,000    ; 21 $ FRANCE  - 5D
       00 00 00
 02BB  00 3C 3C 3C 3C 3C                DB  000,03C,03C,03C,03C,03C,03C,03C,000    ; 22
       3C 3C 00
 02C4  00 01 29 6D FF 6D                DB  000,001,029,6DH,0FF,6DH,029,001,000    ; 23
       29 01 00
 02CD  00 00 20 60 FE 60                DB  000,000,020,060,0FE,060,020,000,000    ; 24
       20 00 00
 02D6  00 00 08 0C FE 0C                DB  000,000,008,00C,0FE,00C,008,000,000    ; 25
       08 00 00
 02DF  00 10 10 10 10 7C                DB  000,010,010,010,010,07C,038,010,000    ; 26
       38 10 00
 02E8  00 10 38 7C 10 10                DB  000,010,038,07C,010,010,010,010,000    ; 27
       10 10 00
 02F1  00 00 38 08 08 08                DB  000,000,038,008,008,008,008,000,000    ; 28
       08 00 00
 02FA  10 38 7C 10 10 10                DB  010,038,07C,010,010,010,07C,038,010    ; 29
       7C 38 10
 0303  00 04 0C 1C 3C 1C                DB  000,004,00C,01C,03C,01C,00C,004,000    ; 30
       0C 04 00
 030C  00 20 30 38 3C 38                DB  000,020,030,038,03C,038,030,020,000    ; 31
       30 20 00
 0315  00 06 0A 12 22 12                DB  000,006,0AH,012,022,012,0AH,006,000    ; 127
       0A 06 00
 031E  01 5C 00 00 00 00                DB  001,05C,000,000,000,000,000,000,000    ; 128 $ FRANCE  - 5C
       00 00 00
 0327  02 7D 00 00 00 00                DB  002,7DH,000,000,000,000,000,000,000    ; 129 $ GERMANY - 7D
```

*Listing 5 continued on page 372*


*The Micromint MPX-16 Microcomputer System.*

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*Listing 5 continued:*

```
                00 00 00
        0330    01 7B 00 00 00 00     DB  001,7BH,000,000,000,000,000,000,000   ; 130 ! FRANCE  - 7B
                00 00 00
        0339    05 7D 00 00 00 00     DB  005,7DH,000,000,000,000,000,000,000   ; 131 ! SWEDEN  - 7D
                00 00 00
        0342    02 7B 00 00 00 00     DB  002,7BH,000,000,000,000,000,000,000   ; 132 ! GERMANY - 7B
                00 00 00
        034B    01 40 00 00 00 00     DB  001,040,000,000,000,000,000,000,000   ; 133 ! FRANCE  - 40
                00 00 00
        0354    02 07 55 F5 B5 B5     DB  002,007,055,0F5,0B5,0B5,0FE,04F,001   ; 134
                FE 4F 01
        035D    00 71 89 89 8F 88     DB  000,071,089,089,08F,088,088,050,000   ; 135
                88 50 00
        0366    00 0E 5F D5 95 95     DB  000,00E,05F,0D5,095,095,0D5,5DH,00C   ; 136
                D5 5D 0C
        036F    00 1C BE AA 2A 2A     DB  000,01C,0BE,0AA,02A,02A,0AA,0BA,01B   ; 137
                AA BA 1B
        0378    01 7D 00 00 00 00     DB  001,7DH,000,000,000,000,000,000,000   ; 138 ! FRANCE  - 7D
                00 00 00
        0381    00 A2 A2 3E 1E 82     DB  000,0A2,0A2,03E,01E,082,082,000,000   ; 139
                82 00 00
        038A    00 52 D2 9E 8E C2     DB  000,052,0D2,09E,08E,0C2,042,000,000   ; 140
                42 00 00
        0393    00 12 92 DE 4E 02     DB  000,012,092,0DE,04E,002,002,000,000   ; 141
                02 00 00
        039C    02 5B 00 00 00 00     DB  002,5BH,000,000,000,000,000,000,000   ; 142 ! GERMANY - 5B
                00 00 00
        03A5    03 47 4E BA B2 BA     DB  003,047,04E,0BA,0B2,0BA,04E,047,003   ; 143
                4E 47 03
        03AE    05 40 00 00 00 00     DB  005,040,000,000,000,000,000,000,000   ; 144 ! SWEDEN  - 40
                00 00 00
        03B7    04 7B 00 00 00 00     DB  004,7BH,000,000,000,000,000,000,000   ; 145 ! DENMARK - 7B
                00 00 00
        03C0    04 5B 00 00 00 00     DB  004,5BH,000,000,000,000,000,000,000   ; 146 ! DENMARK - 5B
                00 00 00
        03C9    00 0E 5F D1 91 91     DB  000,00E,05F,0D1,091,091,0D1,05F,00E   ; 147
                D1 5F 0E
        03D2    02 7C 00 00 00 00     DB  002,07C,000,000,000,000,000,000,000   ; 148 ! GERMANY - 7C
                00 00 00
        03DB    00 0E 1F 91 D1 51     DB  000,00E,01F,091,0D1,051,011,01F,00E   ; 149
                11 1F 0E
        03E4    00 5E DF 81 81 C1     DB  000,05E,0DF,081,081,0C1,05E,01F,001   ; 150
                5E 1F 01
        03ED    01 7C 00 00 00 00     DB  001,07C,000,000,000,000,000,000,000   ; 151 ! FRANCE  - 7C
                00 00 00
        03F6    20 80 99 0F 06 0C     DB  020,080,099,00F,006,00C,098,080,020   ; 152
                98 80 20
        03FF    02 5C 00 00 00 00     DB  002,05C,000,000,000,000,000,000,000   ; 153 ! GERMANY - 5C
                00 00 00
        0408    02 5D 00 00 00 00     DB  002,5DH,000,000,000,000,000,000,000   ; 154 ! GERMANY - 5D
                00 00 00
        0411    18 3C 66 42 FF FF     DB  018,03C,066,042,0FF,0FF,042,066,024   ; 155
                42 66 24
        041A    03 23 00 00 00 00     DB  003,023,000,000,000,000,000,000,000   ; 156 ! ENGLAND - 23
                00 00 00
        0423    00 00 94 54 3F 54     DB  000,000,094,054,03F,054,094,000,000   ; 157
                94 00 00
        042C    07 23 00 00 00 00     DB  007,023,000,000,000,000,000,000,000   ; 158 ! SPAIN   - 23
                00 00 00
        0435    00 04 12 12 7C 90     DB  000,004,012,012,07C,090,090,040,000   ; 159
                90 40 00
        043E    04 0E 2A 6A EA AA     DB  004,00E,02A,06A,0EA,0AA,03C,01E,002   ; 160
                3C 1E 02
        0447    00 12 12 5E CE 82     DB  000,012,012,05E,0CE,082,002,000,000   ; 161
                02 00 00
        0450    00 0E 1F 11 51 D1     DB  000,00E,01F,011,051,0D1,091,01F,00E   ; 162
                91 1F 0E
        0459    00 1E 1F 41 C1 81     DB  000,01E,01F,041,0C1,081,01E,01F,001   ; 163
                1E 1F 01
        0462    07 7C 00 00 00 00     DB  007,07C,000,000,000,000,000,000,000   ; 164 ! SPAIN   - 7C
                00 00 00
        046B    07 5C 00 00 00 00     DB  007,05C,000,000,000,000,000,000,000   ; 165 ! SPAIN   - 5C
                00 00 00
        0474    00 12 BA AA AA AA     DB  000,012,0BA,0AA,0AA,0AA,072,07A,00A   ; 166
                72 7A 0A
        047D    00 72 FA 8A 8A 8A     DB  000,072,0FA,08A,08A,08A,08A,0FA,072   ; 167
                8A FA 72
        0486    07 5D 00 00 00 00     DB  007,5DH,000,000,000,000,000,000,000   ; 168 ! SPAIN   - 5D
                00 00 00
        048F    00 00 38 20 20 20     DB  000,000,038,020,020,020,020,000,000   ; 169
                20 00 00
        0498    00 00 20 20 20 20     DB  000,000,020,020,020,020,038,000,000   ; 170
                38 00 00
        04A1    00 42 F4 08 10 29     DB  000,042,0F4,008,010,029,053,015,009   ; 171
                53 15 09
        04AA    00 42 F4 08 12 26     DB  000,042,0F4,008,012,026,04A,01F,002   ; 172
                4A 1F 02
        04B3    07 5B 00 00 00 00     DB  007,5BH,000,000,000,000,000,000,000   ; 173 ! SPAIN   - 5B
                00 00 00
        04BC    10 38 6C 44 10 38     DB  010,038,06C,044,010,038,06C,044,000   ; 174
                6C 44 00
        04C5    00 44 6C 38 10 44     DB  000,044,06C,038,010,044,06C,038,010   ; 175
                6C 38 10
        04CE    00 55 00 AA 00 55     DB  000,055,000,0AA,000,055,000,0AA,000   ; 176
                00 AA 00
        04D7    55 AA 55 AA 55 AA     DB  055,0AA,055,0AA,055,0AA,055,0AA,055   ; 177
                55 AA 55
        04E0    FF AA FF 55 FF AA     DB  0FF,0AA,0FF,055,0FF,0AA,0FF,055,0FF   ; 178
                FF 55 FF
        04E9    00 00 00 00 FF 00     DB  000,000,000,000,0FF,000,000,000,000   ; 179
                00 00 00
        04F2    08 08 08 08 FF 00     DB  008,008,008,008,0FF,000,000,000,000   ; 180
                00 00 00
        04FB    28 28 28 28 FF 00     DB  028,028,028,028,0FF,000,000,000,000   ; 181
                00 00 00
        0504    08 08 08 FF 00 00     DB  008,008,008,0FF,000,000,0FF,000,000   ; 182
                FF 00 00
        050D    08 08 08 0F 08 08     DB  008,008,008,00F,008,008,00F,000,000   ; 183
                0F 00 00
        0516    28 28 28 28 3F 00     DB  028,028,028,028,03F,000,000,000,000   ; 184
                00 00 00
        051F    28 28 28 EF 00 00     DB  028,028,028,0EF,000,000,0FF,000,000   ; 185
                FF 00 00
        0528    00 00 00 FF 00 00     DB  000,000,000,0FF,000,000,0FF,000,000   ; 186
                FF 00 00
        0531    28 28 28 2F 20 20     DB  028,028,028,02F,020,020,03F,000,000   ; 187
                3F 00 00
        053A    28 28 28 E8 08 08     DB  028,028,028,0E8,008,008,0F8,000,000   ; 188
                F8 00 00
        0543    08 08 08 F8 08 08     DB  008,008,008,0F8,008,008,0F8,000,000   ; 189
                F8 00 00
        054C    28 28 28 28 F8 00     DB  028,028,028,028,0F8,000,000,000,000   ; 190
                00 00 00
        0555    08 08 08 08 0F 00     DB  008,008,008,008,00F,000,000,000,000   ; 191
                00 00 00
        055E    00 00 00 00 F8 08     DB  000,000,000,000,0F8,008,008,008,008   ; 192
                08 08 08
        0567    08 08 08 08 F8 08     DB  008,008,008,008,0F8,008,008,008,008   ; 193
                08 08 08
        0570    08 08 08 08 0F 08     DB  008,008,008,008,00F,008,008,008,008   ; 194
                08 08 08
        0579    00 00 00 00 FF 08     DB  000,000,000,000,0FF,008,008,008,008   ; 195
                08 08 08
        0582    08 08 08 08 08 08     DB  008,008,008,008,008,008,008,008,008   ; 196
                08 08 08
        058B    08 08 08 08 FF 08     DB  008,008,008,008,0FF,008,008,008,008   ; 197
                08 08 08
        0594    00 00 00 00 FF 28     DB  000,000,000,000,0FF,028,028,028,028   ; 198
                28 28 28
        059D    00 00 00 FF 00 00     DB  000,000,000,0FF,000,000,0FF,008,008   ; 199
                FF 08 08
        05A6    00 00 00 F8 08 08     DB  000,000,000,0F8,008,008,0E8,028,028   ; 200
                E8 28 28
        05AF    00 00 00 3F 20 20     DB  000,000,000,03F,020,020,02F,028,028   ; 201
                2F 28 28
```

*Listing 5 continued on page 374*

*Listing 5 continued:*

```
05B8  28 28 28 E8 08 08          DB  028,028,028,0E8,008,008,0E8,028,028   ; 202
      E8 28 28
05C1  28 28 28 2F 20 20          DB  028,028,028,02F,020,020,02F,028,028   ; 203
      2F 28 28
05CA  00 00 00 FF 00 00          DB  000,000,000,0FF,000,000,0EF,028,028   ; 204
      EF 28 28
05D3  28 28 28 28 28 28          DB  028,028,028,028,028,028,028,028,028   ; 205
      28 28 28
05DC  28 28 28 EF 00 00          DB  028,028,028,0EF,000,000,0EF,028,028   ; 206
      EF 28 28
05E5  28 28 28 28 E8 28          DB  028,028,028,028,0E8,028,028,028,028   ; 207
      28 28 28
05EE  08 08 08 F8 08 08          DB  008,008,008,0F8,008,008,0F8,008,008   ; 208
      F8 08 08
05F7  28 28 28 28 2F 28          DB  028,028,028,028,02F,028,028,028,028   ; 209
      28 28 28
0600  08 08 08 0F 08 08          DB  008,008,008,00F,008,008,00F,008,008   ; 210
      0F 08 08
0609  00 00 00 F8 08 08          DB  000,000,000,0F8,008,008,0F8,008,008   ; 211
      F8 08 08
0612  00 00 00 00 F8 28          DB  000,000,000,000,0F8,028,028,028,028   ; 212
      28 28 28
061B  00 00 00 00 3F 28          DB  000,000,000,000,03F,028,028,028,028   ; 213
      28 28 28
0624  00 00 00 0F 08 08          DB  000,000,000,00F,008,008,00F,008,008   ; 214
      0F 08 08
062D  08 08 08 FF 08 08          DB  008,008,008,0FF,008,008,0FF,008,008   ; 215
      FF 08 08
0636  28 28 28 28 FF 28          DB  028,028,028,028,0FF,028,028,028,028   ; 216
      28 28 28
063F  08 08 08 08 F8 00          DB  008,008,008,008,0F8,000,000,000,000   ; 217
      00 00 00
0648  00 00 00 00 0F 08          DB  000,000,000,000,00F,008,008,008,008   ; 218
      08 08 08
0651  FF FF FF FF FF FF          DB  0FF,0FF,0FF,0FF,0FF,0FF,0FF,0FF,0FF   ; 219
      FF FF FF
065A  0F 0F 0F 0F 0F 0F          DB  00F,00F,00F,00F,00F,00F,00F,00F,00F   ; 220
      0F 0F 0F
0663  FF FF FF FF FF 00          DB  0FF,0FF,0FF,0FF,0FF,000,000,000,000   ; 221
      00 00 00
066C  00 00 00 00 00 FF          DB  000,000,000,000,000,0FF,0FF,0FF,0FF   ; 222
      FF FF FF
0675  F0 F0 F0 F0 F0 F0          DB  0F0,0F0,0F0,0F0,0F0,0F0,0F0,0F0,0F0   ; 223
      F0 F0 F0
067E  00 3C 42 42 42 3C          DB  000,03C,042,042,042,03C,024,042,000   ; 224
      24 42 00
0687  02 7E 00 00 00 00          DB  002,07E,000,000,000,000,000,000,000   ; 225 ; GERMANY - 7E
      00 00 00
0690  00 7E 40 40 40 40          DB  000,07E,040,040,040,040,040,070,000   ; 226
      40 70 00
0699  00 40 7E 40 40 40          DB  000,040,07E,040,040,040,07E,040,000   ; 227
      7E 40 00
06A2  82 C6 AA 92 82 82          DB  082,0C6,0AA,092,082,082,082,0C6,000   ; 228
      82 C6 00
06AB  00 3C 42 42 42 7C          DB  000,03C,042,042,042,07C,040,040,040   ; 229
      40 40 40
06B4  00 01 7E 04 04 04          DB  000,001,07E,004,004,004,004,078,000   ; 230
      04 78 00
06BD  00 20 40 40 3E 20          DB  000,020,040,040,03E,020,040,040,000   ; 231
      40 40 00
06C6  00 99 A5 A5 E7 A5          DB  000,099,0A5,0A5,0E7,0A5,0A5,099,000   ; 232
      A5 99 00
06CF  00 38 54 92 92 92          DB  000,038,054,092,092,092,054,038,000   ; 233
      54 38 00
06D8  02 3A 46 80 80 80          DB  002,03A,046,080,080,080,046,03A,002   ; 234
      46 3A 02
06E1  00 00 4C B2 92 92          DB  000,000,04C,0B2,092,092,08C,000,000   ; 235
      8C 00 00
06EA  38 44 44 44 38 44          DB  038,044,044,044,038,044,044,044,038   ; 236
      44 44 38
06F3  00 3A 44 4C 54 64          DB  000,03A,044,04C,054,064,044,0B8,000   ; 237
      44 B8 00
06FC  00 00 38 54 92 82          DB  000,000,038,054,092,082,000,000,000   ; 238
      00 00 00
0705  00 1E 20 40 40 40          DB  000,01E,020,040,040,040,020,01E,000   ; 239
      20 1E 00
070E  00 54 54 54 54 54          DB  000,054,054,054,054,054,054,054,000   ; 240
      54 54 00
0717  00 22 22 22 FA 22          DB  000,022,022,022,0FA,022,022,022,000   ; 241
      22 22 00
0720  00 02 8A 8A 52 52          DB  000,002,08A,08A,052,052,022,022,000   ; 242
      22 22 00
0729  00 22 22 52 52 8A          DB  000,022,022,052,052,08A,08A,002,000   ; 243
      8A 02 00
0732  00 00 00 00 7F 80          DB  000,000,000,000,07F,080,080,060,000   ; 244
      80 60 00
073B  00 06 01 01 FE 00          DB  000,006,001,001,0FE,000,000,000,000   ; 245
      00 00 00
0744  00 10 10 10 54 10          DB  000,010,010,010,054,010,010,010,000   ; 246
      10 10 00
074D  00 24 48 48 24 12          DB  000,024,048,048,024,012,012,024,000   ; 247
      12 24 00
0756  00 00 30 48 48 48          DB  000,000,030,048,048,048,030,000,000   ; 248
      30 00 00
075F  00 00 30 78 78 78          DB  000,000,030,078,078,078,030,000,000   ; 249
      30 00 00
0768  00 00 00 10 38 10          DB  000,000,000,010,038,010,000,000,000   ; 250
      00 00 00
0771  10 10 10 08 04 7E          DB  010,010,010,008,004,07E,040,040,040   ; 251
      40 40 40
077A  80 70 80 80 78 00          DB  080,070,080,080,078,000,000,000,000   ; 252
      00 00 00
0783  44 8C 94 64 00 00          DB  044,08C,094,064,000,000,000,000,000   ; 253
      00 00 00
078C  00 00 7C 7C 7C 7C          DB  000,000,07C,07C,07C,07C,07C,000,000   ; 254
      7C 00 00
0795  00 00 00 00 00 00          DB  000,000,000,000,000,000,000,000,000   ; 255
      00 00 00



                       ;******************************
                       ;
                       ;  Set up bits to distinguish between normal graphics characters
                       ;   and those which can use the MX100 International character sets
                       ;
                       ;******************************

000A                       .RADIX 10        ; Back to decimal notation

079E  FF                   BITTYP  DB  11111111B  ; Ascii 0 to 7
079F  FF                           DB  11111111B  ; 8 - 15
07A0  FB                           DB  11111011B  ; 16 - 23
07A1  FF                           DB  11111111B  ; 24 - 31
07A2  81                           DB  10000001B  ; 127 - 134
07A3  EE                           DB  11101110B  ; 135 - 142
07A4  8B                           DB  10001011B  ; 143 - 150
07A5  4A                           DB  01001010B  ; 151 - 158
07A6  F9                           DB  11111001B  ; 159 - 166
07A7  BD                           DB  10111101B  ; 167 - 174
07A8  FF                           DB  11111111B  ; 175 - 182
07A9  FF                           DB  11111111B  ; 183 - 190
07AA  FF                           DB  11111111B  ; 191 - 198
07AB  FF                           DB  11111111B  ; 199 - 206
07AC  FF                           DB  11111111B  ; 207 - 214
07AD  FF                           DB  11111111B  ; 215 - 222
07AE  DF                           DB  11011111B  ; 223 - 230
07AF  FF                           DB  11111111B  ; 231 - 238
07B0  FF                           DB  11111111B  ; 239 - 246
07B1  FF                           DB  11111111B  ; 247 - 254
07B2  80                           DB  10000000B  ; 255



07B3                   LASTONE:   ; All code after this label is freed to DOS use after
                                  ; initialization of the program.
```

*Listing 5 continued on page 376*

*Listing 5 continued:*

```
                                    ;!!!!!!!!!!!!!!!!!!!!!!
                                    ;
                                    ;  Code to load and initialize the printing program...
                                    ;  sets up DOS to keep all code before 'LASTONE' label
                                    ;  safe from overlaying during system operation.
                                    ;
                                    ;!!!!!!!!!!!!!!!!!!!!!!


07B3                                INIT_CODE PROC NEAR

07B3  58                                POP  AX                   ; Remove return address of CALL
                                        ;
                                        ; After this initialization routine is finished, we wish to return
                                        ; control to DOS and prevent DOS from overlaying the PR256 code.
                                        ; This is done by replacing the INT X'20' command found at the front
                                        ; of the Program Segment Prefix control block with an INT X'27'
                                        ; "Program end but stay resident" command.  The address to this instruction
                                        ; is placed on the front of the stack, behind the return address
                                        ; used by this subroutine.  When the initialization is finished, this
                                        ; routine returns to its caller (the main program) which executes a
                                        ; return to the PSP, resulting in the INT X'27' command execution.
                                        ;
07B4  1E                                PUSH DS                   ; move segment address to PSP onto stack
07B5  BF 0000                           MOV  DI,0                 ; Set return to first location in PSP
07B8  57                                PUSH DI                   ;
07B9  50                                PUSH AX                   ; Restore return address
07BA  B0 27                             MOV  AL,NEWINT            ; Set up INT X'27' in PSP
07BC  88 45 01                          MOV  [DI+1],AL            ;

07BF  B8 0000                           MOV  AX,0                 ; set up address to INT 17H vector
07C2  8E D8                             MOV  DS,AX                ;
07C4  BB 005C                           MOV  BX,INTADDR           ;
07C7  C4 3F                             LES  DI,DWORD PTR [BX]    ; Load double word addr to BIOS print rtne
07C9  B8 ---- R                         MOV  AX,SEG DWORD_ADDR    ; Now set up addr to store BIOS addr
07CC  8E D8                             MOV  DS,AX                ;
07CE  89 3E 0004 R                      MOV  DWORD_ADDR,DI        ;
07D2  8C C0                             MOV  AX,ES                ;
07D4  A3 0006 R                         MOV  DWORD_ADDR+2,AX      ; store BIOS print routine address
07D7  B8 ---- R                         MOV  AX,SEG START_UP      ;
07DA  8E C0                             MOV  ES,AX                ; don't forget to save segment addr
07DC  BF 001B R                         MOV  DI,OFFSET START_UP   ;
07DF  B8 0000                           MOV  AX,0                 ;
07E2  8E D8                             MOV  DS,AX                ; Now, address back to INT 17H vector
07E4  BB 005C                           MOV  BX,INTADDR           ;
07E7  89 3F                             MOV  [BX],DI              ;
07E9  8C C7                             MOV  DI,ES                ;
07EB  89 7F 02                          MOV  [BX+2],DI            ;
07EE  BA 07B3 R                         MOV  DX,OFFSET LASTONE    ; Save all code up to 'LASTONE' label
07F1  81 C2 0100                        ADD  DX,0100H             ;   from overlaying by DOS
07F5  C3                                RET                       ; Return to MAIN program



07F6                                INIT_CODE ENDP
07F6                                CODE ENDS
                                    END
```

```
Structures and records:

                N a m e             Width   # fields
                                    Shift   Width   Mask    Initial


PRINTERS . . . . . . . . . . . .    0006    0005
  SYS_MODE . . . . . . . . . . .    0000
  GRAF_CNT . . . . . . . . . . .    0001
  FULL_INSTR . . . . . . . . . .    0003
  GRAF_PRINTER . . . . . . . . .    0004
  INTLSET. . . . . . . . . . . .    0005

Segments and groups:

                N a m e             Size    align   combine class

CODE . . . . . . . . . . . . . .    07F6    PARA    NONE
STACK. . . . . . . . . . . . . .    0050    PARA    STACK

Symbols:

                N a m e             Type    Value   Attr

ARND$BIT_GRAF. . . . . . . . . .    L NEAR  00E2    CODE
AROUND . . . . . . . . . . . . .    L NEAR  01BF    CODE
BIT$CHAR . . . . . . . . . . . .    L NEAR  0131    CODE
BITTYP . . . . . . . . . . . . .    L BYTE  079E    CODE
BITVAL . . . . . . . . . . . . .    L BYTE  01F5    CODE
CHKCHAR. . . . . . . . . . . . .    L NEAR  0123    CODE
DOS$BIT_GRAF. . . . . . . . . .     L NEAR  018D    CODE
DOS$ESC_NULL. . . . . . . . . .     L NEAR  0104    CODE
DOS$ESC_SINGLE. . . . . . . . .     L NEAR  00F7    CODE
DONE . . . . . . . . . . . . . .    L NEAR  01C5    CODE
DWORD_ADDR . . . . . . . . . . .    L WORD  0004    CODE
ESC_CHAR . . . . . . . . . . . .    Number  001B
INIT_CODE. . . . . . . . . . . .    N PROC  07B3    CODE    Length =0043
INTADDR. . . . . . . . . . . . .    Number  005C
LASTONE. . . . . . . . . . . . .    L NEAR  07B3    CODE
LOOP$SEND. . . . . . . . . . . .    L NEAR  01EA    CODE
MASK$BIT_GRAF. . . . . . . . . .    Number  00FE
MASK$ESC_C . . . . . . . . . . .    Number  00BF
MASK$ESC_NULL. . . . . . . . . .    Number  00DF
MASK$ESC_SING. . . . . . . . . .    Number  00EF
MASK$FST_BITS. . . . . . . . . .    Number  00FB
MASK$NEW_INTL. . . . . . . . . .    Number  00F7
MASK$PREV_ESC. . . . . . . . . .    Number  007F
MASK$SEC_BIT6. . . . . . . . . .    Number  00FD
MORE$TO$COME . . . . . . . . . .    L NEAR  0057    CODE
NESC . . . . . . . . . . . . . .    L NEAR  0118    CODE
NEW$INTSET . . . . . . . . . . .    L NEAR  0163    CODE
NEWINT . . . . . . . . . . . . .    Number  0027
NON_EXTND. . . . . . . . . . . .    L NEAR  01BB    CODE
NORM_MODE. . . . . . . . . . . .    L NEAR  006C    CODE
NOT$BIT$MODE . . . . . . . . . .    L NEAR  0059    CODE
NOT$ESC. . . . . . . . . . . . .    L NEAR  0112    CODE
NOT$ESCC . . . . . . . . . . . .    L NEAR  0110    CODE
NOT$ESC_C. . . . . . . . . . . .    L NEAR  00CE    CODE
NOT$ESC_NULL . . . . . . . . . .    L NEAR  00BA    CODE
NOT$ESC_SING . . . . . . . . . .    L NEAR  00AD    CODE
NOT$FST. . . . . . . . . . . . .    L NEAR  0090    CODE
NOT$INT. . . . . . . . . . . . .    L NEAR  00EB    CODE
NOT$INTL . . . . . . . . . . . .    L NEAR  00A4    CODE
NOT$NUL. . . . . . . . . . . . .    L NEAR  00C5    CODE
NOT$NULL . . . . . . . . . . . .    L NEAR  0109    CODE
NOT$SEC. . . . . . . . . . . . .    L NEAR  0081    CODE
NOT$SINGLE . . . . . . . . . . .    L NEAR  00FC    CODE
NOT$VALID. . . . . . . . . . . .    L NEAR  009F    CODE
NUL. . . . . . . . . . . . . . .    Number  0000
PCHAR. . . . . . . . . . . . . .    L NEAR  0030    CODE
PR1. . . . . . . . . . . . . . .    L 0006  0009    CODE
PR2. . . . . . . . . . . . . . .    L 0006  000F    CODE
PR256. . . . . . . . . . . . . .    F PROC  0000    CODE    Length =01CE
PR2BYTE. . . . . . . . . . . . .    N PROC  01D4    CODE    Length =0010
PR3. . . . . . . . . . . . . . .    L 0006  0015    CODE
PR9BYTS. . . . . . . . . . . . .    N PROC  01E4    CODE    Length =0011
PRBYTE . . . . . . . . . . . . .    N PROC  01CE    CODE    Length =0006
SENDCHAR . . . . . . . . . . . .    L NEAR  00C8    CODE
SET$BIT_GRAF . . . . . . . . . .    L NEAR  000D    CODE
START_UP . . . . . . . . . . . .    L NEAR  001B    CODE
TI . . . . . . . . . . . . . . .    L NEAR  0043    CODE
TMPBYTE. . . . . . . . . . . . .    L BYTE  0008    CODE
TO$CHKCHAR . . . . . . . . . . .    L NEAR  0069    CODE

Warning Severe
Errors  Errors
0       0
```

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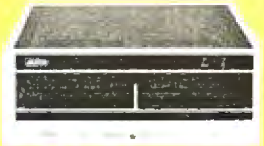

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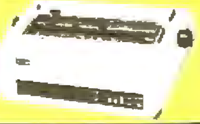

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# Circles and Ellipses on the Apple II

Douglas Priest
8615 West 20th Ave.
Lakewood, CO 80215

Given a center point and a radius, the problem of constructing a circle is fairly simple. However, suppose you know only several points on a circumference. This makes things a bit more complicated, but it's nothing a trusty Apple II can't handle. Similarly, plotting an ellipse from the two foci and a point on the perimeter may seem tricky, but it is easily accomplished.

The programs in listings 1 and 2 perform these tasks on an Apple II using Applesoft BASIC. They are designed to be used as subroutines, with slight modifications, but they can be used by themselves to design graphic displays.

The first program (see listing 1) accepts three points, (X1, Y1), (X2, Y2), and (X3, Y3), and plots a circle on the screen. The perpendicular bisector of the line (X1, Y1), (X2, Y2) passes through the point

$$\left(\frac{X1 + X2}{2}, \frac{Y1 + Y2}{2}\right)$$

and has slope

$$A = \frac{-1}{(Y2 - Y1)/(X2 - X1)} = \frac{X1 - X2}{Y2 - Y1}$$

From this information, the program finds the y-intercept B. Using the same method, it calculates the slope C and y-intercept D of the perpendicular bisector of (X2, Y2), (X3, Y3). The intersection of the resulting lines, Y = AX + B and Y = CX + D, is given by

$$X_c = \frac{D - B}{A - C} \quad \text{and} \quad Y_c = AX_c + B$$

The program then uses the distance formula to find a radius:

$$R = \sqrt{(X_c - X1)^2 + (Y_c - Y1)^2}$$

and plots a standard circle.

The second program (see listing 2) allows you to input two foci (F1 and F2) and a third point on the perimeter of the ellipse. By finding the distance from the first focus (see figure 1) to the point, and from the point to the second focus, and dividing this distance by 2, the program determines the semimajor axis. The length is also that of two sides of an isosceles triangle whose base is the line connecting the foci and whose altitude is the semiminor axis. The program finds this axis by first

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$$D = A^2 + \frac{B^2}{4} - 2A \frac{B}{2} \cos \alpha$$

The center of the ellipse is the point halfway between the foci. With this information, the program can now construct the ellipse.

### Program Notes

Both programs set the origin (0, 0) in the bottom left corner. To restore it to the upper left, delete every "159 −."

Lines 30, 40, 70, and 80 in listing 1 will give the same result more efficiently if (X1 + X2)/2 (or Y1 + Y2, as the case may be) is substituted for (X2 − X1)/2 + X1. This change can also be made in listing 2, line 20.

Listing 1 uses the paddles to input the necessary points, while listing 2 uses the keyboard. However, any routine at the appropriate lines that return values for X1, Y1, X2, Y2, X3, and Y3 (for the circle program), or X1, Y1, X2, Y2, PX, and PY (for the ellipse program), can be substituted.

In listing 1, if all three points lie in a straight line, "NO SOLUTION" is printed. If part of a shape lies outside the screen boundaries, both programs continue plotting when the shape reenters the screen. ■

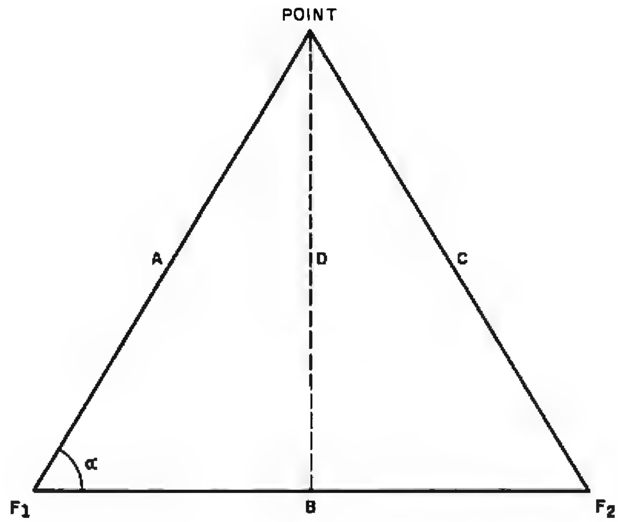


**Figure 1:** *Illustration of the method used to construct the ellipse. Enter the two foci (F1 and F2) and the point.*

**Listing 1:** *The circle program. Enter three points on the circle's perimeter and the program will draw the circle.*

```
10 P = 3.14159265
20  HGR : HCOLOR= 3: GOSUB 230
30 QX = (X2 - X1) / 2 + X1
40 QY = (Y2 - Y1) / 2 + Y1
50 A = (X1 - X2) / (Y2 - Y1)
60 B = QY - A * QX
70 QX = (X3 - X2) / 2 + X2
80 QY = (Y3 - Y2) / 2 + Y2
90 C = (X2 - X3) / (Y3 - Y2)
100 D = QY - C * QX
110  IF A = C THEN  TEXT : PRINT
     "NO SOLUTION": END
120 P1 = (D - B) / (A - C)
130 P2 = A * P1 + B
140 R =  SQR ((P1 - X1) ^ 2 + (P2
    - Y1) ^ 2)
150  HPLOT P1 + R,159 - P2
160  FOR O = 0 TO 2 * P STEP P /
     36
170 X = R *  COS (O) + P1:Y = 159
    - R *  SIN (O) - P2
180  IF X < 0 OR X > 279 OR Y < 0
     OR Y > 159 THEN 200
190  HPLOT  TO X,Y
200  NEXT O
```

Listing 1 continued on page 384

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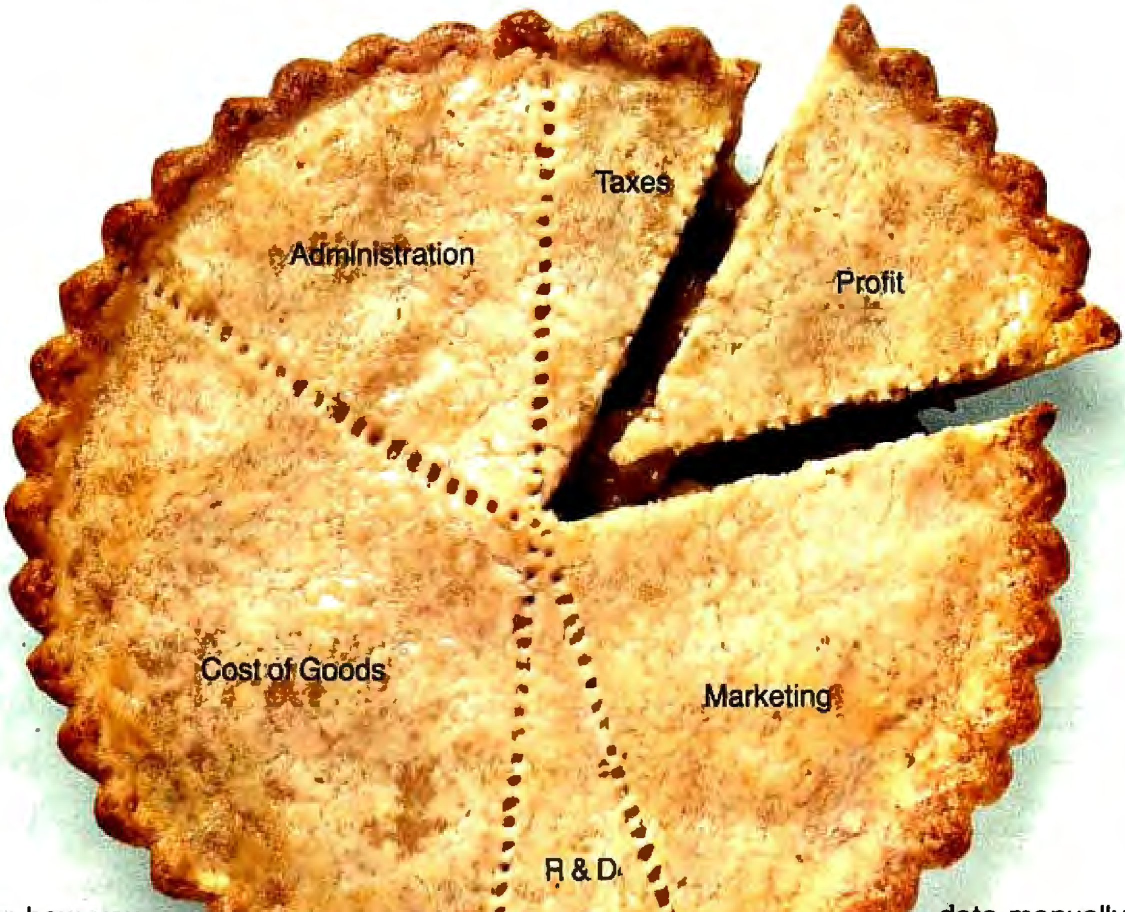


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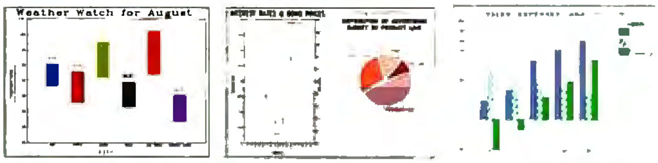

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*Listing 1 continued:*

```
210  END
220  REM  INPUT FROM PADDLES (PRE
     SS BUTTON TO ACCEPT POINT)
230  PRINT "POINT 1:";: GOSUB 270
     : PRINT X","Y:X1 = X:Y1 = Y
240  PRINT "POINT 2:";: GOSUB 270
     : PRINT X","Y:X2 = X:Y2 = Y
250  PRINT "POINT 3:";: GOSUB 270
     : PRINT X","Y:X3 = X:Y3 = Y
260  RETURN
270 X =  INT ( PDL (0) * 1.095):Y
     =  INT ( PDL (1) * .625)
280  HCOLOR= 3: HPLOT X,Y: IF  PEEK
     ( - 16287) > 127 THEN 300
290  HCOLOR= 0: HPLOT X,Y: GOTO 2
     70
300  IF  PEEK ( - 16287) > 127 THEN
     300
310 Y = 159 - Y: RETURN
```

**Listing 2:** *The ellipse program. Enter the two foci and a point on the perimeter. The program will draw the ellipse based on the location of the points.*

```
10  HGR : HCOLOR= 3: GOSUB 160:P =
     3.14159265
20 OX = (X2 - X1) / 2 + X1:OY = (
     Y2 - Y1) / 2 + Y1
30 N =  SQR ((X1 - PX) ^ 2 + (Y1 -
     PY) ^ 2) +  SQR ((X2 - PX) ^
     2 + (Y2 - PY) ^ 2)
40 A = N / 2
50 B =  SQR (A ^ 2 - ((X1 - OX) ^
     2 + (Y1 - OY) ^ 2))
60 Q =  ATN ((Y2 - Y1) / (X2 - X1
     ))
70  HPLOT OX,159 - OY
80  FOR O = 0 TO 2 * P STEP P / 3
     6
90 R = A * B /  SQR ((A *  SIN (O
     )) ^ 2 + (B *  COS (O)) ^ 2)
100 X = R *  COS (O + Q) + OX:Y =
     R *  SIN (O + Q) + OY
110  IF X < 0 OR X > 279 OR Y < 0
     OR Y > 159 THEN 130
120  HPLOT  TO X,159 - Y
130  NEXT O
140  END
150  REM  INPUT (FROM KEYBOARD)
160  INPUT "FIRST FOCUS:";X1,Y1
170  HPLOT X1,159 - Y1
180  INPUT "SECOND FOCUS:";X2,Y2
190  HPLOT X2,159 - Y2
200  INPUT "POINT:";PX,PY
210  HPLOT PX,159 - PY
220  RETURN
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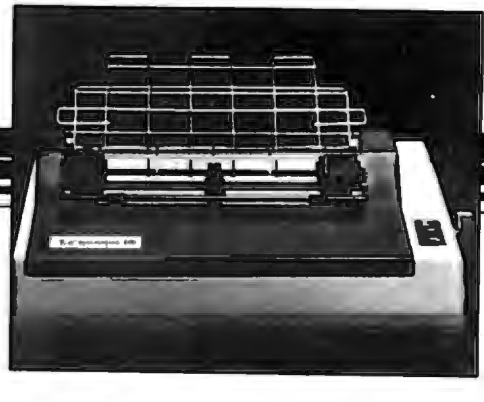

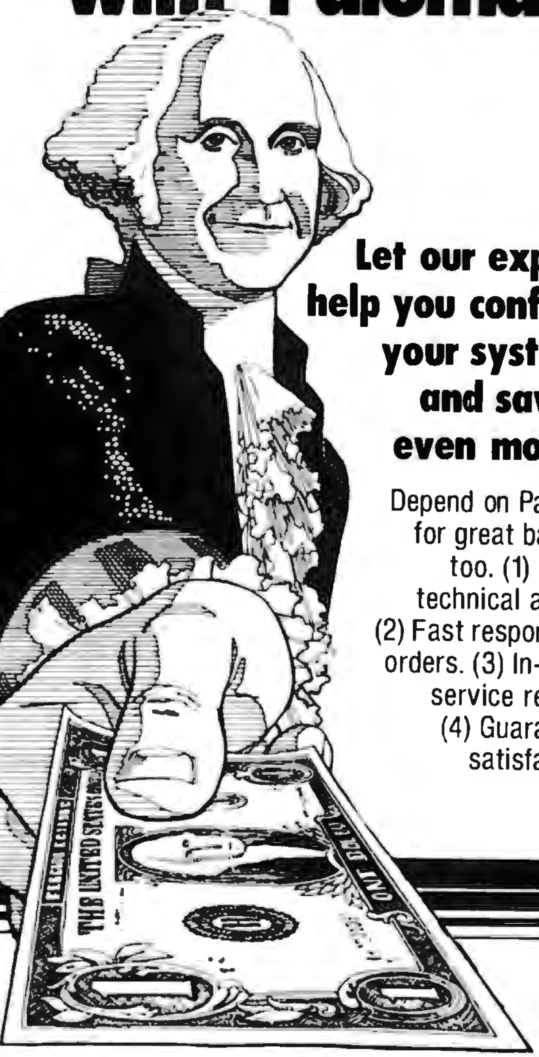

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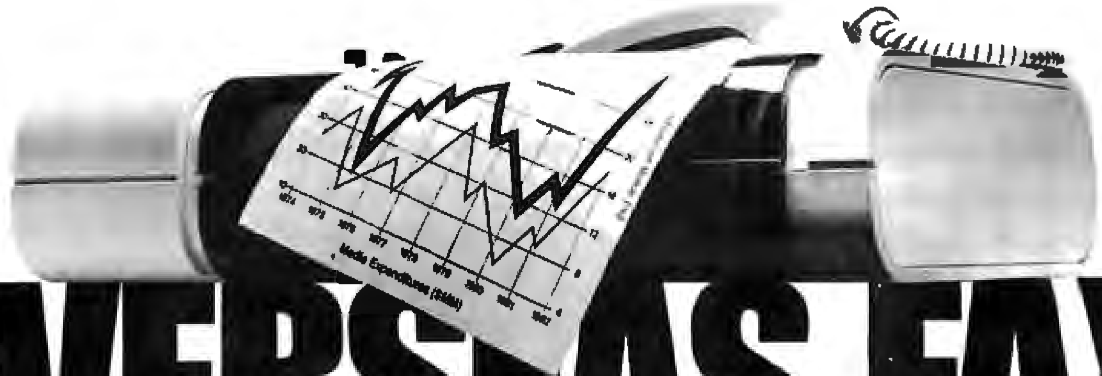

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# Keywords in a Fuzzy Context

*CBASIC programs for bibliographic search that will tell you the degree to which various articles meet your requirements.*

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I used to rack my brain trying to remember where I had read an article that contained just the information I needed for one project or another. I knew I'd read it somewhere, but I was at a loss to recall the source. As my library of periodicals grew, so did my frustration.

Then I read an article (see reference 1) in which the author, Ronald Yager, described the use of *fuzzy-set* theory in searching a bibliography. Needless to say, I had found the elegant solution to my problem. The next step was to realize Yager's brainchild by implementing it.

Shortly afterward, I began writing a set of programs in CBASIC. In writing them, I set myself several goals: to adhere to the description in Yager's article, to minimize the amount of computer memory required, and to make the programs user-friendly and crash-proof. To my surprise, I found that achieving the third goal required much more effort and code than I had anticipated.

The advantage of applying fuzzy-set theory to a bibliographic search is that you can ask for references to articles that satisfy more than one criterion. You formulate your interrogation as a logical connection of concepts; the bibliographic search system uses fuzzy-set theory to interpret the interrogation and gives you information on the degree to which the articles in the bibliography satisfy it. Then the system lists those articles that meet various criteria to the degree you had specified.

**Fuzzy sets allow you to introduce the "degree of belonging" concept.**

The search system also includes programs to build and modify both the bibliography file and an associated file containing descriptive keywords for the library. A third file, built interactively when a new library is first established, describes the record structure of the bibliographic and keyword files and contains other program initialization data. Other utility programs list the keyword vocabulary to the console or printer and compress a bibliographic file after many record deletions have been made.

## Why Fuzzy Sets?

For bibliographic searching, fuzzy sets are clearly superior to normal Boolean sets. In classical set theory, a variable can assume only two values: true or false, one or zero. An element either belongs to a set or does not. Fuzzy sets allow me to introduce the "degree of belonging" concept and still retain the ability to perform the logical operations equivalent to the AND, OR, NOT, and IMPLICATION of two-valued logic.

Two-valued logic lets me search a bibliography (with descriptive keywords attached) for all articles described as, say,

(entertaining
OR educational)
AND NOT lengthy.

But this kind of search can provide no information on *how* entertaining,

| Boolean Operation | Fuzzy Notation | Fuzzy Definition |
|---|---|---|
| x AND y | x * y | min(x,y) |
| x OR y | x + y | max(x,y) |
| NOT y | ( y )' | 1 - y |
| x IMPLIES y | x # y | max(1 – x,y) |

**Table 1:** *Notation and definition for fuzzy-set operations.*

educational, or lengthy the reported articles are. The use of fuzzy sets, however, lets me qualify each keyword descriptor by a numeric indication, in the range of 0 to 1, for the degree to which the keyword applies to an article. In addition, when I interrogate the bibliography I can now qualify each keyword I use in the search with a number between 0 and 1 to indicate the importance of that quality to me for this search.

For the sake of illustration, let's recast the two-valued example above into one using fuzzy sets. Let's suppose that one of the articles in the bibliography is described as entertaining (0.5), educational (0.8), and lengthy (0.3). Let us further suppose that I interrogate the bibliography with the following interrogation phrase:

(entertaining (0.2)
OR educational (0.9))
AND NOT lengthy (1.0)

For each of the articles in the file, the search process will first perform a logical AND on the values of corresponding keywords in the interrogation and in the article descriptors, and replace the keywords in the interrogation phrase with the results. Carrying out this expansion for our example, we have

((0.2 AND 0.5)
OR (0.9 AND 0.8))
AND NOT (1.0 AND 0.3)

When we reduce this expression using the definitions in table 1 for fuzzy operations, we obtain, in three steps:

(0.2 OR 0.8) AND NOT (0.3)
0.8 AND 0.7
0.7

This article, then, would be rated as satisfying my interrogation request at the 0.7 level. If the search had encountered a second article with the same keywords and descriptors except that its length had a value of 0.9, it would have received a rating of 0.1. The difference in ratings reflects the importance I attached to brevity.

**A traditional search can provide no information on how entertaining, educational, or lengthy the reported articles are.**

This is the basis for the method used in the bibliographic search system. The actual method employed is somewhat more flexible because the interrogation phrase is entered as a logical connection of concepts. The concept words need not be in the keyword vocabulary; the program asks you to define each concept in terms of keywords from the vocabulary and ratings associated with the keywords. Thus, using the fuzzy symbology from table 1, I could have produced the same results as in the last example by either of two sequences:

An interrogation phrase of ((entertaining + educational)* (lengthy)') followed by defining the concepts as

entertaining: entertaining 0.2
educational: educational 0.9
lengthy: lengthy 1.0

An interrogation phrase of (entertaining*(lengthy)') followed by defining the concepts as

entertaining: entertaining 0.2
educational 0.9
lengthy: lengthy 1.0

It is important to note that the only link between words (concepts) in the interrogation phrase and keywords in the bibliographic file is that established by the list of concept definitions. In effect, this allows us to redefine a keyword, as we did with the word "entertaining" in the second sequence above.

## System Overview

The bibliographic search system consists of seven separate programs chained together (using the CBASIC CHAIN statement to transfer control) under control of a main driver, BIBLIO, shown in listing 1. BIBLIO first reads a file of initialization data, then displays the menu of functions available, and finally executes the selected function. If there is no initialization data on file, the main driver will call the program PARMS (see listing 2), which interacts with the user to define the system parameters as a file called <library>.DEF. The term <library> denotes a user-chosen name that applies to all files associated with a particular bibliography; <library>.VOC, the second of three necessary files, contains the vocabulary of keywords and is built or modified by the program VOCBLD (see listing 3). After VOCBLD has executed, it automatically chains to the program VOCLST (see listing 4), which will list the keywords on the console or printer. VOCLST may also be called independently from the main menu.

To increase the efficiency of searching the list of keywords, the file <library>.VOC is maintained in lexicographic order. BIBBLD (see listing 5) builds and modifies the file of articles, <library>.BIB. No ordering is maintained in this file; articles are added by appending them to the end of the file. The program deletes articles by serially reading and displaying records of articles from the <library>.BIB file, letting the user designate records for deletion, and substituting five Zs for the first five characters of the first field of the designated records. Records so marked are ignored when the file is searched for articles. When enough records have been marked to make it wise to do so, the user runs CMPRBIB (see listing 6) to compress the <library>.BIB file. This program reads and rewrites the <library>.BIB file and eliminates all records marked for deletion, thus reclaiming wasted disk space.

The heart of this system of programs is the function that searches the bibliography file. This has been split into two programs, BIBSRCH (see listing 7) and BIBSR2 (see listing 8). BIBSR2, a continuation of BIBSRCH, has been split from it to conserve memory. The user initiates a search by entering an interrogation phrase that consists of one or more words (concepts) joined or modified by logical operators. Parentheses establish precedence for the operations. Permissible operators are the fuzzy equivalents, defined in table 1, of the Boolean AND, OR, NOT, and IMPLICATION operators. The user is then prompted to define each of the concepts he has entered in terms of keywords found in the keyword vocabulary for the library to be searched. Next, the search routine scans the <library>.BIB file of articles, calculating and recording the degree to which each article satisfies the interrogation phrase. Then the program displays the number of articles that meet or exceed each of the 11 possible degrees of satisfaction (0.0, 0.1, 0.2 . . . 1.0). Next, the user is asked for a minimum satisfaction threshold; the program then retrieves and lists all articles that meet or exceed this threshold.

The system parameter file, <library>.DEF, is generated by the program PARMS and read by the initialization section of BIBLIO. Composed of numeric data only, it is read and written in serial fashion. Lines 37–46 of listing 1 define the items in this file. The keyword vocabulary file, <library>.VOC, contains fixed-length records, each record holding

**Listing 1:** *BIBLIO, the driver routine for the bibliographic search system, initializes the system parameters, displays a menu of functions, and chains to the selected function.*

```
1:    REM ----------FILE BIBLIO.BAS
2:
3:    REM          ******* FUZZY BIBLIOGRAPHY SEARCH *******
4:    REM          *    Written by: Thomas A. Smith              *
5:    REM          *              1525 Lyndhurst Ave.,           *
6:    REM          *              Camarillo, CA 93010            *
7:    REM          ****************************************
8:
9:    REM MAIN DRIVER AND MENU
10:
11:   REM SET UP COMMON FOR CHAINING
12:   %CHAIN 40,4000,0,600
13:   COMMON KEYWD$(1),LIBNAME$,RLEN%,TRUE%,AUTH.LEN%,TITL.LEN%
14:   COMMON MAXBIB%,MAXDESC%,MAXDEF%,MAXKEYS%,MAXCON%,CONCEPT$(1)
15:   COMMON ISS.LEN%,CLS$,ERR%,JOUR.LEN%,KWD.LEN%,CMD$(1)
16:   COMMON LFT%(1),RGHT%(1),CON.KEY%(2),CON.RATE(2),QUERY$,L%
17:
18:   REM INITIALIZE
19:   IF LEN(LIBNAME$)=0 THEN \
20:     LIBNAME$=COMMAND$
21:   CLS$=CHR$(31) : TRUE%=-1
22:   PRINT CLS$
23:   IF LEN(LIBNAME$)=0 THEN \
24:     INPUT "PLEASE ENTER LIBRARY NAME: ";LIBNAME$
25:
26:   REM IF NO DEFINITIONS ON FILE GO TO DEFINITION MODULE
27:   IF END #3 THEN 14
28:   OPEN LIBNAME$+".DEF" AS 3
29:   IF SIZE(LIBNAME$+".DEF")=0 THEN \
30:     DELETE 3 : CHAIN "PARMS"
31:   GOTO 13
32:   14 CHAIN "PARMS"
33:
34:   13 REM OTHERWISE READ DEFINITIONS
35:   IF END #3 THEN  12
36:   READ #3;    \
37:   MAXKEYS%,   \           REM MAX NUMBER KEYWORDS IN VOCABULARY
38:   MAXDESC%,   \           REM MAX KEYWORDS PER BIBLIO ARTICLE
39:   MAXDEF%,    \           REM MAX KEYWORDS PER CONCEPT DEFINITION
40:   MAXCON%,    \           REM MAX NUMBER CONCEPTS PER QUERY
41:   MAXBIB%,    \           REM MAX NUMBER ARTICLES IN BIBLIO FILE
42:   AUTH.LEN%,  \           REM AUTHOR NAME FIELD LENGTH
43:   TITL.LEN%,  \           REM ARTICLE TITLE FIELD LENGTH
44:   JOUR.LEN%,  \           REM JOURNAL NAME FIELD LENGTH
45:   ISS.LEN%,   \           REM ISSUE IDENTIFIER FIELD LENGTH
46:   KWD.LEN%                REM KEYWORD FIELD LENGTH
47:   12 CLOSE 3
48:
49:                           REM TOTAL ARTICLE RECORD LENGTH
50:   RLEN%=AUTH.LEN% +JOUR.LEN% + ISS.LEN% + TITL.LEN% + \
51:         3*(MAXDESC%+1) + 2
52:   DIM KEYWD$(MAXKEYS%)
53:
54:   REM DISPLAY MENU AND GET SELECTION
55:     PRINT CLS$ : PRINT
56:     PRINT TAB(12); "--------------BIBLIOGRAPHY SEARCH--------------"
57:     PRINT
58:     PRINT TAB(12); "1    BUILD/MODIFY BIBLIOGRAPHY"
59:     PRINT TAB(12); "2    BUILD/MODIFY KEYWORD VOCABULARY"
60:     PRINT TAB(12); "3    LIST KEYWORD VOCABULARY WORDS"
61:     PRINT TAB(12); "4    SEARCH BIBLIOGRAPHY FILE"
62:     PRINT TAB(12); "5    COMPRESS BIBLIOGRAPHY FILE"
63:     PRINT TAB(12); "6    DONE--EXIT TO SYSTEM"
64:     OPT%=7 : PRINT : PRINT
65:     WHILE (OPT%>6) OR (OPT%<1)
66:     INPUT "PLEASE SELECT DESIRED FUNCTION BY NUMBER: ";OPT%
67:     IF (OPT%>6) OR (OPT%<1) THEN \
68:       PRINT "ILLEGAL FUNCTION NUMBER--REENTER"
69:       WEND
70:
71:   REM EXECUTE SELECTED FUNCTION
72:     IF OPT%=6 THEN STOP
73:     IF OPT%=1 THEN CHAIN "BIBBLD"
74:     IF OPT%=2 THEN CHAIN "VOCBLD"
75:     IF OPT%=3 THEN CHAIN "VOCLST"
76:     IF OPT%=4 THEN CHAIN "BIBSRCH"
77:     IF OPT%=5 THEN CHAIN "CMPRBIB"
78:   STOP
```

**Listing 2:** *PARMS, the system parameter definition program, is automatically called from BIBLIO when a new library is being established. PARMS interacts with the user to build a file containing the system file descriptions and other parameters.*

```
REM      --FILE PARMS.BAS

REM PROGRAM PARAMETER DEFINITION MODULE
```

*Listing 2 continued on page 392*

*Listing 2 continued:*

```
COMMON KEYWD$(1),LIBNAME$,RLEN%,TRUE%,AUTH.LEN%,TITL.LEN%
COMMON MAXBIB%,MAXDESC%,MAXDEF%,MAXKEYS%,MAXCON%,CONCEPT$(1)
COMMON ISS.LEN%,CLS$,ERR%,JOUR.LEN%,KWD.LEN%,CMD$(1)
COMMON LFT%(1),RGHT%(1),CON.KEY%(2),CON.RATE(2),QUERY$,L%
DIM SPARM%(4)

SPACE%=FRE
SPACE%=SPACE%-4000
10 PRINT CLS$
PRINT TAB(12);"-----PARAMETER DEFINITION FOR ";
PRINT LIBNAME$;"-----"
PRINT
PRINT \
 "THIS MODULE WILL DEFINE THE PARAMETERS FOR THE LIBRARY "; LIBNAME$
INPUT "IF YOU DO NOT WISH TO PROCEED ENTER S ELSE ENTER C: ";ANS$
IF UCASE$(LEFT$(ANS$,1))<>"C" THEN STOP
PRINT \
"** FIRST WE DEFINE THE ARTICLE RECORD FIELD SIZES **"
12 PRINT \
"YOU HAVE A MAXIMUM OF 250 CHARACTERS THAT MAY BE ALLOCATED"
PRINT \
"FOR EACH ARTICLE RECORD. EACH KEYWORD DESCRIPTOR ATTACHED"
PRINT \
"WILL CONSUME THREE OF THESE."
INPUT \
"WHAT IS THE MAXIMUM NUMBER OF DESCRIPTORS PER ARTICLE? ";MAXDESC%
PRINT USING \
"YOU HAVE ### CHARACTERS REMAINING."; 250-3*MAXDESC%
13 PRINT \
"ENTER MAXIMUM FIELD LENGTHS, IN ORDER, FOR AUTHOR, TITLE,"
PRINT \
"JOURNAL, AND ISSUE---ALL ON ONE LINE.  SEPARATE ENTRIES BY"
PRINT \
"ONE OR MORE SPACES AND FOLLOW LAST ENTRY WITH RETURN."
GOSUB 100
IF V%<>5 THEN \
  PRINT "INCORRECT NUMBER OF ENTRIES---RE-ENTER" :\
  GOTO 13
AUTH.LEN%=SPARM%(1) : TITL.LEN%=SPARM%(2)
JOUR.LEN%=SPARM%(3) : ISS.LEN% =SPARM%(4)
RLEN%=AUTH.LEN%+TITL.LEN%+JOUR.LEN%+ISS.LEN%
RLEN%=RLEN%+3*(MAXDESC%+1)+2
IF RLEN%>255 THEN \
  PRINT USING "RECORD CONTAINS ##### CHARACTERS"; RLEN%-5 :\
  PRINT "THE MAXIMUM IS 250 ---PLEASE RE-DEFINE FIELDS" :\
  GOTO 12

PRINT CLS$
PRINT \
"** NOW WE SET THE MAXIMUM SIZES OF OTHER PARAMETERS **"
40 PRINT \
"ENTER, IN ORDER, THE MAX TO BE ALLOWED FOR :"
PRINT \
"CHARS PER KEYWORD, NO. OF KEYWORDS IN VOCABULARY (<256)"
PRINT \
"NO. CONCEPTS PER INTERROGATION, NO. KEYWORDS PER CONCEPT."
PRINT \
"SEPARATE ENTRIES BY SPACES AND FOLLOW LAST WITH RETURN."
GOSUB 100
IF V%<>5 THEN \
  PRINT "INCORRECT NUMBER OF ENTRIES -- RE-ENTER" :\
  GOTO 40
KWD.LEN%= SPARM%(1) : MAXKEYS%=SPARM%(2)
MAXCON% = SPARM%(3) : MAXDEF% =SPARM%(4)
IF MAXKEYS%>255 THEN MAXKEYS%=255
INPUT "CAPACITY OF ONE SIDE OF ONE DISK (KILOBYTES): ";D.CAP
KY.FIL%=2*MAXKEYS%*(KWD.LEN%+2)
KY.FIL%=1024*(INT%(KY.FIL%/1024)+1)
D.CAP=(1000*D.CAP-1024-KY.FIL%)/RLEN%
D.CAP=D.CAP-1
RL%=8*(MAXCON%+1)*(MAXDEF%+2)
IN%=2*(MAXCON%+1)*(MAXDEF%+1) + 4*(MAXCON%+1)
ST%=(MAXKEYS%+1)*KWD.LEN%
MEM%=(SPACE%-RL%-IN%-ST%)/2
PRINT USING \
"YOU HAVE DISK SPACE FOR ###### ARTICLES. "; D.CAP
PRINT USING \
"YOU HAVE MEMORY SPACE FOR ######. ARTICLES. "; MEM%
IF MEM%<D.CAP THEN MSPACE=MEM% ELSE MSPACE=D.CAP
PRINT USING \
"  #### ARTICLES IS THE MAXIMUM YOU MAY HAVE. "; MSPACE
IN UT \
"DO YOU WISH TO RE ALLOCATE THE AVAILABLE SPACE (Y/N)  ";ANS$
IF UCASE$(LEFT$(ANS$,1))="Y" THEN 10
INPUT "MAXIMUM NO. OF ARTICLES DESIRED: ";MAXBIB%
IF MAXBIB%>MSPACE THEN MAXBIB%=MSPACE

CREATE LIBNAME$+".DEF" AS 1
PRINT #1; \
  MAXKEYS%,MAXDESC%,MAXDEF%,MAXCON%,
  MAXBIB%,AUTH.LEN%,TITL.LEN%,JOUR.LEN%, \
  ISS.LEN%, KWD.LEN%
CLOSE 1
CHAIN "BIBLIO"
100 INPU   - "; D 4$ ;     1 ; U% 1
WHILE (I    N(DUM$) AND
  WHILE MID$(DUM$,I%,1  " " : I%       WEND
```

*Listing 2 continued on page 393*

one keyword; record length is the system parameter of line 46, listing 1. The maximum length of this file is defined in line 37 of listing 1 and cannot exceed 255 keywords.

The bibliography file, <library>.BIB, contains fixed-length records with five fields each. The first four fields contain the author's name, the article title, the journal name, and the journal issue. The system parameters in lines 42–45 of listing 1 specify the maximum number of characters that each of these fields can contain. The last of the five fields in an article record contains the keyword descriptor data, three characters per descriptor. The first two characters of each descriptor are the ASCII (American Standard Code for Information Interchange) representation of the hexadecimally encoded keyword index number; the third is the ASCII hexadecimally encoded value of the article applicability rating for the keyword, scaled up by a factor of 10.

The maximum record length for an article is 255 keywords; of these, two are required as record delimiters by CBASIC and three are used to flag the end of the keyword descriptor list. Thus the author, title, journal, and issue field lengths added to three times the number of keyword descriptors must not exceed 250. The maximum number of keyword descriptors that may be attached to an article is defined by the parameter in line 38 of listing 1.

## Building a Library

Let's walk through each of the program functions in the order you would follow to build a new library. By way of example, I will often refer to the representations of the video displays shown in listings 9–14. All user inputs in these display listings have been underlined for easy identification.

First, we call up the program for our library named COMPJOUR with the CP/M command CRUN2 BIBLIO COMPJOUR. If we had not included the library name, the BIBLIO program would have asked for one. The library name may be preceded by a disk-drive specifier; if none is specified, the system will assume the files are assigned to the drive that was selected prior to the run command. Because we are building a new library, BIBLIO will not find any files called COMPJOUR and will immediately branch to the system parameter-definition program PARMS. Listing 9 represents the video screen as we define the contents of the system parameter file COMPJOUR.DEF by responding to requests from PARMS. PARMS first gives us a chance to exit back to the operating system in case we have mistyped the library name. If the name is correct and we want to proceed, we enter a C and PARMS begins the first phase of the definition process. This phase sets up the field lengths for the article records and is completed as shown in listing 9.

The second phase, shown in the screen copy in listing 10, completes the definition process by defining parameters for the keyword vocabulary file and setting the sizes of arrays. We are asked to state the capacity of one disk surface so that the program can calculate an upper limit for the number of articles that can be stored. The number of K bytes entered should be the data storage capacity *minus* the combined size of all programs that must reside on the same disk. Because the bibliographic programs occupy 17K bytes and the CBASIC run-time interpreter requires 17K bytes of disk space, we will enter a figure of 206K bytes, which is the maximum capacity left for data storage if we have one single-sided single-density 8-inch disk. After PARMS is given this number, it informs us of the maximum number of articles that can be accommodated in the available disk and memory space. The amount of memory stated in listing 10 (13,823) is for a 64K-byte system. A 48K-byte system would provide sufficient space for processing about 5600 articles.

Before PARMS writes the COMPJOUR.DEF file, it gives us a chance to change the definitions. We might want, for example, to increase the number of articles that the disk can accommodate at the expense of the article-record size. Once the parameters file, the keyword vocabulary file, and the article file have been built, we can still redefine some of

*Listing 2 continued:*

```
    SPARM%(V%)=VAL(RIGHT$(DUM$,LEN(DUM$)-I%+1))
    V%=V%+1
    WHILE (MID$(DUM$,I%,1)<>" ") AND (I%<LEN(DUM$))
      I%=I%+1 : WEND
    WEND
RETURN
```

**Listing 3:** *VOCBLD, selected by menu item 2 from BIBLIO, lets the user build or modify the file containing the vocabulary of keywords.*

```
    REM              FILE VOCBLD.BAS

    REM BUILD/ENLARGE KEYWORD VOCABULARY

    COMMON KEYWD$(1),LIBNAME$,RLEN%,TRUE%,AUTH.  N%,I     %
    COMMON MAXBIB%,MAXDESC%,MAXDEF%,MAXKEYS%,MA....%,CONCEPT$(1)
    COMMON  SS.LEN%,CLS$,ERR%,JOUR.LEN%,KWD.LEN%,CMD$(1)
    COMMON LFT%(1),RGHT%(1),CON.KEY%(2),CON.RATE(2),QUERY$,L%
    DIM DKEY%(MAXKEYS%),V%(MAXKEYS%),MOVE%(MAXKEYS%)
    DIM L.STK%(8),R.STK%(8)
    4E1 REM BUILD/ENLARGE/CHANGE VOCABULARY FILE
    PRINT CLS$
    PRINT TAB(12);"------KEYWORD VOCABULARY BUILD/MODIFY------"
    PRINT
    BLANK$="                                                  "
    ZEES$="zzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzz"
    FOR I%=1 TO MAXKEYS% :  MOVE%(I%)=0 : V%(I%)=I% : NEXT I%
    DEL%=0

    REM IF NO FILE THEN BUILD ONE
    IF END #1 THEN 4.1E1
    OPEN LIBNAME$+".VOC" AS 1
    IF SIZE(LIBNAME$+".VOC")=0 THEN \
      DELETE 1 : GOTO 4.1E1

    REM OTHERWISE READ THE FILE
    IF END #1 THEN 4.2E1
    VOC.LEN%=1
    WHILE TRUE%
      READ #1; LINE KEYWD$(VOC.LEN%)
      VOC.LEN%=VOC.LEN%+1
      WEND
    4.2E1 CLOSE 1
    VOC.LEN%=VOC.LEN%-1
    NEW%=0
    OLD.NUM%=VOC.LEN%
    E%=RENAME(LIBNAME$+".VEK",LIBNAME$+".VOC")
    CREATE LIBNAME$+".VTM" AS 1

    INPUT "DO YOU WISH TO ADD OR DELETE (A/D)? ";ANS$
    ANS$=UCASE$(LEFT$(ANS$,1))
    IF ANS$="A" THEN 4.5E1

    REM DELETE KEYWORDS
    WHILE TRUE%
      INPUT "ENTER KEYWORD NUMBER: ";LINE TEMP$
      IF LEN(TEMP$)=0 THEN 4.4E1
      J%=VAL(TEMP$) : DEL%=DEL%+1 : DKEY%(DEL%)=J%
      KEYWD$(J%)=LEFT$(ZEES$,KWD.LEN%)
      WEND

    4.5E1 REM GET A NEW KEYWORD
    WHILE TRUE%
      IF VOC.LEN%>=MAXKEYS% THEN \
        PRINT "KEYWORD VOCABULARY FULL" :\
        GOTO 4.4E1
      4.55E1 PRINT "ENTER KEYWORD #"; VOC.LEN%+1;" : ";
      INPUT "";LINE TEMP$
      IF LEN(TEMP$)=0 THEN 4.4E1
      TEMP$=UCASE$(TEMP$)
      I%=0
      WHILE I%<LEN(TEMP$) : I%=I%+1
        IF MID$(TEMP$,I%,1)=" " THEN \
          PRINT "KEYWORDS MAY NOT CONTAIN BLANKS---RE-ENTER" :\
          GOTO 4.55E1
          WEND
      VOC.LEN%=VOC.LEN%+1 : KEYWD$(VOC.LEN%)=LEFT$(TEMP$+BLANK$,KWD.LEN%)
      WEND

    4.1E1 REM BUILD FROM SCRATCH
    CREATE LIBNAME$+".VOC" AS 1
    VOC.LEN%=0
    NEW%=-1
    GOTO 4.5E1

    4.4E1 REM QUICKSORT ARRAY OF KEYWORDS, KEEPING TRACK OF MOVES
    PRINT "SORTING...."
```

*Listing 3 continued on page 394*

*Listing 3 continued:*

```
S%=1 : L.STK%(1)=1 : R.STK%(1)=VOC.LEN%
4.41E1 L%=L.STK%(S%) : R%=R.STK%(S%) : S%=S%-1
  4.422E1 I%=L% : J%=R% : X$=KEYWD$(INT%((L%+R%)/2))
    4.43E1 WHILE KEYWD$(I%)<X$ : I%=I%+1 : WEND
    WHILE X$<KEYWD$(J%) : J%=J%-1 : WEND
    IF I%<=J% THEN \
      W$=KEYWD$(I%) : KEYWD$(I%)=KEYWD$(J%) :\
      KEYWD$(J%)=W$ : TEMP%=V%(I%) :\
      V%(I%)=V%(J%) : V%(J%)=TEMP% :\
      I%=I%+1 : J%=J%-1
    IF I%<=J% THEN 4.43E1
  IF (J%-L%) >= (R%-I%) THEN 4.44E1
  IF I%<R% THEN \
    S%=S%+1 : L.STK%(S%)=I% : R.STK%(S%)=R%
  R%=J%
  GOTO 4.45E1
  4.44E1 IF L%<J% THEN \
    S%=S%+1 : L.STK%(S%)=L% : R.STK%(S%)=J%
  L%=I%
  4.45E1 IF L%<R% THEN 4.422E1
IF S%<>0 THEN 4.41E1
REM RE-SHUFFLE MOVE VECTOR
IF NEW% THEN 4.42E1
  FOR I%=1 TO VOC.LEN%
    IF V%(I%)- OLD.NUM% THEN \
      MOVE%(V%(I%))=I% V%(I%)
    NEXT I%
IF DEL%<=0 THEN 4.42E1
FOR I%=1 TO DEL%
  MOVE%(DKEY%(I%))=999
  NEXT I%
VOC.LEN%=VOC.LEN%-DEL%
4.42E1 REM WRITE KEYWD$  ARRAY TO DISK
IF END #1 THEN 4.6E1
FOR I%=1 TO VOC.LEN%
  PRINT USING "&"; #1; KEYWD$(I%)
  NEXT I%
CLOSE 1
PRINT VOC.LEN%; " KEYWORDS WRITTEN TO VOCABULARY"
IF NOT NEW% THEN \
  E%=RENAME (LIBNAME$+".VOC",LIBNAME$+".VTM") :\
  OPEN LIBNAME$+".VBK" AS 1 :\
  DELETE 1 :\
  GOSUB 5E1
CHAIN "VOCLST"
4.6E1 PRINT "FILE WRITE ERROR"
IF NEW% THEN DELETE 1 ELSE CLOSE 1 :\
  E%=RENAME (LIBNAME$+".VOC", LIBNAME$+".VBK") :\
  OPEN LIBNAME$+".VTM" AS 1 :\
  DELETE 1
INPUT "PRESS RETURN TO GO BACK TO MENU "; LINE ANS$
4.9E1 CHAIN "BIBLIO"
REM CONVERT TWO ASCII HEX TO INTEGER
DEF FN.TWO.INT%(DUM$)
TEN%=ASC(MID$(DUM$,1,1))
IF TEN%>64 THEN TEN%=TEN%-55 ELSE TEN%=TEN%-48
ONE%=ASC(MID$(DUM$,2,1))
IF ONE%>64 THEN ONE%=ONE%-55 ELSE ONE%=ONE%-48
FN.TWO.INT%=16*TEN% + ONE%
RETURN
FEND
REM CONVERT INTEGER TO TWO ASCII HEX
DEF FN.INT.TWO$(DUM%)
HI%=DUM%/16 : LO%=DUM%-16*HI%
IF HI%<10 THEN HI%=HI%+48 ELSE HI%=HI%+55
IF LO%<10 THEN LO%=LO%+48 ELSE LO%=LO%+55
FN.INT.TWO$=CHR$(HI%) + CHR$(LO%)
RETURN
FEND
5E1 REM ALTER KEYWORD NUMBERS IN BIBLIO FILE FOR NEW ORDERING
REM IF THERE IS NO BIBLIO FILE WE ARE DONE
IF END #2 THEN 5.5E1
OPEN LIBNAME$+".BIB" RECL RLEN% AS 2
IF SIZE(LIBNAME$+".BIB")=0 THEN \
  DELETE 2 : RETURN
REM OTHERWISE WE READ AND MODIFY
PRINT "MODIFYING KEYWORD DESCRIPTORS IN BIBLIO...."
IF END #2 THEN 5.4E1
RNUM%=2
READ #2,1; LINE TEMP$
DESC.BEG%=AUTH.LEN%+TITL.LEN%+JOUR.LEN%+ISS.LEN%+1
WHILE TRUE%
  READ #2,RNUM%; LINE TEMP$
  I%=DESC.BEG% : L1%=LEN(TEMP$)
  WHILE TRUE%
    DUM$=MID$(TEMP$,I%,3)
    IF DUM$="FFF" THEN 5.3E1
```

*Listing 3 continued on page 395*

these parameters. This might be desirable if changes have occurred in either our disk or memory capacity. None of the parameters entered in listing 9 can be altered, nor can the first parameter entered in listing 10, but any or all of the rest may be. The safest way to accomplish a redefinition is to rename the existing COMPJOUR.DEF file to save it as a backup and then rerun BIBLIO, which will let us generate a new COMPJOUR.DEF file as described above. We can then display the contents of both files on the video screen by using the CP/M command TYPE in order to verify that the new file is correct. When the parameter definition is completed, the program displays the menu shown in listing 11 and asks us to make a selection. This menu reappears after completion of any of the six listed tasks—except the last, which exits to CP/M. Our next step is to build a vocabulary of keywords. Accordingly, we select menu item 2 and branch to the program VOCBLD.

Listing 12 represents the video display as we use VOCBLD to add to an existing library of 110 words. The display is the same for building a new vocabulary except that the query about adding or deleting is not present and the keyword numbers start with 1. Keyword entries may not contain spaces. To enter a multiple-word keyword, we hyphenate it as shown in the first keyword entry in listing 12. We terminate the entry of keywords by pressing only the Return key in response to the keyword entry prompt.

Once all the keywords have been entered, VOCBLD sorts them into alphabetic order and then notifies us of the total number contained in the file COMPJOUR.VOC after it has written or rewritten the file. If a file of articles, COMPJOUR.BIB, has already been created, VOCBLD will next scan it and modify the keyword numbers attached to each article to reflect the reordered vocabulary of keywords. VOCBLD informs us that it is doing this in the last line of listing 12. As its last step, VOCBLD calls up the vocabulary listing program VOCLST to give us an up-to-date printout of the vocabulary such as that shown in listing 13. We can execute VOCLST at any time by selecting menu item 3 and directing output to the printer or the video display. After the vocabulary is listed, the display reverts to the main menu.

To continue creating a new library, we select menu item 1, which causes BIBLD to execute. As shown in listing 14, BIBLD prompts us to enter each item in an article record and to terminate data entry by responding to the AUTHOR prompt by pressing the Return key. The display in listing 14 actually shows an addition to a file of articles that already existed; the only difference in the display is the question in the second line. When we enter the keywords and their ratings, we must separate them by spaces; we must also enter the keywords exactly as they appear in the vocabulary. When we finish entering articles, BIBLD updates the COMPJOUR.BIB file, informs us of the number of articles on file, and then transfers back to the menu display when we press Return.

## Searching the Library

Now that we have built a library, we can search it. Selecting menu item 4 calls BIBSRCH, which puts us in the search mode and, as shown in listing 15, prompts us to enter the interrogation phrase. The phrase we have chosen, entered in the third line of the display, expresses interest in articles about graphics that use a plotter; in addition, the phrase states (through the # sign for implication) that if the article describes a program, the program should be in BASIC. Next, BIBSRCH asks us to define each of the words, or concepts, used in our interrogation; recall that these concepts need not be keywords. The definitions entered tell BIBSRCH to interpret the concept GRAPHICS to mean exactly what the keyword GRAPHICS means; to interpret PLOTTER as meaning either of the keywords PLOTTER or PRINTER but that we prefer PLOTTER; to interpret PROGRAM to mean either of the keywords PROGRAM or LISTING; and, finally, to interpret BASIC to mean the same as the keyword BASIC.

*Listing 3 continued:*

```
      K%=FN.TWO.INT%(DUM$)
      IF MOVE%(K%)=999 THEN \
         DUM2$="" \
        ELSE \
         K%=K%+MOVE%(K%) :\
         DUM2$=FN.INT.TWO$(K%) + RIGHT$(DUM$,1)
      TEMP1$=LEFT$(TEMP$,I%-1)+DUM2$+RIGHT$(TEMP$,L1%-I%-2)
      TEMP$=LEFT$(TEMP1$+"    ",L1%)
      IF LEN(DUM2$)>0 THEN I%=I%+3
      WEND
   5.3E1 PRINT USING "&"; #2,RNUM%; TEMP$
   RNUM%=RNUM%+1
   WEND
5.4E1 CLOSE 2
5.5E1 RETURN
```

**Listing 4:** *VOCLST, called automatically from VOCBLD after any modifications to the keyword vocabulary, lists the vocabulary on the screen or printer. VOCLST can also be executed by selecting menu item 3 in BIBLIO.*

```
REM -------FILE VOCLST.BAS

REM VOCABULARY LIST TO CONSOLE/PRINTER
COMMON KEYWD$(1),LIBNAME$,RLEN%,TRUE%,AUTH.LEN%,TITL.LEN%
COMMON MAXBIB%,MAXDESC%,MAXDEF%,MAXKEYS%,MAXCON%,CONCEPT$(1)
COMMON ISS.LEN%,CLS$,ERR%,JOUR.LEN%,KWD,KWD.LEN%,CMD$(1)
COMMON LFT%(1),RGHT%(1),CON.KEY%(2),CON.RATE(2),QUERY$,L%

PRINT CLS$ : PRINT
PRINT TAB(12);"----------KEYWORD VOCABULARY LISTER-----------"
PRINT
INPUT "DO YOU WISH A PRINTED LISTING (Y/N)? ";ANS$
IF UCASE$(LEFT$(ANS$,1))="Y" THEN \
  LPRINTER : COL%=4 \
  ELSE PRINT CLS$ : COL%=3

REM IF NO VOCABULARY FILE RETURN TO MENU
IF END #1 THEN 3.3E1
OPEN LIBNAME$+".VOC" AS 1
IF SIZE(LIBNAME$+".VOC")=0 THEN \
  DELETE 1 : GOTO 3.3E1

REM OTHERWISE READ COMPLETE VOCABULARY
IF END #1 THEN 3.1E1
I%=1
WHILE TRUE%
  READ #1;LINE KEYWD$(I%)
  I%=I%+1
  WEND
3.1E1 I%=I%-1
CLOSE 1

REM LIST IN FOUR COLUMNS FOR PRINTER, THREE FOR SCREEN
IF COL%=4 THEN LPRINTER :\
  FOR J%=1 TO 5 : PRINT : NEXT J% :\
  PRINT TAB(23);LIBNAME$;" KEYWORD VOCABULARY" :\
  PRINT TAB(23);"-------------------------------"
N.ROW%=INT%(I%/COL%)
IF I%>(N.ROW%*COL%) THEN N.ROW%=N.ROW%+1
FOR J%=1 TO N.ROW%
  FOR K%=0 TO COL%-1
    IND%=J%+K%*N.ROW%
    IF IND%>I% THEN 3.2E1
    PRINT USING "###"; IND%;
    PRINT " "+KEYWD$(IND%);
    NEXT K%
  3.2E1 PRINT
  NEXT J%
PRINT
IF COL%=4 THEN PRINT : PRINT: PRINT : PRINT
CONSOLE
PRINT

3.4E1 INPUT "PRESS RETURN TO GO BACK TO MENU"; LINE ANS$
CHAIN "BIBLIO"

3.3E1 PRINT "NO VOCABULARY FILE NAMED "; LIBNAME$
GOTO 3.4E1
```

**Listing 5:** *BIBLD, called by menu selection 1 in BIBLIO, is used to build or modify the bibliographic file of articles.*

```
REM -------FILE BIBBLD.BAS

REM  BIBLIO BUILD/MODIFY ROUTINE
```

*Listing 5 continued on page 396*

*Listing 5 continued:*

```
COMMON KEYWD$(1),LIBNAME$,RLEN%,TRUE%,AUTH.LEN%,TITL.LEN%
COMMON MAXBIB%,MAXDESC%,MAXDEF%,MAXKEYS%,MAXCON%,CONCEPT$(1)
COMMON ISS.LEN%,CLS$,ERR%,JOUR.LEN%,KWD.LEN%,CMD$(1)
COMMON LFT%(1),RGHT%(1),CON.KEY%(2),CON.RATE(2),QUERY$,L%
GOSUB 6E1
CHAIN "BIBLIO"
STOP

REM CONVERT INTEGER TO TWO ASCII HEX
DEF FN.INT.TWO$(DUM%)
HI%=DUM%/16 : LO%=DUM%-16*HI%
IF HI%<10 THEN HI%=HI%+48 ELSE HI%=HI%+55
IF LO%<10 THEN LO%=LO%+48 ELSE LO%=LO%+55
FN.INT.TWO$=CHR$(HI%) + CHR$(LO%)
RETURN
FEND

REM CONVERT ONE DIGIT REAL TO ASCII HEX
DEF FN.REALONE$(DUM)
ONE%=INT%(10.0*DUM)
IF ONE%<10 THEN ONE%=ONE%+48 ELSE ONE%=ONE%+55
FN.REALONE$=CHR$(ONE%)
RETURN
FEND

6E1 REM BUILD/MODIFY BIBLIOGRAPHY FILE
PRINT CLS$
PRINT TAB(12); "------------BIBLIO BUILD/MODIFY-----------"
PRINT

REM IF NO VOCABULARY FILE,EXIT TO MENU
IF END #1 THEN 6.1E1
OPEN LIBNAME$+".VOC" AS 1
IF SIZE(LIBNAME$+".VOC")=0 THEN \
  DELETE 1 : GOTO 6.1E1
VOC.LEN%=1

REM OTHERWISE READ VOCABULARY
IF END #1 THEN 6.2E1
WHILE TRUE%
  READ #1;KEYWD$(VOC.LEN%)
  VOC.LEN%=VOC.LEN%+1
  WEND
6.2E1 CLOSE 1
VOC.LEN%=VOC.LEN%-1

REM IF NO BIBLIO FILE, GO BUILD ONE
IF END #2 THEN 6.3E1
OPEN LIBNAME$+".BIB" RECL RLEN% AS 2
IF SIZE(LIBNAME$+".BIB")=0 THEN \
  DELETE 2 : GOTO 6.3E1

REM OTHERWISE WE WANT TO ADD OR DELETE
INPUT "DO YOU WISH TO ADD OR DELETE ARTICLES (A/D)? ";ANS$
ANS$=UCASE$(LEFT$(ANS$,1))
IF ANS$="D" THEN 4E1

REM FIND LAST SECTOR AND READ BIBLIO TO EOF
IF END #2 THEN 6.37E1
READ #2,1; LINE BUFF$
BIB.LEN%=VAL(BUFF$)
READ #2,BIB.LEN%-2;
WHILE TRUE%
  READ #2;BUFF$
  WEND
GOTO 6.37E1

6.3E1 REM BUILD IT
BIB.LEN%=0
CREATE LIBNAME$+".BIB" RECL RLEN% AS 2
PRINT USING "######"; #2,1; BIB.LEN%

REM GET ENTRIES FOR BIBLIO AND WRITE TO FILE
6.37E1 BLANK$="                                        "
PRINT "PRESSING RETURN IN RESPONSE TO THE PROMPT 'AUTHOR'"
PRINT "TERMINATES THIS ROUTINE. "
PRINT
WHILE TRUE%
  IF BIB.LEN%>=MAXBIB% THEN 6.34E1
  BUFF$=""
  INPUT "AUTHOR :  "; LINE AUTHOR$
  IF LEN(AUTHOR$)=0 THEN \
    PRINT USING "&"; #2; CHR$(26) :\
    GOTO 6.32E1
  INPUT "TITLE :   "; LINE TITLE$
  INPUT "JOURNAL : "; LINE JOURNAL$
  INPUT "ISSUE :   "; LINE ISSUE$
  AUTHOR$=LEFT$(AUTHOR$+BLANK$,AUTH.LEN%)
  TITLE$=LEFT$(TITLE$+BLANK$,TITL.LEN%)
  JOURNAL$=LEFT$(JOURNAL$+BLANK$,JOUR.LEN%)
  ISSUE$=LEFT$(ISSUE$+BLANK$,ISS.LEN%)
  6.33E1 BUFF$=AUTHOR$+TITLE$+JOURNAL$+ISSUE$
  PRINT "ENTER KEYWORDS AND RATINGS, I.E., KEYWORD1 0.5 KEYWORD2 0.6"

REM GET KEYWORDS AND RATINGS--CODE INTO ASCII HEX
  CMD$="" : KEY%=0 : ERR%=0
  INPUT ">"; LINE CMD$
```

*Listing 5 continued on page 397*

Before we continue, a few notes on the syntax of an interrogation phrase seem appropriate. Parentheses establish the precedence of the operations; the complete phrase must be enclosed in parentheses and it may not contain spaces. The fuzzy-operator notation is defined in table 1; the NOT operator must be immediately preceded by a right parenthesis, marking the end of the expression to which the NOT applies.

After BIBSRCH has parsed the interrogation phrase and defined the concepts according to our instructions, the program chains to BIBSR2, the second half of the search program. BIBSR2 scans each article on file, calculating the degree to which each one satisfies our interrogation. The amount of time required for this search can be substantial for a large bibliography, but as long as we see that the disk is being accessed properly, we can be sure the search is proceeding normally. When this scan is over, the video display represented in listing 16 appears with a summary of the results of the search. We can then enter the rating level that we want articles to meet or exceed. Next we indicate whether we want printed output for the search report. When the program has this choice, it prints or displays the report as shown in listing 17. The report begins with a section recounting the specifications for the search, which is followed by articles that meet those specifications.

## Some Notes and Cautions

Three of the system's capabilities remain to be addressed. We can delete keywords from the vocabulary under menu item 2. The display is essentially the same as that for adding keywords (see listing 12), except that we are asked to enter the index number for the keyword rather than the keyword itself. Menu item 1 lets us delete articles from the bibliography. This is a slow process because each article in the file is read and displayed, and we are asked to choose to keep or delete each article. Those we designate for deletion are flagged and then rewritten; those we designate for retention are rewritten unchanged.

After enough records have been flagged for deletion to make it worthwhile to recover their space, menu item 6 can compress the file. We can use an alternate method of deleting articles if enough disk space is available. The file of articles can be read by ED, the CP/M editor; because each article will appear to the editor as one line, the line positioning and kill commands can be used to delete articles. If we use this method, the total record count contained in the first record of the file must be changed to reflect the new total.

You will need to change line 21 of the program BIBLIO to set the clear-screen command to that required by your terminal. The display and printer formatting in these programs assumes a line length of at least 64 characters for the display and 80 for the printer. If your lines are shorter, you may wish to change the output formatting.

## Possible Extensions

The programs I have described can be run on systems with at least 40K bytes of memory and one disk drive. As the examples illustrate, the use of fuzzy sets provides information on the degree to which articles meet certain requirements. A traditional keyword search would not provide this information.

Many businesses could take advantage of the application of fuzzy sets to the search process. The system could match customer preferences with product or service descriptions and rate each service or product for customer satisfaction. Real-estate and mail-order firms come readily to mind. You may devise other applications to extend and improve the capabilities of the bibliographic search system. ■


References

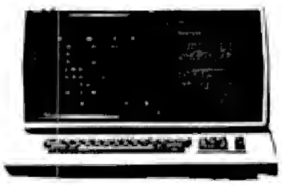
1. Yager, R. "A Logical On-Line Bibliographic Searcher: An Application of Fuzzy Sets." *IEEE Transactions on Systems, Man, and Cybernetics*, vol. SMC-10, no. 1, January 1980, p. 51.
2. Watson, S. "Fuzzy Decision Analysis." *IEEE Transactions on Systems, Man, and Cybernetics*, vol. SMC-9, no. 1, January 1979, p. 1.


*Listing 5 continued:*

```
101:    IF (LEN(CMD$)=0)  THEN 6.31E1
102:    SW%=-1 : I%=1 : W.NUM%=0
103:    WHILE (I%<LEN(CMD$))
104:      IF KEY%>=MAXDESC% THEN 6.39E1
105:      WHILE (MID$(CMD$,I%,1)=" ")
106:        I%=I%+1
107:      WEND
108:      DUM$=RIGHT$(CMD$,LEN(CMD$)-I%+1)
109:      IF NOT SW% THEN 6.36E1
110:        W.NUM%=W.NUM%+1
111:        GOSUB 19E1
112:        IF ERR% THEN 6.33E1
113:        BUFF$=BUFF$+FN.INT.TWO$(KB%)
114:        SW%=0
115:        GOTO 6.38E1
116:      6.36E1 CH$=LEFT$(DUM$,1)
117:        IF (CH$<>".") AND ((CH$<"0") OR (CH$>"9")) THEN \
118:          PRINT "KEYWORDS MAY NOT CONTAIN BLANKS---RE-ENTER LINE" :\
119:          GOTO 6.33E1
120:        IF LEFT$(DUM$,1)="." THEN \
121:          RAT=VAL("0"+DUM$) \
122:        ELSE RAT=VAL(DUM$)
123:        BUFF$=BUFF$+FN.REALONE$(RAT)
124:        KEY%=KEY%+1
125:        SW%=-1
126:      6.38E1 WHILE (MID$(CMD$,I%,1)<>" ") AND (I%<LEN(CMD$))
127:        I%=I%+1
128:      WEND
129:    WEND
130:    6.31E1 BUFF$=BUFF$+"FFF"
131:    PRINT USING "&"; #2; BUFF$
132:    BIB.LEN%=BIB.LEN%+1
133:    WEND
134:
135: 4E1 REM READ AND DISPLAY ARTICLES, SAVING OR DELETING AS WE GO
136: R.REC%=2 : DEL%=0
137: READ #2,1; LINE BUFF$
138: PRINT "TO DELETE RESPOND TO THE PROMPT ' > ' WITH AT LEAST TWO"
139: PRINT "DEPRESSIONS OF LB SIGN #, THEN RETURN.  DEPRESS ONLY THE"
140: PRINT "RETURN TO SAVE, ENTER E THEN RETURN TO EXIT TO MENU"
141: PRINT
142: IF END #2 THEN 4.4E1
143: WHILE TRUE%
144:   READ #2,R.REC%; LINE BUFF$
145:   PRINT MID$(BUFF$,AUTH.LEN%+TITL.LEN%+1,JOUR.LEN%);
146:   PRINT TAB(JOUR.LEN%+2); MID$(BUFF$,AUTH.LEN%+1,TITL.LEN%)
147:   PRINT MID$(BUFF$,AUTH.LEN%+TITL.LEN%+JOUR.LEN%+1,ISS.LEN%);
148:   PRINT TAB(JOUR.LEN%+2); LEFT$(BUFF$,AUTH.LEN%)
149:   PRINT
150:   INPUT "> "; LINE ANS$
151:   IF UCASE$(LEFT$(ANS$,1))="E" THEN 4.4E1
152:   IF LEFT$(ANS$,2)="##" THEN \
153:     PRINT USING "&"; #2,R.REC%;"ZZZZZ"+RIGHT$(BUFF$,RLEN%-7) :\
154:     DEL%=DEL%+1
155:   R.REC%=R.REC%+1
156:   WEND
157: 4.4E1 PRINT DEL%; " ARTICLES MARKED DELETED"
158: CLOSE 2
159: GOTO 6.7E1
160:
161: 6.34E1 PRINT "FILE FULL---NO MORE ARTICLES CAN BE WRITTEN"
162: 6.32E1 PRINT BIB.LEN%; " ARTICLES ON FILE"
163: PRINT USING "######"; #2,1; BIB.LEN%
164: CLOSE 2
165: GOTO 6.7E1
166:
167: 6.1E1 PRINT "NO VOCABULARY FILE NAMED "; LIBNAME$
168: 6.7E1 INPUT "PRESS RETURN TO GO BACK TO MENU "; LINE ANS$
169: RETURN
170:
171: 6.39E1 REM TOO MANY KEYWORDS ENTERED
172: KEY%=0
173: BUFF$=LEFT$(BUFF$,AUTH.LEN%+TITL.LEN%+JOUR.LEN%+ISS.LEN%)
174: PRINT "NO MORE THAN ";MAXDESC%; " KEYWORDS PER ARTICLE CAN"
175: PRINT "BE ENTERED.  PLEASE SHORTEN LIST AND RE-ENTER"
176: GOTO 6.33E1
177:
178: 19E1 REM BREAKOUT KEYWORD AND FIND ITS NUMBER
179: IR%=1
180: WHILE MID$(DUM$,IR%,1) <>" " : IR%=IR%+1 : WEND
181: WORD$=LEFT$(DUM$,IR%-1)+BLANK$
182: WORD$=LEFT$(WORD$,16)
183: WORD$=UCASE$(WORD$)
184: REM BINARY SEARCH FOR WORD IN KEYWORD ARRAY
185: IB%=1 : JB%=VOC.LEN%
186: 19.1E1 KB%=(IB%+JB%)/2
187  IF WORD$>KEYWD$(KB%) THEN \
188:   IB%=KB%+1 \
189:   ELSE JB%=KB%-1
190: IF (WORD$<>KEYWD$(KB%)) AND (IB%<=JB%) THEN 19.1E1
191: IF WORD$<>KEYWD$(KB%) THEN 19.3E1
192: I%=IR%+I%-1
   : RETURN
194:
195  19.3E1 PRINT USING "CANNOT FIND KEYWORD \###"; W.NUM%
196: INPUT "PRESS RETURN TO RE-ENTER COMPLETE LINE "; LINE ANS$
197: ERR%=-1 : RETURN
```

*Additional listing on page 400*

## EAGLE



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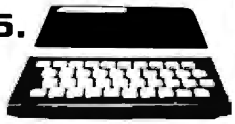

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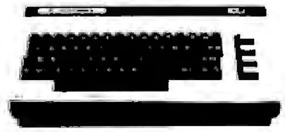

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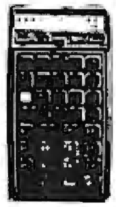

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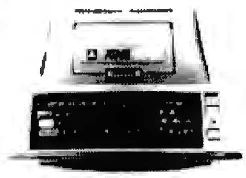

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|---|---|
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|---|---|
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**Listing 6:** *CMPRBIB, called by menu selection 5, compresses the file of articles by removing all articles that have been marked for deletion by BIBLD.*

```
REM------FILE CMPRBIB.BAS

REM COMPRESS BIBLIOGRAPHY FILE BY REMOVING MARKED ARTICLES

COMMON KEYWD$(1),LIBNAME$,RLEN%,TRUE%,AUTH.LEN%,TITL.LEN%
COMMON MAXBIB%,MAXDESC%,MAXDEF%,MAXKEYS%,MAXCON%,CONCEPT$(1)
COMMON ISS.LEN%,CLS$,ERR%,JOUR.LEN%,KWD.LEN%,CMD$(1)
COMMON LFT%(1),RGHT%(1),CON.KEY%(2),CON.RATE(2),QUERY$,L%

PRINT CLS$
PRINT TAB(12);"------COMPRESS BIBLIOGRAPHY------"
PRINT

REM IF NO BIBLIO FILE THEN GO BACK TO MENU
IF END #2 THEN 5.9E1
OPEN LIBNAME$+".BIB" RECL RLEN% AS 2
IF SIZE(LIBNAME$+".BIB")=0 THEN \
  DELETE 2 : GOTO 5.9E1

REM OTHERWISE SCAN AND DELETE
R.REC%=1 : W.REC%=1 : DEL%=0
IF END #2 THEN 5.8E1
READ #2,1; LINE BUFF$
WHILE TRUE%
  READ #2,R.REC%;LINE BUFF$
  IF LEFT$(BUFF$,5)="ZZZZZ" THEN 5.2E1
    IF R.REC%<>W.REC% THEN \
      PRINT USING "&"; #2,W.REC%; BUFF$
    R.REC%=R.REC%+1 : W.REC%=W.REC%+1
    GOTO 5.3E1
  5.2E1 R.REC%=R.REC%+1 : DEL%=DEL%+1
  5.3E1 WEND
5.8E1 PRINT USING "&"; #2,W.REC%; CHR$(26)
PRINT USING "######"; #2,1; W.REC%-2
CLOSE 2
PRINT W.REC%-2; " ARTICLES ON FILE"
PRINT DEL%; " ARTICLES WERE REMOVED"
5.5E1 INPUT "PRESS RETURN TO GO BACK TO MENU";LINE ANS$
CHAIN "BIBLIO"
5.9E1 PRINT "NO BIBLIO FILE NAMED ";LIBNAME$
GOTO 5.5E1
```

**Listing 7:** *BIBSRCH, called by menu selection 4, is the first of two programs that execute in sequence to search the file of articles and report the results. BIBSRCH receives an interrogation from the user, checks it for syntax, and interacts with the user to define the interrogation in terms of vocabulary keywords.*

```
REM -------FILE BIBSRCH.BAS

REM FIRST SEGMENT OF BIBLIOGRAPHY SEARCH ROUTINE
COMMON KEYWD$(1),LIBNAME$,RLEN%,TRUE%,AUTH.LEN%,TITL.LEN%
COMMON MAXBIB%,MAXDESC%,MAXDEF%,MAXKEYS%,MAXCON%,CONCEPT$(1)
COMMON ISS.LEN%,CLS$,ERR%,JOUR.LEN%,KWD.LEN%,CMD$(1)
COMMON LFT%(1),RGHT%(1),CON.KEY%(2),CON.RATE(2),QUERY$,L%
DIM LFT%(MAXCON%), CONCEPT$(MAXCON%), CON.KEY%(MAXCON%,MAXDEF%+1)
DIM CON.RATE(MAXCON%,MAXDEF%+1),RGHT%(MAXCON%),CMD$(MAXCON%)
CONSOLE
ERR%=0
BLANK$="                                                        "
PRINT CLS$
PRINT TAB(12); "--------BIBLIOGRAPHY SEARCH--------"
PRINT

REM READ KEYWORD VOCABULARY

REM IF NO VOCABULARY FILE EXIT TO SYSTEM
IF END #1 THEN 34E1
OPEN LIBNAME$+".VOC" AS 1
IF SIZE(LIBNAME$+".VOC")=0 THEN \
  DELETE 1 : GOTO 34E1

REM OTHERWISE READ IT ALL
IF END #1 THEN 33E1
VOC.LEN%=1
WHILE TRUE%
  READ #1; LINE KEYWD$(VOC.LEN%)
  VOC.LEN%=VOC.LEN%+1
  WEND
33E1 CLOSE 1
VOC.LEN%=VOC.LEN%-1

REM IF NO BIBLIO FILE, EXIT TO SYSTEM
```

*Listing 7 continued on page 402*

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| TS-802 | Integrated ! Computer | 3295 | 2632 |
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| TS-1602GH | 16 Bit 802H Ty Computer | 6995 | Call |
| TS-806-20 | Multi-User Co | 7195 | Call |
| TS-816 | Multi User Co | 8995 | Call |
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| TV-910 | Televideo 910 | 699 | 573 |
| TV-912 | Televideo 912C | 925 | 685 |
| TV-920 | Televideo 920C | 995 | 737 |
| TV-925 | Televideo 925 | 995 | 745 |
| TV-950 | Televideo 950 | 1195 | 921 |
| TV-9010 | Second Page ( 912/920 | 80 | 50 |
| TV-9050 | One Additional Page fc 925/950 | 95 | 62 |
| TV-9051 | Three Additional Page for 950 | 120 | 95 |
| TV-MM | Far Any Televic | 60 | 53 |
| TS-24-001 | TeleSolutions · CalcStar | 790 | Call |
| TS-100 | WordStar | 495 | 280 |
| TS-150 | SpellStar | 250 | 154 |
| TS-200 | MailMerge | 250 | 171 |
| TS-300 | DataStar | 295 | 238 |
| TS-400 | Supersort | 250 | 164 |
| TS-1000 | CalcStar | 145 | 128 |
| TS-806H/20 | 20 MB Expansion for TS-( | 3600 | 2948 |
| TS-TW | Telewriter - NEC 3500 | 2195 | 1629 |

## NORTHSTAR

| ORDER NO. | DESCRIPTION | LIST | AEI PRICE |
|---|---|---|---|
| NS-94404 | Adv-2Q-64K Computer | 3599 | Call |
| NS-97404 | Adv-1Q-64K-HD-5 Computer | 4999 | Call |
| NS-94401 | Hrz-2Q-64K Horizon | 3599 | Call |
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|---|---|---|---|
| ZVM-121 | Green Screen Monit | 160 | 99 |
| Z-19-CN | Z-19 Terminal | 895 | 672 |
| ZT-1-A | Auto-Dial Terminal | 699 | 526 |
| Z-25-AA | Z-25 Dot Matrix Printer | 1499 | 1198 |
| Z-89-81 | Z-89 Computer System | 2499 | 1952 |
| Z-90-82 | Z-90 Computer System | 2799 | 2176 |
| Z-89-X | Z-89 w/o Integral Drive | 2495 | 1749 |
| Z-90-80 | Z-90 w/o Integral Drive | 2895 | 1950 |
| Z-37 | Z-37 Dual 5" Disk Drives | 1995 | 1593 |
| Z-87-89 | Z87 Dual 5" Disk Drives | 999 | 898 |
| Z-87-90 | Same Disk add 400K to Z-90 | 999 | 898 |
| ZS-67 | Z-67 Winch Floppy Dri | 5995 | 4747 |
| Z-47-DA | Z47 Dual 8 | 3695 | Call |

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| ORDER NO. | DESCRIPTION | LIST | AEI PRICE |
|---|---|---|---|
| NE-3510-1 | NEC 3510 Spinwriter R/O Serial 35 CPS | 1895 | 1500 |
| NE-3515-1 | NEC 3515 Spinwriter R/O Serial Diablo Compatible | 1925 | 1594 |
| NE-3530-1 | NEC 3530 Spinwriter | 2190 | 1764 |
| NE-3550-1 | NEC 3550 Spinwriter R/O Parallel IBM Compatible | 2350 | 2065 |
| NE-35-TRAC | Bi-directional Tractor | 265 | 237 |
| NE-7710-1 | NEC 7710 Spinwriter R/ Serial 55 CPS | 3085 | 2276 |
| NE-7715-1 | NEC 7715 Spinwriter R, Serial Diablo Comp. | 3165 | 2600 |
| NE-7720-1 | NEC 7720 Spinwriter K Serial 55 CPS | 3610 | 2917 |
| NE-7725-1 | NEC 7725 Spinwriter K Serial Diablo Comp. | 3710 | 3041 |
| NE-7730-1 | NEC 7730 Spinwriter | 3085 | 2276 |
| NE-PC-8023 | Parallel | 695 | 506 |

PLUS OTHER ACCESS ES

## STAR

| ORDER NO. | DESCRIPTION | LIST | AEI PRICE |
|---|---|---|---|
| DP-8480-IP | 80 Column Dot Printer - Parallel | 449 | Call |
| DP-8480-TS | 80 Column Dot I Printer - Serial | 464 | Call |
| Gemini-10 | 10" Carriage - Parallel | 499 | Call |
| Gemini-15 | 15" Carriage - Parallel | 649 | Call |
| | Serial Interface Card | 85 | Call |
| DP-8240 | 40 Column Dot Matrix Parallel or Serial | 250 | Call |

## OKIDATA

| ORDER NO. | DESCRIPTION | LIST | AEI PRICE |
|---|---|---|---|
| OK-82A | Okidata Microline 82A with Tractor Feed | 719 | 486 |
| OK-83A | Okidata Microline | 1195 | 713 |
| OK-84A-P | Okidata Microline - Parallel | 1395 | Call |
| OK-84A-S | Okidata M - Serial | 1495 | Call |
| OK-G-82 | Okigraph I for 82A | 99 | 36 |
| OK-G-83 | Okigraph I for 83A | 99 | 36 |
| OK-2K | 2K Buffer/Serial BD. all Models | 140 | 119 |

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| ORDER NO. | DESCRIPTION | LIST | AEI PRICE |
|---|---|---|---|
| MT1605 | Serial 200 CPS | 1695 | 1441 |
| MT1602 | Parallel 200 CPS | 1695 | 1441 |
| MT1805 | Serial - 200 CPS | 1995 | Call |
| MT1802 | Parallel - 200 CPS or 50 CPS | 1995 | Call |
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- DEC VT-180 CP/M 5¼"
- Eagle CP/M 5¼"
- Heath Z-90 CP/M 5¼"
- Heath Zenith CP/M 5¼
- Hewlett Packard 125 C
- Hewlett Packard 8 7 CI
- IBM P.C. CP/M 86
- IBM P.C. DOS
- NEC CP/M 5¼"
- Northstar Advantage CP/M 5
- Northstar Horizon CP/M 5¼"
- Ohio Scientific C-3 CP/M 5¼
- Osborne CP/M 5¼"
- Otrona CP/M 5¼"
- QD-Micropolis Mod
- Sanyo 1000 CP/M 5
- Sirius Victor 5¼"
- Software for 8086 Co
- Standard CP/M 5¼"
- Superbrain 5¼"
- Timex/Sinclair ZX81
- TRS-80 Cassette Models I & II
- TRS-80 Diskette Models I & III
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*Listing 7 continued:*

```
IF END #2 THEN 34E1
OPEN LIBNAME$+".BIB" AS 2
IF SIZE(LIBNAME$+".BIB")=0 THEN \
  DELETE 2 : GOTO 34E1
CLOSE 2

REM OTHERWISE GET A QUERY, CHECK SYNTAX AND PARSE
GOSUB 1E1

REM THEN DEFINE QUERY IN TERMS OF KEYWORDS IN VOCABULARY
GOSUB 18E1

REM NOW TO THE REST OF SEARCH ROUTINE
CHAIN "BIBSR2"
STOP

REM FUNCTION TO RECOGNIZE FUZZY OPERATORS AND PARENS
DEF FNSPEC.CH%(DUM$,POSIT%)
CH$=MID$(DUM$,POSIT%,1)
FNSPEC.CH%=0
IF (CH$="#") OR ((CH$>="'") AND (CH$<="+")) THEN FNSPEC.CH%=-1
RETURN
FEND

REM GET AND PARSE AN INTERROGATION PHRASE
1E1 ERR%=0
1.2E1 QUERY$=""
PRINT "ENTER INTERROGATION PHRASE"
INPUT ">"; LINE QUERY$
QUERY$=UCASE$(QUERY$)

REM ROUGH SYNTAX CHECK
I%=1
IF LEFT$(QUERY$,1)<>"(" THEN \
  ERR%=3 : GOSUB 9E1 : ERR%=0 : GOTO 1.2E1
PAREN%=0
WHILE I%<=LEN(QUERY$)
  IF MID$(QUERY$,I%,1)="(" THEN PAREN%=PAREN%+1
  IF MID$(QUERY$,I%,1)=")" THEN PAREN%=PAREN%-1
  I%=I%+1
  WEND
IF PAREN% THEN ERR%=4 : GOSUB 9E1: ERR%=0 : GOTO 1.2E1

REM NOW TO PARSE
PTR.ONE%=1 : PTR.TWO%=1: L%=0
1.1E1 WHILE (FNSPEC.CH%(QUERY$,PTR.ONE%)) AND (PTR.ONE%<LEN(QUERY$))
  PTR.ONE%=PTR.ONE%+1
  WEND
IF PTR.ONE%>=LEN(QUERY$) THEN RETURN
L%=L%+1
LFT%(L%)=PTR.ONE%
PTR.TWO%=PTR.ONE%
WHILE NOT FNSPEC.CH%(QUERY$,PTR.TWO%)
  PTR.TWO%=PTR.TWO%+1
  WEND
RGHT%(L%)=PTR.TWO%
CONCEPT$(L%)=MID$(QUERY$,LFT%(L%),RGHT%(L%)-LFT%(L%))
PTR.ONE%=PTR.TWO%
GOTO 1.1E1
RETURN


9E1 REM ERROR COMMENTOR
ON ERR% GOTO 9.1E1,9.2E1,9.4E1,9.5E1,9.6E1
9.1E1 PRINT "AN ILLEGAL KEYWORD INPUT--";
GOTO 9.3E1
9.2E1 PRINT "RATINGS MUST BE IN RANGE 0.0...1.0--";
GOTO 9.3E1
9.4E1 PRINT "ENTIRE PHRASE MUST BE ENCLOSED IN PARENS--";
GOTO 9.3E1
9.5E1 PRINT "RIGHT AND LEFT PARENS MUST BE BALANCED--";
GOTO 9.3E1
9.6E1 PRINT "KEYWORDS MAY NOT CONTAIN BLANKS--";
9.3E1 PRINT "RE-ENTER PHRASE"
RETURN


18E1 REM DEFINE CONCEPTS IN TERMS OF KEYWORDS
PRINT "PLEASE DEFINE EACH OF THE CONCEPTS YOU HAVE ENTERED"
PRINT "IN TERMS OF KEYWORDS AND THEIR APPLICABILITY"
PRINT "EXAMPLE : THEORY 0.6 APPLICATIONS 0.8"
PRINT
FOR J%=1 TO L%
  18.3E1 KEY%=0
  PRINT CONCEPT$(J%);
  INPUT ": "; LINE CMD$(J%)
  CMD$(J%)=UCASE$(CMD$(J%))
  SW%=-1 : I%=1
  WHILE (I%<LEN(CMD$(J%))) AND (KEY%<MAXDEF%)
    WHILE MID$(CMD$(J%),I%,1)=" " : I%=I%+1 : WEND
    DUM$=RIGHT$(CMD$(J%),LEN(CMD$(J%))-I%+1)
    IF NOT SW% THEN 18.7E1
      KEY%=KEY%+1
      GOSUB 8E1
      CON.KEY%(J%,KEY%)=KB%
      SW%=0
```

*Listing 7 continued on page 404*

*Listing 7 continued:*

```
          GOTO 18.8E1
        18.7E1 CH$=LEFT$(DUM$,1)
        IF (CH$<>".") AND ((CH$<"0") OR (CH$>"9")) THEN \
          ERR%=5 : GOSUB 9E1 : ERR%=0 : GOTO 18.3E1
        IF CH$="." THEN \
          CON.RATE(J%,KEY%)=VAL("0"+DUM$) \
        ELSE CON.RATE(J%,KEY%)=VAL(DUM$)
          IF (CON.RATE(J%,KEY%)>1.0) OR (CON.RATE(J%,KEY%)<0.0) THEN\
            ERR%=2 : GOSUB 9E1 :\
            ERR%=0 : GOTO 18.3E1
          SW%=-1
        18.8E1 WHILE (MID$(CMD$(J%),I%,1)<>" ") AND (I%<LEN(CMD$(J%)))
          I%=I%+1
          WEND
        WEND
        CON.KEY%(J%,KEY%+1)=0 : CON.RATE(J%,KEY%+1)=0.0
    NEXT J%
RETURN


8E1 REM BREAKOUT KEYWORD FROM INPUT STRING AND FIND NUMBER
IR%=1
WHILE MID$(DUM$,IR%,1)<>" " : IR%=IR%+1 : WEND
WORD$=LEFT$(DUM$,IR%-1) + BLANK$
WORD$=LEFT$(WORD$,KWD.LEN%)
REM BINARY SEARCH FOR WORD IN KEYWORD ARRAY
IB%=1 : JB%=VOC.LEN%
8.1E1 KB%=(JB%+IB%)/2
IF WORD$>KEYWD$(KB%) THEN \
  IB%=KB%+1 \
  ELSE JB%=KB%-1
IF (WORD$<>KEYWD$(KB%)) AND (IB%<=JB%) THEN 8.1E1
IF (WORD$<>KEYWD$(KB%)) THEN \
    ERR%=1 : GOSUB 9E1 : ERR%=0 :\
  GOTO 18.3E1
I%=IR%+I%-1
RETURN

REM NO FILES
34E1 PRINT "NO LIBRARY FILE NAMED "; LIBNAME$
INPUT "PRESS RETURN TO EXIT TO SYSTEM "; LINE ANS$
STOP
```

**Listing 8:** *BIBSR2 is the second of the two portions of the search program. It scans the file of articles, calculating a satisfaction rating for each, summarizes the scan results, and lists those articles that meet your specifications.*

```
REM -------FILE BIBSR2.BAS

REM SEGMENT TWO OF BIBLIOGRAPHY SEARCH PROGRAM
COMMON KEYWD$(1),LIBNAME$,RLEN%,TRUE%,AUTH.LEN%,TITL.LEN%
COMMON MAXBIB%,MAXDESC%,MAXDEF%,MAXKEYS%,MAXCON%,CONCEPT$(1)
COMMON ISS.LEN%,CLS$,ERR%,JOUR.LEN%,KWD.LEN%,CMD$(1)
COMMON LFT%(1),RGHT%(1),CON.KEY%(2),CON.RATE(2),QUERY$,L%
DIM OP.STK$(MAXCON%), V.STK(MAXCON%), ART.KEY%(MAXDESC%)
DIM RPT%(11), ART.VAL(MAXDESC%),V(MAXCON%),RATING%(MAXBIB%)
GOSUB 19E1
CHAIN "BIBLIO"
STOP

REM FUZZY LOGICAL FUNCTIONS
DEF FN.ZADEH(A,B,CH$)
ERR%=0
IF CH$="*" THEN 4E1
IF CH$="+" THEN 4.1E1
IF CH$<>"#" THEN FN.ZADEH=0: ERR%=3 : RETURN
IF B>(1.0-A) THEN FN.ZADEH=B ELSE FN.ZADEH=1.0-A
RETURN
4E1 IF A<B THEN FN.ZADEH=A ELSE FN.ZADEH=B
RETURN
4.1E1 IF A>B THEN FN.ZADEH=A ELSE FN.ZADEH=B
RETURN
FEND

3E1 REM BUILD STRING Y$ FROM QUERY$ BY REPLACING CONCEPT
REM NAMES WITH THEIR VALUES
Y$="" : Y$=LEFT$(QUERY$,LFT%(1)-1)
LFT%(L%+1)=LEN(QUERY$)+1
FOR I%=1 TO L%
  V$=STR$(V(I%))
  Y$=Y$+V$+MID$(QUERY$,RGHT%(I%),LFT%(I%+1)-RGHT%(I%))
  NEXT I%
RETURN

2E1 REM REDUCE Y$ BY PERFORMING FUZZY LOGICAL OPS
J%=1 : L1%=LEN(Y$)
IF LEFT$(Y$,1)<>"(" THEN RETURN
WHILE MID$(Y$,J%,1)<>")"
  J%=J%+1 : WEND
I%=J%
```

*Listing 8 continued on page 406*

*Listing 8 continued:*

```
WHILE MID$(Y$,I%,1)<>"("
  I%=I%-1  : WEND
I%=I%+1
M%=I%
V.PTR%=MAXCON% : OP.PTR%=MAXCON%
2.2E1 K%=M%
WHILE (ASC(MID$(Y$,K%,1))>=44)
  K%=K%+1  : WEND
V.STK(V.PTR%)=VAL(MID$(Y$,M%,K%-M%))
V.PTR%=V.PTR%-1
IF K%=J% THEN 2.1E1
OP.STK$(OP.PTR%)=MID$(Y$,K%,1)
OP.PTR%=OP.PTR%-1
M%=K%+1
GOTO 2.2E1
2.1E1 WHILE OP.PTR%<MAXCON%
  OP.PTR%=OP.PTR%+1 : OP$=OP.STK$(OP.PTR%)
  V.PTR%=V.PTR%+1   : V1=V.STK(V.PTR%)
  V.PTR%=V.PTR%+1   : V2=V.STK(V.PTR%)
  T=FN.ZADEH(V1,V2,OP$)
  IF ERR% THEN RETURN
  V.STK(V.PTR%)=T  :  V.PTR%=V.PTR%-1
  WEND
V.PTR%=V.PTR%+1  :  V1=V.STK(V.PTR%)
IF MID$(Y$,J%+1,1)="'" THEN \
  V1=1.0-V1 : \
  Y$=LEFT$(Y$,I%-2)+STR$(V1)+RIGHT$(Y$,L1%-J%-1) \
  ELSE \
  Y$=LEFT$(Y$,I%-2)+STR$(V1)+RIGHT$(Y$,L1%-J%)
GOTO 2E1
RETURN

REM CONVERT TWO ASCII HEX TO INTEGER
DEF FN.TWO.INT%(DUM$)
TEN%=ASC(MID$(DUM$,1,1))
IF TEN%>64 THEN TEN%=TEN%-55 ELSE TEN%=TEN%-48
ONE%=ASC(MID$(DUM$,2,1))
IF ONE%>64 THEN ONE%=ONE%-55 ELSE ONE%=ONE%-48
FN.TWO.INT%=16*TEN%+ ONE%
RETURN
FEND

REM CONVERT ONE ASCII HEX TO REAL
DEF FN.ONEREAL(DUM$)
ONE%=ASC(MID$(DUM$,3,1))
IF ONE%>64 THEN ONE%=ONE%-55 ELSE ONE%=ONE%-48
FN.ONEREAL=ONE%/10.0
RETURN
FEND


19E1 REM READ IN BIBLIO AND CALCULATE SATISFACTION LEVELS
IF END #2 THEN 20.1E1
BIB.LEN%=0 : DESC.BEG%=AUTH.LEN%+TITL.LEN%+JOUR.LEN%+ISS.LEN%+1
OPEN LIBNAME$+".BIB" AS 2 BUFF 16 RECS 128
READ #2; LINE BUFF$
WHILE TRUE%
  READ #2; LINE BUFF$
  BIB.LEN%=BIB.LEN%+1
  IF LEFT$(BUFF$,5)="ZZZZZ" THEN \
    RATING%(BIB.LEN%)=0 : GOTO 19.5E1
  REM DECODE DESCRIPTORS
  K%=DESC.BEG% : DESC.NO%=0
  WHILE TRUE%
    DUM$=MID$(BUFF$,K%,3)
    IF DUM$="FFF" THEN 19.1E1
    DESC.NO%=DESC.NO%+1
    ART.KEY%(DESC.NO%)=FN.TWO.INT%(DUM$)
    ART.VAL(DESC.NO%)=FN.ONEREAL(DUM$)
    K%=K%+3
    WEND

  19.1E1 REM DETERMINE ARTICLE VALUE V(J%) FOR EACH CONCEPT
  FOR J%=1 TO L%
    KEY%=1 : MIN=1.0 : MAX=0.0
    WHILE CON.KEY%(J%,KEY%)<>0
      REM FIND MATCHING ART.KEY%
      RAL=0.0
      FOR I%=1 TO DESC.NO%
        IF ART.KEY%(I%)=CON.KEY%(J%,KEY%) THEN \
          RAL=ART.VAL(I%)
        NEXT I%
      IF RAL<CON.RATE(J%,KEY%) THEN MIN=RAL ELSE \
        MIN=CON.RATE(J%,KEY%)
      IF MIN>MAX THEN MAX=MIN
      KEY%=KEY%+1
      WEND
    V(J%)=MAX
    NEXT J%
  GOSUB 3E1
  GOSUB 2E1
  IF ERR% THEN 22E1
  RATING%(BIB.LEN%)=10*VAL(Y$)
  19.5E1 WEND
20.1E1 CLOSE 2

21E1 REM SEARCH OVER RATINGS TO COMPUTE #ARTICLES VS RATINGS
```

*Listing 8 continued on page 410*

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# is Here!

***The world's most powerful* programming language is now available for your IBM® Personal Computer.**

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`N[CS⍋N;]`—To sort a list of names N according to collating sequence CS

`(I+1)⊥C` —To calculate the final balance on a cash-flow stream C at varying interest rates I

`M⌹N`—To multiply matrix M by the inverse of matrix N

`M×M` —To multiply M by itself

`((⍳⍴A)=A⍳A)/A`—To remove any duplicates from a list of data

`99+25?900` —To generate 25 different random numbers between 100 and 999

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Circle 178 on inquiry card.

*Listing 8 continued:*

```
FOR I%=1 TO 11 : RPT%(I%)=0 : NEXT I%
FOR I%=1 TO BIB.LEN%
  K%=RATING%(I%) + 1
  RPT%(K%)=RPT%(K%)+1
  NEXT I%
FOR I%= 10 TO 1 STEP -1
  RPT%(I%)=RPT%(I%) + RPT%(I%+1)
  NEXT I%
21.3E1 PRINT CLS$
PRINT TAB(11); "NUMBER OF ARTICLES THAT MEET OR EXCEED RATINGS OF"
PRINT TAB(28); "0.0.....1.0"
PRINT
PRINT TAB(11);"RATINGS";TAB(22);"#ARTICLES";
PRINT TAB(39); "RATINGS";TAB(50);"#ARTICLES"
PRINT
FOR I%=1 TO 6
  FOR K%=0 TO 1
    IND%=I%+6*K%
    IF IND%>11 THEN 21.9E1
    PRINT USING "#.#";TAB(13+28*K%); (IND%-1)/10.0;
    PRINT USING "###"; TAB(24+28*K%); RPT%(IND%);
    NEXT K%
  21.9E1 PRINT
  NEXT I%
PRINT

REM FIND AND LIST ARTICLES THAT MEET MINIMUM THRESHOLD
INPUT "ENTER MINIMUM RATING DESIRED FOR ARTICLE PRINTOUT: ";MINRAT
GOSUB 24E1
OPEN LIBNAME$+".BIB" RECL RLEN% AS 2
I%=0
IF END #2 THEN 21.2E1
WHILE I%<BIB.LEN%
I%=I%+1
  IF RATING%(I%) < INT%(10.0*MINRAT) THEN 21.1E1
  READ #2,I%+1; LINE BUFF$
  GOSUB 25E1
  21.1E1 WEND
21.2E1 CLOSE 2

CONSOLE
INPUT "DO YOU WISH TO RE-SEARCH WITH DIFFERENT THRESHOLD(Y/N) ";ANS$
IF UCASE$(LEFT$(ANS$,1))="Y" THEN 21.3E1
FOR I%=1 TO MAXCON% : OP.STK$(I%)="" : NEXT I%
RETURN

22E1 PRINT "INVALID FUZZY OPERATOR IN INTERROGATION PHRASE"
INPUT "PRESS RETURN TO RESTART SEARCH ROUTINE "; LINE ANS$
CHAIN "BIBSRCH"

24E1 REM PRINT OUTPUT HEADER INFO
INPUT "DO YOU WISH A PRINTED OUTPUT (Y/N)? "; PRNT$
IN%=1 : LLEN%=63
IF UCASE$(LEFT$(PRNT$,1))="Y" THEN \
  LPRINTER : IN%=6 : LLEN%=79 :\
  FOR IP%=1 TO 5 : PRINT : NEXT IP%
PRINT TAB(21); "Fuzzy Search of Library "; LIBNAME$
PRINT TAB(IN%);
FOR IP%=1 TO 63 : PRINT "-"; : NEXT IP% : PRINT
PRINT TAB(IN%); "Interrogation Phrase :"
PRINT TAB(IN%+3); QUERY$
PRINT TAB(IN%); "Interrogation Phrase Definitions :"
FOR IP%=1 TO L%
  PRINT TAB(IN%+3); CONCEPT$(IP%); " : ";
  PRINT CMD$(IP%)
  NEXT IP%
PRINT TAB(IN%); "Selection Level : ";
PRINT USING "#.#"; MINRAT
PRINT TAB(IN%);
FOR IP%=1 TO 63 : PRINT "-"; : NEXT IP% : PRINT
LCNT%=L%+13
RETURN

25E1 REM PRINT ARTICLE DATA
SP%=IN%+5
IF JOUR.LEN%>ISS.LEN% THEN SP%=SP%+JOUR.LEN% \
  ELSE SP%=SP%+ISS.LEN%
IF LCNT%>57 THEN \
  FOR IP%=1 TO 71-LCNT% : PRINT : NEXT IP% :LCNT%=LCNT%+5
PRINT TAB(IN%);"Record : ";
PRINT USING "####"; I%;
IF (SP%+11)>LLEN% THEN PRINT TAB(IN%); : LCNT%=LCNT%+1 :\
  ELSE PRINT TAB(SP%);
PRINT "Level : ";
PRINT USING "#.#"; RATING%(I%)/10.0
PRINT TAB(IN%); MID$(BUFF$,AUTH.LEN%+TITL.LEN%+1,JOUR.LEN%);
IF (SP%+TITL.LEN%)>LLEN% THEN PRINT TAB(IN%); : LCNT%=LCNT%+1 :\
  ELSE PRINT TAB(SP%);
PRINT MID$(BUFF$,AUTH.LEN%+1,TITL.LEN%)
PRINT TAB(IN%);MID$(BUFF$,AUTH.LEN%+TITL.LEN%+JOUR.LEN%+1,ISS.LEN%);
IF (SP%+AUTH.LEN%)>LLEN% THEN PRINT TAB(IN%); : LCNT%=LCNT%+1 :\
  ELSE PRINT TAB(SP%);
PRINT LEFT$(BUFF$,AUTH.LEN%)
PRINT
LCNT%=LCNT%+4
RETURN
```

*Additional listing on page 412*

**Listing 9:** *A copy of the first screen displayed by PARMS during the definition of parameters for a new library called COMPJOUR. Entries made by the user are underlined.*

```
              -----PARAMETER DEFINITION FOR COMPJOUR----

THIS MODULE WILL DEFINE THE PARAMETERS FOR THE LIBRARY COMPJOUR
IF YOU DO NOT WISH TO PROCEED ENTER S ELSE ENTER C  C

** FIRST WE DEFINE THE ARTICLE RECORD FIELD SIZES **
YOU HAVE A MAXIMUM OF 250 CHARACTERS THAT MAY BE ALLOCATED
FOR EACH ARTICLE RECORD.  EACH KEYWORD DESCRIPTOR ATTACHED
WILL CONSUME THREE OF THESE.
WHAT IS THE MAXIMUM NUMBER OF DESCRIPTORS PER ARTICLE?  8

YOU HAVE 226 CHARACTERS REMAINING.
ENTER MAXIMUM FIELD LENGTHS, IN ORDER, FOR AUTHOR, TITLE,
JOURNAL, AND ISSUE---ALL ON ONE LINE.  SEPARATE ENTRIES BY
ONE OR MORE SPACES AND FOLLOW LAST ENTRY WITH RETURN.
   17 50 16 16
```

**Listing 10:** *A copy of the second screen displayed by PARMS, which completes the parameter definitions for COMPJOUR.*

```
** NOW WE SET THE MAXIMUM SIZES OF OTHER PARAMETERS **
ENTER, IN ORDER, THE MAX TO BE ALLOWED FOR :
CHARS PER KEYWORD, NO. OF KEYWORDS IN VOCABULARY (<256)
NO. CONCEPTS PER INTERROGATION, NO. KEYWORDS PER CONCEPT.
SEPARATE ENTRIES BY SPACES AND FOLLOW LAST WITH RETURN.
>  16 150 8 8

CAPACITY OF ONE SIDE OF ONE DISK (KILOBYTES):  206

YOU HAVE DISK SPACE FOR     1552 ARTICLES.
YOU HAVE MEMORY SPACE FOR   13823 ARTICLES.
  1552 ARTICLES IS THE MAXIMUM YOU MAY HAVE.
DO YOU WISH TO RE-ALLOCATE THE AVAILABLE SPACE (Y/N)?  N

MAXIMUM NO. OF ARTICLES DESIRED:  1500
```

**Listing 11:** *The menu of system functions is redisplayed after a selected function has been completed. The second step in building a library is to select menu item 2 to build/modify the keyword vocabulary.*

```
           -----------BIBLIOGRAPHY SEARCH----------

           1     BUILD/MODIFY BIBLIOGRAPHY
           2     BUILD/MODIFY KEYWORD VOCABULARY
           3     LIST KEYWORD VOCABULARY WORDS
           4     SEARCH BIBLIOGRAPHY FILE
           5     COMPRESS BIBLIOGRAPHY FILE
           6     DONE--EXIT TO SYSTEM

PLEASE SELECT DESIRED FUNCTION BY NUMBER:  2
```

**Listing 12:** *The screen display as you add three new keywords to the vocabulary. You signal the end of the sequence of entries by pressing the return key in response to the prompt for another keyword.*

```
            ---------KEYWORD VOCABULARY BUILD/MODIFY-

DO YOU WISH TO ADD OR DELETE (A/D)?  A

ENTER KEYWORD # 110   :  FUZZY-SET

ENTER KEYWORD # 111   :  CODE

ENTER KEYWORD # 112   :  BALLY

ENTER KEYWORD # 113   :

SORTING....
 112 KEYWORDS WRITTEN TO VOCABULARY
MODIFYING KEYWORD DESCRIPTORS IN BIBLIO....
```

*Additional listing on page 414*

**Listing 13:** *After any modifications to the keyword vocabulary, a listing of the complete vocabulary appears on either the display or the printer. The printed output is in four columns; the display output would be in three columns.*

```
                            COMPJOUR KEYWORD VOCABULARY
                            ---------------------------
  1 A-I                    29 CP'M2.2              57 INTERPRETER          85 QUEUE
  2 ACCOUNTING             30 CRT                  58 INVENTORY            86 RANDOM
  3 ALGORITHM              31 DATA                 59 LANGUAGE             87 RECORDER
  4 ANALOG                 32 DEBUG                60 LAPLACE              88 REGRESSION
  5 ANALYSIS               33 DECIMAL              61 LINEAR               89 REVIEW
  6 APL                    34 DECISIONS            62 LINKED-LIST          90 SCHEDULING
  7 APPLICATIONS           35 DESIGN               63 LISTING              91 SEARCH
  8 ASSEMBLER              36 DIFFERENTIAL         64 LISTS                92 SERIAL
  9 ASSEMBLY               37 DIGITAL              65 LOGIC                93 SET
 10 ASTRONAUTICS           38 DISASSEMBLER         66 MAILING              94 SIMULATION
 11 BALLY                  39 DISK                 67 MANAGEMENT           95 SORT
 12 BASIC                  40 DRIVER               68 MATHEMATICS          96 SPACE
 13 BOOLEAN                41 DUMP                 69 MATRIX               97 STATISTICS
 14 BUDGET                 42 EBASIC               70 MCOS                 98 STRING
 15 BUSBASIC               43 EDITOR               71 MERGE                99 STRUCTURED
 16 BUSINESS               44 FILE                 72 MODEM               100 STRUCTURED
 17 CBASIC                 45 FINANCIAL            73 MOTION              101 TERMINAL
 18 CIRCUITS               46 FORMATTER            74 MSBASIC             102 TEST
 19 CODE                   47 FOURIER              75 NSBASIC             103 THEORY
 20 COMMUNICATIONS         48 FUZZY-SET            76 PARALLEL            104 THREE-DIMENSIONS
 21 COMPILER               49 GAME                 77 PASCAL              105 TRANSCENDENTAL
 22 COMPRESSION            50 GRAPHICS             78 PERSONAL            106 TRANSLATOR
 23 CONSTRUCTION           51 HARDWARE             79 PERSPECTIVE         107 TREES
 24 CONTROL                52 HASHING              80 PHYSICS             108 TRS-80
 25 CONVERSION             53 HEXADECIMAL          81 PLOTTER             109 TUTORIAL
 26 COPY                   54 INPUT/OUTPUT         82 PRINTER             110 UTILITY
 27 CORRELATION            55 INTEGRATION          83 PROGRAM             111 WARNIER-ORR
 28 CP/M                   56 INTERFACE            84 PSEUDORANDOM        112 Z-80
```




Circle 341 on Inquiry card.
Circle 208 on Inquiry card.

**Listing 14:** *The screen display as an article is being added to the bibliography (using menu function 1).*

```
            ----------BIBLIO BUILD/MODIFY----------

DO YOU WISH TO ADD OR DELETE ARTICLES (A/D)?  A

PRESSING RETURN IN RESPONSE TO THE PROMPT 'AUTHOR'
TERMINATES THIS ROUTINE.

AUTHOR :     Watson, S.

TITLE :      Fuzzy Decision Analysis

JOURNAL :    IEEE

ISSUE :      __________

 NTER KEYWC              ATINGS, I.E., KEYWORD1 0.5 KEYWORD2 0.6
  FUZZY-SET              STONS 0.9 ANALYSIS 0.9 APPLICATIONS 0.4

AUTHOR :

 62  ARTICLES ON FILE
PRESS RETURN TO GO BACK TO MENU
```

**Listing 15:** *The display after selecting menu item 4 to search the bibliography file. After entering the interrogation phrase, you must define each concept in the phrase in terms of keywords that are contained in the relevant vocabulary.*

```
             --------BIBLIOGRAPHY SEARCH--------

ENTER INTERROGATION PHRASE
  (GRAPHICS*PLOTTER*(PROGRAM#BASIC))

PLEASE DEFINE EACH OF THE CONCEPTS YOU HAVE ENTERED
IN TERMS OF KEYWORDS AND THEIR APPLICABILITY
EXAMPLE : THEORY 0.6 APPLICATIONS 0.8

GRAPHICS:  GRAPHICS 1.0

PLOTTER:   PLOTTER 0.9 PRINTER 0.4

PROGRAM:   PROGRAM 1.0 LISTING 1.0

BASIC:   BASIC 1.0
```

**Listing 16:** *After the search of the article file is completed, a summary of the results is displayed, and you enter the minimum rating for articles to be listed.*

```
        NUMBER OF ARTICLES THAT MEET OR EXCEED RATINGS OF
                        0.0.....1.0

        RATINGS     #ARTICLES          RATINGS     #ARTICLES

          0.0           62               0.6          1
          0.1            2               0.7          1
          0.2            2               0.8          1
          0.3            2               0.9          0
          0.4            2               1.0          0
          0.5            1

ENTER MINIMUM RATING DESIRED FOR ARTICLE PRINTOUT:  0.2

DO YOU WISH A PRINTED OUTPUT (Y/N)?  Y
```

**Listing 17:** *The report given at the conclusion of the search. The header summarizes the search specifications. The articles that meet the specifications follow.*

```
              Fuzzy Se   h of Library COMPJOUR
--------------------------------------------------------------
Interrogation Phrase :
   (GRAPHICS*PLOTTER*(PROGRAM#BASIC))
Interrogation Phrase Definitions :
   GRAPHICS : GRAPHICS 1.0
   PLOTTER : PLOTTER 0.9 PRINTER 0.4
   PROGRAM : PROGRAM 1.0 LISTING 1.0
   BASIC : BASIC 1.0
Selection Level : 0.2
--------------------------------------------------------------
Record :   17         Level : 0.8
BYTE                  Hidden Line Subroutines for 3-dimensional Plotting
May 78 p49            Gottlieb, M.

Record :   56         Level : 0.4
BYTE                  Image Processing With a Printer
Feb 81 p220           Calkins, C.A.
```

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# ROTERP: An Interpretive Language for Robot Control

*High-level languages may help bridge the gap between artificial intelligence and the home experimenter's robot.*

Gary Liming
1224 South Wheaton
St. Charles, MO 63301

A quick survey of the information being published on experimental robotics and artificial intelligence reveals a gap in practical information between the two subjects where there should be a bridge. Paradoxically, while most experiments in artificial intelligence are performed in high-level languages (notably LISP), most books and articles for robotics experimenters concentrate on hardware design and leave software control to assembly-language routines.

The assembly-language approach to robot control involves combining routines to produce a particular behavior in a robot. This method does have practical advantages: it requires little initial planning, it is usually memory-efficient, and the code can be entered by using simple switches or a keypad, making more expensive peripherals dedicated to the robot unnecessary. A major drawback, however, is the time and effort it takes to reorganize the routines to produce new behavior in the robot.

Perhaps the greatest disadvantage of using assembly language is the difficulty other experimenters have understanding the origins of a robot's behavior. Because assembly language is difficult to read, the underlying cause of the robot's behavior may elude even the well-versed experimenter. Duplicating the behavior of a robot with a different processor is usually even more difficult.

A microprocessor specifically designed for robotic control would resolve these problems. Such a microprocessor would use simple commands that exercise all of the robot's capabilities. A program for this microprocessor might look something like listing 1, which causes the robot to slowly walk a three-foot square. In addition to being easier to understand than assembly language, the program requires only 24 bytes of storage.

**Listing 1:** *This example of a first attempt at a robotic language suggests how a robot-control language should look. Instructions are simple enough to be very flexible (they might be used in any number of situations) yet powerful enough so that the programmer doesn't get bogged down in details.*

```
0000  05         SLOW
0001  08         FEET
0002  30  0003   FORWARD 3
0005  34  0090   TURN RIGHT 90
0008  30  0003   FORWARD 3
0011  34  0090   TURN RIGHT 90
0014  30  0003   FORWARD 3
0017  34  0090   TURN RIGHT 90
0020  30  0003   FORWARD 3
0023  00         HALT
```

## Enter the "Pseudoprocessor"

Our theoretical microprocessor would be practical only if all the components of the robot could be anticipated and mass production could justify its cost. In fact, custom processors have been used in intelligent instruments and even in sophisticated toys, but an experimental robot is a low-volume item and must be flexible enough to accommodate major new functions and devices. To expect all experimenters to use the same microprocessor is unrealistic.

In lieu of a custom microprocessor, we might create a "pseudoprocessor" in software. Not only would it execute our robotic instructions, but it would be easy to extend or modify as well. This pseudoprocessor could be in the form of a small interpreter, possibly in PROM (programmable read-only memory). The interpreter

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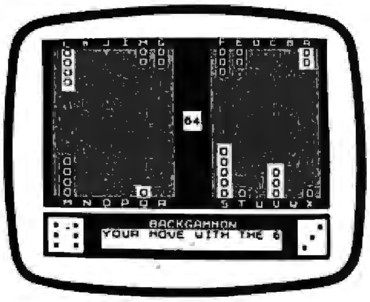


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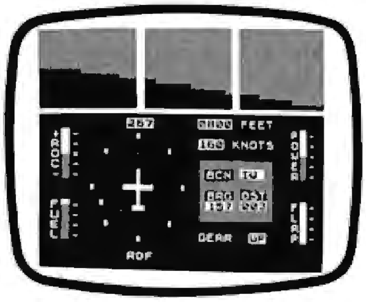


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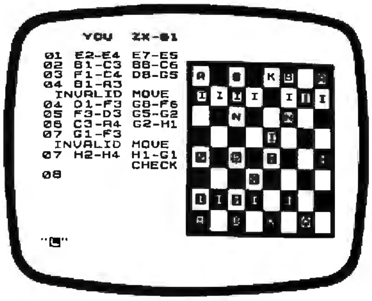


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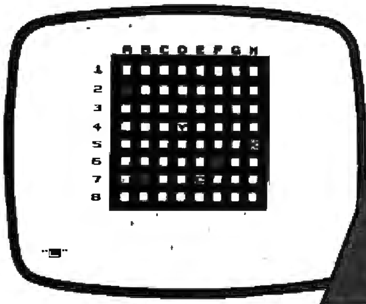

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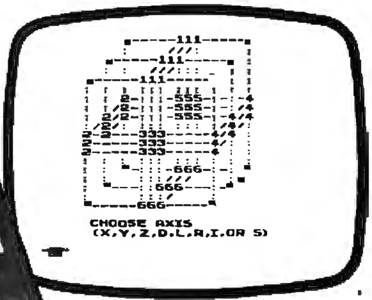


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**Table 1:** *Attributes of a simple experimental robot.*

would fetch each instruction of the program from memory and call an appropriate routine to execute that instruction. The pseudoprocessor technique is not new; languages like Pascal and even some adventure-type games have been implemented for microprocessor systems using the concept.

If all of this sounds like an argument on behalf of the use of high-level languages, it is. A robotic pseudoprocessor has a number of advantages. First, it provides programming at a behavioral level that is easy for the programmer (or anyone else) to understand. And it creates programs that are less machine-dependent. It is also conducive to the creation of more powerful instructions than those on most microprocessors. Finally, it can be extended and modified, if designed properly.

### A Simple Design

Let's see how the pseudoprocessor approach can be applied in a simple example. Table 1 shows the attributes of a basic experimental robot. It consists of an SBC (single-board computer) like many of those currently available, a frame and motors constructed with treads or wheels for mobility, some proximity sensors and light detectors, a bell or buzzer, and a numeric display and keypad (found on the SBC).

Given these simple peripheral devices, we can envision what a pseudoprocessor for a robot will look like. Of course, it will need instructions to turn the drive motors on and off and to acquire data from the sensors. It will have registers to count units of time and distance. Instructions that change the program flow and conditional testing will enhance its ability to make decisions. And it will include such standard items as a program counter, general-purpose registers, and I/O (input/output) instructions.

Figure 1 shows the architecture of the interpreter for the simple robot I named ROTERP. It has 26 general-purpose 16-bit registers, a program counter, condition codes, and some special-purpose registers. (I chose to have 26 general-purpose registers because they are easily represented by the letters of the alphabet.)

The array register, a location that points to the array being referenced, functions like an index register found on other processors. The speed register is a location for a number that the movement instructions use to determine a rate of speed. The distance-units register is a location that movement instructions use to set a scale for movement, and the time-units register specifies a time scale.

To produce a particular behavior, the registers are manipulated by the

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instruction set given in table 2, which shows each instruction op (operation) code, its associated mnemonic, the type of operand it uses, and the number of bytes per instruction. Although the op codes are shown in hexadecimal, they could easily be given in decimal; hexadecimal was chosen only for convenience. The first 64 instructions control the robot's movement while the last 64 instructions control the processor registers. Because ROTERP uses 8-bit op codes, 128 possible instructions are still available for expansion.

In order to understand the origin of behavior in our simple robot, we need to look more closely at the instructions it follows. The first group of instructions, op codes 00 through 0F hexadecimal, are all 1-byte instructions. HALT simply returns control to the monitor ROM (read-only memory) on the SBC. ZERO initializes all the processor registers except the program counter. FAST, MEDIUM, and SLOW place a predetermined number in the speed register. Similarly, INCHES, FEET, and METERS store a value in the distance-units register, and MILLSEC, SECONDS, and HOURS set the time-units register. REPEAT places the starting address of the program into the program counter and normally causes it to loop indefinitely at the end of a program. RETURN signals the end of a subroutine.

The next group of instructions, 10 through 1F hexadecimal, are each 2 bytes long and use a single-byte operand to specify a general-purpose register that contains a working value. For instance, BEEP C, represented as 17 03, causes the robot to beep the number of times indicated by register C. FORWARD B (10 02) causes the robot to move forward the number of units defined in register B. Similarly, HESITATE A (19 01) causes the robot to wait A units of time, DISPLAY A displays register A, and ENTER A places a number from the keypad in register A. TEST tests the indicated register and sets the appropriate condition codes. RANDOM returns a random number and places it in the given register. SCAN and PROXIMITY read the respective

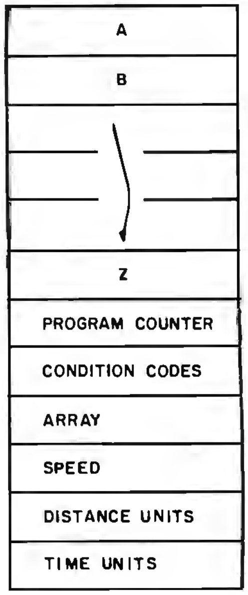


**Figure 1:** *Architecture of ROTERP, the interpreter for a simple robot. The interpreter handles 16-bit-wide registers (there is a general-purpose register for each letter of the alphabet as well as registers for condition codes and special purposes).*

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00 | HALT | | 1 | 20 | FORWARD | RC* | 2 | 40 | JUMP | R | 2 | 60 | SET | R,R | 3 |
| 01 | ZERO | | 1 | 21 | REVERSE | RC | 2 | 41 | JUMPEQ | R | 2 | 61 | ADD | R,R | 3 |
| 02 | | | | 22 | RIGHT | RC | 2 | 42 | JUMPNE | R | 2 | 62 | SUB | R,R | 3 |
| 03 | FAST | | 1 | 23 | LEFT | RC | 2 | 43 | | | | 63 | MUL | R,R | 3 |
| 04 | MEDIUM | | 1 | 24 | RTURN | RC | 2 | 44 | SBROUTNE | R | 2 | 64 | DIV | R,R | 3 |
| 05 | SLOW | | 1 | 25 | LTURN | RC | 2 | 45 | ARRAY | R | 2 | 65 | | | |
| 06 | | | | 26 | | | | 46 | | | | 66 | | | |
| 07 | INCHES | | 1 | 27 | | | | 47 | | | | 67 | COMPARE | R,R | 3 |
| 08 | FEET | | 1 | 28 | | | | 48 | | | | 68 | GET | R,R | 3 |
| 09 | METERS | | 1 | 29 | | | | 49 | | | | 69 | PUT | R,R | 3 |
| 1A | MILLISEC | | 1 | 2A | | | | 4A | | | | 6A | | | |
| 0B | SECONDS | | 1 | 2B | | | | 4B | | | | 6B | | | |
| 0C | HOURS | | 1 | 2C | | | | 4C | | | | 6C | | | |
| 0D | | | | 2D | | | | 5D | INCRMENT | R | 2 | 6D | | | |
| 0E | REPEAT | | 1 | 2E | | | | 4E | DECRMENT | R | 2 | 6E | | | |
| 0F | RETURN | | 1 | 2F | | | | 4F | CLEAR | R | 2 | 6F | | | |
| 10 | FORWARD | R* | 2 | 30 | FORWARD | N* | 3 | 50 | JUMP | N | 3 | 70 | SET | N,R | 4 |
| 11 | REVERSE | R | 2 | 31 | REVERSE | N | 3 | 51 | JUMPEQ | N | 3 | 71 | ADD | N,R | 4 |
| 12 | RIGHT | R | 2 | 32 | RIGHT | N | 3 | 52 | JUMPNE | N | 3 | 72 | SUB | N,R | 4 |
| 13 | LEFT | R | 2 | 33 | LEFT | N | 3 | 53 | | | | 73 | MUL | N,R | 4 |
| 14 | RTURN | R | 2 | 34 | RTURN | N | 3 | 54 | SBROUTNE | N | 3 | 74 | DIV | N,R | 4 |
| 15 | LTURN | R | 2 | 35 | LTURN | N | 3 | 55 | ARRAY | N | 3 | 75 | | | |
| 16 | | | | 36 | | | | 56 | | | | 76 | | | |
| 17 | BEEP | R | 2 | 37 | BEEP | N | 3 | 57 | | | | 77 | COMPARE | N,R | 4 |
| 18 | DISPLAY | R | 2 | 38 | DISPLAY | N | 3 | 58 | | | | 78 | GET | N,R | 4 |
| 19 | HESITATE | R | 2 | 39 | HESITATE | N | 3 | 59 | | | | 79 | PUT | N,R | 4 |
| 1A | | | | 3A | CALL | N | 3 | 5A | | | | 7A | | | |
| 1B | TEST | R | 2 | 3B | | | | 5B | | | | 7B | | | |
| 1C | ENTER | R | 3 | 3C | | | | 5C | | | | 7C | | | |
| 1D | RANDOM | R | 2 | 3D | | | | 5D | | | | 7D | | | |
| 1E | SCAN | R | 2 | 3E | | | | 5E | | | | 7E | | | |
| 1F | PROXIMITY | R | 2 | 3F | | | | 5F | | | | 7F | | | |

**Table 2:** *Pseudoprocessor instruction set (*R = Register, N = Number, RC = Register Count).*

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devices and place the result into the specified register.

The next group of instructions, 20 through 2F hexadecimal, cause their respective motions until the proximity register changes; then motion ceases. The elapsed distance units are then recorded in the given register.

Instructions 30 through 3F hexadecimal are 3-byte commands that use an immediate 16-bit constant for the operand. For example, BEEP 7 (37 0007) signals the robot to beep seven times. In other respects, this group mirrors the group 10 hexadecimal instructions, except for the CALL instruction; CALL is a "hook" to an assembly-language subroutine, and its operand is a 16-bit absolute address.

Five instructions work with the processor registers. JUMP A takes the signed 16-bit value in register A and adds it to the program counter. JUMPEQ and JUMPNE are conditional jumps that test the condition code register. SBROUTNE is a simple subroutine call to a section of the program, and it terminates with a RETURN instruction. Each processor register instruction uses an operand that is a relative offset to the program counter so that the resulting code is position-independent.

The ARRAY instruction declares the array being referenced by adding its operand to the program counter and placing the resulting address in the array register. The INCRMENT, DECRMENT, and CLEAR instructions are added for convenience.

GET and PUT are used with the ARRAY instruction. After an array has been declared, a GET 5,B (70 0005 02) reads the fifth 16-bit element from the array and stores it in register B. The PUT A,B instruction (69 01 02) uses the number in register A as the offset into the array and places the number found there in register B.

Finally, the register-manipulation instructions use a constant or a register to perform an operation on another register. For instance, ADD B,C (60 02 03) means "add register B to register C." COMPARE compares a constant or a register to another register and then sets the appropriate condition code.

## Some Examples

Armed with these instructions, let's try them on a simple program. Suppose we want our simple robot to search for a source of light in the room, determine how far away it is, and then report back to us. The resulting program might look something like listing 2. In this program, the robot turns to the right until it faces a source of light. Then it moves forward until it senses or bumps into the source of light, whereupon it moves back to its starting position, displays the distance, and stops. This program requires only 17 bytes through the keypad.

Of course, that is assuming the light sensor is mounted on the front of the robot and the path to the light source is unobstructed. If the program has to take obstructions into account, a triangulation scheme could be worked into it (but that, as they say, is left "as an exercise for the

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**Listing 2:** *Sample program written in ROTERP. The robot is commanded to scan the room for a light source, determine its distance, and display the information.*

```
0000    12    0001    START    RIGHT            1
0003    2B    01               SCAN             A
0005    2E    01               TEST             A
0007    42    FFF8             JUMPEQ       START
0010    30    02               COUNT FORWARD    B
0012    21    02               REVERSE          B
0014    28    02               DISPLAY          B
0016    00                     HALT
```



reader"). Imagine how much more difficult it would be in assembly language!

Let's try programming the robot to survey a room. An array can be declared to store distances and positions, data that can be acquired during the robot's trips back and forth throughout the room until it is familiar with its surroundings.

Even this simple robot can be taught to wake you when the sun comes up. Just give it explicit instructions to go to an eastern bedroom window and then let the program loop patiently until light appears. At dawn the robot will retrace its steps to your bed and beep insistently.

### The Implementation

The implementation of ROTERP is easier than I would have expected. This version fits into a single 2K-byte 2716 EPROM (erasable programmable read-only memory). It is also fairly memory-efficient: the memory required for the registers, temporary locations, and a 10-deep nested call stack is only 128 bytes, leaving the rest of available memory for program storage. (I used a Motorola MEK 6800 D2 microprocessor kit to arrive at these figures.)

Figure 2 shows the modules that need to be written to form the complete interpreter. The first module allocates some memory for all of the 16-bit processor registers, some temporary storage for use by the interpreter, and enough memory for a subroutine call stack, which must accommodate as many nested calls as might be reasonably needed. You can use 1 byte to allocate as many as 256 general-purpose registers. The tradeoff is simply between memory used by ROTERP and the amount of memory left for program storage.

The initialization module is entered after the program is placed into memory. First it places the fixed starting address of the program into the program counter, sets up any interrupt-service-routine vectors that are needed, and initializes any device that needs it. Next it calls a subroutine that clears all of the general-purpose registers and places some default values into the special-purpose reg-

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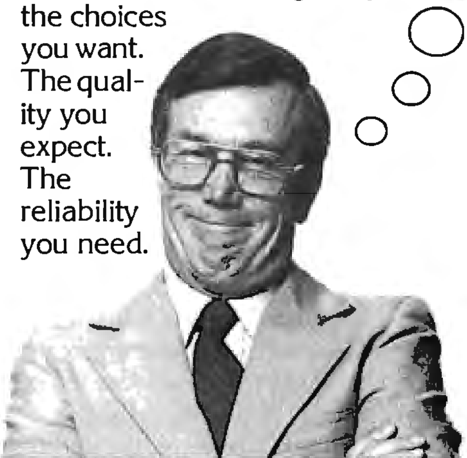

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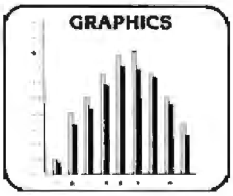


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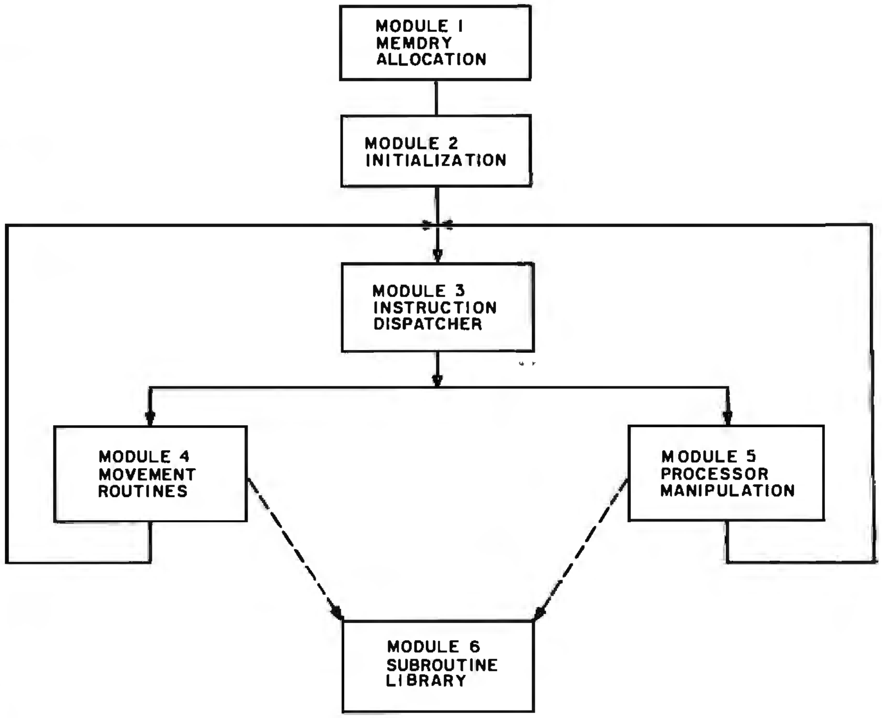



**Figure 2:** *Block diagram of ROTERP modules.*

isters. ROTERP uses SECONDS, FEET, and SLOW as defaults. This "clear and default" function is expressed as a subroutine because it is also called by the ZERO instruction.

Execution then continues into the instruction dispatch module, which contains a jump table used to pass control to the routine that executes the current instruction. If any invalid op code is executed, control is transferred to a routine that displays an error code and jumps the SBC monitor. This jump table is 256 bytes long because all op codes greater than 7F are currently treated as invalid instructions. If you want all 256 possible instructions, the jump table size would increase to 512 bytes.

The next section, which contains all the routines that carry out each instruction, is divided into two modules: one for execution of movement instructions and one for register-manipulation instructions. The instruction routines in the movement module are very dependent on the hardware scheme that controls the direction and speed of the motors. The motors can be interrupt-driven or controlled with timing loops in the manner of stepping motors and simple relay-operated DC motors.

All of the movement routines have many functions in common. First, they get the operands, translate them from a register designation to a working number as needed, and assign a temporary location to each working number. A scaling routine then translates the number of distance or time units into an absolute number expected by the motor handler. The op code itself serves as a direction indicator.

Next, the motor handler is called to perform the motion. And the last function every instruction performs is to add the length of the instruction to the program counter so that it points to the next instruction to be executed. Control is then passed back to the instruction dispatcher.

Because many of the instructions must perform common functions, the functions are expressed as subroutines and placed in the last module, the subroutine library. The subroutine library also includes routines that do common register operations like 16-bit addition, subtraction, multiplication, and division. The library is designed not only to save duplication of code but to permit the easy addition of new instructions.

To add a new instruction, you

simply place the new entry in the jump table and call the appropriate "fetch operand" routines. If the instruction is in the register-manipulation group, you can call many of the existing subroutines in the library to reduce the amount of new code that needs to be written. (If the instruction involves the use of an entirely new device, you must write a handler for that device, as you would in any case.) Finally, an existing routine increments the program counter and jumps back to the instruction dispatcher.

### Extensions

If you find yourself using a particular sequence of instructions repeatedly, a single new instruction will make your program both shorter and easier to write. And the processor is not limited to expanding new instructions: a new device may be complex enough to warrant the use of a new special-purpose register. If you expect to use many different arrays, adding new array registers is only a matter of allocating space for them and assigning new op codes that call the same subroutines that the present ARRAY instruction uses.

The simple architecture and instruction set presented here should not be considered complete or taken for the optimum design of a pseudoprocessor for robots. Each design should be tailored individually to the kinds of experiments that you expect to do. For example, if you want a link to a host computer, the instruction dispatch module can be modified to receive instructions from a serial-line interface instead of reading them from memory. Two other options exist: the processor can be oriented around 32-bit registers if more precision is desired, or it can use 8-bit registers if less precision is needed. Expressing movement routines in terms of relative polar or Cartesian coordinates might be more desirable.

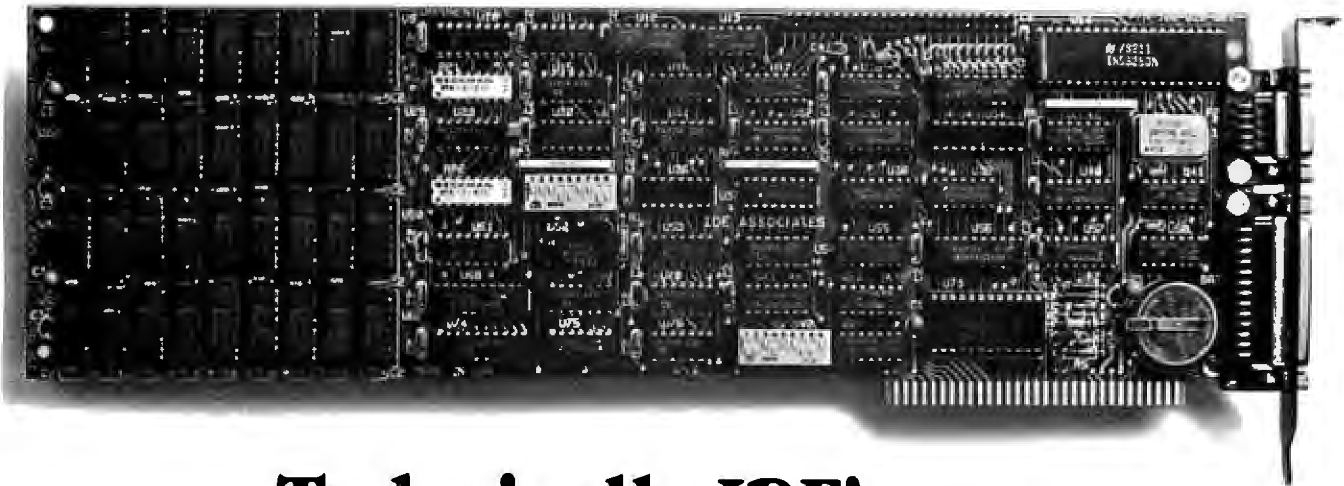
For maximum flexibility, one interpreter could include all of these features. If one byte does not sufficiently represent all of the different instructions, a 16-bit op code could be used. Better yet, a single instruction that changes jump tables would allow you to switch between whole instruction sets. The ultimate step forward, though, would be a translator that would produce running code from the instruction mnemonics. This translator would resolve symbolic references and might be the precursor of even higher-level "macro" statements of behavior. New language constructs, such as those found in LISP, might be implemented for ease of integrating the work being done in other areas of artificial intelligence.

### Summary

ROTERP illustrates how a pseudoprocessor can control the increasing mber of devices that can be incorporated into an experimental robot. With careful planning, you will be able to improve and expand the interpreter without difficulty. By tailoring robot's processor tc he kind of behavior it will perform, the robot becomes a much easier tool to work with.■





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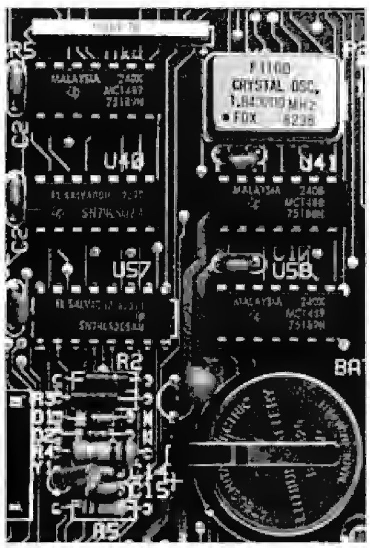

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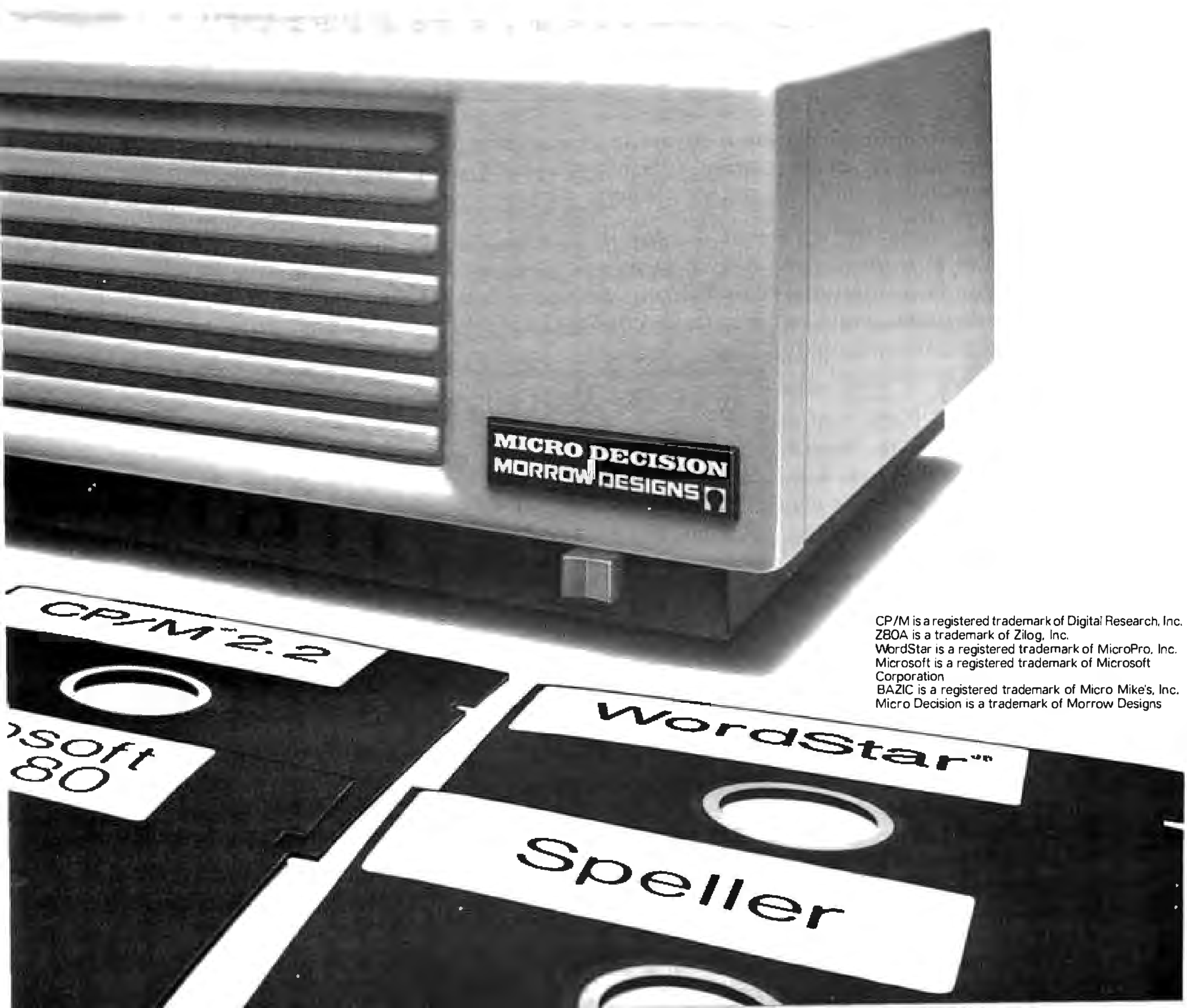


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# Using SOUND Arguments for High-Precision RTTY

*How to generate radioteletype audio frequencies from an Atari 800.*

Scott Persson
4719 Valley St.
Omaha, NE 68106

This article focuses on the audio capabilities of the Atari 800 microcomputer. These include synthesized speech, automatic Touch-Tone (a registered trademark of the Bell System) dialing, Morse-code generation, and many more. A direct use of the Atari's sound capabilities may be demonstrated by the ease with which it will generate the proper sound frequencies for the transmission of amateur radioteletype. With only a shielded cable between the Atari's monitor jack and the VHF (very high frequency) radio as interface, a completely new method of "interfaceless" data transmission for microcomputers is born. Previously, microcomputers had been sending radioteletype by controlling expensive outboard tone generators, but with the Atari 800's four built-in tone generators, who needs the expense of an interface?

## Introduction to RTTY

Amateur radioteletype (RTTY) signals are composed of two precise audio-frequency tones which alternate in patterns to produce character combinations, usually in the five-level Baudot or Murray code. The higher of the two tones is the *space* tone and the lower is the *mark* tone. The difference in frequency between the space and the mark tones is the *shift*. Radioteletype normally uses two shifts; the mark tone for both has been standardized at 2125 Hz (hertz, or cycles per second). For a 170-Hz shift, the space tone is 2295 Hz (2125 + 170); for an 850-Hz shift, the space tone is 2975 Hz (2125 + 850). The Atari 800 will generate some of these frequencies.

**With the Atari 800's four built-in tone generators, who needs the expense of an interface?**

## Simple Audio-Frequency Generation

The sound generators within the Atari are clocked at 63.921 kHz (kilohertz). Each generator is associated with a memory location and the value within that location is constantly being decremented from 255 to 0 at the clock frequency. The decrement interval is determined by the Atari BASIC SOUND statement parameters. The frequency of the audio that is produced is determined by the number of times per second that the corresponding memory location counts down to 0. The exact frequency of a SOUND statement can be determined with the following equation:

$$F_{OUT} = \frac{F_{IN}}{2N} \qquad (1)$$

where $F_{OUT}$ is the frequency actually obtained from the computer, $F_{IN}$ is 63,921 Hz, and $N$ is the second SOUND command parameter (0 to 255) plus 1.

For example, $N$ would equal 14 + 1, or 15, in the command "SOUND 0,14,10,15." We can compute the exact frequency as follows:

$$F_{OUT} = \frac{F_{IN}}{2N} = \frac{63{,}921}{2(15)}$$

| BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |
|---|---|---|---|---|---|---|---|

| Bit | Function |
|---|---|
| 7 | Not discussed. |
| 6 | Clock Generator 1 with 1.789790 MHz, instead of 63.9210 kHz. |
| 5 | Clock Generator 3 with 1.789790 MHz, instead of 63.9210 kHz. |
| 4 | Clock Generator 2 with Generator 1, instead of 63.9210 kHz. |
| 3 | Clock Generator 4 with Generator 3, instead of 63.9210 kHz. |
| 2 | Not discussed. |
| 1 | Not discussed. |
| 0 | Change normal clock frequency of 63.9210 kHz to 15.6999 kHz. |

**Figure 1:** *The 1-byte audio-control register (AUDCTL) shown as bit 0 through bit 7. AUDCTL is used to link generators together and to increase the clock rate.*

$$= \frac{63{,}921}{30}$$

$$= 2130.69 \text{ Hz}$$

This result is fairly close to our mark tone of 2125 Hz. In fact, this tone works just fine for radioteletype. The space tone of 2295 Hz used in 170-Hz shift can be approximated by making $N$ equal 13 to get 2282.89 Hz. I used this combination in my teletypewriter program (see listing 1) for several months until the local hams converted to an 850-Hz shift (2975 Hz). In order to generate 2975 Hz, you must make $N$ equal 10.74, an impossibility because the SOUND statement rounds all arguments into integers. Thus, 10.74 becomes 10, which yields a frequency of 3196 Hz.

### Complex Audio-Frequency Generation

High-precision sound generation is possible because the Atari's designers allow you to *link* two of the four sound generators together, so you're not limited to an 8-bit integer number. Thus, the range of the SOUND parameter can be expanded from 0 through 255 ( 0 through FF hexadecimal) to 0 through 65,535 (0 through FFFF hexadecimal). This means passing the generators 16 bits of information, rather than 8 bits. To do so, you cannot use the SOUND statement; all instructions and information passed to the generators must be entered directly into memory using the POKE statement.

To link the generators, you must become somewhat familiar with AUDCTL, the audio-control register (see figure 1). AUDCTL is located at memory address 53,768 (D208 hexadecimal) and writes data into the audio-mode control register. In order to link generators 1 and 2, bit 4 must be a 1; to link generators 3 and 4, bit 3 must be a 1. These bits are turned on by entering into the AUDCTL register a decimal number which is the sum of the powers of 2 that correspond to the bits you want turned on. For example, to turn on bits 3 and 4, add $2^3$ and $2^4$ (8 + 16) to get 24, and place that value into AUDCTL with the POKE statement.

The added audio-frequency precision requires the use of a faster clock rate for the generator pairs. Normally, the clock rate is 63.921 kHz and bits 0, 5, and 6 of AUDCTL are zero. To get a faster rate, turn on bit 5 if generators 1 and 2 are paired or bit 6 if generators 3 and 4 are paired. The new clock rate is 1.78979 megahertz (MHz). The increased clock rate means that a new equation is necessary to determine the output:

$$F_{OUT} = \frac{F_{IN}}{2(N+M)} \qquad (2)$$

where $F_{OUT}$ is the frequency actually



*Text continued on page 444*

**Listing 1:** *Radioteletype program for an Atari 800. For more information on the program, see the text box on page 442.*

```
1 REM ********************************
2 REM *   40WPM ATARI RTTY PROGRAM    *
3 REM *      ALL RIGHTS RESERVED      *
4 REM * PROGRAMMER: SCOTT PERSSON.    *
5 REM * DATE:         04-07-81.       *
6 REM * MEMORY:       10420 BYTES     *
7 REM ********************************
8 CLR :POKE 752,1:GOTO 13
9 REM ****** BAUDOT GENERATOR *******
10 A=A(1,P):B=A(2,P):C=A(3,P):D=A(4,P):E=A(5,P):V=A(6,P):POKE 53760,SF:FOR T=1 T
O 5:NEXT T:POKE 53760,A
11 FOR T=1 TO 6:NEXT T:POKE 53760,B:FOR T=1 TO 5:NEXT T:POKE 53760,C:FOR T=1 TO
6:NEXT T:POKE 53760,D
12 FOR T=1 TO 5:NEXT T:POKE 53760,E:FOR T=1 TO 6:NEXT T:POKE 53760,MF:FOR T=1 TO
 8:NEXT T:RETURN
13 REM ****** FREQUENCY INPUT *******
14 ? ">";"<ENTER MARK FREQUENCY>  ";:INPUT MF:MF=(1789790/(2*MF))-7:IF MF-INT(MF
)>=0.5 THEN MF=INT(MF+1)
15 ? :? "<ENTER SPACE FREQUENCY> ";:INPUT SF:SF=(1789790/(2*SF))-7:IF SF-INT(SF)
>=0.5 THEN SF=INT(SF+1)
16 MF=INT(MF-256):SF=INT(SF-256):POKE 53768,120:POKE 53762,1
17 REM ************ MAIN ************
18 DIM A(6,124):POKE 82,2:POKE 764,255:POKE 83,36:? ">";:POSITION 2,1:? "<PLEASE
 WAIT>";:FOR T=1 TO 56
19 READ A:READ B:READ C:READ D:READ E:READ F:READ G:READ H:A(0,A)=B:A(1,A)=C:A(2
,A)=D:A(3,A)=E:A(4,A)=F
20 A(5,A)=G:A(6,A)=H:NEXT T:GOSUB 41:POSITION 2,1:? "<STDBY>        ATARI 800 TEL
ETYPE";:L=0:V=0:GOTO 38
21 IF PEEK(764)=255 THEN POKE 77,1:GOTO 21
22 P=PEEK(764):POKE 764,255:IF P=12 THEN 32
23 IF P=124 THEN GOSUB 10:GOTO 21
24 IF P=60 THEN GOSUB 10:GOTO 21
25 IF P=28 THEN 35
26 IF P=39 THEN 37
27 IF L>64 THEN SETCOLOR 2,2,8
28 L=L+1:IF L=71 THEN P=12:GOTO 32
29 IF ((A(0,P)>64 AND A(0,P)<91) OR P=33) AND V=1 THEN R=P:P=60:GOSUB 10:P=R:GOT
O 31
30 IF (A(0,P)<65 OR A(0,P)>90) AND P<>33 AND V=0 THEN R=P:P=124:GOSUB 10:P=R
31 GOSUB 10:? CHR$(A(0,P));:GOTO 21
32 SETCOLOR 2,9,4:GOSUB 10:P=28:GOSUB 10:P=60:GOSUB 10:L=0:IF PEEK(84)<21 THEN 3
4
33 ? ">":POSITION 2,1:? "<TRANSMIT>      ATARI 800 TELETYPE":? :POKE 752,0:GOTO 2
1
34 POSITION 2,PEEK(84)+1:? " ";"";:GOTO 21
35 IF PEEK(84)<21 THEN GOSUB 10:POSITION PEEK(85),PEEK(84)+1:? " ";"";:GOTO 21
36 GOSUB 10:POKE 84,3:POSITION PEEK(85),PEEK(84):? " ";"";:GOTO 21
37 GOSUB 45:POSITION 2,1:? "<STDBY>       ":POKE 764,255:POKE 752,1
38 IF PEEK(764)<>39 THEN POKE 77,1:GOTO 38
39 GOSUB 45:? ">":POSITION 2,1:? "<TRANSMIT>      ATARI 800 TELETYPE":? :POKE 752
,0:? " ";"";
40 POKE 764,255:POKE 53760,MF:POKE 53763,226:GOTO 21
41 REM ****** ARRAY CONVERSION ******
42 FOR X=1 TO 5:FOR Y=0 TO 124:IF A(X,Y)=1 THEN A(X,Y)=SF:GOTO 44
43 A(X,Y)=MF
44 NEXT Y:NEXT X:RETURN
45 REM ********** MORSE ID ***********
46 POKE 752,1:POSITION 2,1:? "<IDENTIFY> ":POKE 53760,25:P=7:GOSUB 51:P=21:GOSUB
 51:GOSUB 51
47 FOR T=1 TO 21:NEXT T:GOSUB 51:P=7:FOR S=1 TO 3:GOSUB 51:NEXT S:FOR T=1 TO 21:
NEXT T
48 P=21:FOR S=1 TO 5:GOSUB 51:NEXT S:FOR T=1 TO 21:NEXT T:GOSUB 51:GOSUB 51:P=7:
GOSUB 51:P=21
```

*Listing 1 continued on page 440*

*Listing 1 continued:*

```
49 GOSUB 51:FOR T=1 TO 21:NEXT T:P=7:FOR S=1 TO 2:GOSUB 51:P=21:GOSUB 51:GOSUB 5
1:P=7:GOSUB 51
50 FOR T=1 TO 21:NEXT T:NEXT S:POKE 53760,MF:RETURN
51 POKE 53763,226:FOR T=1 TO P:NEXT T:POKE 53763,224:FOR T=1 TO 5:NEXT T:RETURN
900 DATA 63,65,0,0,1,1,1,0
901 DATA 21,66,0,1,1,0,0,0
902 DATA 18,67,1,0,0,0,1,0
903 DATA 58,68,0,1,1,0,1,0
904 DATA 42,69,0,1,1,1,1,0
905 DATA 56,70,0,1,0,0,1,0
906 DATA 61,71,1,0,1,0,0,0
907 DATA 57,72,1,1,0,1,0,0
908 DATA 13,73,1,0,0,1,1,0
909 DATA 1,74,0,0,1,0,1,0
910 DATA 5,75,0,0,0,0,1,0
911 DATA 0,76,1,0,1,1,0,0
912 DATA 37,77,1,1,0,0,0,0
913 DATA 35,78,1,1,0,0,1,0
914 DATA 8,79,1,1,1,0,0,0
915 DATA 10,80,1,0,0,1,0,0
916 DATA 47,81,0,0,0,1,0,0
917 DATA 40,82,1,0,1,0,1,0
918 DATA 62,83,0,1,0,1,1,0
919 DATA 45,84,1,1,1,1,0,0
920 DATA 11,85,0,0,0,1,1,0
921 DATA 16,86,1,0,0,0,0,0
922 DATA 46,87,0,0,1,1,0,0
923 DATA 22,88,0,1,0,0,0,0
924 DATA 43,89,0,1,0,1,0,0
925 DATA 23,90,0,1,1,1,0,0
926 DATA 31,49,0,0,0,1,0,1
927 DATA 30,50,0,0,1,1,0,1
928 DATA 26,51,0,1,1,1,1,1
929 DATA 24,52,1,0,1,0,1,1
930 DATA 29,53,1,1,1,1,0,1
931 DATA 27,54,0,1,0,1,0,1
932 DATA 51,55,0,0,0,1,1,1
933 DATA 53,56,1,0,0,1,1,1
934 DATA 48,57,1,1,1,0,0,1
935 DATA 50,48,1,0,0,1,0,1
```

*Listing 1 continued on page 442*

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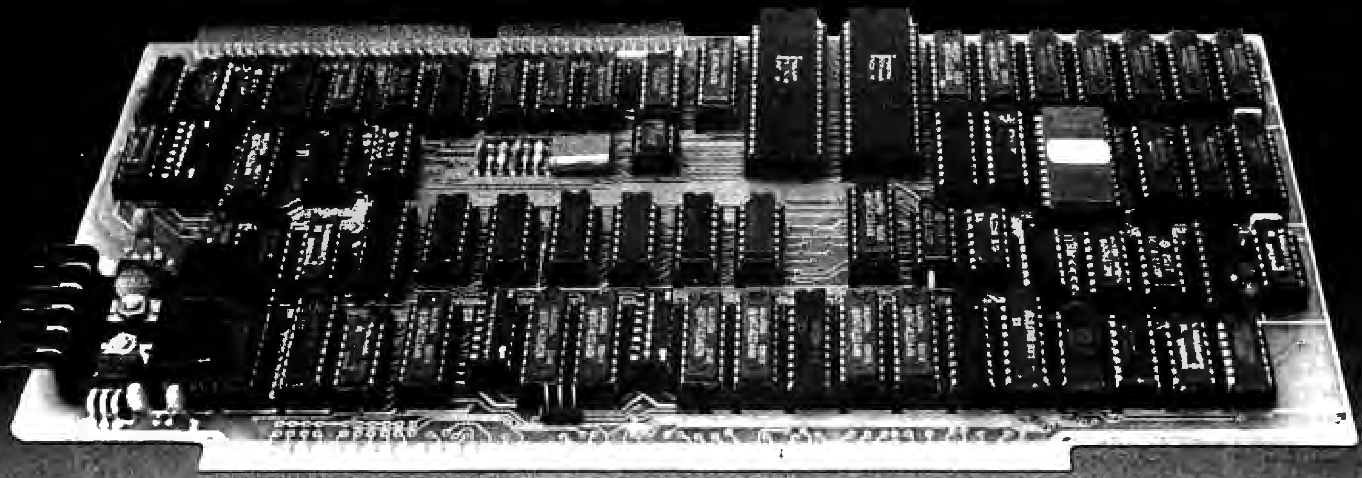

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*Listing 1 continued:*

```
936 DATA 60,32,0,0,0,0,0,0
937 DATA 124,32,0,0,1,0,0,1
938 DATA 12,32,1,1,1,0,1,0
939 DATA 33,32,1,1,0,1,1,0
940 DATA 14,45,0,0,1,1,1,1
941 DATA 88,36,0,1,1,0,1,1
942 DATA 95,33,0,1,0,0,1,1
943 DATA 91,38,1,0,1,0,0,1
944 DATA 90,35,1,1,0,1,0,1
945 DATA 115,39,0,0,1,0,1,1
946 DATA 112,40,0,0,0,0,1,1
947 DATA 114,41,1,0,1,1,0,1
948 DATA 94,34,0,1,1,1,0,1
949 DATA 38,47,0,1,0,0,0,1
950 DATA 66,58,1,0,0,0,1,1
951 DATA 2,59,1,0,0,0,0,1
952 DATA 102,63,0,1,1,0,0,1
953 DATA 32,44,1,1,0,0,1,1
954 DATA 34,46,1,1,0,0,0,1
955 DATA 28,28,1,0,1,1,1,0
```

### The Radioteletype Program

*The program I used to implement radioteletype frequencies is presented in listing 1. The following paragraphs comment on the significant lines of the program.*

*Lines 10 through 12 (timing loops) must be placed at the program's beginning because the BASIC interpreter looks for line calls (GOTO and GOSUB) from line 0. If the loops were any deeper in the program, the timing loop delays would be in error.*

*Lines 14 and 15 contain the input routine, where you enter the mark and space frequencies you wish to use.*

*Line 16 sets up the high-precision generator pair, then sets the high-order byte of the pair to 1, which will make the pair generate at radioteletype frequencies.*

*Lines 18 and 19 read character data into A, a two-dimensional array, using scalar variables A through H (see DATA statements in lines 900 through 955). Of these variables, A represents the keyboard code for the key that will be pressed, B is the ATASCII (Atari ASCII code) equivalent for the character in variable A, variables C through G collectively form the 5-bit Baudot equivalent (0 for mark tone and 1 for space tone), and H is a figures/letters-shift flag. H equals 0 if the character is in lower (letters) shift, 1 if the character is in upper (figures) shift.*

*Line 21 looks for keyboard input from memory location CH (hexadecimal 01FC).*

*Lines 22-26 look for special-case RTTY characters, such as (the Atari-logo key), Carriage Return, Linefeed, Ltrs (letters shift), Figs (figure shift), and Bell. The program includes automatic up- and down-shifting, and will generate a combined Linefeed/Ltrs upon receipt of a Carriage Return. The program loops constantly until the Atari-logo key is pressed. The Atari-logo key will also terminate RTTY transmission and return the program to standby looping.*

*Line 27 changes the screen color when over 64 characters have been typed on one line, to remind you that only 5 characters remain on a standard RTTY line. If you continue to type, a combined Carriage Return/Linefeed/Ltrs will be sent automatically when you reach 70 characters.*

*Lines 46 through 51 contain the Morse-code identification routine. This must be changed for your call sign. To do so, change the values of P (dit = 7, dah = 21), the number of repetitions (GOSUB 51), and the placement of the delays between characters (FOR T = 1 to 21:NEXT T). The existing call sign is WB0QPP.*

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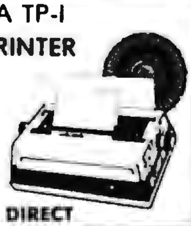

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| BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 | |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | – OFF |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | – 1/2 VOLUME |
| 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | – FULL VOLUME |

**Figure 2:** *The audio-control registers (AUDC1 to AUDC4) control the volume of the corresponding audio generator (1 to 4). The volume range is from 224 to 239 decimal.*

*Text continued from page 438:*

obtained from the computer, $F_{IN}$ is 1,789,790 Hz (1.78979 MHz), $N$ is the number to be passed to the generator pair, and $M$ is always 7 for a generator pair.

For example, we'll find the value of $N$ to yield the space tone 2975 Hz used in 850-Hz shift radioteletype:

$$F_{OUT} = \frac{F_{IN}}{2(N+7)}$$

$$2975 = \frac{1,789,790}{2(N+7)}$$

$$N = 293.8$$

The closest integer value for $N$ is 294. By passing the generator pair 294, we get an audio-output frequency of 2973.07 Hz, only about 0.06 percent off our goal.

Our next problem is to put the value 294 into memory. Obviously it cannot be entered as an 8-bit integer because the maximum integer value is 255. However, by passing the generator pair 16 bits of information we can easily denote the decimal number 294 in two 8-bit "pieces." First, convert the decimal number obtained from equation 2 into a 2-byte hexadecimal number: the decimal number 294 equals the hexadecimal number 0126. The two most significant digits (01) make up the *high-order byte* and the two least significant digits (26) make up the *low-order byte*. Next, convert each hexadecimal byte back to its decimal value, individually: 01 hexadecimal equals 1 decimal and 26 hexadecimal equals 38 decimal. These numbers are then passed to the audio-frequency registers (AUDF1 through AUDF4). Using the POKE command, place the high-order byte into the high AUDF register of the pair and the low-order byte into the low AUDF register.

## Volume Control

Once the frequency is determined, the volume must be set because its default value is zero. The volume is controlled by the audio-channel control registers (AUDC1 through AUDC4, see figure 2). Because the generators are paired, it is necessary to turn on only AUDC2 or AUDC4 for output. For full volume, use the POKE command to place the number 239 into the appropriate AUDC; for zero volume, use POKE to enter the number 224. The values within that range will vary the volume proportionately.

## Putting It Together

To create high-precision audio, follow these steps:

- Set up the generator pair(s) and increase the clock rate by changing the AUDCTL register with the POKE command.
- Choose an output frequency and obtain $N$ from equation 2.
- Split $N$ into two hexadecimal bytes and then convert each byte into its decimal equivalent.
- Use the POKE command to place

**Listing 2:** *This short program will set up generator pairs 1 and 2 and 3 and 4 and prepare them for high-precision sound generation. To obtain a given frequency, use the number N from equation 2 in the format HB (high-order byte) and LB (low-order byte); e.g., for 1050 Hz the number is 845. HB = 845/256 or 3; LB = 77 (the remainder). The value for VOLUME should be determined empirically.*

```
10 POKE 53768,120          REM SETS UP THE PAIRS
20 POKE 53762,HB           REM HB -- HIGH ORDER BYTE
30 POKE 53760,LB           REM LB -- LOW ORDER BYTE
40 POKE 53763,VOLUME       REM VOLUME = 160(OFF) TO 175(FULL)
```

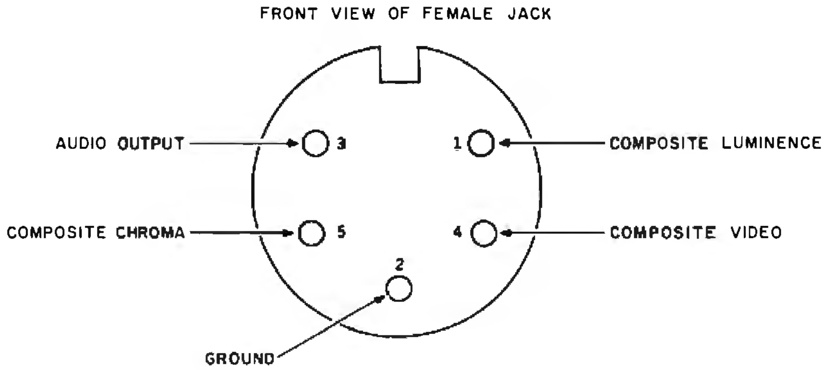


**Figure 3:** *The pinout from the Atari monitor jack (front view). The audio frequencies are taken from pins 2 and 3.*

*A BASIC assembly-language version of the RTTY program is available on cassette from the author for $15. It features RTTY transmission and reception at any speed and any audio shift. It comes preprogrammed with the individual's call sign. For information send a stamped, self-addressed envelope to:*

*Scott Persson WB0QPP*
*4719 Valley St.*
*Omaha, NE 68106*

the high byte into the high AUDF of the generator pair and the low byte into the low AUDF.

•Choose a volume level and use POKE to place the value (224 to 239) into either AUDC2 or AUDC4.

You can use the program presented in listing 2 to experiment with high-precision frequency generation.

The audio output from the Atari comes from the monitor jack, which is located on the right side of the computer near the peripheral jack (see figure 3). The audio frequencies are taken from pins 2 and 3; note that pin 2 is the ground. A 5-pin DIN (Deutsche Industrie Norm) plug and shielded audio cable are the only interface necessary. There are few hams who can boast of 99.94-percent tone accuracy—much less a $2 interface—and it's all accessible with a little SOUND thinking. ■

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## Programming Quickies

# Computing Telescope Parameters with the OSI Superboard II


R. B. Minton, c/o BYTE, POB 372, Hancock, NH 03449


The program in listing 1 is written for the Ohio Scientific Superboard II and will run in 4K bytes of programmable memory. It computes various optical parameters for a Newtonian reflecting telescope and should be useful to anyone who already owns a reflector or is considering buying or making one.

The program computes a telescope's power, F number (focal ratio), eye relief, Ramsden disk diameter, magnitude limit, resolving power (Dawes' limit), prime-focus scale, and the size (in arc-seconds and microns) of a star image at various angular and linear distances from the optical axis. This will certainly be a blessing to stargazers, because knowing the size of star images helps evaluate the performance of a telescope. The program also computes what the axial spherical aberration would be if the telescope's primary (main) mirror were spherical instead of parabolic. This is useful to anyone making a Newtonian reflector and wanting the focal length long enough so that the mirror will not have to be parabolized.

### Entering the Variables

Enter the aperture (the main mirror diameter) and the focal length in inches. (These may already be known or can be measured.) Enter the eyepiece focal length in millimeters. If you prefer to use inches, delete line 280. The usual types of eyepieces are Ramsden, Kellner, Plossel, orthoscopic, symmetrical, or Erfle. Enter the first letter of the type of eyepiece for the eye relief calculation (the distance the eye should be positioned from the outside glass surface of the eyepiece). Distances other than this will result in a restricted field of view and uncomfortable viewing.

### Evaluating the Output

After these four values are entered, the program produces the first of three screens of data. The first lists the input data for verification, the telescope's power, the eye relief, the diameter of the Ramsden disk, the magnitude

**Listing 1:** *A BASIC program for the Ohio Scientific Superboard II that computes optical parameters for a Newtonian telescope. The program will run in 4K bytes of programmable memory and compute telescope power, F number, eye relief, Ramsden disk diameter, magnitude limit, resolving power, prime-focus scale, and the size of a star image at various angular and linear distances from the optical axis.*

```
10 REM PROGRAM TELESCOPE OPTICS
20 REM BY R. B. MINTON
30 PI=3.14159
40 Q=180 : JJ=250
50 KN=.3
60 K=(Q/PI)*3600
70 FOR X=1 TO 32:PRINT:NEXT
80 PRINT "PROGRAM TELESCOPE COM-":PRINT
90 PRINT "PUTES VARIOUS PARAME-":PRINT
100 PRINT "TERS FOR A REFLECTING":PRINT
110 PRINT "TELESCOPE":PRINT
120 FOR X=1 TO 3000:NEXT
130 FOR X=1 TO 32:PRINT:NEXT
140 PRINT "ENTER APERTURE":PRINT
150 INPUT A:PRINT
160 PRINT "ENTER MIRROR F. L.":PRINT
170 INPUT FL:PRINT
180 FO=FL/A
190 FO=INT(100*FO)/100
200 PRINT "ENTER EYEPIECE F. L.":PRINT
210 INPUT EF:PRINT
220 PRINT "ENTER EYEPIECE TYPE":PRINT
230 INPUT A$:PRINT
240 IF A$="P" THEN KN=.75
250 IF A$="O" THEN KN=.8
260 IF A$="S" THEN KN=.8
270 IF A$="E" THEN KN=.35
280 EF=EF/25.4
290 EF=INT(100*EF)/100
300 PO=FL/EF
310 PA=INT(PO+.5)
320 RD=A/PO
330 RD=INT(1000*(RD+.0005))/1000
340 ER=(FL*EF*KN)/(FL-EF)
350 ER=INT(100*ER)/100
360 MA=9+(5*(LOG(A)/LOG(10)))
370 MA=INT(10*(MA+.05))/10
380 DL=4.56/A
390 DL=INT(100*(DL+.005))/100
400 SC=8120.66/FL
410 FOR X=1 TO 32:PRINT:NEXT
420 PRINT "APERTURE=";A:PRINT
430 PRINT "MIRROR F. L. =";FL:PRINT
440 PRINT "TELESCOPE F/NO=";FO:PRINT
450 PRINT "EYEPIECE F. L. =";EF:PRINT
460 PRINT "TELESCOPE POWER =";PA:PRINT
470 PRINT "EYE RELIEF=";ER:PRINT
480 PRINT "RAMSDEN DISK=";RD:PRINT
490 PRINT "MAG. LIMIT=";MA:PRINT
500 PRINT "DAWES LIMIT=";DL:PRINT
510 PRINT "P. F. SCALE=";SC:PRINT
520 PRINT "ENTER C TO CONTINUE":PRINT
530 INPUT A$:PRINT
540 IF A$<>"C" GOTO 970
550 FOR X=1 TO 32:PRINT:NEXT
560 PRINT "ENTER FIELD DIA.(DEG)":PRINT
570 INPUT FD:PRINT
580 FR=FD/2
590 PRINT "ENTER STEP SIZE":PRINT
600 INPUT SS:PRINT
610 PRINT "ANGLE COMA  ASTIG.":PRINT
620 FOR I=SS TO FR STEP SS
630 FA=I*(PI/Q)
640 CO=(FA/(16*(FO*FO)))*K
650 AS=((FA*FA)/(2*FO))*K
660 PRINT I;CO;AS:PRINT
670 FOR J=1 TO JJ:NEXT J
680 NEXT I
690 SP=(.0078/(FO*FO*FO))*K
700 PRINT "AX. SP. AB. =";SP:PRINT
710 PRINT "ENTER C TO CONTINUE":PRINT
720 INPUT A$:PRINT
730 IF A$<> "C" GOTO 970
740 FOR X=1 TO 32:PRINT:NEXT
750 PRINT "RADIUS COMA  ASTIG.":PRINT
760 FOR I=2 TO 18 STEP 2
770 FA=(I*SC)/K
780 CO=(FA/(16*(FO*FO)))*K
790 CO=CO/SC
800 CO=(INT((CO+.0005)*1000)/1000)*1000
810 AS=((FA*FA)/(2*FO))*K
820 AS=AS/SC
830 AS=(INT((AS+.0005)*1000)/1000)*1000
840 PRINT " ";I;"  ";CO;"  ";AS:PRINT
850 FOR J=1 TO JJ:NEXT J
860 NEXT I
870 SP=SP/SC
880 SP=(INT((SP+.0005)*1000)/1000*1000
890 PRINT "AX. SP. AB. =";SP:PRINT
900 PRINT "MORE COMPUTATIONS?":PRINT
910 INPUT A$:PRINT
920 IF A$="N" GOTO 970
930 PRINT "DIFFERENT OPTICS?":PRINT
940 INPUT A$:PRINT
950 IF A$="Y" GOTO 130
960 GOTO 550
970 PRINT "END OF RUN":PRINT
980 END
```

limit, the Dawes' limit, and the prime-focus scale. The Ramsden disk is the diameter of the beam of light entering the eye. If it is larger than the pupil diameter, some light is being wasted. An eyepiece should be used with a focal length that gives a Ramsden disk no larger than 0.25 or 0.20 inch. The magnitude limit will indicate approximately the faintest star visible with the telescope. The Dawes' limit gives the resolving power in arc-seconds of a parabolic mirror with a good *figure* (good optical performance). Indeed, the main function of a telescope is to gather light, up to the magnitude limit, and increase resolution, up to the Dawes' limit. The average naked eye can see a sixth-magnitude star and has a resolution of 60 to 120 arc-seconds. The prime-focus scale is expressed in arc-seconds per millimeter and allows computing the size of an object if one were to photograph it at prime-focus and with no supplementary optics.

The second screen of data requires entering the field diameter in degrees and the step size. A small to medium-sized telescope has a maximum angular field of view of usually 0.25° to 1° for the lowest-powered eyepiece. The field can be judged by looking at the moon, which is close to 0.50° in diameter. If 1.0 and 0.1 are entered as field and step size, the program will output the angular diameters of the two major optical aberrations, coma and astigmatism, 0.1° to 0.5° from the optical axis. Both coma and astigmatism are zero-valued on axis for a parabolic mirror. The combined effect of these aberrations is to make what is a small, round, sharp star image at the center of the field appear as a fan-shaped and elongated image near the edge of the field of view. The severity of their effects can be judged by comparing the computed values to the Dawes' limit. If the values are larger, they will be visible to the eye. If the values are five to ten times larger, they may be objectionable to the viewer. Lines 670 and 850 slow the listing and may be deleted. The "AX. SP. AB." is the axial spherical aberration in arc-seconds, and later in microns.

The third screen of data is similar to the second except the values of coma and astigmatism are recorded in microns (a linear measure) instead of arc-seconds (an angular measure). A micron is $10^{-4}$ cm or 0.001 mm. This output is useful to the person taking photographs through a telescope at prime focus with a 35 mm camera. The field radius and step size are defined by line 760 as 18 mm and 2 mm, respectively. Star image sizes of 20 microns to 50 microns are acceptable for photography. The scale is used to compute the size of an object on film. The formula is *size = angular diameter* (in arc-seconds) / prime-focus scale (in arc-seconds per millimeter). For example, the moon is ½ × 60 arc-min/deg × 60 arc-sec/min or about 1800 arc-seconds; and would have an 1800/180 or 10 mm diameter for a telescope with a focal length of 45 inches (1143 mm).

Many of the values are rounded to two or three decimal places in accordance with the expected accuracy of the input data and the limitations of the observer, telescope, and observing environment. ■

# Binary-Format Number Storage on the Apple II Disk

*A machine-language routine to read and write binary data to a text file.*

David Eyes
266 Broadway
Arlington, MA 02174

A limitation of the Applesoft DOS (disk operating system) is its inability to store a number in its binary floating-point form in a disk text file. Applesoft uses this form, a 32-bit binary number (the mantissa) times 2 to a given power (the exponent), to represent a real number to itself.

If all numeric data could be written to a text file in that form, you would be able to use direct-access files efficiently and accurately. Each real number would always be 5 bytes long, giving you complete control over field and record lengths. If you need to make frequent inquiries or updates to selected records, a direct-access file is the most effective type of organization. This article describes machine-language subroutines that permit the most efficient use of disk space by storing a number in the same binary floating-point form that is used for internal memory.

## Output Limitations

Although many BASICs have a PUT or similar command that will store the internal binary form of a number, the only output command available to Applesoft is PRINT. This command is typically used to send data to your video screen or printer, but can also send data to your disk. When PRINT is used for output, it converts data to a string of ASCII (American National Standard Code for Information Interchange) characters. Because the disk is a storage device and not a human-readable display, this conversion to ASCII is unnecessary and presents a real problem if you expect to use direct-access files with any degree of efficiency.

**PRINT is the only Applesoft output command and it converts data to ASCII.**

In disk operations, file space must be defined for each field or item of data to be stored. If the data stored is in character form, due to the use of PRINT for output, the field size must allow for the maximum possible number length because the range of numbers used in most practical computer applications varies greatly. With DOS, this need to precisely define field lengths in a text file is especially critical when using the "relative-record" addressing method. This form of direct access allows you to move the "position in the file pointer" forward to a specific location on the disk where the data for a given record is stored.

If each record is a fixed length, it is simple to decide how many bytes the pointer must be advanced into the file in order to access a given record. You just multiply the record length by the position of the record relative to the beginning of the file. DOS will make these calculations for you if you specify an L (length) parameter in your OPEN statement and an R (relative-record) parameter in your READ or WRITE statement.

DOS will not enforce your record length, however. If the data you write to a given record proves to be longer than the space defined, DOS will simply write past the allocation and over any data stored in the successive record, destroying its original contents. Keeping track of the field lengths within records is the programmer's responsibility.

**About the Author**
*David Eyes is the product manager for professional software with Hayden Software Company.*

**Listing 1:** *A program to display the decimal values of each of the 5 bytes of the real variable "A." Each variable table entry is 7 bytes long. The first 2 bytes are the characters of the variable name. With a real variable, the next 5 bytes represent the number itself. Running this program will let you input any number into variable "A" and see the different decimal values each of the 5 bytes acquires.*

```
100 A = 0
110 B =  PEEK (105) +  PEEK (106) * 256
120 B = B + 2
130 C = B
140  INPUT A
160  FOR X = 1 TO 5
170  PRINT  PEEK (C);" ";
190 C = C + 1
200  NEXT X
210  PRINT
220  GOTO 130
```

**Listing 2:** *By inserting these lines into the program in listing 1, you have a crude method of outputting the floating-point representation of a real number to the disk.*

```
150 A$ = ""
180 A$ = A$ +  CHR$ ( PEEK (C))
220  PRINT A$
```

By writing the numeric data to the file in the binary floating-point form, you would gain control over your field and record lengths because each real number would always be 5 bytes long. To do this, the internal DOS routines that read and write data to a file must be accessed. The data is written byte by byte directly from an internal floating-point representation of the number and the conversion to a string of ASCII characters is bypassed.

Using the CHR$ function, for example, it is easy to see how to generate and output any binary data (see listing 1). If you then access the memory locations where the floating-point number is stored and these values are used to generate a string value using CHR$, this string can be output directly to disk with PRINT (see listing 2).

## DOS Complications

DOS text files (the only ones supporting direct access) are called "text" files because that is exactly what DOS expects to be put there. The ASCII codes for characters are significant only to 7 bits and DOS uses the eighth, high-order bit of each byte for its own purposes. For DOS to include the full ASCII character set, it has to distinguish the end-of-file marker for text files, 00 hexadecimal, from the ASCII null character, which is also 00 hexadecimal. It is able to do this because the high-order bit of every byte written to a text file is normally set high on output. The null character then becomes 80 hexadecimal.

For our purposes, this action has the unfortunate effect of eliminating one-eighth of the information contained in a stream of floating-point data. DOS complicates things further by setting the same high-order bit low on input when data is being returned from the disk.

The solution to these DOS complications involves saving the status of the high-order bit in each of the 5 bytes to corresponding bits of a sixth byte. This is then made part of the output and the information needed to reconstruct the data in its original form upon return from the disk is retained.

## A Machine-Language Answer

The principles involved in this method of binary-format number storage have been illustrated using the example of BASIC PEEKs and CHR$ functions. However, the problem has now reached a level of complexity that requires the speed and efficiency of machine code.

The program CONVERT (see listing 3), written in 6502 assembly language, initializes a USR function that can be accessed from BASIC. (See the Applesoft reference manual for a description of the USR function.) Depending on whether a file has been opened for writing or reading, the routine either encodes the real expression passed in the USR function and writes it to disk or reads and decodes it, restoring the high-order bits, and returns it as the value of the function.

The first segment of code, executed when the program is BRUN at the start of a BASIC program, initializes the pointers to the start of the USR function in locations 0A through 0C hexadecimal. This initialization section also sets the MON C,I,O flags to 0. DOS monitoring is basically meaningless when outputting binary data and may cause undesirable side effects.

The USR function is invoked somewhat differently from BASIC, depending upon whether reading or writing is desired. The file must first have been opened and then selected for the desired operation using DOS. To write a real value to the disk, the expression is passed to the subroutine as the argument of the USR function. To satisfy the syntax, the USR statement appears on the right of the assignment statement, with a dummy variable on the left. To read a value from the disk, a dummy variable is used as the argument of the USR function and the value read is assigned to the variable on the left of the equal sign.

## Writing to Disk

When control is passed to the USR routine CONVERT, the program first

**Listing 3:** *The program CONVERT is called as a USR function to read and write floating-point representations of real variables to the Apple II disk.*

```
LISA 2.5                    CONVERT: FLOATING-POINT DISK I/O

0800                       TTL 'CONVERT: FLOATING-POINT DISK I/O'
0800            ;
0800            ;
0800            ;
0800            ;         CONVERT
0800            ;
0800            ;         COPYRIGHT 1981
0800            ;
0800            ;         BY DAVID EYES
0800            ;
0800            ;         USR function for the Apple II.
0800            ;         Reads and writes floating-point
0800            ;         representations of real variables
0800            ;         to Apple II disk.  For use with
0800            ;         direct access, fixed length record
0800            ;         disk storage.
0800            ;
0800            ;
0800            ;
0300                       ORG $300
0300                       OBJ $800
0093            TEMP       EPZ $93
009D            FAC        EPZ $9D
00A0            CHAR       EPZ $A0
00FF            CTRLBYTE   EPZ $FF
0001            SIGNFLAG   EPZ %00000001
0300            ;
0300            ;         RAMTOP must be set to highest
0300            ;         available RAM memory location
0300            ;
BFFF            RAMTOP     EQU $BFFF
9EE0            SWITCH     EQU RAMTOP-$211F
A2FC            CLOSE      EQU RAMTOP-$1D03
A68C            GETBYTE    EQU RAMTOP-$1973
A6D2            ERROR      EQU RAMTOP-$192D
AA51            STATUS     EQU RAMTOP-$15AE
AA52            CSWSTATE   EQU RAMTOP-$15AD
AA5E            MONFLAG    EQU RAMTOP-$15A1
EB21            FACK       EQU $EB21
EB53            ARGTOFAC   EQU $EB53
E9E3            MOVEARG    EQU $E9E3
FDED            COUT       EQU $FDED
0300            ;
0300            ;
0300            ;         Initialize USR function by
0300            ;         moving jump instruction to
0300            ;         start of program to page zero
0300            ;
0300            ;
0300 A9 4C                 LDA #$4C
0302 85 0A                 STA $0A
0304 A9 13                 LDA #ENTER
0306 85 0B                 STA $0B
0308 A9 03                 LDA /ENTER
030A 85 0C                 STA $0C
030C A9 00                 LDA #$00
030E 8D 5E AA              STA MONFLAG         ; Disable mon c,i,o
0311 60                    RTS
```

*Listing 3 continued on page 456*

*Listing 3 continued:*

```
0312                          PAG
0312               ;
0312               ;
0312               ;          Main program
0312               ;
0312               ;
0312 00            XSAVE      HEX 00              ; X-register save
0313               ;
0313               ENTER:
0313 AD 51 AA                 LDA STATUS          ; See if a READ
0316               ;                                command is active
0316 C9 01                    CMP #$01
0318 D0 3A                    BNE WRITE
031A               ;
031A               ;
031A               ;
031A               ;          READ gets control byte from
031A               ;          disk, then uses it to restore
031A               ;          high-order bit of data coming
031A               ;          in from disk.  Returns a real
031A               ;          value to USR function.
031A               ;
031A               ;
031A               ;
031A               READ:
031A 20 8C A6                 JSR GETBYTE         ; Get next textfile byte
031D D0 03                    BNE >1
031F 4C 93 03                 JMP ENDDATA         ; If value is $00,
0322               ;                                then end of file
0322               ^1:
0322 0A                       ASL                 ; skip unused bits
0323 0A                       ASL
0324 0A                       ASL
0325 85 FF                    STA CTRLBYTE
0327 A2 00                    LDX #$00
0329               ^2:
0329 8E 12 03                 STX XSAVE
032C 20 8C A6                 JSR GETBYTE         ; Get next byte
032F D0 03                    BNE >3
0331 4C 93 03                 JMP ENDDATA         ; Test end of file
0334               ^3:
0334 AE 12 03                 LDX XSAVE
0337 06 FF                    ASL CTRLBYTE        ; Advance next bit
0339               ;                                into carry
0339 B0 02                    BCS >4
033B 49 80                    EOR #%10000000      ; Set data bit low
033D               ;                                if control bit low
033D               ^4:
033D 95 93                    STA TEMP,X          ; Save
033F E8                       INX
0340 E0 05                    CPX #$05
0342 D0 E5                    BNE <2
0344 A9 93                    LDA #TEMP           ; Set up registers
0346 A0 00                    LDY /TEMP           ; for call to MOVEARG
0348 20 E3 E9                 JSR MOVEARG         ; Move TEMP to ARG
034B 20 53 EB                 JSR ARGTOFAC        ; Move ARG to FAC
034E A9 00                    LDA #$00
0350 8D 52 AA                 STA CSWSTATE        ; Set CSWSTATE TO
0353               ;                                'start of line'
0353 60                       RTS
0354                          PAG
0354               ;
0354               ;
0354               ;
```

*Listing 3 continued:*

```
0354                ;          WRITE first encodes control byte
0354                ;          then puts real data passed by USR
0354                ;          onto disk.
0354                ;
0354                ;
0354                ;
0354                WRITE:
0354 20 21 EB                    JSR PACK          ; Move and pack floating-point
0357                ;                                accumulator to TEMP
0357 A9 01                       LDA #SIGNFLAG
0359 85 FF                       STA CTRLBYTE      ; Initialize control byte
035B A2 00                       LDX #$00
035D                ^1:
035D 06 FF                       ASL CTRLBYTE      ; Advance to next position
035F B5 93                       LDA TEMP,X
0361 10 06                       BPL >2
0363 A9 01                       LDA #SIGNFLAG
0365 05 FF                       ORA CTRLBYTE      ; Set bit if high
0367 85 FF                       STA CTRLBYTE
0369                ^2:
0369 E8                          INX
036A E0 05                       CPX #$05
036C D0 EF                       BNE <1
036E                ;                                Begin write
036E A9 04                       LDA #$04
0370 8D 52 AA                    STA CSWSTATE      ; Set output state to 'write'
0373 A5 FF                       LDA CTRLBYTE      ; Control byte is written first
0375 09 80                       ORA #$80          ; Set high-order bit
0377 20 ED FD                    JSR COUT          ; Write it
037A A2 00                       LDX #00
037C                ^3:
037C A9 04                       LDA #$04
037E 8D 52 AA                    STA CSWSTATE
0381 B5 93                       LDA TEMP,X
0383 09 80                       ORA #$80
0385 20 ED FD                    JSR COUT
0388 E8                          INX
0389 E0 05                       CPX #$05
038B D0 EF                       BNE <3
038D A9 05                       LDA #$05
038F 8D 52 AA                    STA CSWSTATE
0392 60                          RTS
0393                ;                                End of data error
0393                ENDDATA:
0393 20 FC A2                    JSR CLOSE         ; Close file
0396 20 E0 9E                    JSR SWITCH        ; Switch I/O pointers
0399 A9 05                       LDA #$05          ; Set error code to 5
039B 4C D2 A6                    JMP ERROR
039E                             END

***** END OF ASSEMBLY
```

checks the setting of the DOS READ status flag. If the file has been opened for reading, the low-order bit will be set to 1. With this check, either the WRITE or READ routine is executed.

WRITE begins by calling the Applesoft PACK routine that moves the value in the floating-point accumulator into one of the zero-page floating-point registers in the packed (5-byte) form. The USR function has placed the value of its argument in the primary floating-point accumulator (in an expanded 6-byte form).

As explained above, the contents of the high-order bit will be set high when writing to a text file. Before this is done, however, these values must be preserved in the location labeled CRTLBYTE. This location is first set to the value 1. Each of the five locations of the real number in TEMP is stepped through. If the high-order bit is set, the sign flag in the processor status register will likewise be set and the value in CRTLBYTE will be ORed with the single digit in SIGNFLAG. CRTLBYTE is shifted left one position during each iteration; each of the 5 bits in CRTLBYTE thus comes to correspond to the setting of the high-order bits in the 5 data bytes that comprise the floating-point number.

With the control byte encoded, data may now be written to the file beginning with the control byte. Because DOS is monitoring the output, the CSWSTATE (character output switch state) location must first be set to 4, the "write data to file" state. This is done before each byte is written, canceling the effect of any carriage return that may appear in the binary data. Thus, DOS is prevented from prematurely exiting the WRITE mode if it next encounters data that it could interpret as a Control-D character. (The sequence carriage return and Control-D signals that the characters that follow are to be interpreted as a DOS command.)

Before the WRITE, which is accomplished by a call to COUT, the data in the accumulator is ORed with 80 hexadecimal, permitting DOS to detect an end-of-data error during a subsequent READ.

Having written the 5 bytes of binary data that comprise the floating-point number, the CSWSTATE is set to 5, the beginning of a write data line, so that any DOS commands invoked via Control-D after the USR call will be detected. This has the same result as ending a WRITE with a carriage return without actually having done so.

### Reading Binary Data

The READ routine, to which the USR function branches if a DOS READ command is active, reverses this process. The control byte is read first, then shifted left three times to advance past the unused bits, leaving the first "control" bit in the carry flag. As the data comes in with the high-order bit set, it will be exclusive-ORed with 80 hexadecimal, setting it low if the corresponding bit in the control byte is also low. With the control bit shifted into the carry flag during each iteration of the loop that reads in the rest of the data, the correct value is restored to the real number.

As each byte is read in, it is compared with the end-of-data marker, 00 hexadecimal, to determine if the end of the file has been reached. This is a possibility if the file pointer has been improperly positioned. If this is the case, control jumps to the routine ENDDATA, which, via a call to the appropriate DOS routine, closes the file and either prints the "end-of-data" error message or passes the error code to an Applesoft ONERR handler.

Otherwise, as the number is being read in, it is stored in the register TEMP. After the high-order bits have been restored to their proper settings, the number is moved to the floating-point accumulator via calls to the Applesoft routines MOVEARG and ARGTOFAC. Finally, the CSWSTATE is set to 0, "start of line," to monitor any DOS commands that may follow the USR statement. With the restored real number in the floating-point accumulator, the USR function will return to BASIC and assign this value to the real variable on the left of the equal sign.



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**Listing 4:** *A sample program showing how the USR function is used.*

```
10 D$ =  CHR$ (4)
20  PRINT D$;"BRUN CONVERT.OBJ,A$300"
30  PRINT D$;"OPEN TEST"
40  PRINT D$;"WRITE TEST"
50  FOR X = 1 TO 10
60  READ A,A$
70 B =  USR (A)
80  PRINT A$
90  NEXT X
100  PRINT D$;"CLOSE TEST"
110  PRINT D$;"OPEN TEST,L12"
120  PRINT D$
130  INPUT "WHICH RECORD WOULD YOU LIKE? ";R
140  IF R = 0 THEN 220
150 R = R - 1
160  PRINT D$;"READ TEST,R";R
170 A =  USR (B)
180  INPUT A$
190  PRINT "THE CONTENTS OF RECORD ";R + 1;" ARE: "
200  PRINT A,A$
210  GOTO 120
220  PRINT D$;"CLOSE TEST"
230  DATA   233.44, APPLE, 5, HOUSE, .001
240  DATA  WRITE, 455.002, 12345, 233.1, WORDS
250  DATA   5, 54321, -23, HAPPY, -2E+23
260  DATA  MOUSE, 0, CLOCK, 3.123456, HELLO
```

## USR and Applesoft

The program DIRECT (see listing 4) demonstrates how this function can be used from Applesoft. First, the program CONVERT is loaded into memory at location 300 hexadecimal with BRUN, and the initialization procedure is executed. A small random-access file is then built by reading 10 values in the DATA statements and writing them to the disk file TEST. The role of the dummy variables in the USR has been explained above. For the sake of illustration, a string field is also written to the file immediately following the USR call to show how character data and binary numeric data can be mixed as desired to build a record. Note that as the data is written to the file sequentially, with each record being filled completely, it is not necessary to make calls to POSITION by specifying a record parameter with each WRITE. And since the binary floating-point number is always 6 bytes, there is no need for a field delimiter such as a carriage return. Therefore, care must be taken when mixing USR with PRINT and INPUT in a given record.

Once the file has been built, the direct-access feature can be seen when the user is prompted for a record selection. (Although DOS numbers records from 0, they are numbered here from 1. An entry of 0 exits the loop.)

When the file is reopened, a length parameter of 12 is used: a 6-byte real field, consisting of control byte and data, and a 5-byte string followed by a carriage return as a field delimiter. The READ command actually sets the record number to be selected. Having been positioned to the appropriate location in the file, USR fetches the next 6 bytes and translates them into a real variable.

This simple program illustrates the principles of direct access of binary-format numeric data using the machine-language program CONVERT. I hope these functions will make possible more ambitious applications requiring direct access, as well as allow more efficient use of disk storage. ■

### References


1. Luebbert, William F. *What's Where in the Apple: An Atlas to the Apple Computer.* Chelmsford, MA: Micro Ink, 1981.
2. Worth, Don and Pieter Lechner. *Beneath Apple DOS.* Reseda, CA: Quality Software, 1981.

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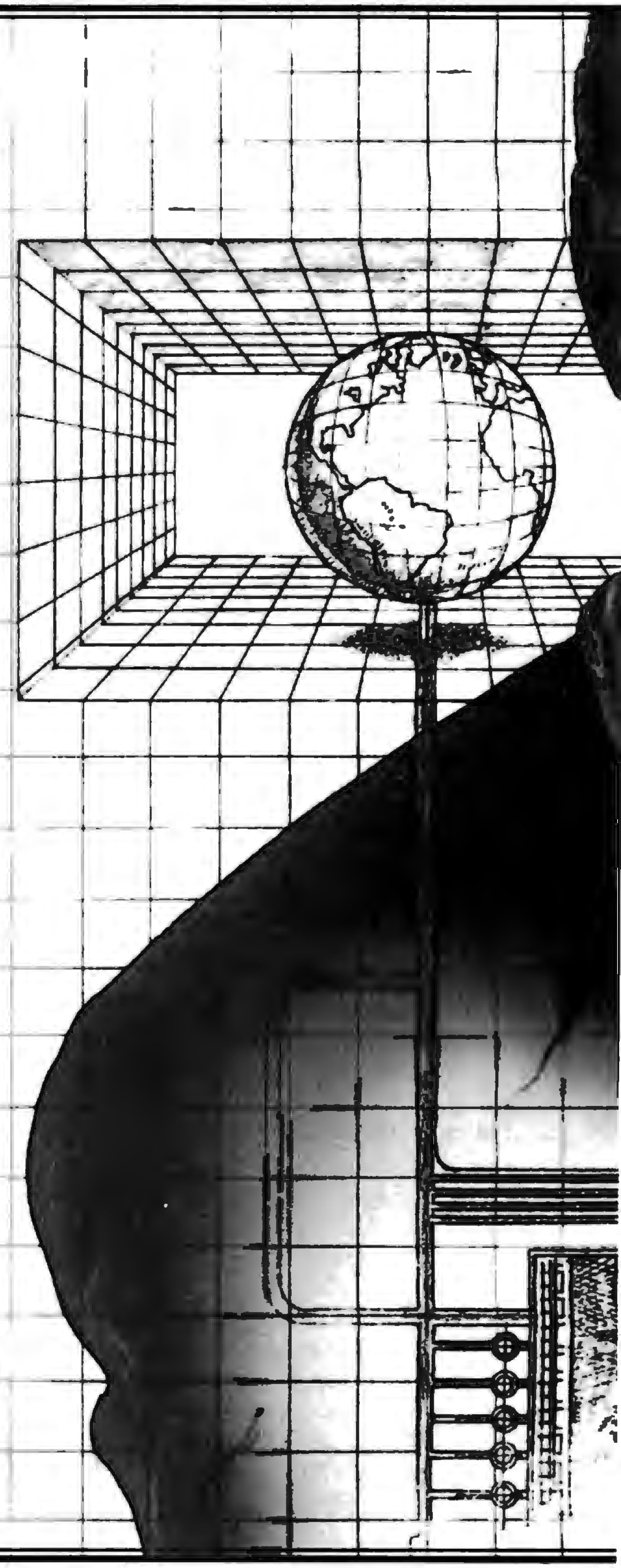

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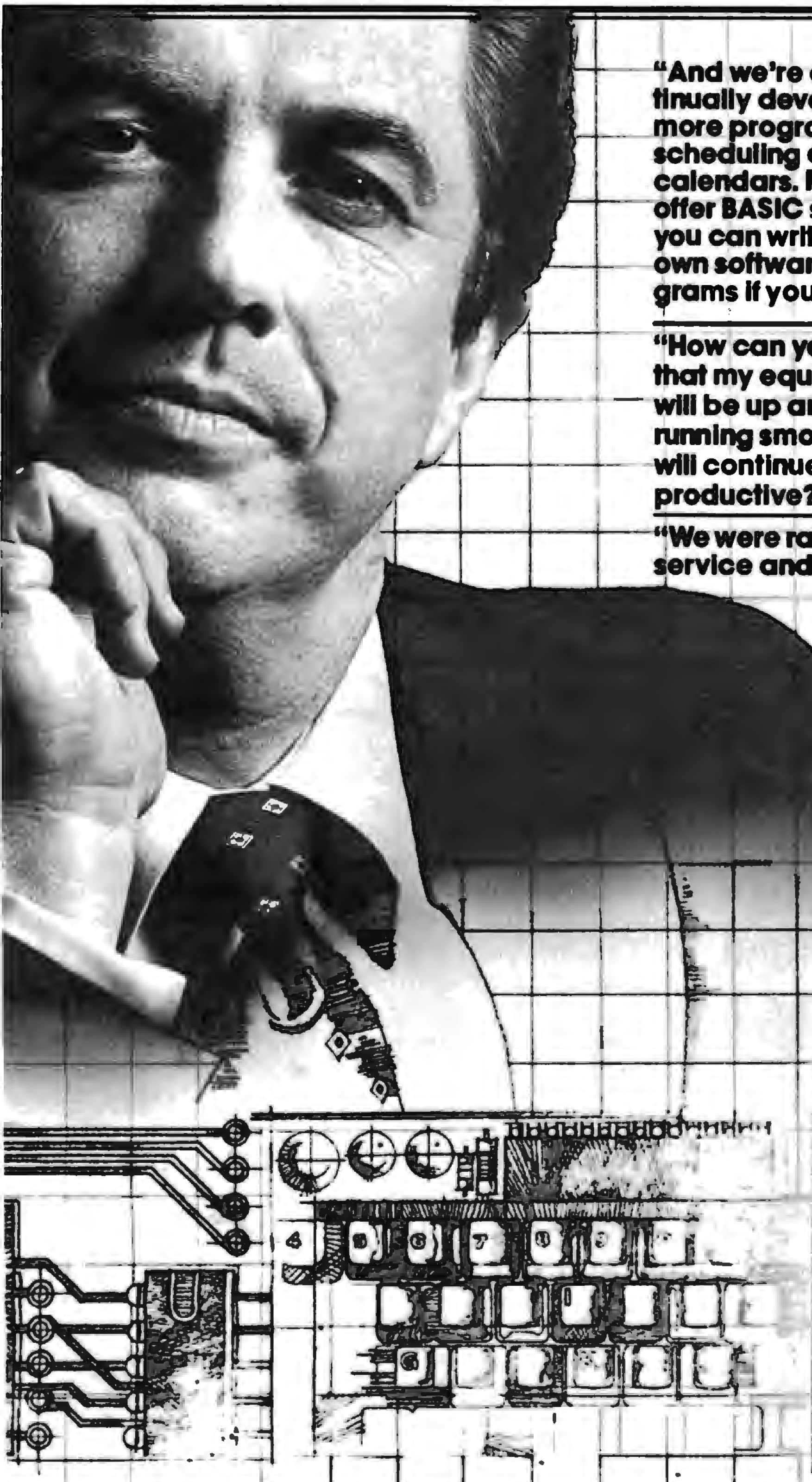

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# Adding a Trace to North Star BASIC


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One drawback of North Star BASIC is that it lacks the trace feature found in many other BASICs. This feature is handy in debugging because it allows you to watch the flow of control through your program as it is executing.

I added a trace to my version of North Star BASIC (Release 5), and this System Note provides you with the programs involved.

Without a listing of the BASIC interpreter, it would be difficult, if not impossible, to add new commands directly. Fortunately, North Star provides the "hook" required to turn on and off the trace via the "Control-C" routine. This routine starts in hexadecimal memory location 2964 and is entered after each line of the BASIC program is interpreted and executed. By replacing the first few bytes of the Control-C routine with a jump out to a user-supplied program, it is possible to gain control after each BASIC line is executed.

Due to the fact that the trace routine needs to print out the current BASIC line number, all that remains is a way to retrieve that value. After some trial and error using a monitor program, I discovered that the line number's binary value was stored in the 2 bytes starting at location 59C4. With this information, writing a user-callable assembly-language package that would print out the line number after each line was executed was straightforward. Listing 1 is the routine that accomplishes this. There are three entry points: one each for turning the trace feature on and off; one (not called by the user) for printing the trace.

Listing 2 is a subroutine that the trace program calls to convert the internal binary representation of the line number to ASCII (American National Standard Code for Information Interchange). It was taken from the run-time utilities found in *The BYTE Book of Pascal* (Blaise Liffick, editor; Peterborough NH: BYTE Books, 1979). Listing 3 is a hexadecimal dump of the trace package when it's link-loaded at hexadecimal location 1000. To use the package, the BASIC program must call the assembly-language routine at PLACIT to start the trace and at DELTRC to delete the trace. For the example in listing 3 the BASIC statements would look like this:

```
100 Y = CALL(4096) \ REM TURN ON TRACE \
     Y IS A DUMMY VARIABLE
```

and

```
200 Y = CALL(4110) \ REM TURN OFF TRACE
```

Listing 4 is an example of a simple BASIC program using the trace feature. It shows how the results of the actual trace would appear. ■

**Listing 1:** *Machine-language program that implements a trace function in North Star BASIC. By modifying the correct memory locations, the user can force the BASIC interpreter to jump to this routine after executing each program line.*

```
MAKRO ASSEMBLER AMA.2
0000               ODSPASC       LIBRY
0000               DSPASC        EXTRN
0000               ;PLACE THE TRAP
0000               PLACIT        ENTRY
0000   216429                    LXI      H,2964H
0003   3EC3                      MVI      A,0C3H ; OP-CODE FOR JUMP
0005   77                        MOV      M,A    ; STORE
0006   23                        INX      H
0007   111E00                    LXI      D,TRCSTRT
000A   73                        MOV      M,E    ; LSH OF JUMP ADDRESS
000B   23                        INX      H
000C   72                        MOV      M,D    ; MSH OF JUMP ADDRESS
000D   C9                        RET      ; TRAP HAS BEEN PLACED
000E               DELTRC        ENTRY    ; ENTER HERE TO DELETE TRACE
000E   116429                    LXI      D,02964H
0011   211A00                    LXI      H,ORIGCODE ; ADDR OF COPY OF ORIGINAL C
ODE
0014   010400                    LXI      B,4
0017   EDB0                      LDIR
0019   C9                        RET
001A   DB03        ORIGCODE      IN       3
001C   E602                      ANI      2
001E               TRCSTRT       ENTRY    ; ENTER HERE TO PRINT TRACE
001E   2AC459                    LHLD     059C4H ; THIS IS THE ADDR W/THE LINE #
0021   2B                        DCX      H
0022   7E                        MOV      A,M
0023   FE5C                      CPI      5CH ; CHECK FOR SLASH (\)
0025   281E                      JRZ      DONE ; IF SO, DON'T PRINT ANYTHING
0027   325800                    STA      BYTE2
002A   2B                        DCX      H
002B   7E                        MOV      A,M
002C   325700                    STA      BYTE1
002F   215900                    LXI      H,MSG
0032   0E07                      MVI      C,7 ; C IS CHARACTER COUNT
0034   CD4C00                    CALL     PRTLOOP ; TO PRINT 'AT'
0037   2A5700                    LHLD     BYTE1 ; DSPASC EXPECTS INPUT IN HL
003A   CD0000                    CALL     DSPASC
003D   215900                    LXI      H,MSG
0040   0E03                      MVI      C,3
0042   CD4C00                    CALL     PRTLOOP
0045   DB03        DONE          IN       3
0047   E602                      ANI      2
0049   F26829                    JP       2968H
004C   46          PRTLOOP       MOV      B,M ; PUT THE CHARACTER IN B
004D   AF                        XRA      A ; ZERO OUT A
004E   CD0D20                    CALL     020DH ; CHAR OUT
0051   0D                        DCR      C ; DECREMENT COUNT
0052   41                        MOV      B,C ; TO TEST
0053   23                        INX      H ; JUST IN CASE
0054   10F6                      DJNZ     PRTLOOP
0056   C9                        RET
0057   00          BYTE1         DB       0
0058   00          BYTE2         DB       0
0059   0D0A2041    MSG           DB       0DH,0AH,' AT '
       5420
MAKRO ASSEMBLER AMA.2
0000   ERRORS
SYMBOL TABLE
```

*Listing 1 continued on page 464*

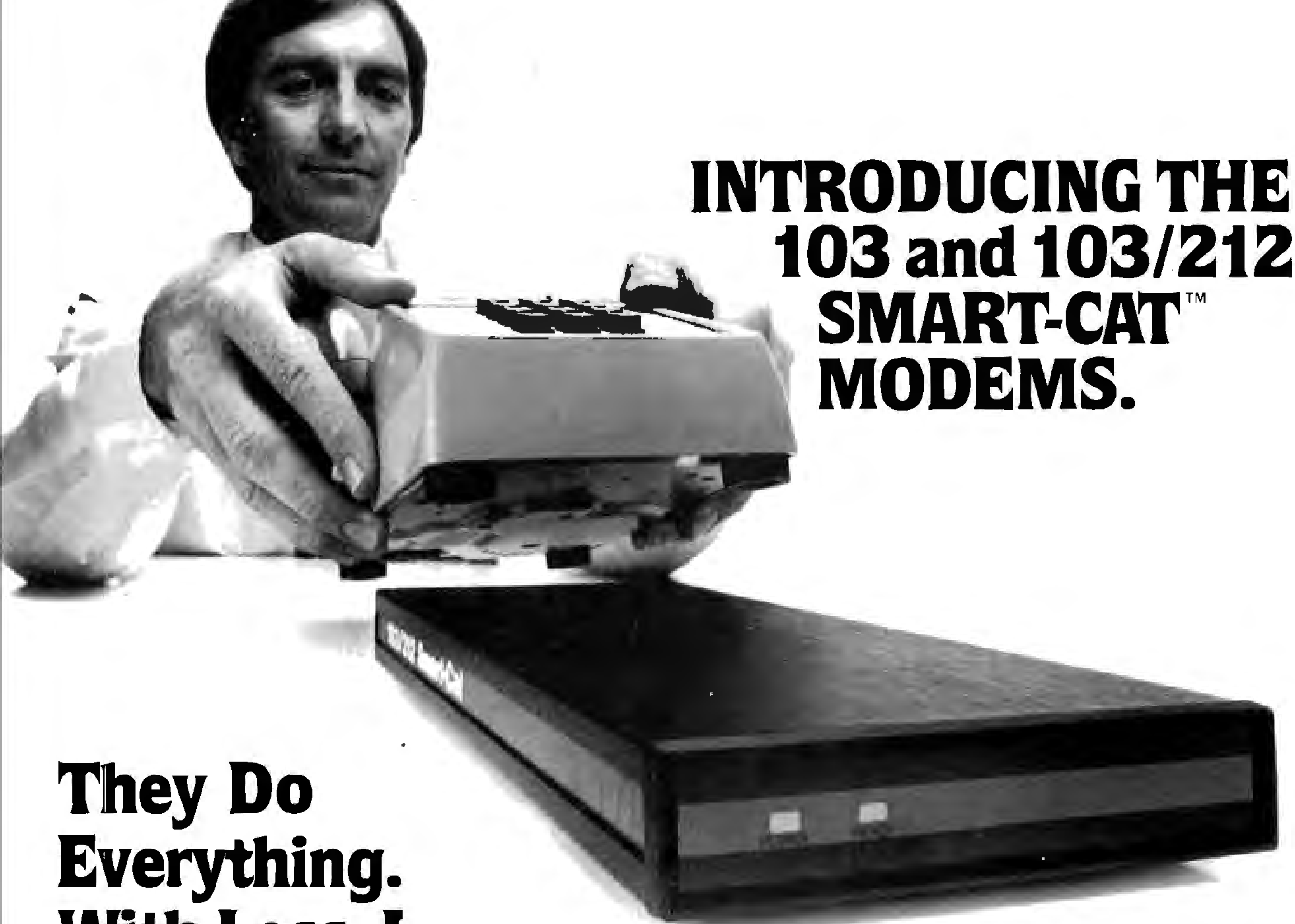
*Listing 1 continued:*

```
BYTE1       0057 01  BYTE2      0058 01  DELTRC      000E 01  DONE        0045 01
DSPASC      003C 03  MSG        0059 01  ODSPASC     0000 83  ORIGCODE    001A 01
PLACIT      0000 01  PRTLOOP    004C 01  TRCSTRT     001E 01
```

**Listing 2:** *Subroutine called by the main program to convert BASIC line numbers, stored in binary form, into ASCII characters.*

```
MAKRO ASSEMBLER AMA.2
0000                ;TAKEN FROM "THE BYTE BOOK OF PASCAL" PAGES 207-210
0000                ; THIS IS A SUBSET OF THE PASCAL RUNTIME ROUTINES WHICH
0000                ; CONVERTS BINARY DATA TO ASCII, AND PRINTS IT OUT.  THE
0000                ; INPUT IS A 16-BIT QUANTITY IN THE H-L REGISTER PAIR.
0000                ; THE OUTPUT IS THE ASCII REPRESENTATION ON THE CRT.
0000                DSPASC      ENTRY       ; THIS IS LOCATION 1B7D
0000                ;                         IN THE REFERENCE LISTING
0000  AF                        XRA         A
0001  3D                        DCR         A
0002  F5                        PUSH        PSW
0003  A4                        ANA         H
0004  F20F00                    JP          Y3
0007  062D                      MVI         B,'-'
0009  CD0D20                    CALL        OUTP
000C  CD2800                    CALL        NEGH
000F  010A00        Y3          LXI         B,10
0012  CD6D00                    CALL        DIV16
0015  3E30                      MVI         A,30H
0017  83                        ADD         E
0018  F5                        PUSH        PSW
0019  7C                        MOV         A,H
001A  B5                        ORA         L
001B  C20F00                    JNZ         Y3
001E  F1                        POP         PSW
001F  47            WR          MOV         B,A
0020  CD0D20                    CALL        OUTP
0023  F1                        POP         PSW
0024  F21F00                    JP          WR
0027  C9                        RET
0028                NEGH        ENTRY
0028  AF                        XRA         A
0029  95                        SUB         L
002A  6F                        MOV         L,A
002B  9C                        SBB         H
002C  95                        SUB         L
002D  67                        MOV         H,A
002E  D680                      SUI         80H
0030  B5                        ORA         L
0031  C0                        RNZ
0032  C33F00                    JMP         OVFL
0035                ;
0035                NEGB        ENTRY
0035  AF                        XRA         A
0036  91                        SUB         C
0037  4F                        MOV         C,A
0038  98                        SBB         B
0039  91                        SUB         C
003A  47                        MOV         B,A
003B  D680                      SUI         80H
003D  B1                        ORA         C
003E  C0                        RNZ
003F                OVFL
```

*Listing 2 continued on page 468*



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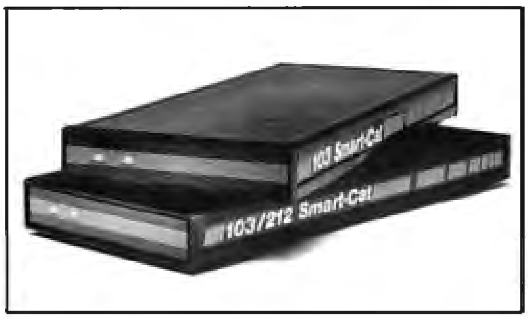


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*Listing 2 continued:*

```
003F  218400             LXI     H,SM2
0042  CD4600             CALL    PRINT
0045  C9                 RET     ; WAS 'JMP  PUSH' IN ORIG LIST
0046             ;
0046             PRINT
0046  0E0A               MVI     C,0AH
MAKRO ASSEMBLER AMA.2
0048             PNT
0048  46                 MOV     B,M
0049  23                 INX     H
004A  CD0D20             CALL    OUTP
004D  B9                 CMP     C
004E  C24800             JNZ     PNT
0051  C9                 RET
0052             ;
0052             DVCK    ENTRY
0052  215E00             LXI     H,DM1
0055  CD4600             CALL    PRINT
0058  210000             LXI     H,0
005B  54                 MOV     D,H
005C  5D                 MOV     E,L
005D  C9                 RET
005E  20444956   DM1     DB      ' DIVIDE CHECK',0DH,0AH
      49444520
      43484543
      4B0D0A
006D             DIV16   ENTRY
006D  78                 MOV     A,B
006E  B1                 ORA     C
006F  CA5200             JZ      DVCK
0072  AF                 XRA     A
0073  80                 ADD     B
0074  F5                 PUSH    PSW
0075  F43500             CP      NEGB
0078  AF                 XRA     A
0079  84                 ADD     H
007A  F5                 PUSH    PSW
007B  FC2800             CM      NEGH
007E  EB                 XCHG
007F  210000             LXI     H,0
0082  3E10               MVI     A,10H
0084  29         D2      DAD     H
0085  EB                 XCHG
0086  29                 DAD     H
0087  EB                 XCHG
0088  D28C00             JNC     D3
008B  23                 INX     H
008C  E5         D3      PUSH    H
008D  09                 DAD     B
008E  D29B00             JNC     D4
0091  1C                 INR     E
0092  33                 INX     SP
0093  33                 INX     SP
0094  3D                 DCR     A
0095  C28400             JNZ     D2
0098  C3A000             JMP     D4A
009B  E1         D4      POP     H
009C  3D                 DCR     A
009D  C28400             JNZ     D2
00A0  EB         D4A     XCHG
00A1  C1                 POP     B
```

*Listing 2 continued on page 470*

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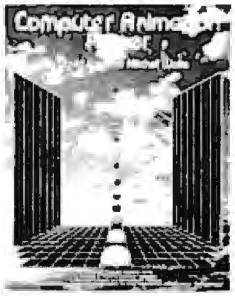

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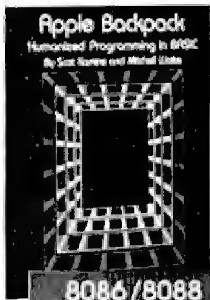


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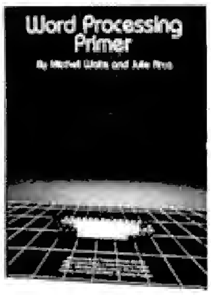
## Word Processing Primer
**by Mitchell Waite and Julie Arca**

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*Listing 2 continued:*

```
00A2   F1                             POP          PSW
00A3   A8                             XRA          B
00A4   FC2800                         CM           NEGH
00A7   7A                             MOV          A,D
00A8   B3                             ORA          E
00A9   C8                             RZ
MAKRO ASSEMBLER AMA.2
00AA   AF                             XRA          A
00AB   80                             ADD          B
00AC   F0                             RP
00AD   AF                             XRA          A
00AE   93                             SUB          E
00AF   5F                             MOV          E,A
00B0   9A                             SBB          D
00B1   93                             SUB          E
00B2   57                             MOV          D,A
00B3   C9                             RET
200D                OUTP              EQU          200DH
00B4   204F5645     SM2               DB           ' OVERFLOW',13,10
       52464C4F
       570D0A

00BF
MAKRO ASSEMBLER AMA.2
0000   ERRORS
SYMBOL TABLE
D2          0084 01   D3          008C 01   D4          009B 01   D4A         00A0 01
DIV16       006D 01   DM1         005E 01   DSPASC      0000 01   DVCK        0052 01
NEGB        003E 01   NEGH        0028 01   OUTP        200D 00   OVFL        003F 01
PNT         004B 01   PRINT       0046 01   SM2         00B4 01   WR          001F 01
Y3          00CF 01
```

**Listing 3:** *Hexadecimal dump of the trace routine as it would appear after being link-loaded to memory location 1000.*

```
+>DH 1000-111D
1000   21 64 29 3E   C3 77 23 11   1E 10 73 23   72 C9 11 64
1010   29 21 1A 10   01 04 00 ED   B0 C9 DB 03   E6 02 2A C4
1020   59 2B 7E FE   5C 28 1E 32   58 10 2B 7E   32 57 10 21
1030   59 10 0E 07   CD 4C 10 2A   57 10 CD 5F   10 21 59 10
1040   0E 03 CD 4C   10 DB 03 E6   02 F2 68 29   46 AF CD 0D
1050   20 0D 41 23   10 F6 C9 00   00 0D 0A 20   41 54 20 AF
1060   3D F5 A4 F2   6E 10 06 2D   CD 0D 20 CD   87 10 01 0A
1070   00 CD CC 10   3E 30 83 F5   7C B5 C2 6E   10 F1 47 CD
1080   0D 20 F1 F2   7E 10 C9 AF   95 6F 9C 95   67 D6 80 B5
1090   C0 C3 9E 10   AF 91 4F 98   91 47 D6 80   B1 C0 21 13
10A0   11 CD A5 10   C9 0E 0A 46   23 CD 0D 20   B9 C2 A7 10
10B0   C9 21 BD 10   CD A5 10 21   00 00 54 5D   C9 20 44 49
10C0   56 49 44 45   20 43 48 45   43 4B 0D 0A   78 B1 CA B1
10D0   10 AF 80 F5   F4 94 10 AF   84 F5 FC 87   10 EB 21 00
10E0   00 3E 10 29   EB 29 EB D2   EB 10 23 E5   09 D2 FA 10
10F0   1C 33 33 3D   C2 E3 10 C3   FF 10 E1 3D   C2 E3 10 EB
1100   C1 F1 A8 FC   87 10 7A B3   C8 AF 80 F0   AF 93 5F 9A
1110   93 57 C9 20   4F 56 45 52   46 4C 4F 57   0D 0A
```

*Listing 4 is on page 472*

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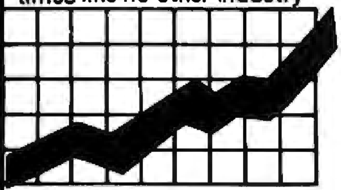

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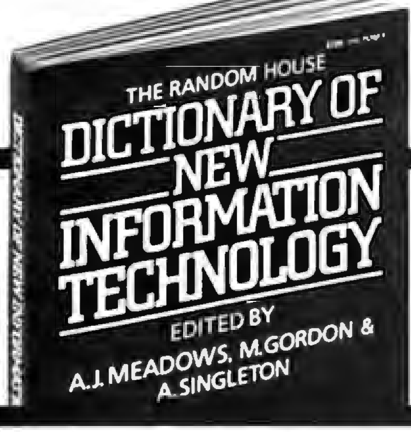
**Listing 4:** *Simple BASIC program and the results of running the trace routine. As each line of program code is interpreted, the trace routine displays the current line number.*

```
100 REM SAMPLE PROGRAM TO ILLUSTRATE TRACE USAGE
110 FOR I=1 TO 3
120 X=RND(-1)
130 Y=CALL(4096) \ REM TURN ON TRACE
140 IF X>.5 THEN 150 ELSE 160
150 S1=S1+1 \ GOTO 170
160 S2=S2+1
170 Y=CALL(4110) \ REM TURN OFF TRACE
180 NEXT I
190 PRINT S1,S2
READY

RUN

 AT   140
 AT   160
 AT   170
 AT   140
 AT   150
 AT   170
 AT   140
 AT   160
 AT   170
 1 2
READY
```

Circle 444 on inquiry card.

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*March*
**Courses for Developers and Users of Computer Systems**, various sites throughout the U.S. Among the courses being offered by the AMA (American Management Associations) are "Fundamentals of Data Processing for the Nondata Processing Executive," "Fundamentals of Data Processing for Administrative Assistants and Office Support Staff," and "Database Concepts and Design." For complete registration and course information, contact the AMA, 135 West 50th St., New York, NY 10020, (212) 586-8100.

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**Courses in C Language and Unix**, various sites throughout the U.S. Three 5-day courses are offered by Plum Hall Inc. The "C Programming Workshop," a hands-on course, covers all aspects of the C language for individuals able to program in another language. The "Advanced C Topics Seminar" covers efficiency, portability, readability, debugging, packaging, and interfacing. An introductory course, the "Unix Workshop" focuses on software development. Each course fee is $1000. For details, contact Joan Hall, Plum Hall Inc., 1 Spruce Ave., Cardiff, NJ 08232, (609) 927-3770.

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**Intel Microcomputer Workshops**, various sites throughout the U.S. Contact Intel Corp., Mail Stop SV3-1, 3065 Bowers Ave., Santa Clara, CA 95051.

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*March 14-15*
**The Seventh Annual Conference of the Michigan Association for Computer Users in Learning—MACUL '83**, Hyatt Regency, Dearborn, MI. Sessions and speakers will highlight this conference. For more information, contact Betty VandenBosch Shaw, Coordinator of Mathematics, Flint Community Schools, 923 East Kearsley, Flint, MI 48502, (313) 762-1007.

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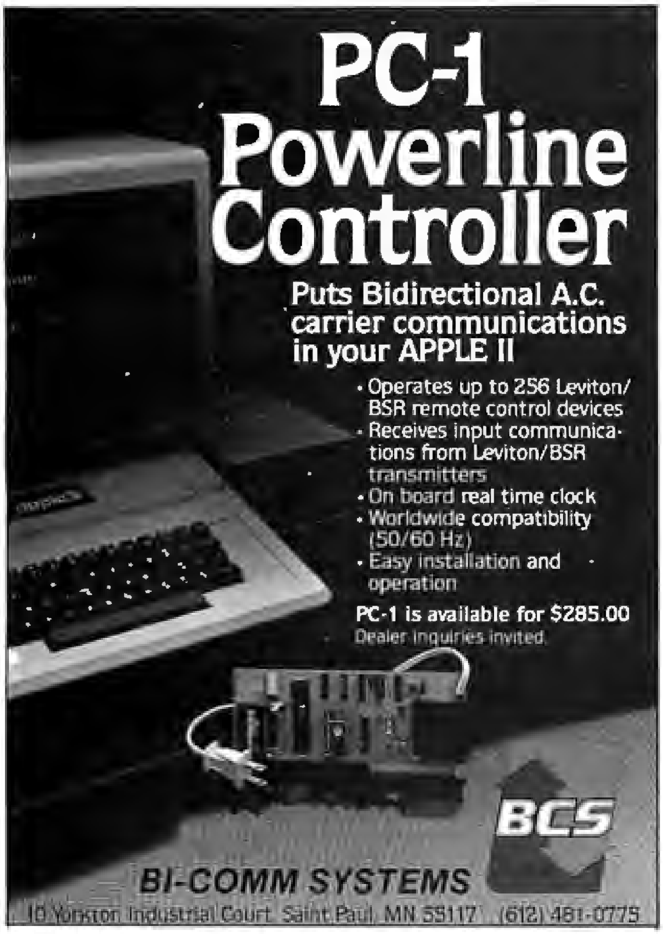

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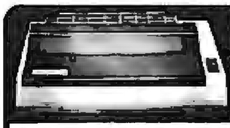

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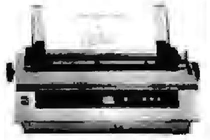

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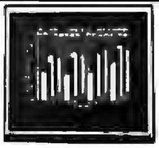

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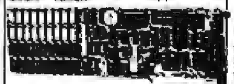

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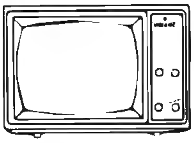

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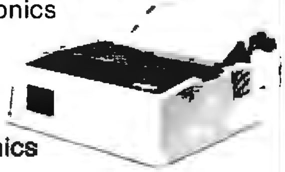

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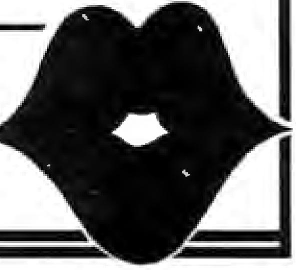

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## Event Queue

*March 15-16*
**Selecting a Microcomputer for Scientific and Engineering Applications**, Colorado School of Mines, Golden, CO. This short course reviews hardware and software technology for potential buyers of microcomputers in relation to specific scientific and engineering applications. The fee is $195. Contact the Space Office, Colorado School of Mines, Golden, CO 80401, (303) 273-3321.

*March 16-17*
**Business-Expo**, Albert Thomas Convention and Exhibit Center, Houston, TX. This show features everything from computers, copiers, and telephone equipment to interior decorating, office design, and financial consulting. More than 20 seminars on business technologies will be offered. Complete details are available from Business-Expo, 702 East Northland Towers, 15565 Northland Dr., Southfield, MI 48075, (313) 569-8280.

*March 17-19*
**The New Jersey Business Computer Show**, Holiday Inn (North), Exit 14, New Jersey Turnpike. This "strictly business" show will feature small business systems, word processors, software, and accessories. For further information, contact the Kengore Corp., POB 13, Franklin Park, NJ 08823, (201) 297-2526.

*March 17-19*
**The Third Annual Microcomputers in Education Conference**, Arizona State University, Tempe. The theme for this conference is "Forward to the 3 Cs: Communicating, Calculating, and Computing." Demonstrations, workshops, and presentations will emphasize the potential of computers to revolutionize the learning process. Topics to be explored include how computers are changing the nature of: content in subject areas, teaching, and what it means to be well educated. University credit will be available. Further information can be obtained from Marilyn Sue Ford, B-47 Payne Hall, College of Education, Arizona State University, Tempe, AZ 85287, (602) 965-7363.

*March 18-20*
**The Eighth West Coast Computer Faire**, Civic Auditorium and Brooks Hall, San Francisco, CA. Attendance this year is expected to reach 40,000. More than 600 exhibitors and a wide assortment of seminars make this one of the largest annual computer shows. For more information, contact The Computer Faire, 333 Swett Rd., Woodside, CA 94602, (415) 851-7075.

*March 19*
**The Sixth Annual PACS Computer Games Festival**, La Salle College Ballroom, 20th and Olney, Philadelphia, PA. This show is sponsored by the La Salle College Physics Department and PACS (Philadelphia Area Computer Society). The theme is "Computers in Daily Life." Contact Stephen A. Longo, Physics Department, La Salle College, Philadelphia, PA 19141, (215) 951-1255.

*March 21-24*
**Interface '83**, Miami Beach Convention Center, Miami, FL. This conference will cover all aspects of data communications and information processing in technology, management, policy, and strategy. It is cosponsored by McGraw-Hill's *Business Week* and *Data Communications* magazines. For further details, contact The Interface Group, 160 Speen St., POB 927, Framingham, MA 01701, (800) 225-4620; in Massachusetts, (617) 879-4502.

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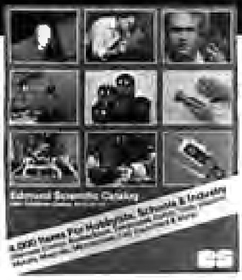

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*March 21-24*
**Personal Microcomputer Interfacing and Scientific Instrumentation Automation**, Virginia Polytechnic Institute and State University, Blacksburg, VA. This is a hands-on workshop where the participant designs and tests concepts with the actual hardware. The fee is $595. For more information, contact Dr. Linda Leffel, C.E.C., Virginia Tech, Blacksburg, VA 24061, (703) 961-4848.

*March 21-25*
**Auditing in the Contemporary Computer Environment**, San Diego, CA. This course is designed for internal auditors and financial and data-processing professionals. It provides a comprehensive audit approach for computer-based systems, including how to evaluate controls and how to design a program of tests using questionnaires, checklists, software tools, and flow charts. For details, contact Marge Umlor, EDP Auditors Foundation, 373 South Schmale Rd., Carol Stream, IL 60187.

*March 22-24*
**Cincinnati Business Show**, Exhibition-Convention Center, Cincinnati, OH. A wide range of products and services will be displayed, including computers, satellite equipment, electronic mail systems, and telecommunications equipment. For more information, contact Ray G. Nemo, Cincinnati Business Show, 10608 Millington Court, Cincinnati, OH 45242, (513) 791-6300.

*March 24-25*
**Computers in Construction**, Orlando, FL. This seminar is designed to assist construction contractors and construction management firms in acquiring computer systems. The registration fee is $395. For further information, contact CIP Information Services Inc., 1105-F Spring St., Silver Spring, MD 20910, (301) 589-7933.

*March 24-25*
**The Western Educational Computing Workshops**, Hayward, CA. These workshops, sponsored by the California Educational Computing Consortium, provide demonstrations and hands-on experience with new computer applications, software, and hardware. Contact Jerry Rose, Computer Center, California State University, 25800 Hillary St., Hayward, CA 94542.

*March 24-25*
**Workshop on Performance and Evaluation of Local Area Networks**, Worcester, MA. This workshop will seek to increase interaction and communications between active researchers and systems developers on the performance and evaluation of local-area networks. Contact T. C. Ting, Computer Science Department, Worcester Polytechnic Institute, Worcester, MA 01609, (617) 793-5670.

*March 25*
**Communication Aids and Computers: A Voice for the Non-Vocal**, Stokes Auditorium, Children's Hospital, Philadelphia, PA. This conference will present recent advances in technology, methodology, and research as they relate to computers and speech technology. Sessions will include lectures, videotapes, and equipment demonstrations. The registration fee is $75. This conference is sponsored by the Children's Seashore House and the Division of Child Development and Rehabilitation of the Children's Hospital of Philadelphia. For further information, contact Joan Bruno, Chief Speech Pathologist, Children's Seashore House, 4100 Atlantic Ave., Atlantic City, NJ 08404, (609) 345-5191, ext. 205.

*March 27*
**The 1983 Greater Baltimore Hamboree and Computerfest**, Maryland State Fairgrounds Exhibition Complex, Timonium. Personal computers, business systems, software, and a flea market highlight this electronics show. Guest speakers will address a variety of topics. Admission is $3. Contact the Greater Baltimore Hamboree and Computerfest, POB 95, Timonium, MD 21093, (301) 561-1282.

*March 27-30*
**The 1983 National Conference on Higher Education**, Washington Hilton Hotel, Washington, DC. This conference is sponsored by the American Association for Higher Education (AAHE). It features tutorials, workshops, program sessions, and formal addresses. The theme is "Colleges Enter the Information Society." For full details, contact the AAHE, Suite 600, One Dupont Circle, Washington, DC 20036, (202) 293-6440.

*March 28-30*
**The Third Florida Instructional Computing Conference**, Curtis Hixon Convention Center and the Hyatt Regency Hotel, Tampa, FL. More than 100 exhibitors will demonstrate educational hardware and software. Conference sessions will be geared toward administrative personnel and teachers. Fourteen workshops will be conducted on such topics as beginning computer literacy, Logo, courseware evaluation, and the administrative uses of computers. For details, contact Dianne Cothran, Florida Department of Education, Educational Technology Section, Knott Building, Tallahassee, FL 32301, (904) 488-0980.

*March 28-31*
**National Design Engineering Show and Conference**, McCormick Place, Chicago, IL. The conference is sponsored by the American Society of Mechanical Engineers' design engineering division. It will run concurrently with the National Plant Engineering and Maintenance Show and Conference. Details are available from Clapp & Poliak Inc., 708 Third Ave., New York, NY 10017, (212) 661-8410.

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**HOW TO BECOME A SUCCESSFUL COMPUTER CONSULTANT** $28.
by Leslie Nelson, 4th revised edition, December 1981
The rewards of the consultant can be high: freedom, more satisfying work and doubled or tripled income. This manual provides comprehensive background information and step-by-step directions for those interested to explore this lucrative field.

**HOW TO START YOUR OWN COMPUTER STORE** $145.
1st printing, April 1983
Computer store strategies. Optimum product mix. Brands to avoid. Working with distributors. Software selection. When to consider franchises. Where to find good personnel. Selecting the right location. The start-up plan. The seven best promotion strategies. Financial plan. Three low budget approaches.

**HOW TO START YOUR OWN WORD PROCESSING SERVICE** $48.
by Leslie Nelson, 2nd edition, November 1982
Turn a small investment into a steady, money making business that adds $10,000, $50,000 or $100,000 to your income. Detailed start-up, marketing and operations plans are included.

**HOW TO SELL YOUR MICRO SOFTWARE** $19.95
By B.J. Korites, Ph.D, May 1982
The best practical guide for those with software to sell. Detailed discussion of the eight best marketing strategies. How to sell through distributors, brokers, computer manufacturers. Advertising techniques. Pricing. Software security.

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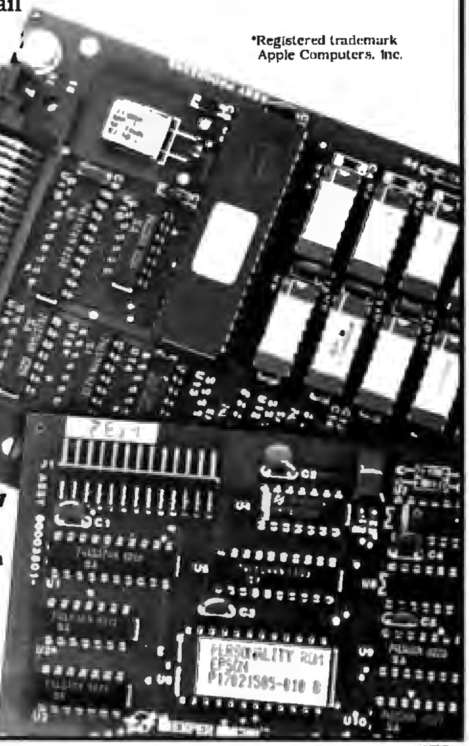

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## Event Queue

### April 1983

*April 3-17*
**The First London Computer Festival**, Central Hall, Westminster, and City University, London, England. Seminars, conferences, exhibitions, workshops, and competitions will be featured. For information, contact the Secretary to the Consortium, GLC Central Computer Service, Room 431, County Hall, London SE1, England; tel: (01) 633-3348.

*April 5-8*
**Computers/Graphics in the Building Process**, Convention Center, Washington, DC. The focus of this international event will be on the needs of private sector and federal users for computer/graphics applications in architecture, engineering, design, planning, and management of the building process. This event is cosponsored by the National Academy of Sciences' Advisory Board on the Built Environment (ABBE) and the World Computer Graphics Association (WCGA). For details, contact the WCGA, Suite 399, 2033 M St. NW, Washington, DC 20036, (202) 775-9956.

*April 5-8*
**The Second Annual Convention and Exposition of the Electronic Funds Transfer Association—EFT Expo**, Riviera Hotel, Las Vegas, NV. General and concurrent sessions will focus on electronic payment systems and services. Topics to be covered include automated teller machines, home information and financial services, legal issues, and technical standards. Further information is available from the EFT Association, Suite 800, 1029 Vermont Ave. NW, Washington, DC 20005, (202) 783-3555.

*April 10-13*
**APL83**, Sheraton Washington Hotel, Washington, DC. This conference and exhibition includes hands-on displays and presentations of technical papers. For details, contact D & S Whyte Associates, Conference and Exhibits Manager, Suite 200, 117 King St., Alexandria, VA 22314, (703) 548-2802.

*April 11-13*
**IBM-MVS Training Seminars**, Chicago, IL. Two seminars are offered: "MVS Internals Overview for Data Processing and Operations Management" and "MVS Internals for Systems Programmers." These courses run for 1½ and 2½ days, respectively. For complete information, contact ACTS Corp., 11910 Gate Way, Austin, TX 78759, (512) 258-7869.

*April 11-15*
**Intergraphics '83**, Takanawa Prince Convention Center, Tokyo, Japan. This conference and exhibition will cover a wide range of computer-graphics topics, including business and management graphics, virtual machine languages, and chemical and biochemical applications of computer graphics. Contact the World Computer Graphics Association, Suite 250, 2033 M St. NW, Washington, DC 20036, (202) 775-9556.

*April 13-20*
**Hanover Fair '83—Cebit '83**, Hanover, West Germany. The Hanover Fair is one of the world's largest industrial trade fairs. Attention will be paid to office equipment and data-processing technology. More than 1200 exhibitors from 30 countries will display their products to a crowd of more than 200,000. Full information is available from the Hanover Fairs Information Center, Salem Industrial Park, POB 338, Whitehouse, NJ 08888,

(800) 526-5978; in New Jersey, (201) 534-9044.

*April 14-17*
**The Second Annual New York Computer Show and Software Exhibition**, Nassau Coliseum, Uniondale, NY. This show features printers, software, hard disks, modems, memory cards, cartridges, publications, support services, and other peripherals and accessories. Admission is $5 for adults and $3 for children. Contact Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

*April 15-16*
**The Thirteenth Annual Virginia Computer Users Conference—VCUC**, Marriott Hotel, Blacksburg, VA. This conference is organized and run by the Virginia Tech Student Chapter of the Association for Computing Machinery in cooperation with the Virginia Polytechnic Computer Science Department. Topics of interest include Ada, human factors, and computer graphics. For more information, contact Luanne Melown or Paula Brimer, Virginia Polytechnic Institute and State University, 562 McBryde Hall, Blacksburg, VA 24061, (703) 961-6931.

*April 15-17*
**The Use of Computers in Psychology**, Hilton, Wilmington, NC. With a focus on microcomputers, the five planned symposia will explore such issues as statistical and therapeutic applications and the use and misuse of microcomputers in psychological assessment. For complete details, write to Steven R. Edelman, Association of Eastern North Carolina Psychologists, 105 Lou Dr., Goldsboro, NC 27530.

*April 16-17*
**The Eighth Annual Trenton Computer Festival**, Trenton State College, NJ. This festival includes short courses, user group meetings, demonstrations, commercial exhibits, and a flea market. Admission for the two days is $5. Contact Dr. Allen Katz, Trenton State College, Hillwood Lakes CN 550, Trenton, NJ 08625, (609) 771-2487.

*April 18-21*
**The Thirteenth International Symposium on Industrial Robots and The Robots 7 Conference and Exposition**, Conrad Hilton Hotel and McCormick Place, Chicago, IL. The theme for this event, "Robotics: The Emerging Challenge," will be investigated through more than a dozen conference sessions, four special forums, and three basic sessions. More than 150 companies will exhibit industrial robots and components. This event is cosponsored by Robotics International of the Society of Manufacturing Engineers and the Robot Institute of America (RIA). Full details are available from Ms. Pat Van Doren, Conference Coordinator, SME Technical Activities, One SME Dr., POB 930, Dearborn, MI 48128, (313) 271-1500, ext. 369.

*April 19-21*
**Electro/83—High-Technology Electronics Exhibition and Convention**, Coliseum and Sheraton Centre, New York, NY. This show runs concurrently with the Mini/Micro-Northeast exposition. For information, contact Electronic Conventions Inc., 999 North Sepulveda Blvd., El Segundo, CA 90245, (800) 421-6816; in California, (800) 262-4208 or (213) 772-2965.

## Event Queue

*April 19-21*
**Infocom 83**, Town and Country Hotel, San Diego, CA. The theme for this second annual joint conference of the IEEE Computer and Communications Societies is "Computers and Communications Integration: Reality and Illusion." Topics of interest include computer network architectures, computer communications standards, and integrated services digital networks. A series of tutorials will be held the day before this conference begins. For further information, contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

*April 20-22*
**Symposium on Computer-Aided Geometry Modeling,** Hampton, VA. For information, contact John Shoosmith, Mail Stop 125, NASA Langley Research Center, Hampton, VA 23665, (804) 827-3466.

*April 21-22*
**Computers in Construction,** New York, NY. For details, see March 24-25.

*April 22*
**Microcomputers in Physics Instruction,** Wilkes College, Wilkes-Barre, PA. This session is sponsored by the Central Pennsylvania Section of the American Association of Physics Teachers. For information, contact F. J. Donahoe, Wilkes College, Box 111, Wilkes-Barre, PA 18766.

*April 24-29*
**The HP 3000 International Users Group Conference,** Montreal, Quebec, Canada. The theme for this conference is "Systems Designed with Users in Mind." Technical papers, vendor exhibits, and a lecture by Isaac Asimov will highlight this conference. Full details are available from Ms. Renaye Lee, Conference Manager, HP 3000 IUG, Suite 205, 289 South San Antonio Rd., Los Altos, CA 94022, (415) 941-9960.

*April 25-27*
**The 1983 Symposium on Security and Privacy,** Claremont Hotel, Oakland/Berkeley, CA. Papers and panel sessions will explore such topics as security testing and evaluation, application security, and cryptographic protocol. For further details, contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

*April 25-27*
**Workshop on Software Engineering Technology Transfer,** Konover Hotel, Miami Beach, FL. This workshop will probe some of the problems affecting the use of software engineering tools, techniques, and methodologies, in such areas as marketing, engineering, sales, and customer service. For further information, contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

*April 26-28*
**Exploitation '83—The HP1000 International User Group Conference,** Heathrow Penta Hotel, Heathrow, London, England. Papers and commercial exhibits about getting the most from your system will be featured. For full details, contact the HP1000 Conference Centre, Conference Services Ltd., 3 Bute St., London SW7 3EY, England; tel: 01-584 4226; Telex: 916054.

*April 26-28*
**Hi-Tech 83,** McCormick Place, Chicago, IL. This show will cover all aspects of automated production from design to shipping. Exhibits and sessions will focus on robotics, computer-aided design, and automatic assembly equipment and systems. The Third Information Management Exposition and Conference for

Manufacturing: Info/Manufacturing will run concurrently with Hi-Tech 83. Further information is available from Clapp & Poliak Inc., 708 Third Ave., New York, NY 10017, (212) 661-8410.

*April 28-30*
**Ed Com/Spring** '83, Washington, DC. In more than 300 session hours educators will address, evaluate, and analyze the development of computers in education. Demonstrations, seminars, hands-on experience, and panel sessions will display hardware, software, and publications. For more information, contact Carol Houts, Judco Computer Expos Inc., Suite 201, 2629 North Scottsdale Rd., Scottsdale, AZ 85257, (800) 528-2355; in Arizona, (602) 990-1715.

*April 28-May 1*
**The Third Annual Southwest Computer Show and Software Exposition**, Market Hall, Dallas, TX. This show features printers, modems, video displays, plug-in boards, cartridges, software, and support services. Admission is $5 for adults and $3 for children. Full details are available from Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

## May 1983

*May 1-4*
**The Thirtieth International Technical Communication Conference**, Sheraton-St. Louis Hotel, St. Louis, MO. This conference is sponsored by the Society for Technical Communication (STC). It will focus on such issues as industrial instruction, consumer education, and safety. For full details, contact the STC, 815 15th St. NW, Washington, DC 20005, (202) 737-0035.

*May 2-5*
**Test and Measurement World Expo**, Convention Center, San Jose, CA. More than 50 workshops will explore instruments and techniques critical to performing timely and cost-effective failure analyses of microelectronic circuits and components. Topics to be addressed include X-ray microradiography and surface analysis techniques. Full particulars are available from Meg Bowen, Test and Measurement World Expo, 215 Brighton Ave., Boston, MA 02134, (617) 254-1445.

*May 10-11*
**Selecting a Microcomputer for Scientific and Engineering Applications**, Golden, CO. For details, see March 15-16.

*May 10-12*
**Mini/Micro-Northwest**, Portland, OR. Running concurrently with Northcon/83, this show addresses such topics as aerospace electronics, laser applications, and signal and image processing. Contact Electronic Conventions Inc., Suite 410, 999 North Sepulveda Blvd., El Segundo, CA 90245, (800) 421-6816; in California, (800) 262-4208 or (213) 772-2965.

*May 11-15*
**Computa '83: The Third International Exhibition on Computer and Information Processing Technology**, World Trade Centre, Singapore. Information is available from Kallman Associates, 5 Maple Court, Ridgewood, NJ 07450, (201) 652-7070.

*May 16-19*
**National Computer Conference**, Anaheim and Disneyland Hotel Convention Centers, Anaheim, CA. This show features exhibits of computer products and services, technical sessions, seminars, and formal addresses. For complete information, contact the American Federation of Information Processing Societies Inc., 1815 North Lynn St., Arlington, VA 22209, (703) 558-3624.

*May 17-20*
**Technology/Invention New Product Expo**, Expo Mart, Monroeville, PA. This show will feature everything from diesel fuel-injection systems to spring-loaded fly swatters. Further details can be obtained from Gary F. Brown, Technology/Inpex, Suite 400, 701 Smithfield St., Pittsburgh, PA 15222, (412) 288-1344.

*May 18-20*
**The Fifth National Conference of the Cognitive Science Society**, University of Rochester, Rochester, NY. This conference will consist of lectures, panels, commentaries, and papers. Contact the Cognitive Science Conference, Dewey Hall, University of Rochester, Rochester, NY 14627, (716) 275-5402.

*May 18-20*
**Mipro-83: The Sixth Microprocessors/Microcomputers Course/Conference**, Congress Center, Hotel Adriatic, Opatija, Yugoslavia. The theme for this conference is "Advanced Microcomputer Application Techniques and New Trends." It is geared toward hardware and software specialists and managers involved with the development, production, and management of microcomputer-based systems. For details, contact Mr. P. Dragojlović, Mipro Secretariat, Trg P. Togliatti 4, 51000 Rijeka, Yugoslavia.

*May 19-20*
**Computers in Construction**, Denver, CO. For details, see March 24-25.

*May 22-25*
**The Eighteenth Annual Meeting and Exhibit Program of the AAMI**, Loews Anatole, Dallas, TX. Topics on the docket include anesthesia instrumentation and technology, computer applications, personnel management, and technology transfer. Roundtable discussions, tutorials, and an exhibit program will be featured. For details, contact the Association for the Advancement of Medical Instrumentation, Suite 602, 1901 North Fort Meyer Dr., Arlington, VA 22209, (703) 525-4890.

*May 31-June 2*
**The Second Canadian Computer-Aided Design/Computer-Aided Manufacturing and Robotics Exposition and Conference**, International Centre, Toronto, Ontario, Canada. Leading international companies will demonstrate industrial robots, automatic assembly equipment, optical scanners, and numerically controlled machine tools. Technical papers will focus on such topics as robot-vision systems and design analysis. For information, contact Hugh F. Macgregor & Associates, 662 Queen St. W, Toronto, Ontario M6J 1E5, Canada, (416) 363-2201.■

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc, notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, POB 372, Hancock NH 03449. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

# Software Received

## Apple

**APAD 2.0,** a set of three programs for designing impedance matching and attenuation circuits for use in audio-frequency transmission circuits. The programs design T, PI, H, and O pads. For the Apple II Plus; cassette or floppy disk, $15. Forbes Enterprises, 21832 99th Ave. SE, Snohomish, WA 98290.

**Apple BASIC: Data File Programming,** a book and software combination. This package shows you how to create and maintain data files. Using a step-by-step approach, you can write a simple database-management program. For the Apple II; floppy disk, $19.95. Wiley Professional Software, 1 Wiley Dr., Somerset, NJ 08873.

**Banner Magic,** a program that can create lettered banners. Using any printer, you can enter your message and have it printed with letters up to 7 inches high. Program options are entered via a menu. For the Apple II; floppy disk, $24.95. Phoenix Software Inc., 64 Lake Zurich Dr., Lake Zurich, IL 60047.

**Computing Without Mathematics,** a book and software combination. This package offers a hands-on approach to learning the essentials of BASIC and Pascal. Word processing and data management are also covered. For the Apple II; floppy disk, $25. Microcomputer Educational Materials, POB 6184, Santa Barbara, CA 93111.

**Editor/Assembler,** an editor and assembler package that features disk-oriented, menu-driven operation within memory emulation. This package includes full-screen editor and detailed manual. For the Apple II; floppy disk, $89.95. Custom Micro Systems Ltd., 16921 108th St., Edmonton, Alberta T5X 3B2, Canada.

**Interstellar Sharks,** an adventure-type game. You become a member of a vast galactic corporate empire. Your goal is to reach the planet Triskelion by choosing a character and following a career path to success. For the Apple II; floppy disk, $32.95. Interactive Fantasies Inc., 28035 Dorothy Dr., Agoura, CA 91301.

**Jawbreaker,** an arcade-type game. You find yourself in a candy store. You must negotiate a maze, eat the candy, and avoid the happy faces which are trying to catch you and pull your teeth. For the Apple II and III; floppy disk, $29.95. Sierra On-line Inc., 36575 Mudge Ranch Rd., Coarsegold, CA 93614.

**Linear Programming Model,** a program to develop a model for the allocation of resources based on mathematical formulas. Variables in the formula correspond to resources and resource constraints. For the Apple II; floppy disk, $29.95. Microphase Systems, POB 10461, Tallahassee, FL 32302.

**Lunar Leeper,** an arcade-type game for one player. You start by rescuing your men from the Lunar Leepers and progress toward the destruction of the giant eyeball. Eight levels of play. For the Apple II and III; floppy disk, $29.95. Sierra On-line Inc. (see address above).

**Micro on the Apple, Volume 3,** a book and software combination. This package includes programming aids for Applesoft and machine language, graphics utilites, games, and tutorial and reference articles. For the Apple II; floppy disk, $24.95. Micro Ink Inc., POB 6502, Chelmsford, MA 01824.

**PFS: Graph on the Apple III,** a graphics development package. It is designed to produce bar, line, or pie charts with labels and to work with the PFS:File package, Visicalc files, or to stand alone. For the Apple III; floppy disk, $125. Software Publishing Corp., 1901 Landings Dr., Mountain View, CA 94043.

**Pest Patrol,** an arcade-type game. The object of this game is to kill all the insects. You are given five cans of bug spray to use. But beware: the bugs are tough and fight back with bombs. For the Apple II and III; floppy disk, $29.95. Sierra On-line Inc. (see address above).

**Proof,** a spelling checker/proofreader program. It can accept input from the keyboard or floppy disk. Files can be either ASCII, text, or binary. The dictionary contains 44,711 words. For the Apple II; floppy disk, $192. Cambrian Software, Gwynllys, Groeslon, Caernafon, Gwynedd, LL54 7ST, Wales.

**Sherwood Forest,** a graphics adventure-type game. You must help Robin Hood win the hand of Maid Marian. You control his actions through simple commands in order to move around Sherwood Forest. For the Apple II; floppy disk, $34.95. Phoenix Software Inc. (see address above).

**Spy's Demise,** an arcade-type game. Your mission is to find the solution to the secret code. You must avoid the guards and collect the clues that are hidden throughout the diplomatic mission. For the Apple II; floppy disk, $29.95. Penguin Software, 830 4th Ave., Geneva, IL 60134.

## Atari

**Basics of Animation,** a set of tutorial programs designed to show you how to move shapes on a video screen. The package covers the PRINT and PLOT commands and the use of player/missile graphics. For the Atari 400/800; floppy disk, $19.95. Educational Software Inc., 4565 Cherryvale Ave., Soquel, CA 95073.

**Dragonstomper,** an arcade- and adventure-type game. You have been cast back into the past where you must battle and search for the Amulet of the Druids. The game features three levels of play. For the Atari Video Computer System; cartridge, $17.95. Starpath Corp., POB 209, Santa Clara, CA 95050.

**The Home Filing Manager,** a simple database-management program. The program and manual help you develop your own computerized filing system using an index-card format for data storage. For the Atari 400/800; floppy disk, $49.95. Atari Inc., 1312 Crossman Rd., POB 61657, Sunnyvale, CA 94086.

**Mad-Netter,** an arcade-type game. As the Mad-Netter, you must try to capture all the butterflies to score points. But beware of the killer bees, slimy snakes, and mad dogs. For the Atari 400/800; floppy disk, $34.95. Computer Magic Ltd., POB 2634, Huntington Station, NY 11745.

**Monster Maze,** an arcade-type game. You are trapped in a three-dimensional maze and more than 40 mutants are chasing you. You must collect gold bars and vitamins to escape. For the Atari 400/800; cartridge, $39.95. Epyx/Automated Simulations Inc., 1043 Kiel Court, Sunnyvale, CA 94086.

**Platter Mania,** an arcade-type game. You beome a circus performer doing the famous spinning plate trick. Keep your plates spinning on the sticks; the more plates, the higher your score. For the Atari 400/800; cartridge, $39.95. Epyx/Automated Simulations Inc. (see address above).

**Pogoman,** an arcade-type game. As Pogoman, you must help the city conserve electricity by turning off all the street lights. You leap about avoiding cars, cats, chickens, and fire hydrants. For the Atari 400/800; floppy disk, $39.95. Computer Magic Ltd. (see address above).

**Sound & Music,** an educational program. This package introduces Atari computer owners to audio programming techniques. It ranges from simple SOUND statements to chords and complete songs. For the Atari 400/800; floppy disk, $19.95. Educational Software Inc. (see address above).

**Speedway Blast,** an arcade-type game. Your neighborhood has been invaded by asphalt-eating monsters. You must jump into your hot rod and blast the buggers. You must be wary of monster eggs and holes. For the Atari 400/800; cartridge, $39.95. Innovative Design Software Inc., POB 1658, Las Cruces, NM 88004.

## CP/M

**AList,** a database-management program. This program is set up to handle alphabetically ordered information (e.g., telephone or mail lists), but can be configured for other uses. For CP/M-based systems; floppy disk, $150. Honor System Software, 2562 East Glade, Mesa, AZ 85204.

**Forest,** an adventure-type game. The King has given you a mission to complete in his forest. It may be as simple as gathering firewood or as difficult as destroying an evil creature. For CP/M-based systems; floppy disk, $29.95. Centaur, 501 Jackson, Charleston, IL 61920.

**Trakmaster,** a disk-library cataloging system. This system lets you maintain expanded descriptions of each file, locate a file by its description, and easily make backups and copies of files. For the CP/M-based systems; floppy disk, $150. Microfusion, Suite 105, 5580 La Jolla Blvd., La Jolla, CA 92037.

## IBM Personal Computer

**Expense-Track I,** a menu-driven program to keep track of expenses in the home or small business. Each expense has a date, description, category, method and payment code, and tax status. For the IBM Personal Computer; floppy disk, $29. Sapana Micro Software, 1305 South Rouse, Pittsburg, KS 66762.

**Fun Key,** a utility to program IBM Personal Computer function keys. All 10 keys can be programmed for commonly used commands. Files of function-key commands can be saved for use with any applications program. For the IBM Personal Computer; floppy disk, $24.95. Bourbaki Inc., 431 Main St., Boise, ID 83702.

**Galactic Encounters,** a Star Trek-type game. You become the commander of an Illiad Star Cruiser. You must destroy all the Kaons in your galaxy. Your ship is equipped with phasers, torpedoes, and energy shields. For the IBM Personal Computer; floppy disk, $34.95. Micro Productions Inc., POB 147, Georgetown, TX 78626.

**Invoice-Generator-PA/DO,** a program to maintain and print invoices for a dentist's office. Based on forms for the Illinois Department of Public Aid, this program stores data on up to 275 invoices per disk. For the IBM Personal Computer; floppy disk, $49. Sapana Micro Software (see address above).

**Mail-Track I,** a mailing-list maintenance program. This program keeps your mailing list in ZIP code order and allows you to search, sort, edit, and delete entries. It can attach special messages to labels, as well as print the labels. For the IBM Personal Computer; floppy disk, $29. Sapana Micro Software (see address above).

**Xywrite,** a text-editing system that edits standard ASCII text files. It can merge files and print while editing. Online prompting is standard. For use with 40- or 80-column displays. For the IBM Personal Computer; floppy disk, $50. Xyquest Inc., POB 372, Bedford, MA 01730.

## TRS-80

**Fast BASIC Beyond TRS-80 BASIC,** a book and software combination. This package shows you how to increase the speed of your programs by combining machine-language subroutines with BASIC programs. For the TRS-80 Models I and III; cassette or floppy disk, $19.95. Wiley Professional Software, 1 Wiley Dr., Somerset, NJ 08873.

**The TRS-80 Means Business,** a book and software combination. This package covers the basics of using the Model II for day-to-day business applications. The program disk includes modules to develop your own programs. For the TRS-80 Model II; floppy disk, $32.90. Wiley Professional Software (see address above).

### VIC-20

**Paratrooper,** an arcade-type game. You must shoot the helicopters and paratroopers falling from the sky. Game has four levels of play. For the VIC-20; cassette, $19.95. The Electric Co., POB 388, Lake Havasu City, AZ 86403.

**Quick Brown Fox,** a word-processing package that has all standard word-processing features. It operates by means of menu selections. Files may be saved on disk or cassette. For the VIC-20 and Commodore 64; cartridge, $65. Quick Brown Fox, Suite 4F, 548 Broadway, New York, NY 10012.

**Rescue at Rigel,** an adventure game with graphics. Your mission is to rescue the 10 prisoners from the hands of the High Tollah, a race of evil aliens. You must beat the clock to free the prisoners. For the VIC-20; cassette, $29.95. Epyx/Automated Simulations Inc., 1043 Kiel Court, Sunnyvale, CA 94086.

**Sword of Fargoal,** an adventure game with graphics. You enter an everchanging dungeon searching for the Sword of Fargoal. You must grope your way through the dungeon and fight the monsters. For the VIC-20; cassette, $39.95. Epyx/Automated Simulations Inc. (see address above).

### ZX81

**Compu-Stat,** a statistics package that calculates most descriptive statistics and includes mean, median, 95-percent confidence limits, standard deviation, variance, range, and other methods. For the Timex/Sinclair 1000 and ZX81; cassette, $9.95. Computercraft, 156 Drakes Lane, Summertown, TN 38483.

**CFastduet,** two utility programs that quickly read and write programs and data to a cassette tape. These programs can read or write data files. Requires 16K bytes of RAM. For the Timex/Sinclair 1000 and ZX81; cassette, $21.50. Cosmonics, POB 10358, San Jose, CA 95157.

**Fun and Games Package,** a set of three programs. Draw pictures on the screen, pilot a Lunar Lander on the moon, and make and break secret codes. For the Timex/Sinclair 1000 and ZX81; BASIC listing, $1. Florida Creations, POB 16422, Jacksonville, FL 32245.

**Tax Return Helper,** a set of seven programs for the preparation of 1982 income tax returns. This package covers IRS forms 1040 and schedules A, B, C, C1/C2, D, and E. The forms can be printed or saved on tape. For the Timex/Sinclair 1000 and ZX81; cassette, $14. Ksoft, 845 Wellner Rd., Naperville, IL 60540.

### Other Computers

**Visi-Checkbook,** a program that stores a full year's worth of checkbook entries and allows you to balance your checkbook, prepare month-to-month comparisons, analyze single expenses, and draw a bar graph of expenses. For the TI-99/4A; cassette, $12.98. Design Strategies, 69-B Bethel Church Rd., Jackson, NJ 08527.■





### Educational Journal Seeks Articles

*Elementary School Guidance and Counseling* will devote its Fall 1983 issue to the impact of computers on elementary schools. Articles that focus on the implications of computers in schools for guidance counselors are sought. For information or to submit an article for consideration, contact Dr. Don Dinkmeyer Jr., 4010 Northwest 99 Ave., Coral Springs, FL 33065, or Dr. Jon Carlson, Route 4, Box 492, Lake Geneva, WI 53147.■

# Ask BYTE

## Conducted by Steve Ciarcia

### Pascal Talking Sweet on OSI

Dear Steve,

I have heard a lot of talk about the Pascal language, and everyone seems to say it's a good language. I want to take a course in Pascal, but I would like to have a computer at home with a Pascal compiler. I own an OSI (Ohio Scientific Inc.) C1P but there doesn't seem to be a version of Pascal for it. Do you know of any company that has one? What would be involved in custom-designing a compiler for my machine? Also, how do I amplify the output signal from an I/O port to drive a small motor or relay through a transistor?

I'm also thinking of interfacing your speech synthesizer to my C1P. My "Centronics" parallel interface, though, has a few lines that I don't understand. What are the signals: $\overline{\phantom{XX}}$ $\overline{\text{RS}}$, $\overline{\text{DS}}$, $\overline{\text{ACK}}$, and $\overline{\text{BUSY}}$? Which ones do I connect to STB, $\overline{\text{A}}$/R, $\overline{\text{ENABLE}}$, and GND connections of the Sweet Talker?

**Marc Weigel**
**Delta, British Columbia, Canada**

*A tiny Pascal is available for OSI computers. It uses the OS65D operating system and is implemented in fig-FORTH. It's available for $65 from OSI Software & Hardware, 3336 Avondale Court, Windsor, Ontario N9E 1X6, Canada.*

*Assuming that you have a TTL-level output port on your computer, all that is necessary for driving a small motor or relay is to use this output to control an NPN transistor as shown in the schematic diagram (figure 1).*

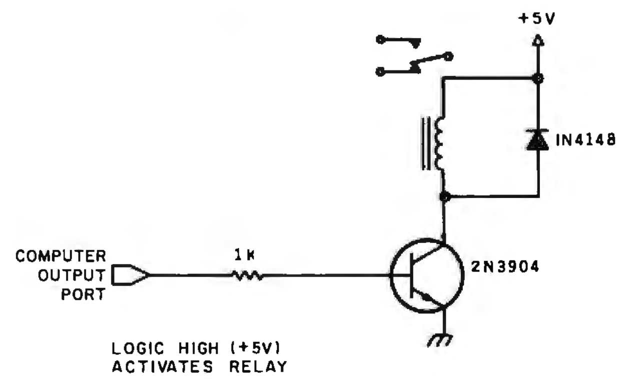



**Figure 1**

*Here's how the Sweet Talker speech synthesizer can be attached to your Centronics output port: the data strobe $\overline{\phantom{XX}}$ is connected to the $\overline{\text{STB}}$ line on the Sweet Talker (pin 21). The $\overline{\text{USY}}$ line is hooked to the $\overline{\text{A}}$/R line (pin 8). The $\overline{\text{UNIT SELECT}}$ (pin 25 of the Centronics port) should be tied to pin 34 (ground) of the Centronics port and to pins 12 ($\overline{\text{ENABLE}}$) and D (ground) of the Sweet Talker board. . . .* **Steve**

### Decoding Rotary Pulses

Dear Steve,

I would like to build a pulse decoder for remote control that's similar to the Touch-Tone decoder in your December 1981 Circuit Cellar, except that I want to be able to decode rotary-dial pulses. (See "Build a Touch-Tone Decoder for Remote Control," page 42.)

I have connected the leads from the earpiece of my phone to the cassette input port on my Apple II Plus. My program writes the values of this address into memory, but the numbers make no sense because they fluctuate even when I have no input to the port.

Should I use a bandpass filter to detect the pulses? If so, what would the frequencies be?

I'm really stuck, Steve. Any suggestions or ideas you could give me would be greatly appreciated.

Thanks.

**Hans Tanner**
**Montreal, Quebec, Canada**

*Before discussing your problem with the cassette interface for pulse-tone decoding, I should warn you that the pulses sent by a rotary-dial telephone go to the central office only and are not available at extension phones on the same line. If you plan to use this method for telephone remote control, you will be unsuccessful.*

*The Apple II's cassette port is designed to look for high-frequency pulses at a particular rate and not at relatively random, low-frequency pulses. Hence, your cassette port is not the proper input port. Amplify the pulses from the telephone receiver and use the output of the amplifier to switch a transistor. The output of the transistor can feed a 5-volt signal to a one-shot circuit to yield clean pulses of a known width. These pulses can then be easily counted and used for whatever purpose you desire. . . .* **Steve**

### Take My APU. . . Please

Dear Steve,

I have been reading your column since you began writing for BYTE and have enjoyed it very much. I also enjoyed your book *Take my Computer. . .Please* (available fron BYTE/McGraw-Hill Book Co., POB 400, Hightstown, NJ 08520).

One topic you, along with most of the industry, seem to have ignored: designing with arithmetic processors (APUs) and APU peripherials (e.g., Intel's 8231-2). Is there a reason for this? I am very interested in such devices but find the lack of information discouraging.

Can you provide any information on these devices or let me know if you plan to discuss them in the future?

**Michael Scott**
**Downers Grove, IL**

*APUs are tricky devices that are rather difficult to work with because they don't always function as intended. Also, special software must be written to drive them, due to the fact that most high-level languages have their own arithmetic routines.*

*APUs do, however, offer increased processing speed. They are mainly used in dedicated applications, and there has been very little interest in them for microcomputer applications. Finally, you're right: there is not much literature available, other than from the manufacturers. . . .* **Steve**

## Sophisticated Modems Expensive

Dear Steve,

I'm a college student, and I'll be taking some computer courses this fall. I've been using my OSI (Ohio Scientific Inc.) Challenger 1P as a remote terminal to access Dartmouth timesharing. It has worked fairly well, but its 23-character line and 300-bps (bit per second) acoustic modem, which date from the Dark Ages, have tested the limits of my patience.

I'm planning to buy a standard video terminal, which will solve one problem. Do you know of any plans for building a 1200-bps originate-only modem? The cheapest (assembled) ones I can find cost more than $600 and do everything but make coffee. What makes these units so expensive?

**Greg Beasley**
**Dartmouth College**
**Hanover, NH**

*The 1200-bps modems on the market today are indeed sophisticated and expensive. They offer a multitude of features that enhance communications with the many database utilities—e.g., The Source and Compuserve—that now proliferate. One reason for their high cost lies in the complexity of the filters that are required to transmit and receive data over a standard telephone line. These filters determine important operating parameters, such as signal-to-noise ratio and dynamic range, and can affect receiver sensitivity and adjacent channel rejection.*

*Two standards for 1200-bps modems have evolved: Bell Model 202 and Bell Model 212. The Bell Model 202 requires significantly greater bandwidth and is limited to half-duplex operation on 2-wire lines. The Bell Model 212 is the preferred standard and is the one that is used in those expensive modems. . . .*
**Steve**

## A Simple Break Key in One-Shot

Dear Steve,

I have an Osborne 1 that I would like to expand with both a communications device (e.g., a modem) and interface to the S-100 bus. This, however, presents two somewhat unrelated problems.

First, many commercial data-processing systems recognize the Break key, but most software-terminal packages ignore this command. However, the Break key is often the only way to interrupt a service bureau during transmission. The service bureaus recognize the Break key on most terminals, but they do not respond to control C or any other set of characters, including escape. What is the Break signal, and how can I achieve it?

My second question concerns mating the S-100 bus to an Osborne 1. Osborne, perhaps attempting to cut expenses, did not bring out any of the system buses. I know that the 8080 and the Z80 use the S-100 bus, but some interfacing is required. Could you tell me something about that, or at least where to look? I use my IEEE port to drive my printer, so I feel that it would not be a good choice for hard disks, etc.

Thank you.

**Barry Millman**
**Ottawa, Ontario, Canada**

*The Break key is used to indicate a need for immediate attention. It's a unique signal and is not in the standard ASCII code. Pressing this key causes the data line to go high for approximately 300 ms (milliseconds) and is interpreted by the computer as a break signal. This condition always occurs when you're* *operating in a full-duplex mode, but it can occur during half-duplex operation only when the terminal is transmitting. When the computer is transmitting, the Break key is unrecognized. A simple way to achieve this 300-ms pulse is through the use of a one-shot circuit.*

*An excellent description of the S-100 bus and interfacing other buses to it can be found in the book by Elmer C. Poe and James C. Goodwin* The S-100 & Other Micro Buses, *published by Howard W. Sams & Co. Inc. . . .* **Steve**

## Bank Selecting Addresses More Memory

Dear Steve,

I own an Atari 800 and wish to increase its memory (it has 24K bytes now). While reading a recent issue of BYTE, I saw an ad for a 128K-byte RAM card. But as I understood it, the Atari can use only 48K bytes of memory. How can the Atari use the additional 80K bytes? Also, what is bank-selected memory and how is it used?

**Mark Webb**
**Miles City, MT**

*While the 6502 processor in the Atari 800 can address 64K bytes of memory, 16K bytes of address space are reserved for ROM (read-only memory) and I/O (input/output) ports. Therefore, the maximum memory that can be addressed is 48K bytes.*

*More than 48K bytes can be addressed by a technique known as* bank selecting. *By using one of the I/O ports, different blocks of memory can be selected and addressed. In the case of the 128K-byte RAM card, an additional 104K bytes of memory are available for program storage. This memory can be used as if it were a disk, but it's much faster because its access time is on the order of microseconds.*

*With this arrangement, it is possible to load many graphic pictures into memory and call them to the screen very quickly. A database or dictionary can also be bank-selected to decrease search time. . . .* **Steve**

## Silent 700 Turned Into a Printer

Dear Steve,

My company recently bought a Radio Shack TRS-80 Model II. We also have a neglected Texas Instruments Silent 700 portable terminal (from our timesharing days). Is there a way to use the TI terminal as a printer? If so, how?

**Gary G. Schwartz**
**New York, NY**

*Connecting a terminal to a computer is simply a matter of wiring it to the serial or parallel port. Use the Model II's serial port in your case. The TRSDOS operating system has printer setup commands that allow proper configuration of your particular printer.*

*Because there are so many versions of the TI Silent 700, it's possible that the input port on your unit has an acoustic coupler, rather than a serial-interface port. It is then necessary to go inside the box and find the serial output from the coupler. Consult TI for information or obtain the terminal's schematic diagram to see how this can be accomplished.*

*As a last resort, an inexpensive modem such as the one described in this month's Circuit Cellar, "Build the ECM-103, An Originate/Answer Modem" (page 26), can be connected between the terminal and the computer. This would eliminate any internal wiring and still provide the printer features. . . .* **Steve**

## Correction

*The Pickles & Trout TVM-04 direct-entry video kit mentioned in the January 1983 Ask BYTE is no longer available. I apologize for any inconvenience this may have caused. . . .* **Steve** ■

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

If you are a subscriber to The Source, chat with Steve (TCE317) directly. Due to the high volume of inquiries, personal replies cannot be given. Be sure to include "Ask BYTE" in the address.

# Books Received

*CBM Professional Computer Guide*, Adam Osborne, Jim Strasma, and Ellen Strasma. Berkeley, CA: Osborne/McGraw-Hill, 1982; 512 pages, 37 by 55 cm, softcover, ISBN 0-931988-75-6, $15.

*The Complete Home Video Handbook*, Mark Dunton and David Owen. New York: Random House, 1982; 224 pages, 43 by 62 cm, hardcover, ISBN 0-394-52761-5, $19.95.

*Decision Tables in Software Engineering*, Richard B. Hurley. New York: Van Nostrand Reinhold, 1983; 176 pages, 37 by 55 cm, hardcover, ISBN 0-442-23599-2, $18.95.

*Design of Computer Data Files*, Owen Hanson. Rockville, MD: Computer Science Press, 1982; 358 pages, 37 by 56 cm, hardcover, ISBN 0-914894-17-X, $24.95.

*Digital and Microprocessor Engineering*, S. J. Cahill. New York: Halsted Press, 1982; 513 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-470-27301-1, $89.95.

*Essentials of COBOL Programming: A Structured Approach*, Gerald N. Pitts and Barry L. Bateman. Rockville, MD: Computer Science Press, 1982; 145 pages, 36 by 53.6 cm, softcover, ISBN 0-914894-34-X, $14.95.

*Executive Guide to Wordstar*, Philip E. Massie. Culver City, CA: Culver City Cannon Co. (POB 444), 1982; 24 pages, 23 by 51 cm, softcover, ISBN 0-910517-00-2, $5.75.

*Face to File Communication: A Psychological Approach to Information Systems*, Bruce Christie. New York: John Wiley & Sons, 1981; 306 pages, 37 by 55 cm, hardcover, ISBN 0-471-27939-0, $35.75.

*The Forrest Mims Circuit Scrapbook*, Forrest Mims. New York: McGraw-Hill, 1983; 141 pages, 51 by 66 cm, softcover, ISBN 0-07-042389-X, $14.95.

*Global Stakes: The Future of High Technology in America*, James Botkin, Dan Dimancescu, and Ray Stata, with John McClellan. Cambridge, MA: Ballinger Publishing Co., 1982; 248 pages, 38 by 56 cm, hardcover, ISBN 0-88410-886-4, $17.50.

*How to Break into Data Processing*, Laura Steibel Sessions. Englewood Cliffs, NJ: Prentice-Hall, 1982; 130 pages, 33 by 48 cm, softcover, ISBN 0-13-402479-6, $6.95.

*The Illiac IV: The First Supercomputer*, R. Michael Hord. Rockville, MD: Computer Science Press, 1982; 350 pages, 37 by 56 cm, hardcover, ISBN 0-914894-71-4, $29.95.

*Introduction to Interactive Computer Graphics*, Joan E. Scott. New York: John Wiley & Sons, 1982; 255 pages, 37 by 55 cm, hardcover, ISBN 0-471-05773-8, $25.95.

*Introduction to the Z80 Microcomputer*, Adi J. Khambata. New York: John Wiley & Sons, 1982; 336 pages, 51 by 66 cm, softcover, ISBN 0-471-86167-7, $11.95.

*Kids and the Apple*, Edward H. Carlson. Reston, VA: Reston Publishing Co., 1982; 218 pages, 50 by 65 cm, spiral bound, ISBN 0-8359-3669-4, $19.95.

*Management Control of Data Processing: Preventing Management-By-Crisis*, W. H. Inmon. Englewood Cliffs, NJ: Prentice-Hall, 1983; 326 pages, 43 by 57 cm, hardcover, ISBN 0-13-548123-6, $24.95.

*Microcomputer Architecture and Programming*, John F. Wakerly. New York: John Wiley & Sons, 1981; 692 pages, 41 by 55 cm, hardcover, ISBN 0-471-05232-9, $32.95.

*Microcomputer Graphics and Programming Techniques*, Harry Katzan Jr. New York: Van Nostrand Reinhold, 1982; 240 pages, 37 by 55 cm, hardcover, ISBN 0-442-28419-5, $18.95.

*Microcomputer Uses in Small Business*, John K. Jackson. Kirkland, WA: Datamasters (12700 Northeast 124th St.), 1982; 79 pages, 50 by 65 cm, softcover, ISBN-none, $9.95.

*Microprocessor Instruction Sets and Software Principles*, David L. Heiserman. Englewood Cliffs, NJ: Prentice-Hall, 1983; 440 pages, 43 by 57 cm, hardcover, ISBN 0-13-581090-6, $29.95.

*Personal Microcomputing in the Corporate Environment*. Albany, NY: Advanced Management Research Inc., 1982; 35 pages, 51 by 67 cm, softcover, ISBN-none, $35.

*Picture This Too!* David D. Thornburg. Reading, MA: Addison-Wesley, 1982; 224 pages, 51 by 66 cm, spiral bound, ISBN 0-201-07767-1, $14.95.

*Principles of Database Systems*, 2nd edition, Jeffrey D. Ullman. Rockville, MD: Computer Science Press, 1982; 484 pages, 37 by 56 cm, hardcover, ISBN 0-914894-36-6, $24.95.

*Run: Computer Education*, Dennis O. Harper and James H. Stewart. Monterey, CA: Brooks/Cole Publishing Co., 1983; 245 pages, 50 by 66 cm, softcover, ISBN 0-534-01265-5, $15.95.

*Software Testing Techniques*, Boris Beizer. New York: Van Nostrand Reinhold, 1983; 320 pages, 38 by 55 cm, hardcover, ISBN 0-442-24592-0, $27.50.

*Techniques for Creating Golden Delicious Games for the Apple Computer*, Howard M. Franklin, Joanne Koltnow, and Leroy Finkel. New York: John Wiley & Sons, 1982; 150 pages, 40.6 by 60 cm, softcover, ISBN 0-471-09083-2, $12.95.

*TRS-80 Assembly Language Subroutines*, William Barden Jr. Englewood Cliffs, NJ: Prentice-Hall, 1982; 232 pages, 50 by 65 cm, spiral bound, ISBN 0-13-931188-2, $18.95.

*Using the Osborne 1 Computer*, T. G. Lewis. Reston, VA: Reston Publishing Co., 1983; 211 pages, 37 by 56 cm, hardcover, ISBN 0-8359-8142-8, $19.95.

*VIC Innovative Computing*, Clifford Ramshaw. Nashville, TN: Melbourne House Software Inc. (347 Redwood Dr.), 1982; 147 pages, 33 by 50 cm, softcover, ISBN-none, $14.95. ■

This is a list of books received at BYTE Publications during this past month. Although 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.

# Clubs and Newsletters

## Ergonomically Speaking

*The Ergonomics Newsletter*, produced by the Koffler Group, an ergonomics consulting firm, reports on worldwide developments in human-factors engineering. The subscription rate is $126 in North America and $165 elsewhere. Two-year, multiple-copy, and educational discounts are available. For a free sample issue, contact *The Ergonomics Newsletter*, The Koffler Group, 1301 Lachman Lane, Pacific Palisades, CA 90272, or call (213) 459-4429.

## Collect The Stack

*The Stack* is a monthly newsletter produced by the Long Island Computer Association (LICA). Meetings are held on the third Friday of each month at 8 p.m. at the New York Institute of Technology. Anyone interested in computers may attend. The $12 annual membership fee includes a subscription to *The Stack*. For further information, write to LICA, POB 71, Hicksville, NY 11801.

## Northwestern Atari Enthusiasts

The Atari Computer Enthusiasts (ACE) of Eugene, Oregon, an independent group not affiliated with Atari Inc., meets on the second Wednesday of each month at 7:30 p.m. The $10 annual membership fee includes the ACE newsletter; overseas subscriptions are $20 a year. Articles contributed to the newsletter are welcome. For more information, contact ACE, 3662 Vine Maple Dr., Eugene, OR 97405.

## Compuswap In New Jersey

Compuswap is an APF Users Group that produces a bimonthly newsletter containing updates on software and news about the APF Imagination Machine. The $15 annual membership fee includes a subscription to the group's newsletter. Inquiries may be sent with a self-addressed stamped envelope to Compuswap, POB 1373, West Caldwell, NJ 07006.

## News for Video Users

*Interactive Video Technology* has the latest news on developments and products for interactive video training in medicine, industry, and education. The subscription rate is $45 a year. For further information, write to Heartland Communications, 223 Sunrise Dr., Shreve, OH 44676, or call (216) 567-3732.

## Pascal for IBM PC

USUS (UCSD-Pascal System User's Society) has formed an IBM Personal Computer special-interest group to serve as a clearinghouse for information on the implementation, optimization, and use of the Pascal system. Individual memberships in USUS are $20 annually. Membership in the IBM PC group is open to any USUS member. Applications are available from the USUS Secretary, POB 1148, La Jolla, CA 92038.

## Syntax Quarterly

*Syntax Quarterly*, a new publication of the Harvard Group, offers programs, reviews, and products exclusively for Timex/Sinclair computer users. A one-year subscription (4 issues) costs $15. If you also want to subscribe to *Syntax*, a newsletter for Timex/Sinclair users, a combined subscription (4 issues of the quarterly and 12 issues of the newsletter) costs $39. Contact the Harvard Group, RD 2, Box 457, Harvard, MA 01451, or call (617) 456-3661.

## Seattle Computer Products Users

The Seattle Computer Products Users Group (SCPUG) promotes the sharing of knowledge among users of 8086/MS-DOS-based systems. The group offers a forum for discussion, system software, and a bulletin board. Membership is $10 a year and includes a newsletter. For further information, contact either Frank Warren, SCPUG, 25190 Cypress Ave. #213, Hayward, CA 94544, (415) 785-7499; or Joseph Boykin, 47-4 Sheridan Dr., Shrewsbury, MA 01545, (617) 845-1074.

## Remember RAMS

*Memory Pages* is the official monthly newsletter of the Rochester Area Microcomputer Society (RAMS). It contains minutes of the meetings, announcements, and a calendar of events. Membership in RAMS runs from October to September. The membership dues are $7.50 or $4 after April; institutional or commercial dues are $20. For more information, write to RAMS, POB 90808, Rochester, NY 14609.

## LNW BBS at 1200 bps

The LNW User Group bulletin board system (BBS) has been upgraded to operate with the Hayes Microcomputer Products 1200 Smartmodem. The system works with both 300- and 1200-bps modem The LNW User Group offers members the 300-bps Smartmodem for $200 and the 1200-bps Smartmodem for $550. For more information, call (516) 924-9229 (voice) or 924-8115 (BBS). A subscription to the group's newsletter is available for $25. For more information, write to the Suffolk County Computer Association, LNW User Group, 244 Mill Rd., Yaphank, NY 11980.

## News from the District of Columbia

The Public Service Satellite Consortium produces a monthly newsletter that contains a calendar of events, articles, and conference reports. The newsletter is available to PSSC members and any interested parties. Address inquiries to Michelle Wesley, Suite 907, 1660 L St. NW, Washington, DC 20036, or call (202) 331-1154. ■

# News and Speculation about Personal Computing

**Conducted by Sol Libes**

**Random Rumors:** Tandy is believed to be readying three new computers for introduction this spring. Two are upgrades of the TRS-80 Model II and Model III (to be called the Model IV and Model 12, respectively) and the third is a portable briefcase system called the M100. The Model IV will have 128K bytes of RAM and an 80-column display. The Model 12 will add expansion slots and a larger power supply to the Model II. Also, look for the battleship-gray cases to be a thing of the past (the color conflicts with office decor). Tandy is expected to finally start shipping its long-awaited multiuser operating system for the Model 16 this month.

DEC (Digital Equipment Corporation) is supposedly working on a Unix operating system for its personal computers. . . . DEC is also hinting about several new 32-bit VAX systems, using a single-chip microprocessor and a four-chip processor set, due for introduction next year. . . . There are rumblings that IBM will soon introduce a 4-inch floppy disk capable of storing 250K bytes. . . . Also, Xerox is expected to finally release Smalltalk-80, and the first implementation will be on the firm's model 1100 Scientific Information system. . . . Digital Research is reportedly planning to release a C compiler. . . . Fortune Systems is believed to be developing a small-scale, low-cost version of its 32:16 machine using the new Motorola 68008 microprocessor (which requires only an 8-bit-wide data path, similar to Intel's 8088). . . . Texas Instruments (TI) is expected to introduce a new version of the 99/4 with 64K bytes of memory and a CP/M option, to compete with the Commodore 64. TI is also expected to shortly announce a portable compact computer. . . . It is rumored that Sperry Univac and Mitsubishi are negotiating a private-label deal for a CP/M-based system.

**Mattel Computer:** Mattel Electronics introduced the Aquarius computer at the January Consumer Electronics Show. With a Z80A processor and 4K bytes of RAM in the basic version for under $200, the machine can be expanded with a variety of peripherals. Memory cartridges can increase RAM to 52K bytes, and two expansion modules offer the options of dual disk drives and game controllers. What's more, with the disk-drive addition, the system will run CP/M 3.0. . . . **P. C.**

**S-100 Bus Standard Adopted:** The IEEE has finally adopted the S-100/IEEE-696 bus standard for microcomputer systems. This standard, which has been in the works for over three years (typical development time for an IEEE standard) and required the approval of four separate committees, is an important one because the S-100 bus is the most popular bus system used by microcomputer manufacturers. Currently close to 150 manufacturers make a total of over 500 different plug-in boards for S-100 systems. Hence, the standard will ensure a high degree of compatibility among different manufacturers' products.

Even more important, the standard provides for implementing future changes in the state of the art in microcomputer systems. The standard allows up to 16 megabytes of direct memory addressing, up to 64K I/O ports, up to 10 vectored interrupts, up to 16 masters, with a mix of up to 22 masters and slaves (including a front-panel option), and the flexibility of configuring a system any way the user wishes. Manufacturers have already introduced S-100 processor cards for half a dozen different 8-bit microprocessors (Intel's 8080 and 8085, Zilog's Z80, MOS Technology's 6502, and Motorola's 6800 and 6809) and seven different 16-bit microprocessors (TI's 9900, DEC's LSI-11, Intel's 8086 and 8088, Zilog's Z8000, Motorola's 68000, and National Semiconductor's 16032). More processor cards are expected.

The S-100 manufacturers lead the industry in implementing new technical developments. They were the first to introduce to the personal computer marketplace 16-bit systems; the CP/M, MS-DOS, OASIS, and TurboDos operating systems; floppy-disk systems; hard-disk systems; virtual-disk systems; cache-memory systems; multiprocessing; and multiuser systems. In all probability they will continue to lead in the introduction of state-of-the-art features.

Credit for the development of the S-100/IEEE-696 bus standard goes to George Morrow of Morrow Designs and Kels Elmquist of Ithaca Intersystems for drafting the original standard, and to Mark Garetz of Compupro who finalized the standard and piloted it through the committees to final adoption. It is expected that the standard will be published in a final form by the IEEE. To find out about receiving a copy, send a stamped, self-addressed, business-size envelope to Mark Garetz, Compupro, Box 2355, Oakland Airport, CA 94614.

**Visicorp's Visi On:** Way back in 1981, Xerox demonstrated its Star personal workstation computer system at the National Computer Conference (NCC). The system featured a startling new operating system designed for neophyte computer users and displayed a menu of graphic images, called icons, depicting objects normally found in the office: file cabinets, file folders, a printer, etc., all on a page-format, bit-mapped video display. The cursor was controlled with a thing called a mouse, which the user could roll around on the desk to allow motion between menus and items in the menus. For example, it allowed the user to very easily "cut and paste" together text. The system effectively limited the keyboard to the minor role of text entry. The Star heralded the new generation of user-friendly computers; the only hitch was that the cost was "out of sight," and Xerox has yet to go into production on the system.

Several companies showed similar products at last year's NCC. Although lower in cost than the Xerox system, they too had prices that limited their acceptance. And Apple has introduced such an operating system on its new 68000-based Lisa.

Now comes word that Visicorp will release this summer a software package for the IBM Personal Computer (others to follow) that provides many of these features. Called Visi On, it provides "windows" in which text and other files can be viewed, moved, and shuffled around using a two-button mouse cursor controller (interfaced via an RS-232C serial port). The software is written largely in C and is designed to be machine- and operating-system independent. A minimal system on the IBM Personal Computer will require 128K bytes of memory (more memory is desirable; 512K bytes is recommended when using concurrent CP/M). Visicorp is also said to be readying communications and networking software.

If Visi On will indeed provide these promised features it could have a serious impact on Apple's new 16-bit systems, which are expected to provide similar features (some of Apple's key designers worked on the Xerox Star) and be much more expensive.

**IBM Doings:** There is a rumor afloat that IBM will leave both Digital Research and Microsoft out in the cold. It is suggested that, having just introduced Unix for the firm's Series/1 minicomputers, IBM will go for complete product-line compatibility by eventually offering Unix (not Xenix) for the Personal Computer, dropping CP/M-86 and PC-DOS (MS-DOS) entirely. . . . **M. H.**

In an act reminiscent of Apple Computer, IBM has notified its dealers that it will not condone reselling of its systems to unauthorized dealers. However, it has not gone as far as Apple did in threatening to terminate such dealers. Further, IBM has curtailed production of machines with only 16K bytes of memory to prevent unauthorized resellers from purchasing units for expansion with non-IBM memory and disk drives.

IBM now has about 500 dealers (including 300 Computerland dealers) and is expanding its dealer network rapidly, leading to intense competition in some areas. For example, in southern California, an area noted for hefty discounting, one dealer has advertised a price of $2405 on an IBM Personal Computer system listing for $3085—more than a 20% discount. Furthermore, several IBM Product Centers have offered special promotions that have included 10% discounts and other inducements. Also, IBM has instituted a 22% discount program for school purchases.

IBM is expected to finally introduce its hard-disk option for the Personal Computer next month or the month after. It is expected to use the Seagate 5¼-inch drive and Xebec controller, and will provide from 10 to 60 megabytes of storage.

Matsushita has signed a contract to manufacture computers for IBM that will be sold by IBM Japan Ltd. The first systems are expected to go on the market this spring with prices ranging from $4000 to $6000. Colby Computer of Palo Alto, California, has introduced a kit to convert an IBM Personal Computer into a 26-pound portable computer. Just remove the IBM motherboard and disk drive from IBM's box and install it in the Colby PC-1 box, which also contains a 9-inch video monitor.

IBM and Carnegie-Mellon University have entered into an agreement to develop a microcomputer network (with 7500 workstations) over a three-year period. The project will involve the development of a 32-bit machine with 1 megabyte of memory and a high-resolution bit-mapped graphics screen and tablet. Initially, the network will use 1000 of the new IBM 68000-based microcomputers, with the 32-bit machines being added as they are developed. Students will be expected to either lease or purchase the systems.

**Apple News:** Much to the surprise of industry experts, Apple Computer Inc. showed a very strong income increase for the last quarter of last year, ending September 24. Income increased 71% to almost $19 million and sales jumped 80% to almost $176 million. Considering the age of the Apple II, the friction between Apple and its dealers, and the competition from IBM, analysts expected stunted growth. Instead Apple shipped over 300,000 systems in the past year, about twice the number of IBM Personal Computers (IBM's revenues are believed to be greater, however). Experts now expect that Apple's sales growth will continue to be strong into the beginning of this year. It's also interesting to note that Apple is in the process of increasing its work force from 3500 to 4900 employees, apparently betting on the acceptance of the new Lisa, Mackintosh, and lower-cost Apple II systems.

Although Apple's market share decreased, the overall growth of the market has resulted in increased sales for Apple. Apple has decided to become aggressive in its campaign to halt transshipping of machines from authorized dealers to unauthorized discounters. It has hired a Phoenix-based law firm to track the origins of transshipped computers and is promising to take action against dealers it suspects have violated their agreement. Apple claims to have cut off a few dealers already for this reason.

Steve Wozniak, a cofounder of Apple Computer Inc., has joined forces with Digital Research to develop a new product for the Apple II. It is an add-on card that will allow the Apple II to run CP/M-Plus (also known as CP/M version 3) and support the new emerging GSX-80 graphics standard. The board will be produced and marketed by ALS (Advanced Logic Systems) of Sunnyvale, California.

**CP/M-Plus Introduced:** Digital Research Inc. has finally released its new version of CP/M for 8-bit machines. Digital Research calls it CP/M-Plus, but most computer experimenters will probably refer to it as CP/M version 3.0. Certainly it is a major upgrade of CP/M, offering many new features and performance enhancements. Most particularly it takes advantage of the fact that 8-bit systems are going beyond the traditional 64K-byte memory bounds. CP/M-Plus is designed for systems with banked memory where the size of the DOS (disk operating system) is no longer a problem. The memory space for programs now can be as great as 62K bytes, with additional buffers for I/O. Thus we can expect to see 8-bit CP/M-Plus systems, typically with 256K bytes of memory and high-speed performance, particularly for hard-disk systems.

CP/M-Plus also offers such features as I/O redirection (in the manner of Unix), date and time stamping, file passwords, a command-line editor, and a Help command. Maximum total floppy-disk drive capacity is now up to 512 megabytes and file size is now up to 32 megabytes maximum. Another big improvement is the documentation. Previous CP/M documentation was written for very advanced programmers. The new documentation is much more down-to-earth and more professionally produced. There are 26 new BDOS (basic disk operating system) functions and 16 new BIOS (basic input/output system) functions. Most CP/M version 2.2 application programs should run under CP/M-Plus with no change; however, some problems can be expected with certain debugging and disk utilities.

We now await the new version of MS-DOS from Microsoft to see its enhancements. In any case, CP/M-Plus will no doubt add new life to the 8-bit microcomputer world, and 8-bit machines will continue to compete strongly with the emerging 16-bit machines. Now if Digital Research would just add concurrency (multitasking) to CP/M-80, the company would have a very attractive product!

**New 32-Bit Desktop System:** Hewlett-Packard (HP) is the first company to announce a 32-bit desktop computer system. Called the 9800, it will employ HP's own 32-bit microprocessor chip set and will provide a claimed performance equivalent to IBM's 370/150. Prices will start at $28,000. Shipments are expected to start in this quarter. The machine is expected to be oriented to the scientific and engineering markets.

HP appears to have scored a coup over competitors in the 32-bit field. AT & T (American Telephone and Telegraph) is expected to introduce a 32-bit system later this year, and Intel is expected to introduce a new 32-bit microprocessor that is suitable for desktop computer use.

**Portable Market Accelerates:** Adam Osborne in effect created the portable computer market with his Osborne 1 computer. In 1981, his first year of business, he claimed to have done $10 million worth of business. Last year he claimed $100 million, and he is shooting for $1 billion by the mid-1980s. Several competitors have entered the market with machines that are either lower in price or have better features, or both.

The portable-computer market presently appears to be the fastest-growing segment of the personal computer market. Apple Computer Inc. is known to be working on a portable system, as are Tandy, IBM, DEC, and several Japanese companies. Systems from over a dozen manufacturers are expected to be out by year-end. One Japanese portable is already being marketed in Japan. The Japanese firms are expected to be very strong in the portable-computer arena because of their advantage in display technology.

The next big innovation in portable computers is expected to be the new 3-inch floppy-disks and hard-disk drives for mass storage. Although some people question the reliability of a Winchester hard-disk drive in a portable system, such units are expected shortly.

**How Are They All Doing?** According to a report generated by Portia Isaacson and Egil Juliussen of Future Computing Inc. (a market-research firm), the microcomputer system with the largest base of customers by the end of 1982 was the Commodore VIC-20, with about 750,000 systems sold. Second and third were the Apple II and Timex/Sinclair 1000, both with about 600,000 systems, followed closely by the Texas Instruments TI-99/4A, with about 575,000 systems. The report says that, during 1982, the VIC-20, Timex/Sinclair 1000, and TI-99/4A overtook the Apple II by selling at a rate of at least three to one. This is accounted for by the fact that the VIC-20 and TI-99/4A are being sold by over 8000 mass-merchandising stores such as K-Mart and Toys-R-Us, while the Apple II is sold only through 1000 computer stores.

**AT & T Offers to Support Unix:** In a surprise move, AT & T has announced that it will provide support for Unix to source-code licensees. Binary licensees (end users) must get support from Unix vendors. The support will include telephone hotlines for troubleshooting, technical consultants, seminars, newsletters, electronic mail reports of problems, and periodic releases of updates.

AT & T has also released Unix System V, an upgrade from the System III. It provides enhanced screen editing, text processing, file-system maintenance, and communications. Further, it has "tighter" code (meaning it is a more concise and streamlined program) and is claimed to operate more efficiently.

Some commercial users of Unix are complaining that they have only just finished transporting System III to their machines (System III was announced only a year ago), and now they will have to spend more development time on System V. Complaints have also been heard regarding the Unix standard, based on System III, which has nearly been completed and now will have to go back for reworking.

Western Electric has opened what is considered the world's largest software development facility in Lisle, Illinois. The firm plans to have 1700 people there shortly, with 2400 expected eventually. Industry experts feel that this is a prelude to a future AT & T assault into the general-computer marketplace via a thrust into the software business. AT & T is rumored to be readying a computer using the Bellmac-32 32-bit microprocessor for introduction next year.

IBM has introduced Unix for its Series/1 minicomputers, and the firm is expected to also make it available for the 4300 mainframe series. IBM is reportedly readying a 32-bit version of the Series/1 for introduction this year.

In an interesting sidelight, Tandy Corporation has asked the Justice Department to forbid AT & T's using the Bell name when that firm goes into the computer and other businesses. They contend that the new logo and name, American Bell, is just not enough of a departure and that the use of the name "Bell" will give AT & T too much of an advantage.

**Micro-Floppy Makers Vie for a Standard:** It's chaos in micro-floppy land, with manufacturers trying to make 3-inch, 3¼-inch, 3½-inch, and 4-inch floppy disks the standard, and so far no one is succeeding. Recently, Shugart Associates introduced its 3½-inch drive. However, Micro Peripherals Inc., which had previously endorsed the 3½-inch drive, has switched to the Hitachi 3-inch drive. Then there's the 3¼-inch drive being pushed by Seagate Technology, Tabor Corp., and Dysan Inc. Also, IBM is believed to be working on a 4-inch drive. In the meantime, Tandon (one of the prime factors in the floppy marketplace), along with Verbatim, has decided to go with the Sony 3½-inch drive. . . . **A. L.**

Whatever size becomes standard for micro-floppies might also become a standard size for micro-hard disks. One company, Syquest, has already introduced a 3.9-inch hard-disk drive with removable media.

**Local-Area Network Market Developing:** Nestar and Corvus have pioneered the low-cost microcomputer LAN (local-area network) market. Recently they were joined by 3Com, and a battle is shaping up for market share. Although the early versions of these systems were slow, newer upgrades are providing much higher performance. Nestar and 3Com provide sophisticated networking software for their systems while Corvus supports a wide variety of different personal computers on its system.

Companies such as DEC and HP appear to be going with the more expensive Ethernet system. In the meantime, close to two years of wrangling have gone on in the IEEE LAN standard committee; manufacturers fail to agree on an industry LAN standard, and about two dozen different systems have been introduced. This may lead to chaos in the LAN marketplace. IBM is expected to introduce soon yet another system, which because of IBM's position in the computer market may become the de facto standard.

**Battle in the Classroom:** People tend to get hooked on the first computer they are trained on. Hence, Apple, Tandy, IBM, TI, and Atari all want to get their machines into schools so that students will influence their parents to buy systems, and later the graduates will purchase their own systems.

So far Apple seems to be winning the battle of the classroom: thousands of Apple II systems are installed, and a federal bill may be passed to allow companies to write off twice the manufacturing cost of computers they donate to primary and secondary schools. The bill has already passed the House of Representatives.

IBM has moved into the fray with a 22% discount to accredited schools and colleges on its basic Personal Computer system. Further, as I mentioned earlier, IBM has entered into a development project with Carnegie-Mellon University that is expected to have far-reaching impact in the educational world. Carnegie-Mellon is also negotiating with Warner Communications (Atari's parent company) to make the Carnegie-Mellon/IBM systems available to homes via cable television.

Commodore and Tandy offer special deals to schools and have also been successful in installing a large number of computers in schools. DEC has just signed a contract with Rochester Institute of Technology to sell DEC personal computers to RIT students, faculty, and staff at about a 40% discount (does it pay to enroll as a student to buy a system?).

**Virtual Disk Systems:** The continuing decrease in memory cost has led to the introduction of disk-emulator systems that substantially speed up system performance. In applications such as database systems and sorting that make a large number of disk accesses, the ultimate speed of the system is determined by the access time of the disk rather than the processor used. Thus a system that allows disk files, buffer files, and temporary intermediate files to be stored in solid-state memory speeds up program execution sometimes by as much as 100 times. The only disadvantage is that if power is shut down before the data is transferred from the virtual disk in memory to the actual disk, data will be lost.

There are at least five manufacturers of such systems, including Semidisk Systems, Beaverton, Oregon; Magnolia Microsystems, Seattle, Washington; GG Engineering, San Leandro, California; Axlon, Sunnyvale, California; and Macrotech International, Canoga Park, California.

**Top Three Operating Systems:** The UCSD p-System, from Softech Microsystems, now appears to rank third in the popularity contest for single-user microcomputer operating systems. CP/M still ranks first, and is still far out in front. Second is MS-DOS from Microsoft. Although, it's doubtful that the p-System will move up a notch in the race, it is interesting to note that the system is already available on DEC, HP, Osborne, TI, Phillips, Zenith, Commodore, Sage, Nixdorf, and Victor computers.

**Robots with a Sense of Touch:** MIT (Massachusetts Institute of Technology) reports that a research program has developed a much-improved tactile sensing system for robots that provides a very human-like sense of touch. The new sensor system is intended to be used as part of a tendon-actuated mechanical finger that operates much like a human finger. The device is made up of 256 tactile sensors that fit on the tip of a finger.

The Artificial Intelligence Laboratory at MIT is developing tactile recognition programs that allow the sensor to determine the general shape of an object it is touching, if it has any bumps or depressions, and if the object can be rolled. Research is also expected in the area of texture recognition and construction of a touch picture of an object as the sensor is moved across the object.

**Retailers Complain About Low Profits:** It is estimated that there are now over 2500 computer stores in the U.S. doing about $2.5 billion in sales. However, the proliferation of stores and the poor economy are leading to competition and discounting that are combining to hurt independent computer retailers. Many microcomputer stores were started in garages and basements a few years ago by hobbyists who hoped to profit from their passions. Now a number of these stores are finding themselves undercapitalized, trapped in the complexities of retailing, and squeezed between low manufacturer discounts and high mail-order dealer discounts. More computers are now sold through mass merchandisers than through computer stores. As a result, several hundred of these pioneering computer stores closed last year, and more are expected to close this year.

**Las Vegas Show:** Several new computers were introduced at the winter Consumer Electronics Show (CES) in Las Vegas. Commodore made a splash with a portable version of the 64, offering a built-in color display and two drives for $1595. Another entry was the firm's hand-held computer with 4K bytes, expandable to 16K bytes. This same machine is being manufactured by Toshiba. . . .TI introduced the 99/2, designed to go head-to-head with the Timex/Sinclair 1000, with a $99.95 price tag. Also on display was the Compact Computer 40, a battery-operated system with 6K bytes of RAM and an optional four-color printer/plotter.

Spectra Video drew much attention with its SV 318 computer, a 32K-byte ROM, 32K-byte RAM system (expandable to 96K bytes of ROM and 144K bytes of RAM), with a base price of $299. A wide range of peripherals are available, and the system is compatible with CP/M 3.0. Perhaps its most distinguishing physical characteristic is the joystick on the keyboard panel. Entex is offering the 2000 Piggyback Computer, a keyboard for the Atari 2600 including 8K bytes of BASIC and 3K bytes of RAM, for $95. The Timex/Sinclair 2000 (the American version of England's Spectrum computer) was announced at the show, and a $15 rebate was offered on the Timex/Sinclair 1000. . . . **P. C.**

**More Imports from Japan:** The Commerce Department reports that IC (integrated circuit) imports from Japan for the first 9 months of last year doubled in dollar volume, while U.S. IC exports to Japan rose 27%, causing a trade deficit of $227 million. The Japanese now have 7% of the total U.S. IC market. Consumption of ICs in Japan last year rose 15%, while in the U.S. IC makers were laying off employees and operating at 70% of capacity—all at a time when tariffs between the U.S. and Japan were equalized.

**OSI Division Sold:** Ohio Scientific Inc., one of the earliest personal-computer makers (begun in 1975 and later bought out by M/A-COM Inc.), has reportedly been sold to Kendata Inc. of Stamford, Connecticut. OSI has been in financial difficulties for several years and reportedly had a substantial loss in 1982. Kendata, founded only last year, sells and leases small-business computers (e.g., Victor, Altos, and North Star) and has 22 employees (versus 200 at OSI). OSI reportedly has sold 38,000 systems and has 400 dealers.

**Random News Bits:** CBS is reported preparing to open its first computer store in Berkeley, California, with the hope of eventually establishing a chain of stores. . . . Non-Linear Systems, Solana Beach, California, reports that it is now shipping 10,000 Kaypro II portable computers each month. . . . Quantum Science Corporation, a New York research firm, estimates that the Japanese currently have a 1.7% share of the U.S. small-business computer market (estimated at $7.9 million), and the firm expects this to increase to about 3.5% by 1986. . . . Syquest Technology has lined up a second source for its 3.9-inch Winchester drive, which puts the company in a prime position as a hard-disk supplier for portable computers. . . . Centronics Data Computer Corporation has quietly dropped its plans to produce the Quietwriter printer which was announced with great fanfare two years ago. . . . Drivetec, Palo Alto, California, has introduced a 5¼-inch floppy-disk drive storing 3.3 megabytes. It is half-height and has a track density of 192 tracks per inch. . . . Intel has introduced the 7114 4-megabit bubble-memory device that it expects to start sampling by early summer. . . . The French government now levies a fine on suppliers who use Anglicized jargon in program and computer documentation. . . . ADAPSO (Association of Data Processing Service Organizations) has finally recognized the microcomputer and established a Microcomputer Software Association. . . . Atari has announced the Atari 1200XL Home Computer System for introduction this summer. Look for it to be a direct competitor for the Commodore 64 and the new Apple IIe.■

**MAIL:** *I receive a large number of letters each month as a result of this column. If you write to me and wish a response, please include a self-addressed, stamped envelope.*

**Sol Libes**
**c/o BYTE Publications**
**POB 372**
**Hancock, NH 03449**■



 Circle 504 on inquiry card.

# What's New?

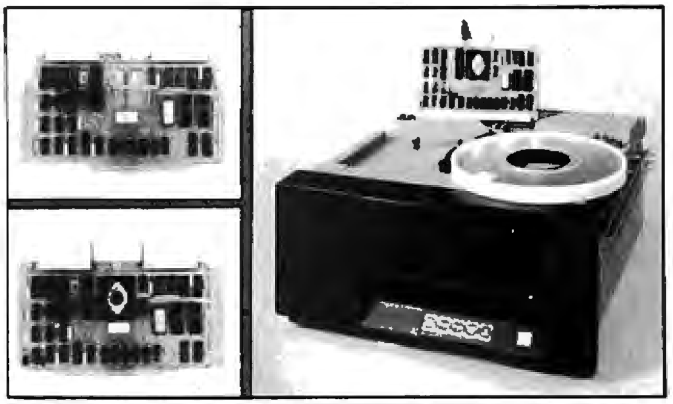
## MASS STORAGE


### Streaming Tape Cartridge for Winchester Backup

The Slider from Data Electronics is a ¼-inch digital cartridge tape drive designed to match the backup requirements of current 5¼-inch Winchester disk systems. The Slider features streaming operation with 10 megabytes of storage, a read/write head with write drivers and read preamplifiers, and interface logic with motion control and status reporting. It uses an ANSI-standard 450-foot magnetic-tape cartridge and incorporates GCR (group code recording). The Slider has a recording density of up to 10,000 flux changes per inch.

The Slider is available in a variety of packages: open frame, slide mounted, and desktop in multiple mounting configurations. In OEM (original equipment manufacturer) quantities, the Slider costs less than $500. For purchasing and ordering information, contact Data Electronics Inc., 10150 Sorrento Valley Rd., San Diego, CA 92121, (619) 452-7840.

**Circle 550 on inquiry card.**



### Intelligent Controllers Interface to Popular Buses

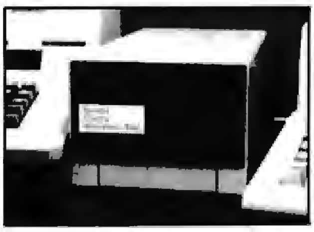
A family of intelligent controllers that hook IBM-compatible 9-track formatted tape drives to a variety of popular computer buses has been introduced by Alloy Engineering Company. The ITS family of 8085-based controllers links such drives as the Cipher Microstreamer to S-100, SS-50, and Radio Shack TRS-80 buses. These controllers feature software-selectable ASCII-to-EBCDIC (extended binary-coded decimal interchange code) conversion in firmware. Software is supported under the following operating systems: CP/M, MP/M, DPC/OS, OS-9, and TRSDOS.

In OEM (original equipment manufacturer) quantities, the ITS family costs $650 per unit. For more information, contact Alloy Engineering Co. Inc., Computer Products Division, 12 Mercer Rd., Natick, MA 01760, (617) 655-3900.

**Circle 552 on inquiry card.**

### Hard-Disk System for Apples and IBM PC

The Hobbyist is a 5¼-inch hard-disk drive designed to work with the Apple II and III and the IBM Personal Computer. Produced by Santa Clara Systems, this drive includes 5 megabytes of storage capacity, a controller, host adapter, operating software, cable, and cabinet. The Hobbyist costs $1995. Contact Santa Clara Systems Inc., 560 Division St., Campbell, CA 95008, (408) 374-6972.



**Circle 551 on inquiry card.**

### Microfloppies for HP Computers

Hewlett-Packard is marketing a family of 3½-inch mass-storage systems for its personal, business, and technical computers. Each microfloppy system uses a 3½-inch Sony drive and HP electronics. Presently, the firm has three packages available: a single-drive 270K-byte system, a 540K-byte dual-drive model, and a 4.6-megabyte Winchester disk coupled with a single 3½-inch microfloppy. The 3½-inch disk drive transfers 17,800 bytes of information per second. The disk, which can record 135 tracks of data per inch, is wrapped in a hard polymer housing. The drive has a sliding cover for the read/write opening, which protects against contamination from dust and dirt.

The 3½-inch drive systems are compatible with HP Series 80, 100, and 200 personal computers and

the HP 1000 desktop computer family. Prices range from $1200 to $4975. The 3½-inch media cost $59 per box of 10. Full details are available from your local Hewlett-Packard sales office.
Circle 553 on inquiry card.

### Elite Drives for Apples

The Elite line of 5¼-inch floppy-disk drives from Rana Systems are Apple-compatible. Standard features include storage capacities of up to 625K bytes, the ability to work with Apple's and Rana Systems' controller cards, and DOS 3.3, Pascal 1.1, and CP/M compatibility. The Elite controller card lets you hook any combination of four Apple or Rana Systems drives to the Apple II, and it automatically boots 13- and 16-sector disks.

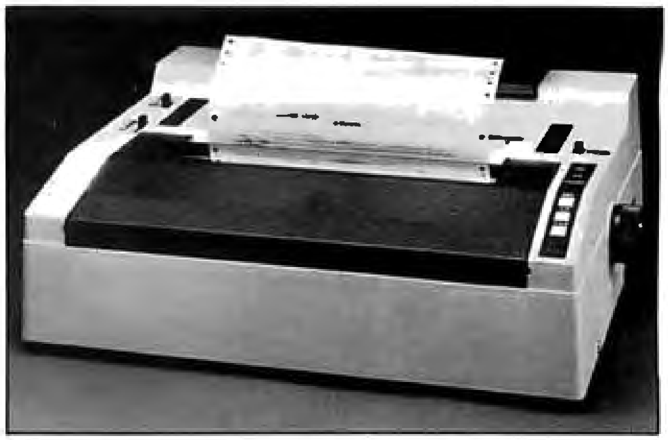
The Elite One, a single-sided, 40-track drive providing 163K bytes of storage, costs $379. A double-sided, 40-track drive with 326K bytes of storage, the Elite Two is $649. The Elite Three is a double-sided, 80-track drive priced at $849. Each Elite drive comes with a user manual and an enhancer disk. Optionally, they can be purchased with the controller card for $519, $749, and $949, respectively. The controller card alone is $145. For further details, contact Rana Systems, 20620 South Leapwood Ave., Carson, CA 90746, (800) 421-2207; in California, call (800) 262-1221 or (213) 538-2353.
Circle 554 on inquiry card.

## COMDEX REPORT

### Big Screen for IBM Personal Computer

Quadscreen, a 17-inch monitor for the IBM Personal Computer from Quadram Corporation, was on display at the Fall Comdex in Las Vegas. Capable of displaying 10,240 characters simultaneously, this P4 phosphor high-resolution monochrome screen can use a 5 by 7 character matrix to achieve a 160-character by 64-line display. A split-screen feature gives you side-by-side 80-character by 64-line screens, and a bit-mapped graphics mode permits an addressable resolution of 960 horizontal by 512 vertical. Screen attributes include reverse video and forward and backward scroll. Built-in, user-definable character sets and driver firmware in read-only memory are standard. Quadscreen has full IBM PC-DOS/BIOS compatibility.

An optional P39 green-phosphor screen is available for Quadscreen. Priced at $1950, Quadscreen comes with a cable, software, and a controller that uses only one slot on the Personal Computer. For information, contact Quadram Corp., 4357 Park Dr., Norcross, GA 30093, (404) 923-6666.
Circle 555 on inquiry card.



### Printer Features Variable-Speed Operation

The 8600 dot-matrix impact printer with variable-speed operation and an 18-wire print head was introduced at Comdex by C. Itoh Electronics Inc. This printer features task-dominant print speeds of 180 cps (characters per second) for data and list processing, 90 cps for high-resolution graphics, and 60 cps for near letter-quality output. Using a 9 by 9 matrix, the 8600 offers an 80-character-per-line format, built-in graphics mode, a 2K-byte buffer (expandable in 2K-byte increments) that reduces the central processor overhead, and parallel and serial interfacing with X/ON and X/OFF protocol. Paper feed is either bidirectional roll or optional tractor feed. The platen distance is adjustable for a variety of form thicknesses. Automatic vertical and horizontal tabbing and variable forms-length selection with electronic vertical formatting are standard. Print features include proportional spacing, eight character sizes, the ability to mix fonts during single line passes, and eight user-selectable alphabets, ranging from English to Japanese.

The 8600 dot-matrix printer costs approximately $1400. Quantity discounts are offered. Purchasing and technical details are available from C. Itoh Electronics Inc., 5301 Beethoven St., Los Angeles, CA 90066, (213) 306-6700.
Circle 556 on inquiry card.

### Irma Links IBM PC to 3270 Controllers

Technical Analysis Corporation's Irma, the first interface for direct native-mode coaxial cable attachment of IBM Personal Computers to IBM 3270 controllers, was announced at Comdex. Irma is a printed-circuit board that fits into any available slot in the PC. It is attached by coaxial cable to most IBM 3270 controllers and emulates an IBM 3278 display. It operates in native 3278 mode and requires no additional telephone lines, modems, or communications front-end support for local or remote environments. Standard features include an internal 1920-character screen buffer, emulation of 3270 monochrome and color character displays of up to 80 characters by 24 lines, a set of subroutines for selective transfer of data from emulated 3278 screens, and onboard diagnostics. In addition, Irma provides complete IBM 3278-2 terminal function compatibility and the ability to save full screens of mainframe data on floppy disk or on hard copy.

Irma works with any IBM 3274, 3276, or integral terminal controller that uses Type A terminal adapters. It lists for $1195; quantity discounts are available. For full details, contact Technical Analysis Corp., 120 West Wieuca Rd. NE, Atlanta, GA 30042, (800) 241-4762; in Georgia, (404) 252-1045.
Circle 557 on inquiry card.

## Local Network Unveiled at Comdex

At Comdex, Vector Graphic introduced LINC (local interactive network communications), a local-area network scheme that uses telephone wire to connect up to 15 single-user Vector 4 microcomputers. LINC is described as a high-speed token-passing network that uses a distributed control technique which eliminates the need for a dedicated master station or a file server. All members of a LINC network can share large disk files, high-speed printers, communications facilities, and an electronic mail service. Each workstation will support an individual printer and can function as a stand-alone word or data processor while connected to the network. LINC uses SDLC (synchronous data-link control) protocol technology. The data rate is 750,000 bits per second using RS-422A transmission standards. Network software resembles that of a multiuser operating system, and the workstations can run CP/M- and MP/M-type applications programs.

Complementing the LINC network is the Vector 4 Intelligent Workstation. This workstation, a full-function microcomputer without local disk storage, is ready to plug onto the network. Priced at $3750, it comes with a built-in controller board containing an amplifier that maintains signal strength over long distances.

The Vector 4 comes in two other configurations: the Vector 4/20 has two 630K-byte 5¼-inch floppy-disk drives; the Vector 4/30 carries a single floppy disk and a 5¼-inch 5-megabyte Winchester disk drive. A LINC upgrade kit is available for either the 4/20 or 4/30 for $750, including network software. For complete details, contact Vector Graphic Inc., 500 North Ventu Park Rd., Thousand Oaks, CA 91320, (805) 499-5831.
Circle 558 on inquiry card.


## Portable Peripheral for Communications

Axlon demonstrated its Datalink Series 1000 portable personal communications terminal at Comdex. Datalink measures 1⅝ by 3$^{9}/_{16}$ by 6¾ inches and weighs less than a pound. Designed for a variety of markets, this terminal can be used to transmit or retrieve information from a personal telephone directory or a database such as the New York Stock Exchange. Dataline has a 16-character tilted green-fluorescent display, keyboard-selectable 110- or 300-bit-per-second character speeds, a built-in RS-232C-compatible output port, and an alphanumeric typewriter keyboard. Rechargeable batteries and a built-in direct-connect telephone modem are standard.

Datalink options include acoustic cups, a 40-character-per-line printer, and a television display interface with 2K bytes of memory. It costs $399 and is available from Axlon Inc., 70 Daggett Dr., San Jose, CA 95134, (408) 945-0500.
Circle 559 on inquiry card.

## Personal Computer Network System

The PLAN 4000 system from Nestar Systems will simultaneously support the IBM PC and Apple II and III computers in a vendor-independent network. This system was designed for users requiring dedicated and accessible computing power with full communications capabilities for sharing and accessing information. PLAN 4000 is built around Datapoint Corporation's ARCnet and Xerox's Ethernet technologies, and it supports up to 548 megabytes of disk stroage for each file server online. The file server manages access to storage for all users connected to the network, and multiple file servers can be added. Functions possible with PLAN 4000 include automatic printing with a variety of printers, local and worldwide electronic mail communications, direct user access to IBM mainframes, Telex communications from individual workstations, and bridges to other networks.

Workstations attach to PLAN 4000 by means of a plug-in network interface card, which is $595. A 40-station network costs approximately $1800 per workstation, which includes support for up to 137 megabytes of disk storage and 45 megabytes of digital cartridge tape backup, a print server, an IBM 3270 server, and electronic mail capabilities. A number of network configurations can be arranged. For complete specifications and purchasing information, contact Nestar Systems Inc., 2585 East Bayshore Rd., Palo Alto, CA 94303, (415) 493-2223.

Circle 560 on inquiry card.

### Half-Height Winchester Uses Thin-Film Disks

Seagate Technology unveiled a half-height 5¼-inch micro Winchester disk drive at the Fall Comdex. The ST206 drive uses ferrite read/write heads for higher frequency response and a flux density of 9074 fcpi (flux changes per inch). Its thin-film plated media are capable of storing 6.38 megabytes of unformatted data or 5 megabytes of formatted data. Fully compatible with the industry-standard ST506 interface, the ST206 was designed to be a companion to half-height floppy-disk drives in single-slot intelligent terminals and portable computers. Technical specifications include a 5-megabit-per-second transfer rate, average access time of 85 milliseconds (including settling) using a split-band positioner and a stepper-motor-driven actuator, a stored-data density of 10,416 bytes per track (unformatted), and 9.33-millisecond average latency. Dimensions for the ST206 are 1.625 by 5.75 by 8 inches.

In 500-unit lots, the ST206 costs $745. Seagate Technology is located at 360 El Pueblo Rd., Scotts Valley, CA 95066, (408) 438-6550.

Circle 561 on inquiry card.

### Serial Dot-Matrix Printers

Okidata introduced two serial dot-matrix printers at Comdex. The Microline Models 92 and 93 provide correspondence-quality printing and data-processing capabilities. Both models give you bidirectional data processing with short-line seeking logic at 160 cps (characters per second) and high-resolution correspondence-quality printing at 40 cps. These printers have enhanced and emphasized printing, dot-addressable graphics, downline-loadable character sets that allow you to create custom characters and symbols, and a 9-pin stored-energy printhead. User forms controls for vertical tab, top of form, and up to 10 forms lengths are provided through switch and program control. The mean time between failures is 4000 hours, and the mean time to repair is 15 minutes. These printers come with a Centronics-compatible parallel interface. A high-performance RS-232C serial interface is available optionally.

The Model 92's maximum column width is 136 characters at 17 cpi (characters per inch). It has a standard roller platen to accommodate friction and pin paper feeds. A tractor feed is optional. The Model 93 has a roller platen and tractor feed for forms up to 16 inches wide. Contact Okidata Corp., 111 Gaither Dr., Mount Laurel, NJ 08054, (800) 654-3282; in New Jersey, (609) 235-2600.

Circle 562 on inquiry card.

### Bisynchronous Communications Interface

North Star Computers is marketing a software package that provides a 2780/3780 bisynchronous communications link between Advantage and Horizon microcomputers and large mainframes. With the Northlink 2780/3780 Bisync, North

Star systems can transmit batched files between their equipment and computers from such manufacturers as IBM, Hewlett-Packard, and Data General. Northlink can provide the same service when it is used as a gateway on North Star's local-area network, Northnet.

The Northlink 2780/3780 Bisync costs $499. Contact North Star Computers Inc., 14440 Catalina St., San Leandro, CA 94577.

Circle 563 on inquiry card.

## SOFTWARE

### Hayden Software Products

The Hayden Software Company markets business, entertainment, professional, and utility software packages. Designed for small businesses with CP/M-based systems, the Basic Accounting System provides general ledger, accounts payable and receivable, payroll, and inventory program modules. For the home, Hayden offers arcade-type games such as Bulldog Pinball, an Atari version of the popular pinball game. The PIE Writer word processor for the IBM Personal Computer and Apple IIs equipped with an 80-column board is available. Hayden also distributes a shape-drawing program and a communications system for use with the Apple II and Hayes Micromodem II. For information, contact Hayden Software Co., 600 Suffolk St., Lowell, MA 01853, (617) 937-0200.

Circle 564 on inquiry card.

### Sophisticated Word Processor

The Gutenberg Word and Print Processing Program for the Apple II is a user-friendly word processor suitable for text creation and secretarial tasks. It offers a split-screen text editor, user-definable screen and printer characters for multilanguage documents, and automatic centering of up to 32 user-definable foreign accent marks. Gutenberg has an unlimited variety of such formats as multiple columns, shaped text, complex tabulations, and multiple levels of indentation. Standard features include global search and replace with eight different masks and counter, programmable keyboard abilities for data capturing, and high- or low-resolution editing modes. Gutenberg supports graphics, pictures, and text in proportionally spaced characters in all justification modes. It works with most popular dot-matrix and daisy-wheel printers, including Apple DPM, Centronics 737 and 739, Epson MX-80/100 with Graftrax-Plus, NEC 8023A-C, C. Itoh F-10, and Qume Sprint 5/45 and 9/45. It supports a variety of parallel and serial printer-interface cards.

Gutenberg runs on 48K-byte Apple II computers equipped with one disk drive. A shift-key modification is required. The suggested retail price is $325, which includes a backup disk, documentation, a ruler, and a shift-key modification cable. A demonstration disk copy is available at participating Apple dealers. Contact Micromation Ltd., Suite 406, 1 Yorkdale Rd., Toronto, Ontario M6A 3A1, Canada, (416) 781-6675.

Circle 565 on inquiry card.

### Software for Fun and Profit

Digital Marketing Corporation's software line ranges from games to sophisticated financial planning and analysis programs. The company has software for word processing, real estate analysis, accounting, customer and product profiles, communications, bibliography collations, medical billing and accounts receivable, proofreading, project and time management, and data compression. Digital Marketing programs are available in most microcomputer formats and run on the IBM Personal Computer and CP/M-, CP/M-86-, and MS-DOS-based systems. For full details, contact Digital Marketing Corp., 2670 Cherry Lane, Walnut Creek, CA 94596, (415) 938-2880.

Circle 566 on inquiry card.

## SYSTEMS

### Business Computers with 8/16-Bit Architecture

Digilog Business Systems recently started shipping two dual 8/16-bit desktop business computers. The Systems 1016 and 1516 are built on the Z80A processor and Intel's 80186 processor. Standard features include 64K bytes of RAM (random-access read/write memory) for the Z80A, 128K bytes of RAM for the 80186, the CP/M operating system, a 12-inch monitor, 73-key keyboard, and floppy-disk or Winchester-disk storage. Both models can operate as stand-alone 8- or 16-bit computers and serve as workstations in an 8-bit Digilog multiuser network. The System 1016 is offered with 720K bytes of floppy-disk storage or with 1.6 megabytes of Winchester storage. Its companion model can be configured for 5 or 10 megabytes of Winchester storage.

Options include both the CP/M-86 operating system and 128K bytes of additional RAM for the 80186 processor. Prices range from $3995 to $6995, depending upon model and storage capacities. The additional RAM costs $450. Further information is available from Digilog Business Systems Inc., Welsh Road and Park Drive, POB 355, Montgomeryville, PA 18936, (215) 628-4810.

Circle 567 on inquiry card.

## Entry-Level Computer Has Sound and Graphics

The NEC Home Electronics PC-6000 is an entry-level computer system for home and school. The PC-6000 features sound, color, and the ability to work with black-and-white or color televisions or a NEC composite-video monitor. This system contains 16K bytes of RAM (random-access read/write memory), 16K bytes of ROM (read-only memory), Microsoft BASIC with enhanced graphics and sound capabilities for use with joysticks, and the ability to produce nine colors that enhance text and graphics. The PC-6000's music function has an eight-octave range and uses three independent sound generators. Its 71-key typewriter-style keyboard provides 10 different functions by means of 5 function keys. More than 30 software packages are available for the PC-6000, including games and personal finance programs.

Options for the PC-6000 include a 5¼-inch floppy-disk drive, a cassette data recorder, a 40-character thermal printer, a pressure-sensitive touch-panel for creating images, RAM and ROM cartridge for an additional 16K bytes of memory, an RS-232C interface, and 12-inch monochromatic or color display monitors. The PC-6000 costs less than $450 and is available from NEC Home Electronics Inc., 1401 Estes Ave., Elk Grove, IL 60007, (312) 228-5900.

Circle 568 on inquiry card.

## System Supports Five Users

The 16-bit Altos 586 microcomputer supports five users and offers integral Ethernet and Altos-Net network interfaces. The 586 is supplied with a 10-MHz 8086 processor, 256K or 512K bytes of RAM (random-access read/write memory), keyboard, bit-mapped monitor, Multibus-type architecture, proprietary memory-management, power failure detection, and a battery-backed clock and calendar. The 586's six RS-232C ports are upgradable to ten through an integral communications board offering an auto-dial/auto-answer modem. This board provides communication with large mainframes and such protocols as IBM 2780/3780 (synchronous) and X.25. Software includes the Xenix/Unix operating system and the Altos ABS/86 business package. The 586 will support MS-DOS, PICK, CP/M-86, MP/M-86, and Oasis-16 operating systems. Languages such as BASIC, COBOL, FORTRAN, Pascal, and C can be used.

As many as 32 Altos 586s can be networked using high-speed twisted pair cable, which allows more than 200 users to share files, send electronic mail, and pool printers and peripherals. Networking is accomplished with RS-422A cabling connected to the integral interface and Altos-Net software.

Two versions of the 586 family are available. The 586-2 offers dual 5¼-inch 1-megabyte floppy-disk drives and costs $4990. The 586-10 features 10-megabyte 5¼-inch hard-disk storage with floppy-disk backup. It costs $7990. Both are upgradable to 20 megabytes. Contact Altos Computer Systems, 2360 Bering Dr., San Jose, CA 95131, (408) 946-6700.

Circle 569 on inquiry card.

# PUBLICATIONS

## Computer Curriculum for Teachers, Administrators

Slated for release in May, My Students Use Computers: A Comprehensive Guide for the K-8 Curriculum provides a scope and a set of objectives for integrating computer-related skills and knowledge into the kindergarten through 8th grade curriculum. It's based on a three-year project funded by a grant from the National Science Foundation and developed by Beverly Hunter of the Human Resources Research Organization and an advisory panel of computer educators. Seventy teachers and specialists contributed to this guide, which contains 90 detailed lesson plans and activities for each grade level, guidance for staff development, and a comprehensive list of additional resources. The material was classroom tested throughout the 1981-82 school year.

My Students Use Computers is $23.95, case bound. A shorter spiral bound version for classroom teachers containing only the grade-specific objectives, activities, and resource section costs $14.95. It's available directly from the Reston Publishing Co., 11480 Sunset Hills Rd., Reston, VA 22090, (800) 336-0338; in Virginia, (703) 437-8900.

Circle 570 on inquiry card.

# What's New?

## Bibliography Lists Computer Periodicals

Microcomputing Periodicals: An Annotated Bibliography lists more than 400 computing magazines and newsletters. Periodicals covered touch all bases from general and specific applications, such as medicine, to individual products. Among the facts provided by this bibliography are subscription address, frequency of publication, and brief descriptions of contents, scope, and audience. An appendix of periodicals that have changed names or ceased publication and a subject index are included.

Microcomputing Periodicals: An Annotated Bibliography is updated constantly. It's $15 from Microcomputing Periodicals, 53 Fraserwood Ave. #2, Toronto, Ontario M6B 2N6, Canada.

Circle 571 on inquiry card.

## Detailed Specifications Given In Catalog

The Electronic Power Conversion Division of Gould Inc. has produced a 16-page catalog describing its line of Super Isolation Transformers and AC line conditioners in ratings from 110 V AC to 60 kVA. This free catalog has detailed technical descriptions of five different product lines. AC power-line problems and the appropriate line-conditioning device necessary to solve them are discussed.

The Handbook of AC Power Problems is also available from Gould. It discusses in layman's terms power-line problems that plague computers. The handbook costs $4. Contact Gould Inc., Electronic Power Conversion Division, 2727 Kurtz St., San Diego, CA 92110, (714) 291-4211.

Circle 572 on inquiry card.

## Z89/Z90 Software Directory

The Zenith Data Systems Software Directory lists more than 400 programs for Zenith Z89 and Z90 desktop computers. This directory has full-page outlines of accounting, agribusiness, communications, database, graphics, inventory and time management, word processing, and other software packages aimed at business users. Each entry lists the vendor's name and telephone number and provides a summary of the product's features, operating system requirements, programming language, disk size and format, number of drives, minimum memory, and whether source code is available.

The Zenith Data Systems Software Directory costs $25 at Zenith computer dealers and Heathkit Electronic Centers. Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025.

Circle 573 on inquiry card.

## PERIPHERALS

### Intelligent Printer Option

The Intelligent Graphics Processor (IPG) merges matrix line printing with microprocessor technology. IPG enables Printronix P-Series printers to perform a variety of functions ranging from forms generation, bar codes, and line or box segment graphics to stored logo graphics and overlays. Programming the IPG is said to be achieved with a simple data file and a command format that's easy to understand and program.

IPG is available as a factory-installed option or as an upgrade for 150-, 300-, and 600-line-per-minute P-Series printers. The suggested price is $1495. For full particulars, contact Printronix Inc., 17500 Cartwright Rd., POB 19559, Irvine, CA 92713, (714) 549-7700.

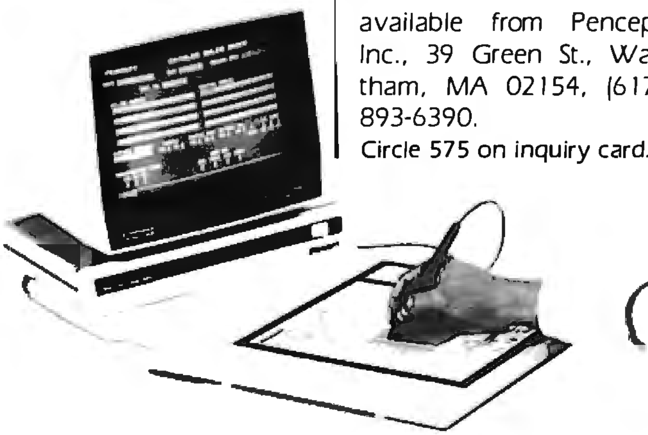
Circle 574 on inquiry card.

### Handprint Data to Your Computer

First shipments of Pencept's Personal Penpad, which lets you handprint data into your personal computer, begin this month. Made up of a writing tablet, a control unit, and an electronic pen, Penpad is purported to be able to recognize the full complement of alphabetic and numeric characters and 15 special characters such as dollar and equal signs. Designed to immediately recognize handprinted data, Penpad builds a memory image of a character by analyzing its shape as it is written. Each character shape is equivalent to 2000 bits of data, which is then further reduced to 7-bit ASCII code and displayed on a video screen. Penpad is equipped with function boxes that merely require a check for initialization. These function boxes can be predefined or specified for individual applications. Other standard features include edit and delete capabilities.

In single units, Personal Penpad costs $3500; quantity discounts are offered. Further details are available from Pencept Inc., 39 Green St., Waltham, MA 02154, (617) 893-6390.

Circle 575 on inquiry card.



# What's New?


## Vectrix Unveils Color Graphics Line

A line of color graphics systems built on the NEC GDC and the 16-bit 8088 microprocessor has been released by Vectrix Corporation. Intended as a graphics display for a host computer and targeted at both the end-user and OEM (original equipment manufacturer) markets, the VX Series comprises two graphics processors, a 13-inch RGB (red/green/blue) monitor, a color printer, and a keyboard.

The VX128 graphics processor has 627 by 480 pixel resolution, serial and parallel interfaces, eight simultaneous colors, and three-dimensional vector graphics with rotation, scaling, translation, perspective, clipping, viewport, polygons, and filled polygons. This system has the ability to mix graphics and characters using built-in user-definable characters. Bidirectional access to individual pixels is permitted. Also featured are graphics RAM (random-access read/write memory) and high-speed hardware generation of lines, arcs, and multiply or divide.

An enhanced VX128, the VX384 gives you 512 simultaneous colors for shading and bit-plane animation for three-dimensional solid modeling, presentation graphics, and image processing.

Prices for optional equipment range from $295 to $1495. The VX128 costs $1995. The VX384 is available as an add-on board for the VX128 for $2000 or as a stand-alone unit for $3995. OEM discounts can be arranged. For details, contact Vectrix Corp., 700 Battleground Ave., Greensboro, NC 27401, (800) 334-8181; in North Carolina, (919) 272-3479.

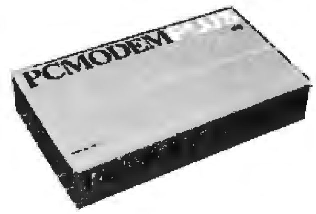
Circle 576 on inquiry card.

## Disk-Emulation System

Semidisk, a high-capacity disk-emulation system, is designed for Radio Shack TRS-80 Model IIs, the IBM Personal Computer, and S-100-bus-based systems. It's made up of a memory board that plugs into a single slot on the computer's bus and driver software. Like a disk, Semidisk gives you a directory and lets you read, write, execute, or modify files. It can store 512K bytes of data and transfer data at a rate of 200K bytes per second. System highlights include an I/O-mapped hardware interface and a 64k-bit by 1-bit dynamic RAM (random-access read/write memory) chip. All data enters Semidisk through four I/O ports that can be readdressed to any one of 64 locations. Extended addressing or bank-selecting techniques for storing data are not required. Up to 8 megabytes of storage can be achieved with additional Semidisks.

Semidisk software comes in a variety of formats, including 8-inch single-density floppy disk, 8-inch TRS-80 Model II double-density disks, 5¼-inch double-density North Star disks, and IBM Personal Computer 5¼-inch floppy disks. Inquiries about special formats are invited. It runs with the CP/M 2.2 operating system. For the IBM Personal Computer, it requires MS-DOS or CP/M-86. Including documentation and source code, Semidisk costs $1995, postpaid. A 1-megabyte version is $2295, and the user's manual is $10. Contact Semidisk Systems, POB GG, Beaverton, OR 97075, (503) 642-3100.

Circle 577 on inquiry card.




## Modem Links IBM PC to Information Services

Ven-Tel's PC Modem Plus is a communications package that connects the IBM Personal Computer to The Source, the Dow Jones News/Retrieval Service, and other information databases. The PC Modem Plus comprises a microprocessor-based auto-answer/auto-dial 300-bps (bit-per-second) modem outfitted with a 2K-byte buffer and an extra serial port, menu-driven communications software, and a standard modular telephone cable. It can operate in both half- and full-duplex modes and is said to be completely hardware- and software-compatible with the Personal Computer. It plugs into the Personal Computer's chassis and can be expanded to 1200-bps full-duplex (Bell 212A-compatible) operation by means of a piggyback card.

The PC Modem Plus has a suggested price of $389, which includes operating instructions. For full ordering and technical information, contact Ven-Tel Inc., 2342 Walsh Ave., Santa Clara, CA 95051, (408) 727-5721.

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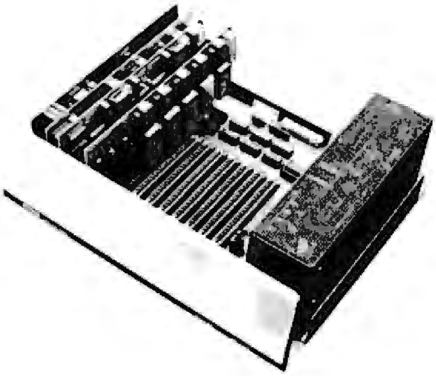

## Measurement and Control Systems for Apple and IBM Computers

Data Acquisition Systems is marketing a family of measurement and control systems for the Apple II and the IBM Personal Computer. The DAS Series 500 comprises four modular units, each of which has the ability to accept up to to 12 additional I/O library modules for applications flexibility. Standard system components and capabilities include software sampling rates surpassing 20,000 samples per second for A/D (analog-to-digital) inputs, a real-time clock for time-stamping, three programmable interval timers, and internal power supplies. These devices can handle 15,000 conversions per second at 14 bits and offer integrated hardware and software capabilities.

The general-purpose System 500 is said to be configurable for virtually any combination of A/D or D/A inputs and outputs. The System 510, a high-performance data-acquisition system, is tailored for applications requiring A/D conversions. Purported to be a complete measurement and control unit, the System 520 has both A/D inputs and outputs and device-control capabilities. The System 530 features high resolution, low noise, and speed for accurate digitization and generation of complex analog signals.

DAS Series 500 systems use a multitasking language known as Soft500. According to the manufacturer, Soft500 extends Applesoft BASIC for data acquisition, measurement, and control functions. It consists of a real-time, interrupt-driven operating environment and more than 40 statements. For the IBM PC, Soft500 functions as an extended BASIC. This software supports transparent data storage to 768K bytes with memory expansion cards for the Apple II or up to 1 megabyte for the PC.

The Series 500 ranges in price from $2700 to $4400. For full specifications, contact Data Acquisition Systems Inc., 349 Congress St., Boston, MA 02210, (617) 423-7691.

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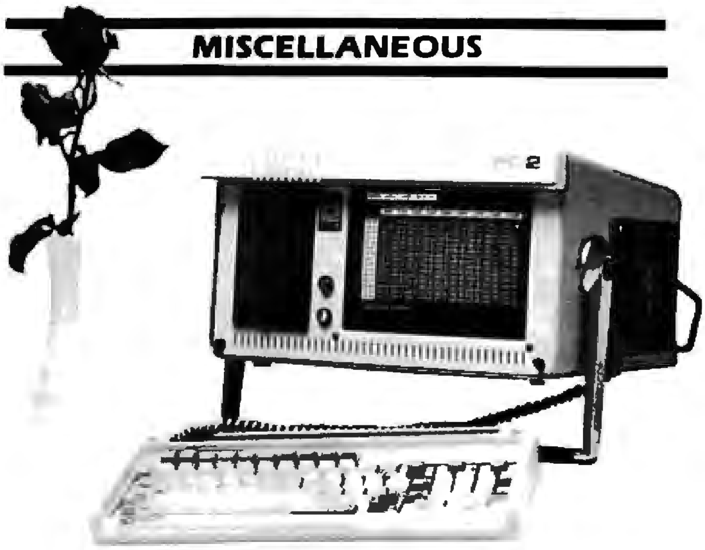
# MISCELLANEOUS



## Portable PC-Compatible Computer Kit

The Colby PC-I Conversion Kit allows IBM Personal Computer users to transfer the PC's capabilities into a 26-pound portable unit. The kit includes a 9-inch high-resolution display, switching power supply, wire harness, and interface, enclosed in a 15- by 17- by 8½-inch case with a handle. PC-I is designed to operate with the PC's disk drive, system board, plug-in boards, and keyboard. The conversion is said to require less than one hour and can be performed at participating dealers.

Future options for the PC-I include a modem, a snap-on keyboard, 5¼-inch dual disk-drive capability, and a local networking system. The Colby PC-I costs $899. For purchasing information or specification sheets, contact Colby Computer, 2 Palo Alto Square, Palo Alto, CA 94304, (415) 493-7788.

Circle 580 on inquiry card.

## Plug-in CP/M Interface for Apple

Advanced Logic Systems, in cooperation with Digital Research, has announced a plug-in CP/M interface card that lets Apple II and Apple II Plus users run CP/M-compatible applications software. The CP/M Card plugs directly into the Apple and provides an additional 64K bytes of memory. The card uses a 6-MHz Z80B microprocessor and has automatic bank switching with cache memory. It conforms to standard Apple protocols for direct memory access and interrupts. The package includes Digital Research's CP/M

Plus 3.0, CBASIC, and GSX-80 CP/M software and menu-driven utilities from Advanced Logic Systems.

The CP/M Card requires a 48K-byte Apple with two disk drives, DOS 3.3, and a video monitor with an 80-column card. It costs $399 and can be ordered from Advanced Logic Systems, 1195 East Arques Ave., Sunnyvale, CA 94086, (408) 730-0306.

Circle 581 on inquiry card.

### Hard Plastic Display Filters

Optech video-display filters have a low-reflection surface that eliminates glare and provides optimum contrast and readability. These filters are made of hard plastic and are supplied with a gasket that seals out dust. Optech filters cost $30 and are available in a variety of sizes to fit most popular displays. For details, contact SGL Homalite, 11 Brookside Dr., Wilmington, DE 19804, (302) 652-3686.

Circle 582 on inquiry card.

### Video Cassette Learning Library

The Video Cassette Learning Library from Stoneware is designed to teach new users of Apple II/III computers and IBM Personal Computers how to make their systems work. These video cassettes offer a self-paced, hands-on approach that explains the operation of each computer. The cassettes contain 10 chapters, which guide you from assembling your system to programming in BASIC. This series of how-to video cassettes was produced for Stoneware by Kennen Publishing.

The Video Cassette Learning Library is available in VHS or Beta format. Each cassette is $120. Contact Stoneware Inc., 50 Belvedere St., San Rafael, CA 94901.

Circle 583 on inquiry card.

### Computer Work Centers

Once A Tree is offering a line of computer furniture. All items come ready to assemble and are made from solid oak, hand rubbed with oil. A basic computer desk costs $249.95, a utility shelf is $39.95, and a printer stand is priced at $164.95. Dealer inquiries are invited. Contact Once A Tree/Amaro & Son Inc., 3192 Commercial St., San Diego, CA 92113, (619) 421-0441.

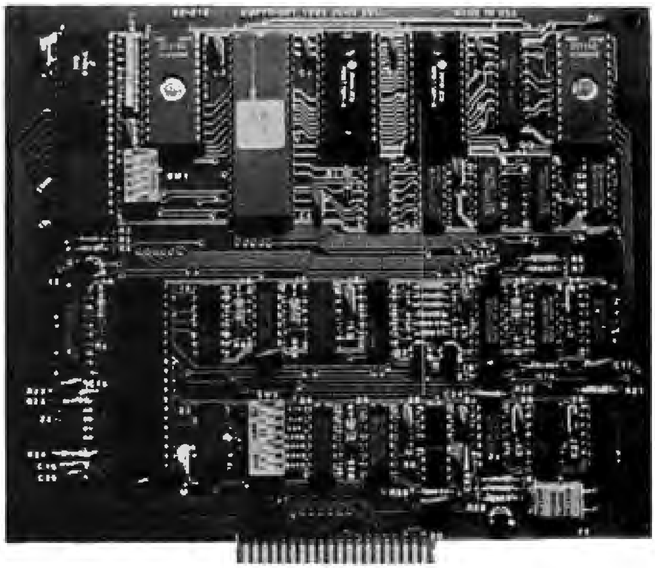
Circle 584 on inquiry card.

# VIDEO TERMINAL BOARD 82-018

This is a complete stand alone Video Terminal board. All that is needed besides this board is a parallel ASCII keyboard, standard NTSC monitor, and a power supply. It displays 80 columns by 25 lines of UPPER and lower case characters. Data is transferred by RS232 at rates of 110 baud to 9600 baud — switch selectable. The UART is controlled (parity etc.) by a 5 pos. dip switch.

Complete source listing is included in the documentation. Both the character generator and the CRT program are in 2716 EPROMS to allow easy modification to your needs.

This board uses a 6502 Microprocessor and a 6545-1 CRT controller. The 6502 runs during the horz. and vert. blanking (45% of the time). The serial input port is interrupt driven. A 1500 character silo is used to store data until the 6502 can display it.



**Features**

- **6502 Microprocessor**
- **6545-1 CRT controller**
- **2716 EPROM char. gen.**
- **2716 EPROM program**
- **4K RAM (6116)**
- **2K EPROM 2716**
- **RS232 I/O for direct connection to computer or modem.**
- **80 columns x 25 line display**
- **Size 6.2" x 7.2"**
- **Output for speaker (bell)**
- **Power +5 700Ma.**
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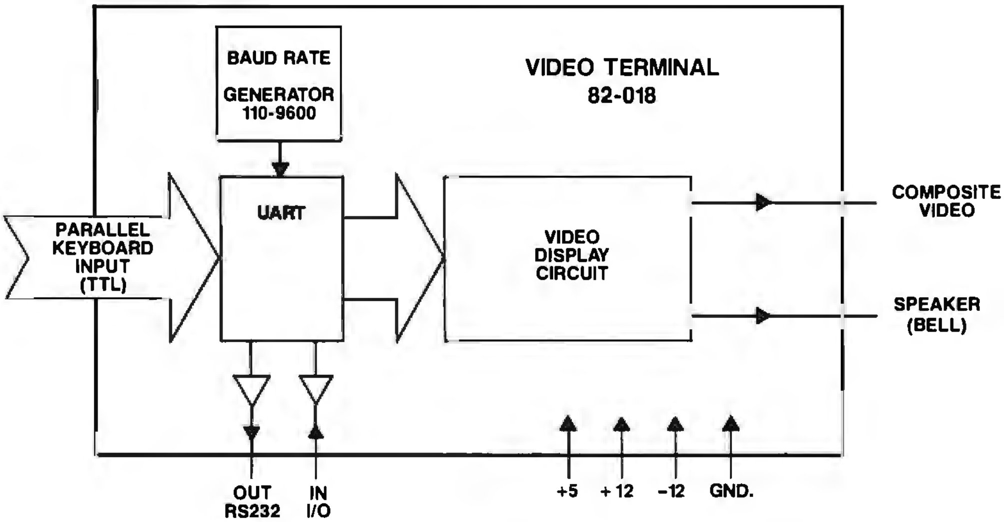


This board is available assembled and tested, or bare board with the two EPROMS and crystal.

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| Assembled and tested | #82-018A | $199.95 |
| Bare board with EPROMS and crystal | #82-018B | $ 89.95 |

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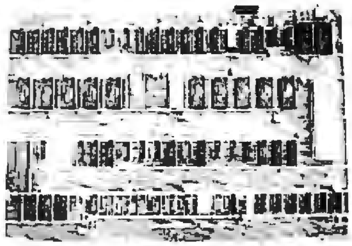

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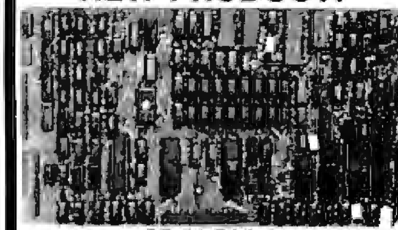

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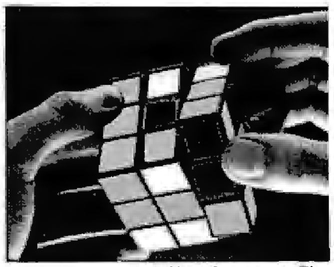

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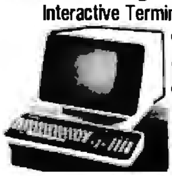

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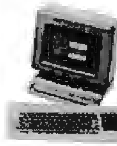

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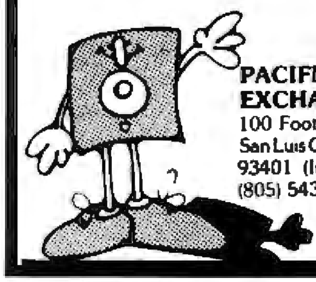

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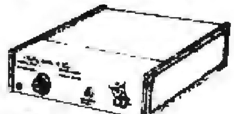

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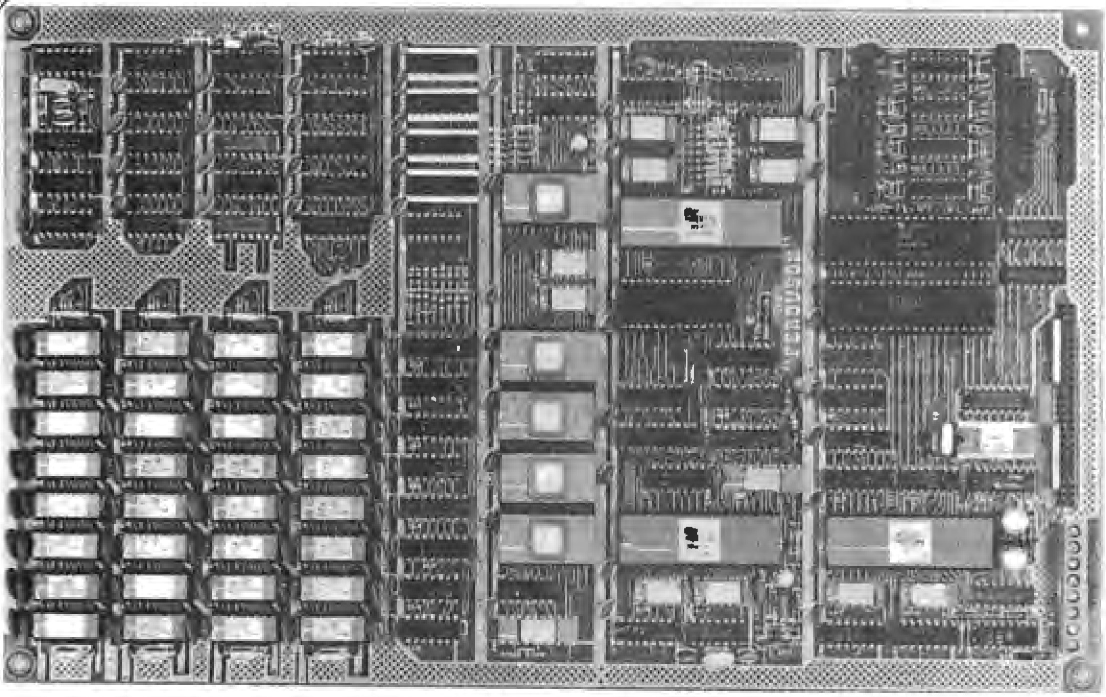

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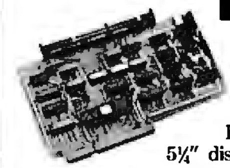

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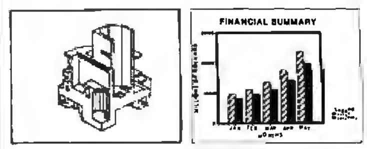


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| MX80 FT III | 489 |
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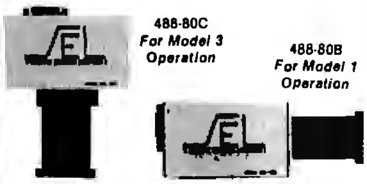


Model 488-80B or 488-80C Price: $375.
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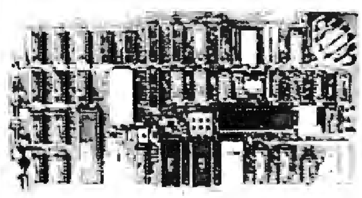
**SINGLE BOARD COMPUTER WITH VIDEO OUTPUT**



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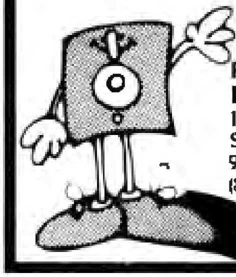

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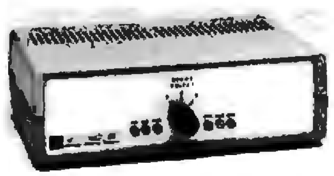

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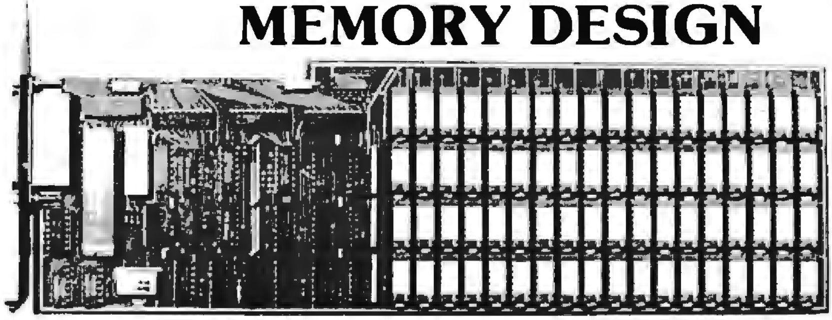

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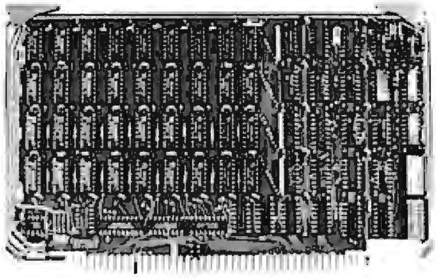

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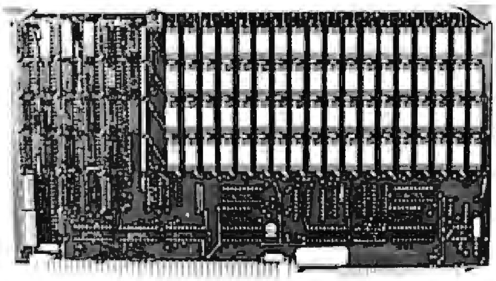

## 512KB SINGLE BOARD MULTIBUS MEMORY

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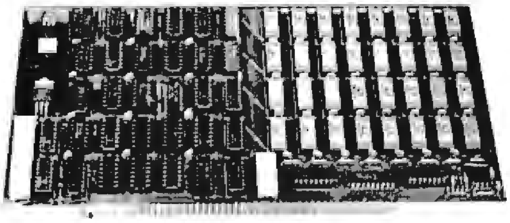

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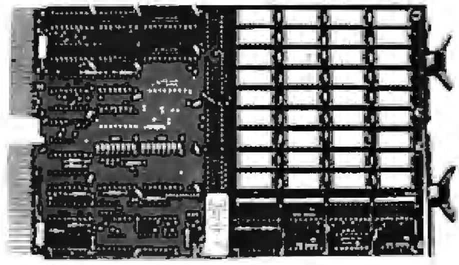

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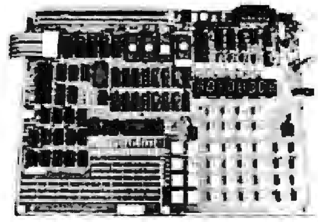

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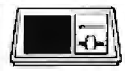

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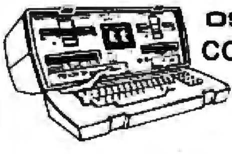

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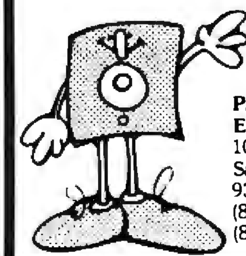

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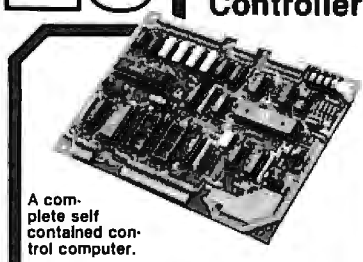

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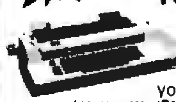

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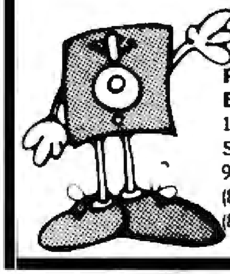

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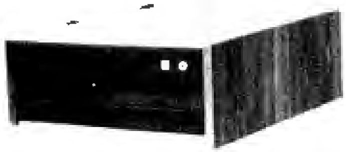

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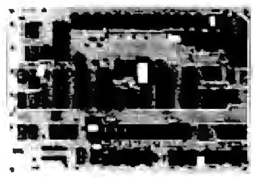

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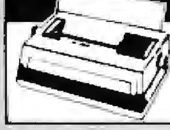

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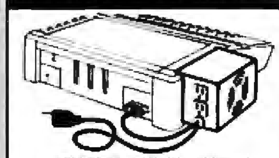

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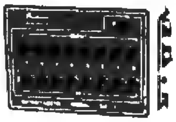

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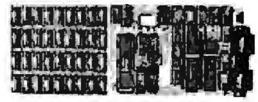

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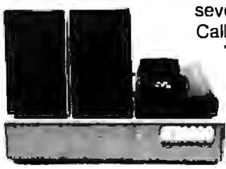

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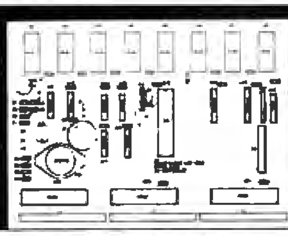

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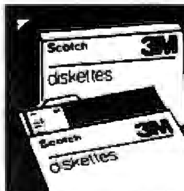


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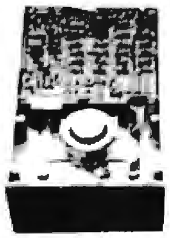

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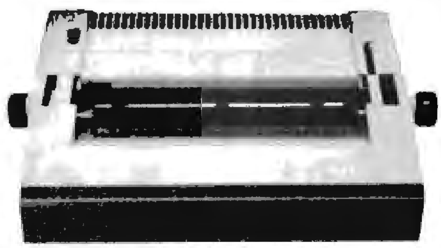

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| 84A serial | $1119 |
| 2K Buffer | $ 50 |
| Graphics 82A, 83A | $ 73 |

C-ITOH SPECIAL

| | |
|---|---|
| Comet II (125 cps) | $ 499 |
| Full 15" width text printer | |

C-ITOH PRINTERS

| | |
|---|---|
| 80 col. parallel printer | $ 449 |
| 80 col. serial printer | $ 589 |
| 132 col. parallel printer | $ 679 |
| 132 col. serial printer | $ 729 |
| Prac. Peripheral 8K Serial Buffer with X on/off Epson | $ 111 |
| Graphics Prowriter (120 cps) | $ 444 |

STAR PRINTERS

| | |
|---|---|
| Gemini 10 and 15 | Call for Pricing |

## LETTER QUALITY

serial or parallel

| | |
|---|---|
| C-ITOH F10 | $1345 |
| Brother HRI | $ 849 |
| Smith Corona TPI | $ 569 |

## PRINTER CONNECTORS

| | |
|---|---|
| TRS-80 Cables only | $ 22 |
| Apple Int. & Cable | $ 79 |
| Atari-printer Cable | $ 24 |
| IBM PC-printer Cable | $ 24 |
| Male Centronics-printer Cable | $ 24 |
| RS232 male-male | $ 19 |

*"Configured for any computer, please specify your computer"*

| | |
|---|---|
| IDS Cable | $ 33 |
| Apple Graphics Card with Cable to Epson/NEC/C-ITOH | $ 89 |

## MONITORS

| | |
|---|---|
| Zenith ZVM-121 Green | $ 90 |
| TECO ED 1200 line Hires Green | $111 |
| NEC Anti Glare Green | $155 |
| AMDEK 300G | $155 |
| AMDEK Color I | $333 |
| AMDEK Color II (IBM Available) | $699 |

## IBM

| | |
|---|---|
| Monte Carlo Card 64K | $ 399 |
| I-C Magic | $ 69 |

## VERBATIM

| | |
|---|---|
| 5¼" SS/SD | $22.50 |
| 5¼" SS/DD | $24.00 |
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| 8" DS/DD | $39.00 |
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Available in soft sector and hard sector 10/16

## IBM/APPLE DRIVES

| | |
|---|---|
| • Tandon TMS-100-1 | $202 |
| TMS-100-2 | $265 |
| TMS-100-4 | $383 |
| • Software patch for IBM | $ 66 |
| • RANA Elite 1 Add on Drive | $333 |
| Quad drive Apple controller | $ 99 |
| For Elite 2/3/4 write for price/availability | $ 99 |
| • DAVONG (Apple and IBM) 5 MB | $1525 |
| 10 MB | $2025 |
| 15 MB | $2245 |

## NEC PERSONAL COMPUTER

| | |
|---|---|
| PC-8001 | $699 |
| PC-8012 | $459 |
| PC-8031 | $699 |

COMING!—NEW NEC-APC

## GENERIC DISKETTES

| | |
|---|---|
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| | |
|---|---|
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| 8" | $ 3.50 |

## MODEMS

| | |
|---|---|
| Hayes Smart Modem | $212 |
| Hayes Micro Modem | $259 |
| Hayes Chronograph | $179 |
| Apple - Cat II | $279 |
| IBM - Smart Modem Cables | $ 22 |

## RAM CARDS

| | |
|---|---|
| Apple 16K Card | $ 66 |
| 32K Card | $125 |
| IBM 64K Quad Board | $375 |
| Apple Vista Vision 80 | $242 |

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w/o Keyboard =48K RAM=
**$399.**
w/o Pwr. Supply

| Microswitch Keyboard | Power Supply w/ Purchase | APPLE Reference Manl. |
|---|---|---|
| $75.00 | $95.00 | $18.00 |

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|---|---|
| 3inch Mini FAN | $8.95 |
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| 8155 | $11.50 |
| ER2501 | $4.95 |
| AY5 1013A | $2.95 |
| 8202 | $29.95 |
| 6522 | $5.25 |
| 8255 | $4.50 |
| 8748-8 | $31.00 |
| MC6800 | $7.75 |
| MC6802 | $14.95 |
| MC6850 | $4.50 |
| MC6821 | $4.95 |
| 6331 | $1.25 |
| 4116-2 | 8/9.95 |
| 2716(5v) | 3.25ea |
| 2732(5v) | 5.25ea |
| 2532(5v) | 8.75ea. |
| Z80 A CPU | 5.25ea. |

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$49.95

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|---|---|---|
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| DS/DD | 32.40 | 37.40 |

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## COMPONENTS

| | |
|---|---|
| 74LS00 | .24 |
| 74LS02 | .24 |
| 74LS03 | .24 |
| 74LS04 | .24 |
| 74LS05 | .24 |
| 74LS0[illegible] | .30 |
| 74LS08 | .28 |
| 74LS10 | .24 |
| 74LS11 | .33 |
| 74LS12 | .33 |
| 74LS13 | .45 |
| 74LS14 | .89 |
| 74LS20 | .24 |
| 74LS21 | .24 |
| 74LS26 | .30 |
| 74LS27 | .28 |
| 74LS28 | .32 |
| 74LS30 | .24 |
| 74LS32 | .32 |
| 74LS37 | .50 |
| 74LS38 | .32 |
| 74LS42 | .50 |
| 74LS48 | .70 |
| 74LS51 | .24 |
| 74LS55 | .35 |
| 74LS74 | .35 |
| 74LS75 | .48 |
| 74LS83 | .70 |
| 74LS86 | .38 |
| 74LS90 | .60 |
| 74LS91 | .85 |
| 74LS92 | .65 |
| 74LS93 | .60 |
| 74LS95 | .80 |
| 74LS107 | .38 |
| 74LS109 | .38 |
| 74LS112 | .40 |
| 74LS113 | .40 |
| 74LS114 | .45 |
| 74LS122 | .40 |
| 74LS123 | .85 |
| 74LS125 | .90 |
| 74LS126 | .85 |
| 74LS132 | .70 |
| 74LS136 | .50 |
| 74LS138 | .65 |
| 74LS139 | .65 |
| 74LS145 | 1.10 |
| 74LS151 | .70 |
| 74LS153 | .70 |
| 74LS157 | .70 |
| 74LS158 | .70 |
| 74LS161 | .85 |
| 74LS162 | .85 |
| 74LS163 | .85 |
| 74LS164 | .85 |
| 74LS165 | .85 |
| 74LS169 | 1.55 |
| 74LS170 | 1.55 |
| 74LS174 | .85 |
| 74LS175 | .85 |
| 74LS190 | .90 |
| 74LS191 | .90 |
| 74LS221 | 1.10 |
| 74LS240 | .95 |
| 74LS241 | .95 |
| 74LS244 | .85 |
| 74LS245 | 1.65 |
| 74LS248 | 1.00 |
| 74LS249 | .90 |
| 74LS251 | 1.20 |
| 74LS253 | .80 |
| 74LS257 | .80 |
| 74LS258 | .80 |
| 74LS259 | 1.25 |
| 74LS260 | .60 |
| 74LS273 | 1.50 |
| 74LS275 | 3.00 |
| 74LS279 | .50 |
| 74LS283 | .75 |
| 74LS373 | .90 |
| 74LS374 | 1.50 |
| 74LS377 | 1.40 |

7400 SERIES

| | | | |
|---|---|---|---|
| 7400 | 18 | 7454 | 19 |
| 7402 | 18 | 7470 | 30 |
| 7404 | 18 | 7472 | 25 |
| 7406 | 21 | 7474 | 30 |
| 7408 | 23 | 7475 | 40 |
| 7409 | 18 | 7476 | 30 |
| 7410 | 18 | 7480 | 55 |
| 7411 | 22 | 7481 | 1 00 |
| 7412 | 28 | 7489 | 3 [illegible] |
| 7413 | 32 | 7490 | 30 |
| 7414 | 45 | 7491 | 35 |
| 7416 | 24 | 7492 | 45 |
| 7417 | 24 | 7494 | 60 |
| 7420 | 18 | 7495 | 50 |
| 7421 | 30 | 74100 | 90 |
| 7425 | 25 | 74107 | 25 |
| 7427 | 25 | 74122 | 40 |
| 7430 | 18 | 74125 | 40 |
| 7432 | 25 | 74144 | 2 50 |
| 7438 | 25 | 74145 | 50 |
| 7440 | 18 | 74148 | 1 00 |
| 7442 | 45 | 74154 | 1 00 |
| 7443 | 60 | 74157 | 45 |
| 7444 | 60 | 74160 | 60 |
| 7445 | 60 | 74161 | 80 |
| 7447 | 60 | 74166 | 90 |
| 7448 | 60 | 74174 | 80 |
| 7450 | 18 | 74181 | 1 [illegible] |
| 7451 | 18 | 74393 | 1.00 |
| 7453 | 19 | | |

74S SERIES

| | |
|---|---|
| 74S00 | 35 |
| 74S02 | [illegible] |
| 74S03 | [illegible] |
| 74S04 | 45 |
| 74S05 | [illegible] |
| 74S08 | [illegible] |
| 74S10 | [illegible] |
| 74S15 | [illegible] |
| 74S20 | [illegible] |
| 74S22 | 75 |
| 74S30 | 35 |
| 74S37 | [illegible] |
| 74S51 | [illegible] |
| 74S65 | [illegible] |
| 74S74 | [illegible] |
| 74S85 | 2 00 |
| 74S86 | 1 10 |
| 74S112 | 1 45 |
| 74S132 | 1 10 |
| 74S138 | 95 |
| 74S140 | [illegible] |
| 74S158 | 1 25 |
| 74S174 | 95 |
| 74S175 | 95 |
| 74S181 | 4 00 |
| 74S182 | [illegible] |
| 74S188 | 3 50 |
| 74S240 | 3 50 |
| 74S244 | 3 50 |
| 74S471 | 9 50 |
| 74S472 | 15 00 |

STATIC RAMS

| | | |
|---|---|---|
| 2111 | 2 85 | 8/2 50ea |
| 2112 | 2 85 | 8/2 50ea |
| 2114 | 2 00 | 8/14 00 |
| 2114L 200NS | 2 25 | 4/2 00ea |
| HM6116 150NS | 8 25 | |

DYNAMIC RAMS

| | | |
|---|---|---|
| 4027 | 2 00 | 8/1 75ea |
| 4116 200ns | 1 50 | |
| 4164 200ns | 7.95 | |

MISC

| | |
|---|---|
| 8T26 | 1 20 |
| 8T28 | 1 20 |
| 8038 | 2 75 |
| 8080A | 3 75 |
| 8155 | 10 50 |
| 8255 | 4 50 |
| MC1330 | 1 45 |
| MC1350 | 1 10 |
| MC1358 | 1 35 |
| MC1458 | 55 |
| LM380 | 1 10 |
| LM386 | 1 40 |
| LM565 | 95 |
| LM741 | 25 |
| LM1310 | 2 90 |

EPROMS

| | | |
|---|---|---|
| 1702 | 4 25 | 8/3 95 ea |
| 2708 | 3 25 | 8/2 99 ea |
| 2716(5V) | 3 95 | 8/3 65 ea |
| TMS2716 | 8 95 | 8/8 00 ea |
| 2732(5V) | 8 95 | 8/7 75 ea |
| TMS2532 | 11 50 | 8/10 25ea |

VOLTAGE REGULATORS

7805
7806
7808
7812
[illegible] .85
7905
[illegible]
7912
7918

MORE MISC

| | |
|---|---|
| 8212 | 1 95 |
| 8216 | 1 80 |
| 1103A | 95 |
| N82S185 | 8 95 |
| AY5 1013A | 3 00 |
| 1488 | 95 |
| 1489 | 95 |
| MC6802 | 9 95 |
| MC6821P | 4 95 |
| MC6850P | 3 25 |

CPU S

| | |
|---|---|
| Z80 | 8 50 |
| Z80A | 6 00 |
| Z80A PIO | 6 00 |
| 6502 | 6 80 |
| 6502A | 12 00 |
| 8085A | 8 50 |
| MC6800 | 7 75 |

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*Two asynchronous serial RS-232C I/O ports, one parallel printer I/O port, real time clock-calender, includes software*

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*15 MHz bandwith with 700 lines/inch, P31 green phosphor, switchable 40 or 80 columns, small, light-weight & portable.*

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VDM-65092 *Deluxe 9"* ____ $179.95

### 12" COLOR MONITORS - Taxan
*18 MHz high resolution RGB color monitors fully compatible with Apple II and IBM PC, unlimited colors available.*

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VDA-821200 *RGB card for Apple II* ____ $99.95

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*Reasonably priced color video monitors.*

VDC-80130 *13" Color I* ____ $379.95
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### SUPERQUAD - Adv. Micro Digital
*Single board, standard size S-100 computer system, 4 MHz Z-80A, single or double density disk controller for 5¼" or 8" drives. 64K RAM, extended addressing, up to 4K of EPROM, 2 serial & 2 parallel I/O ports, real time interrupt clock, CP/M compatible.*

CPC-30800A *A & T* ____ $724.95

## Sub-Systems

### Disk Sub-Systems - Jade
*Handsome metal cabinet with proportionally balanced air flow system, rugged dual drive power supply, power cable kit, power switch, line cord, fuse holder, cooling fan, never-mar rubber feet, all necessary hardware to mount 2-8" disk drives, power supply, and fan, does not include signal cable.*

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END-000420 *Bare cabinet* ____ $49.95
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END-000434 *A & T w/2 SA-801* ____ $1195.00

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END-000834 *A & T w/2 TM848-* ____ $1179.95

## 5¼" Disk Drives

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MSM-551001 ____ $219.95 ea 2 for **$199.95 ea**

***Shugart SA400L*** *single-sided double-density 40 track*
MSM-104000 ____ $234.95 ea 2 for **$224.95 ea**

***Shugart SA455*** *half-size double-sided 48 TPI*
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MSM-104650 ____ $399.95 ea 2 for **$379.95 ea**

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MSM-551002 ____ $294.95 ea 2 for **$269.95 ea**

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MSM-104500 ____ $349.95 ea 2 for **$329.95 ea**

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MSM-551003 ____ $294.95 ea 2 for **$269.95 ea**

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## S-100 EPROM Boards

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*2708, 2716 EPROM board with on-board programmer.*

MEM-99510K *Kit with manual* ____ $154.95
MEM-99510A *A & T with manu* ____ $219.95

### PROM-100 - SD Systems
*2708, 2716, 2732 EPROM programmer with software.*

MEM-99520K *Kit with software* ____ $189.95
____ $249.95

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### STARMICRONICS GEMENI
*High speed dot matrix printers with all the features of the higher-priced best-selling machines for a lot less money!!! **100 CPS**, 9 x 9 dot matrix with true lower case descenders, high-resolution bit image and block graphics, superscript & subscript, underlining, backspacing, double strike and emphasized print modes, proportional space font, friction feed, tractor feed, and roll paper, 5, 6, 8½, 10, 12, & 17 pitch, programable line spacing, **FREE 2.3K buffer**, Epson pin and plug compatible, user replaceable print head. extended 6 month factory warranty.*

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### HIGH-SPEED, HIGH QUALITY - Okidata
***Microline 82A*** *80/132 column, **120 CPS**, 9 x 9 dot matrix, friction feed, pin feed, adjustable tractor feed (optional), handles 4 part forms up to 9.5" wide, rear & bottom feed, paper tear bar, 100% duty cycle/200,000,000 character print head, bi-directional/logic seeking, **both serial & parallel interfaces included**, front panel switch & program control of 10 different form lengths, uses inexpensive spool type ribbons, double width & condensed characters, true lower case descenders & graphics*

PRM-43082 *with FREE tractor* ____ CALL

***Microline 83A*** *132/232 column, 120 CPS, forms up to 15" wide, removable tractor, plus all the features of the 82A.*

PRM-43083 *with FREE tractor* ____ CALL

***Microline 84*** *132/232 column, Hi-speed 200 CPS, full dot graphics built in, plus all the features of the 83A.*

PRM-43084 *Centronics parallel* ____ CALL
PRM-43085 *Serial with 2K buffer* ____ CALL

IOP-2100A *Apple card and cable* ____ $69.95
PRA-27087 *TRS-80 cable* ____ $24.95
PRA-43081 *2K hi speed serial card* ____ $149.95
PRA-43082 *Hi-res graphics ROMs* ____ $49.95
PRA-43083 *Hi-graphics ROMs 83A* ____ $49.95
PRA-43088 *Tractor option for 82A* ____ $49.95

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### ULTRA-VIOLET EPROM ERASERS
*Inexpensive erasers for industry or home.*

XME-3100A *Spectronics w/o timer* ____ $69.50
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XME-3200A *Economy model* ____ $49.95

## Quality

### LETTER QUALITY PRINTER - COMREX
*Uses standard daisy wheels and ribbon cartridges, 16 CPS bi-directional printing, semi-automatic paper loader (single sheet or fan fold), 10/12/15 pitch, up to 16" paper, built-in noise suppression cover.*

PRD-11001 *Centronics parallel* ____ $899.95
PRD-11002 *RS-232C serial model* ____ $969.95
PRA-11000 *Tractor Option* ____ $119.95

### STARWRITER F-10 - C. Itoh
*New 40 CPS daisy wheel printer with full 15" carriage, uses standard Diablo print wheels and ribbons, both parallel and serial interfaces included.*

PRD-22010 *Starwriter F-10* ____ $1495.95

## S-100 MotherBoards

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*Silent, simple, and on sale - a better motherboard*

***6 Slot (5¼" x 8⅝")***

MBS-061B *Bare board* ____ $22.95
MBS-061K *Kit* ____ $39.95
MBS-061A *A &* ____ $69.95

MBS-121B *Bare board* ____ $34.95
MBS-121K *Kit* ____ $69.95
MBS-121A *A & T* ____ $109.95

***18 Slot (14½" x 8⅝")***

MBS-181B *Bare board* ____ $54.95
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## APPLE II ACCESSORIES

### APPLE DISK DRIVE - Apple Compatible

*Totally Apple compatible, 143,360 bytes per drive on DOS 3.3, full one year factory warranty, half-track capability reads all Apple software, plugs right into Apple controller as second drive, DOS 3.3, 3.2.1, Pascal, & CP/M compatible.*

**MSM-123200** *Add-on Apple Drive* ______ **$269.95**
**MSM-123100** *Controller* ______ **$99.95**

### 16K RAM CARD - for Apple II

*Expand your Apple II to 64K, use as language card, full 1 year warranty. Why spend $175.00 ?*

**MEX-16700A** *Save over $115.00* ______ **$59.95**

### Z-CARD for Apple II - A.L.S.

*Two computers in one, Z-80 & 6502, more than doubles the power and potential of your Apple, includes Z-80 CPU card CP/M 2.2 and complete manual set, Pascal compatible, utilities are menu-driven, one year warranty.*

**CPX-62800A** *A & T with CP/M 2.2* ______ **$159.95**

### SMARTERM II - A.L.S.

*80 column x 24 line video card for Apple II, addressable 25th status line, normal/inverse or high/low video, 128 ASCII characters, upper and lower case, 7 x 9 dot matrix with true descenders, standard Data Media terminal control codes, CP/M Pascal & Fortran compatible, 50/60 Hz, 40/80 column selection from keyboard.*

**IOV-2500A** *ALS Smarterm II* ______ **$169.95**

### SERIAL I/O CARD - A.L.S.

*Full feature serial card for modems & printers, baud rates from 110 to 19,200, CTC/RTS & X-on/X-off protocols, auto line feed, RS-232C cable interface included.*

**IOI-1000A** *A & T "Dispatcher Card"* ______ **$129.95**

### CP/M 3.0 CARD for APPLE - A.L.S.

**The most powerful card availability for your Apple!**
*6 MHz, Z-80B, additional 64K of RAM, CP/M plus 3.0, 100% CP/M 2.2 compatibility, C basic, CP/M Graphics, 3005 faster than any other CP/M for Apple. One year warranty.*

**CPX-82810A** *A.L.S. CP/M Card* ______ **$349.95**

### 2 MEGABYTES for Apple II

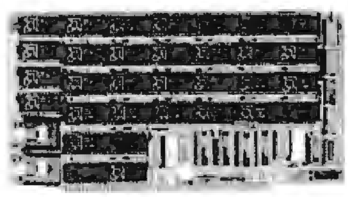
*Complete package includes: Two 8" double-density disk drives, Vista double-density 8" disk controller, cabinet, power supply, & cables, DOS 3.2/3.3, CP/M 2.2, & Pascal compatible.*

**1 MegaByte Package** *Kit* ______ **$1495.00**
**1 MegaByte Package** *A & T* ______ **$1695.00**
**2 MegaByte Package** *Kit* ______ **$1795.00**
**2 MegaByte Package** *A & T* ______ **$1995.95**

### MODEM CARD FOR APPLE - SSM

***Better than Hayes!! Better than Novation!!*** *Direct connect ModemCard plugs directly into Apple - no external components, auto-dial, auto-answer, Bell 103 compatible, full and half duplex, touch-tone or pulse dialing generated on board, Micromodem II software compatible, displays modem information on screen, audio monitoring of phone line, no serial port required, two year factory warranty,* ***FREE Source Subsription*** *with purchase of Transend software.*

**IOM-2430A** *ModemCard* ______ **$289.95**
**SFA-55770010M** *Transend 1 w/Source* ______ **$79.95**
**SFA-55770010M** *Transend 2 w/Source* ______ **$129.95**
**SFA-55770030M** *Transend 3 w/Source* ______ **$239.95**



## S-100 MEMORY BOARDS

### 64K STATIC RAM - Jade

*Uses new 2K x 8 static RAMs, fully supports IEEE 696 24 bit extended addressing, 200ns RAMs, lower 32K or entire board phantomable, 2716 EPROMs may be subbed for RAMs, any 2K segment of upper 8K may be disabled, low power typically less than 500ma.*

**MEM-99152B** *Bare board* ______ **$49.95**
**MEM-99152K** *Kit less RAM* ______ **$99.95**
**MEM-32152K** *32K kit* ______ **$199.95**
**MEM-56152K** *56K kit* ______ **$289.95**
**MEM-64152K** *64K kit* ______ **$299.95**
**Assembled & Tested** ______ **add $50.00**

### 256 RAMDISK - SD Systems

*ExpandoRAM III expandable from 64K to 256K using 64KX1 RAM chips, compatible with CP/M, MP/M, Oasis, & most other Z-80 based systems, functions as ultra-high speed disk drive when used with optional RAMDISK software.*

**MEM-65064A** *64K A & T* ______ **$474.95**
**MEM-65128A** *128K A & T* ______ **$574.95**
**MEM-65192A** *192K A & T* ______ **$674.95**
**MEM-65256A** *256K A & T* ______ **$774.95**
**SFC-55009000F** *RAMDISK sftwr CP/M 2.2* ______ **$44.95**
**SFC-55009000F** *RAMDISK with EXRAM III* - **$24.95**

### 64K RAM BOARD - C.C.S.

*IEEE S-100, supports front panels, bank select, fail-sale refresh 4MHz, extended addressing, list price $575.00 - less than half price!!!*

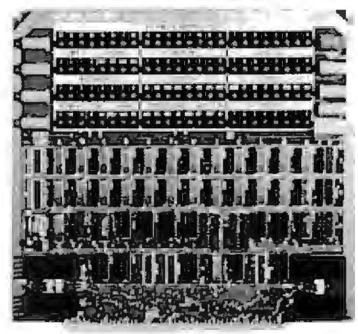
**MEM-64565A** ______ **$199.95**

## S-100 VIDEO BOARDS

### MICROANGELO - Scion

*Ultra-high-resolution 512 x 480, 256color or black & white S-100 video board*

**IOV-1500A** *A & T* ______ **$799.95**



## S-100 I/O BOARDS

### THE BUS PROBE - Jade

***Inexpensive S-100 Diagnostic Analyzer***

*So your computer is down. And you don't have an oscilloscope. And you don't have a front panel... You're not alone - most computers have their occasional bad days. But without diagnostic equipment such as an oscilloscope (expensive!) or a front panel (expensive!), it can be very difficult to pinpoint the problem. Even if you have an extender board with a superfast logic probe, you can't see more than one signal at a time. You're stuck, right?*

*Not anymore: Jade is proud to offer our cost-effective solution to the problems mentioned above:* ***THE BUS PROBE.***

*Whether you're a hobbyist with a cantankerous kluge or a field technician with an anxious computer owner breathing down your neck, you'll find THE BUS PROBE speeds your repair time remarkably. Just plug in THE BUS PROBE and you'll be able to see all the IEEE S-100 signals in action. THE BUS PROBE allows you to see inputs, outputs, memory reads and writes, instruction fetches, DMA channels vectored interrupts, 8 or 16 bit wide data transfers, plus the three bus supply voltages.*

**TSX-200B** *Bare board* ______ **$59.95**
**TSX-200K** *Kit* ______ **129.95**
**TSX-200A** *A & T* ______ **$159.95**

### I/O-4 - SSM Microcomputer

*2 serial I/O ports plus 2 parallel I/O ports.*

**IOI-1010B** *Bare board w/manual* ______ **$35.95**
**IOI-1010K** *Kit with Manual* ______ **$179.95**
**IOI-1010A** *A & T* ______ **$249.95**

### I/O-5 - SSM Microcomputer

*Two serial & 3 parallel I/O ports, 110-19.2K Baud*

**IOI-1015A** *A & T* ______ **$289.95**

### INTERFACER 4 - CompuPro

*3 serial, 1 parallel, 1 Centronics parallel.*

**IOI-1840A** *A & T* ______ **$314.95**
**IOI-1840C** *CSC* ______ **$414.95**

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Circle 230 on inquiry card.

# LOWER PRICES !!!

## S-100 CPU BOARDS

### SBC-200 - SD Systems

*4 MHz Z-80A CPU with serial & parallel I/O, 1K RAM, 8K ROM space, monitor PROM included.*

**CPC-30200A** *A & T* — **$329.95**

### THE BIG Z - Jade

*2 or 4 MHz switchable Z-80 CPU board with serial I/O, accomodates 2708, 2716, or 2732 EPROM, baud rates from 75 to 9600.*

**CPU-30201B** *Bare board w/manual* — **$35.00**
**CPU-30201K** *Kit with Manual* — **$149.95**
**CPU-30201A** *A & T with Manual* — **$199.95**

### 2810 Z-80 CPU - C.C.S.

*2 or 4 MHz Z-80 CPU with serial I/O port & on board monitor PROM, front panel compatible.*

**CPU-30400A** *A & T with PROM* — **$289.95**

### CPU-Z - CompuPro

*2/4 MHz Z80A CPU, 24 bit addressing.*

**CPU-30500A** *2/4 MHz A & T* — **$279.95**
**CPU-30500C** *3/6 MHz CSC* — **$374.95**

### 8085/8088 - CompuPro

*Both 8 & 16 bit CPUs, standard 8 bit S-100 bus, up to 8 MHz, accesses 16 Megabytes of memory.*

**CPU-20510A** *6 MHz A & T* — **$398.95**
**CPU-20510C** *6/8 MHz CSC* — **$497.95**

## DRIVES

Siemens FDD ... ied double-density
**MSF-201120** — $274.95 ea 2 for $249.95 ea

***Shugart SA810*** *half-size single-sided double-density*
**MSF-108100** — $424.95 ea 2 for $394.95 ea

***Shugart SA860*** *half-size double-sided double-density*
**MSF-108600** — $574.95 ea 2 for $549.95 ea

***Shugart SA801R*** *single-sided double-density*
**MSF-10801R** — $394.95 ea 2 for $389.95 ea

***Shugart SA851R*** *double-sided double-density*
**MSF-10851R** — $554.95 ea 2 for $529.95 ea

***Tandon TM848-1*** *single-sided double-den thin-line*
**MSF-558481** — $379.95 ea 2 for $369.95 ea

***Tandon TM848-2*** *double-sided double-den thin-line*
**MSF-558482** — $494.95 ea 2 for $484.95 ea

***Qume DT-8*** *double-sided double-density*
**MSF-750080** — $524.95 ea 2 for $498.95 ea

## MODEMS

### SMART BUY In MODEMS - Signalman

*1200 and/or 300 baud, direct connect, automatic answer or orginate selection, auto-answer/auto-dial on deluxe models, IBM model plugs directly into an IBM option slot and does not require a serial port (a $300.00 savings!), 9v battery allows total portability, full one year warranty.*

**IOM-5600A** *300 baud direct connect* — *$69.95*
**IOM-5610A** *300 baud Deluxe* — *$149.95*
**IOM-5620A** *1200/300 baud Deluxe* — *$369.95*
**IOM-5630A** *300 baud for IBM PC* — *$269.95*
**IOM-5640A** *300 baud for TI 99/4* — *$119.95*
**IOM-5650A** *300 baud for Osborne* — *$119.95*
**IOM-5660A** *300 baud Atari 850* — *$99.95*
**IOM-5670A** *300 baud PET/CBM* — *$169.95*

### 1200 BAUD SMARTMODEM - Hayes

*1200 and 300 baud, all the features of the standard Smartmodem plus 1200 baud, 212 compatible, full or half duplex.*

**IOM-5500A** *Smartmodem 1200* — **$599.95**

### SMARTMODEM - Hayes

*Sophisticated direct-connect auto-answer/auto-dial modem, touch-tone or pulse dialing, RS-232C interface, programmable*

**IOM-5400A** *Smartmodem* — **$224.95**
**IOK-1500A** *Hayes Chronograph* — **$218.95**
**IOM-2010A** *Micromodem II w/Te* — **$329.95**
**IOM-2012A** *Terminal program fo* — **$89.95**
**IOM-1100A** *Micromodem 100* — **$368.95**

### 1200 BAUD SMART CAT - Novaton

*103/212 Smart Cat & 103 Smart Cat, 1200 & 300baud, built-in dialer, auto re-dial if busy, auto answer/disconnect, direct connect, LED readout displays mode, analog/digital loop-back self tests, usable with multi-line phones.*

**IOM-5241A** *300 baud 103 Smart Cat* — **$229.95**
**IOM-5251A** *1200 baud 212/103 Smart Cat* — **$549.95**
**IOM-5261A** *300 baud 103 J-Cat* — **$129.95**

### J-CAT™ MODEM - Novation

*1/5 the size of ordinary modems, Bell 103, manual or auto-answer, automatic answer/originate, direct conect, built-in self-test, two LED's and audio "beeps" provide complete status information.*

**IOM-5261A** *Novation* — **$149.95**

## S-100 CONTROLLERS

### DISK 1 - CompuPro

*8" or 5¼" DMA disk controller, single or double density, single or double sided, 10 MHz.*

**IOD-1810A** *A & T* — **$449.95**
**IOD-1810C** *CSC* — **$554.95**

### VERSAFLOPPY II - SD Systems

*Double density disk controller for any combination of 5¼" and 8" single or double sided, analog phase-locked loop data separator, vectored interrupts, CP/M 2.2 & Oasis compatible, control/diagnostic software PROM included.*

**IOD-1160A** *A & T with PROM* — **$359.95**
**SFC-55009047F** *CP/M 3.0 witt* — **$99.95**

### 2242 DISK CONTROLLER - C.C.S.

*5¼" or 8" double density disk controller with on-board boot loader ROM, free CP/M 2.2 & manual set.*

**IOD-1300A** *A & T with CP/M 2.2* — **$399.95**

### DOUBLE D - Jade

*High reliablity double density disk controller with on-board Z-80A, auxiliary printer port, IEEE S-100, can function in multi-user interrupt driven bus.*

**IOD-1200B** *Bare board & hdwr man* — **$59.95**
**IOD-1200K** *Kit w/hdwr & sftwr man* — **$299.95**
**IOD-1200A** *A & T w/hdwr & sftwr man* — **$325.95**
**SFC-59002001f** *CP/M 2.2 with Double D* — **$99.95**

## NEW! CP/M PLUS 3.0

*CP/M 3.0 is Digital Research's latest version of the industry standard disk operating system. It features many performance improvements such as intelligent record buffering, improved directory handling, "HELP" facility, time/date stamping of files and many more improvements. AND A TREMENDOUS INCREASE IN SPEED !!!, it is fully CP/M 2.2 compatible and requires no changes to your existing application software. Available only to Versafloppy II owners with SBC-200 CPU's*

- ***CP/M 2.2 compatible***
- ***Easily customized***
- ***Easier to learn and use***
- ***High performance file system***
- ***Automatic disk log-in of removable media***
- ***Support for 1 to 16 banks of RAM***
- ***Supports up to 16 drives of 512 Megabytes each***
- ***Up to ten times faster than CP/M 2.2***
- ***Console I/O re-direction***
- ***Easy to use system utilities with HELP facility***
- ***Power batch facility***
- ***Designed for application programmers***
- ***Resident system extensions***

**SFC-55009057F** *CP/M 3.0 8" with manuals* — **$200.00**
**SFC-55009057M** *CP/M 3.0 Manual* — **$30.00**

THREE BOARD SET — SD Systems

# FREE CP/M 3.0

## Save $800.00

*S-100 board set with 4 MHz Z-80A, 64K of RAM expandable to 256K, serial and parallel I/O ports, double-density disk controller for 5¼" and 8" disk drives, new and improved CP/M 3.0 manual set, system monitor, control and diagnostic software. Includes SD Systems SBC-200, 64K ExpandoRAM III, Versafloppy II, and FREE CP/M 3.0 - all boards are assembled & tested.*

*** 64K Board Set with FREE CP/M 3.0** — **$1195.00**
**256K Board Set with FREE CP/M 3.0** — **$1395.00**

**LIMITED QUANTITY**

Circle 230 on inquiry card.

# JADE

# *Computer Products*

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# DoKay Computer Products, Inc.

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## EPROMS

| | | |
|---|---|---|
| 1702 | Ins | 2.95 |
| 2708 | 450ns | 2.98 |
| 2758 | 5V450ns | 9.70 |
| TMS 2516 | 5V450ns | 5.70 |
| 2716 | 5V450ns | 3.44 |
| 2716-1 | 5V 350ns | 5.70 |
| TMS 2716 | 450ns | 8.70 |
| 2532 | 5V450ns | 7.80 |
| 2732 | 5V450ns | 4.15 |
| 2764 | 5V450ns | 12.95 |
| MC68764 | 5V450ns (24pin) | 39.00 |

## DYNAMIC RAMS

| | | |
|---|---|---|
| TMS 4027 | 250 | 1.99 |
| MK 4108 | 200ns | 1.74 |
| MM 5298 | 250ns | 1.74 |
| 4116 | 150ns | 1.74 |
| 4116 | 200ns | 1.24 |
| 4116 | 250ns | 1.14 |
| 2118 | 5V 150ns | 4.90 |
| MK 4816 | 5V300ns | 5.25 |
| 4164-200 | 5V 200ns | 5.45 |
| 4164-150 | 5V150ns | 6.35 |

## STATIC RAMS

| | | | |
|---|---|---|---|
| 2101 | 450ns | | 1.80 |
| 2101-1 | 450ns | | .78 |
| 2101L-2 | 250ns | LP | 1.54 |
| 2112 | 450ns | | 2.48 |
| 2112 | 450ns | | 2.68 |
| 2114 | 450ns | | 1.74 |
| 2114 L-3 | 300ns | LP | 1.84 |
| 2114 L-2 | 200ns | LP | 1.94 |
| 2147 | 55ns | | 8.90 |
| TMS 4044-4 | 450ns | | 3.15 |
| TMS 4044-3 | 300ns | | 3.45 |
| TMS 4044-2 | 200ns | | 3.90 |
| MK 4118 | 250ns | | 9.70 |
| TMM2016 | 200ns | | 4.15 |
| TMM2016 | 150ns | | 5.44 |
| TMM2016 | 100ns | | 7.44 |
| HM6116-4 | 200ns | | 4.90 |
| HM6616-3 | 150ns | | 5.75 |
| HM6116-2 | 120ns | | 6.95 |
| Z-6132 | 300ns | | 32.95 |

LP = Low Power

# 16K APPLE* II RAM CARD

| | |
|---|---|
| BARE BOARD | 14.00 |
| KIT | |
| ASSEMBLED | 42.50 |

*Apple is a trademark of Apple Computer, Inc.

## INTERFACE

| | |
|---|---|
| 8T26 | 1.65 |
| 8T28 | 1.95 |
| 8T95 | .95 |
| 8T96 | .95 |
| 8T97 | .95 |
| 8T98 | .95 |
| DM8131 | 2.90 |
| DP8304 | 2.25 |
| DS8836 | 1.25 |

## RESISTORS

1/4 WATT 5% CARBON FILM
ALL STANDARD VALUES
FROM 1 OHM TO 10 MEG OHM

| | |
|---|---|
| 50 PCS. SAME VALUE | .0200 |
| 100 PCS. SAME VALUE | .0150 |
| 1000 PCS. SAME VALUE | .0125 |

## We Will Beat Any Competitors' Prices!

## 6500

| | |
|---|---|
| **1 MHZ** | |
| 6502 | |
| 6504 | 5.44 |
| 6505 | 6.85 |
| 6507 | 7.60 |
| 6520 | 9.85 |
| 6522 | 4.30 |
| 6532 | 7.90 |
| 6545 | 9.90 |
| 6551 | 16.95 |
| **2 MHZ** | |
| 6502A | 9.95 |
| 6522A | 10.90 |
| 6532A | 11.90 |
| 6545A | 27.90 |
| 6551A | 11.90 |
| **3 MHZ** | |
| 6502B | 11.90 |

## 74LS

| | | | | | |
|---|---|---|---|---|---|
| 74LS00 | .23 | 74LS123 | .94 | 74LS253 | .58 |
| 74LS01 | .23 | 74LS124 | 2.89 | 74LS257 | .58 |
| 74LS02 | .23 | 74LS125 | .94 | 74LS258 | .78 |
| 74LS03 | .23 | 74LS126 | .78 | 74LS259 | 2.74 |
| 74LS04 | .23 | 74LS132 | .74 | 74LS260 | .59 |
| 74LS05 | .23 | 74LS136 | .48 | 74LS266 | .48 |
| 74LS08 | 23 | 74LS137 | .94 | 74LS273 | 1.48 |
| 74LS10 | .23 | 74LS138 | .74 | 74LS275 | 3.20 |
| 74LS11 | .29 | 74LS139 | .74 | 74LS279 | .48 |
| 74LS12 | .29 | 74LS145 | 1.09 | 74LS280 | 1.94 |
| 74LS13 | .39 | 74LS147 | 2.19 | 74LS283 | .94 |
| 74LS14 | .58 | 74LS148 | 1.19 | 74LS290 | .88 |
| 74LS15 | .29 | 74LS151 | .54 | 74LS293 | .88 |
| 74LS20 | .23 | 74LS153 | .54 | 74LS295 | .98 |
| 74LS21 | .29 | 74LS154 | 1.74 | 74LS298 | .88 |
| 74LS22 | .23 | 74LS155 | .68 | 74LS324 | 1.74 |
| 74LS26 | .29 | 74LS156 | .68 | 74LS352 | 1.28 |
| 74LS27 | .24 | 74LS157 | .64 | 74LS353 | 1.28 |
| 74LS28 | .29 | 74LS158 | .58 | 74LS363 | 1.34 |
| 74LS30 | .24 | 74LS160 | .68 | 74LS364 | 1.94 |
| 74LS32 | .28 | 74LS161 | .64 | 74LS365 | .48 |
| 74LS33 | .54 | 74LS162 | .68 | 74LS366 | .48 |
| 74LS37 | .54 | 74LS163 | .68 | 74LS367 | .44 |
| 74LS38 | .34 | 74LS164 | .68 | 74LS368 | .44 |
| 74LS40 | .24 | 74LS165 | .68 | 74LS373 | .98 |
| 74LS42 | .48 | 74LS166 | 1.94 | 74LS374 | .98 |
| 74LS47 | .74 | 74LS168 | 1.68 | 74LS377 | 1.39 |
| 74LS48 | .74 | 74LS169 | 1.68 | 74LS378 | 1.14 |
| 74LS49 | .74 | 74LS170 | 1.68 | 74LS379 | 1.34 |
| 74LS51 | .24 | 74LS173 | .68 | 74LS385 | 1.88 |
| 74LS54 | .24 | 74LS174 | .54 | 74LS386 | .44 |
| 74LS55 | .28 | 74LS175 | .88 | 74LS390 | 1.18 |
| 74LS63 | 1.19 | 74LS181 | 1.48 | 74LS393 | 1.18 |
| 74LS73 | .35 | 74LS189 | 8.90 | 74LS395 | 1.18 |
| 74LS74 | 38. | 74LS190 | .78 | 74LS399 | 1.58 |
| 74LS75 | .38 | 74LS191 | .88 | 74LS424 | 2.88 |
| 74LS76 | .38 | 74LS192 | .68 | 74LS447 | .36 |
| 74LS78 | .48 | 74LS193 | .68 | 74LS490 | 1.88 |
| 74LS83 | .59 | 74LS194 | .88 | 74LS668 | 1.64 |
| 74LS85 | .95 | 74LS195 | .74 | 74LS669 | 1.84 |
| 74LS86 | .38 | 74LS196 | .78 | 74LS670 | 1.48 |
| 74LS90 | .54 | 74LS197 | .78 | 74LS674 | 9.45 |
| 74LS91 | .74 | 74LS221 | 1.09 | 74LS682 | 2.98 |
| 74LS92 | .54. | 74LS240 | .94 | 74LS683 | 2.38 |
| 74LS93 | .54 | 74LS241 | .94 | 74LS684 | 2.38 |
| 74LS95 | .74 | 74LS242 | .64 | 74LS685 | 2.38 |
| 74LS96 | .78 | 74LS243 | .64 | 74LS688 | 2.38 |
| 74LS107 | .38 | 74LS244 | .89 | 74LS689 | 2.38 |
| 74LS109 | .38 | 74LS245 | 1.88 | | |
| 74LS112 | .38 | 74LS247 | .74 | 81LS95 | 1.48 |
| 74LS113 | .38 | 74LS248 | 1.19 | 81LS96 | 1.48 |
| 74LS114 | .38 | 74LS249 | .88 | 81LS97 | 1.48 |
| 74LS122 | .44 | 74LS251 | .58 | 81LS98 | 1.48 |

## UARTS

| | |
|---|---|
| AY3 1014 | 5.80 |
| AY5 1013 | 3.90 |
| AY5 2376 | 10.90 |
| TR 1602 | 3.85 |
| IM 6402 | 7.80 |
| IM 6403 | 8.80 |

## LEDS

| | |
|---|---|
| Jumbo Red | 10/1.00 |
| Jumbo Green | 6/1.00 |
| Jumbo Yellow | 6/1.00 |

## DIP SWITCHES

| | |
|---|---|
| | .84 |
| 4 Position | .94 |
| 5 Position | 1.98 |
| 6 Position | 2.74 |
| 7 Position | 2.48 |
| 8 Position | 1.24 |

## EXAR

| | |
|---|---|
| XR 2206 | 3.70 |
| XR 2207 | 3.70 |
| XR 2208 | 3.85 |
| XR 2211 | 5.20 |
| XR 2240 | 3.20 |

## RCA

| | |
|---|---|
| CA 3010 | |
| CA 3013 | 94 |
| CA 3023 | 1.98 |
| CA 3035 | 2.74 |
| CA 3039 | 2.48 |
| CA 3046 | 1.24 |
| CA 3053 | 1.45 |
| CA 3059 | 2.89 |
| CA 3060 | 2.89 |
| CA 3065 | 1.74 |
| CA 3080 | 1.09 |
| CA 3081 | 1.64 |
| CA 3082 | 1.64 |
| CA 3083 | 1.64 |
| CA 3086 | .80 |
| CA 3089 | 2.89 |
| CA 3130 | 1.24 |
| CA 3140 | 1.14 |
| CA 3146 | 1.74 |
| CA 3160 | 1.14 |
| CA 3401 | .58 |
| CA 3600 | 3.40 |

## CMOS

| | | | | | |
|---|---|---|---|---|---|
| 4000 | .24 | 4066 | .89 | 74C89 | 4.45 |
| 4001 | .29 | 4093 | .90 | 74C90 | 1.74 |
| 4002 | .24 | 4098 | 2.48 | 74C93 | .98 |
| 4006 | .89 | 4099 | 1.89 | 74C95 | .88 |
| 4007 | .24 | 4502 | .89 | 74C107 | 5.70 |
| 4008 | .89 | 4503 | .59 | 74C150 | 2.25 |
| 4009 | .44 | 4508 | 1.89 | 74C151 | 3.25 |
| 4010 | .44 | 4510 | .84 | 74C154 | 1.75 |
| 4011 | .29 | 4511 | .84 | 74C157 | 1.18 |
| 4012 | .24 | 4512 | .84 | 74C160 | 1.18 |
| 4013 | .38 | 4514 | 1.19 | 74C161 | 1.99 |
| 4014 | .78 | 4515 | 1.78 | 74C162 | 1.18 |
| 4015 | .38 | 4516 | 1.49 | 74C163 | 1.38 |
| 4016 | .38 | 4518 | .89 | 74C164 | 1.99 |
| 4017 | .68 | 4519 | .38 | 74C165 | .78 |
| 4018 | .78 | 4520 | .78 | 74C173 | 1.18 |
| 4019 | .38 | 4522 | 1.19 | 74C174 | 1.18 |
| 4020 | .74 | 4526 | 1.19 | 74C175 | 1.48 |
| 4021 | .78 | 4527 | 1.89 | 74C192 | 1.48 |
| 4022 | .78 | 4528 | 1.19 | 74C193 | 1.38 |
| 4023 | .34 | 4531 | .89 | 74C195 | 5.70 |
| 4024 | .74 | 4532 | 1.89 | 74C200 | 1.74 |
| 4025 | .34 | 4538 | 1.89 | 74C221 | 2.44 |
| 4026 | .59 | 4539 | 1.89 | 74C373 | 2.74 |
| 4027 | .44 | 4543 | 1.19 | 74C374 | .38 |
| 4028 | .68 | 4555 | .89 | 74C901 | .84 |
| 4029 | .78 | 4556 | .89 | 74C902 | .84 |
| 4030 | .38 | 4581 | 1.18 | 74C903 | 10.90 |
| 4034 | 1.94 | 4582 | 1.90 | 74C905 | .94 |
| 4035 | .84 | 4584 | .74 | 74C906 | .99 |
| 4040 | .73 | 4585 | | 74C907 | 1.99 |
| 4041 | .74 | | | 74C908 | 2.74 |
| 4042 | .68 | 80C07 | .89 | 74C909 | 9.90 |
| 4043 | .74 | 80C95 | .89 | 74C910 | 8.90 |
| 4044 | .74 | 80C96 | .89 | 74C911 | 8.90 |
| 4046 | .84 | 80C97 | .89 | 74C912 | 1.94 |
| 4047 | .89 | 80C98 | 1.14 | 74C914 | 1.18 |
| 4049 | .34 | | | 74C915 | 2.74 |
| 4050 | .34 | 74C00 | | 74C918 | 15.95 |
| 4051 | .78 | 74C02 | .34 | 74C920 | 15.95 |
| 4053 | .78 | 74C04 | .34 | 74C921 | 4.45 |
| 4060 | .88 | 74C08 | .34 | 74C922 | 4.90 |
| 4066 | .38 | 74C10 | .34 | 74C923 | 5.90 |
| 4068 | .39 | 74C14 | .58 | 74C925 | 7.90 |
| 4069 | .28 | 74C20 | .34 | 74C926 | 7.90 |
| 4070 | .35 | 74C30 | .34 | 74C927 | 7.90 |
| 4071 | .29 | 74C32 | .49 | 74C928 | 16.95 |
| 4072 | .29 | 74C42 | 1.28 | 74C929 | |
| 4073 | .29 | 74C48 | 1.19 | 74C930 | |
| 4075 | .29 | 74C73 | .64 | | |
| 4076 | .78 | 74C74 | .64 | 14409 | 12.85 |
| 4078 | .28 | 74C76 | .79 | 14410 | 12.85 |
| 4081 | .89 | 74C83 | 1.94 | 14411 | 11.85 |
| 4082 | | 74C85 | 1.94 | 14412 | 12.85 |
| 4085 | | 74C86 | .38 | 14419 | 4.85 |

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| LM323K | 3.75 | LM1414 | 1.49 |
| LM324 | .59 | LM1458 | .55 |
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|---|---|
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| 6800 | 4.75 |
| 6802 | 8.65 |
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| 6809 | 11.95 |
| 6809 E | 17.95 |
| 6810 | 2.90 |
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| 6828 | 14.90 |
| 6840 | 7.95 |
| 6843 | 32.95 |
| 6844 | 32.95 |
| 6845 | 16.90 |
| 6847 | 11.95 |
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| 6883 | 22.95 |
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| 9334 | 2.39 |
| 9368 | 3.69 |
| 9401 | 8.95 |
| 9601 | .69 |
| 9602 | 1.39 |
| 96S02 | 1.79 |

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| 3242 | 6.95 |
| MC 3470 | 7.95 |
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| ULN 2003 | 5.95 |
| CA 3146 | 1.75 |
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| 2.0 | 3.90 | 8.0 | 3.00 |
| 2.097152 | 3.90 | 10.0 | 3.00 |
| 2.4576 | 3.90 | 14.31818 | 3.90 |
| 3.2768 | 3.90 | 18.0 | 3.00 |
| 3.579545 | 3.00 | 18.432 | 3.00 |
| 4.0 | 3.00 | 20.0 | 3.00 |
| 5.0 | 3.00 | 22.1184 | 3.00 |
| 5.0688 | 3.90 | 32.0 | 3.90 |

## IC Sockets

| | ST | W/W |
|---|---|---|
| 8 PIN | .10 | .49 |
| 14 PIN | .12 | .50 |
| 16 PIN | .15 | .57 |
| 18 PIN | .20 | .85 |
| 20 PIN | .25 | .99 |
| 22 PIN | .25 | 1.30 |
| 24 PIN | .25 | 1.40 |
| 28 PIN | .35 | 1.50 |
| 40 PIN | .40 | 1.80 |

ST = Soldertail
W/W = Wirewrap

## VOLTAGE REGULATORS

| | | | |
|---|---|---|---|
| 7805T | .75 | 7908T | .85 |
| 7808T | .75 | 7912T | .85 |
| 7812T | .75 | 7915T | .85 |
| 7815T | .75 | 7924T | .95 |
| 7824T | .85 | | |
| 7805K | 1.29 | 7905K | 1.39 |
| 7812K | 1.29 | 7912K | 1.39 |
| 7815K | 1.29 | 7915K | 1.39 |
| 7824K | 1.29 | 7924K | 1.39 |
| 7905T | .85 | | |

T = TO-220
K = TO-3

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| 8035 | 6.95 | 8239 | 4.75 |
| 8039 | 7.59 | 8243 | 4.75 |
| 8080A | 3.90 | 8250 | 14.90 |
| 8085A | 7.95 | 8251 | 4.50 |
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| 8155 | 7.75 | 8253-5 | 9.75 |
| 8156 | 8.75 | 8255 | 4.50 |
| 8185 | 29.00 | 8255-5 | 5.20 |
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| 8748 | 14.95 | 8259 | 6.85 |
| 8755 | 29.95 | 8272 | 39.00 |
| 8202 | 27.95 | 8275 | 29.00 |
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| 8214 | 3.75 | 8282 | 6.50 |
| 8216 | 1.75 | 8283 | 6.50 |
| 8224 | 2.45 | 8284 | 5.50 |
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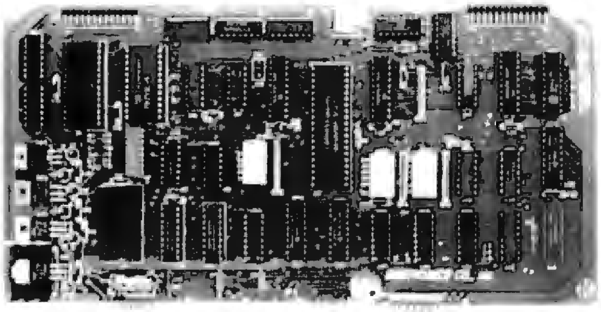
Circle 154 on inquiry card.



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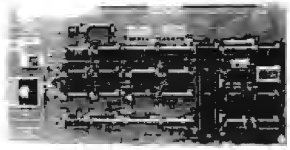

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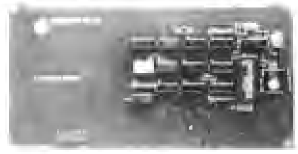

S-100 IEEE
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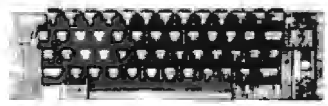

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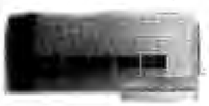
## SUNTRONICS PROTOTYPE BOARDS



**APPLE Prototype Board.** Double sided glass with gold plated Apple and General Purpose terminals. Containsmatrix of 17 x 63 solderplateddonuts on .15 x .1 spacing. Great for 14, 16, 24 pin IC s.
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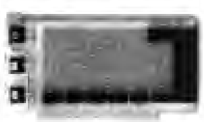

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## General Purpose Experimental Prototype Boards
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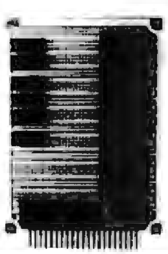

15/30 pin, 3⅛ x 4½ board w/.1 x.2 hole spacing and power strip run every 1.2 . Allows 6x7 8pin IC s or 2x3 24pin IC s
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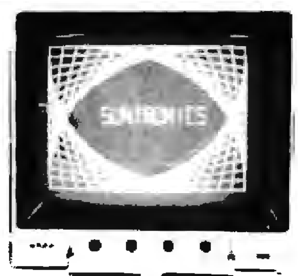
SAMWOO
# MONITORS

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# FULL SIZE KEYBOARD CONVERSION

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Introductory Priced At **$69.95**

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**SUN KD-81**

# EASY TO INSTALL

- **No Soldering**
- **No Modifications**

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KD-81 Features:

- Full Size Keyboard with 41 Keys
- Full Size Space Bar
- Allows Touch Typing
- Keyboard Case Holds Both Keyboard and Computer
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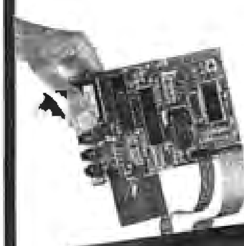
- Easy Assembly
- Two Color Imprinted Key Tops for Easy Reading
- Key Tops have Commands and Graphics Spelled Out for Easy Programming
- Measures 10¾" x 7¼" x 2⅛"

Check out these simple instal-lation steps!



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3. Plug the 2 ribbon cables into the connectors on the KD-81 keyboard.
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| 21L02-2 | 1.49 | 4044 | 3.99 | 6605 | 7.99 |
| 21L02-4 | 1.29 | 4050 | 4.69 | 9130 | 8.99 |
| 2111 | 3.49 | 4060 | 4.69 | 9140 | 8.99 |
| 2112 | 3.49 | 4096 | 3.99 | 93415 | 6.99 |
| 2114 | 1.99 | 4115 | 1.49 | 93425 | 6.99 |
| 2114L-2 | 3.25 | 4200 | 7.95 | | |
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| 2125 | 6.99 | 5280 | 4.60 | | |

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| 8205 | 2.69 | 6810 | 4.75 | 6520 | 6.95 |
| 8212 | 2.75 | 6820 | 6.50 | 6522 | 9.95 |
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| 8216 | 2.75 | 6828 | 10.50 | 6532 | 17.95 |
| 8224 | 2.95 | 6834 | 16.95 | 6551 | 19.95 |
| 8226 | 2.95 | 6845 | 22.95 | Z80-PIO | 6.50 |
| 8228 | 3.95 | 6847 | 22.95 | Z80A-PIO | 9.50 |
| 8243 | 9.50 | 6850 | 5.25 | Z80-CTC | 6.50 |
| 8250 | 14.95 | 6852 | 5.25 | Z80A-CTC | 9.50 |
| 8251 | 8.50 | 6860 | 10.95 | Z80-DMA | 19.95 |
| 8253 | 11.95 | 6862 | 10.95 | Z80A-DMA | 27.95 |
| 8255 | 4.50 | 6875 | 5.95 | Z80-SIO | 24.95 |
| 8257 | 9.50 | 6880 | 2.49 | Z80A-SIO | 29.95 |

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|---|---|---|---|
| 2764 (8Kx8) TS | $69.95 | 2708 (450nS) | $5.75 |
| 2732 (4Kx8) TS | 12.95 | 2708 (650nS) | 5.25 |
| 2716/2516; 5V (2Kx8) TS | 7.95 | 1702A | 5.75 |
| TMS2716, 5V, 12V | 17.95 | MM5203AQ | 14.50 |
| 2758, 5V, (450nS) | 3.50 | MM5204Q | 8.95 |

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|---|---|---|---|
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| 2513-005(5V) Lower | 10.95 | DAC100 | 9.95 |
| 2513-ADM3 (5V) Lower | 14.95 | 8038 Function Generator | 4.50 |
| MCM66710 ASCII Shifted | 12.95 | MC4024VCO | 2.95 |
| MCM66740 Math Symbol | 13.95 | LM566VCO | 1.95 |
| MCM66750 Alpha Control | 13.45 | XR2206 Function Generator | 5.25 |
| 1771-01 8" & Minifloppy | 24.95 | TR1602B(5V,12V) | 3.95 |
| 1781 Dual Floppy | 29.95 | AY51013 (5V, 12V) | 4.95 |
| 1791-01 Dual Floppy | 36.95 | AY51014A/1612 (5-14V) | 6.95 |
| 1791-02 Dual Floppy | 44.95 | AY51015A/1863 (5V) | 6.95 |
| 1793 DD,DS Floppy | 44.95 | IM6402 | 7.95 |
| 1797 DD,DS Floppy | 54.95 | IM6403 | 8.95 |
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| 2143 Clock Generator | 18.95 | 1671B Astros | 24.95 |
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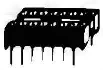
| 8701 10 bit Binary | 22.00 | 4702 | 14.95 |
| 8703 8 bit TS | 13.50 | WD1941 | 9.95 |
| 9400 Volt to Freq Conv. | 7.25 | COM5016 | 16.95 |
| 8750 3½ Digit BCD | 13.95 | INS8250 | 15.95 |
| 1408L6 6 bit | 3.95 | AY5-2376 | 13.75 |
| 1408L8 8 bit | 5.95 | AY5-3600 | 13.75 |
| DAC01 D to A | 5.95 | MM5740AAC | 8.95 |

## SOCKETS



### LOW PROFILE SOCKETS (TIN)

| | 1-24 | 25-49 | 50-100 |
|---|---|---|---|
| 8 pin LP | .16 | .15 | .14 |
| 14 pin LP | .20 | .19 | .18 |
| 16 pin LP | .22 | .21 | .20 |
| 18 pin LP | .29 | .28 | .27 |
| 20 pin LP | .34 | .32 | .30 |
| 22 pin LP | .29 | .27 | .24 |
| 24 pin LP | .38 | .37 | .36 |
| 28 pin LP | .45 | .44 | .43 |
| 40 pin LP | .60 | .59 | .58 |

### 3L WIREWRAP SOCKETS (GOLD)

| | 1-24 | 25-49 | 50-100 |
|---|---|---|---|
| 8 pin WW | .55 | .54 | .49 |
| 10 pin WW (Tin) | .65 | .63 | .58 |
| 14 pin WW | .75 | .73 | .67 |
| 16 pin WW | .80 | .77 | .70 |
| 18 pin WW | .95 | .90 | .81 |
| 20 pin WW | 1.15 | 1.08 | .99 |
| 22 pin WW | 1.45 | 1.35 | 1.23 |
| 24 pin WW | 1.35 | 1.26 | 1.14 |
| 28 pin WW | 1.60 | 1.53 | 1.38 |
| 40 pin WW | 2.20 | 2.09 | 1.89 |

## LINEAR

| | | | |
|---|---|---|---|
| 78H05K | $5.95 | LM1414N | $1.90 |
| 78M06 | 1.49 | LM1458CN/N | .49 |
| 78M.G. | 1.49 | MC1488N | .99 |
| LM108AH | 2.95 | MC1489N | .99 |
| LM300H | .99 | LM1496N | .89 |
| LM301CN | .35 | LM1556N | 1.50 |
| LM304H | 1.98 | LM1820N | .95 |
| LM305H | 1.89 | LM1850N | .95 |
| LM306H | 3.25 | LM1889N | 3.10 |
| LM307CN | .29 | LM2111N | 1.75 |
| LM308CN | .98 | LM2900N | .99 |
| LM309K | 1.49 | LM2901N | 2.50 |
| LM310CN | 1.25 | LM2917N | 2.95 |
| LM311D/CN | .89 | CA3013T | 2.19 |
| LM312H | 1.75 | CA3018T | 1.99 |
| LM317T | 1.70 | CA3021T | 3.49 |
| LM318CN | 1.49 | CA3023T | 2.99 |
| LM319N/H | 1.25 | CA3035T | 2.75 |
| LM320K-XX* | 1.35 | CA3039T | 1.29 |
| LM320T-XX* | 1.39 | CA3046N | 1.29 |
| LM320H-XX* | 1.25 | LM3053N | 1.49 |
| LM323K | 4.95 | CA3059N | 3.19 |
| LM324N | .95 | CA3060N | 3.19 |
| LM337K | 5.95 | CA3062N | 4.95 |
| LM338K | 6.95 | LM3065N | 1.49 |
| LM339N | .95 | CA3080T | 1.29 |
| LM340K-XX* | 1.75 | CA3081N | 1.69 |
| LM340T-XX* | 1.25 | CA3082N | 1.69 |
| LM340H-XX* | 1.25 | CA3083N | 1.55 |
| LM344H | 1.95 | CA3086N | .80 |
| LM348N | 1.20 | CA3089N | 2.99 |
| LM350K | 5.60 | CA3096N | 3.49 |
| LM358CN | .98 | CA3097N | 1.99 |
| LM360N | 1.49 | CA3130T | 1.30 |
| LM372N | 1.95 | CA3140T | 1.19 |
| LM376N | 3.75 | CA3146N | 2.49 |
| LM377N | 2.75 | CA3160T | 1.19 |
| LM380CN/N | 1.25 | CA3190N | 1.95 |
| LM381N | 1.79 | CA3410N | .59 |
| LM383T | 1.95 | MC3423N | 1.49 |
| LM386N | 1.25 | MC3480N | 3.95 |
| LM387N | 1.40 | SG3524N | 3.95 |
| LM390N | 1.95 | CA3600N | 3.39 |
| NE531V/T | 3.75 | LM3900N | .59 |
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| NE556N | .98 | LM3909N | .98 |
| NE561T | 19.95 | LM3914N | 3.75 |
| NE565N/H | 1.25 | LM3915N | 3.95 |
| NE566H/V | 1.75 | LM3916N | 3.75 |
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| NE592N | 2.75 | RC4136N | 1.10 |
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| LM709N/H | .29 | RC4194TK | 4.95 |
| LM710N/H | .75 | RC4195TK | 5.40 |
| LM711N/H | .39 | ULN2001 | 1.25 |
| LM715N | 1.95 | ULN2003 | 1.50 |
| LM723N/H | .65 | SN75450N | .59 |
| LM733N/H | .98 | SN75451N | .35 |
| LM739N | 1.15 | SN75452N | .49 |
| LM741CN/H | .33 | SN75453N | .49 |
| LM741CN-14 | .19 | SN75454N | .49 |
| LM747N/H | .75 | SN75491N | .89 |
| LM748N/H | .39 | SN75492N | .89 |
| LM760CN | 2.95 | SN75493N | .89 |
| LM1310N | 1.90 | SN75494N | .89 |
| MC1330 | 1.95 | TL494CN | 4.20 |
| MC1350 | 1.95 | TL496CP | 1.65 |
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|---|---|---|---|---|---|
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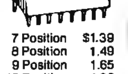
| 74S03 | .45 | 74S134 | .66 | 74S253 | 1.35 |
| 74S04 | .52 | 74S135 | 1.15 | 74S257 | 1.29 |
| 74S05 | .52 | 74S136 | 1.69 | 74S258 | 1.29 |
| 74S08 | .49 | 74S138 | 1.29 | 74S260 | .75 |
| 74S09 | .49 | 74S139 | 1.29 | 74S280 | 2.79 |
| 74S10 | .42 | 74S140 | .73 | 74S287 | 2.99 |
| 74S11 | .42 | 74S151 | 1.29 | 74S288 | 2.55 |
| 74S15 | .42 | 74S153 | 1.29 | 74S373 | 3.10 |
| 74S20 | .42 | 74S157 | 1.29 | 74S374 | 3.10 |
| 74S22 | .42 | 74S158 | 1.29 | 74S387 | 2.75 |
| 74S30 | .42 | 74S160 | 2.79 | 74S471 | 7.95 |
| 74S32 | .49 | 74S174 | 1.49 | 74S472 | 7.95 |
| 74S38 | 1.19 | 74S175 | 1.49 | 74S473 | 7.95 |
| 74S40 | .49 | 74S188 | 2.69 | 74S474 | 9.95 |
| 74S51 | .42 | 74S194 | 1.89 | 74S475 | 9.95 |
| 74S64 | .46 | 74S195 | 1.89 | 74S570 | 5.75 |
| 74S65 | .46 | 74S196 | 1.69 | 74S571 | 5.75 |
| 74S74 | .69 | 74S240 | 2.75 | 74S572 | 8.95 |
| 74S86 | .72 | 74S241 | 2.75 | 74S573 | 8.95 |
| 74S112 | .72 | 74S242 | 2.99 | 74S940 | 2.90 |
| 74S113 | .72 | 74S243 | 2.99 | 74S941 | 2.90 |
| 74S114 | .72 | | | | |

## DIP SWITCHES



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| 2 Position | $ .99 | 7 Position | $1.39 |
| 4 Position | 1.19 | 8 Position | 1.49 |
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| 7402 | .22 | 7479 | 4.60 | 74163 | .87 |
| 7403 | .22 | 7480 | .49 | 74164 | .87 |
| 7404 | .22 | 7482 | .95 | 74165 | .87 |
| 7405 | .23 | 7483 | .55 | 74166 | 1.20 |
| 7406 | .35 | 7485 | .65 | 74167 | 1.95 |
| 7407 | .35 | 7486 | .35 | 74170 | 1.69 |
| 7408 | .26 | 7489 | 1.75 | 74172 | 4.75 |
| 7409 | .23 | 7490 | .39 | 74173 | .79 |
| 7410 | .22 | 7491 | .57 | 74174 | .89 |
| 7411 | .29 | 7492 | .45 | 74175 | .85 |
| 7412 | .29 | 7493 | .45 | 74176 | .75 |
| 7413 | .39 | 7494 | .69 | 74177 | .75 |
| 7414 | .59 | 7495 | .65 | 74179 | 1.34 |
| 7416 | .29 | 7496 | .69 | 74180 | .75 |
| 7417 | .29 | 7497 | 2.90 | 74181 | 1.75 |
| 7420 | .22 | 74100 | 2.90 | 74182 | .75 |
| 7421 | .35 | 74107 | .32 | 74184 | 2.25 |
| 7422 | .29 | 74109 | .37 | 74185 | 2.25 |
| 7423 | .29 | 74116 | 1.95 | 74186 | 9.95 |
| 7425 | .29 | 74121 | .29 | 74188 | 3.90 |
| 7426 | .29 | 74122 | .39 | 74190 | 1.15 |
| 7427 | .25 | 74123 | .59 | 74191 | 1.15 |
| 7429 | .45 | 74125 | .39 | 74192 | .65 |
| 7430 | .23 | 74126 | .44 | 74193 | .85 |
| 7432 | .29 | 74128 | .59 | 74194 | .85 |
| 7437 | .25 | 74132 | .69 | 74195 | .66 |
| 7438 | .29 | 74136 | .75 | 74196 | .85 |
| 7439 | .29 | 74139 | .95 | 74197 | .85 |
| 7440 | .19 | 74141 | .79 | 74198 | 1.39 |
| 7441 | .79 | 74142 | 2.95 | 74199 | 1.39 |
| 7442 | .57 | 74143 | 2.95 | 74221 | 1.19 |
| 7443 | .95 | 74144 | 2.95 | 74251 | .95 |
| 7444 | .95 | 74145 | .62 | 74273 | 1.05 |
| 7445 | .79 | 74147 | 1.95 | 74276 | 1.89 |
| 7446 | .79 | 74148 | 1.20 | 74279 | .75 |
| 7447 | .65 | 74150 | 1.09 | 74283 | 1.40 |
| 7448 | .79 | 74151 | .67 | 74284 | 3.90 |
| 7450 | .19 | 74152 | .67 | 74285 | 3.90 |
| 7451 | .19 | 74153 | .67 | 74290 | 1.25 |
| 7453 | .19 | 74154 | 1.19 | 74298 | .95 |
| 7454 | .19 | 74155 | .78 | 74365 | .68 |
| 7459 | .25 | 74156 | .78 | 74366 | .68 |
| 7460 | .23 | 74157 | .69 | 74367 | .68 |
| 7470 | .29 | 74158 | 1.85 | 74368 | .68 |
| 7472 | .29 | 74159 | 2.49 | 74390 | 1.45 |
| 7473 | .34 | 74160 | .86 | 74393 | 1.90 |
| 7474 | .34 | | | 74490 | 1.90 |

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|---|---|---|---|---|---|
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| 74LS02 | .28 | 74LS122 | .55 | 74LS248 | 1.10 |
| 74LS03 | .28 | 74LS123 | 1.19 | 74LS249 | 1.19 |
| 74LS04 | .35 | 74LS124 | 1.35 | 74LS251 | 1.40 |
| 74LS05 | .28 | 74LS125 | .89 | 74LS253 | 1.40 |
| 74LS08 | .28 | 74LS126 | .52 | 74LS257 | .85 |
| 74LS09 | .35 | 74LS132 | .79 | 74LS258 | .98 |
| 74LS10 | .28 | 74LS136 | .49 | 74LS259 | 2.95 |
| 74LS11 | .39 | 74LS138 | .85 | 74LS260 | .65 |
| 74LS12 | .33 | 74LS139 | .85 | 74LS261 | 2.49 |
| 74LS13 | .47 | 74LS145 | 1.25 | 74LS266 | .59 |
| 74LS14 | .95 | 74LS148 | 1.49 | 74LS273 | 1.75 |
| 74LS15 | .33 | 74LS151 | .79 | 74LS275 | 4.40 |
| 74LS20 | .26 | 74LS153 | .79 | 74LS279 | .59 |
| 74LS21 | .33 | 74LS154 | 1.70 | 74LS283 | .99 |
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| 74LS26 | .33 | 74LS156 | .99 | 74LS293 | .99 |
| 74LS27 | .33 | 74LS157 | .85 | 74LS295 | 1.10 |
| 74LS28 | .33 | 74LS158 | .75 | 74LS296 | 1.19 |
| 74LS30 | .26 | 74LS160 | 1.05 | 74LS324 | 1.75 |
| 74LS32 | .33 | 74LS161 | 1.15 | 74LS347 | 1.95 |
| 74LS33 | .55 | 74LS162 | 1.05 | 74LS348 | 1.95 |
| 74LS37 | .45 | 74LS163 | 1.05 | 74LS352 | 1.19 |
| 74LS38 | .39 | 74LS164 | 1.19 | 74LS353 | 1.19 |
| 74LS40 | .26 | 74LS166 | .89 | 74LS363 | 1.49 |
| 74LS42 | .79 | 74LS166 | 2.48 | 74LS365 | .69 |
| 74LS47 | .79 | 74LS168 | 1.15 | 74LS366 | .69 |
| 74LS48 | .95 | 74LS169 | 1.15 | 74LS367 | .69 |
| 74LS51 | .26 | 74LS170 | 1.99 | 74LS368 | .69 |
| 74LS54 | .29 | 74LS173 | .89 | 74LS373 | 1.89 |
| 74LS55 | .29 | 74LS174 | .89 | 74LS374 | 1.89 |
| 74LS73 | .45 | 74LS175 | .89 | 74LS375 | .69 |
| 74LS74 | .42 | 74LS181 | 2.20 | 74LS377 | 1.95 |
| 74LS75 | .59 | 74LS190 | 1.15 | 74LS385 | 1.95 |
| 74LS76 | .45 | 74LS191 | 1.15 | 74LS386 | .65 |
| 74LS78 | .45 | 74LS192 | .98 | 74LS390 | 1.95 |
| 74LS83A | .79 | 74LS193 | .98 | 74LS393 | 1.95 |
| 74LS85 | 1.19 | 74LS194 | 1.15 | 74LS395 | 1.70 |
| 74LS86 | .45 | 74LS195 | .95 | 74LS399 | 2.35 |
| 74LS90 | .57 | 74LS196 | .89 | 74LS424 | 2.95 |
| 74LS92 | .75 | 74LS197 | .89 | 74LS668 | 1.75 |
| 74LS93 | .75 | 74LS221 | 1.15 | 74LS670 | 2.29 |
| 74LS95 | .88 | 74LS240 | 1.69 | 81LS95 | 1.69 |
| 74LS96 | .98 | 74LS242 | 1.69 | 81LS96 | 1.69 |
| 74LS107 | .45 | 74LS243 | 1.89 | 81LS97 | 1.69 |
| 74LS109 | .45 | 74LS244 | 1.49 | 81LS98 | 1.69 |
| 74LS112 | .43 | | | | |

VOLUME PRICING CALL TOLL FREE

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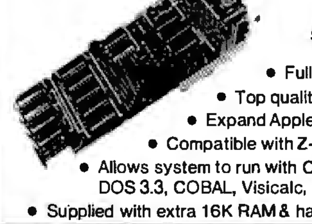
| 4002 | .35 | 4041 | 1.25 | 4094 | 2.95 |
| 4006 | 1.05 | 4042 | .95 | 4098 | 2.29 |
| 4007 | .25 | 4043 | .85 | 4099 | 2.25 |
| 4008 | 1.39 | 4044 | .85 | 14408 | 12.95 |
| 4009 | .45 | 4046 | 1.75 | 14409 | 12.95 |
| 4010 | .45 | 4047 | 1.25 | 14410 | 12.95 |
| 4011 | .35 | 4048 | .99 | 14412 | 12.95 |
| 4012 | .25 | 4049 | .45 | 14415 | 8.95 |
| 4013 | .45 | 4050 | .69 | 14419 | 4.95 |
| 4014 | 1.39 | 4051 | 1.10 | 4501 | .39 |
| 4015 | 1.15 | 4052 | 1.10 | 4502 | 1.65 |
| 4016 | .59 | 4053 | 1.10 | 4503 | .69 |
| 4017 | 1.19 | 4055 | 3.95 | 4505 | 8.95 |
| 4018 | .89 | 4056 | 2.95 | 4506 | .75 |
| 4019 | .45 | 4059 | 9.25 | 4507 | .95 |
| 4020 | 1.10 | 4060 | 1.39 | 4508 | 3.75 |
| 4021 | 1.19 | 4066 | .75 | 4510 | 1.19 |
| 4022 | 1.15 | 4069 | .35 | 4511 | 1.19 |
| 4023 | .29 | 4070 | .49 | 4512 | 1.39 |
| 4024 | .75 | 4071 | .35 | 4515 | 2.75 |
| 4025 | .25 | 4072 | .35 | 4516 | 1.45 |
| 4027 | .85 | 4073 | .35 | 4518 | 1.39 |
| 4028 | .85 | 4075 | .35 | 4520 | 1.25 |
| 4029 | 1.29 | 4076 | 1.29 | 4555 | 4.95 |
| 4030 | .45 | 4077 | .35 | 4556 | .99 |
| 4031 | 3.25 | 4078 | .35 | 4566 | 2.25 |
| 4032 | 2.15 | 4081 | .35 | 80C95 | 1.50 |
| 4034 | 3.25 | 4082 | .35 | 80C97 | 1.25 |
| 4035 | .95 | 4085 | 1.95 | | |

## 16K Apple™ Ramcard

LIST 195
ACP
$59.95



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- Allows system to run with CP/M™, PASCAL, DOS 3.3, COBAL, Visicalc, etc.
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2 or 4 MHz Expandable Uses 2114L's

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|---|---|
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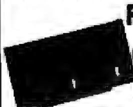
| • 32K 4 MHz A&T | • 339.00 |
| BARE BOARD | 39.95 |
| Bare Bdw/all parts less mem. | 99.95 |

## 64K CMOS RAMCARD



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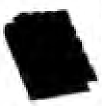

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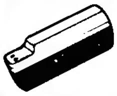

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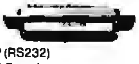
## CONNECTORS



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| DB25S Female | 3.75 |
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| Set with Hood, Sale | 7.50 |
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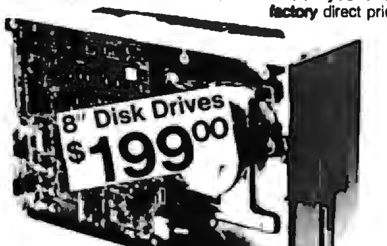


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| Telephone Receptionist adapt | 995 | 875 |
| PS3276/Bisyn Emulator | 1295 | 1150 |
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| 200 Baud Direct Modum | 349 | 299 |
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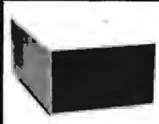

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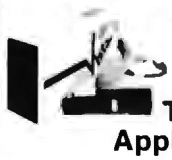

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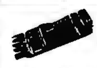
## 16K RAM CARD



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**MEMOREX**
**VERBATIM**

### Single Side Double Density

| | Soft Sector | 10 Sector | 16 Sector | |
|---|---|---|---|---|
| SCOTCH | 744D-0 | 744D-10 | 744D-16 | 26.50 |
| MEMOREX | 3481 | 3483 | 3485 | 26.50 |
| VERBATIM | 525-01 | 525-10 | NA | 26.50 |
| MAXELL | M01 | MH1-10 | MH1-16 | 29.85 |
| DYSAN | 104/1D | 107/1D | NA | 45.00 |

### Double Side Double Density

| | | | | |
|---|---|---|---|---|
| SCOTCH | 745-0 | 745-10 | 745-16 | 42.50 |
| VERBATIM | 550-01 | 550-10 | NA | 42.50 |
| MAXELL | MD2-D | MH2-10D | MH2-16D | 45.00 |
| DYSAN | 104/2D | 107/2D | NA | 49.50 |
| DYSAN 96 | 204/2D | NA | NA | 59.50 |

### EIGHT INCH DISKETTES

| Single Side Single Density | | |
|---|---|---|
| SCOTCH | 740-0 | 29.50 |
| MEMOREX | 3060 | 29.50 |
| DYSAN | 3740/1 | 39.50 |

| Thirty Two Sector | | |
|---|---|---|
| SCOTCH | 740-32 | 29.50 |

| Single Side Double Density | | |
|---|---|---|
| SCOTCH | 741-0 | 39.00 |
| MEMOREX | 3090 | 35.00 |
| DYSAN | 3740/D | 57.50 |

| Double side Double Density | | |
|---|---|---|
| SCOTCH | 743-0 | 47.50 |
| MEMOREX | 3114 | 39.50 |
| DYSAN | 3740/2D | 65.00 |

**Microswitch ASCII KEYBOARD $79**

**Each keyboard contains 81 high reliability Hall Effect keys. Outputs seven bit parallel ASCII    MIC-81SD5  3 Lbs.**

**HITEK KEYBOARD $24.95**

This Hitek keyboard is the same unit used by Lear Siegler in their middle line CRT terminals. The keyboard features 58 unencoded metal on metal contacts (HIK-58). Matching numeric cluster with 15 keys is available for $9.95 (HIK-15). Buy both of these units for only $29.90 and save $5.00 (HIK-5815)

# MEMORY

| 16K DYNAMIC | 2732 EPROM |
|---|---|
| **1.95** | **4.95** |
| 4116 150ns. | 450ns. |
| **64K DYNAMIC** | **16K STATIC** |
| **6.95** | **4.95** |
| 4164 150ns. | 6116 200ns. |

## 2764 EPROM SALE $9.95

### DYNAMIC MEMORY

| | | 1-31 | 32+ | 100+ |
|---|---|---|---|---|
| 4027 4K dynamic 250ns | ICM-4027250 | 1.99 | 1.85 | 1.75 |
| 4116 150ns. 16K | ICM-4116150 | 1.95 | 1.85 | 1.75 |
| 4116 200ns. 16K | ICM-4116200 | 1.75 | 1.65 | 1.50 |
| 4164 150ns. 64K 128 refresh | ICM-4164150 | 6.95 | 6.50 | 5.90 |
| 41256 150ns. 256K | ICM-41256150 | Available March83 | | |

### STATIC MEMORY

| | | | | |
|---|---|---|---|---|
| 21L02 200ns. 1K static | ICM-21L02200 | 1.49 | 1.29 | 1.15 |
| 21L02 450ns. 1K static | ICM-21L02450 | 1.29 | 1.15 | .99 |
| 2112 450ns. 2K static | ICM-2112450 | 2.99 | 2.65 | 2.75 |
| 2114 300ns. 1K x 4 | ICM-2114300 | 1.95 | 1.85 | 1.75 |
| 4044 TMS-150ns. 4K x 1 | ICM-4044450 | 3.49 | 3.25 | 2.99 |
| 5257 300ns. 4K x 1 | ICM-5257300 | 2.50 | 2.25 | 1.99 |
| 6116 P4 200ns. 2K x 8 | ICM-6116200 | 4.95 | 4.80 | 4.65 |
| 6116 P3 150ns. 2K x 8 | ICM-6116150 | 5.95 | 5.75 | 5.60 |
| 6167/2167 100ns. 16K x 1 (20pin) | ICM-6167100 | 8.95 | 8.50 | 7.90 |

### EPROMS

| | | | | |
|---|---|---|---|---|
| 2708 450ns. 1K x 8 | ICE-2708 | 4.95 | 4.75 | 4.55 |
| 2716 450ns. 2K x 8 | ICE-2716 | 4.95 | 4.75 | 4.55 |
| 2716TMS 450ns. Tri-voltage | ICE-2716TMS | 7.95 | 7.65 | 7.25 |
| 2732 450ns. 4K x 8 | ICE-2732 | 4.95 | 4.75 | 4.55 |
| 2732 350ns. 4K x 8 | ICE-2732350 | 8.50 | 8.00 | 7.60 |
| 2532 450ns. 4K x 8 | ICE-2532 | 10.50 | 9.90 | 9.50 |
| 2764 350ns. 8K x 8 | ICE-2764 | 10.95 | 10.50 | 9.95 |
| 27128 350ns. 16K x 8 | ICE-27128 | Available March83 | | |

# CONNECTORS

**S-100 Gold $2.95**

**DB25P $2.50**

GOLD EDGE CONNECTORS

| | each | 10+ |
|---|---|---|
| S-100 .125" centers | | |
| Imsai solder .250" row | $2.95 | $2.50 |
| Imsai wire wrap (TI) | 3.95 | 3.30 |
| Sullins Hi-Rel. .250" | 4.50 | 4.00 |
| Sullins Hi-Rel. W/W | 5.35 | 4.90 |
| Sullins / Altair .140" | 4.95 | 4.50 |
| .156" Centers (standard) | | |
| 22/44 Kim Eyelet | 3.50 | 3.15 |
| 36/72 Digital Group S/T | 5.95 | 5.50 |
| 36/72 Digital Group W/W | 6.60 | 6.15 |
| 43/86 Motorola 6800 S/T | 6.00 | 5.45 |
| 43/86 Moto. 6800 W/W | 7.00 | 6.80 |

| "D" Type | each | 10-24 | 25+ |
|---|---|---|---|
| DE9P male | $1.60 | $1.40 | $1.30 |
| DE9S female | 2.25 | 2.00 | 1.90 |
| DE hood | 1.50 | 1.35 | 1.20 |
| DA15P male | 2.35 | 2.15 | 2.00 |
| DA15S female | 3.25 | 3.10 | 2.90 |
| DA hood 2/P | 1.60 | 1.35 | 1.30 |
| DB25P male | 2.50 | 2.35 | 2.25 |
| DB25S female | 3.35 | 3.15 | 3.05 |
| DB hood 2/P | 1.35 | 1.15 | 1.05 |
| DC37P male | 4.20 | 4.00 | 3.70 |
| DC37S female | 6.00 | 5.75 | 5.50 |
| DC hood 2/P | 2.25 | 2.00 | 1.75 |
| DD50P male | 5.50 | 5.10 | 4.75 |
| DD50S female | 9.40 | 8.80 | 8.00 |
| DD50 hood 2/P | 2.60 | 2.40 | 2.10 |

INTEGRATED CIRCUIT SOCKETS

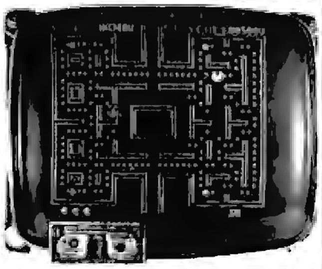
| | Low Profile each | Low Profile 100+ | Wire Wrap each | Wire Wrap 100+ |
|---|---|---|---|---|
| 8 pin | $.10 | $.09 | $.46 | $.41 |
| 14 pin | .10 | .09 | .45 | .41 |
| 16 pin | .12 | .11 | .50 | .45 |
| 18 pin | .15 | .13 | .68 | .61 |
| 24 pin | .26 | .24 | .94 | .87 |
| 40 pin | .42 | .40 | 1.60 | 1.47 |

| CENTRONICS | | | |
|---|---|---|---|
| 57-30360 | 7.95 | 6.75 | 5.75 |

| RIBBON CABLE CONNECTORS | | | |
|---|---|---|---|
| 17/34 5" disk | 4.85 | 4.15 | 3.95 |
| 20/40 TRS-80 | 5.65 | 5.05 | 4.70 |
| 25/50 8" disk | 5.90 | 5.35 | 4.90 |

## 23" COMPOSITE MONITOR $159

Ideal monitor for classroom demonstrations.



Ever try gathering a classroom of students around a 12" monitor? Here is your opportunity to purchase a 23" high resolution monitor at a reasonable price.
These units accept standard composite video signals generated by most personal computers including the Apple and IBM. Attach it your computer and in second you are shooting down Klingons in wide screen video.
MOT-BV23 35 Lbs. Monitors are open frame and for safety should be enclosed. Wood grained enclosure for above $35.00 additional CAL-ENC23 15 Lbs.

### Eight Inch Single Sided

| | One | Two | Ten |
|---|---|---|---|
| SHUGART SA801R | $395 | 385 | 375 |
| SIEMENS FDD100-8 | 259 | 259 | 225 |
| TANDON 848-1 SLIMLINE | 379 | 369 | 359 |
| **Eight Inch Double Sided** | | | |
| SHUGART SA851R | 525 | 495 | 475 |
| QUME DATA TRACK 8 | 525 | 495 | 475 |
| MITSUBISHI M2894-63 | 485 | 475 | 469 |
| OLIVETTI 802/851 | 369 | 359 | 349 |
| TANDON 848-2 SLIMLINE | 495 | 485 | 475 |
| SHUGART 860 THINLINE | 569 | 549 | 539 |
| **Five Inch Single Sided** | | | |
| SHUGART SA400 | 215 | 209 | 199 |
| TANDON TM 100-1 | 209 | 199 | 195 |
| **Five Inch Double Sided** | | | |
| SHUGART SA450 | 349 | 329 | 315 |
| TANDON TM 100-2 | 295 | 269 | 259 |
| TANDON 96TPI TM100-4 | 369 | 355 | 350 |
| OLIVETTI 502 ⅔ height | 239 | 225 | 215 |
| **Three Inch Rigid Floppy** | | | |
| HITACHI-AMDEK | call for pricing | | |
| **Five Inch Winchesters** | | | |
| SEAGATE 506 6 Megabyte | 759 | 725 | 695 |
| SEAGATE 512 12 Megabyte | 995 | 960 | 960 |
| TANDON 603SE 14 Megabyte | 995 | 960 | 895 |
| WESTERN DYNAX removable | 995 | 960 | 950 |

***Upon request, all drives are supplied with power connectors and manual***

## $750 *Eight Inch Subsystem*

**Two Siemens FDD100-8 disk drives with power suppy. 4" exhaust fan complete with all necessary power cables.**

Same as above but with:

| | | | | | |
|---|---|---|---|---|---|
| Shugart 801R | MS02801 | $1195 | Olivetti 802 | CAL2802 | $1250 |
| Shugart 851R | MS02851 | 1450 | Qume DT8 | MSD8DT | 1450 |

## *ECLIPSE 100* $695

***INDUSTRIAL S-100 MAINFRAME***

Suitable for hospital and industrial applications. Constructed from 304 brushed stainless steel. Modualar 500 with torod power supply provides +8 volts at 30 Amps and ±16 volts at 4 Amps. Supplied with standard 18 slot Faraday mother board. Auxiliary switched AC receptacles. The Eclipse 100 can be either table or rack mounted. Provisions for internally mounting a ten megabyte Winchester disk drive.
The Eclipse 100 is the perfect mainframe to fill the void left by the now defunct TEI Corporation. EPS-100 50 lbs.

VISA

Shipping: First five pounds $3.00. Each additional $.50.
Foreign orders: 10% shipping. Excess will be refunded.
California residents add 6½% sales tax. COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a "strong" Dun & Bradstreet.
Warehouse: 15608 Inglewood Blvd. Visitors by appointment.

**TOLL FREE ORDER LINE**
**(800) 421-5041**
**TECHNICAL & CALIFORNIA**
**(213) 679-9001**

# California Digital

**Post Office Box 3097 B • Torrance, California 90503**

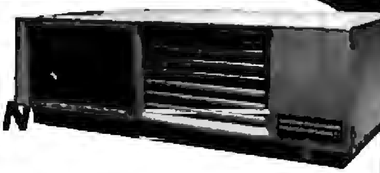
# Super Buy $239

## SIEMENS FDD 100-8 8" DISK DRIVE

10 Drives $209 • 100 Drives $175

California Digital has recently participated in the purchase of several thousand Siemens FDD 100-8 floppy disk drives. These units are electronically and physically similar to that of the Shugart 801R. Any application that will accept the Shugart will work with the Siemens FDD 100-8.
All units are new and shipped in factory sealed boxes. Because of the extremely low price we expect a quick sell out. SEA-F1008 17 lbs. Manual and power connectors supplied free upon request. Also available: Two drive subsystem supplied in metal enclosure with power supply and exhaust fan. $750.00 CAL-2F1008.

## MORROW DESIGNS MICRO DECISION



# $1195

Includes $1800 worth of free software:

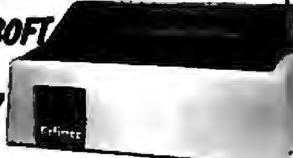
Buy before month end and California Digital will supply, free of any additional cost, 50 Diskettes and a 5¼" Flip & File.

- Digital Research 2.2 CP/M
- MicroPro Wordstar
- Electronic Spreadsheet
- NorthStar Bazic
- Spelling Checker
- Microsoft Basic 80

The Morrow Micro Decision offers one of the best values in small business computers. Standard features include 64K of RAM, 4MHz Z 80 CPU, two RS232 serial ports, dual density floppy disk controller capable of supporting four disk drives, and a 200 Kilobyte 5¼" disk drive. The unit is powered by a low noise switching power supply.
The low profile enclosure should blend in to most any office environment. The Micro Decision is delivered complete with CP/M 2.2 as well as Basic 80 and Wordstar. Available options include a second disk drive and a video terminal. MDS-MD1 18 lbs.

# PRINTERS

## ECLIPSE 80FT



# $297

### MATRIX PRINTERS

| | | |
|---|---|---|
| Star Gemini-10 friction & tractor 100char/sec parallel | STR-G10 | 359 00 |
| Star Eclipse 80FT friction & tractor | STR-E80FT | 297.00 |
| Okidata 82A serial & parallel 9½" paper | OKI-82A | 459 00 |
| Okidata 83A serial & parallel 15" paper | OKI-83A | 695.00 |
| Okidata 84A serial & parallel 15" paper | OKI-84A | 1079.00 |
| Okidata2350 (new) 350 char/sec | OKI-2350 | 1995 00 |
| EpsonMX80FT with graphtrax, friction & tractor feed | EPS-MX80FT | 519 00 |
| EpsonMX100 with graphtrax, 15" paper | EPS-MX100 | 695 00 |
| NEC8023A parallel 9½" paper, graphics | NEC-8023A | 485 00 |
| Anadex 9500A high speed 15" paper | ADX-9500A | 1279.00 |
| Anadex 9501A high speedwith graphics | ADX-9501A | 1279 00 |
| Datasouth 180 high speed 180 cps 15 | DSI-180 | 1295 00 |
| Quantex 7030 corespondence quality 180 char/sec | QTX-7030 | 1535 00 |
| Prowriter 8510 parallel 9½" paper | PRO-8510P | 495 00 |
| Prowriter 8510 serial 9½ paper | PRO-8510S | 639 00 |
| Prowriter II 15 paper | PRO-2P | 750 00 |
| Printronix P300 high speed printer 300lines per minute. | PTX-P300 | 4500 00 |
| Printronix P600 ultra high speed 600 lines per minute | PTX-P600 | 6150 00 |
| Mannesmann Tally 1805 200 char/sec serial | MAN-1805 | 1650 00 |

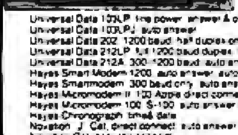
### WORD PROCESSING PRINTERS

| | | |
|---|---|---|
| NEC7710 55char/second, serial interface | NEC-7710 | 2379.00 |
| NEC7730 same as above only parellel interface | NEC-7730 | 2379.00 |
| NEC3510 15 serial | NEC-3510 | 1775.00 |
| Diablo630 40 char/sec serial | DBL-630 | 2250.00 |
| Brother HR11 daiseywheel | BTH-HR1S | 855.00 |
| Brother HR11 serialinterface | BTH-HR1S | 895.00 |
| Smith Corona TP-1 daisy wheel printer serial | SCM-TP1S | 659.00 |
| Starwriter F10 serial | PRO-F10S | 1475.00 |
| Starwriter F10 parallel | PRO-F10P | 1475 00 |

# EPSON MX80 RIBBONS $6.95

# MONITORS

| | |
|---|---|
| Zenith Z121 green phosphor 12 40/80 column switch ZTH-Z12 | 115.00 |
| BMC 12A green phosphor 15 Mhz composit video BMC-12A | 88 00 |
| BMC 12EN green phosphor 20 Mhz high resolution BMC-12EN | 139 00 |
| NEC JB1201 green phospher 18 Mhz composit video NEC-JB1201 | 169 00 |
| NEC JB1260 green phospher commercial grade composit NEC-1260 | 129 00 |
| Motorola 23 open frame b/w white composit video MOT BW23 | 159.00 |
| Motorola 12 open frame b/w / white requies horz sync & pow MOT-BW12 | 69 00 |
| Conrac 9 open frame requires horz sync & power supply CON-BV9 | 59 00 |
| (COLOR) | |
| NEC JC1201 composit color NEC-JC1201 | 325 00 |
| NEC RGB monitor NEC-1202DM | 8750C |
| BMC 13 Composit video BMC-1400CL | 273 00 |
| BMC 13 RGB color monitor BMC-1401RGB | 329 00 |
| BMC interface card for Apple II for above RGB BMC-81RGB | 149 00 |
| Comrex Hitachi 13 RGB high res monitor COM 6600 | 539 00 |
| Comrex Hitachi 13 Composit color monitor COM 6500 | 395 00 |
| Amdek color #1 composit video AMD-100 | 349 00 |
| Amdek color #2 high res RGB color monitor AMD-200 | 739.00 |
| Amdek color #3 commercial grade color RGB AMD 300 | 475 00 |



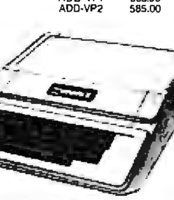
## Direct Connect MODEMS

| | | |
|---|---|---|
| Universal Data 103LP line power answer & originate | UDS-103LP | 169 00 |
| Universal Data 103LPJ auto answer | UDS-103LPJ | 209 00 |
| Universal Data 202 1200 baud half duplex only | UDS-202LP | 209 00 |
| Universal Data 212LP full 1200 baud duplex line power | UDS-212LP | 450 00 |
| Universal Data 212A 300/1200 baud auto answer | UDS-212A | 595 00 |
| Hayes Smart Modem 1200 auto answer auto dial | HYS-212AD | 575 00 |
| Hayes Smartmodem 300 baud only auto answer, auto dial | HYS-103AD | 229 00 |
| Hayes Micromodem II 103 Apple direct connect | HYS-MM2 | 279 00 |
| Hayes Micromodem 100 S-100 auto answer auto dial | HYS-100 | 318 00 |
| Hayes Chronograph time& date | HYS-CHR232 | 199 00 |
| Novation J Cat, direct connect auto answer | NOV-JCAT | 119 00 |
| Novation Cat, acoustic connect | NOV-CAT | 159 00 |
| Novation D Cat, direct connect via handset not phone line | NOV-DCAT | 169 00 |
| Novation SmartCat 103 auto answer auto dial | NOV-SC103 | 219 00 |
| Novation SmartCat 103/212 1200 baud auto dial | NOV-SC212 | 529 00 |
| Pennel 300/1200 baud, auto log on auto dial | PEN-212A | $795 00 |
| Signalman Mark I direct connect with terminal cable | SOL-MK1 | 85 00 |
| U S Robotics 212A 300/1200 baud | USR-212A | 485 00 |

# TERMINALS

| | | |
|---|---|---|
| Freedom 50, split screen, detatchable keyboard | LIB-F50 | 495.00 |
| Visual 50, detatchable, keyboard selectable settings. | VSL-50 | 635.00 |
| Visual 50 Green screen | VSL-50G | 650.00 |
| Visuel330, emulates DEC, DG, LSI, green | VSL-330G | 995.00 |
| Ampex Dialogue 80 green screen, twopage, func. keys | APX-D80G | 685.00 |
| Ampex Dialouge 80 amber screen, two page, func keys | APX-D80A | 685.00 |
| Wyse 100, horz & vert. split screen, metal enclosure | WYS-100 | 825.00 |
| Televideo 910 Plus, block mode | TVI-910P | 595.00 |
| Televideo 925, detatchable keyboard, 22 function keys | TVI-925 | 795.00 |
| Televideo 950, graphic char., split screen, 22 func. | TVI-950 | 985.00 |
| Televideo 970, 14 green screen, 132 column, European | TVI-970 | March |
| Zenith 19 terminal, VT52 compatible. | ZTH-Z19 | 765.00 |
| ADDS Viewpoint A1 detatchable keyboard | ADD-VP1 | 585.00 |
| ADDS Viewpoint A2, xycursor | ADD-VP2 | 585.00 |

# APPLE 48K Plus $1089



### APPLE BRAND PRODUCTS

| | | |
|---|---|---|
| APL-48P | Apple Plus 48K RAM | |
| APL-DSK1 | Apple disk with controller card | 560 00 |
| APL-DSK2 | Apple disk without controller card | 495 00 |

### XITEN

| | | |
|---|---|---|
| XTN-G10 | Xiten 10 Megabyte Gallium hard disk | 1 995 00 |
| XTN-16K | 16K RAM card for Apple II | 69 00 |

### RANA SYSTEMS

| | | |
|---|---|---|
| RAN-APL1 | Apple add on disk drive with controller | 525 00 |
| RAN-APL2 | Apple add on drive without controller | 395 00 |

### CALIFORNIA COMPUTER SYSTEMS

| | | |
|---|---|---|
| CCS-7710 | Asynchronous Serial Interface | 125.00 |
| CCS-7728 | Centronics Parallel Interface | 95 00 |
| CCS-7720 | Apple Parallel Interface | 95 00 |
| CCS-7114 | 12K Rom/Prom Module | 115 00 |
| CCS-7424 | Calendar/Clock Module | 95 00 |
| CCS-7440 | Programmable Timer | 95 00 |
| CCS-7811B | Arithmetic Processor for Apple II plus | 319 00 |

### MOUNTAIN COMPUTERS, INC.

| | | |
|---|---|---|
| MTN-CPS | CPS Multifunction Card | 169 00 |
| MTN-TCLK | Clock/Calendar | |
| MTN-STLK | Supertalker SD200 | 149 00 |
| MTN-ROMF | Rom Plus with Keyboard filter | 169 00 |
| MTN-ROMRTR | Rom Writer with Eprom socket | 145 00 |
| MTN-ADDA | A-D/D-A Converter | 269 00 |
| MTN-BSR | X-10 Control Card for BSR system | 149.00 |

### MICRO SOFT

| | | |
|---|---|---|
| MSF-SFTCRD | Microsoft Z-80CPU card | 249 00 |
| MSF-16KRAM | Microsoft 16K RAM card | 125 00 |

### VISTA

| | | |
|---|---|---|
| VSA-A800 | Vista 8" controller card | 489 00 |
| VSA-VIS80 | Vista Vision 80 | 269 00 |
| MCI-CNTRL | Micro Sci disk drive controller | 89 00 |

### FOURTH DIMENSION

| | | |
|---|---|---|
| FON-SPRDRV | Super Drive-35 track Apple add on | 329 00 |

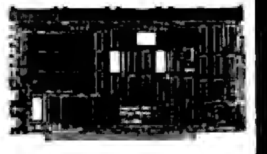
### SORRENTO VALLEY ASSOC

| | | |
|---|---|---|
| SVA-221 | Single sided single density controller | 360 00 |
| SVA-222 | Double sided single density controller | 380 00 |
| SVA-223 | Single or double sided double density | 475 00 |

### ADVANCED BUSINESS TECH

| | | |
|---|---|---|
| ABT-13KEYN | 13 key pad for new Apple | 85 00 |

# S-100 BOARDS



### 16 BIT MICROPROCESSORS

| | | |
|---|---|---|
| GBT-8687 | Godbout 8086/8087 Microprocessor board | 495 00 |
| GBT-8587 | Godbout 8088/8085 dual 8 bit microprocesser | 359 00 |
| SEA-8086 | Seattle Computer 16 bit micro two boardset | 669 00 |
| TEC-8086 | Tecmar Computer 16bit microprocessor | 595 00 |
| LOM-8086 | Lomas Data Systems Lighting One | call |

### SINGLE BOARD COMPUTERS

| | | |
|---|---|---|
| WAV-BLT1 | Wavemate Bullet 1 with floppy 256K (not S-100) | 795 00 |
| AMD-Z80 | Advanced Micro Digital floppy & 64K | 750 00 |
| TEL-FDC1 | Teletek FDC1 Single board NEC765 controller | 675 00 |

### 8 BIT MICROPROCESSORS

| | | |
|---|---|---|
| GBT-Z80 | Godbout Z80 8 bit CPU 24 bit extended address | 250 00 |
| CCS-2810 | California Computer Z-80 microprocessor | 275 00 |
| SDS-SBC200 | SD SystemsSBC-200 Z-80 microprocessor | 275 00 |
| MSM-Z80 | Measurement System Z-80 2810 microprocessor | 425 00 |
| TAR-Z80 | TarbellElectronics Z-80 with two RS232 ports | 395 00 |

### FLOPPY DISK CONTROLLERS

| | | |
|---|---|---|
| GBT-DSK1 | Godbout DiskOnedoubledensity NEC-765 | 395 00 |
| MDS-DJ2 | Morrow Designs Disk Jockey II with CPM | 350 00 |
| MDS-DJ1 | Morrow Designs Disk Jockey I single density | 225 00 |
| CCS-2422 | California Computer 2422 withCPM | 339 00 |
| TAR-DDC | Tarbell Electronics double density controller | 419 00 |
| TAR-SDC | Tarbell Electronics single density controller | 279 00 |

### CPM OPERATING SYSTEM

| | | |
|---|---|---|
| GBT-CPM22 | Godbout CPM 22 for Disk One 8 bit operation | 160 00 |
| GBT-CPM860 | Godbout CPM 86 for Disk One for use with 8088 | 265 00 |
| GBT-CPM86 | Godbout CPM 86 for operation with 8086 board | 265 00 |

### HARD DISK CONTROLLER

| | | |
|---|---|---|
| GBT-DSK2 | Godbout Disk II hard disk controller | [illegible] |
| GBT DSK3 | Godbout Disk III hard disk controller | |
| MDS-W506 | Morrow Designs Winchester for Seagate 506 | 495 00 |
| WDI-1000 | Western Digital WD-1000 (not S-100) | 495 00 |

### EPROM BOARDS

| | | |
|---|---|---|
| ADS-PB100 | Ackerman Digital Prom Blaster 100 | 275 00 |
| SDS-P100 | SD Systems Prom-100 programmer | 260 00 |
| SSM-PB1 | SSM Prom programmer up to 2716 | 195 00 |
| DGR-P32 | Digital Research 32K Eprom read only board | 105 00 |

### STATIC MEMORY BOARDS

| | | |
|---|---|---|
| CAL S64 | California Digital Static 64 8/16 bit (6167) | 595 00 |
| GBT-R16 | Godbout Ram 16 64K memory 8/16 bit | 760 00 |
| GBT-R17 | Godbout Ram 17 64K memory 8 bit 24bit add | 395 00 |
| GBT-R20 | GodboutRam 20 32k static memory 4K bound | 375 00 |
| GBT-R21 | Godbout Ram 21 128K 8/16 bit static memory | 995 00 |
| CCS-2116 | California Comuter 2116 16K static memory | [illegible] |

### DYNAMIC MEMORY BOARDS

| | | |
|---|---|---|
| CAL-D256 | California Digital 256K dynamic memory 8 bit | [illegible] |
| SDS-EX3 | SD Systems ExpandoramIII256K dynamic | [illegible] |
| CCS-2065 | California Computers 2065 64K dynamic | [illegible] |
| MSM-DMS54 | Measurement Systems DMS6400 (Alpha Micro) | [illegible] |

### INTERFACE BOARDS

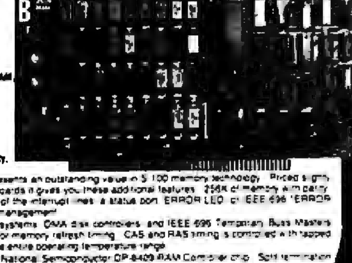
| | | |
|---|---|---|
| MDS SW1 | Morrow Designs Switchboard 2 serial 4 parallel | [illegible] |
| MDS MB1 | Morrow Designs Multiboard 3 serial/2 parallel | [illegible] |
| GBT [illegible] | Godbout Interfacer I 2 serial ports | [illegible] |
| GBT 150A | Godbout Interfacer II 1 serial 3 parallel | [illegible] |
| GBT 135A | Godbout Interfacer III with 5 serial ports | [illegible] |
| GBT 138A | Godbout Interfacer III with 8 serial ports | [illegible] |
| GBT [illegible] | Godbout Interfacer IV 3 serial/2 parallel | [illegible] |
| CCS 2710 | California Computer 4 port serialinterface | [illegible] |
| CCS 2720 | California Computer 2 serial / 2 parallel | [illegible] |
| CCS 2720 | California Computer 4 port parallel | [illegible] |

### SPECIAL FUNCTION BOARDS

| | | |
|---|---|---|
| HYS-S100 | D.C. Hayes Micromodem S 100 FCC approved | [illegible] |
| [illegible] | Ackerman Digital Bytemaker w/ Vertrax Ingdule | [illegible] |
| [illegible] | [illegible] Computer clock calendar board | [illegible] |
| SCN M100 | Sirius Micrographic graphics [illegible] | [illegible] |
| GBT SP[illegible] | Godbout Spectrum 100 color video board | [illegible] |
| TEC [illegible] | Tecmar A/D 12 bit accuracy 16 channel | [illegible] |
| GBT SYS1 | Godbout System support board | [illegible] |
| GBT SYS9511 | Godbout System Support with 8231 9511 math chip | [illegible] |
| MUL [illegible] | Mullins extender board with test points | [illegible] |
| MUL IC[illegible] | Mullins Opto Isolator controls 8 channels | [illegible] |
| ADS KG[illegible] | Ackerman Digital Kluge prototype board | [illegible] |
| IOT W100 | I O Technology wire wrap prototype board | 49 00 |
| ARI WW100 | Artec Electronics Wire wrap proto board | 25 00 |
| ARI GP100 | Artec Electronics General purpose solder | 25 00 |
| CAL MB18 | California Digital 18 slot motherboard | 35 00 |

# 256K DYNAMIC MEMORY BOARD

# $495



- 256 kilobytes of memory using 64K dynamic RAM.
- Over one megabyte of memory using the new 256K dynamic RAM chips.
- Error detection-trap capability.
- Individual 16K block can be relocated to any boundry within a megabyte of RAM.
- 24 bit addressing and phantom mode capability.

The California Digital 256K RAM board represents an outstanding value in S-100 memory technology. Priced [illegible] above earlier generation 64K dynamic ram boards it gives you these additional features: 256K of memory with parity. Parity error feature can be jumpered to any of the interrupt lines, a status port, ERROR LED or IEEE 696 "ERROR" signal. 24 or 16 bit addressing with memory management.
Proper operation with front panel equipped systems, DMA disk controllers, and IEEE 696 Temporary Buss Masters assured with an on the board M1 generator for memory refresh timing. CAS and RAS timing is controlled with tapped digital delay lines for proper operation over the entire operating temperature range.
The board is very recent in design using the National Semiconductor DP-8409 RAM Controller chip. Split termination networks are used on all address lines, CAS line and RAS lines eliminating the last traces of ringing. The board uses two separate voltage regulators. One for the DRAMs and one for the interface logic increasing the noise immunity of the ram array. Typical power dissipation is 6 watts.
Documentation includes theory of operation, configuration guide, a schematic, and application notes of the use of the memory management options. CAL-256K 2 Lbs.

VISA

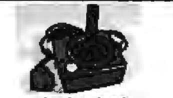
master charge

Shipping: First five pounds $3.00. Each additional $.50.
Foreign orders: 10% shipping. Excess will be refunded.
California residents add 6½% sales tax. COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a "strong" Dun & Bradstreet.
Warehouse: 15608 Inglewood Blvd. Visitors by appointment.

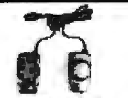
**TOLL FREE ORDER LINE**
**(800)421-5041**
**TECHNICAL & CALIFORNIA**
**(213)679-9001**

Circle 231 on Inquiry card.

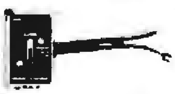
## ATARI



**JOYSTICKS**
JSA (2) . . . $6.95/pair



**PADDLES**
JSP (2) . . . $4.95/pair

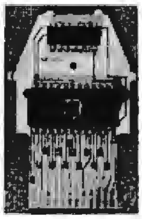


## TV GAME SWITCH

Switches TV to video game or computer operation. Used on Atari.

**TGS-1 . . . $2.95 ea.**

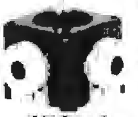
## VIDEO GAME CHIPS



Pull-outs from hand-held video games. AP2000 consists of one MM2716Q EPROM and one 74LS04. AP2002 consists of two MM2716 EPROMs and one 74LS04. These EPROMs are mounted on a circuit board with a 12-pin edge card connection. EPROMs can be reprogrammed for other applications.

AP2000 . . . . . . . . . . $2.49 ea. or 2 for $3.95
AP2002 . . . . . . . . . . $3.49 ea. or 2 for $6.49

## JOYSTICKS



JS-5K (Pictured)

| | | |
|---|---|---|
| JS-5K | 5K Linear Taper Pots | $5.25 |
| JS-100K | 100K Linear Taper Pots | $4.95 |
| JS-150K | 150K Linear Taper Pots | $4.75 |
| JVC-40 | 40K (2) Video Controller in Case | $4.95 |

JS KNOB Knob for JS5K,100K,150K . . . . . $.99 ea.
JVC KNOB Knob for JVC-40 . . . . . . . . . . . . . $.99 ea.

## Jameco Digital Thermometer Kit

Dual sensors — switch controls for indoor/outdoor or dual monitoring — can be extended to 500 feet. Continuous LED .8" ht. display. Range: -40°F to 199°F, -40°C to 100°C. Accuracy ±1° nominal. Calibrate for Fahrenheit/Celsius. Simulated walnut case. AC wall adapter included. Size: 6¾"L x 3¼"H x 1½"D.

**JE300 . . . . . . $39.95**

## BOOKS

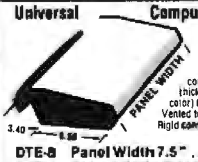
NATIONAL SEMICONDUCTOR — INTERSIL — INTEL

| | | |
|---|---|---|
| 30001 | National CMOS Data Book (1981) . (640 pages) 74C, CD4000, and A/D Converters | $8.95 |
| 30002 | National Interface Data Book (1980) . (704 pages) DP, DS8000, DS3600, DS5700, etc. | $6.95 |
| 30003 | National Linear Data Book (1982) . (1376 pages) LM, LF, ADC, DAC, LH Series | $11.95 |
| 30004 | National Series 80—Board Level Computer (1980) (224 pages) | $4.95 |
| 30005 | National TTL Logic Data Book (1981) . (624 pages) 7400,LS,L,H,S, and DM8000 Series | $9.95 |

**30006 Above (3) 30001,3,5 as set . . $24.95**

| | | |
|---|---|---|
| 30008 | National Memory Data Book (1980) (464 pages) RAMs, ROMs, PROMs, EPROMs Series | $6.95 |
| 30009 | Intersil Data Book (1983) (1356 pages) Complete line | $9.95 |
| 30010 | National Audio/Radio Handbook (1980) (240 pages) Pre-Amps, AM, FM & FM Stereo, Power Amps | $5.95 |
| 30011 | National Linear Application Handbook (1980) (736 pages) Application Notes, Linear Briefs, etc. | $15.95 |
| 30012 | National PAL Data Book (1982) (176 pages) Data Sheet, PAL Design | $5.95 |
| 30013 | Zilog Data Book (1983) (641 pages) Microprocessors and Support Chips | $7.95 |
| 010400 | Intel Component Data Book (1982) (1405 pg.) Full data sheets for Intel's products incl. mem. devices, microproc., periph. & ind./mil. products | $14.95 |
| 205610 | Intel Peripheral Design Handbook (1981) (828 pages) Full data sheets, application notes for Intel peripheral device components | $9.95 |

## Universal Computer Keyboard Enclosures





"DTE" Blank Desk-Top Enclosures are designed for easy modification. High strength epoxy molded end pieces in mocha brown finish. Sliding rear/bottom panel for service/component access. Top/bott. panels .080" thick alum. anodize type 1200 finish (gold tint color) for best paint adhesion after modification. Vented top & bottom panels for cooling efficiency. Rigid construction provides unlimited applications. Assembly instructions included.

DTE-8 Panel Width 7.5" . . . . . . . . . . . . . . . . . $24.95
DTE-11 Panel Width 10.13" . . . . . . . . . . . . . . . $27.95
DTE-14 Panel Width 13.5" . . . . . . . . . . . . . . . $29.95
DTE-20 Panel Width 19.25" . . . . . . . . . . . . . . $34.95

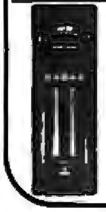
## Mostek DC/DC Converter

**+5 VOLTS TO -9 VOLTS**

Input: +5V. Output: -9V (regulated) @ 30mA. Printed circuit mounting. Specifications incl.

DC10 . . . . . . . . . $2.95 ea. or 2/$4.95

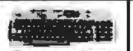
## Battery Checker



Easy-to-use hand-held battery checker tests AA, AAA, C, D, and 216 batteries. A multi-colored meter shows if battery is good, weak or needs replacing. Size: 6¼"L x 2¼"W x 1-7/8"H.

BC-1 . . . . . . . . . . . . . . $6.95 ea.

## KEYBOARDS — POWER SUPPLIES

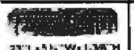


17½"L x 8"W x 1½"H

**DATANETICS 73-KEY KEYBOARD** *Apple Compatible*
Data Entry Keyboard uses MM5740 AEE/N encoder chip (included). 73-Key Keyboard features 11-key numeric keypad. SPST switching. 24-pin edge card connection. Includes pin-out.
Part No. KB261 (Fits DTE-20 Enclosure) . . . . . . . . . . $49.95 each

16¾"L x 5½"W x 1½"H

**MICRO SWITCH 69-KEY KEYBOARD**
Data Entry Keyboard, Encoded Output. 8-bit Parallel EBC DIC. Switching: Hall Effect. 24-pin Edge Card Connection. Complete w/Pin Connection. Can easily be modified to ASCII code.
Part No. KB69SD12-2 (Fits into DTE-20 Enclosure) . . . . . $19.95 each

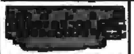


23"L x 5½"W x 1-3/8"H

**MICRO SWITCH 85-KEY KEYBOARD**
Word Processing Keyboard. 26 Pin Edge Card Connection. Supply Voltage +5VDC. Main Keyboard is QWERTY. Additional Key Pads for Cursor and word processing functions.
Part No. 85SD18-1 . . . . . . . . . . $29.95 each

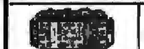
18¾"L x 5½"W x 1½"H

**MICRO SWITCH 88-KEY KEYBOARD (PARALLEL**
Data Entry Keyboard used in a Mobile 1640 Terminal. Supply Voltage: +5V, -12V. Switching: Hall Effect — 10-pin Edge Card Connection. Schematic included. Uses 8048 Encoder Chip.
Part No. 88SD22 (Fits into DTE-20 Enclosure) . . . . . . $49.95 each



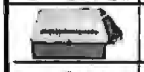
11¾"L x 3½"W x 1½"H

**HI-TEK 58-KEY KEYBOARD**
SPST switching, mechanical, monolithic housing, charcoal gray keycaps. Keyboard is not mounted on circuit board (each key is individually accessible). Used to replace touch-membrane found on Sinclair, Atari, and TRS-80 computers.
Part No. K-58 (Fits DTE-14 Enclosure) . . . . . . . . . . $19.95 each



9¾"L x 4½"W x 1½"H

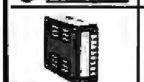
**ALPS 29-KEY CALCULATOR KEYBOARD**
Features one 6-position decimal select switch, one 3-position switch, and two 2-position switches, mechanical SPST switching. 20-pin edge card connection. Pin-out included.
Part No. KB297040 (Fits DTE-11 Enclosure) . . . . . . . . . . $4.95 each



**POWER SUPPLY +5VDC @ 1 AMP REGULATED** *Transaction Tech*
Output +5VDC @ 1A (also +30VDC) reg. Input 115VAC 60Hz. 2-tone (black/beige) self-enclosed case. 6 ft., 3 cond. black power cord. 6½"W x 7"D x 2¾"H. Wt. 3 lbs. Data sheet incl.
Part No. PS51194 . . . . . . . . . . $19.95 each

**POWER SUPPLY +5VDC @ 3 AMP REGULATED** *Deltron*
Input: 115VAC, 47-440Hz. Output: 5VDC Adjustable @ 3 amp, 6VDC @ 2.5 amp. Adjustable current limit. Ripple & Noise: 1MV rms, 5MV p-p — 3 mounting surfaces. UL recognized. Size: 4"W x 4½"L x 2-7/16"H - wt. 2 lbs. Data sheet included.
Part No. DPS-1 . . . . . . . . . . $29.95 each

**POWER SUPPLY +5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING**
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.5 amp. Fan volt./power supply select switches (115/230VAC). Output: 5VDC @ 7.5 amp, 12VDC @ 1.5 amp. 8 ft. blk. pwr. cord. 11½"W x 13¾"D x 3¾"H. Wt. 6 lbs.
Part No. PS94VD . . . . . . . . . . $49.95 each



**POWER SUPPLY 4-Channel Switching Power Supply**
Microprocessor, mini-computer, terminal, medical equipment and process control applications. Input: 90-130VAC 47-440Hz. Output: +5VDC @ 5A, -5VDC @ 1A, +12VDC @ 1A, -12VDC @ 1A. Line reg.: ±0.2%. Ripple: 25mV p-p. Load reg.: ±1%. Overcurrent protection. Adj. 5V main output ±10%. 6-3/8"L x 1-7/8"W x 4-15/16"H. Wt. 1½ lbs.
Part No. FCS-604A . . . . . . . . . . $69.95 each

**POWER SUPPLY Adjustable Switching 4-24VDC to 5 Amps**
Adj. 4-24VDC: 5VDC @ 5A, 6VDC @ 4.8A, 9VDC @ 4.1A, 12VDC @ 3.3A, 15VDC @ 1.6A, 24VDC @ .5A. Overvoltage Protection. Input: 115VAC 50/60Hz. Output variations within 20mV. 8.75"L x 4.25"W x 2.25"H. Wt. 3.25 lbs.
JE224 Kit . . . . . . . . . . $79.95 each
JE224A Assembled & Tested . . . . . . . . . . $99.95 each

### 84-Key Keyboard

**CA153A . . . . . . . . . $69.95**

### CONTROL DATA

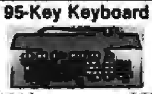
**Data Entry Keyboards**

RS232 Interface
—
FT2 Shielded Base
—
SPST Switching
—
Momentary Contact Keyswitches
—
30" Interface Cable
—
Attractive Case

### 104-Key Keyboard

**CA148 . . . . . . . . . . $99.95**

### 95-Key Keyboard



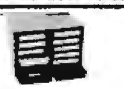
**CA154A . . . . . . . . . $79.95**

### 80-Key Keyboard

**CA150C . . . . . . . . . $89.95**

Color; keycaps: black, blue, red - cover: black w/beige base. 21½"x9"x3½". 6 lbs.

## BUG BOX™ STORAGE SYSTEMS



BUG CAGE™ (BGC-001-____) with Bug Boxes

**BUG BOX™** — 30 individual compartments • Stores 60 8-pin or 30 14- or 16-pin DIPs • Bug rugs not included • Clear plastic cover slides & locks • Cover marked w/numbers 1-30 • Compartment size: 1" x 3.75" x .5" deep • Box size: 4.9" x 3.3" x .6" • Weight: 1.75 oz.

**BUG BOX™**
Please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

| Part No./Color Code | QTY | PRICE |
|---|---|---|
| BGX-001-( ) | 1 | $ 2.29 |
| BGX-010-( ) | 10 | 19.99 |
| ANTI-STATIC | | |
| BGX-001-( )AS | 1 | $ 3.29 |
| BGX-010-( )AS | 10 | 28.89 |

**BUG CAGE™** — 12 locations store Bug Boxes, Big Bug Boxes or Bug Trays • Modular and interlocking • Heavy duty injection molded plastic • Each cage has 6 slip-on locations • 2 cages per pkg. • Cage size: 5-1/8" x 5" x 3-7/8" • 4 colors available — please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

| Part No./Color Code | Price |
|---|---|
| BGC-001-( ) 2 Cages (6loc. ea.) | $11.95/pkg. |

**BUG TRAY™** — Stores in Bug Cage • Molded plastic • Three styles: Open (1 compartment 3.05" x 4.6" x .6"); Vertical (5 compartments .5" x 4.6" x .6"); and Horizontal (8 compartments .4" x 3.95" x .6") • Ideal for tools, hardware, components, etc. • Tray size: 3.55" x 5.05" x .6" • Black color only

| PART NO | DESCRIPTION | PRICE |
|---|---|---|
| BTH-001 | Horizontal Bug Tray | $1.95 |
| BTV-001 | Vertical Bug Tray | 1.95 |
| BTO-001 | Open Bug Tray | 1.95 |
| BTX-003 | 1 of each Bug Tray (3) | 4.98 |

**BUG RUG™** — Static discharge protection for CMOS and MOSFET devices • Pre-cut to dimensions of BUG BOX (1" x .35")

| Part No | Description | Price |
|---|---|---|
| BRG-030 | 30 foam rectangles for Bug Box | $1.98 |
| BBR-036 | 6 foam rec. for LSI Big Bug Box | 1.98 |

**CAGE KEEPER™** — Pins column of Bug Boxes in Bug Cage

| | | Price |
|---|---|---|
| CKP-005 | 5 inch | $4.98/pkg. |
| CKP-010 | 10 inch | 6.98/pkg. |

**LSI BIG BUG BOX™** — Designed to store large IC's, Resistors, Capacitors and Diodes • Divided into three compartments measuring 1" x 4.15" x .5" deep • Three vertical and three horizontal dividers included • Bug Rugs not included • Box size: 4.9" x 3.3" x .6" • Weight: 1.75 oz.

**LSI BIG BUG BOX™**
Please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

| PART NO./COLOR CODE | QTY | PRICE |
|---|---|---|
| BLX-001-( ) | 1 | $ 3.29 |
| BLX-010-( ) | 10 | 28.79 |
| ANTI-STATIC | | |
| BLX-001-( )AS | 1 | $ 4.29 |
| BLX-010-( )AS | 10 | 37.89 |

**BACK PACK™** — Self-adhesive labels for the back of ICs • Shows exact internal logic in relation to IC pins • 532 labels in each package (including several blank labels) • Each Package for 8, 14, 16, 24, 28 and 40-pin ICs • Combo package includes 1,068 labels for TTL and CMOS ICs • Microprocessor package contains 744 labels

| Part No. | Description | Price |
|---|---|---|
| BPT-012 | TTL | $7.95 |
| BPC-012 | CMOS | 8.95 |
| BPM-012 | Combo | 14.95 |
| BPU-012 | Microprocessor | 9.95 |

**BUG TAGS™** — Self-adhesive, easy-to-read labels for marking Bug Box and LSI Big Bug Box • Most popular components

| PART NO | DESCRIPTION | QTY. | PRICE |
|---|---|---|---|
| BTT-200 | TTL | 200 | $4.98 |
| BTC-200 | CMOS | 200 | 4.98 |
| BTK-200 | LS Schottky | 200 | 4.98 |
| BTS-200 | Special | 200 | 4.98 |
| BTM-800 | Mixer | 800 | 13.95 |

MORE BUG TAGS AVAILABLE!

### ★ ★ ★ BUG BOX SYSTEMS INTRODUCTORY SPECIAL ★ ★ ★

Your choice: regular or anti-static. Includes 2-Bug Cages (12 locations); 8-Bug Boxes, 3-LSI Big Bug Boxes, 1-horizontal Bug Tray; 1-open Bug Tray; 1-vertical Bug Tray; 1 package Bug Rug for regular Bug Boxes; 1 package Bug Rug for LSI Big Bug Boxes; 1 package Mixer Labels (800 each). Color: Bug Boxes and Cages - Blue, Bug Trays - Black.

SP-BUG Regular (Retail value $58.45) . . . . . . . . . . *Sale Price $49.95*
SP-BUG-AS Anti-Static (Retail value $67.45) . . . . . . . . . . *Sale Price $59.95*

**$10.00 Minimum Order — U.S. Funds Only**
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3/83 ***PHONE ORDERS WELCOME — (415) 592-8097 Telex: 176043***

## EXPAND YOUR MEMORY

### TRS-80 to 16K, 32K, or 48K

**Model 1 = From 4K to 16K Requires (1) One Kit
Model 3 = From 4K to 48K Requires (3) Three Kits
Color = From 4K to 16K Requires (1) One Kit

**Model 1 equipped with Expansion Board up to 48K Two Kits Required — One Kit Required for each 16K of Expansion -

TRS-16K3 *200ns for Color & Model III . . . . . . . $12.95
TRS-16K4 *250ns for Model I . . . . . . . . . . . . . . . . $10.95

### TRS-80 Color 32K or 64K Conversion Kit

Kit comes complete with 8 each 4164-2 (200ns) 64K dynamic RAMs and conversion documentation. Converts TRS-80 color computers with D and E circuit boards, and all new color computers to 32K. Minor modifications of 32K memory will allow the use of all 64K of the dynamic RAM.

**TRS-64K2 . . . . . . . . . . . . . . . . . . . . . $54.95**

### 5¼" Mini-Floppy Disk Drive



FOR TRS-80 MODEL I (Industry Standard)
Features single or double density. Recording mode: FM single, MFM double density. Power: +12VDC (±0.6V) 1.6A max., +5VDC (±0.25V) 0.8A max. Unit as pic. at left (does not incl. case, power supply, cables). 30-pg. data book incl. Wt. 3¼ lbs. Size: 5¾"W x 8"D x 3¼"H.

Part No. *Limited Quantity!* Price
FD200 . . . . . . . . . . . . . . $179.95
Single-sided, 40 tracks, 250K bytes capacity
FD250 . . . . . . . . . . . . . . $199.95
Double-sided, 35 tracks, 438K bytes capacity

### Siemens 8" Floppy Disk Drive

- Shugart 801R compatible
- Single-Sided
- 77 Tracks
- 400/800K Bytes Capacity
- Industry Standard

The FDD100-8 8" Floppy Disk Drive (Industry Standard) features single or double density. Recording mode: FM single, MFM double density. Transfer rate: 250K bits/sec. single density; 500K bits/sec. double density. The FDD100-8 is designed to work with the single-sided soft sectored IBM Diskette I, or eq. disk cartridge. Hard-sectored option available. Power: 115/230VAC @ 50-60Hz, +24VDC @ 1.7 amps max., +5VDC @ 1.2 amps max. Unit as pictured above (does not include case, power supply, or cables). Size 8.55"W x 14"L x 4.5"H. Weighs 12 lbs. Incl. 96-pg. manual.

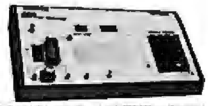
| Part No. | | Price |
|---|---|---|
| FDD100-8 | Buy 1 for | $269.95 each |
| FDD100-8 | Buy 2 for | $259.95 each |
| *FDD100-8* | *Buy 10 for* | *$249.95 each* |

### 2708,2716,2732 & 2764 EPROM Programmer

## JE664 EPROM PROGRAMMER

**8K TO 64K EPROMS — 24 AND 28 PIN PACKAGES**
Self-Contained — Requires No Additional Systems for Operation

NEW!



• Programs, validates, and checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer Interface for editing/program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power Input: 115VAC, 60Hz, < 10W power consumption • Enclosure: Color-coordinated, light tan panels w/molded mocha brown end pieces • Size: 15-5/8"L x 8¾"D x 3½"H • Wt.: 5¾ lbs.

**JE664-A** EPROM Programmer . . . . . . . . . . **$995.00**
Assembled & Tested (Includes JM16A Module)

**JE665 — RS232C INTERFACE OPTION** — The JE665 RS232C Interface Option implements computer access to the JE664's RAM. Sample software written in BASIC provided for TRS-80* Model I, Level II Computer. Baud rate: 9600. Word Lgth: 8 bits - odd parity. Stop bits: 2. Option may be adapted to other computers.

**JE664-ARS** EPROM Prog. w/JE665 Option . . . . . . **$1195.00**
Assembled and Tested (Includes JM16A Module)

**EPROM JUMPER MODULES** — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets JE664 for proper programming pulses to the EPROM & configures EPROM socket connections for that particular EPROM

| Part No. | EPROM | EPROM MANUFACTURER | PRICE |
|---|---|---|---|
| JM08A | 2708 | AMD, Motorola, National, Intel, TI | $14.95 |
| JM16A | 2716, TMS2516 | Intel, Motorola, National, NEC, TI | $14.95 |
| JM16B | TMS2716 | Motorola, TI (+5,-12,+12) | $14.95 |
| JM32A | TMS2532 | Motorola, TI | $14.95 |
| JM32B | 2732 | AMD, Fujitsu, NEC, Hitachi, Intel | $14.95 |
| JM64A | MCM68764, MCM68L764 | Motorola | $14.95 |
| JM64B | 2764 | Intel | $14.95 |
| JM64C | TMS2564 | TI | $14.95 |

## UV-EPROM Eraser

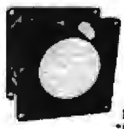
8 Chips — 51 Minutes

1 Chip — 37 Minutes

Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

UVS-11EL Replacement Bulb . . . . . . . . $16.95
**DE-4** UV-EPROM Eraser . . . . **$79.95**

## Sprite-style Fan

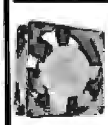


- 36cfm free air delivery
- 3.125" sq. x 1.665" depth
- 10 yrs. cont. duty at 20°C
- 115V 50/60Hz

*Metal Frame*

PWS2107U Cleaned & tested (used) . . . . . $ 8.95 ea.
*PWS2107F New . . . . . . . . . . . . . . $14.95 ea.

## Muffin-style Fan



- 105cfm free air delivery
- 4.68" sq. x 1.50" depth
- 10 yrs. cont. duty at 20°C
- Impedance protected, ambients to 70°C
- 115V 50/60Hz 14W Wt. 17 oz.

*Metal Frame*

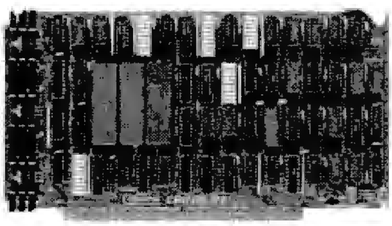
MU2A1-U Cleaned & tested (used) . . . . . . $9.95 ea.
*MU2A-1N New . . . . . . . . . . . . . . $14.95 ea.

Circle 231 on inquiry card.

# PRIORITY ONE ELECTRONICS

## THERE ARE NO BETTER BOARDS — THERE ARE NO BETTER PRICES!

## CompuPro FROM PRIORITY ONE ELECTRONICS



### CPU BOARDS

#### CO-PROCESSOR 8086/8087

*16 bit 8 or 10 MHz 8086 CPU with sockets for 8087 and 80130*

| Part No. | Description | List Price | Our Price |
|---|---|---|---|
| BOGBT186A | A&T 8MHz 8086 only | $695.00 | $624.89 |
| BOGBT186C | CSC 10MHz 8086 only | $850.00 | $764.89 |
| BOGBT186A87 | A&T with 8087 option | $995.00 | $925.00 |
| BOGBT186C87 | CSC with 8087 option* | $1150.00 | $1065.00 |

*8087 Limits clock speed to 5MHz

#### 816 DUAL PROCESSOR 8085-8088

*6 or 8 MHz provides true 16 Bit Powerwith a standard 8 bit S-100 bus*

| | | | |
|---|---|---|---|
| BOGBT1812A | A&T 6MHz | $425.00 | $398.89 |
| BOGBT1812C | CSC 6/8 MHz | $525.00 | $497.89 |

#### 68K - 68000 16 BIT CPU

*16 bit 8 or 10 MHz on-board sockets for 2716. 2732, or 2764 EPROMs for up to 8K x 16 of memory*

| | | | |
|---|---|---|---|
| BOGBT184A | A&T 8MHz | $695.00 | $625.00 |
| BOGBT184C | CSC 10MHz | $850.00 | $765.00 |

#### FORTH OPERATING SYSTEM FOR 68K CPU

*Requires a DISK 1, 64K of CompuPro memory, and an INTERFACER 3 or 4.*

| | | | |
|---|---|---|---|
| BOGBT68KOS | FORTH operating system | | $200.00 |

#### CPUZ - Z80B CPU NOW 6MHz!

*3/6 MHz Z80B CPU with 24 Bit Addressing. FASTEST Z80 CPU AVAILABLE!*

| | | | |
|---|---|---|---|
| BOGBT160A | 3/6 MHz A&T | $295.00 | $279.89 |
| BOGBT160C | 3/6 MHz CSC | $395.00 | $374.89 |


*When 2 or more 8" disk drives are purchased with Disk 1 Controller.

### DISK CONTROLLERS

#### DISK 1 FLOPPY CONTROLLER - OUR BEST!

*Fast DMA, Soft Sector, Controls Up to Four 8" or 5¼" Single or Double Density Drives.*

| | | | |
|---|---|---|---|
| BOPD8171ACPM | A&T w/CPM 2.2 & BIOS | $670.00 | $495.00 |
| | *When purchased with two 8" disk drives only. | | $450.00 |
| BOPD8171CCPM | CSC w/CP/M 2.2 & BIOS | $770.00 | $595.00 |
| BOGBT171A | Disk 1 Controller A&T | $495.00 | $449.89 |
| BOGBT171C | Disk 1 Controller CSC | $595.00 | $550.00 |
| BOGBTCPM80 | CP/M 2.2 for Z80/8085 w/manual & BIOS 8" S/D disk | | $174.89 |
| BOGBTCPM86 | CP/M 2.2 for 8086 w/manuals & BIOS 8" S/D disk. | | $299.89 |

#### DISK 2/SELECTOR CHANNEL HARD DISK CONTROLLER

*Fast DMA 2 board set. controls 4 Shugart 4000 series or Fujitsu 2300 type drives. Includes CP/M 2.2'*

| | | | |
|---|---|---|---|
| BOGBT177A | Assembled & Tested | $795.00 | $750.00 |
| BOGBT177C | CSC | $895.00 | $850.00 |


### CMOS RAM SALE!

#### RAM 17 - 64K CMOS STATIC RAM

*12 MHz, RAM 17, 2 Watt, DMA Compatible 24 Bit Addressing*

| Part No. | Description | List Price | Our Price |
|---|---|---|---|
| BOGBTRAM17 | 64K A&T 10MHz | | $319.00 |
| BOGBT175A64 | 64K A&T 12MHz | $499.00 | $460.00 |
| BOGBT175C64 | 64K CSC 12MHz | $599.00 | $550.00 |

#### RAM 16 - 32K x 16 BIT CMOS STATIC RAM

*8 and/or 16 Bit*

*816 12 MHz, RAM 16, 32K x 16 or 64K x 8 IEEE/696 16 Bit 2 Watt. 24 Bit Addressing*

| | | | |
|---|---|---|---|
| BOGBTRAM16 | 64K A&T 10MHz | | $349.00 |
| BOGBT180A | 64K A&T 12MHz | $550.00 | $510.00 |
| BOGBT180C | 64K CSC 12MHz | $650.00 | $610.00 |


#### NEW! RAM 21 - 128K STATIC RAM

*816 RAM 21 12MHz, 128K x 8 or 64K x 16 IEEE/696 8 or 16 Bit, 1 2 Amps, 24 Bit Addressing*

| | | | |
|---|---|---|---|
| BOGBT190A | 128K A&T | $1095.00 | $ 995.00 |
| BOGBT190C | 128K CSC (816) | $1245.00 | $1125.00 |

#### M-DRIVE SOLID STATE DISK DRIVE, 3500% FASTER!!

*Not really, but the next best thing for CompuPro 8085/88 Users. Call for Details on M-Drive.*

*M-Drive requires a 6MHz CPU 8085/88 dual processor, Disk 1 DMA disk controller and System Support 1 Multifunction Board.*

| | | |
|---|---|---|
| BOGBTMD128KA | 128K of A&T memory & M-Drive Software | $1198.00 |
| BOGBTMD128KC | 128K of CSC memory & M-Drive Software | $1398.00 |
| BOGBTM0256KA | 256K of A&T memory & M-Drive Software | $2395.00 |
| BOGBTM0256KC | 256K of CSC memory & M-Drive Software | $2795.00 |

#### M-DRIVE/H HARDWARE LOGICAL DISK SYSTEM

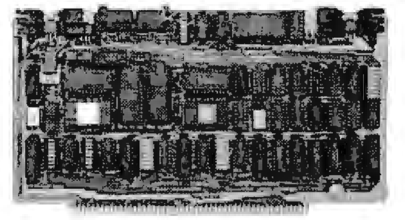
*Interfaces through two I/O ports, and runs at 10MHz. IEEE 696 compatible. Requires any CompuPro CPU and a Disk 1. Each board contains 512K of fast, low power (900mA) RAM, with parity checking.*

| | | | |
|---|---|---|---|
| 06GBT197A | M-DRIVE/H w/software, A&T | $1895.00 | $1775.00 |
| 06GBT197C | M-DRIVE/H w/software, CSC | $2095.00 | $1950.00 |

#### S-100 MAINFRAME

*110V 60Hz CVT Mainframe uses famous 20 slot CompuPro Motherboard (55 lbs.)*

| | | | |
|---|---|---|---|
| BOGBTENC20RM | 20 Slot Rackmount | $895.00 | $825.00 |
| BOGBTENC20DK | 20 Slot Desk Top | $825.00 | $760.00 |



### I/O BOARDS

#### SYSTEM SUPPORT 1 MULTIFUNCTION BOARD

*Serial port (software prog. baud), 4K EPROM or RAM provision, 15 levels of interrupt, real time clock, optional math processor*

| Part No. | Description | List Price | Our Price |
|---|---|---|---|
| BOGBT162A | Assembled & Tested | $395.00 | $359.89 |
| BOGBT162C | CSC | $495.00 | $459.69 |
| BOGBT8231 | Math Chip | | $195.00 |
| BOGBT8232 | Math Chip | | $195.00 |
| BOGBT162AM1 | A&T w/8231 Math Chip | | $490.00 |
| BOGBT162CM1 | CSC w/8231 Math Chip | | $654.89 |
| BOGBT162AM2 | A&T w/8232 Math Chip | | $490.00 |
| BOGBT162CM2 | CSC w/8232 Math Chip | | $654.89 |

#### MPX CHANNEL BOARDS

*I/O Multiplexer, using 8085A-2 CPU on board w/4K RAM*

| | | | |
|---|---|---|---|
| BOGBT166A4 | Assembled & Tested | $495.00 | $444.89 |
| BOGBT166C4 | CSC | $595.00 | $534.89 |
| | *With 16K RAM* | | |
| BOGBT166A16 | Assembled & Tested | $649.00 | $584.89 |
| BOGBT166C16 | CSC | $749.00 | $674.89 |

#### INTERFACER 1

*Two Serial I/O*

| | | | |
|---|---|---|---|
| BOGBT133A | Assembled & Tested | $249.00 | $218.89 |
| BOGBT133C | CSC | $324.00 | $289.89 |

#### INTERFACER 2

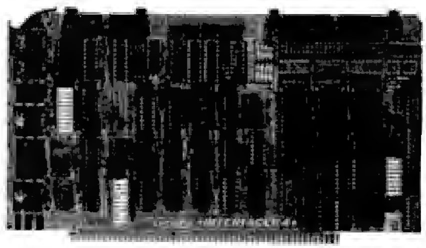
*Three parallel, one serial I/O board*

| | | | |
|---|---|---|---|
| BOGBT150A | Assembled & Tested | $249.00 | $218.89 |
| BOGBT150C | CSC | $324.00 | $289.00 |

#### INTERFACER 3

*Eight-channel multi-user serial I/O board*

| | | | |
|---|---|---|---|
| BOGBT1748A | Assembled & Tested | $699.00 | $828.89 |
| BOGBT1748C | CSC 200 hr. 8 port | $849.00 | $748.69 |
| BOGBT1745A | Assembled & Tested | $599.00 | $558.89 |
| BOGBT1745C | CSC 200 hr. 5 port | $699.00 | $628.89 |



#### INTERFACER 4

*Three Serial, 1 Parallel, 1 Centronics Parallel*

| | | | |
|---|---|---|---|
| BOGBT187A | Assembled & Tested | $395.00 | $314.89 |
| BOGBT187C | CSC | $495.00 | $414.89 |

#### SPECTRUM COLOR GRAPHICS

*Color Graphics board with Parallel I/O*

| | | | |
|---|---|---|---|
| BOGBT144A | Assembled & Tested | $299.00 | $285.00 |
| BOGBT144C | CSC | $395.00 | $375.00 |

### S-100 MOTHERBOARDS

*Active termination, 6-12-20 Slot*

| | | | |
|---|---|---|---|
| BOGBT153A | A&T 6 slot, 2 lbs. | $140.00 | $125.00 |
| BOGBT153C | CSC 6 slot, 2 lbs. | $190.00 | $155.00 |
| BOGBT154A | A&T 12 slot, 3 lbs. | $175.00 | $155.00 |
| BOGBT154C | CSC 12 slot, 3 lbs. | $240.00 | $220.00 |
| BOGBT155A | A&T 20 slot, 4 lbs. | $265.00 | $235.00 |
| BOGBT155C | CSC 20 slot, 4 lbs. | $340.00 | $310.00 |

Circle 354 on inquiry card.

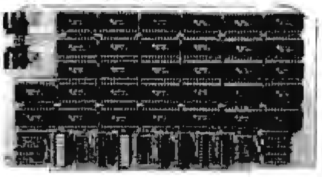
# PRIORITY ONE ELECTRONICS

## CompuPro 10 MHz 64KBytes
## S-100 STATIC RAM - ULTRA LOW POWER - ONLY 2 WATTS
## ASSEMBLED & TESTED - ONE YEAR WARRANTY
# $299*

**UNBELIEVABLE! While the rest of the industry struggles to attain 6MHz, CompuPro has effortlessly jumped from 10 to 12MHz. The power consumption (400mA; 2 Watts) is still the lowest in spite of running nearly twice as fast. Priority One Electronics has purchased the remainder of CompuPro's 10MHz boards and are offering them at these unprecedented prices.**

## RAM 17

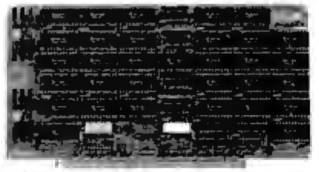
- Extremely low power consumption (2 watts typical)
- Flawlessly handles any DMA device per IEEE 696 specifications
- Single +5 Volt operation (requires no other supply voltages)
- Switch-Selectable choice of 24 address lines conforming to IEEE 696/S-100 extended addressing
- 2K windows, individually selectable at E000, E800, F000, and F800 permits use with older memory-mapped disk controllers or ROM (i.e., Morrow, NorthStar)
- Any 16K block may be disabled; dip switch selectable 2K disable from XXE000 - FFFF in 2K increments
- Switch Selectable PHANTOM disable



**SALE PRICE: $319.00 ea.**
*List Price: $599.00*
***2 or More: $299.00 ea.**
**BOGBTRAM17 Assembled & Tested**

## 816 RAM 16

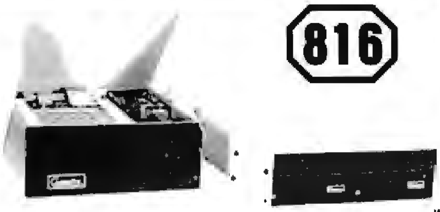
- Board addressable as one 64K x 8 or 32K x 16 block; DIP switch selectable on any 64K boundary
- Extremely low power consumption (2 watts typical)
- Meets or exceeds all IEEE 696/S-100 specifications
- Flawlessly handles any DMA device per IEEE 696 specifications
- Single +5 Volt operation (requires no other supply voltages)
- 24 bit addressing; conforms to IEEE 696 specifications
- 8 or 16 bit data transfer dependant on SXTRQ. Conforms with IEEE696 timing requirements for XTRQ and SIXTN



**SALE PRICE: $349.00 ea.**
*List Price: $650.00*
**2 or More: $325.00 ea.**
**BOGBTRAM16 Assembled & Tested**

## CompuPro SYSTEM 816
## FOR THOSE WHO DEMAND EXCELLENCE

816



The **CompuPro** family of system packages excel in high level business, industrial, and scientific computing environments.

Each package includes a unique combination of **CompuPro** system components, optimized for common single and multi-user applications. All systems run 8 and 16 bit software, and all single-user systems may be easily upgraded to multi-user opertion. The result is a computer which can grow as your computing requirements grow.

### SYSTEM 816 BASIC COMPONENTS

**HARDWARE:**
- Desktop enclosure with 20 slot motherboard
- Dual QUME DT8 floppy drives in a cabinet with power supply
- Dual CPU 8085/8088
- Memory is comprised of multiples of RAM 17 64K static memory boards
- High speed Disk 1 DMA floppy disk controller board
- System Support One board: Clock/calendar, RAM/ROM/Math processor options, RS-232 serial port, dual interrupt controllers, 3 interval timers
- All internal cables

**SOFTWARE:**
- CP/M 2.2™ and CP/M 86™ operating systems
- CompuPro M-DRIVE™ for solid state disk drive
- SuperCalc-86™ spreadsheet program by Sorcim
- dBase II™ data base software by Ashton Tate

### SYSTEM 816/A™

**System 816/A** gives superb computing today with an option for future expansion - all the way up to sophisticated multi-user operation.

### SYSTEM 816/A BASIC SPECIFICATIONS

8 bit processor: 6MHz 8085  16 bit processor: 8MHz 8088
Disk storage: Up to 2.4 Megabytes. Single or double sided, single or double density, expandable to 4.8 Megabytes.
Main memory: 128K - expandable to: 1 Megabyte
Serial ports: 4  Parallel ports: 1
Centronics/Epson ports: 1
Software: CP/M 2.2, CP/M-86, M-Drive, SuperCalc-86, dBase.
Convenience features: Clock/calendar, interrupt controllers, interval timers, and math processor option.
*Save over $1000.00 compared to all components purchased separately.*

| | | |
|---|---|---|
| BOGBTSYS816ADA | Single user system desk top, A&T | $5495.00 |
| BOGBTSYS816ADC | Single user system desk top, CSC | $6045.00 |

*(All Systems shipped Freight Collect)*

### SYSTEM 816/B™

**System 816/B** delivers state-of-the-art single user computing today, with an option for future expansion to multi-user operation.

### SYSTEM 816/B Basic Specifications:

8 bit processor: 6MHz 8085 - 16 bit processor: 8MHz 8088
Disk storage: Up to 2.4 Megabytes. Single or double sided, single or double density, expandable to 4.8 Megabytes.
Main memory: 256 K - expandable to: 1 Megabyte
Serial ports: 6
Software: CP/M 2.2, CP/M-86, M-Drive, SuperCalc-86, dBase II
Convenience features: Clock/calendar, interrupt controllers, interval timers, and math processor option.
*Save over $1800.00 compared to all components purchased separately.*

| | | |
|---|---|---|
| BOGBTSYS816BDA | Single user system desk top, A&T | $6995.00 |
| BOGBTSYS816BDC | Single user system desk top, CSC | $7795.00 |

### SYSTEM 816/C

**System 816/C** is the system of choice for firms which need superior computing power now, with the option to expand into an even more powerful system in the future. **System 816/C** supports up to three users simply by adding appropriate terminals: for more users, just add more **CompuPro** RAM and terminals.

### SYSTEM 816/C BASIC SPECIFICATIONS

8 bit processor: 6MHz 8085 - 16 bit processor: 8MHz 8088
Disk storage: Up to 2.4 Megabytes. Single or double sided, single or double density, expandable to 4.8 Megabytes.
Main memory: 384K - expandable to: 1 Megabyte
Serial ports: 9
Software CP/M 22, CP/M-86, MP/M 8-16, M-Drive, SuperCalc-86, dBase II
Convenience features: Clock/calendar, interrupt controllers, interval timers, and math processor option.
*Save over $2300.00 compared to all components purchased separately.*

| | | |
|---|---|---|
| BOGBTSYS816CDA | Multi-user system desk top, A&T | $8995.00 |
| BOGBTSYS816CDC | Multi-user system desk top, CSC | $9995.00 |

## MINICOMPUTER REGULATORS


GS SOLA ELECTRIC

The Sola Micro/Mini Computer Ultra Isolated Regulator provides instantaneous voltage regulation, and ultra isolation from both transverse and common mode noise for any type of load. It also suppresses transients, protects against overloads and serves as a portable dedicated line. It is the ultimate in AC line conditioning equipment.

### PORTADLE 120VAC 60 Hz SINGLE PHASE

| Part No. | Maximum Output VA Rating | Dimensions L x W x D (Approx.) | Approx. Shipping Weight | Price List | Price SALE |
|---|---|---|---|---|---|
| BOSLAB313070 | 70 | 12 x 6 x 6 | 10 lbs. | $196.20 | $159.00 |
| BOSLA6313114 | 140 | 12 x 6 x 6 | 18 | $257.15 | $208.40 |
| BOSLA6313125 | 250 | 14 x 8 x 8 | 31 | $305.55 | $248.05 |
| BOSLAB313150 | 500 | 17 x 9 x 9 | 47 | $424.40 | $344.00 |
| BOSLA6313175 | 750 | 17 x 9 x 9 | 60† | $541.40 | $438.80 |
| BDSLAB313210 | 1000 | 17 x 9 x 9 | 75† | $627.10 | $508.25 |
| BDSLAB313220 | 2000* | 17 x 11 x 11 | 108† | $1066.40 | $864.35 |

Output voltage is 120VAC ±3% for an input voltage of 95-130VAC
*Unit has 30 Amp twist receptacle.
Also available are Hard Wired and 50Hz models
† Shipped Freight Collect

## DIRECT CONNECT MODEM
# $79.00
### 0 - 300 BAUD
### MURA MM-100

NEW!

- 0 - 300 baud
- RS232C interface
- Full duplex
- Carrier detect indicator
- Bell 103 compatible
- Low voltage
- Originate/Answer switch selectable

| | | List Price | SALE |
|---|---|---|---|
| BOMURMM100 | 0 - 300 baud modem *(Shipping Weight: 2 lbs.)* | $99.95 | $79.00 |
| BDCNORS232BF | RS232 cable | | $19.95 |

*Cables also available for Atari, TI, Vic 20, & Timex*

MasterCard VISA
## PRIORITY ONE ELECTRONICS
9161 DEERING AVE. CHATSWORTH, CA 91311

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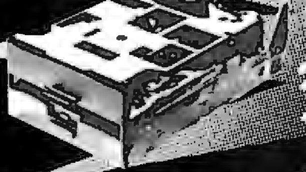

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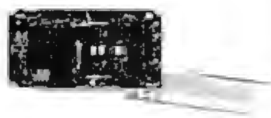

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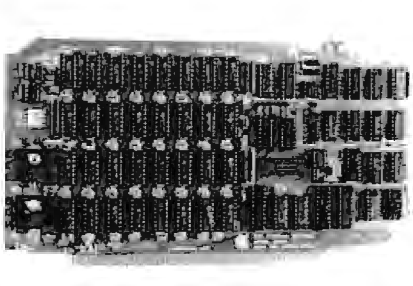

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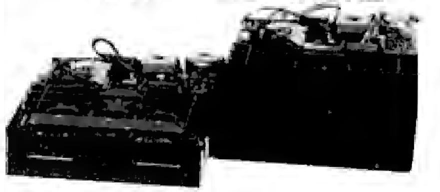

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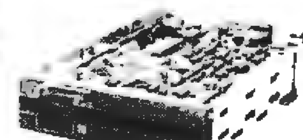

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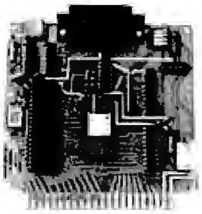

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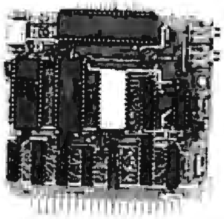

The Z8 Memory, I/O Expansion & Cassette Interface Board (Z8 Expansion Board for short) allows you to add up to 8K of additional memory plus three 8-bit parallel ports to your Z8 Basic Computer/Controller. The memory expansion will support any combination of byte wide RAM memory chips or 2716 or 2732 EPROM. The cassette interface is 300 baud Kansas City Standard (2400Hz/1200Hz).

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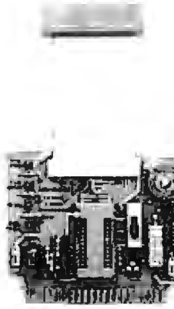

The EPROM Programmer board allows you to transfer application programs in BASIC or Assembly language directly from RAM to either 2716 or 2732 EPROMS. Requires Z8 Basic Expansion Board for operation.
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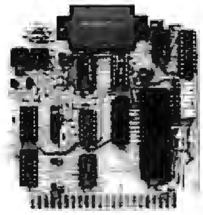

The Serial Expansion Board adds an additional RS-232C serial port to the Z8 system. It runs at 75 to 19,200 baud in all standard protocols. The 20 ma. current loop is opto-isolated for reliability and protection.

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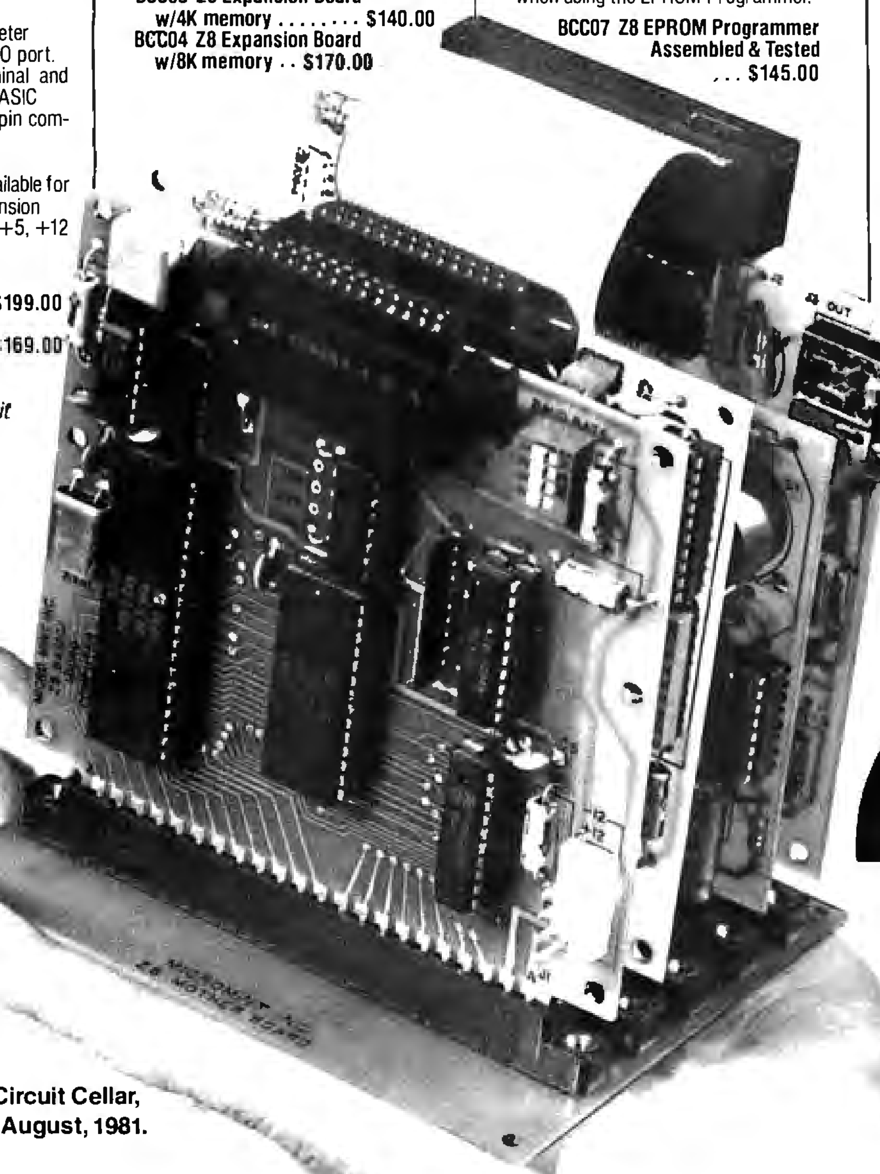

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FOR YOUR APPLE II

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* Rotron whisper fan is the quietest, most reliable on the market

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* 120 cps, 9x9 Dot Matrix
* 50% faster than EPSON
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MOUNTED ON PC BOARD
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+5 VOLT 4 AMP
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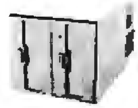

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**CCS SYSTEM 2410 . . $1995.00**

- Includes CP/M® 2.2
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**CCS 2300 System, A & T . . 1695.00**

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| 2810 CPU | *Only*—255.00 |
| 2422 Disk Controller | *Only*—330.00 |
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**Choose the System that fits your needs!** A complete computer system ready to add on a terminal and printer. All Systems include CP/M® software and system manual set. Full six-month parts and labor warranty excluding drives which carry the full O.E.M. manufacturers warranty. All **S-100-4** Systems advertised are in stock assembled and tested available for immediate delivery.

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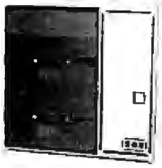

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An inexpensive but powerful system featuring a 4 slot **S-100** bus chassis with the **XOR S-100** board set; 4-MHZ Z-80 CPU ★ 64K dynamic memory ★ multi-sector mixed density disk controller ★ 2-RS232 output ports in the rear for your terminal and printer ★ 3 eight-bit parallel ports on the CPU ready to add a cable and interface to your printer ★ All above systems are in stock ★ Includes CP/M® 2.2.

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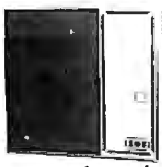

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These **S-100-4** Systems may be very small in size (9"H x 9½"W x 18½"L) but look at the size of the ATASI® 5¼" Winchester hard disks we offer!

**4 models to choose from**

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| ★ #3046 36 Megabyte* System | $4495.00 |

The above systems include a 96 TPI double sided double density 5¼" floppy as standard. The hard disk is controlled via Western Digital's controller for hard disks. Other features are the same as system at left.
*Megabyte sizes mentioned above are the available storage space after formatting.

## TAPE BACKUP

**WITH HARD DISK**

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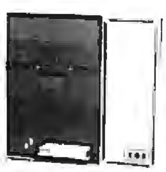

Now available through U.$ Micro Sales, the **XOR IRWIN 510 S-100-4** tape backup system with 10 megabytes of hard disk storage. Back up your hard disk on a mini-tape (we're talking 10 meg.) in less than 3½ minutes! The above system includes a 96 TPI DS/DD floppy drive and this system's modular design allows you to add a second floppy for only **$395.00**.

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| Scribble (Formatter) | 145.00 |
| (Both Mince & Scribble) | 245.00 |
| Final Word (Word Processor) | 265.00 |
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| Quickcode (Program Generator, Screen Builder for dBASE II | 250.00 |
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| FMS-80-11 | 440.00 |
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| CalcStar (Elec. Spreadsheet) | 145.00 |
| BT-80 (Rec. Retreival) | 175.00 |
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| SuperCalc | 265.00 |
| Mailman (M/L Manager) | 119.00 |
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| MBasic Compiler | 325.00 |
| CBasic 2 | 100.00 |
| CB-80 (Compiler) | 455.00 |
| Fortran-80 | 375.00 |
| PL/I-80 (Language) | 450.00 |
| Pascal MT+ (Language) | 445.00 |
| Pascal MT+ (Compiler) | 310.00 |
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| C Compiler (Language) | 215.00 |
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| Crosstalk | 160.00 |
| BSTAM | 149.00 |
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| Term II | 150.00 |

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| Smart Key | 50.00 |
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| Disk-Edit | 90.00 |

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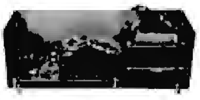

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For 2 - 8" or 5" Drives
+ 5VDC @ 4 Amps
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AC Cables for 2 Drives **$7.50**
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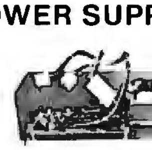

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+16VDC @ 6 Amps
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PC Board Design
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Okidata 82A 80 Column ........... 465.00
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SA801R ...... $388.00ea. Two for $379.00ea.
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**BLOWOUT SPECIAL**
Siemans 120-8 SS/DD (full 90 day warranty)... 235.00

## S-100 MOD KIT by XOR

For test or systems applications
Complete S-100 12 Slot Mainframe with Disk Drive Power Supply for 4 Drives.

SPECIFICATIONS

| Unregulated | Regulated |
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| +8V @ 30A | +5V @ 5A |
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**$225.00** Kit with 12 S-100 Bus Connectors
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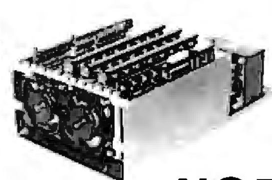
Cooling Power
4 1/8"
Low Velocity Whisper Fans
*Only* $18.00 ea.
Finger Guards $2.50 each.



**XOR S-100 MOD**

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**$1695.00**

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★ Includes CP/M® 2.2 and Manl
★ Two Separate Power Supplys
★ All Cables Provided
★ XOR S-100 Board Set
★ Dimensions only 9" x 9" x 18½"

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★★★SPECIAL OF THE MONTH★★★
**8" Dual Drive Subsytem 1.2 Meg** Includes two Siemans 120-8 SS/DD Drives, Cables, Power Supplies and Cabinet. A & T ................... *Only*—$675.00

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**$1795.00**

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★ Feather Touch Capacitance Kybrd
★ 60 Key Standard ASCII
★SDRDC Type Screen Attribute Sel
★ 8 Special Function Keys
★ Hall Intensity
★ 20 Screen Editing Keys

*COMPUTER*
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★ Includes CP/M® 2.2
★ Programmable Keyboard Set
★ 8 Slot S-100 Bus

**S-100-8 System Complete With:**
Shugart 801R Subsystem* (#S-1000-22) ... $2675.00
Shugart 851R Subsystem* (#S-1000-23) ... 2925.00
Qume DT-8 Subsystem* (#S-1000-24) ...... 2950.00
Shugart SA 400 Minis (#S-1000-25) ......... 2350.00
Complete System, No Drives (#S-1000-21).. 1795.00

**Available in Horizontal or Vertical Cabinet*

## 100 MEG! IN YOUR S-100-12*

Introducing a major breakthrough in technology... The removable cartridge disk called the **Alpha-10™**. 10 megabytes of removable storage space (14 meg unformatted) with the speed and reliability a Winchester offers. The complete system includes the **XOR Z-80** based 64K board set, the **S1-MOD** power supply/mother board, the Alpha-10™ drive (w/ 3 cartridges), sitting alongside a Shugart 851 DS/DD multi-sector floppy disk, CP/M® 2.2 software and manuals, and we'll even throw in a 6 month parts and labor exclusive warranty.

(#S1000-75) ..... *Complete* **$3995.00**

If you already own an **S-100-12** w/2 floppies buy an Alpha-10™ upgrade package. Includes Alpha-10™ cartridge drive, cartridge control board, **S-100** interface board w/all necessary cables, software and manuals. System price includes 3 10 meg cartridges. (#S-1000-80) ......... **$1995.00**

*Extra cartridges available (#M-2000-51), **$50.00**
ALPHA-10™ is a product manufactured by IOMEGA™ CORP.

Apple 8" Disk Controller Card ....... $395.00
ZVX4 Dual Density, Single & Double Sided - Auto Boot
Disk 2 + 2 Single Density Single or Dual Sided
SVA ........... 300.00

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| **Novation** - DCAT 300 Baud Direct Con. Ans/Orig. . | 165.00 |
| **Novation** - AUTOCAT Auto/Ans/Orig Direct Con.. | 235.00 |
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Circle 437 on inquiry card.

# Unclassified Ads

**FOR SALE:** Ohio Scientific CBP-DF, color video system, keyboard with numeric keypad, 48K RAM, dual 8-inch floppy disks, serial modem port, serial printer port, Centronics printer port, home control port, tone output, DAC output, and two joysticks. Lots of software, including UCSD Pascal. Complete documentation (service manual, technical notes, and more). Also, Okidata ML80 printer and acoustic modem included. $3700 or best offer. Scott Ellsworth, 4260-1 Wilmington Dr., Camp Springs, MD 20335, (301) 599-1847.

**FOR SALE:** Commodore PET 2001 with 8K bytes of memory and internal cooling fan. Lots of documentation, schematics, instruction and learning manuals, programs, games, and miscellaneous hardware. Excellent condition, hardly used (another potential hobby that time didn't permit). $500 or best offer. James Yu, 25 Clarkson Farm Dr., Chesterfield, MO 63017, (314) 227-1094 evenings, 342-2625 days.

**FOR SALE:** 16K Interact home computer, 1500-bps built-in cassette player, connects to your color TV, complete with Level 2 BASIC and Microchess program tapes, two joysticks, and a service manual. Worth over $800, will sell for $350 or best offer. Apple Tree Press Inc., Attn: Tom Stevens, 120 South Liberty, Rushville, IL 62681, (217) 322-6558 between 1 p.m. and 5 p.m.

**WANTED:** SwTPC MP-R EPROM programmer. B. K. Erickson, 304 Southfield Dr., Fayetteville, NY 13066.

**FOR SALE:** A STD-Bus Z80 system consisting of a Mostek MDX-CPU-II Z80 board, MDX-PIO board, MDX-SIO board, and a Prolog #7702 2716 EPROM card (16K). This is contained in a blue cabinet measuring 14 by 21½ by 12 inches with a key-locking door. The power supply produces −12V,1A; two 5V,5A supplies. The motherboard has 9 sockets with room for 16. Removed from service, less than two years old, and in excellent working order. Documentation included. Makes a great base for CP/M. $500 firm. Billy Garrett, 5515 West Market St., Apt. 801, Greensboro, NC 27409, (919) 852-0323.

**WANTED:** Norwegian user group is looking for used ZX81s and other compatible equipment. Also, looking for used disk drives and Percom Doubler for TRS-80. Will swap or sell programs for both ZX81 and TRS-80. Ski ZX-group, c/o Jan Otto Reberg, Bjerkelundveien 15, 1400 Ski, Norway.

**WANTED:** Information for interfacing the Polyphormic system with the Trendata 1000 printer. Any information at all on the Trendata printer would be most helpful. Dr. James F. Calhoun, Dept. of Psychology, Psychology Clinic, University of Georgia, Athens, GA 30602.

**FOR SALE:** IBM PC components and software: two 5¼-inch disk drives, $200. Game Control Adapter, $45. Peach Tree accounting: General Ledger, Account Receivable, Account Payable, $550. Everything is brand new. T.L. Dawson, 11908 Broad Oaks A, Austin, TX 78759, (512) 258-6117.

**WANTED:** To correspond with Sinclair ZX81 (16K) users who wish to exchange software and information, or who know of a Sinclair bulletin board system. Steve Ketler, 46225 Strathcona Rd., Chilliwack, British Columbia V2P 3T1, Canada.

**FOR TRADE:** Want to swap programs for the TRS-80 Color Computer. Send your list of programs and I'll send mine. James L. Payette, Box 250, Echo Bay, Ontario P0S 1C0, Canada.

**FOR SALE:** TI-743 KSR terminal and Novation Cat modem. Allows telephone direct-connect communications at 300 bps. Terminal has full ASCII keyboard and 80-column thermal printer. Modem is compatible with Bell 103 orig/ans. Rarely used, in excellent shape. Best offer. Randy Miyazaki, 797 Sweetwater Way, San Jose, CA 95133, (408) 738-8330.

**FOR SALE:** Versafloppy disk controller, S-100 bus-compatible. Operates with single-density, single- or double-sided 5¼- or 8-inch drives: $150. Tarik Isani, 601 Alleghany St., Blacksburg, VA 24060, (703) 953-1490.

**WANTED:** Need information on Digital's PDP-8 and interfacing to a cassette tape player/recorder. Art G. Granzeier III, 2860 B Sabre Dr., Tyndall AFB, FL 32403.

**FOR SALE:** California Computer Systems 2210A system (4MHz Z80, 64K, DS/DD floppy disk controller, CP/M 2.2), Televideo 920C terminal, two Oume DT-8 drives in enclosure with power supply and fan. Best offer for any or all. Steve Dirickson, 33 Granite St. #205, New London, CT 06320, (203) 444-7348.

**WANTED:** Golf-handicap program listing, hints, assistance, etc. Trying to develop a program for my Osborne 1 and my golf association. Loren Martindale, 1746 West 25th Lane, Yuma, AZ 85364.

**FOR SALE:** Rockwell System 65 Microcomputer Development System, 32K RAM, 1 MHz. Includes 16K static RAM module, PROM programming module, OS2 and OS3 operating systems with 6502 assembler, editor, diagnostic, and debug/monitor packages, plus User 65 host and buffer modules for in-circuit emulation. All documentation, factory serviced, and ready to go. Cost $8840, new in 9/81. Yours for $3000 firm. Dennis Neff, 26712 Calle Maria, Mission Viejo, CA 92691, (714) 855-9585.

**WANTED:** High school student needs used or surplus computer equipment. Can use anything from tapes and disks to drives and monitors. Nels Bruckner, 36823 Jasper-Lowell Rd., Jasper, OR 97401.

**WANTED:** Information on IMSAI 8080 kit. My kit is incomplete. I am a beginner computer hobbyist and would like to finish the kit. Any help would be appreciated. Also, some issues of Kilobaud Microcomputing for sale. J. Richard Laredo, 3211 West Rohmann Ave., Peoria, IL 61604, (309) 673-7854.

**WANTED:** Engineering student would like to purchase a 10-MHz, or better, oscilloscope; M68000 single-board computer; PCB manufacturing equipment; databooks and manuals. If you have (but are not using) any of this equipment, make me an offer. Tim Nye, 443 Simcoe St., Amherstburg, Ontario N9V 1N4 Canada.

**FOR SALE:** Heath H-19A video terminal assembled and tested. Complete documentation and schematics. Priced much lower than Zenith Z-19 yet completely compatible. Suitable for use with any RS-232C modem or computer with serial output. Hugh Henriques, 2416 Vails Gate Heights Dr., New Windsor, NY 12550, (914) 565-3926.

**FOR SALE:** O-bus backplanes, H9270 (4 by 4), H9281-8B (2 by 8), and H9281-8C (2 by 12). Would like $100 each, but will consider all offers. Bob Gordon, POB 394, Burlington, VT 05402, (802) 985-2911.

**FOR SALE:** Apple Integer BASIC firmware ROM card. This card has the old monitor ROM which contains instruction trace, single-step facilities, and 16-bit multiply-and-divide instructions: $100. Mark L. Engel, 345 Black Rock Ave., New Britain, CT 06052, (203) 229-0077.

**FOR SALE:** Sinclair ZX81 with 16K, manual, cassette cord, power cord, and TV connector; $150 value, first $125 takes all. J. Mcmanus, 102 Brookside Rd., Darien, CT 06820, (203) 655-6568.

**FOR SALE:** S-100 boards: 8K Godbout Econoram II static-memory board, 8K Logos I static-memory board. Both assembled and in excellent condition: $60 each. Stanley Lee, 164 Fallswater Road NE, Calgary, Alberta T3J 1B3, Canada, (403) 259-8440.

**FOR SALE:** Centronics Micro printer with four extra rolls of paper: $150. Intel SDK-85 System Design Kit: $100. Vector rack-mount card cage with Compupro 6-slot motherboard: $100. CCS Floating Point Math Card for Apple: $200. Keith Sharman, 42 Rossmere Close SE, Medicine Hat, Alberta T1B 2J8 Canada, (403) 526-0594.

**WANTED:** A small to medium computer system for nonprofit educational organization. Needed for fund raising and bookkeeping. Any donation would be fully tax deductible. Will consider anything. Mike Robinson, Kansas City Capital, Route #1, Waverly, MO 64096, (816) 493-2285.

**WANTED:** Someone to program (burn) Signetics Prom #82S115. I can supply chip plus program on 5V-2716 or paper tape. Sid Tallman, University of Miami, Tritium Lab, 4600 Rickenbacker Causeway, Miami, FL 33149.

**FOR SALE:** BYTE, first issue to present, 13 volumes bound in blue buckram; 1982 issues unbound: $300 or best offer. Kilobaud Microcomputing, first issue to present, 10 volumes bound in brown buckram; 1982 issues unbound: $275 or best offer. Possible trade for Apple hardware. A. Osroff, 6774 Sunny Brae Dr., San Diego, CA 92119, (714) 461-6573.

**FOR SALE:** Commodore PET 2001 series with 8K RAM, Betsi interface board, 24K Expandoram memory board, Kimsi-Plus power supply, and a cassette with several programs including Space Invaders, Checkers 3.0, and Dunjonquest—Temple of Apshai. Best offer over $500. Donald Burden, Rt. 3, Box 219, Floyds Knobs, IN 47119.

**FOR SALE:** Netronics Elf II with kluge board, 4K RAM board, three 86-pin gold-edge connectors, tiny BASIC on cassette, full BASIC in EPROM, and Giant board. Also, Netronics ASC II encoded keyboard, video-display board, and RF modulator. Also, Emerson cassette recorder and homebrew power supply. Full documentation included. Complete operating system in excellent condition, $350 or best offer. Will sell separately. John Mills, 52 Audubon St., New Britain, CT 06053, (203) 229-3370.

**FOR SALE:** Apple package: 48K Apple II Plus, two disk drives, 16K Apple language card, Hayes Micromodem II, Mountain CPS serial/parallel card with clock, and four boxes of disks. Software: BASIC, Pascal, Visicalc, Visiterm, DOS 3.3, DOS toolkit, Peachtree Accounting System for CP/M (A/R, A/P, G/L, Payroll), all manuals included. Plus, a free used Dataproducts matrix printer not hooked into system yet, but works. Complete package: FOB $3800. Art Manzo, 1130 Hopkins Ave., Redwood City, CA 94062, (415) 367-8833.

**WANTED:** Replacement keyboard for Commodore PET Model 2001. Symbols have worn off the old calculator-style keys. Mark Zimmermann, 219 Dale Dr., Silver Spring, MD 20910, (301) 565-2166.

**WANTED:** Need any DECtape controller (preferably for PDP-9/15) DEC M boards, etc. for PDP-15. Will trade DEC A, B, G, R, W series boards, empty DEC racks, power supplies, etc. Also for trade or sale one new DL11W I/O port for PDP-11s. Looking for other users of DEC machines, we have running PDP-7, 8, 9, 15, and people scrapping their antique DEC equipment. Dave Razler, 33A Clubhouse Rd., Storrs, CT 06268, (203) 429-0054.

**FOR EXCHANGE:** Want computer equipment: printers, displays, hard-disk systems, software, etc. in exchange for oak furniture. Vern Blanchard, POB 445, Ramona, CA 92065, (714) 789-6149.

# Unclassified Ads

**FOR SALE:** Storage Oscilloscope, Tektronix Model 7834 with 7A19, 7A26, 7B80, 7B85, 7D15, as well as Solder/Desolder PPS 100A by Page. Sean Hegna or Ann Thagard, 235 East Bayfront, Balboa Island, Newport Beach, CA 92662, (714) 673-3383.

**FOR SALE:** Persci 277 dual-disk drive. Fastest 8-inch floppy-disk drive on the market. Functions as two conventional drives. 1.8-ms track-to-track seek time. Voice-coil servo positioner: $400. Robert Morein, 1570 Arran Way, Dresher, PA 19025, (215) 628-8684.

**FOR SALE:** Two Percom data separators: $20 each. Cashier's check or postal money order. Construction Engineering Inc., 125 Irving St., POB 2154, Framingham, MA 01701.

**NEEDED:** Someone to modify Radio Shack's Mailing List II program for use with extra disk drives. Joe Flores, 4247 North Arica Ave., Rosemead, CA 91770, (213) 287-2195.

**FOR SALE:** Datel 30 printer: IBM Selectric mechanism, serial input, needs work. $300 or best offer. Jeff Spirer, 3530 Henry Hudson Parkway, Bronx, NY 10463, (212) 796-6060, 10 a.m. to 3 p.m.

**WANTED:** Protocol Converter. I need to communicate with IBM 2780 bisynchronous protocol through an asynchronous RS-232C serial port. I need a Black Box Catalog A/S-2 protocol converter or equivalent. Jim Hutchins, 3713 Forest Lane, Garland, TX 75042, (214) 272-5431.

**FOR SALE:** DECwriter II Model LA 36: Complete with Omnitec modem. Not currently in use. Best offer. Peter B. Roll, (516) 671-5100.

**WANTED:** Correspondence from anyone who has had experience using the Phasestore 5075 system, manufactured by California Micro Computer Company, in conjunction with an IBM 50, 60, or 75 electronic typewriter. W.J. Buchanan, 11421 Key West Dr. NE, Albuquerque, NM 87111.

**FOR SALE:** Digital Group Z80 with 62K, 256 by 256 graphics board (8K), audio-cassette board, eight parallel ports, and four RS-232C serial ports. Quad Phi-Deck drive with controller, disk-drive controller board (no drives), real-time clock/interrupt board, P.A. printer, full ASCII keyboard, and Sanyo 9-inch monitor. Also, Oasis 5.3, Phimon, Image, and more. $2000 or best offer. Tommy S. Davis, Rt. 1 Box 61, Driggs, ID 83422, (307) 353-2578.

**FOR SALE:** IBM Selectric I/O terminal and ball in working condition: $275 (needs character adjustment). Oscilloscopes, Hewlett-Packard dual trace: $250. Tektronix, dual- and quad-trace, dual-writing beam: $295. DEC 11/05 cabinet with power supply, sockets, and fans as supplied by DEC: $295. Televideo Model 912, like new: $495. Core memory system in cabinet made by Fabritek for DEC PDP-11 computers: make an offer. Microfiche reader manufactured by Recordak: $85. Also, have many DEC module boards. Murray Marcus, 918 Rockmont Court, Orlando, FL 32804, (305) 299-4229.

**FOR SALE:** Ohio Scientific Challenger 4 personal minicomputer with OS65D operating system, 32K processor memory, two 5¼-inch disk drives, and a Microline 80-cps dot-matrix printer; includes 20 disks, software, and games: $200 or best offer. Also have #33 Teletypewriter: $200 or best offer. Stella Ellis, POB 233, Westchester, IL 60153, (312) 345-2770.

**WANTED:** Programming job to work on at home. I am an electrical engineer with 3 years' experience in micro software, 2½ years in micro hardware, and 2½ years in other digital hardware. I have a Sphere and TRS-80 Model I with disk, but am willing to buy more equipment (like an IBM PC) if needed. Charles Skeldon, 5119 Irving Ave. N, Minneapolis, MN 55430, (612) 588-9088, after 6 p.m.

**WANTED:** Exchange sailboat design: theory and navigation programs in BASIC or Pascal. Brent Farler, 10810 East 33rd Court, Tulsa, OK 74145.

**WANTED:** Individual who uses computers for stock market investment decisions would like contact with any user clubs in the Louisville, Kentucky area. Also, with individuals using computer-assisted forecasting for any market. This includes subscribers to The Granville Market Letter, The Professional Investor, and other financial advisories. W.C. Gaines, 1814 Lafontenay Court, Louisville, KY 40223, (502) 244-0756.

**FOR SALE:** Teletype Model 43 printing terminal with a Multitech acoustic modem: $800. Brian Keller, 1801 Pomme Rd., Arnold, MO 63010, (314) 296-6230.

**FOR SALE:** SwTPC 4K Memory Boards, $35 each or all five for $150. Would consider trade for Percom LFD Disk Controller, with Smoketran and complete documentation. Richard Carreras, (505) 298-9187.

**FOR SALE:** ASR-33 Teletype. Distributor checked. Good condition. Used in bug book experiments as typewriter printer/paper punch. ASR manual included: $175. Pay shipping on delivery. G. Pilant, 1332 Mass., Joplin, MO 64801, (417) 623-9991.

## BOMB

## BYTE's Ongoing Monitor Box

| Article # | Page | Article | Author(s) |
|---|---|---|---|
| 1 | 26 | Build the ECM-103, an Originate/Answer Modem | Ciarcia |
| 2 | 34 | The Enhanced VIC-20, Part 2: Adding a 3K-Byte Memory Board | Swank |
| 3 | 44 | A User's View of COMDEX | Pournelle |
| 4 | 56 | The Promise of Perpendicular Magnetic Recording | Johnson |
| 5 | 68 | New Developments in Floppy Disks | Moran |
| 6 | 86 | Optical-Memory Media | Rothchild |
| 7 | 110 | Will Removable Hard Disks Replace the Floppy? | Sarisky |
| 8 | 122 | The Winchester Odyssey, From Manufacturer to User | Toreson |
| 9 | 130 | Building a Hard-Disk Interface for an S-100 Bus System, Part 1: Introduction | Cruce, Alexander |
| 10 | 152 | NAPLPS: A New Standard for Text and Graphics, Part 2: Basic Features | Fleming |
| 11 | 190 | MP/M II | Schmitt |
| 12 | 218 | User's Column: Sage in Bloom, Zeke II, CBIOS Traps, Language Debate Continues | Pournelle |
| 13 | 247 | Project Nebula | Carlson |
| 14 | 248 | Legionnaire | Williams |
| 15 | 251 | Omega Race for the VIC-20 | Wszola |
| 16 | 256 | Quickcode | Green |
| 17 | 262 | A Faster Binary Search | Larson |
| 18 | 282 | Hayes's Stack Smartmodem | McEntire |
| 19 | 295 | Data Collection with a Microcomputer | Kelly |
| 20 | 310 | Build This Memory, Part 1: How to Construct a Low-Cost Memory with 4116 Memory Devices | Spitzer |
| 21 | 331 | A Peek into the IBM PC | Field |
| 22 | 389 | Keywords in a Fuzzy Context | Smith |
| 23 | 418 | ROTERP: An Interpretive Language for Robot Control | Liming |
| 24 | 436 | Using SOUND Arguments for High-Precision RTTY | Persson |
| 25 | 453 | Binary-Format Number Storage on the Apple II Disk | Eyes |

### Part 2 Is Number 1

Steve Ciarcia won the December BOMB contest with the second part of "Build the Circuit Cellar MPX-16 Computer System." He will receive the $100 kitty. Second place goes to Jerry Pournelle for his User's Column "A Slew of Languages, a Slap at Documentation, and a Curse at Keyboards." This honor brings with it a $50 purse. Chris Crawford won third place for sharing his experience in game design in the article "Design Techniques and Ideals for Computer Games."

# Reader Service


Inquiry No. Page No.

118 1st NATIONAL COMP. 228, 229
2 800 SOFTWARE 157
3 A.S.T.RESEARCH 240, 241
4 AB COMPUTERS 523
5 ABACUS DATA INC. 231
482 ACTION COMPUTER 290
8 ACTIVE ELECTRONICS 382
7 ADDMASTER CORP. 522
8 ADV.COMP.PROD. 538, 539
* ADV.DIGITAL CORP. 81
149 ADV.LOGIC SYSTEMS 181
10 ADV.SYS.CONCEPTS 514
12 ADVANCED COMP.TECH. 526
* ALF PRODUCTS, INC. 88
13 ALL ELECTRONICS CORP. 508
14 ALPHA BYTE COMP.PROD. 54, 55
15 ALPHA BYTE COMP.PROD. 315
17 ALSPA COMP.SYS. 373
18 ALTOS COMP.SYS. 188, 189
19 AMANUENSIS 202
20 AMDEK CORP. 59
21 AMER.SMALL BUSN.COMP. 473
22 AMER.SQUARE COMP. 158
493 ANATRON 354, 355
23 ANUDATA 526
25 APPARAT INC. 167
26 APPLE COMPUTER INC. 168, 169
28 APPLEWARE, INC. 516
29 APPLIED ANALYTICS 246
* APPLIED CREATIVE TECH.INC. 22
30 APPLIED SOFTWARE TECH. 131
31 ARBA 350
474 ARCHIVES INC. 471
32 ARTIFICIAL INT'L.RESRCH. 514
33 ASHTON-TATE 208, 209
34 ASPEN SFTW.CO. 78
* AT & T LONG LINES 388
35 ATLANTIC CABINET CORP. 514
36 ATLANTIS COMP.SERV. 512
37 ATSUKO COMPUTING INT'L. 526
38 AUTOCONTROL INC. 526
39 AUTOMATED EQUPMNT. 401
40 AVOCET 347
41 AXLON 61
42 AXLON 257
43 B&B ELECTR. 522
* BARGAIN BOARDS 524
44 BASF SYSTEMS 153
45 BAUSCH & LOMB INSTR.SYS. 199
46 BAUSCH & LOMB INSTR.SYS. 199
47 BAY TECHNICAL ASSOC. 308
125 BEAR COMP. 458
48 BELL, JOHN ENGR. 509
49 BELLE DE ST.CLAIRE 481
50 BHRT 227
506 BHRT 424
51 BI-COMM SYSTEM 475
53 BISON PROD INC. 294
54 BISON PROD INC. 294
58 BLAT RESRCH. & DEVELOP. 481
59 BMC SYSTEMS, INC. 125
60 BOTTOM LINE, THE 197
52 BRS 105
62 BT ENTERPRISES 518
63 BUSINESS MANAGER 253
* BYTE BACK ISSUES 473
* BYTE BOOK CLUB 416, 417
* BYTE BOOKS 205
64 BYTE INDUSTRIES 471
* BYTE PUBL.INC. 458
65 BYTEK COMP. SYS. 384
66 BYTEWRITER 58
67 C-SYSTEMS 526
68 CAB-TEK, INC. 480
69 CALIF. DATA CORP. 512
* CALIF. DIGITAL 540, 541
* CALIF.MICRO.COMP. 469
71 CAVERLY'S INC. 522
72 CCM INC. 522
73 CDEX CORP. 171
74 CDR SYSTEMS 518
75 CENTENNIAL SOFTWARE 132
76 CHECK-MATE 476
77 CHECKS-TO-GO 144
78 CHIPS & DALE 526
79 CHRISLIN INDUSTRIES 521
80 CLAFF, WILLIAM J. 524
81 COGITATE 512
483 COLORADO CHIPS 508
494 COLORADO COMP.PERIPH. 459
82 COLUMBIA DATA PROD. 225
83 COLUMBIA NATIONAL 176
84 COMMUNICAL, INC. 244
85 COMMUNICATION CABLE 528
86 COMMUNICATIONS ELECTR. 525
365 COMPATIBLE/QT 306

Inquiry No. Page No.

500 COMPAQ 191
136 COMP. ENTREPRENEUR 245
87 COMP.COMPNTS.UNLTD. 519
88 COMPONENTS EXPRESS 475
89 COMPUADD 514
90 COMPUADD 514
91 COMPUCART 223
92 COMPUPRO/GODBOUT 200, 201
* COMPUPRO/GODBOUT 338, 339
93 COMPUPRO/GODBOUT 444, 445
94 COMPUSERVE 280, 281
358 COMPUSHACK 285
360 COMPUSHACK 364, 365
95 COMPUTER APPARATUS 530
96 COMPUTER CHANNEL 529
97 COMPUTER DISCOUNT PROD. 527
470 COMPUTER EXCHANGE 108, 109
471 COMPUTER EXCHANGE 108, 109
472 COMPUTER EXCHANGE 108, 109
101 COMPUTER HORIZON 524
102 COMPUTER INNOVATIONS 72
103 COMPUTER LEARNING TREE 220
104 COMPUTER MAIL ORDER 398, 399
105 COMPUTER PERIPH.INC. 69
106 COMPUTER PERIPH.INC. 237
107 COMPUTER PLUS 482
11 COMPUTER PUBLISHING CO. 174
108 COMPUTER SOLUTIONS 309
109 COMPUTER SPCLTIES. 149
* COMPUTER WAREHOUSE 259
110 COMPUTERLINE INT'L-A 325
111 COMPUTERLINE INT'L-A 378, 379
112 COMPUTERLINE INT'L-B 506
113 COMPUTERS & MORE 524
114 COMPUTERS WHOLESALE 139
115 COMPUVIEW PROD.INC. 63
116 CONCORD COMP.PROD. 530
117 CONCURRENT CORP. 62
* CONNECTICUT MICRO COMP. 430
120 CONTINUUM 160
121 CONTROL C SOFTWARE 104
122 COST PLUS COMP. 522
* COUGAR MT. SOFTWARE 234
124 CPU SHOP, THE 515
126 CREATIVITY UNLTD. 489
127 CROMEMCO CII, 1
128 CROMEMCO 2
130 CSCS 508
503 C.S.D. INC. 242
131 CUESTA SYSTEMS 516
132 CUSTOM COMP.TECH. 124
* CYBERNETICS INC. 289
134 D.C.POSTAGE 528
135 DAMAN 528
137 DATA EXCHANGE 512
217 DATA MAIL 333
138 DATA MANAGEMENT SYS. 518
497 DATA MASTER 459
139 DATA SOURCE SYS.CORP. 283
140 DATASOUTH COMP.CORP. 335
141 DATASOUTH COMP.CORP. 420
142 DECISION RESOURCES 383
143 DESIGNWARE INC. 489
144 DIGISOFT 187
341 DIGISOFT COMP. 414
145 DIGITAL DIMENSIONS 446
146 DIGITAL MARKETING 6
148 DIGITAL RESEARCH 33
149 DIGITAL RESEARCH 181
150 DIGITAL RESEARCH 343
* DIGITAL RESEARCH COMP. 517
152 DISCOUNT SOFTWARE 155
* DMA 411
154 DOKAY COMP.PROD.INC. 534, 535
* DOW JONES SFTW. 177, 178, 179
157 DUAL SYS.CONTROL CORP. 211
158 DYNACOMP 518
159 DYSAN CORP. 9
160 DYSAN CORP. 344, 345
244 EASTERN ENTERPRISES 475
162 ECONOMY PERIPHERALS 516
163 ECOSOFT 469
164 EDGE MICROSYSTEMS 514
165 EDMUND SCIENTIFIC CO. 477
169 ELECTRONIC CONTROL 462
172 ELLIS COMPUTING 147
173 EMERGING TECH.CONSLT. 488
* EMPIRICAL RESRCH.GRP. 154
166 EMS 510
167 EMS 520
175 ENERCOMP 438
176 ENGINEERING SPECIALTIES 148
177 EPSON AMERICA 99
178 EPSON AMERICA 408, 409
179 ESSEX PUBLISHING 479
180 EXPOTEK 222

Inquiry No. Page No.

181 EXTENDED PROCESSING 508
486 FACIT/DATA ROYAL 15
182 FORMULA INT'L. 349
183 FOX & GELLER INC. 375
184 FRANKLIN COMP.CORP. 367
430 FROBCO 522
185 G-H COMPUTER SYS. 512
186 GARDEN OF EDEN COMP. 508
187 GENERAL SOFTWARE INC. 212
188 GENIE COMP.CORP. 336, 337
189 GIFFORD COMP. SYS. 203
189 G&G ENGINEERING 203
192 GILTRONIX INC. 520
193 GTCO CORP. 137
194 GTEK INC. 286
195 HANDWELL CORP. 516
196 HAYES MICROCOMP.PROD. 46, 47
198 HAZELTINE CORP. 341
119 HEATH COMPANY 304, 305
200 HEWLETT-PACKARD 84, 85
478 HOBB-Y-TRONIX INC. 529
201 HOFFMAN COMP. PROD. 510
202 HUMAN DESIGN SYSTEM 87
484 I.B.C. 19
485 I.B.C. 19
496 I.C.E. CORP. 459
204 I.T.M. 432
205 IBM CORP. 120, 121
206 IDE CORPORATION 433
207 IMS INTERNATIONAL 123
208 INCOMM 414
504 INFORMATION REDUCTION RESEARCH 496
210 INFOSCRIBE 76
221 INNOVATIVE COMM. 520
501 INNOVATIVE RESEARCH 242
211 INSIGHT ENTERPRISES 510
212 INSTITUTE-SCTF.ANALYSIS 514
213 INT'L.MICRO SYS. 363
214 INT'L.MICRO SYS. 421
215 INTEGRAL DATA SYS. 279
216 INTEGRAND 412
218 INTELLIGENT ARTEFACTS 333
219 INTERACTIVE MICROWRE. 384
220 INTERACTIVE STRUCT. 79
222 INTERCONTN.MICROSYS. 313
223 INTERDATA SYSTEMS INC. 524
224 INTERTEC DATA SYS. 11
225 IPEX INT'L. 524
226 IRONSIDES COMP. CORP. 133
227 ISA CO.LTD. 162
228 J.C.SYSTEMS 20
229 JADE COMP.PROD. 531
230 JADE COMP.PROD. 532, 533
231 JAMECO ELECTR. 542, 543
232 JDR MICRODEVICES 550, 551
233 JDR MICRODEVICES 552, 553
234 JRT SYSTEMS 319
236 JVB ELECTRONICS 516
237 K & D ELECTRONICS 520
238 KERN PUBLISHING 243
239 KEY TRONICS CORP. 35
240 KRELL SOFTWARE 404
241 LABORATORY MICROSYS. 510
242 LANIER BUSN.PROD. 460, 461
243 LEADING EDGE PROD. CIII
245 LEHMANN & ASSOC. 524
246 LIGO RESEARCH INC. 173
247 LOGIC PROGRAMMING ASSOC. 516
248 LOGICAL DEVICES 380
249 LOGICAL MICROCOMPUTER 303
487 LOGO COMP.SYS. 73
250 LOMAS DATA PRODUCTS 405
491 LOTUS DEVELOPMENT 266, 267
251 LYBEN COMP.SYS. 528
252 LYCO COMPUTER 431
* MACMILLAN BOOK CLUBS 353
253 MACROTECH INT'L. 235
254 MAILCOMP INC. 427
256 MANNESMANN TALLY 165
* MARTIN MARIETTA CORP. 428
259 MARYMAC INDUSTRIES 264
260 MAXELL DATA PRODUCTS 135
168 MBI 528
* McGRAW-HILL/BYTE BOOK CO. 469
261 MEDIA DISTRIBUTING 300
262 MEDIA DISTRIBUTING 301
263 MEGA CO. 472
264 MEMORY MERCHANT 239
265 METAMORPHIC SYS.INC. 17
266 METASOFT CORP 422
267 MFJ ENTERPRISES INC. 415
269 MICRO AGE COMP.STORE 221
270 MICRO BUSN.WORLD 270

Inquiry No. Page No.

271 MICRO LOGIC 518
273 MICRO MANAGEMENT SYS. 443
277 MICRO MART 472
274 MICRO MIDWEST 514
275 MICRO MINT 371
481 MICRO MINT 549
502 MICRO MINT 242
276 MICRO SCI 18
278 MICRO WORKS, THE 271
268 MICROADE 528
279 MICROCOMP.BUSN.IND. 254, 255
281 MICRODYNAMICS 520
282 MICROHOUSE 12, 13
283 MICROPERIPH.CORP,THE 522
284 MICROPROCESSORS UNLTD. 528
* MICROSOFT 117
* MICROSOFT 232, 233
287 MICROTECH EXPORTS 406
288 MICROWARE 510
289 MINI MICRO MART 381
290 MK RESEARCH 512
292 MONITOR DYNAMICS 512
255 MONUMENT COMP.SERV. 236
* MOORE BUSN.FORMS 226
295 MORROW DESIGNS 83
296 MORROW DESIGNS 434, 435
297 MOUNTAIN VIEW PRESS 403
299 MULLEN COMP. PROD. 111
300 MUSYS 477
301 NABU COMMERCIAL TERMINALS 219
302 NEBS 284
303 NEC HOME ELECTR.USA 159
304 NEC HOME ELECTR. USA 161
305 NEC HOME ELECTR. USA 163
309 NEC INFORMATION SYS. 112, 113, 114, 115
310 NEC INFORMATION SYS. 351
* NETRONICS 558
311 NETWORK CONSULTING CORP. 102
312 NEW GENERATION SYS. 182
492 NEW MEDIA GRAPHICS 516
136 N.K. INC 489
313 NON-LINEAR SYS. INC. 92
314 NORTH HILLS CORP. 510
315 NORTH HILLS CORP. 518
316 NORTHWEST MICROSYS. DESGN. 522
317 NOVATION 466
318 NOVATION 467
319 NOVELL DATA SYS. 57
* NRI SCHOOLS ELECTR. DIV. 385
320 OASIS SYSTEMS 66, 67
321 OMEGA MICROWARE INC. 291
322 ORANGE MICRO 140
323 ORANGE MICRO 141
325 ORGANIZATIONAL MANAGEMENT SYS. 510
326 ORTHOCODE GROUP 214
327 ORYX SOFTWARE 413
* OSBORNE COMPUTERS 145
329 OSM COMPUTER 23
* OWENS ASSOC. 426
330 P.R.I.C.E. 510
331 PACIFIC EXCHANGES 508, 512, 516, 520, 524, 526
337 PALOMAR COMP.EQUIP. 386, 387
338 PAN AMERICAN H.H.C. INC. 482
339 PANASONIC H.H.C. 150, 151
340 PARTRAN CO., THE 528
342 PERCOM DATA 7
343 PERIPHERAL MARKETING INC. 518
344 PERSONAL COMP.SYS. 299
345 PERSONAL SYS.TECHN. 143
346 PHASER 65
347 PICKLES & TROUT 156
498 PION INC. 317
348 PLUS & PLUS CO, LTD. 258
349 POPCOM 261
350 PRACTICAL PERIPH. 24, 25
351 PRAGMATIC DESIGNS 128
352 PRINCETON GRAPHIC SYS. 37
354 PRIORITY ONE 544, 545
355 PRIORITY ONE 546, 547
356 PRIORITY ONE 548
361 PROGRAMMERS SFTW. EX. 288
363 PURCHASING AGENT,THE 94
364 QANTEX DIV. 91
365 QT/COMPATIBLE 306
366 QUADRAM CORP. 216, 217
367 QUADRAM CORP. 423
368 QUARK ENGINEERING 265
369 QUASAR COMPANY 89
461 QUBIE DIST 95
462 QUBIE DIST 185
370 QUME CORP. 96, 97
372 RACET COMPUTES LTD. 471
373 RADIO SHACK CIV
374 RANA SYSTEMS 42, 43
375 RCA 361
376 RCS INC. 488
324 RED BARON 292, 293
377 RED GATE PUBL.CO. 90
378 RIXON 324
379 ROLAND CORP. 101


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## Reader Service


| Inquiry No. | Page No. |
|---|---|
| 410 | RTL PROGRAMMING AIDS 508 |
| 381 | S&W COMPUTER SUPPLY 472 |
| 382 | S-100 INC. 274 |
| 383 | SAGE COMP.TECH. 287 |
| 488 | SATURN SYSTEMS 129 |
| 384 | SCIENTIFIC ENG. 520 |
| 476 | SCION CORP 5 |
| 477 | SCION CORP 5 |
| * | SCOTTSDALE SYSTEMS 377 |
| 386 | SEARS GROUP, THE 524 |
| 388 | SEIKOSHA CORP. 107 |
| 389 | SIERRA DATA SCIENCES 39 |
| 390 | SIERRA DATA SCIENCES 402 |
| 391 | SIGEN CORP. 260 |
| 392 | SIGMATEK 520 |
| 393 | SILVER-REED AMERICA, INC. 136 |
| * | SINCLAIR RESEARCH 419 |
| 394 | SLR 508 |
| 395 | SLUDER 480 |
| 396 | SOFTCORP INT'L. 186 |
| 235 | SOFTWARE ASSOC. 238 |
| 397 | SOFTWARE BANC 359 |
| 398 | SOFTWARE PUBLISHERS 528 |
| 399 | SOFTWARE TECHNIQUE 510 |
| 400 | SONICS MICRO SYS. 75 |
| 473 | STANDARD SOFTWARE 312 |

| Inquiry No. | Page No. |
|---|---|
| 401 | STAR COMPUTER 207 |
| * | STAR LOGIC 442 |
| 499 | STAR MICRONICS 369 |
| 403 | STEMMOS LTD. 198 |
| 404 | STREET ELECTR. CORP. 48 |
| 405 | STSC INC. 407 |
| 406 | SUNTRONICS 536, 537 |
| 407 | SUPERSOFT 195 |
| 408 | SYNCOM SYSTEMS 52 |
| 409 | SYQUEST TECH. 119 |
| 380 | SYSTEMED 512 |
| 411 | SYSTEMS STRATEGIES 260 |
| 412 | TAB BOOKS 465 |
| 413 | TALLGRASS TECH. 82 |
| 414 | TARBELL ELECTR. 486 |
| 415 | TATUM LABS 447 |
| 357 | TAVA CORP 269 |
| 359 | TAVA CORP 330 |
| 416 | TAYCO BUSINESS FORMS 518 |
| 417 | TDK ELECTRONICS 175 |
| 419 | TECH-DATA CORP. 526 |
| 420 | TECMAR INC. 263 |
| * | TEKTRONIX INC. 71 |
| 421 | TELECON SYSTEMS 40 |
| 422 | TELETEK 51 |
| 423 | TERMINALS TERRIFIC 450 |

| Inquiry No. | Page No. |
|---|---|
| * | TEXAS COMP.SYS. 437 |
| 425 | TEXAS INSTRUMENTS 183 |
| * | TEXAS INSTRUMENTS 272, 273 |
| 426 | TEXPRINT 516 |
| 387 | TIMESAVER SYS. 526 |
| 427 | TIMESHARING DEV. INC. 410 |
| 479 | TINNEY, RBT GRAPHICS 213 |
| 480 | TINNEY, RBT GRAPHICS 252 |
| 428 | TOSHIBA AMERICA INC. 429 |
| 495 | TOPAZ 93 |
| 429 | TOTAL ACCESS 425 |
| 153 | TRAKSTOR 513 |
| 489 | TRILOG 448 |
| 490 | TRILOG 449 |
| 432 | TRISOFT 358 |
| 433 | TRISTAR DATA SYS. 400 |
| 435 | TSK ELECTR.CORP. 77 |
| 436 | TYCOMP COMPANY 447 |
| 437 | U.S. MICRO SALES 554, 555 |
| 438 | U.S. ROBOTICS 118 |
| 439 | U.S. EXCHANGE 514 |
| 440 | ULTRA MAGNETICS TECHN. 215 |
| 441 | UNITED SFTW.CO. 103 |
| 442 | VECTRIX 41 |
| 443 | VIDEX 21 |
| 444 | VINTAGE BOOKS 473 |

| Inquiry No. | Page No. |
|---|---|
| 445 | VISUAL TECH,INC. 127 |
| 446 | VOTRAX 277 |
| 449 | WADSWORTH ELECT.PUBL. 275 |
| 450 | WASHINGTON COMP.SERV. 236 |
| 451 | WASHINGTON COMP.SERV. 511 |
| 452 | WE SOFTWARE 518 |
| 453 | WESPER MICROSYSTEMS 479 |
| * | WESTICO INC. 49 |
| 454 | WESTWARE 357 |
| 455 | WESTWARE 357 |
| 456 | WHITESMITHS LTD 50 |
| 457 | WIN/MILL RESEARCH INC. 508 |
| 458 | WINTEK CORP. 520 |
| 459 | WINTERHALTER & ASSOC. 477 |
| 460 | WORDTECH SYSTEMS 64 |
| 464 | WW COMPONENT SUPPLY 441 |
| 465 | WYSE TECHNOLOGY 193 |
| 466 | X COMP 329 |
| 467 | YANG ELECTRONIC 522 |
| * | ZILOG COMP. SYS. 53 |


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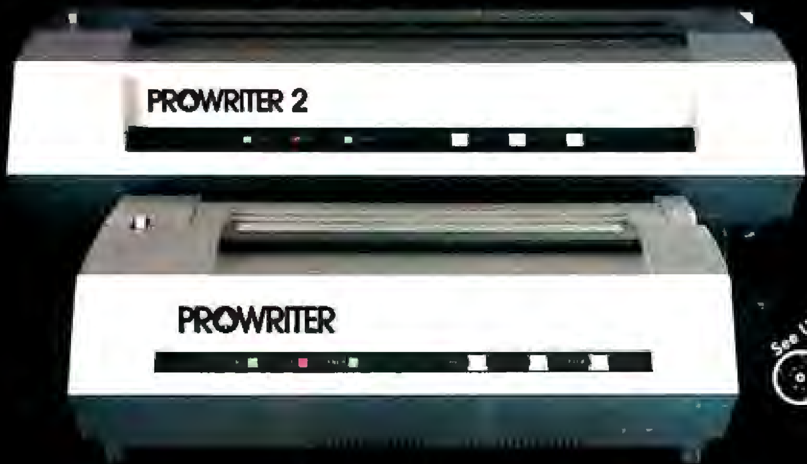


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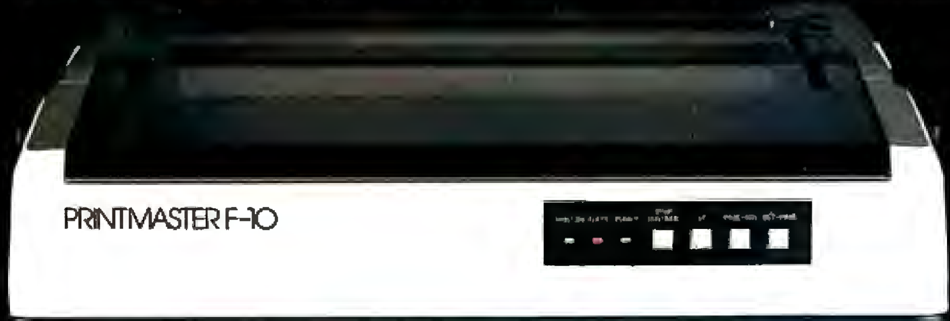


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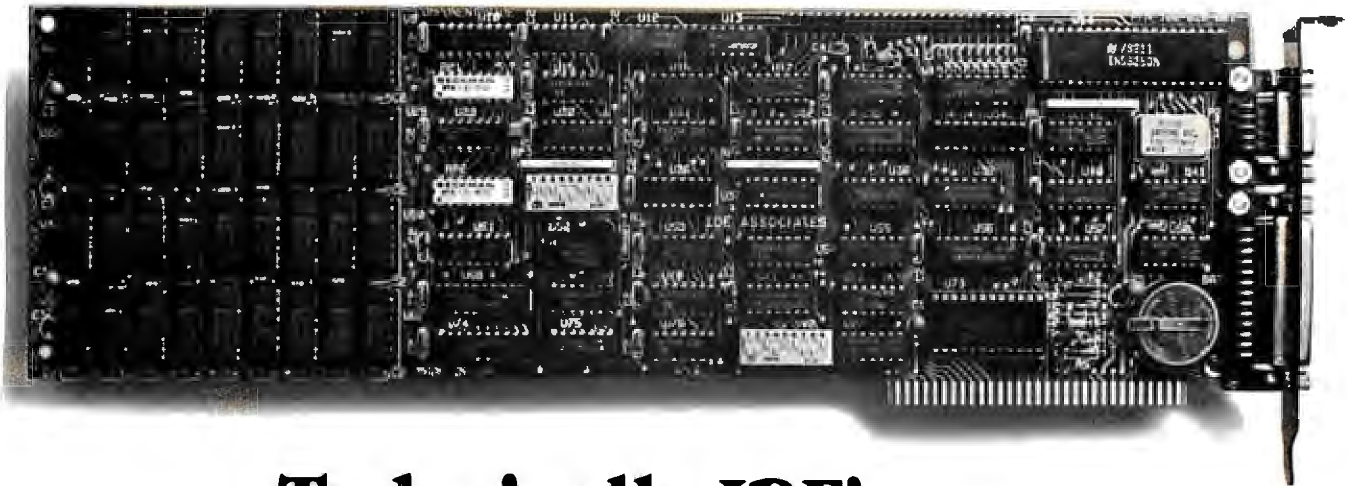

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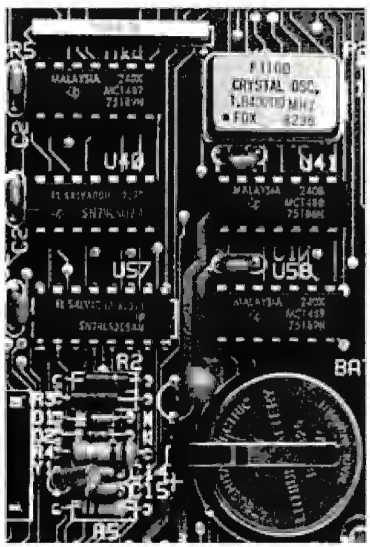

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