BYTE®

the small systems journal

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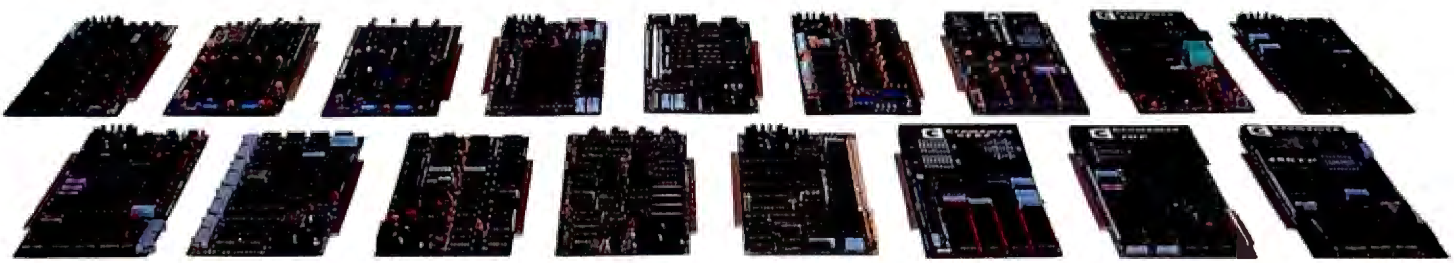
HUMAN FACTORS ENGINEERING

IXO TELECOMPUTING SYSTEM

A new small computer that won't limit you tomorrow

New Cromemco System One shown with our high-capability terminal and printer.



Expandability

Here's a low-priced computer that won't run out of memory capacity or expandability halfway through your project.

Typically, computer usage tends to grow, requiring more capability, more memory, more storage. Without a lot of capability and expandability, your computer can be obsolete from the start.

The new System One is a real building-block machine. It has capability and expandability by the carload.

Look at these features:

- **Z80-A processor**
- **64K of RAM**
- **780K of disk storage**
- **CRT and printer interfaces**
- **Eight S-100 card slots, allowing expansion with**
  - **— color graphics**
  - **— additional memory**
  - **— additional interfaces for telecommunications, data acquisition, etc.**
- **Small size**

GENEROUS DISK STORAGE

The 780K of disk storage in the System One Model CS-1 is much greater than what is typically available in small computers. But here, too, you have a choice since a second version, Model CS-1H, has a 5″ Winchester drive that gives you **5 megabytes** of disk storage.

MULTI-USER, MULTI-TASKING CAPABILITY

Believe it or not, this new computer even offers multi-user capability when used with our advanced CROMIX* operating system option. Not only does this outstanding O/S support multiple users on this computer but does so with powerful features like multiple directories, file protection and record level lock. CROMIX lets you run multiple jobs as well.

In addition to our highly-acclaimed CROMIX, there is our CDOS*. This is an enhanced CP/M† type system designed for single-user applications. CP/M and a wealth of CP/M-compatible software are also available for the new System One through third-party vendors.

COLOR GRAPHICS/WORD PROCESSING

This small computer even gives you the option of outstanding high-resolution color graphics with our Model SDI interface and two-port RAM cards.

Then there's our tremendously wide range of Cromemco software including packages for word processing, business, and much more, all usable with the new System One.

ANTI-OBSOLESCENCE/LOW-PRICED

As you can see, the new One offers you a lot of performance. It's obviously designed with anti-obsolescence in mind.

What's more, it's priced at only $3,995. That's considerably less than many machines with much less capability. And it's not that much more than many machines that have little or nothing in the way of expandability.

Physically, the One is small — 7″ high. And it's all-metal in construction. It's only 14⅛″ wide, ideal for desk top use. A rack mount option is also available.

CONTACT YOUR REP NOW

Get all the details on this important building-block computer. Get in touch with your Cromemco rep now. He'll show you how the new System One can grow with your task.

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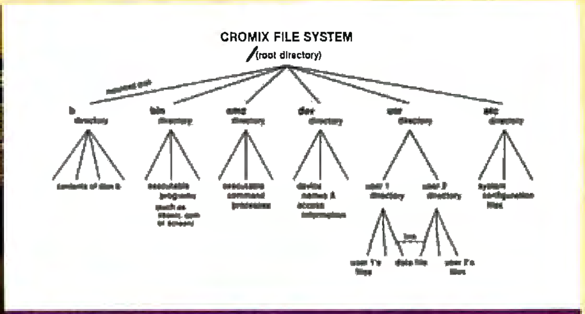

CROMIX*— Cromemco's outstanding UNIX†– like operating system

CROMIX is just the kind of major development you've come to expect from Cromemco. After all, we're already well-known for the most respected software in the microcomputer field.

And now we've come up with the industry's first UNIX-lookalike for microcomputers. It's a tried and proven operating system. It's available on both 5″ and 8″ diskettes for Cromemco systems with 128K or more of memory.

Here are just some of the features you get in this powerful Cromemco system:

- Multi-user and multi-tasking capability
- Hierarchical directories
- Completely compatible file, device, and interprocess I/O
- Extensive subsystem support

FILE SYSTEM

One of the important features of our CROMIX is its file system comprised of hierarchical directories. It's a tree structure of three types of files: data files, directories, and device files. File, device, and interprocess I/O are compatible among these file types (input and output may be redirected interchangeably from and to any source or destination).

The tree structure allows different directories to be maintained for different users or functions with no chance of conflict.

PROTECTED FILES

Because of the hierarchical structure of the file system, CROMIX maintains separate ownership of every file and directory. All files can thus be protected from access by other users of the system. In fact, each file is protected by **four separate access privileges** in each of the three user categories.

TREMENDOUS ADDRESS SPACE, FAST ACCESS

The flexible file system and generalized disk structure of CROMIX give a disk address space in excess of one gigabyte per volume — file size is limited only by available disk capacity.

Speed of access to disk files has also been optimized. Average access speeds far surpass any yet implemented on microcomputers.

'C' COMPILER AVAILABLE, TOO

Cromemco offers a wide range of languages that operate under CROMIX. These include a high-level command process language and extensive subsystem support such as COBOL, FORTRAN IV, RATFOR, LISP, and 32K and 16K BASICs.

There is even our highly-acclaimed 'C' compiler which allows a programmer fingertip access to CROMIX system calls.

THE STANDARD O-S FOR THE FUTURE

The power and breadth of its features make CROMIX the standard for the next generation of microcomputer operating systems.

And yet it is available for a surprisingly low $595.

The thing to do is to get all this capability working for you now. Get in touch with your Cromemco rep today.

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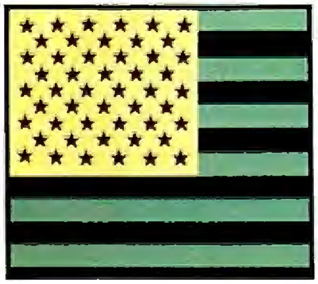

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In This Issue

As computer technology continues to make inroads into our lives, the man/machine interface assumes greater importance in the total system design. Human-factors engineering, our theme this month, is the discipline concerned with the need for friendly computers. Our cover, photographed by Paul Avis, features a new, user-friendly product, the IXO Telecomputing System. For a detailed description of this hand-held terminal see Chris Morgan's editorial.

To help you make your systems user-friendly, we present "A Human-Factors Style Guide for Program Design" by Henry Simpson and "Designing the Star User Interface" by Dr. David Canfield Smith, Charles Irby, Ralph Kimball, Bill Verplank and Eric Harslem. In "A Human-Factors Case Study Based on the IBM Personal Computer," Robert G. Cooper Jr., Paul Thain Marston, John Durrett, and Theron Stimmel discuss the Personal Computer from a human-factors perspective. Steve Ciarcia demonstrates how to use infrared systems, William Barden Jr. presents a collection of projects for the TRS-80 Color Computer, Gregg Williams treats us to a sneak preview of Epson's new portable computer, and Bob Katz reviews the Hewlett-Packard Interface Loop.

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Editorial

A Revolution in Your Pocket

by Chris Morgan, Editor in Chief

Imagine a terminal that costs about $500 and can:

- access the Source, Compuserve, Dow Jones, or other remote database or computer services
- automatically handle the protocols to access these services so that you need only enter your password to be online
- have a full ASCII character set
- have a built-in modem with autodialer and full- and half-duplex capability
- be able to emulate other terminals
- have an uninterruptible power supply
- fit in your pocket
- operate from a battery

Sounds amazing, doesn't it? Yet it's not fantasy; the product does exist. It's called the IXO Telecomputing System (hereafter referred to as the Telecomputer), and it's featured on our cover this month.

Photo 1: *The IXO Telecomputing System. It's a complete pocket terminal with built-in modem and autodialer that will sell for about $500. The phone number displayed is IXO's Access Center.*

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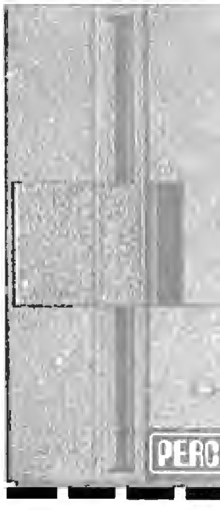

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Editorial

I first saw the Telecomputer nearly a year and a half ago when I visited its inventors, husband-and-wife team Bob and Holly Doyle, at their Cambridge-based company, Macrocosmos. The Doyles conceived of a portable but powerful computer terminal, and with the aid of electronic-design wizards Michael Suchoff and Andy Barber, they built a limited number of prototypes. The Doyles later joined forces with former Mattel Electronics president Jeff Rochlis to form IXO Inc., the company that markets the Telecomputer. I received one of the prototypes for testing last year and I've been using it ever since. I'm still amazed at the features packed into its exceedingly small package.

This month's theme is human-factors engineering, and the IXO Telecomputer is an excellent example of a terminal designed with the user in mind. The Telecomputer, which will be generally available this summer, has a lot to offer in addition to its human factoring. It has, for instance, a sophisticated security-protection system and innovative, compact circuitry. I'll touch on these topics, but my main objective here is to discuss the implications of IXO's design philosophy.

Photo 2: *The Telecomputer is powered by a built-in Polaroid Polapulse flat battery.*

Photo 3: *The FCC-registered Telecomputer is designed to attach directly to a phone using a standard modular jack. When in use, the terminal draws all of its power from the phone line.*

Editorial

Photo 4: *Four peripherals for the Telecomputer (clockwise from upper left): an acoustic interface (not the same as an acoustic coupler because the modem circuitry is already contained inside the terminal); the RS-232C interface, a video interface; and a 20-column printer.*

The Telecomputer marks the beginning of a whole new "genus" of computer products: no-compromise portable computers that are truly user-friendly. Let's take a closer look at its features.

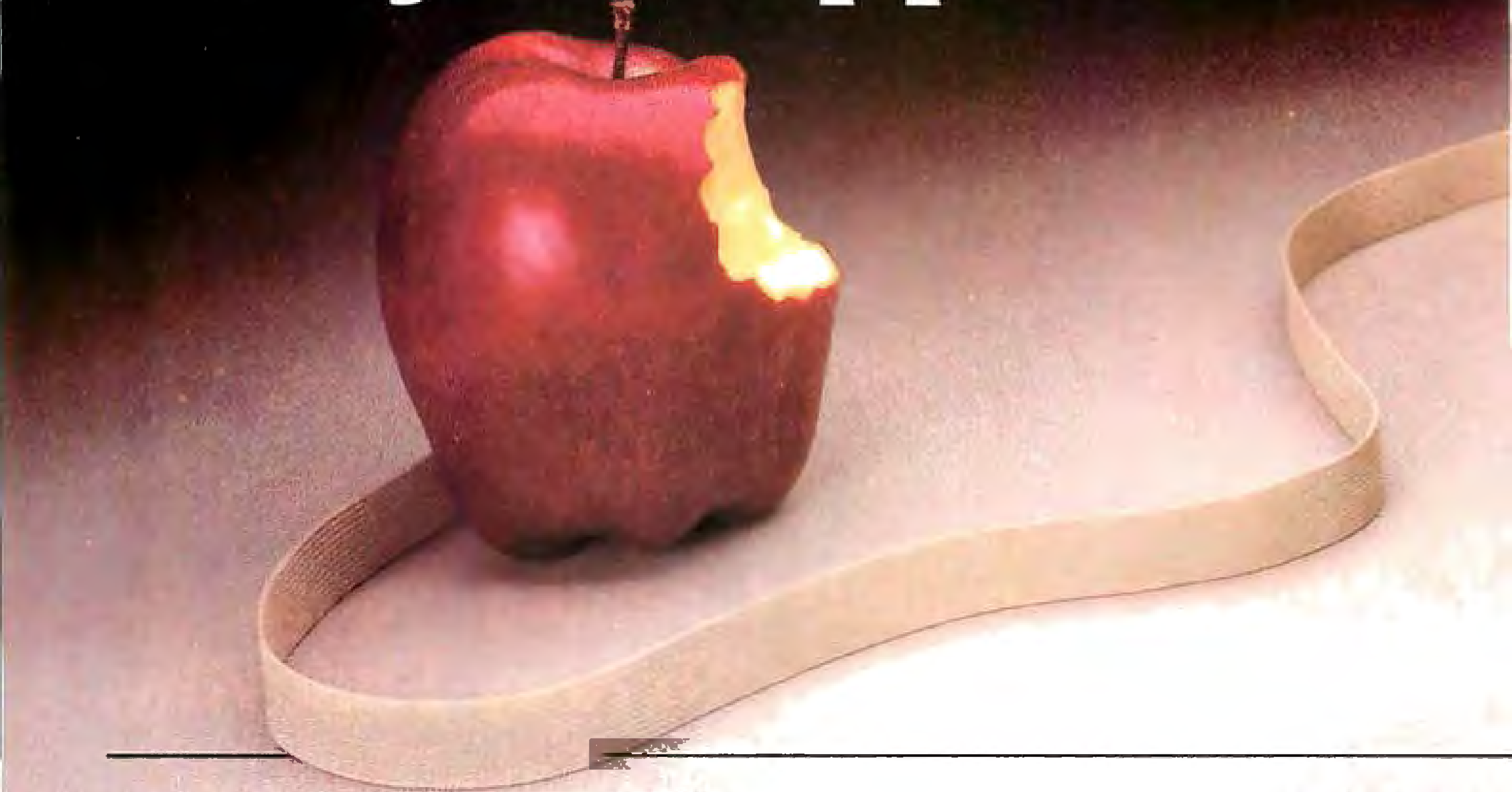
The Telecomputer comes in a small plastic case containing densely packed CMOS circuitry and a Polaroid Polapulse flat battery to drive it (see photo 2). The heart of the design is an NEC 4-bit microprocessor with 1K bytes of CMOS RAM (random access read/write memory).

The keyboard, which is slightly too small for extended typing sessions, contains several unusual keys to help the naive user (and sometimes the not-so-naive user). These include the YES, NO, DON'T KNOW, HELP, and PHONE keys. They are brightly colored to attract your attention. The HOLD, SLOW, FAST, REPT, GO BACK, CLR CHAR, and CLR ENTR keys are dark blue. The usual BREAK, ESCAPE, and CONTROL keys are gray. The blue and gray colors tend to keep the more complex keys in the background in order not to distract or intimidate the beginner.

A Session with the Telecomputer

After you remove the Telecomputer from its box and turn it on, you then connect it to your telephone line by plugging your telephone cord's modular jack into the female socket at the back of the terminal (see photo 3). At this point the Telecomputer begins to draw all of its power from the phone line while the phone is "off hook," i.e., while the phone is in use (a clever arrangement by the machine's designers). Since the phone companies require all phone devices to draw 20 milliamps to prove that the devices are using the lines anyway, this becomes a perfect source of power for CMOS circuitry! In fact, telephone devices are allowed to draw 5 microamps while "on hook," so it becomes theoretically possible to trickle-charge a battery.

The disk drive that puts more byte into your Apple.



Introducing the first totally compatible Floppy Disk Drive.

Rana Systems has designed a totally compatible disk drive for Apple, that's better than Apple's. A high density, high capacity disk drive and controller that offers a myriad of features Apple never thought of. Unique advantages that get the maximum efficiency out of your existing Apple II® hardware and software.

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We're a step ahead of Apple because we have a faster step.

Holding more information is even more valuable when you can get it faster. The Rana System track positioning mechanism is engineered to access three to four times faster track to track, with greater accuracy than Apple's. Our disk drive offers safeguards like a stall provision to protect spin motor burnout,

an advanced write protect feature that keeps your information where you put it, and an energy saving device that "powers down" when your disk drive is taking a break.

We even took a bite out of Apple's price.

Our most popular model is 25% more economical per byte than Apple's, providing you with maximum performance, superior cost efficiency, and totally compatible styling. It also comes with a free diskette containing all the optional software and supports you'll need to enhance the capacity and performance. And it's all backed up with an efficient service support system, and a full 90 day warranty.

The Rana System Floppy Disk Drive. Just plug it into your Apple and all those delicious extra bytes will be yours.

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Editorial

After you hit the ON switch, the unit's liquid-crystal one-line display begins presenting a series of questions in menu format. The first query you see is "ACCESS CENTER?" The best way to learn about the unit is to dial the Access Center, a remote computer resource center maintained by IXO to service Telecomputer customers. You simply type in the telephone number and the unit automatically dials it. The Telecomputer senses whether your phone line is Touch-Tone or rotary-dial and sends out the appropriate signals. Once online, you can experiment with the simulated services offered by the Access Center, including a checkbook-balancing program, a travel-agency simulation that demonstrates booking airline flights, a television guide database to help you find TV show times, and so on. The main purpose of this exercise is to illustrate the advantages of services using plain English dialogue back and forth between the user and the computer. In time, real versions of such computer services will be available. When connected to the Access Center, you can always press the HELP key if you get stuck and get a more detailed explanation of what to do next. You can also press the DON'T KNOW key if in doubt as to the correct reply to the computer's questions. (If only the existing databases had these features!) The Telecomputer's designers have been trying for some time to convince the people who run the databases to adopt these user-friendly approaches. Let's hope they do.

The most important feature of the Access Center is that it can download protocols for The Source, Compuserve, and Dow Jones into your terminal's RAM. (These were the three services available at the time I evaluated the unit; more will undoubtedly be added later.) Downloading protocols takes about 30 seconds and needs to be done only once because the information is permanently stored in the terminal as long as the battery holds up, which is at least a year—longer if you're "off-hook" frequently. Once you're connected, the Access Center asks you to type in a password that you must use in all future dealings with the Center and also asks for your name.

I was surprised the second time I called the center to find that it greeted me with "HELLO CHRIS. PASSWORD?" It's hard to convey the excitement of seeing a message like this on a miniature terminal connected directly to your phone line. Future shock, indeed.

The next time I used the terminal, I decided to get on the Dow Jones database and analyze some stocks. I powered up the Telecomputer, entered my password, and it immediately asked "DOW JONES?" The downloading had worked! Out of curiosity I pressed NO and the terminal stepped to the next item: "THE SOURCE?" NO again. "COMPUSERVE?" NO. "MANUAL ACCESS?" (The latter mode lets you dial any general database or computer by entering a telephone number.) I cycled around to "DOW JONES?" again and pressed YES. (Incidentally, you can type "yes", "Y", hit the YES key, or the ENTER key to tell the terminal yes. The designers have obviously thought of every possibility to

Circle 333 on inquiry card. →

James Martin, data-processing and futures expert, offers the following predictions about the role of the pocket terminal ten years in the future. The following excerpt is from his book, *Telematic Society: A Challenge for Tomorrow* (Prentice-Hall, 1981).

Pocket terminals mushroom in sales and drop in cost as fast as pocket calculators did a decade earlier. Most people who carried a pocket calculator now have a pocket terminal. The pocket terminal, however, has an almost endless range of applications. It can access many computers and data banks via the public data networks. The pocket terminal becomes a consumer product (as opposed to a product for businesspeople) on sale at supermarkets, with human factoring that is simple and often amusing. The public regard it as a companion which enables them to find good restaurants, display jokes on any subject, book airline and theatre seats, contact medical programs, check what their stockbroker computer has to say, send messages, and check their electronic mailbox.

Public data networks are ubiquitous and cheap, and accessible from every telephone. Their cost is independent of distance within most countries.

keep naive users from getting stuck.)

You've probably gone through the usual tedium of identifying your terminal, hitting carriage returns, and going through all the usual make-work dialogue required to get onto databases. The Telecomputer eliminates all that. Once the Access Center downloads its protocols to your terminal, your terminal automatically completes the dialogue with, say, Dow Jones. You need only enter your password and you're instantly online. It takes only a couple of seconds. If you regularly access several databases or electronic mail services, you'll appreciate not having to memorize a lot of annoying protocols. This sort of elegant engineering will help popularize computers.

Another useful feature is the pair of speed-control keys, labeled SLOW and FAST, that control the speed at which text scrolls across the display by sending XON and XOFF control characters to the remote computer. Every time you press one of the keys the display incrementally slows down or speeds up. You can slow the display down to transcribe messages or speed it up to quickly scan through material.

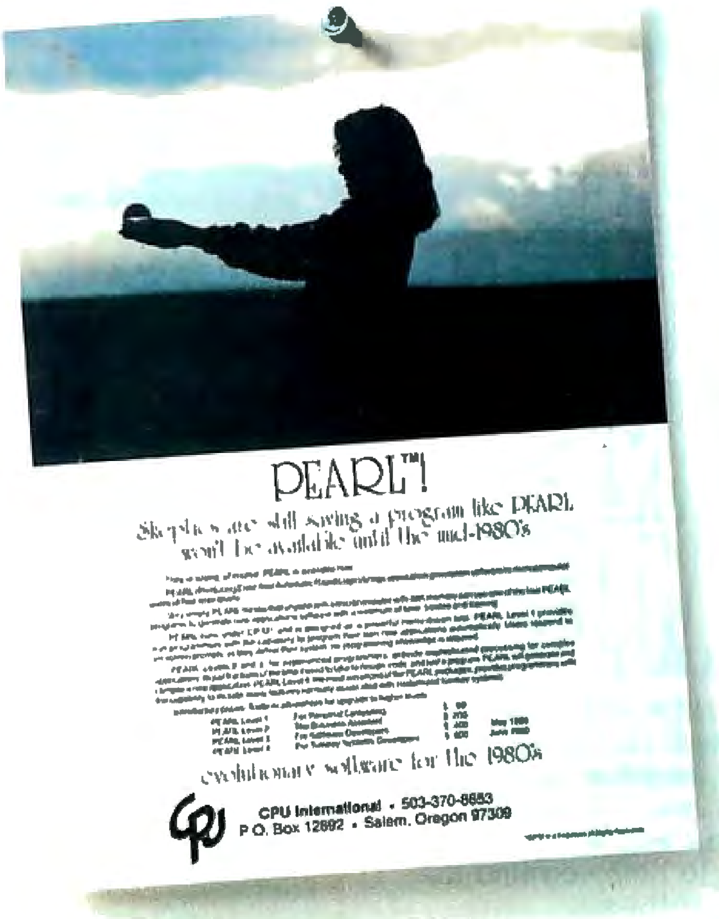
There's little more to add about the operation of the Telecomputer—it's that simple. The built-in autodialer remembers your local Tymnet and Telenet numbers after you enter them once. It even shuts itself off if not used for eight minutes, first giving you an audible warning. The machine is truly "goof-proof."

Peripherals for the Telecomputer (see photo 4), including an acoustic interface (not the same as an acoustic coupler because the modem circuitry is already contained inside the Telecomputer—therefore the price is lower); a 20-column thermal dot-matrix printer made by Olivetti; an RS-232C interface; and a video interface designed for use with both TV sets and video monitors, will be available by July.

Design Philosophy

It's no surprise that the Telecomputer takes a human-factors approach. Its designers come from strong backgrounds in consumer electronics. Bob and Holly Doyle have invented more than a dozen computer toys, including Parker Brothers' best-selling Merlin and Stop Thief. While at Mattel Electronics, Jeff Rochlis supervised the production of the Intellivision personal computer and hand-held games such as Brain Baffler (to which the Telecomputer bears a coincidental resemblance). Rochlis's four design goals were to make the Telecomputer cheap (it will sell for approximately $500 to $550); portable; easy to use (meaning both ease of access to databases and ease of use via plain English dialogues); and secure.

That last point deserves a volume in itself. Someone once said that today's electronic mail services are more like "postcard" services because the security measures are so lax that any half-competent programmer can crack them. The Telecomputer's three-way security keying system goes a long way to correcting this situation. The user



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CPU International is the former name of Relational Systems International. PEARL (Producing Error-Free Automatic Rapid Logic) has a password, the terminal has a built-in password (unknown to the user), and the host computer has a password. (This is the proposed standard. Presently, only the IXO Access Center computer adheres to it.) The host computer combines its password with both the user's password and the terminal password in complex, randomized ways to make it virtually impossible for someone else to emulate your terminal with another terminal or computer, even if he knows your password. It's an admirable approach to securing data. I hope manufacturers will pay serious attention to it.

The Telegraphic Age

Rochlis likes to compare today's computer age to the telegraphic age of the nineteenth century. In many ways, he says, the technique of talking to computers is still in its "telegraphic" stage. Back when the telegraph was the chief means for long-distance communication, telegraph operators were required as intermediaries for all transactions. Unfortunately, they "spoke" a different language than their clients: Morse code. Today, most of the public at large do not know how to operate computer terminals and must rely on computer operators. The latter are in effect the most expensive "peripherals" of all. To bring computing power to the people, we must supply them with cheap *and* easy-to-use computers and terminals.

There is a trend this year toward the development of briefcase-sized computers and terminals. (See the report about Epson's new HX-20 portable computer on page 104.) And that's just the beginning: watch for a series of new, small computers from both America and Japan. But size and cost alone will not guarantee the success of these machines with the general public. Human engineering has to be our paramount concern in the personal-computing field; the IXO terminal is a major step in this direction.

* * *

Piracy Addendum

Many people have asked me to comment on the issues of software piracy raised in Jerry Pournelle's January column. (See "User's Column: Operating Systems, Languages, Statistics, Pirates, and the Lone Wolf," January 1982 BYTE, page 132.) My only comment is that, while I sympathize with many of the opinions expressed by Jerry's "mad friend" Mac Lean, my overall attitude toward copying software has not changed since I spoke out in the May 1981 editorial. Nevertheless, I think it's important to air opposing viewpoints in BYTE. The debate is healthy and being overly dogmatic serves no useful purpose. I'd like to hear more from readers about this issue.■

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Letters

The Missing LINC

I keep seeing the "personal computer era" referred to as having begun in the mid-1970s, as if it required the microchip to make it possible to design hardware and software for a single-user computer. But there are important antecedents to this, dating back twenty years, and they were not hand-held calculators so much as proper computers with analog interfaces and mass storage—namely, lab computers.

In 1962, at MIT's Lincoln Labs, Wesley Clark and Charles Molnar designed the LINC (Laboratory INstrument Computer), to be used in a research lab in a manner analogous to an oscilloscope. It wasn't merely its display and analog-to-digital converters (hence joysticks and Spacewar) which made it unique: its software was designed to enable the scientist-user to program without a professional programming staff. Much of the design rationale was process-control oriented (hence interrupts) so that online data analysis could be performed during an experiment, allowing modification to the experimental protocol. But having such a friendly computer in the room, shared only with the other users of the same lab, created the atmosphere of "personal computing" a decade before mass-market economics extended it.

The first 24 LINCs (with their small memories and dual small-reel magnetic tapes—so-called LINCtapes—which were the forerunners of the floppies) were built under a government research grant and distributed around the country in 1963 to various physics, chemistry, and life sciences labs (they were especially important in my own field of neurobiology). With the plans in the public domain, several computer manufacturers began selling them (Digital Equipment Corporation's version cost $54,000—and in 1966 dollars, at that) and improving on the design (DEC's LINC-8 and PDP-12 were the major extensions). In essence, thousands of users experienced the personal computer revolution in the 1960s and helped shape its present philosophy.

It is curious how this heritage has been forgotten in the great expansion. One consequence is an excessive amount of reinventing the wheel. The interactive software packages developed by LINC users (especially at Washington University and the University of Wisconsin) were excellent—I have yet to see a statistics-and-plotting package for microcomputers which equals LINDSY for the LINC, and the LINC's text editor and operating system (LAP) puts CP/M to shame. And—another forerunner of the present microcomputer situation—the really good general-purpose software came from small groups, not manufacturers.

Most people tend to compare new microcomputer software to fancier mainframe versions, but it is often more appropriate to compare it to the lab computer antecedents, which shared a similar philosophy. It is the design philosophy for microcomputers that so sets them apart from the staffed mini- and main-frame computers, and it is that single-user-as-master philosophy that was so extensively developed by the LINC users.

William H. Calvin, Ph.D.
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Computer Scrabble*

We were pleased to see an article discussing the feasibility of a computer opponent for Selchow & Righter's popular Scrabble word game (see "Computer Scrabble," December 1981 BYTE, page 320). Others who are intrigued by this concept will appreciate knowing that the state of the art in microcomputer Scrabble has made a great leap forward. It is far beyond the boundaries that Mr. Roehrig tells us will not be broken by anything less than a new, superior generation of microcomputers.

"Monty plays the Scrabble Brand Crossword Game" (a computer-opponent program available on disk for the Apple II and TRS-80 Models I and III from Ritam Corporation for $39.95) demonstrates both speed and ability, within the constraints of today's microcomputers.

Monty spends an average of only 4½ minutes per move at the highest skill level, and yet it uses an extensive word list (over 50,000), based in part on the *Official Scrabble Players Dictionary.*

As for memory, the program requires no more than 48K bytes for Apple and 32K bytes for TRS-80 versions, much of which is devoted to machine-language graphics, music, and other user-interface requirements. The dictionary is accessed from disk and is stored in an average of only two bytes per word (with an average length of 6 or 7 letters) by use of advanced compression techniques. In addition, Monty is capable of challenging other players' words, based on linguistic analysis, without accessing the disk.

To give Mr. Roehrig's efforts due credit, the "game's complexities" do offer a challenge! It took us several major design breakthroughs, over four man-years of programming (for three different computers), and a lot of determination to develop "Monty plays Scrabble" without conceding to "certain constraints" on word length, search, and placement.

Although his conclusion that "improved computerized Scrabble will require a faster host computer with more memory capacity" has been disproved by example, we thank Mr. Roehrig for his article. It makes our endeavor seem quite worthwhile when we learn that we've achieved the impossible!

By the way, Mr. Roehrig neglected to properly acknowledge that Scrabble is a trademark of the Selchow & Righter Company, and to disclaim, as does Ritam, any sponsorship or endorsement by Selchow & Righter.

Robert Walls, President
Ritam Corporation
POB 921
Fairfield, IA 52556

* *Scrabble is a registered trademark of Selchow & Righter Company. We apologize for not acknowledging this in a prior article. . . .* MH

More Commbat

I would like to thank George Stewart for his excellent and perceptive review, "Commbat: A Tele-Game for Two," in the December 1981 BYTE (page 100). He captured my motivation for creating Commbat in the first paragraph.

The problems he mentioned of synchronizing both systems upon initial start-up

and keyboard sluggishness are a result of accommodating the TRS-80 Model I's RS-232 port. It cannot interrupt the processor when it has a character, so it must be operated in a polled-loop configuration in order not to lose data. As long as Model Is or their look-alikes are a significant part of the market this 'problem' will be necessary. I believe the first release of Commbat was the one reviewed. As a result of the synchronization problem, the current release, Commbat Version 2.1, has a split-screen dumb-terminal option that is presented to the user upon start-up. This mode can be entered without any particular worries as to timing by both participants, and when both are communicating they can exit to the game. This mode also allows communications to be established through some of the dial-up services that can handle pass-through communications between users.

At last report, the Atari version of this game was in production and should be available soon from Adventure International, and an Apple version is on the way. The major feature of these different versions is that they will all play against each other. My intention is to keep Commbat system independent; as other systems become a significant portion of the market they will get their own compatible version. Anyone who buys Commbat will be able to play anyone else who has ever bought it, regardless of equipment.

The second game of this planned series is finished and will be marketed in the near future, and the third is coming along well.

Robert A. Schilling
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Palm Bay, FL 32905

No Contest

Despite the "battle" for dominance portrayed in the "Unix vs. CP/M" item in the November 1981 BYTELINES column (page 306), the position of the apologists for CP/M has become all but untenable. The implication that Unix and CP/M can be compared on the same terms is wholly misleading. Unix is a full-featured operating system which is widely regarded as the finest ever written, while CP/M is little more than a program loader.

The only reason for the continuing popularity of CP/M is summed up in the column's last sentence: "CP/M appears to have much more public-domain and commercial software for it than does Unix." As the computer community recognizes that Unix is bound to become the standard 16-bit microcomputer operating system, commercial applications software for it will inevitably begin to appear. And, since most Unix software is written in the powerful C programming language rather than in assembly language or some dialect of BASIC, we can be sure that the commercial software which will eventually be available under Unix will be of higher quality than that found in the CP/M market.

John Lynn Roseman
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Toward a Structured Assembler

I have just finished reading the two-part article "Toward a Structured 6809 Assembly Language" (November 1981 BYTE, page 370, and December 1981 BYTE, page 198). I found the article quite interesting, especially since I have been selling a structured assembler (STASM09) package since 1980. STASM09 uses a pre-/post-processor to generate the appropriate internal labels and to modify the listing to provide automatic indentation of the listing. (The indentation of the code provides graphic display of the structure of the program module.)

STASM09 provides the IF. . .ELSE. . . ENDIF but not the WHILE. . .ENDWH or REPEAT. . .UNTIL constructs described by Mr. Walker in his article. Instead, STASM09 provides a more general DO. . .ENDO construct with several methods to BREAK out of the loop. This allows both the WHILE and REPEAT functions to be implemented. In addition, STASM09 provides a COUNT function that can be used to control the number of times a loop is traversed.

STASM09 is designed to run under the FLEX operating system from Technical Systems Consultants rather than the more industrially oriented Motorola operating system. STASM09 is available on a 5¼-inch, single-density disk for $49.95, including shipping and handling, from Sansaska Systems, 3311 Concord Blvd., Concord, CA 94519.

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Incidentally, I have noticed a possible problem with the macros defined in part 2 of the article. When an error condition is recognized in a macro, a long branch to the EXBUG monitor is inserted into the code. Since this can occur in code that is entirely relocatable, the relative offset of this error jump will be wrong any time the program is relocated. If this happens, the results will be entirely unpredictable and possibly very hard to debug.

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A Recipe for Standards

I have been involved with the microprocessor standards work of the IEEE (Institute of Electrical and Electronics Engineers) Computer Society from its beginning (August 1977), so Chris Morgan's editorial in the November 1981 BYTE caught my eye. The question is "Can we agree on standards?" The correct answer is a qualified "Yes," and the "heated debate" usually occurs only when that qualification is violated.

What is this qualification? The standard must be done *right*. The right way to establish a standard, once the need for a standard is apparent, requires three steps:

- First define the objectives of the standard that the potential users can agree on.
- Examine the marketplace to see if there exist any widely accepted products that are designed to specifications that meet or are near the objectives. This examination can go four ways: (1) if there are no products, establish a design team of competent technical people to design specifications; (2) if there is one product fully meeting the objectives, adopt its specifications; (3) if there are one or more products close to the objectives but in some way inadequate; establish a design team to adopt one (impartially, if possible) and to produce from it adequate specifications; (4) if there are several incompatible products whose specifications fully meet the objectives, establish an impartial selection board to choose one set. (In this case it is usually too late to define a standard, but sometimes the need for it will reshape the marketplace.)
- Write the specifications into a draft standard and take it out for public review. This is a necessary safeguard against per-

sonal bias and technical incompetence in the designers. All responses to this review step must be dealt with before the standard can be established. The draft standard need not be modified for every response, since some of them will themselves be biased or incompetent, but all responses must be considered.

The American National Standards Institute (ANSI) and the IEEE, as a member of ANSI, are set up to develop standards by these procedures, and the standards so developed do receive wide public acceptance. Although it is still being reviewed and revised, the proposed standard for the S-100 bus is an example of such success.

What about the wrong way? Usually it is some variety of "Let's standardize on *my* way of doing it." A lot of standards are proposed this way, and some actually succeed. If they succeed, it is in spite of the attitude, not because of it, and then only because the proposer has done the technical homework and controls the marketplace (for example, IBM, which is known for this attitude).

How does DIF fit in? [**Editor's Note:** *DIF, for Data Interchange Format, is a method for representing data in a program so that it can be transported directly to other programs. See "DIF: A Format Between Applications Programs" by Candace E. Kalish and Malinda F. Mayer, November 1981 BYTE, page 174.*] Software Arts is promoting DIF as a standard, using the "let's do it my way" approach. It may succeed at this, because Visicalc happens to dominate the market. It may even be that DIF is a good technical proposal, but we cannot know this without the proper review procedures, which Software Arts has bypassed.

I think it is unfortunate that monopoly industries like IBM and Software Arts can wield such Machiavellian powers as to impose on the rest of the world standards like EBCDIC (extended-binary-coded-decimal interchange code) and (possibly) DIF without the benefit of good technical review.

Tom Pittman
Itty Bitty Computers
POB 23189
San Jose, CA 95153

I concur with Mr. Pittman's rational approach to the establishment of a standard. However, our industry does not always behave rationally. I take issue with the implication that IBM and Software Arts are necessarily Machiavellian or even monopolistic. To be monopolistic, by definition a company must have exclusive control of the means of producing a product or service. Visicalc may be the best-selling microcomputer program of all time, but that hardly excludes competitors from offering their own types of spreadsheet programs. In the case of IBM, whatever its past record has been in the mainframe market, its behavior in the personal computing market has been remarkably open and nonmonopolistic, if I may use that term . . . CM

Multicolored Players, or The Atari Tutorial Debated

I enjoyed reading Chris Crawford's "The Atari Tutorial, Part 3: Player-Missile Graphics" in the November 1981

BYTE (page 312). I believe, however, he has made an error. On page 319 he stated that multicolored players are not possible unless you use display-list interrupts. On the contrary, there *is* a way to produce multicolored players in BASIC very easily. If you look on page III.7 of the Atari Hardware Manual, you will see that setting the fifth bit of GPRIOR ($26F) at location 623 decimal will cause a logical OR function of the colors of player 0 with player 1 and player 2 with player 3. The result is a choice of three colors in the overlapped region. The following program demonstrates this effect:

```
10  A= PEEK(106) – 8:POKE 54279,A:REM
    SET UP PLAYER – MISSILE GRAPHICS
20  POKE 559,46:POKE 53277,3:REM
    DOUBLE – WIDTH RESOLUTION
30  POKE 704,26:POKE 705,102:REM
    PLAYER 0 & 1 COLORS
40  PMBASE = 256*A + 512
50  FOR I= 0 TO 256:POKE
    PMBASE + I,0:NEXT I
60  FOR I = 0 TO 7:READ A:POKE
    PMBASE + 48 + I,A:NEXT I
70  DATA 255,255,195,195,195,195,255,255
80  FOR I = 0 TO 7:READ A:POKE
    PMBASE + 176 + I,A:NEXT I
90  DATA 60,60,60,60,60,60,60,60
100 L = 100:R = 148:POKE 53248,L:POKE
    53249,R
110 FOR T=0 TO 1000:NEXT T
120 FOR I = 1 TO 24:L = L + 1:R = R – 1
130 POKE 53248,L:POKE 53249,R:NEXT I
140 FOR T=0 TO 300:NEXT T
150 POKE 623,32:REM SET BIT 5 OF
    GPRIOR
160 GOTO 160
```

Lines 50-100 POKE the player images into the player graphics buffer and set their horizontal positions. Lines 110-160 let you see the player images coming together and then the three colors being produced as one player. Remember that to move this three-colored player requires you to POKE the same horizontal position into the horizontal-position registers of both player 0 and player 1.

Peter Hecke
767 Bergen Blvd.
Ridgefield, NJ 07657

Chris Crawford replies:

Thank you for your program; it demonstrates the OR function of GPRIOR bit 5 very well. This technique, however, does not *create a multicolored player. Instead, it creates a three-colored object using two players—certainly a useful technique for "getting more for your money" with two players. If you are not otherwise using all your players, you can create a multicolored object by overlapping several players of different colors. With the technique you describe, you can get seven colors (the normal five plus two "overlap" colors), although you do not have full control over the overlap colors; without this technique, the most you can get is five colors (if you use all four players and the missiles as a fifth player).*

The method I referred to in my article modifies the display list to execute an assembly-language display-list interrupt routine to change the color register of a given player while the video image is being drawn. This technique can produce one *player that has multiple colors, but it has two disadvantages: first, it can only produce images striped horizontally with different colors; and second, unless you change the display list on the fly, the multicolored player cannot move vertically (display-list interrupts are tied to a certain horizontal line of the video display).*

Thanks for sharing your letter and program with other BYTE *readers and me.*

Wanted: Education in Computerized Business Systems

Students interested in obtaining a university education in the development of business-oriented computer systems should investigate the programs offered by the business schools. Paul Brady in his article on "Bridging the 10-percent Gap" (see the October 1981 BYTE, page 264) identifies the need for this type of training, which combines courses on computers with courses on business organizations and management skills. However, his comments do not indicate that such programs already exist. Rigorous computer science programs provide excellent technical and theoretical training but are not typically designed to produce business-systems analysts and application programmers. For further information on the educational issues involved and a survey of programs offered, see the article by Jay F. Nunamaker Jr., "Educational Programs in Information Systems," *Communications of the ACM*, March 1981, and the in-depth report on "the DPMA Model" in *Computerworld*, September 21, 1981.

Hugh Howson
Professor Invite
Université du Québec à Montréal
Case postale 8888, Succursale "A"
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The Generic Word Processor

A word-processing system for all your needs.

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Philip Schrodt
Department of Political Science
Northwestern University
Evanston, IL 60201

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Before implementing the system, carefully study figure 1 to familiarize yourself with the main features of the GWP word-processing unit.

Initialization

The word-processing units supplied with your GWP are factory-fresh and uninitialized. Before they can be used, they must be initialized using the GWP initialization unit (see figure 2). Because of the importance of this unit, we designed it with a distinctive shape so that it will not be misplaced among the voluminous vital papers on your desk.

To initialize a word-processing unit, carefully place the character insertion subunit into the left side of the initialization unit and rotate the word-processing unit approximately 2000 degrees clockwise while exerting moderate pressure on the word-processing unit in the direction of the initializer. Check for successful initialization by attempting a character insertion. If the insertion fails, repeat the initialization procedure. The word-processing unit will have to be reinitialized periodically; do this whenever necessary. (*Warning:* do not attempt to initialize the word-processing unit past its character deletion subunit. Doing so may damage both the word processor and the initializer.)

Editor's Note: *Once in a while we come across a product that's so useful we feel compelled to bring it to our readers' attention. The Generic Word Processor System (GWP) is such a product, incorporating the essentials of a word processor in a sublimely simple form.*

With the manufacturer's permission, we are reprinting the documentation for this product. After working with the GWP for several weeks, we're delighted by the feeling of total control that the system gives us and are certain you will be too. No more accidentally erased files, no damaged disks, no hardware problems . . . **SJW.**

Operating the Word Processor

The GWP can perform all the basic functions featured in word processors that cost thousands of dollars more. Furthermore, because the GWP does not require electricity, it can operate during power blackouts, electrical storms, and nuclear attacks. By conserving precious energy resources, it helps free our beloved country from the maniacal clutches of OPEC.

Basic functions of the word processor are listed below:

Inserting text: Use the character-insertion subunit to write in the words you wish to insert, applying moderate downward pressure to the unit. Be sure to write clearly so that the typist can follow what you have written.

Deleting text: With moderate downward pressure, rub the character-deletion subunit across the text to be deleted. Repeat this procedure several times. The text will gradually disappear, whereupon you will be able to insert new text.

Underlining: Using the character-insertion subunit, place the unit slightly below and to the left of the first character you wish to underline. Move the unit to the right until you reach the last character to be underlined.

Bold face: Repeat the text-insertion procedure twice, pressing downward with greater pressure than you would normally apply.

Move to beginning of text: With the text you are working on in hand,

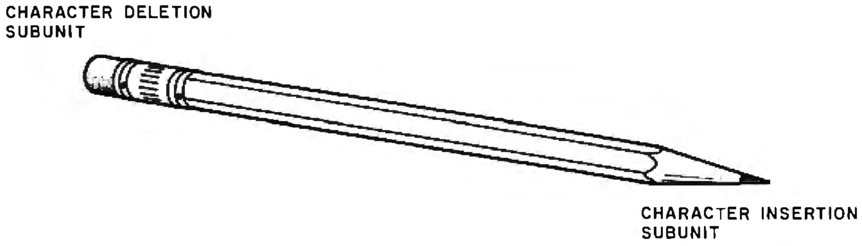

Figure 1: *The GWP System word-processing unit is composed of the character-insertion subunit (at right) and the character-deletion subunit (at left).*

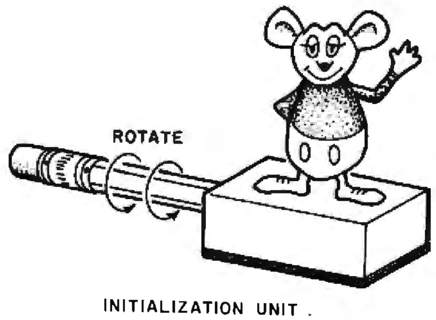

Figure 2: *The word-processing initialization unit, which should be operated over a wastebasket.*

Figure 3: *The block text extraction and replacement units, commonly run in unison.*

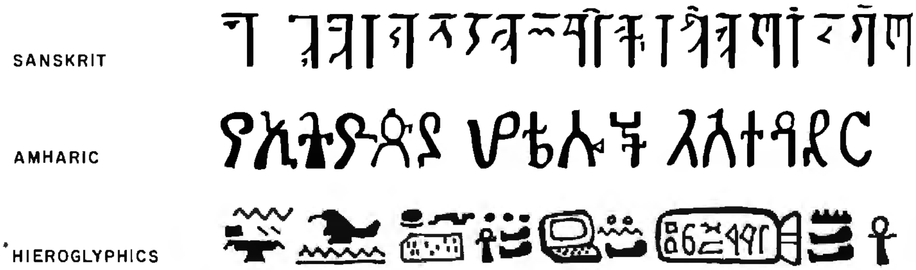

Figure 4: *Sample type fonts illustrating the wide variety available with the GWP System. The manufacturer claims that if a language can be written, the GWP System can be adapted to it.*

move the unit to the beginning of the text.

Move to end of text: Take the text you are working on and move the unit to the end of the text.

Moving blocks of text: Block moves require use of the block text extraction unit and the block text replacement unit pictured in figure 3. By means of the block text extractor unit, sever the paper immediately above and below the text you wish to move. Instructions for operating the extractor unit are etched on the side of the unit in Korean. If you still have difficulty operating the unit, call our service department for consulting help at our introductory fee of $50 per hour, or ask any 5-year-old child.

After separating the text to be moved, open the lid of the block text replacement unit and, grasping the block text replacement medium application unit, spread the block text replacement medium on the back of the text. Move the text to the new location and affix it to another sheet of paper with gentle but firm pressure. In a few minutes, your text will be permanently affixed in the new location.

Other Features

Page numbering: After writing your entire text, inscribe a 1 on the first page, a 2 on the second page, etc. When you finish, all of the pages will be numbered.

Centering: Determine where the center of the page is by looking at it. The center is usually near the middle of the page. Place the text to be centered evenly on each side of the center. It is now centered.

Special fonts: The GWP System is extremely versatile and easily adaptable to specialized type fonts such as Sanskrit, Amharic, and hieroglyphics (see figure 4). You will find these fonts valuable in business correspondence, particularly if you are in frequent contact with Vedic gurus, Egyptologists, or Ethiopian Airlines.

Saving files: Put the work you have finished in a safe place, one where nobody will find it or spill coffee on it. If it is not disturbed, it will be there when you return.

Deleting files: Take any files you no longer need and deposit them in the wastebasket. They probably will be gone in the morning. In most offices, this can also be accomplished by leaving the files in the open, forgetting to remove them from the copying machine, or writing CONFIDENTIAL on the file in bold letters.

Appending files: Place the first file on top of the second file. Treat the two files as though they were one file.

Justification: Most word processors have little justification. This word processor has no justification at all, as it does not even lend prestige to the office where it is used, which is the justification for most word processors.

Printing Files

A printer for the GWP must be purchased separately. For convenience of operation, we recommend an ordinary typewriter and a typist. Give the text to the typist and tell him or her to type it. Printing speed can be improved by increasing the wages of the typist, threatening to withhold the wages of the typist, kidnapping pets, plants, or children of the typist, instigating intimidating tactics, and other conventional office-personnel management techniques. Printing speed can be decreased by asking to see the text, making continual changes in the text, asking the typist to answer the phone, decreasing the typist's wages, and installing a conventional electronic word processor. You will soon learn to adjust the printing speed to the optimal level for your particular needs.

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Use Infrared Communication for Remote Control

The Texas Instruments SN76832AN Infrared Remote-Control Receiver simplifies the tough job of receiving modulated infrared light.

Steve Ciarcia
POB 582
Glastonbury, CT 06033

Two dozen images of Howard Cosell danced before my eyes. Suddenly there were two dozen images of acid indigestion, and then, just as suddenly, Howard Cosell was back.

Undaunted, I stood my ground, which happened to be in the television department of a large store a few miles from home. I was wielding a small box covered with push-button switches, trying out a display of remote-controlled TV sets.

There has been a silent revolution going on in the TV remote-control business. Silent indeed. No longer do the control boxes emit ultrasonic impulses that drive all the dogs in the household into hysterics. Today's remote-controlled TV sets receive viewers' instructions on beams of infrared light.

Detecting an information-bearing infrared beam in an infrared-saturated environment is a signal-to-noise horror show.

The silent revolution has also made controlling the sets easier. Ultrasonic remote-control units, because of their complexity and cost, usually have had only two or three control channels, making channel changing a tedious, repetitive task and limiting the set functions that could be remotely commanded.

Infrared-light units are not only practical; they have become much more sophisticated, often making available thirty or more control channels for less than the cost of a pair of ultrasonic transducers.

To supply the demand for support circuitry to build remote-control systems, several semiconductor manufacturers (such as General Instrument, Hitachi, Signetics, and Texas Instruments) are producing integrated circuits that encode and decode the command information used in these TV remote controls. Most encoder chips are designed to accept a keyboard input and directly modulate an infrared light source. At the receiving end, the encoded data stream is decoded by a decoder chip and a few discrete components.

I decided to buy a pair of infrared encoder/decoder chips and build a

About the Author

Fifteen years ago, Steve Ciarcia (pronounced "see-AR-see-uh") gave up a promising career as a security guard for the Famous Writers' School to become an electrical engineer and computer consultant. He has experience in nuclear instrumentation, process control, digital design, product development, and marketing. In addition to writing for BYTE magazine, he has published several books, including Build Your Own Z80 Computer *(BYTE Books, 1981).*

When he's not working in his Circuit Cellar, he enjoys cooking such foods as Eggplant Siciliana and Shrimp Provençale and driving his DeTamaso Pantera sports car.

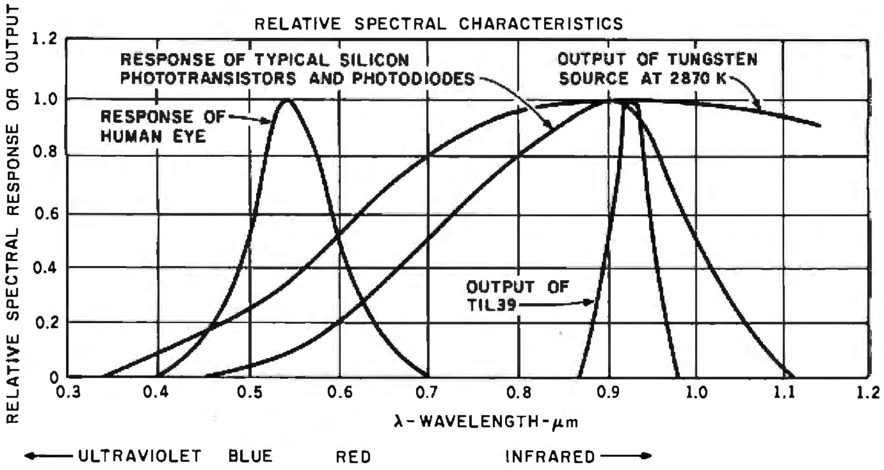


Figure 1: *Relative spectral characteristics of infrared light-emitting diodes and photodiodes.*

quick and dirty remote-control unit. It was going to be so easy.

Not so fast! There was a missing link: detecting the beam of infrared light so it could be decoded.

To Find a Missing Link

Was I going to let a little thing like a beam of light stop me? Of course not. I started investigating how to sense a beam of infrared light.

Once again I found myself working on a topic about which I could find very little published information of use in practical experimentation. I suspect there have been few magazine articles dealing with infrared-light communication because of the difficulty in detecting an information-bearing beam of infrared light in an infrared-saturated environment. It's a signal-to-noise horror show! The sensitivities and dynamic ranges required are beyond simple amplifier-design techniques. My goal of building an inexpensive remote-control scheme using TV-set encoder/decoder chips therefore had to wait until I first designed a reliable infrared communication receiver.

This article contains both a discussion of optical communication and a construction project of a useful infrared-light transmitter/receiver interface for use with a personal computer. Along the way I attempt to answer some basic questions including the following: In what kind of applications can light transmission be useful? Why use infrared rather than visible light? What is the best choice of optoelectronic components for each application?

Why Use Light?

Light is used in communication for two major reasons: the medium's immunity to certain forms of interference and the relative ease of providing security for the communications link. Electrically noisy motors and other equipment generate electromagnetic interference (EMI) that can play havoc with radio-wave transmissions, and ambient noise can disrupt ultrasonic communication. These problems do not bother light beams, and a protected line-of-sight beam path or waveguide provides fair security against unauthorized interception.

Light can also be used in providing physical security for premises; a prowler might step over a tripwire, but he wouldn't know to avoid an invisible shaft of infrared light aimed at a detector in an alarm system.

What Is Infrared Light?

The segment of the electromagnetic spectrum that we perceive optically as visible light is narrow. On both sides of this band of visible light are regions of radiation that we can't see but which otherwise exhibit similar optical properties. Radiation of wavelengths shorter than we can see is called ultraviolet (UV) light, while wavelengths longer than we can see form infrared (IR) light. Any warm object radiates some amount of infrared radiation.

(Some may quibble with my use of the term "light" to discuss radiation that cannot be seen. I feel that any radiation that can be manipulated optically [by lenses and the like] should be called light, and that's how I am using the term in this article.)

The spectral graph of figure 1 shows that the visible band has wavelengths between about 400 and 700 nm (nanometers). Within the range of 400 to 700 nm, the different frequencies are perceived as different colors. For example, a light beam of 550-nm wavelength is perceived as green. What we perceive as white light contains all the visible frequencies.

Transmitting information on a beam of light is done much the same way as on a radio wave. The light must be amplitude-modulated at some carrier frequency, say 40 kHz. This allows the receiver to differentiate between the light coming from the transmitter and unmodulated ambient light. The data to be transmitted can be modulated onto the carrier in a number of ways, including amplitude and frequency modulation, pulse-width modulation (PWM), and pulse-code modulation (PCM).

For my application of a simple optical remote-control system, the less complicated PCM technique seemed best. This merely consists of turning the 40-kHz-modulated light on and off. At the receiving end, the presence of light is interpreted as a logic 1 and the absence of light as a logic 0.

Why use so high a carrier frequency? We have to use a frequency high enough that the communication is not susceptible to interference. The operating environment of our infrared system may contain such sources of interference as fluorescent lights, which flash at 120 Hz, or television sets, whose screens emit light with interference patterns at over 15 kHz. For open-air optical communication, frequencies at or above 40 kHz are preferred.

Any electrically excited light source can be amplitude modulated, but not

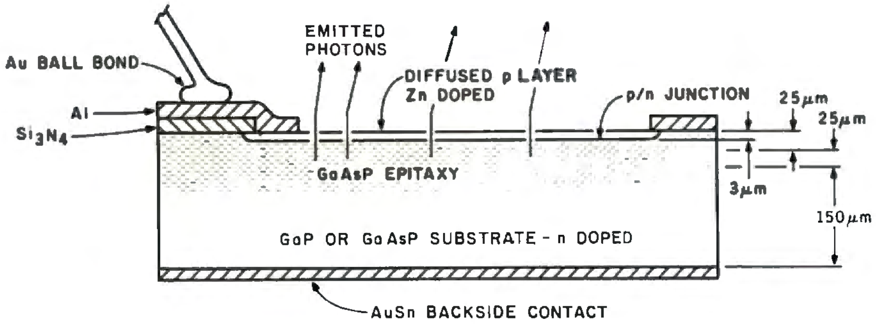


Figure 2: *Cross section of the structure of a standard visible red light-emitting diode.*

Blue LEDs at Last

Longtime readers of BYTE may recall Steve's article from several years ago on a self-refreshing LED graphics display (see reference 2). In it, he described how single-color graphic images can be formed on display panels containing arrays of many red light-emitting diodes and suggested that multicolor images could be displayed on a panel that contained arrays of triads of different-color LEDs. But his suggestion was ahead of technology. At that time, no practical method was known for making an LED that could emit blue light.

Now the blue-light barrier has been broken, and in a way eminently suitable to flat-panel graphics displays. In October 1981, the Sanyo Electric Company of Japan unveiled an LED lamp component that contains two separate LED chips, one of which emits blue light at a wavelength of 480 nanometers (see reference 3). The blue-emitting chip is formed from two liquid-phase-epitaxial layers of silicon carbide grown on a silicon-carbide wafer. The other chip, made of gallium phosphide with four epitaxial layers, can emit both red light at 700 nanometers and green light at 565 nanometers. A single component that can produce all three additive primary colors makes possible a full-color, flat-panel LED graphics display.

The voltage potential dropped by the blue LED chip is about 3.5 V, producing 2 mcd (millicandelas) of light, while the two-color chip drops 2 V for 3 mcd of green light and 1.9 V for 3 mcd of red light. Thus we see that real components reflect the theoretical predictions of greater efficiency at longer wavelengths. . . . RSS

all of them at 40 kHz. Modulating a 100-watt incandescent light bulb at such a high frequency is out of the question: the thermal time constant of the filament is much too long. The only light sources capable of switching at such a frequency are electroluminescent devices, of which the light-emitting diode (LED) is the least expensive and most familiar.

In a light-emitting diode, shown in figure 2 on page 42, light is generated when a forward-bias current is applied. This causes electrons to be injected into the n-type (negative-doped, electron-rich) semiconductor material and holes (shortages of electrons) to be injected into the p-type (positive-doped, electron-poor) material.

When the injected electrons and holes recombine with the majority carriers at the p/n junction, energy is released in the form of photons. The pattern of radiation emission can be controlled somewhat by reflective surfaces within the mounting structure and by plastic lenses. Generally, a spherical dome lens with a narrow beam width is best for communication.

The color of the light emitted depends upon what semiconductor materials are used in the p/n junction and how they are doped (seeded with selected impurities): the amounts of energy released in the electron/hole recombinations of different materials vary, and the wavelength (and therefore the color) of light varies in a direct relation to the amount of energy contained in its photons.

Most of the semiconductor materials used in LEDs are compounds of gallium: gallium arsenide phosphide (GaAsP, which emits red, orange, or yellow light), gallium phosphide (GaP, green emitting), gallium aluminum arsenide (GaAlAs, red emitting), and gallium arsenide (GaAs, which emits infrared photons at about 900 to 1000 nm). The efficiency of an LED depends upon wavelength. The longer the wavelength, the higher the efficiency (see the text box "Blue LEDs at Last").

Operating at longer wavelengths, infrared LEDs are more efficient than visible-light red or green LEDs; IR LEDs are therefore preferred for line-of-sight beam breaking or communication. For a given power input, an IR LED produces a brighter light than a green LED. Many IR LEDs have radiant-power outputs of more than 10 mW (milliwatts)—for instance, the TIL39 component I have been experimenting with has an 11-mW output at 940 nm.

Efficiency is important, because an LED is almost a point source of light. The illumination it casts on a surface is proportional to its brightness and inversely proportional to the square of the distance to the surface. If we want our open-air communication link to operate over distances as great as 10 meters, our LED light source must be very bright to produce an acceptable signal-to-noise (S/N) ratio using an ordinary-sized receiving photosensor measuring perhaps 0.1 cm^2 (square centimeter).

Other incentives for using IR light are reduced sensitivity to ambient visible light, greater ability to pierce through fog or smoke, and better reflection off most surfaces for a greater chance that the receiver will be able to see the light source.

Choosing the Light Detector

Choosing the proper light detector is as important as selecting the light emitter. Selectivity, response, and inherent noise are important considerations.

There are many materials which function as photoconductors. The simplest are bulk materials such as cadmium selenide (CdSe), lead sulfide (PbS), and cadmium sulfide (CdS).

Generally these materials exhibit poor temperature stability and are sensitive over a very broad range of wavelengths.

The familiar semiconductors germanium (Ge) and silicon (Si), on the other hand, are sensitive chiefly to the near-infrared (wavelengths close to the visible range) light radiated by IR LEDs.

Two types of devices that use silicon and germanium are photodiodes and phototransistors. Phototransistors are constructed in much the same manner as commonplace planar-diffused transistors. The base area is usually made large to provide an area into which incident light can penetrate and generate electron/hole pairs. Phototransistors are subject to the variation in performance typical of all transistors.

Many of the bad traits of phototransistors are eliminated in *PIN photodiodes*. The term PIN is an acronym meaning that the components are made from three layers of different types of semiconductor material: p-type, "intrinsic," and n-type. A PIN photodiode is one in which two heavily doped p and n regions are separated by a lightly doped region (which exhibits mostly properties intrinsic to the substance). Its large depletion region (interface region between the p-type and intrinsic layers) provides the PIN photodiode with much faster speed, lower noise, and greater efficiency at longer wavelengths.

Photo 1 shows a TIL413 infrared-sensitive PIN photodiode (right) and a TIL39 infrared light-emitting diode (left).

Photo 1: *The TIL413 infrared-sensitive PIN photodiode (right) and the TIL39 infrared light-emitting diode (left).*

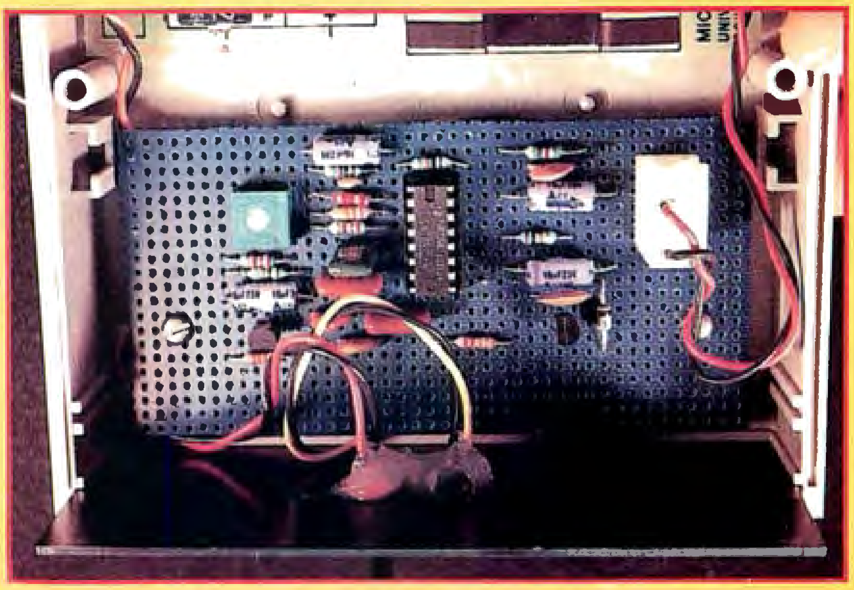


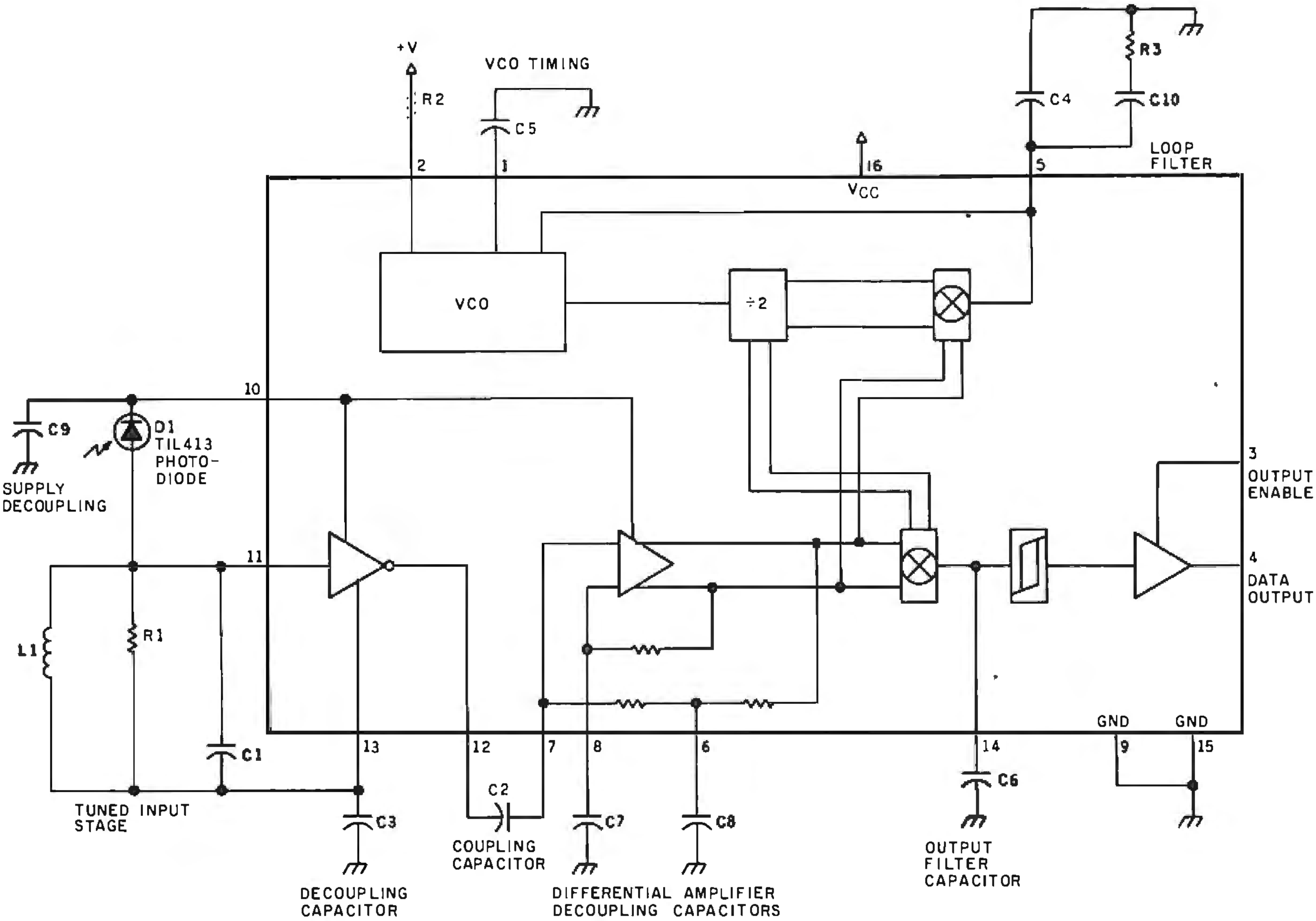
Photo 2: *Prototype of the infrared-light remote-control or communication receiver of figure 4.*

Ready-Made IR Detector

Designing a reliable infrared-light detector/receiver is no simple task; it has been the major obstacle in designing any infrared communication system. The engineer must coax his receiver into extracting the transmitted data from a dismaying amount of background noise, and he must take care that his design will withstand the impairments to theoretical performance caused by deviations from ideal component values and manufacturing techniques. But there is nothing conceptually complicated in the receiver, just a photodiode and a series of amplifiers and filters.

I haven't presented an infrared communication system before now because I couldn't design one that I felt readers could successfully duplicate. But recently I discovered that an integrated circuit has been developed to do all the hard work. Texas Instruments recognized the need and designed a chip which eliminates all the frustrations in building the IR receiver.

The new component is the SN76832AN Infrared Remote-Control Receiver. This chip replaces a combination of several integrated cir-



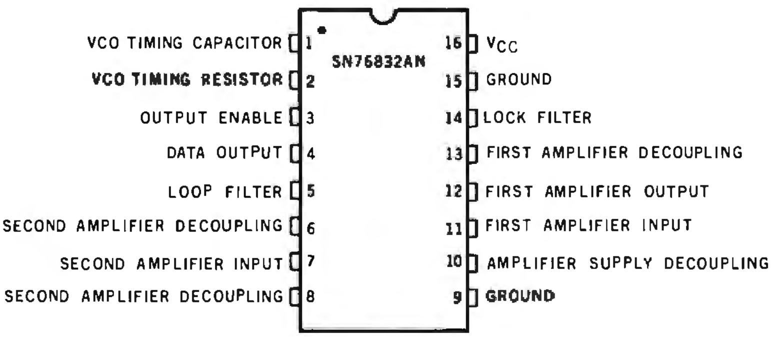


Figure 3: *Block diagram of the internal structure of the Texas Instruments SN76832AN Infrared Remote-Control Receiver.*

cuits and discrete components. It connects directly to a PIN photodiode and is designed to receive and detect digitally encoded information modulated on a carrier (typically 40 kHz). It has an open-collector gated output suitable for direct operation with a microprocessor. For the benefit of readers of BYTE, the Micromint will be distributing a kit that includes the SN76832AN (see page 49).

A block diagram of the SN76832AN receiver chip is shown in figure 3. Inside the receiver chip, the signal from the photodiode is connected to an amplifier with an input impedance of 220 kilohms and a typical gain of 1.6 million volts/amp at 40 kHz. The output of this first amplifier stage is fed to a differential amplifier coupled to the demodulator section.

The receiver chip demodulates the signal by comparing its amplitude and phase with that of reference signals produced by a voltage-controlled oscillator (VCO) and a frequency divider. The bandwidth and capture frequency are controlled by external passive components. The demodulated output signal is filtered and gated by the output-enable control signal. (A high level on the output-enable line causes the demodulated signal to appear on the output line. If the demodulated signal is to be constantly present, the output-enable line should be tied high.)

Figure 4 on page 45 is a schematic diagram of the completed circuit for a very sensitive IR receiver which operates at a carrier frequency of 40 kHz. A prototype is shown in photo 2.

In the receiver circuit of figure 4, potentiometer R1 sets the frequency of the VCO, which is twice that of the capture frequency (the center frequency of the incoming modulated carrier signal). With the external oscillator-control components shown, this circuit can detect carrier frequencies from 20 kHz to 70 kHz. The rest of the components, however, are optimized for 40-kHz operation. The photodiode I suggest is a type TIL413, because it has a spherical lens that allows it to "see" over a wider angle,

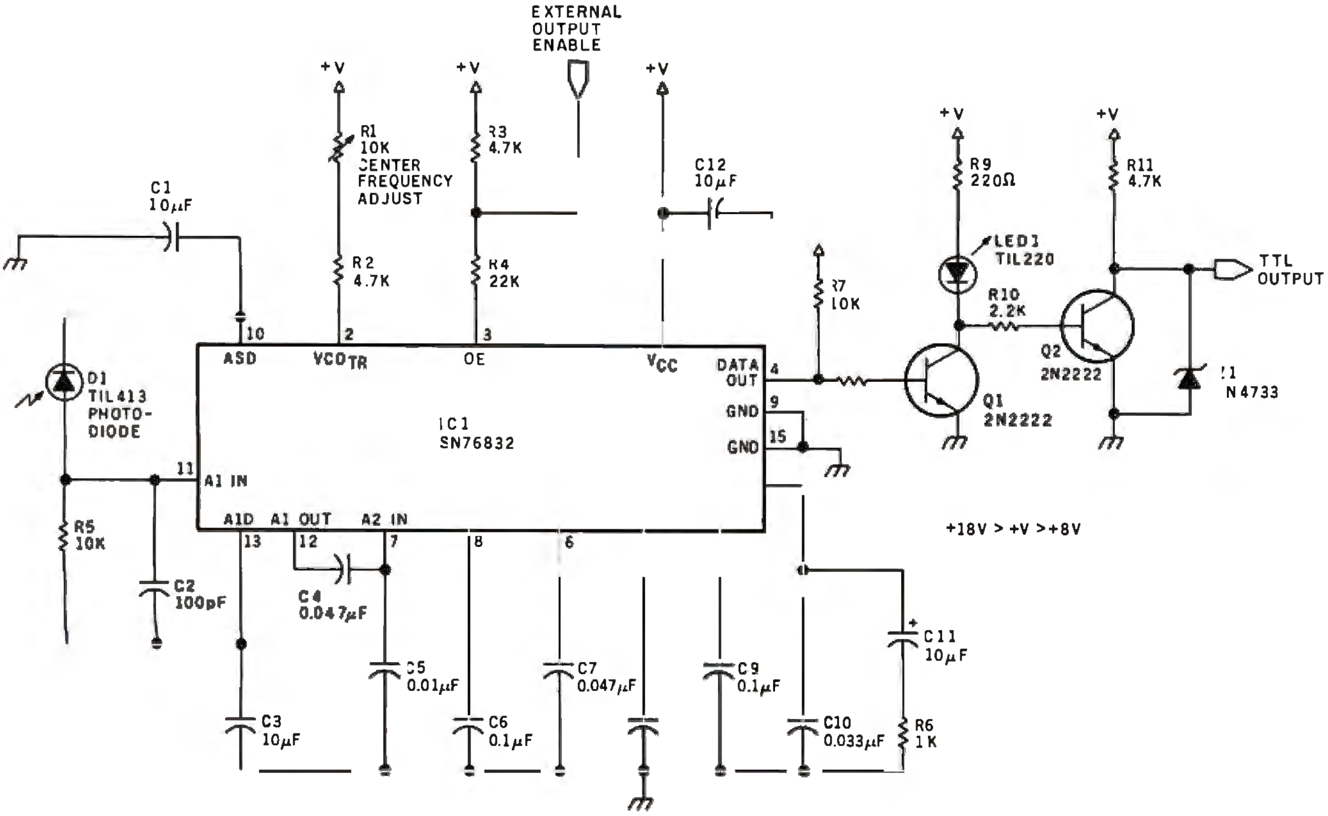


Figure 4: *Schematic diagram of a remote-control or communication circuit based on the SN76832AN. This circuit is set up for use at 40 kHz, although the voltage-controlled oscillator can be adjusted from 20 kHz to 70 kHz. Any voltage from +8 V to +18 V may power the circuit.*

thus enhancing the effective sensitivity. In a pinch other photodiodes such as the TIL100 may be used.

The data output is permanently enabled in my design unless the external-output-enable line is brought to ground potential by external means. The output signal is buffered and level-shifted through transistors Q1 and Q2 to provide a TTL- (transistor-transistor logic) compatible output. The circuit runs at any voltage between +8 V (volts) and +18 V. I run it at +12 V.

When the circuit "sees" a 40-kHz-modulated infrared light beam, the output goes to a normally high state, and the indicator light (LED1) comes on. The output then changes state in accordance with the demodulated data, exactly duplicating the sequence of the logic levels of the input signal that was fed into the infrared transmitter.

Photo 3: *Prototype of the infrared transmitter assembly, internal view.*

Photo 4: *The assembled infrared remote-control/communication system. On the left is the infrared receiver; the transmitter is to the right. The TIL413 photodiode is the small projection to the right of center of the receiver's front panel; the small projection on the left is a visible red LED that lights when the infrared carrier is detected.*

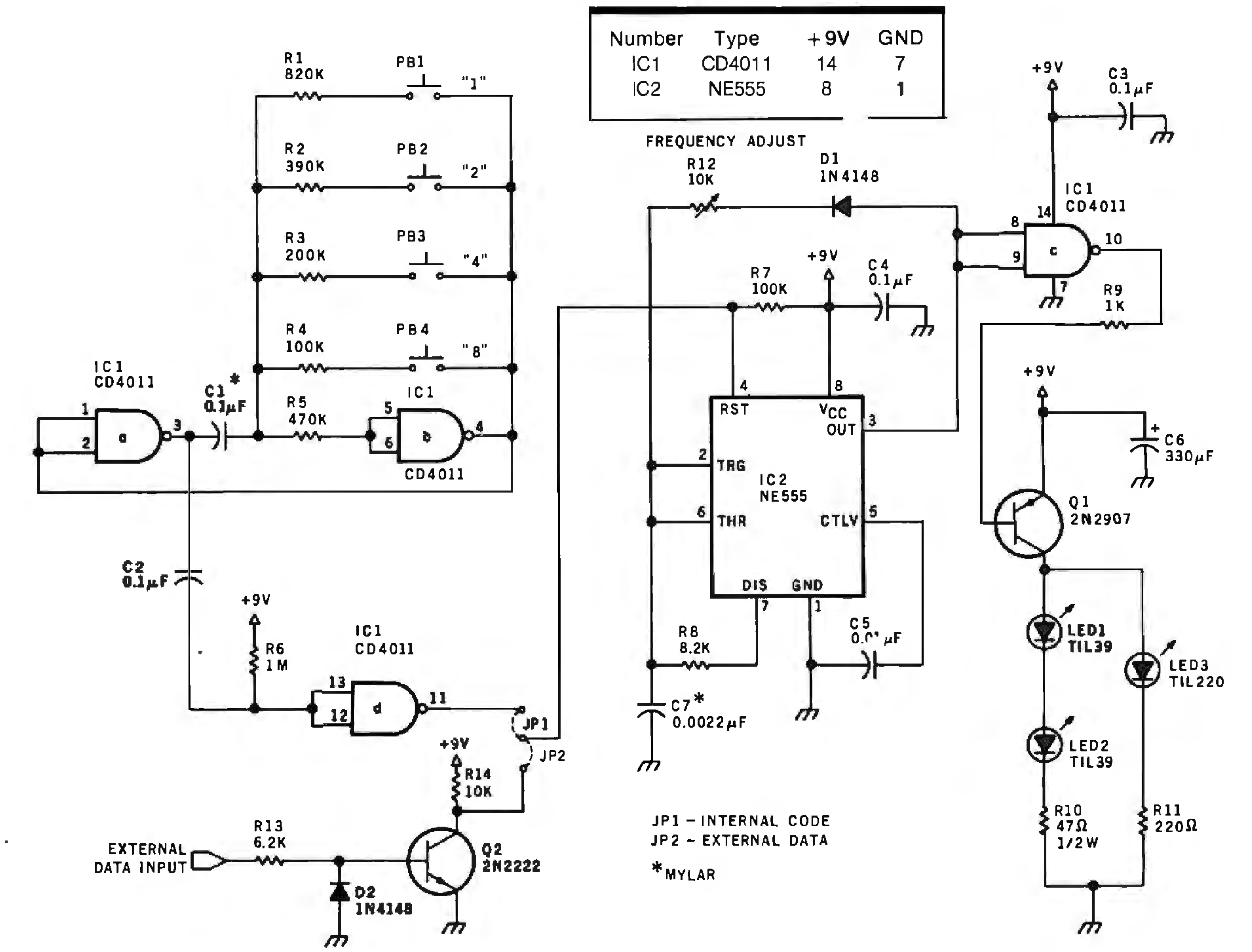


Figure 5: *Schematic diagram of a handheld infrared remote-control transmitter. Four pushbutton switches actuate a NAND gate wired as an oscillator; different frequencies may be selected for testing or in communicating simple command functions. Two high-power infrared and one visible indicator light-emitting diodes are modulated at a carrier frequency of 40 kHz; control signals are sent as a simple on/off modulation of the 40-kHz-modulated light beam.*

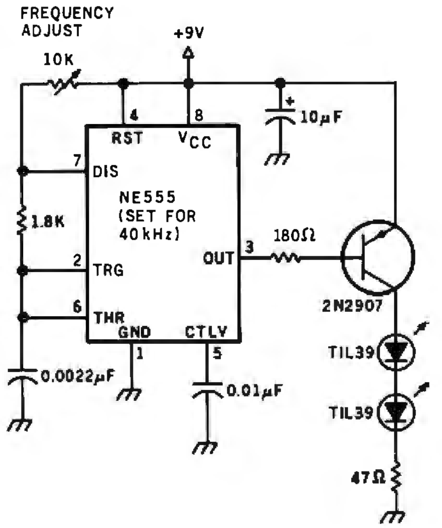


Figure 6: *A simple circuit that provides only a 40-kHz carrier modulation for an infrared beam. This may be used for simple beam-breaking intrusion-detection schemes.*

A Matching Transmitter

After building and testing the receiver section, I argued with myself about an appropriate transmitter. The "hardware" side of me wanted to follow up on the inspiration that got me started on the project by using one of those complex encoder/decoder chip sets previously mentioned. The encoder chip would be built into the transmitter, and the decoder would be connected to the infrared-receiver circuit, providing parallel decoded outputs.

The "software" side of me (I do have one!) argued that anything these chips could do in encoding and decoding could be done by any fairly competent programmer in a few lines of code. The real challenge of the project was creating the infrared-light communication link, not encoding and decoding the signal.

In the end, I decided that my inspiring vision was not worth the trouble, and I designed a relatively simple transmitter essentially consisting of a gated 40-kHz oscillator driving a pair of high-power infrared LEDs. As you can see in the schematic diagram of figure 5, jumper connections on the oscillator can be changed to allow modulation from an external signal source or to allow the communication link to be tested by your pushing one of the four pushbutton switches connected to the CD4011 NAND-gate component (IC1). The prototype transmitter circuitry is shown in photo 3 on page 45. The assembled transmitter and receiver are shown in photo 4 on the same page.

In the transmitter circuit, IC1 is configured as a low-frequency oscillator. The four switches control the frequency of the oscillator. With the "1" button pressed, an 8-Hz, 50-percent-duty-cycle waveform is directed to the IR LEDs. Pressing "2" produces a 16-Hz waveform, pressing "4" produces a 32-Hz waveform, and pressing "8" produces a 64-Hz waveform (the exact frequencies may vary somewhat). By pressing two or more of the buttons together, a total of 16 distinct frequencies can be created.

System Testing and Use

To test the transmitter and receiver, aim the transmitter's IR LEDs in the general direction of the receiver unit and press the buttons. The output signal from the receiver should be the frequency corresponding to the switch operated on the transmitter.

The single-bit output of the receiver can be connected to any convenient input line on your computer (such as a game-paddle input), and a simple program can be written to count and determine the frequency of the input signal. While much higher frequencies can be transmitted by this system, I chose these low, pulsed frequencies so that even a BASIC program could count the frequency. Nevertheless, if the frequencies are still too fast, simply substitute a higher capacitance for C1 in the transmitter circuit of figure 5 on page 46.

The external modulation input of the transmitter is quite suitable for use in a wireless data link. Attach a serial output from your computer to the external data-input line, and connect the output of the receiver to another computer or to a remotely located printer.

In fulfillment of my original plan, I decided to configure the transmitter in my infrared remote-control system as a hand-held actuator.

If you simply want an infrared beam source for use as an intrusion detector in a security system, you don't have to build the entire data-transmission circuit; the simple

Photo 5: *The familiar BSR X-10 hand-held control unit. This was built to work using ultrasonic pulses, but it can be modified to use infrared light. The added infrared LED can be seen on top of the housing.*

40-kHz oscillator in figure 6 on page 46 will work nicely.

TV-Set Controllers, Too

After building the IR receiver and transmitter circuits described, I discovered that signals from any of the commercial TV-set remote-control transmitters could be received just as easily as those from the transmitting device I had designed. Most set controls operate with carriers in the 38-kHz to 41-kHz range. Of course, the data output that you get is a coded bit stream, generally 5 to 12 bits repeating every half second, but this should be no obstacle.

While I haven't analyzed the coded TV-set-control data, they should be susceptible to differentiation by the same methods that worked for my simple frequency input. Perhaps you'd have to use a machine-language program to catch the fast data (about 25 milliseconds per word), but the results would be a professional-quality, very versatile remote interface to your computer.

BSR Goes Infrared

The remote-control transmitters for television sets are not the only means to an elegant remote-control

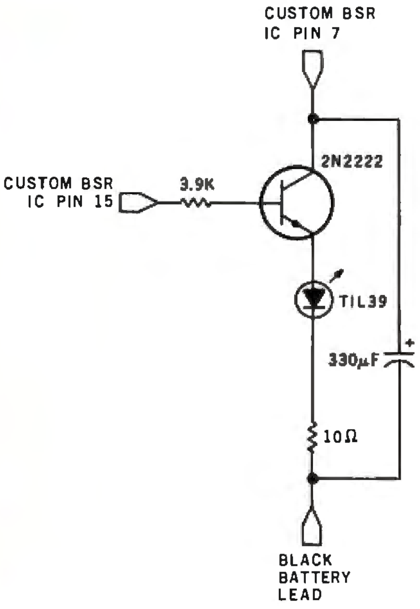


Figure 7: *Modification of the hand-held ultrasonic transmitter of the BSR X-10 Home Control System that converts it to infrared-light operation.*

system for your computer.

Perhaps you have on hand the hand-held transmitter from the BSR X-10 Home Control System. (Some of you may remember when I wrote about the BSR X-10; see reference 1.) This unit was made to work using ultrasonic sound, but it can be easily adapted for IR transmission to work with the receiver circuit in this article. Photo 5 shows the adapted BSR X-10 transmitter.

The modification is outlined in figure 7 and shown in photo 6 on page 48. Note that the ground connection should be the black lead directly connecting to the battery. The other two circuit connections are to pins 7 and 14 on the integrated circuit as illustrated. The BSR transmitter already operates using a carrier frequency of 40 kHz. The modification is simply to add an emitter-follower IR LED driver to the output section. The existing ultrasonic transducer can be cut out or used concurrently with the optical transmitter.

The message transmitted by the X-10 hand-held unit is approximately 100 milliseconds (ms) long and is composed of 13 eight-millisecond segments, each of which consists of a burst of 40-kHz signal. The reception

Photo 6: *Interior view of the modified BSR X-10 hand-held transmitter, modified according to figure 7.*

of the 40-kHz carrier will be marked by a high logic level coming out of the infrared receiver board for the duration of the 40-kHz signal. The coded data is sent as a series of 1.2-ms and 4-ms bursts, representing logic 0 and 1 respectively. The complete 13-bit message consists of a start bit (logic 1), 5 data bits corresponding to the key being pressed, 5 bits representing the logical inversion of the first 5 data bits, and 2 stop bits (logic 1). The binary codes and the transmission sequence are shown graphically in figure 8 on page 49.

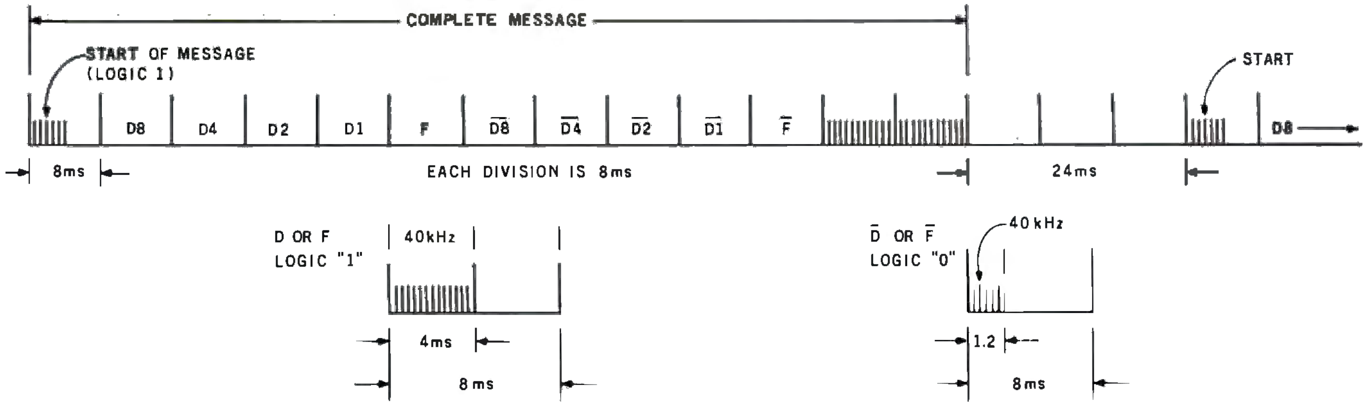
I'm sorry I was halfway through writing this article before I thought to use the BSR X-10 controller. After the idea struck home, I took a pizza break. Then I came back to the Circuit Cellar, added the modification of figure 7, and verified correct data reception using an oscilloscope. I haven't actually written the code to interpret the BSR controller's signals yet. But considering the well-documented transmission protocol used in the BSR, it may be easier to use this unit rather than figure out the unknown coding of a TV remote-control unit.

The longer the wavelength of its light, the higher the efficiency of an LED.

In Conclusion

Building a reliable infrared receiver has been a goal of mine for a long time. Many of my first designs did eventually work, but they couldn't be easily duplicated. Since I believe that many other experimenters are equally interested in IR communication and have experienced similar frustrations, I have arranged with Micromint to make available a complete kit of the infrared-communication circuits shown in figures 4 and 5. Included with these kits is a complete data sheet on the SN76832AN should you care to configure it for another frequency range.

If you try infrared communication and are successful, you might develop applications for it that have previously been ignored. Certainly experimenters like myself have been looking for better types of man/machine interaction than presently exist. Until computer speech recognition becomes



CHANNEL NUMBER OR FUNCTION	BINARY CODE D8	D4	D2	D1	F
1	0	1	1	0	0
2	1	1	1	0	0
3	0	0	1	0	0
4	1	0	1	0	0
5	0	0	0	1	0
6	1	0	0	1	0
7	0	1	0	1	0
8	1	1	0	1	0
9	0	1	1	1	0
10	1	1	1	1	0
11	0	0	1	1	0
12	1	0	1	1	0
13	0	0	0	0	0
14	1	0	0	0	0
15	0	1	0	0	0
16	1	1	0	0	0
ALL OFF	0	0	0	0	1
ALL LIGHTS ON	0	0	0	1	1
ON	0	0	1	0	1
OFF	0	0	1	1	1
DIM	0	1	0	0	1
BRIGHT	0	1	0	1	1

Figure 8: *Timing diagram and binary command-code table used by the BSR X-10 Home Control System.*

practical, we shall have to be satisfied with pushing buttons to communicate with computers. But perhaps the infrared transmitter and receiver in this article can make the connection a little more convenient.

Next Month:

It's been a long time since I wrote about time, time as measured by a computer's real-time clock. Next month, we'll look at plans for connecting a versatile clock to a personal computer. ■

Editor's Note: *Steve often refers to previous Circuit Cellar articles as reference material for each month's current article. Most of these past articles are available in reprint books from BYTE Books, 70 Main St., Peterborough, NH 03458.* Ciarcia's Circuit Cellar, Volume I *covers articles that appeared in BYTE from September 1977 through November 1978.* Ciarcia's Circuit Cellar, Volume II *contains 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.*

Parts Source

The following is available from:
The Micromint Inc.
917 Midway
Woodmere, NY 11598
telephone (516) 374-6793
(for technical data)
(800) 645-3479
(orders only)

Infrared Transmitter/Receiver Kit $42

Includes two printed-circuit boards (one for the transmitter and one for the receiver) and all components shown in figures 4 and 5. Does not include the cases and power supplies shown in the prototype photos. Assembly manual and specification sheets provided.

Please include $2 for delivery within the United States or $6 for foreign delivery. Residents of New York state please add 7% sales tax.

References

1. Ciarcia, Steve. "Computerize a Home," BYTE, January 1980, page 28.
2. Ciarcia, Steve. "Self-Refreshing LED Graphics Display," BYTE, October 1979, page 58. Reprinted in *Ciarcia's Circuit Cellar, Volume II.* Peterborough, NH: BYTE Books, 1981, page 109.
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How to Use Color Displays Effectively

A look at the elements of color vision and their implications for programmers

Color is becoming an affordable option for personal computers, but like any new tool, it has special limitations and requirements.

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Walk into a computer store these days and you'll be blitzed by color: games with vividly colored objects moving amid colored textual instructions; graphs representing many relationships at once, using a different color for each; and screens full of color-highlighted text. If you're a veteran of the black-and-white days of personal computing, you'll probably feel like celebrating.

After spending some time with one of those colorful systems, however, your eyes may give you quite a different message. Where did those shadows on the screen come from? Why is the red fading in and out? Is that a purple enemy ship or a blue friendly ship?

Your eyes will be telling you that something is wrong with the color; it actually seems to *interfere* with the presentation of information. Misuse of color is all too common in software designed to take advantage of this new small-computer capability. Like all new tools, color has its own special limitations and requirements, many of which are based on human physiology and psychology.

Color vision is a complex process of three interacting variables: hue, brightness and saturation.

Physiology of Color Vision

The eye receives light in an area known as the *retina*. An extension of the brain, the retina is the most complex component of the eye. The light-sensitive cells within the retina are called *rods* and *cones*. Rods respond to low levels of illumination, producing visual sensations of shades of gray but no color. They respond most to blue light and require about 30 minutes to totally adapt to changes in illumination brightness.

Cones respond to high illumination, producing visual sensations of color and detail. They require about 7 minutes to totally adapt to changes in illumination. Each cone is sensitive to red, green, or blue light; blue receptors are significantly less sensitive than are green and red.

Near the retina's center is a slight depression called the *fovea*. Here, light has unobstructed access to the

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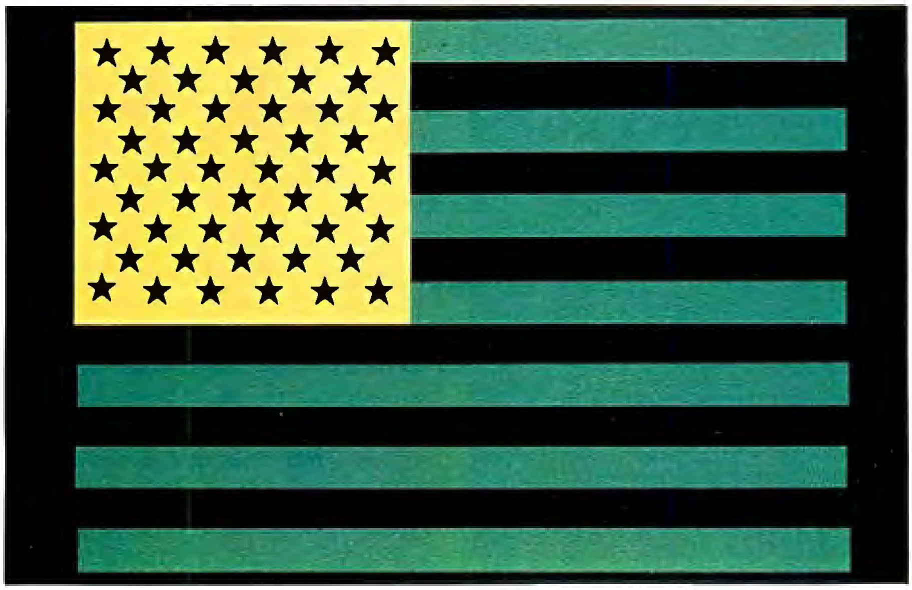

Photo 1: *Green and yellow against a dark background can cause confusion by producing the sensation of shadows and afterimages with color reversal. For a demonstration, stare at the center of the flag for 30 seconds, then look at a blank white surface.*

cones, which cover this area and are responsible for sharply detailed vision. The number of cones gradually decreases from maximum concentration at the fovea toward the edge of the retina, where the concentration of rods is greatest. Because a high concentration of cones produces detailed visual experiences, the sharpness of an image decreases as the distance from the fovea increases.

Besides determining sharpness, the retinal area receiving light affects color perception as well. In the fovea, the eye is sensitive to all colors. Moving away from the fovea toward the edge of the retina, red and green become difficult to perceive. Even farther from the center, yellow and blue become difficult to perceive. At the extreme periphery of the retina, only black, white, and shades of gray are perceived.

Current Theory

The current theory of color perception is based on an opponent-process mechanism. Three opponent receptions—blue/yellow, green/red, and white/black—produce color sensation by increasing and decreasing neural firing rates. The theory emphasizes adaption, contrast, color appearances, and afterimages to explain color vision. For example, since it's impossible to see a mixture of red and green in the same patch of light, these sensations are explained as results of opposite and incompatible activity in the same system.

The opponent-process theory has several implications for programmers setting up color displays. If the goal is to convey text or graphic information, opponent-color combinations should always be avoided. Yellow on a blue field and red on a green field produce the sensation of "shadows" on the display and afterimages with color reversal. This phenomenon is illustrated in photo 1. Certain other color combinations are undesirable because the colors tend to "vibrate" (imagine red on blue as an example).

These characteristics and limitations of the visual system lead to the following recommendations about color display organization:

- Since red and green areas of the color spectrum are reduced at the edge of the eye's visual field, don't use red and green outside the normal line of sight or place codes in these colors where they're likely to be overlooked. If they must be used at the periphery of the visual field, first get the user's attention by making the codes blink before beginning continuous display .
- For best viewing on a black background, always code alphanumerics in red, white, or yellow.
- Limit blue to large nonfoveal areas (i.e., nonfocal); blue characters are more difficult to read than other characters.

Psychophysical Factors

Psychophysical factors also affect how we perceive color. Color vision is a complex process of three interacting variables: hue, brightness and saturation. *Hue* is what we normally think of as color (e.g., red and green are different hues). *Brightness* is related to the intensity of light reaching the retina. Generally, higher-intensity light sources appear brightly

Guidelines for Using Color Effectively

Select compatible color combinations. Avoid red/green, blue/yellow, green/blue, and red/blue pairs.

Use high color contrast for character/background pairs.

Highly saturated colors are generally limited on inexpensive color displays, so stay within the primary hues of red, blue and green.

For casual users, limit the number of colors in one display to four. For experienced, long-term users, up to seven colors may be used.

Always code alphanumeric information in red, white, or yellow and confine light blue to large background areas.

Since red and green are not easily visible at the periphery of the eye's visual field, code signals to be perceived in this area in white.

Assign colors in ways that agree with the usual denotations. For example, use red for "stop" or "danger" and green for "go" or "all-clear."

Incorporate shape as well as color when possible. This redundant coding improves communication and makes the system usable by color-blind individuals.

When fast responses are needed, use highly saturated red or blue prompts rather than yellow.

If color coding has been used to teach relationships, use the same color coding when the individual is tested or expected to apply the learned relationships.

As the number of colors increases, increase the size of the color-coded objects.

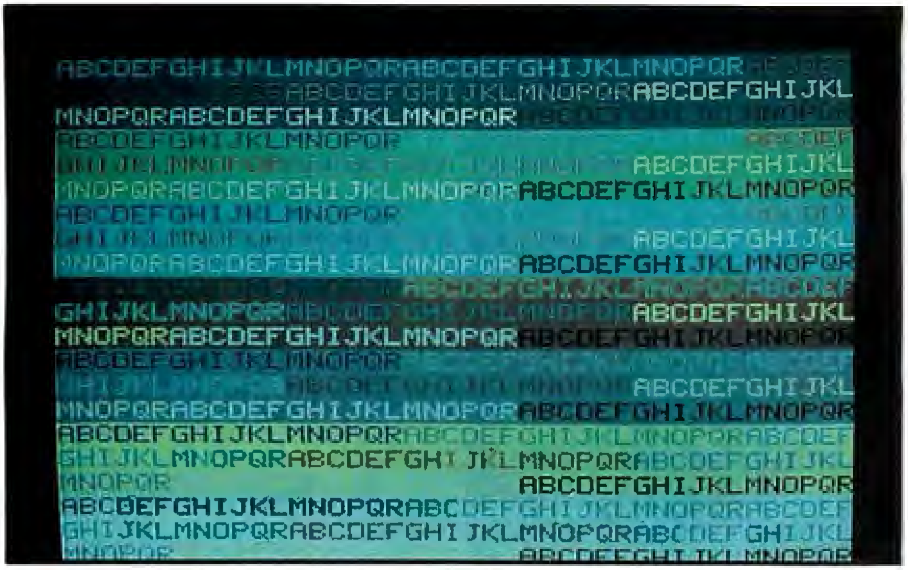

Photo 2: *Reduction in contrast lowers our ability to determine details, as illustrated in the various foreground and background color combinations.*

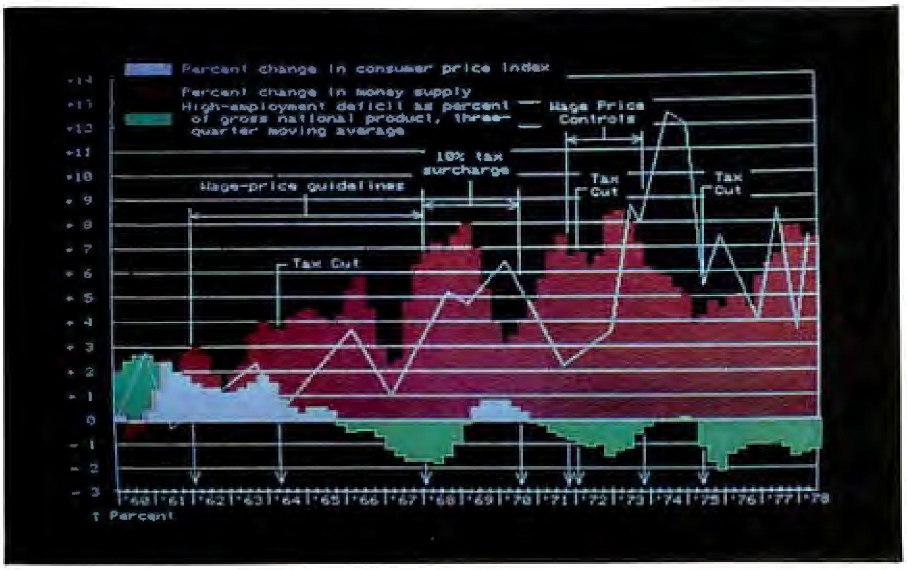

Photo 3a: *Common denotations used incorrectly: green shouldn't be used to show deficit.*

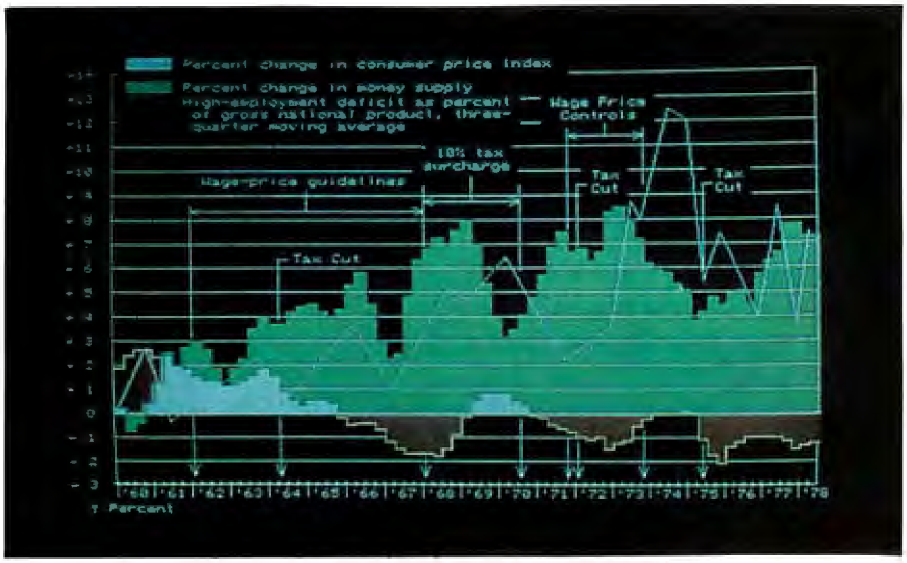

Photo 3b: *Common denotations used correctly to portray the same information.*

colored while lower-intensity light sources appear more dull. The retina, however, is also sensitive to differences among various wavelengths in the color spectrum. For instance, yellow is perceived as the brightest spectral color, while red and blue are perceived as the least bright.

Saturation, which is produced by the interaction of hue and brightness, is diminished by adding white light. For example, a fully saturated spectral red becomes pink when you add white light. In terms of hue, it's still red, but a red of decreased saturation. Highly saturated colors are easiest to read. (Unfortunately, displays capable of producing saturated colors are among the most expensive.)

Contrast is another variable that interacts with the physiological components of the human eye. While brightness is essentially a measure of the intensity of a light stimulus, contrast is the relative brightness of signal over background. The greater the contrast, the better the readability of a display. In other words, darker colors (red or blue) are not as visible as light colors (white or yellow) when both are viewed on a dark background. By using higher contrast, you produce more readable graphics. This phenomenon arises from characteristics of the human visual system. Lower contrast reduces our ability to determine details, as illustrated in the various foreground/background combinations presented in photo 2.

Research has indicated that visual acuity depends on the size and color of a symbol as well as the type of background. In fact, symbol size must be increased as the number of colors increases.

Another factor affecting display visibility is the *environment* in which a task is performed. Artificial or natural lighting in the work environment can reduce foreground-to-background contrast. Too, sensitivity to color increases as the eye adapts to darkness. Improper lighting can result in reduced performance, discomfort, and fatigue in addition to limiting the effectiveness of color changes. Illumination surrounding a color-display task can have a significant effect on the time required to re-

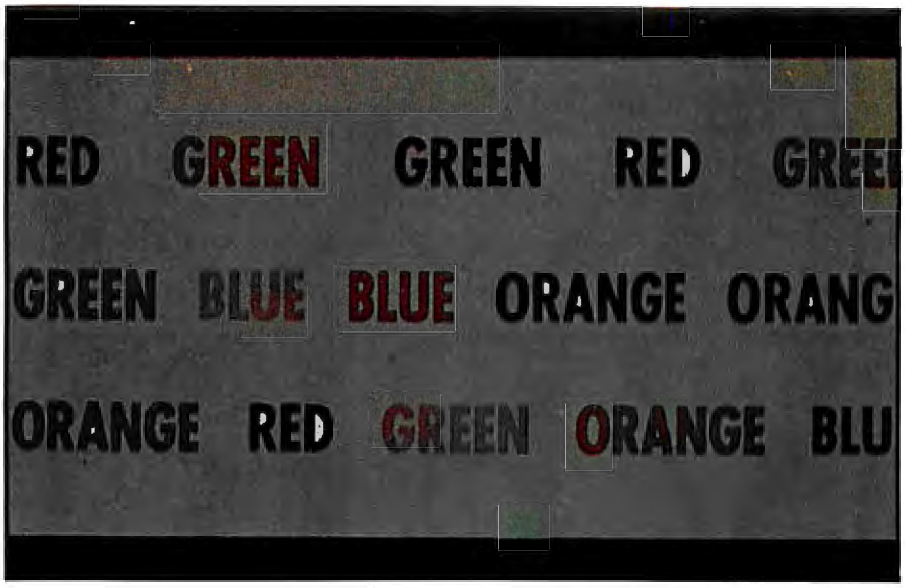

Photo 4: *The words are easy to read, but try naming the colors!*

spond to the displayed information. Response times range from fastest for red and blue to slower for yellow and yellow-orange. When programming games and other interactive tasks, consider the user's environment.

Remember that not all individuals have a perfect visual system. About 6 to 10 percent of the male population is color-blind, meaning that their eyes have defective color receptors and are unable to perceive certain colors. This factor affects less than .05 percent of the female population. Out of consideration for color-blind individuals, programmers can code redundantly, i.e., use both color and shape for coding.

For *memory's* sake, a limited number of color codes should be employed in most contexts. Users have recognized more than 50 colors with training, but the average user shouldn't be expected to remember more than 5 to 7 colors. This is the "magic number" usually associated with short-term memory (the memory you use to keep a telephone number in mind from the page to the dial). Novel displays should have no more than 4 colors, since this number is well below the average limit of short-term memory. This provides your brain with some memory space for other decision-making activities while the meaning of colors is being processed.

Color also influences *attention* (where you are looking and what you are thinking about). By carefully using color to manipulate attention, you can partition material at key points, organize it, and code or give meaning to it. Again, the number of colors used is important; having too many can interfere with the attention-gaining potential of color. You pay attention to the first flash of red, but by the tenth, it's routine.

Our *understanding* of information can also be significantly affected by color. Material presented in color is generally processed faster than the same material presented in black-and-white. Apparently, color helps the computer operator organize work by directing his or her attention to what's important. No differences in the interpretation of information presented in either color or black-and-white are observed *if* adequate study time is allowed.

Color can assist learning if used as a redundant cue or to highlight key concepts. However, the color coding of the concepts and responses must be matched for optimum performance.

Common denotations of color should be considered when you plan color displays. For example, most people assume that red denotes "stop," "danger," or "down." Usually, green indicates "go," "up," or "OK," and yellow means "caution," "slow," or "test."

Any application of color to a specific task should employ these color denotations to achieve maximum performance. Graphics using red and green in ways contrary to accepted meanings interferes with information processing and can result in incorrect conclusions. Conversely, applying these two colors in agreement with their usual denotations actually assists information processing. For a clearer idea of this, compare photos 3a and 3b. Photo 4 illustrates the confusion that can result from improper color coding. Guidelines for the effective use of color in displays are summarized in the text box.

Conclusions

Color motivates. It gets attention. If applied with its limitations and requirements in mind, color can be a powerful manipulator of our attention, memory, and understanding. ■

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A Human-Factors Case Study Based on the IBM Personal Computer

Members of a human-factors evaluation team put the Personal Computer to the test.

Robert G. Cooper Jr.
Paul Thain Marston
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Theron Stimmel
Center for Automated Systems
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How user-friendly is the new IBM Personal Computer? How hard is it to learn to use? Will I get eyestrain from using it eight hours a day? Are the manuals complete, understandable, and easy to use? Does it operate efficiently for an experienced user? Are the error messages informative? These are some of the questions that a human-factors specialist would pose in evaluating any computer system. In this article we will use the IBM Personal Computer as an example in evaluating human-factors issues in microcomputers.

Microcomputers present a special challenge to the human-factors specialist because the group of operators is diverse and the machine is used for many different tasks. Thus, it's impossible to specify any single set of criteria by which to measure the computer's human-factors performance.

We will examine here some of the features of the IBM Personal Computer that involve consideration of human factors to illustrate that the set of criteria fluctuates. A complete human-factors evaluation of the Personal Computer would be far too extensive to present here. Our discussion should not be interpreted as either a complete or a representative assessment of the Personal Computer's overall quality from a human-factors perspective.

We chose the IBM Personal Computer as an appropriate model for illustrating the process of human-factors evaluation for two reasons. First, it is a new model and marks the entry into the microcomputer market by the largest computer manufacturer. Thus, it has generated substantial interest. Second, because it is a new model, it will almost inevitably exhibit some human-factors flaws despite the best efforts of the designers and engineers.

Expert users often uncover new human-factors problems.

Evaluation Procedures

Two kinds of information go into any human-factors evaluation: judgments made by human-factors specialists based on their knowledge of previous research and their experience with similar systems and observations of users operating the system.

The data collected often include:

- types of errors made
- frequency of different types of errors
- frequency of consulting instruction manuals or seeking other kinds of aid
- user comments about strengths and weaknesses of the system
- user suggestions about needed additions or changes to the system

Most human-factors specialists prefer to draw conclusions based on empirical data collected from users of the specific system. However, because this way of evaluating a system is very time-consuming and expensive, most human-factors analyses, including those done at CASE, are based on a combination of the two methods.

For the evaluation of the Personal Computer, we asked several types of users to operate the system. Some had experience on other systems, including substantial programming ex-

About the Authors

The authors are psychologists at the Center for Automated Systems in Education (CASE) in San Marcos, Texas.

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perience. Some were adults—like many in the target market for the Personal Computer—with little or no previous experience with computers. And some were children from age 10 to 14 with at least some experience programming microcomputers at home or in school.

An important group missing from this set of users was individuals who have had extensive experience on the Personal Computer. People with experience on a particular system often have the most informative comments. They often demonstrate that apparent problems can be minimized simply by changing the operating procedures. Because they are competent enough to use the full set of features a system offers, they often uncover new human-factors problems. However, because the Personal Computer is so new, we couldn't find such a group of users, and we didn't have the Personal Computer long enough at CASE to develop such a group. Also, because of limited time and resources we couldn't test using standard scientific methodology. Rather than following a carefully planned procedure, we made new procedures as we went along, responding to insights from the test group. This type of evolutionary process normally occurs before an actual human-factors experiment is conducted. Then a consistent procedure is established so that all participants are asked to do the same set of tasks.

Hardware Characteristics

We will begin our examination of the Personal Computer by looking at some of the human-factors characteristics of the overall packaging. In its simplest form it consists of three units: the computer, the keyboard, and the display. For many applications, it is irrelevant whether these three components are integrated or separate. For others, separate-component packaging is a decided advantage because it offers flexibility in choosing a display or the option of locating the main unit with the disk drive away from potentially destructive young hands (see also the discussion of the keyboard below). However, for a user who must move the system from place to place, the benefits of one-piece packaging may bias him or her toward an integrated system like the Superbrain or TRS-80 Model III. For a school system, the separate units are at least a complication: three units rather than one must be anchored permanently to avoid accidental damage or pilfering.

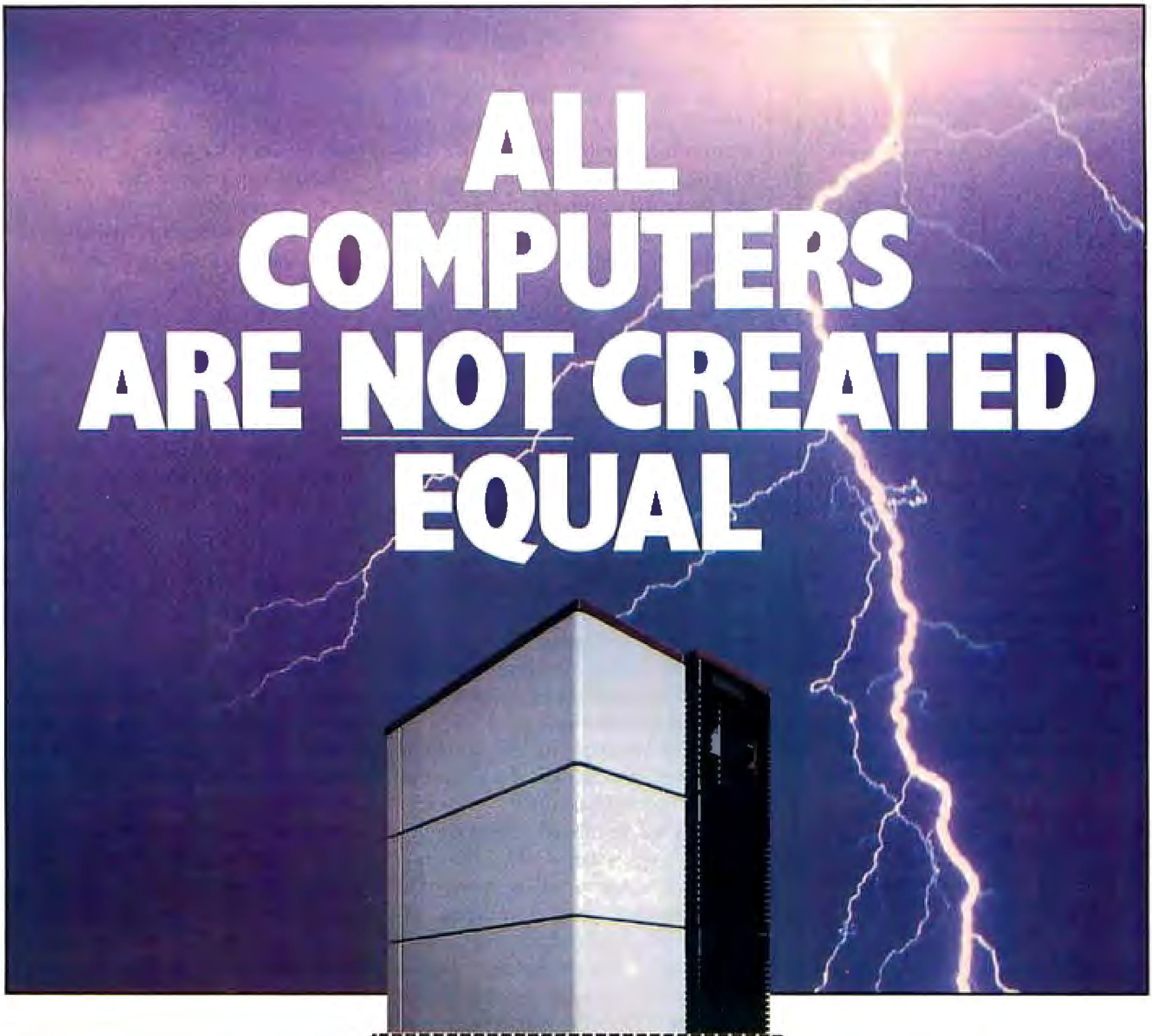
A second characteristic, which has been the focus of substantial human-

CASE

Researchers at the Center for Automated Systems in Education (CASE) at Southwest Texas State University conducted the human-factors research on the IBM Personal Computer discussed in this article. The staff of CASE is engaged in teaching, research, and development in the area of the human-factors considerations associated with computer-based systems. Although much of the early work by CASE emphasized human-factors issues in the use of computers in educational settings, recent projects, including work for Control Data Corporation (CDC), Comshare, and Polaroid, encompass a much broader range of human-factors issues in computer systems.

The procedure at CASE is first to define the scope for a particular human-factors analysis. Once the issues are clarified, researchers collect data from previously published human-factors studies as well as more general psychological studies in the areas of perception, cognition, and learning. Occasionally, previous research is adequate, but more frequently it is used to further clarify issues and design the appropriate research study to answer the specific human-factors issue being studied.

In some ways the analysis of the IBM Personal Computer presented here is not characteristic of our usual research because no single task or user group is anticipated for the Personal Computer. As a result, researchers simulated a range of human-factors experiments that represent the kind of research which would be done in a full-scale human-factors analysis of a microcomputer. Thus, the general approach and analysis presented here typify work conducted by groups like CASE on human-factors issues and problems in computer systems.



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factors research, is the quality of the display. This of course depends largely on the monitor used. The IBM monochrome monitor, the only monitor supplied by IBM for the Personal Computer, meets or exceeds all the standard criteria with respect to character size and clarity, screen brightness, freedom from flicker, etc. All the users we questioned were impressed by the display, even those who did not in general like green-phosphor screens. When evaluating a display for a large group of potential users (for example, for a school system), the criteria based on the results of published experiments are particularly useful because they were developed from data on a representative sample of users. When an individual evaluates a display for personal use, experience with the display may be more useful than reading published results because the published criteria are more stringent than many people require.

A third feature of the Personal Computer, on which a substantial amount of human-factors research exists, is the keyboard. Despite some of the advantages of alternate keyboard designs, it appears that American National Standards Institute (ANSI) standard and related keyboards (sometimes called QWERTY keyboards because of the first row of letters) will continue to dominate the field because of conversion and retraining expense. Therefore, we will examine the IBM keyboard from within these standard constraints.

The keyboard "feel," the tactile sensation of typing on it, was highly praised by all who used it, particularly those who were familiar with other microcomputer keyboards. Frequently mentioned virtues included the ability to move and change the angle of the keyboard, the sculpturing of the keys, and the keyboard's curved-plane surface. However, every user complained about the Enter and the left Shift keys (see photos 1a-1f). The Enter key is about ½ inch farther to the right than most users expected, and the left Shift key is about ½ inch farther to the right with the backslash key inserted between the Z and the Shift key. These unconventional locations caused errors initially, but extended practice usually eliminated such errors after about a week.

Again, the importance of the keyboard layout depends on the context in which the computer will be used. For occasional use by individuals who frequently type on other keyboards (e.g., by a secretary in an office or by someone at home who does a substantial amount of typing at work), the keyboard layout may be a major annoyance. For the individual who types mostly on the IBM keyboard, it should be no problem. Also, if the use of the computer involves nontext materials, as in financial planning or playing games, the layout may be less important than if the computer is needed for word processing.

The inclusion of an extra key between the Z and the left Shift key may become standard in the future. In Europe, many keyboards have this extra key to facilitate typing extra characters required in some languages. Some word processors in the U.S. are using this style keyboard to accommodate extra functions required in word processing. So what is a potential human-factors problem today may be an asset in the future. However, on several Japanese keyboards, it is the right Shift key that is moved to allow the addition of an extra key, illustrating that no standard exists for these additions.

The keyboard of the NEC PC-8001 suggests one near-term solution. On this computer the user can select, with a single button, either an almost-ANSI-standard keyboard (with the right Shift key out of place) or a keyboard with the letters in alphabetical order (which is helpful for young children). This flexibility could be expanded to let users program the arrangement of their own keyboards.

Documentation

Human-factors considerations are especially significant in the area of documentation. Minimally, documentation needs to fulfill three func-

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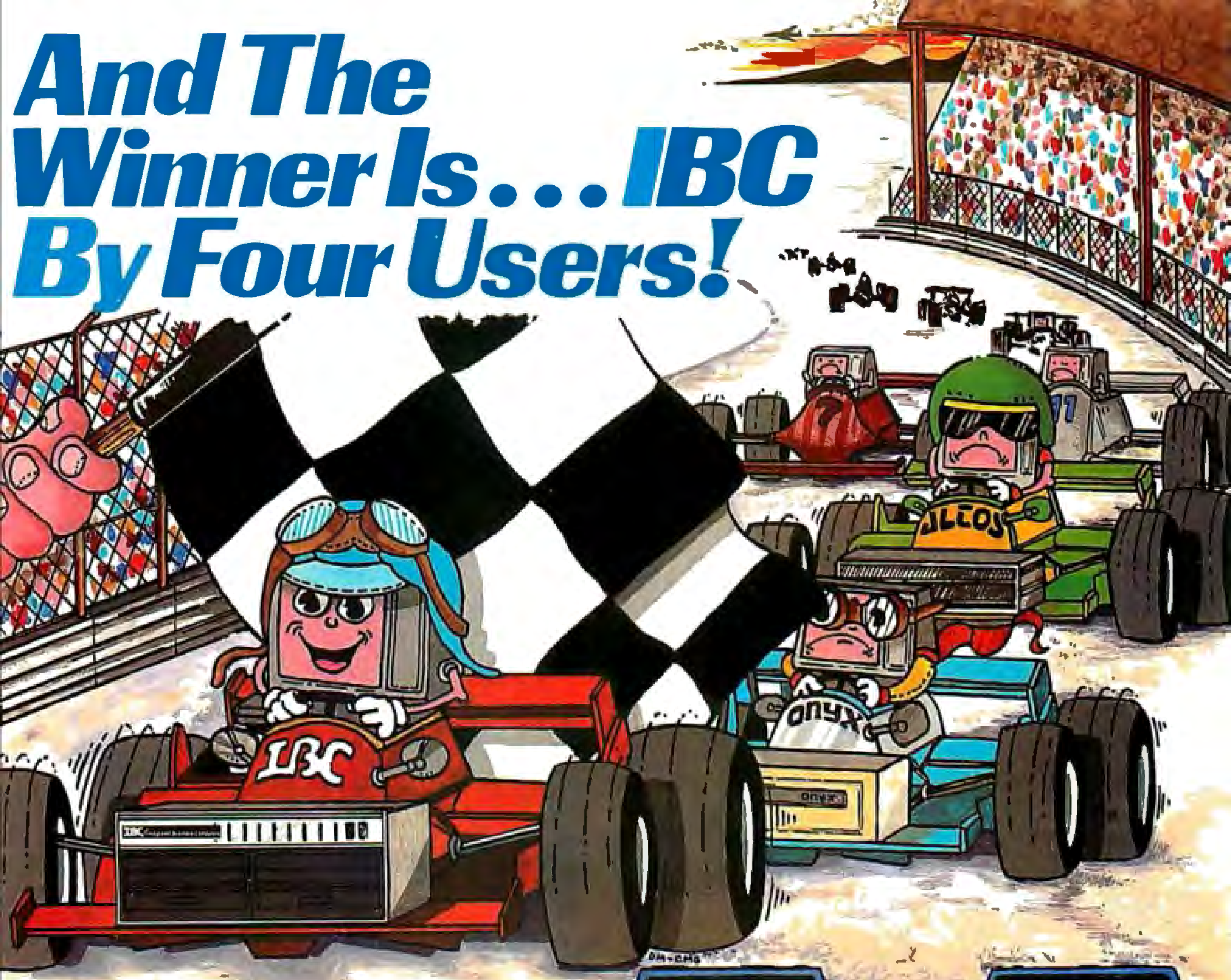

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1a

1b

1c

1d

1e

1f

Photos 1a-1f: *Comparisons of keyboards. All have letters in the same position, but note the variation in the placement of the Shift, Return, and other special symbols. Note also the various solutions to the problem of where to put all the keys not needed on ordinary typewriters.*

tions: initial training in using the system, quick reference for momentarily forgotten information, and complete documentation of capabilities and how to access them. Ideally, many other functions will be served, including guidance on uses for system features, information to aid in debugging (including common errors and their symptoms), etc.

The manuals for the Personal Computer have received very high praise. Gregg Williams in "A Closer Look at the IBM Personal Computer" (January 1982 BYTE, page 36) wrote,

"They will set the standard for all microcomputer documentation in the future." Our analysis of the manuals is less enthusiastic, although in many ways the documentation is excellent.

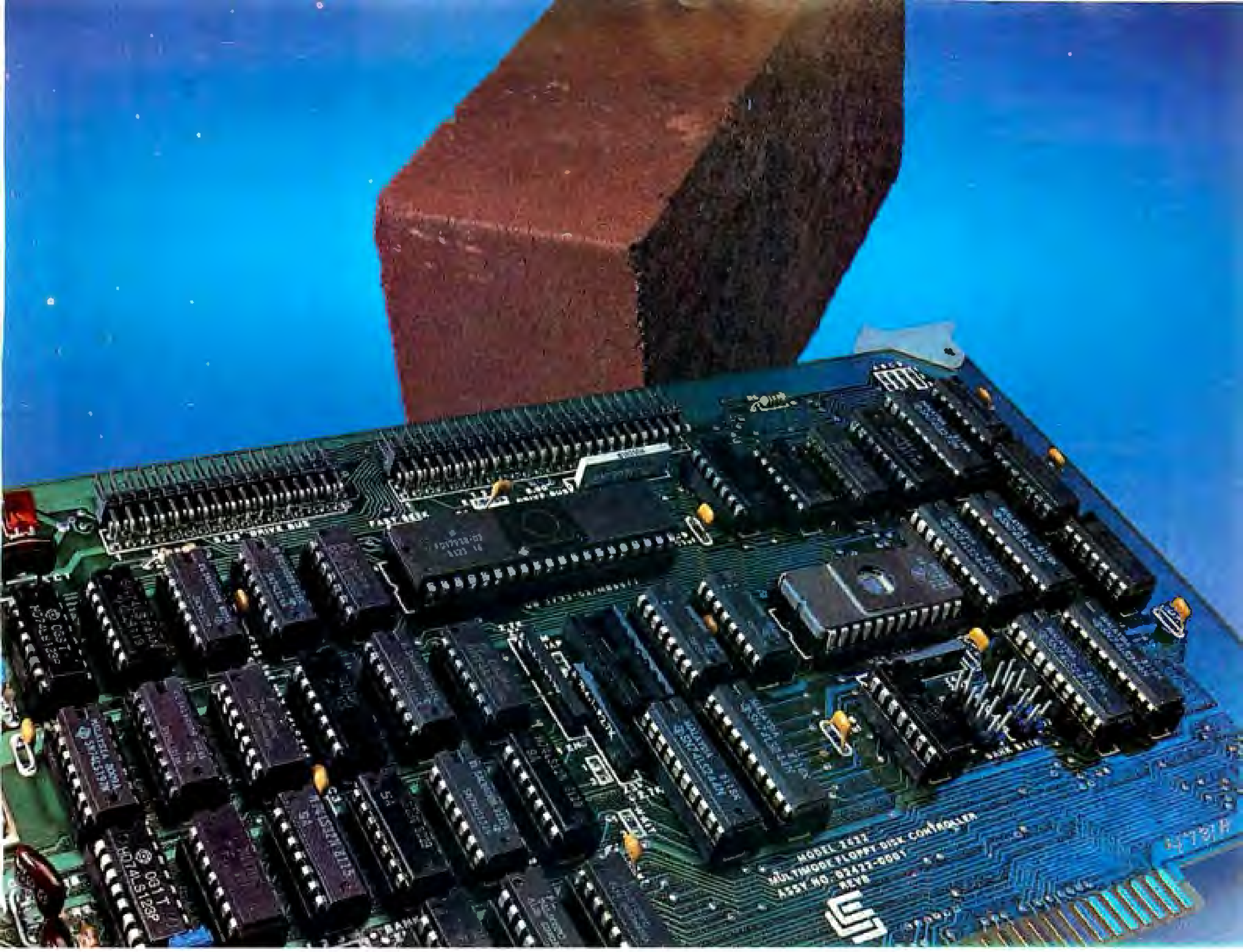
We will take a look at the BASIC manual first to illustrate some of the strengths and weaknesses of the documentation. The manual is for reference and does not claim to be a programming tutorial. For its stated purpose the manual is quite good. All users who had prior knowledge of BASIC had no difficulty programming on the Personal Computer, including using some of the special features of IBM's version of BASIC. The features of the manual that are most useful are the index and the brief and extended descriptions of every command, statement, and function. The extended descriptions are most complete for those features that are unique to IBM's BASIC and include informative examples.

There are five parts to each keyword description: format, version, purpose, remarks, and example. The only drawback is that some information is omitted, apparently because it does not fall neatly into any of the categories. For example, restrictions and probable error messages from mistakes are only included in some of the descriptions. For the FOR and NEXT statements, information about errors is given in the body of the remarks section, and no information is given at all about restrictions on the amount of nesting or about overflow in nesting, which will lead to an "out of memory" error. Despite these problems, the manual can be used effectively.

IBM has left the market for tutorial manuals to outside publishers.

As adequate as this manual is for the experienced user, it does not fill the need of the novice for an instruction manual. General instruction manuals do exist (e.g., *Basic BASIC* and *Advanced BASIC*), but the idiosyncrasies of different BASICs have led to a demand for instruction manuals for individual machines. According to our observations, novice IBM users had much greater difficulty with IBM's reference manual than do novices starting out on an Apple II Plus with Apple's instruction manual. IBM apparently made a conscious decision to leave the novice market to the independent producers of computer manuals and books. An IBM spokesperson assured us that such independent sources are already hard at work and their manuals should be out shortly, but until such manuals are written, a hole remains in the documentation from the perspective of the computer novice.

In the interim, IBM could make two simple additions to the current manual that would be helpful. One is a quick-reference card that could be removed from the manual; it would decrease the need to flip back and



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forth from the brief- to extended-description sections of the manual. Second, a comment could be added to the preface about the existence of Appendix D, which discusses the differences between IBM Personal Computer BASIC and other BASICs. None of our novice users discovered this appendix within the first hour of trying to learn to program in BASIC (we showed it to them after an hour), and such information would have been very useful in trying to use the general manuals for BASIC. Of course, these changes would be useful for more experienced users also.

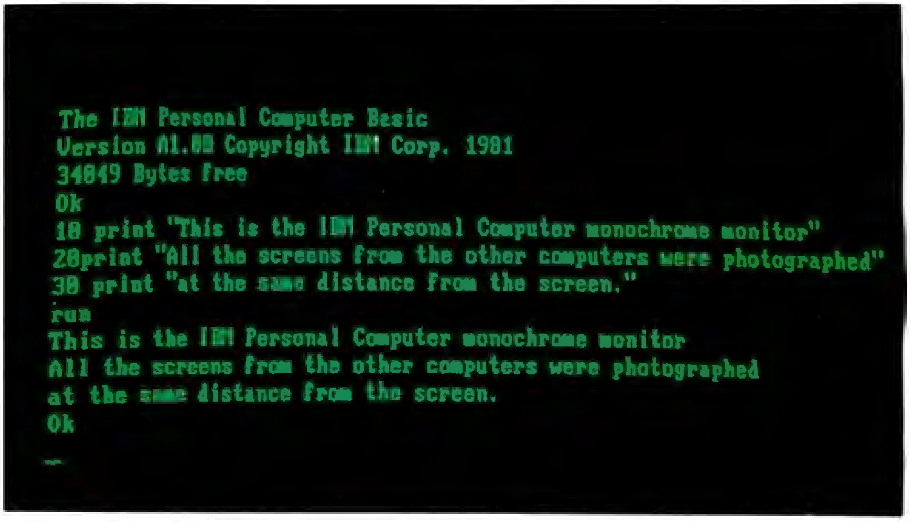
IBM's *Guide to Operations* presents a similar problem. It appears to be written for novices and contains excellent illustrations and very clearly written instructions. However, crucial pieces of information are

IBM's monochrome monitor meets or exceeds all the standard human-factors criteria for video displays.

either left out or have odd locations in the manual. For example, we had several novices set up the computer from scratch. Perhaps because we were watching with notepad in hand, all followed the written instructions scrupulously. As instructed on page 2—6, they turned on the system for the first self-test after connecting the keyboard and power cord. Four out of five continued on to page 2—7 and began to connect the cables for the display and printer without first turning off the system, and would have done so had we not stopped them. Next, the manual calls for the use of the diagnostic disk on page 2—16 without any cautions about the handling of disks. This information is contained several pages later. None of our novices mishandled the disk. But if they had mishandled it and were looking in the problems section because the disk would not load, the warning there would obviously be too late.

Because the Personal Computer we used for our evaluations had a defect

2a



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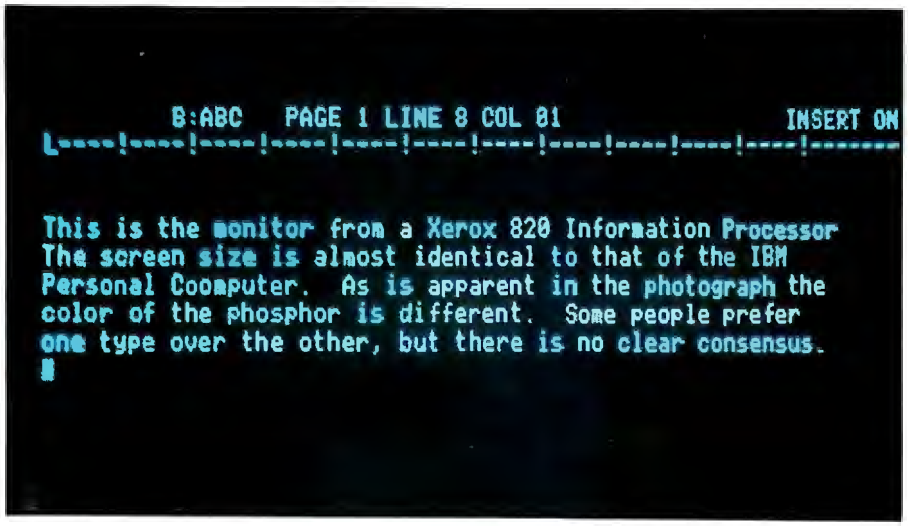
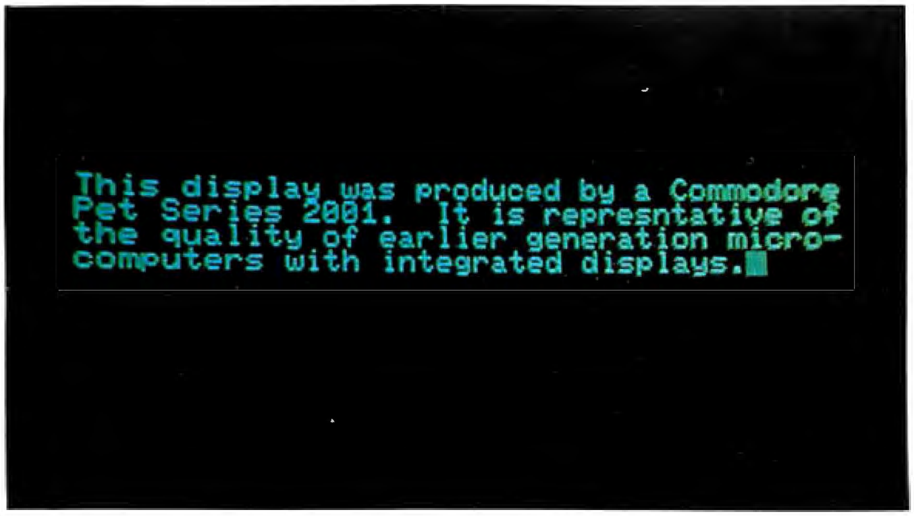


2c

Photos 2a-2e: *A representative sampling of computer video displays.*



2d

2e

in the power supply and disk system when first received, we noticed another documentation problem. We had decided to have a novice unpack and set up the system. He progressed through the setup procedures to the point of loading the diagnostic disk, which wouldn't load. In response to this failure he repeated all the previous steps, looping through the procedures twice. He then turned to the section "Problem Determination Procedures." This proved fruitless because, by the time he reached page 4—7, he was reassured that the system was working because it met the criteria of correct information on the screen and correct auditory response (one short beep). At this point our novice gave up. It took another eight minutes for the "experts," who had been observing, to discover on page 4—8 the statement "Error messages may or may not remain on screen. So look quickly." An error message had flashed on and off shortly after the power was turned on.

Two documentation requirements illustrated here are that warnings, cautions, and other crucial information should appear very early in the manual before the relevant error can be made and that error conditions ought to lead to a permanent message that is terminated only by user action.

We discussed the problems described in the last two paragraphs with people from IBM and the local Computerland store. Both commented that the Personal Computer is not being sold by mail order and that a purchaser would be given substantial training before taking the computer home. Although this may lessen the necessity of the above requirements in some ways, we do not believe it eliminates them. It is poor practice to leave the task of conveying such important information to a group over which IBM has little if any control. In addition, people other than the original purchaser may need to learn to use the computer. Instruction manuals should be complete and sufficient to allow one to learn and use the system in isolation, even if this is not the ideal context for learning.

All the IBM manuals fit in 8½- by 5½-inch, hardcover, three-ring binders. The advantages of this format include easy updating. Sections are added to the *Guide to Operations* each time a new option (e.g., communications interface or printer) is added to the system. However, there are some negative human-factors consequences of this format. Three times during our testing, a manual was dropped in such a way that the binder came open and pages fell out. For a home or business user, this would probably be only an occasional annoyance. However, in a school setting these manuals would not be acceptable. Something more durable is required. The specific use for which the system is intended will determine whether this is a significant human-factors failing.

IBM does have some human-factors problems with its manuals for the Personal Computer. However, compared to documentation that other new computers have had when they were first introduced, the IBM manuals are outstanding. And they compare favorably even with the updated offerings from other manufacturers.

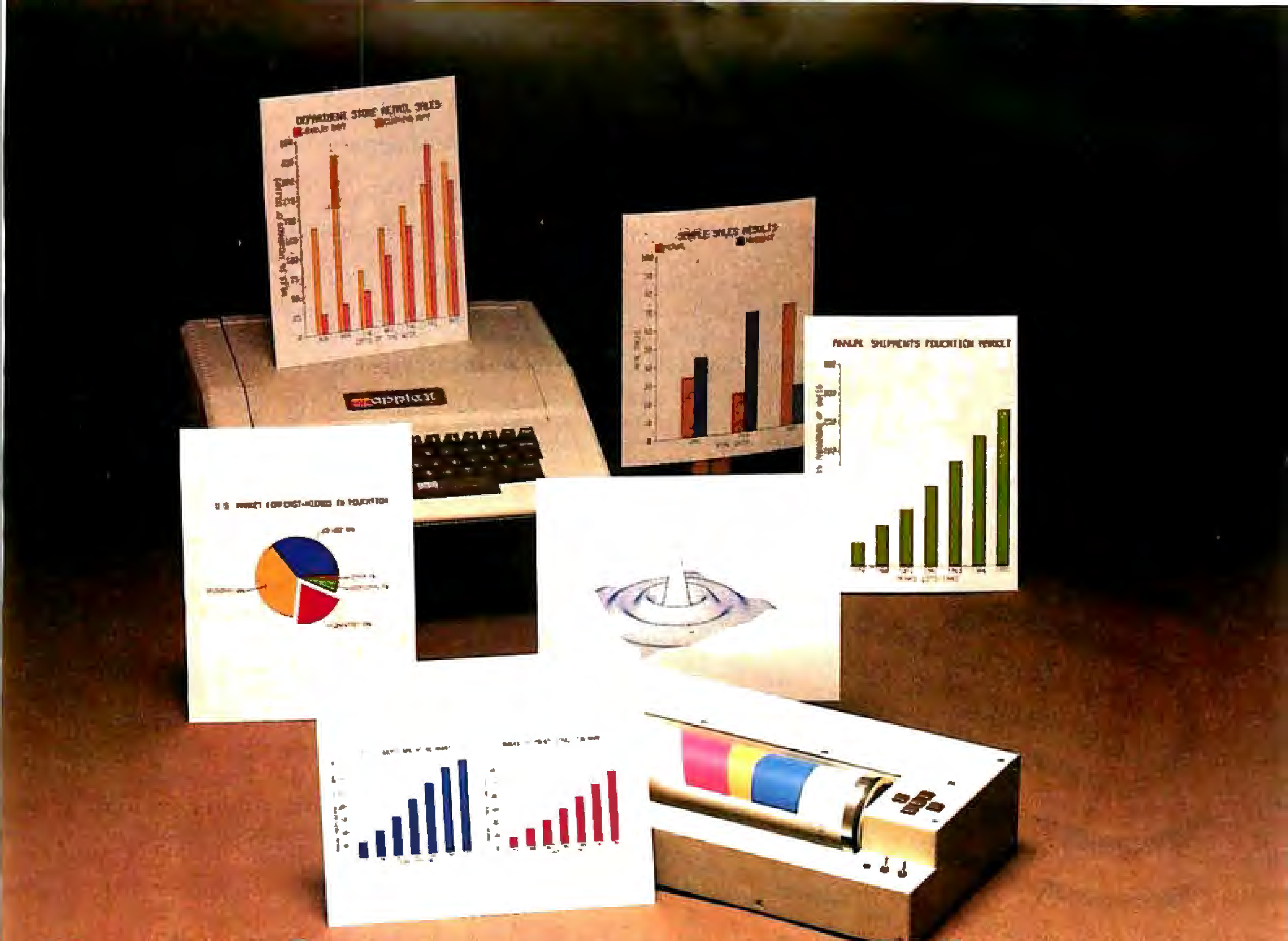
Operational Characteristics

A human-factors evaluation of the functional operation of the Personal Computer is the most difficult to do without a specific task in mind and without a long period of time in which to observe users trying to accomplish this task. Also, an examination of the individual features of the Personal Computer reveals that many of the best features from microcomputers of other manufacturers have been incorporated. A separate examination of each feature in terms of how it helps facilitate people's ability to use the system would start to sound like an IBM press release. However, the Personal Computer's versatility (in itself a human-factors asset) does entail human-factors costs. For example, many individuals have happily used their microcomputer for years without being bothered by lack of precision or by rounding errors. On the other hand, the use of some computers for business bookkeeping is problematic because of limited precision. The IBM

The error message appeared on the screen so briefly the operator never noticed.

Personal Computer (and several others) offers the choice of single or double precision. This is an advantage to business users but requires a decision by other users ("Is 6-digit precision enough, or do I need 17?"). Some users may find that they prefer the old situation in which they obtain 9-digit precision (sufficient for home bookkeeping) automatically and do not have to make the determination.

The system reset procedure on the Personal Computer provides a different perspective on the problem of assessing human factors without a specific context. For purposes of comparison, it is important to be aware of the human-factors problem with the system reset on the Apple II. On the Apple II, an operator would push the key labeled Reset, an extremely simple procedure. Unfortunately it was too simple, and because the Reset key was directly above the Return key, it often occurred accidentally. Apple corrected this problem on the more recently produced versions by giving the user the option of choosing to re-



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quire a control key plus Reset for a reset to occur.

On the Personal Computer, the operator initiates a system reset by holding down the Control and Alternate keys and then pressing the Delete key. This procedure is certainly cumbersome enough that it is unlikely to occur by chance. Is it too cumbersome? Because the operator uses three keys, none of which is labeled Reset, will the procedure be forgotten by those who need to use it? Without considering a specific context we can't answer these questions, but we can consider the kind of criteria a human-factors specialist would use in answering them for some particular context. First, how frequently is a system reset executed? If it occurs extremely rarely (as might be the case for someone using already developed software), it probably is all right if the command is forgotten and the user has to look it up. If it is used quite frequently (perhaps in debugging complex programs), it will be remembered because of the constant use. If it is used occasionally, it may be hard to remember and yet be frustrating to have to look up each time. Second, what are the consequences of making a mistake when trying to execute a system reset? If delay in a reset or if some combination of related keys might lead to dire consequences in some application, then for that application the Personal Computer would have a major human-factors failing. Third, what alternatives are available and how do they interact with other human-factors characteristics of the system? For example, a separate key could be used as on the Apple II, but that either adds another key to the keyboard or takes up a key that might have been used for some other function. Too many keys produce an added memory load on the human operator, just as multi-keystroke commands do. The human factors trade-offs here must be evaluated in terms of the way the system will be used.

The Personal Computer has ten special-function keys called "soft keys," which have a set of default functions but can be changed by the user. The "soft keys" are a very popular characteristic among the experienced users we questioned. However, because the keys can be redefined, they are labeled F1 through F10—not very effective labels for remembering their functions. The Personal Computer solves this problem by displaying partial labels at the bottom of the screen (for all 10 keys on an 80-column display and for the first 5 on a 40-column display). We expect that those operators using a television display (40 columns) and others not wanting the labels at the bottom of the screen will tape a list of the ten functions somewhere near the computer. In some ways it would have been nice if space had been left on the keyboard for labeling these keys. However, that would have had the undesirable effect of enlarging the keyboard. Again, there are always trade-offs.

The relation of the line-editor pro-

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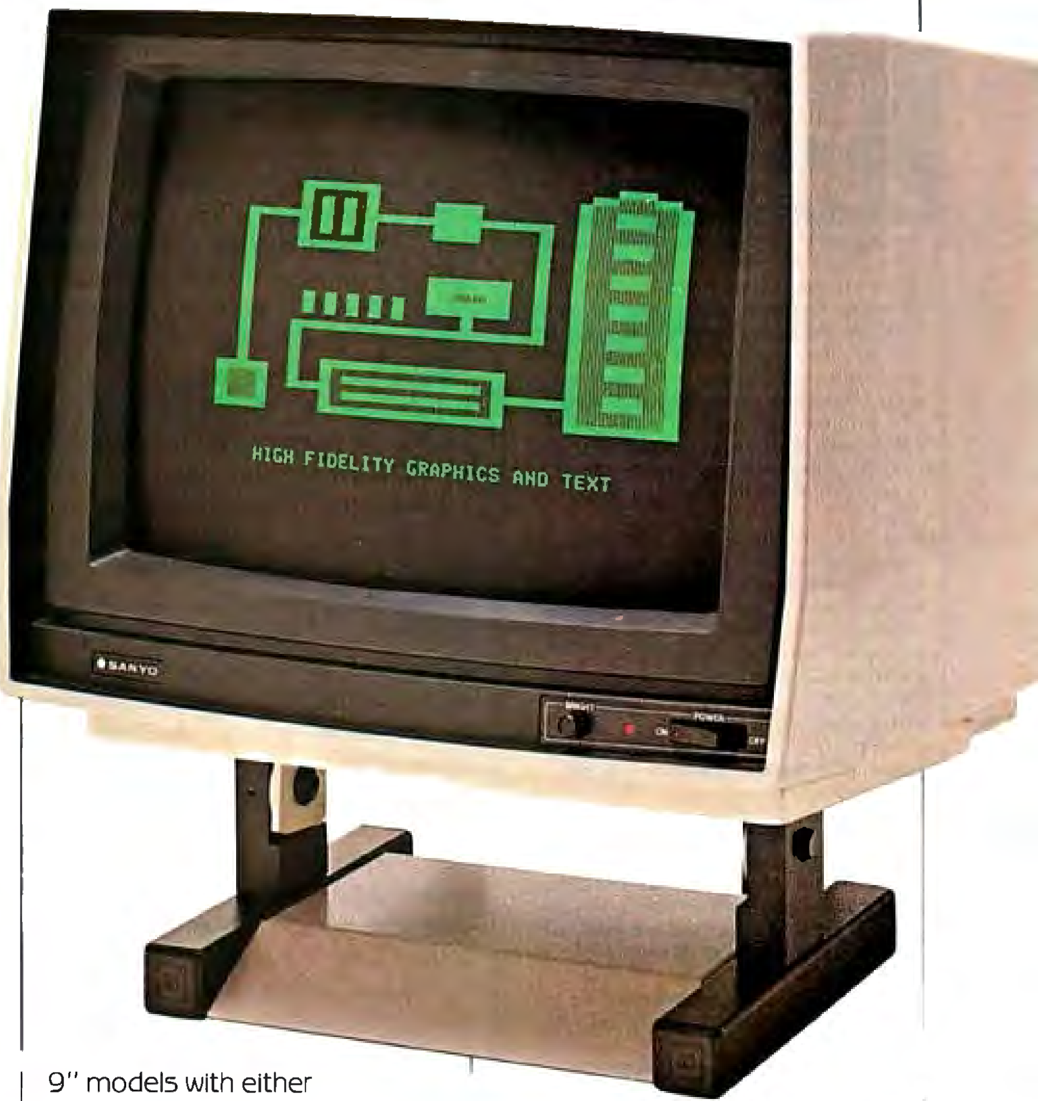

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gram that is part of the disk operating system (DOS) to some of the characteristics of BASIC is another human-factors issue. Using the line editor, for example, the Personal Computer lists lines 100 to 200 with a command of the form "100, 200 L" and deletes with a command of the form "100, 200 D". In BASIC, lines are listed with a command of the form "LIST 100-200" and deleted with a command of the form "DELETE 100-200". The difference in syntax adds a memory burden for no intrinsic reason to anyone who uses both capabilities of the Personal Computer. An experienced user who was asked to use the line editor had trouble with the syntax. On the second day he used it he made errors and had to go to the manual to check the syntax of the commands. This syntax problem is a relatively minor issue when considering the line-editor program and BASIC but is representative of the more general class of differences in syntax that can lead to disastrous mistakes (not necessarily on the IBM machine). Perhaps the best example of syntax-function problems is that of commands for copying: on some systems the source is first and the destination second, whereas on others the reverse is true. Errors that were the product of moving from one system to the other can and have resulted in the loss of crucial files.

Conclusions

We have illustrated the process of human-factors evaluation of microcomputers and its importance. Understanding that the user is part of the system is crucial to understanding the human-factors approach. Just as no single language is best for all programming, no single system design is best for all users. We have presented some general principles that apply to all systems but, for the most part, evaluations must take into account requirements of the specific, potential user. Groups like CASE, which perform human-factors evaluation, start by determining the requirements of the user, then they evaluate the human-factors characteristics of the hardware, software, and documentation in terms of those requirements.

Because user needs vary so, it was almost certain that the IBM Personal Computer would have some human-factors failings; it could not be all things to all people. Although we did not attempt to perform a complete evaluation, our overall impression of the human-factors design of the Personal Computer is very positive. IBM has begun to put substantial emphasis on human-factors design, and the IBM Personal Computer exhibits many positive results of the efforts of human-factors specialists. However, some of the simple and easily changed human-factors failings that we uncovered could have been detected from relatively simple observations of users.

If you are considering purchasing a microcomputer, these comments have two major implications. First, be clear about the use or uses to which the system will be put, and then concentrate on human-factors characteristics that are relevant to those uses. Do not buy a computer that will be used primarily for word processing on the basis of the enthusiastic recommendation from someone who uses his for home finance and playing games. Second, get as much information on the actual use of the system as possible. Use it yourself in the way you intend to use it; do not just go through a set of demonstration programs, even if they are designed to illustrate the features of the programs you will be using. Try to find someone who is already using the system in an application similar to the one you anticipate. As mentioned previously, we find experienced users to be one of the best sources of human-factors insights. If you make use of the insights of others, you may avoid being the source of negative human-factors insights about your own system. ■

Acknowledgment

BYTE would like to thank Computerland product manager Richard Mandel and the Austin, Texas, Computerland store for equipment and assistance provided during the preparation of this article.

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The Hewlett-Packard Interface Loop—HPIL

Unique Two-Wire System Allows Low-Cost Data Collection

Robert Katz
248 East 90 St. #3B
New York, NY 10028

The most intriguing feature of the Hewlett-Packard HP-41C has been the multiple plug-in port on the unit's back (see Steve Leibson's *"The Input/Output Primer, Part 3,"* page 186). Until now, four ports have been available for plug-in RAMs, ROMs, a card reader, a thermal printer, and a bar-code reader. Yet users have been begging for the chance to let the HP-41C talk to the outside world. Hewlett-Packard is very protective of its products and does not publish specifications of the connections to these ports. Justifiably, because the calculator's delicate CMOS (complementary metal-oxide semiconductor) circuitry can be damaged easily by improper connections.

The public demands and Hewlett-Packard responds. By announcing the Hewlett-Packard Interface Loop (HP-IL), Hewlett-Packard has provided users with much more than they've been requesting. The HP-41C was a quantum leap beyond conventional calculators, and, remarkably, the HPIL is a quantum leap for the HP-41C.

The Loop Hardware

HPIL operation is powerful and sophisticated, but the hardware is simple, small, and easy to interconnect. A board called the HPIL Module (HP82160A) plugs into any of the four ports on the back of the HP-41C. The module receives its power from the HHC's internal batteries. Two 71-cm (28-inch), 2-wire cables extend from the module; at their ends are 2-pin male and female con-

At a Glance

Name
Hewlett-Packard Interface Loop (HPIL)

Manufacturer
Hewlett-Packard
1000 Northeast Circle Blvd.
Corvallis, OR 97330

Price
HP82160A HPIL Module: $125, available now; HP82183 Extended I/O ROM: price to be announced, available summer 1982; HP82180A Extended Functions/Memory Module: $75, available now; HP82181A Extended Memory Module: $75, available now; HP82166 HPIL Converter: $395 for a prototyping kit including 2 converters, test board, HPIL cables and manual, or $1250 in quantities of 10 with no accessories, available spring 1982; HP82182A Time Module: $75, available mid-1982; HP82161A Digital Cassette Drive: $550, available now; HP82162A Thermal Printer/Plotter: $495, available now; HP3468A Programmable Digital Multimeter: $695 plus $125 for battery option, available now; HP82938A HPIL Interface Card for HP Series 80 Personal Computers: $295, available now;

Description
HPIL is a complete software and hardware system that turns the HP-41C handheld computer/calculator into a general-purpose, data collection, measurement, and analysis tool as well as an equipment controller.

Other features
Simple 2-wire connectors, "transparent" operating system

Hardware options
Digital Data Cassette, Thermal Printer/Plotter, Programmable Multimeter, GPIO Interface, Computer Interface, among others

Audience
Original equipment manufacturers (computer-aided manufacturing), instrumentation manufacturers, hobbyists, others

About the Author
Robert Katz, who prefers to be called "Bob," is a recording engineer for records, TV, and radio. He also dabbles in computers.

A Day in the Life of an HP-41C

I prefer to call my HP-41C an HHC. That way I don't have to call it a "calculator" or a "computer." Hewlett-Packard calls it both a "calculator" and a "system." Actually, the versatile HP-41C can be treated any way the user desires. Its power and flexibility are illustrated by the following tour of the HP-41C world.

It's morning and I find no cash in my pockets. No, the HP-41C cannot mint money, but its continuous memory can tell me how much I have in my checking account. Upon pushing RCL *(recall), the legend* RCL *appears in the alphanumeric liquid-crystal display. To the right, two* prompts *(cursors) can be seen; these prompts are the HHC's signal to supply a two-digit number in response. Since data register 9 contains the amount of my checking account balance, I punch* 0 *and* 9. *The HP-41C answers with $127.59000.*

I only need to display two digits after the decimal, so I push SHIFT *for secondary key functions, then* FIX *and* 2. *Each key gives a satisfying "thunk" when pressed; tactile feedback has always been a Hewlett-Packard feature. The display is even more helpful by naming each button's function as it is pushed. It's also easy to cancel or correct a function if a mistake is made. By using the back arrow key ←, the screen unambiguously shows each correction, and HP-41C error messages appear in English.*

I see that I have exactly $127.59 in my checking account. Before deciding to deplete the account, I run downstairs to check the just-delivered mail and happily discover the arrival of a check for $300. Pushing 3 0 0 STO + 0 9 *adds the $300 to my checking account (at least within the calculator). In addition, I push* Σ+ *and see the number 12, marking the twelfth deposit I have made since I began to count deposits in the Sigma registers. The Sigma registers can compute the mean (average) of all my deposits, the standard deviation, and other statistical functions. To find the mean, I push* XEQ *(for* execute *or* run*) and then spell out* M-E-A-N. *This ability to call a function by spelling out its name is very much a computer-like action.*

After stopping at the bank, I head for the recording studio where I work as an acoustical consultant and maintenance man. Arriving at the studio, I discover a volume unit (VU) meter that reads too low. I apply a sine wave to the recording console's input; 2.0 volts (V) are measured across the output terminals, yet the meter reads 0 VU. Thanks to a program I've written, my HP-41C can talk to me in English and clue me in to the decibel error of the meter (see listings 1 and 2). I can call this program in two ways. One way is by name as above: XEQ d-B-V, *and the program begins running. Since I use the dBV program a lot, I reduced the keystrokes to a single one via the USER mode.*

In USER mode, the HP-41C is customized for individual use; programs or functions can be reassigned to any keys. The entire keyboard can even be reconfigured if desired, then returned to normal by a second push of the USER *key. An added attraction is a keyboard overlay which allows you to identify reassigned keys with stick-on labels. Thus, a small, uncluttered keyboard can call literally hundreds of functions.*

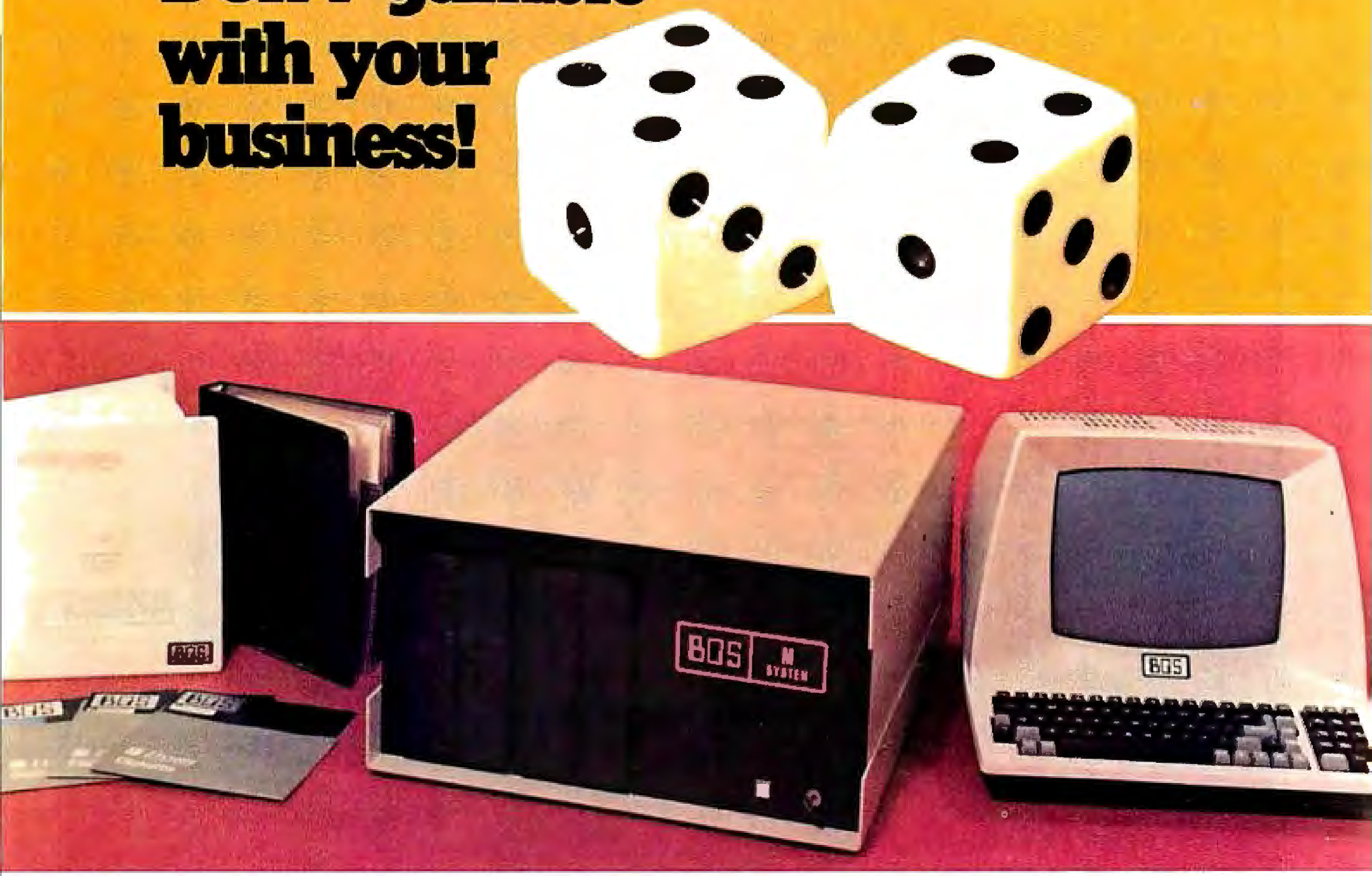
Throughout the course of the morning, I will use several HP-41C functions and two other programs. When the job is done, I attach the HP-41C to one of many available accessories, a battery-powered thermal printer. With the aid of still another program, it prints out an invoice of parts and labor performed on this job.

On the way to the next job, a friend and I play a game of Hangman on the HP-41C. This game is included in the Games Pac, which is designed to help while away those between-business hours. More serious Standard Module Pacs are available to help perform engineering and scientific tasks, among others. The average application module price is $35. The COPY function permits copying any program from ROM (read-only memory) to RAM (random-access read/write memory) to allow customizing. For example, I have added personalized prompts to the game of Hangman.

Listing 1: A single key depression in USER mode executes the author's program dBV. The calculator first prompts for a voltage entry; response is 2.0 V, and the RUN key is pressed. The calculator asks for reference voltage; 0.775 V is assumed if RUN is pressed. The answer is 8.2 dB over 0.775-V reference. Next, the program is run with a different reference voltage (1.23 V, which is 4 dB above a one-milliwatt reference across 600 ohms). The answer is 4.2 dB over 1.23 V. Another key depression in USER mode executes the author's program VOLTS. The calculator indicates that 1.55 V is 6 dB over 0.775 V. The display is formatted to two decimal places but can easily be changed.

```
          XEQ  "dBV"
VOLTS?
  2.0        RUN
REF?R/S=STND
             RUN
8.2 dB/0.8 V
          XEQ  "dBV"
VOLTS?
  2.0        RUN
REF?R/S=STND
 1.23        RUN
4.2 dB/1.2 V
 XEQ  "VOLTS"
dB?
 6.00        RUN
REF?R/S=STND
             RUN
1.55 V/0.77
```

Don't gamble with your business!



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The powerful programming ability of the HP-41C is enabled by an extended version of the RPN language that Hewlett-Packard introduced to the public in 1971 with the world's first handheld scientific calculator, the HP-35. Over 130 scientific functions and 56 programmable flags are available, some of which keep track of the status of peripheral devices as well as control the peripheral's status. While all previously made calculators were hardware-intensive *devices, the HP-41C is a* software-intensive *device. As such, each plug-in module adds completely new functions, giving the HHC a new personality.*

Hewlett-Packard has taken a lot of care in naming functions so one can remember them easily, but if I forget the name of a function and don't have the instruction manual handy, I'm not helpless. I can call up a CATALOG, a directory of the many functions available. Three such catalogs exist in the HP-41C (see listing 3). Usually this list is enough to jog my memory.

The future of the HP-41C is virtually unlimited. If there were enough demand, a higher-level language such as FORTH or even BASIC could be implemented in a plug-in ROM. However, I find that the versatility of RPN eliminates the need of a higher-level language in most applications. A BASIC interpreter would run markedly slower than RPN. FORTH might be faster than BASIC, but the experienced user soon discovers that new functions can be added in a remarkably FORTH-like manner.

Listing 2: A single key depression in USER mode executes the author's program PTOF (pitch to frequency). The calculator asks for the note, and the operator responds with "B Flat," one octave below middle C. The answer is 223 Hz; the note and its octave are also given. Next comes a printout of the first 22 steps of the PTOF program. Note the compact nature of the RPN code. Each line's interpretation follows: 01—ALPHA Label; 02 and 03—store loop control number in register 00; 04 and 05—store ALPHA string in register 01; 06—display format with no digits following the decimal; 07 through 09—these steps display the PROMPT shown above; 10—the operator's note is stored in the X register; 11—clear flag 22, the digit entry flag; 12 through 14—these steps display the second PROMPT shown in the running program; 15 through 17—if flag 22 is clear, store 0 in register Z. Otherwise, store the octave number there; 18 through 22—some of the alphanumeric manipulations available to the HP-41C user. A complete listing of this program is available from Hewlett-Packard's Users' Library. Write to Hewlett-Packard, Corvallis Division, 1000 Northeast Circle Blvd., Corvallis, OR 97330 for information on how to join the Library.

```
   XEQ  "PTOF"
NOTE?
BF
          RUN
OCTAVE?R/S=0
   -1     RUN
233 HZ. BF/-
1
       PRP ""

 01+LBL  "PTO
           F"
 02 .005
 03 STO 00
 04 "CDEFGA"
 05 ASTO 01
 06 FIX 0
 07 "NOTE?"
 08 AON
 09 PROMPT
 10 ASTO X
 11 CF 22
 12 "OCTAVE?
       R/S=0"
 13 AOFF
 14 PROMPT
 15 FC?C 22
 16 0
 17 STO Z
 18 XEQ 05
 19 ARCL Y
 20 ASTO Y
 21 ASHF
 22 ASTO T
```

Listing 3: A printout of the HP-41C's CATALOG 1 function, which lists all user programs in RAM, including the number of bytes required. Total room used here is 1148 bytes. Approximately 1064 bytes are free in the HP-41CV for more user programs, an astounding amount of storage ability for an HHC.

```
              CAT 1
LBL'HEX
END         268 BYTES
LBL'PTOF
END         203 BYTES
LBL'dBV
LBL'VOLTS
LBL'dBM
LBL'WATTS
END         292 BYTES
LBL'Z
END         62 BYTES
LBL'FREQ
END         19 BYTES
LBL'PAR
LBL'RPAR
END         37 BYTES
LBL'HANG
END         262 BYTES
.END.       33 BYTES
```

Text continued from page 76

nectors. The cables are simple stranded wire; gauge is of little importance. Cable lengths can be up to 10 meters between devices when using simple stranded wire. Distances of up to 100 meters are possible with twisted, shielded, pair wire. Each HPIL peripheral (e.g., printer or data cassette) is equipped with two corresponding mating connectors. Extension cables are available from Hewlett-Packard.

Plug the two loose cables into the side of the peripheral and you're ready to go. If there is more than one peripheral, connect the devices in a sort of daisy chain. In this loop, information passes from a sending device

Photo 1: *The HPIL Module.*

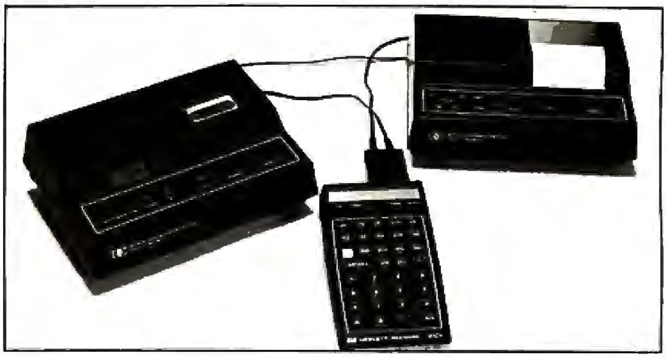

Photo 2: *HP-41C connected to an HPIL Module, Digital Cassette Drive, and Thermal Printer/Plotter in the loop.*

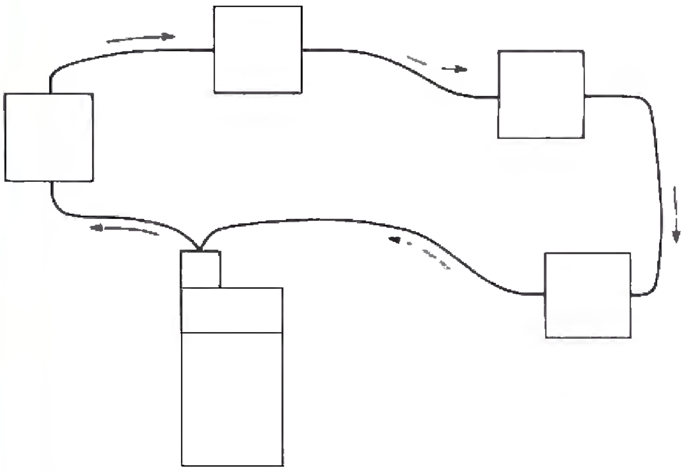

Figure 1: *The HPIL is a continuous loop, with data and instructions traveling from an originating device back to that device for a complete, bit-for-bit error check.*

through all the other devices. When data return to the source, they are completely checked for errors (see photos 1 and 2 as well as figure 1). Since each succeeding battery-operable device uses its own power to retransmit the data it receives, total power in the loop is shared equally, minimizing battery drain. All communication between devices is supervised by the HPIL Module, which is now available for $125.

Circle 431 on inquiry card.

HPIL Specifications: The New Firmware

As mentioned earlier, plugging a ROM into the HP-41C gives it a new personality. The HPIL Module is no exception. Within it are the routines essential for turning this portable, programmable calculator into a versatile "outside world" controller. Three types of HPIL routines are supported: printer-type operations (also suitable for video display and for controlling external devices); mass storage operations (for digital cassette or disk drive); and interface control operations (largely used for controlling external devices).

The HP-41C as controller can address each device in the loop by a unique number. The HPIL Module is capable of addressing up to 30 devices in the loop, certainly a quantity large enough to satisfy most users. If that's not enough, the addition of a module called the Extended I/O (Input/Output) ROM will allow the HP-41C to extend its address capability to a total of 961 devices on the loop. If still more devices are needed, loops can be connected through an HPIL Converter. (Each loop, however, must have its own controller.) The Extended I/O ROM has additional capabilities which I'll discuss later.

The calculator/controller designates which peripheral is to be a sending device (called a *talker*) because there can be only one talker at a time. The other devices on the loop become *listeners*. When so instructed, listeners can also act upon data passing through. For example, a printer can print information, a video display can display it, etc.

Hewlett-Packard does not intend to publish the actual voltage levels or the digital nature of the commands used within the two-wire HPIL loop. It has revealed that the HPIL communicates with the outside world through the HPIL Converter, a general-purpose interface board designed to be attached to the user's GPIO (general-purpose input/output device) equipment. For example, an original equipment manufacturer (OEM) may wish to install an HPIL Converter within its electronic voltmeter, enabling the voltmeter to be programmed by an HP-41C or other computer. Hewlett-Packard intends to aid other manufacturers by providing all the details necessary for them to successfully communicate with the HPIL Converter. An overview of converter hardware connections will be presented in a later section.

An Asynchronous Communication Loop

Quite a few more essential details are known about the loop's *protocol*. The HPIL is an asynchronous communication loop whose speed self-adjusts to that of the slowest *active* device in the loop. For example, if a slow printer is connected within the loop but is not to be used, the controller can instruct the printer to ignore data/instructions and pass them on to the next loop device. That way the loop can operate at its fastest possible speed. The Extended I/O ROM will even allow a means for the Digital Cassette Drive to pass data to the printer through an essentially inert HP-41C. In this mode, the HP-41C will become a relay device rather than a controller and will not retard loop operation.

HPIL Speed

Just how fast is the HPIL loop? Depending on circumstances, it can approach speeds of 40,000 bps (bits per second). While this is many times faster than most RS-232C serial links, the HPIL can be slower than the parallel-based IEEE-STD-488 bus. (Originally known as GPIB or HPIB for Hewlett-Packard Interface Bus, the present IEEE-STD-488 was developed by Hewlett-Packard.) The HPIL is intended to be a low-cost, noncompetitive alternative to IEEE-STD-488. The HPIL *is* competition, however, for the more antiquated RS-232C. Just the fact that the HPIL uses only two wires gives it a definite advantage; then there is the availability of an HHC as a controller.

Let's look at the speed of this asynchronous loop in more detail. Since instructions as well as data are sent around the loop, the instruction cycle of the controller may become a significant factor. In almost all cases, the loop controller will be the HP-41C portable calculator. While microcode (machine language) runs through the HP-41C at a speed of about 350 kHz, the practicalities of the Macro Instruction Interpreter effectively make an instruction cycle much slower. An instruction such as ENTER↑, originally keyed into program memory by the operator, takes about 40 ms to execute. This includes the overhead of the Instruction Interpreter and the HP-41C Operating System. Therefore, practical data throughput speed will probably average about 150 bytes per second (1200 bps). The 40,000-bps HPIL maximum could only be managed by, for example, an HP-80 series computer running a machine-language controller program or by controllers Hewlett-Packard is now developing.

Using the Loop

Operation of the loop can be completely transparent to the user. When a printer is in the loop, the operator (or a running program) simply executes a PRINT function; the HPIL searches for the first available printer to perform the function using a unique feature called an *accessory poll*. Optionally, the operator (or a program) may specify a particular printer by means of the SELECT function. In this case, the operator becomes only a little more involved with HPIL operation.

Manufacturing plants may wish to have the HPIL control a set of relays and read a number of indicators. The HP-41C is ideally suited to that task. Its alphanumeric capabilities and versatile keyboard allow programs to be written so that they can talk to the plant operators in plain English while performing complex underlying operations.

Efficient firmware in the HPIL Module is available, allowing a user to perform READ/WRITE functions onto a mass storage device (such as the Hewlett-Packard Digital Cassette Drive) or PRINT functions. Firmware supports either the Hewlett-Packard printer or any ASCII-compatible standard printer having a parallel port. Using less efficient instruction methods, the present firmware also allows the HP-41C to query and change the status of relays, monitors, voltmeters, or hundreds of other devices.

More Efficient I/O Operation

The Extended Input/Output ROM plugs into the back of the calculator and will add the following functions to the firmware:

- Extended addressing of up to 961 devices on the loop
- User access to all additional functions involved with


SX Is a
Two Letter Word...
RESET POWER

Listing 4: *The DIRECTORY that leads every HP digital cassette. Owners of the Card Reader will be interested to know that file ALL is a WRITEALL file containing the complete status of an HP-41CV. This file loads in about 25 seconds as opposed to the several minutes and inconvenience of using over 10 magnetic cards. More than 50 files of this size can be stored on one cassette!*

```
                      DIR
NAME     TYPE     REGS
HEX      PR         39
STATUS   KE          1
TEST     ST         10
ALL      WA        336
PTO      PR         29
dBY      PR         42
Z        PR          9
```

control and query of external devices attached to the loop

- A routine to enable bar-code generation on the new HP82162A Thermal Printer/Plotter
- A routine to allow one or more cassette copies to be generated; especially valuable when distributing software or data for OEM use
- An external device will be able to "call" the controller for service requests

The HP82183 Extended I/O ROM will be available by the summer of 1982, with price to be announced.

Extended Functions/Solid-State Mass Memory

The HP82180A Extended Functions/Memory Module adds firmware as well as additional read/write memory to the HP-41C. While this new product is not directly involved with HPIL operations, it is being introduced now in an effort to make the HP-41C a more "friendly," versatile controller and, of course, an even more powerful HHC. HP-41C owners not interested in controlling external devices can still make use of the Extended Functions/Memory Module. First, this device adds 47 new functions not included in the HP-41C mainframe. Second, the HP82180A and two companion Extended Memory Modules can increase the solid-state memory space of the calculator by 4.2K bytes to a whopping, handheld total of 6.2K bytes.

Many users will look forward to a programmable ASSIGN function, which will enable special-purpose keys to be automatically assigned and later cancelled within specific programs. Previously, key assignments had to be executed manually. Note that the *software-intensive* design of the original HP-41C is what makes these post-production enhancements possible.

Another extended function allows alphanumeric manipulations previously manageable but relatively cumbersome in the standard HP-41C. For example, the leftmost character of an alphabetic string can be identified by a program and then acted upon. The 104-step program PTOF (partially described in listing 2) could be reduced to approximately 80 steps and would run faster with the new extended functions.

Additional memory of 889 bytes is contained in the HP82180A; its companion, the HP82181A Extended Memory Module adds 1666 bytes. Two HP82181A units can be used at any one time. With all three modules plugged in, 4221 bytes of extended memory are available to the user. The additional 4.2K-byte memory is called *extended* memory to distinguish it from the *resident* memory of the HP-41C. Extended memory is not online in the sense that programs can be executed directly or that data can be used directly. Instead, the new read/write memory is organized in a *file and register format,* just as on a disk drive and with equivalent access speed.

For example, two completely different specialized calculators could be kept in solid-state storage and downloaded into the main RAM on demand. ASCII data of up to 4221 characters could be collected and stored in the field to be acted later on by the HHC, by a computer, or transferred to the new Digital Cassette Drive. It will not be necessary to "wipe" information in main RAM in order to move data from the extended memory to the Digital Cassette Drive. Data within the extended memory can also be sorted, alphabetized, or otherwise organized at disk-access speeds. The HP82180A Extended Functions/Memory Module is now available for $75, as is the HP82181A Extended Memory Module.

Industry Reaction to the HPIL

The HPIL is certainly a versatile system, but what's the catch? For now, there *is* one little catch: other manufacturers may design peripherals to attach to the HPIL, but the only loop controller presently available is a Hewlett-Packard product. Therefore, a turnkey system would contain at least two Hewlett-Packard products—the HPIL Converter and an HPIL controller. The company says that the converter hardware will support controller operation. Unfortunately, the software to run a controller is very complex, causing concern over possible improper HPIL operation. Nevertheless, manufacturers who wish to develop a controller for the HPIL may contact Hewlett-Packard for details. Despite the Hewlett-Packard monopoly on the controller, the HPIL will probably become popular with other manufacturers simply because the versatility of Hewlett-Packard's most powerful calculator makes it the ultimate controller.

HPIL Peripherals: The Digital Cassette Drive

To me, the most intriguing new peripheral is the Digital Cassette Drive. Using digitally certified magnetic tape, it is truly a *mass* storage device (see photo 2). Up to 131,072 bytes of online mass storage will fit into a small cassette similar in size to an audio microcassette. The drive itself is compact, and its flip-top cover contains a convenient storage space for two cassettes. The magnetic storage is 50 times the size of the HP-41CV RAM and, according to Hewlett-Packard, contains enough mass memory to accommodate all the programs from the 26 HP-41 Solutions Books onto one tape. If this is not enough online capacity, HPIL firmware even allows "chaining" of multiple drives. The user or a running pro-

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Photo 3: *With the HP-41, HP82160A, HPIL Interface Module, HP-85, and HP82938A HPIL Interface Card, portable data collection, direct data transfer, and sophisticated data analysis are made easy.*

gram simply calls a file by its name. The HPIL firmware searches the directory at the head of each cassette until it finds the selected file, then loads the file from that drive into RAM.

The cassette drive is of digital quality. It records data with parity, and a VERIFY function is available to check for errors. Being HPIL compatible, it can be addressed by controllers yet to be developed for the loop. Powered by rechargeable batteries, the drive has a standby power mode feature, especially valuable where operation on batteries and without human intervention is expected for long periods. The controller *automatically* calls a POWER UP function when it wishes to access the cassette drive. As a result, this unit is truly field operable.

Using a two-track format, the cassette drive is bidirectional (one track per direction) with two speeds: 23 centimeters (9 inches) per second read/write speed and 76 centimeters (30 inches) per second search/rewind speed. For those concerned about potential head wear at these speeds, the company asserts that the tape-to-head pressure is so light that head wear is insignificant. Data density is 335 bits per centimeter. Format is 256 bytes per record, with 512 records available per cassette.

When a file is called, the machine first reads the directory at the head of the cassette for the location of the named file (see listing 4 for an example of a tape directory). Then the cassette rapidly (76 cm/s) winds to the file and reads it back to the HPIL. Before writing a file, the machine looks through the directory to see if the name already exists. If so, it will rewrite (record over) that file. If not, and if space is available on the medium, it will add the new file name to the directory, speedily jump to the free spot on the tape, then record the new file, all under HPIL control.

Seven different types of files may be recorded: Program, Data, Key Assignments, Status (condition of the HHC—useful for reestablishing conditions after a running program has been interrupted), Writeall (entire contents of the calculator), ASCII, and Unknown.

To check the effective speed of the cassette drive, I recorded and then read back a Writeall file (2352 bytes). I timed the machine from the moment I pressed the last key of the READALL command to the time the read was completed. It took 27.5 seconds; therefore, effective average speed of data transfer using cassette is 85.5 bytes per second (684 bps). The read/write speed on the medium is a respectable 963 bytes per second, but, as you can see, tape-cuing time must lower the real speed considerably. The same amount of information could be loaded from a typical disk drive in a couple of seconds.

New Thermal Printer

Probably the most important feature of the new thermal printer is its HPIL capability, which allows it to be addressed by future controllers and computers. The HP82162A Printer/Plotter includes all the features of the earlier HP82143 as well as the ability to print bar code. Since it too runs on rechargeable batteries, a standby power mode is included.

For those who are unfamiliar with the earlier printer, its features include: ASCII standard upper and lowercase characters and special characters, double-wide printing option, a 24-character line, user-definable characters, and plotting capabilities. HP-41C users should immediately see the potential of the HPIL interface plus printer plotting—an input signal can now be plotted in real time.

More HPIL Peripherals

The HP3468A Digital Multimeter (DMM) is programmable through the HPIL. Its 12-character alphanumeric display can output messages generated by the controller or by the DMM. Resolution is adjustable from 3 to 5 digits, with increased resolution resulting in a proportional trade-off in speed.

The HP82938A HPIL Interface Card shown in photo 3 plugs into the Hewlett-Packard Series 80 personal computer. The computer will then be able to take control of the loop. It can also be programmed to store and analyze data collected on the calculator. ROMs for the Series 80 machines are compatible with the HPIL Interface Card, allowing the computer to use the printer, cassette drive, and all future HPIL peripherals.

The HP82182A Time Module plugs directly into the HP-41C. This will allow the unit to be turned off and then "awakened" automatically by the timer's programmable ALARM function. The program will start running the line at which the HP-41C was positioned when it was turned off (or when it turned itself off). Since OFF is a programmable function, the process can be repeated indefinitely. The timer becomes especially useful in a controller situation, allowing measurements to be taken at regular intervals, devices to be turned off, pressures regulated, etc. This module can also display time and date and provide calendar data over a 2738-year span.

The HPIL Converter

The key to the HPIL's success will be the availability of

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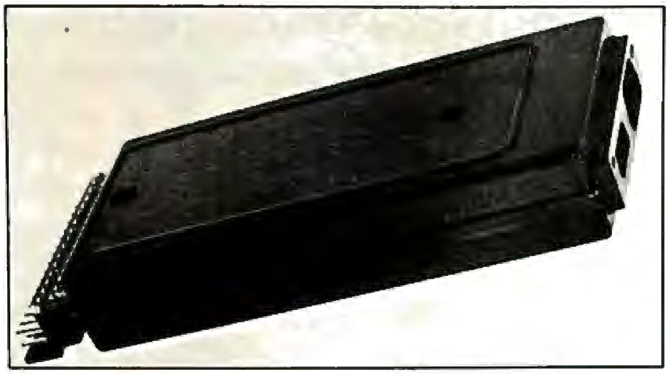

Photo 4: *The HPIL Converter (4.5 by 11 by 2 cm) connects the HPIL loop with the outside world.*

the HPIL Converter. This component (see photo 4) is designed to interface the HPIL with the outside world. OEMs may wish to build HPIL capability into components such as measurement instruments, enabling programmable control by an inexpensive HHC rather than a much more costly computer.

BYTE readers who have connected hardware to computer input/output ports are probably familiar with a VIA (versatile interface adapter) or a PIA (peripheral interface adapter). Applying a similar philosophy, the HPIL Converter is a much smarter device. The converter contains the necessary firmware to recognize HPIL instructions and to convert specific instructions and data from the serial HPIL format to a dual 8-bit parallel format. As a matter of fact, one of the sample schematics presented in the converter manual is an interface with a Centronics-style parallel printer connector.

Hewlett-Packard supplies a 34-pin printed-circuit-type mating connector; a standard ribbon connector will also work. Power for the HPIL Converter (+5 V DC at 90 mA) is derived from the host device. All input/output lines are TTL-compatible and include two bidirectional 8-bit ports, three input handshake lines, three output handshake lines, and several special-purpose lines. The latter are used for triggering external devices and for communicating special conditions such as power down, power up, or service request. Complete hookup details for programming negative or positive logic strobes, full or half duplex operation, and more are furnished in the HPIL Converter documentation.

Some Revisionist Thoughts

The addition of all this hardware to the Hewlett-Packard arsenal poses a couple of logistical problems. The first problem concerns battery charging; there are too many plugs and not enough sockets. The HP-41C, printer, and cassette drive each come with identical-style power connectors. A power transformer and a charging cable are also furnished with each unit. It is certainly inconvenient to have to find wall sockets for all these devices. I hope that Hewlett-Packard relieves the conges-

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Photo 5: *Hewlett-Packard's HP82163A Video Interface connects a monitor or TV to HP's interface loop. This permits handheld computers like the HP-41C—previously limited by a single-line display—to display information in a 16-line by 32-character video format. Aided by the new interface (available by the end of 1982), HP-41C owners can review up to 16 program steps at a time.*

tion by introducing a charger capable of powering several peripherals at once.

The second logistical problem is more serious. Hewlett-Packard has supplied a "horn of plenty" in modules, but there are only four sockets to receive them. A user may very well need to operate several of these modules simultaneously. Hopefully, the company will soon supply a "piggyback module adapter" of some sort to relieve the problem. Outside of the above, very few complaints can be made about Hewlett-Packard's well-supported products.

The Future

With the introduction of the HPIL Loop, Hewlett-Packard has made a commitment to issue a series of new HPIL controllers, peripherals, and instruments. Expect to see in the near future a video/TV monitor interface (shown in photo 5), an 80-character/line impact printer, an HPIL/RS-232C converter, and a self-powered version of the GPIO board designed for the home hobbyist. No official corporate announcement has been made at this writing, but Hewlett-Packard probably will introduce these items before the end of the year.

I'm sure someone will ask about word processing with the HP-41C and the HPIL. It's conceivable but not without an external keyboard since the HP-41C is only good for "hunt and peck" typing. Its alphanumeric capabilities and portability will lend themselves to many other unique jobs in the very near future.

Conclusions

As usual, Hewlett-Packard's documentation is excellent. Prototypes of the new products must have been in use within the Corvallis, Oregon, plant for a considerable length of time because the style of the instruction manuals reflects much experience with the products.

With any new and complicated product, there are bound to be bugs. The ones I have found so far have been minor. My experience is that Hewlett-Packard's Corvallis Division will respond to consumer complaints quickly and efficiently.

The potentials of the HPIL loop are literally awe-inspiring. As such, it is difficult for me to make an overall evaluation other than that the future looks bright. I suggest you read on to page 94 and delight in what's just over the HPIL horizon. ■

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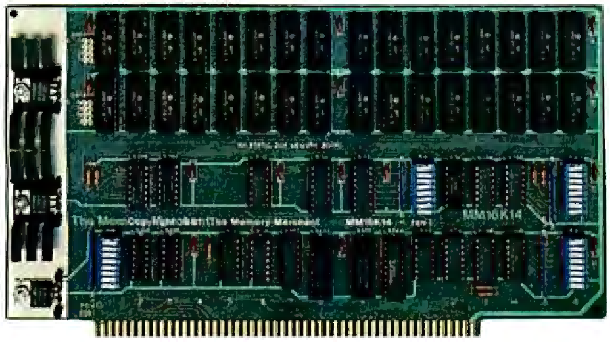

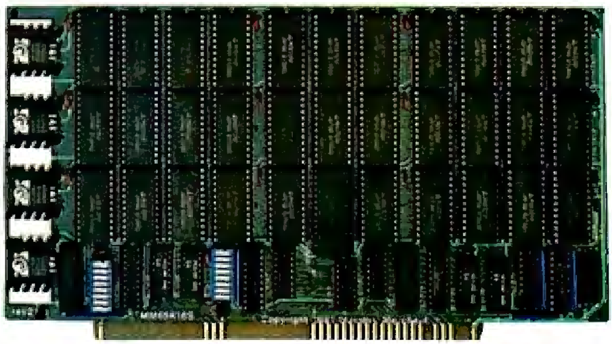

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A Future Day in the Life of an HP-41C

It's morning (February 1, 1983), and I find no cash in my pockets. No, the HP-41C cannot mint money, but it can call the bank for me and engage in a friendly conversation with the bank's computer. I plug the Modem Management Pack into a blank slot and connect the HP-41C to an HPIL converter which in turn has been hooked up to a telephone coupler. I quickly learn that the check from Detroit finally cleared, and my checking account is good for $1000.

Later, I arrive at the recording studio and discover a faulty VU meter (things haven't changed much). I am now carrying a powerful tool consisting of my trusty HP-41C attached to an HPIL Converter, an A/D (analog-to-digital) converter, and a long cable terminating in alligator clips. These components make up not just a programmable multimeter, but a complete measurement and analysis system customized by the user—me!

The HHC tells me that there is 2.0 V across the console's output terminals, which represents 4.2 dBs above the reference of 1.23 V. I suspect an intermittent connection, so I've programmed the HP-41C to beep whenever a change in level occurs (a high-frequency beep if the level goes up, low-frequency if it goes down) and to display the new voltage and dB level. When I wiggle a loose resistor on the circuit board, the HP-41C cheerfully beeps to signal the cause of the problem. Even in 1983, cold solder joints and bad connections cause the majority of service problems.

My next job is rather distantly located, but this time the HP-41C is not available to play Hangman. It has a much more important job to do—it's helping to fly my Beechcraft. You see, back in 1981, the Hewlett-Packard company produced a custom ROM for the Beech Aircraft Corporation, turning the HP-41C into a revolutionary flight-planning system capable of saving thousands of gallons of fuel a year. Well, today (1984?) this system has been updated so that the plane is equipped with an HPIL Converter. Since instrument data is now transmitted directly to the HP-41C, the pilot does not need to key in information about fuel flow, speed of descent, wind velocity, or air speed.

Of course, as soon as I get the money, the next step will be to purchase the HP-41C Auto Pilot. By 1985, I will be able to plan my flight at home on the portable HP-41C, carry it with me to the airport, and plug it into the control panel of my airplane. Thus, it will help me in the air and continue to serve me on the ground.

The preceding "science fiction" story is based entirely on components that are available today and on technology that is completely within reach. We have only begun to dream.

Strawberry Tree's Dual Thermometer Card for the Apple

Dr. William Murray
RD #3, Box 363
Montrose, PA 18801

If you've ever needed to monitor temperatures over an extended period of time, then Strawberry Tree's Dual Thermometer Card is for your Apple. Actually, the card is part of a complete package that also contains a disk, two thermometer probes, and a user's manual.

The thermometer card has an internal clock that can be set when the system is loaded, or, if a clock/calendar card is present in the system, the clock can be set automatically. This feature enables your Apple to record the time at which temperature data is taken. Data-sampling intervals can also be set to occur at any preset time by means of the internal timer. The current temperature, along with the maximum and minimum, can be recorded for each probe and stored on disk or sent to a printer as output.

Everything in the package (see photo 1) is first class, which helps justify the retail price of $260. The card has fully socketed integrated circuits (ICs) and gold-plated edge connectors. The 83-page manual covers virtually every topic from installation to software modification. The software is a refreshing departure from many Apple peripherals on the market today. It is usable, understandable, and can be modified if necessary.

Photo 1: *Strawberry Tree's complete package of temperature-monitoring equipment for the Apple.*

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80 character by 24 line format, plus 25th line for operator messages and prompts.

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Keypad in calculator format permits fast, easy entry of numeric data.

*In kit form, F.O.B. Benton Harbor, MI. Also available the completely assembled Zenith Z-19 at $895. Prices and specifications are subject to change without notice.

†Heath Company and Veritechnology Electronics Corporation are wholly-owned subsidiaries of Zenith Radio Corporation. The Heathkit Electronic Centers are operated by Veritechnology Electronics Corporation.

CP-202C

At A Glance

Name
Dual Thermometer Card for the Apple II

Use
Long- and short-term temperature measurements

Manufacturer
Strawberry Tree Computers
949 Cascade Drive
Sunnyvale, CA 94087

Price
$260

Features
Two temperature-sensing probes, Apple hardware board, software contained on a 5¼-inch disk, user's manual

Capabilities
Reads present temperature of each probe, keeps track of maximum and minimum of each probe, and records temperature difference between probes. Also records date and time when samples are taken and sends data to printer or to disk for storage.

Hardware required
Apple II Plus with 48K bytes of memory or Apple II having 48K bytes of memory with Applesoft; disk drive with DOS 3.2, 3.21, or 3.3 (will load on 13- or 16-sector machines).

Additional options
Will output with no modifications to almost all printers that have been correctly interfaced; will set the date and time directly from a Mountain Hardware card; otherwise, the internal clock can be set from the keyboard.

Hardware

The thermometer card contains 12 ICs that draw 70 mA (milliamperes) from the +5-volt supply and 30 mA from the +12-volt supply. If the need arises, up to 7 cards can be installed in an Apple II, permitting you to monitor 14 different temperatures. The probes come with 10 feet of wire but can be extended to 500 feet without loss of accuracy. The probes are electrically isolated from their 0.19-inch by 0.65-inch case but cannot be immersed in water or other conductive fluids. (Special probes are available upon request.) For noncritical applications, the probes could be enclosed in a boilable freezer bag. The accompanying loss in sensitivity wouldn't affect results where slow temperature changes are expected. The accuracy of the unit is 0.4° from −20° to 50°C and within 1° from −50° to −20° and 50° to 100°C.

The thermometer card contains two major sections—a timer and an analog-to-digital converter. Its data-acquisition is similar to that used by the Apple's game paddles: resistance changes from the probes are used to alter the timing of a latch. The precision of the timing circuit is much more accurate, however, than the Apple's simple circuit and is fully described in the user's manual.

Because the system is set up to be slot independent, the card can be located anywhere (yes, even slot 0) without major modifications. External devices such as fans or heaters can be controlled using the data obtained from the dual thermometer board with the addition of the necessary interface hardware. This makes the device helpful not only for monitoring temperatures but also for controlling them.

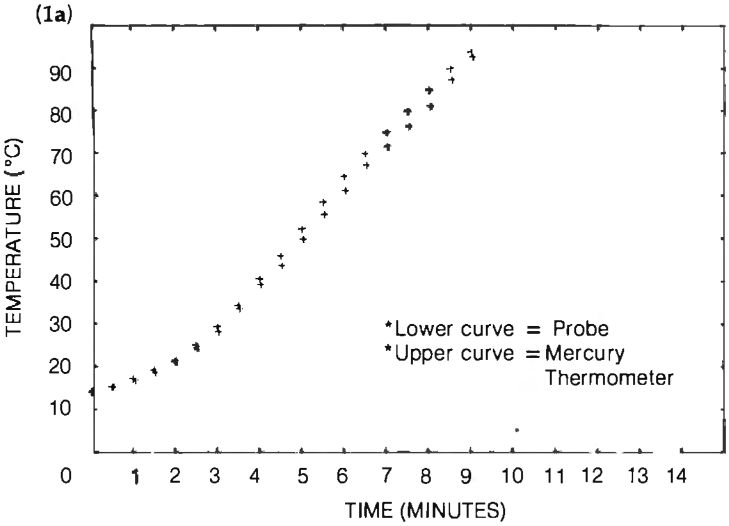
Software

The software will load on 16- or 13-sector machines (DOS 3.3 or 3.2) without modification. When the disk is loaded, the time must be set from the keyboard if a clock/calendar is not available. This shouldn't be much of an inconvenience once the equipment is up and running. The internal clock of the dual thermometer is triggered by the Apple's crystal-controlled clock, so accuracy shouldn't be a problem.

The second thing that must be done upon starting the system is to set up the data-measuring parameters. The program gives you the ability to:

- choose one or two probes for temperature measurement
- monitor maximum and minimum temperatures of both probes
- set alarms for temperatures above and below the preset maximum and minimums
- record the difference between the two thermometers
- specify output in Fahrenheit, Celsius, or absolute (Kelvin)
- record data at predefined intervals on a printer or disk

If the same setup is used frequently, it too can be recorded on disk, eliminating the necessity of entering the same information each time.



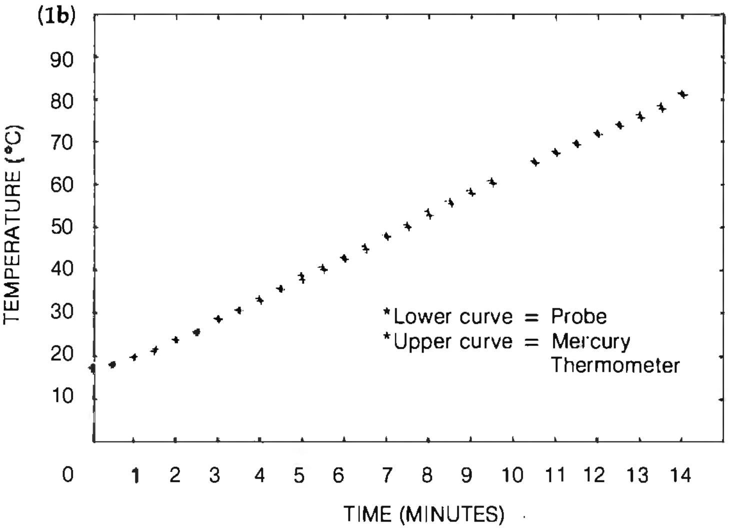


Figure 1: *Tracking Strawberry Tree's thermometer probe versus a laboratory mercury thermometer. Figure 1a shows responses to an 8.89°C/minute rate of change; figure 1b shows responses to a 4.57°C/minute rate of change.*

One missing feature, however, is a method for obtaining an average temperature for the collected data. If desired, the software can be modified to accumulate the sum of all temperature samples taken and divide that sum by the total number of samples. This should be an easy modification since the disk is not "copy protected," and the software is fully described in the user's manual.

Limitations

One of the major limitations of the Strawberry Tree Dual Thermometer card is the stabilizing time necessary for accurate measurements. The manual states that the probe requires 4 minutes to stabilize to within 0.1° for a 100° change. For comparison, a laboratory-grade mercury bulb thermometer will stabilize over the same temperature change in approximately 10 seconds. This would limit application of the device where large temperature variations can occur in relatively short time intervals.

Appendix E of the user's manual addresses this issue and offers several suggestions for obtaining greater accuracy. Figure 1 shows two experimental plots. Each plot contains two curves, one of the probe and one of a mercury bulb thermometer. In figure 1a, the average rate of change is 8.89°C per minute, while that of figure 1b is 4.57°C per minute. The rapid change in temperature with respect to time in figure 1a produces as much as a 4° error between probe and mercury thermometer. When the rate of change is slowed by a factor of 2, the two devices give about the same reading. This drawback won't be a problem where temperature variations change slowly. Indeed, given the required stabilization time, I found the probes to be well within their rated accuracy.

Applications

The possible applications of this dual thermometer board are many because of the careful attention given to writing the software. With the ability to record data on a printer or disk, many long-term temperature studies can be undertaken.

An engineer could use the dual-thermometer board in a solar heating experiment. One thermometer probe would monitor the internal temperature of the solar collector while the other would record the surrounding temperature. The data collected would help determine the best angle for the collector, the best collector coating for maximum heat gain, etc. With the card, readings for an entire day could be gathered automatically.

A homeowner might want to do a long-term energy study by monitoring the temperature difference between the inside and outside of the house. After keeping track of temperature differences and the amount of oil, gas, or electricity used per month, the most efficient temperature setting for the house could be determined by plotting a curve of temperature difference versus fuel consumption.

A scientist desiring to monitor the temperature of a microscopic culture might wish to record the information on a printer as it is gathered. A further possibility would be to have the computer sound an alarm if the culture got too hot or cold (this could be done by setting the alarms for the probe at the maximum and minimum limits).

Conclusions

The hardware and software of the Strawberry Tree Dual Thermometer board are excellent, with all operations fully supported and documented. Any modifications to the BASIC program should be straightforward and require only fundamental programming skills.

The temperature probes can be located at distances up to 500 feet, offering great flexibility in probe placement. Special probes can be ordered for immersion in liquids. Two probes can be used at the same time, each recording its present temperature, maximum, minimum, and the temperature difference between the two.

The software permits readings to be calibrated in Fahrenheit, Celsius, or Kelvin. Data can be recorded on a printer or disk at preset intervals. An alarm can be set for each probe to indicate when a preset maximum or minimum temperature has been passed. ■

Software Psychology: Human Factors In Computer and Information Systems

Ben Shneiderman
Winthrop Publishers Inc.
Cambridge, MA, 1980
320 pages, hardcover
$24.95

Reviewed by
Bruce Robert Evans
16 Marwin Road
Pickering Ontario
Canada L1V 2N7

Until recently, computers have been the domain of professionals. With the advent of personal computers, information networks, and dedicated controllers in equipment, programmers and designers must be aware of the impact of software on end users and vice versa. Much has been written about human engineering, but nothing has appeared about humanizing software. *Software Psychology* will help the systems engineer and programmer remedy this deficiency.

The layout of the book reflects the author's background in the psychology of learning. At the beginning of each chapter, there is a list of the section headings, followed by an explanation of what is to come. Two summaries, one of practical points for the programmer and one of possible leads for the psychology researcher, follow the body of the book. The repetition distressed me, but with time it became obvious that it was achieving the desired purpose—I was retaining the material.

Shneiderman starts by analyzing what programmers do. Using one of the key tenets of management analysis, he delineates tasks and their performance. Without generalizing, the author dissects some of the well-entrenched "truths." Do comments clarify a program? Do symbolic variable names help? Expect your prejudices to be challenged. The author insists on measuring as he attempts to assess a programmer's output. Many commonly held beliefs topple. For example, while the number of lines produced may be acceptable criterion for one program, the efficiency of style may be better in another.

Chapters seven and eight, in which Shneiderman discusses database systems, should be read by all programmers. In them, the author explores possible sources of friction between programmers and nonprofessional users. Ways of dealing with irate nonprofessional users (Why is my credit card bill different from what I think it should be?) are discussed.

In chapter nine, Shneiderman discusses programming languages, emphasizing the attempts to create new languages that will correct some of the faults of existing ones. (Does a month go by when someone doesn't come up with the "perfect language"?) The author stresses that because no one language covers all situations, programmers should consider the advantages and disadvantages of each when writing for a nonprofessional.

Chapter ten, "Interactive Interface Issues," justifies the entire book. In it, Shneiderman indicates the need for more study of the psychologic impact of computer programming on the end user. He discusses computer systems from the user's point of view and points out user demands of which the programmer may be completely unaware.

In summary, Ben Shneiderman guides the systems engineer in deciding what a customer wants and needs, suggests how the software should be written, and assists in its evaluation. At the same time, the author shows the programmer what the software user wants and how the end user looks at a computer system. Often the user is very different psychologically and intellectually from the programmer; the successful programmer must be aware of this. ■

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Product Description

The Epson HX-20

The First BYTE-sized Computer

Gregg Williams
Senior Editor

Unfortunately, no monthly magazine can be completely up to date on a given subject—some new product or idea always appears between the time we send the magazine to the printer and the day you see that same issue. However, we did get a chance to preview a product so exciting that we "stopped the presses" to get it into this issue.

The Epson HX-20 microcomputer (see photo 1) is a remarkable unit that might be dubbed the first "notebook computer"—larger than a pocket computer and smaller than a briefcase computer, it is about the size of a notebook. It weighs in at 1.73 kilograms (3 pounds, 13 ounces) and measures 28.9 by 21.6 by 4.44 centimeters (11.375 by 8.5 by 1.75 inches)—somewhat lighter than but almost the same size as two issues of BYTE. The HX-20 has a full version of Microsoft BASIC, 16K bytes of memory, a standard-size and standard-configuration keyboard, a 24-character-per-line printer, a built-in cassette interface, and a 20-character by 4-line liquid-crystal display. The product will be officially announced at the National Computer Conference in June. Epson plans to have its distributors fully stocked with HX-20s by the time it is officially introduced.

The unit was lent to us for a few days by Chris Rutkowski of Epson America Inc. Since this was a sneak preview of the HX-20, Chris told us some but not much about it. Most of the details below are a result of our physical inspection of the unit. For example, executing the BASIC statement "PRINT FRE(X)" produces the answer 12,832. This leads me to believe that the unit has 16K bytes of RAM (random-access read/write memory),

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Photo 1: *A prototype of the HX-20 microcomputer. The final unit will have a different keyboard layout.*

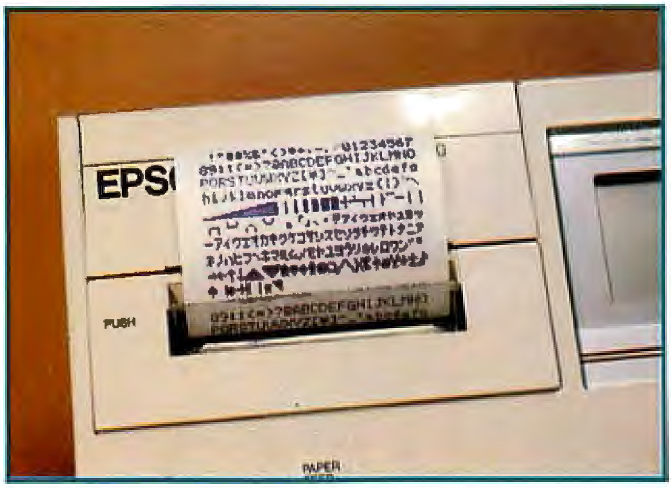

Photo 2: *The HX-20 printer and a printout of its character set. The Japanese katakana characters will be replaced in the U.S. version of the unit by geometric symbols that can be combined to make larger graphic images.*

Photo 3: *The liquid-crystal display of the HX-20, which gives four rows of 20 characters each.*

12,832 of which are free for BASIC programs and data.

The unit we saw is a prototype of the final unit, which may be packaged somewhat differently and which will have a typewriter-style keyboard layout. Aside from the layout, the present keyboard is very good—it is standard-sized (a very important feature if the computer is used for programming, word processing, data entry, or similar applications) and the keys have a good feel. The printer can display 24 characters per line, each in a 5 by 7 dot matrix (see photo 2). The LCD (liquid-crystal display) provides four rows of 20 characters, each displayed within a 6 by 8 dot matrix (see photo 3). Both the printer and the LCD can show graphics, numbers, punctuation, and uppercase and lowercase letters. The LCD is ultimately 120 dots by 32 dots, each of which can be controlled by BASIC. Because Epson is a subsidiary of Seiko (the watchmakers), you might suspect the HX-20 to contain a clock; it does. The clock is accessed from BASIC by reading the variable TIME$. Setting the clock is just as easy.

The cassette interface is said to transfer information at about 2400 bits per second (about 300 bytes per second) onto a standard dictating machine microcassette. This area of the unit appears to be detachable, which may indicate other storage options and/or telecommunication potential.

The unit has several interesting sockets. The rear of the unit contains a socket for a power supply (the unit is estimated to run 50 to 100 hours on the internal nicad batteries), as well as two DIN sockets marked SERIAL (with holes for five pins) and RS-232C (with holes for seven pins). The left side contains a long, narrow, recessed plug containing two rows of 20 pins each (perhaps a system bus of some kind), and the right side contains plugs for an external cassette recorder, as well as a small phono jack marked BARCODE (which means that the unit is capable of reading bar codes). In addition, the right side of the unit contains a recessed Reset key and an on-off switch. (The unit, however, is never really "off"; this switch turns off the LCD display, but retains the program currently in memory.)

Few details on the internal organization of the machine are yet available. It contains CMOS (complementary metal-oxide semiconductor) memory to keep the power consumption low. The HX-20 also uses the 6301 microprocessor, a CMOS version of the Motorola 6801 microprocessor.

The price? Epson hadn't decided at the time this was written, but I was led to believe that it would be under $1000.

I hope you are as tantalized by this information as I am. More information will be available after the unit is introduced at the NCC in June. Until then, it is enough to know that microcomputers are becoming more portable, more powerful, *and* cheaper at the same time, a trend that will probably not stop with the HX-20.■

A Human-Factors Style Guide for Program Design

Taking the user into account in the design of software.

Henry Simpson
Anacapa Sciences Inc.
P.O. Drawer Q
Santa Barbara, CA 93102

Human factors is a small but growing discipline which seeks to provide a method for taking into account human strengths and limitations during the design of computer hardware and software. In this article, I'll present a brief introduction to human factors and discuss its application to program design. I'll define six human-factors design principles and show how they can be applied to three areas of program design: data entry, display-screen design, and sequence control.

Human factors can be applied to any area in which a human being interacts with a machine. The discipline applies, or at least can and should be applied, to many aspects of man's interaction with computers. The most obvious area, and the one most people think of when considering human factors, is hardware design. Human-factors specialists often design video displays and controls.

More recently, human factors has been applied to software design. Research has led to the development of human-factors guidelines that programmers can use to make their programs easier to use and less prone to error. Human factors is also important to the design of computer operating systems, programming languages, and documentation, although the discipline has received less attention in those areas.

Human factors matter because people must operate machines. If you fail to take people into account during design, then your machine (or system or program) may be difficult or impossible for people to operate. As obvious as it seems, this point is often overlooked. Consider some recent examples. No brand names are mentioned in what follows, but you may recognize some of the players:

- The microcomputer whose nonstandard keyboard made it awkward for touch-typists—all keys were there, but they were the wrong kind of keys and in the wrong locations. (The keyboard has since been redesigned.)

The more serious the error consequences, the more designers should consider human factors.

- The minicomputer whose operating system identifies program errors with numeric codes that are contained in three separate manuals. (This machine was recently discontinued.)
- The computer program whose screen displays are cluttered and confusing, whose data-entry sequences permit input errors that cause the program to interrupt, whose menus can lead the operator down blind alleys and into stable program states from which he or she cannot escape. The documentation for this program consists of three smudged photocopies of an original that displays creative spelling and grammar and omits many important details.

We often blame human error for disasters and near disasters, from nuclear near-meltdowns to bank errors in checking account balances. Equally often, we blame "the computer" for some ill fate that befalls us. Seldom do we recognize that neither man nor machine alone is completely responsible. In today's complex world, man and machine work together interactively. The "system" is the combination of both.

When we design things, it is usually fairly easy for us technically oriented people to take into account the limitations of our hardware. However, we are likely to forget that the operator or maintainer of our system has limitations. We can design much better systems—more workable and more maintainable—if we accurately take human limitations into account.

What are human limitations? First and most obvious, no two human be-

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ings are alike. They vary in size, strength, acuity, intelligence, education, and level of motivation. The general requirement for considering human factors in the design of your system, whether hardware or software, is to *recognize the needs of the users*. The type of user varies with the application. If you are designing an arcade game with a coin slot and two push buttons, you are aiming at a different sector of the population than if you are developing a computer-based econometric model to predict the gross national product in 1985. Either of those programs can be written for specific, definable, homogeneous groups of users.

More often than not, however, the hardware or software we design will be used by a varied group that ranges widely in sophistication. Knowing your system users and recognizing their needs are the first two steps in taking human factors into consideration during system design.

In general, the rules for designing a system with the user in mind parallel those for good writing: define your system users, know their limitations, and find the simplest way to get your message across.

That which separates good programs from bad cannot always be described in terms of simple, obvious things such as bad keyboard designs or cumbersome error-handling procedures. I can name some general qualities to look for, however. First, programs that consider human factors are generally easier to learn and use than those that do not. They usually have simpler displays, are less likely to "bomb," and are supported by good user documentation; they appear to be written for less specialized users and not for computer experts. These programs also refrain from trying to make the machine behave as if it were a human being. Poorly designed programs lack some or all of these features.

To illustrate when human factors matter I'll limit my discussion to software design and, more specifically, to microcomputer software in which the operator controls the computer and interacts continuously with it. This scope includes such applications as games, business and scientific programs, computer graphics, and computer music but excludes most control, robotics, and other minimally interactive applications.

A human-factors purist might say that serious consideration of human factors *always* matters, but this simply isn't true. You can decide in each case how important human factors are by looking at four different aspects of your program: (1) number of people who will operate the program, (2) diversity of the operators' backgrounds, (3) complexity of the program, and (4) consequences of operator error.

Obviously, the more people who will operate your program, the more time and energy you will invest in its development. If you are running a business, you want to assure that your A/R (accounts receivable) program works efficiently and effectively because it will cost you money and

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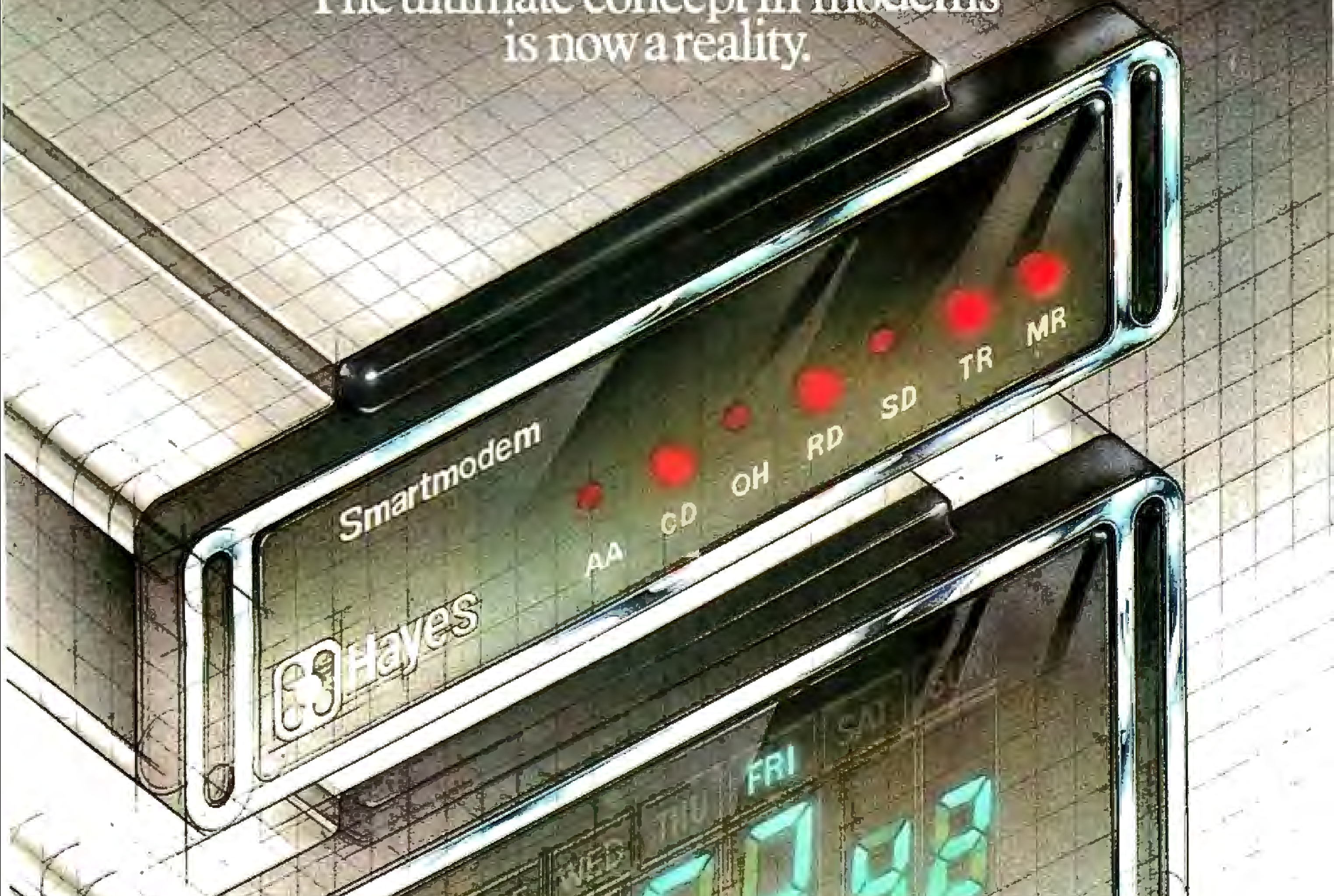

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perhaps your credit rating if it doesn't.

If that same program must serve a wide group—ranging, say, from clerk to company president—then you must assure that the program serves all levels well. This takes special effort during program design.

The more complex the program, the greater the chance of error, and the more you must strive to reduce the likelihood of error by carefully considering human factors.

Last, and probably most important, are error consequences. The more serious these are, the more important the human element becomes. If the reactor core will melt down, the navigator will get lost, or the names and addresses of all the people who owe you money will disappear, then the consequences of error are very serious indeed. If the worst that can happen is that the bouncing ball in your game program may disappear from the screen, then the consequences are not quite so serious (unless you depend upon the program for your livelihood).

In sum, if you are writing programs purely for your own use and are not tracking important data, then you have probably spent too much time on this article already. On the other hand, if you are writing programs for a wide and varied group of users to track things that matter to them, then human-factors considerations *are* important.

Design Principles

If you decide to apply human factors to your program design, where do you begin? Probably the best way is to familiarize yourself with some general human-factors design principles. Six such principles are presented below. These principles grow out of behavioral research conducted over the last several decades, although their application to program design is recent. Later in this article I'll give specific examples of how these principles may be applied.

Provide Feedback: People need to know that an action they have taken has had an effect. When you turn the wheel of your automobile, you receive feedback in the form of resistance from the wheel, centrifugal force on your body, and movement of your visual field. In turn, you adjust the rate at which you turn the wheel to conform to the feedback you are receiving. Without this feedback, you would find it much more difficult to control your automobile.

The user of your program also needs feedback. If he makes a keyboard entry and nothing appears on the screen, then he has no way of knowing that his action has had an effect. In consequence, he may repeat his action or try another, possibly causing something unintended to happen.

Feedback should be immediate and obvious. Show it on the screen in a place where it is expected.

Be Consistent: Mention "consistency" in a group and someone will probably quote Emerson to the effect that it is the "hobgoblin of little minds." Emerson may have been able to get along without it in certain trivial matters, but computer programmers cannot. The tools and programming languages with which they work are based on rigid adherence to rules of syntax, the order of programming operations, and the laws of mathematics. Rigid adherence to these "laws of the machine," which are internally consistent, reduces uncertainties and makes it possible to program the machine exactly. Human beings can tolerate more ambiguity than machines, but ambiguity reduces people's effectiveness. If we paid half as much attention to consistency in our programs' interactions with human beings as we do in the interactions between programs and machines, most of our programs would be improved.

What, exactly, do we mean by "consistency"? One way of defining it is as a set of rules that you, the programmer, establish for yourself and follow compulsively. These rules per-

mit the operator to learn one part of your program's operation and then to apply the new knowledge to other parts of the program. For example, you might make a rule that all of your error messages will appear on the bottom line of the display screen. When the operator sees one error message displayed on the bottom line, he expects all others to be displayed there, too. If they are, then the rule is adhered to, and the operator will not have to learn a new rule for each new display. If not, then the operator's learning task is that much more difficult.

Minimize Human Memory Demands: Psychologists have determined that human beings possess two types of memory—short-term and long-term. A vast amount of research has been conducted on the subject, most of which will interest only the specialist. About human memory, the computer programmer needs to recognize two things. The first of these is obvious, the second less so.

First, computers have better memories than people. (We said it was obvious.) Data stored on magnetic media are never forgotten.

Second, computers always remember things exactly as they were stored. People usually do, but sometimes they get things mixed up.

What follows from these two points is that, when designing programs, you should rely on computer memory as much as possible. Suppose, for example, that your program has many subprograms. How should the operator select a subprogram—from a displayed menu or by entering a memorized mnemonic? Although selection with memorized mnemonics (used in "program-like languages") has advantages in some situations, the displayed menu depends much less on operator memory and is generally preferable. (Some players of Star Trek games may recall the frustration with which they attempted to master the game in the absence of displayed menu options.)

Keep the Program Simple: Simplicity in programming, as in writing, does not come easily or painlessly. You must work to achieve even the appearance of simplicity. Simplicity usually results from paring down or editing. In programming, as in writing, simplicity is an ideal that one strives to achieve by conscious design, by trial and modification, by cutting away the unnecessary, and by reorganizing and rearranging.

Match the Program to the Operator's Skill Level: You must determine the operator's skill level before you write your program. Determine also if operators of differing skill levels will use the same program. Human-factors specialists do these two things systematically by conducting a task analysis. There are several ways to do this, but usually it involves defining what *mission* a system must perform, what *functions* are involved in this mission, and what *tasks* are required to accomplish the functions. Conducting task analyses is time-consuming, technical, expensive, and probably beyond your needs or interests. Still, you do need to think about operator tasks as you write your program and ask questions like the following:

- What will operators be expected to do?
- What decisions must they make?
- What must they know to make the decisions?
- What skill levels will be required?

Consider these questions before you write your program. Then design your program so that it matches the skill level of your system users.

Sustain Operator Orientation: If you have ever been lost then you know what *not* being oriented is. Anyone who has ever used a computer has had the experience of getting into some new program and not being able to find the way out. This often happens when you try the program without first reading the manual (as all of us are prone to do).

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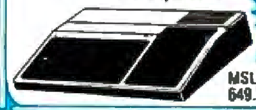

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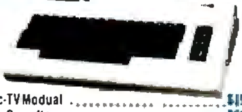

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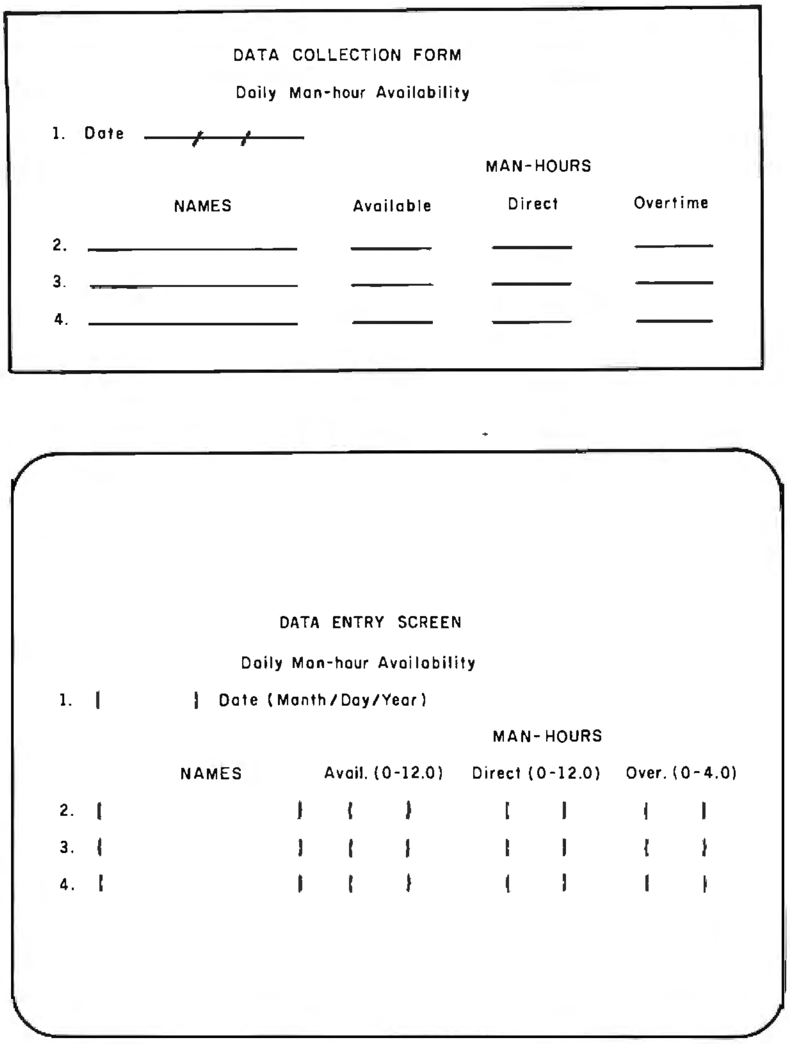

Figure 1: *A data-collection form and the data-entry screen that goes with it. The data-entry screen resembles the form. Prompts shown in parentheses on the screen make clear the expected data formats and give range limits. The brackets serve as field delimiters, showing the maximum length allowed for each entry.*

grammer to minimize the possibility of disorientation. Provide your operator with signposts that tell him where he is and how to get back to where he came from. Menu-driven programs often do this by providing a main menu which serves as a home base. The program begins with this menu from which the operator can select various subprograms, perform them, and then return.

Some game programs are intentional mazes, consciously designed to disorient the operator. If that's your intention, all well and good. But if it's not, remember that an unwanted maze is about as much fun as an inaccurate road map on a dark and rainy night.

The six principles described above reduce to one idea: know the needs of your system users. Recognize that they need feedback to avoid confusion, consistency to ease the learning process, minimal strain on memory capacity, simplicity rather than complexity, demands gauged to their skill levels, and constant, clear orientation.

The remainder of this article will focus on three areas of computer programming: data entry, display-screen design, and sequence control. Data entry concerns how you get data into a database; display-screen design concerns layout of video-terminal-display screens; and sequence control concerns how you interact with your program to get it to do something.

I'll show how the six human-factors principles apply in each of these areas. In most cases, recommendations made are based on research that has shown that the suggested feature permits more effective man-machine interaction. In a few cases, recommendations are based on prevailing practice. None of these guidelines should be applied blindly, and all of us will find it necessary to ignore them from time to time. But most of these are simple things to do, and if you follow them, you will write a better program.

Data Entry

The following guidelines apply mainly to programs in which data are entered through the keyboard to build a database which the program accesses later. Typically, the data entry process consists of the following sequence of steps:

- presentation of a prompt
- data entry by the operator
- display of entered data on the screen
- error test
- presentation of an error message if entered data fail error test
- editing of data
- acceptance of data into database

Prompting: If data are to be entered into the computer from a standardized data-entry form, then the data-entry screen should resemble that form as closely as possible. The cursor should move from field to field as the operator fills in the form. It is easier to write a program consisting of a series of INPUT statements that cause the screen to scroll. However, the operator can more readily orient himself to a screen that looks like a data-entry form. Figure 1 shows a data-collection form and a data-entry screen designed to elicit the necessary data. The screen presents prompts, states acceptable ranges, and delimits fields.

The program should provide a prompt for every data input. The prompt should be brief and specific, and show the range limits and entry

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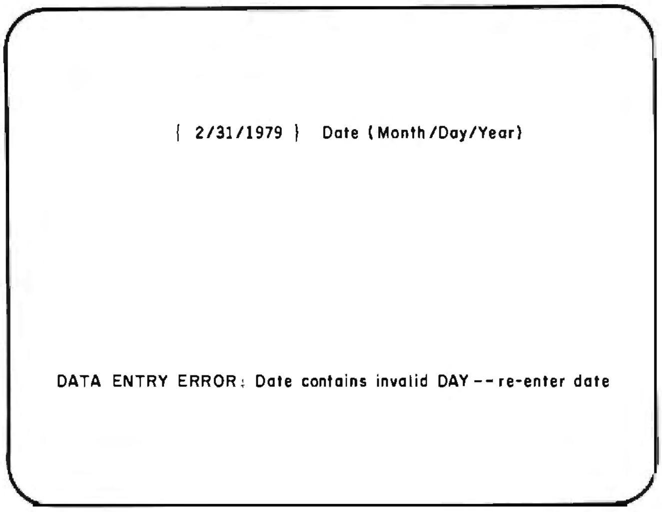

Figure 2: *A sample error message. The message is specific and helps the operator correct the error identified.*

format of data to be entered. Range limits or entry format can be shown parenthetically after the prompt. For example, a date entered in the form of month-day-year could be prompted as follows: "Enter Date (Month/Day/Year)." If there is a length limit, then this length should be shown on the screen using an underline, pair of brackets, or other visual cue. If certain data entries have *default* values (i.e., values that the computer will assign unless the operator enters others), then display the default values—do not rely on operator memory. If there are similar or identical data-entry requirements in different parts of the program, prompt consistently. One way to do this is to put data-entry statements into subroutines that can be called from various parts of the program.

Entering Data: You do not always control the length of the data to be entered, but when you do, keep length to a minimum. This saves keystrokes and time and reduces errors. Provide feedback by displaying entered data on the screen. If data being entered consist of logically related groups, then permit the user to enter several fields together, rather than requiring him to enter each item separately.

Error Check: Check all entered data for errors. The types of checks you must make depend upon the data and what will be done with them. Anticipate possible errors, check for them, and protect against them. For example, if the entry is supposed to be a number, anticipate what will happen when (not if) the operator enters a letter. Many programmers protect against this by taking all inputs as character strings and then converting them to equivalent numeric values.

Analyze the situation and be ready for errors. Are there range or length limits to what is acceptable? Is it possible for the operator to enter something that will cause an illegal program action to take place—for example, dividing by zero or attempting to take a substring of illegal length?

When an entry error is detected, alert the operator, identify the error, and tell him how to recover. In other words: *alert, identify, direct.* Alerting signals must differ from the customary background. An audio tone—a beep—is alerting but meaningless if the program is already emitting a continuous stream of beeps. Similarly, a flashing message can effectively alert, provided that the screen is not filled with other flashing messages. Many programmers reserve the use of both sound and flashing messages for those conditions that truly require an alert.

The error message itself should be placed consistently from screen to screen. Ideally, it should appear near the erroneous entry. The content of the message must tell what is wrong—for example, that the entered value is too long. If error identification will permit the operator to figure out what to do next, then that is *all* the message needs to contain. However, if many possible actions may be taken, then the message must also tell the operator which to take. If prompts to the user are adequate, then it should be possible in most cases for the operator to figure out what corrective action to take based solely on definition of the error. Figure 2 shows a helpful error message.

Editing: Editing is an important part of the data-entry process, and no data-entry program is complete without editing capability. Being human, operators will make data-entry errors that they may not recognize until later. You should therefore permit them to edit entries before the program accepts data into a database. Many programs permit data to be edited at three stages: during initial data entry (while being typed in), after a block of related entries has been made, and after the data have become part of the database.

The first editing capability is routine and in fact most people probably do not think of this as editing. If you make a typing error, you can usually back up the cursor before data are stored. The last capability, editing the actual database, varies in importance, but in many programs with large databases it is considered as necessary as utility programs for copying files, purging files, or the main menu itself.

Less routine, often ignored, yet very important is the block editing capability mentioned above. Often the program user will not recognize an error until after he has made several data entries. If he cannot go back and correct the error at that point, it may be uncorrectable, or he may have to use a separate database editing program to make the correction. The way block editing typically works is that after the operator has made a set of related entries, the screen presents a prompt asking if he wants to edit any earlier entries. If he

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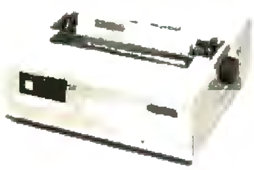

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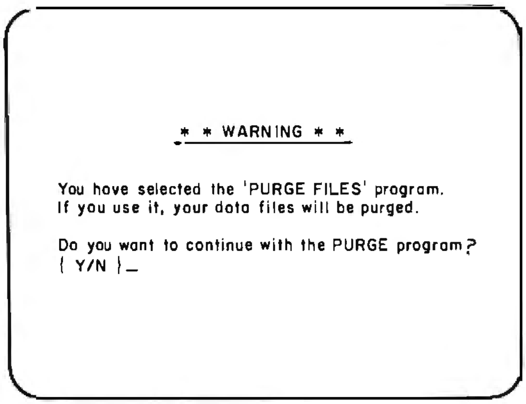

Figure 3: *A message that protects the operator against a serious error. The operator must confirm the decision to purge the data files before the program will proceed.*

indicates that he does, the program asks him to define the entry he wants to correct, usually by line number. Then the cursor moves to the appropriate data-input field to permit re-entry of data, and the edit prompt reappears to permit corrections. When the operator indicates that he has no more changes to make, the program moves on to the next step.

Certain data entries have far-reaching effects. A "profound, irreversible data entry" is one that will significantly affect the database or a phase of program operation. How profound the data entry is depends, of course, on the situation. Consequences of data-entry errors in these cases vary from inconvenience (you are delayed because you must print a report) to disaster (you just purged six months' worth of data).

Clearly, it is important to protect the operator from such traps by providing "fail-safe" devices. The general idea is to make the operator action more complex than for usual data entry. One way is to make data entry require two stages. For example, when the operator selects the "FIRE ICBM" program from the menu, firing does not occur immediately but causes a message to appear on the screen that tells what will happen next. This is accompanied by a prompt that permits the operator either to continue or to back out.

Protect your operator against himself. The programmer who writes a program that will purge all files at the stroke of a single key deserves no mercy and will receive none from program users. Figure 3 shows a message that provides sufficient warning to the operator before beginning to purge data.

Display Screen Design

Screen layout design is partly art and partly science but all programmers can profit by observing the guidelines in this section.

Designing a good screen requires planning. Many experienced programmers find that a screen design aid, consisting of a paper matrix that identifies all possible character locations on the screen, is useful. This permits design of the screen with paper and pencil. The design can be perfected before it is committed to code. (It is much faster to make pencil erasures than to change a series of tab settings.)

As a general rule, access screens by paging, not by scrolling. Keep in mind that people find it easier to read stationary pages than moving pages. The only people who like to read scrolling information are those at the end of hot news wires. Unless your program has that sort of application, clear the screen before you put up a new display.

Most displays need a title to tell the operator what he is looking at. The title should be centered at the top of the screen.

Display screen designers center displayed information primarily for aesthetic considerations, although centering assumes more practical importance with large screen displays. With large screens, if information is not centered, the operator will spend his time turned to the left side of the screen instead of along a more natural line of sight—straight ahead.

Your screens will probably contain a variety of different types of information: title block, numerical information, prompt line, error-message line, operating-mode indicator, etc. Analyze your needs and determine how many different categories apply. Then allocate a screen area for each information category.

Assure that information on screens does not stray from its assigned area. This is an application of the consistency principle discussed earlier. The more complex your screen displays, the more important it is to allocate areas. If you have complex screens and do not design them consistently, you will confuse the operator.

If possible, separate each area of the screen from the next by at least three rows or columns of blank spaces. Different blocks can also be separated by lines, which will make the separation more distinct. More effective still is to color-code different screen areas.

"Keep it simple" has become a cliché but is valuable and important advice. Unfortunately, keeping it simple is, to use another cliché, easier said than done. What, after all, is "simple"? And when is something "not simple enough?"

Finding the answers to these questions requires you to take a close look at the information needs of your program users at each point in your program. Present no more information than necessary.

Some programmers use the "one logically connected thought or step per screen" rule. Where much information must be conveyed, these programmers break it up into logical thoughts or steps and present each one on a separate screen. This is like the rule of presenting one idea in each paragraph of prose.

Programmers in the "densely packed display" school of thought hold the view that if they can get

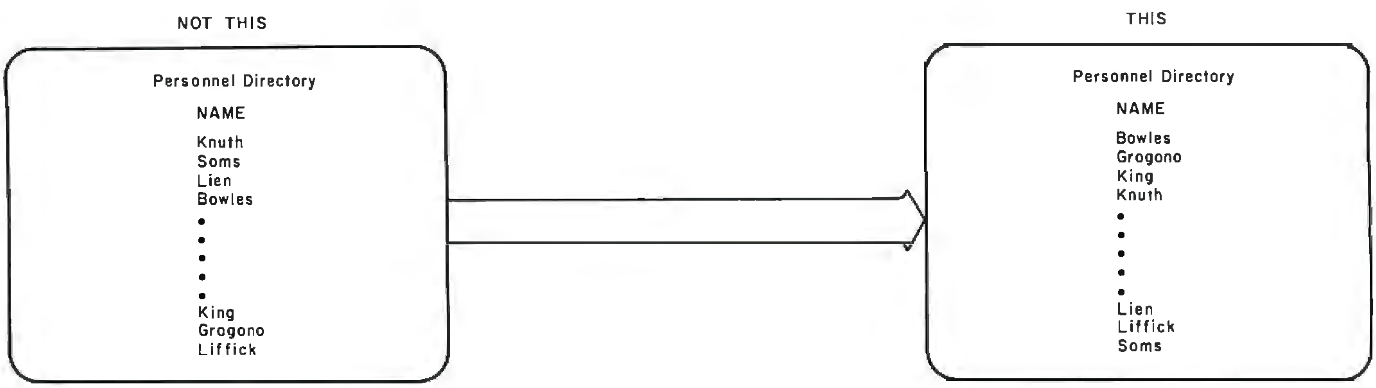

Figure 4: *The same list presented in random order and in alphabetical order. Recognizable orderings—e.g., alphabetical, numerical, and chronological—make data easier for the operator to comprehend.*

everything onto one screen they are saving something. What, exactly, they are saving is unclear, although they must gain a certain satisfaction by rising to the challenge of making everything fit. This satisfaction resembles the exultation of the first guy who engraved the Declaration of Independence on the head of a pin. Judge for yourself how useful that was.

In designing screen displays, it is important to follow prevailing conventions. Because of experience with written language, people have certain built-in expectations for the way information will be presented to them. If you don't follow convention in displaying information, you make things more difficult for the operator.

Think of your display screen as the page of a book. In a book, information is normally presented in lines that are read from left to right and from top to bottom. Numeric information is usually presented in tabular format, i.e., beneath column headings and from top to bottom. Certain obvious things you should avoid are printing numeric information from left to right or presenting very wide columns of text. If in doubt, recall how you have seen such information portrayed in books.

You should display information in a recognizable order. Some screens present directories or lists through which the operator must search. A menu is one such list, although it is usually short, with the most frequently called options listed at the top and the least frequently at the bottom (more on this later). Long directories or lists should be presented in an order that the operator will recognize, for example, alphabetic, numeric, or chronological order. This simplifies the search and saves time. Figure 4 shows the same information presented in random order and again in alphabetical order. Judge for yourself which ordering makes it easier to find the name "Grogono."

Long strings should be broken up. A "long" string is one that has more than about five independent characters. By "independent" we mean characters that do not unite to form a recognizable whole such as a person's name. A telephone number without the separating hyphen would be such a string. People have difficulty recognizing and separating the individual characters of long strings. If you have

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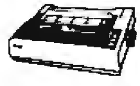

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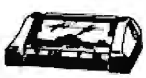

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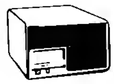

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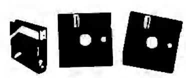

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           Amt Last Pmt :       3.69
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Figure 5: *Standard methods of presenting text and numbers on the screen. Text is easier to read if left-justified. Numbers are easier to read if right-justified and aligned on the decimal point (if any).*

ever tried to count over to, say, the 15th character of a 40-character string, you know the problem.

Elements of the string can be more readily located if you display the string as several short strings, (i.e., consisting of five or fewer characters) separated by spaces. (Better yet, find an explicit, uncoded method to present your information.)

According to standard practice, text is normally justified to the left side of the screen or to a defined tab value. Numerical information is normally justified to the right. Where the number of decimal places may vary on successive lines, decimal points on all lines should align at a particular tab value. These conventions are carry-overs from mainframe practice, where the availability of sophisticated formatting statements makes alignment easy. Justifying numbers to the right and aligning decimal points are more difficult with most microcomputer BASICs, although subroutines for performing these functions have appeared in publications, and most moderately skilled programmers can write their own. Figure 5 illustrates conventional alignment of information on the display screen.

Sequence Control

Sequence control is the manner in which the operator controls the sequence of program operations. In menu-driven programs, the operator exercises sequence control through menu choices. These let the operator select the subprograms he needs to do his job.

An operator can exercise sequence control in many other ways. Control simply requires an interaction or "dialogue" with the program. The menu-driven program permits a particular type of dialogue. Other common dialogue types are question and answer, query, program-like language, and action code.

In *question-and-answer* dialogue the program displays a question and the operator responds with an answer. The expected answer is one of a limited set of alternatives, such as "yes" or "no." Example: Program asks whether output should be displayed on video terminal or printer.

Query dialogue is an extension of question and answer: a question is posed but the number of alternatives is large. Example: Program requests the number of the file it should display.

Program-like language dialogue uses a defined set of commands to control the program. Valid commands are usually brief mnemonic abbreviations of action words. Example: Command words used to control the Star Wars game.


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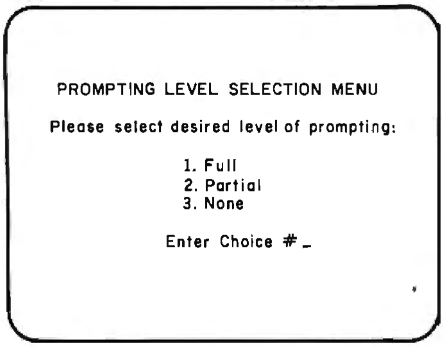

Figure 6: *Menu which allows the operator to choose the prompting level. Features like this accommodate operators who differ in skill.*

Action code dialogue usually involves the use of specially defined and labeled function keys for calling up displays or programs. User-defined function keys are not widely available on microcomputers, but we will see more of them in the future. The new IBM Personal Computer has 15 or more user-defined function keys.

Beside these methods, sequence control can be exercised in a number of other ways—in fact, via any channels that permit the operator to enter data into the computer and receive feedback. Possibilities include trackball, joystick, optical device, human voice, and whatever else creative minds can invent and implement.

The Old Standby—the Menu-Driven Program

In this article I cannot cover sequence-control design principles that apply to all dialogue types. For one thing, there isn't room. But more important, the research with many of these methods is limited, and I can offer few definitive recommendations. For these reasons, I will focus on that old standby, the menu-driven program. Though its origin is traceable to the earliest days of computing machinery, the menu-driven program remains the principal means by which people carry on dialogues with computers. Until people perfect ways of talking with computers, the menu-driven program will probably remain the mainstay.

There are good reasons for its popularity and success. First, it makes no demands on human memory. Menu options are displayed on the screen and the operator picks the one he wants. This makes a menu-driven program easy to learn. Second, menus help the operator orient himself because they explicitly display the available "roads" (subprograms) from each "crossroad" (menu).

Menu-driven programs have certain drawbacks as well. Storing and generating menus cost memory and time overhead. Once familiar with a program, operators may find that layers of menus impede progress more than they help.

For all that, the menu-driven program is a good vehicle for our discussion of sequence control because most people are familiar with it. Many of the design principles I will discuss in relation to it can be extended to other types of dialogues as well.

Your menu-driven program should be self-explanatory. The operator should not have to refer constantly to a manual to figure out how to make something happen. Obviously, you cannot explain everything within the program, but you should provide screens that describe special sequence-control features. For example, suppose that your program has several subprograms, each containing sub-subprograms, and so on, and that different program levels are accessed through layers of menus. Suppose further that you have designed certain sequence-control features to shortcut some menus so that the experienced operator can move quickly around to different parts of the program. Special features such as these should be explained within the program, either on separate screens which precede menus or, if the explanation is brief enough, on menus themselves.

Your program will function, of course, without built-in screen documentation. However, the operator will learn the intricacies of your program much more quickly if you do your explaining when and where he needs it—within the program itself.

If the operators using your program will vary in skill level, attempt to build in features that will accommodate skill growth. For example, let the operator select the level of prompting—full, partial, or none. This will help the inexperienced operator gain skill and confidence and save the experienced operator a lot of time. Make the choice of the prompting-level convenient, as shown in figure 6.

Your program may have one menu or several, depending on complexity. If it is a complex program with many options, analyze how each subprogram will be used. Determine which subprograms are functionally related. Estimate how often each menu choice will be made. You may be able to make a very long menu into a number of short ones.

Functional relationships and *frequency of use* of the subprograms are the two most important criteria to consider in designing a menu. List functionally related subprograms on the same menu. If possible, list frequently called subprograms on the same menu. If these requirements conflict, let functional relationships rule menu design. Avoid designing very long menus that contain a grab bag of unrelated options. This only makes sense if all programs are equally likely to be called under all conditions. That is seldom the case.

Make menu choices brief, explicit, and distinct from one another. To make up the label, consider exactly what each subprogram does and then label it accordingly.

Use terminology consistently. For example, don't call subprograms that do essentially the same thing by different names in the same program—don't call a program "edit" in one place and "modify/delete" in another.

The menu itself has three essential parts: (1) title, (2) list of menu choices, and (3) prompt line. Some menus also contain a statement that directs the operator to "select one of the menu choices." This feature is useful to operators unfamiliar with computers and can be considered optional.

```
                MAIN MENU

Select one of the following programs by
entering its number

        1. ENTER DATA
        2. GENERATE REPORTS
        3. EDIT DATA BASE
        4. START NEW FILE
        5. PURGE FILE
        6. QUIT

      Enter Choice #_
```

Figure 7: *Menu showing the three essential menu parts: title, list of choices, and prompt line. Some menus also have a directive to prompt operators unfamiliar with the system.*[1]

Center the menu title at top of the display and put the word "menu" at the end of the title. If you are providing the (optional) directive line, print this next, offset to the left, so that it is recognized as an instruction and not a title. Center the prompt and the data input field at the bottom of the screen. The prompt should be brief and explicit, for example, "ENTER CHOICE #," as shown in figure 7.

Menu selection can be done in several different ways: by entering the number of a menu option, by entering a letter, by typing in the menu choice, and by moving a cursor to the choice. Typing in the menu choice label usually requires several keystrokes and should be avoided. Most microcomputer software is not set up to permit cursor selection of menu choices.

The most common selection method is to type in a number or letter. In general, short menus should permit selection by letter—preferably the first letter of the choice label. (This can present problems if different menu choices start with the same letter.) On longer menus, numbered menu choices are more convenient.

If you do use numbers, then any list of numbered items appearing on one of your display screens will resemble a menu. This may cause confusion. Minimize confusion by titling menus as menus and titling other displays appropriately. Avoid numbered items on nonmenu displays, if possible. If you are presenting a list of instructions, for example, precede each instruction by a bullet instead of a number.

Conclusion

This brief excursion into the world of human factors covered areas of interest to the average microcomputer programmer. Much more is written on the subject, and those interested should consult the references listed at the end of this article.

Note that application of human-factors considerations to software design is immature as a technology and that much research still needs to be done. At present there is no single source to which the reader can refer to find all the important answers. (Martin's book is comprehensive but aimed primarily at the mainframe user.) Much of what is now available comes as technical reports that present recommendations cautiously labeled as "preliminary" or "tentative" findings.

In this article, I have attempted to congeal this somewhat indefinite material into a form that is useful to the average reader. Much has been left out because of inapplicability to microcomputers or because the material was of a specialized nature and would probably not be of interest. In general, what was presented is based on the references, although at some points I have condensed and simplified things. I hope that I have not distorted any author's intentions in the process. ■

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The Atari Tutorial

Part 8: Generating Sound with Software

The sound capabilities of the Atari 400 and 800 computers are influenced by the software technique used.

Bob Fraser
1639 Martin Ave.
Sunnyvale, CA 94087

The sound system in the Atari 400 and 800 microcomputers can be used in two basic ways: static and dynamic. Static sound generation is the simpler of the two. The program sets a few sound generators, turns to other activities for a while, and then turns them off. Dynamic sound generation is more difficult. The computer must continuously update the sound generators during program execution. For example:

```
SOUND 0,120,8,8
```

generates a static sound, while:

```
FOR X=0 TO 255
  SOUND 0,X,8,8
NEXT X
```

generates a dynamic sound.

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Static Sound

Although static sound is normally limited to beeps, clicks, and buzzes, there are exceptions. Two examples are the programs given last month as special effects in the sections on high-pass filters and 16-bit sound. Another way to obtain interesting effects is to use interference, as in this example:

```
SOUND 0,255,10,8
SOUND 1,254,10,8
```

The strange effect is a result of closely phased peaks and valleys. Figure 1 shows two channels independently running sine waves at slightly different frequencies and their sum. The sum curve shows the strange interference pattern created when these two channels are added.

Figure 1 also shows that, at some points in time, the waves are assisting each other; at other points, they oppose each other. Adding the volumes of two waves whose peaks coincide will yield a wave with twice the strength or volume. Similarly, adding the volumes of two waves while one is at maximum and the other is at minimum will result in a cancellation of both of them. On the graph of the sum curve, we can see this effect. An interesting project would be writing a program to plot interaction patterns of two, three, and four channels; the program would display graphs like that of figure 1. You might discover some unique sounds.

The slighter the difference in frequency between the two channels, the longer the pattern of repetition. To understand this, draw some graphs similar to figure 1 and study the interaction. As an example, try the following BASIC statements:

```
SOUND 0,255,10,8
SOUND 1,254,10,8
SOUND 1,253,10,8
SOUND 1,252,10,8
```

As the difference in frequency grows, the period of repetition decreases.

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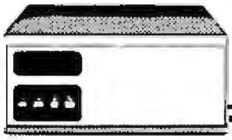

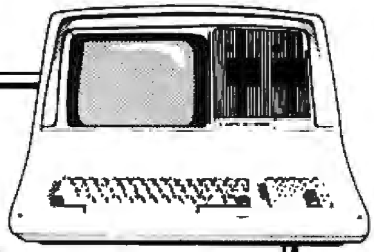

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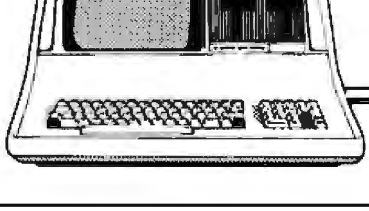

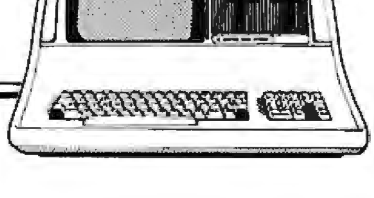

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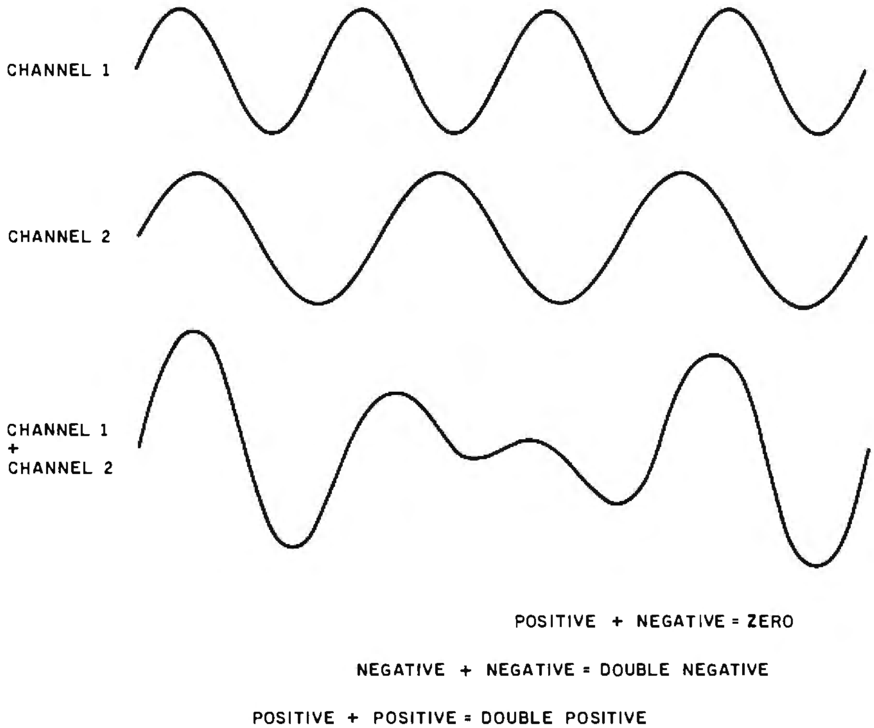

Figure 1: *Complex waveform generation from the addition of waveforms.*

Listing 1: *Using machine language to assist BASIC in generating multiple-note chords on the Atari 400/800. This demonstration program uses a short machine-language program placed in the BASIC string SIMUL$ (see lines 25 and 9999) to specify the frequency- and control-register values of up to four of the Atari sound generators. It is done quickly enough to make all the generators seem to start simultaneously (BASIC is too slow to do this). Note the use of the string SIMUL$ to store the machine-language program and the USR call in line 50 to execute it.*

```
10   SOUND 0,0,0,0:DIM SIMUL$(16)
15   REM read in machine lang. program
20   RESTORE 9999:X=1
25   READ Q: IF Q< > -1 THEN SIMUL$(X)=CHR$(Q):X=X+1:GOTO 25
26   REM read and then play sound data
27   RESTORE 100
30   READ F1,C1,F2,C2,F3,C3,F4,C4
40   IF F1 = -1 THEN END
50   X=USR(ADR(SIMUL$),F1,C1,F2,C2,F3,C3,F4,C4)
55   FOR X=0 TO 150:NEXT X
60   GOTO 30
90   REM sound data
100  DATA 182,168,0,0,0,0,0,0
110  DATA 162,168,182,166,0,0,0,0
120  DATA 144,168,162,166,35,166,0,0
130  DATA 128,168,144,166,40,166,35,166
140  DATA 121,168,128,166,45,166,40,166
150  DATA 108,168,121,166,47,166,45,166
160  DATA 96,168,108,166,53,166,47,166
170  DATA 91,168,96,166,60,166,53,166
999  DATA -1,0,0,0,0,0,0,0
9000 REM
9010 REM
9020 REM this data contains the machine lang. program,
9030 REM and is read into SIMUL$
9999 DATA 104,133,203,162,0,104,104,157,0,210,232,228,203,208,246,96,-1
```

Dynamic Sound

More complex sound effects normally require the use of dynamic sound techniques. Three levels of dynamic sound generation are available to the Atari 400/800 programmer: sound in BASIC, 60-hertz (Hz) interrupt sound, and sound in machine code.

BASIC Sound

BASIC is somewhat limited in its handling of sound generation. As you may have noticed, the SOUND statement negates any special AUDCTL setting. [*The audio-control register AUDCTL was discussed in last month's installment of "The Atari Tutorial."* . . . **GW**] This problem can be avoided by poking values directly into the sound registers, rather than using the SOUND statement.

In addition, the use of BASIC to control sound generation is somewhat limited because of its slowness. If the program is not completely dedicated to sound generation, there is seldom enough processor time to do more than static sound or choppy dynamic sound. The only alternative is to temporarily halt all other processing while generating sound.

Another problem can occur when using the computer to play music on more than one channel. If all four channels are used, the time separation between the first SOUND statement and the fourth can be substantial enough to make a noticeable delay between the different channels.

The program in listing 1 solves this problem. SIMUL$ is a tiny machine-language program that pokes all four sound channels very quickly. A BASIC program using SIMUL$ can rapidly manipulate all four channels. Any program can call SIMUL$ by putting the sound-register values inside the USR function as in line 50 of the demonstration program. The parameters should be ordered as shown, with the control-register value following the frequency-register value for each channel; this ordering is followed one to four times, once for each sound channel to

be set. As a speed consideration, as well as a convenience, SIMUL$ allows you to specify sound for less than four channels (i.e., channels 1 through 3, channels 1 and 2, or just channel 1). Simply omit the unused parameters from the USR function.

SIMUL$ offers another distinct advantage to the BASIC programmer. The AUDCTL register is reset upon execution of any SOUND statement in BASIC. However, using SIMUL$, no SOUND statements are executed; thus, the AUDCTL setting is retained.

Another method of sound generation in BASIC is impractical. This method uses the volume-only bit of any of the four audio-control registers. Type in and run the following program:

```
SOUND 0,0,0,0
10 POKE 53761,16:
  POKE 53761,31:
  GOTO 10
```

This program sets the volume-only bit in channel 1 and modulates the volume from 0 to 15 as fast as BASIC can. Although it uses all the processing time available to BASIC, it produces only a low buzz.

60-Hz Interrupt

This technique is probably the most versatile and practical of all methods available to the Atari computer programmer.

Precisely every 1/60 second the computer hardware automatically generates an interrupt. When this happens, the computer temporarily leaves the main program (the program running on the system—BASIC, Star Raiders, etc.). It then executes an interrupt service routine, a small machine-language routine designed specifically for servicing these interrupts. When the interrupt service routine finishes, it executes a special machine-language instruction that restores the computer to the interrupted program. This all occurs in such a way (if done properly) that the program execution is not affected. In fact, it has no idea that it ever stopped!

The interrupt service routine currently resident on the Atari 400/800

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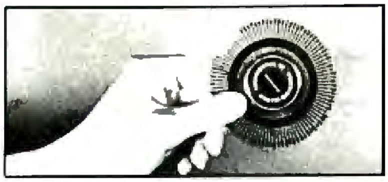

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computers maintains timers, translates controller information, and performs other chores requiring regular attention.

Before the interrupt service routine returns to the main program, it can be made to execute any user routine—for example, your sound-generation routine. This is an ideal situation for sound generation since the timing is precisely controlled, and especially since another program can be executing without paying heed to the sound generator. Even more impressive is its versatility. Because it is a machine-language program, the interrupt sound program will lend itself equally well to a main program written in any language—BASIC, assembly language, FORTH, Pascal. In fact, the sound generator will require few, if any, modifications to work with another program or even another language.

A *table-driven* routine offers maximum flexibility and simplicity for such a purpose. Table-driven refers to a type of program that accesses data tables in memory for its information. In the case of the sound generator, the data tables would contain the frequency values and possibly the audio-control-register values. The interrupt service routine would simply read the next entries in the data table and put them into their respective audio registers. Using this method, notes could change as often as 60 times per second, fast enough for most applications.

Once such a program has been written and placed in memory (for example, at location 600 hexadecimal, the beginning of the page of memory reserved for the user), you need to install it as a part of the 60-Hz interrupt service routine. This is accomplished by a method known as *vector stealing*.

Direct control of sound registers with a dedicated machine-language routine opens new doors in sound generation.

Memory locations 224 and 225 hexadecimal contain the address of a small routine called XITVBL (eXIT Vertical BLank interrupt service routine), which is designed to be executed after all 60-Hz interrupt processing is complete, restoring the computer to the main program as previously discussed.

The following procedure shows how vector stealing can be used to install your sound routine:

1. Place your program in memory (e.g., 600 hexadecimal).
2. Verify that the last instruction executed is a JMP $E462 (since location E462 hexadecimal is the XITVBL routine, this will make the main program continue).
3. Load the X register with the high byte of your routine's address (a 6 in this case).
4. Load the Y register with the low byte of your routine's address (a 0 in this case).
5. Load the accumulator with a 7.
6. Do a JSR $E45C (to set locations 224 and 225 hexadecimal).

Steps 3 through 6 are required to change the value of the pointer at locations 224 and 225 hexadecimal without error. The routine called is SETVBV (SET Vertical Blank Vectors), which simply puts the address of your routine into locations 224 and 225 hexadecimal. Once installed, the system works as follows when an interrupt occurs:

1. The computer's interrupt routine is executed.
2. The computer jumps to the program whose address is in locations 224 and 225 hexadecimal, which is now your routine.
3. Your routine executes.
4. Your routine then jumps to XITVBL.
5. XITVBL restores the computer's state previous to the interrupt and makes it resume normal operation.

[An elusive and infuriating "bug" may occur when a 60-Hz interrupt routine involving arithmetic operations (ADC and SBC op codes) is used as part of a BASIC program. The Atari BASIC floating-point routines set the 6502 decimal flag and cause add and subtract operations to be done in binary-coded decimal (BCD) instead of binary. If the 60-Hz interrupt occurs during a BASIC floating-point operation, the interrupt routine will be in decimal—not binary—mode unless you execute a CLD instruction at the beginning of the routine. My thanks to Chris Crawford of Atari for pointing out this bug. . . . GW]

If you do not wish to implement such a program yourself, one is available from the Atari Program Exchange. The package is called INSOMNIA (Interrupt Sound Initializer/Alterer). It allows creation and modification of sound data while you listen and is accompanied by an interrupt sound generator that is table-driven and compatible with any language. For more information, contact the Atari Program Exchange, 155 Moffett Park Dr., POB 427, Sunnyvale, CA 94086.

Machine-Code Sound Generation

Direct control of sound registers with a dedicated machine-language routine opens new doors in sound generation. The technique is as follows: write a program similar to the 60-Hz interrupt routine in that it is table-driven. However, the only routine now being executed by the Atari is dedicated to sound generation. By expending much more processor time on sound generation, you can produce higher-quality sounds. Consider, for example, the output of a typical 60-Hz interrupt music routine; its output will look something like figure 2a.

The volume-only bit offers a tremendous capacity for accurate sound reproduction.

Since much more processing time is available with a dedicated machine-language routine, you can change the frequency at very high speed *during* the note's playing time. For example, suppose you discover that whenever any piano key is struck it produces the characteristic sequence of frequencies shown in figure 2b.

The graph in figure 2b is called the *piano envelope*. To simulate a piano, the idea is to apply the piano envelope very quickly to the "plain-vanilla" square-wave beep. The note is thus slightly modified during its playing time. For example, a piano simulation of the three notes in figure 2a would be modified to look like figure 2c. This is essentially the same sound produced by the standard music routine of figure 2a, only the

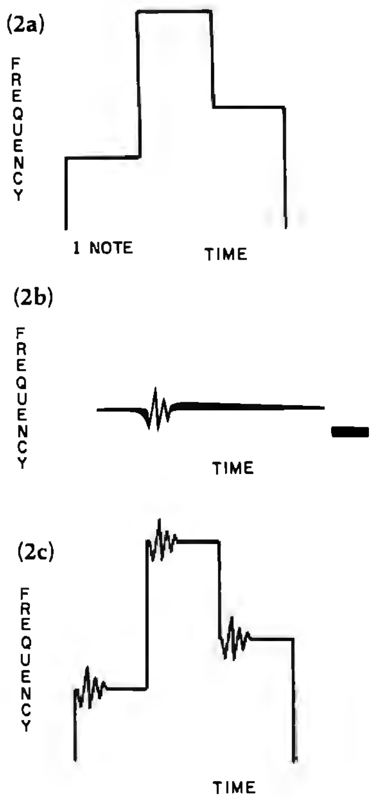

Figure 2: *Complex waveform generation under computer control. Figure 2a shows a frequency-versus-time plot of three simple notes generated by one of the Atari sound generators. If the complete resources of the computer are used to modulate the frequency (or other parameters) of the notes while they are being played, the computer can produce highly complex sounds. For example, if we find that a frequency envelope such as figure 2b simulates the sound of a piano, the envelope can be superimposed on the generated notes of figure 2a to give a modified set of notes that has a graph like that of figure 2c.*

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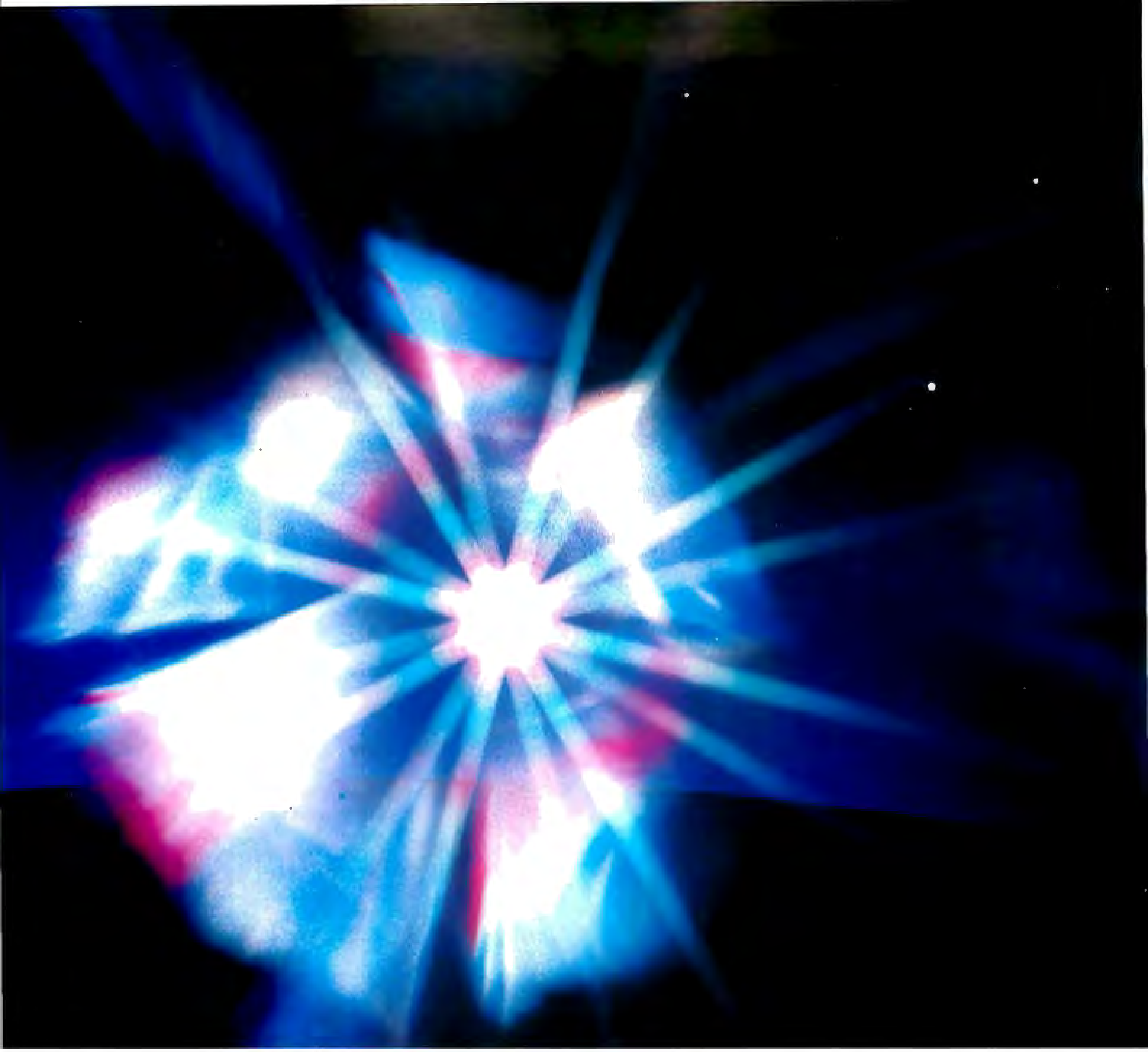

Listing 2: *A machine-language program that uses the waveform mode of the Atari 400/800 to generate tones with a sine wave amplitude envelope (tones normally produced by the Atari have a square-wave amplitude).*

```
0100 ;
0110 ; VONLY          Bob Fraser 7-23-81
0120 ;
0130 ;
0140 ; volume-only AUDC1-4 bit test routine
0150 ;
0160 ;
0170 ;
0180 ;
0190 AUDCTL = $D208
0200 AUDF1 = $D200
0210 AUDC1 = $D201
0220 SKCTL = $D20F
0230 ;
0240 ;
0250                  * = $B0
0260 TEMPO            .BYTE 1
0270 MSC              .BYTE 0
0280 ;
0290 ;
0300 ;
0310                  * = $4000
0320                  LDA #0
0330                  STA AUDCTL
0340                  LDA #3
0350                  STA SKCTL
0360                  LDX #0
0370 ;
0380                  LDA #0
0390                  STA $D40E ; disable vertical blank interrupt
0400                  STA $D20E ; disable nonmaskable interrupts
0410                  STA $D400 ; disable screen DMA
0420 ;
0430 ;
0440 ;
0450 LOO              LDA DTAB,X
0460                  STA MSC
0470 ;
0480                  LDA VTAB,X
0490 L0               LDY TEMPO
0500                  STA AUDC1
0510 L1               DEY
0520                  BNE L1
0530 ;
0540 ;                dec most significant counter
0550                  DEC MSC
0560                  BNE L0
0570 ;
0580 ;
0590 ;                new note
0600 ;
0610                  INX
0620                  CPX NC
0630                  BNE LOO
0640 ;
0650 ;                wrap note pointer
0660                  LDX #0
0670                  BEQ LOO
0680 ;
0690 ;
0700 NC               .BYTE 28 ; note count
0710 ;
0720 ;                table of volumes to be played in succession
0730 VTAB
0740                  .BYTE 24,25,26,27,28,29,30,31
0750                  .BYTE 30,29,28,27,26,25,24
0760                  .BYTE 23,22,21,20,19,18,17
0770                  .BYTE 18,19,20,21,22,23
0780 ;
0790 ;                this table contains the duration of each entry
                      above
0800 DTAB
0810                  .BYTE 1,1,1,2,2,2,3,6
0820                  .BYTE 3,2,2,2,1,1,1
0830                  .BYTE 1,1,2,2,2,3,6
0840                  .BYTE 3,2,2,2,1,1
```

notes now have a piano tone and they sound much prettier than just unmodulated beeps. Unfortunately, all other processing had to be sacrificed to get that piano tone. The sound channel is no longer updated only once every note; it is now done perhaps 100 times within the note's duration.

Volume-Only Sound

As indicated earlier, the AUDC*n* volume-only bits aren't of much use in BASIC. This is due entirely to the fact that BASIC is too slow to effectively use them. However, this is not the case with machine language.

As mentioned last month, the volume-only bit of the AUDC*n* registers offers a tremendous capacity for accurate sound reproduction. True waveform generation (within the time and volume resolution limits of the computer) is made possible with this bit. Instead of just putting a piano flavor into the music, you can now make it closely replicate a piano sound. Unfortunately, it can never precisely duplicate an instrument. Four bits (16 values) is not enough volume resolution for true high-quality work. Nevertheless, the technique does generate surprisingly good sounds. The program in listing 2 demonstrates the use of one of the volume-only bits. If you have an assembler, type it in and try it. Surprisingly, speed is not really a problem here. The wave has almost sixty steps, and the program can still be made to play the wave at up to 10 kilohertz.

Remove lines 390 through 410 and try the program once more. It will sound quite broken up. The cause is the 60-Hz interrupt discussed in the previous section. You can actually hear the interrupts taking place since all sound stops during that time.

Line 410 disables screen DMA (direct memory access). By disabling screen DMA, the ANTIC chip within the Atari 400/800 no longer "steals" time from the 6502 processor to get data from screen memory in time to display it on the video display. This is why the screen goes to a solid background color when the program is executed. Disabling screen DMA serves two purposes: to speed up the 6502 processor and to make the timing consistent, since screen DMA steals cycles at odd intervals.

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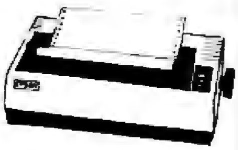

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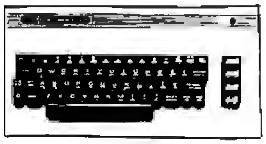

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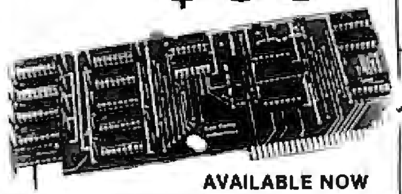

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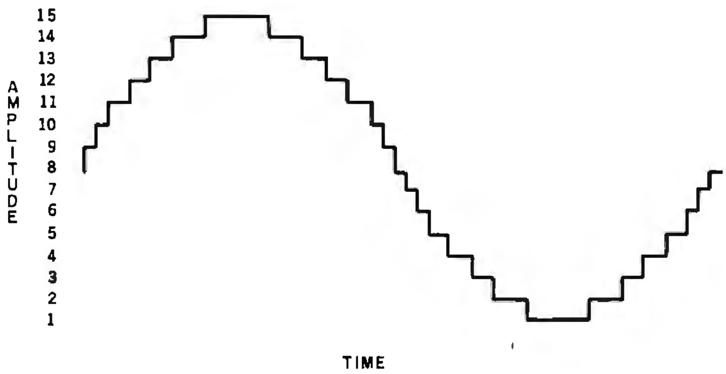

Figure 3: *An amplitude-versus-time graph of the sine wave sound produced by listing 2.*

In this demonstration program, the sound created is a close approximation to a sine wave. A graph of the waveform is given in figure 3.

The Role of Sound in Programs

This article and last month's installment of "The Atari Tutorial" have discussed the technical aspects of sound generation with the Atari 400 and 800 computers. However, the programmer must also understand the broader role of sound in the complete software package.

Moviemakers have long understood the importance of mood-setting background music. The recent *Star Wars* movies by George Lucas are excellent examples. When Darth Vader enters the room, you immediately fear and hate him because of the menacing background rhythms accompanying his entry. You know to gleefully applaud when Luke Skywalker saves Princess Leia because gallant music plays in the background. Likewise, horror films can frighten you merely by playing eerie music, even though the action may be completely ordinary.

Tatio America's Space Invaders program for the Atari 400/800 issues a personal threat to the player with its echoing stomp. As the tempo increases, knuckles whiten and teeth grind. When you fire a photon torpedo in Atari's Star Raiders game, the computer gives you a "launch" sound that decreases in frequency as the torpedo speeds away from you. The effective use of sound can increase your involvement with a game or other program.

Impressionistic sounds affect our subconscious and our state of mind. This may be due to the fact that sounds, if present, are continuously entering our mind whether or not we are actively listening. Visual inputs, on the other hand, require the user's attention. If we are distracted from the TV set, we cease to concentrate on the picture and the image leaves our mind. Sound therefore offers the programmer a direct path to the users' minds—bypassing their thought processes and zeroing in on their emotions. ■

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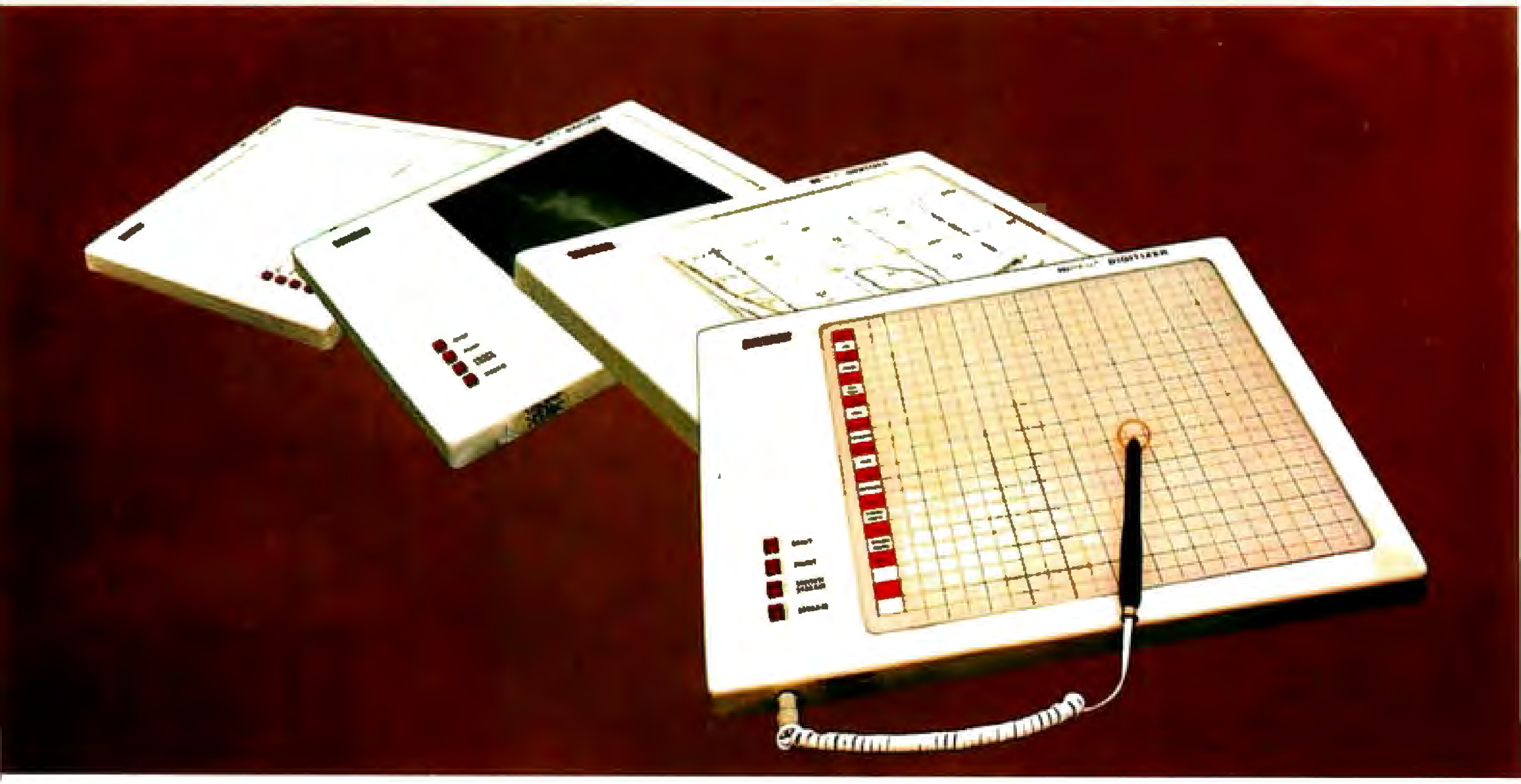

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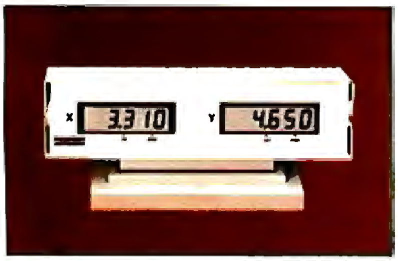

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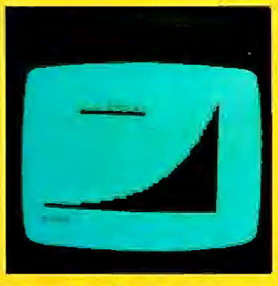

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Book Reviews

The Mind's I

Douglas R. Hofstadter
and Daniel C. Dennett,
Basic Books Inc.,
New York, 1981.
501 pages, hardcover
$15.50

Reviewed by Lloyd Milligan
8604 Maywood Dr.
Columbia, SC 29209

This book is designed to provoke, disturb, and befuddle its readers, to make the obvious strange and, perhaps, to make the strange obvious.

(from the Preface)

Most people take considerable pleasure in being astonished. Witness the popular television show *That's Incredible.* For those who are less easily astonished, but who enjoy a special kind of challenge, Douglas R. Hofstadter and Daniel C. Dennett have "composed and arranged" *The Mind's I,* a splendid collection of essays on mind and consciousness, "self and soul." Each essay concludes with a "Reflection" based on the editors' own thoughts and reactions.

Of all the pursuits of man, science has been the most productive. In the present century, the so-called neurosciences (neurobiology, neurochemistry, neuropsychology, etc.) have contributed significantly to our understanding of how the human brain works. Paradoxically, however, deep issues of both historical and enduring interest have been on the whole ignored by these new sciences. The denial of mind and consciousness as valid topics of scientific inquiry may be traced to the influence of logical positivism, operationalism, and behaviorism. *The Mind's I* could be said to be about those things that behaviorism denies.

A recurring theme or device in many of these essays is the "thought experiment." In a thought experiment, one imagines all the procedures and conditions of an experiment and attempts to imagine or deduce what the outcome would be. The power of a thought experiment—and also its weakness—comes from imagining procedures which cannot be carried out in reality. The key to distinguishing whether a thought experiment could be realizable is to decide if the conditions of the experiment are possible "in principle." In reading these essays I was sometimes reminded of Mark Twain's satire on facts and miracles: ". . . if it is a Miracle, any sort of evidence will answer, but if it is a Fact, proof is necessary." It is often difficult to know whether a suggested condition is merely technically infeasible or impossible in principle. Fortunately, Hofstadter and Dennett provide some assistance in this regard, but there is still a danger—thought experiments that support your point of view will seem more likely to be realizable than those that oppose it.

Thus far it may not be obvious why *The Mind's I* has special interest to computer enthusiasts. That it does is partly due to a new breed of cognitive psychologists—called computer scientists—whose major research interest is artificial intelligence (AI). If your concept of AI is based on the Eliza program, then you probably need to be brought up to date. Current AI research involves topics such as simulating human ability to understand stories (Roger Schank et al.; discussed by John R. Searle in "Minds, Brains, and Programs," page 353). Such projects shed new light on the meaning of "understanding," and at the same time expose the awesome complexity of human knowledge database design. In one sense, the ultimate goal of AI research is to give objective meaning to concepts that have heretofore been understood only in the subjective sense.

The brain's hardware, which at the very least "supports" thought, cannot be ignored. Several thought experiments in this book focus on the neural-circuit description of brain functioning. It is easy to slip from this focus to the assumption that the brain is purely a digital machine. This assumption is unwarranted even at the cellular level. For example, synapses (connections between nerve cells) are *not* strictly analogous to logic gates. Thousands of axon terminals may impinge upon the dendrites of a single cell. The events that transpire there (at the synapse) are more analog than digital in nature. One may even speculate that it is *not* possible "in principle" to model these processes sequentially in real time.

While reading these essays I found myself formulating point-by-point replies. More often than not, Hofstadter or Dennett expressed my approval or misgivings more clearly than I could have done. Their comments not only reflect on the essays themselves, but go on to present new variations on related themes. The reader is compelled to reflect on the reflection, and so on, until intellectual fatigue sets in.

A common thread runs through this collection, but it is not easy to discern. Various conceptions of mind, self, and soul are set up, exposed, scrutinized; the idea is to inquire which, if any, of these are *possible* models of mind, self, or soul. The mind as a program of immense intricacy, involving deep "level-crossing" structures (e.g., how can a thought influence a synapse?) and Gödelian loops, is one idea that emerges.

The Mind's I does not explain the mind's I. Perhaps it aims to describe what such an explanation would be like. In one reflection, Hofstadter is careful to distinguish emulation of the mind from simulation. Explanation is at least one step further removed. And while this book does not pretend to "explain" self or soul, the impression emerges that, with thoughtful consideration, these problems of the ages may be tractable, after all.

At another level, *The Mind's I* expresses a tone of personal warmth and enthusiasm. The authors inquire of one of Stanislaw Lem's essays, "Is this poetry, philosophy, or science?" I asked myself the same question about the book as a whole and concluded that it is a combination of all three. One thing that the book is not is *hocus pocus.* Hofstadter and Dennett eschew pseudoscience. Their views are completely compatible with the scientific world view. It's just that science has not yet made deep inroads into the problems that make up the main focus of this book. Perhaps this deficiency will yield in part to the union of computer science, neuroscience, cognitive science, philosophy, and linguistics. ■

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A Po(r)tpourri of Ideas

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Three inexpensive hardware/software projects to let you use the cassette port for a tone generator, telephone dialer, and RS-232C output channel.

William Barden Jr.
28122 Orsola
Mission Viejo, CA 92692

There's always an advantage in using existing hardware to interface external devices—there's no need to perform address decoding, to hook up to a multiline bus, or to design and implement controller functions. The cassette port is the most rudimentary input/output port in the TRS-80 Models I and III. It was originally designed to interface to an audio cassette recorder so that BASIC and machine-language programs and data could be saved and loaded. The cassette port, however, can be used in a variety of other ways. In this article, I'll describe three projects that use *cassette-port output*.

These projects will work with a Model I system *without* the expansion interface and with any Model III. The projects are a tone generator with volume control, a telephone dialer, and an RS-232C driver. A fourth use, controlling a nuclear fast-breeder reactor, was to be included, but still needs a little polishing up. Perhaps in a later article . . .

Cassette Logic

The TRS-80 Models I and III use similar logic in the cassette output, as shown in figure 1. The REMote output to turn on the recorder is slightly different in address decoding between the Models I and III, but in both cases it simply closes a relay. Two normally open relay contacts go to pins 1 and 3 of the cassette jack, a 5-pin DIN connector. The relay output won't be used for these projects, since some of

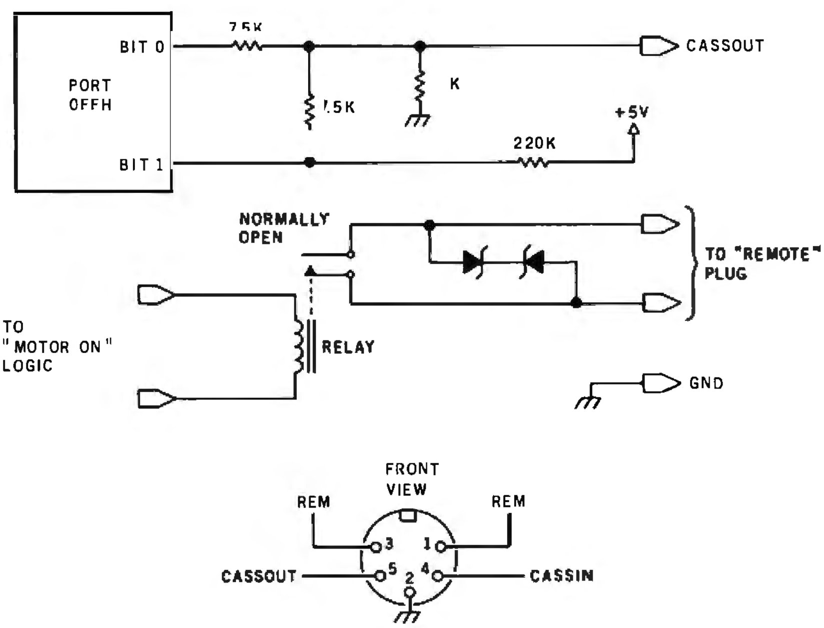

Figure 1: *Model I/III cassette output is performed by a two-bit latch that generates three voltage levels. The three voltage levels can produce a square wave with a positive-going pulse, a negative-going pulse, and a zero level. A motor relay connects two normally open contacts.*

About the Author

William Barden Jr. has written many books on microcomputer programming and design. He is a member of the Association for Computing Machinery and the Institute of Electrical and Electronics Engineers.

Port 0FF Hexadecimal Bit 1	Bit 0	CASSOUT Voltage (V)
1	0	≅0
0	0	≅0.4
0	1	≅0.8
1	1	≅0.4

Table 1: *CASSOUT voltages. The two latch bits produce four voltage levels. The 11 configuration is redundant and is not used.*

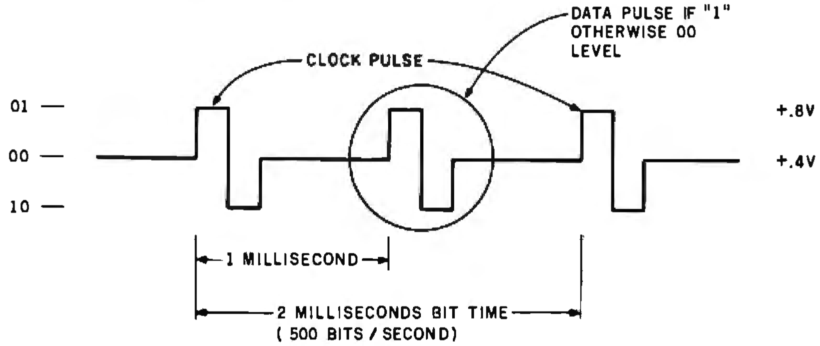

Figure 2: *The recording technique for 500 bps uses a clock pulse spaced at 2-ms intervals. A data pulse at the midpoint between clock pulses represents a 1; the absence of a data pulse represents a 0.*

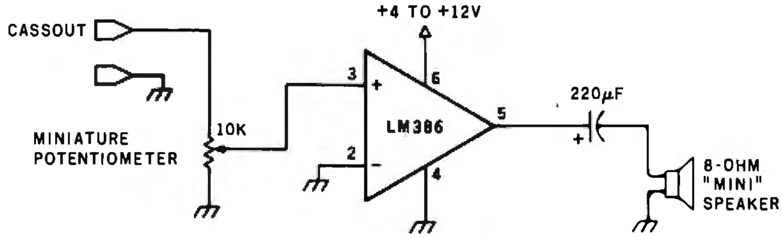

Figure 3: *In the TONOUT electronics, an LM386 audio-amplifier chip is driven by the CASSOUT signal. The output of the LM386 drives a small speaker.*

the earlier relays were prone to "sticking" (especially when used to control the AC supply for milling machines).

Instead, what will be used is the output that normally goes to the AUXiliary input of the cassette recorder to write data on the tape. This is a single line connected to pin 5 (CASSOUT) of the DIN connector. This line is driven by two bits at I/O address 0FF hexadecimal in both the Models I and III.

Three voltage levels can be output to the CASSOUT line, depending upon the configuration of the two least significant bits of port 0FF hexadecimal (see table 1). A bit configuration of 01 binary produces about 0 volts (V), 00 produces about 0.4 V, and 10 produces about 0.8 V. Bit configuration 11 is redundant as it generates 0.4 V again.

The three voltage levels are used to write data onto the cassette in the 500-bits-per-second (bps) mode, as shown in figure 2. A single square-wave cycle is first generated to produce a clock pulse. Then, either another cycle is output, representing a 1 data bit, or no cycle is output, representing a 0 data bit.

The Model III also has 1500-bps capability. In this mode, continuous *frequency-shift keying* is used, with 1320-hertz (Hz) and 2680-Hz tones representing the data. Only the 0- and 0.8-V levels are used for this scheme.

In both cases, the major part of the logic is in the ROM (read-only memory) firmware. The electronics really just consist of the two output latches and a few resistors.

In the following projects, I'll use the two bits of port 0FF hexadecimal to generate square waves for musical tones, telephone dialing, and RS-232C output. The greater part of the design effort, as in the TRS-80 cassette functions, is in the software. The hardware will consist of three simple circuits with a minimum of parts.

(**A note about connectors:** For connecting all three projects to your TRS-80 cassette port, use a standard, thin-walled, 5-pin DIN plug, such as Radio Shack's catalog item 274-003.)

A Musical Tone Generator

Our first project produces six octaves of notes representing the first six octaves on the piano keyboard. The notes are square waves, rich in odd-order harmonics. Two volume levels can be output, one using the 0- and 0.4-V levels, and a second using the 0- and 0.8-V levels.

The circuit shown in figure 3 uses the CASSOUT output as an input to an LM386 audio amplifier. The LM386 requires only a capacitor and 8-ohm (Ω) speaker to implement a complete audio amplifier. A miniature 10-kΩ potentiometer is used at the input for volume control. The power supply for the LM386 can be any convenient voltage from +4 to +12 V. A 6-V battery works fine for the power supply, or you can obtain a low-priced power-supply kit from Radio Shack.

TONOUT (listing 1) is an assem-

Listing 1: *TONOUT is a Z80 subroutine to output tones through the cassette port. The code is to be embedded in the BASIC program of listing 3.*

```
9000                        ORG     9000H
                    ;*************************************************************
                    ;* TONE OUTPUT. OUTPUTS TONE THROUGH CASSETTE PORT.          *
                    ;*        ENTRY: HL=> PARAMETER BLOCK                         *
                    ;*              PARAM+0=DURATION CNT IN 2 BYTES               *
                    ;*                     +2=FREQ CNT*(18.04 MICROSECS MOD I     *
                    ;*                       15.79 MICROSECS MOD III), 2 BYTES    *
                    ;*                     +4=LEVEL: 2=LOW,3=HIGH, ONE BYTE       *
                    ;*        EXIT:  AFTER TONE HAS SOUNDED                       *
                    ;*************************************************************
                    ;
9000 CD7F0A  TONOUT  CALL    0A7FH           ;GET HL
9003 E5              PUSH    HL              ;TRANSFER TO IX
9004 DDE1            POP     IX
9006 DD4E04          LD      C,(IX+4)        ;PUT LEVEL IN C
9009 DD6603          LD      H,(IX+3)        ;MSB FREQUENCY
900C DD6E02          LD      L,(IX+2)        ;LSB FREQUENCY
900F 7C              LD      A,H             ;GET MSB FREQ CNT
9010 B7              OR      A               ;TEST FOR ZERO
9011 2022            JR      NZ,LOWFRE       ;GO IF LOW FREQUENCY
                    ; HIGH FREQUENCY HERE
9013 45              LD      B,L             ;GET FREQUENCY COUNT
9014 DD6601          LD      H,(IX+1)        ;MSB OF DURATION
9017 DD6E00          LD      L,(IX+0)        ;LSB OF DURATION
901A 2B              DEC     HL              ;FOR JR NC'
901B 11FFFF          LD      DE,-1           ;FOR FREQ LOOP
901E 79      HI010   LD      ,C                ;LEVEL TO A (4)
901F EE02            XOR     2                 ;NOW 00 OR 01 (7)
9021 D3FF            OUT     (0FFH),A          ;TURN ON (11)
9023 78              LD      A,B               ;GET FREQ COUNT (4)
9024 3D      HI020   DEC     A                   ;ON LOOP (4)
9025 20FD            JR      NZ,HI020            ;LOOP TIL 0 (12/7)
9027 79              LD      A,C               ;DUMMY (4)
9028 3E02            LD      A,2               ;NOW 10 (7)
902A D3FF            OUT     (0FFH),A          ;TURN OFF (11)
902C 78              LD      A,B               ;GET FREQ COUNT (4)
902D 3D      HI030   DEC     A                   ;OFF LOOP (4)
902E 20FD            JR      NZ,HI030            ;LOOP TIL 0 (12/7)
9030 19              ADD     HL,DE             ;DECREMENT DUR CNT (11)
9031 38EB            JR      C,HI010           ;GO IF NOT 0 (12/7)
9033 1823            JR      LOW090          ;RETURN TO BASIC
                    ; LOW FREQUENCY HERE
9035 E5      LOWFRE  PUSH    HL              ;FREQ COUNT TO DE
9036 D1              POP     DE
9037 CB83            RES     0,E             ;MAKE EVEN
9039 DD4600          LD         IX+0)        ;DURATION CNT TO B
903C 79      LOW010  LD                        ;GET LEVEL (4)
903D EE02            XOR     2                 ;NOW 00 OR 01 (7)
903F D3FF            OUT     (0FFH),A          ;TURN ON (11)
9041 62              LD      H,D               ;GET FREQ COUNT (4)
9042 6B              LD      L,E               ;(4)
9043 2B      LOW020  DEC     HL                  ;DECR FREQ CNT (6)
9044 2B              DEC     HL                  ;(6)
9045 7C              LD      A,H                 ;TEST HL (4)
9046 B5              OR      L                   ;(4)
9047 20FA            JR      NZ,LOW020           ;GO IF NOT 0 (12/7)
9049 79              LD      A,C               ;DUMMY (4)
904A 3E02            LD      A,2               ;NOW 10 (7)
904C D3FF            OUT     (0FFH),A          ;TURN OFF (11)
904E 62              LD      H,D               ;GET FREQ COUNT (4)
904F 6B              LD      L,E               ;(4)
9050 2B      LOW030  DEC     HL                  ;DECR FREQ CNT (6)
9051 2B              DEC     HL                  ;(6)
9052 7C              LD      A,H                 ;TEST HL (4)
9053 B5              OR      L                   ;(4)
9054 20FA            JR      NZ,LOW030           ;GO IF NOT 0 (12/7)
9056 10E4            DJNZ    LOW010            ;GO IF D CNT NOT 0 (13/8)
9058 C9      LOW090  RET                     ;RETURN TO BASIC
0000                 END
```

bly-language program that drives the circuit to produce square waves from about 20 Hz to over 10,000 Hz. The extreme low and high frequencies won't come out very well (if at all) in the LM386, but for the middle range, tones sound fine. If you're a purist, you might consider using CASSOUT as an input to an amplifier with better fidelity.

TONOUT is designed to interface to a BASIC program. It is completely relocatable (more about that later) and requires three parameters from the BASIC code—a frequency count, a duration count, and a level.

The frequency count is a value from 1 to 65,535 that is used to control a timing loop. Each count causes a delay of 18.04 microseconds (μs) for

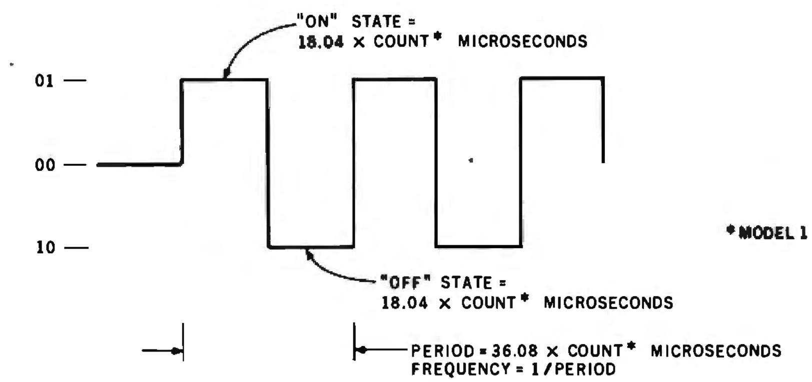

Figure 4: *A timing loop turns on the CASSOUT signal and then turns it off. The same frequency count is used for both the on and off delays; hence, the period of the tone is twice the delay time.*

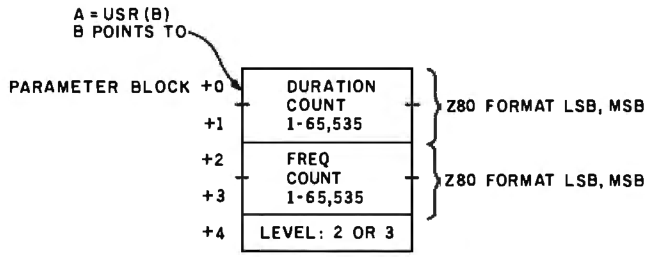

Figure 5: *Three parameters are used to interface to TONOUT from BASIC. A duration count is held in two bytes, a frequency count in two bytes, and a level in one byte. The counts are in standard Z80 address format: least significant byte followed by most significant byte.*

the Model I (15.79 for the Model III) on the "on" and "off" portions of the square wave, as shown in figure 4. Therefore, the frequencies of the square waves produced are 1/(36.08E-6) and 1/(31.58E-6), respectively.

The duration count of 1 to 65,535 determines the length of time the tone is played. In fact, the duration count is the number of cycles of the tone. Thus, the length of time the tone plays is dependent upon the tone's frequency. To play a "quarter note," the duration count would be 25 for a 100-Hz tone, 50 for 200-Hz, and so forth. The duration count is 1/frequency times the fraction of a second the tone is to be played.

The third parameter is volume level. A value of 2 is low and 3 is high. The level parameter is in one byte.

The main problem in TONOUT is how to get the "tightest" possible loop to toggle port hexadecimal 0FF bits on and off and still allow for low-frequency notes with a longer duration. The approach used here is to split TONOUT into two segments of code, one for high-frequency notes, and one for low-frequency notes.

TONOUT is entered from BASIC by a DEFUSR call. The CALL 0A7FH gets the argument from BASIC and puts it into the HL register pair. The argument in this case is a pointer to a parameter block of the three arguments in 7 bytes (see figure 5). This pointer is transferred to the IX register.

The level parameter is put into the C register and the frequency count is put into HL. Next, the frequency count is tested for magnitude. If the H register is nonzero, the frequency count is greater than 255, and a low-frequency note is played.

If the frequency count is less than 256, the high-frequency segment is executed. The single byte of the frequency count is transferred to the B register. Also, the two bytes of the duration count are transferred to HL and decremented by one for the JR C loop. (C will decrement below 0 before the loop is terminated.) The DE register pair is loaded with −1 for a "tight" timing loop.

The output portion of the loop consists of two almost identical segments. Lines 350 through 400 are the "on" portion that turns on the "top" of the square wave. Lines 410 through 460 turn off the output. Both portions decrement the frequency count in a timing loop that determines the frequency. The voltage level for the "on" portion is determined by performing an XOR of binary 10 and the level parameter to produce either a 00 (low) or 01 (high).

After one complete cycle, the duration count in HL is decremented by an ADD HL,DE. If the result is not negative, another cycle is generated.

The code from line 510 through the end is a similar routine for low-frequency notes. In this case, the frequency count is held in HL and decremented twice. The frequency count is first made even by a RES 0 instruction for a test of decrementing down to zero. The duration count is assumed to be 254 or less and is held in B for a DJNZ instruction.

Using TONOUT with BASIC

TONOUT can be used to generate tones other than musical notes. The precise frequencies generated are:

$$1/((42.49 + 18.04 \times \text{count}) \times 10^{-6})$$

for high-frequency tones and:

$$1/((41.15 + 18.04 \times \text{count}) \times 10^{-6})$$

for low-frequency tones. These formulas are for the Model I. Use (37 + 15.79 × count) and (36 + 15.79 × count) for the Model III. The 18.04 (or 15.79) represents the on/off loop times; the other constants represent the "overhead" for the frequency and duration timing.

BASIC can easily be used to build up a table of values for matching frequency counts to musical notes.

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Listing 2: *A BASIC program to generate frequency-delay values that, when input to the TONOUT routine, will reproduce tones in standard pitch. Results are shown in table 2.*

```
20 'PROGRAM TO FIND BEST FIT FOR 8 OCTAVES
40 DIM NT$(11)
60 A$="A A#B C C#D D#E F F#G G#"
80 FOR J=0 TO 11
100 NT$(J)=MID$(A$,J*2+1,2)
120 NEXT J
140 FOR I=0 TO 7
160 RESTORE
180 LPRINT "OCTAVE ";I+1
200 FOR J=0 TO 11
220 LPRINT NT$(J);"=";
240 N=(27.5*2↑I)*2↑((J)/12):LPRINTN;
260 CT=((1/N)-36.5E-6)/15.79E-6
280 LPRINT "F CNT=";CT
300 NEXT J
320 NEXT I
```

OCTAVE 1

A	= 27.5	F CNT = 2300.64
A#	= 29.1352	F CNT = 2171.39
B	= 30.8677	F CNT = 2049.39
C	= 32.7032	F CNT = 1934.23
C#	= 34.6478	F CNT = 1825.54
D	= 36.7081	F CNT = 1722.95
D#	= 38.8909	F CNT = 1626.12
E	= 41.2035	F CNT = 1534.73
F	= 43.6535	F CNT = 1448.46
F#	= 46.2493	F CNT = 1367.03
G	= 48.9994	F CNT = 1290.18
G#	= 51.9131	F CNT = 1217.64

Table 2: *Calculating counts for musical notes. A short BASIC program can match TONOUT frequency counts with standard pitch values. Here are the results.*

OCTAVE	MODEL I
1	2013,1900,1793,1692,1597,1508,1423,1343,1268,1196,1129,1065
2	1005,949,896,845,798,753,710,670,632,597,563,532
3	502,473,447,421,398,375,345,334,315,297,280,265
4	250,235,222,210,198,186,176,166,154,147,139,131
5	124,117,110,104,98,92,87,82,77,73,68,64
6	61,57,54,51,48,45,42,40,37,35,33,31

OCTAVE	MODEL III
1	2300,2171,2049,1934,1826,1723,1626,1535,1448,1367,1290,1218
2	1149,1085,1024,966,912,860,812,766,723,682,644,608
3	573,541,511,482,455,429,405,382,360,340,321,303
4	286,269,254,240,226,213,201,190,179,169,159,150
5	142,134,126,119,112,106,99,94,88,83,78,74
6	70,66,62,58,55,52,49,46,43,40,38,36

Table 3: *Frequency counts for standard pitch. Six octaves of note values are represented by the values in the table. Models I and III use slightly different values because of the difference in clock rates.*

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Listing 3: *The BASIC program to demonstrate tone generation with the Model I/III cassette port. The DATA statements contain the machine-language codes of the TONOUT subroutine.*

```
40 REM SAMPLE TONOUT DRIVER
50 DATA 205, 127, 10, 229, 221, 225, 221, 78, 4, 221
51 DATA 102, 3, 221, 110, 2, 124, 183, 35, 34, 69
52 DATA 221, 102, 1, 221, 110, 0, 43, 17, 255, 235
53 DATA 121, 238, 2, 211, 255, 120, 61, 32, 253, 121
54 DATA 62, 3, 211, 255, 120, 61, 32, 253, 25, 56
55 DATA 235, 24, 35, 229, 209, 203, 131, 221, 70, 0
56 DATA 121, 238, 2, 211, 255, 98, 107, 43, 43, 1,9
57 DATA 181, 32, 250, 121, 62, 2, 211, 255, 98, 107
58 DATA 43, 43, 124, 181, 32, 250, 16, 228, 201
60 FOR I=36864-65536 TO 36952-65536
62 READ A:POKE I,A
64 NEXT I
100 DEFUSR0=&H9000
110 INPUT D,F,L
120 POKE &HA001,INT(D/256):POKE &HA000,D-(INT(D/256))*256
130 POKE &HA003,INT(F/256):POKE &HA002,F-(INT(F/256))*256
140 POKE &HA004,L
150 A=USR0(&HA000)
160 GOTO 110
```

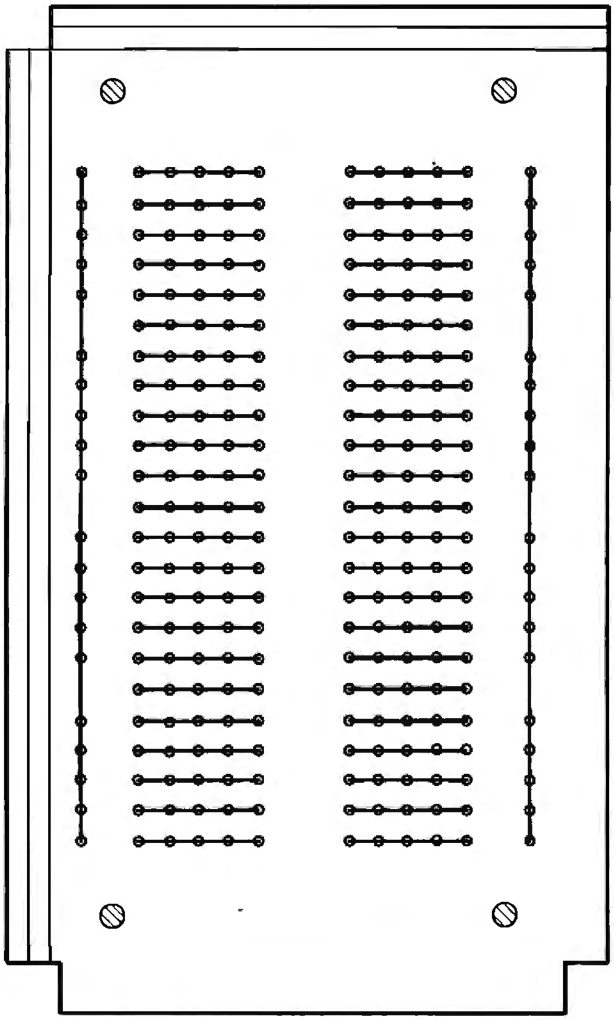

Figure 6: *Radio Shack's Experimenter Socket project board uses a matrix of holes into which component leads can be plugged. The holes are organized into 46 sets of five plus two buses.*

Listing 2 shows a Model III BASIC program for converting to standard pitch (A = 440 Hz). (The Model I version is identical except for the constants.) This scheme has 12 notes per octave: A, A# (A sharp), B, C, C#, D, D#, E, F, F#, G, and G#, each calculated by raising 2 to successive one-twelfth powers. The notes of each octave double in frequency over the preceding octave.

The first portion of output from the program of listing 2 is shown in table 2. Table 3 shows suggested integer counts for the notes for the Models I and III.

Listing 3 shows the TONOUT program incorporated into a BASIC program as DATA values. The DATA values are the machine-language bytes of TONOUT. TONOUT is relocatable and can be moved anywhere in RAM (random-access read/write memory). The program in listing 3 moves the bytes to 9000 hexadecimal by a series of POKEs. It then INPUTs a duration count, frequency count, and level value for experimentation.

Constructing the Electronics

All three projects in this article use a similar construction method. Radio Shack carries an Experimenter Socket project board, which is a matrix of 23 rows, each with two halves, as shown in figure 6. Each of the 46 row segments is connected electrically. Two buses run down the board on the extreme right and left.

Components can be plugged into the board with a minimum of fuss. The interconnections for the TONOUT electronics are shown in figure 7, along with the power supply, speaker, and cassette plug connections. Make the connections to the 5-pin DIN plug, as shown in figure 8.

To get precise frequencies for TONOUT, it's a good idea to disable the real-time clock interrupts in the Models I and III. If the real-time clock is running (and it may be, even without a display), the timing on tones may be off by 4 percent, and there may be some modulation on the tone. Add a disable interrupt (DI) instruction (243 decimal) at the beginning of TONOUT and an enable in-

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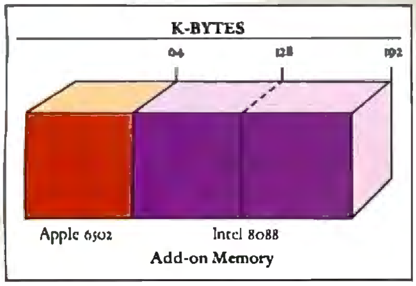

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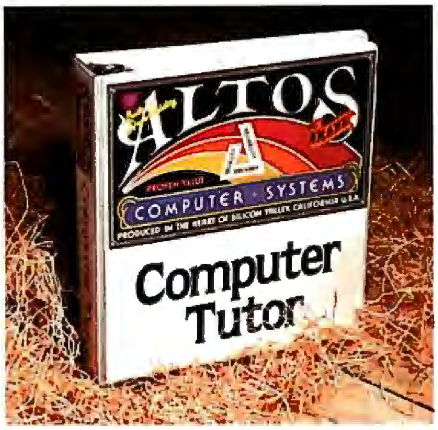

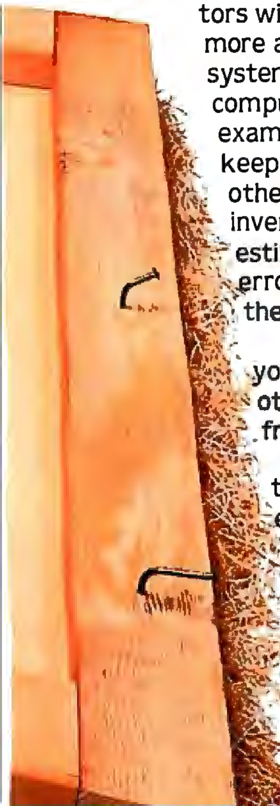

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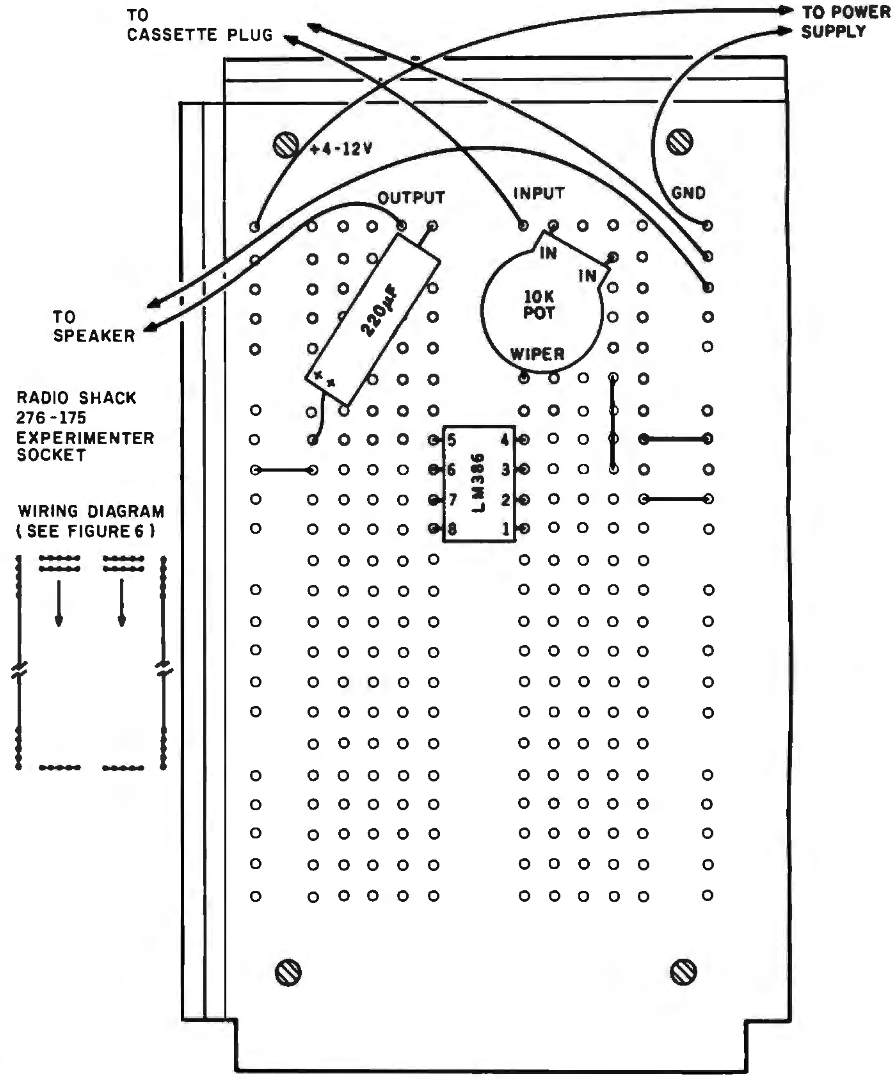

Figure 7: *The TONOUT circuit is mounted on a project board. It uses three components. The 10-kΩ potentiometer can be adjusted for a comfortable volume.*

terrupt (EI) instruction (251 decimal) right before the 201 decimal for the RET; modify the POKE loop accordingly. The DI and EI were omitted from TONOUT to give the user some flexibility in using the project in different configurations.

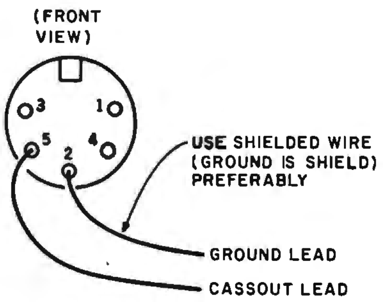

Figure 8: *Two wires are connected to the 5-pin DIN plug for the cassette port. Shielded wire is preferable, but any wire will suffice.*

A Telephone Dialer

Our second cassette-output project is a pulse-type telephone dialer (TELDIL). Most telephone lines, even those using tone dialing, will accept dialing by a series of break/make pulses, spaced at defined intervals—similar to those created by a rotary-dial telephone. See figure 9 for an illustration of pulse dialing.

The circuit for TELDIL is shown in figure 10. Put simply, the circuit opens and closes a relay to generate pulses, which are then transmitted to the telephone line through a special Data Access Arrangement (DAA) required by and available from the telephone company. The TELDIL

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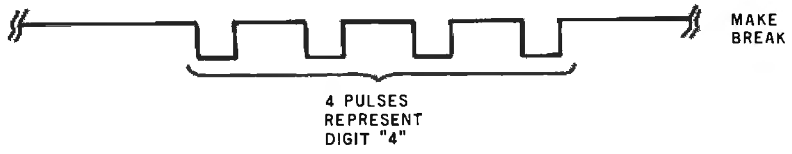

Figure 9: *Standard rotary dialing outputs a series of evenly spaced pulses to represent the digits 0 through 9.*

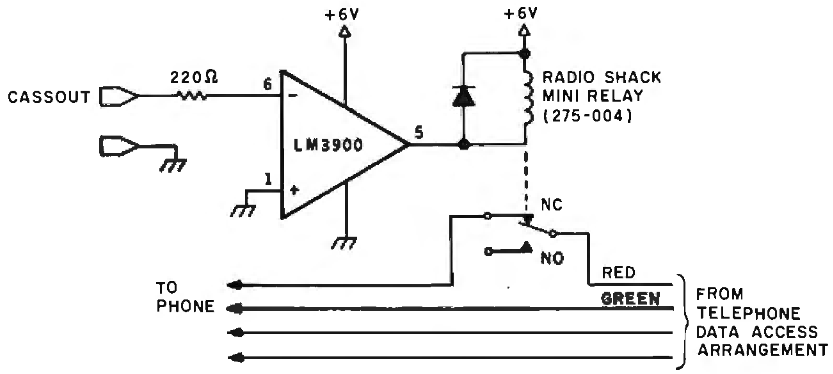

Figure 10: *The telephone-dialing circuit uses an operational amplifier to trigger a small relay. The relay opens and closes the telephone line through the Data Access Arrangement to simulate a rotary-dial pulse.*

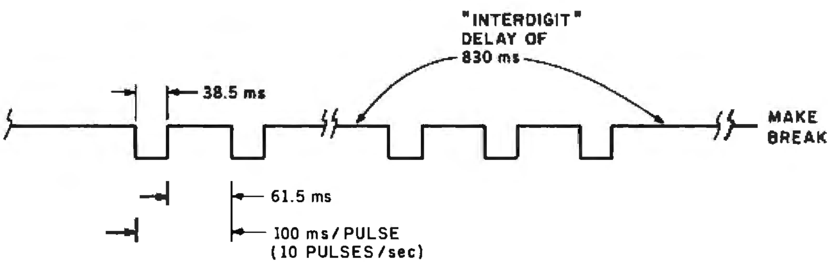

Figure 11: *TELDIL breaks the circuit for 38.5 ms. Pulses are spaced at 100-ms intervals, representing 10 pulses per second. An interdigit delay of 830 ms separates the pulse trains for each digit.*

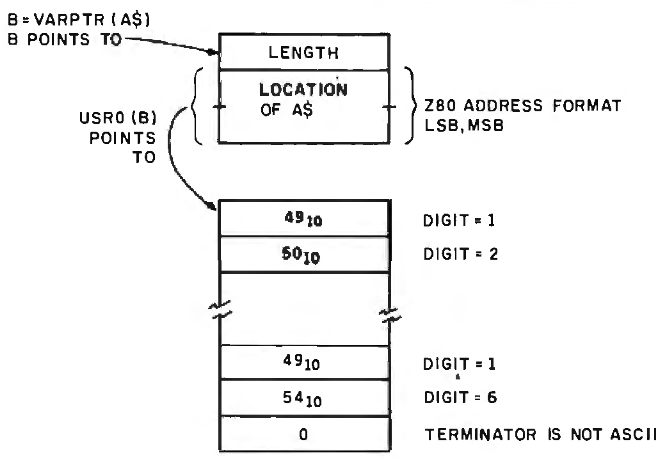

Figure 12: *BASIC passes a pointer to TELDIL. The pointer references a list of ASCII digits representing decimal values; the list is terminated by any non-ASCII value, e.g., binary 0.*

relay is driven by an LM3900 operational amplifier (op amp), which in turn is driven by the TRS-80's CASSOUT line.

Whenever the CASSOUT output level is greater than or less than 0 V, enough current flows through the 220-Ω resistor to turn on the LM3900, bringing the output on pin 5 to 0 V. This closes the relay and breaks the connection to the DAA. The diode (Radio Shack's 1N4000-series diode, catalog number 276-1102) across the relay coil is necessary to prevent high-voltage "spikes" from the inductive load of the relay coil from damaging the LM3900.

The software for TELDIL is also a relocatable assembly-language program that interfaces to BASIC (see listing 4). Although the version shown here uses a delay loop for the Model I, there is enough "leeway" in the constants to use the same code for the Model III as well. The "make/break" rate for digits is limited to 10 pulses per second for most telephone systems. The circuit is broken for about 38.5 milliseconds (ms) for each pulse, and then made for 61.5 ms, as shown in figure 11. Interdigit delay is about 830 ms. These delays can be adjusted for faster dialing on an experimental basis.

BASIC passes a pointer to TELDIL in the USR call. The pointer references a string of ASCII decimal digits, such as "17145551212." Any number of digits can be used. The last byte of the string is a non-ASCII digit, such as binary 0 (see figure 12).

TELDIL uses two loops. The outer loop from lines 250 through 480 picks up the ASCII digit from the string, tests it for valid ASCII decimal codes of 0 through 9, converts the digit into a stream of 1 through 10 pulses on the line, and increments the string pointer. It also delays 830 ms for the interdigit delay.

The inner loop at lines 330 through 430 pulses the line for each digit. The line is broken by outputting binary 01 to port 0FF hexadecimal and then delaying 38.5 ms. The line is then reconnected for 61.5 ms. The number of pulses is held in the B register, and the DJNZ repeats the loop for the number of pulses required.

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Listing 4: *TELDIL is a Z80 subroutine to simulate a rotary telephone dialer.*

```
9000                00100               ORG      9000H
                    00110 ;*******************************************************
                    00120 ;* TELEPHONE DIALER. DIALS ANY NUMBER OF DIGITS FOR    *
                    00130 ;* ROTARY-TYPE PHONE THROUGH CASSETTE PORT.            *
                    00140 ;*     ENTRY: HL=> STRING OF ASCII DECIMAL DIGITS, TERM- *
                    00150 ;*             INATED BY NON-ASCII                     *
                    00160 ;*     EXIT:  AFTER NUMBER HAS BEEN DIALED             *
                    00170 ;*******************************************************
                    00180 ;
0604                00190 PULSE     EQU      1540           ;38.5 MS PULSE
099C                00200 WAIT1     EQU      2460           ;10 PULSES PER SECOND
7814                00210 WAIT2     EQU      30740          ;830 MS INTERDIGIT
9000 CD7F0A         00220 TELDIL    CALL     0A7FH          ;GET ARGUMENT IN HL
9003 E5             00230           PUSH     HL             ;MOVE TO IX
9004 DDE1           00240           POP      IX             ;IX POINTS TO STRING
9006 DD7E00         00250 TEL005    LD       A,(IX)           ;GET NEXT DIGIT
9009 D630           00260           SUB      30H              ;CONVERT TO BINARY
900B 2002           00270           JR       NZ,TEL010        ;GO IF NOT 0
900D 3E0A           00280           LD       A,10             ;0-USE 10 PULSES
900F 3828           00290 TEL010    JR       C,TEL090         ;RTN IF LT 30H
9011 FE0B           00300           CP       11               ;TEST FOR GT 10
9013 3024           00310           JR       NC,TEL090        ;RETURN IF GT 10
9015 47             00320           LD       B,A              ;# OF PULSES IN B
9016 3E01           00330 TEL020    LD       A,1                ;ON CODE
9018 D3FF           00340           OUT      (0FFH),A           ;TURN ON RELAY
901A 210406         00350           LD       HL,PULSE           ;DELAY CONSTANT
901D 0E00           00360           LD       C,0                ;RETURN FLAG
901F 1819           00370           JR       DELAY              ;DELAY
9021 3E02           00380 TEL030    LD       A,2                ;OFF CODE
9023 D3FF           00390           OUT      (0FFH),A           ;TURN OFF RELAY
9025 219C09         00400           LD       HL,WAIT1           ;BETWEEN PULSE DELAY
9028 0E01           00410           LD       C,1                ;RETURN FLAG
902A 180E           00420           JR       DELAY              ;DELAY
902C 10E8           00430 TEL040    DJNZ     TEL020             ;LOOP IF MORE PULSES
902E 211478         00440           LD       HL,WAIT2         ;BETWEEN DIGITS DELAY
9031 0E02           00450           LD       C,2              ;RETURN FLAG
9033 1805           00460           JR       DELAY            ;DELAY
9035 DD23           00470 TEL050    INC      IX               ;BUMP STRING POINTER
9037 18CD           00480           JR       TEL005           ;LOOP FOR NEXT DIGIT
9039 C9             00490 TEL090    RET                     ;RETURN TO BASIC
                    00500 ; DELAYS 24.81*CNT IN MICROSECS + OVERHEAD
903A 2B             00510 DELAY     DEC      HL               ;DECREMENT DELAY COUNT
903B ED5F           00520           LD       A,R              ;TIME WASTER
903D ED5F           00530           LD       A,R              ;TIME WASTER
903F 7C             00540           LD       A,H              ;TEST HL
9040 B5             00550           OR       L
9041 20F7           00560           JR       NZ,DELAY         ;LOOP IF NOT DONE
9043 CB49           00570           BIT      1,C            ;TEST FOR RTN PNT 2
9045 20EE           00580           JR       NZ,TEL050      ;GO IF RTN PNT 2
9047 CB41           00590           BIT      0,C            ;TEST FOR RTN PNT 1
9049 20E1           00600           JR       NZ,TEL040      ;GO IF RTN PNT 1
904B 18D4           00610           JR       TEL030         ;RTN PNT 0
0000                00620           END
```

Listing 5: *A BASIC program to demonstrate telephone dialing via the TRS-80 cassette port. The DATA statements contain the machine-language codes of the TELDIL subroutine.*

```
40 REM SAMPLE TELDIL DRIVER
60 A=0:B=0:C=0:A$=""
80 DATA 205, 127, 10, 229, 221, 225, 221, 126, 0, 214
100 DATA 48, 32, 2, 62, 10, 56, 40, 254, 11, 48
120 DATA 36, 71, 62, 1, 211, 255, 33, 4, 6, 14
140 DATA 0, 24, 25, 62, 2, 211, 255, 33, 156, 9
160 DATA 14, 1, 24, 14, 16, 232, 33, 20, 120, 14
180 DATA 2, 24, 5, 221, 35, 24, 205, 201, 43, 237
200 DATA 95, 237, 95, 124, 181, 32, 247, 203, 73, 32
220 DATA 238, 203, 65, 32, 225, 24,212
240 CLEAR 500
260 DEFUSR0=&H9000
280 FOR I=36864-65536 TO 36940-65536
300 READ A:POKE I,A
320 NEXT I
340 INPUT A$: A$=A$+CHR$(0)
360 B=VARPTR(A$)
380 C=PEEK(B+1)+(PEEK(B+2))*256
400 A=USR0(C-65536)
420 GOTO 340
```

DELAY is a simple time-delay routine that delays 24.81 μs times the HL count. To keep the code relocatable, DELAY is not entered via an ordinary CALL, which would have a nonrelocatable address, but is called with a code for the three return points.

Listing 5 shows the machine-language code of TELDIL incorporated within a BASIC program. In this case, it is moved to 9000 hexadecimal, but it could be relocated to any convenient area in memory. The ASCII string is INPUT and a CHR$(0) is concatenated to the string for the terminating character.

VARPTR is used to find the string location. Make certain that VARPTR is used immediately before the USR call because string variables *move*. The "C-65536" adjusts for addresses in the upper 32K bytes of RAM; for a 32K- or 48K-byte system, this would normally be the area in which string variables would be located. String variables within a BASIC program line, however, have addresses that represent the location of the program line, and the argument in the USR call must be adjusted accordingly.

Constructing the TELDIL Circuit

TELDIL uses the project board discussed earlier (see TONOUT). The components are connected as shown in figure 13. Power-supply voltage should be more than 6 V; the relay shown will not work well with a 5-V supply. The cassette plug is connected as shown in figure 8.

A Serial Driver

Our third project using the cassette output is an RS-232C output port that can be used to drive a serial printer, modem, or other serial device. Standard rates of 300, 600, 1200, and 2400 bps can be selected with 10 bits per character.

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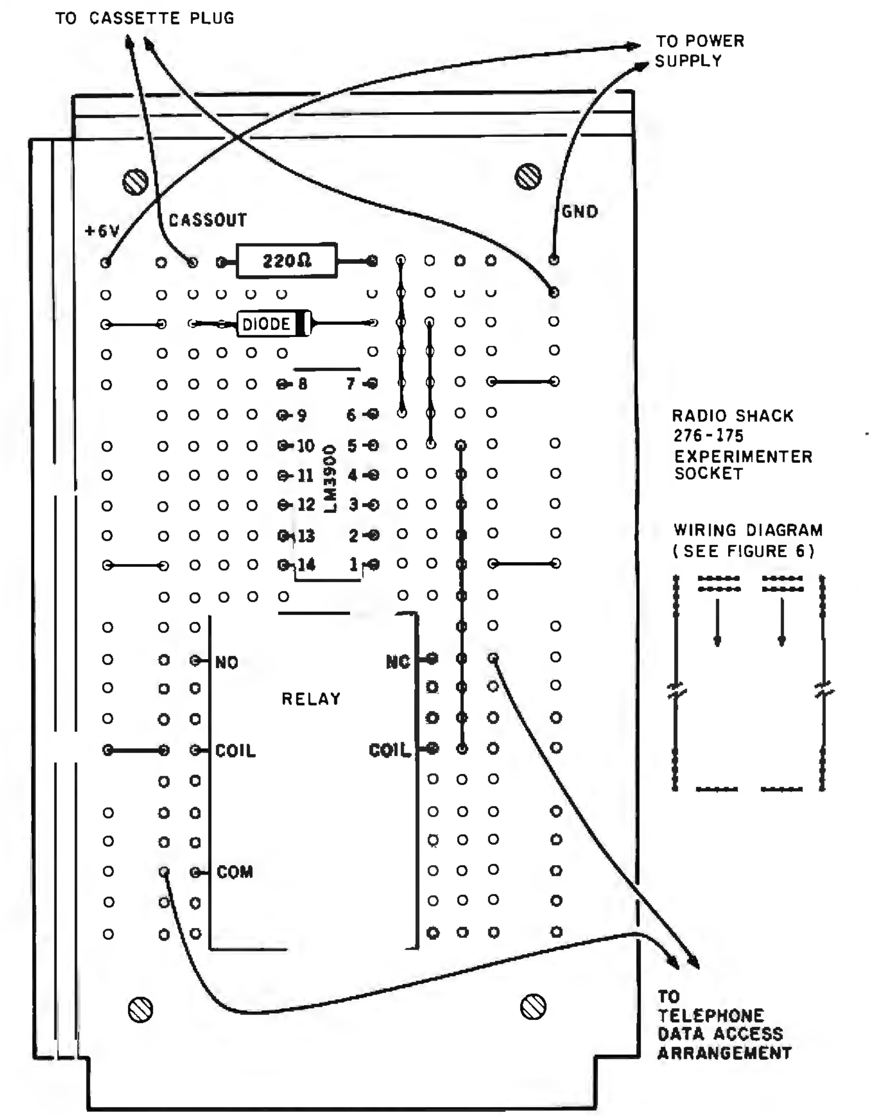

Figure 13: *The TELDIL circuit is mounted on a project board. The relay leads can be trimmed, "built-up" with solder, and pushed into the project-board holes.*

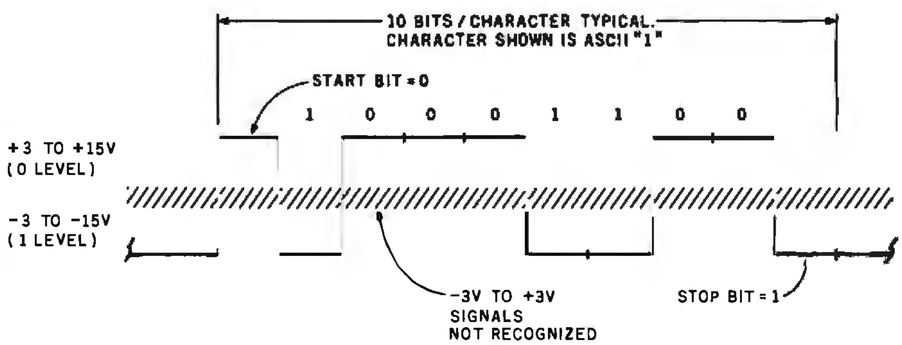

Figure 14: *Logic is inverted in standard RS-232C signals. A 1 is represented by a negative voltage; a 0 by a positive voltage. Voltage levels from −3 to +3 V will not be recognized as legitimate values.*

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Each byte to be transmitted occurs at *asynchronous*, or irregular, times. The line is normally at a 1 level. A start bit leads the output and signals the receiving device that data are coming in. Eight data bits follow, with the least significant bit first. A stop bit puts the line at the 1 level after transmission, in preparation for the next character.

The spacing for the 10 bits depends upon the transmission rate. Rates of 300, 600, 1200, and 2400 bps (bits per second) represent "bit times" of 3.333, 1.666, 0.833, and 0.416 ms, respectively.

The chief problem now is to convert the low voltage levels of CASSOUT into the two RS-232C voltages. This is done with an LM741 comparator, as shown in figure 15. The supply voltages used with the comparator are +6 to +12 V and −6 to −12 V. Batteries will work fine, and the voltages are not critical.

The voltage-divider input to the plus ("+") input of the LM741 is biased at about (220/15000) × V+, where V+ is the positive supply voltage. This puts the plus input at about 1/10 V for a +6-V supply, or about 1/20 V for a +12-V. The output of the 741 will be −6 to −12 (1 level) whenever CASSOUT is greater than the plus input level, and +6 to +12 V (0 level) whenever CASSOUT is less than the plus input level.

BASIC initializes the port controlling CASSOUT to binary 00 (0.44 V), and so the TD (transmit data) line at reset is normally −6 to −12 V. By toggling the CASSOUT line at the appropriate rate, you can generate the RS-232C signals.

SEROUT (see listing 6) is a relocatable assembly-language program called from BASIC by a USR call. Two parameters are passed: the byte to be transmitted and the transmission rate to be used. The byte can be any value from 0 through 255. If seven data bits are to be transmitted (as in data-communications applications), make the eighth bit 0.

SEROUT first picks up the transmission-rate code and puts it into the HL register pair. The code is a delay count for the DELAY subroutine. The byte to be transmitted is moved to the D register.

Line 260 turns on CASSOUT to generate a start bit. A delay of one bit time is then done. The loop from lines 320 through 410 outputs the eight data bits, from least significant to most significant. A 1 bit is generated by sending a 01 to port 0FF hexadecimal, and a 0 bit is generated by sending a 10. A duration of one bit time is used for each bit.

A stop bit is generated in line 430 after the eight data bits. This leaves the TD line at the 1 level in prepara-

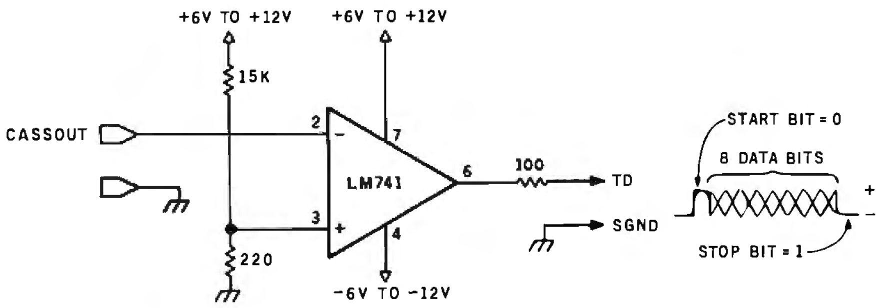

Figure 15: *The SEROUT project uses an operational amplifier to generate a positive and negative voltage representing RS-232C data signals. Any convenient positive and negative voltage may be used.*

Listing 6: *SEROUT is a Z80 subroutine to perform RS-232C output through the Model I/III cassette port.*

```
9000              00100          ORG     9000H
                  00110 ;*****************************************************
                  00120 ;* SERIAL OUT THROUGH CASSETTE PORT.                 *
                  00130 ;*    ENTRY:  H=BYTE TO BE TRANSMITTED               *
                  00140 ;*            L=BAUD RATE: 300=201,600=100,1200=51,  *
                  00150 ;*                         2400=23 (MOD I)/ 230,115, *
                  00160 ;*                         58,26 (MOD III)           *
                  00170 ;*    EXIT:   AFTER OUTPUT                           *
                  00180 ;*****************************************************
                  00190 ;
9000 CD7F0A       00200 SEROUT  CALL    0A7FH           ;GET PARAMETERS
9003 54           00210         LD      D,H             ;MOVE DATA TO D
9004 2600         00220         LD      H,0             ;HL NOW HAS DELAY CNT
9006 E5           00230         PUSH    HL              ;TRANSFER CNT TO IY
9007 FDE1         00240         POP     IY
9009 3E02         00250         LD      A,2             ;START BIT
900B D3FF         00260         OUT     (0FFH),A        ;OUTPUT
900D FDE5         00270         PUSH    IY              ;DELAY CNT TO HL
900F E1           00280         POP     HL
9010 0E00         00290         LD      C,0             ;FLAG FOR RTN
9012 1820         00300         JR      DELAY           ;DELAY ONE BIT TIME
9014 0608         00310 SER040  LD      B,8             ;SETUP DATA BIT LOOP
9016 3E02         00320 SER050  LD      A,2               ;0 BIT TO A
9018 CB3A         00330         SRL     D                 ;SHIFT OUT DATA BIT
901A 3001         00340         JR      NC,SER055         ;GO IF DATA BIT=0
901C 3D           00350         DEC     A                 ;DATA BIT=1
901D D3FF         00360 SER055  OUT     (0FFH),A          ;OUTPUT
901F FDE5         00370         PUSH    IY                ;DELAY CNT TO HL
9021 E1           00380         POP     HL
9022 0E01         00390         LD      C,1               ;FLAG FOR RTN
9024 180E         00400         JR      DELAY             ;DELAY
9026 10EE         00410 SER060  DJNZ    SER050            ;LOOP IF MORE BITS
9028 3E01         00420         LD      A,1             ;STOP BIT
902A D3FF         00430         OUT     (0FFH),A        ;OUTPUT
902C FDE5         00440         PUSH    IY              ;DELAY CNT TO HL
902E E1           00450         POP     HL
902F 0E02         00460         LD      C,2             ;FLAG FOR RTN
9031 1801         00470         JR      DELAY           ;DELAY
9033 C9           00480 SER070  RET                     ;RETURN TO BASIC
                  00490 ; DELAYS 14.6*CNT IN MICROSECS (MOD I)  + OVERHEAD
9034 2B           00500 DELAY   DEC     HL                ;DECREMENT DELAY COUNT
9035 7C           00510         LD      A,H               ;TEST HL
9036 B5           00520         OR      L
9037 20FB         00530         JR      NZ,DELAY          ;LOOP IF NOT DONE
9039 CB49         00540         BIT     1,C             ;TEST FOR RTN PNT 2
903B 20F6         00550         JR      NZ,SER070       ;GO IF RTN PNT 2
903D CB41         00560         BIT     0,C             ;TEST FOR RTN PNT 1
903F 20E5         00570         JR      NZ,SER060       ;GO IF RTN PNT 1
9041 18D1         00580         JR      SER040          ;RTN PNT 0
0000              00590         END
```

tion for the next start bit.

The DELAY subroutine is called by relative jumps with a return flag to keep the code relocatable.

Listing 7 shows a sample BASIC driver that contains the machine code for SEROUT as DATA statements. The code is relocated to start at 9000 hexadecimal. For demonstration, an ASCII 0 is continually output at a user-specified rate.

The actual BASIC code to be used depends a great deal upon the application. If you are using SEROUT

Listing 7: *A sample BASIC driver for the SEROUT subroutine. The DATA statements contain machine-language codes for the subroutine. This program outputs a continuous stream of ASCII zeros.*

```
100 REM SAMPLE SEROUT DRIVER
110 DATA 205, 127, 10, 84, 38, 0, 229, [illegible], 225, 62
120 DATA 2, 211, 255, 253, 229, 225, 14, 0, 24, 32
130 DATA 6, 8, 62, 2, 203, 58, 48, 1, 61, 211
140 DATA 255, 253, 229, 225, 14, 1, 24, 14, 16, 238
150 DATA 62, 1, 211, 255, 253, 229, 225, 14, 2, 24
160 DATA 1, 201, 43, 124, 181, 32, 251, 203, 73, 32
170 DATA 246, 203, 65, 32, 229, 24, 209
180 FOR I=36864 TO 36930
190 READ A:POKE I-65536,A
200 NEXT I
210 DEFUSR0=&H9000
220 INPUT "RATE?";RT
230 CH=48
240 B=USR0(CH*256+RT)
250 GOTO 240
```

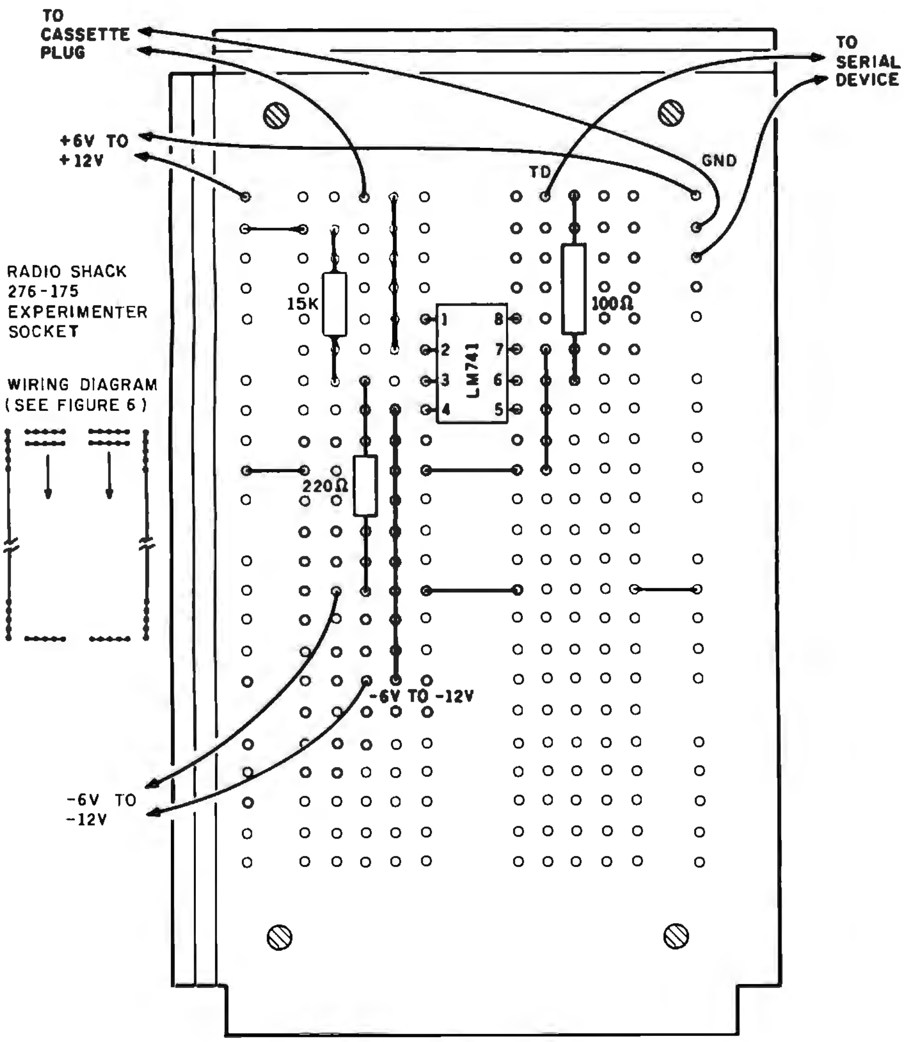

Figure 16: *The SEROUT circuit is mounted on a project board. Two sets of power-supply connections are required.*

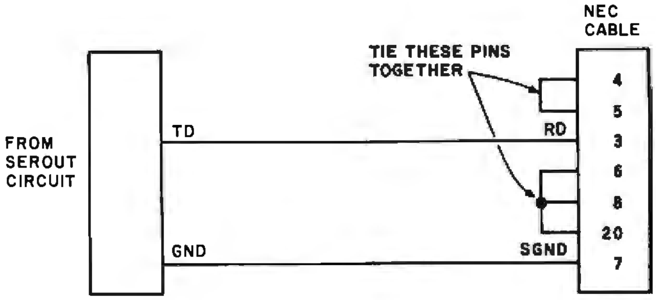

Figure 17: *I connected an NEC Spinwriter to the SEROUT circuit with two wires and some "jumper" interconnections on the Spinwriter side. Other RS-232C devices will require similar connections.*

as a printer driver, you'll have to make certain that the printer can accept characters at the rate you'll be transmitting. This is usually not a problem except on carriage return/line feeds where the print mechanism is busy for relatively long times as the carriage returns. If a character is output during this busy condition, it may be disregarded and lost.

The bit-delay times shown are values obtained by trial and error with the real-time clock active. You may have to adjust these on an experimental basis, depending upon your system. Output a line of characters continuously at different bit rates. Find the high and low values at which you start to lose characters and choose a midpoint value for your standard bit rate. For high bit rates, turn off the interrupts using DI and EI as described in TONOUT.

Constructing the Electronics

Figure 16 shows the project-board layout for SEROUT. Two sets of power-supply leads connect to the positive and negative supplies. The TD line and ground connect to the serial device.

The serial device may require other signals to be tied high to simulate a "ready" condition. Again, this depends upon the device and can't be detailed here. A typical connection to an NEC Spinwriter is shown in figure 17.

The projects presented here show what can be done with the cassette output port on a lowly 16K-byte TRS-80 Model I without an expansion interface. I'll cover transmission in the opposite direction—CASSIN—in another article. Perhaps by then the breeder reactor program will be working for CASSOUT. Hmmm . . . I keep getting these "Coolant Temperature Critical" indications. . . . ■

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The Input/Output Primer

Part 3: The Parallel and HPIB (IEEE-488) Interfaces

An introduction to two common interfaces between computers and other devices.

Steve Leibson
Auto-Trol Technology Corporation
12500 North Washington St.
POB 33815
Denver, CO 80233

This article is the third in Steve Leibson's six-part series, The Input/Output Primer. *The series describes problems involved in communications between computers and the outside world and explains how some of these problems have been solved. The three remaining articles will discuss BCD and serial interfaces; character codes; and interrupts, buffers, grounds, and signal degradation. "An I/O Glossary," which defines many terms used in these articles, appeared with the series' first installment (February 1982* BYTE, *page 122).*

Last month, in addition to describing interrupts and DMA (direct memory access), I presented general information about interfaces. In this article, I'll examine two specific types of hardware interfaces: the parallel and the HPIB or GPIB (IEEE-488) interfaces (see Robert Katz's review of the Hewlett-Packard Interface Loop, page 76).

First, however, let's briefly review why these interfaces are necessary. As information-processing machines, computers require paths for raw data to enter and for processed information to exit. A common computer-design technique is to create one universal path leading both into and out of the processor. That path is the I/O (input/output) bus.

Data inversion occurs in software, not in the interface.

This concept simplifies computer design but introduces a complication: whatever the design of the I/O bus, the computer will be incompatible with many I/O devices. Some older devices use different signal levels; other devices have different data formats. Most devices will be slow enough to degrade the computer's performance seriously if it must wait on every data transaction.

The complication is solved through the use of interfaces, which act as transformers of voltage levels, data formats, and transaction speeds. Interfaces enable the computer to communicate with a vast array of peripheral devices.

The Parallel Interface

Simple peripherals often have interface requirements much like those of the computer's I/O bus. Data is transferred over a set of data lines (usually 8); a signal line indicates when the next chunk of information is ready. On a second signal line, the peripheral indicates its readiness to accept another piece of data.

This type of interface is a *parallel interface,* so named because the data lines are parallel, and multiple bits of data are simultaneously transferred in parallel. The HP 98032A is a parallel interface designed for Hewlett-Packard's 9800-series computers. The I/O bus described in earlier installments of this primer was taken from the 9800 computer. I'll use the 98032A 16-bit interface as an example of parallel interfacing.

Keep in mind that the I/O bus has 16 bidirectional data lines. Data is handled in 16-bit chunks and flows

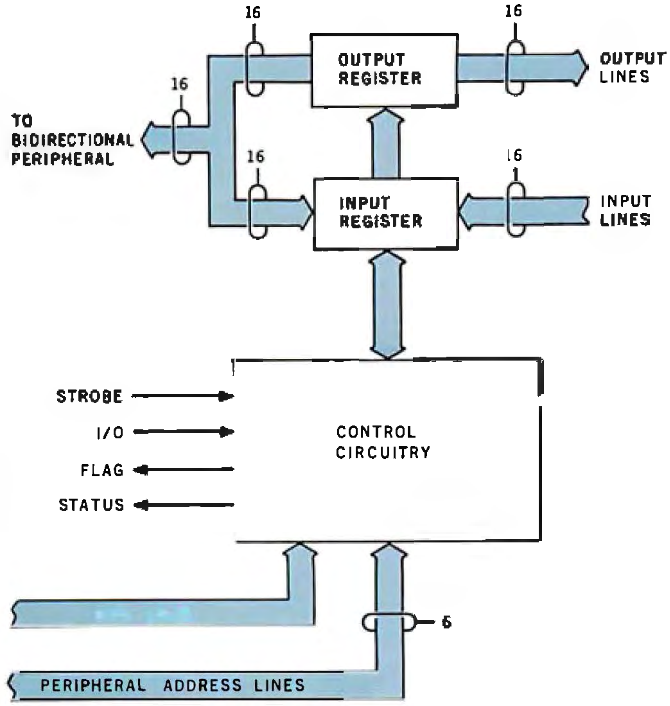

Figure 6: *Block diagram of the Hewlett-Packard 98032 parallel interface. The parallel interface consists of registers and buffers. One register is for output, the other for input. The 32 unidirectional lines can be used as one set of bidirectional lines. If a peripheral has a bidirectional interface, these two sets of lines can be connected to form a bidirectional peripheral bus. Control circuitry in the interface accepts information from the computer and then sends the information to the peripheral. The same control circuitry can also, at the request of the computer, request information from the peripheral, then signal the computer when the information has been acquired.*

over these lines either into or out of the computer, but not in both directions at the same time.

The 98032A interface splits the I/O bus into two sets of data lines: 16 output lines and 16 input lines (see figure 6). This configuration is more compatible with unidirectional peripherals. Excess lines are left unconnected. Out of 32 data lines, only 8 might be used by a unidirectional, 8-bit peripheral.

As mentioned above, interfaces sometimes serve to transform the signal voltage levels used on an I/O bus to those required by a peripheral. Our sample I/O bus uses TTL (transistor-transistor logic) levels, meaning that a low logic level is represented by a voltage between 0 and +0.7 volts (V). A high logic level is represented by a voltage between +2.0 and +5.5 V. The input lines of the 98032A parallel interface connect to TTL circuitry in the interface, so TTL levels are required from the peripheral. The data output lines of the 98032A are driven by transistor circuits that can withstand +30 V for a high level. The low level is still between 0 and +0.7 V for TTL compatibility.

Remember that when discussing logic signal lines, only two signal levels are allowed. One level corresponds to a logic 1 and the other to a logic 0. If the higher voltage corresponds to a logic 1 and the lower level to a logic 0, the signals are said to be *positive-true*. If the lower voltage level corresponds to a logic 1 and the higher voltage to logic 0, the signal is called *negative-true*.

To sum up:

1. I/O bus lines are the conductors used to transfer data between the computer and the interface.
2. Interface input and output lines are the conductors used to transfer data between the interface and the peripheral.

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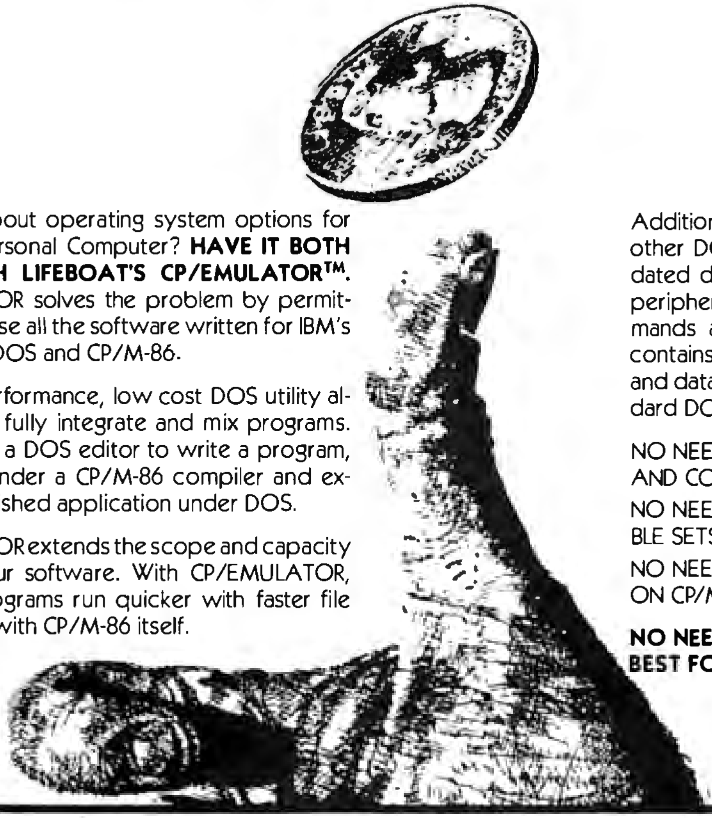

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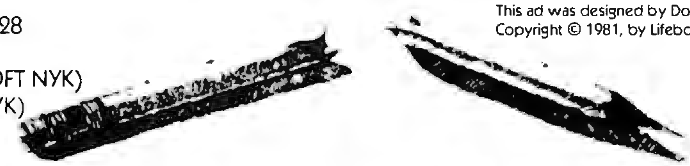

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(1a) Input Registers

Register Code	Function
R4	Data Input
R5	Interface Status
R6	High Byte Data Input
R7	(Not Used)

(1b) Output Registers

Register Code	Function
R4	Data Output
R5	Interface Control
R6	High Byte Data Output
R7	Data Transfer Trigger

Table 1: *Interface definitions for the 98032A parallel interface. Table 1a defines the input registers, and table 1b defines the output registers.*

Register Architecture

I stated earlier that each interface would have a unique address on the I/O bus and would be selected by the peripheral address line on that bus. Each interface is divided into registers that are individually addressable by means of a register code. The register model divides the interface into eight different registers. Four of these are output registers that take data from the computer (the computer *outputs* to them). The other four are input registers, supplying data to the computer (the computer gets *input* from them).

Let's now assign a function to each of these interface registers. The 98032A interface uses the definitions shown in tables 1a and 1b.

R4 registers are the primary means of data transfer between the computer and the interface, and in turn, the peripheral. The R4 output data register is directly connected to the output signal lines of the 98032A. The R4 data input register is connected to the interface input lines. The R6 input and R6 output registers allow the 98032A to be used as two 8-bit interfaces instead of one 16-bit interface. The R6 registers read or control the upper eight data lines when the interface is in the byte mode, that is, when the interface is handling data in 8-bit

R5 Input Register (Interface Status)

Bit #:	7	6	5	4	3	2	1	0
Bit Name:	INT	DMA	1	0	IID	IOD	STI1	STI0

Table 2a: *R5 input register. This register contains interface and peripheral status information.*

R5 Output Register (Interface Control)

Bit #:	7	6	5	4	3	2	1	0
Bit Name:	INT	DMA	RESET	AHS	X	X	CTL1	CTL0

Table 2b: *R5 output register. This register is used to control the interface and peripheral devices.*

units instead of 16-bit units.

When the computer places data in the R4 output register, the pattern of that data appears on the output signal lines. However, when the computer reads the R4 input register, the data reflects only the contents of the R4 input register; it may not reflect the current state of the interface input lines. (To clarify this difference, I'll look closely at how the interface communicates with a peripheral. First, however, I'll finish discussing the remaining registers.)

Control and Status Registers

The computer uses the R5 input and R5 output registers to control the interface and to read the interface and peripheral status. The R5 input register contains several pieces of important status information. Only the lower 8 bits of this register are used. The meanings of these 8 bits are listed in table 2a.

The INT and DMA bits are used for interrupts and direct memory access, both of which were discussed last month. Bits 5 and 4 are interface identification bits. The 10 pattern (bit 5 set to 1, bit 4 set to 0) identifies the 98032A interface as a type 2 interface (10 is 2 in binary). Software in the computer uses the interface ID bits (bits 3 and 2) to decide how to communicate with the interface. The proper *software driver* must be selected to operate the interface. Other types of interfaces have different ID patterns and call for different drivers.

Computer software can also use the IID and IOD bits. IID stands for *invert input data*; IOD stands for *invert output data*. These bits allow the computer to interface with peripherals using either positive-true or negative-true signals. The IID and IOD bits are set with jumper wires in the 98032A interface.

It's important to note that data in-

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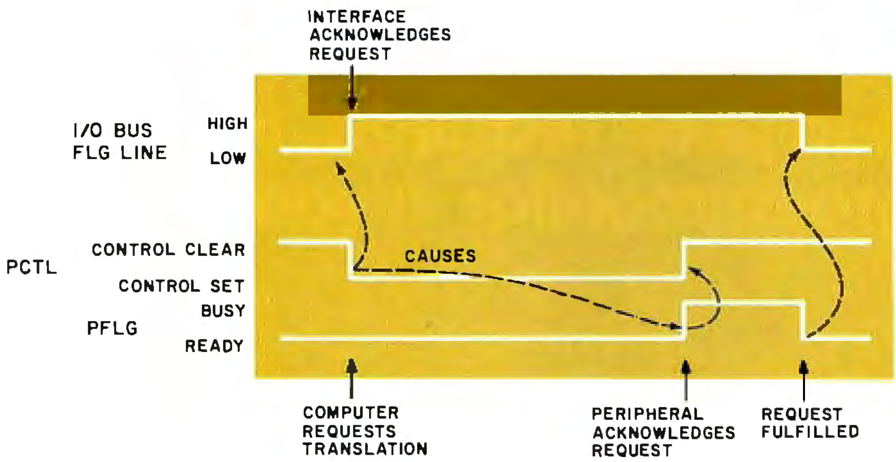

Figure 7: *Representation of the handshake between the HP 98032 parallel interface and a peripheral device. When the computer requests a transaction, the interface uses the FLG line on the I/O bus to signal the computer that it's busy. Then, the PCTL (peripheral control) line is set to request an operation by the peripheral. Later, the peripheral acknowledges the request by setting the PFLG (peripheral flag) line to busy. When the peripheral completes the transaction, it sets the PFLG line to ready, causing the interface to lower the I/O bus flag line and thereby tell the computer that the transaction is complete. This sequence governs both input and output. Direction lines between the computer, the interface, and the peripheral determine the direction of the transaction.*

version occurs in software, not in the interface. The computer may choose to ignore these status bits for certain classes of I/O operations. Other interfaces may implement data inversion in hardware so that, if selected, the inversion will always occur.

The two remaining bits in the interface status register, STI1 and STI0, are status inputs brought out on two signal lines. The peripheral can call on these for any user-defined function. Unlike the R4 input register, the STI1 and STI0 bits reflect the current state of the STI signal lines.

Interface control is through the R5 output register. Table 2b lists the bit pattern for this register. The INT and DMA bits are used in the interrupt and direct memory access modes mentioned earlier. The RESET bit is used to place the interface in the initial power-up state. It can also be used to reset the attached peripheral to a known state if the peripheral has a reset input. I/O processes often stall, for example, when the printer runs out of paper or a disk drive door is left open. A reset capability allows the computer to change its mind and stop what it has started.

The AHS bit enables auto-handshake. When this bit is set, the data-transfer trigger (R7 output) isn't needed. This characteristic is convenient for high-speed transactions and is habitually used with DMA. Bits 3 and 2 are unused in the R5 output register.

CTL1 and CTL0 are general-purpose control bits. These register bits are connected to two signal output lines and can be used to control the attached peripheral device. A signal over these output lines can be given to latch a printer door shut while printing is taking place.

Peripheral Handshaking

Note that the R7 output register is called the *data-transfer trigger*. When used in conjunction with the R4 input and output registers, the data-transfer trigger forms a handshake mechanism that synchronizes the fast computer and the slower peripheral.

Placing data on the output lines or reading the levels on the input lines connecting the interface to a peripheral device isn't sufficient for smooth data flow. A set of signals indicating "new data available" and "ready to accept data" is needed.

These signal lines are called *handshake* lines. The interface and the peripheral each control a handshake line. The meaning of the signal for each line depends on the direction of data flow. If the computer is sending through the interface to the peripheral, the line controlled by the computer means "new data available." The line controlled by the peripheral would then signify "ready for new data." If the data flow is reversed, the signal meanings are also reversed.

Let's call the line controlled by the interface the *peripheral control* (PCTL) and the line controlled by the peripheral the *peripheral flag* (PFLG). With the addition of these two lines, the foundation is laid for discussing the handshake mechanism.

Data Output

Output is simpler than input. As has been mentioned, the computer can set the state of the interface output lines by placing information in the R4 output register. The handshake is started when the computer performs a write to the interface's R7 output register.

The interface recognizes the data-transfer trigger and responds by changing the state of PCTL from "clear" to "set," which indicates to the peripheral that "new data is ready" on the interface's output lines. The peripheral is expected to acquire the data now. The peripheral responds to "new data ready" by changing PFLG from the "ready" to "busy" state. This means the peripheral is busy accepting the data.

From the time the computer performs the R7 output register write until the time the peripheral returns to a "ready" state after processing the data, the interface is busy carrying out the transfer. It's extremely important that the computer not change the R4 output register during this time. Otherwise, there's no way to tell what data the peripheral will get. For this reason, the interface and the computer also have a handshake mechanism. While the interface is busy sending the information to the peripheral, the interface indicates this situation to the computer on the interface flag line. Figure 7 illustrates the peripheral-interface handshake.

Data Input

Data input from a peripheral is more complex. Three steps are involved. First, the computer reads the R4 input register to let the interface know that a data-input operation is pending. (The computer throws away the data obtained.) The interface recognizes this and indicates the situation to the peripheral with a data-direction line (this line tells the peripheral which direction the data is to go).

Next, the computer writes to R7 output, giving the data-transfer trigger. This causes the interface to go busy and to place the PCTL signal line in the "set" state, signifying to the peripheral that data is requested. The peripheral then goes busy until it has acquired the data. It signals its busy state on the PFLG line.

After the peripheral performs the operations necessary to get the requested data, it places the data on the interface input lines and returns PFLG to the ready state. When the peripheral returns to the ready state, the transition of the PFLG signal from "busy" to "ready" causes the data on the input lines to be placed or "latched" into the R4 input register. This causes the interface to signal the computer that the interface is now ready with the requested data. The computer then performs another read from the R4 input register to get the data.

Note that the R4 input register contains the information present on the input lines at the busy-to-ready transition of the PFLG line. Any changes on the input lines after that transition will not be reflected in the R4 input register. Notice also that the peripheral-interface handshake for input is the same as that for output.

Some peripherals, by the way, are so simple that they can't perform a handshake. An example of this would occur if the 98032A were used to drive signal lights directly. Lights have no handshake lines. They always follow their data (power) inputs. In these instances, you can connect the PFLG and PCTL lines to each other so that the 98032A handshakes with itself. This results in 16 "latched" output lines and 16 input lines that

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Most peripherals using the parallel interface use only 8 bits. This allows 256 combinations (2^8) on the data lines. If these combinations are treated as codes representing characters, then 8 bits can represent numerals, upper and lower case letters, punctuation marks, and other printable characters. Most peripherals communicate this way, but there are exceptions. A floppy-disk drive may require the full 16-bit interface. Some plotters use 12 bits. Analog-to-digital converters come in 10-, 12- or 16-bit sizes. A single 16-bit interface can serve all these kinds of peripherals.

The IEEE-488 Standard Interface

Computer designers strive to incorporate the latest parts and the fastest logic in new and different configurations. In addition, designers of computer peripherals are always creating new classes of devices. The result has been a multitude of interfaces, each optimized for a single kind of computer or peripheral. Few of these interfaces are compatible with any of the others.

This situation is similar to that of the American railroads during the early 1800s. Because dozens of track gauges existed, cars of one railroad couldn't travel on the tracks of another. Reminiscent of the speed with which railroads standardized track gauges, the computer industry quickly agreed on an interfacing standard, published in 1975 by the Institute of Electrical and Electronics Engineers (IEEE). It was the first comprehensive, nearly universal interfacing standard for computers and instrumentation. The first version, IEEE Standard Digital Interface for Programmable Instrumentation (IEEE-STD-488-1975) was slightly revised in 1978 and is now IEEE-STD-488-1978.

This standard defines a general-purpose interface, one designed for instrumentation systems requiring limited-distance communications. The intent of IEEE-STD-488-1978 (hereafter, "IEEE-488") is to pin down as many variables of an interface as possible while still maintaining good flexibility and wide applicability. The interface is also defined without reference to the hardware circuitry required to implement the interface. This allows new products to take advantage of new technologies, resulting in faster and less expensive construction of instruments, peripherals, and systems.

The HP 98032A parallel interface has two separate groups of data lines: 16 for input and 16 for output. This allows interfacing to a wide variety of peripherals with varied interfaces. Devices with 8, 10, 12, or 16 data lines can be accommodated. A popular version of the 98032A has a cable with no connector attached. The system builder must select a connector and assign the pin numbering since there are no standards as to how to connect this type of interface.

By contrast, the IEEE-488 standard precisely specifies signal levels (both voltage and current) and signal timings. Building a system can be as simple as removing components from their boxes and plugging them in. Interconnection hardware is defined so that two interconnected instruments can communicate. Their understanding each other, however, is *not* guaranteed by the standard.

Using the IEEE-488 standard is like using the international telephone system. You can call anywhere on earth because a compatible communications network, the telephone system, exists. Sounds you make can reach the other end of the connection, and you can hear the sounds made by the person at that other end. The hardware for communications is all in place, but there's no guarantee that you'll understand what the other person is saying or vice versa. Hardware compatability does not guarantee language compatibility.

Hewlett-Packard has an implementation of the IEEE-488 standard which it calls the HPIB or Hewlett-Packard Instrumentation Bus. HPIB is a combination of the hardware interface specified by the IEEE-488 standard and a communications technique that makes it possible for instruments to communicate with each other. The standardization also allows the system designer to communicate what's going on in the system.

The IEEE-488 standard is so general that almost any peripheral or instrument can be purchased in an HPIB version. Voltmeters, power supplies, signal generators, printers, plotters, and disk drives are only a few of the devices available. All may be connected on the same bus.

Unlike the parallel interface, which connects a single device with the computer, the HPIB interface makes it possible to connect as many as 15 devices (including the computer). HPIB is indeed a bus, similar in concept to the I/O bus of the computer.

Controllers, Talkers, Listeners

Only two entities reside on the I/O bus: the computer and the interface. The computer is always in control of the I/O bus, and the interfaces are slaves, doing the computer's bidding.

Three types of devices exist on the HPIB: controllers, talkers, and listeners. These types are actually attributes and may exist alone or in combination within any given peripheral. For example, the HPIB interface allows a computer to be a talker, listener, and controller. A voltmeter may only be a talker limited to supplying the system with information, while a printer may only be a listener limited to accepting data from the system. Further, any of the HPIB attributes may or may not be active at a given time.

Figure 8 illustrates how an HPIB system might be structured. The lines on the right of the figure represent the HPIB's 16 signal lines. The 16 signal lines are divided into 3 groups, the first of which is composed of 8 data lines. Forming the data bus, these bidirectional signal lines carry information and messages between devices on the bus. The second group, the data byte transfer control group, is composed of 3 lines: DAV (data valid), NRFD (not ready for data), and NDAC (not data accepted). As the names imply, this group is used to sequence the flow of information over the data lines. The 5 remaining

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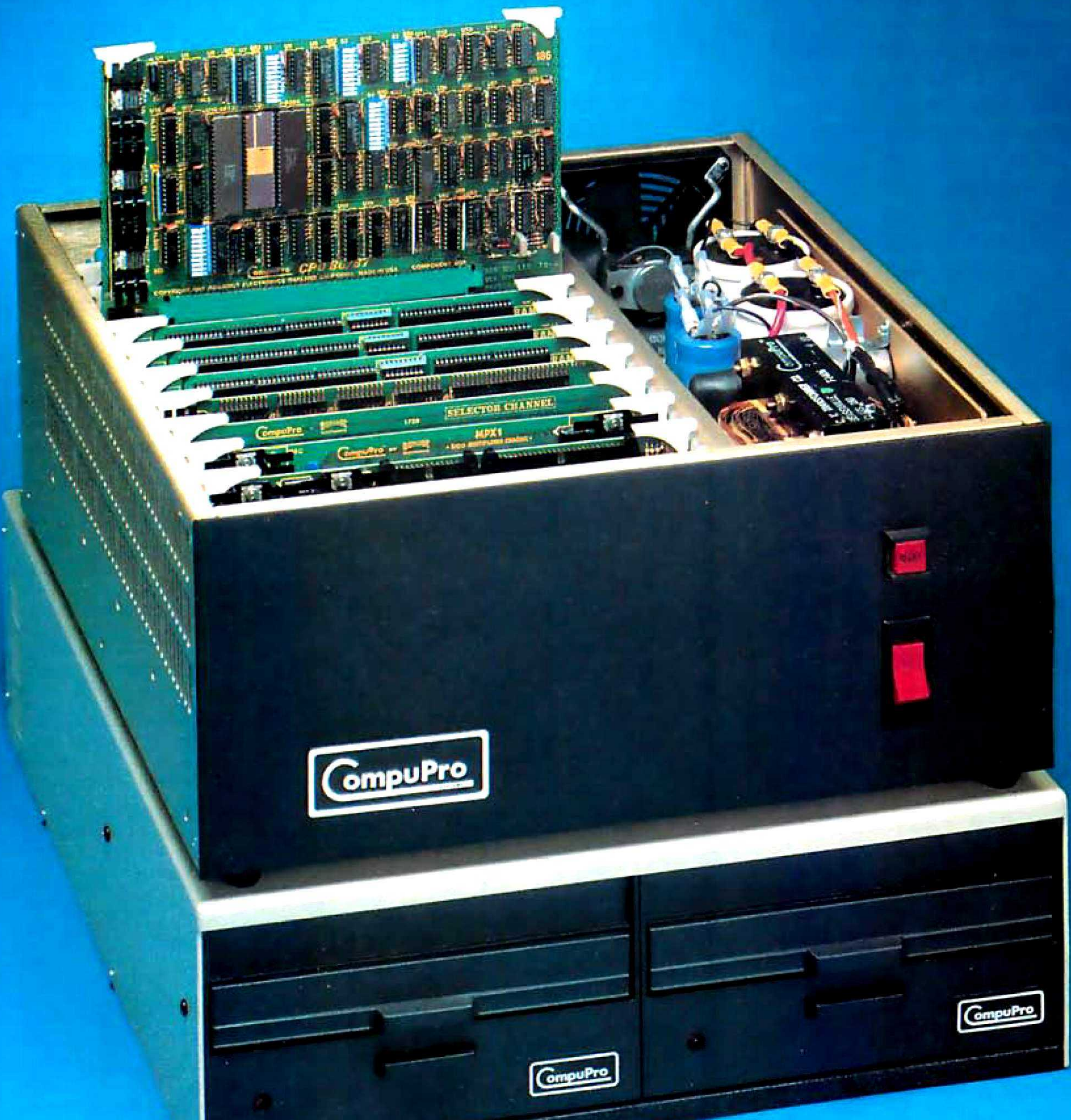

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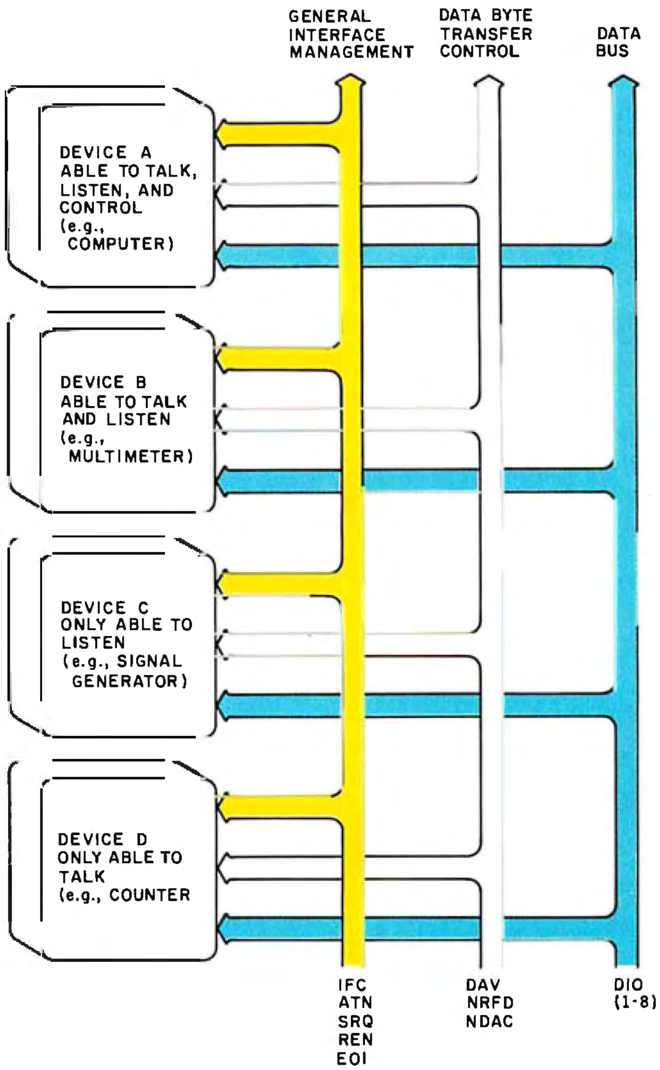

Figure 8: *Sample configuration of the IEEE-488-1978 interface bus. Devices on the bus can be talkers, listeners, or controllers. Controllers manage the bus, activating and deactivating listeners. Talkers place data on the bus. Listeners accept data from the bus. A device connected to the bus can be a talker, a listener, a controller, or any combination of the three. Most computers, like device A, are talker, listener, and controller so that the computer can configure the bus, then send and receive information. Device B, a multimeter, can talk and listen, sending readings and receiving set-up information such as range and function. Device C, a signal generator, listens only. Printers are usually listeners. Device D, a frequency counter, talks only, placing readings on the bus. The IEEE-488-1978 bus is divided into three sets of signals. The data bus carries the information being transferred. Data byte transfer control lines sequence the flow of information. The general interface management lines have special functions: IFC (interface clear) resets the bus interfaces; ATN (attention) sends bus commands; and SRQ (service request) signals bus interrupts.*

lines form the third group of signal lines: the general interface management group. These lines carry control and status information about the devices connected to the bus.

Assigning Roles

Figure 8 shows 4 devices attached to the HPIB. Device A has the talker, listener, and controller attributes. As a controller, device A may assign the role of active talker to any device on the bus capable of undertaking that role, including itself. As a talker, device A can supply information to other devices on the bus. As a listener, device A can accept information from the other talkers on the bus. A computer is likely to have all three attributes.

Although device A is the only controller shown in figure 8, more than one controller is allowed in an HPIB system. To prevent conflicts, however, only one controller can be active at a time. Control may be passed from one controller to another by means of a sequence defined in the standard. A controller designated the *system controller* becomes the active controller when the system is turned on. All other controllers must remain passive until control is passed to them.

Device B in figure 8 is both a talker and a listener. It can be addressed by the controller and made an active talker or listener. An active talker controls the DAV signal line in the data byte transfer control group. An active listener controls the NRFD and NDAC signal lines.

Device C can only be a listener. Device D is limited to being a talker. Either of these devices may be made active by the controller. A data transaction is controlled by both the active talker and the active listener. The talker drives the bus with data, while the listener accepts the information transmitted by the talker. To avoid conflict, only one talker can be active at a time. However, several listeners can be active at once.

Transferring Information

The possibility of several active listeners receiving data simultaneously presents a problem because those listeners may not accept data at the same rate. Data-transfer speed must be paced by the slowest active listener, or that listener may lose data.

The data transfer rate on the HPIB is controlled by an electronic voting system called the *open collector*. This voting system requires unanimous agreement among active listeners and the active talker before the data transaction is completed. Information transfer takes place as follows:

1. All active listeners indicate on the NRFD line their state of readiness to accept a new piece of information. This signal line is usually connected to +5 V through a resistor. If an active listener is not ready, it pulls the NRFD line down to 0 V by turning on a transistor con-

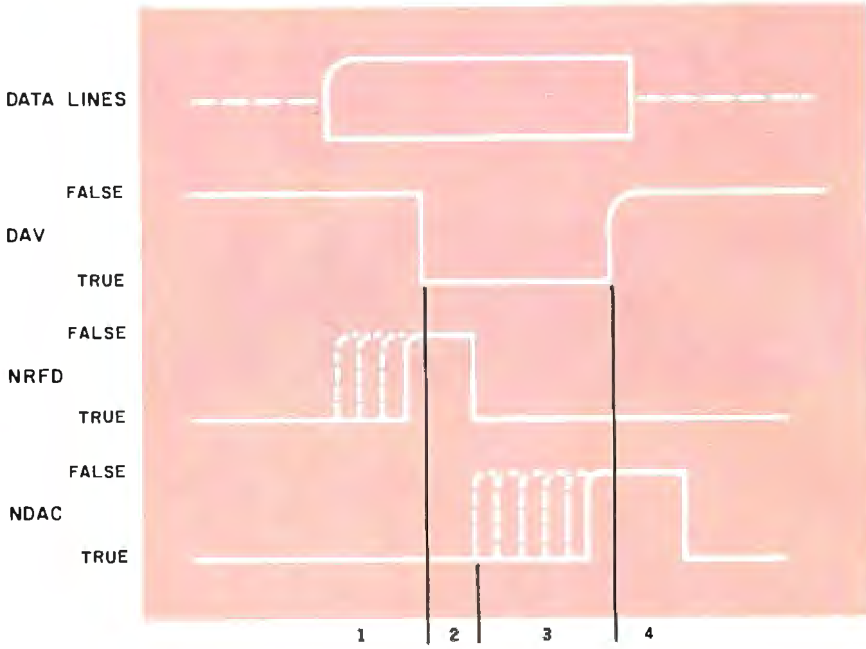

Figure 9: *Diagram of timing on the IEEE-488-1978 bus. Data transfers occur with a unique 3-wire handshake. First, the active talker waits for all active listeners to release the NRFD (not ready for data) line. When this happens, the signal rises to a positive level. The talker then places the data on the data lines, waits 2 microseconds, and drives the DAV (data valid) line low, indicating that the data should now be accepted. Recognizing the transition in the DAV line, the active listeners drive NRFD low. The active listeners have as much time as necessary to release NDAC (not data accepted). When all active listeners do release NDAC, its voltage rises to a positive level. This tells the talker to release DAV. At the release of DAV, the listeners pull NDAC low again. This restores the bus to the original state, where it is ready for another transfer.*

nected to the signal line. The activated transistor acts as a short to ground, pulling the voltage on the NRFD line to ground potential or 0 V. When the listener is ready to accept data, it turns off this transistor. When all active listeners turn off their transistors, the resistor connected to +5 V pulls the NRFD signal line up to around +5 V. The active talker observes the state of the NRFD line and will not start the data transfer until the signal line reaches a high voltage level.

2. The active talker observes that the NRFD line has gone high. It places a data byte on the data lines and waits 2 microseconds (0.000002 seconds). It then asserts DAV by pulling it low to 0 V. This 2-microsecond wait, called *settling time*, allows the data to reach valid logic levels on the data lines. The assertion of DAV is a signal to the active listener(s) to read the information on the data bus. The listeners acknowledge the assertion of DAV by immediately pulling back down on NRFD.
3. Until now, the active listeners have held NDAC low. When DAV is asserted and all of the active listeners accept the data on the data lines, they will release NDAC. As the slowest active listener releases NDAC, the pullup resistor will cause the signal line to go high.
4. The active talker observes the NDAC line in a high state. It acknowledges the listeners' acceptance of the data by releasing DAV. The release of DAV signals the listeners that the data transfer is complete; they again pull NDAC low in preparation for the next transfer.

Figure 9 shows a timing diagram of the complete handshake. Note that control of the data transfer is effected by the *active* talkers and listener(s). Once the controller has configured the bus, it takes no part in subsequent

Information Type	Bit # 7	6	5	4	3	2	1	0
Bus command	X	0	0	C	C	C	C	C
Listen Address	X	0	1	L	L	L	L	L
Talk Address	X	1	0	T	T	T	T	T
Secondary Address	X	1	1	S	S	S	S	S

Table 1: *Interface definitions for the 98032A parallel interface. Table 1a defines the input registers, and table 1b defines the output registers.*

transactions until reconfiguration is desired.

Configuring It Out

Now that data transfer on the HPIB has been covered, let's consider how the bus is configured. One of the general interface management lines is called ATN (attention). The active controller manages this line. ATN signifies whether the data transfers on the bus are data or control information. The active talker controls data transactions, as explained above, but the active controller supervises control transfers.

When the controller wishes to configure the HPIB, it asserts the ATN line. This causes any active talker to relinquish control of the DAV line. Transmission of control information occurs in the same manner as transfer of data. The difference is that when ATN is asserted, the active controller takes the place of the active talker, and both talkers and listeners accept the information. All devices, whether active or not, accept information transmitted by the controller when ATN is asserted.

The active talker and active listeners may be designated during the transmission of control information. The data lines carry control information after ATN has been asserted. Table 3 lists the meanings of the control data bits.

Note that bit 7 is not used. Bits 6 and 5 serve to classify the control information as to command type. A control transfer with bits 6 and 5 set to 0 is a bus command that directly controls devices on the bus. Triggering a function and passing control from the active listener to a passive one are two examples of bus commands.

Transmission of a control byte with bit 6 set to 0 and bit 5 to 1 activates a listener. A listener that observes its address in the lower 5 bits of a listen address control byte becomes active. When ATN is negated, it will assume control of NDAC and NRFD. Listeners that

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don't observe their listen addresses in a control transfer don't change state, remaining as they were before the controller asserted ATN.

Deactivating Listeners

The HPIB provides a way to deactivate all active listeners. The 5 bits of the listen address allow 32 listen addresses. These addresses range from 0 to 31. Address 31 is the "unlisten" address. Active listeners observing the unlisten address in a listen command's address field will go inactive. The definition of talk addresses is similar to that for listen addresses—with one exception: any active talker that observes a talk command to another device will go inactive. As a result, activating one talker guarantees deactivation of any other active talkers. This prevents conflicts on the bus. Talk-address 31 is the "untalk" address. When the controller issues an untalk command, no active talkers are left on the bus.

Secondary addresses are used to address subunits within a device. Some HPIB instruments are actually clusters of devices, but secondary addressing allows addressing of a device within such a cluster.

The remaining four lines in the general interface-management group serve to control the interface sections of the HPIB devices. IFC (interface clear) may be called on by the active controller to override all bus activity and to place the bus in a known state. This signal aborts any data transfers in progress and is used only when something has gone wrong.

The REN (remote enable) signal allows the HPIB to control a device. The active controller uses the REN line to indicate to an active listener whether or not the listener will use the information sent to it by a talker.

EOI (end or identify) is applied in two ways. First, the active talker may assert it to designate a data byte as the last in a message. EOI is also part of a serial poll, which will be discussed later.

The SRQ (service request) signal enables a device to get the active controller's attention. This signal is a request, not a demand. The controller may ignore SRQ as long as it wishes. When the controller finally does acknowledge SRQ, it has to determine which device is requesting service. Since SRQ is shared by all devices on the bus, the requester isn't identified immediately.

Polling Along

A controller can employ two methods to determine the address of the device requesting service. Both methods are called *polls*. A poll is the controller's request for status information. The controller may request the status of any device individually by addressing the device as a talker and sending that device a serial-poll enable command. This constitutes one of the bus commands a controller can send when it asserts ATN. Using the *serial poll*, the controller can obtain 8 bits of status information from the addressed device. The controller then sends a serial-poll disable command to the device, returning it to data mode.

Once the controller has configured the bus, it takes no part in subsequent transactions until reconfiguration is desired.

Serial polling's advantage lies in the fact that 8 bits of poll information are obtained from each device polled. One bit can be used to indicate whether or not the device is requesting service. The remaining 7 bits are available for other purposes. A disadvantage of the serial poll is speed. Each device on the bus must be polled in turn, since more than one device may be requesting service.

A faster method of polling is the *parallel poll*. The parallel poll is performed when the active controller asserts both ATN and EOI. Up to 8 devices may respond, each on a different data line. The only information obtained in a parallel poll is whether or not a device is requesting service. Since each device has only 1 bit to respond with, obtaining further information is impossible.

You Don't Have to Know

One of the IEEE-488 standard's best features is that a system user doesn't have to know any of the information presented in this article. The standard, if followed by all the manufacturers of the devices put on a bus, guarantees that devices can talk to each other. This assumes that the system builder doesn't violate the standard by placing two devices at the same address, or by connecting two system controllers to the bus.

What then *does* the system user need to know? The standard does not specify the messages and data formats, both of which depend on the application. For example, if a voltmeter wants to tell the computer that it detects +1.234 volts at its input, what does it send to the computer as data? Most computers and computer languages prefer ASCII characters. HPIB specifies that ASCII is to be used. Next, the data format must be determined. Will the digits be sent most significant or least significant first? Again, most computers and languages prefer the digits just as you might type them, from most significant to least.

Thus, the voltmeter might send the following sequence of characters:

+ 1 . 2 3 4 <CR> <LF>

The <CR> and <LF> characters stand for carriage return and linefeed. These characters are often used as message terminators in computer communications. <LF> alone is usually sufficient.

The definition of messages and message formats leaves the IEEE-488 standard and enters the realm of HPIB. This higher-level implementation removes yet another layer of interface problems from the shoulders of the system user.

Next month, I'll discuss two other major types of interface: the BCD interface, often used when a computer receives data from scientific instruments, and the serial interface, used to transmit data over a single wire. We'll see how each evolved to deal with specific problems in communications. ■

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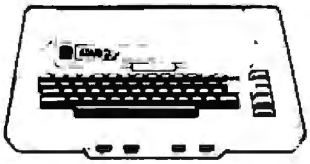
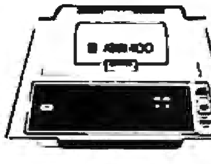


ATARI



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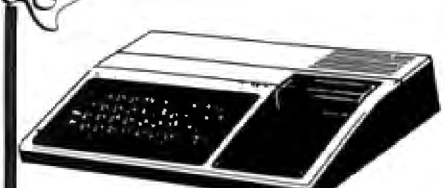

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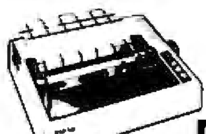

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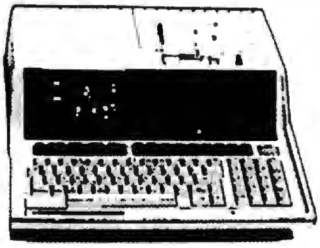

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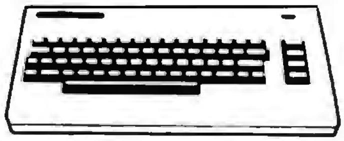

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The Osborne 1, Zeke's New Friends, and Spelling Revisited

A seasoned computer user looks at new products and updates.

Jerry Pournelle
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"It's the great software drought," said my mad friend Mac Lean. "Have you noticed? There's no good new software. Just updates and revisions and new versions of old programs."

"Not true," I protested. "Just yesterday I got Sorcim's Supercalc."

"Sure. The CP/M version of a year-old Apple program. Good stuff. Useful. Excellent. But not new."

"Hmm. Maybe you're right. Well, at least they're improving old programs. I have an update for Spellguard."

"Aha," said my mad friend. "Tell me, are you still using Spellguard?"

"Yep."

"Thought you had a whole mess of new spelling programs."

"I do. Here's one of them." I held up Microproof. "But I don't use them. Better to stay with Spellguard. Especially now, with its improved dictionary."

Which is true. I suppose it comes as no surprise that I am very interested in spelling and editing programs.

After all, words are my business . . . I need good spelling programs.

After all, words are my business, and I am, according to Robert Heinlein, one of the "wurst spellurs" he has ever encountered. I *need* good spelling programs, and I have to use them a lot, which means I'm interested in speed and convenience, which is why I stick with Spellguard despite its lack of certain features.

Example: in my previous Spellguard review [see November 1981 BYTE, page 449], I said "it corrects spelling." BYTE's editors, in the interest of accuracy, changed that to "finds and marks spelling errors." Other programs, such as Microproof, *correct* spelling errors. All true, but irrelevant. The job to be performed is spelling correction, and Spellguard does that [also see "Five Spelling-Correction Programs for CP/M-Based Systems" by Phil Lemmons, November 1981 BYTE, page 434].

Example: Microproof's specifications make it sound far better than Spellguard. (Let me call them MP and SG from here on.) MP has a 50,000-word dictionary compared to SG's 20,000. MP knows about plurals and prefixes; you can tag a word as a noun or an adjective or an adverb, and MP will take the root and add suffixes and prefixes and such like. Finally, MP lets you correct the word and will then go off and put that word in your text file, while all SG does is mark it for you to go fix using your standard editor.

Sounds great, doesn't it?

The trouble comes when you use it. That's presuming you even try; the manual was enough to cause me to leave MP in the box for over a month.

(Digression. The Microproof manual, which, according to its interior blurbs, was written by "an acknowledged expert in the field of programmed learning," is a general-purpose thing, intended for several versions of the program; and because it's never made clear what version you have, it's unutterably confusing. And that sort of thing happens all the time.

TO ALL SOFTWARE PUBLISHERS: look, if you want to charge $100 and more for programs, you can darned well furnish a manual tailored for *each* program!)

In Microproof's favor, I have to say that when you actually start using the program—as opposed to trying to figure out how to use it—it gets simple. The prompts are clear and the procedures are simple.

But it's slow. Ye gods, it's slow to work with. Instead of leaving the instructions on the screen and using the same entry line over and over again, as SG does, MP clears the screen and rewrites it, prompts and instructions and all, for each word it didn't recognize—dozens of them. Eventually you get through that, after which MP reads your text file and corrects it. That, however, takes about as long as it would have taken to load your editor, bring in the file, and search for the marked blocks; and because, if you're like me anyway, you'll want to *see* the corrected text and possibly reformat it before printing it and sending it out, you'll have to load the editor and text file anyway.

Now about those prefix and suffix "features." I suspect they have something to do with the fact that I CANNOT get Microproof to believe that "index," "kilobyte," "milestone," "undoubtedly," "Unix," and "automatic" are words. I went through my third "User's Column" (the one reviewing Spellguard!) as a test file *four times* and each time I patiently entered those words into the MP dictionary; and next pass I got them read back to me as misspellings.

(To make the test fair, I used Microproof on this text too, and not only won't it admit that the above are words after two passes, but until I entered it, it didn't recognize Microproof! Meaning, I would suppose, that they didn't use the program on their own manual. If they won't use it, why should anyone?)

There's worse. MP doesn't know about apostrophes. It gives me the "weren" of "weren't" as a candidate word. It does the same with "doesn." And if you use dashes! Spellguard understands dashes and hyphens, but if you have a double hyphen (which represents a typeset dash) in your text, SP thinks that is two separate words and examines each. Microproof offers me the "program—as" and "it—it" that I used above as candidate words. If you use many dashes in your text, you will, I assure you, go quite mad after about the third pass Microproof makes at your text.

Finally, Microproof doesn't know much about error handling. It takes forever to go through a 6500-word text file; and if you've left insufficient space on your disk for the original file plus a backup (.BAK) file, then when Microproof finds that out, it simply dumps the job, leaving you either in CP/M or the monitor, depending on just how confused MP got. Either way, you've lost all the work you just did.

So. Microproof is a heroic effort to make a more convenient spelling program. They tried to do right. The concept was good. The execution, though, leaves something to be desired.

There's a version geared to work

with either Electric Pencil or Scripsit for the TRS-80 Model I (and III) and TRSDOS. (Microproof has recently fixed most of the problems, partly because I sent a preliminary copy of this review to them. See next column for details; Microproof is now competitive with Spellguard.)

Which, incidentally, has been greatly improved. Now there's an explicit way to remove misspelled words erroneously entered into the dictionary. Also, the updated version packs the dictionary into half the space and runs about twice as fast. It took me just about an hour, using Microproof, to shape up a 6500-word column; with new Spellguard, the whole job (including looking up and entering into the program's dictionary about 100 new words) took fewer than 20 minutes.

The Spellguard documentation remains excellent, as clear and precise as anything I've seen in the field. Still highly recommended.

Zeke's New Friends

A few minutes ago, Arthur C. Clarke called me from Sri Lanka. (He lives there. I think the nation has declared him a national treasure; I know that when Robert Heinlein visited him, Dr. Clarke was able to arrange for a Sri Lanka air force helicopter to take Robert about the country.)

Arthur had seen some of my computer articles, and what he wanted to know was what everyone nowadays wants to know: what do you buy for a first computer?

Unfortunately, the answer is, it depends. But let's look at the problem. It's not unrelated to a second difficulty, one I have myself.

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I was talking with Ezekial, my friend who happens to be a Cromemco Z-2.

"I'm getting old, boss," he said.

"You were built in 1977!"

"Yeah. In this business, that's *old*. Look, we've written five books and dozens of columns and hundreds of letters. I do all your taxes and accounting. I compile all your programs, in twenty languages. I even play games with you."

"OK, OK, so what do you want?"

"Some rest. A bit of help. Look, I'll make you a deal. I'll help you write books, same as always, but you go get something faster, something new, to do all that compiling and calculating."

"Never thought I'd hear you say it," I said. "Better is the enemy of good enough. And you're plenty good enough!"

"Could use help, boss. Big responsibility, being the only computer around here. Especially now that you're so busy with the Citizen's Advisory Council on National Space Policy stuff and the L-5 Society." (Plug: if you're interested in helping the space program, join L-5. It's $20 a year; send fee to L-5 Society, 1060 E. Elm, Tucson, AZ 85719. Contributions tax deductible within the framework of the law. Secretary this year: Jerry Pournelle.)

"What happens," Zeke continued, "if I get sick?"

I thought about it a long time. He's right, of course. He *is* getting old; and he's utterly spoiled me. I can't conceive of writing without a computer. I live in terror that Zeke is going to quit on me. Actually I don't; he's rarely given cause for alarm. A couple of times in the early days we had glitches that brought Tony Pietsch out—always in the middle of the night; nice chap, Tony—but they always got fixed without having to take Zeke away. But not long ago something gave out in the disk power supply, keeping Zeke shut down for nearly a week. True, I was out of town at the time, but it could have been a disaster.

I needed a second computer. But what?

In the middle of the dilemma, Adam Osborne sent me his new Osborne 1.

That darned near solved my problem. Osborne's machine is *good*. The first models had some faulty characteristics, but Adam is an honorable man—and also smart enough not to risk his reputation by sharp practices. They're planning retrofits to take care of all major difficulties and most minor ones.

The worst of these was the shift lock, which was worse than useless. Then, too, with that tiny screen you needed smooth vertical scrolling (it already had good horizontal scrolling). There have been some other minor annoyances, but as I said, Adam's been fixing them. The new Osborne 1 computers—out by the time this is published—will incorporate the improvements, including true three-key rollover and a decent shift lock, and various other fixes. Those who have already bought the machines will be able to get them retrofitted absolutely free.

One thing I thought would be a pain turned out not to be. That's the tiny video screen. Adam has sent me his larger video monitor, which you can connect to the Osborne 1 with a cable, but I find I don't use it. The little screen turns out to be just at the right focal distance when I sit at the console; and for someone like me, who wears bifocal glasses, that's a real boon.

I carried the Osborne 1 out to Cal Tech's Jet Propulsion Laboratories for the Voyager 2 encounter with Saturn. There were over a hundred members of the science press corps packed into JPL's Von Karman Center (the press facility). Most had typewriters. One or two had big, cumbersome word processors. At least one was a terminal connected through a network to the parent system in New York. Nobody had anything near as convenient as the Osborne 1, which is quiet and fast responding.

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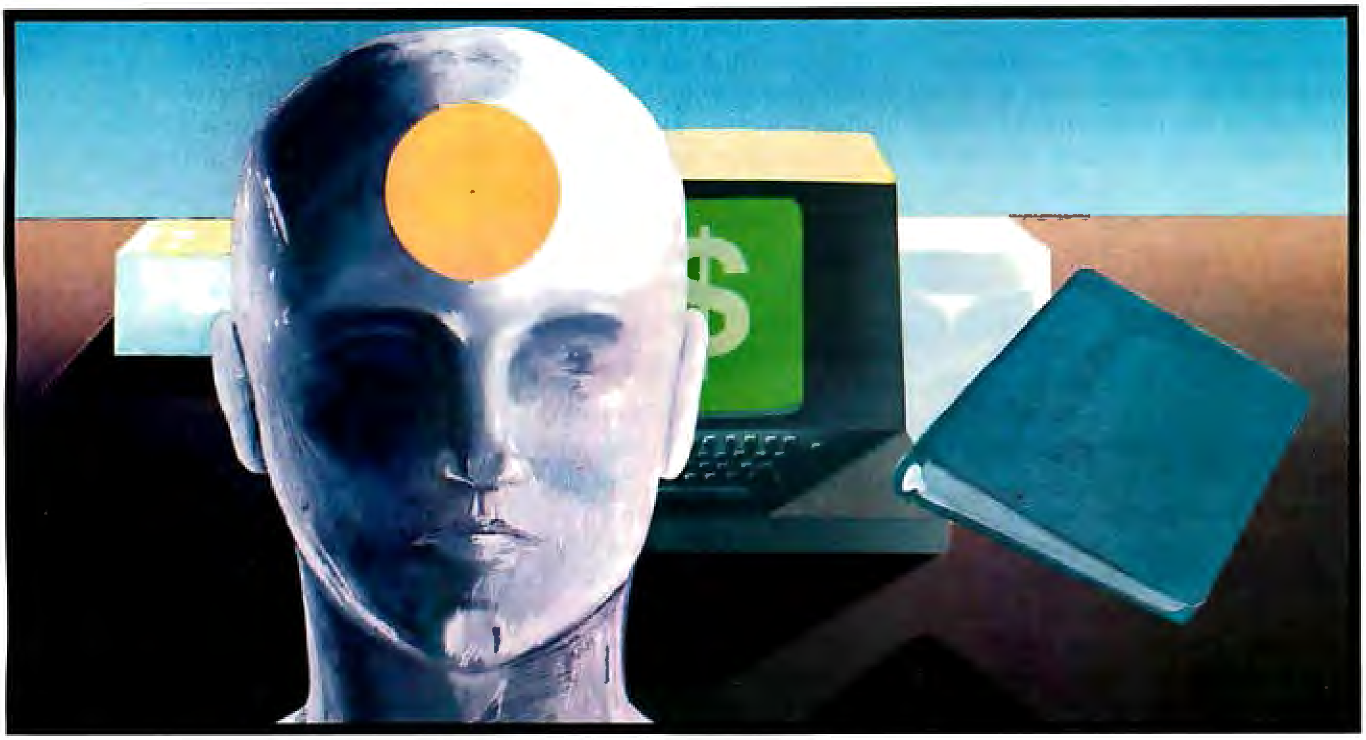

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Everyone came to look at it. "How can you stand that tiny screen?" asked Eric Burgess, senior science correspondent present. (Eric's the chap who first thought of the message plaque to be attached to the space probes. I was there when he got the idea. But that's another story.) He stared over my shoulder. "It's so small."

"Try it," I invited. I got up to give him my place and watched as he realized that when you're sitting at the machine you can read it at least as easily as you can a book. Before the encounter was over, a dozen science writers were ready to go buy an Osborne 1.

I also took it to the meeting of the Citizen's Advisory Council on National Space Policy (which I chair) and used it to take notes during the meeting. It was amazing: I was able to type notes and suggestions and ideas into the Osborne 1 without disrupting the meeting at all. The Osborne 1 is quiet and efficient and not at all distracting.

In other words, I like the Osborne 1. You can't beat it for the price, under $2000 bucks with over a thousand dollars' worth of software. An Osborne and an Epson printer will put you in the computer/word-processing business cheaper than anything I can think of, and the Osborne 1 is a real computer, using the CP/M operating system and adult software like Wordstar and Supercalc and dBase II; it's not a toy.

So. For those who haven't a lot of money to spend and want to get going in computers, I don't hesitate to recommend the Osborne 1—as a first system. However, it is a limited system. It wasn't designed for lots of expansion capabilities, and it's never going to be able to use them. But as a first machine, it has a lot going for it, and not just the price.

When I first got the Osborne 1, I thought I'd solve one of my problems, which is, how can I have someone entering letters and files and old books while I'm using Ezekial? I certainly am not going to have a multiuser microcomputer, which defeats the whole concept of decentralized computing. Our TRS-80 Model I with Omikron's CP/M conversion will do the job, but it's often in use as the boys check out new games and educational stuff; worse, the TRS-80 keyboard is plain awful, driving my editorial associates crazy. Even the boys get weary of it.

No, I needed a second machine, with a good text editor. Aha, says I. I'll use the Osborne 1. Of course the Osborne 1 has only 5¼-inch disks, and Ezekial has 8-inch disks, but that's all right. The TRS-80 has both 5¼-inch and 8-inch Lobo disks, and those work fine, and under CP/M we can copy files from the little disks to

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the big disks using the PIP utility routine. So all we have to do is to take a disk from the Osborne 1 to the TRS-80 and. . . .

It doesn't work. The Osborne disk format is different from the Omikron's format. And, talking to Mike McCulloch of Osborne Computer Corporation, I find there's no easy solution to the problem. If there were a "standard" 5¼-inch disk format (as there is a standard for 8-inch disks—the IBM single-density soft-sectored format), then Osborne would use it. Indeed, when Osborne goes to double density for disks, it'll use the new IBM 5¼-inch double-density format. But Osborne can't use a standard until one exists.

Which means that the only way to get files from the Osborne 1 to Zeke is to send them out the Osborne 1's serial port. Now the Osborne 1 has such ports, both RS-232C and modem ports, so that's not impossible, and nowadays Osborne will furnish you with software to accomplish the job (well, to accomplish the Osborne 1 end of the job; obviously you'll have to have appropriate software on the other end to catch what the Osborne 1 is pitching).

Moreover, the Osborne 1 format may yet become the "standard" for 5¼-inch single-density disks. According to McCulloch, the major software houses have been given copies of the specifications as well as an Osborne 1 machine and have been invited to offer software on disks readable by the Osborne 1; Adam Osborne has no intention of cutting his users off from the vast marketplace of CP/M software. Just the opposite.

So. By now you get the idea. The Osborne 1 is as good an entry-level system as I have seen. The only products that come close to it are the new IBM Personal Computer and the Heath/Zenith H-89, and both come with only one disk drive and very little software at a price a good bit higher than the Osborne 1.

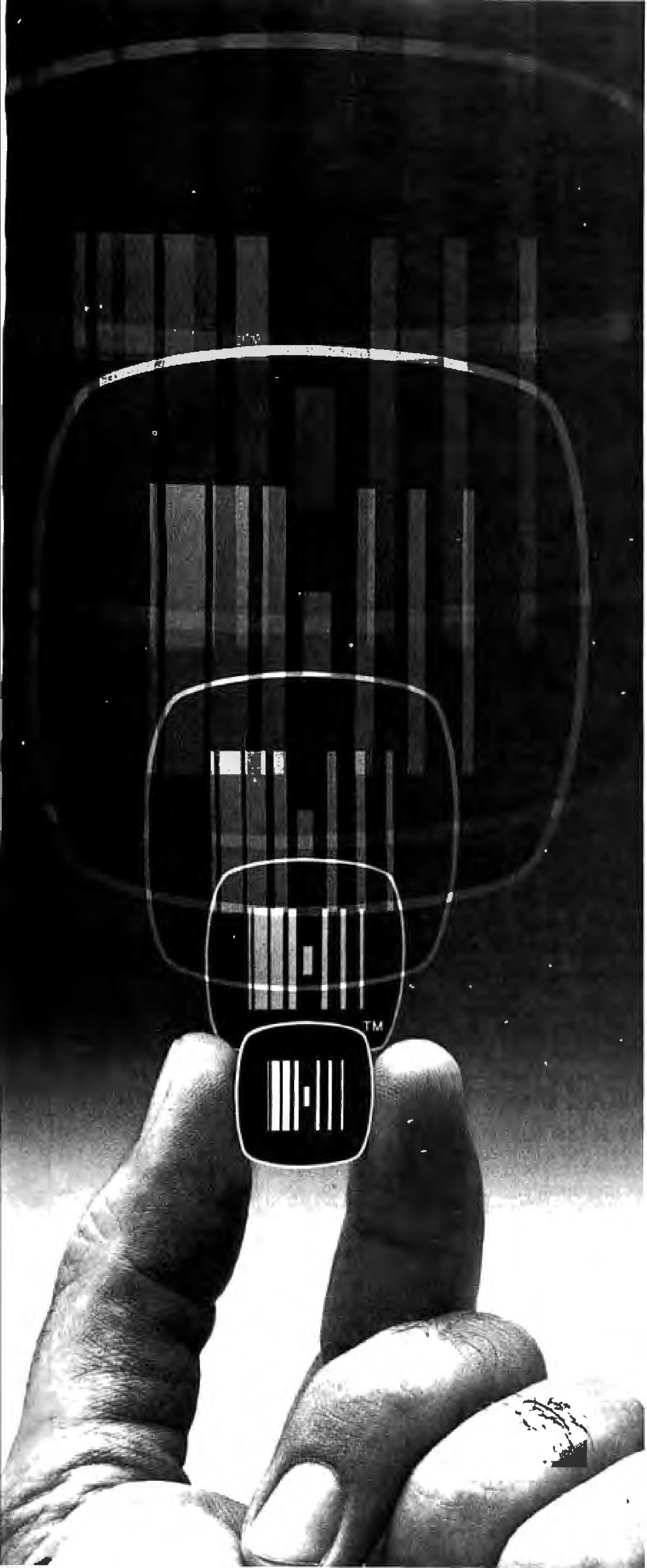
I did not, however, recommend the Osborne 1 to Arthur Clarke; and I never seriously considered it as the new machine Zeke wanted me to set up as his assistant. It's not that I won't keep mine and use it as a portable for a very long time; but I need more machine than can be bought for $2000, and so does Arthur Clarke.

Candidates

"Maybe," I said to my mad friend, "maybe I'll get an H-89. I can get it with CP/M and a printer and get a company to fit a case for it. I see advertised a board that will let it talk to 8-inch disks, which will solve the problem of communicating with Zeke. I can end up with a portable."

"Good thinking, as long as you think of it as a spare. Your real machine needs an expandable bus."

"True. But for a portable. . . . In fact," I said in boyish enthusiasm, "maybe I'll get it as a kit and build it so



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I can *understand* the machine."

"Sounds like about as much fun as an appendectomy," said Mac Lean.

I can always count on him to prick any silly bubbles like that.

In the middle of all that came another emergency. Dr. Stefan T. Possony, my long-time friend, associate, and collaborator, decided to get a computer. He'd seen Ezekial, and he wanted him. Or one like him.

Not long ago the solution to the problem would have been simple. We'd simply hand money to Tony Pietsch of Proteus Engineering, he would produce an updated clone of Ezekial, and all would be well. Unfortunately, Tony's in great demand as a consultant and has just about gone out of the systems-integration business.

So, what to get? For Stefan, and for me.

It didn't take much research to come to several conclusions. First, a professional system ought to have 8-inch floppy-disk drives. The little disks are fine for entry-level learning systems, but they're just not solid enough—and won't hold enough files—for professional work. Second, the system has to use Digital Research's CP/M operating system. With Xerox, Wang, and DEC (Digital Equipment Corporation) coming into the field, CP/M is more than a de facto standard, it's a necessity. Third, the S-100 bus (in a quiet version and built to the IEEE standard, if at all possible) is still the most versatile small-computer system going and will be for some time. An S-100 with a Z80 processor is *the* way to go.

"But why not the new IBM Personal Computer?" one of my sane friends asked. "It has an expansion bus. Not the S-100, true, but a bus. And CP/M-86, and IBM maintenance and—"

And 5¼-inch floppy disks, which even with IBM behind them are going to be a problem. Furthermore, as of right now (fall, 1981) the local people selling the IBM know nothing about software availability, although with Microsoft's support I expect that to change by the time you read this.

The IBM may sweep the field; heaven knows it's a handsome enough unit. I learned to write with an IBM typewriter keyboard, and I've found few computer keyboards up to the Selectric—and the new IBM computer keyboard is even nicer. Indeed, I'm thinking seriously of getting an IBM. But for all of IBM's prodigious reputation, it hasn't a lot of experience with small computers. Until it gains some, I think I'll wait. Besides, IBM Personal Computers weren't available back last summer when Stefan wanted his machine.

So. What to get? And how to install it long distance? That really presented a problem. Possony knows nothing about computers, and there aren't too many off-the-shelf S-100 systems. I could get a Vector; although I've no direct experience with them, people I trust tell me they're excellent.

But then I remembered: I have a good friend, Dr. Colin Mick (Decision Information Services, POB 5849, Stanford, CA 94305, (415) 327-5797), in the Stanford area, where Dr. Possony lives. A quick phone call, and Colin foolishly volunteered to help Stefan. It turned out well. Colin installed a CCS (California Computer Systems) system with a Heath/Zenith Z-19 terminal in Stefan's house. He chose CCS because that's what he has, and he knows some of the CCS design team; the result has been so successful that Colin is now much in demand as a small-systems consultant.

Another result is that Possony, already one of the world's most prolific writers on foreign affairs and international politics, has more than doubled his output. He *loves* his new system; and when you consider that Stefan is a Viennese intellectual, who got his Ph.D. the year after I was born

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and who knows very little about machines, that's quite a statement. It's also a great testimony to Colin's patience and instructional capability.

Decision Information Services got one thing out of it. They're writing a book for first users. Given Colin's understanding of computers and Stefan's ability to ask penetrating questions, I wouldn't be surprised to see it become the best book ever done on the subject.

So. That was one candidate. CCS seemed a very good system, and certainly a lot of them are being sold.

Tony, meanwhile, was putting together a Godbout (Compupro), with the dual 8085/8088 8-bit/16-bit capability. And Richard Frank, of Sorcim, had told me he uses Godbout units for all his development work because he considers them the most rugged and reliable systems available.

I stewed for a while, then called Bill Godbout. The result is that Zeke's big brother is sitting in the next room.

Understand that I've nothing against the CCS system. Quite the opposite. It's an excellent system and one of those I recommend. But the Godbout is more than that. It's built like a Mack truck. You couldn't hurt it with a nine-pound sledge. When it comes to rugged reliability, Godbout is *the* way to go for my money; and Tony says the bus is the quietest he's ever worked with.

What we have is the Godbout (Compupro) S-100 box, Godbout's disk controller and interfacer board, his 8085/88 processors as well as the Z80 processor (obviously you can't use both at the same time), 128K bytes of Godbout memory, and his system support vectored interrupt board. The disk drives are Qume double-sided double-density 8-inch drives with a Vista box and power supply.

I confess to being a bit worried about double-sided double-density disks. Asking for trouble, I thought; but I was wrong. With the Godbout controller and Qume drives my disks are as quiet as the Icom drives ever were—and they're wonderfully fast.

We're still shaking down the Godbout system. When it's all done and checked out, I intend to get another set of Qumes and install them in Zeke. More on both the Qumes and the Godbout another time.

WRITE Arrives

So. Zeke has two new friends, the Osborne and the Godbout; and he's about to get new disk drives.

There's more happening here at Chaos Manor. Tony Pietsch's new text editor, WRITE, is done at last. I'm using it to do this column.

Write is much like Electric Pencil without bugs. It ought to be: back when I started writing with computers, Pencil was the best editor around, and we put together a system to work with it. Unfortunately, Pencil has bugs. One, the tendency to drop letters at the ends of lines, is notorious. Another is a needlessly complex handshaking routine to couple Pencil to the Diablo (that one's so severe we use a special CP/M BIOS [basic input/output system] reserved just for Pencil). There are other problems, and over the years my partner Larry Niven and I have been making lists of Pencil's faults. We've also made notes on just what we'd like in a text creation editor, features that Pencil never had.

Anton (Tony) Pietsch has been collecting those notes and writing an editor to fit. In these columns and in pieces for BYTE's companion *onComputing*, now called *Popular Computing*, I've several times announced that it would be ready "real soon now." I'm happy to say that this time it's here and it works.

But this version will only work for systems with memory-mapped video display. For the Godbout that's simple enough: we use an Ithaca IA-1100 Write-Only Memory video output board addressed to hexadecimal address FC00, and a separate keyboard. The system normally operates through an H-19 terminal, but it can be rigged up to think that Ezekial is its terminal—or to work with my regular keyboard, putting the output up on my big 15-inch monitor screen

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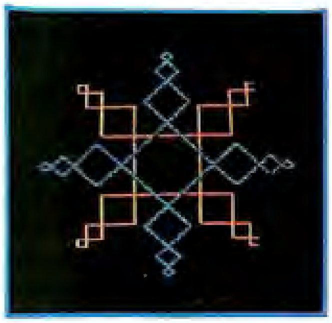

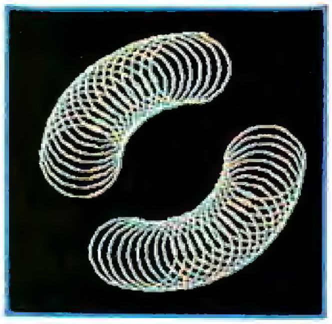

This book is published in two versions: *Apple Logo* is for users of Apple Logo™ software (distributed by Apple Computer Company) and contains an appendix for users of TI Logo™. *Logo* is specifically for users of Logo software developed at MIT for the Apple II computer (distributed by Krell Software and Terrapin, Inc.). *Logo* also contains appendices that enable users of Apple Logo™ and TI Logo™ to carry out the projects in the book. Be sure to specify *Apple Logo* or *Logo* when ordering!

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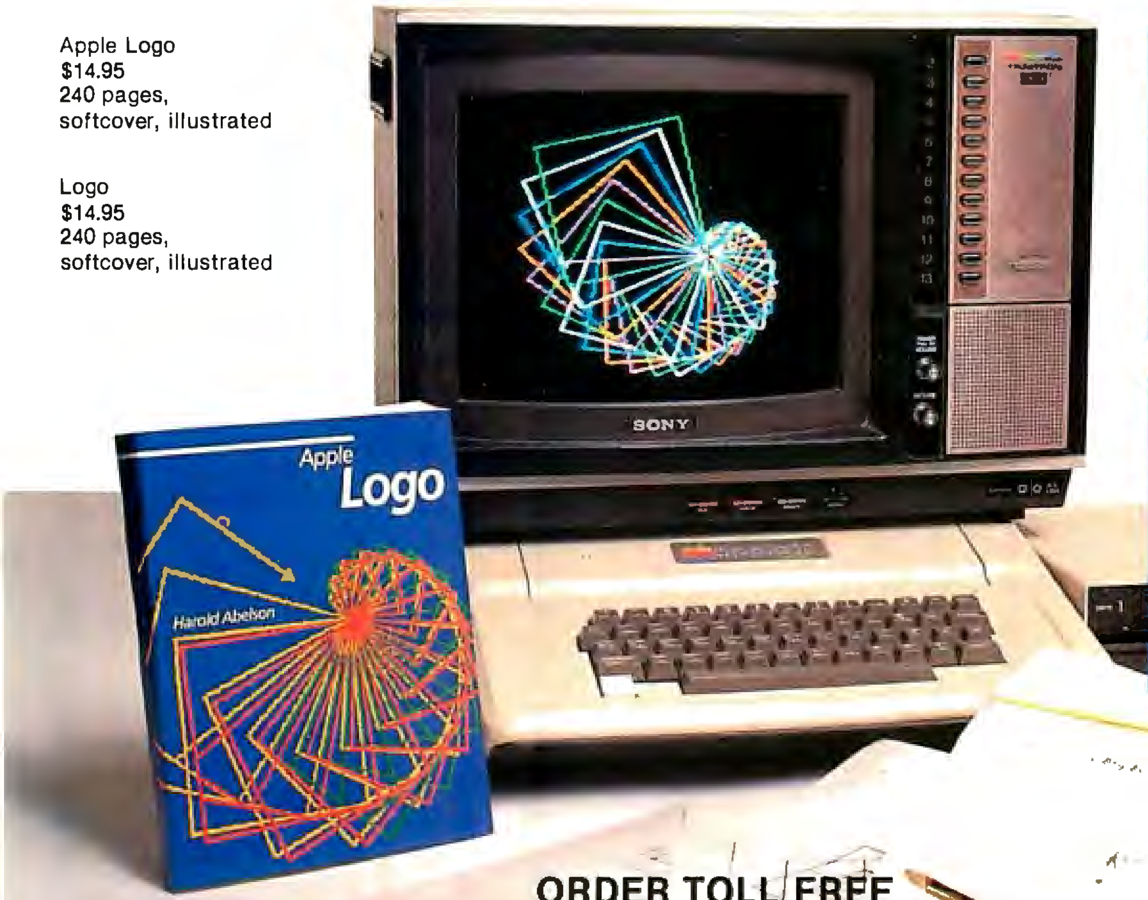

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through the IA-1100. This is one of the advantages of an S-100 bus system. You can configure it to do nifty things like that.

Anyway, back to WRITE. Why is it so good that I'm willing to overlay some of my memory with video and have special boards, and such like? Can it be as good as *all that*?

It depends on what you want an editor for. I have no doubt that some of the really fancy "window-type" editors based on the MIT EMACS editor or built around special display boards may be more elegant in theory. Moreover, Micropro's Wordmaster remains, in my judgment, the best *programming* editor ever invented.

But for just sitting down and writing I want something as nearly invisible as can be made. I don't want to think about my editor. I don't want it to natter at me about line numbers and column numbers and such. I don't want it drawing funny lines across the screen to mark the ends of pages. I don't want it clicking disks at me, or running out of disk space and giving me no chance to change disks.

And if I want to pull some text in from another disk somewhere, I want to be able to do that. If I want to write some text out onto a safety disk, I want to be able to do that, too. If I want to print out my text on paper, I don't want to have to double-space it on the screen in order to get it double-spaced on the manuscript.

And for heaven's sake, if I fiddle around with a paragraph and snip off words here and add some there, I don't want to have to reformat the text! My editor should do that for me, silently, easily, automatically.

And that's what I have in WRITE. A nearly invisible editor. Add to that a really powerful macro-command capability, with loops and global searches and deletes, and an ability to link disk files so that the program treats them as if they were one enormous file.

Add it all up and it's WRITE, Writers' Really Incredible Text Editor. I'm sure I'll have more to say about it another time. Meanwhile, if your system will run Electric Pencil under CP/M, it will run WRITE, which will be able to read all your old Pencil files. (It will also read Wordstar and Wordmaster files.) If you do creative writing, you'll appreciate WRITE a *lot*. Highly recommended.

One more note on text editors. People ask me what I have against Wordstar. My answer is simple. Lots of friends use Wordstar, and I use it on the Osborne. It's a good editor to run on a terminal. Like all editors on terminals, the scrolling is ugly, but that's not Wordstar's fault. Micropro International continually works to add features and capabilities, and it's done well.

What Micropro can't do is correct the basic deficiency, which is the two-keystroke command system with delay in between strokes. When I want to delete a line, or scroll, or go from the beginning to the end of the text, I want to do that *right now*. I don't want to hit control-Q, then remember that "c" takes me to the end of the text unless I've hit the space bar in between, in which case—

Nor do I want a bunch of prompts and lines and menu items on the screen. OK, so you can suppress those menu descriptions—provided, of course, that you remember all the command items. But you won't. Wordstar has too many features. Now that would be all right if you could ignore most of them, but you can't. They take up single-stroke control characters so that there are none left for the functions you want to have happen *fast*. In contrast, WRITE's approach is to use the single-strokes for such things as toggling insert/delete modes, opening a hole in the text for long insertions, and marking blocks of

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text and moving them; and, much as Wordmaster does, it allows you to use the macro-command capability for all the really complicated stuff. WRITE also has the menu available at any time: simply hit Escape and you'll see a whole list of instructions, pages of them if you like. But you don't see them unless you want to. I wish Wordstar had taken that approach.

I do recommend Wordstar for some purposes. First, it works on a terminal. Because it knows where the ends of pages are, it can do indexing. It formats on screen; what you see is what you get, an intolerable disadvantage when what you want is a simple double-spaced manuscript (who wants his *on-screen* text double-spaced?) but a real boon if you're publishing a newsletter or other matter requiring holes for illustration. It has a good mail-merge utility. If you can use any of those features, Wordstar is the only program that has them.

Incidentally, there are a couple of candidates for Wordstar's crown, one of them being MINCE (acronym for MINCE Is Not Complete EMACS) which emulates EMACS, the MIT (Massachusetts Institute of Technology) full-screen editor and is certainly the best editor if you want to write LISP programs. MINCE works on terminals (but not with memory-mapped video; at least I've never been able to get it running on Zeke). Now that the Godbout with the H-19 is up and running, we'll have a more thorough report. But when it comes to creating text, you won't beat WRITE. Or so say I.

muSimp/muMath

Some time ago, I got a copy of muSimp/muMath from the Soft Warehouse. Marketing of these programs has since been taken over by Microsoft, which has probably enhanced the documentation—at least it usually does.

There's nothing quite like muMath [For another review see "The muSimp/muMath-79 Symbolic Math System" by Gregg Williams, November 1980 BYTE, page 324]. The basic concept comes from MACSYMA, the symbolic-algebra programs continually under development at MIT's computer laboratories, which run on the DEC PDP-10. Obviously, there is no way to put the full power of a PDP-10 into a microcomputer—although the Godbout 8085/88 comes closer than I would have thought possible a few years ago.

MuMath consists of a core plus a whole series of auxiliary routines. The programs are written in LISP, but you don't have to know LISP to use them. (It would help, though. Boy would it help.) MuSimp is another package of routines which will also work with muMath. Together they will do a surprising lot of useful work. You could, for example, write a Visicalc in muSimp/muMath, and I suspect it would work quite well. There are also examples of how to write a database system using them.

In other words, muSimp/muMath have a lot more power than appears on the surface (or, indeed, is hinted at in the advertisements).

Their primary purpose, though, is to do symbolic math. And here I have to confess a fault. When I first got muSimp/muMath, I tended to compare them to MACSYMA, and of course these programs written for 8-bit microprocessors came up wanting. How could they not? What I should have done was find someone who never had access to MACSYMA and ask what she thought of them, and recently that's what I did.

"Wonderful," said my lovely friend. "I've never even suspected you could do things like that on a computer.

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How long has this been going on?"

I shrugged.

"You mean I went through three semesters of calculus and did ALL THOSE PROBLEMS while you had a computer program that would do differentiation and integrals? And I mashed through Physics I and II and solved problems with a hand calculator when all that time Ezekial could have done my homework?" By now she was screaming.

"Uh, well—" Under the circumstances I did the only sensible thing a man could do. I hid behind my wife.

But my lovely friend did have a point. True, muSimp/muMath are limited in what they can do, but they can do differentiation, integrals, and algebra. They can factor and expand polynomials. They can do matrix operations and simplify equations, and do it all symbolically, the way you'd mess around with the equations using pencil and paper.

The programs aren't perfect. They tend to run out of memory easily. The way to escape that is to set up a kind of subprogram consisting of those elements of muSimp/muMath that you need for your particular problem, leaving out all the parts that won't affect what you're doing. For example, you can configure a system that understands trigonometry and complex numbers but doesn't know that matrices and integrals exist. And so forth.

There are other limits. The documentation isn't exactly encrypted, but it's pretty dense. You really have to want to use the programs to dig your way through that stuff, and as I said earlier, it would help a lot if you understood LISP. The authors of the muSimp documents plainly do understand LISP, and although they don't expect you to, they keep hoping you will.

Still in all, there's no real competition for muSimp/muMath. If you want to do symbolic algebra, if you want to use your computer to help you get through Calculus 102 and Physics 203, then you probably need muSimp/muMath.

Recommended for those who need it, with reservations as noted.

BASCOM Improves

More good news. Microsoft has done it again. It has improved its BASCOM BASIC Compiler.

What Microsoft has done is twofold: it's added program CHAINing with COMMON storage, meaning that you can break a program apart into pieces and execute it in parts, passing variables to each chunk as called. This greatly reduces the size of the program code that must be in memory at a given time, which means that it saves free memory and that you can run bigger programs with more variables.

Second, Microsoft has greatly cut down on the run-time package, so the total size of the programs is—or can be—smaller, and also larger programs can be compiled and linked.

More good news. Microsoft has partially dropped the restrictive licensing provision that made you pay a royalty on any program you sold that had been compiled with BASCOM.

The bad news on that front is that it has dropped the royalty requirement only for the *old* BASCOM; if you want to use the new, with the CHAIN and COMMON keywords and smaller run-time package and all that nifty stuff, you still have to pay for each copy you sell. Alas. But I suspect free enterprise will end that; it's only a matter of time.

Meanwhile, the new BASCOM is very nice indeed. Take a trivial example: an old Star Trek game I've been playing with. As you might suspect, my Star Trek is the *ultimate* game, with invisible Romulans, and shields for the Klingons, and enemy bases, and attacks on Federation bases, and Federation trading ships, and black holes, and—well, you get the idea.

The game was originally written in EBASIC, a public-domain precursor to Gordon Eubanks' CBASIC. I added to it and translated it into CBASIC, but eventually the program outgrew that. Besides, it was getting awfully slow. What I wanted to do, therefore, was

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translate it into Microsoft BASIC and compile it; but I couldn't because the program was just too large. I could break it into pieces for the Microsoft interpreter, but that was even slower than CBASIC.

Comes new BASCOM and I've done it. Now I have a setup program which invents the game universe and makes the maps; then it calls in another program which processes commands; and every now and then still another program comes in and massages the data. It all works, letting me have a Star Trek so complicated that even I am beginning to think it's finished.

Anyway, that's how the new compiler works. On a more serious note, it will compile my tiny database.

And here I have a problem. Should I review software that I have written? Certainly I have an obligation to tell you it's mine. I try to be objective, but certainly I could overlook flaws in my own programs.

Minimum Data Base

Minimum Data Base grew like Topsy. It started a long time ago with a thing called the People's Data Base by Yogesh Gupta and others. It was, in fact, the very first program I ever got running. When I bought Zeke, Mac Lean and Tony Pietsch handed me Debbie (a Microsoft-like BASIC that came with the Icom disk drives and, ugh, FDOS operating system); and they handed me a listing of the People's Data Base.

"Get that running," they ordered.

So I tried. Lord I tried. And I certainly learned that semicolons are not colons, that single quote marks are not double quotes, that BASIC has a *very* precise syntax and improvements are not tolerated, and that I needed to keep my temper well enough so as not to throw anything heavy at Ezekial.

Eventually I got it running. It wasn't a bad little program; more to the point, it was well structured, with a main routine and a series of subroutines, some of which themselves called other subroutines. There were no GOTO statements except within sub-

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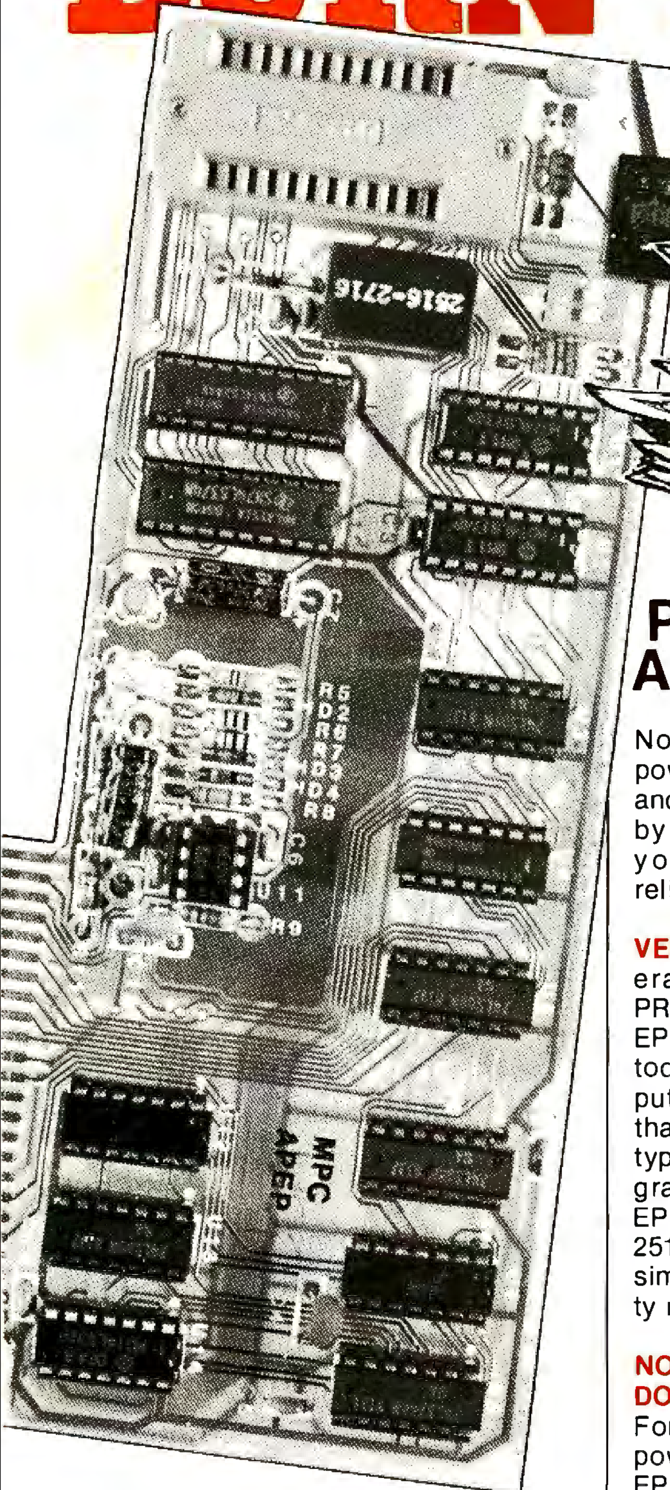

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routines. None of this grasshopper jumping about that so ruins BASIC's reputation.

The program was limited, and soon I ran into the limits. So I began to improve it. The sort algorithm used was a bubble sort. That wouldn't do, so I put in a Shell-sort algorithm. There were no disk operations. I fixed that. The command menu was processed inefficiently, so I rewrote that and renamed most of the commands. The "delete entry" system was asinine, and I set up an entirely new way to handle that. And so forth.

Year after year the silly thing grew—and I found I was using it for *everything*. It keeps phone numbers and addresses. It keeps the list of members of the Space Council and the L-5 Board. When the Boy Scouts go hiking, a PDATA (after the original People's Data Base) lets me make lists by meal (what are we eating for Thursday dinner?), or by who is carrying what (who's got Friday's lunch?), and all that. When I do an anthology, a PDATA file keeps track of who has how many shares and what they've been paid. When new royalties come in, it calculates what the new payment is and then writes the cover letter, makes mailing labels, and writes the checks.

Versatile. And darned easy to use.

"You ought to sell it," said Barry Workman of Workman Associates. "Let me handle it for you. It won't make you rich, but what do you care? People out there need the program."

"Maybe," said I. "What if—gulp—what if someone reviews it and doesn't like the documentation? I can stand not being thought an elegant programmer, but—"

"Don't worry about it. I learned to use it, didn't I?"

I shrugged. "Also, look, there's very little new in there. True, I didn't steal it from Gupta and the People's Data Base; there probably aren't ten lines of code left from their original. But it's all very straightforward code. Nothing elegant at all."

"That's the value," Workman said. "Look, lots of people want a general-purpose do-all program, which is what this is. I notice that when you did all that statistical analysis, you used your PDATA thing."

"Yeah."

"And your Christmas cards are on it, and you used to keep your checkbook balance—"

"I don't do that any more. I use a Journal now."

"Yeah, but you used to," Barry said.

Eventually he wore me down. So, I mention PDATA, a small database and do-all, available from Workman Associates. If I didn't already have it, I'd probably buy it; I can't conceive of living without it, and I wouldn't have time to write it again.

It *is* useful. And it's in both CBASIC and Microsoft BASIC, with the Microsoft version compilable by BASCOM—except that BASCOM will not compile the general program because it won't compile anything with arrays defined by variables. PDATA creates databases and dimensions them according to the number of fields you've specified, but BASCOM wants to know those dimensions in advance. This means that you can compile FONES (the telephone program) or NAND (name and address) or any set whose structure you know in advance, but you can't just compile PDATA.

On the other hand, one reason PDATA is so useful is that you can run it interactively in interpreted Microsoft BASIC and write your own special-purpose routines (such as the one that determines what my contributors ought to be paid, given the total royalty). If you know BASIC at all, you can do a lot with PDATA.

So. Useful, yes. But it is not a rival to dBase II and doesn't claim to be. All it claims to be is a very useful little general-purpose data handler that provides a structure to let you mash data. And it will do all the statistics taught in elementary stat courses: sums, averages, standard deviations, medians, means, and correlations between two variables.

I've always liked it, and I'm happy to share it.

Next time, more on Zeke's new friends and a lot more on financial programs. ■

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Book Reviews

Handbook of Digital IC Applications

by David L. Heiserman
Prentice-Hall Inc.
Englewood Cliffs, NJ
1980, 428 pages, $21.95

Reviewed by
Clifford R. Mosley
Network Test
and Training Facility
Building 25, Code 850.2
Goddard Space Flight Center
Greenbelt, MD 20771

Ordering a book without first reading the fine print is a risky thing to do. I have found that getting what you order is not always the same as getting what you want. When I first saw the title of this book, I thought, naturally enough, "This is a book full of digital IC application projects." Because I'm always anxious to build new gadgets, I promptly ordered the book. When it arrived, I tore open the package, flipped open the book, and found myself totally let down! It was not a collection of projects, but a book about basic digital concepts and devices.

But I had paid good money for the book, and the least I could do was give it a closer look. When I overcame my initial prejudice, I discovered that it did, in fact, have some very good characteristics.

Handbook of Digital IC Applications appears to have been primarily designed as a textbook for a technical school or intermediate engineering course in digital design. At the end of each segment, Heiserman has included an exercise on key points to encourage further study. Answers to selected exercises are included in the back of the book, allowing readers to check the accuracy of their quiz answers. Despite the fact that the book is targeted for a technical audience, I feel that a serious hobbyist with a fair math background could learn a great deal. The text is supported by many helpful illustrations and is written in a pleasantly explicit style.

Basic combinational logic (AND, OR, INVERT, etc.) and Boolean algebra are the dominant subjects of the beginning chapters of the book. These fundamentals are discussed in a little greater detail than in most books of this type. Heiserman then moves into a discussion of digital hardware, detailing the design aspects of interfacing TTL (transistor-transistor logic) and CMOS (complementary metal-oxide semiconductor) logic with some of the more common input and output devices. He also discusses some of the problems encountered when combining TTL and CMOS logic within the same system and describes flip-flops, counters, timers, code converters, display drivers, AOI (AND-OR-INVERT) circuits, and other similar digital devices.

In the final chapters, Heiserman introduces more complex devices such as data selectors, data multiplexers/demultiplexers, parity generators/detectors, arithmetic circuits, and memory circuits.

One of the greatest strengths of the book is Chapter 11, where Heiserman uses a refreshing approach to present an application of the basic theory of the earlier chapters. He leads the reader through the design of a simple digital measuring system (in this case a frequency counter), developing each unit of the system as a separate block, then illustrating the process of integrating all of the blocks into a complete system.

The book has some weak points. It lacks a glossary, and the index is a little skimpy. Both are important in a technical book in order to quickly locate information. These faults reduce the overall effectiveness of the book as a learning aid.

Also, some minor technical (or possibly editing) errors tend to confuse the reader. One example can be found in the first chapter, where the typical power consumption of a CMOS gate is listed at 10 ns (nanoseconds). As it is standard practice to measure power consumption in units of watts, I assume that Heiserman intended the text to read 10 nw (nanowatts).

Conclusion

Handbook of Digital IC Applications is well written and superbly illustrated and would make an adequate digital-design textbook or tutorial for a serious hobbyist. Although it wasn't the book I thought I had ordered, I am nevertheless pleased to have it as a part of my reference library. ■

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Designing the Star User Interface

The Star user interface adheres rigorously to a small set of principles designed to make the system seem friendly by simplifying the human-machine interface.

Dr. David Canfield Smith, Charles Irby,
Ralph Kimball, and Bill Verplank
Xerox Corporation
3333 Coyote Hill Rd.
Palo Alto, CA 94304

Eric Harslem
Xerox Corporation
El Segundo, CA 90245

In April 1981, Xerox announced the 8010 Star Information System, a new personal computer designed for offices. Consisting of a processor, a large display, a keyboard, and a cursor-control device (see photo 1), it is intended for business professionals who handle information.

Star is a multifunction system combining document creation, data processing, and electronic filing, mailing, and printing. Document creation includes text editing and formatting, graphics editing, mathematical formula editing, and page layout. Data processing deals with homogeneous, relational databases that can be sorted, filtered, and formatted under user control. Filing is an example of a network service utilizing the Ethernet local-area network (see references 9 and 13). Files may be stored on a work station's disk, on a file server on the work station's network, or on a file server on a different network. Mailing permits users of work stations to communicate with one another. Printing utilizes laser-driven raster printers capable of printing both text and graphics.

As Jonathan Seybold has written, "This is a very different product: Different because it truly bridges word processing and typesetting functions; different because it has a broader range of capabilities than anything which has preceded it; and different because it introduces to the commercial market radically new concepts in human engineering." (See reference 15.)

The Star user interface adheres rigorously to a small set of design principles. These principles make the system seem familiar and friendly, simplify the human-machine interaction, unify the nearly two dozen functional areas of Star, and allow user experience in one area to apply in others. In reference 17, we presented an overview of the features in Star. Here, we describe the principles behind those features and illustrate the principles with examples. This discussion is addressed to the designers of other computer programs and systems—large and small.

About the Authors
These five Xerox employees have worked on the Star user interface project for the past five years. Their academic backgrounds are in computer science and psychology.

Star Architecture

Before describing Star's user interface, several essential aspects of the Star architecture should be pointed out. Without these elements, it would have been impossible to design an interface anything like the present one.

The Star hardware was modeled after the experimental Xerox Alto computer (see reference 19). Like Alto, Star consists of a Xerox-developed, high-bandwidth, MSI (medium-scale integration) processor; local disk storage; a bit-mapped display screen having a 72-dots-per-inch resolution; a pointing device called the "mouse"; and a connection to the Ethernet network. Stars are higher-performance machines than Altos, being about three times as fast, having 512K bytes of main memory (versus 256K bytes on most Altos), 10

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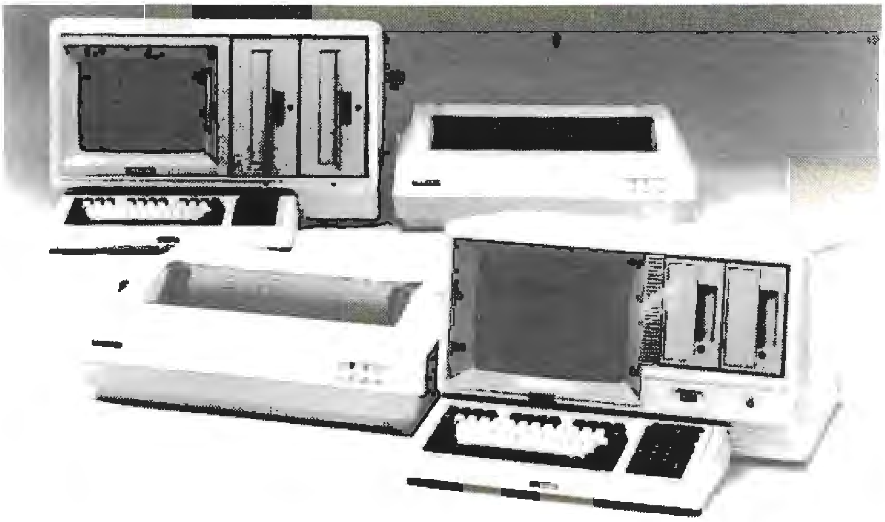

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Photo 1: *A Star work station showing the processor, display, keyboard, and mouse.*

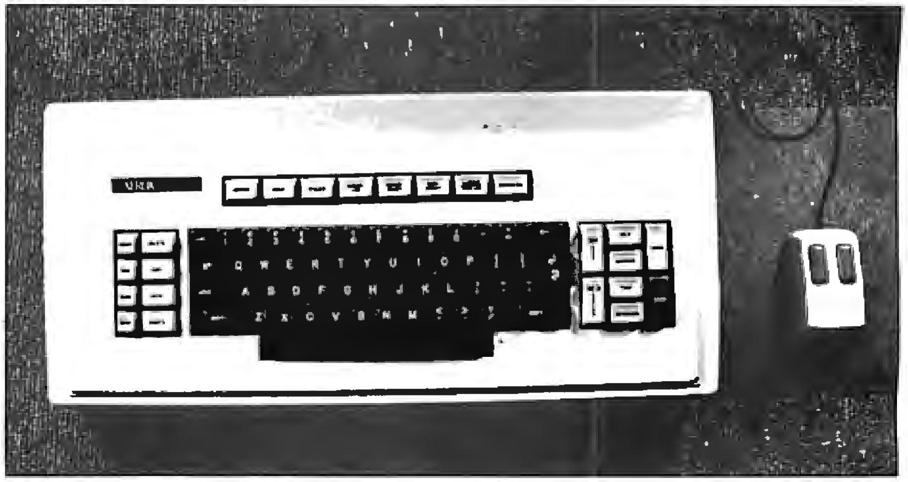

Photo 2: *The Star keyboard and mouse. Note the two buttons on top of the mouse.*

or 29 megabytes of disk memory (versus 2.5 megabytes), a 10½- by 13½-inch display screen (versus 10½ by 8 inches), and a 10-megabits-per-second Ethernet (versus 3 megabits). Typically, Stars, like Altos, are linked via Ethernets to each other and to shared file, mail, and print servers. Communication servers connect Ethernets to one another either directly or over telephone lines, enabling internetwork communication. (For a detailed description of the Xerox Alto computer, see the September 1981 BYTE article "The Xerox Alto Computer" by Thomas A. Wadlow on page 58.)

The most important ingredient of the user interface is the bit-mapped display screen. Both Star and Alto devote a portion of main memory to the screen: 100K bytes in Star, 50K bytes (usually) in Alto. Every screen dot can be individually turned on or off by setting or resetting the corresponding bit in memory. It should be obvious that this gives both computers an excellent ability to portray visual images. We believe that all impressive office systems of the future will have bit-mapped displays. Memory cost will soon be insignificant enough that they will be feasible even in home computers. Visual communication is effective, and it can't be exploited without graphics flexibility.

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There must be a way to change dots on the screen quickly. Star has a high memory bandwidth, about 90 megahertz (MHz). The entire Star screen is repainted from memory 39 times per second, about a 50-MHz data rate between memory and the screen. This would swamp most computer memories. However, since Star's memory is double-ported, refreshing the display does not appreciably slow down processor memory access. Star also has separate logic devoted solely to refreshing the display. Finally, special microcode has been written to assist in changing the contents of memory quickly, permitting a variety of screen processing that would not otherwise be practical (see reference 8).

People need a way to quickly point to items on the screen. Cursor step keys are too slow; nor are they suitable for graphics. Both Star and Alto use a pointing device called the mouse (see photo 2). First developed at Stanford Research Institute (see reference 6), Xerox's version has a ball on the bottom that turns as the mouse slides over a flat surface such as a table. Electronics sense the ball rotation and guide a cursor on the screen in corresponding motions. The mouse possesses several important attributes:

- It is a "Fitts's law" device. That is, after some practice you can point with a mouse as quickly and easily as you can with the tip of your finger. The limitations on pointing speed are those inherent in the human nervous system (see references 3 and 7).
- It stays where it was left when you are not touching it. It doesn't have to be picked up like a light pen or stylus.
- It has buttons on top that can be sensed under program control. The buttons let you point to and interact with objects on the screen in a variety of ways.

Every Star and Alto has its own hard disk for local storage of programs and data. This enhances their personal nature, providing consistent access to information regardless of how many other machines are on the network or what anyone else is doing. Larger programs can be written, using the disk for swapping.

The Ethernet lets both Stars and Altos have a distributed architecture. Each machine is connected to an Ethernet. Other machines on the Ethernet are dedicated as "servers"—machines that are attached to a resource and provide access to that resource.

Star Design Methodology

We have learned from Star the importance of formulating the fundamental concepts (the user's conceptual model) *before* software is written, rather than tacking on a user interface *afterward*. Xerox devoted about thirty work-years to the design of the Star user interface. It was designed *before* the functionality of the system was fully decided. It was even designed *before* the computer hardware was built. We worked for two years *before* we wrote a single line of actual product software. Jonathan Seybold put it this way, "Most system design efforts start with hardware specifications, follow this with a set of functional specifications for the software, then try to figure out a logical user interface and command structure. The Star project started the other way around: the paramount concern was to define a conceptual model of how the user would relate to the system. Hardware and software followed from this." (See reference 15.)

In fact, before we even began designing the model, we developed a methodology by which we would do the design. Our methodology report (see reference 10) stated:

> One of the most troublesome and least understood aspects of interactive systems is the *user interface*. In the design of user interfaces, we are concerned with several issues: the provision of languages by which users can express their commands to the computer; the design of display representations that show the state of the system to the user; and other more abstract issues that affect the user's understanding of the system's behavior. Many of these issues are highly subjective and are therefore often addressed in an *ad hoc* fashion. We believe, however,

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that more rigorous approaches to user interface design can be developed. . . .

These design methodologies are all unsatisfactory for the same basic reason: they all omit an essential step that must precede the design of any successful user interface, namely *task analysis*. By this we mean the analysis of the task performed by the user, or users, prior to introducing the proposed computer system. Task analysis involves establishing who the users are, what their goals are in performing the task, what information they use in performing it, what information they generate, and what methods they employ. The descriptions of input and output information should include an analysis of the various *objects*, or individual types of information entity, employed by the user. . . .

The purpose of task analysis is to simplify the remaining stages in user interface design. The *current task description*, with its breakdown of the information objects and methods presently employed, offers a starting point for the definition of a corresponding set of objects and methods to be provided by the computer system. The idea behind this phase of design is to build up a new *task environment* for the user, in which he can work to accomplish the same goals as before, surrounded now by a different set of objects, and employing new methods.

Prototyping is another crucial element of the design process. System designers should be prepared to implement the new or difficult concepts and then to *throw away* that code when doing the actual implementation. As Frederick Brooks says, the question "is not *whether* to build a pilot system and throw it away. You *will* do that. The only question is whether to plan in advance to build a throwaway, or to promise to deliver the throwaway to customers. . . . Hence *plan to throw one away; you will, anyhow.*" (See reference 2.) The Alto served as a valuable prototype for Star. Over a thousand Altos were eventually built. Alto users have had several thousand work-years of experience with them over a period of eight years, making Alto perhaps the largest prototyping effort ever. Dozens of experimental programs were written for the Alto by members of the Xerox Palo Alto Research Center. Without the creative ideas of the authors of those systems, Star in its present form would have been impossible. In addition, we ourselves programmed various aspects of the Star design on Alto, but all of it was "throwaway" code. Alto, with its bit-mapped display screen, was powerful enough to implement and test our ideas on visual interaction.

Some types of concepts are inherently difficult for people to grasp. Without being too formal about it, our experience before and during the Star design led us to the following classification:

Easy	*Hard*
concrete	abstract
visible	invisible
copying	creating
choosing	filling in
recognizing	generating
editing	programming
interactive	batch

The characteristics on the left were incorporated into the Star user's conceptual model. The characteristics on the right we attempted to avoid.

Principles Used

The following main goals were pursued in designing the Star user interface:

- familiar user's conceptual model
- seeing and pointing versus remembering and typing
- what you see is what you get
- universal commands
- consistency
- simplicity
- modeless interaction
- user tailorability

We will discuss each of these in turn.

Familiar User's Conceptual Model

A *user's conceptual model* is the set of concepts a person gradually acquires to explain the behavior of a system, whether it be a computer

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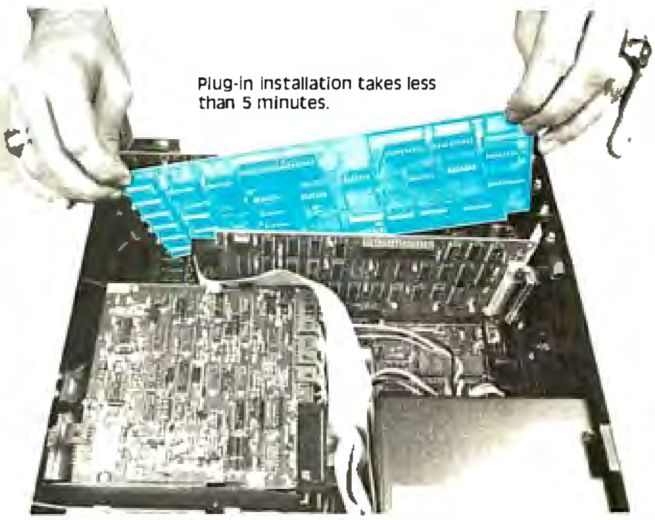

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system, a physical system, or a hypothetical system. It is the model developed in the mind of the user that enables that person to understand and interact with the system. The first task for a system designer is to decide what model is preferable for users of the system. This extremely important step is often neglected or done poorly. The Star designers devoted several work-years at the outset of the project discussing and evolving what we considered an appropriate model for an office information system: the metaphor of a physical office.

The designer of a computer system can choose to pursue familiar analogies and metaphors or to introduce entirely new functions requiring new approaches. Each option has advantages and disadvantages. We decided to create electronic counterparts to the physical objects in an office: paper, folders, file cabinets, mail boxes, and so on—an electronic metaphor for the office. We hoped this would make the electronic "world" seem more familiar, less alien, and require less training. (Our initial experiences with users have confirmed this.) We further decided to make the electronic analogues be *concrete objects*. Documents would be more than file names on a disk; they would also be represented by pictures on the display screen. They would be selected by pointing to them with the mouse and clicking one of the buttons. Once selected, they would be moved, copied, or deleted by pushing the appropriate key. Moving a document became the electronic equivalent of picking up a piece of paper and walking somewhere with it. To file a document, you would move it to a picture of a file drawer, just as you take a physical piece of paper to a physical file cabinet.

The reason that the user's conceptual model should be decided *first*

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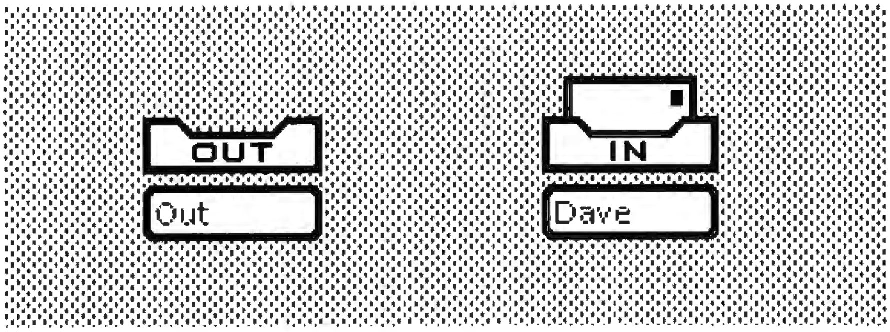

Figure 1: *In-basket and out-basket icons. The in-basket contains an envelope indicating that mail has been received. (This figure was taken directly from the Star screen. Therefore, the text appears at screen resolution.)*

when designing a system is that the approach adopted *changes the functionality of the system.* An example is electronic mail. Most electronic-mail systems draw a distinction between *messages* and *files* to be sent to other people. Typically, one program sends messages and a different program handles file transfers, each with its own interface. But we observed that offices make no such distinction. Everything arrives through the mail, from one-page memos to books and reports, from intraoffice mail to international mail. Therefore, this became part of Star's physical-office metaphor. Star users mail documents of any size, from one page to many pages. Messages are short documents, just as in the real world. User actions are the same whether the recipients are in the next office or in another country.

A physical metaphor can simplify and clarify a system. In addition to eliminating the artificial distinctions of traditional computers, it can eliminate commands by taking advantage of more general concepts. For example, since moving a document on the screen is the equivalent of picking up a piece of paper and walking somewhere with it, there is no "send mail" command. You simply move it to a picture of an out-basket. Nor is there a "receive mail" command. New mail appears in the in-basket as it is received. When new mail is waiting, an envelope appears in the picture of the in-basket (see figure 1). This is a simple, familiar, nontechnical approach to computer mail. And it's easy once the physical-office metaphor is adopted!

While we want an analogy with the physical world for familiarity, we don't want to limit ourselves to its capabilities. One of the raisons d'être for Star is that physical objects do not provide people with enough power to manage the increasing complexity of the "information age." For example, we can take advantage of the computer's ability to search rapidly by providing a search function for its electronic file drawers, thus helping to solve the long-standing problem of lost files.

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The "Desktop"

Every user's initial view of Star is the "Desktop," which resembles the top of an office desk, together with surrounding furniture and equipment. It represents your working environment—where your current projects and accessible resources reside. On the screen are displayed pictures of familiar office objects, such as documents, folders, file drawers, in-baskets, and out-baskets. These objects are displayed as small pictures or "icons," as shown in figure 2.

You can "open" an icon to deal with what it represents. This enables you to read documents, inspect the contents of folders and file drawers, see what mail you have received, etc. When opened, an icon expands into a larger form called a "window," which displays the icon's contents. Windows are the principal mechanism for displaying and manipulating information.

The Desktop "surface" is displayed as a distinctive gray pattern. This restful design makes the icons and windows on it stand out crisply, minimizing eyestrain. The surface is organized as an array of one-inch squares, 14 wide by 11 high. An icon can be placed in any square, giving a maximum of 154 icons. Star centers an icon in its square, making it easy to line up icons neatly. The Desktop always occupies the entire display screen; even when windows appear on the screen, the Desktop continues to exist "beneath" them.

The Desktop is the principal Star technique for realizing the physical-office metaphor. The icons on it are visible, concrete embodiments of the corresponding physical objects. Star users are encouraged to think of the objects on the Desktop in physical terms. Therefore, you can move the icons around to arrange your Desktop as you wish. (Messy Desktops are certainly possible, just as in real life.) Two icons cannot occupy the same space (a basic law of physics). Although moving a document to a Desktop resource such as a printer involves transferring the document icon to the same square as the printer icon, the printer immediately "absorbs" the document, queuing it for printing. You can leave

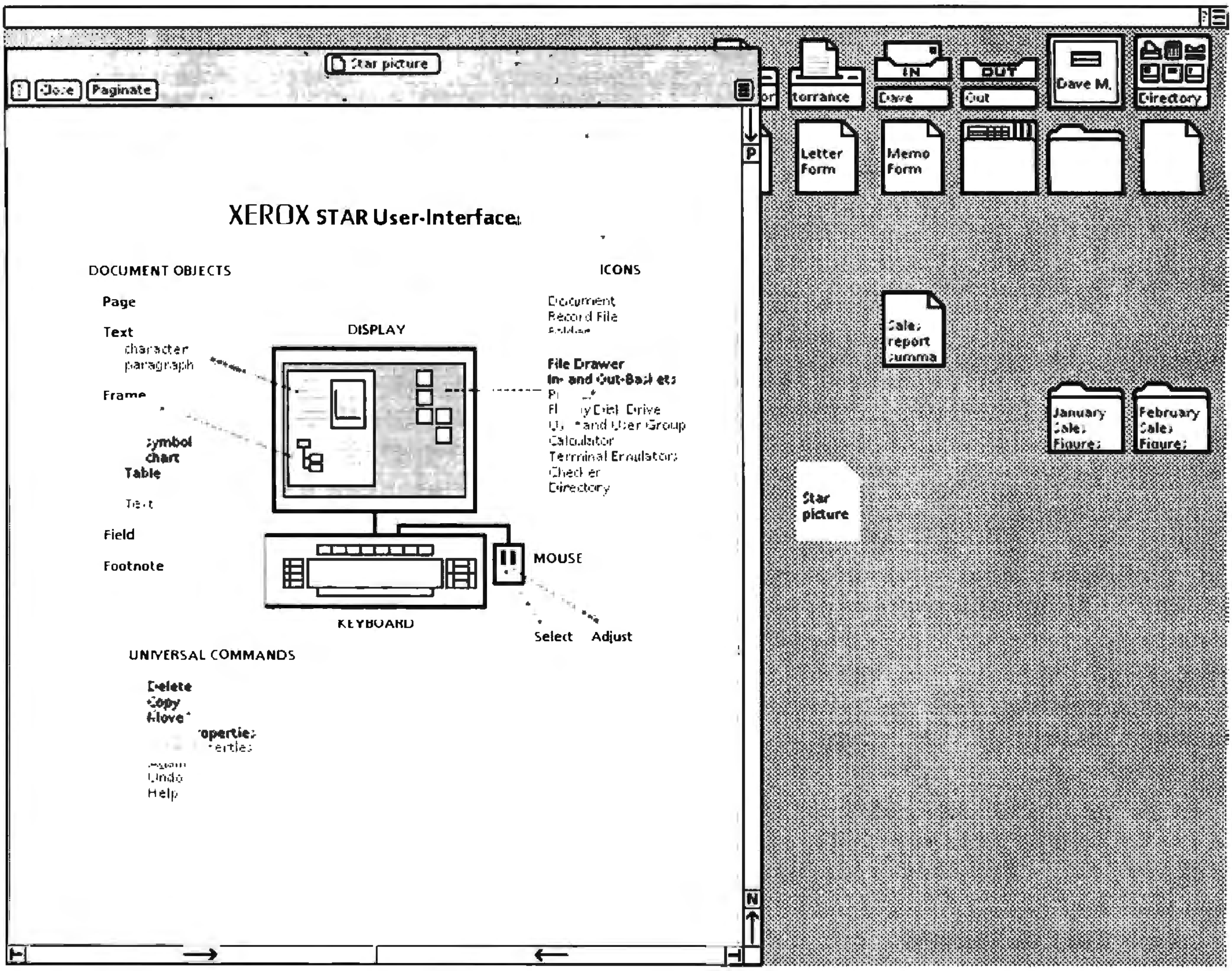

Figure 2: *A Desktop as it appears on the Star screen. Several commonly used icons appear across the top of the screen, including documents to serve as "form-pad" sources for letters, memos, and blank paper. An open window displaying a document containing an illustration is also shown.*

The revolutionary Discovery multiprocessor is the only system that allows the total integration of powerful 16 bit 8086 processors with the more standard Z-80 user processors. The DISCOVERY system may be configured in any 8 bit/16 bit combination, or as a totally exclusive 16 bit system only to provide the ultimate in performance and flexibility in advanced micro systems.

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documents on your Desktop indefinitely, just as on a real desk, or you can file them away in folders or file drawers. Our intention and hope is that users will *intuit* things to do with icons, and that those things will indeed be part of the system. This will happen if:

(a) Star models the real world accurately enough. Its *similarity* with the office environment preserves your familiar way of working and your existing concepts and knowledge.
(b) Sufficient *uniformity* is in the system. Star's principles and "generic" commands (discussed below) are applied throughout the system, allowing lessons learned in one area to apply to others.

The model of a physical office provides a simple base from which learning can proceed in an incremental fashion. You are not exposed to entirely new concepts all at once. Much of your existing knowledge is embedded in the base.

In a functionally rich system, it is probably not possible to represent everything in terms of a single model. There may need to be more than one model. For example, Star's records-processing facility cannot use the physical-office model because physical offices have no "records processing" worthy of the name. Therefore, we invented a different model, a record file as a collection of *fields*. A record can be displayed as a row in a *table* or as filled-in fields in a *form*. Querying is accomplished by filling in a blank example of a record with predicates describing the desired values, which is philosophically similar to Zloof's "Query-by-Example" (see reference 21).

Of course, the number of different user models in a system must be kept to a minimum. And they should not overlap; a new model should be introduced only when an existing one does not cover the situation.

Seeing and Pointing

A well-designed system makes everything relevant to a task visible on the screen. It doesn't hide things under CODE+key combinations or

force you to remember conventions. That burdens your memory. During conscious thought, the brain utilizes several levels of memory, the most important being the "short-term memory." Many studies have analyzed the short-term memory and its role in thinking. Two conclusions stand out: (1) conscious thought deals with concepts in the short-term memory (see reference 1) and (2) the capacity of the short-term memory is limited (see reference 14). When everything being dealt with in a computer system is visible, the display screen relieves the load on the short-term memory by acting as a sort of "visual cache." Thinking becomes easier and more productive. A well-designed computer system can actually improve the *quality* of your thinking (see reference 16). In addition, visual communication is often more efficient than linear communication; a picture is worth a thousand words.

A subtle thing happens when everything is visible: *the display becomes reality*. The user model becomes identical with what is on the screen. Objects can be understood purely in terms of their visible characteristics. Actions can be understood in terms of their effects on the screen. This lets users *conduct experiments* to test, verify, and expand their understanding—the essence of experimental science.

In Star, we have tried to make the objects and actions in the system *visible*. Everything to be dealt with and all commands and effects have a visible representation on the display screen or on the keyboard. You never have to remember that, for example, CODE+Q does something in one context and something different in another context. In fact, our desire to eliminate this possibility led us to

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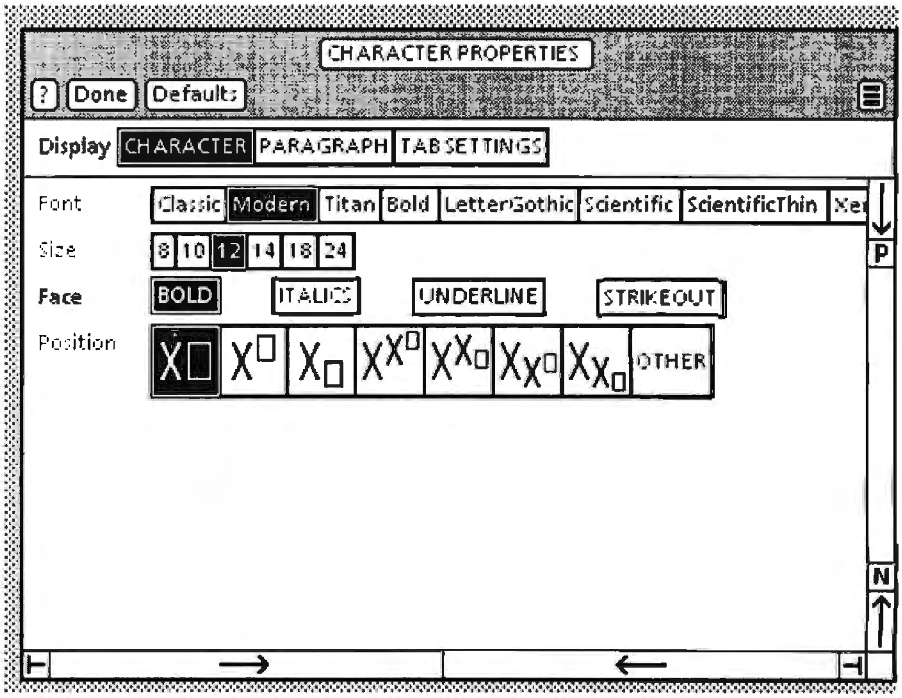

Figure 3: *The property sheet for text characters.*

abolish the CODE key. (We have yet to see a computer system with a CODE key that doesn't violate the principle of visibility.) You never invoke a command or push a key and have nothing visible happen. At the very least, a message is posted explaining that the command doesn't work in this context, or it is not implemented, or there is an error. It is disastrous to the user's model when you invoke an action and the system does nothing in response. We have seen people push a key several times in one system or another trying to get a response. They are not sure whether the system has "heard" them or not. Sometimes the system is simply throwing away their keystrokes. Sometimes it is just slow and is *queuing* the keystrokes; you can imagine the unpredictable behavior that is possible.

We have already mentioned icons and windows as mechanisms for making the concepts in Star visible. Other such mechanisms are Star's *property and option sheets.* Most objects in Star have properties. A property sheet is a two-dimensional, form-like environment that displays those properties. Figure 3 shows the character property sheet. It appears on the screen whenever you make a text selection and push the PROPERTIES key. It contains such properties as type font and size; bold, italic, underline, and strikeout face; and superscript/subscript positioning. Instead of having to remember the properties of characters, the current settings of those properties, and, worst of all, how to change those properties, property sheets simply *show everything on the screen. All* the options are presented. To change one, you point to it with the mouse and push a button. Properties in effect are displayed in reverse video.

This mechanism is used for *all* properties of *all* objects in the system. Star contains a couple of hundred properties. To keep you from being overwhelmed with information, property sheets display only the properties relevant to the type of object currently selected (e.g., character, paragraph, page, graphic line, formula element, frame, document, or folder). This is an example of "progressive disclosure": hiding complexity until it is needed. It is also one of the clearest examples of how an emphasis on visibility can reduce the amount of remembering and typing required.

Property sheets may be thought of as an *alternate representation* for ob-

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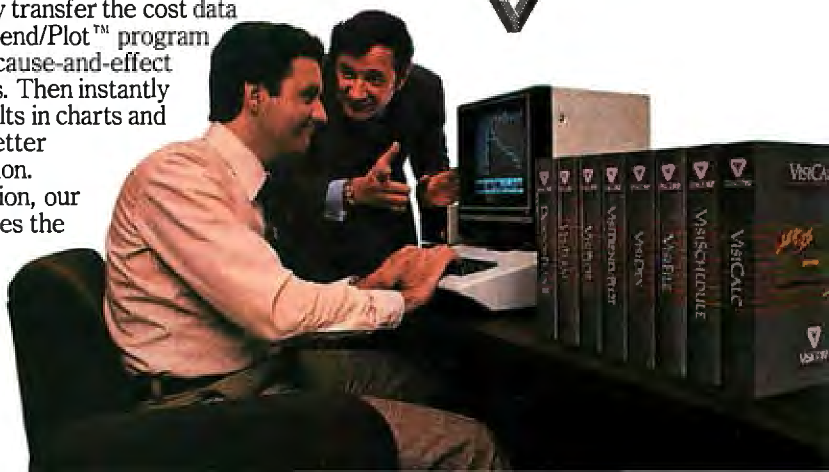

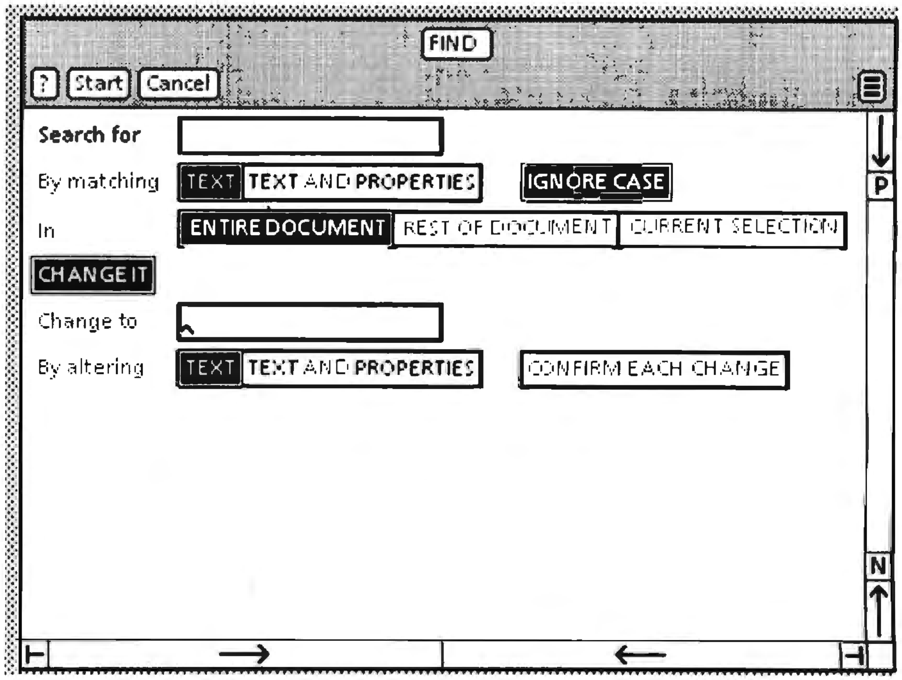

Figure 4: *The option sheet for the Find command showing both the Search and Substitute options. The last two lines of options appear only when CHANGE IT is turned on.*

jects. The screen shows you the visible characteristics of objects, such as the type font of text characters or the names of icons. Property sheets show you the underlying structure of objects as they make this structure visible and accessible.

Invisibility also plagues the commands in some systems. Commands often have several arguments and options that you must remember with no assistance from the system. Star addresses this problem with *option sheets* (see figure 4), a two-dimensional, form-like environment that displays the arguments to commands. It serves the same function for command arguments that property sheets do for object properties.

What You See Is What You Get

"What you see is what you get" (or WYSIWYG) refers to the situation in which the display screen portrays an accurate rendition of the printed page. In systems having such capabilities as multiple fonts and variable line spacing, WYSIWYG requires a bit-mapped display because only that has sufficient graphic power to render those characteristics accurately.

WYSIWYG is a simplifying technique for document-creation systems. All **composition** is done *on the screen*. It eliminates the iterations that plague users of document compilers. You can examine the appearance of a page *on the screen* and make changes until it looks right. The printed page will look the same (see figure 5). Anyone who has used a document compiler or post-processor knows how valuable WYSIWYG is. The first powerful WYSIWYG editor was Bravo, an experimental editor developed for Alto at the Xerox Palo Alto Research Center (see reference 12). The text-editor aspects of Star were derived from Bravo.

Trade-offs are involved in WYSIWYG editors, chiefly having to do with the lower resolution of display screens. It is never possible to get an *exact* representation of a printed page on the screen since most screens have only 50 to 100 dots per inch (72 in Star), while most printers have higher resolution. Completely accurate character positioning is not possible. Nor is it usually possible to represent shape differences for fonts smaller than eight points in size since there are too few dots per character to

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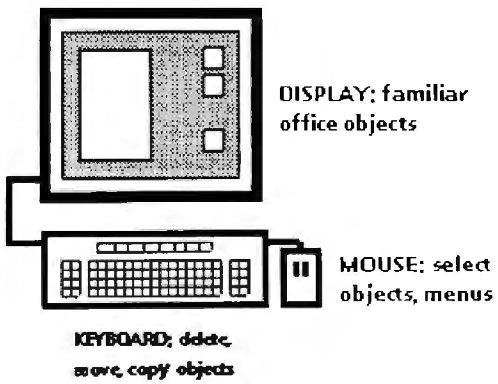
The mouse - A unique pointing device that allows the user to quickly select any text, graphic or office object on the display.

See and Point

All Star functions are visible to the user on the keyboard or on the screen. The user does filing and retrieval by selecting them with the mouse and touching the MOVE, COPY, DELETE or PROPERTIES command keys. Text and graphics are edited with the same keys.



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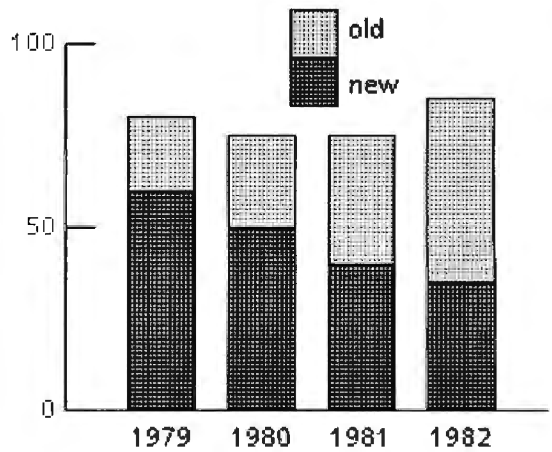

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Star users are likely to do more of their own composition and layout, controlling the entire process including printing and distribution.

Text and Graphics

To replace typesetting, Star offers a choice of type fonts and sizes, from 8 point to 24 point.

Here is a sentence of 8-point text.
Here is a sentence of 10-point text.
Here is a sentence of 12-point text.
Here is a sentence of 14-point text.
Here is a sentence of 18-point text.

Figure 5: *A Star document showing multicolumn text, graphics, and formulas. This is the way the **document** appears on the screen. It is also the way it will print (at higher resolution, of course).*

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P.O. Box 240947 • Charlotte, NC 28224 • 704/523-8500 be recognizable. Even 10-point ("normal" size) fonts may be uncomfortably small on the screen, necessitating a magnified mode for viewing text. WYSIWYG requires very careful design of the screen fonts in order to keep text on the screen readable and attractive. Nevertheless, the increase in productivity made possible by WYSIWYG editors more than outweighs these difficulties.

Universal Commands

Star has a few commands that can be used throughout the system: MOVE, COPY, DELETE, SHOW PROPERTIES, COPY PROPERTIES, AGAIN, UNDO, and HELP. Each performs the same way regardless of the type of object selected. Thus, we call them "universal" or "generic" commands. For example, you follow the same set of actions to move text in a document and to move a line in an illustration or a document in a folder: select the object, push the MOVE key, and indicate a destination. (HELP and UNDO don't use a selection.) Each generic command has a key devoted to it on the keyboard.

These commands are far more basic than the commands in other computer systems. They strip away the extraneous application-specific semantics to get at the underlying principles. Star's generic commands derive from fundamental computer-science concepts because they also underlie operations in programming languages. For example, much program manipulation of data structures involves moving or copying values from one data structure to another. Since Star's generic commands embody fundamental underlying concepts, they are widely applicable. Each command fills a variety of needs, meaning fewer commands are required. This simplicity is desirable in itself, but it has another subtle advantage: it makes it easy for users to form a model of the system. People can use what they understand. Just as progress in science derives from simple, clear theories, progress in the usability of computers is coming to depend on simple, clear user interfaces.

MOVE is the most powerful command in the system. It is used during text editing to rearrange letters in a word, words in a sentence, sentences in a paragraph, and paragraphs in a document. It is used during graphics editing to move picture elements, such as lines and rectangles, around in an illustration. It is used during formula editing to move mathematical structures, such as summations and integrals, around in an equation. It replaces the conventional "store file" and "retrieve file" commands; you simply move an icon into or out of a file drawer or folder. It eliminates the "send mail" and "receive mail" commands; you move an icon to an out-basket or from an in-basket. It replaces the "print" command; you move an icon to a printer. And so on. MOVE strips away much of the historical clutter of computer commands. It is more fundamental than the myriad of commands it replaces. It is simultaneously more powerful and simpler.

Much simplification comes from Star's object-oriented interface. The action of setting properties also replaces a myriad of commands. For example, changing paragraph margins is a command in many systems. In Star, you do it by selecting a paragraph object and setting its MARGINS property. (For more information on object-oriented languages, see the August 1981 BYTE.)

Consistency

Consistency asserts that mechanisms should be used in the same way wherever they occur. For example, if the left mouse button is used to select a character, the same button should be used to select a graphic line or an icon. Everyone agrees that consistency is an admirable goal. However, it is perhaps the single hardest characteristic of all to achieve in a computer system. In fact, in systems of even moderate complexity, consistency may not be well defined.

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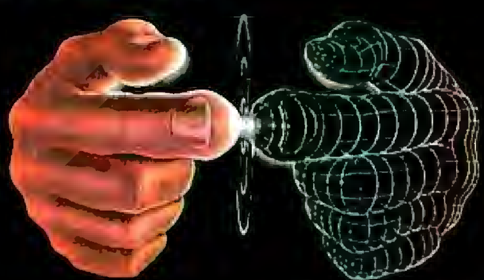

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sus in Star is what should happen to a document after it has been printed. Recall that a user prints a document by selecting its icon, invoking MOVE, and designating a printer icon. The printer absorbs the document, queuing it for printing. What happens to that document icon after printing is completed? The two plausible alternatives are:

1. The system deletes the icon.
2. The system does not delete the icon, which leads to several further alternatives:
   - 2a. The system puts the icon back where it came from (i.e., where it was before MOVE was invoked).
   - 2b. The system puts the icon at an arbitrary spot on the Desktop.
   - 2c. The system leaves the icon in the printer. You must move it out of the printer explicitly.

The consistency argument for the first alternative goes as follows: when you move an icon to an out-basket, the system mails it and then deletes it from your Desktop. When you move an icon to a file drawer, the system files it and then deletes it from your Desktop. Therefore, when you move an icon to a printer, the system should print it and then delete it from your Desktop. Function icons should behave consistently with one another.

The consistency argument for the second alternative is: the user's conceptual model at the Desktop level is the physical-office metaphor. Icons are supposed to behave similarly to their physical counterparts. It makes sense that icons are deleted after they are mailed because after you put a piece of paper in a physical out-basket and the mailperson picks it up, it *is* gone. However, the physical analogue for printers is the office copier, and there is no notion of deleting a piece of paper when you make a copy of it. Function icons should behave consistently with their physical counterparts.

There is no one right answer here. Both arguments emphasize a dimension of consistency. In this case, the dimensions happen to overlap. We eventually chose alternative 2a for the following reasons:

1. *Model dominance*—The physical metaphor is the stronger model at the Desktop level. Analogy with physical counterparts *does* form the basis for people's understanding of what icons are and how they behave. Argument 1 advocates an *implicit* model that must be learned; argument 2 advocates an *explicit* model that people already have when they are introduced to the system. Since people do use their existing knowledge when confronted with new situations, the design of the system should be based on that knowledge. This is especially important if people are to be able to *intuit* new uses for the features they have learned.

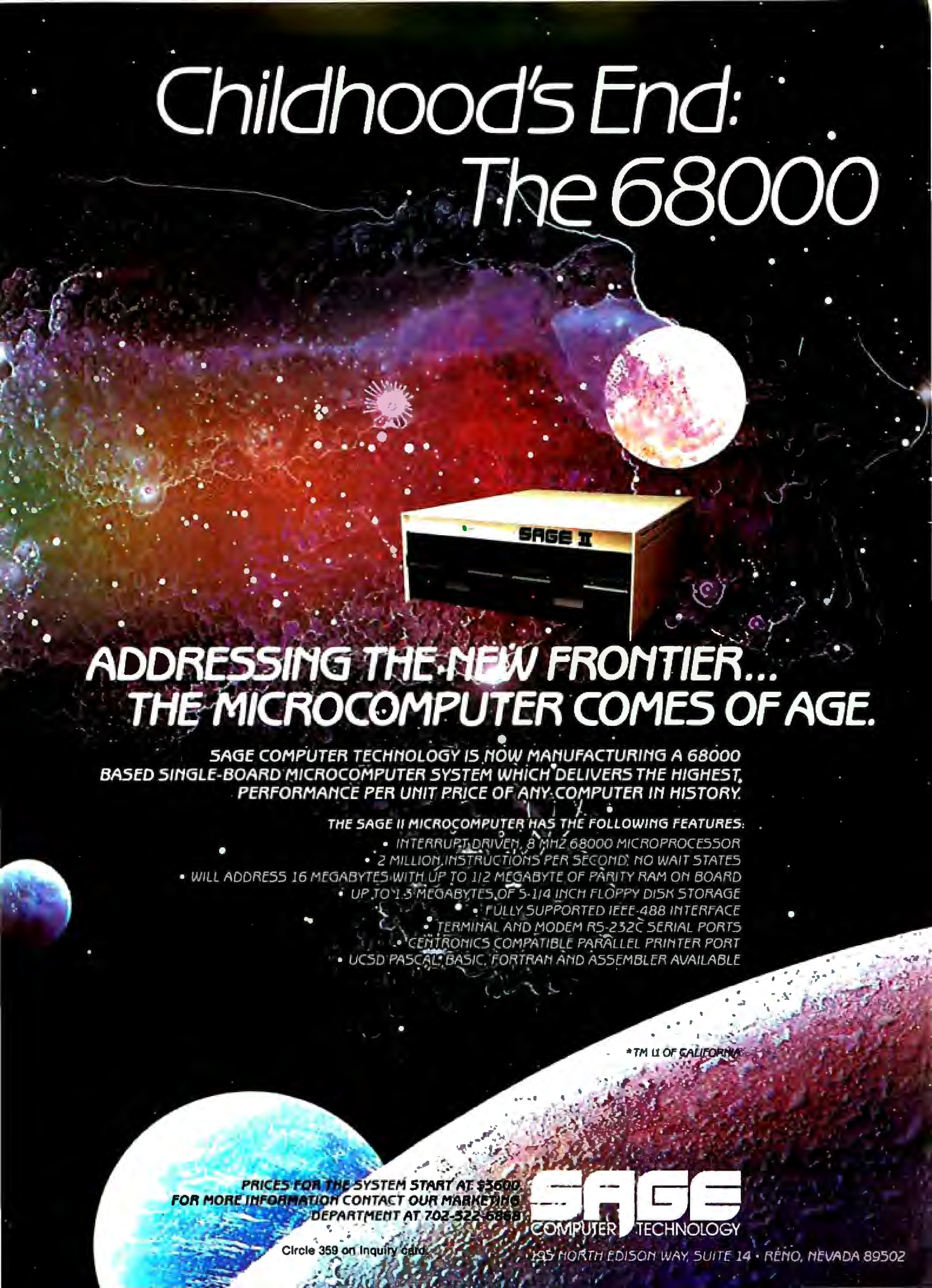
2. *Pragmatics*—It is dangerous to delete things when users don't expect it. The first time a person labors over a document, gets it just right, prints it, and finds that it has disappeared, that person is going to become *very nervous*, not to mention angry. We also decided to put it back where it came from (2a instead of 2b or 2c) for the pragmatic reason that this involves slightly less work on the user's part.

3. *Seriousness*—When you file or mail an icon, it is not deleted entirely from the system. It still exists in the file drawer or in the recipients' in-baskets. If you want it back, you can move it back out of the file drawer or send a message to one of the recipients asking to have a copy sent back. Deleting after printing, however, is final; if you move a document to a printer and the printer deletes it, that document is gone for good.

One way to get consistency into a system is to adhere to *paradigms* for operations. By applying a successful way of working in one area to other areas, a system acquires a unity that is both apparent and real. Paradigms that Star uses are:

• *Editing*—Much of what you do in Star can be thought of as editing. In addition to the conventional text, graphics, and formula editing, you manage your files by *editing filing windows*. You arrange your working environment by *editing your Desktop*. You alter properties by *editing property sheets*. Even programming can be thought of as *editing data structures* (see reference 16).

• *Information retrieval*—A lot of



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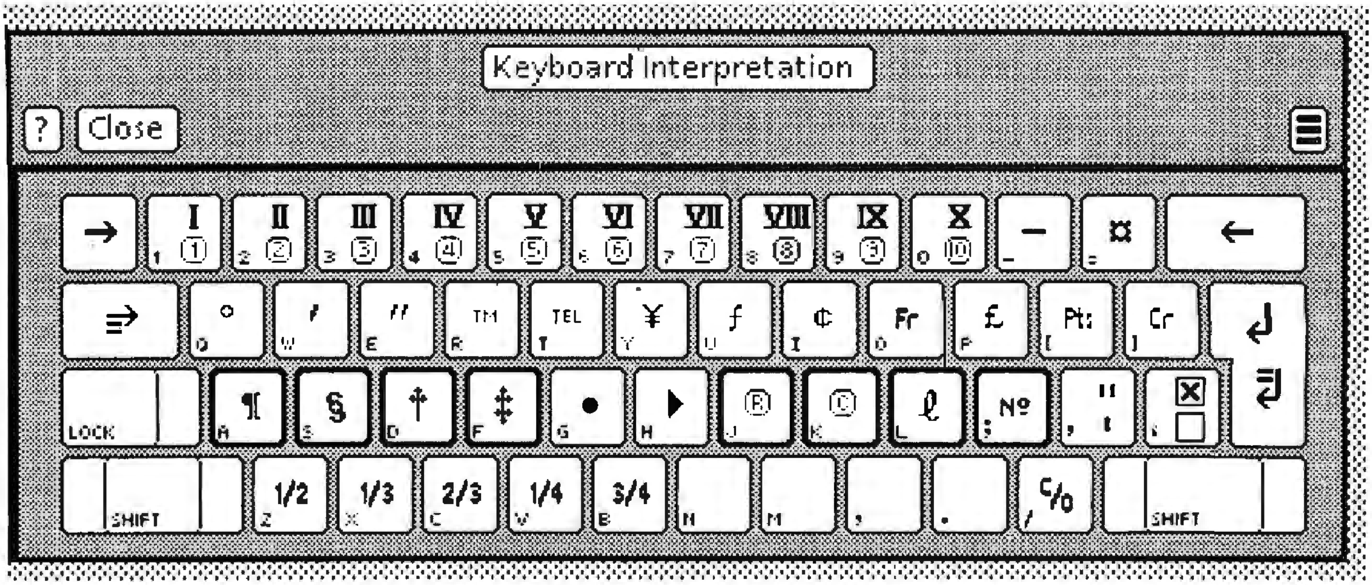


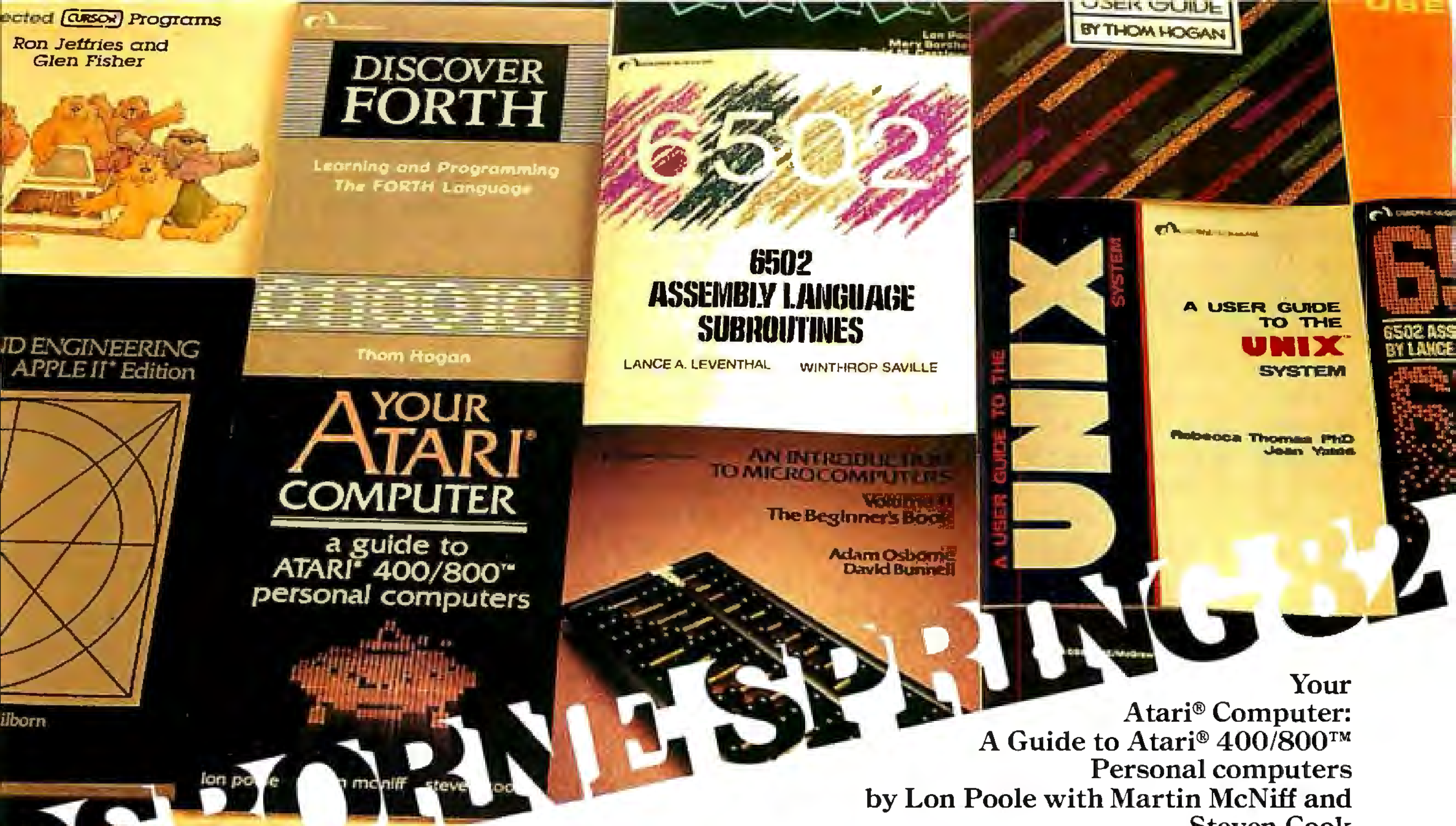
Figure 6: *The keyboard-interpretation window serves as the source of characters that may be entered from the keyboard. The character set shown here contains a variety of office symbols.*

power can be gained by applying information-retrieval techniques to information wherever it exists in a system. Star broadens the definition of "database." In addition to the traditional notion as represented by its record files, Star views file drawers as databases of documents, in-baskets as databases of mail, etc. This teaches users to think of information retrieval as a general tool applicable throughout the system.

• *Copying*—Star elevates the concept of "copying" to a high level: that of a paradigm for creating. In all the various domains of Star, you *create by copying*. Creating something out of nothing is a difficult task. Everyone has observed that it is easier to modify an existing document or program than to write it originally. Picasso once said, "The most awful thing for a painter is the white canvas . . . To copy others is necessary." (See reference 20.) Star makes a serious attempt to alleviate the problem of the "white canvas" by making copying a practical aid to creation. For example, you create new icons by copying existing ones. Graphics are created by copying existing graphic images and modifying them. In a sense, you can even type characters in Star's 2^{16}-character set by "copying" them from keyboard windows (see figure 6).

These paradigms *change the very way you think*. They lead to new habits and models of behavior that are more powerful and productive. They can lead to a *human-machine synergism*.

Star obtains additional consistency by using the class and subclass no-



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tions of Simula (see reference 4) and Smalltalk (see reference 11). The clearest example of this is classifying icons at a higher level into *data icons* and *function icons*. Data icons represent objects on which actions are performed. Currently, the three types (i.e., subclasses) of data icons are documents, folders, and record files. Function icons represent objects that perform actions. Function icons are of many types, with more being added as the system evolves: file drawers, in- and out-baskets, printers, floppy-disk drives, calculators, terminal emulators, etc.

In general, anything that can be done to one data icon can be done to all, regardless of its type, size, or location. All data icons can be moved, copied, deleted, filed, mailed, printed, opened, closed, and a variety of other operations applied. Most function icons will accept any data icon; for example, you can move any data icon to an out-basket. This use of the class concept in the user-interface design reduces the artificial distinctions that occur in some systems.

Simplicity

Simplicity is another principle with which no one can disagree. Obviously, a simple system is better than a complicated one if they have the same capabilities. Unfortunately, the world is never as simple as that. Typically, a trade-off exists between easy novice use and efficient expert use. The two goals are not always compatible. In Star, we have tried to follow Alan Kay's maxim: "simple things should be simple; complex things should be possible." To do this, it was sometimes necessary to make common things simple at the expense of uncommon things being harder. Simplicity, like consistency, is not a clear-cut principle.

One way to make a system appear simple is to make it uniform and consistent, as we discussed earlier. Adhering to those principles leads to a *simple user's model*. Simple models are easier to understand and work with than intricate ones.

Another way to achieve simplicity is to minimize the redundancy in a system. Having two or more ways to do something increases the complexity without increasing the capabilities. The ideal system would have a minimum of powerful commands that obtained all the desired functionality and that did not overlap. That was the motivation for Star's "generic" commands. But again the world is not so simple. General mechanisms are often inconvenient for high-frequency actions. For example, the SHOW PROPERTIES command is Star's general mechanism for changing properties, but it is too much of an interruption during typing. Therefore, we added keys to optimize the changing of certain character properties: BOLD, ITALICS, UNDERLINE, SUPERSCRIPT, SUBSCRIPT, LARGER/SMALLER (font), CENTER (paragraph). These significantly speed up typing, but they don't add any new functionality. In this case, we felt the trade-off was worth

it because typing is a frequent activity. "Minimum redundancy" is a good but not absolute guideline.

In general, it is better to introduce new *general* mechanisms by which "experts" can obtain accelerators rather than add a lot of special one-purpose-only features. Star's mechanisms are discussed below under "User Tailorability."

Another way to have the system as a whole appear simple is to make each of its parts simple. In particular, the system should avoid overloading the semantics of the parts. Each part should be kept conceptually clean. Sometimes, this may involve a major redesign of the user interface. An example from Star is the mouse, which has been used on the Alto for eight years. Before that, it was used on the NLS system at Stanford Research Institute (see reference 5). All of those mice have three buttons on top. Star has only two. Why did we depart from "tradition"? We observed that the dozens of Alto programs all had different semantics for the mouse buttons. Some used them one way, some another. There was no consistency between systems. Sometimes, there was not even consistency *within* a system. For example, Bravo uses the mouse buttons for selecting text, scrolling windows, and creating and deleting windows, depending on where the cursor is when you push a mouse button. Each of the three buttons has its own meaning in each of the different regions. It is difficult to remember which button does what where.

Thus, we decided to simplify the mouse for Star. Since it is apparently quite a temptation to overload the semantics of the buttons, we eliminated temptation by eliminating buttons. Well then, why didn't we use a one-button mouse? Here the plot thickens. We did consider and prototype a one-button mouse interface. One button is sufficient (with a little cleverness) to provide all the functionality needed in a mouse. But when we tested the interface on naive users, as we did with a variety of features, we found that they had a lot of trouble making selections with it. In fact, we prototyped and tested six different semantics for the mouse buttons: one one-button, four two-button, and a three-button design. We were chagrined to find that while some were better than others, *none of them* was completely easy to use, even though, a priori, it seemed like all of them would work! We then took the most successful features of two of the two-button designs and prototyped and tested them as a seventh design. To our relief, it not only tested better than any of the other six, everyone found it simple and trouble-free to use.

This story has a couple of morals:

- The intuition of designers is error-prone, no matter how good or bad they are.
- The critical parts of a system should be tested on representative users, preferably of the "lowest common denominator" type.
- What is simplest along any one dimension (e.g., number of buttons) is not necessarily conceptually simplest for users; in particular, minimizing the number of keystrokes may not make a system easier to use.

Modeless Interaction

Larry Tesler defines a *mode* as follows:

> A mode of an interactive computer system is a state of the user interface that lasts for a period of time, is not associated with any particular object, and has no role other than to place an interpretation on operator input. (See reference 18.)

Many computer systems use modes because there are too few keys on the keyboard to represent all the available commands. Therefore, the interpretation of the keys depends on the mode or state the system is in. Modes can and do cause trouble by making habitual actions cause unexpected results. If you do not notice what mode the system is in, you may find yourself invoking a sequence of commands quite different from what you had intended.

Our favorite story about modes, probably apocryphal, involves Bravo. In Bravo, the main typing keys are normally interpreted as commands. The "i" key invokes the Insert command, which puts the system in "insert mode." In insert mode, Bravo interprets keystrokes as letters. The story goes that a person intended to type the word "edit" into his document, but he forgot to enter insert mode first. Bravo interpreted "edit" as the following commands:

E(verything)	select everything in the document
D(elete)	delete it
I(nsert)	enter insert mode
t	type a "t"

The entire contents of the document were replaced by the letter "t." This makes the point, perhaps too strongly, that modes should be introduced into a user interface with caution, if at all.

Commands in Star take the form of noun-verb. You specify the object of interest (the noun) and then invoke a command to manipulate it (the verb). Specifying an object is called "making a selection." Star provides powerful selection mechanisms that reduce the number and complexity of commands in the system. Typically, you will exercise more dexterity and judgment in making a selection than in invoking a command. The object (noun) is almost always specified before the action (verb) to be performed. This helps make the command interface modeless; you can change your mind as to which object to affect simply by making a new selection before invoking the **command.** No "accept" function is needed to terminate or confirm commands since invoking the command is the last step. Inserting text does not even require a command; you simply make a selection and begin typing. The text is placed after the end of the selection.

The noun-verb command form does not by itself imply that a command interface is modeless. Bravo also uses the noun-verb form; yet, it is a highly modal editor (although the latest version of Bravo has drastically reduced its modalness). The difference is that Bravo tries to make

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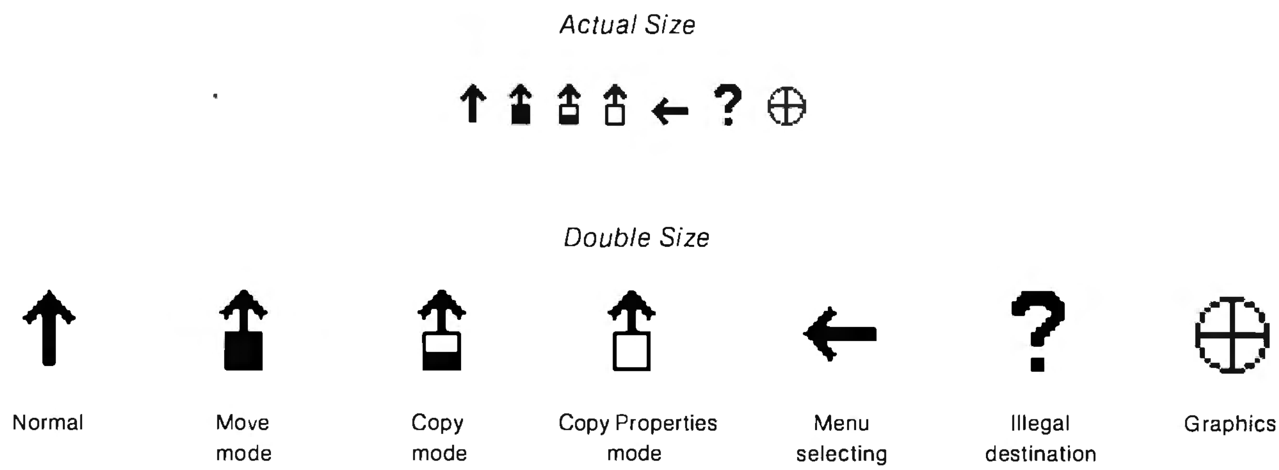

Figure 7: *Some of the cursor shapes used by the Star to indicate the state of the system. The cursor is a 16- by 16-bit map that can be changed under program control.*

one mechanism (the main typing keys) serve more than one function (entering letters and invoking commands). This inevitably leads to confusion. Star avoids the problem by having special keys on the keyboard devoted solely to invoking functions. The main typing keys only enter characters. (This is another example of the simplicity principle: avoid overloading mechanisms with meanings.)

Modes are not necessarily bad. Some modes can be helpful by simplifying the specification of extended commands. For example, Star uses a "field fill-in order specification mode." In this mode, you can specify the order in which the NEXT key will step through the fields in the document. Invoking the SET FILL-IN ORDER command puts the system in the mode. Each field you now select is added to the fill-in order. You terminate the mode by pushing the STOP key. Star also utilizes temporary modes as part of the MOVE, COPY, and COPY PROPERTIES commands. For example, to move an object, you select it, push the MOVE key that puts the system in "move mode," and then select the destination. These modes work for two reasons. First, *they are visible*. Star posts a message in the Message Area at the top of the screen indicating that a mode is in effect. The message remains there for the duration of the mode. Star also changes the shape of the cursor as an additional indication. You can always tell the state of the system by inspection (see figure 7). Second, *the allowable actions are constrained during modes*. The only action that is allowed—except for actions directly related to the mode—is scrolling to another part of the document. This constraint makes it even more apparent that the system is in an unusual state.

User Tailorability

No matter how general or powerful a system is, it will never satisfy all its potential users. People always want ways to speed up often-performed operations. Yet, everyone is different. The only solution is to design the system with provisions for user extensibility built in. The following mechanisms are provided by Star:

- You can tailor the appearance of your system in a variety of ways. The simplest is to choose the icons you want on your Desktop, thus tailoring your working environment. At a more sophisticated level, a work station can be purchased with or without certain functions. For example, not everyone may want the equation facility. Xerox calls this "product factoring."
- You can set up blank documents with text, paragraph, and page layout defaults. For example, you might set up one document with the normal text font being 10-point Classic and another with it being 12-point Modern italic. The documents need not be blank; they may contain fixed text and graphics, and fields for variable fill-in. A typical form might be a business-letter form with address, addressee, salutation, and body fields, each field with its own default text style. Or it might be an accounting form with lines and tables. Or it might be a mail form with To, From, and Subject fields, and a heading tailored to each individual. Whatever the form or document, you can put it on your Desktop and make new instances of it by selecting it and invoking COPY. Thus, each form can act like a "pad of paper" from which new sheets can be "torn off."

  Interesting documents to set up are "transfer sheets," documents containing a variety of graphics symbols tailored to different applications. For example, you might have a transfer sheet containing buildings in different sizes and shapes, or one devoted to furniture, animals, geometric shapes, flowchart symbols, circuit components, logos, or a hundred other possibilities. Each sheet would make it easier to create a certain type of illustration. Graphics experts could even construct the symbols on the sheets, so that users could create high-quality illustrations without needing as much skill.
- You can tailor your filing system by changing the sort order in file drawers and folders. You can also control the

TRS-80* COMPUTING EDITION

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Percom's DOUBLER II™ tolerates wide variations in media, drives

GARLAND, TEXAS — May 22, 1981 - Harold Mauch, president of Percom Data Company, announced here today that an improved version of the Company's innovative DOUBLER® adapter, a double-density plug-in module for TRS-80* Model I computers, is now available.

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Moreover, a DOUBLER II equips a Model I with the hardware required to run Model III diskettes.

(*Ed. Note*: See "OS-80®: Bridging the TRS-80* software compatibility gap" elsewhere on this page.)

The critical clock-data separation circuitry of the DOUBLER II is a proprietary design *called a ROM-programmed digital phase-lock loop data separator.*

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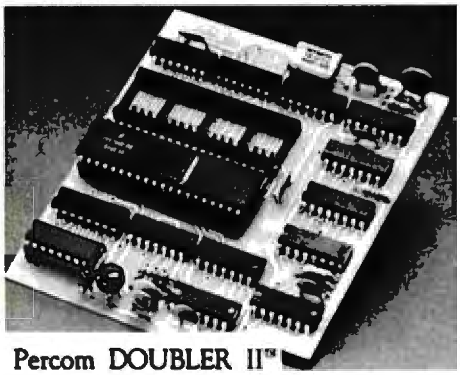

Percom DOUBLER II™

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Ed. note: Opening the TRS-80 Expansion Interface may void the Tandy limited 90-day warranty. Circle 327 on inquiry card.

All that glitters is not gold

OS-80™ Bridging the TRS-80* software compatibility gap

Compatibility between TRS-80* Model I diskettes and the new Model III is about as genuine as a gold-plated lead Krugerrand.

True, Model I TRSDOS* diskettes can be *read* on a Model III. But first they must be converted and re-recorded for Model III operation.

And you *cannot write* to a Model I TRSDOS* diskette. Not with a Model III. You cannot add a file. Delete a file. Or in any way modify a Model I TRSDOS diskette with a Model III computer.

Furthermore, your converted TRSDOS diskettes cannot be converted *back* for Model I operation.

TRSDOS is a one-way street. And there's no re-treating. A point to consider before switching the company's payroll to your new Model III.

Real software compatibility should allow the *direct, immediate* interchangeability of Model I and Model III diskettes. No read-only limitations, no conversion/re-recording steps and no chance to be left high and dry with Model III diskettes that can't be run on a Model I.

What's the answer? The answer is Percom's OS-80™ family of TRS-80 disk operating systems.

OS-80 programs allow *direct, immediate* interchangeability of Model I and Model III diskettes.

You can run Model I single-density diskettes on a Model III; install Percom's plug-in DOUBLER® adapter in your Model I, and you can run double-density Model III diskettes on a Model I.

There's no conversion, no re-recording.

Slip an OS-80 diskette out of your Model I and insert it directly in a Model III.

And vice-versa.

Just have the correct OS-80 disk operating system — OS-80, OS-80D or OS-80/III — in each computer.

Moreover, with OS-80 systems, you can add, delete, and update files. You can read *and write* diskettes regardless of the system of origin.

OS-80 is the original Percom TRS-80 DOS for BASIC programmers.

Even OS-80 utilities are written in BASIC.

OS-80 is the Percom system about which a user wrote, in Creative Computing magazine, "... the best $30.00 you will ever spend."†

Requiring only seven Kbytes of memory, OS-80 disk operating systems reside completely in RAM. There's no need to dedicate a drive exclusively for a system diskette.

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The Percom OS-80 DOS supports single-density operation of the Model I computer — price is $29.95; the OS-80D supports double-density operation of Model I computers equipped with a DOUBLER or DOUBLER II; and, OS-80/III — for the Model III of course — supports both single- and double-density operation. OS-80D and OS-80/III each sell for $49.95. Circle 328 on inquiry card.

Circuit misapplication causes diskette read, format problems.

High resolution key to reliable data separation

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Unreliable data-clock separation causes format verification failures and repeated read retries.

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The problem is most severe on high-number (high-density) inner file tracks.

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The Percom Separator substitutes a *high-resolution* digital data separator circuit, one which operates at 16 megahertz, for the low-resolution one-megahertz circuit of the Tandy design.

Separator circuits that operate at lower frequencies — for example, two- or four-megahertz — were found by Percom to provide only marginally improved performance over the original Tandy circuit.

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The SEPARATOR, which sells for only $29.95, may be purchased from authorized Percom retailers or ordered directly from the factory. The factory toll-free order number is 1-800-527-1222.

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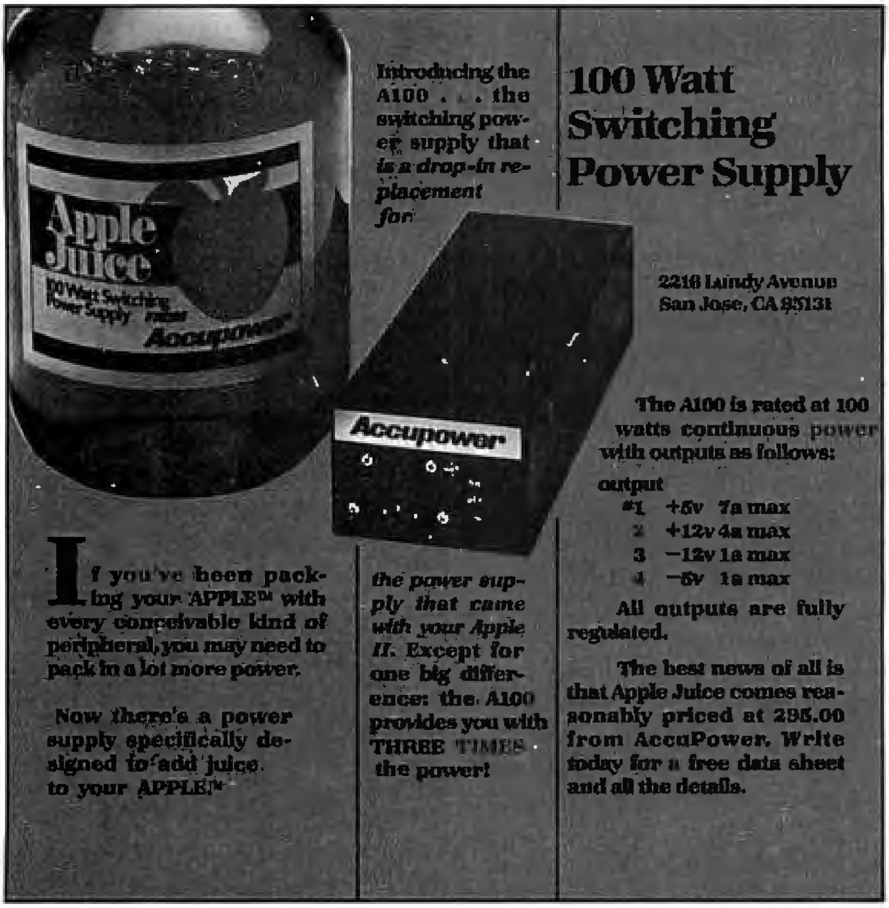

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Summary

In the 1980s, the most important factors affecting how prevalent computer usage becomes will be reduced

cost, increased functionality, improved availability and servicing, and, perhaps most important of all, progress in user-interface design. The first three alone are necessary, but not sufficient for widespread use. Reduced cost will allow people to *buy* computers, but improved user interfaces will allow people to *use* computers. In this article, we have presented some principles and techniques that we hope will lead to better user interfaces.

User-interface design is still an art, not a science. Many times during the Star design we were amazed at the depth and subtlety of user-interface issues, even such supposedly straightforward issues as consistency and simplicity. Often there is no one "right" answer. Much of the time there is no scientific evidence to support one alternative over another, just intuition. Almost always there are trade-offs. Perhaps by the end of the decade, user-interface design will be a more rigorous process. We hope that we have contributed to that progress. ■

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Designing a Text Editor? The User Comes First

A system's power is measured in ease of use.

Steven Jong
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In choosing or designing any computer system—hardware or software—the most important consideration is the human interface: if a system doesn't work for the user, it's not a working system. This article presents observations on the crucial relationship between human factors and the design of text editors for video-display terminals. These observations are drawn from my experience with a number of editors on computers of various sizes and from software-design and human-factors literature. All the features described here exist on at least one editor. My aim is to give you some things to look for if you want to buy—or write—an outstanding text editor.

The first and most important design goal is *ease of use*. This should surprise no one. James Martin (see reference 7) pointed out back in 1973: "To be effective [in the next decade], systems will have to be designed from the outside in. The terminal or console operator, instead of being a peripheral consideration, will become the tail that wags the whole dog." Text editors are, to most users, the outermost layer of their computer system—the layer they deal with most. Timesharing users spend over half their time using a text editor, and editing commands account for about fifteen percent of all commands they enter. Personal-computer users may exceed those figures. Ease of use, therefore, weighs most heavily on editor design.

What, then, makes a good text editor? Human-factors literature suggests many characteristics of the laudable text editor. Different authors espouse perfectly reasonable but totally contradictory principles. You'll have to evaluate your needs when designing one feature in and another out (see text box on page 298.)

Screen Display Features

Let's consider what you want or need to see on the text display.

The top or bottom display line (but not both) should provide program and system status information, such as the file name, the current file line number, the last command invoked, the time, and program prompts. This keeps you informed as to the system state and is well worth the overhead. Another line could display the current tab stops and margins, if they are to be controlled by the user (see figure 1).

When you enter a keystroke in the middle of a line of text, one of two things may happen. The character at the cursor position may be overstruck by the new character; or the new character may be inserted at the cursor position and characters from the cursor position on move to the right to accommodate it. Existing editors use both modes, but overstrike editors require a separate insert/stop-insert function and don't prevent you from accidentally replacing text. From the user's viewpoint, a display mode that allows accidental erasure of text is undesirable.

A screen-editor window is limited by the size of the screen. To minimize the effects of this limitation and allow you to browse through text, there must be a command to scroll text, both vertically and horizontally (see figure 2). (An editor that allows horizontal scrolling can display overlong lines as truncated, with the ends of the lines offscreen, which seems most natural.) You should be able to scroll through the file continuously and stop whenever you want. This suggests that scrolling should continue as long as some particular key is depressed and stop the instant the key is released.

How fast should the display scroll? The Honeywell WP 6 word processor lets you scroll at the rate of about ten lines per second. This allows browsing, but is slow if you want to traverse several screens' worth of text. It also limits scrolling to the text within the current page of memory. The scrolling function built into Radio Shack Model II computers gets you from one end of a file to the other very nicely, but too quickly to read anything. It would be nice to scroll and also maneuver using some other mechanism, such as "go to string," "go to page," etc.

You may want to mark blocks of text for movement, reproduction, or

About the Author

Steven Jong, a principal software technical writer, holds a master's degree in science communication from Boston University.

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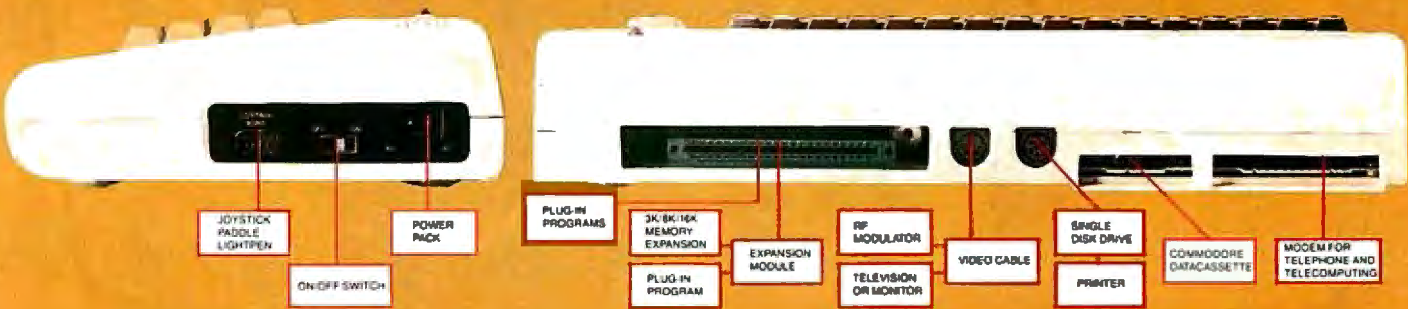

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►  ►          Harold
LETTER      PAGE 1   LINE 16  Press DEL to delete, or RETURN to cancel.
```

Figure 1: *An idealized screen-editor display. The larger the display area, the better. Spaces, tabs, and carriage returns are indicated by special symbols. "S" in the tab line indicates single spacing; "◄" indicates that the line length is 64 characters; "!" indicates a tab stop. Besides showing its user a window of text, the screen highlights selected blocks, prompts for action, and displays program and system status.*

deletion. Text editors on some minicomputers display plain text in low-intensity characters and mark blocks using high-intensity characters. Microcomputer-based word processors tend to use inverse-video characters for the same function.

A useful, advanced feature is multifile editing. The best way to display multiple files on the screen is to use multiple windows. The screen can, for instance, be bisected by a line of dashes, with one file displayed above and the other below. Some editors dedicate a portion of the screen as a message window for prompts and error messages. This window should not be too large, of course; three or four lines is typical.

Many text editors employ the beep signal, a simple and powerful attention-getting device that, unfortunately, is often misused. More than one word-processing system uses the signal in an inconsistent and annoying way: beeping when users enter some things right (sign-in lines, for instance), and yet also beeping when users enter some things incorrectly (a function key during a search); often they remain silent during many other kinds of errors. In my opinion, the beeper is best left to signaling errors.

The coming flood of color computers will soon bring a generation of full-color software. Four colors—red, green, blue, and yellow—are probably sufficient for text displays; green is generally acknowledged as easiest on the eyes. Color could highlight a search string, an error message, or a prompt. Color could also mark portions of a file. For instance, various parts of a document could be marked in green (draft), yellow (comments), red (technical questions), and so forth. However, color should not be the *only* distinguishing feature of important messages, because four percent of the population are color blind.

Word-Processing Features

Certain functions apply strictly to word processing. One is a dot-filled display in which each space character is represented by a dot smaller than a period. The dots simplify counting spaces and aligning text vertically. One might argue that a dot-filled screen appears too "busy," but most users of Wang and Lanier word processors, which feature dot-filled screens, are happy with them.

A good word-processing editor should perform "word wrapping",

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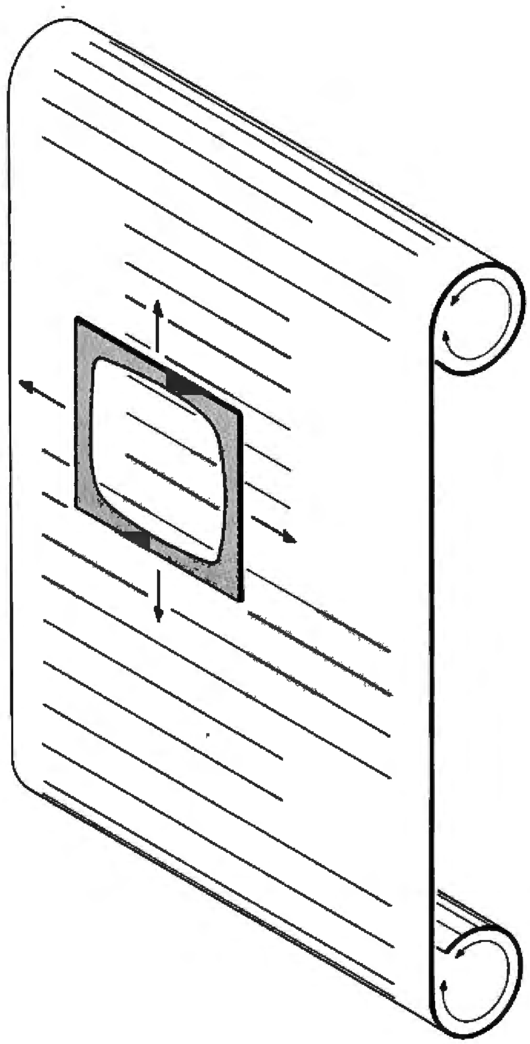

Figure 2: *Vertical and horizontal scrolling provide a flexible "window" to text. Conceptually, either the screen or the text can be thought of as moving.*

i.e., a word being typed in that exceeds the specified line length is carried down to start a new line. This relieves you of having to decide when to end a line. Word wrapping is one of the two most useful features of a word-processing editor (the other is character deletion). It is possible both to break lines and justify them at the same time; Micropro International's Wordstar microcomputer-based editor does this.

When characters are inserted into the middle of a line, a word-processing editor should reformat the rest of the text automatically. In practice, this proves difficult. Some editors, for instance, temporarily clear the screen from the cursor position to the end of the screen during text insertion (see figure 3). New text can be entered and formatted; when the user signals that insertion is finished, the rest of the text is reformatted. The ideal editor would reformat text continuously during insertion, but I have seen no editor that does. Instead, most include a separate "reformat" command to reformat the current paragraph after insertion is finished.

Navigating Through the File

Now that we know how to display text, we must deal with the problem of finding our way through it. Addressing text is a prerequisite to manipulating text. The more power and flexiblity you have in addressing, the better.

The basic cursor movement is "quadridirectional," or up/down/left/right, universally offered by screen editors. Boundary conditions, however, may vary from one editor to the next. For instance, if the cursor is in column 1 (the left extreme of the screen) and you try to move the cursor to the left, one screen editor might treat your action as an error; another editor might oblige the request by moving the cursor to the last character of the previous line.

What happens when you try to move the cursor past the end of a line? Usually, editors will not allow cursor movement, or at least text insertion, past the end of a line. In practice this proves a limitation, and there is no ease-of-use justification for it. It could, in fact, imply an attempt to enter spaces (perhaps the user is trying to make columnar text column by column).

Commands that move the cursor a single character at a time are not enough. There should also be commands to move by word, line, sentence, paragraph, screen, page image, and column; the ability to go to the top or the bottom of a file at a single keystroke is also useful. Combining cursor-movement commands with a Repeat key is also very important (an advanced video terminal may include an automatic-repeat function if a key is held down). An alternative for terminals without repeat functions is to allow commands to accept numeric arguments so that a user could, for instance, skip four sentences.

Signaling Commands

Now we turn to the mechanism by which you signal that you are entering a command (the nature of which is not yet important). Single-character command names are best for fast typing. Screen editors must use nonalphanumeric characters, because alphanumeric keystrokes must always appear as entered. The next simplest arrangement is to use control characters, because the CTL (Control) key is standard on most computer keyboards. CTL-W, then, might mean "write file." Of course, entering some command sequences would require two hands.

Designers of some computer systems, thinking of novice users, in-

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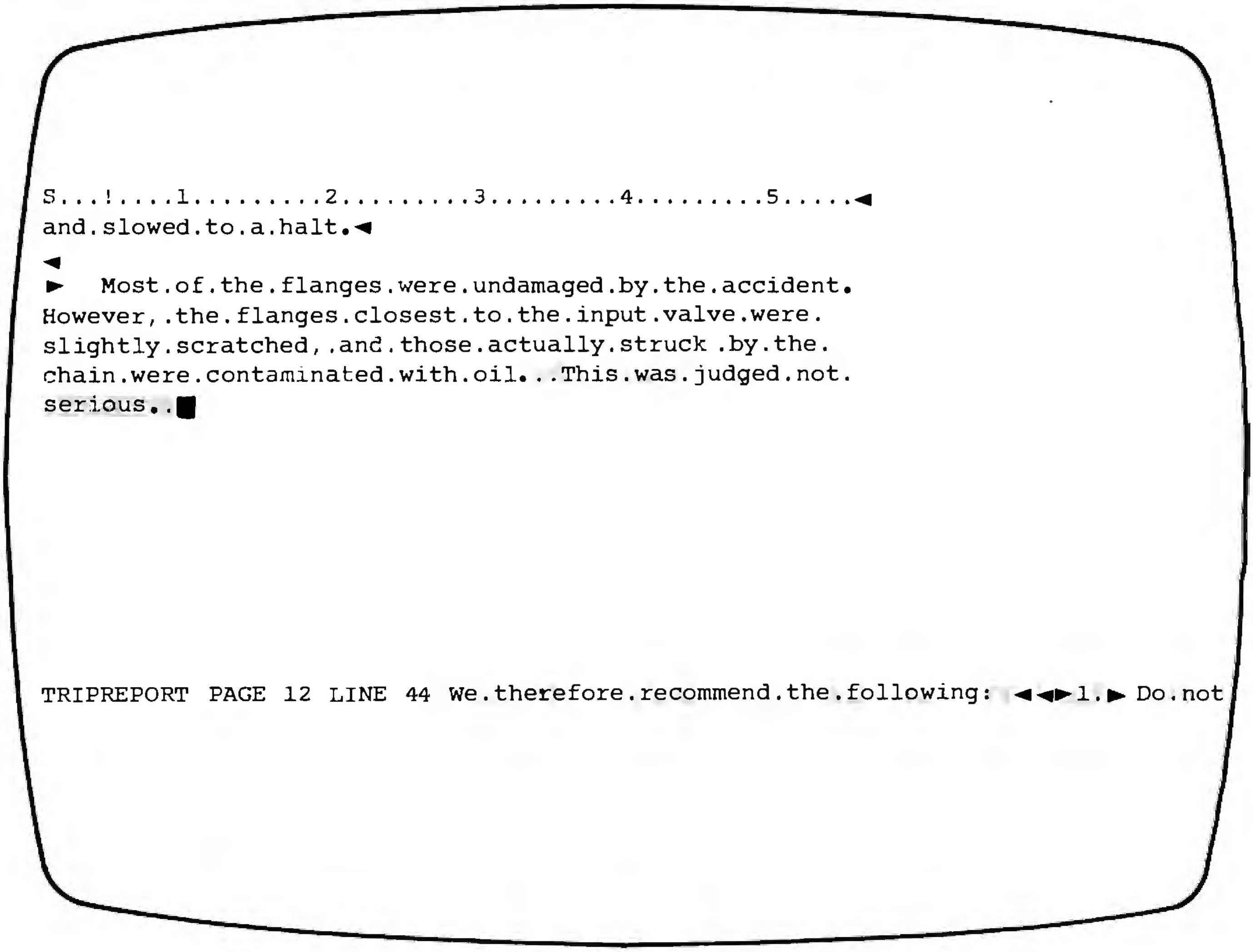

Figure 3: *Text insertion on a typical minicomputer-based word processing editor. The screen is cleared from the point of insertion; new text is displayed in proper format. The display logic is simpler than for reformatting the screen after every character is entered. In the illustration, inserted text is highlighted.*

variably turn to special-function keys for signal commands. They feel the simplest possible arrangement is to give each function its own labeled key, reinforcing the what-you-see-is-what-you-get nature of screen editors. But before assigning all functions to dedicated keys, a designer should consider what adjustments skilled typists must make to reach function keys located on the periphery of a keyboard, and whether certain functions are too important to be invoked with single keystrokes. The rush toward function keys in the business market may slow as human-factors specialists research these questions. In the microcomputer marketplace, function keys are uncommon, and a general-purpose screen editor would be fatally limited if it required function keys.

Ease-of-use considerations suggest the use of prompts for procedural commands. If you press the Search key on a Wang word processor, the system prompts: "For what?" in the message window. It searches for whatever is typed in response to the prompt. Press the Delete key; it prompts: "Delete what?" Mark text for deletion, and press the Execute key to actually delete it. This prompting helps beginning users, though in time they become conditioned to ignore the prompts.

Commands can be assigned to individual keys mnemonically, physically, or symbolically. For example, to signal quadridirectional cursor movement, a mnemonic assignment scheme could be U, D, L, and R (for up, down, left, and right); a physical assignment scheme could be W, Z, A, and S (spatially simulating a cursor keypad—try it on your own keyboard!); and a symbolic assignment scheme could be ^, V, <, and > (symbolizing arrows). There are other possibilities: another mnemonic could be F, B, P, and N (forward, backward, previous, and next); and another physical scheme could be I, J, K, and M (for the right hand instead of the left). All of these arrangements are used on various systems. Whatever the scheme, commands must be logically arranged, even at the expense of leaving out a function because there is no reasonable key to which it can be assigned. A command that is hard to call will be hard to remember and, ultimately, hard to use.

If key assignments are not completely logical, the results may be

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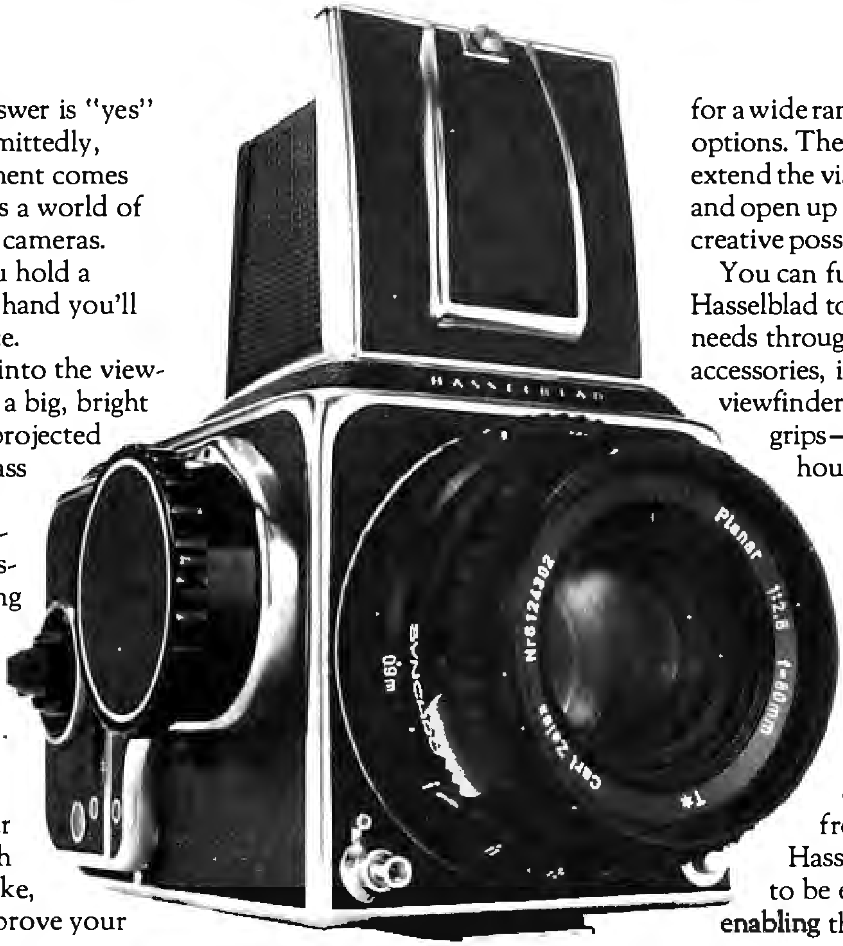

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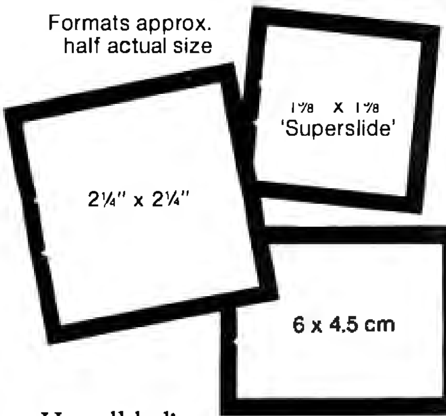

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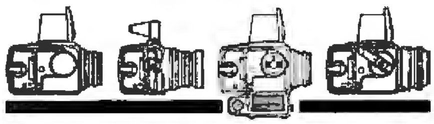

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catastrophic. I recall a Boston University student who some years ago ran afoul of the RAX line editor written for the school's IBM 360/50 system. He went to a computing center adviser and explained that he was searching for what he thought was the next line of his file. Although he had checked most of his file, he couldn't find the elusive line. When the adviser examined the file, she discovered that most of it had been deleted. When asked what commands he had been using, the student replied that he didn't know much about the editor, but that U meant go up, and didn't D mean go down? It was a perfectly reasonable assumption; unfortunately, while U did mean up, N (next) meant down, and D meant delete.

The first commands to assign should be the basic ones given in table 1. They form a simple, symmetrical, and complete set of editing functions. Note that the Search command requires some sort of command sequence to signal the editor that the search string has been specified. The Return key is natural for this purpose (at the cost of making the Return character a difficult string to search for).

Unless the editor handles routine file I/O (input/output) operations—creating, deleting, reading from, and writing to files—expect it to work only with an operating system. These operations must be invisible to the user.

Idiot-Proofing

Designers, preoccupied with establishing responses to correct keystrokes, often neglect incorrect ones. Because editors are used so extensively they should never abort, no matter what you enter. The process of "idiot-proofing" interactive programs was described by Anthony Wasserman in 1973 (see reference 11). It involves anticipating incorrect entries, missing input, inadvertent keystrokes (e.g., BREAK, CTL, and ESCape), and transmission errors (which are rare in personal computer terminals). An example of non-idiot-proof hardware is found in some versions of the Apple II computer keyboard. The Reset key is in a hard-to-miss location—just above the Return key; many applications packages carry warnings never to press it while using their programs. One magazine printed a letter suggesting that Apple users place a rubber grommet beneath the key, to make it harder to push. A software example of non-idiot-proofing is the Electric Pencil I's tendency to drop keystrokes entered by fast typists. The very point of word processing is to increase throughput; a program that drops keystrokes invokes paranoia in its users and slows them down.

The use of "kill rings" is a nice, practical application of idiot-proofing. Deletions larger than single characters are not discarded, but stored temporarily in a stack. If text is deleted by accident, it can be retrieved by a command. This truly protects users from themselves. Editors with kill rings actually make it difficult to lose text.

Power versus Ease of Use

In general, the more powerful a system is (i.e., the more capabilities it has), the more difficult it is to use. There are two reasons for this: first, the sheer number of commands makes them hard to remember; second, it becomes impossible to assign commands to keys or names in a consistent manner. Many editors have forty or more commands; for them, any single-key naming scheme soon collapses. Editors on the market today delete text at the keystrokes D (delete), G (gobble), W (wipe), and K (kill). Some compromise between power and ease of use is needed.

Function keys are a liability for a powerful editor. Consider the Atex typesetting system, on which all functions are visible as function keys. There are, however, 32 function keys, and each can be prefixed with the shift key and/or a "supershift" key—making a total of 128 functions, assigned four to a key. Given the complexity of typesetting systems and the desire to provide an easy-to-use system, this end was inevitable.

What is needed is a hierarchy of

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READ (file)	read a file into the edit buffer at the current cursor location—implies file insertion, concatenation
WRITE (file)	save the contents of the edit buffer—implies file creation, overwriting; if file name is not given, write to current file
DELETE (object)	delete the character to the left, to the right, or at the cursor and reformat the screen; for advanced use, object can be a character, word, sentence, block, screen, etc.
SEARCH (object)	move the cursor to/past the string "object", which can be defined explicitly or, for advanced use, defined using metasymbols
Cursor movement (scroll)	move by character, or, for advanced use, by word, sentence, block, screen, etc.; moving the cursor past the edges of the screen can imply vertical/horizontal scrolling
QUIT	terminate the edit session; prompt for confirmation if changes have not been saved (abandoning changes may be intended)

Table 1: *These basic editing commands form a logical and symmetrical set of commonly used functions. Character insertion is always permitted. Note that the read and write functions imply file creation and deletion functions that an operating system or the editor must perform automatically.*

commands, divided into a basic group and an advanced group. The basic commands, which by definition are used most often, must be the easiest to signal. Some other signaling mechanism can be used for more esoteric functions.

The command hierarchy of the EMACS screen editor is an interesting attempt to reconcile the need for simplicity and logic in commands with the power of a large command repertoire. EMACS is a general-purpose tool that runs on a number of mainframe systems (a microcomputer version, called MINCE, is available from Mark of the Unicorn, POB 423, Arlington, MA 02174). It was originally developed in 1974 at the Massachusetts Institute of Technology by Richard Stallman (see reference 10). Since then, many user-written extensions have been added to the basic package.

The EMACS hierarchy has four levels, using the prefixes CTL (control), ESC (Escape), CTL-X (press the Control and X keys simultaneously), and ESC X (press the Escape key and then the X key). The first two prefixes are for simple commands; the second two are for more advanced commands. For instance, CTL-B moves the cursor back one character, while ESC B moves the cursor back one word; CTL-D deletes the current character, while ESC D deletes the preceding word.

Simple functions are simply named and thus simple to remember. CTL-X precedes some actions considered too important for single keystrokes; the sequence CTL-X CTL-C, for instance, is required to quit the editor. (Requiring multiple keystrokes to exit an editor is one of the simplest and best applications of idiot-proofing I have encountered.)

More powerful functions are called by entering ESC X and a string; for instance, "ESC X fillon" turns on word wrapping. This hierarchy allows an unlimited number of editor functions at the cost of forcing you to learn the hierarchy. EMACS can grow in power without compromising on the integrity of the fundamental command structure.

Text-editing Commands

The simple functions thus far described would be useful for editing any kind of sequential file. Other functions are more suited to editing text.

First, consider searching for a character string. Two popular display mechanisms are *display results* and *incremental search*. In display-results searches, the editor moves the cursor to the end of (and perhaps highlights) the string being sought only after you signal the end of the search string with some sort of escape sequence. This is the more common mechanism.

In incremental searching, the editor searches as each character of the string is entered. In theory, you need enter only the minimum string necessary to locate a desired point. If I

Design Guidelines

The literature abounds with contradictory guidelines for text-editor design, but the following summaries of various sources present widely supported principles for promoting ease of use.

In designing a system, minimize the need for memorization. Optimize operations—common operations should execute rapidly. Also, change the display as little as possible. Engineer for errors: design out common ones, provide good error messages, allow user actions to be reversed, and ensure data structure integrity.

Hansen (1971)

Minimize the need to learn about the system. Provide online help messages for the novice and built-in short cuts for experienced users. Provide a response for every possible user input.

Wasserman (1973)

Keep the system simple and responsive with immediate, unambiguous feedback. The user should initiate all actions and be able to quit at any time. The system should be flexible, allowing abbreviations, command files, prompting, and subsetting of the command structure.

Cheriton (1976)

In the command language, provide a complete and symmetric set of functions as well as convenient and consistent abbreviations for commands and command arguments. Simple functions should be simple to do, and in general the language should do what a reasonably intelligent user would expect. The system should prompt for confirmation before allowing irreversible actions (e.g., deleting files).

Muchnick (1976)

Allow browsing through text, and let the user see corrections as they're made. Provide status messages that give evidence of the system state.

Gebhardt and Stellmacher (1978)

Keep in mind that different users prefer different types of text editors; i.e., sophisticated users prefer a powerful editor, while beginners prefer a simple one. Also, different kinds of text require different editing commands (e.g., "forward paragraph" for editing text as opposed to "forward procedure" for editing PL/I programs).

Stallman (1979)

were searching through a text file for the word "there," I would certainly not enter just "th." Using incremental searching, though, I could safely try it and see if it would suffice; if not, I could continue typing characters until I got where I wanted. Though incremental searching is not as useful in practice as it sounds, the display algorithm is useful for highlighting blocks (see below).

Line editors usually have very powerful string-search functions that use *metacharacters* (characters used to describe or delineate other characters). The usual convention is to use ^ (caret) for the beginning of a line, $ (dollar sign) for the end of a line, . (period) for "any character," and * (asterisk) for "any number of the preceding character." Thus the search string ^the.*fox$ is interpreted to specify a line beginning with "the," ending with "fox," and having any number of arbitrary characters in between. Metacharacter searches are powerful and precise. Sophisticated users find metacharacter searching almost indispensable. But searching for a metacharacter itself requires using an "escape sequence" (pressing a series of keys to escape from one mode of operation into another), a concept beginners find hard to grasp. Ease of use compels us to abandon metacharacters, however reluctantly.

One function built around character searching is search-and-replace. There are four logical variations: replace once, replace-*n*-times, replace interactively, and replace globally. In interactive search-and-replace you should have, at every replacement point, the option of replacing, skipping, or quitting. In practice, all but replace-*n*-times prove useful and should be available.

Most line editors cannot locate strings that span lines. This is a severe limitation, often forcing you to enter text in some artificial manner (such as having every sentence on a separate line). A screen editor should not be so limited.

The basic text-editing command set should include an interactive routine for moving and copying text blocks. Three locations are required: the first and last characters of the block to be operated on and the location the block will be moved (or copied) to. Ease of use suggests that the routines prompt you for this information and highlight the text block.

The Honeywell WP 6 text editor provides a powerful mechanism for outlining text blocks. You position the cursor to the first character of the block and press, for instance, the Copy function key. The system prompts, "Copy What?" in the message area and highlights the character at the cursor position. The system then enters a single-character search mode; you can move the cursor to any character by entering that character. Entering three spaces advances the cursor three words; entering a period, carriage return, or page mark advances the cursor one sentence, paragraph, or page, respectively. The

quadridirectional keys also work, either extending or reducing the block. Since the block is highlighted, you know exactly what is being copied. Once the block is marked, you press the Execute key, and the system prompts, "Copy it to where?" Position the cursor to the character before which the block is to be copied and press Execute again to complete the operation.

Messages to the User

System messages are, historically, coded as an afterthought. But because messages are among the most visible aspects of the software they are among the most important, especially for inexperienced users. Time is well invested in good system messages.

Messages should be polite, not imperious; straight, not funny; neutral, not personal. There are good and well-known reasons for this statement. For instance, how many times would you endure an error message like "YOU BLEW IT, BUD!!!" before becoming thoroughly annoyed? Human-factors research involved with large systems has shown that users are uncomfortable with computers that appear to be too lifelike, ordering them around or controlling them instead of vice versa. Ben Shneiderman (see reference 9) cites the Library of Congress database computer, which is available for public use. The programmers had to change prompts like "ENTER NEXT COMMAND" to "READY FOR NEXT COMMAND" because many people felt uncomfortable being ordered around by the computer.

Error messages are often written from an internal point of view and couched in terms of software interfaces, as if the author were peering out at the world from the port of a disk drive. Useful messages can only be written from the user's point of view. Ideally, an error message should say what went wrong, what has happened as a consequence of the error, and how to correct the error. For example, infinitely better than "HOLD BUFFER OVERFLOW," which describes an error in terms of an internal software event, is "LINE TOO LONG; REJECTED. RE-ENTER LINE." The latter succinctly tells what the user did wrong, what happened, and how to rectify the situation.

Help messages, which programmers would never think of providing for themselves, are an important aid to using any computer system. EMACS provides an elaborate, table-driven help system that provides a one-line description of what each keystroke does, a multiline help message for the same command, or a summary of related topics gathered through substring retrieval. Much is possible on a microcomputer system as well. Wordstar boasts an impressive online help facility with four levels of detail. Everyone from an experienced user to a rank amateur can obtain an appropriate level of assistance. It also has a HELP function, which describes the use of each key.

One grace note that seldom appears is the "in progress" message, which notifies you that some function is underway. EMACS, for instance, uses the messages "Reading. . . ," "Read," "Writing. . . ," and "Written" for the common I/O commands. I always include such messages in the command files I write; the system on which I work is subject to great fluctuations in load, and users tell me it's comforting to know their jobs haven't "curled up and died."

Multilingual Editors

Word-processing editors are specialized to the needs of editing English language text; they word-wrap lines and recognize constructs such as words, sentences, and paragraphs. A more generalized editing tool would be more useful to, say, Pascal programmers if it could format Pascal programs, balance parentheses (move the cursor between one parenthesis and its corresponding partner), recognize constructs such as procedures, and insert comment lines in the proper format. One can imagine the utility of an editor that recognizes PL/I, BASIC, FORTRAN, COBOL, LISP, etc. In fact, EMACS does this, making it a general-purpose tool and not just a word-processing editor.

Conclusion

Software designers make many decisions about how their software will behave. There are several reasons for choosing one form of behavior over another, based on established human-factors principles. An inefficient editor with a smooth user interface will be better received, and ultimately more useful, than an efficient editor with an ill-planned user interface. In the long run, software should be designed—and selected—not on the basis of what is most machine-efficient, but on the basis of how well people can use it. ■

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Managing Words

What Capabilities Should You Have with a Text Editor?

The ideal text editor is defined, drawing on the experience of many users.

Craig A. Finseth
Mark of the Unicorn Inc.
POB 423
Arlington, MA 02174

When moving from a typewriter to a computer-based text editor, you will encounter a bewildering array of new capabilities—some worth more than others. This article will single out the useful features (i.e., those capabilities that make a text editor more powerful or easier to use) from mere gadgetry. Although many of the features described here are often overlooked at first, they will be appreciated long after the first thrill of a new machine has worn off.

When you move from a typewriter to a text editor, expect to spend some time learning the new capabilities available to you. Among text-editor manufacturers, the temptation to cut the learning period short at the expense of providing more sophisticated editing capabilities is ever present. By simplifying, the manufacturer can demonstrate and teach people how to use all of the capabilities in a few minutes. Unfortunately, after these first few minutes there is no more to learn and no easier way of doing editing than by the few, simple operations that have been taught. As a rule of thumb, anything as easy to learn as a typewriter is as useful as a typewriter.

The following is a list of features desirable in a text editor. Not all features, however, will be useful to everyone. If you're planning to buy a text editor, you might want to check the list carefully, noting which features would serve your purposes best.

Study the features of a text editor carefully before you decide to buy it.

Screen Editor: The editor should be a screen editor. This means that the video display is used as a "window" onto the file, showing its current state. Thus, you are quickly given feedback about what your text looks like. You can then immediately see where something needs to be changed.

A screen-oriented editor usually uses some sort of cursor to indicate the active editing point. In general, the cursor must be moved to the text that is to be changed before any changes can be made. There are (usually) a number of commands that move the cursor to different points in the text. For example, one command will place the cursor at the end of a line, another will place it at the beginning of a paragraph, and so on depending on the capabilities of a given unit.

Backup Copy: A good editor allows you to edit a copy of the file and not the file itself, thus creating an implicit backup copy to which you can return if you accidentally destroy the file. Yet this backup copy will not clutter up precious space on your disks.

A good editor will let you read in a file and write it out to several other files, perhaps after making minor changes, without exiting the editor. This capability is much easier to provide (and thus more common) in editors that edit a copy of the file.

Large Files: A good editor will be able to handle very large files smoothly and elegantly. When the file that is being edited becomes too large to fit in memory, parts of it should be stored on disk until needed.

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However—and this is most important—none of the internal "breaking into pieces" should be visible to the user. Specifically, you should not have to manually break your file up into pieces, nor should there be commands to "edit the next section of the file." You should always be able to edit any part of your file on demand and never be in a position where backing up before a certain point in the file is impossible.

Multiple Buffers and Windows: When using a typewriter, you can easily switch back and forth between tasks, or you can look at several documents at once. You don't want to give up these abilities when you move to a computer. Thus, an editor should have multiple buffers and multiple windows.

Multiple buffers store each document separately and allow you to switch back and forth between them at will. Any changes that have been made to any of the documents will still be there, intact, if you should switch away from a buffer and then back again.

An editor with multiple windows will "split" your video screen so that you can look at parts of two or more documents at the same time (or two parts of the same document). With this ability, you can make changes in one file based on what you are reading in another one.

Speed: The editor should be fast enough so that it doesn't slow you down. This means that it should scan the keyboard often enough to retain all the characters that have been typed and that there should be little or no delay between a command and its execution. Response time is most important on the frequently executed commands, such as those that move you around in the file or window, and less important on the infrequently used ones, such as those that read or write files.

If two commands are entered quickly, or a second one is entered while the editor is updating the screen after executing the first, it is more efficient if the screen update is aborted and the next command executed immediately. Thus, executing sixteen "next-screen" commands in quick succession will show the sixteenth screen of text only, not all fifteen in between. Note that on some operating system/hardware configurations, it is not possible to detect the second or later commands, so this feature is not always available.

Large Screen: The video-terminal screen should be as large as possible. A standard screen has 24 lines and 80 columns. An 80-column display is usually wide enough for text, but 24 lines represents only about a third of a sheet of paper. This small size can produce a feeling of "blindness" in users because their attention is focused on such a small part of the text. Unfortunately, 24 lines is by far the most common size. However, larger screens do exist: for example, the Ann Arbor Ambassador terminal will display up to 60 lines at once

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Due to the 24-line size of most screens, it is important that the editor devote as much of the screen as possible to displaying text and minimize the space devoted to unchanging status displays. A video terminal is very good at displaying things that change, and that capability should be used to advantage by a text editor.

Physical Keyboard Characteristics: The physical characteristics of a keyboard are important, too. First and foremost, the keyboard and screen should be in separate cases (commonly called a "detachable keyboard"). By separating the two, the keyboard can be adjusted to fit the user, instead of forcing the user to adapt to the keyboard. This capability is important if you are using the terminal eight hours a day.

A keyboard should have a comfortable, solid feel and should not miss or double type characters (i.e., if you type "forty," it should not send a "orty," "fforty," or "fgorty"). In addition, the Shift and Control keys should work smoothly with the rest of the keyboard so that you indeed get a "Forty" and not a "forty," "FOrty," or "fOrty." Finally, there should be no sharp edges or other nuisances to annoy you. The basic question is "Will I be comfortable typing my next ten *million* characters on this keyboard?" (Ten million characters is about a year's worth of typing and editing.)

Keyboard Setup: The editor should be set up for use by touch-typists. If you cannot touch-type, the specific arrangement will make little difference to you. If you can touch-type, you should look for an editor with a set of commands that will rarely require your fingers to leave the "home position" (the A,S,D,F,J,K,L, and semicolon keys).

Unfortunately for touch-typists, special-function keys (usually located above the number keys or to the right of the basic keyboard) are inefficient. It can take one or two seconds to move a hand off to one side and back again. This amount of time is unacceptably long for a touch-typist, who can easily type ten characters within that time.

Unfortunately for beginners, it takes somewhat longer to learn to use an editor that has all of its commands on the "basic keyboard" than it takes to learn an editor with rows of keys, each carefully labeled with its use. On the other hand, after three weeks, the typist will be able to use the basic-keyboard editor much more quickly than the special-key editor, and the extra learning time will be paid back many times over. (Just think how much longer those ten million characters would take to type if you had to move your hands around to type them.)

Mnemonic Commands: Regarding basic-keyboard editors, there are two schools of thought. One school holds that commands should be mnemonically bound (e.g., ForwardCharacter is on F, BackwardCharacter is on B, NextLine is on N, and PreviousLine is on P). The other school holds that commands should be positionally bound (e.g., ForwardCharacter on D, BackwardCharacter on S, NextLine on X, and PreviousLine on E—a glance at the keyboard will verify that these are indeed arranged in some sort of order).

The arguments for and against these systems are similar to the arguments about function keys. The positionally arranged commands are quicker to learn for a nontypist. However, the mnemonically arranged commands are easier to learn for a typist (who never looks at the keyboard and must stop and think for a while to realize that the E key is, indeed, above the S and D keys). In addition, the mnemonically arranged commands tend to be more evenly spaced around the keyboard. Thus, they are typed with both hands and can be typed quickly.

Commands Should Match What Is Being Edited: The commands given to the editor should match the material being edited. Everything that is edited has characters, lines, and regions (arbitrary blocks of text) as elements. A text file (or document) also has words, sentences, and paragraphs. A computer program (say, in Pascal) has tokens, statements, statement groups, and procedures. There should be commands to move over and to delete any of these units.

Insert vs. Overwrite: Whether to insert or to overwrite characters is yet another controversy. To enter text, a typed character could overwrite (replace) an existing character. This is useful if you are editing a table of numbers. Another option would be to insert the character between the two surrounding characters. (Think about proofreaders' marks. There are marks to delete and marks to insert, but no marks to overwrite text.)

Consider the basic editing operation of replacing one word with another completely different one. The easiest way to do it is to delete the old word and type the new one (inserting it, of course). The overwrite way is to type the new word. If the new one is shorter, the rest of the old one must be deleted. If the new one is longer, this situation must be noticed in the middle of typing it, and you must enter some sort of "insert mode" in order to finish the word. This is most inconvenient for touch-typists, who think of words as indivisible objects.

The ideal editor has available both ways of entering text and allows you to select between them. However, it should be tailored for inserting new text, as that is more useful for the bulk of editing.

Control Characters: A good text editor should use control characters for commands. By using them as commands, the "ordinary" characters are kept free for what they are most useful: text.

Recovery from Deletions: Assume that you have learned the editor well and are typing away, giving it move and delete commands and merrily inserting text. Suddenly, you realize—too late—that you didn't really want to delete that sentence. What do you do?

A good editor will have some sort of "undelete" operation to bring back the last object or objects that were deleted, thus saving you from having to remember and reenter the deleted text.

State Save: Although you'll probably spend most of your time in the editor, you occasionally must leave it and do something else. However, if you are using multiple buffers to advantage, it can take quite a while to write each buffer to disk and then read them all back in again. Thus, an editor should have either the ability to save what it knows and so pick up quickly where it left off (called *state save*) or the ability to temporarily escape to the operating system and allow you to do some work. The crucial point is that you can resume editing without having to manually reconstruct where you left off.

Modifiability: Even if an editor has all of these features and seems right in every way, there are probably ways to change it to make using it just a little bit easier. You should be able to make modifications in two areas.

First, you should be able to tailor the editor's default values for controlling parameters such as the right margin. By having the editor match your tastes immediately, you will save quite a bit of time and annoyance by not having to reenter

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your preferred values each time you use the editor (this point is slightly less important if the editor has state save).

Second, the people who created the editor have their own ideas about how they think an editor should work. You might not like some of them. Thus, you should be able to change the editor in a basic way. (Perhaps you'd like the StringSearch command to leave you at the end of the file if it can't find the string, instead of leaving you where you were when you gave the command.) To make this sort of change, you need access to at least a portion of the source code. This code must be well written so as to be easy to change, and there must be thorough documentation so that whoever is actually making the changes can make them with a minimum of fuss.

Final Note

The list of features presented here is not the product of any one person's thinking. It was created item by item over a period of several years through the interaction of a large community of users, all of whom had their own ideas about what an editor should be like.

These users were largely at the Massachusetts Institute of Technology, and the editor that is the result of their ideas is called EMACS. Several versions of this editor exist: the original EMACS on DEC PDP-10 and DEC-20 computers, Multics EMACS on Honeywell Multics systems, ZWEI on LISP machines, and MINCE on CP/M systems.■

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Two Word Processors for North Star

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Two new word processors for the North Star DOS (disk operating system) offer broad capabilities that rival the leader among CP/M word processors, Wordstar. Each sells for just under $500 and provides high-performance word processing, text editing, and print formatting, although they take vastly different approaches to these tasks.

In brief, the Benchmark word processor, from Metasoft, was seemingly designed for someone who needs retraining after every coffee break. There is a starting command menu, which branches at the touch of a key to six different subsystems (create, revise, view, print, merge, and disk procedures), and each subsystem has *its* own detailed menu. The user can enter a ? almost anywhere along the way and get two screens of concise command information.

The other word processor, Lettergo, from Datek Systems Inc., provides one menu for disk operations and a 10-command print-formatting line at the top of the working screen. The remaining user information is contained in the manual, not the program.

Both programs give a general-purpose computer (the North Star Horizon or another S-100 system) the power of a *dedicated* word processor costing $7500 to $15,000. (A dedicated system is one that performs one job well, but can't do anything else.) Of course, Benchmark or Lettergo programs cannot be used simultaneously with other software (business, scientific, or recreational applications), but they can be used sequentially.

Upon order from the publisher or distributor, both Benchmark and Lettergo can be configured for various manufacturers' hardware or reconfigured to accom-

At a Glance

Software
Benchmark

Type
Word processor

Manufacturer
Metasoft Corporation
711 E. Cottonwood, Suite E
Casa Grande, AZ 85222

Price
$499.95

Format
North Star DOS 5¼-inch double density and quad density; North Star CP/M; CP/M 2.2 8-inch single density; Zenith Z-89; NEC PC-8000; Vector; Superbrain

Language Used
Assembler

Documentation
108-page loose-leaf manual

Audience
Secretarial, especially for offices with large volumes of routine and repetitive material, such as law offices

At a Glance

Software
Lettergo

Type
Word processor

Manufacturer
Datek Systems Inc.
4786 Lee Highway
Arlington, VA 22207

Price
$495

Format
North Star DOS 5¼-inch double density and quad density (CP/M 5¼-inch and 8-inch coming)

Language Used
Assembler

Documentation
84-page loose-leaf manual, 26 pages devoted to beginner tutorial, the rest to the reference manual; appended 11-page manual (same format) for MailMerj mailing-list program

Audience
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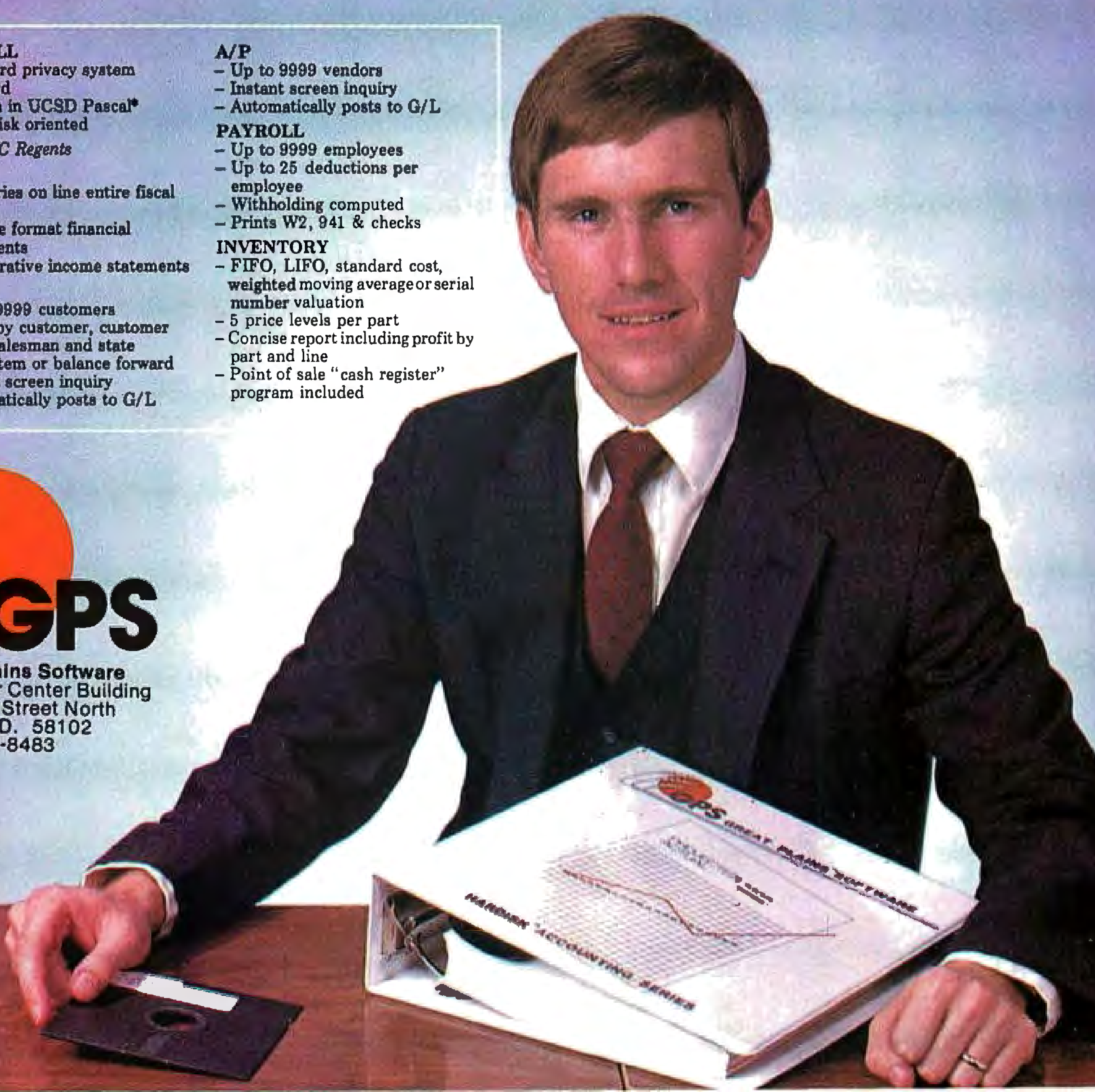

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Cursor movement		
bottom of document	Y	Y
next block or paragraph	N	N
next screen	Y[1]	N[1]
next sentence	Y	N
next word	Y	N
top of document	Y	Y
up, down, right, left	Y	Y
Copy block	Y	Y
Copy from another file	Y	Y
Delete		
block	Y	Y
character	Y	Y[2,3]
Find text	Y	Y
Find and replace (once)	Y	Y
Find and replace (all occurrences)	Y	Y
'Help' screen or aid	Y	N
Insert		
block	Y	Y
character	Y	Y
Move block	Y	Y
Video display		
change margins	Y	Y
change tabs	Y	Y
Printing:		
Justification		
left justified	Y	Y
left ragged	N	N
right justified	Y	Y
right ragged	Y	Y
Line spacing		
set to single or double	Y	Y
set to triple or more	Y	Y
Page layout		
go to new page	Y	Y[4]
set bottom margin	Y	Y
set indentation	Y	Y
set right and left margins	Y	Y
set top margin	Y	Y
maximum characters per line	155	78
Page numbering		
basic	Y	Y
varying position or format	Y	Y[5]
Printer control		
allows pause for positioning form	Y	Y
print draft copy	Y	?
feed single sheets	Y	Y
bidirectional printing	Y	Y
Text variations		
bold face	Y[6]	Y
centering	Y	Y
columnar output	Y	Y
footers	Y	Y
headers	Y	Y
subscripts	Y	Y
superscripts	Y	Y
underlining	Y	Y
All features changeable in middle of document	Y	Y
Miscellaneous Features:		
Attach phrases of 2000 words to a single key	Y	N

Notes:
1. Next page
2. Delete to end of line
3. Delete entire line
4. Force end of page
5. Eight positions, including alternate sides
6. "Shadow" print, darker than bold

Table 1: *Comparison of the features of Benchmark and Lettergo. "Y" stands for Yes and "N" for No.*

modate user changes in hardware. Review copies of each system came ready to run on my double-density North Star and were configured to accommodate my Soroc 120 terminal and Diablo 1610 printer. All I had to do was boot, load, and edit. The Lettergo system is designed to work on a variety of different terminals, printers, and Z80-based computers. The manual has detailed instructions for such printers as the NEC 5500, Diablo 1610/1620, and Anadex 9500/01, and for such terminals as the TVI-900, ACT-V, and Hazeltine 1500. Datek configures the software for a particular user's hardware. The Benchmark system arrives as a "configurator disk," which produces a data disk and a program disk. The configuration disk allows the user to configure Benchmark for various hardware, including Diablo, NEC, TI, Centronics, and Qume printers, and Soroc, Hazeltine, Heath, Televideo, Adds Regent, IMS WP, and Tandy II terminals.

After seeing these two systems in action and using them almost interchangeably for a couple of months, I have the same complaints about both, but they are complaints that extend to many other word processors as well. First, neither shows right-hand justification on the screen, leaving it up to you to imagine what the printed text will look like. Second, neither will spool-print, which means that printing a long manuscript with my relatively slow Diablo can occupy the computer for a long time.

One other complaint is the excess of riches. With either system, you can direct the printer to overstrike, boldface, and underline *simultaneously*. This may be useful for someone drafting legislation or revising a contract, but it seems like overkill; the added complexity gets in the way.

Although both Benchmark and Lettergo were designed with the same mass market in mind—the high-production office secretary—each reflects its origins. Benchmark (according to distributor R & B Computers, of Tempe, Arizona) originated in a lawyer's office, and certain functions, capabilities, and examples in the manual reflect that background. Lettergo, on the other hand, was written by Gregory Heise, owner of a computer shop and a high-class hacker of long standing. Heise had watched many novices struggle with unnecessary complication and poor documentation and, as a result, tried to simplify Lettergo as much as possible.

Both word processors do everything that leading word processors should do: automatic line wraparound on input, block moves, global search and replace, right-margin justification, automatic pagination, automatic headings and footings, underscoring, subscripting and superscripting, and so on (see table 1).

Both can generate personalized form letters with their merge capabilities. Benchmark uses either an internal pattern/letter, keying in the necessary changes from the terminal, or a letter and mail list generated by a separate software package, Mail List, which is a list manager with print capability (suggested retail, $399). Lettergo uses a BASIC language MailMerj program, which is included on the word-processing disk, to produce form letters.

Word-processing packages have evolved to the point where certain specific features—many of them mentioned above—should be taken for granted. When considering a new package, the prospective user should ask, "What can it do that's really useful that the others can't?" and "How easy is it to learn, use, and adapt?"

Benchmark

Designed for use by someone "who doesn't know a byte from a bite," Benchmark merits praise for the time and effort that went into its menus and safeguards. One of the processor's features is that it does not use control characters, except on the least capable of terminals. To instruct the processor to do something, the user enters the command mode and hits a single key: F for Finish, I for Insert, J for Jump to a page, D for Delete, and so on. When you use a command that can make irretrievable changes, such as killing a document or quitting at the wrong place, Benchmark asks if you really mean it. And if you do, you must hit the Rub or Execute key.

Benchmark's Hallmarks

Now, for the especially nice things about Benchmark. It automatically maintains a remarkably detailed directory of what is on the data disks, including titles of up to 30 characters, initials of the author of each document and the operator of the system at the time the document was produced, time and date of last revision, number of K

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bytes of disk space used by each document, a running total of the amount of disk space used, and a warning when a disk is getting full. All together, this can be a super filing system. And once the user knows the system, he or she can bypass all the menus and prompts. (The literature claims that the entire system can be learned in one day, but real facility takes longer.)

Printed line length of up to 155 characters is supported, which is useful for spread sheets and other financial documents.

Cursor control includes nine movements: left, right, up, down, home, next word, first character next line, first line any page, and next screen of text.

Finally, the best for last: a simple set of commands allows the user to attach up to 52 separate "phrases" to single-letter keys. Each phrase can be up to *2000 characters long*, and it can be called and inserted at the cursor position with the preset key. This is an excellent feature for repetitive jobs involving such projects as legal documents and form letters. It's hard to understand why Metasoft doesn't place more emphasis on this feature.

On the less positive side, Benchmark operates with a program disk and a data disk, using two drives. (Files *can* be saved to the program disk, but there isn't much room there.) The program is disk buffered, text is read into RAM (random-access read/write memory), then sent to the printer. With my North Star system, which has 56K bytes of memory, the drives are constantly active on long documents and that slows the printing process. Metasoft comments that "64K is nice" for long documents.

Another drawback is that simply having all those menus tends to make the user reliant on them, and as a result slows use of the program. This is probably not a legitimate complaint for an office situation where a secretary is running hard for four or five hours a day and uses the facilities and capabilities until they become second nature, but it can be a problem for those who spend most of their time creating text and very little time formatting and printing.

Finally, as noted earlier, Benchmark provides no spool printing or on-screen right justification.

Lettergo

If Benchmark is the high-performance secretary's ultimate weapon, then Lettergo is for users who rely on a word processor, but not necessarily for high volumes of routine work. Lettergo has one menu, disk-operation commands—and that's it. The menu is so spartan (Save, Load, Directory, Kill, Quit, Merge, and Free) that Heise used part of it for the copyright.

The Control key gets a workout on the Lettergo system because Lettergo uses control characters for editing functions (Control B returns the cursor to the beginning of the document, Control E scrolls toward the end, Control X reverses scrolls, Control P starts output to the printer from the cursor location, and so on, through all the letters of the alphabet). Even after using Lettergo extensively, I'd hate to take a test on the functions of all the keys. About 99 percent of the work can be performed with fewer than half of the control keys, so the demands on human memory are not as great as they seem.

Lettergo's Goodies

For all its versatility, Lettergo is remarkably easy to learn and operate. While Heise's excellent manual does not make any untoward claims about ease of learning, my wife, when faced with the sudden realization that a truly massive work she'd undertaken would require at least one full rewrite and a final retype, learned to use Lettergo (with *no previous computer experience*) in one long afternoon.

Although simple and chatty, the manual doesn't talk down to the user. It presumes virtually no previous computer knowledge and is a basic, step-by-step tutorial, followed by a complete reference manual that expands on the first section, and concluding with a section on how to set up the various types of hardware that can be used with Lettergo.

Lettergo drives the printer from system memory, rather than off the disk, which means that print speed is limited only by the speed of the printer. And the system makes it easy to format for printing by providing a format line across the top of each text screen. The line contains 10 single letters followed by two numbers each, so that a maximum of 30 characters provides full control over what the printer will produce. The formatting commands include L for line length, P for lines to a page, and

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Numeric pad	**14 keys**	11 keys	14 keys
Function keys	**14**	3	10
Display color	**Green**	White	Green
Operation			
Horizontal tabs	**Yes**	No	Yes
Insert/Delete	**Yes**	No	No
Page mode	**Yes**	No	No
Transmit field	**Yes**	No	No
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S for line spacing—an arrangement that is quick and easy to use. Any of the formatting commands can be changed at any time or any place in the document, through the use of *dot commands*—a period at the left margin, followed by the letter indicating which formatting command is to be changed. For instance, .L78-58 will shorten the line length of text following the command by 20 characters, while .L58-78 will return the text to the original length. This is not a unique system, but many word processors do not show the changes on the screen, as Lettergo does.

If a revised file is longer than the space allotted for the original version of the file, Lettergo will save the new version further along on the disk and kill the original, without telling the user. When disk capacity is reached, the program will automatically compact the disk (rewrite all the disk files in a contiguous manner), thus eliminating all those holes along the way. The user can control this housekeeping if he or she wants, though Heise did not include the command in the disk-operations menu. (Nor did he include the information that you can direct output to devices other than the video display or printer, though that capability is provided in a single control character from the disk menu. This capability is handy if you have a homebrew spooler sitting around in high memory, disguised as another device.)

Among the disadvantages of Lettergo are that two operations are necessary to move a block of type: one to move it to the new location, the second to kill the block at the old location. A command that automatically deletes at the old location while moving to the new location would be more useful. Heise describes the two-step operation as a safeguard.

Another drawback is that maximum output line length is 78 characters. If you are printing at a pitch of 12 characters per inch, that is a bit restricting. Most financial documents are too wide for Lettergo.

Finally, as noted earlier, Lettergo has no spooling capability and no on-screen right-hand justification.

Conclusions

These two systems provide truly flexible, powerful, and complete screen-oriented word processing, something that was previously unavailable to the North Star DOS user. The prices are not excessive (each costs $500), considering the word-processing power that these software packages provide, and each system has advantages for different users. Benchmark is beautifully suited to the office environment, while Lettergo can serve in the office provided there is no need for wide margins. It is even more useful in such word-processing applications as freelance writing.

Neither demands much computer knowledge beyond knowing how to turn on the machine, and both have been thoroughly tested in working environments: Benchmark in legal applications and Lettergo in government offices. Field proof is important in a time when some high-priced software does not deliver anywhere near what is promised. Both of these systems do. ■

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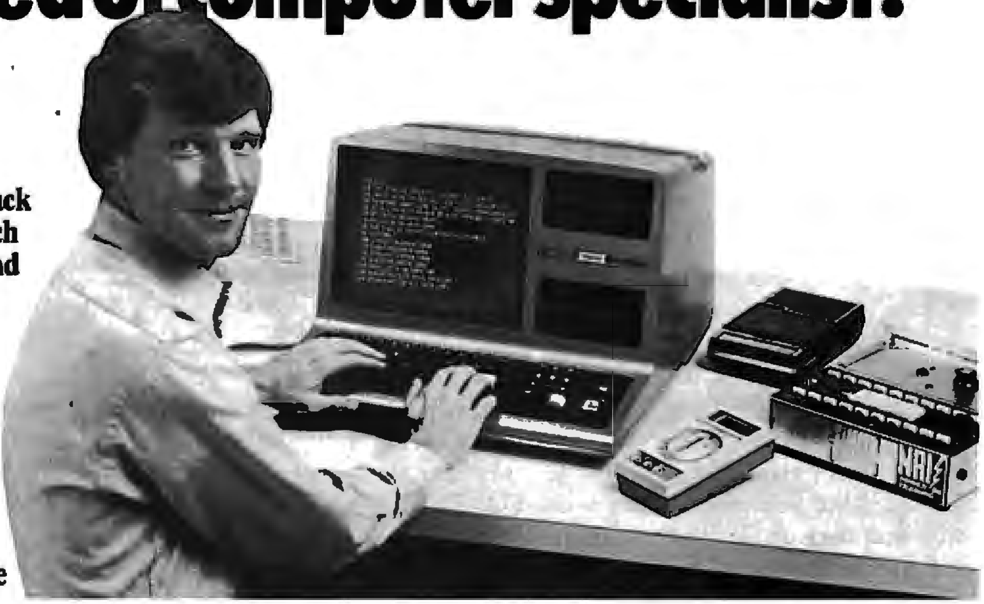

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A Disk Operating System for FORTH

An in-depth look at how a DOS operates

Peter Reece
152 Hillcrest Ave.
Dundas, Ontario
Canada L9H 4Y2

A disk operating system (DOS) is the heart of any computer system. Without a powerful and easy-to-use DOS, creating and maintaining programs and data on the system can be cumbersome if not impossible. This is because the DOS offers utilities of various types which manipulate files and, in general, perform all of the "housekeeping" chores essential to the system's smooth operation. In addition, most DOSes attempt to be user-friendly. That is, they are designed to make operation of the computer as simple and foolproof as possible.

This article describes the creation of a DOS for the FORTH language. FORTH is powerful, but it lacks a DOS in the usual sense. That is, it does not come with utilities to handle the normal operating-system constructs common in computer systems. For example, no options are available to have named files, to query disk space, to run named programs, and so on.

The DOS described here, appropriately called FORTHDOS, allows creating and deleting named files, maintaining directories of named files, listing statistics on disk usage, generating files by type (sequential, random, or block), listing files, allocating disk space, adding named utilities, getting help with commands, write-protecting any disk or file area, file copying, giving error messages, and many other features. FORTHDOS is a powerful, efficient, and easy-to-use DOS for single-user FORTH systems.

A complete listing of FORTHDOS is given in listing 1. Before discussing this listing, however, let's look at some of the rationale involved in producing this or, for that matter, *any* DOS.

FORTHDOS is a powerful, efficient, and easy-to-use DOS for single-user FORTH systems.

Features of DOS Packages

All DOSes contain commands for file manipulation. These commands usually invoke primitive operations or "primitives" responsible for: sequential and random-access file control, commands for creation and deletion of files, file space allocation algorithms, and similar types of file access controls.

Another class of DOS commands contains commands descriptive in nature and used mainly to display information. Examples of this class are those which list a directory of system or user files, show the system status, generate file listings, or alter the write- or security-protection status of files.

A third class of DOS commands concerns program control. These commands are exemplified by compiler calls (the compiler calls the DOS to determine how and where to place compiled files) and by commands allowing you to add primitives to your own software or even to add your own pseudo-DOS commands. An example of the latter is in the CP/M disk-operating system, which allows you to create custom commands via the use of .COM files.

A final class of DOS functions consists of utilities. While not strictly part of the DOS structure itself, utilities are often available as part of a DOS package. For example, a file copy utility such as PIP in CP/M or COPY in TRSDOS may be considered as a separate class of DOS commands.

Table 1 lists by command class FORTHDOS features usually found in typical DOS packages. Note that all of the common commands, ranging from creating a file to allocating disk storage space for random access, are available in FORTHDOS. As this article will discuss, all of these commands depend ultimately on a very simple structure—the *bit map* and the primitives that manipulate it.

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Class 1: File Manipulation

WBLK	—Primitive to write a record. This primitive contains machine-language code to access a given sector from a given track on a given drive. (System specific.)
RBLK	—The read-record primitive corresponding to WBLK.
MAKE	—Primitive to enter/create a file in the directory.
READ	—Primitive to perform a sequential-access file read.
WRITE	—Performs a sequential-access write to a file.
RREAD	—Primitive to perform a random-access file read.
RWRITE	—Performs a random-access file write.
MOUNT	—Loads a disk directory into RAM.
REMOVE	—Writes a disk directory from system RAM to disk.

Class 2: Examples of Informative Commands

FREE	—Reports on disk and RAM space used/remaining.
HELP	—Lists information on DOS commands and their uses.
FSIZE	—Reports on the size and status of any file.
FILES	—Types a full directory of the disk plus relevant information.
BLOCKS	—Types a list of all records active for a given file.

Class 3: Examples of Commands for Program Control

NAME	—Enters a file name into the DOS for future use.
RUN	—Compiles and executes a program.
LOOKUP	—Checks to see if a given file name is on disk.
COPYALL	—Copies a file to another file from a program.
DINIT	—Initializes a new directory.
PROT?	—Sees if a given file is write-protected.
DPUTNM	—Saves a given file name into a directory.
KILL	—Deletes a file under program control.

Class 4: Examples of DOS utilities

FCOPY	—Copies a file to another (old/new) file.
XCOPY	—Like FCOPY but copies to a non-current disk.
BCOPY	—Copies records grouped by contiguous record numbers.
PROTECT	—Declares a file as write-protected.
UNPROTECT	—Declares a file to be read/write accessible.
TYPE	—Types a file to the console device.
PTYPE	—Prompts for format information, then prints on printer.
RENAME	—Gives a new name to an old file.
ASSIGN	—Forces DOS to assign a given record number to a file.
LOCK	—Prevents DOS from accessing read/write a record number.
KILL	—Deletes a file from the directory.
TIME	—Prints current time of day.
TIMESET	—Sets time of day.

Table 1: *FORTHDOS commands divided into classes of commands found in typical DOSes.*

Bit Maps

Although a DOS designer has many strategies to choose from in setting up a system, almost all DOSes use a bit map approach to regulating file activity on a disk. A *bit map* is a small byte array in which each bit represents the smallest logical grouping of bytes on a disk. Such a grouping is typically called a *record* or, in a FORTH-based system, a *block*.

Suppose we are designing a DOS using a 5¼-inch, 35-track disk. We could format this disk in many ways (by writing EOR or end-of-record marks onto the disk). We might use the TRSDOS scheme where EOR marks are written to yield a record size of 256 bytes or one record per sector. Since there are 35 tracks per disk and 10 records per sector, this equals 350 records per disk containing 350 times 256 or 89,600 bytes of storage.

We now need some scheme for keeping track of whether or not a given record is available for use, or if it is part of an existing user file. If we used the TRSDOS scheme mentioned above, a simple way to do this would be to create a bit map 350 bits long (just under 45 bytes) in which the first (high-order) bit represents the first record on the disk and the last (low-order) bit represents the last (350th) record on the disk. If a given record were in use, we would set the appropriate bit in the bit map to 1; otherwise we would set the bit to 0. This simple scheme would allow a DOS to keep track of all available records. Notice that since only a small amount of storage would be necessary (45 bytes), the entire activity of the disk could easily fit into free memory in a section reserved for system use. We will use a modified version of this scheme based on the traditional unit of storage in FORTH, the *block*.

In FORTHDOS, since records (blocks) are 1024 bytes long, a 35-track disk having 89,600 bytes of storage would require only 11 bytes of storage plus 1 bit (1 bit represents 1024 bytes):

$$11 \text{ bytes} \times 8 \text{ bits per byte} + 1 \text{ bit} = 89 \text{ blocks per disk}$$

In practice, this value is actually 86 blocks per disk, since a formatted disk has fewer available bytes for data than does the unformatted disk described above. This means that 11 bytes are easily enough to contain information on every data record available to the user. Figure 1 shows how FORTHDOS uses this simple scheme to map disk activity. Having developed this scheme of mapping record activity on the disk (given a specific disk format), we now need to develop a method of mapping file activity (i.e., activity of groups of records).

Bit Maps for User Files

Once we have settled on a format for each disk, we must determine whether or not to allow a file to use all records on the disk if they are available. This will determine the length of a file's bit map. If we refer again to the 35-track disk formatted as discussed above, a possible 86 blocks are available for use by any one file. For simplicity, let's allow files to be 86 blocks long. This would mean that, like the disk activity bit map, each file bit map would be 11

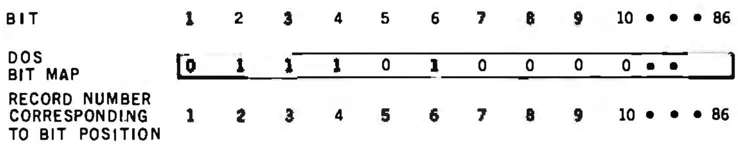

Figure 1: *Sample FORTHDOS disk bit map. A 1 in the bit map indicates that the corresponding record number is in use. In this sample, records 2, 3, 4, and 6 are in use.*

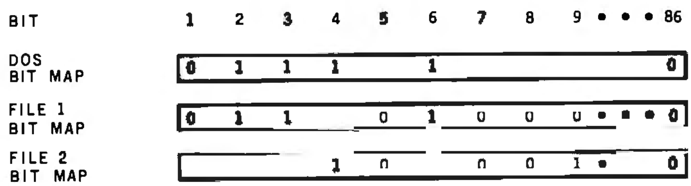

Figure 2: *FORTHDOS bit map and file activity bit map. FILE1 is shown as using blocks 2, 3, and 6, while FILE2 is shown using blocks 4 and 9. The DOS bit map indicates which blocks are in use regardless of what file the blocks belong to; blocks 2, 3, 4, 6, and 9 are therefore indicated by the DOS bit map as being in use.*

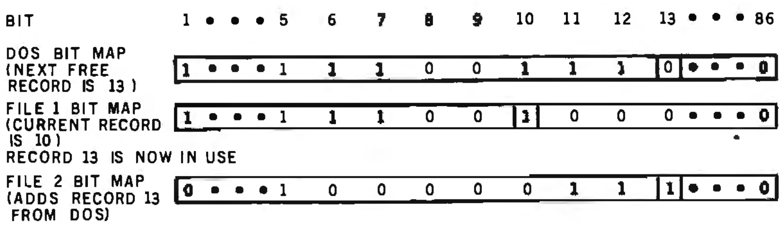

Figure 3: *Using DNXT to find the next free record. As indicated in the DOS bit map, the next free record is 13. DNXT will scan the DOS bit map, find the free record, and change its corresponding bit to a 1.*

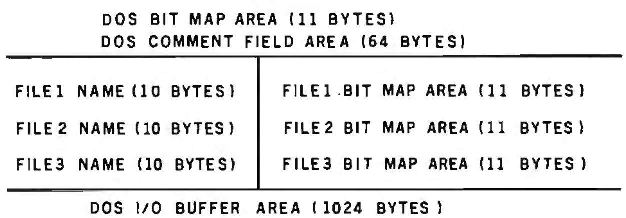

Figure 4: *FORTHDOS buffer area. FORTHDOS places all file bit maps and the DOS bit map in a common buffer area. This allows you to have as many files open at one time as you need.*

bytes long. Figure 2 shows our bit map structure so far—one disk activity bit map (called DOS bit map) and multiple file activity bit maps.

What of space contention, though? If each file bit map can map any record in the system, how does the DOS determine the file assignment of each record? The answer is very simple. A FORTHDOS primitive (DNXT) scans the disk-activity bit map from high- to low-order bits until it finds a 0 (unused record). That bit is changed to a 1, thereby marking the corresponding record as being in use. DNXT then marks the same bit in the CURRENT file (i.e., the file requesting a free record) as also being in use. In figure 3, record 13 of both the DOS bit map and the FILE1 bit map is initially 0.

When FILE2 in figure 3 requests a free record, a call to DNXT causes the DOS bit map to be scanned. The next free record found by DNXT in this example would be record 13. This record's corresponding bit is then set to 1 in both the DOS and FILE2 bit maps (see figure 3). In this way, free records are allocated on a first-come, first-served basis by the DNXT primitive in the DOS.

Two points are important here. First, note that DNXT does not care if the record number returned is the next consecutive record in the bit map, but it will return consecutive records if possible (i.e., if the record is not in use). This means that DNXT will produce contiguous records for a given file wherever possible. This shortens head-seek times across the disk.

A primitive discussed below— KILL , which deallocates records—may be used by a clever DOS designer to ensure that a maximum amount of contiguous space is available. (Many DOS packages have disk cleanup utilities which periodically remap bit maps so as to maximize the amount of contiguous record allocation per file. For small systems, this is not needed.) A second point to note about this file bit map scheme is that it provides a simple method for inserting both sequential- and random-access file primitives into FORTHDOS.

Sequential and Random Access

In a *sequential-access file,* data records are accessed one after the other, without any gaps in the numeric sequence of records in the file. The ninth record cannot be accessed after the tenth has been read without starting over at the first record and reading up to the ninth again. In a *random-access file,* on the other hand, data from any record number may be accessed at any time. The ninth record may be accessed after the tenth or, for that matter, after any other record. *Relative pointers* are used in a random-access file. The record which the DOS has mapped in the bit map as record 341 may be relative record 10 to the user. That is, it may be the tenth record relative to the first record in the file. The DOS takes care of the correct translation of this relative record 10 into absolute record 341 on the disk.

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FORTH and Punctuation

FORTH uses punctuation in some of its words, which makes representing them in text a difficult problem. For example, one FORTH word is {(")}, which could be taken to mean one of several character combinations. (For your information, the word has three characters and is made from a left parenthesis followed by a double quote mark and a right parenthesis.)

To decrease the chance of confusion while trying not to clutter text unnecessarily, we will sparingly *use braces, { }, to isolate the character string within as a FORTH word or phrase. (For example, the above word would be written { (") } .) Braces will be used only under the following situations:*

- *When the material being quoted is a phrase of FORTH words (e.g., { 26 LOAD } or { 3 5 + })*
- *with the FORTH words { . } (period), { , } (comma), { : } (colon), { ; } (semicolon), { ? } (question mark), { ! } (exclamation point), { ' } (single quote mark), and { " } (double quote mark)*
- *with any word using the above punctuation marks (e.g., { $. } or { ." }).*

All other FORTH words will be set apart by a space on either side of the word; braces will always *signal a FORTH word or phrase. The braces are not part of the word or phrase, and FORTH words will never use braces within the body of a figure or listing. . . .* GW

FORTHDOS on Floppy Disk

The author has agreed to make listings 1 and 2 available for a fee of $8 plus a floppy disk and a self-addressed return envelope. Due to the author's Canadian address and the expense of cashing foreign checks, the $8 must *be paid with an international money order. Also, do not put postage on the return envelope; Canadian postage is included in the $8 fee.*

imize use of contiguous blocks of disk space for sequential and (particularly) random access, many DOS implementations utilize complex memory allocation techniques. FORTHDOS, however, uses multiple-file bit maps, a single DOS bit map, and a common I/O (input/output) buffer to avoid these complications without sacrificing speed or ease of use for small systems. Before describing how this is done for sequential- and random-access files, we must first look at file device control blocks.

File Device Control Blocks

It is common DOS design practice to build OPEN and CLOSE primitives (e.g., OPEN and CLOSE commands in BASIC). The OPEN primitive creates a device control block (DCB) area in memory; this contains information on the file (its size, bit map, etc.) for use by the DOS until the CLOSE primitive writes the information back to the system area of the disk. In addition, OPEN creates a buffer area of RAM (random-access memory) within the DCB into which data is swapped back and forth from the file to other (user) areas of memory. This last point means that as the number of open files increases (as might be the case in a complex program), the amount of memory used by the file DCBs grows very rapidly. This is why many DOS systems limit the number of files which may be open at any given time. This manifests itself as the OUT OF FILE SPACE messages you get while executing a favorite program.

Suppose we use a different method. Suppose that instead of using a DCB area for each file containing file statistics plus buffer space, we use a common small buffer area for all files and keep all file bit maps in memory at one time (they're only 11 bytes long). This allows you to have as many files open at one time as you wish without using up more than 11 bytes per open file (for 35-track disks). Figure 4 illustrates this.

In other words, FORTHDOS uses two buffer areas. The first contains the file bit maps for all files in the system as well as their names and the DOS bit map. I've made this area 1024 bytes long, but it may be any length desired or even swapped in and out of memory as wished, with only current files kept in the buffer. The second buffer area is the one used for file I/O (which I have also made 1024 bytes long). Again, this may be of any length the user wishes.

Since FORTH is a virtual system using a 1024-byte buffer (i.e., FORTH blocks can be seen as virtual memory that is swapped into memory when needed), I have set up the DOS to use this same buffer for all file I/O. Therefore, the total cost to the system for implementing FORTHDOS without a DCB structure is only 1024 bytes of buffer space regardless of the number of open files per disk buffer.

Armed with the conceptual tools of bit maps and DCB usage, let's examine the way in which sequential- and random-access files are accessed through FORTHDOS.

Bit Maps for Sequential and Random Access

Notice in figure 5 that five files are in use (open) and that the record number that would be returned by the next use of DNXT is 53. Suppose we wish to add data to the next record available in the file, labeled ORANGE in figure 5. Assume that ORANGE is a sequential-access file. By using the DOS primitive WRITE , we would add our data from the buffer to ORANGE at record 53. WRITE would work as follows:

1. Call DNXT to calculate where the next free record is on disk (scan DOS bit map). Return with 53.
2. Set bit 53 in the DOS bit map to a 1 (i.e., in use).
3. Set bit 53 in ORANGE bit map to a 1.
4. Write any previous data from BUFF (the FORTHDOS I/O area in memory) if necessary.
5. Write the data from BUFF to record 53.

Note the following points: the file bit map, ORANGE bit map, is filled according to the next available free record in the DOS bit map, not from

```
FILE NAME                        RECORDS USED IN BIT MAP

ORANGE   (3 RECORDS)             2, 10, 14,
PEAR     (5 RECORDS)             1,  3,  4,  5,  6
APPLE    (5 RECORDS)             7,  8,  9, 11, 12
BANANA   (25 RECORDS)            13, 17, 18 ——► 40, 41
TREE     (14 RECORDS)            11, 15, 16, 19, 42——► 51, 52

A CALL TO NEXT WOULD RETURN RECORD 53 (i.e., LAST RECORD
USED WAS 52 IN FILE TREE). AFTER A SEQUENTIAL WRITE TO
FILE ORANGE, ITS BIT MAP WOULD CONTAIN:

ORANGE   (4 RECORDS)             2, 10, 14, 53
```

Figure 5: *Adding records to a sequential-access file.*

```
RELATIVE RECORDS   1    2    3    4    5    6
RECORD NUMBERS    |34   45   72   67   68  |84|   RECORD 84 IS
IN THE BIT MAP                                   CURRENT RECORD
FOR FILE PEAR

        RECORD 34 ——— SEQUENTIAL READ ———► RECORD 84
```

Figure 6: *Random-access record retrieval. To sequentially read record 72, you would have to start at record 34 and go forward. A random read of record 72 would be done by calling RREAD to relative record 3, then doing a direct head move to that record.*

the ORANGE bit map. No other files are affected, regardless of how many are in use. Step 4 above is carried out only if the DOS has not previously taken care of writing the FORTH-DOS I/O buffer through prior processing.

Reading such a sequential file is extremely simple. If we look again at figure 5, we see that the ORANGE bit map shows the file ORANGE to consist of records 2, 10, and 14. The DOS primitive READ scans the ORANGE bit map from high- to low-order bits, moving the next record whose corresponding bit is 1 to the I/O buffer BUFF.

Since the ORANGE bit map contains 1s in positions occupied by corresponding record numbers used by the sequential file ORANGE and 0s elsewhere, it is unnecessary to mark the file on disk with an EOF (end-of-file) marker. It's easier and just as efficient to total the number of ones in ORANGE bit map and have the DOS read only that number of records from the file. Because only 11 bytes are involved, this can be done very rapidly. The only data that gets written to a file is user data without the need for EOR or other such markers. Random access is handled in a slightly different manner.

Random Access

In figure 6, the bit map for PEAR shows that records 34, 45, 72, 67, 68, and 84 are in use. If this were a sequential-access file and we wanted to read record 72, it would be necessary to go to the beginning of the file and scan through until record 72 was found.

By designating the file as random access, however, you can go immediately to record 72. Do so by entering a call to the FORTHDOS primitive RREAD (random-access read) with a relative pointer 3. This tells the DOS to scan PEAR bit map for the third 1 (i.e., the "in-use" bit) encountered. The record number corresponding to this bit will then be read by the same primitive used to read a disk record for a sequential file. The only difference between random and sequential access in FORTHDOS is that the former scans a file bit map prior to an access to locate the absolute record number desired, while the latter must access the DNXT available record.

Scanning is performed (in this example) over 11 bytes only—clearly much faster than forcing the DOS to sequentially read through as many as 86 blocks (an entire disk) before arriving at the desired record. This

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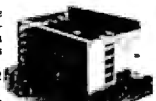

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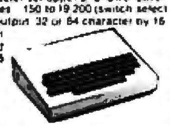

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Circle 143 on inquiry card.

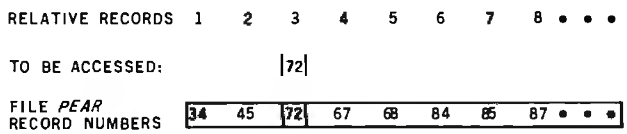


Figure 7: *Interchangeable random/sequential accessing. To change from a sequential- to a random-access read, FORTHDOS would save the value of the current record number being read (84) in the variables TMP and NBLK. FORTHDOS would then call RREAD to read relative record 3 and change the value of NBLK to 72. Then NBLK would be restored to the value of TMP (84), and the sequential read would continue.*

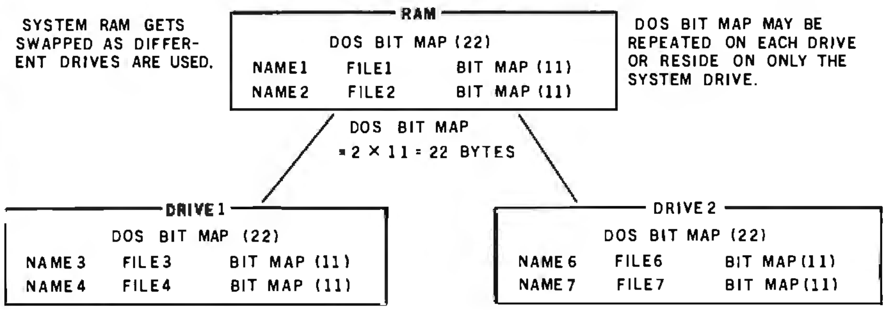


Figure 8: *Swapping disk directories. As each disk is accessed, the disk directory is read from the disk and placed into RAM.*

scheme works quite well and even has a side benefit that adds extra versatility to the DOS; a given file can be sequentially or randomly accessed at any time!

To further clarify this scheme, suppose you are accessing the file PEAR through the FORTHDOS primitives DNXT and READ (sequential read) at record 84. As figure 7 shows, no indicators are present in PEAR bit map to tell us that the file is sequential; only the variable NBLK is associated with current file activity. This variable stores the current record number being accessed from the current file. In figure 7, NBLK contains an 84 (i.e., record 84 is being accessed). If the file is accessed again (refer to figure 7) but this time by the DOS primitive RREAD to access record 72, the DOS will set NBLK to 72 and retrieve that record. Also, if the value of NBLK (72) had been saved prior to invoking RREAD , you can restore this value at any time and continue with sequential access by using the sequential READ again.

As you can see, any FORTHDOS file may alternate between sequential- and random-access read without destroying the integrity of the bit map! This may also be done with write access, but more variables are involved. Consult listing 1 for the names of these variables.

FORTHDOS

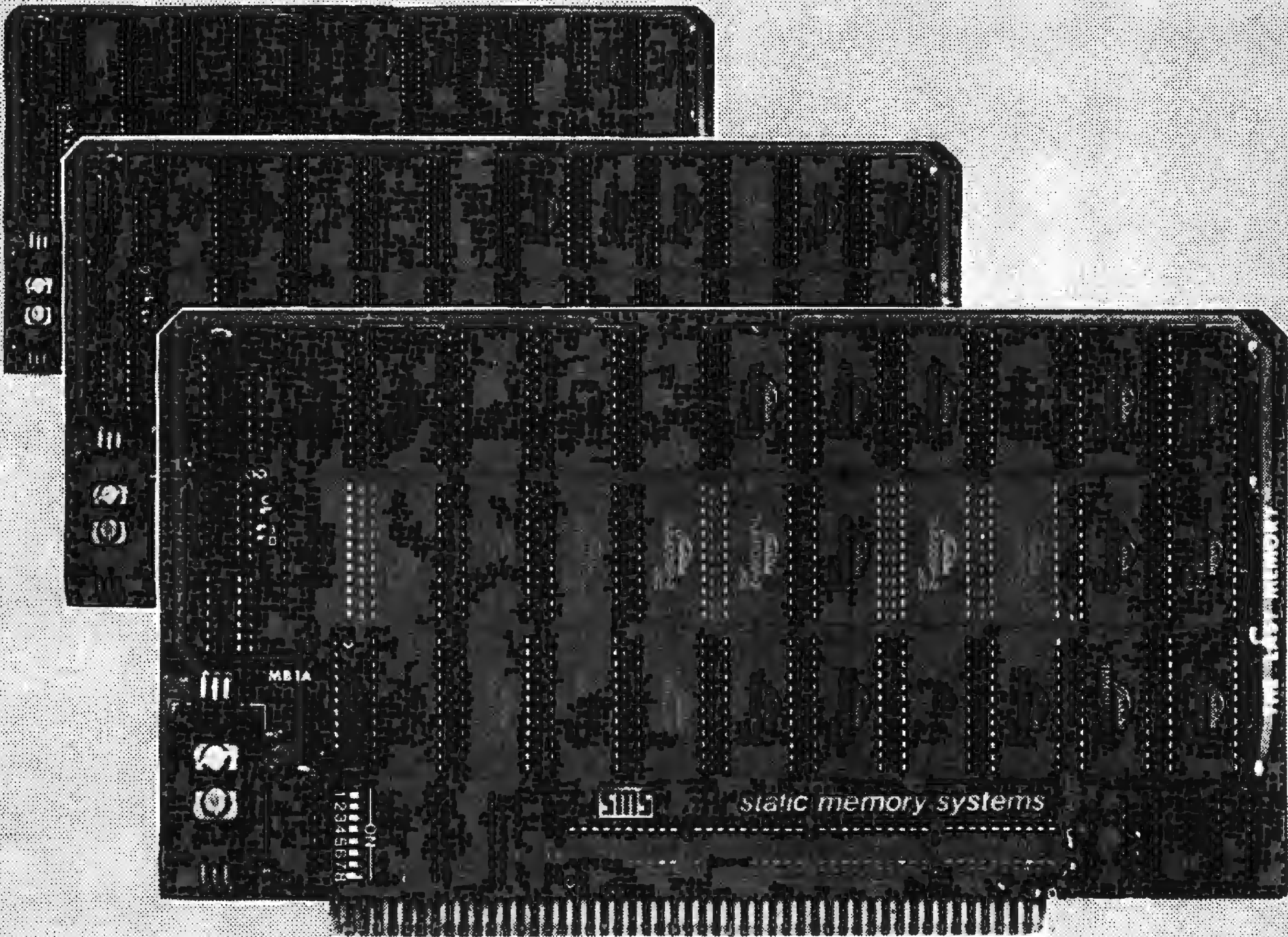
Having discussed the basics of the DOS structure, we can now look at the actual implementation in more detail. Table 2 (on page 348) gives an abbreviated listing of the table 1 commands. All are available in FORTHDOS, with special provisions in the DOS for bypassing terminal interaction when you wish to issue the commands under program control. Some of the functions of the commands change and require parameter passing when accessed through a user's program. Let's briefly step through a few of these commands.

Loading a Directory

Enter the MOUNT command whenever a new disk is inserted into a drive, and enter REMOVE when the disk is taken out. The former reads the file names and bit maps into the DOS memory (1024 bytes, as mentioned earlier). The latter writes this FORTHDOS RAM area back to disk. Figure 4 gives a simplified version of

Text continued on page 348

Circle 384 on inquiry card.


static memory systems

Listing 1: *Disk operating system for FORTH. This DOS is written in the MMSFORTH (version 1.8) dialect of the FORTH language for use on the TRS-80 Model I computer running Level II BASIC. The listing is in two parts, a core package that resides in memory and a utilities package that resides on disk for use as needed. Set DIRBLK and AUXBLK to match your system before LOADing words from { :DOS } to { :BCOPY } inclusive. Also, in this listing the left bracket in the MMSFORTH word 2[(the sixth colon definition in this listing) should actually be an up-arrow symbol.*

```
(" FORTHDOS - a disk operating system - by Peter Reece (c) 1981
: DOS ;      : CARRAY 0 CCONSTANT H +! ;CODE HL POP DE DAD PSH
#TRACKS 256 * 100 / 3 - #DV @ *       ( Use # of disk tracks &)
     CCONSTANT DSKSZ                  (  # of drives to get size)
15360 CONSTANT VIDEO                  ( Start adrs of video ram)
86 VARIABLE DIRBLK                    ( Adrs of directory block)
34 VARIABLE AUXBLK                    ( Adrs of utility progs)
DSKSZ 8 / 1+ CCONSTANT MAPSZ          ( Size of bitmap)
MAPSZ CARRAY BITMAP                   ( Create system bitmap tabl
MAPSZ CARRAY QMAP                     ( Create file bitmap table)
1024 CARRAY DBUFF                     ( Directory holding buffer)
64 CARRAY FNAME     5 CARRAY ONAME    ( File name buffers)
0 DBUFF VARIABLE DADRS                ( Start of directory buffer
0 VARIABLE NBLK                       ( Currently accessed block#
0 CVARIABLE BM1    0 CVARIABLE BM2   0 CVARIABLE BM3 ( Temporary
0 VARIABLE N       0 VARIABLE N1     5 CARRAY TMP     ( storage)

: T# <# # #S #> TYPE ;                     ( Type a number)
: C+! DUP C@ ROT + SWAP C! ;               ( Add tos to cvar)
: C-! DUP C@ ROT - SWAP C! ;               ( Subtract from cvar)
: 2[ DUP 0= IF DROP 1                      ( Raise 2 to tos power
         ELSE 1 SWAP 0 DO 2* LOOP          ( Used to determine a
       THEN ;                              ( record's bit number)
: DZONK 0 0 BITMAP MAPSZ FILL ;            ( Clear the bitmap)
: DGT DUP 8 / DUP ROT ROT 8*               ( Translate the block#
       - SWAP DUP ROT 2[ ;                 ( in tos to bitpostion
: DON DGT SWAP BITMAP C@                   ( Set a block to 'on')
       OR SWAP BITMAP C! ;
: DOFF DGT BM2 C! BITMAP C@                ( Set a block 'off')
       255 BM2 C@ - AND SWAP BITMAP C! ;

: DON? 0 BM2 C! DUP DGT SWAP BITMAP C@      ( If block# in tos is)
     AND SWAP DROP 0=                       ( used, bm2=block#)
        IF DROP ELSE BM2 C! THEN ;          ( else bm2=0)

0 CVARIABLE 1SB                        ( 1st block in a thread)
: DNXT  0 BM1 C! DSKSZ   DO I DON?     ( Find next free)
    BM2 C@ 0= I 1SB C@ >= AND          ( Chk thread integrity)
    IF I BM1 C! LEAVE THEN LOOP        ( Get block into bm2)
    BM2 C@ 0 <> BM1 C@ 0= OR           ( or issue a -1 flag)
    IF  -1 BM2 C!                      ( issue error msg)
        " *** Thread Full ***" ENTER
    THEN ;

( * Access the directory through a virtual buffer)
: DREAD DADRS @ DIRBLK @ RBLK ;                 ( Read directory)
: DWRITE DADRS @ DIRBLK @ WBLK ;                ( Write directory)
: DRD DADRS @ 0 BITMAP MAPSZ MOVE ;             ( Read the bitmap)
: DWR 0 BITMAP DADRS @ MAPSZ MOVE ;             ( Save the bitmap)
: MOUNT DZONK DREAD DRD ;                       ( Mount diskette)
: DSAVE DWR DWRITE ;                            ( Save directory)
: REMOVE DSAVE FLUSH CR " REMOVE DISKETTE" ;    ( Remove diskette)
: DINIT MOUNT 0 DADRS @ 1024 FILL DZONK ;       ( Initialize dir)
```

```
( * Lookup fname: exit tos & bm1=position in directory, or -1)
: LOOKUP -1 BM1 C! DADRS @ 128 + N !      ( 1st 4 letters only)
   13 0 DO                                ( are valid in fname)
        N @ C@ 0 <>
           IF N @ C@ 0 FNAME C@ =
              IF N @ 1+ C@ 1 FNAME C@ =
                 IF N @ 2+ C@ 2 FNAME C@ =
                    IF N @ 3 + C@ 3 FNAME C@ =
                       IF I BM1 C! LEAVE
                       THEN
                    THEN
                 THEN
              THEN
           THEN 64 N +!
        LOOP BM1 C@ ;

( * Add a new filename to the directory)
: DPUTNM LOOKUP 255 <>
     IF " * FILE ALREADY EXISTS" ENTER
     ELSE DADRS @ 128 + N !
        13 0 DO N @ C@ 0 =
              IF 0 FNAME N @ 15 MOVE LEAVE 0 N !
              ELSE 64 N +!
              THEN
           LOOP N @ 0 <>
        IF " * FILE NAME SPACE IS FULL" ENTER
        THEN
     THEN ;

( * Prompt for and input a filename)
: NAME 0 0 FNAME 15 FILL SPACE " FILENAME:" SPACE
  0 FNAME 15 EXPECT ;

( * Obtain the filemap for the file named in 'fname')
: DGTMAP LOOKUP 255 <>
     IF DADRS @ 128 + BM1 C@ 64* + 20 +
        DUP N ! 0 QMAP MAPSZ MOVE
     THEN ;

( * Add a block to thread for 'fname' & leave # on tos, or 0)
: DADD
     DGTMAP DNXT BM2 C@ -1 <>                ( find bitmap for)
     IF BM1 C@ DUP DON DGT SWAP              ( this file, get )
          QMAP C@ OR SWAP QMAP C!            ( next in chain  )
          0 QMAP N @ MAPSZ MOVE BM1 C@       ( put it on tos  )
              ELSE 0
     THEN
  ;
```

Listing 1 continued on page 336

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Listing 1 continued:

```
( * Make a new file & allocate directory space for it)

: 1STBK DGTMAP 85 0 DO I FON?       ( set 1sb)
  BM2 C@ DUP DUP 0 <> IF 1SB C! LEAVE ELSE DROP THEN LOOP ;
: MAKE 0 1SB C! NAME DPUTNM 1STBK ; ( Create/open a file)

( * See if the file in fmap is using the block# in tos)
: FON?
       DUP DGT SWAP QMAP C@
                            AND SWAP DROP 0=
           IF DROP 0 BM2 C!
              ELSE BM2 C!
           THEN
  ;

( * Routine to caluculate adress of a file from DOS RAM)
: RENM DADRS @ 128 + BM1 C@ 64* + N ! ;

( * Kill the file named in fname)
: KILL
   NAME LOOKUP 255 <>
     IF DGTMAP DSKSZ 0
         DO I FON? BM2 C@ 0 <>
               IF BM2 C@ DOFF
               THEN
         LOOP RENM 0 N @ 64 FILL
     THEN ;

( * Read the next block in 'fname' into the buffer at tos)
: READ N1 ! DGTMAP BM1 C@ -1 <>
    IF
       BEGIN NBLK @ DSKSZ >
              IF 0 NBLK !
              THEN
              1 NBLK +! NBLK @ FON? BM2 C@ 0 <>
                    IF N1 @ BM2 C@ RBLK 1
                         ELSE 0
                    THEN
       END
    THEN
  ;

( * Print the # of blocks used by the file in fname)
: FSIZE
    DGTMAP BM1 C@ -1 <>
      IF 0 BM1 C! DSKSZ 0
           DO I FON? BM2 C@ 0 >
               IF 1 BM1 C+!
               THEN
           LOOP
           BM1 C@ SPACE T# SPACE " Blocks"
      THEN
   ;

: PROT?      ( * Returns 1 if the file is protected, 0 therewise
 LOOKUP 255 <> IF RENM N @ 63 + C@ 170 = IF 1 ELSE 0 THEN THEN

( * Write buffer on tos to the file 'fname')
: WRITE
   N1 ! PROT? 0=                             ( don't write if rec)
      IF DADD DUP 0 >                        ( is protected      )
          IF N1 @ SWAP WBLK
             ELSE DROP
          THEN
      THEN
  ;

( * Random access of relative block# on tos to buffer at tos2)
: RFIND
    DUP N ! BM1 C! N1 ! DSKSZ 0
        DO I FON? BM2 C@ 0 >                     ( loop to find )
              IF 1 BM1 C-! BM1 C@ 0 > NOT        ( relative rec#)
                     IF I N ! LEAVE
                     THEN
              THEN
        LOOP
   ;

( * Random read block# at tos to buff at tos2, exit=1 if okay)
: RREAD RFIND BM1 C@ 0 >
      IF 0
        ELSE N1 @ N @ RBLK 1
      THEN ;

( * Random write block# at tos to buff at tos2, exit=1 if okay)
( * Note that user may only write to a block already allocated)
: RWRITE RFIND BM1 C@ 0 >
       IF 0
         ELSE N @ PROT? 1 =
             IF DROP 0
                ELSE N ! N1 @ N @ WBLK 1
             THEN
       THEN ;

( * These words alter the write protect status of a file)
: PROTECT
   NAME LOOKUP 255 <>
      IF RENM 170 N @ 63 + C!
      THEN
   ;

: UNPROTECT
   NAME LOOKUP 255 <>
      IF RENM 0 N @ 63 + C!
      THEN
   ;
```

Listing 1 continued on page 338

Listing 1 continued:

```
( * Prints the number of free blocks on the current disk)
: FREE 0 BM1 C! DSKSZ 0
   DO I DON? BM2 C@ 0 >
      IF 1 BM1 C+!
      THEN
   LOOP
    CR DSKSZ BM1 C@ - T# SPACE " Free disk blocks"
    SPACE " out of" SPACE DSKSZ T# CR ;

( * Loads - compiles - a given filename for execution)
: RUN NAME LOOKUP 255 <> IF CR DSKSZ 0 DO I FON?
  BM2 C@ 0 <> IF I LOAD THEN LOOP THEN CR ;


( * List the file named in 'fname')
: SHOW NAME LOOKUP 255 <> IF FSIZE BM1 C@ DUP 0= IF DROP ELSE
  0 DO VIDEO READ LOOP THEN THEN ;

( * List the file names from the directory)
: FILES DADRS @ 128 + N1 ! CLS 0 23 PTC " Disk Directory"
  1 23 PTC 14 0 DO 131 ECHO LOOP CR CR DADRS @ 64 + 64 TYPE
  0 BM3 C! CR 13 0 DO N1 @ C@ 0 <> IF N1 @ 0 FNAME 15 MOVE
  PROT? 1 = IF " *" ELSE SPACE THEN 0 FNAME 10 TYPE
  FSIZE BM3 C@ 0= IF 1 BM3 C! 220 ECHO ELSE 0 BM3 C! CR THEN
  THEN 64 N1 +! LOOP CR 'S PAD - T# SPACE " Free bytes of"
  SPACE " memory" FREE " (* - write protected file)" CR ;


( * From here on utilities only are listed.  Note that
(   the utilities take space, so they are not core resident
(   unless the user calls them in.  This is done by typing
(   in the name of the utility or command desired.  FORTHDOS
(   then loads the utility from the system area of the
(   appropriate disk, executes the utility, erases the utility
(   from core when done, and returns control to the user.
(   Note that 'assign', 'time', and 'timeset' are not included
(   in this listing since their function is peculiar to my
(   computer system. There are, however, some utilities listed
(   which are not given in the text.
(     You may easily add your own utilities or programs to
(   FORTHDOS by following the scheme used to call utilities.


( * Add any utilities you wish to FORTHDOS starting here.)
: GAUX AUXDOS @ + LOAD ;           ( This word loads the utility
: LOCK 0 GAUX ;
: SETDIR 1 GAUX ;
: RENAME 2 GAUX ;
: COPYALL 3 GAUX ;
: FCOPY 4 GAUX ;
: BLOCKS? 5 GAUX ;
: PSHOW 6 GAUX ;
: BCOPY 7 GAUX ;



( * Lockout any blocks the user wishes to be write protected)
: *LOCK
       BEGIN
           " Block# to be locked out (-1 if none):"
           #IN DUP -1 =
               IF DROP 1
                    ELSE DON 0
               THEN CR
       END
  ;

*LOCK FORGET *LOCK

( * Set up a new directory via prompts to the user)
: *SETDIR CLS 0 23 PTC " NEW DIRECTORY" CR CR
     " Build a new directory (& destroy all files)" Y/N NOT
          IF DINIT CR " Write protect below block#"
                SPACE #IN 0
                    DO I DON
                    LOOP
                CR LOCK 0 0 FNAME 64 FILL
                DIRBLK @ DON DWR DADRS @ 64 + N !
                " Diskette description: "
                0 FNAME 64 EXPECT
                0 FNAME N @ 64 MOVE 0 0 FNAME 64 FILL
                DSAVE
          THEN CR ;
*SETDIR FORGET *SETDIR

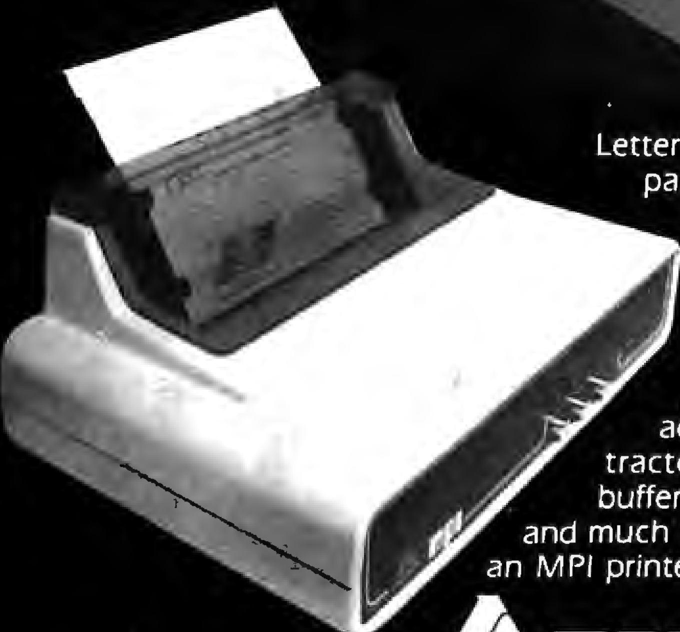

( * Give an old file a new name via the console of a program)
: *RENAME SPACE BM1 C@ -2 <>
  IF " OLD" NAME LOOKUP -1 =
       IF SPACE " * NOT FOUND" ENTER
           ELSE RENM SPACE " NEW"
                NAME 0 FNAME N @ 15 MOVE CR
       THEN
     ELSE LOOKUP 255 <>
           IF @ 0 FNAME SWAP 15 MOVE
           THEN
   THEN ;
*RENAME FORGET *RENAME



( * Copy tos blocks of the file in 'oname' to 'fname')
: *COPYALL 0 DO
```

Listing 1 continued on page 340

Easy.



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Listing 1 continued:

```
                    0 FNAME 0 TMP 5 MOVE
                    0 ONAME 0 FNAME 5 MOVE
                    VIDEO READ
                    0 TMP 0 FNAME 5 MOVE
                    VIDEO WRITE
              LOOP
        CLS 0 ONAME 5 TYPE
        SPACE " copied to" SPACE
        0 FNAME 5 TYPE CR
      ;
*COPYALL FORGET *COPYALL



( * Copy one file to another)
: *FCOPY SPACE " Copy from" NAME LOOKUP -1 =
    IF " * NO SUCH FILE" ENTER
      ELSE FSIZE BM1 C@ N1 !
        0 FNAME 0 ONAME 5 MOVE SPACE " To" NAME
        SPACE LOOKUP 255 =
          IF CR " (New File)" DPUTNM N1 @ COPYALL
            ELSE CR " (Copy over old file)" Y/N NOT
              IF N1 @ COPYALL
              THEN
          THEN
    THEN ;
*FCOPY FORGET *FCOPY



( * Print the blocks used by a given file name)
: *BLOCKS?
           NAME LOOKUP 255 <>
             IF CR " Blocks in use:" SPACE
               DSKSZ 0 DO
                          I FON? BM2 C@ 0 <>
                          IF I T# SPACE
                          THEN
                       LOOP
             THEN
           CR ;
*BLOCKS? FORGET *BLOCKS?

( FORTHDOS Printer routines - header, pagesize, number, etc.)
: PIT ;  0 VARIABLE PAGESZ 0 VARIABLE SPC (" (C) P. Reece 1981"
0 VARIABLE PG 0 VARIABLE START VARIABLE KNT 64 CARRAY TITLE
: GET# CR " Lines/page" #IN PAGESZ ! CR BL 0 TITLE 64 FILL
  " Spacing" #IN SPC ! CR " Starting Page #" #IN PG ! CR
  " Title:" SPACE 0 TITLE 63 EXPECT CR ;
: HEAD KNT @ 0= IF " Page" PG ? SPACE
   30 ECHO 0 TITLE 64 TYPE 29 ECHO CR CR 1 PG +! THEN ;
: KNTDO SPC @ 1 DO 1 KNT +! CR LOOP ;
: GO CLS PCRT 0 KNT ! HEAD  BEGIN START @ FON? BM2 C@ 0 <>
  IF 16 0 DO I BM2 C@ LINE DROP 64 TYPE KNTDO KNT @ PAGESZ @ >=
             IF CR CR CR 7 ECHO KEY DROP 0 KNT ! HEAD THEN LOOP
  THEN 1 START +! START @ DSKSZ > IF 1 ELSE 0 THEN END ;
: *PSHOW NAME LOOKUP 255 <> IF GO CRT CRT CR " Finished"
  15 ECHO 176 CURSOR ! THEN CR ; *PSHOW FORGET PIT



(" Single Drive BLOCK copy - Peter Reece (c) 1980" : TASK ;
0 VARIABLE K  'S PAD - 1024 / 1024 * 1024 - K ! 0 VARIABLE FROM
K @ CONSTANT MAXSZ MAXSZ CARRAY TXT 0 VARIABLE TO 0 VARIABLE EN
: RD CLS 10 0 PTC 23 ECHO " Insert SOURCE Disk" ENTER
   WHILE N @ MAXSZ < END @ FROM @ >= AND PERFORM N @ TXT
   FROM @ RBLK 1024 N +! 12 0 PTC FROM ? " ->" 1 FROM +! PEND ;
: WT CLS 10 0 PTC 23 ECHO " Insert DESTINATION Disk" ENTER
   0 N ! WHILE N @ MAXSZ < K @ TO @ >= AND PERFORM N @
   TXT TO @ WBLK 1024 N +! 12 0 PTC " ->" TO ? 1 TO +! PEND ;
: CYCLE WHILE K @ TO @ >= PERFORM RD WT 0 N ! PEND ;
: *BCOPY CLS 5 0 PTC " START BLOCK#" #IN FROM ! CR " END BLOCK#
   #IN END ! CR " DESTINATION BLOCK#" #IN TO ! END @ FROM @ -
   TO @ + K ! CYCLE CLS " Bcopy Done" CR ; *BCOPY FORGET TASK


( * Same drive FILE copy - minimal RAM, so lots of swaps)
: *XCOPY DSAVE SPACE " Copy from" NAME LOOKUP -1 = ( source?
     IF " * NO SUCH FILE" ENTER                        ( not there
        ELSE DSAVE FSIZE BM1 C@ N1 !                   ( get its sz
             0 FNAME 0 ONAME 5 MOVE SPACE " To" NAME
             N1 @ 0 DO                                 ( 1 at a time
                    CR " Insert SOURCE Disk" ENTER MOUNT
                    0 FNAME 0 TMP 5 MOVE 0 ONAME 0 FNAME 5 MOVE
                    VIDEO READ 0 TMP 0 FNAME 5 MOVE
                    CR " Insert DESTINATION disk" ENTER MOUNT
                    I 0= IF LOOKUP 255 =            ( if a new file
                            IF DPUTNM THEN          ( build it in
                         THEN  VIDEO WRITE DSAVE ( then save it
             LOOP CLS " Xcopy Completed" CR
         THEN
     THEN ;     *XCOPY FORGET *XCOPY    (" (C) Peter Reece 1981"
```

The FORTHDOS Demonstration Program

The FORTHDOS demonstration program (see listing 2) enables you to easily familiarize yourself with all of the primitives (and two utilities—by way of example) described in the article on FORTHDOS. In addition, it illustrates how the basic primitives can be configured to use a shorter record length (here, 64 bytes per record) in a very simple manner. The demonstration program is an application program that illustrates some of the ways to issue calls to FORTHDOS and then deal with the results of those calls. The program has been designed for use on the TRS-80 Model I with 48K bytes of memory running the MMSFORTH system version 1.8. (If you have version 2.0, this program may require modification.)

Applications Programs

Before using the demonstration program, it is important that you realize the role of FORTHDOS in programming. FORTHDOS is a list of primitives that perform various functions in response to calls from a user-written program. Most primitives return status flags for use by the applications software. The software then uses those flags to determine subsequent action following the FORTHDOS call.

The demonstration program given here is an example of a very *simple means of issuing calls to FORTHDOS and viewing the results. It is a straightforward applications program.*

The program has been kept simple for ease in following the logic of accessing FORTHDOS. It should be noted, however, that the resulting limitations of the program are not *limitations of FORTHDOS.*

For example, upon selecting a sequential-write option from the command menu, the demonstration program makes a call to FORTHDOS to write the appropriate record to the file currently opened (i.e., in FNAME). FORTHDOS does so, returning status flags regarding the success of the write operation. It is the demonstration program, not FORTHDOS, that puts the entire block just accessed on the screen, ignoring end-of-file marks, for you to see more clearly what is going on. The DOS acts normally; it is the demonstration program that performs the apparently strange task (as a learning aid) of displaying an entire block of data—even if the block contains data from another file.

The demonstration program is designed as a simple and easy-to-follow application program that calls FORTHDOS primitives. As such, its simplicity may be misleading. Look carefully at the apparent mistakes you discover in the program. They exist for a reason—namely, to illustrate various approaches to calling the primitives. Remember, FORTH-DOS primitives perform transparent actions and return flags (in most cases) to indicate the results of those actions. What your applications program does with the results of FORTHDOS calls or how it uses them (as illustrated by the demonstration program) is strictly up to you.

How to Use the Program

To use this program, first make a backup copy of your MMSFORTH disk. Then type in and save this program (listing 2) on that disk. To use the disk, place it in drive 0 and boot the system. Load the demonstration program by typing { 20 12 LOAD }, then type FORTHDOS and press ENTER. The demonstration program command menu will be displayed on the screen (see figure 12).

Begin checkout by selecting item 1 on the command menu. This option will cause FORTHDOS to read the directory. When this has been done, select item 14 from the menu. This will list the files available for use by the program.

Records vs. Blocks

A word is in order regarding the program's ability to access and deal with 64-character records. FORTHDOS is quite versatile. It is really a series of subroutines callable by a user-written drive program (e.g., the demonstration program). As such, the record length is external to the primitive subroutines and may be controlled totally by the READ and WRITE calls from the user's program. For example, the routines DSKIO and WRITE1 in the program use a 64-character record and count 16 of these records per 1024-byte block (via the variable RREC). This record length could just as easily have been 16 bytes, with RREC counting 64 records before a new block is called into memory by FORTHDOS.

The examples in the program should enable the careful reader of both the article and code to configure his or her system for any record size or even variable record sizes. The program allows you to familiarize yourself with the innards of FORTHDOS. It also allows you to make mistakes and see the results of incorrect calls (potentially by your own software) to the FORTHDOS primitives.

For instance, if in reading to the end of a sequential file you forget to reset the file (item 18 in the menu), you will not be able to read an earlier record (unless you first CLOSE or RESET it). (Note that LIST, item 7, automatically resets the file prior to a list, then returns it to its original state once the listing is completed.) Experimentation will be the best teacher here.

Finally, unlike the wealth of comments and structured code of FORTHDOS as presented in the body of the artcile, this program (listing 2) has a very compact version of FORTHDOS. This is meant to be a run-time package for direct implementation on your system. To incorporate it directly into your own software, eliminate the menu and associated routines by deleting the following words and recompiling:

MENU1 MENU FORTHDOS TITLE

This will leave you with a core of FORTHDOS primitives compactly squeezed into a minimum number of screens and ready to use.

Listing 2: *FORTHDOS demonstration program. Once the program in listing 2a has been loaded, the demonstration program is started by executing the word FORTHDOS. This listing contains a slightly simplified version of the FORTHDOS program as given in listing 1. The differences are as follows: some constants and variables are precalculated to assume a 1-drive, 48K-byte system; the disk-resident utilities at the end of listing 1 are not included in listing 2; some definitions in listing 2 are slightly different from their counterparts in listing 1, although they are functionally the same; other definitions have been changed to reflect a 64-byte record size (see "The FORTHDOS Demonstration Program" text box). Also, in this listing, the apostrophe in the MMSFORTH word { 2' } (block 22) is actually an up-arrow symbol. Listing 2b (block 32) executes a 1-drive block copy routine.*

(2a)

```
BLOCK : 20

 (" FORTHDOS DEMO 1 - (C) Peter Reece 1981"      : DOS ;
 : CARRAY O CCONSTANT H +! ;CODE HL POP DE DAD PSH
 15 CARRAY BITMAP    15 CARRAY QMAP          ( Dos - bitmaps)
 15 CARRAY FNAME                             ( Dos - filename)
 1024 CARRAY DBUF                            ( Dos - directory buf)
 O CVARIABLE RREC    O CVARIABLE WREC        ( Dos - current recrd)
 O VARIABLE RDBK     O CVARIABLE WRBK        ( Dos - current block)
 O CVARIABLE BM1     O CVARIABLE BM2         ( Dos - dummy vars)
 O VARIABLE N        O VARIABLE M            ( Dos - dummy vars)
 O VARIABLE 1SB                              ( Dos - 1st blk in fl)
 O DBUF VARIABLE DADRS                       ( Dos - start of buf)
 O CVARIABLE EOF                             ( Dos - end of file)
 31 CONSTANT BREAK                           ( Break key defntn)
 O VARIABLE P O VARIABLE K O VARIABLE Q      ( Dummies for demo)
 64 CARRAY AR1 64 CARRAY AR2                 ( Dummies for demo)
 O CVARIABLE F1                              ( Dummy for fsz1 demo)
BLOCK : 21

 (" FORTHDOS DEMO 2 - (C) Peter Reece 1981"
 ( * Put/clear a message on the bottom of the crt.)
 : S$ O DO 140 ECHO LOOP ;     : Z1AR BL O AR1 64 FILL ;
 : MSG 14 O PTC 63 S$ 15 O PTC 30 ECHO SPACE ;
 : CMSG ENTER 14 O PTC 30 ECHO 15 O PTC 30 ECHO ;

 ( * Here lie some general purpose utilities.)
 : T# <# # #S #> TYPE ;                   ( Type a formatted #)
 : DELAY 5000 O DO LOOP ;                 ( Delay a bit)
 : NAME BL O FNAME 15 FILL MSG            ( Get file name)
   " FILENAME:" SPACE O FNAME 15 EXPECT CMSG ;
 : C+! DUP @ ROT + SWAP C! ;              ( Byte add)
 : C-! DUP C@ ROT - SWAP C! ;             ( Byte subtract)
 : -! DUP @ ROT - SWAP ! ;                ( Word subtract)
 : TITLE CLS O 12 PTC " FORTHDOS DEMONSTRATION DISKETTE"
   1 12 PTC 31 S$ O 50 PTC " (C) P.Reece" ;
BLOCK : 22

 (" FORTHDOS DEMO 3 - (C) Peter Reece 1981"
 ( * Dos primitives.)
 : 2' DUP O= IF DROP 1 ELSE 1 SWAP O DO 2* LOOP THEN ;
 : DGT DUP 8 / DUP ROT ROT 8* - SWAP DUP ROT 2' ;
 : DON DGT SWAP BITMAP C@ OR SWAP BITMAP C! ;
 : DOFF DGT BM2 C! BITMAP C@ 255 BM2 C@ - AND SWAP BITMAP C! ;
 : DON? O BM2 C! DUP DGT SWAP BITMAP C@ AND SWAP DROP O=
   IF DROP ELSE BM2 C! THEN ; : DNXT O BM1 C! 85 1 DO I DON?
   BM2 C@ O= I 1SB C@ >= AND IF I BM1 C! LEAVE THEN LOOP BM2 C@
   O <> BM1 C@ O= OR IF -1 BM2 C! MSG " THREAD FULL" CMSG THEN ;
 : DREAD DADRS @ O RBLK ;           : DWRITE DADRS @ O WBLK ;
 : DRD DADRS @ O BITMAP 15 MOVE ;   : DZONK O O BITMAP 15 FILL ;
 : DWR O BITMAP DADRS @ 15 MOVE ;
 : MOUNT DZONK DREAD DRD ;          : DSAVE DWR DWRITE ;
 : REMOVE DSAVE FLUSH MSG " Remove disk now" CMSG ;
 : DINIT MOUNT O DADRS @ 1024 FILL DZONK ;
```

```
BLOCK : 23

 (" FORTHDOS DEMO 4 - (C) Peter Reece 1981"
 : LOOK1 -1 BM1 C! N @ C@ O FNAME C@ <> IF -1 BM1 C! ELSE
   15 O DO I FNAME C@ N @ I + C@ =
       IF I BM1 C! ELSE -1 BM1 C! LEAVE THEN
   LOOP THEN BM1 C@ ;
 : LOOKUP DADRS @ 128 + N ! 14 O DO LOOK1 255 =
   IF 64 N +! ELSE I BM1 C! LEAVE THEN LOOP BM1 C@ ;
 : DPUTNM LOOKUP 255 = IF DADRS @ 128 + N ! 14 O DO N @ C@ O=
   IF O FNAME N @ 15 MOVE LEAVE O N ! ELSE 64 N +! THEN LOOP
   N @ O <> IF MSG " FILE SPACE FULL" CMSG 22 M ! THEN THEN ;
 : DGTMAP LOOKUP 255 <> IF DADRS @ 128 + BM1 C@ 64* + 20 +
   DUP N ! O QMAP 15 MOVE THEN ;
 : DADD DGTMAP DNXT BM2 C@ -1 <> IF BM1 C@ DUP DON DGT SWAP QMAP
   C@ OR SWAP QMAP C! O QMAP N @ 15 MOVE BM1 C@ ELSE O THEN ;
 : NREC RDBK @ 1SB C@ - 16* RREC C@ + SPACE
   " (" T# " )" ENTER ;
BLOCK : 24

 (" FORTHDOS DEMO 5 - (C) Peter Reece 1981"
 ( * Dos primitives.)    : CLOSE BL O FNAME 15 FILL ;
 : RENM DADRS @ 128 + BM1 C@ 64* + N ! ;
 : FON? DUP 86 < IF DUP DGT SWAP QMAP C@ AND SWAP DROP O=
   IF DROP O BM2 C! ELSE BM2 C! THEN ELSE DROP O BM2 C! THEN ;
 : KILL LOOKUP 255 <> IF DGTMAP 85 O DO I FON? BM2 C@
   O <> IF BM2 C@ DOFF THEN LOOP RENM O N @ 64 FILL CLOSE THEN ;
 : DTNM SPACE O FNAME 15 TYPE ;                   ( Print filenm)
 : FSZ1 DGTMAP BM1 C@ -1 <> IF O BM1 C! 85 O DO I FON? BM2 C@ O
   > IF 1 BM1 C+! I F1 C! THEN LOOP O ELSE 1 THEN ;
 : FSIZE FSZ1 O= IF BM1 C@ MSG T# " Blocks" CMSG THEN ;
 : FREE O BM1 C! 85 O DO I DON? BM2 C@ O > IF 1 BM1 C+! THEN
   LOOP 85 BM1 C@ - 16* MSG T# SPACE " free records left" CMSG ;
 : BLOCKS? CLS 2 20 PTC " LIST OF BLOCKS IN" DTNM CR 63 S$ CR
   DGTMAP BM1 C@ 255 <> IF 85 O DO I FON? BM2 C@ O >
   IF I . THEN LOOP THEN CR CR ENTER ;
BLOCK : 25

 (" FORTHDOS DEMO 6 - (C) Peter Reece 1981"
 ( * These routines read a 64-byte record from disk.)
 : 1STBK DGTMAP 85 O DO I FON? BM2 C@   ( Get 1st block in fl)
   DUP O <> IF DUP RDBK ! 1SB C! LEAVE ELSE DROP THEN LOOP ;
 : MEOF MSG " END OF FILE REACHED" CMSG ;
 : GRDBK RDBK @ M ! DGTMAP BM1 C@ -1 <>
   IF BEGIN M @ FON? BM2 C@ O <> IF BM2 C@ RDBK ! 1 ELSE
   1 M +! O THEN M @ 85 > IF -1 M ! DROP 1 THEN END THEN ;
 : DSKIO RDBK @ 1+ 85 > IF MSG " DISK FULL" CMSG
   ELSE RREC C@ RDBK @ LINE DROP O AR1 64 MOVE
     1 RREC C+! O AR1 60 TYPE
     RREC C@ 15 > IF O RREC C! 1 RDBK +! GRDBK THEN
     EOF C@ 1 = IF MEOF THEN M @ -1 = IF 1 EOF C! MEOF THEN
     O AR1 C@ 127 = IF 1 EOF C! MEOF THEN THEN ;
 : ZPNTRS O RREC C! 1STBK ;
 : READ MSG 14 O PTC DTNM 15 O PTC DSKIO 14 40 PTC NREC ;
```

Listing 2 continued on page 346

Listing 2 continued:

```
BLOCK : 26

 (" FORTHDOS DEMO 7 - (C) Peter Reece 1981"
 : RENAME DGTMAP N @ 20 [redacted] ! MSG DTNM " to be renamed as:"
   SPACE Z1AR 0 AR1 15 EXPECT 15 0 DO I AR1 C@ M @ I + C! LOOP
   0 AR1 0 FNAME 15 MOVE MSG " DONE" CMSG ;
 : RG 1SB C@ RDBK ! DUP 16 / DUP 16* ROT SWAP - RREC C!
   DUP 0 > IF 0 DO 1 RDBK +! GRDBK LOOP ELSE DROP THEN ;
 : SHOW MSG NAME LOOKUP 255 <> IF FSZ1 0= BM1 C@ 0 > AND IF RREC
 C@ P ! RDBK @ Q ! 0 RREC C! 1STBK CLS BEGIN DSKIO CR EOF C@
 ?KEY BREAK = OR END P @ RREC C! Q @ RDBK ! 0 EOF C! THEN THEN ;
 : PFILE MSG " Enable the printer" CMSG PCRT SHOW CRT ;
 : EOF? FSZ1 DROP 0 K ! F1 C@ BLOCK N ! 15 0 DO I 16* N @ +
  C@ 127 = IF I K ! LEAVE THEN LOOP FSZ1 DROP BM1 C@ 16* K @ + ;
 : EOFMSG MSG " Last record is #" EOF? T# SPACE DTNM CMSG ;
 : RREAD MSG " Record number:" RDBK @ Q ! RREC C@ P ! #IN DUP
   EOF? > IF MSG " Past eof" DROP CMSG ELSE RG MSG DSKIO
   P @ RREC C! Q @ RDBK ! 14 40 PTC ENTER THEN ;

BLOCK : 27

 (" FORTHDOS DEMO 8 - (C) Peter Reece 1981"
 : FILES 0 FNAME 0 AR2 15 MOVE DADRS @ 128 + K !
   CLS 0 23 PTC " Disk Directory" CR DADRS @ 64 + 50 TYPE
   CR 12 0 DO K @ C@ 0 <> IF K @ 0 FNAME 15 MOVE 0 FNAME 15 TYPE
   10 SPACES FSZ1 0= IF BM1 C@ 16* T# SPACE " records" LOOKUP
   DROP RENM N @ 63 + C@ 170 = IF 5 SPACES " Write protected"
   THEN CR THEN THEN 64 K +! LOOP 0 AR2 0 FNAME 15 MOVE FREE ;
 : DSET MSG " Build a new directory" Y/N NOT IF CLS MSG DINIT
   0 DON 1 DON 0 DADRS @ 1024 FILL MSG " Description:" SPACE
   0 AR1 60 EXPECT 0 AR1 DADRS @ 64 + 60 MOVE 42 DADRS @ 20 + 5
   FILL DSAVE ELSE THEN ; : GDSK MSG " INSERT DATA DISK" CMSG
     0 PBLK ! MOUNT DADRS @ 20 + C@ 42 <> IF CLS 23 ECHO
     CR CR 5 SPACES " UNINITIALIZED DISK" DSET THEN ;
 : PROT MSG " Protect" DTNM LOOKUP 255 <> IF Y/N NOT
   IF RENM 170 N @ 63 + C! ELSE RENM 0 N @ 63 + C! THEN
   ELSE MSG " NO SUCH FILE" THEN CMSG ;

BLOCK : 28

 (" FORTHDOS DEMO 9 - (C) Peter Reece 1981"
 ( * These routines perform write operations.)
 : WCK 1 RREC C+! RREC C@ 15 > IF 0 RREC C! 1 RDBK +! FSZ1
   DROP F1 C@ RDBK @ < IF DADD RDBK ! THEN THEN ;
 : WSHOW K @ 15360 1024 MOVE MSG " BLOCK:" RDBK @ T# ;
 : WRITE1 1SB C@ 0= IF DADD DUP 1SB C! RDBK ! 0 RREC C! THEN
   RDBK @ BLOCK K ! WSHOW 0 AR1 RREC C@ 64* K @ + 64 MOVE RENM
   N @ 63 + C@ 170 = IF MSG " Write protected" ELSE K @ RDBK @
   WBLK WSHOW FLUSH WCK MSG " Written to rec#" THEN NREC ;
 : WRITE MSG " Write what:" SPACE Z1AR 0 AR1 64 EXPECT WRITE1 ;
 : RWRITE MSG " Record #" RDBK @ Q ! RREC C@ P ! #IN DUP 0 >
   IF 1 - THEN DUP EOF? > IF MSG " Past eof" DROP CMSG
   ELSE RG MSG DSKIO DELAY WRITE THEN ;
 ( * More menu commands.)
 : MENU1 13 0 PTC " 23 - Write EOF mark" 13 32 PTC
   " 24 - END this demo" ;

BLOCK : 29

 (" FORTHDOS DEMO 10 - (C) Peter Reece 1981"
 ( * Open or create a file.)
 : MAKE 0 1SB C! NAME DPUTNM 0 RREC C! 1STBK ;
 ( * Copy a file to another file, same disk.)
 : FCOPY MSG " COPY FILE" DELAY Z1AR 0 FNAME 0 AR1 15 MOVE
   EOF? 16 / K ! 0 1SB C! 0 EOF C! MAKE
   0 FNAME 0 AR2 15 MOVE 0 AR1 0 FNAME 15 MOVE ZPNTRS
       WHILE K @ 0 > M @ -1 <> AND ?KEY BREAK <> AND
       PERFORM 15360 RDBK @ RBLK
       0 AR2 0 FNAME 15 MOVE   15360 DADD WBLK FLUSH
       0 AR1 0 FNAME 15 MOVE   1 RDBK +! GRDBK
       MSG " FROM BLOCK" RDBK C@ T# DELAY 1 K -!
    PEND 0 AR1 0 FNAME 15 MOVE 0 EOF C! 0 M ! ZPNTRS CLS
    MSG " COPY COMPLETED" CMSG ;
 : CBLK MSG " To max space: select #24," SPACE
   " type 'FORGET DOS 52 LOAD'" CMSG ;

BLOCK : 30

 (" FORTHDOS DEMO 11 - (C) Peter Reece 1981"
 : MENU TITLE 2 0 PTC " 1 - MOUNT a disk" 2 32 PTC " 2 - " SPACE
   " UNMOUNT a disk" 3 0 PTC " 3 - OPEN (or create) a file" 3
  32 PTC " 4 - CLOSE a file" 4 0 PTC " 5 - Seq READ a file" 4
   32 PTC " 6 - Seq WRITE a file" 5 0 PTC " 7 - LIST a file"
  SPACE " (CLEAR to stop)" 5 32 PTC " 8 - LIST blocks" 6 0 PTC
   " 9 - Random READ a record" 6 32 PTC " 10 - Random"
   SPACE " WRITE a record" 7 0 PTC " 11 - RENAME a file"
   7 32 PTC " 12 - KILL a file" 8 0 PTC " 13 - Show"
   SPACE " FREE disk space" 8 32 PTC " 14 - Show disk DIRECTORY"
   9 0 PTC " 15 - COPY to another file" 9 32 PTC " 16 - COPY"
   SPACE " sequential blocks" 10 0 PTC " 17 - PRINT a file"
   10 32 PTC " 18 - RESET Seq File to Begining" 11 0 PTC
   " 19 - Write PROTECT a file" 11 32 PTC " 20 - Show file SIZE"
   12 0 PTC " 21 - CURRENT seq rec number" 12 32 PTC
   " 22 - Find LAST record" MENU1 MSG " Which number:" ;

BLOCK : 31

 (" FORTHDOS DEMO 12 - (C) Peter Reece 1981"
 : ENDIT -5 M ! ;
 : RESET MSG 0 EOF C! ZPNTRS MSG DTNM SPACE " reset" DELAY ;
 : WEOF MSG " Write eof to current record" Y/N NOT IF
   127 0 AR1 C! 127 1 AR1 C! WRITE1 THEN CMSG ;
 ( * Command driver rests here.)
 : FORTHDOS 0 PBLK ! BL 0 FNAME 15 FILL Z1AR ZPNTRS
   BEGIN MENU 0 M ! 15 46 PTC DTNM 15 16 PTC #IN
      NCASE 1    2      3     4     5     6     7     8
            9    10     11    12    13    14    15    16
            17   18     19    20    21    22    23    24 "
            GDSK REMOVE MAKE  CLOSE READ  WRITE SHOW  BLOCKS?
            RREAD RWRITE RENAME KILL FREE FILES FCOPY CBLK
            PFILE RESET PROT  FSIZE NREC  EOFMSG WEOF ENDIT
     CASEND M @ -5 =
   END CLS 8 17 PTC " END OF FORTHDOS DEMO" 15 0 PTC ;
```

(2b)

```
BLOCK : 32

 ( 1 DRIVE BLOCK COPY - PETER REECE/80) : TASK ;
 : CARRAY 0 CCONSTANT H +! ;CODE HL POP DE DAD PSH
 0 VARIABLE K                  PAD 1024 / 1024 * 1024 - K !
 K @ CONSTANT MAXSZ            MAXSZ CARRAY TXT          0 VARIABLE N
 0 VARIABLE FROM               0 VARIABLE END            0 VARIABLE TO
 : READ CLS 10 0 PTC 23 ECHO " Insert SOURCE disk" ENTER
   WHILE N @ MAXSZ < END @ FROM @ >= AND PERFORM N @ TXT
   FROM @ RBLK 1024 N +! 12 0 PTC FROM ? " ->" 1 FROM +! PEND ;
 : WRITE CLS 10 0 PTC 23 ECHO " Insert DESTINATION disk"
   ENTER 0 N ! WHILE N @ MAXSZ < K @ TO @ >= AND PERFORM N @
   TXT TO @ WBLK 1024 N +! 12 0 PTC " ->" TO ? 1 TO +! PEND ;
 : CYCLE WHILE K @ TO @ >= PERFORM READ WRITE 0 N ! PEND ;
 : START CLS 5 0 PTC " Start Block#" #IN FROM ! CR " End Block#"
   #IN END ! CR " Destination Block#" #IN TO ! END @ FROM @ -
   TO @ + K ! CR CYCLE CLS " **Done to" TO @ 1 - . " **" CR ;
 START FORGET TASK
```

FORTHDOS COMMANDS

Help	type this listing	Setdir	set up directory
Mount	mount disk	Assign	set start for file
Remove	remove disk	Run	compile a file
Files	show all files	Read	sequential read
Make	create a file	Write	sequential write
Name	set up a file	Read	random read
Kill	delete a file	Rwrite	random write
Fsize	get size of file	Copyall	copy a file
Type	type a file	Lookup	does a file exist
Rename	rename a file	Prot?	is it protected
Lock	lock out records	Dinit	initialize a directory
Free	print free space	Dsave	save a directory
Fcopy	on disk file copy	Mount	get a directory
Protect	write protect	Dputnm	save a file name
Unprotect	unwrite protect	Xcopy	off disk file copy
Ptype	format, then print	Blocks?	list files record numbers
Time	print time of day	Timeset	set time of day
Bcopy	copy by record numbers	DADD	add record to file bit map
T#	type formatted number		

Table 2: *An abbreviated list of FORTHDOS commands*

Text continued from page 332:

the part of FORTHDOS memory which contains the file names and bit maps. This layout may be adjusted by the DOS to contain as many files and file bit maps as will fit into 1024 bytes. For example, if there are 11 bytes per bit map, 6 bytes per file name, and 11 bytes for DOS bit map, there is space for a maximum of 64 ((1024−11)/17) open files per 35-track disk. To simplify the layout of the following DOS program, I have lowered this value to 14 files per 35-track disk (86K bytes). This number has proved to be sufficient for my own needs.

While there is room to have a single DOS memory area contain files for up to four 35-track drives, you can at your option have a separate "DOS directory" area on each drive. That area is swapped into memory when the pertinent drive is accessed. In the program discussed below, I have followed this latter scheme for ease of explanation. Figure 8 illustrates this swapping.

Building a Directory

The SETDIR command is a FORTHDOS utility which interactively allows you to customize the setup of a directory. It then allocates space on disk for the directory (at a default record number) and initializes the DOS RAM and bit maps.

One interesting function of the SETDIR command allows you to lock out any records which you do not wish to be available to FORTHDOS for later use. This may be done in two ways. SETDIR will first prompt for any record numbers which you wish to be locked out. It will then prompt for a record number below which FORTHDOS is not to be allowed to use for files. This latter feature can be used to automatically lock out whole areas of the disk or, in a multidrive system, entire drives.

This is done in a remarkably simple manner. Suppose that during directory creation (via SETDIR) you indicate that all records below number X are to be locked out. FORTHDOS simply uses the DON primitive (see "Determining Record Status" below) to set 1s into the corresponding record numbers of DOS bit map. Any future calls to DNXT will find these records to be in use already. To protect an entire file, however, FORTHDOS uses a different approach.

Write-Protecting a File

A bit in a file bit map is assigned to indicate the write-protect status of all record numbers active in that bit map. All FORTHDOS primitives that write information to files first check the status of this bit before attempting a write operation. If the bit is 1, no information will be written to the file. (FORTHDOS will return an error indication to the user program if the file has been write-protected.) The UN-

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- VERSALEDGER prints checks. **(IF YOU WANT IT TO)**
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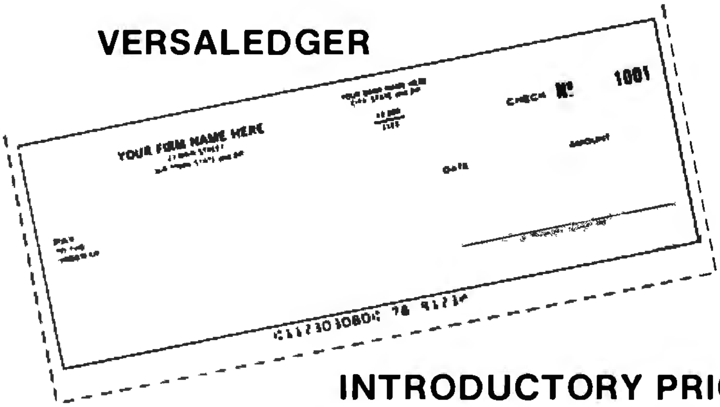

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```
BIT NUMBERS      | 1   2   3   4   5 • • • |
 DOS BIT MAP:      1   0   0   0   0 • • •

1 ) CALL DNXT TO DETERMINE THE NEXT FREE RECORD
    AVAILABLE. DNXT RETURNS RECORD 2.

2 ) CALL DON TO SET THE RECORD NUMBER RETURNED
    BY DNXT TO A 1 (i.e., 'IN USE'). BIT MAP NOW:
                   1   1   0   0   0

3 ) CALL (DON?) WITH A 2 AS THE ENTRY VALUE. (DON?)
    RETURNS A 1, INDICATING THAT RECORD 2 IS IN USE.
    CALL (DON?) WITH A 3 AS THE ENTRY VALUE; AND
    (DON?) RETURNS A 0, INDICATING THAT RECORD 3
    IS AVAILABLE.

4 ) CALL DOFF WITH A 2 AS THE ENTRY VALUE, AND
    RECORD 2 IS FREED FOR FUTURE USE:
                   1   0   0   0   0
```

Figure 9: *Using DON, DON?, and DOFF.*

	ORANGE:	100, 101, 102, 105
a) RECORDS IN USE AT FIRST	*PEAR:*	96, 97, 98, 99
	APPLE:	90, 91, 95
	DOS:	0, 1 ⟶ 100
	ORANGE:	100, 101, 102, 105
b) AFTER KILLING THE FILE PEAR	*APPLE:*	90, 91, 95
	DOS:	0, 1 ⟶ 95, 100
	ORANGE:	100, 101, 102, 105, 96
c) AFTER *DADD*ING TO ORANGE	*APPLE:*	90, 91, 96
	DOS:	0, 1 ⟶ 96, 100

Figure 10: *Killing a file. This shows the results of removing the PEAR file from the disk.*

FILE1	*LINK BYTES* (TO/FROM) (e.g., RECORD 4 LINKS TO 8)	TRACK	HEAD MOVEMENT
RECORD 4	8	2	LITTLE
RECORD 8	72/4	4	LITTLE
RECORD 72	20/8	30	LOTS
RECORD 20	10/72	15	LOTS
RECORD 10	22/20	7	SOME
RECORD 22	85/10	17	SOME
RECORD 85	22/4	35	LOTS

Figure 11: *Link-listed file chains. To read FILE1, the disk head has to cross over 43 tracks for only 3 records.*

PROTECT command writes a 0 to the write-protect bit for the appropriate file. Since this bit is checked before any other write operations are performed, the delay time to check for write-protect status is negligible while the benefits of being able to write-protect individual files at will are many.

Printing a Directory and Determining File Size

The write-protect status of all files on the disk is always reported whenever the FILES command is used to print a directory listing to the terminal. In addition, other DOS information such as file name, size, free disk space, disk comment field, and amount of RAM is also given.

Calculating file size for a directory listing is straightforward. First, the number of 1s in a file bit map are added. The sum is the number of records (or size) of the file. Similarly, to calculate the number of free records remaining on disk, the number of 1s in the DOS bit map are summed. This number is then subtracted from the variable DSKSZ to determine the number of free records remaining. DSKSZ is in turn calculated by the following formula:

$$R = \mathrm{INT}((T*S)/100*D$$

where R is the number of records per system, T is the number of tracks on the disk, S is the record size, and D is the number of disk drives. The INT function in the formula rounds down the quotient $(T*S)/100$ to an integer.

The manner in which FORTHDOS determines whether a given record bit in the file bit map is a 1 is interesting, given that FORTH is a high-level language which lacks bit manipulation capability. To do this, FORTHDOS makes use of three primitives— DON ,{ DON? } , and DOFF . [*"Primitive" here means an MMSFORTH word that performs an elementary function frequently used by later words in the system. . . .* GW] Since these three primitives are used by practically every other primitive in FORTHDOS to determine record status, it will be useful to investigate their use.

Determining Record Status

Look at the DON, DOFF, and DON? primitives in the program listing; then look at figure 9. In the example, DON (disk access on) turns on the bit in the bit map which corresponds to the record number being accessed by the file. This means that the file now "owns" that record, and no other file may write to it unless it is reclaimed by the DOFF (disk access off) primitive. DON? is used to return the record's status (on or off) to other primitives. For instance, DNXT makes frequent use of DON? to scan the DOS bit map when seeking a free record to give to a file.

These three primitives translate the calling record number according to the following formula:

$$2^{[\mathrm{mod}\ r/n]}$$

where r is the record number, n is the number of bytes in the file bit map, and [mod (r/n)] is the remainder of dividing r by n. This has the effect of translating the calling record number into a power of 2 and hence into a bit position within the 11 bytes of the bit map. (In the FORTHDOS listing, 8 bytes are used simply because that is how my own personal system is set up.)

You might argue that it is easier and faster to resort to machine language and simply use a bit rotation command to access more rapidly the status of the appropriate bit. However, for the purposes of maintaining generality in this article I have instead given a high-level language solution in the listing. It works almost as well as a machine-language implementation of this part of FORTHDOS. You can translate the command to the lower-level language of your choice if you wish to increase the overall speed of FORTHDOS through these central primitives.

File Deletion and Allocation

Having followed the development of FORTHDOS thus far, you should have a pretty good idea of the strategies used, but let's review a couple of points for further clarification. As mentioned earlier, many DOS systems use an allocation scheme to adjust file space periodical-

ly so as to maximize contiguous blocks of records. Another reason for periodically using such an adjustment is to clean up empty records.

To understand what this means, look at parts a, b, and c in figure 10. Figure 10a shows the file ORANGE containing four entries in its bit map; records 100, 101, 102, and 105 are in use. The DOS bit map indicates that all records below 100 are in use by other files. The file named PEAR occupies records 96 through 99, and the file APPLE takes records 90, 91, and 95.

Now look at figure 10b. Here, the FORTHDOS command KILL has been used to reclaim records 96, 97, and 98, thereby effectively deleting the file PEAR from disk. (KILL also deletes the name from the directory and performs a number of other housekeeping chores.) In figure 10c, a sequential write is being made to the file ORANGE by issuing a call to the FORTHDOS primitive WRITE. WRITE in turn calls DADD to find the next free block on the disk (through the DNXT primitive) and then return this value to WRITE for I/O transfer of the data in BUFF to disk. A problem arises if we stick to the scheme described (using the first record with a bit-map bit of 0). DNXT will return the value 96 to WRITE, since this was the first free block it found when scanning the DOS bit map, seeking a bit whose value is 0 (i.e., record not in use). This would mean that WRITE would write to record number 96, then 97, 98, 99, and finally 106 as more information is written to the disk.

If this scheme were used, the ORANGE bit map would look like this following the deletion of the file PEAR and five calls to the WRITE primitive:

96 97 98 99 100 101 102 105 106

In addition, this is the order in which records would be read from the file. But this would be incorrect. The true record order is:

100 101 102 105 96 97 98 99 106

There is no way that a simple bit-map scheme can know that record 96 comes after record 105.

FORTHDOS avoids this problem by specifying that no new record added to a FORTHDOS file can have a record number lower than the highest record number already allocated to that file. This ensures that the correct, logical order of records will be given by a series of increasing record numbers. The CVARIABLE named 1SB makes sure this occurs.

Even this method can, however, lead to a more subtle problem. To understand why, let's study a different approach to preserving continuity in a file, that of link-listed record chains.

Link-Listed Records

Link-listing in this context means that whenever a record is written, 2 of its bytes are used to point to the previous record number, and 2 point to the next record (if any). Hence, for a 350-record disk, we are looking at an extra 1400 bytes of storage per disk to maintain the linked chain (or 344 bytes for FORTH, where there are 86 records (blocks) per disk.

While this concept is relatively simple, it is important in any type of link listing to keep the chain from spanning too many different tracks. Otherwise disk-head movement can become excessive as more and more files are killed and created. The disk's seek action across tracks to follow a chain can become slow and "chunky," as figure 11 demonstrates. Linked pointers tend to cause a lot of disk-head movement when the physical distance between the linked records is large, as is the case when several files are killed between writes to the current file.

The scheme outlined so far for having FORTHDOS maintain logical integrity of a file handles two of the link-listed scheme's three problems. First, FORTHDOS requires fewer bytes on disk to handle record allocations. It therefore avoids the problem of needing extra storage. Second, in a

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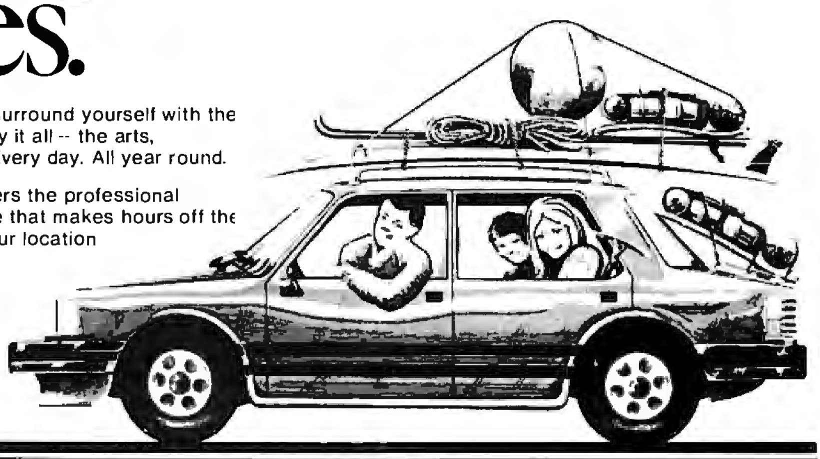

Low Desert - 45 min.
High desert - 98 min.
Beaches - 10 min.
Forest - 25 min.
Mountains - 30 min.
Big mountains - 40 min.
Very big mountains - 240 min.

Skiing - 70 min.
Better skiing - 180 min.
Sailing - 15 min.
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Running - change your shoes
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On Converting FORTHDOS to fig-FORTH

Since a large part of the FORTH community uses the version standardized by the FORTH Interest Group (fig), I have included some notes about MMSFORTH that would help you convert FORTHDOS to fig-FORTH or other versions of FORTH. Peter Reece's thoughtful design has minimized the number of FORTH words that might not be in other FORTH dialects, but here is some information that might not be obvious to non-MMSFORTH users:

- *CCONSTANT and CVARIABLE are like CONSTANT and VARIABLE except that they store a simple 8-bit value (rather than a 16-bit value). CONSTANT and VARIABLE can probably be substituted without harm.*
- *ARRAY defines a one-dimensional array of 16-bit values. CARRAY defines a one-dimensional array of 8-bit variables. Both of these can easily be simulated using the { <BUILDS ... DOES> } construct in FORTH.*
- *The MMSFORTH word { " }, when used at the beginning of a string to be printed, is replaced by { ." } in fig-FORTH.*
- *The { NCASE ... " ... CASEND } construct is best explained by example. The FORTH phrase { NCASE 22 60 114 " WORD22 WORD60 WORD114 CASEND }. If the number on top of the stack is 22, the word CASE22 is executed; if it is 60, CASE60 is executed; if it is 114, CASE114 is executed. If the number is not any of these, control passes to the word after CASEND . One simple though inelegant substitution is a series of nested IF statements.*
- *The MMSFORTH { BEGIN ... END } construct is equivalent to the fig-FORTH { BEGIN... UNTIL } construct.*
- *The MMSFORTH word Y/N prints "(Y/N)?" and waits until either the Y or N key is pressed. In the former case, a 1 is put on the top of the stack; in the latter, 0 is put on top of the stack.*

*I hope the above information makes the conversion easier....*GW

```
                FORTHDOS DEMONSTRATION DISKETTE       (C) P.Reece
                **********************************
1 - MOUNT a disk                     2 -  UNMOUNT a disk
3 - OPEN (or create) a file          4 - CLOSE a file
5 - Seq READ a file                  6 - Seq WRITE a file
7 - LIST a file (CLEAR to stop)      8 - LIST blocks
9 - Random READ a record             10 - Random WRITE a record
11 - RENAME a file                   12 - KILL a file
13 - Show FREE disk space            14 - Show disk DIRECTORY
15 - COPY to another file            16 - COPY sequential blocks
17 - PRINT a file                    18 - RESET Seq File to Begining
19 - Write PROTECT a file            20 - Show file SIZE
21 - CURRENT seq rec number          22 - Find LAST record
23 - Write EOF mark                  24 - END this demo
*****************************************************************
 Which number:
```

Figure 12: *Screen display of commands for the FORTHDOS demonstration program.*

link-listed chain, if one record in the chain is lost (the unhappily common lot of small systems) the entire chain integrity is lost. FORTHDOS keeps all file-record pointers in a memory-resident bit map (a copy of which is stored on the disk), thereby largely avoiding this problem.

The third problem: excessive head movement occurs if files are killed as described above. The solution is to reallocate space on a disk. As figure 11 indicates, the head-movement problem seems likely to occur with most DOSes. Mainframe vendors have hit upon the solution of periodically reallocating disks to decrease the number of noncontiguous records.

The method, used by mainframe computers, involves gathering records scattered throughout the disk into an unused portion of that disk. (These portions are contiguous.) Then the original file(s) is destroyed, and the new file, now in a contiguous area, is used. (Actually, more complex methods are applied, but this is the essence of the scheme.)

FORTHDOS uses a similar system. If the disk heads seem to be moving excessively (listen to them) while typing a file, or if FORTHDOS returns from a disk-write operation with the THREAD FULL message, it is probably time to use the FORTHDOS utility FCOPY (or XCOPY or BCOPY; see table 1). Reallocating with FCOPY is simple enough. Assuming enough contiguous records are on the disk to hold the file you are copying, FCOPY will pull all the records from a scattered file and neatly place them within the new file area in close physical proximity. It will then KILL the old file. The file will have been reallocated to a contiguous area on the disk, which will probably relieve disk-head movement and file-full problems.

This very simple technique can be done to all files on a disk by simply FCOPYing a disk full of files to an empty disk. The new disk will then consist of files whose records are all in contiguous areas. This solution to the allocation problem is easy to perform and memory efficient; if done periodically, it will speed up your disk operation.

FORTHODS in Use

By now, you should have a sufficiently good idea of how FORTHDOS works to be able to use the listing to understand the workings of other commands and features. We can now look at an actual application of FORTHDOS.

Assuming FORTHDOS has been loaded into RAM, you would first MOUNT a formatted disk and interactively initialize it by issuing the SETDIR command. Next, you might create a file for further use by issuing the MAKE command either from the terminal or through transparent calls from a program. Having created some files, you might next write information to one of them sequentially by filling the I/O buffer BUFF and making repeated calls to WRITE. This would probably be done through calls to FORTHDOS from within a user program.

To look at the contents of the file(s) just written, issue a TYPE command from your program or directly from the terminal. To get a formatted listing on the system printer, you can make a call to the PTYPE utility, which would output the file to the printer with page numbers, titles, etc.

At this point, you may wish to

Bright Idea.

BATTERIES AND BULBS is just one of the many bright ideas developed by Alfred Bork and the staff of the Educational Technology Center at UCI. This computer-based learning program makes extensive use of graphics to lead the student through an empirical investigation of electrical circuits using observations simulated on the computer. The computer dialogs for Batteries and Bulbs, as with other UCI-developed course material, is designed to work for students of all ages. Some build intuition, some aid reasoning capability and some increase understanding of science.

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14151 North 76th Street, Scottsdale, Arizona 85260 • (602) 998-4800 query the disk contents so far. To do this, you type FILES; file names, sizes, space allocations, comments, free space, RAM usage, time of day, etc. will appear on the terminal. To protect any files from subsequent inadvertent writing by a program, you could type PROTECT plus the file name. No further writing could then be done to the protected file until UNPROTECT was issued for that file.

Suppose a disk hardware error occurred during a WRITE, putting bad data and checksums into a record. To prevent FORTHDOS from accessing that record in the future, the LOCK command could be given. This would lock out that record from any subsequent read/write operations by FORTHDOS. To make a backup of a file, you could issue the FCOPY command (or XCOPY if copying to a different disk on the *same* drive), which will prompt for information prior to automatically performing the copy. Now that a copy has been made, you might wish to rename some of the old files. To do so, you would issue the RENAME command for a given file. At this point, you might wish for help with the FORTHDOS commands. Assistance can be obtained at any time by simply typing HELP on the terminal or from within a program.

The preceding discussion should give you some idea of the actual usage of FORTHDOS. The other commands in the system are just as easy to use. Some are issued from user software, some by you directly, and others transparently without your knowledge. At the end of the session, you *must* type REMOVE (or have your program call the primitive DSAVE) to ensure that the directory will be saved to disk.

Conclusion

FORTHDOS is a simple but effective single-user DOS. Since it is modular, only the modules required for a given application need to be stored in RAM. This makes FORTHDOS a "tight" and straightforward system. For all its simplicity, it gives the FORTH user all of the capabilities found in most microcomputer DOSes but without the disadvantages of complex structures or high system overheads.

I have been using FORTHDOS for over a year now. Most of its use has been as an integral part of a word processor (which I used, among other things, to write this article). Even after a year of considerable use, I have found no errors in the software, and it gives me all the advantages of a conventional DOS with none of the disadvantages of the traditional "blocks" storage system in FORTH. An added feature: this system remains compatible with the concept of blocks. At any time, I can still edit any block of a file with a conventional FORTH block editor.

FORTHDOS is easily understood (after a little study and experimentation) and easily modified to suit your needs. I hope that you will find it as practical and enjoyable as I have. ■

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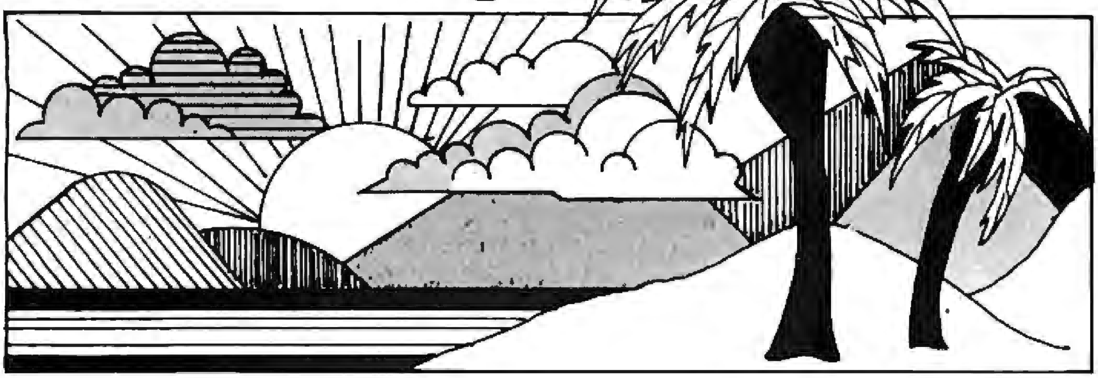

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The substitute instructor walks into your programming class wearing a ruffled collar. You enrolled in evening courses at Avon Community College hoping that the sessions would be intellectually stimulating. Your expectations are high; this instructor is, well—very interesting.

The spade beard is common enough, but his long, velvet-trimmed coat and high stockings resemble the garb Errol Flynn wears in the old movies.

Everything comes together when the instructor turns to sign his name for the class to see. You recognize the script with the ornamental scrollwork under it and realize that if you can only walk away with that autographed slab of chalkboard, you can sell it for millions. The substitute instructor has signed William Shakespeare.

He tells you to call him "Master Will." He says he comes from Stratford—just down the road. His opening remarks come in an Elizabethan accent. Master Will tries to encourage the class:

"...We were not born to sue, but to command...."
(*Richard II*, Act I, scene i)

Continuing, he says he knows that you all have problems making your computer systems do what you want:

"...I see your brows are full of discontent,
Your hearts of sorrow...."
(*Richard II*, IV, i)

"...You know not what you do...."
(*Romeo and Juliet*, I, i)

The instructor of Avon has no doubt that you can all put your systems in good order. He stresses that he doesn't want to make *Much Ado About Nothing* but that attention to detail is important. He's sure that you'll be careful not to write any self-destroying programs, and thus you'll avoid having your *Love's Labour's Lost*.

Master Will suggests the class talk over its programming difficulties. Bring on your problems, he says. He enjoys challenges:

"The bugs which you would fright me with I seek...."
(*The Winter's Tale*, III, ii)

Master Will's confident air makes you certain that he'll be able to help. He assures you that he can show you useful programming techniques:

"...make that appear where it seems hid..."
(*Richard III*, I, ii)

His slightly bulging eyes seem melancholy and very wise as he inspects the flowcharts he has asked you to draw as an exercise:

"...leave these sad designs..."
(*Richard III*, I, ii)

You feel better after he marks your block diagram with a few strokes of his quill pen. Now, he says,

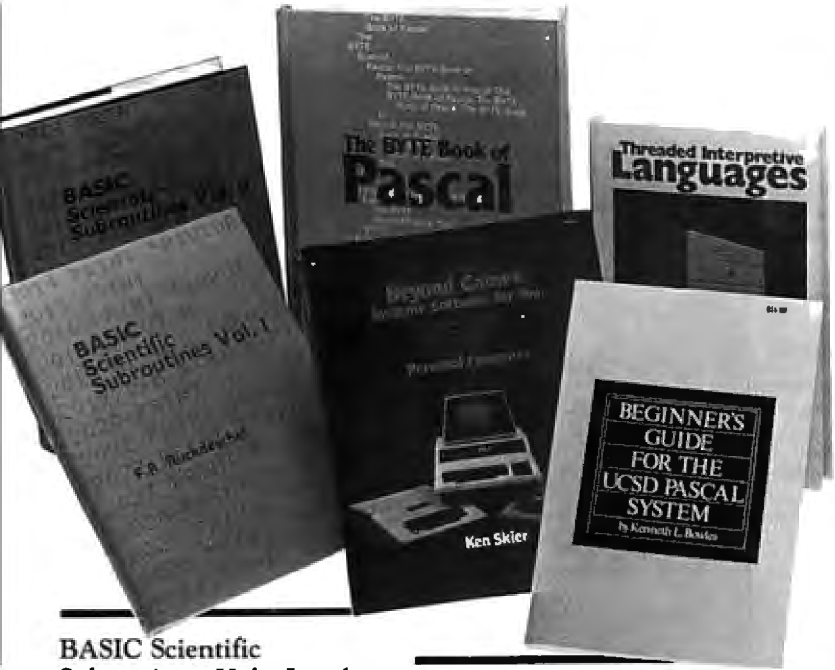
"...What thou woulds't it do
Is done into thy hand...."
(*Antony and Cleopatra*, IV, xiv)

As he leaves (erasing the chalkboard and with it your dreams of avarice), his words fill you with enthusiasm for the nearly limitless horizons of microcomputing:

"...and the end of it
Unknown to the beginning...."
(*Coriolanus*, *III*, i)

He leaves a little quiz scratched in that old-fashioned script. Let's see if you paid attention to what Master Will taught. We've collected some of his writings and translated them into modern computing terms.

All you need is a sharp quill and brain. Match each Shakespearean quote on pages 364 and 366 with the most pertinent modern phrase. Only you will know whether you have ended up *As You Like It* or in the middle of *The Comedy of Errors*. The answers and MicroShakespeare ratings are on page 374.

[**Editor's note:** *Each of the items 1 through 20 matches one of the answers "a" through "t," so read through all the answers before you attempt a match...***PL**]

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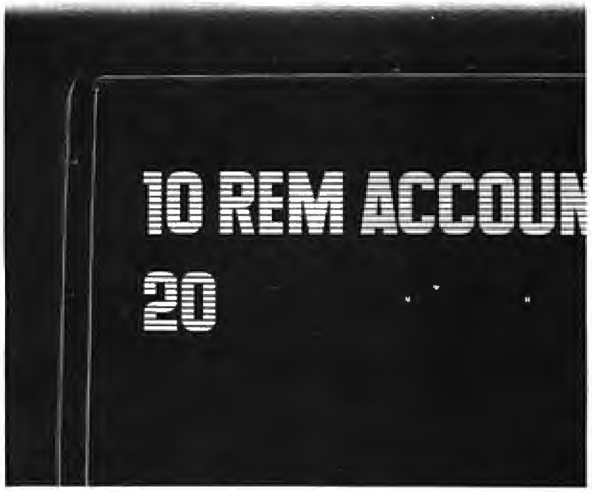
2. ( )	I'll do and I'll do, and I'll do. *Macbeth,* I, iii	b.	Oh, I see—the EQUAL flag is set.
3. ( )	The search so slow! *Cymbeline,* I, ii	c.	What do you think of that function we're tracing on the screen?
4. ( )	A block moved with none... *Much Ado About Nothing,* III, i	d.	It's not responding when you key in binary.
5. ( )	With character too gross... *Measure for Measure,* I, ii	e.	Let's see—it's two NAND's make an OR, and two NOR's make an AND—or is it?
6. ( )	Your memory is bad.... *Love's Labour's Lost,* IV, i	f.	I want to design a board that uses nothing but NAND's and NOR's
7. ( )	I have lost command.... *Antony and Cleopatra,* III, ii	g.	Check where we've halted and what the stack has in it.
8. ( )	On what condition stands it and wherein...? *Richard II,* II, iii	h.	Make sure the 4 MHz pulse is getting through.
9. ( )	...corrupt current of the world... *Hamlet,* III, iii	i.	It filled the area reserved for input with zeros.

BOY, IS THIS COSTING YOU.



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But it's only fair to warn you: business programmers don't go back to BASIC's.

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10. ( ) Lead off this ground, and let's make further.... *The Tempest*, I, ii	j. We're coming up with persistent errors during MEMCHK.
11. ( ) Against this coming end thou shoulds't prepare. *Sonnet*, XIII	k. Even hitting "RESET" doesn't get us out of this loop!
12. ( ) Jump after the inquiry on your own peril.... *Cymbeline*, V, iv	l. You'll be in trouble if you follow the COMPARE with a GO TO.
13. ( ) Four negatives make two affirmatives.... *Twelfth Night*, V, i	m. OK, right here we get a reading of zero volts. Let's see where this line ends up.
14. ( ) Assay the power you have.... *Measure for Measure*, I, iv	n. ...We get all sorts of garbage on the 115 V AC line whenever the dryer or refrigerator goes on.
15. ( ) Dost thou like the plot? *The Tempest*, II, i	o. It'll take all day to find a match.
16. ( ) I would by contraries execute all things.... *The Tempest*, II, i	p. ...if you do that, you'll erase your backup files.
17. ( ) Go, clear thy crystals.... *Henry V*, II, 3	q. Why don't you scope the output of the 7805?
18. ( ) Thou art too base to be acknowledged.... *The Winter's Tale*, IV, iv	r. You need to sum all the variables as you go along, so that you can get the final totals easily.
19. ( ) That action, hence borne out may waste the memory of former days.... *II Henry IV*, IV, v	s. We need finer resolution than we can get with a 5 by 7 dot matrix.
20. ( ) Now I perceive that she hath made compare.... *A Midsummer Night's Dream*, III, ii	t. I'll take care of those iterations in nested loops. in nested loops.

See answers on page 374. ■

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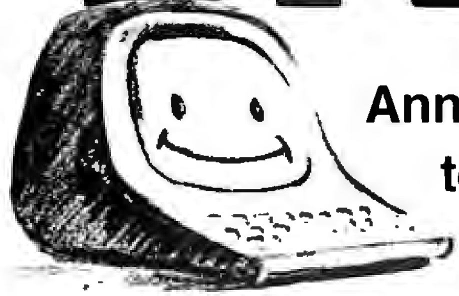

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Selector IV by Micro-Ap

An Information-Management Program

Jack L. Abbott
8525 North 104th Ave.
Peoria, AZ 85345

Selector, nationally advertised as an information-management program, was developed by Micro-Ap of San Ramon, California. This is an overview of Selector's capabilities and limitations. You should look at the program with regard to your particular application before deciding whether to buy it.

For those of you who may be unfamiliar with database or data-management programs, here is a brief description of what they do. They accept data in a format that you establish, sort the data in the order that you wish, and excerpt, summarize, and mathematically manipulate the data according to your instruction. They then present the data in a report format of your design. Potential uses for database programs are limited only by the user's imagination: examples include programs for inventory, form generation, mailing lists, appointment calendars, library document lists, check making, and check-book listing.

At a Glance

Name
Selector IV
Type
Database management program
Manufacturer
Micro-Ap
9807 Davona Dr.
San Ramon, CA 94583
(415) 828-6697
Price
$295
Format
5- or 8-inch floppy disk, or hard disk (running under CP/M 2.2)
Language
CBASIC, version 2.05/35 or later
Computer System
System with 52 K (or more) bytes of RAM running CP/M 1.4x or 2.xx operating system, with 24-line by 80-column cursor-addressable display terminal and a printer
Documentation
Preliminary version, 210 pages in three-ring binder
Audience
Everyone who has a microcomputer

Selector IV, the current version of this program, succeeds version III-C2. Version IV represents a quantum leap forward, especially in its usefulness to someone who is not a skilled programmer. Selector IV lists at $295 and Selector III at $195. My comments in this article address version IV, but for those who have been using version III, Selector IV provides a program for convenient conversion of your data files to a suitable format for version IV.

Selector IV requires a CP/M-compatible (version 1.4, 2.0, or 2.2) operating system, CBASIC version 2.05/35 or later, and a 24-line by 80-column (or larger) video-display capability with absolute cursor addressing and erase-screen functions. Micro-Ap supplies two disks, one with the Selector IV source code and one with the compiled programs. No compilation is necessary, and the program as received runs under CBASIC2. Micro-Ap recommends using a printer: I would say one is essential.

You can adapt Selector to your terminal and computer by menu selection. Micro-Ap will provide Selector in any microcomputer disk format that is in general use, but I had to wait about six weeks to get a disk formatted for Micropolis Mod II (Vector Graphic) drives. Some of the printed descriptions furnished by Micro-Ap state that Selector IV will run in "48 K or more of user memory space" (i.e., 48 K bytes of random-access read/write memory). Micro-Ap interprets this statement to mean that additional memory is required for CP/M, etc., which means that a user needs at least 52 K, and operation is better with 56 or 64 K.

The program documentation is a preliminary version, but this is not a serious limitation. All the required information is present, although a large portion is included in addenda and is not listed in the index. The program explanations in the documentation are very good—the Micro-Ap writer does not presuppose extensive engineering or programming experience.

Running Selector

To initialize the program, tell Selector what kind of equipment you are using, as well as company or personal information that you want the program to use in report headings. Next, define the format of the information you wish to enter. The written instructions are explicit and are supplemented by detailed prompts on the display screen. Configuration of the data "fields" (individual data items) making up one data record (a collection of related items) is simple, and there can be up to eighty fields in one record. These individual fields contain all the information about one subject. In a mailing-list program the subject would be one person or business; in an inventory program the subject would be one product or component. Record length cannot exceed 255 characters. All related records are stored in one file. There is no reasonable data-table format that Selector cannot generate.

After you establish the format of the data to be input, the program presents the format whenever requested and assists in making certain that no mistakes are made in entering the data. On completion of a data-entry session, Selector automatically merges the new data into the existing database and then asks for further instructions.

Once the input format has been defined and the data entered, tell Selector which records you want to select for printing or display by specifying select or sort requirements, called "definitions." Upon request, the program executes these "definitions" by going through the database and picking and sorting the appropriate records.

The final step is to establish how you want the selected data to be presented. Selector provides two ways: "page reports" and "line reports." Selector can send these reports to either the terminal or the printer. A total of as many as 80 different fields from six different files may be presented. You can specify mathematical operations (+, −, /, *) and logical operations (equals, greater than, less than, etc.) on or between data fields. The data fields can be summed.

The page-report function, used to generate forms like invoices or purchase orders which require that data be placed on a specific place on a page, should be one of the most valuable features. However, defining the parameters for this function and troubleshooting its operation take so much time that much of the potential is wasted. Using a series of single-letter and number codes, you must tell the program exactly where each data field is to be placed on the form. Learning the codes is like learning another programming language and it takes a long time to get the report right.

The line-report function is easy to define. It consists of as many data fields as you choose, taken from the records you select, placed one after another on as many lines as required. The line-report function includes mailing-list processing. The mailing list label-printing subprogram is outstanding. It is easy to define, will print from one to

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This menu driven program allows the user to manipulate a variety of different file types. Binary, Text, and Source files may be easily converted into each other. The program may be used with **APPLESOFT*, VISCALC***, and other programs. These program files may be readily adapted for multiple use including editing with **LETTER PERFECT** word processings.

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This menu driven program combined with **LETTER PERFECT** allows user to generate form letters and print mailing labels. With the Atari, you may **CONVERT ATARI DOS FILES**, or Visicalc files compatible for editing with **LETTER PERFECT.** Utility creates Data Base files for Letter Perfect.

LOWER CASE CHARACTER GENERATOR — $24.95

Lower Case Character Generator for the Rev. 7, Apple II or II+ computers. When installed, this Eprom will generate lower case characters to the video screen. Lower case characters set has two dot true descenders. Installation instruction included. Manual includes listing of software for full support and complete instructions for shift key modification. Compatible with **LETTER PERFECT.**

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*Trademarks of: Apple Computer — Atari Computer — Epson America — Hayes Microcomputers — Personal Software — Videx — Bit 3 Inc. — M&R Ent. — Advanced Logic Systems — Vista Computers eight labels across, and prints slightly less than 600 labels an hour (using a Dynabyte 8/2 and an Epson MX-80 printer in a two-across format). Unfortunately, this subprogram works effectively only in batch mode (this in more detail later).

A Sample Application

Listing 1 shows the data-input format of the mailing-list program that I developed to meet my own requirements and to learn the program. In the "Type" column "A" is alphanumeric, "N" is numeric, and "K" is for key. The user can designate any field as key. The program will then have the capability of sorting or selecting data records based upon one or a combination of key fields. In the sample shown, you could select all the records for a state with a given zip code, then select all the people in that state whose last names begin with A, and so on. You could print as many of the individual data fields as you wished, in addition to the key fields, in a given record. My use of field 13 in listing 1 is a good example. I assign "B" for all business entries, "P" for personal entries, and "A" for entries that are both business and personal. When I print a mailing list, I can select and print all the labels for personal entries by selecting "P", all the labels for business entries by selecting "B", and all those that are both business and personal by selecting "A". Based on the records I have selected I can then set up the report to include any other desired fields as well as the key fields, e.g., home address, business address, and city.

A limitation of the Selector program is the inability to function in other than a "batch mode." It takes several minutes to bring Selector up and load the program module that inputs data records. You can then enter data records rapidly. When you exit the data-entry function, Selector will automatically merge the new data with the old and reload the operating program and menu. Before you output a report, you must run the select and sort

Listing 1: *A Selector IV record-definition file. Fields are numbered and named in the first two columns. Key size is the number of characters taken from a key field that actually make up the key. The last column shows the "byte offset" for each field, i.e., the number of bytes into the record counting from the beginning to the first byte in the field.*

```
=================================================================
Record definition file: B:MALIST.DEF    as of APR 23, '1
    Data  file   drive: B       Key/Support drive: B
    Data record length: 218    Key record Length:   19
=================================================================
##        Name        Type   Data Size   Key Size   Byte Offset
=================================================================
 1   FRSTNAME         A        25                          1
 2   LASTNAME         AK       20           10            26
 3   TITLE            A        15                         46
 4   CMPNYNAM         AK       25           10            61
 5   CMPNYADD         A        25                         86
 6   HOMEADDR         A        25                        111
 7   CITY             A        20                        136
 8   STATE            AK        2            2           156
 9   ZIPCODE          NK        5            5           158
10   HOMPHONE         A        14                        163
11   BUSPHONE         A        14                        177
12   REMARKS          A        25                        191
13   BPCODE           AK        1            1           216
=================================================================
```

Answers to MicroShakespeare Quiz

1 - a	6 - j	11 - r	16 - f
2 - t	7 - k	12 - l	17 - h
3 - o	8 - g	13 - e	18 - d
4 - i	9 - n	14 - q	19 - p
5 - s	10 - m	15 - c	20 - b

Number of Correct Matches	MicroShakespeare Rating
20	You're making the best of BYTE and Bard.
17 - 19	Software almost ready to burn into ROM.
13 - 16	Something wrong with housekeeping; GO TO ORG.
9 - 12	Make sure you have the right chips installed.
5 - 8	Clear memory and start over.
4 or fewer	Send for a new processor. ■

An Improved Selector

As this article goes to press, we at BYTE find ourselves once again trying to catch up with an industry that changes faster than we do. The final documentation is now available for Selector IV and the package allows CODASYL-type record-accessing conventions (including one-to-many, many-to-one, and many-to-many record accesses).

Micro-Ap has also introduced Selector V, a machine-language database (compiled from BASIC code through Digital Research's CB80 package) that does not require purchase of any additional language. According to Bob Goodman of Micro-Ap, Selector V works in the same way as Selector IV, but is 3½ to 6 times faster. Added features include the extended record-accessing conventions mentioned above, a removal of the 256-byte record-length restriction of Selector IV, and file and record locking and unlocking capabilities (which can be used when Selector V is used under the MP/M operating system). Selector V lists at $495.

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The MicroPro bonus. Like WordStar, CalcStar is packed with innovative features that make it versatile and easy to use. Features like Automatic Forms Mode, which lets an inexperienced user enter data into a spread sheet quickly and with less chance of error.

CalcStar's greatest innovation is its ability to join with WordStar. Which means, for example, you can use WordStar's printing options, like boldface and underlining, to dress up financial documents. And you can insert sections of CalcStar's spread sheets into your WordStar documents.

This kind of flexibility should come as no surprise if you're already familiar with the MicroPro software family—a line of programs designed to work together to multiply your problem-solving power. Visit your MicroPro dealer to find out just how big a difference *all* our products can make in your business. We predict you'll discover it's not just CalcStar or WordStar that's indispensable. It's MicroPro.

A glance at CalcStar features

Runs on CP/M version 2.0 or above, with 80-column screen, addressable cursor, and at least 48K memory. 56K or more is recommended for fullest utilization.

Highly user friendly: Call up full screen of help or use help menu. WordStar-like cursor commands. User's guide shows you the basics. Install from menu OR a WordStar file.

Stores formulas and formats along with data, for convenience and less chance of error.

Math functions include average, minimum, maximum, logarithms, exponents, and regression analysis.

SOFTWARE THAT MEANS BUSINESS™

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Listing 2: *A CBASIC program for printing a single label or envelope. The program pulls information about an addressee from the Selector IV database as soon as the user gives enough information to identify a record uniquely. If the user doesn't reference a data file, the program lets the user type an address onto an envelope in the system's printer.*

```
REM *********************************************************
REM PROGRAM TITLE:TYPMAL.BAS
REM JACK ABBOTT, PEORIA AZ 6/16/81
REM THIS PROGRAM WILL TYPE ENVELOPES WITH NO OTHER FILE, OTHERWISE
REM PUT MALIST DATA ON B DRIVE, AND THEN RUN THIS PROGRAM.
REM THIS PRO. TYPES ADDRESSES, ENVELOPES, OR LABELS.
INPUT "PUT MALIST.DAT ON B DRIVE THEN PRESS RETURN-";LINE DUMB$
22 T%=0
OPEN "B:MALIST.DAT" AS 1
INPUT "NAME WANTED OR OWN ENVEL. ADDRESS(OWN)-";N$
IF N$="OWN" THEN 150
28 READ #1;LINE MALIST$
T%=T%+1
A%=1
S$=MALIST$
IF MATCH(N$,S$,1)>0 THEN 112
IF END #1 THEN 21
GOTO 28
21 INPUT "NAME NOT FOUND, MORE? Y/N";M$
CLOSE 1
IF M$="Y" THEN 22
GOTO 777
112 INPUT "ENV. OR LABEL,E OR L?";F$
INPUT "BUSINESS OR PERSONAL? B OR P";Z$
IF F$="E" THEN 222
INPUT"PHONE# WANTED?Y/N";E$
INPUT "# OF LABELS WANTED?";I%
G%=1
IF I%>1 THEN Q%=I% ELSE Q%=1
GOTO 666
150 A%=5
GOTO 222
444 CONSOLE
INPUT "MORE?Y/N?";P$
E$="N"
CLOSE 1
IF P$="Y" THEN 22
GOTO 777
666 LPRINTER
C%=25
FOR H=1 TO Q%
670 IF Z$="B" THEN 680
676 B$=LEFT$(S$,C%)
IF RIGHT$(B$,1)=" " THEN 446
PRINT TAB(G%);LEFT$(S$,C%);" ";MID$(S$,26,20)
PRINT TAB(G%);MID$(S$,111,25)
681 PRINT TAB(G%);MID$(S$,136,20)
PRINT TAB(G%);MID$(S$,156,2);CHR$(32);CHR$(32);MID$(S$,158,5)
IF E$="Y" THEN 445
PRINT
677 PRINT
NEXT
GOTO 444
680 PRINT TAB(G%);MID$(S$,61,25)
PRINT TAB(G%);MID$(S$,86,25)
GOTO 681
445 PRINT TAB(G%);MID$(S$,163,13)
GOTO 677
446 C%=C%-1
GOTO 676
222 INPUT "LEGAL OR REGULAR?L OR R";K$
G%=20
IF K$="L" THEN G%=40
INPUT "READY TO PRINT?Y/N";D$
IF D$="N" THEN 444
LPRINTER
PRINT "JACK L. ABBOTT"
PRINT "8525 N. 104TH AVE."
PRINT "PEORIA, ARIZ. 85345"
PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT
CONSOLE
IF A%>1 THEN 180
GOTO 666
180 INPUT "NAME-FIRST LINE?";LINE O$
INPUT "STREET ADDRESS-SECOND LINE?";LINE J$
INPUT "CITY, STATE, ZIP? LAST LINE";LINE V$
LPRINTER
PRINT TAB(G%);O$:PRINT TAB(G%);J$:PRINT TAB(G%);V$
PRINT:PRINT
CONSOLE
GOTO 444
777 STOP
```

definitions on the updated database. These operations take several minutes. The overhead time is acceptable when you're processing lots of records, but unacceptable when you're processing just a few. This may or may not be a problem, depending on what you're using the program for. If you want to enter and then recall a record, as in the case of inputting the data for a single invoice or receipt and then printing it, the time overhead is too great. A printer is a necessity because you can print out data, mark changes on the sheet in pencil, and then enter all the changes at once. In the case of mailing-list information there is no way to pull out and print a single name and address other than to generate a report, and that takes several minutes.

One way to save time is to use the program in listing 2. This CBASIC program scans the data files created by Selector, picks out individual addresses, and prints labels or envelopes. The program also types individual envelopes with your return address and lets you type the addressee, line by line, from the console. Apart from accessing the mailing-list database, the program operates independently of Selector, so it can be compiled separately. You choose functions from a menu and the program will pick any address record if you enter enough letters or numbers to give a unique identity—these identifiers can be first names (as long as there are no duplicates), street numbers, or whatever you decide.

A minor annoyance is Selector's use of the terminal alarm, which sounds whenever anything "noteworthy" happens. Unfortunately the designers find many things noteworthy that I do not (including disk transfers, entry of the day's date, improper inputs), and initially I kept wondering what mistakes I had made whenever the alarm went off. A program toggle should be provided to disable this feature. Another confusing factor is a display heading that tells you when a disk operation is going on so you won't attempt any keyboard action. The heading appears most, but not all of the time, so after a while I forgot to look at the disk-select light. Later, when I started poking at the keys, I wondered why nothing was happening during some disk operations.

Conclusions

The Selector program is written entirely in CBASIC, but the merge and sort functions are fast, so the program as a whole runs rapidly. The program can enter and retrieve many records at a time extremely well, but if you want to switch back and forth between data entry and display, or print in less than several minutes, you will have to modify or supplement program operation.

The mailing-list module is excellent, easy to define, and executes quickly. In addition, the program shown in listing 2 allows you to select and print individual addresses. The line-report function is also excellent and easy to use; unfortunately, the page-report function requires a great deal of effort and time. I find that a printer, preferably with 132-column print capability, is essential for most uses.

Selector should be purchased with the final documentation package, but the program description is clear and well written in the preliminary version, and the program performs exactly as the documentation says it will. Selector has the potential to perform a number of different functions well. If it meets the requirements of your task, it represents a good value when compared to the cost and time of developing custom software. ■

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BUSINESS and UTILITIES

NEW

MAILMASTER (Atari diskette only) — Price: $39.95 Diskette

MAILMASTER is a very versatile software package for managing and manipulating mail lists and mini data bases. Each disk can hold over 600 customer entries containing name, address, 38 letter key words and a phone number. The display is marked so that entries may be made and edited with ease. The status (e.g., disk space left, options, etc.) is shown at all times. Labels may be printed 1,2 or 3 up, and all sorting (zip code and alphabetic) is performed by a fast machine language program.

PERSONAL FINANCE SYSTEM (Atari and North Star only) — Price: $39.95 Diskette

PFS is a single diskette, menu-oriented system composed of ten different programs. Besides recording your expenses and tax deductible items, PFS will sort and summarize expenses by payee, and display information on expenditures by any of 26 user defined codes by month or by payee. PFS will even produce monthly bar graphs of your expenses by category! This powerful package requires only one disk drive, minimal memory (24K Atari, 32K North Star) and will store up to 600 records per disk (and over 1000 records per disk by making a few simple changes to the programs). You can record checks plus cash expenses so that you can finally see where your money goes and eliminate guesswork and tedious hand calculations. Contains high speed machine language sort. PFS has been demonstrated on network (CBS) TV!

FAMILY BUDGET (Apple and Atari only) — Price: $34.95 Diskette

FAMILY BUDGET is a very convenient financial record-keeping program. You will be able to keep track of cash and credit expenditures as well as income on a daily basis. You can record tax deductible items and charitable donations. FAMILY BUDGET also provides a continuous record of all credit transactions. You can make daily cash and charge entries to any of 21 different expense accounts as well as to 5 payroll and tax accounts. Data are easily retrieved giving the user complete control over an otherwise complicated (and unorganized!) subject.

INTELINK (Atari only) — Price: $49.95 Diskette

This software package contains a menu-driven collection of programs for facilitating efficient two-way communications through a full duplex modem (required for use). In one mode of operation you may connect to a data service (e.g., The SOURCE or MicroNet) and quickly load data such as stock quotations onto your diskette for later viewing. This greatly reduces "connect time" and thus the service charge. You may also record the complete contents of a communications session. Additionally, programs written in BASIC, FORTRAN, etc. may be built off-line using the support text editor and later "uploaded" to another computer, making the Atari a *very* smart terminal. Even Atari BASIC programs may be uploaded. Further, a command file may be built off-line and used later as controlling input for a time-share system. That is, you can set up your sequence of time-share commands and programs, and the Atari will transmit them as needed; batch processing. All this adds up to saving both connect time and your time.

NEW

PAYFIVE (Apple II plus diskette, two drives required) — Price: $149.95

This is an enormously flexible employee payroll system with extraordinarily good human engineering features. PAYFIVE prints checks and compiles the required federal, state and local forms for up to 148 employees. The pay methods may be hourly, salary, commission or any combination. There are multiple options for pay periods, and they also can be used in any combination. PAYFIVE includes *many* other features and comes extremely well documented with a 200 page manual. The manual may be purchased separately for $30, and that payment later applied to the software purchase.

SHOPPING LIST (Atari only) — Price: $12.95 Cassette/$16.95 Diskette

SHOPPING LIST stores information on items you purchase at the supermarket. Before going shopping, it will remind you of all the things you might need, and then display (or optionally print) your shopping list and the total cost. Adding, deleting, changing and storing data is very easy. Runs with 16K.

TAX OPTIMIZER (North Star only) — Price: $39.95 Diskette

The TAX OPTIMIZER is an easy-to-use, menu oriented software package which provides a convenient means for analyzing various income tax strategies. The program is designed to provide a quick and easy data entry. Income tax is computed by all tax methods (regular, income averaging, maximum and alternate minimum tax). The user may immediately observe the tax effect of critical financial decisions. TAX OPTIMIZER has been thoroughly field tested in CPA offices and comes complete with the current tax tables in its data files. TAX OPTIMIZER is tax deductible!

NEW NEW

UTIL (Apple only, 48K) — Price: $19.95 Diskette

UTIL is a disk-oriented utility system which permits examining and changing of the contents of DOS 3.2 and 3.3 diskettes at the bit (nibble or byte) level. With UTIL you can easily examine the contents of a diskette sector by sector, restructure these-tor pointers, reallocate sectors (e.g. bad sectors may be "hidden"), and perform many other sophisticated operations. For the experienced programmer.

NEW

TURNKEY AND MENU (Atari only) — Price: $17.95 Diskette

TURNKEY is a utility program which allows you to create autoboot/autorun diskettes easily. Simply load and run TURNKEY, load the program diskette to be modified, and answer the questions! The TURNKEY diskette also comes with DOS 2.0 and includes another program, MENU. MENU lists the contents of your diskette alphabetically, and permits the running of any BASIC program on the diskette by typing a single key. TURNKEY and MENU provide you with the ability to run any program on your diskette by simply turning on the computer and pressing a single key.

NEW NEW

STOCKAID (Atari only) — Price: $29.95 Diskette

STOCKAID provides a powerful set of tools for stock market analysis. With STOCKAID you can display point and figure charts, as well as bar charts with oscillators. You can also examine long term moving averages and on-balance volume features. STOCKAID allows you to input daily data with a single diskette storage capability of 239 days × 16 stocks. Included are stock dividend and split adjustment capabilities. A very professional package!

NEW

SHAPE MAGICIAN (Apple II, 48K, diskette only) — Price: $29.95

At last! An utility for painlessly creating graphics shapes for the Apple. Create, edit and save up to 30 shapes which can then be used to develop arcade games or to simply enhance your programs. Add that professional touch!

EDUCATION

HODGE PODGE (Apple only, 48K Applesoft or Integer BASIC) — Price: $14.95 Cassette/$18.95 Diskette

Let HODGE PODGE be your child's teacher. Pressing any key on your Apple will result in a different and intriguing "happening" related to the letter or number of the chosen key. The program's graphics, color and sound area delight for children from ages 1½ to 7. HODGE PODGE is a non-intimidating teaching device which brings a new dimension to the use of computers in education. See the excellent reviews of this very popular program in INFOWORLD and SOFTALK.

NEW NEW

TEACHERS' AIDE (Atari only) — Price: $13.95 Cassette/$17.95 Diskette

TEACHERS' AIDE consists of three basic modules contained in one program. The first module provides addition and subtraction exercises of varying levels of difficulty. The second module consists of multiplication problems in which the student may be tested both on the final answer and/or on the subtotal answers in the long hand procedure. Several levels of complexity are provided here as well. The third module consists of division problems; one particularly nice feature of the division module is that the long hand division steps can be displayed along with the remainder in order to clearly demonstrate the procedure by which the remainder is derived. Using TEACHER'S AIDE is not merely a drill, but rather a learning experience.

NEW NEW

PHARMACOLOGY UPDATE (PET only) — Price: $169.95 Cassette/$149.95 Diskette

This is DYNACOMP's first educational software entry for the medical profession (more are coming!). PHARMACOLOGY UPDATE was written by a R.N. as a masters project, with the aid of a practicing pharmacologist and an electronics instructor. This package comes in two parts. The first part is a 200 page manual which is divided into 11 sections. Each of these sections provides both concise information and probing questions. The second part consists of 11 programs that are keyed to the text and which test the degree of your understanding of the text material. This package has great educational value for the beginning student as well as the professional interested in an efficient way to review and update his or her knowledge. Available on cassettes (11) or diskette.

NEW

TEACHER'S GRADEBOOK (Apple 48K dual/single drive) — Price $49.95 Diskette

TEACHER'S GRADEBOOK is a *complete* password protected record-keeping system for the classroom. It supports up to nine users, and each user may have data for up to nine classes on one disk (with up to 90 students per class). Typical information which can be entered, edited and processed includes rosters, absences and grades. Summary reports may be displayed (on the screen or printed in various ways, with automatic weighted averaging and conversion to letter grades. This system has been tested ("goof-proofed") in the class environment and is both well-written and well-documented.

ORDERING INFORMATION

All orders are processed and shipped within 48 hours. Please enclose payment with order and include the appropriate computer information. If paying by VISA or Master Card, include all numbers on card. Purchase orders accepted.

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STATISTICS and ENGINEERING

DIGITAL FILTER (Available for all computers) — Price: $39.95 Cassette/$43.95 Diskette

DIGITAL FILTER is a comprehensive data processing program which permits the user to design his own filter function or choose from a menu of filter forms. In the explicit design mode the shape of the frequency transfer function is specified by directly entering points along the desired filter curve. In the menu mode, ideal low pass, high pass and bandpass filters may be approximated to varying degrees according to the number of points used in the calculation. These filters may optionally also be smoothed with a Hanning function. In addition, multi-stage Butterworth filters may be selected. Features of DIGITAL FILTER include plotting of the data before and after filtering, as well as display of the chosen filter functions. Also included are convenient data storage, retrieval and editing procedures.

DATA SMOOTHER (Not available for Atari) — Price: $19.95 Cassette/$23.95 Diskette

This special data smoothing program may be used to rapidly derive useful information from noisy business and engineering data which are equally spaced. The software features choice in degree and range of fit, as well as smoothed first and second derivative calculation. Also included is automatic plotting of the input data and smoothed results.

FOURIER ANALYZER (Available for all computers) — Price: $19.95 Cassette/$23.95 Diskette

Use this program to examine the frequency spectra of limited duration signals. The program features automatic scaling and plotting of the input data and results. Practical applications include the analysis of complicated patterns in such fields as electronics, communications and business.

TFA (Transfer Function Analyzer) — Price: $19.95 Cassette/$23.95 Diskette

This is a special software package which may be used to evaluate the transfer functions of systems such as hi-fi amplifiers and filters by examining their response to pulsed inputs. TFA is a major modification of FOURIER ANALYZER and contains an engineering-oriented decibel versus log-frequency plot as well as data editing features. Whereas FOURIER ANALYZER is designed for educational and scientific use, TFA is an engineering tool. Available for all computers.

HARMONIC ANALYZER (Available for all computers) — Price: $24.95 Cassette/$28.95 Diskette

HARMONIC ANALYZER was designed for the spectrum analysis of repetitive waveforms. Features include data file generation, editing and storage/retrieval as well as data and spectrum plotting. One particularly unique facility is that the input data need not be equally spaced or in order. The original data is sorted and a cubic spline interpolation is used to create the data file required by the FFT algorithm.

FOURIER ANALYZER, TFA and HARMONIC ANALYZER may be purchased together for a combined price of $51.95 (three cassettes) and $63.95 (three diskettes).

REGRESSION I (Available for all computers) — Price: $19.95 Cassette/$23.95 Diskette

REGRESSION I is a unique and exceptionally versatile one-dimensional least squares "polynomial" curve fitting program. Features include very high accuracy; an automatic degree determination option; an extensive internal library of fitting functions; data editing; automatic data, curve and residual plotting; a statistical analysis (eg: standard deviation, correlation coefficient, etc.) and much more. In addition, new fits may be tried without reentering the data. REGRESSION I is certainly the cornerstone program in any data analysis software library.

REGRESSION II (PARAFIT) (Available for all computers) — Price: $19.95 Cassette/$23.95 Diskette

PARAFIT is designed to handle those cases in which the parameters are imbedded (possibly nonlinearly) in the fitting function. The user simply inserts the functional form, including the parameters (A(1), A(2), etc.) as one or more BASIC statement lines. Data, results and residuals may be manipulated and plotted as with REGRESSION I. Use REGRESSION I for polynomial fitting, and PARAFIT for those complicated functions.

MULTILINEAR REGRESSION (MLR) (Available for all computers) — Price: $24.95 Cassette/$28.95 Diskette

MLR is a professional software package for analyzing data sets containing two or more linearly independent variables. Besides performing the basic regression calculation, this program also provides easy to use data entry, storage, retrieval and editing functions. In addition, the user may interrogate the solution by supplying values for the independent variables. The number of variables and data size is limited only by the available memory.

REGRESSION I, II and MULTILINEAR REGRESSION may be purchased together for $51.95 (three cassettes) or $63.95 (three diskettes).

ANOVA (Not available on Atari cassette or for PET/CBM) — Price: $39.95 Cassette/$43.95 Diskette

In the past the ANOVA (analysis of variance) procedure has been limited to the large mainframe computers. Now DYNACOMP has brought the power of this method to small systems. For those conversant with ANOVA, the DYNACOMP software package includes the 1-way, 2-way and N-way procedures. Also provided are the Yates 2^{K-P} factorial designs. For those unfamiliar with ANOVA, do not worry. The accompanying documentation was written in a tutorial fashion (by a professor in the subject) and serves as an excellent introduction to the subject. Accompanying ANOVA is a support program for building the data base. Included are several convenient features including data editing, deleting and appending.

BASIC SCIENTIFIC SUBROUTINES, Volumes 1 and 2 (Not available for Atari)

DYNACOMP is the exclusive distributor for the software keyed to the popular texts *BASIC SCIENTIFIC SUBROUTINES, Volumes 1 and 2* by F. Ruckdeschel (see advertisements in BYTE magazine). These subroutines have been assembled according to chapter. Included with each collection is a menu program which selects and demonstrates each subroutine.

Volume 1
- Collection #1: Chapters 2 and 3 - Data and function plotting; complex variables and functions.
- Collection #2: Chapter 4 - Extended matrix and vector operations.
- Collection #3: Chapters 5 and 6 - Random number generators (Poisson, Gaussian, etc.); series approximations.

Price per collection: $14.95 Cassette/$18.95 Diskette

All three collections are available for $39.95 (three cassettes) and $49.95 (three diskettes).

Volume 2
- Collection #1: Chapter 1 - Linear, polynomial, multidimensional, parametric least squares.
- Collection #2: Chapter 2 - Series approximation techniques (economization, inversion, reversion, shifting, etc.).
- Collection #3: Chapter 3 - Functional approximations by iteration and recursion.
- Collection #4: Chapter 4 - CORDIC approximations to trigonometric, hyperbolic, exponential and logarithmic functions.
- Collection #5: Chapter 5 - Table interpolation, differentiation and integration (Newton, LaGrange, splines).
- Collection #6: Chapter 6 - Methods for finding the real roots of functions.
- Collection #7: Chapter 7 - Methods for finding the complex roots of functions.
- Collection #8: Chapter 8 - Optimization by steepest descent.

Price per collection: $14.95 Cassette/$18.95 Diskette

All eight collections are available for $99.95 (eight cassettes) and $129.95 (eight diskettes).

Because the texts are a vital part of the documentation, *BASIC SCIENTIFIC SUBROUTINES, Volumes 1 and 2* are available from DYNACOMP:

BASIC SCIENTIFIC SUBROUTINES, Vol 1 (319 pages): $19.95 + 75¢ postage
BASIC SCIENTIFIC SUBROUTINES, Vol 2 (790 pages): $23.95 + $1.50 postage

See reviews in KILOBAUD and Dr. Dobbs.

NEW

SOFTNET (Apple II, 48K, diskette only) — Price $129.95

SOFTNET may be used to create models of liquid pipeline systems to evaluate their flow performance. Up to 150 nodes with up to 150 connecting elements may be simulated, and models may be combined to form yet larger models. If you are involved in water distribution systems, chemical fluid flow problems, building plumbing, or similar situations, this is an ideal analysis tool.

NEW

MATCHNET (TRS-80 only) — Price: $19.95 Cassette/$23.95 Diskette

It often takes days to iteratively optimize an L, Pi or T matching network for a particular application. Take a few minutes with MATCHNET and you will have the Q, frequency response and reflection coefficients for any of twelve matching networks. You input the source and load impedance and MATCHNET calculates the R, C, (and L) values and plots (and/or prints) the frequency response and reflection coefficients for each configuration. The reviewer of this program remembers when he use to do this by hand and loves MATCHNET!

ACTIVE CIRCUIT ANALYSIS (ACAP) (48K Apple only) — Price: $25.95 Cassette/$29.95 Diskette

With ACAP you may analyze the response of an active or passive component circuit. The circuit may be probed at equal steps in frequency, and the resulting complex voltages at each component juncture examined; the frequency response of a filter or amplifier may be completely determined with respect to both amplitude and phase. In addition, ACAP prints a statistical analysis of the range of voltage responses which result from tolerance variations in the components. ACAP is easy to learn and use. Circuit descriptions may be saved onto cassette or diskette to be recalled at a later time for execution or editing. ACAP should be part of every circuit designer's program library.

LOGIC SIMULATOR (Apple only; 48K RAM) — Price: $24.95 Cassette/$28.95 Diskette

Test your complicated digital logic design with respect to given set of inputs to determine how well the circuit will operate. The elements which may be simulated include multiple input AND, OR, NOR, EXOR, EXNOR and NAND gates, as well as inverters, J-K and D flip-flops, and one-shots. Inputs may be clocked in with varying clock cycle lengths/displacements and delays may be introduced to probe for glitches and race conditions. A timing diagram for any given set of nodes may be plotted using HIRES graphics. Save your breadboarding until the circuit is checked by LOGIC SIMULATOR.

NEW

NUMBERKRUNCHER (TRS-80 only) — Price: $69.95 Cassette/$73.95 Diskette

This program is the most complete numerical analysis system available for the TRS-80. It can handle up to 255 data sets, each set having a six character name. It includes complete data editing facilities and convenient data input/output capability. The analyses available are multiple linear regression and correlation determination of residuals, data transformations and extensive graphics generation, including axis naming, and more. The supporting documentation is extremely well written and well organized, and includes appendices which describe the numerical procedures used in the program.

NEW

STATSORT (TRS-80 only) — Price: $39.95 Cassette/$43.95 Diskette

STATSORT consists of several menu selected programs which allow the user to create (build, edit, merge), format and print files, (machine) sort them on any field, and numerically analyze (maximum, minimum, average, variance, standard deviation) tabulated data. STATSORT is well documented and easy to use. The cassette version can also be employed to create a data type which can be read by the Radio Shack Advanced Statistical Package.

NEW

STATTEST (TRS-80 only) — Price: $19.95 Cassette/$23.95 Diskette

This is a statistical inference package which helps you make wise decisions in the face of uncertainty. In an interactive fashion you can build and edit data files and test the differences in means, variances and proportions. STATTEST will also perform data analysis as well as do linear correlation and regression. This menu-directed statistical workhorse is rounded out with a chi-square contingency test and a (uniform and normal) random sample generator. The documentation is written by a college professor who guides you through the various tests.

ABOUT DYNACOMP

DYNACOMP is a leading distributor of small system software with sales spanning the world (currently in excess of 50 countries). During the past three years we have greatly enlarged the DYNACOMP product line, but have maintained and improved our high level of quality and customer support. The achievement in quality is apparent from our many repeat customers and the software reviews in such publications as COMPUTRONICS, 80 Software Critique, A.N.A.L.O.G., Softalk, Creative Computing and Kilobaud. DYNACOMP software has also been chosen for demonstration on network television. Our customer support is as close as your phone. It is always friendly. The staff is highly trained and always willing to discuss products or give advice.

MOD III

TRS-80 Model III Features for Your Model I

Add video line print, selectable cursor, and automatic key repeat to your TRS-80 Model I.

Joe W. Rocke
224 West Benson
Ridgecrest, CA 93555

I'm a satisfied owner of a Radio Shack TRS-80 Model I, but I can't help envying some of the features of the new Model III. Its video line print, block cursor, and automatic key repeat are indeed useful additions to the TRS-80's repertoire of programming features.

Numerous video-line-print and cursor routines have been published as individual utility programs; however, because they are individual programs, only one can be used at a time. My working with a friend's Model III spawned dreams of a single utility program that would provide all these capabilities for my Model I. My file of programs included video-line-print and cursor routines, so my thoughts turned to combining the two into a single utility program. An automatic key repeat, a user-selectable cursor, and an audible key beep also crept into this programming daydream.

The dream became reality only after several unsuccessful attempts to combine existing program routines. Initial efforts produced workable programs, but not without adverse side effects. High memory overhead offset the benefits provided, and the key-beep feature resulted in slow keyboard response time. When used with my editor/assembler, the utility routines preempted the memory occupied by the automatic key repeat.

Programming is somewhat akin to building construction. It is often easier to build anew than to remodel the old. With this in mind, I took a fresh program approach, literally starting with a blank video screen. This effort resulted in a utility program that I call MOD III.

The MOD III utility program uses fewer than 170 bytes of RAM, making it practical even on a 16K-byte memory system.

MOD III Features

The MOD III program source code presented in listing 1 provides video line print, a block cursor, and automatic key repeat. This program also provides two added side benefits: the cursor style is user-changeable, and the key repeat automatically provides key debounce. Better still, the program uses fewer than 170 bytes of random-access read/write memory (RAM). This low memory overhead makes the program practical for use with a 16K-byte memory system.

MOD III is compatible with most disk operating systems (DOS), the Beta cassette system, the EDTASM+ editor/assembler, and Level II BASIC. It is written for a Level II 48K-byte system, but may be modified for a 16K- or 32K-byte RAM system by changing the starting address. Changes required for DOS are annotated in the source code remarks (see listing 1).

MOD III was initially written in assembly language to conserve memory space and provide the quick response required for the automatic key-repeat feature. The original plan was to place the program at a low RAM location just under the BASIC block and reset the BASIC pointers. This would eliminate the need to set memory size before loading MOD III. However, in this location it would be wiped out by disk BASIC or by programs such as EDTASM+. Changing the program to load to high memory provided the system and program compatibility desired.

Memory Protect

Because MOD III starts at a high RAM address, it's necessary to set memory size before loading the program. By calculating the number of bytes required for the program, you can establish the starting address that will load the program to the very top of memory to conserve RAM space.

Text continued on page 386

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Listing 1: *The source code listing for MOD III. The key-beep feature has been disabled (see lines 850 through 1100). Remove the semicolons to use that feature.*

```
00010 ;*****************************************************
00020 ;**            KEY-REPEAT AND BLOCK CURSOR            **
00030 ;** WORKS WITH 'DOS' - 'EDTASM' - 'BASIC' - ETC.     **
00040 ;*****************************************************
00050 ;
00060 ;
00070 ;
00080 ;*****************************************************
00090 ;**  FOR JUST 'BLOCK CURSOR' -  USE LINES 1730 UP  --- **
00100 ;**  SEE 'HOOK' LINES:    1170 THRU 1270              **
00110 ;*****************************************************
00120 ;
00130          ORG     0FF4DH          ;48K - CHANGE FOR LESS!!!
00140 ;
00150  **  IF KEY BEEP IS USED THEN 'ORG' MUST BE CHANGED    **
00160 ;
00170 START    LD      HL,START1       ;PUT A 'HOOK' INTO
00180          LD      (4016H),HL      ;KEYBOARD CONTROL
00190          LD      HL,BEGIN        ;FOR 'ZX' AND BLOCK
00200          LD      (401EH),HL      ;CURSOR ROUTINES
00210          LD      A,8FH           ;'BLOCK CURSOR'
00220          LD      (16409),A       ;PUT IT IN 'POKEABLE ROM'
00230 ;
00240          JP      402DH           ;NEWDOS80 SYSTEM
00250 ;
00260 ;        JP      1A19H            FOR BETA, TC-8 BASIC OR
00270 ;                                 NO SYSTEM AT ALL
00280 ;                                 OR NOTE: BELOW
00290 ;*****************************************************
00300 ;** NOTE:  TRSDOS, NEWDOS+, ECT. MAY NOT ACCEPT THE   **
00310 ;** ROM III PROGRAM IN COMMAND MODE BUT WILL RUN IN   **
00320 ;** DISK BASIC.  LOAD ROMIII/CIM (ENTER) THEN BASIC   **
00330 ;** DEFUSR1=&HFF4D:PRINT USR1(0)                      **
00340 ;*****************************************************
00350 ;
00360 ;
00370 ;*****************************************************
00380 ;**       MEMORY SIZE?  PROTECTION STARTS HERE        **
00390 ;**       EQUALS   65375  FOR 48K                     **
00400 ;*****************************************************
00410 ;
00420 START1   LD      HL,4036H        ;HL = KEYBOARD BUFFER
00430          LD      BC,3801H        ;BC = ROW ADDRESS POINTER
00440          LD      D,00H           ;'D' = ROW COUNT 0 TO 6
00450 LP1      LD      A,(BC)          ;ANYTHING PRESSED ??
00460          LD      E,A             ;PUT IT IN 'E' FOR TEST
00470          AND     E               ;CHECK ALL BITS FOR 0
00480          JR      NZ,LP4          ;NOT ZERO GOTO COUNTER
00490          LD      (HL),A          ;LOAD IT TO MEMORY
00500 LP2      INC     D               ;NEXT KEYBOARD ROW
00510          INC     L               ;BUMP KEYBOARD BUFFER
00520          RLC     C               ;POINT TO NEXT ROW
00530          LD      A,C             ;PUT IT IN A FOR TEST
00540          SUB     80H             ;SUBTRACT 128 DECIMAL
00550          JR      NZ,LP1          ;NOT ZERO? CHECK AGAIN!
00560          LD      A,(HL)          ;GET COPY OF OUR CHAR.
00570          LD      B,07H           ;COUNT OF SEVEN
00580 LP3      DEC     L               ;BACKUP KEYBOARD BUFFER
00590          ADD     A,(HL)          ;ADD MEMORY TO 'A'
00600          DJNZ    LP3             ;GO FOR COUNT IN 'B'
00610          CP      00H             ;CHECK FOR ZERO IN 'A'
00620          LD      A,00H           ;ZERO 'A' REGISTER
00630          RET     NZ              ;RETURN WITH CHARACTER
00640          LD      (401AH),A       ;PUT 0 IN KEY CONT. BLK
00650          RET                     ;RETURN TO PROGRAM
00660 LP4      AND     (HL)            ;CHECK EACH BIT FOR 0
00670          JR      Z,LP5           ;GO IF IT IS
00680          LD      A,(401AH)       ;GET BYTE FROM CONT. BLK
00690          INC     A               ;ADD (1) TO IT
00700          LD      (401AH),A       ;PUT IT BACK FOR COUNT
00710          CP      0FFH            ;= 255 DECIMAL ?
00720          JR      NZ,LP2          ;NO = LOOP BACK
00730          DEC     A               ;SUBTRACT (1)
```

Listing 1 continued on page 384

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Listing 1 continued:

```
               LD      (401AH),A        ;STORE NEW VALUE
               LD      A,E              ;CHAR. WAS SAVED IN 'E'
      LP5      LD      (HL),E           ;ADD IT TO MEMORY
               PUSH    BC               ;SAVE COPY IN STACK
               LD      BC,600           ;SHORT DELAY COUNT
               CALL    0060H            ;ROM DEC. BC TO 0
               POP     BC               ;NOW RESTORE 'BC'
               LD      A,(BC)           ;TRANSFER TO 'A'
               AND     E                ;CHECK OUR COPY
               RET     Z                ;RETURN IF ZERO
      ;
      ;****************************************************************
      ;**       KEY BEEP IS HERE BUT 'NOT' BEING USED                **
      ;****************************************************************
      ;
      ;        PUSH    BC               ;SAVE 'BC'
      ;        PUSH    HL               ;SAVE 'HL'
      ;        PUSH    AF               ;SAVE 'AF'
      ;        LD      B,40H            ;= 64 DECIMAL
      ;        LD      A,(403DH)        ;PRINT SIZE FLAG
      ;        AND     0FDH             ;= 253 DECIMAL
      ;        LD      H,A              ;RESULT TO 'H'
      ;        OR      02H              ;OR WITH '2' FOR SOUND
      ;        LD      L,A              ;TRANSFER TO 'L'
      ;LP6     LD      A,L              ;BACK TO 'A' FOR OUTPUT
      ;        OUT     (0FFH),A         ;OUT CASSETTE PORT
      ;        LD      A,H              ;GET BYTE FROM 'H'
      ;        OUT     (0FFH),A         ;OUT CASSETTE PORT
      ;        PUSH    BC               ;SAVE 'BC' FOR COUNT
      ;        LD      B,40H            ;= 64 DECIMAL
      ;LP7     DJNZ    LP7              ;DELAY HERE FOR COUNT
      ;        POP     BC               ;RESTORE 'BC'
      ;        DJNZ    LP6              ;LOOP UNTIL ZERO
      ;        POP     AF               ;RESTORE REGISTERS
      ;        POP     HL               ;DONE WITH BEEP
      ;        POP     BC               ;DON'T FORGET 'BC'
      ;
      ;****************************************************************
      ;**  FOLLOWING JUMP HAS TO BE USED BEEP OR NOT!!!               **
      ;****************************************************************
      ;
               JP      03FBH            ;ROW COUNTER IN ROM
      ;
      ;****************************************************************
      ;**       TO USE JUST 'ZX' AND CURSOR ROUTINE                  **
      ;**     YOU HAVE TO PUT A 'HOOK' IN 401EH AS FOLLOWS           **
      ;****************************************************************
      ;                                                                *
      ;        ORG     0EF00H           ;START SOMEPLACE!             *
      ;                                                                *
      ;START   LD      HL,BEGIN         ;GET ADDRESS                  *
      ;        LD      (401EH),HL       ;STORE IN VIDEO BLOCK         *
      ;        JP      402DH            ;1A19H FOR 'BASIC'            *
      ;****************************************************************
      ;
      ;****************************************************************
      ;**  'ZX'  LINEPRINT STARTS HERE CAN BE CHANGED TO             **
      ;**  ANY VALUE THE USER PLEASES AS LONG AS THE RIGHT           **
      ;**  ROW AND KEY VALUE ARE USED TO CHECK FOR IT ---.           **
      ;****************************************************************
      ;
      BEGIN    EX      AF,AF'           ;SWAP REGISTERS
               EXX                      ;ALL OF THEM !
               LD      A,(3808H)        ;= 'ZX' ROW
               CP      05H              ;= 'ZX' PRESSED ??
               JR      NZ,OUT           ;NO = EXIT FAST
               LD      HL,3C00H         ;THEN POINT TO VIDEO
               LD      E,10H            ;= 16 VIDEO LINES
      LOOP     LD      C,40H            ;= 64 CHRS./LINE
      LOOP1    CALL    TEST             ;CHECK ON PRINTER
               LD      A,(HL)           ;GET FIRST CHARACTER
               LD      (37E8H),A        ;OUTPUT TO PRINTER PORT
               LD      A,(3840H)        ;SPACEBAR ROW
               CP      80H              ;= SPACEBAR PRESSED?
```

Listing 1 continued on page 386

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Listing 1 continued:

```
01480         JR      Z,OUT1        ;YES = EXIT
01490         INC     HL            ;ADD NEXT CHARACTER
01500         DEC     C             ;MINUS (1) CHARACTER
01510         JR      NZ,LOOP1      ;LOOP FOR 64 CHARACTERS
01520         CALL    TEST          ;PRINTER BUSY?
01530         LD      A,0DH         ;CARRIAGE RETURN
01540         LD      (37E8H),A     ;DO IT!
01550         DEC     E             ;NEXT LINE - PLEASE
01560         JR      NZ,LOOP       ;ALL 16 LINES?
01570         JR      OUT           ;GO IF ALL DONE
01580 TEST    LD      A,(37E8H)     ;CHECK BYTE AT PRINTER
01590         CP      3FH           ;63 DEC. = PRINTER BUSY
01600         JR      NZ,TEST       ;LOOP UNTIL READY
01610         RET                   ;RETURN TO CALLER
01620 OUT1    CALL    TEST          ;CHECK ON PRINTER
01630         LD      A,0DH         ;CARRIAGE RETURN
01640         LD      (37E8H),A     ;DO IT ON PRINTER!
01650 OUT     EX      AF,AF'        ;RESTORE REGISTERS
01660         EXX                   ;ALL OF THEM
01670 ;
01680 ;*************************************************************
01690 ;**         CURSOR ROUTINE STARTS HERE AND                 **
01700 ;**         CAN BE USED SEPERATELY ALSO --                 **
01710 ;*************************************************************
01720 ;
01730 CURSOR  CALL    0458H         ;CALL VIDEO ROM DRIVER
01740         PUSH    AF            ;SAVE 'AF'
01750         PUSH    DE            ;SAVE 'DE'
01760         LD      DE,(4020H)    ;CURSOR POSITION
01770         LD      A,(DE)        ;PUT CHARACTER IN 'A'
01780         CP      5FH           ;= NORMAL CURSOR
01790         JR      NZ,EXIT       ;NOT NORMAL = GO
01800 ;
01810 ;*************************************************************
01820 ;**     MEMORY ADDRESS 16409 DECIMAL IS USED TO  --         **
01830 ;**     STORE THE CURSOR CHARACTER OF USER'S CHOICE         **
01840 ;*************************************************************
01850 ;
01860         LD      A,(16409)     ;** POKE 16409 WITH
01870         LD      (DE),A        ;ANY CHARACTER TO SUIT
01880 EXIT    POP     DE            ;YOUR NEEDS FOR A CURSOR
01890         POP     AF            ;EXAMPLE:  POKE 16409,176
01900         RET                   ;RETURN TO PROGRAM
01905         NOP
01910         END     START         ;AUTO STARTS WITH *? /
```

Text continued from page 380:

Subtracting the starting address (in decimal) from the ending address provides the byte count. Subtracting the byte count from the top of memory (in decimal) indicates where the program would have to start to load to the top of memory. Since it is necessary to protect only that portion of memory into which MOD III is loaded, this figure also represents the memory-size value that must be entered upon power-up.

The starting address in listing 1 is for a 48K-byte system. To calculate the starting address for a 16K- or 32K-byte system, subtract 169 (the minimum byte count) from 32,767 (16K) or 49,151 (32K) as applicable. Convert the result to the equivalent hexadecimal notation and use it for the ORG (origin) address in line 130.

The foregoing is applicable to the program as written. If you want to add additional lines or include the key-beep feature, be aware that doing so will increase the program byte count. The memory space occupied by the program must be increased by changing the starting address accordingly.

Very "tight" code was used in writing the MOD III source code to keep memory overhead low. Read-only memory (ROM) routines were used frequently, although not many ROM calls are evident. The approach to im-

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plementing the key-repeat feature was to intercept the ROM keyboard buffer and thus minimize the calls required for this feature.

Hook Lines

Although the program actually starts at the ORG address, the first 20 bytes are used as hook lines that establish conditions for program operation. These lines are used only once each time the program is loaded; therefore, they can be written over after the program is executed. The main program starts at the key-repeat module. This is where memory size must be set. To calculate the memory-size protect number, subtract 21 from the decimal equivalent of the line 130 starting address (the additional byte is used as a safety factor).

Key Beep

A modular approach was used in developing MOD III. Each of the three main features of the program was originally written as a standalone routine. Each routine was debugged, tested, and proven workable before the three were combined into a single program. Note that although the key-beep module has been included in the source listing, it is not a part of the assembled program. (This is due to the use of semicolons, which cause the assembler to treat the program lines as remarks.)

The key-beep feature introduced a few disadvantages. It is necessary to plug the AUXiliary cord into an amplifier to get an audible beep; however, this activates the cassette tape recorder (CTR) OUT line. (I discovered this when loading a program. With key beep active, the CTR started when the PLAY button was pressed.) This isn't a problem as long as you are aware of it.

I use a Radio Shack miniamplifier as a sound source. Beep volume is controlled by the amplifier volume control. At a low level, the beep is barely discernible, reminding me of a "squeaky" key. At a higher level, a sharp, short beep is heard as each key is depressed. But I found that the beep became annoying during long sessions at the keyboard.

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Source Code Modules

The source code listing has been structured to allow use of any one or a combination of the modules. For example, the video-line-print module (lines 1210 through 1580) can be keyed in as a stand-alone program. In doing so, appropriate starting and ending addresses must be added to the routine. Lines 130, 170, 180, 190, and 260 will provide the start and entry points. The following lines must be added to the "ZX" routine to complete a stand-alone listing:

```
1590 JP     0458H   ;GOTO
                     NORMAL
                     VIDEO IN
                     ROM
1600 END    START   ;EQUALS
                     TRANSFER
```

The key-beep routine has been included in the source-code listing for readers who wish to try it. To include the routine when keying in the code, the remark character (;) must be left out. Otherwise, it is not necessary to enter lines 760 through 1010.

The program starting address must be changed to a lower value if the key-beep routine is included. As the program byte count has not been calculated with key beep included, this must be done by picking an arbitrary starting address, assembling the program, and then calculating total byte count. Once the byte count is determined, the starting address can be changed accordingly.

MOD III BASIC Version

A BASIC language version of MOD III is provided in listing 2 for those who do not have an editor/assembler. The program listing is somewhat shorter than the assembly-language version because it does not include key beep.

As written, this program is self-checking for the correct response to RAM-size input (see lines 40 through 100). An INKEY$ routine (see lines 50, 60, and 90) is used for the input to prevent scrolling. If you enter two numbers in response to the RAM-size prompt, the program automatically branches to line 70 to check the input value. It is not necessary to press the ENTER key to conclude the input.

Line 70 checks the validity of the input value. If the A + B input is valid (i.e., 16, 32, or 48), program flow is directed to the corresponding lines. An invalid entry will erase the numbers that were typed after the RAM-size prompt and set up the INKEY$ routine for a new input cycle.

Listing 2: *The BASIC listing for MOD III. The disk BASIC commands have been disabled; remove the apostrophes to enable these lines.*

```
1 '       * MOD3 *  BASIC VERSION 8.1
2 '                   BY
3 '                J.  ROCKE
4 '
10 CLS:PRINT:PRINT TAB(12)"BASIC PROGRAM TO POKE ";CHR$(34);"MOD III";CHR$(34)
20 PRINT:PRINT TAB(11)"INTO MEMORY USING DATA STATEMENTS"
30 PRINT:PRINT TAB(19)"BY:  JOE W. ROCKE":PRINT:PRINT
40 PRINT TAB(3)"<ENTER> THE SIZE OF RAM (16, 32, 48) THEN <RUN> ";CHR$(143);" ";
50 GOSUB90:A=VAL(A$):PRINT@565,A;:A=A*10
60 GOSUB90:B=VAL(A$):PRINT@565,A+B
70 IF (A+B)=16 THEN 110 ELSE IF (A+B)=32 THEN 120 ELSE IF (A+B)=48 THEN 130 ELSE
 PRINT@565,"      "
80 GOTO 50
90 A$=INKEY$:IFA$=""THEN 90
100 RETURN
110 RUN 170
120 TM=PEEK(16561)+PEEK(16562)*256:IFTM<48000 THEN 140 ELSE 350
130 TM=PEEK(16561)+PEEK(16562)*256:IFTM<60000 THEN 140 ELSE 560
140 PRINT@565,"      ":GOTO50
150 '************  16K - ROM III DATA  ************
160 '**      MEMORY SIZE?  32608
170 POKE 16526,77:POKE 16527,127:'NORMAL BASIC
180 'DEFUSR1=&H7F4D:'DISK BASIC
190 FOR Z8= 32589  TO 32767:READ Z9:POKE Z8,Z9:NEXT Z8
200 A=USR(0):'NORMAL BASIC
210 'PRINT USR1(0):'DISK BASIC
220 END
230 DATA 33,97,127,34,22,64,33,170,127,34,30,64,62,143,50
240 DATA 25,64,195,25,26,33,54,64,1,1,56,22,0,10,95,163,32
250 DATA 26,119,20,44,203,1,121,214,128,32,241,126,6,7,45
260 DATA 134,16,252,254,0,62,0,192,50,26,64,201,166,40,16
270 DATA 58,26,64,60,50,26,64,254,255,32,217,61,50,26,64
280 DATA 123,115,197,1,88,2,205,96,0,193,10,163,200,195,251
290 DATA 3,8,217,58,8,56,254,5,32,54,33,0,60,30,16,14,64
300 DATA 205,217,127,126,50,232,55,58,64,56,254,128,40,25
310 DATA 35,13,32,238,205,217,127,62,13,50,232,55,29,32
320 DATA 225,24,16,58,232,55,254,63,32,249,201,205,217,127
330 DATA 62,13,50,232,55,8,217,205,88,4,245,213,237,91,32
340 DATA 64,26,254,95,32,4,58,25,64,18,209,241,201
350 DELETE 10-350
```

Listing 2 continued on page 392

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Listing 2 continued:

```
360 '************  32K - ROM III DATA  ************
370 '**       MEMORY SIZE?  48991
380 POKE 16526,77:POKE 16527,191:'NORMAL BASIC
390 'DEFUSR1=&HBF4D:'DISK BASIC
400 FOR Z8=-16563  TO-16385:READ Z9:POKE Z8,Z9:NEXT Z8
410 A=USR(0):'NORMAL BASIC
420 'PRINT USR1(0):'DISK BASIC
430 END
440 DATA 33,97,191,34,22,64,33,170,191,34,30,64,62,143,50
450 DATA 25,64,195,25,26,33,54,64,1,1,56,22,0,10,95,163,32
460 DATA 26,119,20,44,203,1,121,214,128,32,241,126,6,7,45
470 DATA 134,16,252,254,0,62,0,192,50,26,64,201,166,40,16
480 DATA 58,26,64,60,50,26,64,254,255,32,217,61,50,26,64
490 DATA 123,115,197,1,88,2,205,96,0,193,10,163,200,195,251
500 DATA 3,8,217,58,8,56,254,5,32,54,33,0,60,30,16,14,64
510 DATA 205,217,191,126,50,232,55,58,64,56,254,128,40,25
520 DATA 35,13,32,238,205,217,191,62,13,50,232,55,29,32
530 DATA 225,24,16,58,232,55,254,63,32,249,201,205,217,191
540 DATA 62,13,50,232,55,8,217,205,88,4,245,213,237,91,32
550 DATA 64,26,254,95,32,4,58,25,64,18,209,241,201
560 DELETE 10-560
570 '************  48K - ROM III DATA  ************
580 '**       MEMORY SIZE?  65375
590 POKE 16526,77:POKE 16527,255:'NORMAL BASIC
600 'DEFUSR1=&HFF4D:'DISK BASIC
610 FOR Z8=-179  TO-1:READ Z9:POKE Z8,Z9:NEXT Z8
620 A=USR(0):'NORMAL BASIC
630 'PRINT USR1(0):'DISK BASIC
640 END
650 DATA 33,97,255,34,22,64,33,170,255,34,30,64,62,143,50
660 DATA 25,64,195,25,26,33,54,64,1,1,56,22,0,10,95,163,32
670 DATA 26,119,20,44,203,1,121,214,128,32,241,126,6,7,45
680 DATA 134,16,252,254,0,62,0,192,50,26,64,201,166,40,16
690 DATA 58,26,64,60,50,26,64,254,255,32,217,61,50,26,64
700 DATA 123,115,197,1,88,2,205,96,0,193,10,163,200,195,251
710 DATA 3,8,217,58,8,56,254,5,32,54,33,0,60,30,16,14,64
720 DATA 205,217,255,126,50,232,55,58,64,56,254,128,40,25
730 DATA 35,13,32,238,205,217,255,62,13,50,232,55,29,32
740 DATA 225,24,16,58,232,55,254,63,32,249,201,205,217,255
750 DATA 62,13,50,232,55,8,217,205,88,4,245,213,237,91,32
760 DATA 64,26,254,95,32,4,58,25,64,18,209,241,201
```

This safeguard prevents program execution until a correct RAM size has been input.

The check for RAM size is a vital feature of the BASIC program. The listing contains three data groups, and the computer will always read the first data group unless directed elsewhere. Without lines 40 through 70, the 16K-byte data would be POKEd to memory regardless of memory size. If this were the case in a 32K- or 48K-byte system, you would have only the equivalent of a 16K-byte system available for use.

Upon branching to a data group corresponding to the RAM size, the normal BASIC vectors are POKEd to memory (lines 170, 380, and 590). Data corresponding to the machine code equivalent values are then READ and POKEd to memory (e.g., lines 190, and 230 through 350). Upon completion of the data READ/POKE operation, unnecessary portions of the program are deleted to conserve memory (see lines 350 and 560). This returns the computer to READY status. Entering a RUN command will then activate the MOD III features.

Keying in the BASIC Program

If you shudder at the thought of keying in long, numerical data statements, take heart! The task is not as big as it may first appear if you are content with a program limited to one memory size only. In this case, the RAM-size input lines may be eliminated.

Only the desired memory-size data group need be typed in for an individualized RAM-size program. Using a 16K-byte RAM size as an example, only lines 150 through 340 need be keyed in. These lines will provide the major MOD III features for a 16K-byte system.

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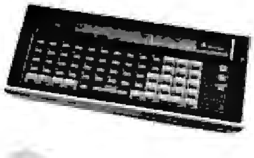

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Figure 1: *Sample output from the video-screen-print routine. If your printer can't handle graphics characters, the source code may have to be modified.*

you have never keyed in a machine code program via a BASIC READ/POKE listing, note that the program should be saved prior to program execution. Therefore, be sure to save the BASIC program to cassette or disk after it is keyed in and before its execution. By doing so, you will have the source code (i.e., the BASIC program) in case the program bombs due to a typing error.

The BASIC program has been written to include both normal and disk BASIC USR(0) routines. To use the program with disk BASIC, it will be necessary to delete the remark (') character used to mask the disk BASIC statements (see lines 180, 210, 390, 420, 600, and 630). The corresponding normal BASIC lines (e.g., 170 and 200) may either be deleted or edited to become remark statements.

Using MOD III

Memory size must be set before running either version of MOD III. The memory protect values for the BASIC version are provided in lines 160, 370, and 580 of listing 2. The assembly-language (system-load) version will automatically execute upon your entering a slash (/) at the *? prompt after program loading is completed.

The MEMORY SIZE? prompt will be the first thing displayed on the video upon running the BASIC version. Upon your response to the prompt, the corresponding data are POKEd to memory. This is a very short run cycle that completes with a READY prompt. Entering RUN at this point results in program execution. Appearance of the block cursor provides the only visual evidence that the program has been POKEd to memory. From this point on, the video-line-print and key-repeat features are also available. Either version of MOD III is completely unobtrusive once it is loaded to protected memory.

Selectable Cursor

The program, as written, provides a block cursor (ASCII 160). The cursor may be changed by POKing in any ASCII (American Standard Code for Information Interchange) character of your choice. This is done by entering a POKE statement without a line number as follows:

POKE 16409,*nn*

where *nn* may be any ASCII number from 35 to 255. For example, POKing in an ASCII 42 will change the cursor to an asterisk (*).

Video Screen Print

Pressing the Z and X keys simultaneously will output to the line printer whatever is displayed on the screen. The printout can be stopped short of a full display print by pressing the space bar. Graphics characters on the video display will also be printed if the printer has graphics capability. The video-line-print feature has been tested with both the Epson and Okidata printers which have graphics capability. Figure 1 is an example of a video-display printout.

A nongraphics printer may print a period or other symbol in place of any graphics character displayed on

the video. The ZX routine may be modified to print a symbol of your choice with a minor change in the source-code listing. However, I haven't investigated this, and such a change must be left to your ingenuity. In attempting to do so, keep in mind that if the ASCII value displayed on the video is greater than 128, it is a graphics character. To modify the program, it would be necessary to load a substitute value less than 128 for a printer character output.

Key Repeat

Holding down any key results in an automatic key repeat. This feature has the advantage of providing a built-in key debounce via an approximate 25-millisecond time-delay loop. Holding down the space bar will automatically advance the cursor. This is convenient for spacing forward to a particular line location.

The key-repeat delay time may be increased if you prefer a slow repeat rate. To increase the time between keystrokes, the only change necessary is to increase the BC count in line 780 of listing 1. For example, changing the line to read:

```
0780 LD BC,1000 ;DELAY COUNT
```

will provide an approximate 50-millisecond delay.

The automatic key-repeat feature has the advantage of providing a built-in key debounce.

Applications

Applications of the MOD III utility features are many. From a cosmetic standpoint, the block cursor provides an aesthetic appearance in keeping with the image that the word "computer" conjures in the minds of many people. I've observed that people sitting at the keyboard for the first time appear to recognize the block cursor automatically as a silent prompt that expects them to do something. I prefer a block cursor simply because of its visibility.

The video-screen-print capability allows you to print out information that may not otherwise be available without altering the program in memory. It is particularly convenient in printing a graphics display, provided the printer has graphics capability.

Automatic key repeat is a nice feature to have, particularly because it costs so little in memory overhead, and I find it more convenient than counting characters when editing a program line. By holding down the space bar, you can quickly advance the cursor to the character to be edited.

Admittedly, MOD III does not emulate all the features of the Model III; but it truly upgrades the capabilities of the Model I at a minimum cost in memory overhead. ■

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The time is approaching when increasing quantities of textual information will be committed to computer storage. Newspapers, professional journals, and library materials in general all lend themselves to reduction to some form of binary coding. Binary coding, in turn, promises to facilitate storage, access, transmission, and searches of much of the material that traditionally has been reduced to the printed word.

At present, reduction of text to binary code is usually accomplished by translating each character of the text into a byte of data. Often, this is a wasteful strategy that fails to take advantage of redundancies and patterns within the English language as it is used. An alternative to character-byte storage of English-language text is the use of binary-coded text. Binary-coded text exploits the repetitive nature of typical written English to provide economies on the order of 60% of medium requirements over traditional character-byte storage. These savings are achieved without loss of information.

The inefficiency of character-byte storage is apparent when one considers the memory devoted to storing a typical six-letter word. Such a word requires 7 bytes of memory—the first 6 bytes store the six letters and the seventh byte stores the trailing blank. Those 7 bytes occupy 56 bits of memory and can take any one of 2^{56} possible states. If there were on the order of 2^{56} different six-letter words in the English language, then allocating 7 bytes to store one of them might be justifiable.

There are, in fact, considerably fewer than 2^{56} six-letter words in the language. One recent compilation analyzed the contents of 500 samples of English language text (*Computational Analysis of Present-Day American English*, H. Kucera and W. N. Francis. Brown University Press, 1967). Those 500 samples of text composed a body of text 1,014,232 words long, but, all together, there were only 50,406 unique words, of which only 6470 were six letters long. Even allowing for the obvious fact that Kucera and Francis did not conduct an exhaustive search of the totality of written English text, it seems apparent that the allocation of 56 bits is an extravagant expenditure of memory for the identification of a six-letter word.

Theoretically, the number of unique character strings that can appear in English-language text is infinte, but in practice it tends to be quite limited. A typical sample of text is composed of the repetitive use of a few common words and the occasional use of obscure ones. Kucera and Francis reported that within their million-word corpus of text the most frequently occurring word, "the," appeared 69,971 times. That word alone accounted for nearly 7% of the words in the text they examined. They further reported that the 100 most frequently used words accounted for some 47% of their corpus of text, and the 1000 most frequently used words accounted for a little more than two-thirds. Not only are a few common words heavily relied upon, but when a less common word is used, it tends to be reused within the same passage. The result is that the number of unique words that appear in any given sample of text tends to be relatively small. The data reported by Kucera and Francis suggest that a typical 2000-word passage would be

expected to contain fewer than 800 unique words.

Actually, English as it is used is even more limited than these data suggest. Kucera and Francis analyzed their work in terms of word types—unique concatinations of letters. Many of the word types that they counted are simply multiple derivatives of the same word root. A random sampling of their word lists indicates that 12% of the 50,406 words they cataloged can be formed by adding "s" or "es" to other entries within the list. Another 4% can be formed by adding "d" or "ed." Obviously, English as it is used relies on a rather small word base.

These properties of English-language usage suggest a strategy for the efficient storage, transmission, and search of English-language text. It is possible to construct a relatively brief dictionary of the character strings most frequently used in English and to assign a unique binary code to each. Then, for any given text to be encoded, a supplemental string list of those strings found to occur within the original text, but not within the dictionary, is put together. The original text is reduced to a series of pointers that indicate entries in either the dictionary or the string list. For such a text, all that needs to be stored is its string list and its pointer list. A decoding program that contains the dictionary within itself can reconstruct an accurate image of the original text from its string and pointer lists.

Experience with this technique has shown that the lists for such a text would require only about 40% as much medium for storage and correspondingly only about 40% as much time for transmission as the same text storage in traditional character-byte format. String searches of binary-coded text achieve even greater advantages over searches of character-byte text. If any of the elements of a target string are not found in the dictionary or in the string list of a given text, then there is no need to scan the pointer list of that text to see if the elements appear in the required order.

Beginning the Encoding Process

Encoding any given piece of text into binary-coded text is a matter of replacing each character string in the original text with a pointer code. Each pointer is a 2-byte code that identifies a string in either the dictionary or in the string list. (See figure 1.) Bits 0 through 6 and 8 through 10 of each pointer code are address bits. Bit 11 indicates whether the dictionary or the string list is being addressed. Bits 12 through 15 indicate one of the recognized word endings shown in table 1. When the pointer is decoded, it is printed as the string to which it points plus the word ending to which it points and an implied trailing blank.

Bit 7 of each pointer is reserved as a continuation code. When this bit is low, it indicates that the pointer has been abbreviated to a single byte and that bits 8 through 15 are implicitly 0. The effect of implying zeros in bits 8 through 15 is to allow the abbreviated, 1-byte pointers to address the first 128 entries in the dictionary while indicating the null string as the word ending. This permits these 128 entries to be represented by 1-byte, rather than 2-byte, pointers.

The first 24 entries of the dictionary are reserved for punctuation marks. (See table 2, page 404.) There are three general classes of punctuation marks: leading punctuation, trailing punctuation, and special codes. The pointers that indicate leading punctuation decode into the mark they represent but do not generate an implied trailing blank. The pointers for trailing punctuation do generate a trailing blank, but they suppress the trailing blank of the preceding character string. Capitalization of the first letter in a word is treated as a form of leading punctuation. During encoding, leading and trailing punctuation are stripped off each string to which they are found attached. The leading codes, if any, are added to the pointer list, followed by the code for the root string, then by the codes for trailing punctuation, if any. For example, if the **English** text contained the string:

"Hello!" ␢

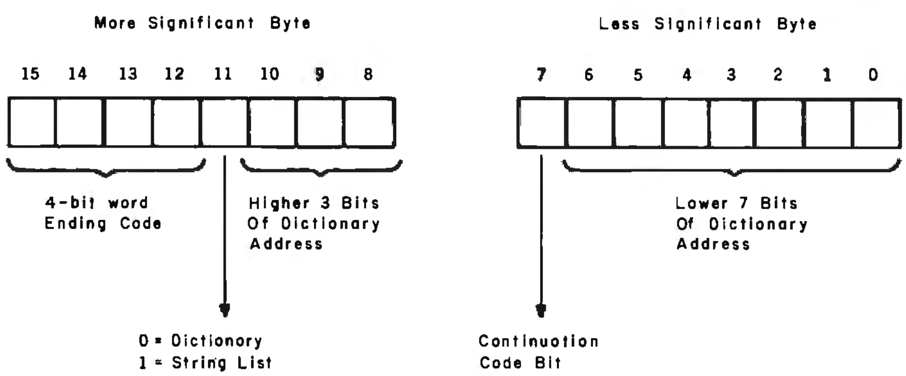

Figure 1: *Diagram of a binary-coded text pointer. Of the 16 bits available, 10 are allocated to dictionary addressing, four define the word-ending code (given in table 1), one identifies the dictionary being addressed, and one is a continuation code. In a text stream, the less significant byte appears first. If bit 7 is a 0, this signals that the more significant byte is all zeros and that the next byte is the less significant byte of the next pointer.*

4-Bit Hexadecimal Code	Word Ending
0	(null string)
1	ments
2	ment
3	ings
4	ions
5	ely
6	ers
7	ion
8	ing
9	ly
A	ed
B	's
C	er
D	es
E	s
F	e

Table 1: *Hexadecimal codes assigned to recognized word endings.*

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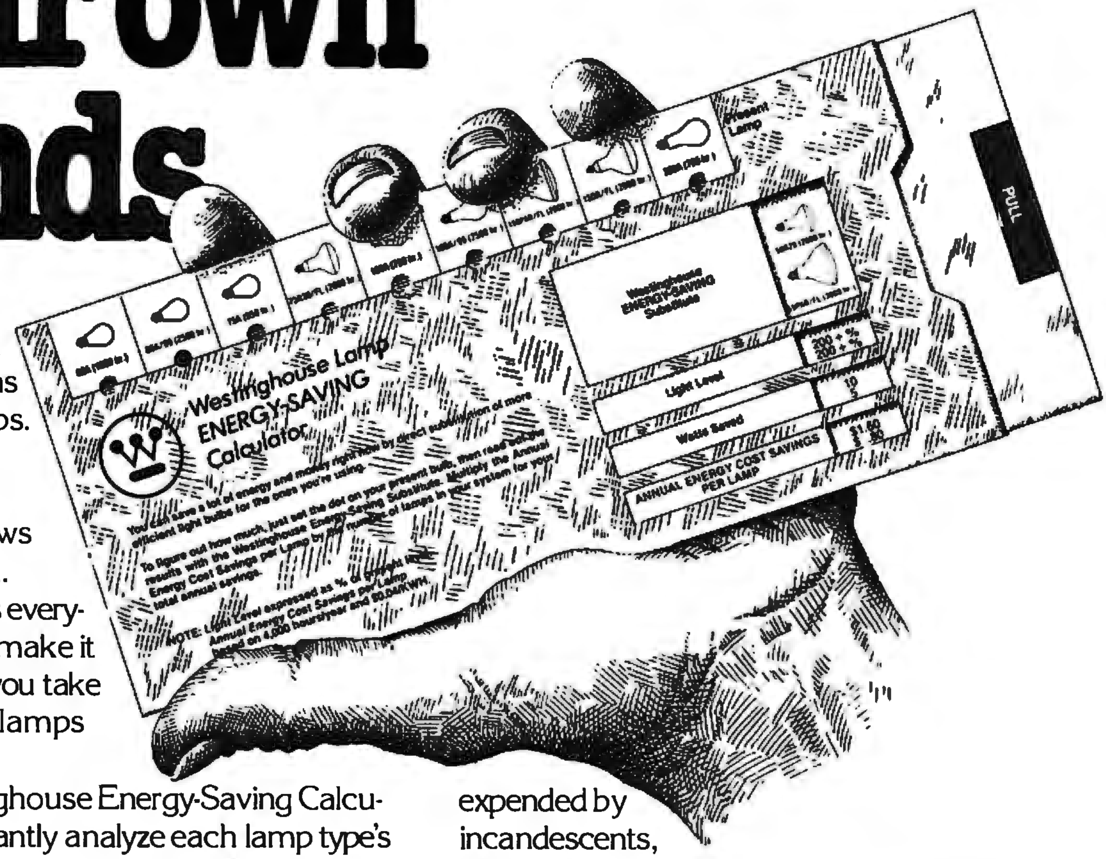

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the corresponding pointer list entry would be:

06 04 xx xx 0B 08

where xx xx is the pointer code for "hello."

The special-punctuation codes include 03 for "space," which is necessary whenever more than one ƀ separates two strings, and 00 for "end-of-line," which is effectively a linefeed/carriage return combination. Codes 01 and 02 are actually abbreviations of frequently occurring concatinations of punctuation codes. The 01 code replaces the sequence of hexadecimal numbers "0F 03 04" whenever that sequence is found in the pointer list. The sequence "0F 03 04" decodes as:

[period, with implied space] [space] [capitalize first letter of next string]

This is a common sequence that typically separates sentences of English-language text; it is efficiently abbreviated into a single byte, 01. Similarly, the special code 02 is the abbreviation for the sequence that begins each paragraph of English.

Pointer Code (Hexadecimal)	Interpretation
00	end-of-line
01	period-space-space-capitalize
02	space-space-space-space-space-capitalize
03	space
04	capitalize first letter of next string
05	leading single quote
06	leading double quote
07	leading left parenthesis
08	trailing double quote
09	trailing comma
0A	trailing right parenthesis
0B	trailing exclamation mark
0C	trailing question mark
0D	trailing colon
0E	trailing semicolon
0F	trailing period
10	trailing single quote
11	
12	
13	
14	reserved (no present application assigned)
15	
16	
17	

Table 2: *Pointer codes for punctuation and other common occurrences. The codes shown here are the first 24 words in the dictionary.*

The Dictionary

After the 24 punctuation codes, the remaining 1000 entries in the dictionary are character strings. Some representative entries in this dictionary (which is too long to be printed in its entirety) are given in table 3. The first string entry in the dictionary (the word "the"), therefore, appears at decimal address 24 and is assigned hexadecimal pointer code 18. The next 103 entries (decimal addresses 25 through 127) are assigned sequential hexadecimal pointer codes from 19 through 7F. These 104 entries are the 104 most frequently used words in the English language, according to Kucera and Francis. Together with the 24 punctuation codes, they occupy the lowest 128 addresses in the dictionary. These are the 128 addresses that can be identified with 1-byte pointers. Given that Kucera and Francis report that the 104 most frequently used words account for some 47% of written language and

because punctuation is fairly common in English, this scheme provides that a bit more than half the pointers for a typical sample of English-language text can be only 1 byte in length.

The remaining 896 string entries in the dictionary are stored in truncated form. Each of these entries is the result of testing the trailing characters of an entry in Kucera and Francis's word list against each of the recognized word endings given in table 1 and lopping off the longest one from the right side of the word. The 105th entry in the dictionary, for example, is the word root "thos." This was generated by testing the 105th entry in Kucera and Francis's word list, "those," against the recognized word endings in table 1. The longest ending that matched was "e." Therefore, "e" was lopped off "those," leaving "thos." The rest of the dictionary was built up in the same manner except that those entries in the Kucera and Francis list that would have resulted in multiple identical entries in the dictionary were ignored. Consequently, words such as "seem," "seems," and "seemed" resulted in only a single dictionary entry, "seem." This scheme allows multiple derivative words to be represented by a single word root in the main dictionary.

Address (Decimal)	Code Pointer (Hexadecimal)	Dictionary Entry
24	0018	THE
25	0019	OF
26	001A	AND
27	001B	TO
28	001C	A
29	001D	IN
30	001E	THAT
31	001F	IS
32	0020	WAS
33	0021	HE
34	0022	FOR
35	0023	IT
36	0024	WITH
37	0025	AS
38	0026	HIS
39	0027	ON
40	0028	BE
.	.	.
.	.	.
.	.	.
1013	07F5	KITCHEN
1014	07F6	PRODUC
1015	07F7	CLOTH
1016	07F8	FAILUR
1017	07F9	FAMOU
1018	07FA	LONDON
1019	07FB	PUBLISH
1020	07FC	QUICK
1021	07FD	REGARD
1022	07FE	YOU'LL
1023	07FF	ACTIY

Table 3: *Entries from the beginning and end of the dictionary of 1024 words or word parts.*

String List

The string list is created sequentially as the encoding program steps through the original text. Each time the encoder encounters a string, it strips that string of leading and trailing punctuation. The remaining string is then tested against each of the elements of the dictionary and against as much of the string list as has already been made up. If no match is found, the string is truncated by lopping off its longest recognized word ending. The dictionary and string list are then searched again. This time, if no match is found, the remaining truncated string is added to the string list.

As the string list is being created, each entry is added to the preexisting list preceded by a single byte that indicates the length of the entry. For example, if the first three entries in the string list were "boy," "day," and "happy," the string list would initially

Information Encoded	3	b	o	y	3	d	a	y	5	h	a	p	p	y
Hexadecimal	03	02	0F	19	03	04	01	19	05	08	01	10	10	19

Table 4: *An example of a string list. This sample shows the encoding of the words "boy," "day," and "happy." A string list is a list of words and word pieces that belong in a coded passage of text but are not listed in the dictionary.*

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read as shown in table 4. ASCII reserves the lower hexadecimal values for control codes, but those codes have no function in the string list. It turns out to be more efficient to give the 90 printable characters hexadecimal codes ranging from 01 to 5A and to reserve the 165 higher codes of 5B through FF for multiple character representations. No extensive or systematic research has been undertaken to identify the most efficient use of these 165 codes, but the following scheme was adopted and employed simply because it seemed reasonable.

Casual inspection of a typical sample of English-language text suggests that, within words, vowels are rarely separated by more than two consonants and that consonants are rarely separated by more than two vowels. This leads to the observation

Hexadecimal Code	Digraph	Hexadecimal Code	Digraph	Hexadecimal Code	Digraph
5B	BA	92	PE	C9	EH
5C	BE	93	PI	CA	EL
5D	BI	94	PO	CB	EI
5E	BO	95	PU	CC	EN
5F	BU	96	PY	CD	EP
60	BY	97	RA	CE	ER
61	CA	98	RE	CF	ES
62	CE	99	RI	D0	ET
63	CI	9A	RO	D1	EV
64	CO	9B	RU	D2	EW
65	CU	9C	RY	D3	IB
66	CY	9D	SA	D4	IC
67	DA	9E	SE	D5	ID
68	DE	9F	SI	D6	IF
69	DI	A0	SO	D7	IG
6A	DO	A1	SU	D8	SH
6B	DU	A2	SY	D9	IL
6C	DY	A3	TA	DA	IM
6D	FA	A4	TE	DB	IN
6E	FE	A5	TI	DC	IP
6F	FI	A6	TO	DD	IR
70	FO	A7	TU	DE	IS
71	FU	A8	TY	DF	IT
72	FY	A9	VA	E0	KV
73	GA	AA	VE	E1	IW
74	GE	AB	VI	E2	OB
75	GI	AC	VO	E3	OC
76	GO	AD	SH	E4	OD
77	GU	AE	VY	E5	OF
78	OY	AF	WA	E6	OG
79	HA	B0	WE	E7	OH
7A	KE	B1	WI	E8	OL
7B	HI	B2	WO	E9	OM
7C	HO	B3	QU	EA	ON
7D	HU	B4	WY	EB	OP
7E	HY	B5	AB	EC	OR
7F	LA	B6	AC	ED	OS
80	LE	B7	AD	EE	OT
81	LI	B8	AF	EF	OV
82	LO	B9	AG	F0	OW
83	LU	BA	AH	F1	UB
84	LY	BB	AL	F2	UC
85	MA	BC	AM	F3	UD
86	ME	BD	AN	F4	UB
87	MI	BE	AP	F5	UG
88	MO	BF	AR	F6	TH
89	MU	C0	AS	F7	UL
8A	MY	C1	AT	F8	UM
8B	NA	C2	AV	F9	UN
8C	NE	C3	AW	FA	UP
8D	NI	C4	EB	FB	UR
8E	NO	C5	EC	FC	US
8F	NU	C6	ED	FD	UT
90	NY	C7	EF	FE	EX
91	PA	C8	EG	FF	ST

Table 5: *A list of 165 common digraphs (two-letter combinations).*

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Circle 466 on inquiry card.

Information	3	b	y	3	d	y	5	a	p
Encoded		o			a		h	p	y
Hexadecimal	03	5E	19	03	67	19	C9	BE	96

Table 6: *An example of a more compactly coded string list. This example uses the same words as table 4 but compresses all possible two-letter combinations into 1 byte as given by the entries of table 5. The encoding of the 2 bytes representing "5h" into the single byte, hexadecimal C9, is not a mistake; this will be interpreted correctly by the decoding algorithm.*

that words are largely composed of a series of consonant-vowel or vowel-consonant digraphs. Table 5 is a list of 165 such digraphs. Notice that within table 5 a few of the less likely consonant-vowel and vowel-consonant digraphs have been replaced by a few of the more likely consonant-consonant digraphs. Each digraph is assigned one of the hexadecimal codes from 5B through FF.

After the encoder has stepped through the entire original text and created the complete string list, it is possible to shorten the string list by scanning it for each of the digraphs coded in table 5 and, when a recognized digraph is found, abbreviating it to the appropriate single-byte hexadecimal code. The result is that the string list of "boy," "day," and "happy" is compressed into the string shown in table 6.

Notice that the hexadecimal code for the "5" preceding "happy" is 05. The hexadecimal code for the letter "e" is also 05. So far as the compressing routine is concerned, there is no difference between "5" and "e," so the "5" and the "h" in "happy" end up being compressed into the digraph "eh" and assigned the hexadecimal code C9. When the encoded text is being decoded and the logical inverse of the compressing routine is being performed, the "5" reappears to serve its indexing function. Compressing the string list in this manner reduces its length by about 30%.

An Application

To demonstrate the practical application of binary-coded text, I have reduced a copy of the Gettysburg Address from normally encoded text to binary-coded text. A copy of the original appears in table 7. The resulting binary-coded-text pointer list and string list appear in table 8. In normal character-byte format, the original text occupies 1474 bytes of memory. The pointer list and string occupy 486 and 136 bytes respectively, or a total of 42% of the length of the original text. Table 9 shows the reconstruction of the first line of the Gettysburg Address from the binary-coded text.

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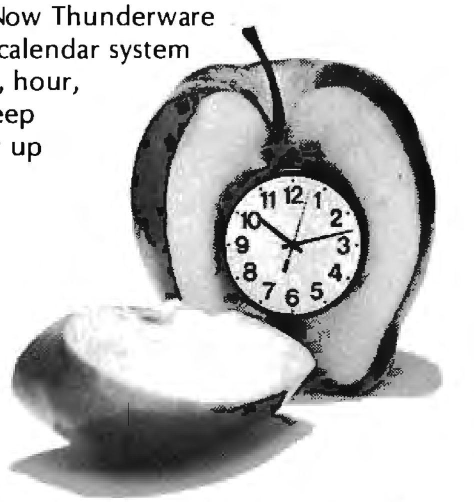

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```
DISK VOLUME 254

*A 006 HELLO            07/07 16:37
*A 006 CLOCK            06/08 09:07
*A 004 FRAME            06/08 09:08
*A 004 DISK INFO        06/17 16:13
*B 003 BACKOFF          06/17 16:13
*B 005 SCREEN           07/24 17:32
*B 002 TCPUTIL          06/17 16:13
*B 004 SDTIME.O         06/17 16:13
*A 007 ADIGCLK          05/19 08:05
*A 011 SET TIME         06/08 09:08
*I 009 IDIGCLK          05/19 08:05
*A 007 TIME             06/08 09:08
*A 003 SLOTFINDER       07/07 16:56
*A 014 DEMO             06/17 16:14
```

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Four score and seven years ago, our fathers brought forth on this continent a new nation, conceived in liberty and dedicated to the proposition that all men are created equal.

Now we are engaged in a great civil war, testing whether that nation or any nation so conceived and so dedicated, can long endure. We are met on a great battlefield of that war. We have come to dedicate a portion of that field, as a final restingplace for those who here gave their lives that that nation might live. It is altogether fitting and proper that we should do this.

But, in a larger sense, we can not dedicate—we can not consecrate—we can not hallow this ground. The brave men, living and dead who struggled here, have consecrated it, far above our poor power to add or detract. The world will little note, nor long remember, what we say here, but it can never forget what they did here. It is for us the living, rather, to be dedicated here to the unfinished work which they have thus far so nobly advanced. It is rather for us to be here dedicated to the great task remaining before us—that from these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion—that we here highly resolve that these dead shall not have died in vain—that this nation, under God, shall have a new birth of freedom—and that government of the people, by the people, for the people shall not perish from the earth.

Table 7: *The Gettysburg Address prior to encoding in binary-coded-text form as in table 8.*

(8a)

04	13	64	98	70	12	F6	D4	EA	A5	8C	0E	14	07	64	0E
62	E0	07	81	50	12	A8	07	68	69	61	F6	10	9A	94	9F
A4	03	98	C1	05	CC	73	74	CC	6B	12	0B	5B	14	14	80
6F	CA	04	04	94	12	F6	BB	A6	74	F6	04	6F	14	A3	2D
D4	EA	9E	03	97	14	06	79	0C	82	17	04	02	97	16	07
FF	9B	07	07	0C	07	68	14	97	03	14	06	70	12	74	F6
F9	6F	8D	D8	03	8E	02	6D	04	A9	0E	03	04	A3	13	0B
C9	EA	EC	C6	D1	EE	06	98	A0	0C	16	02	69	04	A9	DB
C4	DD	F6	06	92	99	D8	00								

(8b)

02	92	02	80	F8	1A	BA	06	F5	E0	FB	02	09	66	84	64
F6	02	81	08	00	27	2C	82	08	1C	57	99	74	09	83	A8
1D	84	08	1A	00	85	A8	1B	18	86	78	1E	3B	8E	01	2F
87	A8	F4	07	0F	00	02	63	40	2F	88	A8	1D	1C	9F	01
E4	07	C9	01	09	93	86	CA	C2	00	1E	99	74	32	61	99
74	4B	83	A8	1A	4B	85	A8	09	54	00	90	01	89	F8	01
40	2F	C7	05	27	1C	9F	01	8A	08	19	1E	C9	01	0F	00
40	33	A2	F1	1B	85	F8	1C	8B	78	19	1E	DE	02	09	25
1C	F1	03	00	C5	84	B1	F1	22	80	F1	45	BA	F0	CB	F2
3F	EC	D3	1E	1E	00	99	74	9D	01	EC	F3	01	23	1F	8C
C8	8D	88	1A	CB	C7	1E	40	00	7C	5F	2C	0F	00	02	30
09	1D	1C	8F	C2	B6	F2	09	40	54	2E	85	F8	8E	08	40
54	2E	00	8F	F8	8E	08	40	54	2E	90	08	2C	FB	03	01
18	91	F8	8E	01	09	00	EC	83	1A	9B	04	09	45	92	A8
BA	F0	09	33	8F	A8	23	09	D8	01	00	C1	F2	66	B9	06
9C	C2	1B	A7	04	32	93	08	01	18	8A	01	46	85	F1	00
AE	F0	09	E9	03	90	01	A7	C5	09	4D	40	BA	01	BA	F0
09	30	23	54	96	C1	00	94	08	4D	35	6F	BA	F0	01	23
1F	22	A8	01	18	EC	83	09	81	C2	09	00	1B	28	85	A8
BA	F0	1B	18	95	A8	8F	01	36	35	33	00	B4	E2	D8	01
4B	96	98	97	A8	01	23	1F	81	C2	22	A8	01	1B	28	BA
F0	00	85	A8	1B	18	9F	01	98	08	F2	86	71	A8	01	BE
08	1E	31	00	5B	99	A8	9B	04	40	A9	F1	E8	A3	9A	78
1B	1E	CF	F5	00	22	36	35	CB	F2	18	9C	01	95	03	E9
F7	19	9A	78	8E	08	1E	00	40	BA	F0	BE	91	9B	F8	1E
5B	9B	04	E6	02	2E	33	9C	A8	1D	00	9D	08	8E	08	1E
2C	99	74	09	95	C1	AC	02	09	E6	02	33	1C	57	9E	08
19	00	DD	05	8E	00	1A	1E	DC	21	19	18	81	F1	09	2A
18	81	F1	09	22	00	18	81	F1	E6	02	2E	9F	08	31	18
F4	04	0F	00	FF	FF										

Table 8: *The Gettysburg Address in binary-coded-text form. Table 8a is the string list for the Address; table 8b is the pointer list. Table 9 shows how the first words of the Address are decoded.*

Limitations

While binary-coded text offers a significant potential for savings in media costs, it is not without its negative considerations. Encoding and decoding require time and memory. Also, the strategies that binary-coded text incorporates for the economic storage of traditional English text do not prove nearly so efficient when applied to irregular language or technical jargon.

The time and memory devoted to encoding and decoding are not as great as they might appear. Encoding is by far the lengthier of the two processes. The work that I did in developing the encoder was done on a Radio Shack TRS-80, which takes just under 30 seconds to encode the Gettysburg Address. Decoding the Gettysburg Address, on the other hand, takes only a few seconds. Inasmuch as any given piece of text needs to be encoded only once and thereafter can be stored for decoding an indefinite number of times, the time devoted to encoding is not necessarily a significant consideration. Decoding takes place at a rate far in excess of human reading speed, so the decoding time is irrelevant in any configuration in which it is being performed by a dedicated unit (such as an intelligent terminal or a microcomputer). The size of the encoder or decoder may or may not be a limiting factor: the encoder and decoder together, including the dictionary, occupy just under 10K bytes.

The fact that the string list is limited to 1024 entries does not really limit the size of the text that can be reduced to binary-coded text. A string list of 1024 entries is probably large enough to accommodate a text of approximately 10,000 words. The encoder can simply treat a text of 20,000 words as if it were two separate texts of 10,000 words each and create a separate string list for each "text." Regardless of the number of string lists the encoder has to generate, the ratio of storage requirements for character-byte text to storage requirements for binary-coded text should remain relatively constant at a ratio of around 5:2.

1. The first line of the Gettysburg Address (as it appears on a 64-character wide display):

b̸b̸b̸b̸b̸Fourb̸scoreb̸andb̸sevenb̸yearsb̸ago,b̸ourb̸fathersb̸b̸broughtb̸forth(lf-cr)

2. The string list for the first line of text of the Gettysburg Address:

Information	4	s	c	r	f	r	t
Encoded			o	5	o		h
Hexadecimal Code	04	13	64	98	70	12	F6

3. The pointer list for the first line of the Gettysburg Address. (Note that the 2-byte pointers appear in less-significant-byte/more-significant-byte order. Each separate pointer code has been underscored to assist the reader in distinguishing 1- and 2-byte codes.)

02 92 02 80 F8 1A BA 06 F5 E0 FB 02 09 66 84 64 F6 02 81 08 00

Decoded:

02		indent and capitalize first letter next word	b̸b̸b̸b̸b̸
92	02	dictionary address 274 plus null word ending	fourb̸
80	F8	string list address 0 plus "e" word ending	scor + eb̸
1A		dictionary address 26 plus null word ending	andb̸
BA	06	dictionary address 826 plus null word ending	sevenb̸
F5	E0	dictionary address 117 plus "s" word ending	year + sb̸
FB	02	dictionary address 379 plus null word ending	ago
09		trailing comma	,b̸
66		dictionary address 102 plus null word ending	ourb̸
84	64	dictionary address 516 plus "ers" word ending	fath + ersb̸
F6	02	dictionary address 374 plus null word ending	broughtb̸
81	08	string list address 1 plus null word ending	forthb̸
00		linefeed/carriage return	

Table 9: *Reconstruction of the first line of the Gettysburg Address from the binary-coded text of table 8.*

Due to the fact that binary-coded text relies so heavily on its dictionary of frequently used words, its efficiency will necessarily suffer when it is confronted with atypical character strings. One tactic for coping with this problem is to use different dictionaries for different categories of texts. In fact, this enhances the efficiency of binary-coded text in general. A list of the 1000 most frequently used words to be found in a library of computer-science journals, for example, will be significantly different from a list of the 1000 most frequently used words in a collection of back issues of the *New York Times*. There is no logical obligation to encode all texts on the basis of the same dictionary. The only requirement of binary-coded text is that the decoding program have available the same dictionary as was used during encoding. ■

The complete encoded dictionary is available from the author for $10.

BYTELINES

News and Speculation About Personal Computing

Conducted by Sol Libes

Random Rumors: Word has it that IBM is developing its own floppy-disk drive for disks less than 5¼ inches in diameter. IBM is also said to be telling potential parts suppliers that it expects to ship approximately 1.2 million personal computers by 1984. And this coming summer the corporation is expected to introduce a larger brother for its Personal Computer. . . . Olivetti and Victor are expected to soon introduce systems that are software compatible with the IBM Personal Computer. . . . In a change of plans, Hitachi Ltd. is postponing introduction of its personal computer into the U.S. until late this year. Hitachi has been showing a prototype 6809-based system at trade shows. Reportedly, they feel that they do not yet have enough software support for it. . . . Mattel Electronics is said to be readying a portable terminal/computer. . . . Xerox may be seriously considering a low-cost portable terminal. . . you can expect similar introductions from Sinclair, Epson, Hitachi, and Alcatel-Electronique (France) at the National Computer Conference (NCC) show in June. All are expected to sell for less than $500. . . . Toshiba is expected to show a portable computer (T-100) using an optional flat-screen liquid-crystal display at the NCC. . . . Rumor has it that Apple will not have its new database/electronic-mailer/user-friendly 68000 system ready for introduction at the NCC. . . . Micropolis is reported to be readying 8-inch Winchester-technology disk drives with capacities of 60, 90, and 180 megabytes for introduction later this year.

Computer Flea Market: On Saturday and Sunday, April 17 and 18, several thousand computer hobbyists will flock to Trenton State College, New Jersey, for the Trenton Computer Festival, the world's largest personal-computer equipment flea market. This annual event is now in its seventh year. Many swap and seller tables, spread over more than eight acres, feature everything from complete computer systems to tiny electronic parts. There will be speakers, user-group meetings, an indoor exhibition area, and a banquet.

The Festival is sponsored by the Amateur Computer Group of New Jersey, the Philadelphia Area Computer Society, and the Trenton State Computer Society; the funds raised help support these nonprofit organizations. For information, call (609) 771-2487 or write to TCF-82, Trenton State College, Trenton, NJ 08625.

New Policies for Intertec: Intertec has been receiving negative press comments lately regarding its warranty policies and other matters. The company has made a series of announcements it feels will improve customer relations.

Intertec will now pay return freight on defective equipment, during the warranty period, and on equipment that arrives damaged to the dealers.

The company is instituting a money-back guarantee during the 90-day warranty. Customers may return their machines for any reason during that period and pay only a restocking charge of 5 percent for the first 15 days and higher percentages beyond that on a sliding scale.

A new user hot-line is available to solve customer problems. Any problem unresolved after 24 hours will be forwarded automatically to the product manager.

A series of across-the-board price reductions were announced last month. The Superbrain has dropped from $3495 to $2995; the Superbrain QD from $3995 to $3495; and the high-end Compustar from $4495 to $3995.

Several additional policy changes have been made to give Intertec dealers added flexibility in discount structures.

Intertec customers will now automatically become members of a company-sponsored user group, which will meet annually. The company is also sponsoring a new magazine for users.

More 68000 Systems: Systems based on Motorola's 68000 microprocessor are now available from Charles River Systems, Computhink, Codata Systems, Cromemco, and Dual Systems Control, as well as Empirical Research Group, Evans and Sutherland, Future Systems, Fortune Systems, Microdasys, Omnibyte, Q1, and Wicat Systems. This list will probably quadruple in size by year-end. And virtually all have or will have Unix-like operating systems. Most are designed to be multiuser systems, although they can be used by a single person. So far, most of the bus-oriented systems introduced use either the Multibus or the S-100 bus. Few, if any, are using the Versabus, specifically designed by Motorola for the 68000. The problem is that the Versabus requires very large and expensive boards and connectors.

Sinclair Flat-Screen: Sinclair Research Ltd. has disclosed an agreement with ICL (International Computers Ltd.), the largest computer maker in England, for ICL to produce a line of office work stations that will use Sinclair's flat video screen CRT and the Sinclair version of BASIC. Plans are for the units to be introduced in Europe and possibly the U.S. in early 1983. The ultra-compact work stations will function as stand-alone computers and also will communicate voice and data via private telephone systems.

Sinclair is also expected to show a prototype portable terminal using the flat screen at the NCC show. A flat-screen pocket television measuring 6 by 4 by 1 inches, retailing for about $100, is expected to be in production later this year.

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The unit, which will have a display three times brighter than conventional television sets and will use one quarter the power, will be made by Timex. According to Sinclair, a major U.S. retail chain has already agreed to buy 300,000 sets.

Sinclair has also disclosed that it is working on a short-distance electronic car that it hopes to have on the road before 1985.

More Flat-Panel Displays: Several manufacturers are already shipping flat-panel displays, suitable for use in video-style terminals, that are based on refinements of existing technologies: gas-discharge (GD), vacuum-fluorescent (VF), and liquid-crystal (LC). Low-cost DC-type GD displays, also known as plasma displays, are already available in sizes as large as 12 lines by 40 characters. AC-type GD displays offer inherent pixel memory, and therefore do not require refreshing and exhibit no flicker; however, they are more complex and consequently more expensive. Electro Plasma, in Millbury, Ohio, already offers an AC GD display that displays 66 lines by 80 characters; Interstate Electronic, in Anaheim, California, offers a 51-line by 85-character display (512 by 512 pixels); and Fujitsu America offers a 25-line by 80-character display (also 512 by 512 pixels).

Ise Electronics, Japan, holds the basic patents on VF technology and has licensed Nippon Electric Company (NEC) and Futuba, as well as its own Noritake Electronics division, to manufacture it. These companies are currently supplying VF displays with as many as 256 by 256 pixels. Color displays are also available on custom order.

LC displays are also increasing in size. For example, Seiko Instruments, Torrance, California, is currently shipping 4-line by 32-character displays. However, LC is the most expensive of the three, and all are still considerably more expensive than the old cathode ray tube (CRT) standby. But prices are dropping as the technology improves and production increases. At this time, the GD display shows the best promise of competing with the CRT.

Reasoning Computer: The Department of Energy's Argonne National Laboratory and Northern Illinois University have developed AURA (automated reasoning assistant), a general-purpose program that appears to mimic some reasoning skills of the human mind. It eliminates the need to understand complex programming when using a computer to solve a problem. The problem must be explained to AURA in terms it can understand, and suggestions must be made for AURA to investigate. AURA does not solve the problem; rather, it points out directions for further study.

IEEE Standards: The Binary Floating Point (P754) and Radix Free Floating Point (P854) standards are being voted on by the Institute of Electrical and Electronics Engineers (IEEE) standards committee members. Standards for Relocatable Object Code Format (P695) and High Level Language (P755) are in draft states. The IEEE Assembly Language Mnemonics Standard (P694) committee is extending the current standard (which most manufacturers seem to ignore) to include several of the newer 16- and 32-bit microprocessors. A committee is being formed to work on a standard for CP/M. A committee on Software Benchmark Standards has also been formed. For more information on IEEE Computer Standards in development contact: Michael Smolin, Chairman, IEEE Computer Standards Committee, c/o Synertek Inc., Box 552, MS#39, Santa Clara, CA 95052.

Research Cooperative: The Semiconductor Industry Association (SIA) is planning to fund basic reasearch projects at U.S. universities through a newly formed Semiconductor Research Cooperative (SRC). Dr. Robert Noyce, Intel Corporation vice-chairman and chairman of SIA, said SRC plans to raise $4 to 5 million from integrated-circuit makers this year. This is being done in response to the huge Japanese investments in research and training of engineers. Manufacturers are being asked to contribute an amount equal to 0.1 percent of their sales of semiconductor devices. Japanese firms would not be welcome to join because American firms are not presently allowed access to research being conducted in Japan's VLSI (very-large-scale integration) laboratories.

SRC would own patents produced by its efforts and would collect royalties from firms that use them. SRC will be staffed by 10 engineers, headed by a full-time director, and controlled by a technical advisory board. Companies so far participating in SRC are Intel, IBM, Digital Equipment Corporation, Motorola, Control Data, Advanced Micro Devices, National Semiconductor, and Fairchild Camera and Instrument. Notable for its absence is Texas Instruments.

Watching IBM: Sears has disclosed that, during its first two months of selling microcomputers via its five computer stores, IBM products have taken a "large lead in sales volume among products carried in the stores." IBM shares shelf space with the NEC PC-8001A, Vector Graphic Series 3, and a Wang word processor.

There are rumors that IBM will shortly announce an enlargement of its Personal Computer dealer base. Reportedly, a large number of independent retailers have applied for dealerships and are awaiting a decision. In the meantime, dealers have been encountering some availability problems because of the large demand for the Personal Computer.

IBM has disclosed that it will enter the industrial robot market shortly. Rumor has it that the robot will be designed for high-speed assembly or component insertion, selling in the $125,000 range.

Telephone Typesetting: For about two years now I have been sending many of the articles and books that I write (with Wordstar on my trusty old S-100-based personal computer) directly to a typesetter via modem (at 600 bits per second, during off hours, using the standard CP/M-modem protocol), to be typeset directly from my file. The turnaround time is terrific, and the prices are great because little labor is involved. The typesetter has his system operating automatically 24 hours a day so that I can dial in at any time

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and send the file. His system receives it automatically, whether he is there or not. He then adds the necessary typesetting control characters and processes the file directly through his machine. Two or three days later the typeset text is in my mailbox.

Typesetters across the country are recognizing the value of hooking up personal computers to their typesetting machines and the phone lines. Check your Yellow Pages for such services in your area.

EEPROM Update: Electrically erasable programmable read-only memories (EEPROMs) allowing erasure of bulk memory and Electrically alterable ROMs (EAROMs) allowing alteration of individual bytes are finally coming to the marketplace. They allow real-time program changes, have reasonable access speeds, and come in less expensive packages than standard EPROMs that are erased by ultraviolet light. At the present time they cost eight to ten times more than EPROMs. However, as production increases they are expected to drop to a competitive price and supersede EPROMs.

Already 16K-bit EEPROMs (2K by 8 bits) are available in limited quantities from Intel, National, General Instrument (GI), and Motorola. And even Hitachi has announced a 64K-bit (8K by 8 bit) EEPROM. In an interesting turn of events, Intel has gone to court and received a preliminary injunction against Seeq Technology prohibiting sharing of EEPROM technology with Zilog or any other company.

EAROMs are also available in limited quantities from GI, National Cash Register (NCR), Nitron, and Toshiba. NCR even makes a 2K by 8-bit EAROM. However, access times are measured in microseconds and dual power sources are required.

In the meantime, 64K-bit EPROMs are reaching full production status, and 128K-bit EPROMs are being sampled. Sixteen-bit-wide EPROMs are expected shortly.

ADAPSO Grant Program: The Association of Data Processing Service Organizations (ADAPSO), Arlington, Virginia, has established a grant and fellowship program for post-secondary students pursuing careers in the computer-services industry. Awards will be up to $1000 per recipient per academic year. The deadline for applying is April 20, 1982.

Unix Look-Alikes: Manufacturers are finally starting to ship the 16-bit Unix-like operating systems they've been advertising for the past year. Some even claim to have Unix-like systems for 8-bit computers. A few have been shipping these 8-bit systems for several months now. Bell Laboratories even has a Z80 version that it is using in-house. As reported last month, Western Electric, bowing to the Unix-like competition, has substantially lowered the price of Unix. It will be a few more months before we know how these new Unix-like systems for the 16-bit systems stack up. Below are some initial impressions.

Unix was designed by Bell Labs to run on the Digital Equipment Corp. PDP-11 models. Although it has been implemented on small PDP-11s, it runs best, with full-feature performance, on the larger PDP-11 machines that have a sophisticated memory-management hardware system. Therefore, to transport Unix to a microcomputer means that it too must have ample memory (at least 256K bytes) and a memory-management system, a good disk system, and a tape backup system for good measure.

Unix was written in C, a high-level systems-oriented language. Therefore, one would think that transporting Unix from one hardware system to another would be an easy job—somewhat on the level of transporting CP/M with its easily modified assembler-language BIOS (basic input/output system) module. However, because of Unix's orientation to the PDP-11 large-system architecture, this conversion takes a few programmer-years to accomplish. Hence the delay in releasing these implementations. In order to cope with this problem, Microsoft, operating under a Western Electric Unix license, has entered into agreements with some other software houses to convert Xenix, a Unix look-alike, to systems for which Microsoft has not yet implemented Xenix systems.

The result is that the microcomputer Unix look-alikes are not full Unix implementations. Many of the larger or less used utilities have been omitted (or, in some cases, they are available at an extra charge). In many cases the floating-point arithmetic or bit-fields have been omitted or restricted. Furthermore, many have adopted different conventions for function and system calls, library modules, and utilities. But even Bell Labs has not maintained compatibility between Unix implementations the way Digital Research has with CP/M.

It is still very early in the Unix versus Unix look-alikes competition. Some suppliers of Unix look-alikes have done a very good job. Others still have a long way to go, but there is no doubt that they will make improvements.

Japan Gaining on U.S: A recent report given by Commerce Undersecretary Lionel Olmer to the House Ways and Means Trade Subcommittee reported that Japan is moving along in a commitment to develop a world-scale computer industry. He reported that the Japanese government's policies, research programs, special tax incentives, direct financial assistance, and joint government-industry efforts were all aimed at "moving the Japanese computer industry to the technological forefront in every major area."

He also reported that they are now concentrating on improving their software capabilities and developing the computer of the future. "There has been a national consensus in Japan that their economic future depends upon a rapid evolution into a knowledge-intensive and technology-intensive economy." He went on to state: "I believe that the real challenge from Japan is just beginning."

Mr. Olmer concluded by stating that a change in "national attitudes" is required for the U.S. to retain its position as the world's premier industrial power. "We must work 'smarter' and save more. We must be willing to take risks. Only in this way can we restore our competitive edge, and 'made in America' will again be the unquestioned world standard for quality."

BYTELINES

Random News Bits: Victor Business Products has introduced an 8088-based system, called Sirius I, that is rumored to be software-compatible with the IBM Personal Computer. The Sirius I was designed by Chuck Peddle, the wizard who created the 6502 microprocessor and the PET computer. Reportedly, Peddle is being sued by Commodore for alleged breach of contract, and he is in the process of countersuing. . . . Honeywell's Minneapolis credit union reports that it now issues about fifteen interest-free loans a week for the purchase of personal computers by Honeywell employees. . . . National Semiconductor is finally shipping samples of its new super 16-bit 16032 microprocessor, with production quantities expected by mid-year. . . . CBS-TV is experimenting with getting audience feedback via The Source (a timesharing information and telecommunications utility accessed via modem) so that viewers can immediately let show producers know what they like and do not like about prime-time shows. . . . Matsushita Electric, Hitachi, and Maxell have agreed to standardize on a new 3-inch compact floppy disk. . . . Atari has reduced the suggested list price of the Atari 800 from $1080 to $890; however, it has increased prices on some software. . . . Sinclair Research reports that by the end of 1981 it had sold over a quarter of a million ZX81 personal computers and that U.S. mail orders alone are 4000 a week. . . . Micropro and Digital Research have filed a joint copyright-infringement lawsuit against Data Equipment Inc., Sunnyvale, California, and its parent company, Dataforce International Inc., for selling "counterfeit copies" of their software.

Super/Duper News: Super/Duper Computers Ltd., Pieinthesky, Utah, has introduced a revolutionary new computer, the Super/Duper MAC-VIII. Based on a patented exclusive pipe-dream architecture, it boasts a speed faster than a bullet. The computer itself is so small that it seems lighter than air, and a new mass production technology is expected to result in a selling price as cheap as dirt. The MAC-VIII cannot be overloaded since it is made of solid steel. The computer will be marketed exclusively by Brooklyn Bridge Sales Inc. . . . Happy April!

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
POB 1192
Mountainside, NJ 07092 ■

BYTE's Bits

RCA to Service Epson MX Printers

RCA Service Company will provide nationwide warranty service for Epson America's MX series of microprocessor-based printers. RCA will also offer a wide variety of maintenance service packages to MX owners and users. Service will be performed by RCA technicians based in ~180 locations throughout the U.S. ■

What's New?

PUBLICATIONS

Smart Ideas from Digital

The fourth edition of Ideas (Index and Description of Educational Application Software) lists more than 300 applications packages for Digital Equipment Corporation's computer systems using the VAX/VMS and RSTS/E operating software. Software packages are alphabetically listed by application under separate VAX/VMS and RSTS/E sections. For your free copy, request publication number EJ 19645-87 from Education Computer Systems Group, Media Response Manager, PK3-2/M94, 129 Parker St., Maynard, MA 01754.

Circle 550 on inquiry card.

Computerist's First Aid Manual

Perfect for those emergencies encountered by computer programmers, the Computerist's First Aid Manual gives detailed instructions for dealing with such maladies as "CRT Eye," "Asteroids Wrist," and "Missile Command Thumb." It also contains information for dealing with other common home computing emergencies. The manual is available for $19.95 from Medi-Comp Inc., 70 Main St., Petersborrow, NH 03458.

Circle R202 on inquiry card.

Computer Graphics Vendor Directory

The 1982 Directory of Computer Graphics Suppliers lists almost 300 vendors of hardware, software, systems, and services. The Directory contains key background information on each company's computer graphics products and services, complete with address, telephone number, and contact person. Among the subjects covered are computer-aided design and manufacturing, business graphics, animation, and image processing. Other features of the Directory include a computer-processed index that categorizes vendors by application and technological focus, technology studies and market reports, and a guide to computer-graphics seminars, conferences, and courses. For additional information, contact Stanley Klein, Computer Graphics Directory, Suite 27, 730 Boston Post Rd., Sudbury, MA 01776.

Circle 551 on inquiry card.

Journal Probes Computers in Education

The Journal of Computers in Mathematics and Science Teaching is a quarterly publication of the Association for Computers in Mathematics and Science Teaching (ACMST), a nonprofit professional organization. The journal explores such topics as "Computer-Based Methods in Chemistry," "A Microcomputer-Assisted Presentation of Atomic Orbits," and "Planning for Microcomputers in the Classroom." Other features of the journal include book reviews, a column on software resources, and a new products section.

Annual ACMST membership costs $7, which includes a subscription to the journal. For additional details, contact ACMST, POB 4455, Austin, TX 78765, (512) 836-4378.

Circle 552 on inquiry card.

CP/M Software Catalog

A catalog listing 50 volumes of low-cost, public-domain CP/M-based software is available from the Special Interest Group for Microcomputers (SIG/M). The complete 50-volume library, housed in single-density 8-inch disks, lists more than 900 programs. The catalog costs $1.50 in the U.S. and Canada and $2.50 elsewhere. Contact SIG/M, POB 97, Iselin, NJ 08830, or call Bill Chin, (201) 778-5140, or Henry Kee, (212) 539-3202.

Software Protection Report

The various resources available for software protection are explored in a 60-page manual from Communication Research Trade. The report explains the differences, advantages, and dangers of comparable security alternatives. Information on trade secret protection, trademarks, and patents is included, and a major portion of the report is devoted to copyright and infringement recourses. In addition, an example program demonstrating the proper display of a copyright notice is provided. The report on software protection is available for $75 from Communication Research Trade, POB 3151, Redwood City, CA 94064.

Circle 553 on inquiry card.

Information Age Papers

A compilation of papers presented in April 1981 at the "Communications in the 21st Century" symposium has been produced by John Wiley & Sons. In Communications in the 21st Century, 20 distinguished scientists, scholars, journalists, and business executives explore such issues as the development of a national communications policy, business strategies for managing the information explosion, and the effects of technology on individuals and institutions. Communications in the 21st Century costs $19.95

and is available from John Wiley & Sons Inc., One Wiley Dr., Somerset, NJ 08873, (201) 469-4400.
Circle 554 on inquiry card.

Test and Measurement Products Catalog

A 432-page directory of test and measurement products is available from Metermaster, a company that represents nearly 40 manufacturers of test and measurement instruments. The catalog contains design and performance specifications for meters, oscilloscopes, and other test and measurement instruments. Product and test equipment categories are organized alphabetically according to manufacturer. A glossary is also provided.

The 1981/1982 Metermaster Catalog is available free of charge to qualified engineers and buyers at Metermaster outlets, or you can write to Metermaster, 5646 Jillson St., Los Angeles, CA 90040, (213) 685-4340. Requests must be submitted on company letterhead.
Circle 555 on inquiry card.

10,000 Components in Free Catalog

Mouser Electronics' 128-page catalog of electronic components contains full product specifications, illustrations, and prices for more than 10,000 items, ranging from clips and coils to potentiometers and plugs. The catalog is available free of charge from Mouser Electronics, 11433 Woodside Ave., Santee, CA 92071, (714) 449-2220.
Circle 556 on inquiry card.

Catalog of Circuit Board Products

A new 16-page catalog that describes products for circuit boards is available free from Pace Inc. Some of the products listed in the catalog are rework and repair boards, desoldering and specialty systems, function accessories, and audio-visual training courses. Request catalog number 781 from Pace Inc., 9893 Brewers Court, Laurel, MD 20707, (301) 490-9860.
Circle 557 on inquiry card.

SYSTEMS

ADM-3 Upgrade Kit

The Interboard-3A Kit turns your Lear Siegler ADM-3 or -3A terminal into a microcomputer. The kit has a 4-MHz Z80 microprocessor with 64K bytes of memory and a floppy-disk controller that fits inside the terminal. A single RS-232C and a Centronics-type parallel port allow peripherals to be attached.

Options for the kit include dual Tandon disk drives with 500K bytes to 2 megabytes of storage, and the CP/M operating system. The Interboard-3A Kit costs $795 and is available from International Systems Marketing, 5161 River Rd., Building #2, Bethesda, MD 20816, (301) 986-0773.
Circle 558 on inquiry card.

Business Computers

BMC Computer's if800 computer series is designed for medium-sized businesses and as an alternative to multiuser, multitasking systems where a common database is unnecessary. The Z80-based if800 computers are completely integrated desktop work stations with a keyboard, a printer, and a 12-inch high-resolution red/green/blue color display. The if800 series features 20 user-programmable function keys, I/O slots supporting a multitude of interfaces, ROM cartridge, light pen, and a built-in printer with screen-print and list capabilities. The CP/M operating system and a color/graphics-enhanced BASIC are standard.

Original equipment manufacturers have four if800 models from which to choose, ranging in price from $4170 to $6570. Three models employ two built-in 5¼-inch disk drives for approximately 800K bytes of media storage; the fourth model has a single floppy-disk drive and a 5-megabyte Winchester hard-disk drive. Additionally, two models carry a direct-connect modem and a selection of supplied software. For details, contact BMC Computer Corp., 860 East Walnut St., Carson, CA 90746, (213) 323-2600.
Circle 559 on inquiry card.

Single-Board Computer

The SYM-2 single-board microcomputer incorporates most features of the SYM-1, plus onboard power supply, choice of three microprocessors (6502, 6809, or 6802), cassette-interface jacks, eight toggle switches for user input, and eight light-emitting diodes for user output. Intended for office and industrial applications, the SYM-2 is software-compatible with SYM-1 programs and firmware. The expansion and applications ports are also compatible with the SYM-1, so expansion devices, such as random-access read/write memory (RAM) or the FDC-1 floppy-disk controller are fully interchangeable between the two machines.

The SYM-2 costs $249. For further details, contact Synertek Inc., Mail Stop 61, POB 552, Santa Clara, CA 95052, (408) 988-5682.

Circle 560 on inquiry card.

Micromaster

The Micromaster computer is a self-contained desktop unit from Barreto and Associates that operates under a modified CP/M operating system. Designed for small- and intermediate-sized businesses, the IEEE S-100-based Micromaster has dual 8085 and 8088 processors and both a 5¼-inch, 5-megabyte Winchester hard-disk drive and 5¼-inch, 96-track-per-inch, 500K-byte floppy-disk drive (additional drives can be used). The Micromaster can operate in either single-user or multiuser environments and its 12-inch video display has an 80-character by 24-line format.

The Micromaster is supplied with 64K bytes of random-access read/write memory (RAM) that is expandable to 16 megabytes, one parallel and one serial port, and a high-level language (BASIC or FORTRAN). The Micromaster is available for $12,500 from Barreto and Associates Inc., 507 West 16, Sedalia, MO 65301.

Circle 561 on inquiry card.

SOFTWARE

TRS-80 Database Manager

Adventure International's Maxi Manager is a database manager for the TRS-80 Models I and III. It supports six different relational search techniques and up to 20 user-defined fields of 40 characters each. Records can be up to 800 characters in length, and Maxi Manager has calculated equation fields plus a report generator.

Maxi Manager requires 48K bytes of RAM (random-access read/write memory) and one disk drive. The software is supplied with more than 180 pages of instructions and examples. Maxi Manger is available for $99.95 from Adventure International, POB 3435, Longwood, FL 32750, (305) 862-6917.

Circle 562 on inquiry card.

Keeping a Stiff Upper LISP

A dialect of the LISP language, the Stiff Upper LISP has more than 120 built-in functions packed into 13K bytes. The user environment includes symbolic break, trace, and single-stepping packages, plus an interaction history with REDOing facilities. Also provided are an extensible editor and an extensible online help facility, both of which are usable from within the LISP environment. Upon initialization, the Stiff Upper LISP reads a file that enables the user to customize the environment to personal preferences. Other features include screen control, a program formatter, closures that maintain their own environments of procedures and data, both lexical and dynamic variable scoping, and tail recursion elimination by the interpreter where appropriate, which makes recursion as efficient as iteration.

Stiff Upper LISP is available, under the CP/M operating system, for $165 from Lifeboat Associates, 1651 Third Ave., New York, NY 10028, (212) 860-0300, or, under TRSDOS, from Tennant and Tennant Computing, 3537 Ridge-moor Dr., Garland, TX 75042, (214) 530-0575.

Circle 563 on inquiry card.

Circle 564 on inquiry card.

68000 Multiprocessor Operating System

MTOS-68K is a real-time, multitasking, multiprocessor operating system for the Motorola MC68000 microprocessor. A modular system deisgned for high throughput, MTOS-68K produces an assembly-language module that can be placed in ROM (read-only memory). It manages task coordination, memory pools, input/output, priority scheduling, interrupt processing, and multiple processors. The system runs on up to 16 separate processors that share a common memory. All processors are equivalent: there are no masters and no slaves. A single copy of MTOS-68K executes on all processors. Without changing application software, system performance can be improved by adding processors. Application software can be written in assembly language or in a high-level language such as Pascal or C.

MTOS-68K is distributed in assembly-language source-code form and is sold for a one-time license fee that permits the licensee to imbed the object program in his or her own products without further charge. For complete

details, contact Industrial Programming Inc., 100 Jericho Quadrangle, Jericho, NY 11753, (516) 938-6600.
Circle 565 on inquiry card.

Two Atari Games

Concom Enterprises has two new game programs for Atari 400/800 microcomputers. Both games are written in BASIC and machine language and feature fast action, sound effects, and high-resolution color graphics. Each requires 16K bytes of RAM (random-access read/write memory). In Close Encounters, two players compete in a space battle, each trying to destroy the other's flying saucer. The game requires two joysticks. The second game, High Voltage, pits you against two killer robots. You are trapped in a field that's surrounded by a high-voltage fence and littered with high-voltage obstacles. Strategy and speed are your keys to survival. High Voltage requires a single joystick.

Both games are available on cassette for $15.95 each. For details, contact Concom Enterprises, 2626 West Touhy, Chicago, IL 60645.

CP/M-Compatible Utility

Lifeboat Associates' Zap80 is a menu-driven 5¼- and 8-inch disk access utility for SB-80 and other CP/M-80-compatible 8080/Z80 operating systems. Zap80 automatically allows direct file viewing and patching by actual memory address. Zap80 is designed for experienced users and includes extensive file-utility servicing to access and patch file sectors, compare files, and so forth. For details, contact Lifeboat Associates, 1651 Third Ave., New York, NY 10028, (212) 860-0300.
Circle 566 on inquiry card.

New Hashing Method Speeds Database Manager

Micro Architect's IDM-X is a general-purpose interactive database manager for the TRS-80 Model II. The IDM-X features a built-in sort/merge package and a fast key-access method that uses a new hashing algorithm. IDM-X supports string, double-precision floating decimal, and integer variables. Other features include formatted numeric fields, using BASIC formats, and an extensive report writer.

The basic components of IDM-X are a database initialization program, a database manipulation program, the report writer, and a report generator. A dual-disk TRS-80 Model II with 64K bytes of memory is required. IDM-X costs $399; the user manual is available separately for $25. For additional information, request a product catalog from Micro Architect Inc., 96 Dothan St., Arlington, MA 02174, (617) 643-4713.
Circle 567 on inquiry card.

CP/M-86 for the IBM Personal Computer

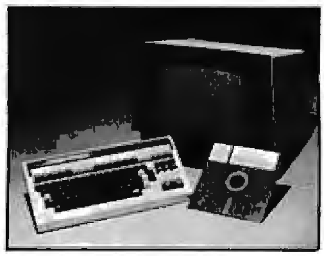
Compuview's CP/M-86 (CP/M is a registered trademark of Digital Research) for the IBM Personal Computer includes an interactive line editor that permits cursor movement to the previous line and horizontal scrolling to a width of 162 characters, and emulation of terminals such as Televideo, the IBM 3101, and the Zenith Z-19. Other features are an increase in disk capacity from the 160K bytes supported by MS-DOS to 193K bytes; the ability to read and write many soft-sectored disk formats, including the Xerox 820's format; support for both serial and parallel printers; a disk formatter; a disk-copy program that makes a fast, "image" copy; the ability to set transmission rates for serial ports; and support of Tecmar's hard-disk drive and other peripherals.

For further information, contact Compuview, Suite 200, 1955 Pauline Blvd., Ann Arbor, MI 48103, (313) 996-1299.
Circle 568 on inquiry card.

Slide Rule Simulator

The Slide-Simulator transforms your TRS-80 Color Computer into a Mannehim-type slide rule. Using high-resolution graphics and controlled by the game paddles, the program simulates full log-log functions. A special expanded viewing option allows easy reading of the scales. The program is available on a 5¼-inch floppy disk. For price information and a catalog of other innovative software, contact Abstract Mathematical Concepts Inc., 70 Main St., Putterboro, NH 03458.

PERIPHERALS



Keyboard Eases Word Processing

A computer designed primarily to handle small-business applications is now available with a keyboard dedicated to word processing. The new keyboard is based on a Visual 200 computer terminal with electronic and mechanical adaptations for Micropro's Wordstar word-processing system. The keyboard allows the user to strike a single color-coded key for center line, release or set margins, clearing or setting tabs, underscore, or any one of 24 other commonly used word-processing commands and cursor movements.

The keyboard option is available on new Prodigy installations or as a field upgrade. For more details, contact Prodigy Systems Inc., 497 Lincoln Highway, Iselin, NJ 08830, (201) 283-2000.
Circle 569 on inquiry card.

Versatile Robot Arm

The Rhino XR-1 computer-controlled robot arm is a versatile, low-cost product for educational or light industrial use. The XR-1 can be run from a modem or any computer with an RS-232C port. Standing 32 inches high, the XR-1 contains six motors, one for each axis point. It can reach up to 32 inches from base to fingertips; radial reach is 22¼ inches from the center of rotation to fingertips. Waist resolution is 0.137 degrees; shoulder resolution is 0.076 degrees. The XR-1's lifting capability and gripping force are approximately 16 ounces.

The Rhino XR-1 computer-controlled robot arm costs $2400. Contact Sandhu Machine Design Inc., 308 South State, Champaign, IL 61820, (217) 352-8485, for further details.

Circle 570 on inquiry card.

Man-Machine Interface at Your Fingertips

The 1780A Infotouch Display screen is a 5- by 9-inch video-display screen with a touch-sensitive overlay. Messages, numbers, graphics, menus, switches, and special characters can be displayed through computer programming to guide an operator's response step by step. The Infotouch's screen displays 16 lines of 80 characters and features 60 definable touch-sense areas. The Infotouch can be used with almost any desktop, home, or large computer.

The 1780A Infotouch Display costs $1995. It's available from the John Fluke Manufacturing Co. Inc., POB C9090, Everett, WA 98206, (800) 426-0361; in Washington, (206) 354-5400.

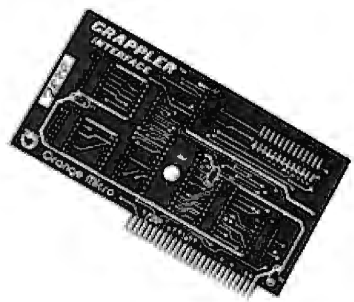
Circle 571 on inquiry card.

Apple III Hard-Disk Storage

Corvus Systems has unveiled new mass-storage units for the Apple III computer based on high-capacity 5- to 20-megabyte Winchester hard-disk systems. The storage modules incorporate an intelligent controller, a proprietary controller, software, and an Apple III interface. Firmware for the intelligent controller supports features such as sector buffering, automatic retries, diagnostics, transparent formatting with cyclic redundancy check (CRC) error detection, and high-speed data transfer using direct memory access (DMA) to random-access read/write memory (RAM) within the controller.

The Apple III Winchester hard-disk mass-storage units range in price from $3750 to $6450. Contact Corvus Systems Inc., 2029 O'Toole Ave., San Jose, CA 95131, (408) 946-7700, for additional information.

Circle 572 on inquiry card.



No More Grappling with Graphics

The Grappler is a Centronics-compatible parallel interface board for the Apple II. It has onboard firmware to copy the Apple's high-resolution graphics screen to a wide variety of printers, such as Anadex, Integral Data Systems, Centronics, and Epson. In the Grappler's standard printing mode, each white dot on the Apple's screen is printed as a black dot on paper. The inverse graphics mode allows you to print the reverse graphics of white-on-black. The double-size option doubles the graphics screen horizontally and vertically. Other features of the Grappler include word wrap-around, variable line and page length, 90-degree text rotation, the ability to skip over perforation, and compatibility with the CP/M operating system and Apple Pascal.

The Grappler is available at Apple dealers and computer stores for $175, including manual and interface cable. For complete information, contact Orange Micro Inc., Suite

G, 3150 East La Palma, Anaheim, CA 92806, (800) 854-8275; in California, (714) 630-3322.

Circle 573 on inquiry card.

Apple II Button Pad

A naval-operated numeric keypad is available from Hindsight Engineering. Designed to plug directly into one of the Apple II's slots, the keypad leaves your hands free for computer operation. (To insure proper interface, operate in a lint-free environment.) The complete package includes the keypad, interface card, connecting cable, complete documentation, and instructions on developing naval dexterity. The package lists for $99.95. Hindsight Engineering, POB 107.5, Pizzaborough, NH 03458.

Circle 1007 on inquiry card.

Hard Disk for the ZX81

Responding to an obvious need of ZX81 owners for more data storage space, Hindsight Engineering has developed a 5-megabyte hard-disk system for the Sinclair ZX81. The system is available in either assembled or kit form. The kit includes instructions for building your own clean room for kit assembly. A DOS will soon be available. For pricing information and a catalog of other products, write to Hindsight Engineering, POB 107.5, Peanutbutter, NH 03458.

High-Quality Low-Cost Terminal

The WY-100 is an intelligent terminal offering an array of features normally found in more expensive products. The WY-100 exhibits ergonomic design with a detached keyboard and a tiltable/rotatable display console. It offers a data-validation ability that ensures accurate keyboard entry and editing capabilities such as character insert and delete. Other standard features include word wrap, display features for forms creation, a split screen for viewing more than one data group simultaneously, a separate I/O port for driving a printer, and an RS-232C port for host computer communications.

The WY-100 costs $995. For complete details, contact Wyse Technology, 2184 Bering Dr., San Jose, CA 95131, (408) 946-3075.

Circle 574 on inquiry card.

256K-byte Memory for IBM

Zobex's 256K-byte RAM (random-access read/write memory) board with parity is fully compatible with the IBM Personal Computer. The memory meets or exceeds IBM memory performance and requires only one expansion slot. The board contains a memory address-decoding scheme carried out by means of an onboard configuration switch that allows each 64K-byte segment on the board to be either disabled or based at any 64K-byte boundary from 0 to 1 megabyte. This allows the board to be used in conjunction with the IBM central processing unit board-mounted 64K-byte memory or mixed with IBM 64K-byte expansion boards.

The 256K-byte memory board costs $998; original equipment manufacturer's discounts are available. Contact Zobex, 7343 J. Ronson Rd., San Diego, CA 92111, (714) 571-6971.

Circle 575 on inquiry card.

Apple-Compatible Drives

A. M. Electronics' 5¼-inch add-on disk drives are designed for "plug-and-go" compatibility with the Apple computer. The drives are completely compatible with Apple disk operating systems and software, and offer 40 tracks of data storage and a 3-millisecond track-to-track access time.

The add-on disk drives for the Apple, complete with case and cable, are available for $345. Contact A. M. Electronics Inc., 3366 Washtenaw Ave., Ann Arbor, MI 48104, (313) 973-2312.

Circle 576 on inquiry card.

Hard Copy from Video Terminals

Axiom Corporation's Model EX-1650 printer can produce full-size hardcopy output directly from almost any video computer or graphics terminal, video monitor, or TV set. Entire pages of displayed data—even complex graphics, alphanumerics, foreign symbols, or hieroglyphics—are rapidly reproduced on the printer. Paper width is 8½ inches, which allows full-sized reproductions of forms, reports, and graphs.

What's New?

The EX-1650 printer with self-adjusting print head, does not require external hardware or software. A single connection to a standard video jack is the printer's sole requirement. A smaller version of the printer, the EX-850, is available. The EX-850 accepts paper 5½ inches wide. The EX-1650 costs $3495. Contact Axion Corp., 1014 Griswold Ave., San Fernando, CA 91340, (213) 245-9244.
Circle 577 on inquiry card.

5¼-Inch Fixed Disk Drives

The new S1 series of 5¼-inch fixed disk drives from Mitsubishi Electronics feature Winchester-design reliability. The S1 series has a high-speed seek time of 75 microseconds (μs) average, 160 μs maximum, which includes settling time. Available with large storage capacities of 3.33, 6.66 to 10 megabytes (unformatted), each disk surface employs one movable head to service 160 data tracks. Further details and specifications can be obtained from Mitsubishi Electronics America Inc., Computer Peripherals Div., 2200 West Artesia Blvd., Compton, CA 90220, (213) 979-6055.
Circle 578 on inquiry card.

Calendar/Clock for Small Computer

The Hayes Stack Chronograph is an RS-232C-compatible calendar/clock for small computers. The Chronograph reports time in hours, minutes, and seconds in 12- or 24-hour modes. The date is output in a year/month/day format with automatic adjustment for leap years. The Chronograph is independently powered, and has a battery backup to maintain time, date, and weekday for up to one year when the power fails or is disconnected.

Simple ASCII (American Standard Code for Information Interchange) character strings let the user set, read, and display calendar/clock data, control the computer alarm, and select various options.

A complete Chronograph system costs $249. Contact Hayes Microcomputer Products Inc., 5835 Peachtree Corners E., Norcross, GA 30092, (404) 449-8791.
Circle 579 on inquiry card.

S-100 Bus for Superbrain

The SBS-100A Interface Adaptor provides the necessary components for converting the Superbrain microcomputer to S-100 bus operations. The unit can be fitted within the Superbrain cabinet to control a single S-100 board or it can be mounted externally in an S-100 box for control over a number of S-100 boards.

The SBS-100A Interface Adaptor board costs $595, including postage but excluding duty fees. For further details, contact Icarus Computer Systems Ltd., Deane House, 27 Greenwood Pl., London NW5 1NN, England, 01-485 5574.
Circle 580 on inquiry card.

Tape Backup Fit for a Chieftain

If you own a Chieftain or Pathfinder system from Smoke Signal Broadcasting, you can now have a tape-streamer backup as an option for your 5¼- or 8-inch Winchester hard-disk system. The tape streamer can store up to 20 megabytes on ¼-inch cartridge tape. With a tape streamer, computer systems can transfer up to 20 megabytes of data in less than five minutes at 90 inches per second. The Chieftain and Pathfinder systems also incorporate two means of backup with the streaming-tape drive: file-by-file or a complete backup with a single command. Drive-to-tape and tape-to-drive data transfers are provided.

The tape streamer is available as a standard option to any Chieftain or Pathfinder Winchester disk-drive system for $1500. Also available are tape-streamer options for Smoke Signal Broadcasting models 98W10, 98W30, and 98W15T20. Contact your local Smoke Signal dealer or Deborah Conrad, Smoke Signal Broadcasting, 31336 Via Colinas, Westlake Village, CA 91362, (213) 889-9340.
Circle 581 on inquiry card.

New Winchester Disk Series

The Pyxis Series of 5¼-inch Winchester disk drives range from 4 to 16 megabytes of unformatted storage capacity. The series is available in four models: the Model 4, a single-disk device with 4 megabytes of storage; the Model 8, a two-disk device with 8 megabytes; the Model 12, a three-disk device with 12 megabytes; and the Model 16, a four-disk device with 16 megabytes of unformatted storage. The Pyxis series interface, form factor, mounting, and power requirements are all compatible with 5¼-inch Winchester-technology industry standards.

In original equipment manufacturer quantities, the Pyxis series ranges in price from $740 (Model 4) to $1290 (Model 16). For details, contact Ampex Corp., Memory Products Division, 200 North Nash St., El Segundo, CA 90245, (213) 640-0150.

Circle 582 on inquiry card.

MISCELLANEOUS

New Products Clean Circuit Boards

Two new products from Texwipe can help keep your printed-circuit boards clean. The first, Gold-Wipes, provides a convenient method to clean and protect the gold fingers and other metallic surfaces on printed-circuit boards. Gold-Wipes are individually foil-wrapped pads that are presaturated with cleaning and lubricating agents. Use of Gold-Wipes can cut down on adhesion, brittle fracture, and abrasion problems. The second product, D-Flux, is a cleaning solvent and brush for dislodging stubborn fluxes from printed-circuit boards. D-Flux's applicator dispenses a controlled amount of solvent, while the brush scrubs off flux. It is designed for use on board repairs, assembly operations, and other environments that require flux removal.

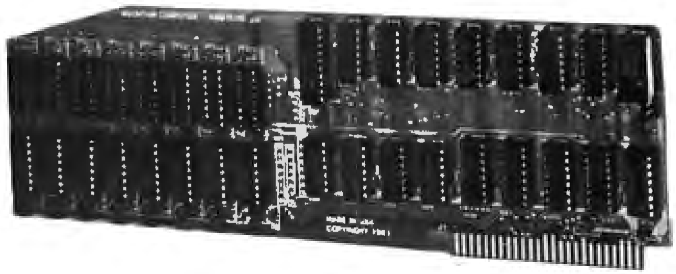
Both products are available directly from the manufacturer, Texwipe Co., Sales Office, POB 575, Upper Saddle River, NJ 07458, (201) 327-5577. Free samples and literature are available upon request.

Circle 583 on inquiry card.

Dynamic-Memory Board for S-100 Systems

Systems Group's new 128K-byte dynamic-memory board is fully compatible with most S-100-based microcomputer systems, including Alpha-Micro, North Star, and Dynabyte. The board has eight independent 16K-byte software-selectable memory banks, each addressable on any 16K-byte boundary. Other features include parity for single-bit error detection, 10 onboard diagnostic LEDs (light-emitting diodes), 4-MHz Z80 operation using transparent refresh, and full compliance with IEEE timing specifications with 20-megabyte extended addressing. The dynamic-memory board's power requirement is 8 watts maximum. Contact Systems Group, 1601 Orangewood Ave., Orange, CA 92668, (714) 633-4460.

Circle 584 on inquiry card.



Dual RAM Board for Apple II

RAMPlus+ is a new dual 16K-byte RAM (random-access read/write memory) card for the Apple II. Two banks of 16K-byte selectable RAM expand the Apple II to 80K bytes of available memory. The second bank of RAM is controlled by user-supplied software. Hardware and software selection of each 16K-byte bank of RAM is user-controlled. The card also supplies its own refresh circuitry.

RAMPlus+ can be installed in any slot on the Apple and does not require cables or the removal of integrated circuits from the Apple motherboard. When RAMPlus+ is in slot 0, it emulates the Apple Language Card. Multiple RAMPlus+ cards can be installed into the same Apple II.

RAMPlus+ is supplied with 16K bytes of installed RAM for $189. The additional 16K-byte plug-in RAM costs $24.95. RAM diagnostics on disk are included. For details, contact Mountain Computer Inc., 300 El Pueblo Rd., Scotts Valley, CA 95066, (408) 438-6650.

Circle 585 on inquiry card.

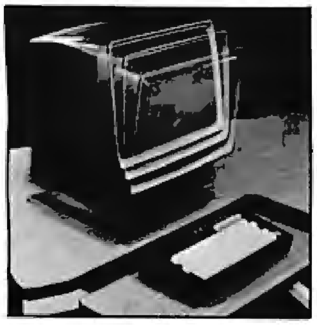
Erase-Only Memory

The Stanislowski Electronics 3131.3 is a 4K-byte, vigorous random-access erase-only memory (RAEOM) Imaginary Metal Oxide Semiconductor (IMOS) integrated circuit (IC). Packaged in a nonstandard 27-pin dual inline package (DIP), the 3131.3 RAEOMIMOSIC has six erasing modes for maximum versatility and is designed for all applications requiring an erase-only memory (EOM). Possible applications include disposing of obsolete data and programs, destroying incriminating evidence, and amusing computer hobbyists.

Due to the patented IMOS process, the 3131.3 remains fully functional even when power is removed, making it ideal for use during power blackouts.

The 3131.3 is priced at $0.59 (more or less) in OEM (optional ephemeral merchandise) quantities. Contact GIGO Enterprises, 70 Main St., St. Peter'sborough, NH 03458.

What's New?



Adjustable Video Monitor Platform

Structural Concepts' new portable, swiveling, tilting, sliding video-monitor platform helps make any desk or tabletop ergonomically safe. The platform tilts 20 degrees up or down from a horizontal position for glare reduction and operator comfort and can swivel a full 360 degrees for shared or angled usage. Additionally, it can slide up to 8 inches frontwards or backwards, which can help reduce eye strain.

The video-monitor platform is available in a variety of sizes for most video monitors. Mounting hardware is not required. Contact Structural Concepts Corp., 17237 Van Wagoner Rd., Spring Lake, MI 49465, (800) 253-5102; in Michigan, (616) 846-3300.

Circle 586 on inquiry card.

Memory Management for the TRS-80 Model III

The Compactors I and IV are the first products in a series of add-on units for Radio Shack's TRS-80 Model III from Hurricane Laboratories. The Compactor I allows the TRS-80 to run CP/M applications and utility programs without altering the TRS-80's operating environment. When installed in the Model III, you can elect to use CP/M version 2.2, TRSDOS, TRS-BASIC, or Hurricane Laboratories' Z80 Diagnostic Monitor, which is a CP/M programming tool.

The Compactor IV gives the TRS-80 Model III an 80-character by 24-line video-display screen and provides an RS-232C serial interface. The Compactor IV lets you use the Model III as a stand-alone computer or as an intelligent terminal to a larger host computer system.

The Compactors I and IV cost $450 and $475, respectively. Contact Hurricane Laboratories Inc., POB 631, Cupertino, CA 95015, (408) 446-0777.

Circle 587 on inquiry card.

Cables Feature Both Male and Female Connectors

Computer System Associates' RS-232C cable sets have both male and female DB-25 connectors attached at each end. This approach eliminates the problem of having the wrong connector for a terminal, video-display device, or computer. Stocking one type of cable will satisfy all data cable requirements. Prices begin at $50. Contact Computer System Associates, 7562 Trade St., San Diego, CA 92121, (714) 566-3911.

Circle 588 on inquiry card.

High-Capacity Memory Board for IBM Personal Computer

Datamac Computer Systems' new high-capacity memory expansion board for the IBM Personal Computer lets you easily upgrade to 544K bytes of memory. The expansion board can be configured in a variety of sizes from 64K bytes to 256K bytes—all with parity.

The 64K-byte board is available for $499. For further details, contact Robert Lindgren, Datamac Computer Systems, 680 Almanor Ave., Sunnyvale, CA 94086 (408) 735-0323.

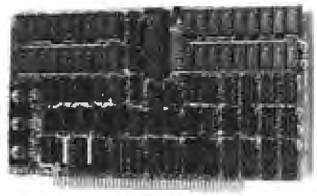
Circle 589 on inquiry card.

Radio Ratings Analysis

Recall is a software package that helps radio stations quickly organize and interpret data furnished by a major radio-station ratings service. Designed to be used with the Apple II microcomputer, Recall can analyze up to four radio stations or four rating books simultaneously. It displays full-color graphics and provides extensive printouts. Different sections of Recall can provide in-depth information on radio-audience flow dynamics, daypart recycling, and market positioning.

The Recall package costs $750, which includes a 100-page manual and support consultation. Contact Media Service Concepts, 1713 N. North Park Ave., Chicago, Il 60614, (312) 951-2680.

Circle 590 on inquiry card.



256K-Byte RAM for the S-100

The Superam 50 RAM (random-access read/write memory) board provides 256K bytes of RAM and is compatible with the IEEE-696 S-100 bus standard. The board can be configured for either bank-select or extended addressing. Bank-select offers 64K-byte banks for memory-protect applications, and each bank can be individually set to any 64K-byte block of the 256K-byte address space. Extended addressing allows memory placement at any 256K-byte boundary segment in a 16-megabyte address field. A parity bit feature that detects single-bit errors per byte is included with the Superam.

The Superam 50 is available in two speeds: the Superam 50-P with a 275-nanosecond maximum access time and the Superam 50-AP with a 225-nanosecond maximum access time. In original equipment manufacturer's quantities, the Superam 50-P costs $1300 and the 50-AP costs $1400. Contact Piiceon Inc., 2350 Bering Dr., San Jose, CA 95131, (408) 946-8030.

Circle 591 on inquiry card.

What's New?

Jon Swanson, staff drafting editor, irons out a few problems in his largest schematic.

Debugging Tool Irons Out Circuit Problems

The General Electric Model F340 Electric Iron serves as a handy debugging tool for crucial logic circuits that must exhibit planar topology or use especially thin-film substrates. Using the latest deionized-vapor-injection technology, the Model F340 can be used with circuits arrayed on fiber substrates up to 0.1 cm (approximately 1/8 inch) thick, assuming proper adjustments for duration of treatment.

Contact General Electric Company, Housewares and Audio Business Division, POB 5105Y, Hillside Station, Bridgeport, CT 06602.■

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

Ask BYTE

Conducted by Steve Ciarcia

VIA Experiment Board

Dear Steve,

I need an I/O (input/output) experiment board that I can plug directly into an Apple II Plus I/O slot. For my purposes, the board must use a Rockwell 6522 VIA (versatile interface adapter). Do you have a schematic diagram of such a board, or do you know of a company or a person that has made one?

Everest McDade
Arden, NC

This interface has generated a lot of discussion, going back to the November 20, 1977, EDN magazine article "EDN System Design Project." The biggest problem with the interface seems to be the "bogus" timing of the phase 2 signal on the Apple II bus. By running the phase 0 signal through two 4050 CMOS (complementary metal-oxide semiconductor) gates in series, the correct phase 0 timing can be achieved. (You can also try adding an 820-ohm resistor and a 56-picofarad capacitor because this will generate an additional 30-nanosecond delay, which should work as well.) The VIA's CS2 signal is then connected to the I/O select signal on the bus. This should solve your problem.

You may also be interested in Kenneth Ciszewski's article "Add a Peripheral Interface Adapter to Your Apple II" (January 1982 BYTE, page 324). . . . **Steve**

Bus Standard Stops Here

Dear Steve,

For several months, some manufacturers were claiming that their product was "compatible with the proposed IEEE S-100 bus standard." Recently I noticed that the wording has changed to ". . . conforms to the IEEE-696 S-100 Standard." From this I infer that the "proposed standard" is now a bona fide standard. Where can I get a copy?

Paul Frost
Beaverton, OR

EDN magazine recently featured an article on various bus standards, including the IEEE-696 S-100 bus standard. The article, "Compare μC-Bus Specs to Find the Bus You Need," by Carl Warren, (EDN, June 10, 1981, page 141), contained a complete definition of the S-100 bus.

For a copy of the standard, contact Howard Fullmer, Chairman IEEE-696 Committee, Parasitic Engineering, POB 6314, Albany, CA 94706, (415) 839-2636. . . . **Steve**

Totem Poles and TTL

Dear Steve,

I have a couple of questions about TTL (transistor-transistor logic). What is the difference between totem-pole and open-collector outputs? And what is an expandable gate? Many thanks!

M. A. M. Felt
Amsterdam, Netherlands

Totem-pole output on a TTL integrated circuit consists of two transistors essentially in series, one above the other (see figure 1). In the high output state, the top transistor conducts, so the output is greater than 2.4 volts (V). In the low output state, the bottom transistor conducts, so the output is less than 0.8 V.

During the transition between states, both transistors are conducting, and large current spikes are induced in the power supply. If not properly bypassed, these transient spikes may trigger other circuits. If a full 5 V are needed during the high state, a pull-up resistor can be used as shown in figure 2.

Open-collector output circuits replace the top transistor and diode of the totem pole with an external pull-up resistor (figure 3). These outputs can then be tied together as in a "wired-NOR" circuit or where an output high voltage greater than 5 V is desired. However, they are noisier and slower than totem-pole outputs.

Tying totem-pole outputs together usually means catastrophic results as each tries to pull the other high or low.

Expanders and gate expanders are TTL devices that allow the expansion of some logic functions. For example, they would be used if a 32-input AND gate were needed. They are not very popular today. . . . **Steve**

Figure 1

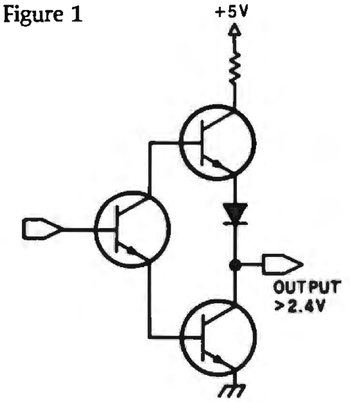


Figure 2

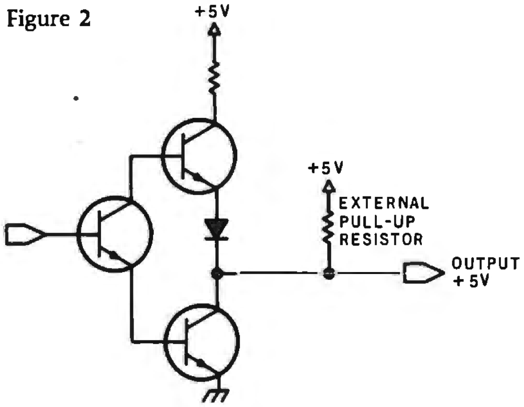
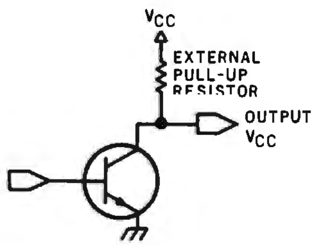


Figure 3



Controlling Heat and Surges

Dear Steve,

I have two problems that I don't believe you have covered. First, in the Tampa/St. Petersburg area, which suffers from power-line noise due to lightning, BSR X-10 control units are often triggered by line surges. It is not really a good idea to leave the X-10 energized during an extended absence. To come home and find the TV, radio, or lights on when they should be off is not too good. This problem probably has an electronic solution.

Second, the TRS-80 Model I is not really designed for 24-hour continuous operation insofar as heat is concerned. To be sure, you can take the two power supplies out of the Expansion Interface, but even that is probably not enough. This problem requires a hardware solution, which may be easy once the necessary ventilation is determined.

R. M. Sanford
Largo, FL

According to reports, BSR X-10 control modules have been tripped by power-line transients. I have not had this problem in my area, so I'm unable to experiment with a fix. A metal-oxide varistor (MOV) across each module would help because they would clip the voltage surge at approximately 130 volts. These units are made by General Electric and are available from major industrial parts suppliers.

You didn't mention whether you were having problems with your TRS-80 because of heat or whether it simply gets hot. The easiest way to cure heat problems is to use a fan for some forced ventilation. This also avoids having to open the box. Placing larger heat sinks on the power transistors will draw off even more heat, but unless the heat can be carried away, nothing is to be gained by this approach.

Small fans are available from many sources, including Radio Shack. Remember to keep the fan motor away from any magnetic media such as disks or tapes. . . . **Steve**

You Get What You Pay For

Dear Steve,

I have a Commodore VIC-20 computer and I would like to get more characters per line. If it is possible, how do I go about doing it? Do I have to add or replace any hardware?

Itshak Mihaeli
Brooklyn, NY

For less than $300, the VIC-20 represents a good value. In designing a computer for that price range, however, some compromises had to be made. One such compromise, as you know, is the screen-display format of 23 lines of 22 characters. The display is memory-mapped (i.e., a certain portion of memory is set aside solely for the screen), so modifying this requires changing both the hardware and the software. Even the VIC's 176 by 176 high-resolution option will not allow any more characters, although different shapes are available under software control.

A comparison of the VIC-20 with four other low-cost microcomputers appeared in the May 1981 BYTE (see page 46). The article, "The Commodore VIC-20 Microcomputer, A Low-Cost, High-Performance Consumer Computer," by Gregg Williams, featured a chart that showed the VIC-20 to be quite comparable to its competition. . . . **Steve**

Sweet Talker Interface

Dear Steve,

I'm interested in interfacing the Sweet Talker speech synthesizer to my Commodore 4032N computer. (See "Build an Unlimited-Vocabulary Speech Synthesizer," September 1981 BYTE, page 38.) Commodore has made a bunch of machines, but virtually all of them have the parallel user's port, also called the VIA (versatile interface adapter) port. The lower 12 pins on the edge connector go to a MOS Technology 6522 VIA and consist of two grounds, eight data lines, a CA1 (an input) handshake line, and a CB2 line (described as "a very powerful connection that has most of the abilities of CA1 but can also act as the input of the VIA shift register").

I know how to program any byte onto the data lines I want, but Commodore is silent about using these "handshake" lines. Can I use one line to sense when it's time to deliver the next phoneme code, and the other to strobe the Sweet Talker once the phoneme is present? Since Apple Computer already has the interface on one model, I'm hoping that a PET/CBM interface will be very similar. Is a ready-made, interfaced PET/CBM version forthcoming? If not, I'd appreciate any help on doing it myself.

Larry Hatch
Menlo Park, CA

The 6522 VIA used in the PET computer is very powerful and versatile; however, a great deal of explanation is required to fully use its features. I strongly suggest that you get a copy of the 6522 Data Sheets *and a* 6500 Series Hardware Manual *for a complete explanation as well as some applications. Both are available from MOS Technology Inc., 950 Rittenhouse Rd., Norristown, PA 19403, (800) 345-6386; in Pennsylvania, (215) 666-7950, ask for marketing.*

*Handshaking lines CA1 and CB2 can control the Sweet Talker, but the proper control word must be written into address location hexadecimal E84C, the peripheral control register. My "Circuit Cellar" article described the necessary programming for the Sweet Talker. This should solve your interface problem. . . .***Steve**

Variable Errors

Dear Steve,

I own an Apple II complete with disk drives, Language card, Silentype printer, Videx 80-column video-display card, and Microsoft Softcard with a Z80 microprocessor. I've tried a couple of your machine-language programs, and although I didn't understand them, they work beautifully. I wrote this simple BASIC program:

```
10 a= 2
20 A= 3
30 Q=a * A
40 Print Q
```

but I got a syntax error in line 10. In my engineering program, I must use lowercase variables.

H. J. Baerwolf
Inglewood, CA

Applesoft BASIC does not recognize lowercase variables, which is why you got the syntax error. The May 1980 Micro, The 6502/6809 Journal *has an article that should solve your problem. (Contact Micro Ink Inc., 34 Chelmsford Ave., POB 6502, Chelmsford, MA 01824, (617) 256-5515.) The program not only handles lowercase variables but it takes care of punctuation, too. . . .***Steve**

Strain-Gage Data Collection

Dear Steve,

I recently read your BYTE articles on the Z8-BASIC microcomputer. (See "Build a Z8-Based Control Computer with BASIC, Part 1," July 1981 BYTE, page 38; "Part 2," August 1981 BYTE, page 50.) My company is interested in using the Z8 in the field of strain-gage data collection. For this application, we would also need an A/D (analog-to-digital) converter of the type used in your second article. Where can we obtain additional information on the ADC0808 A/D converter shown in figure 2 (August 1981 BYTE, page 66)?

G. F. Fornaro
United States Pipe and Foundry Co.
Birmingham, AL

*The Z8-BASIC microcomputer is an excellent choice for strain-gage applications. The ADC0808 is available from National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051, (408) 737-5000. . . .***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, send your questions by electronic mail or 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.

A BASIC Program for Home Cryptography

Ralph Roberts
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The study of codes and cryptograms has always fascinated me, and it takes little imagination to see the power of the personal computer applied to this field. I used cryptographic devices during Army service in the late sixties but now find that my Smoke Signal Chieftain is capable of encoding and decoding at a level much greater than the military devices I once used. That's "clear text" to me.

I devised the program shown in listing 1 as a first experiment in computerized encrypting. Much elaboration is possible, but this program may provide a starting point for you as well. The program is written in Computerware's version 6.0 BASIC but should run in most standard BASICs with minimal changes. If you don't have a disk drive, use data statements or read in the text one line at a time.

Listing 1: *An encoding and decoding program in Computerware's version 6.0 BASIC. The POKE statement at line 10 changes the BASIC's delimiter character from a comma to an end-of-line character to improve handling of commas in text.*

```
*
0001 REM :::. ENCODING, DECODING PROGRAM :::
0002 REM ::: by Ralph Roberts ::::::::::::
0010 POKE( 210,13)
0020 STRING= 124:LINE=100:PRINT:PRINT
0030 PRINT TAB(25),"ENCODING PROGRAM":PRINT:PRINT
0040 INPUT "Password",P$:GOSUB 240
0050 INPUT "Encoding or Decoding (1 or 2)",I
0060 PRINT :IF I=1 INPUT"Name of file to be ENCODED",A$
0070 IF I=2 INPUT"Name of File to be DECODED",A$
0080 IF I=2 LET A=A*(-1)
0090 INPUT "Name of file to receive 'doctored' output",C$
0100 OPEN #1,A$:OPEN #2,C$
0110 READ #1,B$
0120 IF B$="" THEN 230
0130 FOR X=1 TO LEN(B$)
0140 LET B=ASC(MID$(B$,X,1))
0150 IF I=1 LET B=B+A:IF B>123 LET B=(B-123)+32
0160 IF I=2 LET B=B+A:IF B<32 LET B=(B+123)-32
0170 LET D$=D$+CHR$(B)
0180 NEXT X:IF I=1 LET A=A+1:IF A=124 LET A=1
0190 IF I=2 LET A=A-1:IF A=-124 LET A=-1
0200 PRINT :PRINT B$:PRINT D$
0210 WRITE #2,D$:D$="":B$=""
0220 GOTO 110
0230 POKE( 210,44):CLOSE #1:CLOSE #2:END
0240 LET P=LEN(P$)
0250 FOR X=1 TO LEN(P$)
0260 LET P1=P1+ASC(MID$(P$,X,1)):NEXT X
0270 LET A=INT(P1/P):IF A>123 PRINT"Sorry, PASSWORD phrase too big":RUN
0280 RETURN
```

For those of you who need a practical use for this program before reading further, I'll offer this example. If you work with a multiuser system, say in a college or high school, you could store your deep, dark secrets in a format that no one else could decode. Those of us who don't have deep, dark secrets encode just for the fun of it (or so we'd like you to think).

Writing of secrets, I do have one little trick to make this encoding program work more conveniently. In line 10 of listing 1, the POKE statement changes the delimiter character in my BASIC from a comma to an end-of-line (EOL) character. This allows the program to process an entire line in a text file, including commas. If your manual conceals the location of the delimiter character (as mine did), it's easy to concoct a four- or five-line PEEK,POKE routine that will find the location for you. Just successively change each comma in memory (decimal 44) to the EOL character (decimal 13). After each change,

Listing 2: *An encoding run of the encoding-decoding program shown in listing 1.*

```
                        ENCODING PROGRAM


Password ? THE RAIN IN SPAIN FALLS MAINLY ON THE PLAIN
Encoding or Decoding (1 or 2) ? 1

Name of file to be ENCODED ? SECRET.MSG
Name of file to receive 'doctored' output ? SECRET.X9

TO: CIA HEADQUARTERS -- LANGLEY, VIRGINIA   FROM: SECRET AGENT X9 1/2.
<7"c+1)c0-),9=):<-:,cppc4)6/4-Aoc>1:/161)ccc.:75"c;-+:-<c)/-6<c@!ctruq

SUBJECT: CLANDESTINE ENTRY INTO REPUBLIC OF MOLDAVIA
<>+3.,=#d,5*7-.<=27.d.7=,Bd27=8d;.9>+52,d8/d685-*?2*

        TO OBTAIN PLANS ON SECRET 'BOOM-BOOM' MISSLE.
eeeeeeeee>9e9,>+38e:6+8=e98e=/-</>el,997r,9971e73==6/s

     Hi guys. Having wonderful time in Moldavia. Am sending you all
fffff3TfR°d©tf3LaTYRfbZYOP]Q°Wf_TXPfTYf8ZWOLaTLtf,Xf©PYOTYRfdZ°fLWW

this via courier bat. Hope she got through.
°TU_gbUMgO[a©UQ©gNM°ug4[®Qg_TQgS[°g°T©[aSTu

     Went by the secret research facility on the outscirts of Moldavia City
hhhhhDR[ahOfhaURh°RP_Rah_R°RN_PUhSNPVYVafh®[haURh®ba°PV_a°h®Sh:®YQNcVNh0Vaf

and had no trouble buying the blueprints for the dreaded 'boom-boom'
O®RiVORi®]ib°]cPZSiPcgW®UibVSiPZcS©°W®baiT]°ibVSiR°SORSRipP]][vP]][p

missile. They had a concession stand out front selling that and other
®XbbX[TxjCWThjWPSjPjR©]RTbbX©]jbcP]Sj©dcjUa©]cjbT[[X]VjcWPcjP]Sj©cWTa

plans. I'll bring them back in my bootheel. Need anything else? (sgnd) X9 1/2.
°®Q©cyk9r®®kRbY©WkdXU]kRQS[kY©k]ikR__dXUU®yk>UUTkQ©idXY©WkU©cU/kscW©TtkH)k!z"y
```

Listing 3: *A printout of the encoded file produced by the program run shown in listing 2.*

```
<7"c+1)c0-),9=):<-:;cppc4)6/4-Aoc>1:/161)ccc.:75"c;-+:-<c)/-6<c@!ctruq
<>+3.,=#d,5*7-.<=27.d.7=;Bd27=8d;.9>+52,d8/d685-*?2*
eeeeeeeee>9e9,>+38e:6+8=e98e=/-</>e1,997r,9971e73==6/s
fffff3TfR°d©tf3LaTYRfbZYOP]Q°Wf_TXPfTYf8ZWOLaTLtf,Xf©PYOTYRfdZ°fLWW
°TU_gbUMgO[a©UQ©gNM°ug4[®Qg_TQgS[°g°T©[aSTu
hhhhhDR[ahOfhaURh°RP_Rah_R°RN_PUhSNPVYVafh®[haURh®ba°PV_a°h®Sh:©YQNcVNh0Vaf
O®RiVORi©]ib°]cPZSiPcgW®UibVSiPZcS©°W®baiT]°ibVSiR°SORSRipP]][vP]][p
®XbbX[TxjCWThjWPSjPjR©]RTbbX©]jbcP]Sj©dcjUa©]cjbT[[X]VjcWPcjP]Sj©cWTa
°®Q©cyk9r®®kRbY©WkdXU]kRQS[kY©k]ikR__dXUU®yk>UUTkQ©idXY©WkU®cU/kscW©TtkH)k!z"y
```

Listing 4: *A run of the encoding-decoding program, this time decoding the file shown in listing 3.*

```
                           ENCODING PROGRAM


Password ? THE RAIN IN SPAIN FALLS MAINLY ON THE PLAIN
Encoding or Decoding (1 or 2) ? 2

Name of File to be DECODED ? SECRET.X9
Name of file to receive 'doctored' output ? FRM.X9

<7"c+1)c0-),9=):<-:;cppc4)6/4-Λoc>l:/161)ccc.:75"c;-+:-<c)/-6<c@!ctruq
TO: CIA HEADQUARTERS -- LANGLEY, VIRGINIA   FROM: SECRET AGENT X9 1/2.

<>+3.,=#d,5*7-.<=27.d.7=,Bd27=8d;.9>+52,d8/d685-*?2*
SUBJECT: CLANDESTINE ENTRY INTO REPUBLIC OF MOLDAVIA

eeeeeeeee>9e9,>+38e:6+8=e98e=/-</>el,997r,997le73==6/s
         TO OBTAIN PLANS ON SECRET 'BOOM-BOOM' MISSLE.

fffff3TfR°d©tf3LaTYRfbZYOP]Q°Wf_TXPfTYf8ZWOLaTLtf,Xf©PYCTYRfdZ°fLWW
     Hi guys. Having wonderful time in Moldavia. Am sending you all

°TU_gbUMgO[a©UQ©gNM°ug4[®Qg_TQgS[°g°T©[aSTu
this via courier bat. Hope she got through.

hhhhhDR[ahOfhaURh°RP_Rah_R°RN_PUhSNPVYVafh®[haURh®ba°PV_a°h®Sh:®YQNcVNh0Vaf
     Went by the secret research facility on the outscirts of Moldavia City

O®RiVORi®]ib°]cPZSiPcgW©UibVSiPZcS©°W®baiT]°ibVSiR°SORSRipP]][vP]][p
and had no trouble buying the blueprints for the dreaded 'boom-boom'

®XbbX[TxjCWThjWPSjPjR©]RTbbX©]jbcP]Sj©dcjUa©]cjbT[[X]VjcWPcjP]Sj©cWTa
missile. They had a concession stand out front selling that and other

°®Q©cyk9r®®kRbY©WkdXU]kRQS[kY©k]ikR__dXUU©yk>UUTkQ©idXY©WkU®cU/kscW©TtkH)k!z"y
plans. I'll bring them back in my bootheel. Need anything else? (sgnd) X9 1/2.
```

try to read into a string variable a DATA statement consisting of two words separated by a comma. When both words and the comma read in, you've found the location.

Another approach is to use more string variables, creating a new one each time a comma is encountered. Three or four variables would probably suffice, but occasionally you'll lose a space that falls at the front of the next string variable. It's better to find that delimiter character.

Aside from the way it handles commas, this program is really pretty simple—but the code it generates is not. The encryption begins as a simple offset. The program first reads your password (or passphrase) and sums the ASCII values of all the letters and spaces. To obtain the offset, the program divides the sum by the number of letters and spaces in the password. With an offset of 63, for example, every letter is printed 63 characters higher than it actually is (with a wrap-around feature to maintain the desired ASCII range of 32 to 123 and an upward shift of one so no space will be printed). In each succeeding line, the offset is increased by one. This prevents anyone from breaking your code by analyzing frequency of character appearance. Every single letter and space is represented by a *different* character in every line.

For spies, my encoding-decoding program comes in handy almost daily. Listing 2, for example, reveals how I ran the program to encode a message during my last CIA mission behind the Iron Curtain. Listing 3 is the printout of the encoded file I sent to Langley, and listing 4 shows a program run that decoded the same file. Decoding is merely the reverse of the encoding operation, but you must give the password.

With this program and a portable computer like the Osborne 1, you too can be a spy. Go forth, my fellow agents, and have secrets from one another! ■

Software Received

Apple

Adenoids, a medical adventure game for the Apple II. Floppy disk, $29.95. Lymphatic Software, 12 Sinus Way, Psychosomatic, NH 03458.

Amperdump, a high-resolution graphics dump utility program using the Epson MX-80 or -100 printer for the Apple II Plus. Floppy disk, $30. Madwest Software, POB 9822, Madison, WI 53715.

Ampergraph, a graphics utility package to generate plots and graphs for the Apple II. Floppy disk, $30. Madwest Software (see address above).

Antfarm, a language system for teaching programming to children for the Apple II. Floppy disk, $49.95. WIMS Computer Consulting, 6723 East 66th Pl., Tulsa, OK 74133.

Bug Attack, an arcade-type game for the Apple II. Floppy disk, $29.95. Cavalier Computer, POB 2032, Del Mar, CA 92014.

David's Midnight Magic, a high-resolution pinball game for the Apple II. Floppy disk, $34.95. Broderbund Software Inc., 1938 Fourth St., San Rafael, CA 94901.

Hi-Res Secrets, a graphics development package for the Apple II. Floppy disks, $125. Avant-Garde Creations, POB 30160, Eugene, OR 97403.

High-Res Mastertype, a typing instruction game for the Apple II. Floppy disk, $39.95. Lightning Software, POB 11725, Palo Alto, CA 94306.

The Manipulator, a text file utility system for the Apple II. Floppy disk, $34.95. Pear Software, 407 Terrace, Ashland, OR 97520.

Menu Generator, a menu-development software system for the Apple II Plus. Floppy disks, $39.95. Crane Software Inc., Suite 611, 16835 Algonquin, Huntington Beach, CA 92649.

Nutrichec 2.0, a diet and physical activity analysis program for the Apple II Plus. Floppy disk, $59.95. WIMS Computer Consulting (see address above).

Personal Tax Plan, an income tax planning package for the Apple II and the Western Digital Microengine. Floppy disk, $130. Aardvark Software Inc., 783 North Water St., Milwaukee, WI 53202.

Stone of Sisyphus, an adventure game for the Apple II Plus. Floppy disks, $29.95. Adventure International, POB 3435, Longwood, FL 32750.

Ultra Plot, a plotting utility program to create charts and graphs for the Apple II. Floppy disks, $70. Avant-Garde Creations (see address above).

Versaform, a business forms processing package in Pascal for the Apple II. Floppy disk, $389. Applied Software Technology, 15985 Greenwood Rd., Monte Sereno, CA 95030.

CP/M

Ddump 1.6, a sector-oriented disk dump utility program for CP/M. 8-inch floppy disk, $29.95. Elektrokonsult Inc., Konnerudgt. 3, N-3000 Drammen, Norway.

Dtest 1.7, a disk- and disk drive-testing program for CP/M. 8-inch floppy disk, $29.95. Elektrokonsult Inc. (see address above).

The Formula, a multifunctioned, business-oriented data-processing system for CP/M. 8-inch floppy disk, $595. Dynamic Microprocessor Associates, 545 Fifth Ave., New York, NY 10017.

PET

RPL Language, a compiled language system for the PET-2001. Cassette, $71.91; floppy disk $80.91. Samurai Software, POB 2902, Pompano Beach, FL 33062.

Vigil, an interactive graphics and game development system for the VIC-20. Cassette, $35. Abacus Software, POB 7211, Grand Rapids, MI 49510.

TRS-80

ColorFORTH, a FORTH language system for the TRS-80 Color Computer. Cassette, $49.95. Armadillo Software, POB 7661, Austin, TX 78712.

Do-It-Yourself Adventure Kit, an adventure game development program for the TRS-80 Models I and III. Floppy disk, $29.95. Suburban Software Co., R.D. #1, Box 74A, Spring Mills, PA 16875.

Hexspell 2, an extended spelling checker for the TRS-80 Models I and III. Floppy disk, $99. Hexagon Systems, POB 397, Station A, Vancouver, British Columbia V6C 2N2, Canada.

Imperial Arena, a Star Trek-type game for the TRS-80 Model I. Cassette or floppy disk, $15. Richard Bissonnette, POB 476, Amherst, MA 01004.

Linear Programming System, a system to solve linear programming problems for the TRS-80 Model I. Cassette, $9.89. Computer Heroes, 1961 Dunn Rd., East Liverpool, OH 43920.

Macro-Assembler 4004, an emulation of the 4004 microprocessor for the TRS-80 Models I, II, III, IV, etc. Hard disk, $1.95. MacaroonSoft, 45 The Way of All Flesh, Spittingboro, NH 03458.

Newtrieve, an indexing and data-retrieval program for the TRS-80 Models I and III. Floppy disk, $49.95. Unique Printing and Stationery Co., 11 Maiden Ln., New York, NY 10038.

Refware Thesaurus: Builder 1.0, a specialized thesaurus development program for the TRS-80 Model III. Floppy disk, $149.95. Refware, POB 451, Chappaqua, NY 10514.

Silly Syntax, a story creation game for the TRS-80 Color Computer. Cassette, $19.95. Sugar Software, 2153 Leah Ln., Reynoldsburg, OH 43068.

Stone of Sisyphus, an adventure game for the TRS-80 Models I and III. Floppy disks, $29.95. Adventure International, POB 3435, Longwood, FL 32750.

Other Computers

Fifth, a language system for the Atari 400/800. 25 ozs., $7.95. fig-Fork Software Inc., Frodo Alley, Fraternity, NH 03458.

Match/Bowl, two arcade-type games for the Bally Arcade. Cassette, $12.95. Edge, 12046 Flambeau Dr., Palos Heights, IL 60463. ■

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

Base Conversion on the TRS-80 Pocket Computer

David M. Dolan
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Base conversion, indispensable to the programmer, has been a favorite subject for programs since the earliest issues of microcomputer magazines. But because the need for converting numbers from one base to another usually arises while the computer is tied up developing a program, it is impractical to load and use a base-conversion program at the same time. Until Tandy began selling its TRS-80 Pocket Computer, the only other choice was the Texas Instruments Programmer calculator.

Base conversion at first appeared to be a natural for the Pocket Computer (PC). A second glance, however, revealed some obstacles. PC BASIC lacks two functions used extensively in previous base-conversion programs: string-manipulation and the ASC function, which returns the ASCII (American Standard Code for Information Interchange) code for string argument. Could I make a limited BASIC perform like an extended BASIC? It was a challenge I couldn't resist.

The program that met the challenge is shown in listing 1. It will convert any binary, octal, decimal, or hexadecimal number (up to decimal 65535) to its binary, octal, decimal, or hexadecimal equivalent. This represents an improvement over the TI Programmer calculator, which can't handle binary numbers.

The only concession I had to make to the limitations of PC BASIC is this: each digit of a number must be entered separately and followed by Enter. You designate the end of a number by entering a space (SPC), followed by Enter. The program then asks for the base of the number to be converted; you enter 2, 8, 10, or 16. In the same way, the program asks the base to which the number is to be converted. That's all there is to it.

Unfortunately, the Pocket Computer doesn't perform conversions as fast as a larger microcomputer or the TI Programmer. This PC BASIC program takes 15 seconds to change decimal 255 to hexadecimal FF, and 45 seconds to change binary 11111111 11111111 to hexadecimal FFFF. I tried various ways to make the program run faster. Some of them saved memory, but all ran slower. Perhaps you can do better.

Beware of trying to translate this program into other dialects of BASIC. The program takes advantage of some of PC BASIC's peculiarities. Line 500, for instance, makes use of the fact that the string A$ is the same as A$(1), B$ is the same as A$(2), etc.

The sample run of the program is shown in listing 2 on page 438. To produce the printout, I translated the program to run on the TRS-80 Model II. The printout is similar to what you will find on the Pocket Computer. I produced the program listing itself (listing 1) by copying the debugged program by hand directly from the Pocket Computer to a Radio Shack Model II. Although not as reliable as a listing from a running program, this listing was the best one possible at the time. (Since then, Tandy has released a printer for the Pocket Computer.)

If, like me, you're a gadgeteer as well as a computer nut, you may have been looking for an excuse to buy one of the new pocket computers. This base-conversion program may give you that excuse. Depending on your needs, the base-conversion program might justify more than half the price of the new gadget.■

Listing 1: *A program for converting numbers from one base to another. Designed to run on the TRS-80 Pocket Computer, the program can convert a binary, octal, decimal, or hexadecimal number to its equivalent in the other three bases.*

```
10 PAUSE"BASE CONVERSION"
20 PAUSE"ENTER DIGITS SEPARATELY":PAUSE"PRESS ENTER AFTER EACH"
30 CLEAR:FORU=26TO41:INPUT"DIGIT (SPC TO EXIT):";A$(U)
40 IFA$(U)=" "LETU=U-1:GOTO60
50 NEXTU
60 INPUT"BASE OF #(2,8,10,16):";Q
70 INPUT"CONVERT TO(2,8,10,16):";R
80 V=0:W=0
90 FORT=UTO26STEP-1:GOSUBA$(T)
100 IFA(T)>QBEEP1:PAUSE"INVALID INPUT":GOTO30
120 V=V+INT(A(T)*Q^W+.5):W=W+1
130 NEXTT:GOTO300
140 "0":A(T)=0:RETURN
150 "1":A(T)=1:RETURN
160 "2":A(T)=2:RETURN
170 "3":A(T)=3:RETURN
180 "4":A(T)=4:RETURN
190 "5":A(T)=5:RETURN
200 "6":A(T)=6:RETURN
210 "7":A(T)=7:RETURN
220 "8":A(T)=8:RETURN
230 "9":A(T)=9:RETURN
240 "A":A(T)=10:RETURN
250 "B":A(T)=11:RETURN
260 "C":A(T)=12:RETURN
270 "D":A(T)=13:RETURN
280 "E":A(T)=14:RETURN
290 "F":A(T)=15:RETURN
300 A$(26)="0":A$(27)="1":A$(28)="2":A$(29)="3":A$(30)="4":A$(31)="5"
310 A$(32)="6":A$(33)="7":A$(34)="8":A$(35)="9":A$(36)="A"
320 A$(37)="B":A$(38)="C":A$(39)="D":A$(40)="E":A$(41)="F"
350 IFR=16GOSUB400:S$="HEX: ":GOSUB500:GOTO30
360 IFR=10GOSUB400:S$="DEC: ":GOSUB500:GOTO30
370 IFR=8GOSUB400:S$="OCTAL: ":GOSUB500:GOTO30
380 IFR=2GOSUB400:S$="BINARY:":GOSUB500:GOTO30
400 Y=V:W=INT(LOGV/LOGR+.000001):U=1
410 FORT=WTO0STEP-1:X=INT(R^T+.5):Q=INT(Y/X)
420 A$(U)=A$(Q+26):U=U+1:Y=INT(Y-Q*X+.5)
430 NEXTT:RETURN
500 PRINTS$;" ";A$;B$;C$;D$;E$;F$;G$;H$;I$;J$;K$;L$;M$;N$;O$;P$:RETURN
```

Listing 2: *A sample run of the base-conversion program in listing 1. Note that after entering each digit of a number, the user must press Enter. The user marks a digit as the number's last by pressing SPC (space) and then Enter.*

```
Ready
>RUN
BASE CONVERSION

ENTER DIGITS SEPARATELY
DIGIT (SPC TC EXIT):? F
DIGIT (SPC TO EXIT):? C
DIGIT (SPC TO EXIT):? 7
DIGIT (SPC TC EXIT):? E
DIGIT (SPC TO EXIT):?
BASE OF # (2,8,10,16):? 16
CONVERT TO(2,8,10,16):? 2
BINARY  111111000111110

ENTER DIGITS SEPARATELY
DIGIT (SPC TO EXIT):? 3
DIGIT (SPC TO EXIT):? 2
DIGIT (SPC TO EXIT) :? 7
DIGIT (SPC TO EXIT):? 2
DIGIT (SPC TO EXIT):? 5
DIGIT (SPC TO EXIT):?
BASE OF # (2,8,10,16):? 10
CONVERT TO(2,8,10,16):? 16
HEX  7FD5

ENTER DIGITS SEPARATELY
DIGIT (SPC TO EXIT) :? 3
DIGIT (SPC TC EXIT):? 5
DIGIT (SPC TO EXIT):? 7
DIGIT (SPC TO EXIT):?
BASE OF # (2,8,10,16):? 8
CONVERT TO(2,8,10,16):? 16
HEX  EF

ENTER DIGITS SEPARATELY
DIGIT (SPC TO EXIT):?
```

Career Opportunities in Computing

Jacqueline Johnston
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Las Cruces, NM 88001

Rare is the computer hobbyist who has not considered entering the computer field professionally. Just entertaining the thought, however, raises several questions that are difficult to answer. Is there a demand for computer programmers? Is hobby experience of any value in landing a job?

The answer to both questions is "yes." Hobby-level interest in computers can lead to a rewarding and stimulating career as a computer professional. There is an urgent need for qualified programmers and analysts in all sectors of commerce and industry.

Granted, there are differences between home computing and the world of business and industry, but these differences should not deter you from seeking a career in a field you enjoy. In this article we will examine what the computer programmer does in the "real world," what the requirements are in terms of education and experience, where jobs can be found, and what to expect for the general pay scale. The emphasis will be on programmers, but the information is also applicable to related jobs.

About the Author
Jacqueline Johnston, a former guidance counselor, is now a computer programmer with the Business Data Systems Office, White Sands Missile Range. The opinions expressed here are her own and not necessarily those of the White Sands Missile Range or the U.S. Government.

Computer programming is a dynamic career field, and a semiannual survey of 500 companies by *Fortune* magazine shows that programming is virtually recession-proof. The demand for programmers is expected to increase more rapidly than the average demand in other fields, and the trend will continue through the mid-1980s as computer usage expands in business and research. Newspapers and magazines are filled with advertisements for programmers and analysts. In my job as a guidance counselor, I receive countless inquiries from companies searching for computer programmers.

Programming is an attractive field from the standpoint of both salary and working conditions. College placement offices report that computer-oriented graduates receive salary offers of approximately $1691 per month. In a recent poll I conducted of 150 companies hiring programmers, the average entry-level salary was $1665 per month. Experienced programmers can expect higher salaries, ranging up to $50,000 a year.

How to Choose

Programmer—mathematician—computer scientist—engineer. They all sound interesting, but which one is for you? Let's take a look at the work that each entails.

An *engineer* should have a bachelor's degree (often a master's is required) in one or more of the engineering fields: civil, electrical, mechanical, etc. Engineering positions generally involve design work—designing roads, machinery, buildings, or computers. These positions require a solid background in mathematics and some familiarity with computers and programming, as many solutions to engineering problems are arrived at through the use of preexisting or "canned" computer programs. If you are interested in design, an engineering career might be the thing for you. If you prefer programming and hands-on computer work, another field might be more to your liking.

The position of *computer scientist* evolved about ten years ago, so it is relatively new. A bachelor's degree in computer science is needed, and some positions require a master's degree. The educational background is broad in scope, and it includes the study of mathematics, computer hardware, computer operations, systems programming, compiler and assembler design, and high-level languages. Consequently, computer scientists tend to have broad responsibilities in software design and computer-center management.

Mathematicians should have a minimum of a bachelor's degree in mathematics, and usually a minor or a second degree in physics or engineering. These positions involve the development of mathematical solutions to complex problems and the translation of the solutions into efficient computer programs. The work provides an excellent mix of mathematical and programming duties.

Computer programmer positions do not usually require a college degree, but applicable experience is required (and a degree in math, accounting, business administration, computer science, physics, or engineering is a definite asset). Computer programmers do a lot of what they like best—write programs. This may include systems and applications programs. On projects that require analytical solutions involving higher mathematics or engineering principles, an engineer or mathematician will usually perform that part of the job and then turn the project over to the programmer for completion.

Programming Jobs

Broadly speaking, programming can be divided into two principal areas: systems programming and applications programming. Although there is considerable crossover between the two, systems programming involves logical operations, while applications programming involves mathematical and process control operations.

Systems programmers frequently employ complex logical operations and concepts to develop executive control programs, monitors, assemblers, compilers, device utilities, and so forth. Most of their work is done in assembly or machine language and seldom requires the use of mathematics beyond algebra. Notable exceptions are certain system-design processes that require a knowledge of statistics.

Applications programming is a diverse field that can be broken into three broad subfields: scientific, business, and process control. There are many types of jobs within each of the subdivisions; consequently, we will speak only in general terms. Applications programmers must have a strong background in mathematics. Especially important to scientific programmers are algebra, trigonometry, and calculus. The mathematics of finance is essential to business programmers.

Scientific programmers work on problems in all sectors of science and industry, from spaceflight planning to computer design, and from bridge building to chemical analysis. Most scientific programs are written in high-level languages, with FORTRAN and PL/I being the most common.

Business programmers work on financial applications, but there are many other projects such as inventory control and network analysis that fall within the business realm. Business programs are written in high-level languages, such as COBOL, RPG, and FORTRAN.

Process control refers to the use of a computer to monitor data from and transmit commands to external equipment in real time. Applications programmers in this area generally have some familiarity with the hardware of both the computer and the external equipment. Programs for these functions are usually written in assembly language or a high-level language such as FORTRAN, or a combination of the two.

Figure 1: *The plus signs on this map indicate locations of cities where programmer jobs were advertised during a recent one-week survey period. About 210 cities, representing more than 1100 programmer job openings, are illustrated.*

Geographic Distribution

Who has job openings for programmers? Manufacturers, banks, chemical companies, department stores, research firms, fast-food chains, petroleum companies, government agencies, and any scientific or commercial activity you can think of. Where are the jobs located? Everywhere.

Figure 1 is a computer-generated map that shows the locations of cities where job openings for programmers existed during a recent one-week survey period. (This, incidentally, is just one of several uses for the microcomputer in counseling job seekers.) A plus sign is drawn at the location of every city where there were one or more programmer jobs during the survey period.

Since only one plus sign is drawn for any city, regardless of the number of jobs available, there are many more jobs than plus signs. This particular map illustrates jobs in about 210 cities; the total number of jobs was more than 1100. The majority of jobs are concentrated in and around certain large population centers, as is readily apparent on the map. Note especially the concentration of plus signs near San Francisco, Los Angeles, Phoenix, Denver, Dallas, Houston, Chicago, New York City, Washington DC, and Miami.

Requirements

So computer programming sounds like an attractive career field? What are the requirements for entry? Most companies prefer that applicants have a bachelor's degree. Scientific and engineering organizations prefer degrees in computer science, mathematics, engineering, or the physical sciences. Organizations with business applications prefer applicants with coursework in computer science, accounting, and business administration. Of course, some workers with applicable experience in programming may be able to secure a position without a college degree. Good verbal and written-communications skills are always an asset. Normally companies prefer basic familiarity with one or more computer languages.

To keep track of the programming languages that are in demand, I perform a weekly survey of the languages required to qualify for jobs advertised during each survey week. In order to make the data available to my clients in a meaningful form, I use a microcomputer to generate a bar chart of the survey results. The chart created for a recent typical period is illustrated in figure 2. Survey figures are entered by means of the keyboard of a video terminal and the chart itself is printed on a line printer. For the sake of simplicity, the program is written in BASIC (see listing 1). It is brief and straightforward. The only change you might need to make is in the syntax of the PRINT #2 statements that send output to the line printer. (Not all versions of BASIC use this syntax.)

Returning to the bar chart, it's strikingly clear that during the particular survey period illustrated, knowledge of COBOL was required for more jobs than any other language, followed by FORTRAN,

```
                                        LANGUAGES REQUIRED FOR JOB OPENINGS
                                        ADVERTISED DURING WEEK OF 11 MAY 81


     ALGOL  ** 1.9 %

       APL  * .9 %

     BASIC  **** 3.8 %

     COBOL  ******************************************************************** 67.9 %

   FORTRAN  ************************* 25.2 %

    PASCAL  ******* 6.7 %

      PL/1  ************** 13.5 %

       RPG  ******************* 19.4 %

ALL OTHERS  *************** 14.5 %



ASSEMBLERS  ************************************* 36.8 %

            +----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
            0         10        20        30        40        50        60        70        80        90       100
                                    PERCENTAGE OF JOB OPENINGS REQUIRING EACH LANGUAGE
```

Figure 2: *Bar chart showing which programming languages are required to qualify for jobs advertised. Totals exceed 100 percent because many jobs require knowledge of more than one language.*

Listing 1: *BASIC listing of the bar-chart program, which is useful for anyone who wants to keep tabs on programming-language requirements for jobs.*

```
1000 REM    THIS PROGRAM GENERATES A BAR CHART ILLUSTRATING THE PERCENTAGE
1020 REM    OF JOB OPENINGS REQUIRING KNOWLEDGE OF EACH OF THE VARIOUS
1040 REM    PROGRAMMING LANGUAGES.  THE CHART IS BASED ON STATISTICAL
1060 REM    DATA SOLICITED FROM THE USER.
1080 REM
1090 DIM L$(10),N(10)
1100 DATA "     ALGOL","       APL","     BASIC","     COBOL"
1200 DATA "   FORTRAN","    PASCAL","      PL/1","       RPG"
1300 DATA "ALL OTHERS","ASSEMBLERS"
1340 REM
1350 REM    FILE #2 IS THE LINE PRINTER.
1360 REM
1400 OPEN "LP:" FOR OUTPUT AS FILE #2
1500 FOR I=1 TO 10
1600 PRINT #2:
1700 NEXT I
1800 PRINT "SURVEY CONDUCTED FOR WEEK BEGINNING WHEN?"
1900 INPUT W$
1920 REM
1940 REM    FOR EACH OF THE TEN LANGUAGES, READ THE LANGUAGE NAME FROM
1950 REM    THE DATA STATEMENTS AND REQUEST THE NUMBER OF JOBS REQUIRING
1960 REM    THAT LANGUAGE.
1970 REM
2000 FOR I=1 TO 10
2100 READ L$(I)
2200 PRINT "NUMBER OF JOBS REQUIRING ";L$(I);"?"
2300 INPUT N(I)
2400 NEXT I
2500 PRINT "TOTAL NUMBER OF JOBS SURVEYED?"
2600 INPUT T
2640 REM
2650 REM    THE STATEMENTS FROM HERE THROUGH LINE 6000 PRINT OUT THE.
2660 REM    CHART.
2670 REM
2700 PRINT #2:TAB(45);"LANGUAGES REQUIRED FOR JOB OPENINGS"
2800 PRINT #2:TAB(45);"ADVERTISED DURING WEEK OF ";W$
2900 PRINT #2:
3000 PRINT #2:
3100 PRINT #2:
3200 FOR I=1 TO 10
3400 IF I<>10 THEN 4000
3500 PRINT #2:
3600 PRINT #2:
3700 PRINT #2:
3800 PRINT #2:
```

Listing 1 continued on page 443

RPG, and PL/I. Additionally, about a third of all jobs required familiarity with assembly language (though not necessarily for a specific processor). The figures vary somewhat from week to week, but COBOL has been in demand by users of large computers for the past several years and it will probably remain in that position for some time. The rankings of FORTRAN, RPG, and PL/I as they appear on this chart are also fairly representative of their recent and projected demand. Not shown, but of special interest to many applicants, is the fact that almost 20 percent of the jobs surveyed during the period required knowledge of database-management systems. The totals exceed 100 percent because many jobs require knowledge of more than one language.

Civil Service Employment

In addition to openings in the private sector, the federal government offers opportunities to persons with college training or experience in computer programming. Due to the recent cutbacks in hiring, the outlook is not as bright as it is in the private sector, but good opportunities still

Listing 1 continued:

```
3900 PRINT #2:
3940 REM
3950 REM    COMPUTE THE PERCENTAGE AND ROUND IT OFF TO ONE DECIMAL PLACE.
3960 REM
4000 P=INT(1000*(N(I)/T))/10
4010 IF P<=100 THEN 4100
4020 P=100
4040 REM
4050 REM    COMPUTE THE NUMBER OF ASTERISKS TO BE PRINTED.
4060 REM
4100 J=INT(P+.5)
4200 PRINT #2:
4240 REM
4250 REM    PRINT OUT THE LANGUAGE NAME.
4260 REM
4300 PRINT #2:L$(I);"   ";
4400 IF J=0 THEN 4800
4430 REM
4440 REM    PRINT OUT A ROW OF ASTERISKS, THE NUMBER OF WHICH CORRESPONDS
4450 REM    TO THE PERCENTAGE OF JOBS REQUIRING THE LANGUAGE.
4460 REM
4500 FOR K=1 TO J
4600 PRINT #2:"*";
4700 NEXT K
4740 REM
4750 REM    PRINT OUT THE PERCENTAGE AT THE END OF THE LINE OF ASTERISKS.
4760 REM
4800 PRINT #2:P;"%"
4900 NEXT I
5000 PRINT #2:
5020 PRINT #2:
5040 REM
5050 REM    THE STATEMENTS FROM HERE THROUGH LINE 5500 PRINT OUT A
5060 REM    NUMERICAL SCALE AT THE BOTTOM OF THE CHART.
5070 REM
5110 PRINT #2:TAB(11);"+";
5120 FOR I=1 TO 20
5130 PRINT #2:"----+";
5140 NEXT I
5150 PRINT #2:
5300 FOR I=0 TO 100 STEP 10
5400 PRINT #2:TAB(I+10);I;
5500 NEXT I
5600 PRINT #2:
5700 PRINT #2:TAB(37);"PERCENTAGE OF JOB OPENINGS REQUIRING EACH LANGUAGE"
5800 FOR I=1 TO 10
5900 PRINT #2:
6000 NEXT I
6100 STOP
6200 END
```

exist, especially in Washington DC. Government employment is attractive from several standpoints and it offers good benefits in the areas of leave and retirement.

Persons doing computer programming work are usually hired as mathematicians, computer programmers, or computer scientists. Entry-level salaries for these positions range from $12,266 to $15,193 per year.

There are also various trainee positions, a number of which are filled through PACE (Professional and Administrative Career Examination), a written test. Veterans who served between August 5, 1964, and May 7, 1975, may be eligible for a VRA (Veterans Readjustment Appointment). These positions offer training programs, and the veteran need not participate in regular competitive procedures, although he or she must meet the position's minimum requirements.

For more information on jobs with the federal government, contact your local Federal Job Information Center, or call (800) 555-1212 to request a toll-free number.

Going to School

If you are interested in attending college to study computer programming, there are several publications that will help you locate schools offering suitable programs. Some of the most useful books are: *Lovejoy's College Guide*, *Chronicle Guide to Four-Year College Majors*, and *The College Blue Book* (four volumes). These are available at most public libraries, and they list colleges with programs in computer science and mathematics, offer brief descriptions of the colleges, and list tuition, admission requirements, etc.

College credits may also be earned through work experience and independent study. Credits for this knowledge can be awarded through CLEP (College-Level Examination Program) and the ACT (American College Testing) Proficiency Examination Program. For information on costs and registration procedures, write to CLEP and ACT for their pamphlets (see the text box "Free Information," on page 446).

Those eligible for veterans' benefits can receive monthly payments from the VA (Veterans Administration) while attending school. A full-time student with no dependents receives $342 per month, tax free, for forty-five months ($15,390 total). Individuals with dependents receive correspondingly larger payments. A veteran with two dependents, for example, receives a total of $20,880. For more information on VA benefits, contact the VA Regional Office closest to you or the veterans' representative at the college you wish to attend, or call (800) 555-1212 to obtain a toll-free number. Remember, eligibility for veterans' benefits terminates ten years after separation from the service or on December 31, 1989, whichever comes first.

Getting the Job

If you are qualified for entry into the computer programming field, there are several steps that must be taken to secure a position. First, you must prepare an effective resume. Generally, an applicant can prepare a resume without paying a commercial resume writer. If you write it yourself, you will be better prepared to discuss your qualifications during the interview. The resume should be short—never more than two pages, and preferably not more than one. Most resumes are read in ten to fifteen seconds, so the information should be clear and easy to read. The purpose of the resume is to obtain an interview for the applicant. The applicant will usually have to fill out an application form if the firm is interested.

When the re^{s}ume is sent out, a cover letter should accompany it. The letter should be typed, never photocopied or mimeographed, and personalized to the firm receiving it. Addresses of firms hiring computer programmers can be obtained from *The College Placement Annual*, *Ad Search* (a weekly newspaper with employment ads from all over the country), *Career Opportunity Update*, local newspapers, and industry publications such as *ComputerWorld*, *Datamation*, *Electronics*, and *Electronic News*. A new publication, *Peterson's Annual Guide to Careers and Employment for Engineers, Computer Scientists, and Physical Scientists*, lists companies seeking graduates in these fields. (It is available for $13.25, postage paid, from Peterson's Guides Book Order Dept., POB 978, Edison, NJ 08817.)

Free employment counseling and placement services are available at state Job Service offices. There are more than 2400 local offices of the federal-state employment-service system, staffed with professionals who can help with career planning and finding a job. The Employment Service operates a computerized Job Bank system in virtually every state. These Job Banks comprise the largest, most comprehensive and up-to-date source of job openings in the nation. The listings are available on microfiche at your local state-employment service office.

A number of private employment agencies specialize in finding jobs for individuals with technical skills, and bill the client companies, rather than the job seeker, for their services. Although most of these firms are reputable, you should be cautious and read all the fine print before signing a contract.

One of the final steps in the job-hunting process is the job interview. There are many publications and books that offer advice on how to prepare for an efffective interview. It's important to learn as much as possible about the company before the interview, to make a presentable appearance, and to speak with confidence and enthusiasm.

It is a fact of life that choice jobs do not always go to the best-qualified applicant, but to the person who has the best job-hunting skills. The importance of resume preparation and interview technique cannot be overemphasized.

Summary

The transition from computer hobbyist to professional can be rewarding in terms of both personal satisfaction and salary. The employment outlook for computer-related jobs is excellent. In the *1981 College Placement Annual* more than 650 companies and government agencies advertised for computer programmers, and that number is expected to increase. A variety of corporations are represented, from banks to large-scale manufacturing companies. Jobs are available in most locations in the U.S., with the greatest demand in large metropolitan areas.

There are many jobs that involve programming—programmer, mathematician, computer scientist, and engineer. We have looked at the job duties and some of the entrance requirements for these positions. Some require a bachelor's degree and knowledge of one or more programming languages, particularly COBOL and FORTRAN. Those interested in attending college to become proficient in programming have many options to choose from, as an increasing number of schools offer suitable programs. Once you are qualified, it is imperative that you develop your job-hunting skills so that you can pursue the career of your choice. ■

Free Information

1981 Computer Salary Survey and Career Planning Guide: *Source EDP, Suite 1100, 100 South Wacker Dr., Chicago, IL 60606 (or contact your local Source EDP Office).*

Mathematics and Related Positions *(Announcement Q1-1500),* Computer Specialists *(Announcement 420), and other civil service job announcements: United States of America, Office of Personnel Management, 1900 E St., NW, Washington, DC 20415 (or contact your local Job Information Center).*

CLEP May Be For You: *College Board Publication Orders, POB 2815, Princeton, NJ 08541.*

ACT Proficiency Examination Program: *ACT PEP Coordinator, Proficiency Examination Program, POB 168, Iowa City, IA 52240.*

Benefits for Veterans and Service Personnel with Service since January 31, 1955, and Their Dependents: *Veterans Administration, 941 North Capitol St., NE, Washington, DC 20421.*

Occupations in Demand at Job Service Offices: *Consumer Information Center, Pueblo, CO 81009.*

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Converting Apple DOS and Pascal Text Files

Now you can exchange information between DOS 3.3 and Pascal operating systems.

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Wouldn't it be nice to use the Pascal editor on BASIC programs? Perhaps you would like to share Pascal programs with members of a user's group, but your newsletter editor or librarian prefers the text in DOS format. Maybe you can download FORTRAN programs via modem from the school computer. Unfortunately, Pascal doesn't recognize your modem.

Apple's implementation of UCSD Pascal is a real pleasure to use. At the same time, its disk operating system (DOS) is one of the more friendly and its BASIC is handy, if not especially efficient. Each system has its advantages and limitations and its own complement of editors and utilities to speed program development and text preparation. Still, there are occasions when you might want to move information from one environment to the other. Retype everything? No! Let the computer do the work.

To see how this might be accomplished, consider the organization of data on disks in the two systems. DOS 3.3 logically divides the disk into 560 sectors (35 tracks with 16 sectors each). Each sector contains 256 bytes of data. Pascal divides the disk into 280 blocks, each containing 512 bytes. A single DOS 3.3 sector and half of a Pascal block are physically (but not logically) identical. The solution to conversion revolves around this underlying similarity. All that is necessary is a map correlating DOS sector pairs and Pascal blocks.

Listing 1 is a Pascal program called GETDOS. It reads DOS-format text files and writes Pascal-format files. The array MAP contains the information needed to decide which half-block to use for a given sector. The procedure READSEC reads the indicated block and, based on the MAP, decides which half to move into the TEXT array. The procedure GETNAMES prompts the user for source and destination units, as well as a file name. If your system has more than two disk drives, you may want to modify the CASE statement to recognize the extra units. Note that output to the CONSOLE: or PRINTER: is also supported.

These methods may also apply to other operating systems, such as CP/M for the Z80 SoftCard.

Reading the source file is a matter of searching the DOS directory for the indicated file name, getting its track/sector list, and reading the data one sector at a time. Appendix C of the DOS 3.3 manual gives details of the directory and file organization. Files that are not text type or are too large to fit in the Pascal editor are rejected with an appropriate error message.

Since DOS stores text as negative ASCII (i.e., with the high-order bit in each character set to 1) and the Pascal editor expects to see positive ASCII (i.e., the high-order bit clear), the characters must be converted. Writing the destination file is handled two ways. If data are going to a disk file, the conversion is done once and the function BLOCKWRITE is used to speed up the transfer. If data are going to the CONSOLE: or PRINTER:, conversion and output proceed simultaneously one character at a time.

Files can be converted the other way, too. Listing 2 is an Applesoft BASIC program that reads Pascal files and writes DOS 3.3 text files. It bears the remarkably innovative title GETPAS. This program is organized along a line similar to its Pascal counterpart. The principal procedures are set off with REM statements. Since BASIC has no intrinsic procedure analogous to Pascal's UNITREAD, it calls the 6502

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Listing 1: *Program GETDOS is used to convert DOS 3.3 text files to Pascal format files. Reading the source file is a matter of searching the DOS directory for the indicated file name, getting its track/sector list, and reading the data one sector at a time. The array MAP contains the information needed to determine which half-block to use for each sector. The CASE statement can be modified if your system has more than two disk drives.*

```
PROGRAM GETDOS;

(*********************************************************************
 *                                                                   *
 * Program to convert DOS 3.3 text files to Pascal format files.     *
 *                                                                   *
 *********************************************************************)

CONST MAX=18432; (36 blocks of 512 bytes is maximum EDITOR can load.)
       PAGE=256; (DOS sectors are 256 bytes long.)
       CLEAREOL=29; CLEARSCREEN=12;

TYPE BYTE=0..255;
     UNITS=1..12;
     UNTYPED_FILE=FILE;
     SECTOR=RECORD
              BLOCK:0..7;
              HALF:(FIRST, SECOND)
            END;

VAR MAP: PACKED ARRAY[0..15] OF SECTOR;
    BUF: PACKED ARRAY[0..511] OF BYTE;
    TEXT: PACKED ARRAY[0..MAX] OF BYTE;
```

Listing 1 continued:

```
    SOURCEFILE, DESTFILE: STRING;
    SOURCEUNIT, DESTUNIT: UNITS;
    DRIVES: SET OF UNITS;
    BLOCK, TRAK, SEC, BLOCKCOUNT, I: INTEGER;
    PTR: INTEGER; (POINTER TO TEXT ARRAY)
    DONE, FOUND: BOOLEAN; CH: CHAR;
    F: FILE OF CHAR; (For use with CONSOLE: or PRINTER:)
    DISKFILE: UNTYPED_FILE; (For use with BLOCKWRITE)

PROCEDURE INITIALIZE;
  (For each of 16 sectors specify which block to read from)
  (a given track and which half to use as the sector.)
  BEGIN
    MAP[0].BLOCK:=0;   MAP[0].HALF:=FIRST;
    MAP[1].BLOCK:=7;   MAP[1].HALF:=FIRST;
    MAP[2].BLOCK:=6;   MAP[2].HALF:=SECOND;
    MAP[3].BLOCK:=6;   MAP[3].HALF:=FIRST;
    MAP[4].BLOCK:=5;   MAP[4].HALF:=SECOND;
    MAP[5].BLOCK:=5;   MAP[5].HALF:=FIRST;
    MAP[6].BLOCK:=4;   MAP[6].HALF:=SECOND;
    MAP[7].BLOCK:=4;   MAP[7].HALF:=FIRST;
    MAP[8].BLOCK:=3;   MAP[8].HALF:=SECOND;
    MAP[9].BLOCK:=3;   MAP[9].HALF:=FIRST;
    MAP[10].BLOCK:=2;  MAP[10].HALF:=SECOND;
    MAP[11].BLOCK:=2;  MAP[11].HALF:=FIRST;
    MAP[12].BLOCK:=1;  MAP[12].HALF:=SECOND;
    MAP[13].BLOCK:=1;  MAP[13].HALF:=FIRST;
    MAP[14].BLOCK:=0;  MAP[14].HALF:=SECOND;
```

Listing 1 continued on page 450

Listing 1 continued:

```
      MAP[15].BLOCK:=7; MAP[15].HALF:=SECOND;
    END; {INITIALIZE}

PROCEDURE PRINTAT(Y: INTEGER; S: STRING);
    BEGIN GOTOXY(0,Y); WRITE(CHR(CLEAREOL),S) END;
PROCEDURE GETNAMES;
VAR OK: BOOLEAN; DEST: STRING;
    BEGIN
      DRIVES:=[4,5];
      REPEAT
        WRITE(CHR(CLEARSCREEN));
        PRINTAT(2,'*** GETDOS ***  By John Matthews, M.D.');
        PRINTAT(5,'Units:  1. Console:    4. Drive #4');
        PRINTAT(6,'        5. Drive #5:   6. Printer:');
        PRINTAT(8,'Source Unit (4-5): '); READLN(SOURCEUNIT);
        PRINTAT(10,'Destination Unit (1-6): '); READLN(DESTUNIT);
        PRINTAT(12,'Source file name: '); READLN(SOURCEFILE);
        DESTFILE:=SOURCEFILE; STR(DESTUNIT,DEST);
        IF POS('.',SOURCEFILE)=0 THEN DESTFILE:=CONCAT(SOURCEFILE,'.TEXT');
        CASE DESTUNIT OF
          1: DESTFILE:='CONSOLE:';
          2: DESTFILE:='SYSTERM:';
          3: DESTFILE:='NOT AVAILABLE';
          4,5: DESTFILE:=CONCAT('#',DEST,':',DESTFILE);
          6: DESTFILE:='PRINTER:';
          7,8,9,10,11,12: DESTFILE:='NOT IMPLEMENTED';
        END; {CASES of DESTUNIT}
```

Listing 1 continued:

```
      PRINTAT(14,CONCAT('Destination file: ',DESTFILE));
      PRINTAT(16,'<cr> accepts, <e> exits, <sp> restarts ');
      READ(KEYBOARD,CH); OK:= EOLN(KEYBOARD);
      IF CH IN ['E','e',CHR(27)] THEN EXIT(PROGRAM);
    UNTIL OK;
  END; {GETNAMES}

PROCEDURE READSEC;
  BEGIN
    BLOCK:=(TRAK*8)+MAP[SEC].BLOCK;
    UNITREAD(SOURCEUNIT,BUF,512,BLOCK);
      CASE MAP[SEC].HALF OF
        FIRST:MOVELEFT(BUF[0],TEXT[PTR],PAGE);
        SECOND:MOVELEFT(BUF[PAGE],TEXT[PTR],PAGE);
      END; {CASES of MAP}
    PTR:=PTR+PAGE;
  END; {READSEC}

PROCEDURE READSOURCE;
CONST BYTES_PER_ENTRY=35; HEADER=11;
      BLANKS='                         '; {25 Blanks}
VAR NAME, STRING[30]; FILETYPE: BYTE;
    LIMIT, SECTORCOUNT, ENTRY: INTEGER;
    LIST: PACKED ARRAY[1..80,0..1] OF BYTE;
  BEGIN
    {Read catalog from track 17; sectors 15-1}
    PRINTAT(18,'Reading catalog...');
```

Listing 1 continued on page 452

Listing 1 continued:

```
    TRAK:=17; PTR:=0; {Start at beginning of TEXT}
    FOR SEC:=15 DOWNTO 1 DO READSEC;
    {Find sourcefile entry}
    LIMIT:=PTR-1; PTR:=HEADER; ENTRY:=0;
    SOURCEFILE:=CONCAT(SOURCEFILE,' '); {Make name unique}
    REPEAT
      NAME:=COPY(BLANKS,1,LENGTH(SOURCEFILE));
      ENTRY:=ENTRY+1;
      FOR I:= 1 TO LENGTH(SOURCEFILE) DO
        NAME[I]:=CHR(TEXT[PTR+I+2]-128);
      FOUND:= NAME=SOURCEFILE;
      IF NOT FOUND THEN {increment PTR}
        BEGIN IF (ENTRY MOD 7)=0 THEN PTR:=PTR+HEADER,
              PTR:=PTR+BYTES_PER_ENTRY END;
  UNTIL FOUND OR (PTR>LIMIT);
  IF {still} NOT FOUND THEN
    BEGIN PRINTAT(18,'File not found...'); EXIT(READSOURCE) END;
  TRAK:=TEXT[PTR]; SEC:=TEXT[PTR+1]; {Location of track/sector list}
  FILETYPE:=TEXT[PTR+2]; {0 if unlocked TEXT; 128 if locked TEXT}
  SECTORCOUNT:=TEXT[PTR+33]-1; {Minus 1 for the track/sector list}
  IF ((FILETYPE<>0) AND (FILETYPE<>128)) OR (SECTORCOUNT>72) THEN
    BEGIN FOUND:=FALSE; PRINTAT(18,'Not a TEXT file...');
          EXIT(READSOURCE) END;
  {Read the track/sector list}
  PTR:=0; READSEC; PTR:=12; {list starts at byte 12}
  FOR I:= 1 TO SECTORCOUNT DO
    BEGIN LIST[I,0]:=TEXT[PTR]; PTR:=PTR+1;
```

Listing 1 continued:

```
          LIST[I,1]:=TEXT[PTR]; PTR:=PTR+1  END;
   (Finally, null the TEXT buffer and read the data)
   IF ODD(SECTORCOUNT) THEN BLOCKCOUNT:=(SECTORCOUNT+1) DIV 2
     ELSE BLOCKCOUNT:=SECTORCOUNT DIV 2;
   FILLCHAR(TEXT[0],BLOCKCOUNT*512,CHR(0));
   PRINTAT(18,'Reading file...'); PTR:=0;
   FOR I:= 1 TO SECTORCOUNT DO
     BEGIN TRAK:=LIST[I,0]; SEC:=LIST[I,1]; READSEC END;
 END; (READSOURCE)

PROCEDURE WRITEDEST;
VAR NEXTBYTE: BYTE;
  BEGIN
   PTR:=0,
   PRINTAT(18,CONCAT('Put ',DESTFILE,' on line; press <cr> '));
   READ(KEYBOARD,CH);
   IF DESTUNIT IN DRIVES THEN
     BEGIN
       PRINTAT(18,'One moment please...');
       FILLCHAR(BUF[0],512,CHR(0));
       FOR I:=0 TO BLOCKCOUNT*512 DO (convert to positive ASCII)
         IF TEXT[I]>127 THEN TEXT[I]:=TEXT[I]-128;
       PRINTAT(18,CONCAT('Writing to ',DESTFILE,'...'));
       REWRITE(DISKFILE,DESTFILE);
       I =BLOCKWRITE(DISKFILE,BUF,1,0); (Text file header)
       I:=BLOCKWRITE(DISKFILE,BUF,1,1); (Text file header)
       I:=BLOCKWRITE(DISKFILE,TEXT[0],BLOCKCOUNT,2);
```

Listing 1 continued on page 454

Listing 1 continued:

```
      CLOSE(DISKFILE,LOCK);
    END {THEN}
  ELSE
    BEGIN
      PRINTAT(18,CONCAT('Writing to ',DESTFILE,'...'));
      REWRITE(F,DESTFILE);
      WRITELN(F);
      REPEAT
        NEXTBYTE:=TEXT[PTR+1];
        CH:=CHR(TEXT[PTR]-128);
            WRITE(F,CH); PTR:=PTR+1;
          UNTIL NEXTBYTE=0;
          CLOSE(F,LOCK);
        END; {ELSE}
    END; {WRITEDEST}

  BEGIN {MAIN PROGRAM}
    INITIALIZE {sector/block map};
     REPEAT
      GETNAMES {and locations of files},
      READSOURCE {in DOS format};
      IF FOUND THEN WRITEDEST;
      WRITELN; WRITELN;
      WRITE('Another file? (Y/N) ');
      READ(KEYBOARD,CH);
      DONE:= CH IN ['N','n'];
    UNTIL DONE
  END {MAIN}
```

Listing 2: *The Applesoft BASIC program GETPAS is used to convert Pascal text (.TEXT) files to DOS 3.3 text files. The Pascal volume directory is read from blocks 2 through 5 to find the indicated file name. Since BASIC does not have an intrinsic procedure analogous to Pascal's UNITREAD, GETPAS calls the machine-language routine shown in listing 3.*

```
  1  REM GETPAS. PASCAL TO TEXTFILE CONVERSION
  2  REM By J. Matthews, MD   7/6/81
  3  GOTO 200: REM START OF MAIN PROGRAM

  4  REM *** SUBROUTINES ***

100  REM  WRITE FILE (SKIP NULLS)
105 CH =  PEEK (I)
110  IF CH = 16 THEN I = I + 1:CH = 0: IF PEEK(I) > 32 THEN
       FOR J = 33 TO PEEK(I): PRINT " ";: NEXT J:I = I + 1: GOTO 105
115  IF CH = 0 AND I > EN THEN  RETURN
120  IF CH = 0 THEN I = I + 1: GOTO 105
125 I = I + 1: PRINT  CHR$ (CH);: GOTO 105

130  REM  READ A BLOCK
135 SL% = SS:DR% = SD
140 TR% =  INT (BLOCK / 8)
145 PT% =  INT ((BLOCK / 8 - TR%) * 8)
150 SE% = M%(PT%,0): CALL RWTS
155  GOSUB 190:BU% = BU% + PAGE
160 SE% = M%(PT%,1): CALL RWTS
165  GOSUB 190:BU% = BU% + PAGE
170  RETURN

175  REM  CENTER TITLE
180  HTAB 20 -  LEN (T$) / 2: PRINT T$: RETURN

185  REM  ERR TRAP
190  IF ER% <  > 0 THEN  VTAB 20: CALL  - 868:
       PRINT "DOS ERROR...": POP : POP : GOTO 290
195  RETURN

200  REM *** INITIALIZE ***

205 RWTS = 16384: HIMEM: RWTS
210 PRINT  CHR$ (4);"BLOAD RWTS.OBJ0"
215 PAGE = 256
220 BU% = RWTS + PAGE:CM% = 1
225 BEG = BU%:EN = BU% + PAGE
230 M%(0,0) = 0:M%(0,1) = 14
235 M%(1,0) = 13:M%(1,1) = 12
240 M%(2,0) = 11:M%(2,1) = 10
245 M%(3,0) = 9:M%(3,1) = 8
250 M%(4,0) = 7:M%(4,1) = 6
255 M%(5,0) = 5:M%(5,1) = 4
260 M%(6,0) = 3:M%(6,1) = 2
265 M%(7,0) = 1:M%(7,1) = 15

270  REM *** GET FILE NAMES ***

275  HOME : VTAB 3
280 T$ = "*** CONVERT: PASCAL TO TEXT ***": GOSUB 180: PRINT
285 T$ = "BY JOHN MATTHEWS, M.D.": GOSUB 180
290  VTAB 8: HTAB 1
295  PRINT "SOURCE SLOT:  6";
300  HTAB  PEEK (36): GET IN$
```

Listing 2 continued on page 456

Listing 2 continued:

```
305 SS =  VAL (IN$)
310  IF SS = 0 THEN SS = 6
315  IF SS < 0 OR SS > 7 THEN 290
320  PRINT SS
325  VTAB 10: HTAB 1
330  PRINT "SOURCE DRIVE: 1";
335  HTAB  PEEK (36): GET IN$
340 SD =  VAL (IN$)
345  IF SD = 0 THEN SD = 1
350  IF SD < 1 OR SD > 2 THEN 325
355  PRINT SD
360  VTAB 12: HTAB 1
365  PRINT "DESTINATION SLOT:  6";
370  HTAB  PEEK (36): GET IN$
375 DS =  VAL (IN$)
380  IF DS = 0 THEN DS = 6
385  IF DS < 1 OR DS > 7 THEN 360
390  PRINT DS
395  VTAB 14: HTAB 1
400  PRINT "DESTINATION DRIVE: 2";
405  HTAB  PEEK (36): GET IN$
410 DD =  VAL (IN$)
415  IF DD = 0 THEN DD = 2
420  IF DD < 1 OR DD > 2 THEN 395
425  PRINT DD
430  VTAB 16: HTAB 1
435  INPUT "SOURCE FILE: ";SF$: IF LEN(SF$)=0 THEN 430
440  VTAB 18: HTAB 1
445  INPUT "DESTINATION FILE: ";DF$
450  IF  LEN (DF$) = 0 THEN DF$ = SF$: VTAB 18:
       PRINT "DESTINATION FILE: ";DF$
455 L2 =  LEN (SF$)
460  VTAB 20: CALL  - 868: PRINT "PRESS <RET> TO PROCEED;
       <ESC> TO END ";: GET IN$: IF IN$ =  CHR$ (27) THEN 605
465  PRINT : IF IN$ <  >  CHR$ (13) THEN 290
470  IF SD = DD THEN  VTAB 20: PRINT "INSERT THE SOURCE DISK;
       PRESS <RET> ";: INPUT "";IN$

475  REM *** GET DIRECTORY ***

480  VTAB 20: CALL  - 868: PRINT "READING DIRECTORY..."
485 BU% = RWTS + PAGE: FOR BLOCK = 2 TO 5: GOSUB 135: NEXT BLOCK
490 EN = BU%

495  REM *** FIND FILE NAME ***

500  FOR I = BEG TO EN STEP 26:NA$ = ""
505 SB = PEEK (I) + 256 * PEEK (I+1): NB = PEEK (I+2) + 256 * PEEK (I+3):
      L1 =  PEEK (I + 6)
510  IF L1 <  > L2 THEN 525
515  FOR J = I + 7 TO I + L1 + 6:NA$ = NA$ +  CHR$ ( PEEK (J)): NEXT J
520  IF NA$ = SF$ THEN 540
525  NEXT I
530  IF NA$ = "" THEN  VTAB 20: CALL  - 868:
       PRINT "FILE NOT FOUND: PRESS <RET> ";: INPUT "";IN$: GOTO 290

535  REM *** READ SOURCE ***

540  VTAB 20: CALL  - 868: PRINT "READING FILE..."
545 SB = SB + 2:EB = NB - 1:BU% = RWTS + PAGE
```

Listing 2 continued:

```
550  FOR BLOCK = SB TO EB: GOSUB 135: NEXT BLOCK
555  IF SD = DD THEN  VTAB 20: CALL  - 868:
       PRINT "INSERT DESTINATION DISK; PRESS <RET> ";: INPUT "";IN$

560  REM *** WRITE DEST ***

565  VTAB 20: CALL  - 868: PRINT "WRITING..."
570  PRINT  CHR$ (4);"OPEN ";DF$;",D";DD
575  PRINT  CHR$ (4);"DELETE ";DF$
580  PRINT  CHR$ (4);"OPEN ";DF$;",D";DD
585  PRINT  CHR$ (4);"WRITE ";DF$
590 I = BEG:EN = BU% - PAGE: GOSUB 105
595  PRINT  CHR$ (4);"CLOSE ";DF$
600  VTAB 20: CALL  - 868: PRINT "ANOTHER FILE (Y/N) ";:
       GET IN$: IF IN$ = "Y" THEN 270
605  PRINT : END
```

Listing 3 begins on page 458

Text continued from page 447:

machine-language program found in listing 3, that in turn calls the read/write track and sector (RWTS) routines from DOS. (See the DOS 3.3 manual, page 94.) The Applesoft PTRGET routine is used to allow passing variables by name rather than by location using the traditional PEEK and POKE.

The Pascal volume directory is read from blocks 2 through 5 of the disk. It is organized as 26-byte records, the first of which is the volume name:

```
Directory record
   Starting block: integer;
   Next available block: integer;
   File type: integer;
   File name: string[15];
   I/O designation: 0..255;
   Date: packed array occupying 2
      bytes;
   end;
```

Deleted files are marked by setting the length byte of the name string to 0. In reading the file itself, note that text files have a two-block header that ordinarily contains editor settings like environment and markers. The header can be skipped.

Writing the file requires, once again, that the high-order bit of each character be reset. This is done with the standard Applesoft function CHR$. This method is rather slow, but trying to implement a "BLOCK-WRITE" function in BASIC would require writing to both the disk directory and the volume table of contents. This is more safely left to DOS. To mark the end of file, DOS uses the null (ASCII 0) character. Pascal uses these to fill in the unused portions of blocks. Intervening nulls are simply bypassed as the file is written. One further conversion is helpful here. Pascal source lines that are indented are preceded by the data link escape (DLE, ASCII 16) character followed by a single byte specifying the number of spaces to indent plus 32. Without converting these to spaces, the indentation of Pascal text would be lost.

These methods may also apply to other operating systems, such as CP/M for the Z80 Softcard from Microsoft. If the directory and sector organization can be found, the conversion is possible.

These are the tools. Now you have one less excuse to keep your favorite Pascal programs tucked away in the back of a box.■

Listing 3: *A 6502 machine-language routine to interface the BASIC program of listing 2 with the read/write track and sector routine of DOS 3.3 for direct control of disk access. More information on the RWTS routine can be found in the DOS 3.3 manual.*

```
0000:        * RWTS INTERFACE FOR APPLESOFT BASIC
0000:        * J. Matthews, M.D., 7/6/1981
0000:        *
0000:        * Variables passed by name:
0000:        *
0000:        * SL%= SLOT NUMBER
0000:        * DR%= DRIVE 1 OR 2
0000:        * TR%= TRACK 0 TO 34
0000:        * SE%= SECTOR 0 TO 15
0000:        * CM%= 0 (NULL: NO ACTION)
0000:        *    = 1 (READ A SECTOR)
0000:        *    = 2 (WRITE A SECTOR)
0000:        *    = 4 (FORMAT THE DISK)
0000:        * BU%= ADD. OF 256 BYTE BUFFER
0000:        *
0000:        * Returned:
0000:        *
0000:        * ER%= DOS ERROR CODE (0=NONE)
0000:        *
----- NEXT OBJECT FILE NAME IS RWTS.OBJ0
4000:                ORG  $4000
4000:                MSB  OFF
4000:        *
4000:        * I/O Block offsets: DOS 3.3 manual p94-98.
4000:        *
0001:        IBSLOT  EQU  $01         ;SLOT
```

Listing 3 continued:

```
0002:          IBDRVN   EQU   $02           ;DRIVE
0003:          IBVOL    EQU   $03           ;VOLUME
0004:          IBTRK    EQU   $04           ;TRACK
0005:          IBSECT   EQU   $05           ;SECTOR
0008:          IBBUFP   EQU   $08           ;BUFFER POINTER
000C:          IBCMD    EQU   $0C           ;COMMAND
000D:          IBSTAT   EQU   $0D           ;ERROR #
000F:          IOBPSN   EQU   $0F           ;PREVIOUS SLOT
0010:          IOBPDN   EQU   $10           ;PREVIOUS DRIVE
4000:          *
4000:          * Page zero locations:
4000:          *
001E:          TPSAV    EQU   $1E
0048:          IOB      EQU   $48
0083:          VARPNT   EQU   $83
00B8:          TXTPTR   EQU   $B8
4000:          *
4000:          * DOS hooks:
4000:          *
03D9:          RWTS     EQU   $3D9
03E3:          GETIOB   EQU   $3E3
4000:          *
4000:          * Applesoft PTRGET routine.
4000:          *
DFE3:          PTRGET   EQU   $DFE3
4000:          *
4000:20 E3 03  ENTRY    JSR   GETIOB         ;GET I/O BLOCK ADDRESS
```

Listing 3 continued on page 460

Listing 3 continued:

```
4003:84 48      STY  IOB        ;SAVE IT
4005:85 49      STA  IOB+1
4007:A5 B8      LDA  TXTPTR     ;SAVE TXTPTR
4009:85 1E      STA  TPSAV
400B:A5 B9      LDA  TXTPTR+1
400D:85 1F      STA  TPSAV+1
400F:20 79 40   JSR  GETSL%     ;GET SL% (SLOT)
4012:0A         ASL  A          ;TIMES 16
4013:0A         ASL  A
4014:0A         ASL  A
4015:0A         ASL  A
4016:A0 01      LDY  #IBSLOT
4018:91 48      STA  (IOB),Y
401A:20 7F 40   JSR  GETDR%     ;GET DR% (DRIVE)
401D:A0 02      LDY  #IBDRVN
401F:91 48      STA  (IOB),Y
4021:A9 00      LDA  #$00       ;VOLUME=0
4023:A0 03      LDY  #IBVOL
4025:91 48      STA  (IOB),Y
4027:20 85 40   JSR  GETTR%     ;GET TR% (TRACK)
402A:A0 04      LDY  #IBTRK
402C:91 48      STA  (IOB),Y
402E:20 8B 40   JSR  GETSE%     ;GET SE% (SECTOR)
4031:A0 05      LDY  #IBSECT
4033:91 48      STA  (IOB),Y
4035:20 91 40   JSR  GETBU%     ;GET BU% (BUFFER)
```

Listing 3 continued:

```
4038:A0 08          LDY  #IBBUFP
403A:91 48          STA  (IOB),Y      ;LOW BYTE
403C.A0 00          LDY  #$00
403E:B1 83          LDA  (VARPNT),Y
4040:A0 09          LDY  #IBBUFP+1
4042:91 48          STA  (IOB),Y      ;HIGH BYTE
4044:20 97 40       JSR  GETCM%       ;GET CM% (COMMAND)
4047:F0 27          BEQ  RETURN       ;NULL COMMAND
4049:A0 0C          LDY  #IBCMD
404B:91 48          STA  (IOB),Y
404D:20 9D 40       JSR  GETER%       ;GET ER% POINTER
4050:20 E3 03       JSR  GETIOB
4053:20 D9 03       JSR  RWTS
4056:A0 0D          LDY  #IBSTAT
4058:B1 48          LDA  (IOB),Y      ;ERROR CODE
405A:B0 02          BCS  ERROR        ;RWTS SETS C BIT ON ERR
405C:A9 00          LDA  #$00         ;ER%=0 IF C BIT CLEAR
405E:A0 01    ERROR LDY  #$01
4060:91 83          STA  (VARPNT),Y   ;RETURN IBSTSAT IN ER%
4062:B1 48          LDA  (IOB),Y      ;Y=IBSLOT
4064 A0 0F          LDY  #IOBPSN
4066:91 48          STA  (IOB),Y      ;UPDATE SLOT
4068:A0 02          LDY  #IBDRVN
406A:B1 48          LDA  (IOB),Y
406C:A0 10          LDY  #IOBPDN
406E:91 48          STA  (IOB),Y      ;UPDATE DRIVE
```

Listing 3 continued on page 462

Listing 3 continued:

```
4070:A5 1E      RETURN  LDA   TPSAV       ;RESTORE TXTPTR
4072:85 B8              STA   TXTPTR
4074:A5 1F              LDA   TPSAV+1
4076:85 B9              STA   TXTPTR+1
4078:60                 RTS               ;TO APPLESOFT
4079:           *
4079:           * Find Applesoft variables:
4079:           *
4079:20 A3 40   GETSL%  JSR   VARGET
407C:53 4C 25           ASC   'SL%'
407F:20 A3 40   GETDR%  JSR   VARGET
4082:44 52 25           ASC   'DR%'
4085:20 A3 40   GETTR%  JSR   VARGET
4088:54 52 25           ASC   'TR%'
408B:20 A3 40   GETSE%  JSR   VARGET
408E:53 45 25           ASC   'SE%'
4091:20 A3 40   GETBU%  JSR   VARGET
4094:42 55 25           ASC   'BU%'
4097:20 A3 40   GETCM%  JSR   VARGET
409A:43 4D 25           ASC   'CM%'
409D:20 A3 40   GETER%  JSR   VARGET
40A0:45 52 25           ASC   'ER%'
```

Listing 3 continued:

```
40A3:          *
40A3:          * VARGET: On entry to PTRGET, TXTPTR points to first
40A3:          * character of the variable name. On exit, the address
40A3:          * of the variable's value is in VARPNT and Y,A.
40A3:          *
40A3:          * Pop return stack and store variable pointer in TXTPTR.
40A3:          *
40A3:68        VARGET  PLA
40A4:85 B8             STA   TXTPTR
40A6:68                PLA
40A7:85 B9             STA   TXTPTR+1
40A9:          * Increment pointer to first character in ASC string.
40A9:E6 B8             INC   TXTPTR
40AB:D0 02             BNE   VAR1
40AD:E6 B9             INC   TXTPTR+1
40AF:20 E3 DF  VAR1    JSR   PTRGET
40B2:A0 01             LDY   #$01
40B4:B1 83             LDA   (VARPNT),Y
40B6:          * Note return is to second most recent caller
40B6:60                RTS

*** SUCCESSFUL ASSEMBLY: NO ERRORS
```

A Simple Multiprocessor Implementation

A simple connection can be the start of a multiprocessing, multitasking system.

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Have you been looking for an easy way to simultaneously operate more than one computer? If you have, your search is at an end. In this article, I describe a method to control two or more computers connected by serial data lines. Even if the computers are performing completely unrelated tasks, they can still be controlled from a single terminal.

For example, one machine might run a BASIC program, while the other controls your home-security system. Or one could print a data file on a hard-copy device, while the operator updates the same file on the other machine.

Another possibility is the job performed by some very large computers—splitting a single task into segments and processing the segments separately but simultaneously. This provides good news and bad news. The good news is an impressive reduction in the time needed to complete the overall task. The bad news is the complexity of the software required to accomplish this!

For several years, some friends and I kicked around the idea of interconnecting computers. Many gallons of coffee and plenty of discussion yielded many possibilities. We wrote some extensive software to allow the exchanging of programs and data via modems and telephone lines, and played around with multiple-processor printer spoolers, but never did implement multiprocessing.

However, I was given an excellent opportunity to experiment when I upgraded my SwTPC 6800-based dual-disk-drive machine with a Motorola 6809 processor. This was accomplished by making some minor hardware changes and plugging in a new 6809 processor card. The old 6800 card was plugged into another motherboard, with a homemade power supply. A friend had built a wooden cabinet for his SwTPC computer; his original cabinet soon held my second computer. Since my bankroll was limited, extra memory and input/output hardware were added sparingly. Some swapping got me a Shugart Associates SA-400 5¼-inch floppy-disk drive. Before long, I was the proud owner of two almost identical disk-based microsystems, one running a 6800, the other, a 6809.

In certain situations, assigning more than one task to a single processor noticeably increases overall execution time.

Both machines run FLEX, Technical Systems Consultants' (POB 2570, West Lafayette, IN 47906) excellent DOS (disk operating system). FLEX contains a built-in interrupt-driven background (i.e., invisible to, and not interactive with, the user) *printer spooler*, allowing low-priority disk-file printing while the main user task is running in foreground. This is called "limited multitasking." But if two things are happening at once on one computer, isn't that just as good as having two computers? No, not quite.

Spooling is a beautiful feature I use often, but it has a few drawbacks. First, only two tasks are permitted, one of which must be the printing of the contents of a disk file. Second, because the two tasks are swapped under interrupt control, background printing slows or stops while disk accesses, or any operations that mask interrupts, are being performed. This is particularly noticeable when you are using fast printers.

In fact, any single-processor multitasking scheme has an inherent limitation. The available processor time is split between the tasks. As a result, no task can run as fast as it would alone. On I/O- (input/output) intensive tasks, where much time is spent waiting on I/O devices or operator input, the effects of this time division may be unnoticeable. On the other hand, if the tasks rarely have to wait on I/O, execution time may slow down in almost inverse proportion to the number of tasks.

These problems can be avoided by multiprocessing. Since I now had two nearly identical machines, all excuses for not developing a multiprocessing system were gone. Several approaches to putting the system together were considered. The easiest one is to designate one machine as the primary unit, and let it control the other as a secondary machine. All control for the secondary machine has to pass through the primary. Little extra hardware is required, and the software is simple.

Another scheme is to use multiport memory, a special block of memory set up so that either machine may address it. To pass data or instructions between machines, the data are written by one processor to this memory and read by the other. Although very fast, this approach requires special hardware and some complex software. Similar drawbacks would occur if we used DMA (direct memory access—the transmission of data directly between the memory of a computer and a peripheral device, which might be the other processor) to pass data.

Shared-memory, direct-memory-access, and shared-bus multiprocessing systems involve both complex hardware and software.

Another approach is to design a small dedicated controller, such as a single-chip microprocessor with a program in ROM (read-only memory), to control the larger machines. The terminal connects to the controller, which in turn controls the other machines via serial data ports. Several other possibilities exist, including using a shared bus, where two or more processors communicate directly with memory and I/O via read and write instructions, as with the Intel 8086, Zilog Z8000, and Motorola 68000 16-bit microprocessors.

The method chosen for my first try was the simplest—the primary/secondary concept. The machines do not have to be identical, or even similar. Both only need serial ports that can be interconnected, as in figure 1. The ones shown here are serial RS-232C ports. A serial port on the primary machine (designated machine 1) is plugged into the control port of the secondary machine (designated machine 2) where a user terminal would be connected in a single-user system. Any data or commands output from machine 1 through this port are obeyed by machine 2 as though they came directly from the control ter-

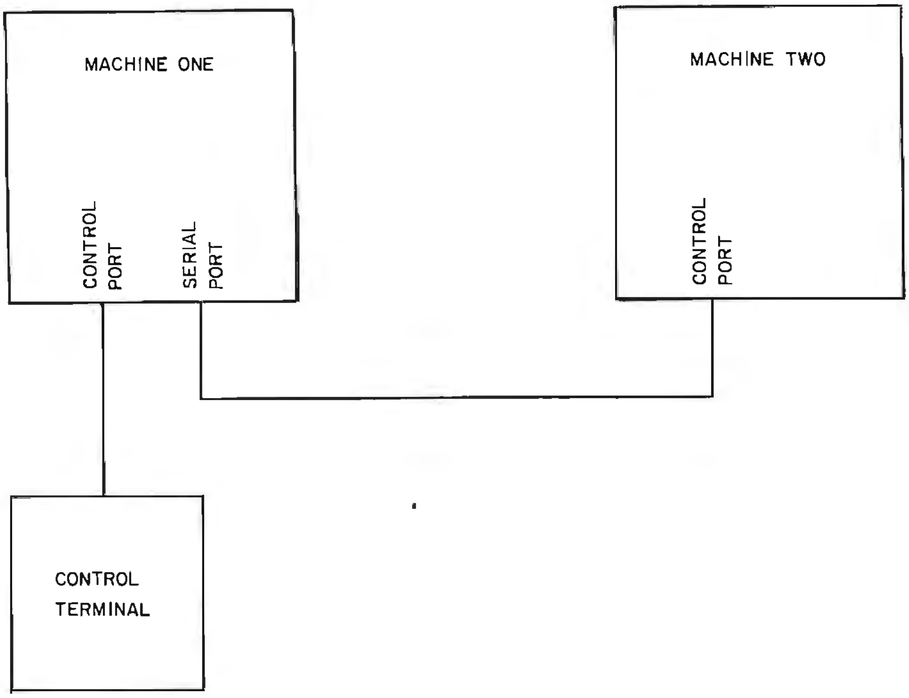

Figure 1: *A simple RS-232C serial connection between two computers can provide the necessary communications interface to create a multiprocessing system.*

minal; it doesn't know the difference. The only hardware change is to cross-connect pins 2 (BA) and 3 (BB) on the RS-232C cable connecting the two machines. This can be done either by making a special cable or by installing a DPDT (double-pole, double-throw) toggle switch on either machine. This is necessary so the transmitted-data line from one machine is connected to the data-receiving line on the other.

Incidentally, the reversing switch is also handy for connecting an external modem to one of your serial ports. It is necessary to reverse pins 2 and 3 in that case, and the switch saves making special cables. See figure 2 for details. Your ports or terminal may have special handshaking requirements, and you may have to tie pin 5 high or perform some other modification to get proper operation. Your hardware instruction book might note the serial interface requirements. (Or see "Build a Null Modem," by Robert Haar, BYTE, February 1981, page 198.)

Be sure the ports connecting the two machines are set for identical data rates, no faster than your control-terminal rate. I suggest running everything at 9600 bps (bits per second), if your control terminal is capable of it.

Software

The program in listing 1, called MACH2 and written in 6809 assembly language, runs in machine 1, but is called only when you "talk" to machine 2. When it is running, all characters typed on the user terminal are routed through machine 1 over the RS-232C line to machine 2, and all responses from machine 2 are routed by the software through machine 1, back to the terminal. It has the effect of the terminal being connected directly to machine 2. After you have started machine 2 on a particular task, typing a Control-X instantly puts you back in control of machine 1. You can now start it on an entirely different job from the one machine 2 is working on. Later, you may wish to talk to machine 2 again, to check on the progress of a job. With the described setup, just type the name of the program, MACH2, and you are again communicating with your second machine. As before, typing a Control-X gets you back to machine 1.

The software necessary to do this is simple. However, I couldn't resist complicating it a bit, using the enhanced instruction set available on the 6809. For instance, moving a program to execute in a different area of memory is painless. Unlike other 8-bit microprocessors, 6809 machine-language programs are easily written to be position-independent. They are not relocatable, as with a linking loader, but truly position-independent. A program doesn't care what its physical address in memory is—put it anywhere, and it runs.

MACH2 is disk-resident. When called, it is loaded into FLEX's "utility-command area" of memory and run. First, the program initializes the serial port used to control the second machine. This has to be done after power-up with any of the software-programmed serial ports before use. Next, the program moves part of itself (the permanent part) to the top of user memory. This does two good things. First, it frees the utility-command area for use by other utility programs. Second, the program is now memory-resident; it doesn't have to be loaded from disk each time you use it.

FLEX has already determined where the top of memory is, and has stored that address in an area reserved for pointers and other parameters. The program gets that address, and moves itself just under it. The system's end-of-memory pointer is changed to a location just below the

Text continued on page 470

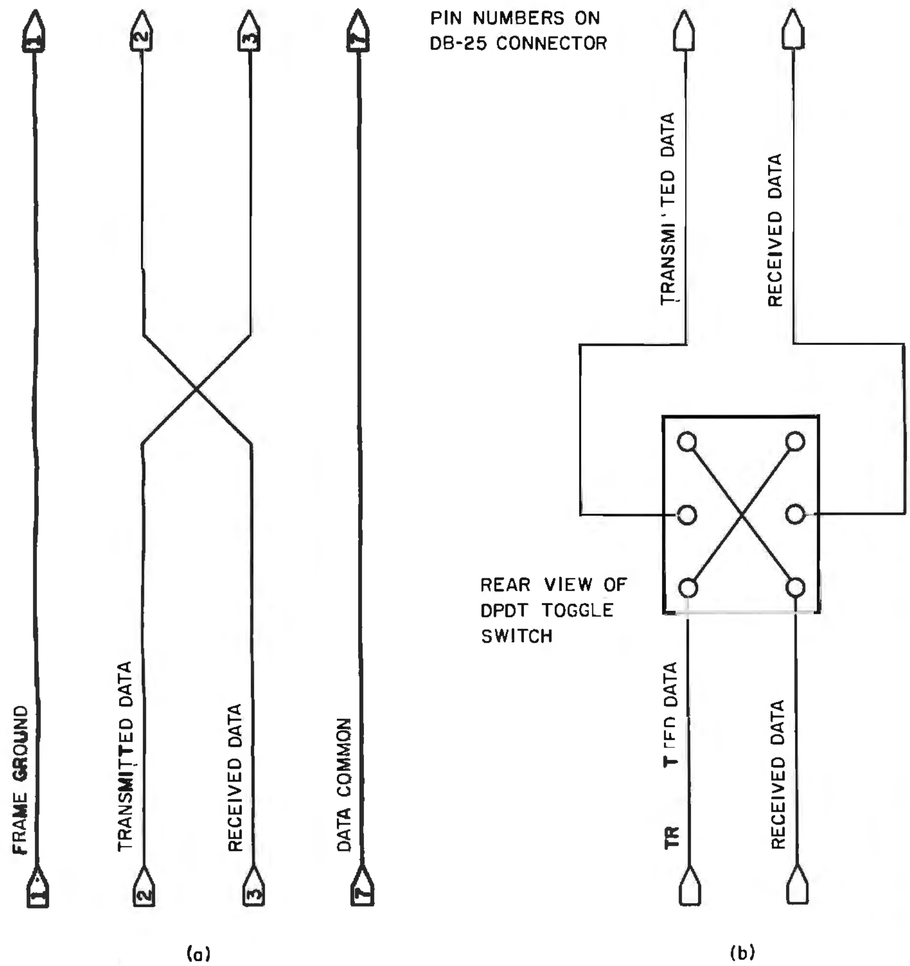

Figure 2: *When connecting two computers' RS-232C ports, it may be necessary to swap the connections to pins 2 (TD, transmit data) and 3 (RD, receive data) in the cable, as in figure 2a, or install a toggle switch, as in figure 2b. Other installation-specific modifications may be necessary to make the serial ports compatible.*

Listing 1: *A 6809 machine-language program, MACH2, that permits a user to control two interconnecting machines from one terminal, allowing the execution of two different tasks by separate processors.*

```
                                NAM    MACH2
                                OPT    PAG

                         * THIS PROGRAM ALLOWS CONTROL OF A SECOND
                         * MACHINE VIA A SERIAL PORT.

                         * ONCE CALLED, THIS PROGRAM IS MEMORY-RESIDENT
                         * AND REQUIRES NO SUBSEQUENT DISK LOADS.
                         * "MEMEND" IN FLEX ($CC2B) IS SET JUST BELOW
                         * THIS PROGRAM SO THAT IT WILL NOT BE WRITTEN
                         * OVER.

                         * OPERATING SYSTEM: 6809 FLEX (TM) T.S.C.
                         * HARDWARE: MACHINE 1- SWTPCO 6809
                         *           MACHINE 2- SWTPCO 6800

                         * WRITTEN 2-5-80  JOHN R. HARRINGTON
                         * EQUATES

                   CD03  WARMS   EQU    $CD03      FLEX9 WARMSTART
                   E004  PORT1   EQU    $E004      CONTROL PORT ADDRESS
                   E008  PORT2   EQU    $E008      PORT TALKING TO SECOND MACHINE
                   CD18  PUTCHR  EQU    $CD18      OUTPUT CHARACTER TO CONTROL PORT
                   CC2B  MEMEND  EQU    $CC2B      "END OF MEMORY" STORAGE
                   CD24  PCRLF   EQU    $CD24      <CRLF> TO CONTROL PORT
                   CD1E  PSTRNG  EQU    $CD1E      <CRLF> AND STRING TO CONTROL PORT
                   CC12  UCTADD  EQU    $CC12      USER COMMAND TABLE ADDRESS

C100                             ORG    $C100

C100 20    01            START   BRA    MACH2      BRANCH OVER VERSION

C102 01                          FCB    1          VERSION 1

C103 BD    CD24          MACH2   JSR    PCRLF
C106 86    03                    LDA    #3         MASTER RESET FOR ACIA PORT
C108 B7    E008                  STA    PORT2
C10B 86    11                    LDA    #$11       8 BITS, NO PARITY, 2 STOP BITS
C10D B7    E008                  STA    PORT2      PORT IS NOW INITIALIZED
C110 FC    CC2B                  LDD    MEMEND     PRESENT END OF MEMORY
C113 FD    C13D                  STD    ORIGME     SAVE IT FOR LATER
C116 83    00D5                  SUBD   #ENDPGM-MACH20 SUBTRACT LENGTH OF PART TO BE MOVED
C119 FD    CC2B                  STD    MEMEND     SET MEMORY END JUST BELOW OUR PROGRAM
C11C 1F    01                    TFR    D,X        MEMEND GOES INTO X
C11E 30    01                    LEAX   1,X        NOW X HAS NEW STARTING ADDRESS
C120 34    10                    PSHS   X          SAVE IT
C122 108E  C210                  LDY    #ENDPGM    LAST BYTE TO BE MOVED
C126 34    20                    PSHS   Y          SAVE ITS  ADDRESS
C128 108E  C13B                  LDY    #MACH20    FIRST BYTE TO BE MOVED
C12C A6    A0            MOVE    LDA    ,Y+        GET A BYTE OF THIS PROGRAM
C12E A7    80                    STA    ,X+        AND MOVE IT
C130 10AC  E4                    CMPY   ,S         FINISHED?
C133 26    F7                    BNE    MOVE       NOT YET
C135 32    62                    LEAS   2,S        FIX STACK
C137 35    10                    PULS   X          GET NEW STARTING ADDRESS
C139 6E    84                    JMP    ,X         AND GO THERE

                         * THE REST OF THIS PROGRAM GETS RELOCATED TO A
                         * NEW SPOT JUST UNDER TOP OF USER MEMORY SPACE.
                         * THE CODE IS POSITION-INDEPENDENT AND WILL RUN
                         * ANYWHERE. PART OF THE CODE MOVED IS AN EXTENSION
                         * TO THE FLEX COMMAND TABLE (COMTBL).
```

Listing 1 continued:

```
C13B 20    02          MACH20  BRA    MACH21      BRANCH AROUND TEMP STORAGE

C13D 0000              ORIGME  FDB    0           ORIGINAL TOP OF MEMORY ADDRESS

C13F 30    8D 0013     MACH21  LEAX   MACH22,PCR GET NEW ADDRESSES FOR ROUTINES
C143 AF    8D 00BC             STX    ADDR1,PCR AND PUT IN COMMAND TABLE
C147 30    8D 0050             LEAX   RESTORE,PCR
C14B AF    8D 00BE             STX    ADDR2,PCR
C14F 30    8D 00AA             LEAX   COMTBL,PCR POINT TO COMMAND TABLE
C153 BF    CC12                STX    UCTADD      TELL FLEX WHERE IT IS NOW
C156 30    8D 004F     MACH22  LEAX   MSG,PCR     "YOU ARE NOW CONTROLLING MACHINE TWO"
C15A BD    CD1E                JSR    PSTRNG
C15D BD    CD24                JSR    PCRLF
C160 8E    E004        MACH23  LDX    #PORT1      POINT TO CONTROL PORT
C163 8D    22                  BSR    CHECK       ANY KEYBOARD INPUT?
C165 24    12                  BCC    MACH25      NOPE
C167 8D    22                  BSR    INPORT      YES- GET THE CHARACTER
C169 81    18                  CMPA   #$18        CONTROL-X?
C16B 26    0A                  BNE    MACH24      NOPE
C16D 30    8D 005F             LEAX   MSG2,PCR    "YOU ARE NOW CONTROLLING MACHINE ONE (6809)"
C171 BD    CD1E                JSR    PSTRNG
C174 7E    CD03        JWARMS  JMP    WARMS       BACK TO FLEX

C177 8D    17          MACH24  BSR    OPORT2      SEND TO SECOND MACHINE
C179 8E    E008        MACH25  LDX    #PORT2      POINT TO SECOND MACHINE
C17C 8D    09                  BSR    CHECK       IS IT TALKING TO US?
C17E 24    E0                  BCC    MACH23      NO, LOOP
C180 8D    09                  BSR    INPORT      YES, GET THE CHARACTER
C182 BD    CD18                JSR    PUTCHR      PRINT ON CRT
C185 20    D9                  BRA    MACH23      AND LOOP FOR MORE

                       * CHECK PORT FOR INPUT- ENTER WITH PORT ADDRESS
                       * IN X REGISTER

C187 A6    84          CHECK   LDA    ,X          GET STATUS BYTE
C189 47                        ASRA               SHIFT STATUS BIT INTO CARRY
C18A 39                        RTS                CARRY SET INDICATES CHARACTER WAITING

                       * INPUT CHARACTER FROM A PORT (ENTER WITH PORT ADDRESS IN X)

C18B A6    01          INPORT  LDA    1,X         GET THE CHARACTER
C18D 84    7F                  ANDA   #$7F        STRIP PARITY BIT, IF ANY
C18F 39                        RTS

                       * SEND CHARACTER TO PORT TWO (SECOND MACHINE)

C190 F6    E008        OPORT2  LDB    PORT2       GET STATUS BYTE
C193 57                        ASRB               SHIFT READY BIT INTO CARRY
C194 57                        ASRB
C195 24    F9                  BCC    OPORT2      LOOP UNTIL READY
C197 B7    E009                STA    PORT2+1     SEND THE CHARACTER
C19A 39                        RTS

                       * RESTORE MACHINE TO ORIGINAL CONDITION

C19B 8E    0000        RESTORE LDX    #0
C19E BF    CC12                STX    UCTADD      CLEAR EXTENSION TO COMMAND TABLE
C1A1 AE    8C 99               LDX    ORIGME,PCR GET ORIGINAL MEMORY END ADDRESS
C1A4 BF    CC2B                STX    MEMEND      PLUG IT BACK IN
C1A7 20    CB                  BRA    JWARMS      AND EXIT
                       * STRINGS

C1A9 20 2D 59 4F       MSG     FCC    / -YOU ARE NOW CONTROLLING MACHINE TWO-/,4
C1D0 20 2D 59 4F       MSG2    FCC    / -YOU ARE NOW CONTROLLING MACHINE ONE (6809)/,4

                       * COMMAND TABLE

C1FD 4D 41 43 48       COMTBL  FCC    /MACH2/,0
C203 C156              ADDR1   FDB    MACH22
C205 52 45 53 54               FCC    /RESTORE/,0
```

Listing 1 continued:

```
C20D C19B          ADDR2   FDB    RESTORE
C20F 00                    FCB    0
C210 00            ENDPGM  FCB    0

                           END    START

0 ERROR(S) DETECTED

SYMBOL TABLE:

ADDR1  C203   ADDR2  C20D   CHECK  C187   COMTBL C1FD   ENDPGM C210
INPORT C18B   JWARMS C174   MACH2  C103   MACH20 C13B   MACH21 C13F
MACH22 C156   MACH23 C160   MACH24 C177   MACH25 C179   MEMEND CC2B
MOVE   C12C   MSG    C1A9   MSG2   C1D0   OPORT2 C190   ORIGME C13D
PCRLF  CD24   PORT1  E004   PORT2  E008   PSTRNG CD1E   PUTCHR CD18
RESTOR C19B   START  C100   UCTADD CC12   WARMS  CD03
```

Text continued from page 467:

program, to protect it. This address is checked by most software, which will not use memory above it, making the program fairly safe from being clobbered. Now that the program is in a safe place, you transfer control to it, and it executes. The flowchart (figure 3) shows how it works. All communication with machine 2 is routed through the program until a Control-X is entered from the keyboard, at which time it jumps to the DOS, putting you back in control of machine 1. Executing the program again sends your communication to machine 2, and so on.

Now comes the tricky part. FLEX allows its command table, the lookup table of memory-resident programs and routines that appear as DOS commands to the user, to be extended to include any number of new commands. The advantage of memory-resident programs is that they don't have to be loaded from disk each time they are used—just type in the name of the program and it's running. FLEX does the difficult part. You just have to create the new command-table extension and tell FLEX where it is. This is done by stuffing the address of the table in a special memory location. Then, whenever you type in a command, FLEX looks at its table, then your table, before looking on the disk for the command.

This is the way it works: after power-up, the first time you type "MACH2" the program is loaded from disk and run. Subsequent calls to MACH2 are instantaneous, since the program is already in memory and the addition to the command table points to it. This feature saves much time and disk wear in a long session. The added command table is physically located at the end of the program. Remember, this is a protected area of memory, not likely to get written over. Two commands are in the table: "MACH2", which connects the terminal to machine 2, as described earlier, and "RESTORE", which turns off the multiprocessing. That is, it restores machine 1 to its original configuration by disabling the new command table and putting the top-of-memory pointer back to its original value.

RESTORE was used mainly during program development and debugging. It is not particularly useful now. No provisions were made in the program for passing data files between

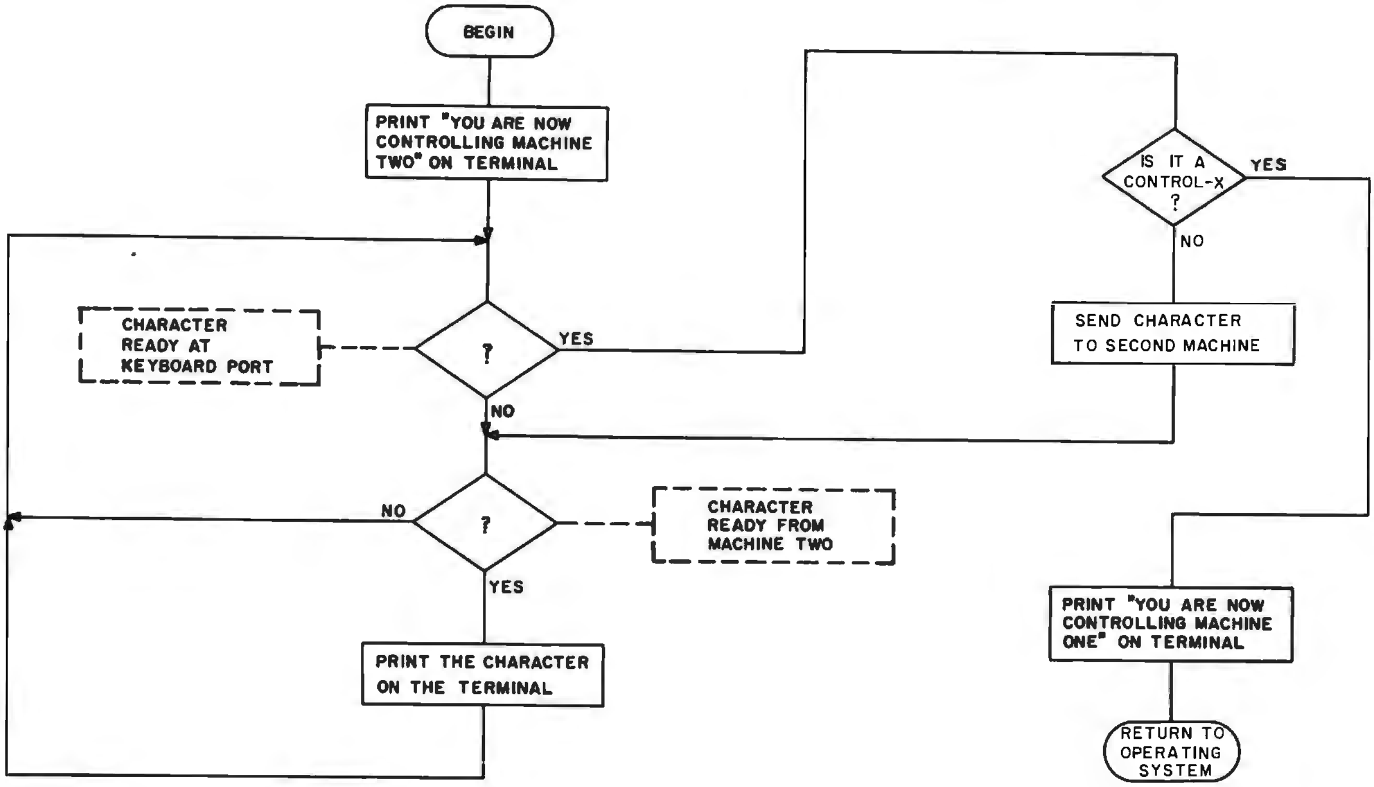

Figure 3: *Flowchart of the algorithm used in the communications and control program given in listing 1.*

machines, just commands. Presently, I move text or data files between machines by swapping disks between drives.

If you are running FLEX on a 6809-based computer, you can use this software as is. If not, the algorithm represented by the flowchart of figure 3 can easily be written in almost any language on any computer. It could even be written in BASIC, if you have latent masochistic tendencies. The extra command table and the self-relocation features are not required, but are handy.

You might even extend the algorithm to control a dozen or more machines. That'll keep you out of trouble for a year or two—trying to dream up a dozen things you need to do simultaneously.

Presently, data transfer is limited to a rate of 9600 bps, the maximum speed available on the serial ports without modification. This just isn't fast enough for some things I have in mind, so my next major project will be dual-port memory for very fast transfer of data between machines. But I think if you try the present scheme, you'll like the results. ■

An Introduction to NSC Tiny BASIC

The Language of the INS8073

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National Semiconductor's new INS8073 Microinterpreter is the first single IC (integrated circuit) that can be programmed in a high-level language. Since a description of the hardware in INS8073-based systems has already appeared elsewhere (see "On-Chip Tiny BASIC Dumps Development Systems," *Electronic Design*, November 22, 1980, page 235), this article will focus on the language of the new chip. Called NSC Tiny BASIC, it resembles other Tiny BASIC interpreters but has certain enhancements, which I'll describe in detail. (See table 1 for a summary of NSC Tiny BASIC features.) Especially noteworthy are NSC Tiny BASIC features that make interrupts and input/output (I/O) routines easy to handle and others that make provisions for multiprocessing.

NSC Tiny BASIC offers advantages to both the inexperienced and the experienced programmer. Using NSC Tiny BASIC, the inexperienced programmer can write comprehensive programs in much less time than equivalent assembly-language programs would require. And since NSC Tiny BASIC lets you jump back and forth between machine code and BASIC, the experienced programmer can write less important routines in BASIC while still using assembly-language for critical routines.

About the Author

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Language Expressions

NSC Tiny BASIC permits the use of 26 variable names: the letters A through Z. The values assigned to these variables are 16-bit signed integers. Fractions or floating-point numbers are not allowed.

All numeric constants are decimal numbers except when preceded by a number sign (#), which indicates a hexadecimal number. For example, "55" would be treated as a decimal number, while "#55" would be treated as hexadecimal (equal to 85 decimal). Decimal constants must be in the range of −32767 to +32767. Relational operators are the standard BASIC symbols (= equal to; > greater than; < less than; <= less than or equal to; >= greater than or equal to; <> not equal to). The relational operators return either a 0 (FALSE) or −1 (TRUE) as a result. Note that >< is an illegal operator.

Standard arithmetic operators are provided for the four basic arithmetic functions (+ addition; − subtraction; / division; * multiplication). The arithmetic is standard 16-bit two's-complement arithmetic. Fractional quotients are truncated at the right, not rounded, and remainders are dropped; therefore, both 16/3 and 17/3 give 5 as a result. As usual, division by zero is not permitted; it will result in an error break.

NSC Tiny BASIC follows the usual algebraic rules for order in evaluating expressions. Parentheses control the order of evaluation, and you should use them liberally. They insure clarity in complicated expressions.

NSC Tiny BASIC provides logical operators AND, OR, and NOT. These perform bitwise logical operations on their 16-bit arguments and produce 16-bit results. The AND and OR operators are called binary operators because they perform an operation on two arguments (or operands). Here's an example of the use of AND, with the binary interpretation shown at right:

```
>LIST
  10 A = 75           A = 0000  0000  0100  1011
  20 B = 99           B = 0000  0000  0110  0011
  30 C = A AND B      C = 0000  0000  0100  0011
  40 PRINT C
>RUN
67
```

The following program shows how the logical AND can be used with other relational operators:

```
>LIST
10 INPUT A
20 INPUT B
30 IF (A>50) AND (B>50) THEN GO TO 60
40 PRINT "ONE OR BOTH ARE SMALL"
50 GO TO 10
60 PRINT "BOTH ARE BIG"
70 GO TO 10
```

If we run the program, console output will look like this:

```
>RUN
? 51
? 52
BOTH ARE BIG
? 51
```

Expressions

Variable Names A—Z
Decimal constants in the range −32767 to +32767
Hexadecimal numbers (preceded by a "#")

Operators

Relational Operators
- =
- >
- <
- >=
- <>

Arithmetic Operators
- +
- −
- /
- *

Logical Operators
- AND
- OR
- NOT

The Indirect Operator

@	Accesses absolute memory locations one byte at a time; e.g., LET X = @6800 assigns value at address 6800 to X.

Functions

MOD (a,b)	Yields absolute value of remainder from division of a by b
RND (a,b)	Generates pseudorandom integer in range from a through b, inclusive
STAT	Represents 8-bit value of the status register
TOP	Yields address of first byte above the program in the current page of RAM
INC	Increments a memory location
DEC	Decrements a memory location

Statements

Input/Output Statements

INPUT	Inputs one or more expressions or numbers, separated by commas (or spaces)
INPUT $ A	Inputs a string to successive memory locations starting at location A
PRINT	Outputs information from program; gives decimal numbers and quoted strings
PRINT $ B	Prints string beginning at address B up to next carriage rturn

Assignment Statements

LET	Sets a variable, memory location, string variable or the status register to value entered

Program-Control Statements

GO TO	Branches to line number
GOSUB	Calls subroutine at line number
RETURN	Returns control from subroutine to line following GOSUB statement
IF/THEN	Shifts program control based on result of logical test
DO/UNTIL	Causes repetition of enclosed statements until specified condition is met
FOR/NEXT	Causes repetition for specified number of times
STEP	Sets size of increment in iterations of FOR/NEXT statements
LINK	Transfers control to a machine-language routine at a specified address
ON	Helps process interrupts; "ON interrupt-#1, 200" transfers control to GOSUB statement at line 200 when specified interrupt occurs.
STOP	Causes program to stop and prints current line number, then returns to edit mode
CONT	Resumes execution of program stopped by STOP
DELAY	Delays execution for specified number of time units up to maximum of 1040 milliseconds
CLEAR	Initializes all variables to 0, disables interrupts, enables BREAK capability, resets all stacks

Commands

NEW	Establishes a new start-of-program address
RUN	Runs the current program
LIST	Lists the current program

Table 1: *A summary of NSC Tiny BASIC features.*

```
? 49
ONE OR BOTH ARE SMALL
? 49
? 49
ONE OR BOTH ARE SMALL
? ^C
STOP AT 10
>
```

The following similar program shows the use of a logical OR with other relational operators:

```
>LIST
10 INPUT A
20 INPUT B
30 IF (A>50) OR (B>50) THEN GO TO 60
40 PRINT "BOTH ARE SMALL"
50 GO TO 10
60 PRINT "ONE OR BOTH ARE BIG"
70 GO TO 10
```

Here's a sample run:

```
>RUN
? 51
? 52
ONE OR BOTH ARE BIG
? 51
? 49
ONE OR BOTH ARE BIG
? 49
? 49
BOTH ARE SMALL
? ^C
STOP AT 10
>
```

The third logical operator (NOT) is unary; i.e., it performs an operation on only one argument. An example follows, again showing the binary interpretation at right:

```
>LIST
  10 A = 11         A = 0000 0000 0000 1011 = 11
                                              10
  20 B = NOT A
  30 PRINT B        B = 1111 1111 1111 0100 = -12
>RUN                                          10
-12
```

Tiny BASIC Functions

NSC Tiny BASIC offers several functions for use in arithmetic expressions. For example, the MOD (or modulo) function returns the absolute value of the remainder from the division a/b, where a and b are arbitrary expressions. If the value of b is zero, an error break will occur as in any division operation. Here's an example of the use of MOD:

```
>LIST
  10 A = 95                  2
  20 B = 44               44 /95
  30 PRINT MOD (A,B)         88
>RUN                          7 MOD (95,44)
  7
```

The NSC Tiny BASIC random-number generator is called RND, and it returns a pseudo-random integer in the range from a through b, inclusive. For the RND function to perform correctly, a should be less than b, and b−a must be less than or equal to 32767 (decimal). A typical example is:

```
>10 PRINT RND (1,100)
>RUN
  27
```

The STAT function returns the 8-bit value of the INS8073 status register. STAT may appear on either side of an assignment statement, enabling you to modify the status register as well as read it. The carry and overflow flags of the status register are usually meaningless, because the NSC Tiny BASIC interpreter itself is continually modifying these flags. The interrupt-enable flag may be altered by an assignment to STAT (e.g., STAT = #FF). Locations of individual flags in the status register are shown in table 2. The function of each bit in the status register is shown in table 3. Here is an example of the use of the STAT function:

```
>LIST
  10 LET A = STAT
  20 PRINT A
>RUN
  176 The decimal number, 176, translates to
  1 0 1 1 0 0 0 0 binary.
```

Other Functions

The TOP function returns the address of the first byte of RAM (random-access read/write memory) above the NSC Tiny BASIC program that is available to the user. This will be the address of the highest byte in the NSC Tiny BASIC program, plus 1. A program can use all the memory in the RAM above and including TOP as scratchpad storage. As an example:

```
>10 PRINT TOP
>RUN
4400      4400 is the first address of unused RAM
```

The INC and DEC functions increment or decrement a memory location X. Here are some examples:

```
10 LET X=1032
20 A=INC(X)
 .
 .
 .
50 B=DEC(X)
60 X=INC(6000)
70 Y=DEC(6000)
```

These instructions are used for multiprocessing and are noninterruptible. This means that if two 8073s are used on the same bus, whenever one processor executes an INC (X) or DEC (X) instruction, the other processor must remain idle. These instructions are generally used for communications between processors in a multiprocessor system.

Statements

The INPUT statement is used to input data to an NSC Tiny BASIC program. One or more items (variables, expressions, etc.), separated by commas, may be entered according to the following formats:

Most Significant Bit	7	6	5	4	3	2	1	0	Least Significant Bit
	CY/L	OV	SB	SA	F3	F2	F1	IE	

Table 2: *A representation of the INS8073 status register. Bits 5 through 0 can be either read or set from NSC Tiny BASIC.*

```
10 INPUT A
20 INPUT B,C
```

When the statement at line 10 is executed, NSC Tiny BASIC prompts you with a question mark. You type in a number, which is assigned to the variable A after you press the RETURN key. NSC Tiny BASIC then prompts

BIT	DESCRIPTION
7	CARRY/LINK (CY/L): This bit is set to 1 if a carry occurs from the most significant bit during an add, a subtract, or any instruction that alters the status register. This bit may also be set by the operations performed by the SHIFT RIGHT WITH LINK (SRL) and the ROTATE RIGHT WITH LINK (RRL) machine-language instructions.
6	OVERFLOW (OV): This bit is set if an arithmetic overflow occurs during a machine-language add or subtract instruction.
	NOTE: Bit 7 and bit 6 may be of little or no use in an NSC Tiny BASIC program.
5	SENSE BIT B (SB): Tied to an external connector pin, this bit can be used to sense external conditions. This is a "read-only" bit; it is not affected when the contents of the accumulator are copied into the status register by a STAT instruction. Sense bit B is also the second interrupt input and may be examined by use of the "ON" command.
4	SENSE BIT A (SA): Like sense bit B, this bit is tied to an external connector pin and serves to sense external conditions. In addition, sense bit A acts as the interrupt input when the INTERRUPT ENABLE (see bit 3 of status register below) is set. This bit is also a "read-only" bit and can be examined with the "ON" command. NSC Tiny BASIC uses this bit as the serial input bit from the TTY or CRT.
3	USER FLAG 3 (F3): This bit can be set or reset as a control function for external events or for software status. It is available as an external output from the INS8073.
2	USER FLAG 2 (F2): Similar to F3. This flag is used by NSC Tiny BASIC to control the paper-tape reader relay.
1	USER FLAG 1 (F1): Similar to F3. This flag is used by NSC Tiny BASIC as the serial-output bit (with inverted data) to the TTY or CRT.
	NOTE: The outputs of flags 1, 2, and 3 of the status register serve as latched flags. These flags are set to the specified state when the contents of the status register are modified by an assignment to STAT, and remain in that state until the contents of the status register are modified under program control.
0	INTERRUPT-ENABLE FLAG (IE): The processor recognizes the interrupt inputs if this flag is set. This bit can be set and reset under program control. When the interrupt-enable flag is set, NSC Tiny BASIC recognizes external interrupt requests received via the SENSE A or B inputs. When reset, this interrupt-enable flag prevents the INS8073 from recognizing interrupt requests.

Table 3: *A summary of the function of each bit in the INS8073 status register.*

you with another question mark, and you type in two numbers, separated by commas. These numbers will be assigned to B and C in that order. A sample run follows:

```
RUN
? 45
? 237, 4455
```

NSC Tiny BASIC would now continue execution of the program.

NSC Tiny BASIC accepts expressions as well as numbers in response to an INPUT request. For example:

```
>LIST
  10 A=10
  20 INPUT B,C
  30 PRINT B,C
>RUN
?A+1,A*2
 11   20
```

The comma between the entered expressions is not mandatory and can be replaced by spaces if the second expression does not start with a plus or minus sign. There must be at least as many expressions in the input list as variables in the INPUT statement. If an error occurs when NSC Tiny BASIC tries to evaluate the typed-in expression, the message

```
RETYPE
```

is printed along with the error message, and the question mark prompt will appear again so that you can type the expressions correctly.

NSC Tiny BASIC allows string input, as described in the section on string handling, found later in this article. INPUT may not be used in the command mode.

The PRINT statement is used to output information from the program. Quoted strings are displayed exactly as they appear, with the quotes removed. Numbers are printed in decimal format. A space precedes positive numbers, and a minus sign precedes negative numbers. All numbers have a trailing space. A semicolon at the end of a PRINT statement suppresses the usual carriage return and line feed with which NSC Tiny BASIC terminates the output.

Strings stored in memory (such as those generated by a string input statement) may also be printed. A typical example:

```
>LIST
  PRINT "THIS IS A STRING"
  20 A=10
  30 B=20
  40 PRINT "10 PLUS 20=", A+B
  RUN
THIS IS A STRING
10 PLUS 20=  30
```

The word LET may be used or omitted in an assignment statement, but the execution of an assignment statement is faster if the word LET is used. The left portion of an assignment statement may be a simple variable (A through Z), STAT, or a memory location, which is indicated by an @ followed by a variable, a number, or an expression in parentheses. Here are some sample assignments:

```
LET X=7
X=7
LET E=I*R
E=I*R
STAT=#70
LET @A=255
@(T+36)=#FF
```

Conditional assignments may be made without using an IF statement. The method hinges on the fact that all predicates are actually evaluated to yield −1 if true and 0 if false. Thus, if a predicate is enclosed in parentheses, it may be used as a multiplier in a statement as shown here:

```
LET X= -A*(A>=0)+A*(A<0)
```

This statement would assign the absolute value of A to X.

Program Control

NSC Tiny BASIC provides an assortment of program-control statements. The GO TO statement permits program branches to a specific line number or a line number called by an arbitrary expression. For example,

```
10 GO TO 50
```

would cause the program to jump from line 10 directly to line 50, but

```
10 GO TO X+5
```

would cause the program to jump from line 10 to line X+5. The value of X is variable, allowing dynamic control of program execution at this point.

The GOSUB and RETURN statements are useful when a computation or operation must be performed at more than one place in a program. Rather than write the routine over again each time it is needed, you employ a GOSUB instruction to "call" the computation or operation (referred to as a subroutine). After the subroutine has been executed, a RETURN instruction (the last instruction of the subroutine) causes the program to resume execution at the next line number following the original GOSUB instruction. An example is shown in figure 1. GOSUBs may be nested up to eight levels deep (including interrupt levels).

The IF. . .THEN statement allows program control to be modified by a logical test condition. The test condition follows the IF clause of the statement. When the test condition is true (nonzero), the THEN portion of the statement will be executed. When the test condition is false (zero), the THEN portion will be ignored and execution will continue at the next numbered line of the program. For example:

```
50 IF X>J THEN GO TO 140
```

NSC Tiny BASIC allows the omission of the word THEN from an IF. . .THEN statement. This omission, also allowed on some larger BASICs, enhances the clarity of the program. The previous example would become:

```
50 IF X>J GO TO 140
```

The DO. . .UNTIL statement is unique to NSC Tiny BASIC. Borrowed from Pascal, this statement is used to program loops, thus keeping GO TO statements to a minimum. The DO. . .UNTIL statement makes NSC Tiny BASIC programs clear in structure and easy to read. The following example shows the use of DO. . .UNTIL statements to print numbers less than 100:

```
10 PRINT 1: PRINT
20 PRINT 2
30 I=3                 :REM I IS NUMBER TESTED
40 DO
50 J=1/2               :REM J IS THE LIMIT
60 N=1                 :REM N IS THE FACTOR
70 DO                  :REM SEEKS A DIVISIBLE
                       FACTOR OF I
80 N=N+2
90 UNTIL (MOD(I,N)=0 OR (N>J))
100 IF N>J PRINT I     :REM NO DIVISIBLE FACTOR
110 I=I+2
120 UNTIL (I>100)      :REM ENDS THE SEARCH
```

By enclosing a 0 or more statements between the DO and the UNTIL <condition> statement (where the <condition> is any arbitrary expression), you cause repetition of the enclosed statements as a group until the <condition> evaluates to a nonzero number (a true condition). DO. . .UNTIL loops can be nested, and NSC Tiny BASIC will report an error if the nesting level becomes too deep (more than eight levels).

The FOR. . .NEXT statement in NSC Tiny BASIC is identical to the FOR. . .NEXT statement in standard

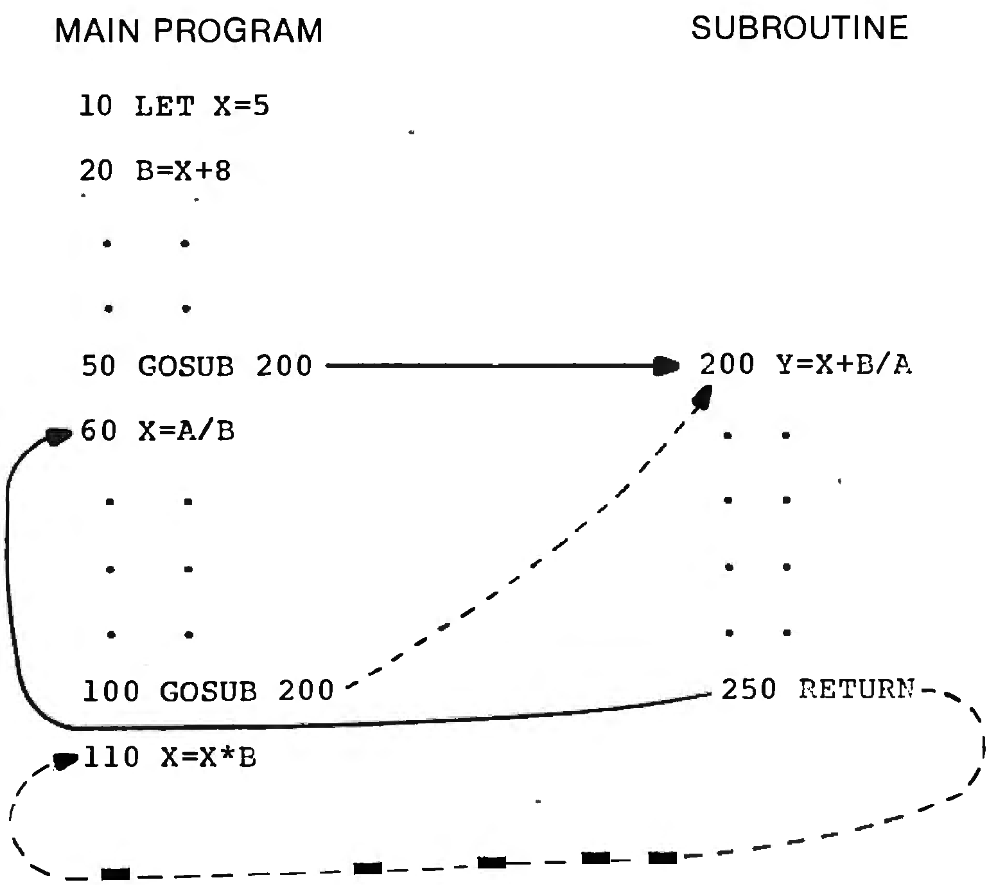

Figure 1: *The effects of the GOSUB and RETURN statements in NSC Tiny BASIC. On the first GOSUB call (line 50), the order of execution follows the solid arrows. On the second GOSUB call (line 100), the order of execution follows the dashed arrows.*

BASICs. A STEP function in the FOR statement may be used to specify the size of the increment in each iteration of the statement. In the absence of a specified STEP, NSC Tiny BASIC assumes a STEP value of +1. The value of the STEP may be either positive or negative. Starting and ending values of the FOR. . .NEXT loop are included in the FOR statement. The loop is repeated when the NEXT statement has been executed, provided the upper limit of the FOR statement has not been reached. When the upper limit is reached, the program will exit from the FOR. . .NEXT loop. NSC Tiny BASIC causes an error break if the variable in the NEXT statement is not the same variable as that used in the FOR statement.

FOR. . .NEXT loops may be nested, and NSC Tiny BASIC will report an error if the nesting level becomes too deep; a depth of four levels of FOR loop nesting is allowed. A FOR loop will be executed at least once, even if the initial value of the control variable already exceeds its bounds before starting. The following program would print the odd integers less than 100:

```
10 N=100                 :REM UPPER LIMIT
20 FOR I=1 TO N STEP 2   :REM START AT 1 WITH
                         STEP OF 2
30 PRINT I               :REM PRINT A NUMBER
40 NEXT I                :REM REPEAT (at line 20)
                         20)
```

When increased execution speed is needed, you can use a LINK statement to transfer control from an NSC Tiny BASIC program to an INS8073 machine-language routine. A statement of the form LINK <address> will cause transfer of control to the INS8073 machine-language routine, starting at the specified address. Control is transferred by execution of a JSR (Jump to Subroutine) instruction.

The INS8073 has two address pointers, P2 and P3, in addition to the program counter and the stack pointer. When a LINK statement transfers control to a machine-language routine, the routine can modify the pointers P2 and P3. The value of pointer P3 is unpredictable; P2 points at the starting location of the storage of A through Z variables. These variables are stored in ascending alphabetical order, two bytes each, low-order byte first. Here is an example:

```
  10 LINK #1800                NSC Tiny BASIC trans-
  20 IF A=0 THEN PR              fers to address #1800
     "SENSE A IS LOW"            to read sensor.
  30 IF A=1 THEN PR
     "SENSE A IS HIGH"
  99 STOP                      Program transfers back
>RUN                             to NSC Tiny BASIC
SENSE A IS HIGH
STOP AT 99
>RUN
SENSE A IS LOW
STOP AT 99
```

The program above requires the machine-language program described below to be loaded into address 1800 hexadecimal.

```
                  .TITLE SENSE    ;THIS PROGRAM
                                  READS SENSE A PIN
  0000            .=01800
  1800 06         LD    A,S       ;TINY BASIC JUMPS
                                  HERE
  1801 D410       AND   A,=16
  1803 6C02       BZ    LOW
  1805 C401       LD    A,=1
  1807 CA00       ST    A,0,P2    ;STORES AC-
                                  CUMULATOR INTO
                                  LOCATION OF
                                  VARIABLE A
  1809 5C         RET             ;RETURN TO TINY
                                  BASIC
       0000       .END
```

The ON statement helps process interrupts. The format of the statement is:

ON interrupt−#, line-number

When the numbered interrupt (interrupt−#) occurs, NSC Tiny BASIC executes a GOSUB statement beginning at the line number given. If the line-number given is zero, the corresponding interrupt is disabled at the software level. Interrupt numbers may be 1 or 2. Use of the ON statement disables console interrupts (BREAK function). Interrupts must also be enabled at the hardware level by setting the interrupt-enable bit in the status register (e.g., using STAT=1).

Although the last line of a program does not have to be a STOP statement, use of a STOP in this way does help in debugging. The STOP statement may be inserted as a breakpoint in an NSC Tiny BASIC program. On encountering a STOP statement, NSC Tiny BASIC prints a stop message and the current line number, then returns to the edit mode. Thus, you can see whether your program has reached the desired point. Any number of STOP statements may appear in the program. By removing the STOP statements one by one, you can test the program in parts until debugging is completed. Execution of a stopped program may be continued after the STOP by a CONT (continue) command.

Other Useful Features

The DELAY statement delays NSC Tiny BASIC for "expr" time units (nominally milliseconds, 1 through 1040). Delay 0 gives the maximum delay of 1040 ms. The format is:

DELAY expr

For example:

```
>10 DELAY 100        Delay 100 ms.
```

The CLEAR statement initializes all variables to 0, disables interrupts, enables BREAK capability from the console, and resets all stacks (GOSUB, FOR. . .NEXT, and DO. . .UNTIL). For example:

10 ON (2,250)	Break is disabled, Interrupt 2 is enabled.
	.
	.
	.
300 CLEAR	Break is reenabled, Interrupt 2 is disabled.

The indirect operator is an NSC Tiny BASIC exclusive, at least in the realm of BASIC. This operator performs the functions of PEEK and POKE with a less cumbersome syntax. The indirect operator can access absolute memory locations and can service input/output devices as well. Its utility is especially significant for microprocessors like the INS8073, for which interfacing is commonly performed through memory addressing.

When an "at" sign (@) precedes a constant, a variable, or an expression in parentheses, that constant, variable, or expression is taken as an unsigned 16-bit address at which a value is to be obtained or stored. Thus, if an input device has an address of #6800 (hexadecimal), the statement

```
LET X=@#6800
```

would input from that device and assign the value of the input to the variable X. If the address of an output device was #6801, the statement

```
@#6801=Y
```

would output the least significant byte of Y to the device. The indirect operator accesses memory locations only one byte at a time. An assignment such as @A=248 changes the memory location pointed to by A to 248 binary (1111 1000), since 248 can be expressed as one byte. However, an assignment such as @A=258 changes the memory location pointed to by A to 2, because expressing the value 258 causes a carry to a ninth bit, which is lost, as shown below:

258_{10} =	1	0000 0010
	extra bit	one byte (stored into location to which A would point)

Only the least significant byte of 258 (which is 2) is stored at the location to which A would point.

In any place where a variable, such as B, would be legal, the construct "@B" (which means the byte located at the memory location whose address is the value of B) would also be legal. Here are some other examples:

40 LET B=6000	Assigns 6000 to B.
50 LET @B=100	Stores decimal 100 in memory location 6000.
60 LET C=@B	Sets C equal to 100.
70 PRINT @6000	Prints 100.
80 LET D=@(A+10*D)	Sets D equal to the value stored in memory location (A+10*D).

Parentheses are required when @ is applied to an expression.

More than one statement can be placed on one program line by placing a colon between the statements. This technique can improve readability of the program and can save memory space. Here is an example of the use of multiple statements:

```
200 PRINT "MY GUESS IS",Y:PRINT "INPUT A
    POSITIVE NUMBER";: INPUT X:
    IF X < =0 GO TO 200
```

If X is negative or zero, you will be instructed to enter a positive number, and the program will return to line 200 for a new guess. If you had entered a positive number correctly, the program would have proceeded to the next numbered line after line 200.

You must use multiple statements per line with care. The above example shows that if the condition of the IF statement is false, control passes to the next program line. Anything else on the line containing multiple statements will be ignored.

String Handling

To input string data, a statement of the form

```
INPUT $ F
```

where F is a starting address, is used. When the program reaches this statement during program execution, NSC Tiny BASIC prompts you with a question mark (?). All line-editing characters may be used (back space, line delete, etc.). If a control-U is typed to delete an entered line, NSC Tiny BASIC will continue to prompt for a line until a line is terminated by a carriage return. The line is stored in consecutive locations, starting at the address pointed to by F, up to and including the carriage return. For example,

```
20 INPUT $ A
```

may also be written

```
20 INPUT $A
```

and inputs a string to successive memory locations starting at A.

An item in a PRINT statement can include a string variable in the form of $B. When the print statement is encountered during program execution, the string will be printed beginning at the address B up to, but not including, a carriage return. A keyboard interrupt will also terminate the printing of the string if the interrupt is detected before the carriage return. For example,

```
50 PRINT $B
```

prints the string beginning at the location pointed to by "B".

Characters in quotes can be assigned to string variables just as numerical values are assigned to other variables. A statement of the form

```
$C="THIS STRING IS A STRING"
```

when encountered during program execution, would cause the characters in quotes to be stored in memory starting at the address indicated by C and going up to and including the carriage return at the end of the line. For example:

```
70 $D="THIS IS A STRING WITH NO
   INPUT STATEMENT."
```

A T is stored at location "D", an H at location "D+1", etc.

Strings can be moved from one memory block to another. A statement of the form

```
$A=$B
```

(where A and B are addresses) will transfer the characters in memory beginning with address B to memory beginning with address A. The last character, normally a carriage return, is also copied. Note that a statement such as

```
$(A+1)=$A
```

would be disastrous, because it fills all of RAM with the first character of $A. Here is an example of moving one memory block to another location:

```
10 A=TOP          :REM A POINTS TO EMPTY
                   RAM ABOVE TOP OF
                   PROGRAM
20 C=TOP+100      :REM C POINTS TO RAM 100
                   BYTES ABOVE A
30 D=TOP+200      :REM D POINTS TO RAM 100
                   BYTES ABOVE C
40 INPUT $A       :REM STORES CHARACTERS
                   WHERE A POINTS
50 PRINT $A
60 LET $C="IS THE STRING INPUT AT LINE 10"
70 $D=$C          :REM STORES CHARACTERS
                   WHERE D POINTS
80 PRINT $D
```

Commands

The NEW command establishes a new start-of-program address equal to the value of "expr". NSC Tiny BASIC then executes its initialization sequence, which clears all variables, resets all hardware/software stacks, disables interrupts, enables BREAK capability from the console, and performs a nondestructive search of RAM. If the value of "expr" points to a ROM (read-only memory) address, the NSC Tiny BASIC program that begins at that address will be automatically executed. The NEW command does not alter memory (including the end-of-program pointer used by the editor). For example:

```
>NEW 1000
```

NEW used without an argument sets the end-of-program pointer equal to the start-of-program pointer, so that a new program may be entered. If a program already exists at the start-of-program address, it will be lost. For example:

```
>NEW 1000   Sets program pointer to 1000
>NEW        Sets end-of-program pointer to 1000
```

The RUN command runs the current program. For example:

```
>RUN        Execution begins at lowest line
            number
```

The CONT (continue) command continues execution of the current program from the point where execution was suspended (via a STOP, console interrupt, or reset). An NSC Tiny BASIC program that is executing can be interrupted by pressing the BREAK or RESET keys on the keyboard. Execution can be resumed by entering the CONT command. For example:

```
>RUN
  THIS IS THE STRING INPUT AT LINE 10
  THIS IS THE STRING INPUT AT LINE 10
  THIS IS THE STRING INPUT AT LINE 10
  THIS IS THE STRING INPUT AT LINE 10 Press
    BREAK or RESET.
^C
>CONT
  THIS IS THE STRING INPUT AT LINE 10
  THIS IS THE STRING INPUT AT LINE 10
  And so on...
```

The LIST(expr) command lists the current program (optionally starting at the line number specified by "expr"). For example:

```
>LIST 10
10 INPUT $A
20 PRINT $A
30 LET $C="IS THE STRING INPUT AT LINE 10"
40 $D=$C
50 PRINT $D
```

Conclusion

NSC Tiny BASIC and the INS8073 Microinterpreter Chip offer many advantages to the programmer. NSC Tiny BASIC's indirect operator represents a substantial improvement over the usual PEEK and POKE statements. The DO . . . UNTIL statement brings the advantages of structured programming into the realm of Tiny BASICs for the first time. These and other advanced features of NSC Tiny BASIC offer you the convenience of a high-level language as well as new possibilities for elegance and efficiency in process-control and other applications often reserved for assembly language.

Furthermore, with NSC Tiny BASIC and the INS8073, transferring programs from RAM to ROM is remarkably simple. Because the INS8073 executes ASCII (American Standard Code for Information Interchange) data, if the program will run in RAM, it will run in ROM. You don't have to put anything in ROM except what you put on paper.

Programmers have already used the INS8073 and NSC Tiny BASIC for a wide variety of applications, including precision measurement of conditions in oil wells and testing the feasibility of the digital design of an FM tuner. In the coming years, the INS8073 and NSC Tiny BASIC will simplify many other complex tasks.■

Easy Entry Program for Radio Shack's Color Computer

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Radio Shack's versatile new TRS-80 Color Computer packs a big bang for a small cost. The power of its 6809 microprocessor is the computer's biggest attraction.

To take full advantage of the 6809, you must develop machine-language programs. The Easy Entry program is a short BASIC program that will greatly help you enter machine-language programs for the Color Computer. By no means does it replace an assembler, but Easy Entry will save you many hours of arduous and error-prone work until you get one. (For more information, see "A Closer Look at the TRS-80 Color Computer," October 1981 BYTE, page 334.)

The Color Computer's BASIC provides the necessary keywords (PEEK, POKE, and USR) to permit entry of machine-language programs. However, using these commands to enter a short program is soon cumbersome and tedious. You must develop, code, and hand-assemble the program, enter it into memory, and test and debug it. And the entry is not that simple.

All values must be converted into decimal values between 0 and 255 before they can be POKEd into the Color Computer. Op codes must be individually converted to decimal from their hexadecimal format in the 6809 data sheets. Negative values must be converted to the form understood by the computer. Decimal addresses greater than 255 must be broken down into two-byte values. Then, after completing all these conversions, each value must be individually POKEd into memory. The Easy Entry program (see listing 1) handles all conversions and POKEs each converted value into its proper memory locations.

Plug-in Programming

If you're serious about assembly-language programming for the Color Computer, you'll need an assembler/editor, which allows much more efficient programming.

*The Color Computer's unique design makes it possible to purchase plug-in ROM cartridges containing editor/assembler programs. Two examples are the Radio Shack Editor/Assembler Program Pack (part number 263250, $39.95) and the Micro Works Software Development System (SDS80C, $89.95). With these utility programs in ROM, the constant problem of loading and relocating programs is eliminated and almost the entire RAM space is available to your program. . .*SJW.

Conversions

Normal Decimal Entries. A single byte value (0 to 255 or −127 to 127) may be specified simply by responding with the desired value on a prompt from the program. For example, to POKE value 98 decimal into the next memory location, input 98 at the next prompt.

Hexadecimal to Decimal Conversions. PEEK and POKE accept and return decimal values for specified memory locations. This is terrific because we live in a decimal-reliant society and are uncomfortable working directly with hexadecimal values. Unfortunately, computers "think" in binary (0s and 1s), which is not easily converted to decimal (and vice versa). However, binary to hexadecimal to binary conversions are relatively straightforward, and the resulting hexadecimal values occupy considerably less room (two characters per byte for hexadecimal versus eight characters for binary).

Listing 1: *The Easy Entry program, written in BASIC for the Color Computer. A complete description of the program is given in table 1.*

```
10   CLS:CLEAR(40):INPUT"START:";A$:A=275:GOSUB200
20   A=VAL(A$)
30   PRINTA;:INPUT"NEXT:";C$:IFC$="*"THENEND
40   A$=RIGHT$(C$,LEN(C$)-1):D$=LEFT$(C$,1)
50   IFD$=","THENGOSUB200ELSEIFD$=";"THENGOSUB300ELSEA$=C$:GOSUB100
60   A=A+1:GOTO30
100 U=VAL(A$):IFLEFT$(A$,1)="-"THENU=256+U
110 POKEA,U:RETURN
200 U=VAL(A$):B=ABS(U):V=-1
210 IFU<0THENU=B:K=1ELSEK=0
220 IFU>=0THENU=U-256:V=V+1:GOTO220
230 U=B-V*256:IFK=1THENU=256-U:V=255-V
240 POKEA,V:A=A+1:POKEA,U:RETURN
300 C=LEN(A$):GOSUB400:J=E:C=C-1:GOSUB400
310 POKEA,16*E+J:RETURN
400 IFC<1THENE=0ELSEE=ASC(MID$(A$,C,1))-48
410 IFE>9THENE=E-7
420 RETURN
500 G$="O":GOSUB700:INPUT"START:";X:INPUT"END:";Y
510 PRINT#-1,X:PRINT#-1,Y
520 FORZ=X TO Y:A=PEEK(Z):PRINT#-1,A:NEXTZ:CLOSE-1:END
600 G$="I":GOSUB700:INPUT#-1,X:INPUT#-1,Y
610 PRINTX,Y:A=275:B=X:U=X:V=-1:GOSUB210
620 FORZ=X TO Y:INPUT#-1,A:POKEZ,A:NEXTZ:CLOSE-1:END
700 INPUT"FILE NAME:";F$:OPENG$,-1,F$:RETURN
```

Since op codes are often specified in hexadecimal and must be converted to decimal before being POKEd into memory, the program handles the conversion for you. To indicate that the current entry is a hexadecimal value, merely precede it with a ";". The acceptable values must be in the 00 to FF range. For example, ;7F tells the program to convert hexadecimal value 7F to decimal 127 before being POKEd into memory.

Decimal to Decimal Conversions. You might question the necessity of converting a decimal value to decimal. POKE will accept values between 0 and 255; if a value exceeds 255, it must be broken down into multiple bytes, which are then POKEd into memory in order, from the most significant to the least significant byte. For example, the decimal value 3500 is broken down into a most-significant-byte value of 13 (decimal) and least-significant-byte value of 172.

This process usually involves manually converting the original value into its hexadecimal equivalent (3500 decimal to 0DAC hexadecimal), breaking the hexadecimal value into two bytes (0D and AC), and then reconverting these two bytes to decimal (0D to 13 and AC to 172). The program will accept any input value which is preceded by a ".", convert that into two bytes of decimal, and POKE both into memory. This gives a value range of 0 to 65535.

Negative Decimal to Positive Decimal. As previously mentioned, the POKE function takes values between 0 and 255. If you wish to POKE a negative number into memory (e.g., a negative branch offset), you must convert the negative value to its positive equivalent. To understand how a negative value has an equivalent positive value, we must look at how the computer "knows" if a value is positive or negative.

When seeking a data value, the computer expects to use the most significant value bit as the sign bit. If the value is 8 bits long, bits 0 to 6 are the value bits and bit 7 (the eighth bit) specifies whether the value is positive or negative. If the sign bit indicates a negative value, the

Listing 2: *This sample program paints the screen purple and then returns to BASIC control. Memory locations 1024 to 1536 are used for video memory in the Color Computer. Value 191 paints one block on the screen purple.*

```
LDB     191     ; C6  191
LDY     1024    ; 10 8E  1024
STB     ,Y+     ; E7 A0
CMPY    1536    ; 10 8C  1536
BLT     -8      ; 2D  -8
RTS             ; 39
```

Listing 3: *This listing shows an Easy Entry program sample run. The machine-language program in listing 2 has been entered.*

```
RUN
START:? 3000                 (Start POKEing at address 3000)
 3000 NEXT:? ;C6             (At address 3000 poke hex value C6)
 3001 NEXT:? 191             (Poke single byte decimal 191)
 3002 NEXT:? ;10
 3003 NEXT:? ;8E
 3004 NEXT:? ,1024           (Poke double byte decimal 191...takes two bytes)
 3006 NEXT:? ;E7
 3007 NEXT:? ;A0
 3008 NEXT:? ;10
 3009 NEXT:? ;8C
 3010 NEXT:? ,1536
 3012 NEXT:? ;2D
 3013 NEXT:? -8              (Poke negative single byte decimal -8)
 3014 NEXT:? ;39
 3015 NEXT:? *               (Done with entering program)
OK                           (Computer response)
Y=USR(1)                     (Execute program)
```

value bits specify the two's complement of the absolute value. This provides an effective value range for 8 bits between −127 and +127. Thus, 255 decimal indicates a negative value and, taking the two's complement of the value bits, we find that we have specified a −1.

The program automatically converts negative decimal values into their positive equivalents. The value may be either 8 or 16 bits.

Operation

The program is simple to operate. On initiation, the program prompts you for the starting address for the first byte of the machine-language program. The address is stored in memory locations 275 and 276, so a simple USR command after entry of the machine-language program executes that program. You are then prompted for each value in sequence, starting at the beginning address. The current address is displayed with each prompt, and this entry loop continues until you enter an asterisk (*) to signify termination of the program-entry session. The program then returns control of the computer to you. (See listings 2 and 3 for examples of an Easy Entry program sample run.)

Saving and Loading Machine-Language Programs

Once you enter and debug a machine-language program, you can save it on tape. Since the Color Computer's BASIC does not allow you to directly save machine-language programs, I have included two routines (lines 500 through 700) that save and load the programs for you. If you have a 4 K-byte machine and are developing a large machine-language program, you can separate these two routines from the main program and load them only when ready to save your program. Lines 210 through 240 and 500 through 700 must be used.

If you wish to leave the program conveniently intact, there are still more than 1700 bytes available for the 4K-byte computer. (If you have 16K bytes of memory, you naturally have lots of space.) You should limit machine-language programs to address 2500 decimal and up.

Type "RUN 500" to save a machine-language program. You will be prompted for the desired file name for program storage and the starting and ending address of the machine-language program. All bytes between the starting and ending addresses are saved on tape. For example, you might have a program with a main loop at address 2500 through 3000, subroutines at 3100 through 3150 and 3400 through 3450, and a data table at 3475 through 3500. You would want to save your program from ad-

Lines	Purpose
Main Routine	
10	Initialize program. Prompt user for starting address and place into 275-276.
20-30	Prompt input from user . . . if "*" then end program.
40-50	Determine type of input. Jump to appropriate subroutine for conversion and POKEing of value.
60	Move to next address and repeat.
Subroutines	
100-110	Value is between −255 and +255. If negative, negate input. POKE value.
200-240	Input (A$) is a decimal value to be converted into two eight-bit values. Line 220 loops, subtracting 256 from U per loop until U is less than zero. Then, the most significant byte is V; least significant byte is U. POKE both bytes and increments POKE pointer A.
300-310	Input is hexadecimal (00-FF). The value is calculated by finding the decimal equivalent of each ASCII value and then adjusting these values to give appropriate results. The final value is then calculated by adding the least significant value (corresponding to least significant hexadecimal entry) to 16 times the most significant entry.
400-420	Input single hexadecimal character (character C in string A$) and return the equivalent decimal value in variable E. If C< 1 then return E = 0.
Save/Load Routines (execute with "RUN 500" or "RUN 600" commands)	
500-520	Input file name, starting and ending addresses, and save specified memory block to cassette tape.
600-620	Input file name. Load file from cassette into memory address found at start of data file. Poke starting address into 275-276 to allow the USR command to execute loaded program.
700	Routine used by 500 and 600. Used to fetch file name of desired file to be saved or loaded.

Table 1: *The Easy Entry program routines and their functions.*

dress 2500 to 3500. All unused addresses between the routines and the tables are also saved.

To load a previously saved machine-language program, type "RUN 600". You will be prompted for the file name of the program to be loaded. The program then reads from the tape the starting and ending addresses used when the program was stored,sorting the program in those memory locations. The starting address of the program being loaded is automatically converted into two bytes and POKEd into memory locations 275 and 276. Thus, if you have a complete program loaded, you can immediately execute it by typing Y=USR(1).

Since Easy Entry loads machine-language programs into specific memory locations, you can save parts of programs, load them all separately, and execute a program. For instance, you might be developing several programs, each using a large subroutine. If the subroutine is subject to changes, or if you store the subroutine with each separate program, it is easy to lose track of revisions. However, if you want that routine at a permanent location (say address 3700 through 4100), you can save it separately from other programs. Then, wishing to execute one program, you load the subroutine, load the program's main body, and execute. Be certain that the proper address is loaded into memory locations 275 and 276 so that the computer knows where to look when you execute the USR command.

How the Routines Work

The save and load routines treat each machine-language program byte as data. To save a program, each byte is consecutively PEEKed at and then sent to the tape using the PRINT#-1 command. The first two pieces of data stored in the data file are the starting and ending addresses of the machine-language program being stored. When the load routine is executed, it reads these two addresses, reads all data from the tape, and POKEs it into the specified memory block.

You might think that saving a large machine-language program to tape and writing each individual byte to tape separately would be time consuming. Thanks to the PRINT#-1 statement's design, this isn't so. Apparently, the Color Computer's BASIC sets aside a buffer used to store the PRINT#-1 data values. When this buffer is full, data is sent to the tape and the buffer is refilled, allowing you to save a machine-language program of 2 K bytes in about 30 seconds. The time required to load a program is similar.

The Easy Entry program requires only about 450 bytes of memory. For a 4 K-byte Color Computer, this leaves almost 2000 bytes of available memory to store machine-language programs. A lot can be accomplished in 2000 bytes of machine language.

Your machine-language programs may be entered starting at address 2200. Little error checking is included in the program to keep it as small as possible. After entering a few values, you should become adept at using the program and save yourself many hours. ■

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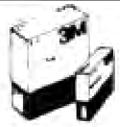

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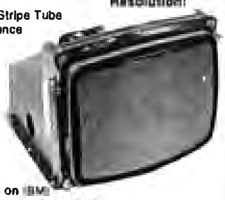

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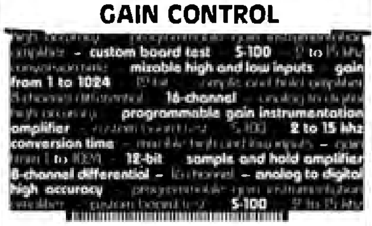

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Clubs and Newsletters

Atari Club in Virginia

The recently formed Virginia Atari Club meets at 5 p.m. on the second Thursday of the month in the NASA Langley Research Activities Building (1222) in Hampton, Virginia. For more information, contact Olaf O. Storaasli, 109 Five Forks Ln., Hampton, VA 23669, (804) 851-4936.

DATAmerica

A newsletter packed with games, reviews, articles, software exchange, and programs is available from DATAmerica Computer User's Group. The group's interests embrace most popular computers, including the Apple II, TRS-80, Sinclair, Atari, PET, and VIC-20. Membership fees are $10 per year. A sample issue of the newsletter is available for $1. Contact DATAmerica, 312 East 84 St. #1A, New York, NY 10028, or through the Micronet RUN MLOM. XBA[70265,742].

International Service Association Formed

The International Association of Service Companies (IASCO) has been formed to provide specialized support services to independent service companies supporting mini- and microcomputer systems. To aid the independent service organization, IASCO has established a Board of Governors to coordinate the activities of several specialized industry committees. The Board's goals hinge around the development of service standards of performance for its membership, the implementation of centralized information centers to aid members, and to prepare and coordinate both technical and managerial educational programs for members. IASCO is currently preparing a support profile listing the various locations throughout the United States and Canada serviced by its membership. This information will be made available to interested parties.

Service companies seeking IASCO membership will be required to meet minimum standards of service performance, service times, test equipment availability, and technical capability. For more information, contact S. Michael Smith, 1409 Centre Circle Dr., Downers Grove, IL 60515, (312) 620-8750.

Color Computer Club Started

Rohit Gupta has started a new computer club for TRS-80 Color Computer owners and users. Annual dues are $4, which includes a monthly newsletter on Color Computer developments. Contact Rohit Gupta, 28 Friars Ln., Springfield, IL 62704.

New Zealand Computer Hobbyists

Micro, the official publication of the New Zealand Microcomputer Club, overflows with news of club projects and activities, classified advertisements, software library happenings, and notes from user groups. The club is investigating the chances of setting up a computerized bulletin-board service and is trying to stock its magazine library. The club would like to discuss the possibility of exchanging publications with groups from overseas. Contact the New Zealand Microcomputer Club Inc., POB 6210, Auckland, New Zealand.

Apple Club Open to Hobbyists

Membership in the Big Red Apple Club is open to anyone who, for geographical reasons, is unable to belong to a local club. All club business is conducted through the monthly newsletter, *The Scarlett Letter*, which also contains programs, utilities, technical tips, and educational applications. A free software library is maintained. Annual fees are $12. The club is a member of the International Apple Corp. Contact John Wrenholt, Big Red Apple Club, 1301 North 19th, Norfolk, NE 68701, (402) 379-3531.

Apples Thrive Down Under

The Apple Users Group (Sydney) has formalized its objectives in a constitution and has elected an executive committee to direct the activities of its large membership. The club meets at the Sydney Grammar School, Science Auditorium, on the second Monday of the month at 6:30 p.m. The group maintains a software library and produces a monthly newsletter, *Applecations*. Contact the Apple Users Group (Sydney), POB 505, Bankstown, New South Wales 2200, Australia, or call Colin Rutherford, (02) 520 0926. ■

Books Received

Apple Pascal Games, Douglas Hergert and Joseph T. Kalash. Berkeley, CA: Sybex, 1981; 371 pages, 17.2 by 22.3 cm, softcover, ISBN 0-89588-074-1, $14.95.

The Apple II Blue Book, A Complete "Where to Find It" Book of Software, Hardware, and Accessories for the Apple II, WIDL Staff. Chicago, IL: WIDL (5245 West Diversey Ave.), 1981; 131 pages, 21 by 26.5 cm, softcover, ISBN none, $19.95.

Computer-Assisted Data Base Design, George U. Hubbard. New York: Van Nostrand Reinhold, 1981; 285 pages, 14.5 by 22.3 cm, hardcover, ISBN 0-442-23205-5, $24.95.

The Captain 80 Book of BASIC Adventures, Robert Liddil. Tacoma, WA: 80-Northwest Publishing, 1981; 252 pages, 20.5 by 27 cm, softcover, ISBN none, $19.95.

Computing Using BASIC, An Interactive Approach, Tonia Cope. New York: Halsted Press, 1981; 351 pages, 14.5 by 22.3 cm, softcover, ISBN 0-470-27280-5, $19.95.

Data Models, Dionysios C. Tsichritzis and Frederick H. Lochovsky. Englewood Cliffs, NJ: Prentice-Hall, 1982; 381 pages, 17.5 by 23.6 cm, hardcover, ISBN 0-13-196428-3, $24.95.

A Dictionary of Minicomputing and Microcomputing, Philip E. Burton. New York: Garland STPM Press, 1982; 347 pages, 14.5 by 22.3 cm, hardcover, ISBN 0-8240-7263-4, $42.50.

Directory of Online Databases, Volume 3, Number 1 (Fall 1981), compiled and edited by Ruth N. Cuadra, David M. Abels, and Judith Wanger. Santa Monica, CA: Cuadra Associates, 1981; 186 pages, 21 by 27.5 cm, softcover, ISSN 0193-6840, $29.95.

Electronic Circuits and Applications, Bernard Grob. New York: McGraw-Hill, 1981; 468 pages, 18.5 by 23.5 cm, hardcover, ISBN 0-07-024931-8, $20.95.

55 Color Computer Programs for the Home, School and Office, Ron Clark. Woodsboro, MD: Arcsoft Publishers, 1981; 127 pages, 13.5 by 21 cm, softcover, ISBN 0-86668-005-5, $9.95.

The Index, The Ultimate Index for All Personal Computer Users, W. H. Wallace. St. Ann, MO: Missouri Indexing (POB 301), 1981; 489 pages, 13 by 20.5 cm, softcover, ISBN none, $14.95.

Instant Freeze-Dried Computer Programming in BASIC, Jerald R. Brown. Beaverton, OR: Dilithium Press, 1982; 193 pages, 20.7 by 27.5 cm, softcover, ISBN 0-918398-57-6, $12.95.

Introduction to Computers and Computer Science, 3rd edition, Richard C. Dorf. San Francisco, CA: Boyd & Fraser Publishing Company, 1981; 617 pages, 16.4 by 23.8 cm, hardcover, ISBN 0-87835-113-2, $18.95.

Introduction to Word Processing, Hal Glatzer. Berkeley, CA: Sybex, 1981; 205 pages, 14.5 by 22.3 cm, softcover, ISBN 0-89588-076-8, $12.95.

JCL in a System 370 Environment, Barry L. Bateman and Gerald N. Pitts. Boston, MA: CBI Publishing, 1982; 182 pages, 18.5 by 23 cm, softcover, ISBN 0-8436-1606-7, $16.95.

Knowledge-Based Systems in Artificial Intelligence, R. Davis and D. B. Lenat. New York: McGraw-Hill, 1982; 490 pages, 23.5 by 16.5 cm, hardcover, ISBN 0-07-001557-7, $39.50.

Pascal: An Introduction to Methodical Programming, 2nd edition, W. Findlay and D. A. Watt. London, England: Pittman Books Ltd., 1981; 404 pages, 14.5 by 22.5 cm, softcover, ISBN 0-273-01714-4, £5.95.

Programming in BASIC-Plus, Jasper J. Sawatzky and Shu-Jen Chen. New York: John Wiley & Sons, 1981; 273 pages, 20.8 by 27.4 cm, softcover, ISBN 0-471-07729-1, $14.95.

The UCSD Pascal Handbook, Randy Clark and Stephen Koehler. Englewood Cliffs, NJ: Prentice-Hall, 1982; 356 pages, 15 by 23 cm, hardcover, ISBN 0-13-935544-8, $19.95.

The Word Processing Handbook, Russell Allen Stultz. Englewood Cliffs, NJ: Prentice-Hall, 1982; 237 pages, 17.5 by 23.5 cm, hardcover, ISBN 0-13-963454-1, $17.95. ■

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.

Event Queue

April 1982

April
Courses from George Washington University, Hampton, VA; Salem, NH; Washington, DC; London, England; and Berlin, West Germany. Among the courses scheduled are "Voice Input/Output," "Microwave Systems Planning," "Writing Professional and Technical Communications," and "Computer Graphics Systems: Design and Applications." For further information, contact Continuing Engineering Education, School of Engineering and Applied Science, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-6106.

April
Courses in Structured Systems, various sites throughout the U.S. Courses in "Structured Systems Design," "Structured Requirements Definition," and "Management Overview of Data Structured Systems Development" are being offered by Ken Orr and Associates. For information on meeting times, places, and fees, contact Ken Orr and Associates Inc., 715 East 8th, Topeka, KS 66607, (800) 255-2459; in Kansas, (913) 233-2349.

April
Fundamentals of Data Processing for Administrative Assistants and Office Support Staff, various sites throughout the U.S. The American Management Associations (AMA) has designed this three-day course for secretaries, assistants, supervisors, and other personnel desiring to learn the fundamentals of data processing and its use in offices. Computer hardware, software, programming languages, and technology will all be covered. The team fee for AMA members is $470 per individual and $550 for nonmembers. Individual fees are $550 for AMA members and $630 for nonmembers. For a schedule of dates and locations, contact the AMA, 135 West 50th St., New York, NY 10020, (212) 586-8100. To register by phone, call (212) 246-0800.

April
Knowledge Engineering in the 1980s, Boston, MA. Expert Systems are computer programs that reason in tasks that require considerable human expertise, such as locating computer malfunctions, monitoring intensive care patients, analyzing noisy signal data, and diagnosing medical problems. This one-day executive briefing provides an introduction to the potential benefits and costs of Expert Systems. For further information, contact Dina Barr, Teknowledge, 151 University Ave., Palo Alto, CA 94301, (415) 326-6827.

April-May
Courses from Boeing Computer Services, various sites throughout the U.S. Boeing Computer Services is offering a wide variety of computer-related courses at its regional service centers. Course topics range from "Introduction to Data Processing" to "Structured Program Development in FORTRAN." For a complete schedule of times, locations, and fees, contact Boeing Computer Services Co., Education and Training Division, POB 24346, Seattle, WA 98124, (206) 575-7700.

April-May
Seminars and Conferences from Datapro Research, various sites throughout the U.S. Among the topics to be pre-

sented are "IBM's Systems Network Architecture," "Data Dictionary/Directory Systems," and "Data Processing: Fundamental Concepts." Enrollment fees are $640 for Datapro subscribers and $690 for nonsubscribers. For a complete catalog with descriptions, dates, and locations, contact Datapro Research Corp., 1805 Underwood Blvd., Delran, NJ 08075, (800) 257-9406; in New Jersey, (609) 764-0100.

April-June
Courses and Seminars from Sira Institute, various sites throughout England. Sira Institute is sponsoring seminars on a wide variety of subjects, ranging from microprocessor familiarization to design and development of microprocessor-based equipment. For details, contact Conferences & Courses Unit, Sira Institute Ltd., South Hill, Chislehurst, Kent BR7 5EH, England.

April-June
Datamation Institute Seminars on Information Management, various sites throughout the U.S. Databases and communications, systems performance, data-processing management, word processing, office automation, computer graphics, and topics of general interest are among the areas to be covered by these two-day seminars. Fees range from $495 to $595. For schedules of times and places, contact Karen Smolens, the Center for Management Research, Datamation Institute Seminar Coordination Office, 850 Boylston St., Chestnut Hill, MA 02167, (617) 738-5020.

April-June
Intensive Two-day Seminars for Professional Development, various sites throughout New England. Among the seminars to be offered by Worcester Polytechnic Institute are "Fundamentals of Data Processing," "Distributed Systems: The Architecture and Utilization of this Revolutionary Technology," and "Microprocessors: Hardware, Software, and Applications." Registration fees range from $445 for a two-day program to $990 for a 7-day executive institute. For complete details, contact Ms. Ginny Bazarian, Office of Continuing Education, Worcester Polytechnic Institute, Worcester, MA 01609, (617) 793-5517.

April-June
The Master Method of Selling Small-Business Systems, Westlake Village, CA. This one-day seminar is designed for mini- and microcomputer manufacturers and software vendors who sell small-business systems. The seminar fee is $150. For details, contact Seminar Information, M. W. L. Inc., 32038 Watergate Court, Westlake Village, CA 91361, (213) 889-2607.

April-June
National Computer Graphics Association Winter/Spring 1982 Seminar Program, various sites throughout the U.S. Topics covered include "Computer Graphics: Technology and Applications," "Successful Business Graphics," and "Applications of Computer Graphics to Transportation Problems." Seminar fees are $395 for association members and $425 for nonmembers. For complete details, contact Eloise Wenker, NCGA Seminar, 2033 M St. NW, #300, Washington, DC 20036, (202) 466-4102.

April-June
One- and Two-day Professional Development Seminars, various sites in the greater Boston area. Among the courses being offered by Boston University are "Business Writing for Results," Improving Customer Service,"

and "Assertive Management." Registration fees range from $295 for a one-day program to $445 for a two-day program. These seminars can be conducted within your company. For details, contact Ms. Joan Merrick, Center for Management Research, 850 Boylston St., Chestnut Hill, MA 02167, (617) 738-5020. For information on the in-company seminars, contact Ms. Elaine Dee at the same address.

April-June

Productivity '82, various sites throughout the U.S. and Canada. This two-day show features hands-on demonstrations of Hewlett-Packard's newest computer and application solutions ranging from personal and small-business computers to the top-of-the-line computer systems for office computing, distributed data processing, and factory automation. Sixteen different seminars are held each day, on such topics as using personal computers, choosing financial and applications software, and preparing easy-to-read graphics. Additional information can be obtained from local Hewlett-Packard sales offices or from Rudanne Clark, Hewlett-Packard, 3000 Hanover St., Palo Alto, CA 94304, (415) 857-7247.

April-July

Computerized Robots, various sites throughout the U.S. This four-day course is tailored for managers concerned with the planning and design of advanced manufacturing methods and for those who will be involved with the development and integration of high-technology robot systems. Course topics include the extent of robot automation in the U.S., Japan, and Europe; technical capabilities and limitations of robots; robot sensory mechanisms, vision, touch, proximity; and programming techniques for robot control. The course fee is $845. For details, contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, (800) 352-8251.

April-July

Computer Network Design and Protocols, various sites throughout the U.S. This four-day course will focus on the practical aspects of network design, interfacing, protocols, and packet switching. Among the topics to be covered are how to determine system requirements and perform design trade-offs, how to carry out network communication and control protocols, and how to evaluate available network hardware and software components. The course fee is $845. For complete details, contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, (800) 352-8251.

April-July

Structured Design and Programming, various sites throughout the U.S. This four-day course emphasizes the development of skills that facilitate the efficient production of reliable, well-documented, and maintainable programs, on time and within budget. Some of the topics to be addressed are structured software design methods, how to write structured programs for mini- and microcomputers, and how to improve program readability and reliability. The course fee is $795. Contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, (800) 352-8251.

Event Queue

April-July
Technical Classes from Zilog, Campbell, CA. Zilog is offering a series of one- to five-day technical classes at its California-based training facility. Topics range from "Microprocessors: A General Introduction" to "Zeus/System 8000 User." Contact Zilog, Training and Education Dept., 1315 Dell Ave., Campbell, CA 95008, (408) 446-4666.

April 13-14
The Sixth Annual Computer/Terminal Fair, University of Dayton Arena, Dayton, OH. This show is sponsored by the University of Dayton. The latest in word processors and mini- and microcomputers will be featured. Contact Dan Schumacher, University of Dayton, 300 College Park Ave., Dayton, OH 45469, (513) 229-3511, for details.

April 13-16
Digital Filters and Spectral Analysis, Los Angeles, CA. This course is intended for project and design engineers responsible for the implementation of advanced digital signal-processing systems. Among the topics to be addressed are digital signal-processing fundamentals, fast Fourier transform algorithms, and finite impulse and recursive filters. Computer programs that implement many of the design techniques discussed in the course are provided in the course materials. The fee is $795. For further information, contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, (800) 352-8251.

April 13-16
Digital Image Processing and Analysis, Boston, MA. Integrated Computer Systems' course in digital image processing is designed for engineers, scientists, technical managers, and other professionals responsible for the specification, design, implementation, or application of digital image processing systems. Among the topics to be covered are image acquisition, image-processing software and database structures, interactive two- and three-dimensional image processing and display, and real-time arrays. Some of the applications examples to be presented are quality assurance and robot vision. The course fee is $795; on-site courses can be arranged. Contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, (800) 352-8251.

April 14-18
Electronic Home Entertainment Show, Arlington Park Race Track Exposition Hall, Arlington Heights, IL. This show will feature audio and video equipment, video games, home computers, and citizen-band radio systems. It will run concurrently with the Fourth Annual Energy & Home Improvement Fair. Contact Expo Management Inc., Suite S2-132 Arcade, The Apparel Center, Chicago, IL 60654, (312) 329-1191.

April 15-16
Software Quality Assurance Technology, San Francisco, CA. This seminar explores how, when, how much, and with what effect programs should be tested to assure their quality. The seminar fee is $450, which includes notes, textbooks, and reference materials. Additional information is available from Ms. Gloria Kulbe, Software Research Associates, POB 2432, San Francisco, CA 94126, (415) 957-1441.

April 15-17
The 1982 Computer Showcase Expo, St. Louis, MO. The Computer Showcase is designed for small-business owners, independent professionals, and corporate managers. Admission is $7.50. For further details, contact the Interface Group, 160 Speen St., POB 927, Framingham, MA 01701, (800) 225-4620; in Massachusetts, (617) 879-4502.

April 15-18
The Second Southwest Computer Show and Office Equipment Exposition, Market Hall, Dallas Market Center, Dallas, TX. This show features mini- and microcomputers for business, education, government, industry, home, and personal use. Data- and word-processing equipment, office machines, computer peripherals, and office supplies will be displayed. General admission is $5. Contact National Computer Shows, 824 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

April 16-17
The Twelfth Annual Virginia Computer Users Conference, Marriott Hotel, Blacksburg, VA. This conference is sponsored in cooperation with the ACM (Association for Computing Machinery). Topics include artificial intelligence, office automation, and database management. Contact Deidre Maskaleris or Wesley Braudaway, 562 McBryde Hall, Virginia Polytechnic Institute & State University, Blacksburg, VA 24061, (703) 961-6931.

April 17-18
The Seventh Annual Trenton Computer Festival (TCF-82), Trenton State College, Trenton, NJ. TCF-82 is devoted exclusively to the needs of personal-computing hobbyists and fans. At TCF-82, manufacturers, stores, and dealers will be exhibiting computer-related products and services. Forums, speakers, a giant outdoor flea market, and a banquet on Saturday night highlight this event. General admission is $5; students pay $3. A space in the flea market costs $10. For further information, contact Dr. Allen Katz, Dept. of Engineering Technology, Trenton Computer Festival, Trenton State College, Hillwood Lakes CN550, Trenton, NJ 08625, (609) 771-2666.

April 19-21
Open Systems Interconnection with X.25 and Other Related Protocols, Denver Marriott Hotel-City Center, Denver, CO. Sponsored by *Data Communications,* a McGraw-Hill publication, this seminar will present a thorough treatment of the basic OSI (Ohio Scientific) Reference Model, describing the seven-layer structure, service definitions, and emerging protocols. Detailed presentations of the X.25 packet protocol will be included. The seminar fee is $690. For further details, contact the McGraw-Hill Conference & Exposition Center, Rm. 3677, 1221 Avenue of the Americas, New York, NY 10020, (212) 997-4930.

April 19-23
The Eighth Annual Reliability Testing Institute, Ramada Inn, Tucson, AZ. This institute is presented by the University of Arizona College of Engineering and the Hughes Aircraft Company, Tucson, Arizona. It seeks to provide engineers, managers, and teachers with a working knowledge of analyzing component, equipment, and system performance and failure data to determine the distributions of their times to failure, failure rates, reliability, and confidence limits. Planning small sample size, short duration, and low-cost tests and analyzing the results will be covered as well as

Event Queue

other testing methods. The fee is $675. Contact Dr. Dimitri Kececioglu, Institute Director, Aerospace and Mechanical Engineering Dept., Building 16, University of Arizona, Tucson, AZ 85721, (602) 626-2495.

April 20-22
D-COM, Hynes Auditorium, Boston, MA. D-COM will bring DEC (Digital Equipment Corporation) vendors together with DEC users. For information, contact Ron Davies, D-COM Inc., 7312 Burdette Court, Bethesda, MD 20817, (301) 469-7650.

April 20-23
The Fourth International Conference on Video and Data Recording, University of Southampton, Southampton, England. This conference is designed for engineers and physicists. Papers, group sessions, and a trade exhibition will be featured. Among the topics to be addressed are "Magnetic and Other Recording Media," "Theory of Recording Processes," and "Coding, Modulation, and Signal Processing." Highlighting this conference will be a forum on digital standards. For further information, contact the Conference Registrar, Institution of Electronic and Radio Engineers, 99 Gower St., London, WC1E 6AZ, England, Tel: 01-388-3071.

April 20-23
VIO-Voice Input/Output for Computers, Boston, MA. This four-day course is designed for product development and design engineers, systems analysts, programmers, and technical managers involved in the planning, design, and implementation of voice input/output systems. The topics to be covered include voice-processing algorithms and software, evaluating VIO hardware components and systems, utilizing speech-synthesis techniques, and designing voice-recognition techniques. Participants will have the opportunity to work with devices that permit online generation of computer voice output, data entry by means of voice input, and voice input for system control. The course fee is $795; on-site courses can be arranged. For information, contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, (800) 352-8251.

April 21-28
Hanover Fair '82, Hanover, West Germany. The annual Hanover Fair is one of the world's largest industrial trade exhibitions. More than 330 American firms are expected to exhibit products, services, and technology at the Fair. Contact M. A. Delia, Hanover Fairs Information Center, POB 338, Whitehouse, NJ 08888, (800) 526-5978; in New Jersey, (201) 534-9044.

April 22
California Computer Show, Hyatt Hotel, Palo Alto, CA. This show is for original equipment manufacturers, knowledgeable users, distributors, and dealers. More than 60 computer manufacturers will be exhibiting mainframes, mini- and microcomputers, and peripherals. Contact Carol Reimer, Norm De Nardi Enterprises, 289 South San Antonio Rd. #204, Los Altos, CA 94022, (415) 941-8440.

April 22-25
New York Computer Show and Office Equipment Exposition, Nassau Coliseum, Uniondale, NY. For details, see April 15-18.

April 23-25
The 1982 Computer Showcase Expo, Miami, FL. For details, see April 15-17.

April 24
Computer Swap America, Santa Clara County Fair Grounds, San Jose, CA. This high-technology flea market features everything from floppy disks to home satellite-receiving stations. Admission is $3. Contact Computer Swap America, POB 52, Palo Alto, CA 94302, (415) 494-6862.

April 25-30
DP Training Managers' Workshop, Washington, DC. This workshop is intended for individuals with less than 18 months' experience in coordinating data-processing training programs. Participants will learn to establish in-house education programs that will meet management objectives and ensure a high return on their organizations' investment in training. The registration fee is $850. Contact Linda Hubacek, Deltak Inc., 1220 Kensington Rd., Oak Brook, IL 60521, (312) 920-0700.

April 27-30
Digital Filters and Spectral Analysis, Washington, DC. For details, see April 13-16.

April 27-28
The Eighth Annual National Computer Security and Privacy Symposium: Top Secret '82, Washington, DC. Sponsored by Honeywell, approximately 22 national authorities on computer security and privacy will speak on a variety of topics. Training workshops in security planning and risk analysis, disaster recovery and contingency planning, and computer fraud investigation will be held. The fee for the symposium is $525; discounts on multiple registrations are available. Contact the Security Symposium Registrar, Honeywell Inc., M/S T-99-4, POB 6000, Phoenix, AZ 85005; or call Jerome Lobel, (602) 249-5370.

April 28-May 1
The Third Annual Conference of the Educational Computing Organization of Ontario, Ontario Institute for Studies in Education (OISE), Toronto, Ontario, Canada. This conference is designed for educators at all levels. Exhibits will be featured. Contact OISE, 252 Bloor St. W, Toronto, Ontario M5S 1V6, (416) 923-6641, for additional details.

April 29-30
An Assessment and Forecast of Computer Graphics, Rye Town Hilton, Port Chester, NY. This conference will assess the present state of computer graphics and will evaluate hardware, software, systems services, and applications. The role of graphics in today's business environment will be considered and factors affecting market growth will be analyzed. Leaders in the industry will present and exchange views with attendees. For further information, contact Carol Sapchin, Frost & Sullivan Inc., 106 Fulton St., New York, NY 10038, (212) 233-1080.

May 1982

May-June
Sensors & Systems '82, various sites throughout the central and western regions of the U.S. This series of three-day conferences will cover all aspects of sensor technology from temperature sensors through to displacement, velocity, acceleration, magnetic field, and moisture. Other topics to be covered include signal conditioning, digital interfaces, and system interfaces. Contact Network Exhibitions, 785 Harriet Ave., Campbell, CA 95008, (408) 370-1661.

Event Queue

May 2-7
DP Training Managers' Workshop, Chicago, IL. For details, see April 25-30.

May 6-9
The Southern California Computer Show & Office Equipment Exposition, Los Angeles Convention Center, Los Angeles, CA. For details, see April 15-18.

May 7-9
The 1982 Computer Showcase Expo, Anaheim, CA. For details, see April 15-17.

May 10-12
Dexpo 82, Marriott Hotel, Atlanta, GA. This exposition features DEC- (Digital Equipment Corporation) compatible hardware, software, and services. Contact Expoconsul International Inc., 19 Yeger Rd., Cranbury, NJ 08512, (609) 799-1661.

May 10-13
The Annual Meeting and Technical Conference of the IEEE Industrial Power Systems Department, Marriott Hotel, Philadelphia, PA. For details, contact Dr. Paul Reece, General Electric Co., 6901 Elmwood Ave., Mail Drop 06302, Philadelphia, PA 19142, (215) 726-2800.

May 10-14
The Twentieth Annual Convention of the Association for Educational Data Systems (AEDS), Sheraton Twin Towers, Orlando, FL. This convention includes presentations on the state of the art in educational computing. Administrative and instructional computing applications will be presented, and new ways of improving educational processes will be explored. Contact AEDS, 1201 Sixteenth St. NW, Washington, DC 20036, (202) 833-4100.

May 12-14
The 1982 Carnahan Conference on Security Technology, Carnahan House Conference Center, Lexington, KY. Among the topics to be addressed at this conference are "Federal Standards for Telecommunications Privacy and Security," "Secure Voice-Bandwidth Modem," and "Multistatic, Airborn Intruder Detection Radar." The registration fee is $325, which includes buffets, a banquet, and a copy of the proceedings. Contact Susan McWain, Office of Continuing Education, College of Engineering, 223 Transportation Research Building, University of Kentucky, Lexington, KY 40506, (606) 257-3971.

May 14-15
The Second Annual Southern California Computers-in-Education Conference, University High Scool, Irvine, CA. This conference covers the application of computers in education from kindergarten through two-year college. All areas of curriculum will be covered, including reading, mathematics, science, language, and special education. Hands-on workshops and field trips are planned. Contact Craig Walker, Arrowview Intermediate School, 2299 North G St., San Bernardino, CA 92405, (714) 886-9118.

May 14-16
Applefest/Boston, Hynes Auditorium, Boston, MA. This show will feature more than 200 displays and booths of Apple-compatible products and accessories. Seminars and panel discussions will be held. Ticket prices are $6 per day or $15 for a three-day pass. Contact National Computer Shows, 824 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

May 15-16
The North American Computer Othello Championship, Learning Resources Center, Andersen Hall, Northwestern University, Evanston, IL. This two-day tournament is sponsored by the United States Othello Association. Champions will be determined in three categories: microcomputer systems (located on site), mainframe systems (telephone hookup), and special-purpose Othello machines. For complete tournament details, write to Professor Peter W. Frey, Dept. of Psychology, Northwestern University, Evanston, IL 60201.

May 16-21
Advanced DP Training Management Workshop, Los Angeles, CA. This workshop is intended for training managers directly responsible for planning, monitoring, and evaluating data-processing training and reporting to upper-level management. The prerequisite for this workshop is completion of Deltak's Training Managers' Workshop (see April 25-30) and a minimum of one year's experience since completion, or the equivalent on-the-job experience. The registration fee is $850. Contact Linda Hubacek, Deltak Inc., 1220 Kensington Rd., Oak Brook, IL 60521, (312) 920-0700.

May 16-19
The First Annual Convention & Exposition of the Electronic Funds Transfer Association—EFT Expo, Fairmont Hotel, Dallas, TX. This convention will feature addresses on a wide range of electronic funds transfer issues, including automated teller interchange, changes in corporate network services, home financial services alternatives, and security. A special forum on the role of electronic funds transfer in the future of financial services deregulation will highlight the convention. An equipment exhibit will be featured. For complete details, contact the Electronic Funds Transfer Association, Suite 800, 1029 Vermont Ave. NW, Washington, DC 20005, (202) 783-3555.

May 18-20
Microcomputers—A New Tool for Foresters, Purdue University, West Lafayette, IN. Sponsored by Purdue University's Department of Forestry and Natural Resources and by the Inventory and Systems Analysis Working Groups of the Society of American Foresters, this conference seeks to advance the professional forester's knowledge of microcomputers and their applications in forestry. Session themes include hardware and software considerations as well as information processing and forest-inventory systems. Contact John W. Moser Jr., Dept. of Forestry and Natural Resources, Purdue University, West Lafayette, IN 47907, (317) 494-3596.

May 19-21
Computer Hong Kong 82, Regent Hotel, Hong Kong. This three-day program, which embraces the Fifth Hong Kong Computer Conference, will focus on the electronic data-processing market. For further details, contact Kallman Associates, 5 Maple Court, Ridgewood, NJ 07450, (201) 652-7070.

May 21-23
The 1982 Computer Showcase Expo, Boston, MA. For details, see April 15-17.

May 22
The Third Annual New Jersey Microcomputer Show & Flea Market, Holiday Inn (North), Newark International Airport, Newark, NJ. This event will feature more than 50 commercial exhibitors and 150

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Event Queue

flea market sellers. Hardware, software, and accessories for all popular systems will be featured. Contact Kengore Corp., 3001 Rte. 27, Franklin Park, NJ 08823, (201) 297-2526, for additional information.

May 23-28

DP Training Managers' Workshop, Dallas, TX. For details, see April 25-30.

June 1982

June 6-11

Advanced DP Training Management Workshop, Calgary, Alberta, Canada. For details, see May 16-21.

June 6-11 and June 20-25

DP Training Managers' Workshop, Philadelphia, PA, and Chicago, IL. For details, see April 25-30.

June 13-16

The Fifteenth Annual Conference of the Association of Small Computer Users in Education, Chatham College, Pittsburgh, PA. This conference will include papers and demonstrations on the educational and administrative uses of computers. Other topics of interest are robotics, Pascal programming, computer literacy, and the use of packaged software in computer courses. For more information, contact Jan Carver, Computer Center, Chatham College, Pittsburgh, PA 15232, (412) 441-8200.

June 15-17

The 1982 IEEE MTT-S International Microwave Symposium, Hyatt Regency Hotel,

A Message to our Subscribers

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Dallas, TX. The theme of this symposium is "Thirty Years of Microwaves." Papers and tutorials on a wide range of topics, including computer-aided design and measurement techniques, microwave field and network theory, as well as satellite communications/microwave systems, will be presented. Contact J. R. Griffin, Texas Instruments Inc., Mail Stop 3432, POB 405, Lewisville, TX 75067, (214) 462-5693.

June 15-17

The Office Automation Show/Conference, Barbican Centre, London, England. For details on this show and conference, contact Clapp & Poliak International, 7315 Wisconsin Ave., Washington, DC 20014, (301) 657-3090.

June 16-18

The Twentieth Annual Meeting of the Association for Computational Linguistics, University of Toronto, Toronto, Ontario, Canada. This meeting features papers on syntax, computational semantics, discourse analysis and speech acts, machine translation, as well as the mathematical and theoretical foundations of computational linguistics. For additional information, contact Don Walker, Artificial Intelligence Center, SRI International, Menlo Park, CA 94025, (415) 859-3071.

June 28-30

National Educational Computing Conference (NECC-82), Radisson-Muehlebach Hotel, Kansas City, MO. This conference features papers, sessions, panel discussions, and exhibits of educational computing products. Among the topics to be addressed are "Computer Use in the Physical Sciences," "Computer Education for Teachers," and "Computer Science, Engineering, and Information Systems Education." For more information, contact E. Michael Staman, NECC-82 General Chairman, Computer Services, 305 Jesse Hall, University of Missouri-Columbia, Columbia, MO 65211. ■

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.

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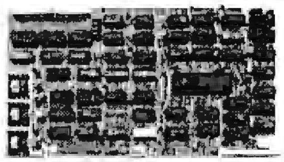

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MDA MXV-21 LSI-11 controller (RX-01, RX-02 compatible)	$1050

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Godbout Z-80A	$ 275
Godbout 8085A	$ 295

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CCS 2116 32K static	$ 625
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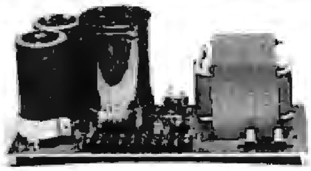

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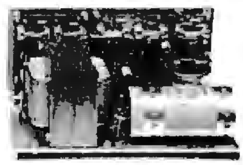

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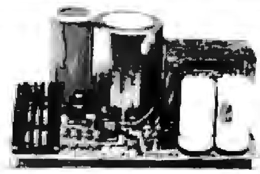

S3 2 in 1 Unit for S-100 and two 8" or 5¼" Disk Drives. It fits most Disk System Mainframes.

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KIT 2	SYSTEM SOURCE	25A	———	3A	3A	———	12" × 5" × 4⅞"	61.95
KIT 3	DISK SYSTEM	15A	1A	2A	2A	4A	14" × 6" × 4⅞"	69.95

DISK DRIVE POWER SUPPLY "R3" REGULATED, OPEN FRAME, ASSY. & TESTED 69.95

SPECS + 5V @ 5A OVP. −5V @ 1A + 24V@ 5A. SHORTS PROTECT 2 SIZES AVAIL. 1) 9" (W) × 6¼" (D) × 4⅜" (H), 2) 9" (W) × 4⅞" (D) × 5¼" (H)
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T_2	110/120	2 × 8 Vac, 25A	28 Vac, CT, 3.5A		3¾" × 4⅜" × 3⅛"	28.95
T_3	110/120	2 × 8 Vac, 15A	28 Vac, CT, 2.5A	48 Vac, CT, 2A	3¾" × 4⅜" × 3⅛"	30.95
T_4	110/120	2 × 8 Vac, 6A	28 Vac, CT, 1.5A	48 Vac, CT, 3A	3¾" × 3⅝" × 3⅛"	23.95
T_5	110/120	2 × 8 Vac, 6A	28 Vac, CT, 2A		3" × 3" × 2½"	15.95

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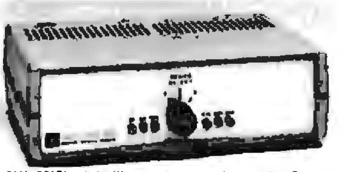

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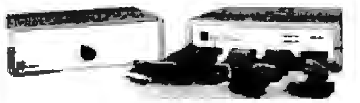

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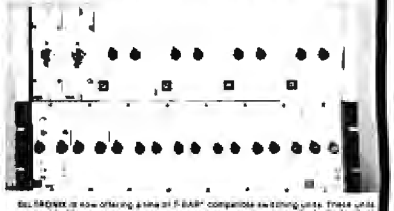

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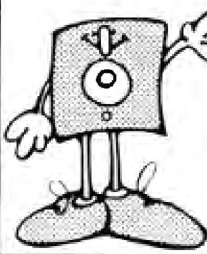

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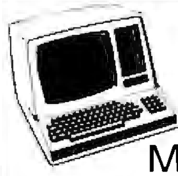

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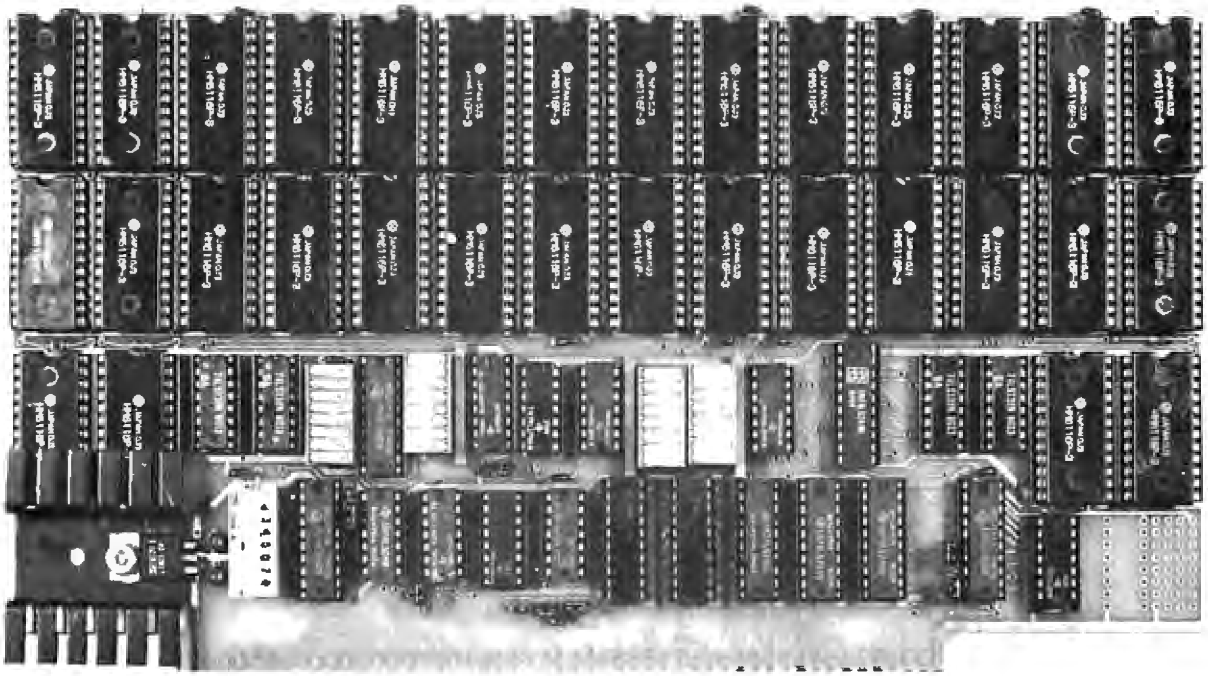

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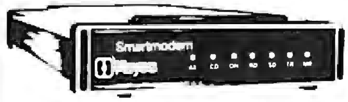

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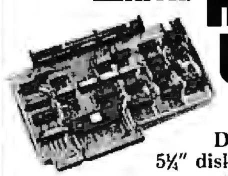

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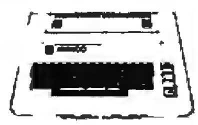

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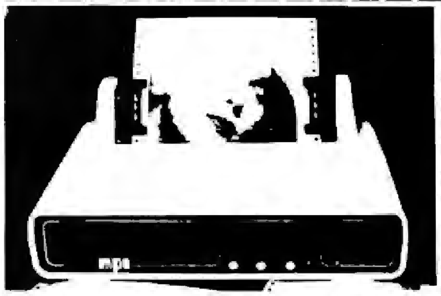

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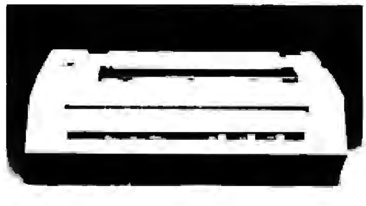

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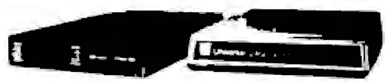

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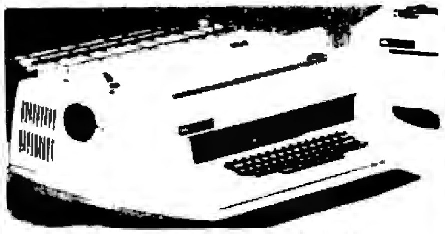

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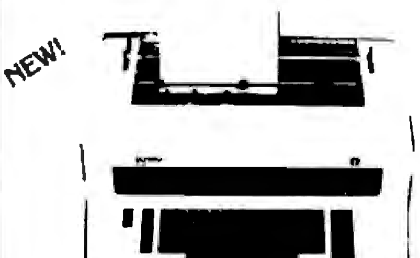

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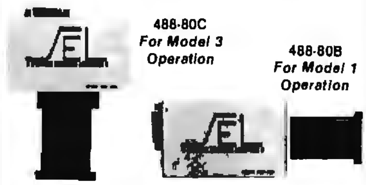

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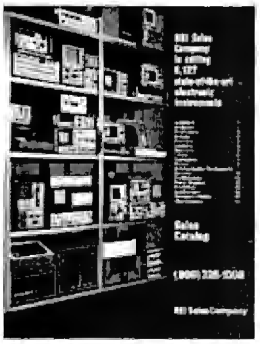

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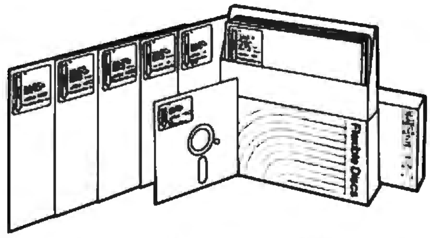

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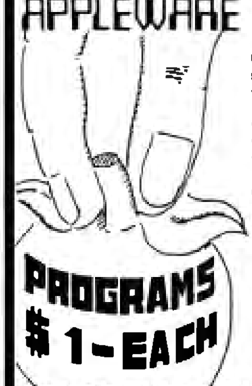

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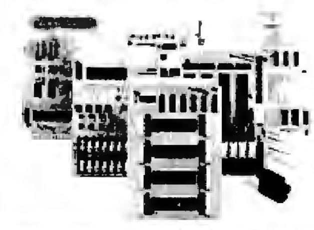

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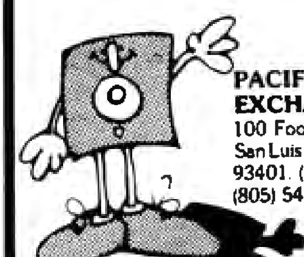

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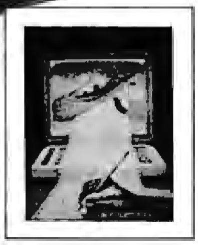
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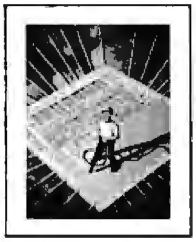
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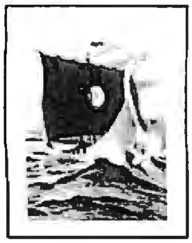
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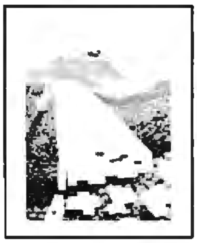
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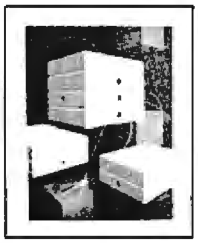
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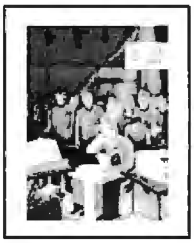
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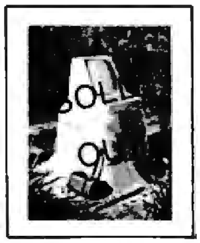
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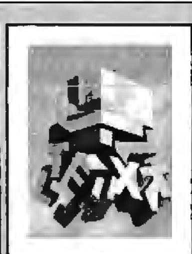
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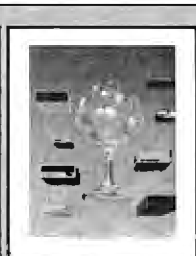
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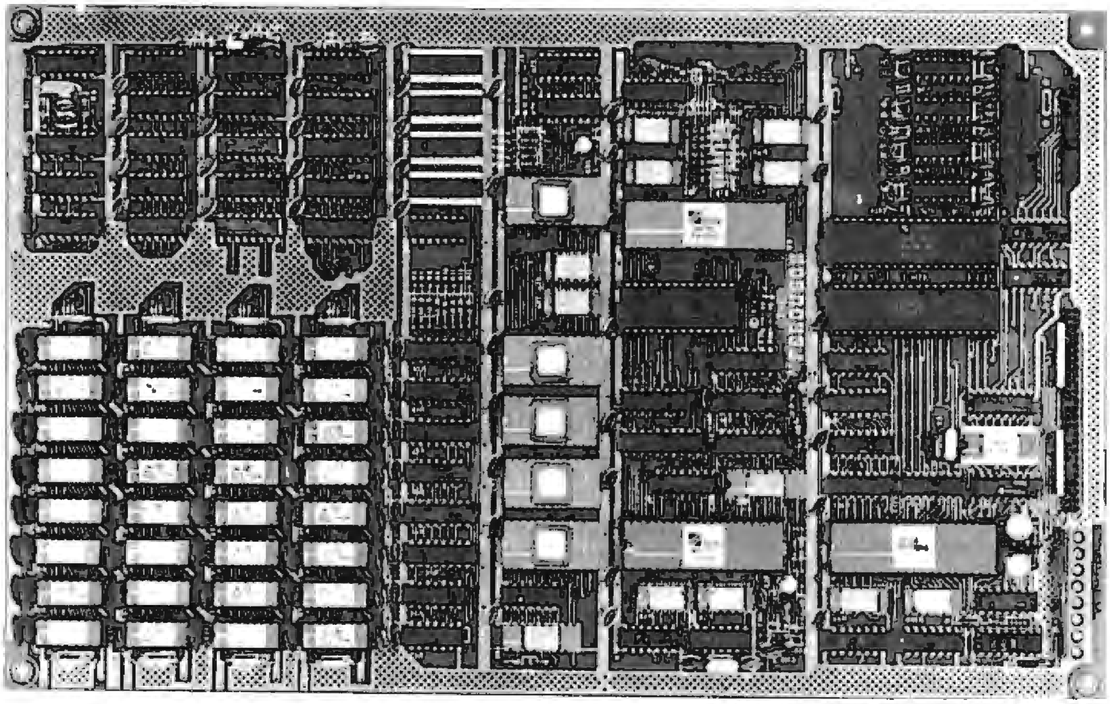

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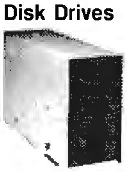

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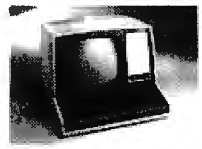

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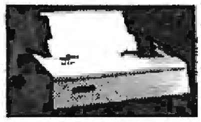
Epson Graftrax	**$ Call**
PaperTiger 560 Gr. & 2K	$ Call
IDS Prism 80	$ Call
IDS Prism 132	$ Call
PaperTiger Access.	$ Call
Olivetti DY 211 Daisy Wheel	**$ Call**
Anadex DP-8000	$ 849
Anadex DP-9500/01	$1389
Okidata Microline 80 Fric. & pin feed	$ Call
Okidata Microline 82A Fric. & pin feed	$ Call
Okidata Microline 83A 120 cps	$ Call
Okidata 84 200 cps	$ Call
Centronics 739	$ 739
Data South 180 cps	$ Call
Monitors	
Leedex 12" B&W	$ 119
Leedex 12" Green Screen	$ 129
Leedex 13" Color	$ 329
Sanyo 9" B&W	$ 149
Sanyo 9" Green Screen	$ 189
Sanyo 12" Green Screen	$ 249
Sanyo 12" B&W	$ 239
Sanyo 13" Color	$ 449
Zenith 13" Color	$ 349



******** Special of the Month ********
Zenith 12" Green Screen
$129

Telecommunications	
Prentice Star Modem 1-yr. guar.	$ 125
Univ. Data System UDS103LP	$ 149
Univ. Data System UDS103JP	$ 185
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Novation D-Cat	$ 149
Novation Auto-Cat	$ 199
Novation Apple Cat II	$ 299
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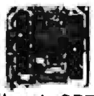
Circle 130 on inquiry card.

CRT CONTROLLER



This Intelligent CRT Controller uses an 8085A CPU & an 8275 integrated CRT Controller. It features:

- 25 lines (80 char./line)
- 5x7 dot matrix
- Upper & lower case
- Two 2716's (controller & char. generator)
- Serial interface RS232 & TTL
- Baud rates of 110, 150, 300, 600, 1200, 2400, 4800 and 9600
- Keyboard scanning system
- Unencoded keyboard required
- Uses +5V & ± 12V Power Supplies
- Does not have graphic capabilities.

Documentation includes program listing and composite video circuit.

Bare Board only (with doc)	$39.95
2716 Char. Gen. A7	$19.95
2716 Program A12	$19.95

A-D CONVERTER

JBEs 16 channel A-D Converter plugs into your Apple II computer. It uses an ADC0817 which incorporates a 16 channel multiplexer and an 8 bit A-D Converter. The 16 inputs are high impedance and the voltage range is 0 to 5.12volts. Conversion time is < 100µsec. The resolution is 8 bits or 256 steps, linearity is ± 1/2 step. Two 16 pin DIP sockets are used for input, GND & reference voltage connections. There are 3 single bit TTL inputs. Doc. includes sample program.

81-132A Assm.	$89.95
81-132K Kit	$69.95
81-132B Bare Board	$29.95

EPROM PROGRAMMER

JBE's EPROM Programmer is designed to program 5V 2516's, 2532's & 2716's. It interfaces to the JBE Parallel I/O card using four ribbon cables. An LED indicates when the EPROM is being programmed. A textool zero insertion force socket is used for the EPROM. Comes with complete documentation for writing and reading EPROM's in the Apple II or Apple II Plus. Cables available separately.

80-244A Assm.	$49.95
80-244K Kit	$39.95
80-244B Bare Board	$24.95

PARTS

6502 MPU	$9.95
6522 VIA	$9.95
Z-80 MPU	$9.95
Z-80 PIO	$9.95
TWO 2114 RAM	$9.95
2716	$14.95
50 pin conn.	$5.95
Dip Jumper 2 ft.	$4.95

6522 APPLE II INTERFACE

The JBE 6522 Parallel Interface for the Apple II Computer, plugs directly into any slot 1 through 7 in the Apple. This card has 2 6522 VIA's that provide:

- Four 8 bit bi-directional I/O ports
- Four 16 bit programmable timer/counters
- Serial shift registers
- Handshaking

A 74LS05 is for timing. Four 16 pin sockets provide easy connections to other peripheral devices. (Dip jumpers with ribbon cables are also available from JBE) The 6522 Parallel I/O card interfaces to the JBE EPROM programmer. Understanding of machine language required to use this board. Inputs and outputs are TTL compatible.

79-295A	$89.95 Assembled
79-295K	$59.95 Kit
79-295B	$19.95 Bareboard

SPEECH SYNTHESIZERS

JBEs Speech Synthesizers use the Votrax SC-01 Phoneme Synthesizer chip. The SC-01 phonetically synthesizes continuous speech of unlimited vocabulary. The SC-01 contains 64 different phonemes and 4 levels of inflection accessed by an 8 bit code. It requires 10 Bytes per second for continuous speech. Both boards have an audio amp for direct connection to an 8 ohm speaker.

Documentation includes basic user programs, a phoneme chart and listing of coded words to help you get started. Documentation for the Apple II® Speech Synthesizer includes a disk with many user programs.

81-088 Apple II Speech Synthesizer	$139.95
81-120 Parallel Input Speech Synthesizer	$149.95

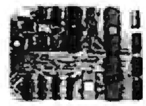
Prices include the SC-01 Chip
SC-01 sold separately for $ 75.95

EPROM EXPANSION CARD

JBE EPROM Expander for the Apple II holds six 5V 2716s for a total of 12K bytes of EPROM. This board takes the place of the on board ROM in the Apple. It is software switchable by the same technique used by the Apple II firmware card. Solder jumpers are for reset to the Apple ROM or EPROM Expansion Card. Use JBE EPROM Programmer and Parallel I/O to program your EPROMs. EPROMs sold separately.

81-085A Assm.	$59.95
81-085K Kit	$49.95
81-085B Bare Board	$39.95

81-260 "SLIM"



Single board large scale Integration Microcomputer. This 4.5 x 6.5 board uses the 6502 Microprocessor, two 6522 VIA's, four 2114 RAM's, 2516, 2716 or 2532 EPROM. The fully buffered 22/44 pin bus is similar to the KIM®, SYM®, and AIM® expansion connector. The four 8 bit I/O ports connect through 16 pin dip sockets. This board was designed for control and is ideal for Personal and OEM use.

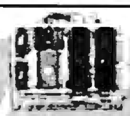
- 6502 MPU
- Two 6522 VIA's
- Four 2114 RAM's (2K bytes)
- One EPROM 2516 or 2532
- Crystal clock 1 Mhz
- Requires 5V 1AMP Power
- 4.5 x 6.5 card
- Power on reset
- Fully buffered-expandable
- Solder mask-both sides

Use your Apple II Computer, JBE 6522 Parallel Interface card and EPROM Programmer as a development system for SLIM.

Prices:

81-260A	$199.95 Assembled
81-260K	$149.95 Kit
81-260B	$ 39.95 Bare Board

6502 MICROCOMPUTER

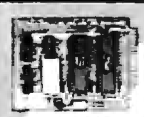


6502 MPU, 6522 VIA, 2716 EPROM, 2114 RAM single board computer. Single 5 volt power supply at 400 Ma. Two independent 8 bit I/O ports with handshake lines. RC controlled 1 Mhz clock.

Complete documentation. I/O lines use 50 pin edge connector. Data and address lines are not accessible. Mod. for 2532 is included. EPROM is not included. 1K RAM, 2K EPROM, 2 I/O ports.

80-153 Assm.	$110.95
80-153 Kit	$ 89.95
80-153 Bare Board	$ 19.95

Z-80 MICROCOMUTER

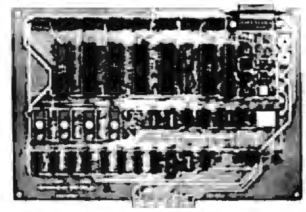


Z-80 MPU, Z-80 PIO, 2716 EPROM, 2114 RAM single board computer. Single 5 volt power supply at 300 Ma. Two independent 8 bit I/O ports with handshake lines. RC controlled 2Mhz clock.

Complete documentation. I/O lines use 50 pin edge connector. Data and address lines are not accessible. Mod. for 2532 is included. EPROM is not included. 1K RAM, 2K EPROM, 2 I/O ports.

80-280 Assm.	$129.95
80-280 Kit	$119.95
80-280 Bare Board	$ 19.95

JBE I MICROCOMPUTER



JBE's 7.75 x 11.75 6502 base Microcomputer has the capacity for 16K of EPROM, 4K of RAM, 8 Parallel Ports and 1 Serial Port. Monitor and Tiny Basic are also available. The fully populated version includes:

- 1 6502 CPU
- 4 6522 VIA (8 Parallel I/O Ports)
- 1 AY5-1013 (Serial I/O Ports)
- 8 2114 RAM (4K)
- 2 2716 EPROM (Monitor & Tiny Basic)

The partially populated version includes:

- 1 6502 CPU
- 1 6522 VIA (2 Parallel I/O Ports)
- 1 AY5-1013 (Serial I/O Port)
- 2 2114 RAM (1K)
- 1 2716 EPROM (with Monitor)

Both versions include sockets for 2716s or 2532s, 8 16 pin sockets for I/O interfacing and a DB25 connector for RS232.

All address and data lines are brought off the board to the 50 pin edge connector. (similar to the Apple II bus)

This board also features power on reset and cassette interface.

81-030 C Fully Populated	$349.95
81-030M Partially Populated	$249.95
81-030B Bare Board	$ 89.95
2716 EPROM (with Monitor)	$ 19.95
2715 EPROM (with Tiny Basic	$ 19.95

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Circle 201 on inquiry card.

Circle 481 on inquiry card.

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6502	7.45	10/6.95	50/6.55	100/6.15
6502A/6512A	8.40	10/7.95	50/7.35	100/6.90
6520 PIA	5.15	10/4.90	50/4.45	100/4.15
6522 VIA	6.45	10/6.10	50/5.75	100/5.45
6532	7.90	10/7.40	50/7.00	100/6.60
2114-L200		3.75	25/3.50	100/3.25
2114-L300		3.15	25/2.90	100/2.65
2716 EPROM		7.00	5/6.45	10/5.90
2532 EPROM				14.50
6116 Hitachi 2K x 8 CMOS RAM				**14.50**
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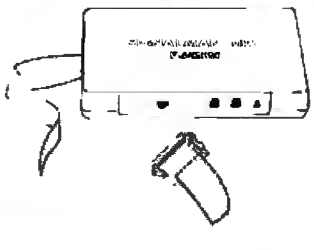

MODEM SPECIAL $99

SIGNALMAN Mk1 from Anchor Automation

DIRECT CONNECT Modem with RS232 Cable and Connector included Fully compatible with all Bell 103 modems 0 to 300 bps, full duplex, frequency shift keyed modulation, automatic ANSW/ORIG selection, direct connect, audible tone carrier detect indicator, self-contained battery powered

PET/CBM Version (Mk1P) $169

For Commodore Computers, the Signalman Mk1P includes connector, cable, and machine language software

STAR MODEM Prentice/Livermore Data Systems

RS232 MODEM	**SALE**	**$128**
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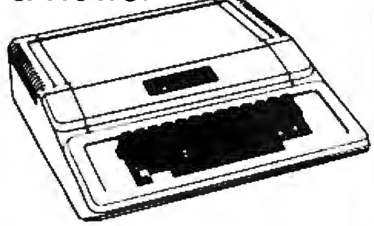
We carry Apple II+ from Bell & Howell



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Full FIG model with all 79 Standard extensions.

Metacompiler for FORTH for independent object code **30**

KMMM PASCAL for PET/CBM $85

Includes translator for true machine language object code.

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Editor, Assembler, Relocator, Linkeditor.

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Super Pet	(1995)	1650
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VIC 20 Color Computer	(299)	259
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Library of PET Subroutines	12

RAM/ROM for PET/CBM

4K or 8K bytes of soft ROM with optional Battery Backup.

Adds extra RAM which can be write protected like ROM.

4K Version - $85 8K Version - $120 Battery Backup - $30

EPROM Programmer for CBM/PET 79

Branding Iron with software/hardware for 2716 and 2532.

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SCOTCH (3M) 5"	10/2.45	50/2.35	100/2.30
SCOTCH (3M) 8"	10/2.60	50/2.45	100/2.40
Verbatim 8" Doubled Dens.	10/3.65	50/3.55	100/3.40
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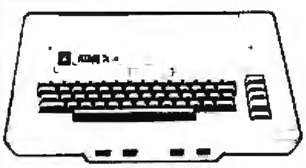

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825 Printer	629	**STAR RAIDERS**	**32**
850 Interface	175	Space Invaders	36
822 Printer	359	Music Composer	45
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Joystick Pair	19	Super Breakout	30
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Pilot	68	First Book of Atari	11

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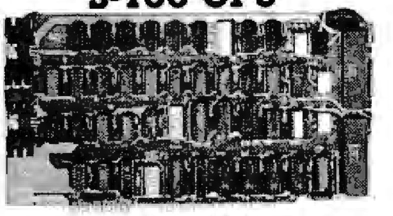
S-100 CPU



CPU-Z - COMPUPRO

2/4 MHZ Z80 CPU 24 Bit Addressing WOW!

PART NO.	DESCRIPTION	LIST PRICE	OUR PRICE
BOGBT 160A	A & T	$295.00	$199.00
BOGBT 160C	CSC 3-6 MHZ	$395.00	$375.00

DUAL PROCESSOR 8085-8088 - COMPUPRO

6 or 8 MZ Provides true 16 Bit Power with a standard 8 bit S-100 bus.

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Not Really, But the Next Best Thing For Godbout 8085/88 Users. Call for Details on M-Drive. See Page 340 of November **BYTE**

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2810 Z80 CPU-CA. COMP. SYST.

2/4 MHZ Z80A CPU with RS232C Serial I/O Port complete with Monitor PROM for 2422 Disk Controller

BOCCS 2810A	A & T	$350.00	$280.00

CB2 Z80 CPU - S.S.M.

2/4 MHZ will accept 2716, or 2732, or RAM RUN/STOP and single step switches

BOSSMCB2K	Kit		$260.00
BOSSMCB2A	A & T	$344.00	$310.00
BOSSMZ80M	SSMZ80 Monitor		$89.00

CBIA 8080 CPU - S.S.M.

8080 CPU, 1K RAM, Holds 1 2708, 1 Bit parallel input port.

BOSSMCB1K	Kit		$183.00
BOSSMCB1A	A & T	$252.00	$225.00
BOSSM8080M	SM 8080 Monitor		$59.00

S-100 I/O BOARDS

SYSTEM SUPPORT I - COMPUPRO

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	$399.00	$360.00
BOGBT162C	CSC	$495.00	$460.00
BOGBT8231	Math Chip		$195.00
BOGBT8232	Math Chip		$195.00
BOGBT162AM1	A&T with 8231 Math Chip		$555.00
BOGBT162CM1	CSC with 8231 Math Chip		$655.00
BOGBT162AM2	A&T with 8232 Math Chip		$555.00
BOGBT162CM2	CSC with 8232 Math Chip		$655.00

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I/O Multiplexer, using 8085A-2 CPU on board With 4K RAM

BOGBT166A4	A & T	$495.00	$445.00
BOGBT166C4	CSC	$595.00	$535.00

With 16K RAM

BOGBT166A16	A & T	$649.00	$585.00
BOGBT166C16	CSC	$749.00	$675.00

INTERFACER I - COMPUPRO

Two Serial I/O

BOGBT133A	A & T	$249.00	$219.00
BOGBT133C	CSC	$324.00	$298.00

INTERFACER II - COMPUPRO

Three parallel, one serial I/O board

BOGBT150A	A & T	$249.00	$219.00
BOGBT150C	CSC	$324.00	$289.00

INTERFACER III - COMPUPRO

Eight channel multi-use serial I/O board

BOGBT1748A	A & T	$699.00	$629.00
BOGBT1748C	CSC 200 hr. Burn In	$849.00	$750.00

INTERFACER 3 WITH 5 SERIAL PORTS

BOGBT1745A	A & T	$599.00	$559.00
BOGBT1745C	CSC 200 hr. Burn In	$699.00	$629.00

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Three Serial, Two parallel

BOMDSMB3200	A & T	$359.00	$329.00

SWITCHBOARD - MORROW DESIGNS

Two serial I/O, four parallel I/O, one status port, one strobe port

BDMDSSB2411		$299.00	$269.00

I/O4 - SSM

Two serial I/O, two parallel I/O

BOSSMI04K	Kit		$210.00
BOSSMI04A	A & T	$290.00	$260.00

I/O 5 - SSM

2 Serial, 3 Parallel including 1 Centronics

BOSSMI051	A & T	$329.00	$309.00

I/O 8 - SSM

8 Port Serial I/O with Timer

BOSSMI08A	A & T	$550.00	$495.00

2710 4 PORT SERIAL - CCS

4 Full handshaking RS232 ports and optional 2K ROM

BOCCS271001	A & T	$360.00	$310.00

2719 2 SERIAL & 2 PARALLEL - CCS

2 RS232 C ports, 2 8 bit parallel ports, & optional 2K ROM

BOCCS271901	A & T	$360.00	$325.00

2720 4 PORT PARALLEL - CCS

4 8 bit parallel ports and optional 2K ROM

BOCCS272001	A & T	$250.00	$225.00

S-100 10 MHZ STATIC RAM

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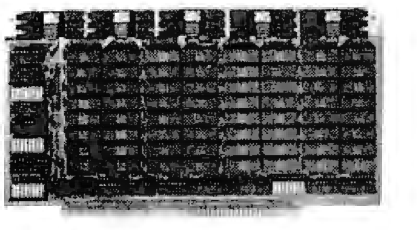
RAM 20 - 32K
SALE $299.00



32K STATIC RAM - COMPUPRO

RAM 20 10 MHZ, 4K byte block disable, bank select or 24 bit addressing available 8, 16, 24 or 32K

PART NO.	DESCRIPTION	LIST PRICE	OUR PRICE
BOGBT164AA8	8K A&T	$210.00	$190.00
BOGBT164AC8	8K CSC	$280.00	$260.00
BOGBT164AA16	16K A&T	$285.00	$260.00
BOGBT164AC16	16K CSC	$355.00	$325.00
BOGBT164AA24	24K A&T	$355.00	$325.00
BOGBT164AC24	24K CSC	$425.00	$385.00
BOGBT164AA32	32K A&T	$425.00	$299.00
BOGBT164AC32	32K CSC	$495.00	$450.00

CMOS STATIC RAM

For a complete analysis of the advantages of CMOS memory, see the "Product Description" on page 416 of the January Issue of **BYTE.**

64K CMOS STATIC RAM - COMPUPRO

RAM 17, 10 MHZ, 2 Watt, DMA Compatable 24 Bit Addressing

BOGBT175A48	48K A&T	$650.00	$619.00
BOGBT175C48	48K CSC 200hr.	$750.00	$710.00
BOGBT175A64	64K A&T	$795.00	$755.00
BOGBT175C64	64K CSC 200hr.	$895.00	$850.00

NEW! 32K x 16 BIT CMOS STATIC RAM - COMPUPRO

RAM 16 10 MHZ, 32K x 16 or 64K x 8 IEEE/696 16 BIT 2 Watt, 24 Bit Addressing

BOGBT180A	64K A&T	$895.00	$850.00
BOGBT180C	64K CSC	$995.00	$945.00

NEW! 128K NMOS STATIC RAM - COMPUPRO

RAM 21 10MHZ 128K X 8 OR 64K x 16 IEEE/696 8 or 16 Bit 1.2 Amps 24 Bit Addressing

BOGBT167A	128K A&T	$1695.00	$1610.00
BOGBT167C	128K CSC	$1895.00	$1795.00

S-100 PROM

PBI PROM PROGRAMMER - SSM

Programs 2708 or 2716's, operates as a 4K/8K EPROM BOARD AS WELL.

BOSSMPB1K	Kit		$179.00
BOSSMPB1A	A & T	$265.00	$220.00

ECONOROM 2708 - COMPUPRO

16K x 8 EPROM Board using 2708. Power on jump to any 256 byte

BOGBT125A	A & T	$135.00	$120.00
BOGBT125C	CSC	$195.00	$175.00

MB8A - SSM

1K/16K 2708 EPROM board, disable in 1K increments

BOSSMMB8AK	Kit		$114.00
BOSSMMB8AA	A & T	$179.00	$159.00

S-100 VIDEO BOARDS

SPECTRUM - COMPUPRO

Color Graphics board with Parallel I/O

BOGBT144A	A & T	$399.00	$349.00
BOGBT144C	CSC	$449.00	$399.00
BOGBT20	Sublogic Universal Graphics Interpreter Software		$35.00

VB - 3 S.S.M.

80 x 25 or 50 character video display Memory Mapped, Parallel Keyboard port

BOSSMVB3K24	80 x 24 Kit		$425.00
BOSSMVB3A24	80 x 24 A&T	$499.00	$440.00
BOSSMVB3UP	80 x 50 Line Upgrade		$ 39.00

VB2-S.S.M.

I/O Mapped Video Board, with Parallel Keyboard port 64 x 16

BOSSMVB2K	Kit		$199.00
BOSSMVB2A	A & T	$269.00	$229.00

VBBB - S.S.M.

Memory Mapped Video Board 64 x 16 character display or 64 x 16 graphics display

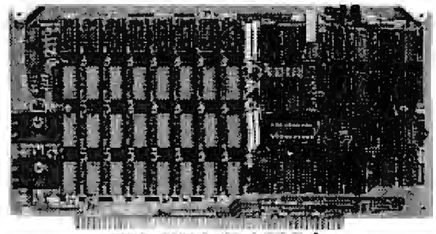
BOSSMVB1K	Kit		$179.00
BOSSMVB1A	A & T	$242.00	$220.00

S-100 MOTHERBOARDS - COMPUPRO

Active termination, 6-12-20 slot

BOGBT153A	A&T 6 slot, 2 lbs	$140.00	$126.00
BOGBT153C	CSC 6 slot, 2 lbs.	$190.00	$175.00
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
BOGTB155C	CSC 20 slot, 4 lbs.	$340.00	$310.00

S-100 DYNAMIC RAM



THE EXPANDABLE 1

PRIORITY 1 ELECTRONICS

THE EXPANDABLE 1" 64K Dynamic Ram board provides your S-100 system with 64K of reliable, high-speed dynamic RAM. Compatable with most of the major S-100 systems on the market, including those with front panels, it supports DMA operations and requires no Wait states with current microprocessors.
• User expandable from 16 to 64K • Supports DMA • Designed to IEEE proposed S-100 bus standards • 2 or 4 MHz operation • Operates with either an 8080 or Z-80 based S-100 system, providing processor-transparent refreshes with both • Supports IMSAI-type front panels • Jumper-selectable Phantom input • Uses Popular 4116 RAMS • All ICs in sockets • Any 16K block can be made bank-independent • Fully buffered address and data lines • Fail-safe refresh circuitry for extended Wait states • Board configuration with reliable, easy-to-configure Berg jumpers

BOPRIEXP116	16K Assembled & Tested	$299.00
BOPRIEXP132	32K Assembled & Tested	$339.00
BOPRIEXP148	48K Assembled & Tested	$379.00
BOPRIEXP164	64K Assembled & Tested	$409.00

S-100 DISK CONTROLLERS

2422A - CA. COMP. SYST.

I/O Mapped, controls 8", single or double density A&T with CPM 2.2 8" S.D.

		LIST PRICE	OUR PRICE
BOCCS2422A		$475.00	$375.00

DISK JOCKEY 2D - MORROW

Memory Mapped, controls 8", single or double density, serial I/O

BOMDIOJ2208	A&T with CP/M 2.2	$399.00	$375.00

S-100 DISK SUBSYSTEMS

DJ2B DISCUS SINGLE SIDED MORROW

8" DBL Density drives with cabinet, power supply controller, with CP/M 2.2 and Microsoft Basic

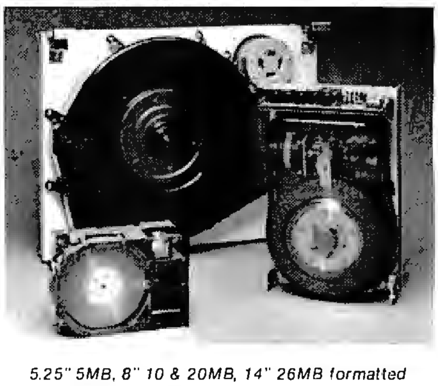
BOMDSF1218	Single Drive System	$1095.00	$950.00
BOMDSF1228	Dual Drive System	$1875.00	$1598.00

DJ2B DISCUS DOUBLE SIDED - MORROW

8" DBL Density/sided drives with cabinet Power supply controller, with CP/M 2.2 and Microsoft Basic

BOMDSF2218	Single Drive System	$1395.00	$1250.00
BOMDSF2228	Dual Drive System	$2495.00	$2050.00

S-100 HARD DISK - MORROW



5.25" 5MB, 8" 10 & 20MB, 14" 26MB formatted hard disk complete with cabinet, P.S., Controller, CP/M 2.2 and Microsoft MBASIC 80

		LIST PRICE	SALE PRICE
BOMDSDMAM5	5 MB	$2495.00	$1995.00
BOMDSM10S	10 MB	$3695.00	$2950.00
BOMDSM20S	20 MB	$4795.00	$3825.00
BOMDSM26S	26 MB	$4495.00	$3495.00

WOW!

OUTPERFORMS MONITORS OF TWICE THE PRICE

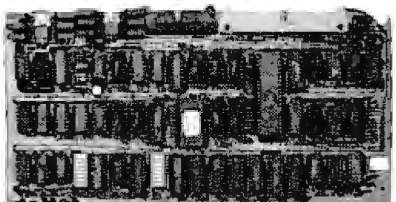
USI has the competition buckling at their knees! You can have a professional performing Video Monitor for a **fraction of the cost!** *The USI EV2131N is a 12" Green, high resolution data display compatable with 80 x 24 computer formats*

BOUSIEV2131N	24 lbs.	$149.00

Circle 334 on inquiry card.

PRIORITY ONE ELECTRONICS

COMPUPRO DMA DISK 1 WITH FREE CP/M 2.2 SALE $450.00



SAVE $220.00

Priority 1 Electronics is pleased to offer the GODBOUT DISK 1 High Performance Disk Controller at our regular low price with CP/M 2.2 and BIOS at no additional cost. That's a savings of $220.00 of the manufacturer's list price.

- Third generation INTEL 8272/NEC 765A LSI floppy disk controller.
- High speed cycle stealing DMA interface for processor independent data transfer between system memory and flexible disk.
- Handles up to four 8 or 5.25 inch floppy disk drives
- Single or double density/single or double sided capability.
- Supports IBM 3740 soft sectored formats.
- 24 bit DMA addressing with data transfer across 64K boundaries for data transfer throughout the 16Mbyte memory map.

PART NO.	DESCRIPTION	LIST PRICE	OUR PRICE
BOPDB171ACPM	A&T w/CP/M 2.2 & BIOS	$670.00	$450.00
BOGBT171C	CSC	$595.00	$555.00
BOGBTCPM80*	CP/M 2.2 for Z80/8085 with manuals & BIOS 8" S/D disk		$175.00
BOGBTOAS8S	Oasis 8 bit single user 8" S/D disk		$500.00
BOGBTOAS8M	Oasis 8 bit multiuser, 8" S/D disk		$850.00

S-100 SYSTEMS

SUPERSIXTEEN — COMPUPRO

HERE IS WHAT EACH PACKAGE INCLUDES:

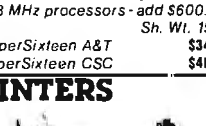
BOGBT1612A 6 MHz 8085/8088 Dual Processor Board
BOGBT171A High Speed DMA Disk Controller
BOGBT162A System Support 1 Multi-Function Board
BOGBT133A Interfacer 1 Dual Serial I/O
BO128K 10MHz Low Power Static Ram
BOGBTCP/M 86 16 Bit Operating System Ready to Load & Go
Cables and Documentation Three interfacer cables one disk I/O cable, complete documentator for all hardware, and manuals for both CP/M operating systems.
Compu Pro's famous 1 Year limited warranty.

Now to the best part of all. If purchased separately, these quality components would list for $4,344.00. BUT SuperSixteen's low package price is an amazing $3,495.00. You save $849.00!(For boards qualified under the Certified System Component high-reliability program - with extended 2 year warranty, 200 hour burn-in and 6/8 MHz processors - add $600.00 to the package price. Sh. Wt. 15 lbs.

BOPOBGBTSJ	SuperSixteen A&T	$3495.00
BOPOBGBTSX	SuperSixteen CSC	$4095.00

PRINTERS

BEST PRICE!



MICROLINE — OKIDATA WITH FRICTION AND TRACTOR FEED

- BI-DIRECTIONAL - 120CPS
- Parallel and Serial I/O
- 9x9 Matrix (Alphanumeric)
- 100 Thru 1200 Baud
- 6/9 or 12 Matrix for Graphics
- Self Test
- 5,8.3, 10,16 Charactrsp/Inch
- Out of Paper Switch
- 6 or 8 Lines per Inch
- Friction or Tractor Feed
- 80 CPL @ 10 CPI for 82A
- 3" to 14" Top of Form (Switch Selectable)
- 132 CPL @ 10 CPI for 83A
- 10 Different Character Sets

PART NO.	DESCRIPTION	LIST PRICE	SALE PRICE
BOOKIDAT82AT(26 lbs)	8 80 CPL @ 10 CPI	$ 799.00	$539.00
BOOKIDAT83AT (37 lbs)	132 CPL @ 10 CPI	$1195.00	$750.00
BOOKISER2KBF	9600 baud with 2K Serial Buffer upgrade with X-on Y-off		$159.00
BOOKIGRAPH	High Resolution Graphics Prom		$99.00

CALL FOR THE NEW MICROLINE 84

MX80 — EPSON

NEED WE SAY MORE?

BOEPNMX80	Tractor Feed 17 lbs	$645.00	$450.00
BOEPNMX100	132 Col. Tractor Feed 24 lbs		$725.00

PRINTER INTERFACES - MICROBYTE

RS232 Serial Conversion for MX80 & MX 100

BOMBSSEII	A & T	$55.00
	Apple Centronics 8 bit parallel interface for Centronics, Epson & OKIDATA printers	
BOMBSAEII	A & T	$55.00
BOMBSAEC1	Cable for above	$14.95

Printer interfaces & cables sold only with printer purchase

S-100 MAINFRAMES

S-100 MICROFRAME - TEI

110V 60HZ CVT Mainframes, the best money can buy!
12 Slot ±8V 17A±16V @ 2A
22 Slot ±8V @ 30A± 16V @ 4A

PART NO.		LIST PRICE	OUR PRICE 1-9	10-24
BOTEIMCS 112	12 Slot Desk	$685.00	$615.00	$570.00
BOTEIMCS 122	22 Slot Desk	$825.00	$760.00	$705.00
BOTEIRM 12	12 Slot Rackmount	$725.00	$720.00	$619.00
BOTEIRM 22	22 Slot Rackmount	$875.00	$850.00	$750.00

Shipping Weight: On 12 Slot Mainframe 45 lbs. On 22 Slot Mainframes 55 lbs.

TEI S-100 FRAMES 3 - 5" DISK CUTOUTS

±8V @ 17±16V @ 1.2A, Internal Cables

			1-9	10-24
BOTEITF12	12 Slot desk	$675.00	$625.00	$580.00
BOTEIRF12	12 Slot Rackmount	$795.00	$715.00	$665.00

Shipping Weight: On 12 Slot Desk 40 lbs. On 12 Slot Rackmount 45 lbs.

DUAL 8" DISK DRIVE CHASSIS - TEI

For Shugart 800/801R or 850/851R with internal power cables provided
+24V @ 1.5A+5V @ 1.0A - 5V @ .25A

			1-9	10-24
BOTEBCFDD	Desk Top	$535.00	$485.00	$455.00
BOTEIRFDD	Rack Mount	$720.00	$670.00	$630.00

CALL FOR NEW TEI PRICES APRIL 1st

S-100 MAINFRAME - COMPUPRO

110V 60HZ CVT Mainframe uses famous 20 slot GODBOUT Motherboard. 55 lbs.

BOGBTENC20RM	20 Slot Rack Mount	$895.00	$825.00
BOGBTENC20DK	20 Slot Desk Top	$825.00	$780.00

S-100 MAINFRAME - CCS

12-slot motherboard with removable termination card

BOCCS220001	Office Cream	35 lbs	$575.00	$535.00
BOCCS220002	Blue	35 lbs	$575.00	$535.00

SOFTWARE - MICROPRO

All software is supplied on 8" Single Density IBM 3740 CP/M Compatable Diskettes

WORDSTAR

Screen-Oriented, integrated word processing system specifically designed for non-technical personnel
BOMPRWRDSTAI $495.00 $300.00

MAIL MERGE WORD STAR OPTION

Powerful file merging tool
BOMPRMLMRGAI (Requires Word Star 2.1 or later) $250.00 $100.00

SPELLSTAR WORD STAR OPTION

One Step "Proofreader" with compressed 20,000 word dictionary and user-created supplemental dictionaries
BOMPRSPLSTAI (Requires Word Star 3.0 or later) $250.00 $150.00

SUPERSORT

Sophisticated program that will select and re-arrange variable length information from data files
BOMPRSPRSRAI $250.00 $150.00

CALC STAR

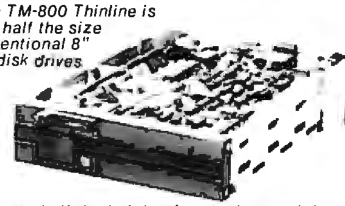
Sophisticated, easy-to-use, electronic spread sheet and financial planner
BOMPRCLCSTAI $295.00 $200.00

DATA STAR

Office-Oriented Data Entry, retrival, and updating system
BOMPRDATSTAI $350.00 $200.00

FLOPPY DISC DRIVES

Tandon TM-800 Thinline is exactly half the size of conventional 8" floppy disk drives



1 ONE

Exactly one-half the height of any other model.
Propietary, high-resolution, read-write heads patented by Tandon
D.C. only operation - no A.C. required
Industry standard interlace.
Three millisecond track-to-track access time 9 lbs.

BOTNDTM8481	Single Sided	$425.00	2 or more	$385.00
BOTNDTM8482	Double Sided	$575.00	2 or more	$550.00
BOTNDTM8M	Manual - not included with drive			$ 10.00

801R - SHUGART

Single sided double density most popular 8" drive

BOSHU801R	$425.00 ea or 2 or more (16 lbs) for	$395.00 ea.
BOSHUSA801RM	Manual for 801R drives	$ 10.00

DT-8 - QUME

DT-8 - QUME
2 OR MORE $499.00

Data track 8 double sided, double density 8"
BOQMEDT8WH Sh. Wt. 16 lbs $525.00 ea.

2 or more $499.00 each

BOQMEDT8M Manual for DT-8 $ 10.00

5¼" DRIVES - TANDON

BOTNDTM1001	Single Sided, 250KB (5 lbs)	$310.00
BOTNDTM1002	Double Sided, 500KB	$370.00
BOTNDTM1003	Single Sided, 500KB	$375.00
BOTNDTM1004	Double Sided, 1000KB	$495.00
BOTNDTM5M	Manual, not included with drive	$ 10.00

DISK CABINETS

V-100 - VISTA

- Desk or rack mountable
- Internal power and data cables
- Drives pull out for easy service and maintenance

BOVISV100 Disk Drive Cabinet (43 lbs) $495.00 $449.00

SINGLE 8" - Q.T.

Single 8" cabinet with power supply
BOQTCDDC8 (22 lbs) $249.00 $225.00

DUAL 8" - Q.T.

Dual 8' cabinet with power supply
BOQTCDDC88 (24) $395.00 $349.00

5" CABINETS - VISTA

BOVIS 9801	Single 5" with P.S.	$75.00
BOVIS 9802	Dual 5" with P.S.	$95.00

TERMINALS

SALE! $525.00

VIEWPOINT — ADDS

Detachable keyboard, RS232 interlace and auxiliary port, 80 x 24 display, tiltable screen SALE
BOADDVWPR Shipping Weight 40 lbs $699.00 $525.00

VT200 — VISUAL TECHNOLOGY

THE MOST RELIABLE TERMINAL WE'VE EVER USED!

Detachable keyboard, RS232C or 20MA interface, 110 to 19200 baud, 12" non glare 80 x 24 display, RS232 Aux. port and composite video out.
BOVSL200 Shipping Weight 55 lbs. $995.00

PRIORITY ONE ELECTRONICS

MEMBER MITA NEDA

9161-B DEERING AVE ● CHATSWORTH, CA 91311

ORDER TOLL FREE (800) 423-5922 CA, AK, HI CALL (213) 709-5464

Terms U.S. VISA MC BAC, Check, Money Order, U.S. Funds Only CA residents add 6% Sales Tax MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $2.50 for the first 3 lbs. plus 25¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone no. Prices subject to change without notice. We will do our best to maintain prices through April, 1982. Credit Card orders will be charged appropriate freight. See November BYTE for 60 page Catalog or send $1.00 for your copy today. Sale prices are for prepaid orders only.

PRIORITY ONE ELECTRONICS

PROTECT YOUR INVESTMENT
PROTECT YOUR DATA WITH

GSC

ISOBAR

With Built-In Noise Filters and Surge Suppressors

ISOLATES SENSITIVE AND VALUABLE EQUIPMENT FROM: *Equipment interaction - Damaging High Voltage Spikes - AC line noise and hash.*
PROTECTS AGAINST: *Voltage transients caused by lightning, contact switching, turn-off of inductive components, noise due to electromagnetic coupling.*
USE THE GSC ISOBAR TO ISOLATE: Microprocessor from peripherals - Lab instruments from noisy equipment - Sensitive pre-amp or tape deck from power amplifier.
THE GSC ISOBAR ELIMINATES: Equipment interaction - Equipment damage from power line spikes and surges - Errors - False printouts - Disk Skips - Audio or video hash.
FEATURES: Inductive isolated ground - Sockets individually filter isolated - Circuit breaker protected at 15A
VOLTAGE TRANSIENT SPIKE PROTECTION: 2000 A peak for up to 6 Sec duration spikes. 1000A, 8/20 Sec protection from repeated spikes.
LOAD HANDLING: 1875 W max. total load; 15A per socket.
INPUT: 125 VAC, 15 amps; standard 3-prong plug.

IBAR 3 Three common outlets built-in circuit breaker, pilot light, hang-up bracket and a 6 foot cord.

		LIST PRICE	OUR PRICE
BDGOFIBAR3	SH. WT. 3 lbs.	$59.95	**$39.95**

IBAR 46 - Four independently isolated outlets. Built-in 15A circuit breaker, pilot light, switch, and 6 foot cord.

BDGOFIBAR46	SH. WT. 4 lbs.	$79.95	**$49.95**

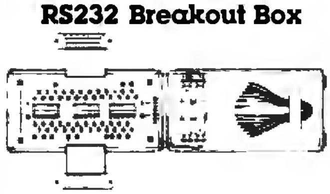
IBAR 86 - 8 outlets, grouped to form 4 independently isolated sets of two. Built in 15A circuit breaker, on/off switch, pilot light.

BDGOFIBAR86	SH. WT. 5 lbs.	$84.95	**$54.95**

IBAR 9RM - Eight rear-mounted outlets grouped to form four independently isolated sets of two, plus one non-isolated convenience outlet on front face. 19" rack mount cabinet. Built in 15A circuit breaker, pilot light, on/off switch, and 6 foot cord.

BDGOFIBAR9RM	SH. WT. 6 lbs.	$99.95	**$74.95**

RS232 Breakout Box



A must for every technician, repair man or systems integrator

The Breakout Box contains 24 Dual-In-Line Switches which allow any of the interface signals (except Pin 1, which is not used) to be interrupted. The switches are located in the center of the main control panel. A 25 way female connector for connecting the box to the DTE is fitted to the left hand side via a ribbon cable and a 25 way male connector for connection to the DCE is similarly connected to the right hand side.

DTE and DCE interface connection pins are located on both sides of the Dual-In-Line switches. Using the jumpers supplied these pins permit monitoring of any of the interface lines with either or both the positive and negative test indicators on the front panel. These pins also permit cross-patching or the connection of an external test meter or oscilloscope.

The Breakout Box contains indicators which monitor the following signals

Pin	Function
2	Transmitted Data
3	Received Data
4	Request to Send
5	Ready for Sending (clear to send)
6	Data Set Ready
8	Data Channel Received Line Signal Detector
15	Transmitter Signal Element Timing
17	Receiver Signal Element Timing
20	Connect Data Set to Line/Data Terminal Ready
21	Signal Quality
22	Ring Indicator
25	Busy

Breakout box is contained in a tough plastic case and is powered by two 1.5 volt penlight batteries. No power is consumed by the tester when not in use. Dimensions: 2.9" x 5.55" x 1.45" Weight: 10 ounces, with batteries

BDDNW232BOX	$199.00	**$159.00**

GLOBAL SPECIALTIES LOGIC PROBES

SPECIFICATIONS *Shipping Wt. 2 lbs*

MODEL	LP1	LP2	LP3
Response	50 ns. 20 ns. single shot event, 10MHz pulse train	300 ns. 1.5MHz pulse train	6 ns typical, tested at 10 ns. 70MHz pulse train
Pulse Mode	High Speed Train or Single Event		

Part No.	Description	List Price	Our Price
BDGSCLP1	Standard 10MHz w/Memory	$50.00	**$45.00**
BDGSCLP2	Economy 1.5MHz	$32.00	**$30.00**
BDGSCLP3	High Speed 70MHz w/Memory	$77.00	**$69.00**
BDGSCDP1	High speed Digital Pulser 100 PPS or single shot	$83.00	**$76.00**
BDGSCLTC1	LP1, DP1 and LM1 in molded case	$240.00	**$220.00**
BDGSCLTC2	LP3, DP1 and LM1 in molded case	$270.00	**$245.00**

MICROCOMPUTER PRODUCTS

MEMORY

PART NO.	PRICE
BD4116AC20	8/$18.00
BD2016P3	8/$72.00
BD2114N3L	8/$28.00
BD5257N3L	8/$50.00
BD2732	8/$120.00
BD2716	8/$50.00
BD2708	8/$20.00

Z80 SERIES

BDZ80A	$14.95
BDZ80AP10	$14.95
BDZ80ACTC	$13.95
BDZ80ADMA	$45.00
BDZ80AS100	$59.95
BDZ80AS101	$59.95
BDZ80AS102	$59.95

UARTS

BDAY51013A	$5.95
BDTR1602B	$5.95
BDTR1863	$6.95
BDIM6402	$7.95

8080 SERIES

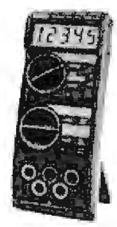
PART NO.	PRICE
BDINS 8080A	$5.50
BDINS 8085A	$19.95
BDDP8212N	$2.95
BDDP8214N	$5.25
BDDP8216N	$2.95
BDDP8224N	$3.25
BDDP8224-4N	$9.95
BDDP8226N	$3.50
BDDP8228N	$5.55
BDDP8238N	$5.55
BDINS8250N	$15.00
BDINS8251N	$7.50
BDINS8253N	$17.95
BDINS8255N	$6.80
BDINS8257N	$16.45
BDINS8259N	$18.00
BDINS8275N	$59.95
BDINS8279N	$49.95

FLOPPY DISC CONTROLLER

BDFD1771B-01	$24.95
BDFD1791B-01	$44.95

KEITHLEY

Handheld DMMs For Every Application and Budget



Easy-to-use Rotary Switches
Large 0.6" LCD displays
dc Voltage
ac Voltage
dc Current
ac Current
Resistance
Diode Test
3½ or 4½ Digit Accuracy
Overload Protection
Externally Accessable Battery & Fuse
Rugged 0.1" ABS Plastic Case
Shock-Mounted PC Board

4½ Digits $235.00

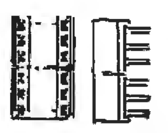
BDKTH130	**#0.5% DCV accuracy, 10M input** impedence auto polarity and current measurement through 10A	**$124.00**
BDKTH131	Same as BDKTH130 except 0.25% accuracy and enhanced band with on top ACV ranges	**$139.00**
BDKTH128	See/hear display includes both over/under threshold indicator arrows, audible tone that operates on all ranges & functions, and adjustable threshold	**$139.00**
BDKTH135	4½ digit, 0.05% accuracy	**$235.00**
BDKTH870	Thermocouple(TC)based themometer	**$199.00**
BDKTH1304	Soft Carrying Case & Stand(handhelds)	**$ 10.00**
BDKTH1306	Deluxe Carrying Case (handhelds)	**$ 25.00**

LCD & LED Bench DMMs

BDKTH169	3½ Digit, LCD Display	**$189.00**
BDKTH176	4½ Digit, LCD Display	**$269.00**
BDKTH179A	4½ Digit, LED Dispay, TRMS	**$359.00**
BDKTH1793	IEEE-488 Interface(Model 179A)	**$325.00**

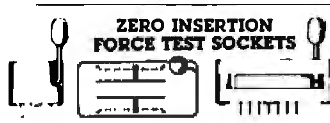
See pp. 42-43 of our Engineering Selection Guide in the November **BYTE** for a complete list of specifications and accessories.

SPECIAL PURCHASE
16 PIN LOW PROFILE IC. C95 SOCKETS
GOLD



BCTIG16LP pkg of 100 .... **$16.00**
BCTIG16LP pkg of 1000 .... **$120.00**
OEMS Stock up at this LOW PRICE!

ZERO INSERTION FORCE TEST SOCKETS



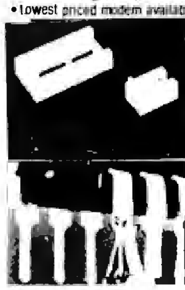
	1-9	10-24
BCZIP16 DIP	$ 5.50	$5.35
BCZIP24 DIP	$ 7.50	$7.25
BCZIP40 DIP	$10.25	$9.85

ANCHOR AUTOMATION

THE SIGNALMAN MK I

MODEM PRICE BREAKTHROUGH!

PRODUCT FEATURES
- Direct Connect Modem
- Built-In RS232C Cable and Connector
- Self-contained 9V Battery - Wall plug transformer available
- Audible carrier detect signal.
- Automatic mode selection.
- Talk/Data switch.
- CONNECTS IN SERIES WITH MODULAR *HANDSET* JACK ON TELEPHONE
- Complete with RS232C and Modular Handset Cables, eliminates need to buy cables — save $20.00 -$30.00, assures correct fit.
- Uses lowcost 9V battery. Eliminates unsightly cords and need for "another"
- AC outlet. Optional plug-in transformer available.
- Audio Transducer eliminates need to view LED to confirm connection—can be placed anywhere (velcro tape provided).
- Advanced IC Circuitry eliminates confusion of who is originator — ends need to manually switch from Originate to Answer and Vice/Versa.
- Permits you to listen/ talk on phone or switch to datacommunications mode.
- Permits you to communicate with most other computer networks.
- Small size, light weight permits you to install the SIGNALMAN anywhere.
- Lowest priced modem available

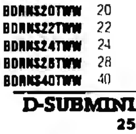


ROBINSON-NUGENT ICN SERIES GOLD 3 LEVEL WIRE WRAP SOCKETS

- 10 μ in GOLD Plated Pins
- Deep Chamfered Closed Entry Contacts
- RN Side Wipe Contact Design
- Phosphor Bronze Contact Material
- Terminal Barbs Allow Self-lock into PC Board
- Rugged Socket Body Design
- Deep Chamfered Closed Entry Contacts

PART NO.	PINS	PRICE 1-9	10-24	25-99	100-249	250-999
BDRNS08WWG	8	.60	.55	.49	.45	.41
BDRNS14WWG	14	.75	.70	.65	.55	.48
BDRNS16WWG	16	.85	.75	.70	.60	.52
BDRNS18WWG	18	1.00	.90	.80	.75	.71
BDRNS20WWG	20	1.20	1.05	.96	.91	.87
BDRNS22WWG	22	1.35	1.25	1.15	1.05	.99
BDRNS24WWG	24	1.35	1.25	1.15	1.05	.99
BDRNS28WWG	28	1.70	1.55	1.40	1.34	1.25
BDRNS40WWG	40	2.20	2.05	1.85	1.60	1.50

GOLD PLATED CONTACTS



TIN PLATED TAILS

NEW!
SELECTIVE PLATED PINS THAT WILL SAVE YOU MONEY BY HAVING GOLD ONLY WHERE IT COUNTS!
Same as above except pins are selectively plated.

PART NO.	PINS	PRICE 1-9	10-24	25-99	100-24	250-99
BDRNS08TWW	8	.55	.50	.45	.41	.37
BDRNS14TWW	14	.65	.55	.50	.47	.44
BDRNS16TWW	16	.75	.65	.52	.51	.46
BDRNS18TWW	18	.90	.79	.75	.70	.65
BDRNS20TWW	20	1.10	.95	.91	.87	.82
BDRNS22TWW	22	1.25	1.15	1.05	.94	.89
BDRNS24TWW	24	1.25	1.15	1.05	.96	.89
BDRNS28TWW	28	1.50	1.45	1.35	1.25	1.15
BDRNS40TWW	40	2.00	1.80	1.60	1.40	1.30

D-SUBMINIATURE CONNECTORS

25 Pin Solder Type

BDCNDDB25P	25 Pin Male	$3.00	$2.75	$2.25

★**BDCNDDB25P** *100 pcs at* **$1.95 ea** ★

BDCNDDB25S	25 Pin Female	$4.00	$3.75	$3.00

★ **BDCNDDB25S** *100 pcs at* **$2.95 ea** ★

BDCNDD851226	2 Pc. Black Hood	$1.90	$1.65	$1.45
BDCNDD851212	1 Pc. Grey Hood	$1.60	$1.45	$1.30
BDCNDP25H	2 Pc. Grey Hood	$1.50	$1.25	$1.10

Call for other D-Subminiature connectors

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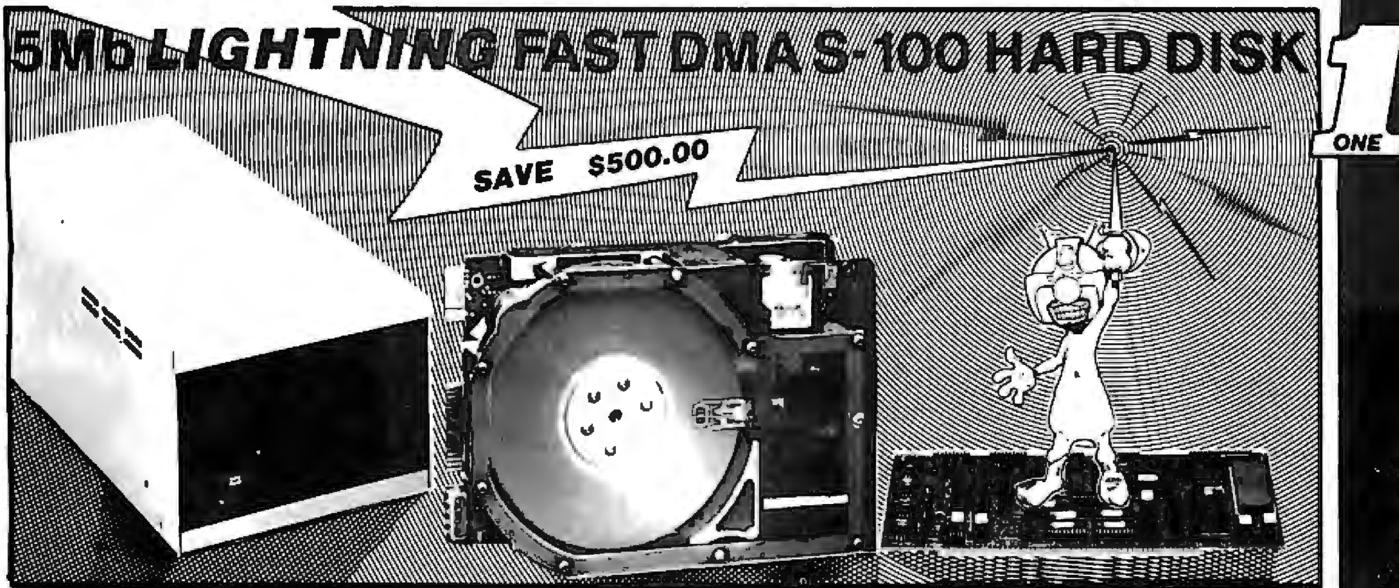
Terms U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6% Sales Tax. MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $2.50 for the first 3 lbs. plus 25¢ for each additional pound. Orders over 50 lbs sent freight collect. Just in case, please include your phone no. Prices subject to change without notice. We will do our beest to maintain prices through April, 1982. Credit Card orders will be charged appropriate freight. See November **BYTE** for 60 page Catalog or send $1.00 for your copy today. Sale prices are for prepaid orders only.

HARD DISK FOR LESS THAN FLOPPIES



DISCUS M5 by MORROW DESIGNS

PRIORITY 1 ONE ELECTRONICS

INTRODUCTORY PRICE: $1995.00

LIST PRICE: $2495.00

PRIORITY 1 ELECTRONICS is pleased to announce Morrow Designs' DISCUS M5, the lowest cost 5 megabyte Winchester sub-system and the fastest. Now you can afford a hard disk for the price of floppies. Morrow Designs is the largest supplier of hard disk sub-systems to the S-100 market. With the new DMA Hard Disk Controller and the ST506 mini-Winchester drive, Morrow has attained speeds over 600,000 bytes per second.

As with all Morrow Designs' systems, Morrow delivers it complete. Drive, controller, cabinet, power supply, fan, transformer, cables, *CP/M 2.2*™ operating system, *Microsoft*™ Basic 80 and a ninety day warranty.

The DISCUS M5 regularly sells for $2495.00. *Priority 1 Electronics* is proud to offer the DISCUS M5 for a limited time at only $1995.00. Winchester speed, 5Mb capacity and reliability for only $1995.00. Three additional drives may be daisy-chained to the controller for future expansion. Perfect to back up each other at the end of each day. Takes seconds, is more reliable than tape and with the outside lock can be unplugged and removed (after the locking screw has been put in place.)

A few facts about the ST506 drive which is being used in the Discus M5:

Key Features:

- Storage Capacity of 6.38 megabytes unformatted, 5.0 megabytes formatted as shipped
- Same physical size and mounting as the minifloppy
- Same DC voltages as the minifloppy
- Band actuator and stepper motor head positioning
- 5.0 megabit/second transfer rate
- Same track capacity as a double density 8 inch floppy
- 170 millisecond random average access time, reduceable to 95 ms via a simple software algorithm
- The only single S-100 DMA Hard disk controller board on the market today
- Fully compatable with high speed 6MHz and 8 MHz CPUs of today and tomorrow
- DMA bus arbitration as outlined by the IEEE 696 standard
- Controls 1 to 4 soft sectored Winchester drives
- Supports both 5¼" and 8" drives
- ST506 or SA 1000 interface compatable
- Variable sector length (256, 512, 1024, or 2048 byte sectors)
- Automatic CRC generation and checking
- Addresses 1 to 16 heads
- Addresses an infinite number of tracks
- Contains its own on-board microprocessor
- 24-bit address burst DMA transfers
- Channel driven
- All disk driver routines resident on the controller
- Variable format
- No buffering required
- Maximum transfer rate 5,000,000 bits per second
- Due to this high transfer rate, a minimum CPU speed of 2.5MHz is required

Pure Speed

The speed of this Winchester controller is enhanced by Morrow's channel driven concept. This DMA hard disk controller (DMAHDC) picks up its commands from the host processor via memory on the system bus. The host processor writes commands into memory and then picks them up during DMA cycles from this memory. The channel, commands and transfers may be located anywhere in the 24-bit address range. At the completion of the command, the controller returns appropriate status and can generate an interrupt. Commands may be chained together by the CPU to allow the controller to execute many commands in succession, generating an interrupt at the end of each command and/or at the end of the completed command chain.

Communications

An imbedded microprocessor enables the user to easily communicate with this intelligent device. All low level disk drive routines are resident on the controller itself.

These include:

format	write a sector
seek	return status
read a header	set DMA address
read a sector	set channel address

Variable sector lengths are available. On Morrow Designs system products 512 byte sector lengths are standard. This is being done to maximize the capacities available on current drive units but may be varied by independent system integrators when desired.

The DMAHDC has been designed for expansion. One to four drives can be attached directly and controlled. One to sixteen drive heads may be addressed. Any number of tracks may be specified during the seek routine by specifying one to two hundred and fifty-six tracks one or more times. Each of the expansion abilities prepare the user to upgrade his system as technology advances to additional platters and tracks.

The controller has no peer today in the S-100 bus market.

Systems Interfaced:

1. North Star
2. Cromemco
3. Vector Graphics
4. Dynabyte
5. Micromation
6. Exidy
7. Imsai
8. Sol
9. California Computer
10. Godbout
11. Ithaca Intersystem

Look to Morrow for answers!

Look to PRIORITY 1 for the best price!

Priority 1 Electronics, as the world's largest stocking distributor of Morrow Designs' products committed to buy an entire production run of DISCUS M5 sub-systems so we can offer them at a special introductory low price. The DISCUS M5 is a good buy at the list price of $2495.00. The DISCUS M5 is an *excellent* value at our introductory low price of:

$1995.00

BOMDSOMAM5	*Software suplied on 8" IBM3740 disk with blank I/O and INSTALL program*
BOMDSOMAM528	*Software configured for Morrow DJ/2D controller and Mult I/O as console*
BOMDSOMAM5DMA	*Software configured for Morrow DJ/DMA controller and Mult I/O as console*
BOMDSOMAM55S	*Software supplied on 5¼" soft sector (IBM/Cromemco disk w/blank I/O and INSTALL program)*
BOMDSOMAM5NS	*Software supplied on 5¼" 10 sector North Star disk with blank I/O and INSTALL program*

VISA master charge MEMBER MITA NEDA

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TO TEKTRONIX . . .
. . . THEN DECIDE!

BDHITV550B 50 MHz, List $1745.00

Sale $1250.00

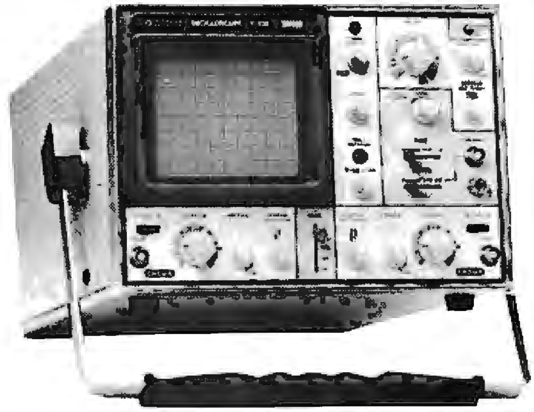
BDHITV352 35 MHz, List $1150.00

Sale $795.00

BDHITV202 20 MHz, List $850.00

Sale $595.00

All HITACHI Scopes come complete with 2, 10 to 1 Probes



SPEC	TEK 2215	HITV1050B	HITV550B	HITV352	HITV202
TRIGGER VIEW	NONE	A, B	A	NONE	NONE
HF REJECTION	NONE	SWITCHABLE YES	SWITCHABLE YES	NONE	NONE
LF REJECTION	NONE	SWITCHABLE YES	SWITCHABLE YES	NONE	NONE
BANO WIOTH LIMIT	NONE	YES 20 MHz	NONE	NONE	NONE
X - Y MEASUREMENTS	YES	YES	YES	YES	YES
CAMERA BEZEL	YES	YES	YES	NO	NO
MULTI POSITION HANDLE	YES	YES	YES	YES	YES
JITTER	10,000:1	20,000:1	20,000:1	——	——
Z AXIS BANDWIDTH 0 - 5 Vpp	DC to 5 MHz	DC to 3.5 MHz	DC to 3.5 MHz	DC to 2 MHz	DC to 2 MHz
POWER CONSUMPTION	50 WATTS	60 WATTS	45 WATTS	45 WATTS	45 WATTS
PROBE CALIBRATOR	YES	YES	YES	YES	YES
MTBF	NOT GIVEN	20,00 HRS TARGET VALUE	20,000 HRS TARGET VALUE	20,000 HRS TARGET VALUE	20,000 HRS TARGET VALUE
A, B CHANNEL GATE OUTPUT	NO	YES	NO	NO	NO
POWER-ON INOICATOR	NO	YES	YES	YES	YES
WARRANTY	1 YEAR	2 YEARS	2 YEARS	2 YEARS	2 YEARS
ALTERNATE SWEEP SEPARATOR	YES	YES	NO	——	——
CRT	8 x 10 OIV INT. GRATICULE P31 PHOSPHOR 10KV ACCEL. V	8 x 10 OIV INT. GRATICULE P31 PHOSPHOR 20KV ACCEL. V.	8 x 10 OIV INT. GRATICULE P31 PHOSPHOR 10KV ACCEL. V	8 x 10 OIV INT. GRATICULE P31 PHOSPHOR 5.2KV ACCEL V.	8 x 10 OIV INT. GRATICULE P31 PHOSPHOR 2KV ACCEL. V
CRT CONTROLS	BRIGHTNESS, AUTO FOCUS BEAM FINOER TRACE ROTATION	BRIGHTNESS AUTO FOCUS BEAM FINOER TRACE ROTATION	BRIGHTNESS AUTO FOCUS TRACE ROTATION	BRIGHTNESS FOCUS TRACE ROTATION	BRIGHTNESS FOCUS TRACE ROTATION

ACCESSORIES

BDHITAP5010	*Accessory pouch for BDHITV550B & BDHITV1050 Oscilloscopes*	$40.00
BDHITDC2035	*Vinyl Dust Cover for BDHITV202 & BDHITV352 Oscilloscopes*	$35.00
BDHITFC5010	*Front Cover For BDHITV550B & BDHIT1050 Oscilloscopes*	$18.00

PRIORITY ONE ELECTRONICS

VISA master charge MEMBER MTA NEDA

TERMS U.S : VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6% Sales Tax. **INCLUDE $15.00 FOR EACH OSCILLOSCOPE** for UPS Surface Shipping and Handling. Just in case, include your phone number. Prices subject to change without notice. We will do our best to maintain these prices through March, 1982. For complete specifications, see our 60 page catalog in the November issue of **BYTE** or send $1.00 for your copy today. Sale Prices are for prepaid orders only. Circle 336 on inquiry card.

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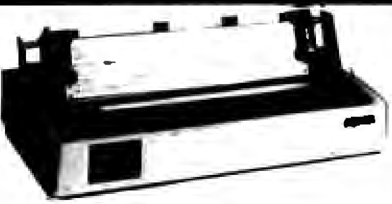
JADE Computer Products

Sunnyvale • Woodland Hills • Hawthorne • San Diego

Printers



BETTER THAN EPSON ! - Okidata

Microline 82A *80/132 column, 120 CPS, 9 x 9 dot matrix, friction feed, pin feed, adjustable tractor feed (removable), 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* $544.95

Microline 83A *132/232 column, 120 CPS, handles forms up to 15" wide, plus all the features of the 82A.*
PRM-43083 *with FREE tractor* $774.95

Microline 84 *132/232 column, 200 CPS, full dot graphics built in, handles forms up to 15" wide, plus all the features of the 83A.*
PRM-43083 *with FREE tractor* ... $1249.95

PRA-27081 *Apple card* $39.95
PRA-27082 *Apple cable* $19.95
PRA-27087 *TRS-80 cable* $24.95
PRA-43081 *Hi speed 2K serial board* $169.95
PRA-43080 *Extra ribbons pkg. of 2* ... $9.95

INEXPENSIVE PRINTERS - Epson

MX-70 *80 column, 80 CPS, 5 x 7 dot matrix, adjustable tractor feed, & graphics*
PRM-27070 *List $459* $399.95

MX-80 *80 column, 80 CPS, bi-directional/logic seeking printing, 9 x 9 dot matrix, adjustable tractor feed, & 64 graphics characters*
PRM-27080 *List $645* $469.95

MX-80FT *same as MX-80 with friction feed added.*
PRM-27082 *List $745* $559.95

MX-100 *132 column, correspondence quality, graphics, up to 15" paper, friction feed & adjustable tractor feed, 9 x 9 dot matrix, 80 CPS.*
PRM-27100 *List $945* $759.95

PRA-27084 *Serial interface* $69.95
PRA-27088 *Serial intf & 2K buffer* .. $144.95
PRA-27081 *Apple card* $74.95
PRA-27082 *Apple cable* $22.95
PRA-27086 *IEEE 488 card* $52.95
PRA-27087 *TRS-80 cable* $32.95
PRA-27085 *Graftrax II* $95.00
PRA-27083 *Extra ribbon* $14.95

Modems

SMARTMODEM - Hayes

Sophisticated direct-connect auto-answer/auto-dial modem, touch-tone or pulse dialing, RS-232C interface, programmable
IOM-5400A *Smartmodem* $249.95
IOK-1500A *Hayes Chronograph* ... $199.95

CAT MODEMS - Novation

CAT *300 baud, acoustic, answer/orginate*
IOM-5200A *List $189.95* $149.95

D-CAT *300 baud direct connect, answer/orginate*
IOM-5201A *List $199.95* $169.95

AUTO-CAT *Auto answer/orginate, direct connect*
IOM-5230A *List $299.95* $239.95

Apple-CAT - Novation

Software selectable 1200 or 300 baud, direct connect, auto-answer/auto-dial, auxiliary 3-wire RS232C serial port for printer.
IOM-5232A *Save $50.00!!!* $325.00

Accessories for Apple

16K MEMORY UPGRADE

Add 16K of RAM to your TRS-80, Apple, or Exidy in just minutes. We've sold thousands of these 16K RAM upgrades which include the appropriate memory chips (as specified by the manufacturer), all necessary jumper blocks, fool-proof instructions, and our 1 year guarantee.
MEX-16100K *TRS-80 kit* $25.00
MEX-16101K *Apple kit* $25.00
MEX-16102K *Exidy kit* $25.00

16K RAM CARD - for Apple II

Expand your Apple to 64K, 1 year warranty
MEX-16500A *Save $70.00 !!!* $129.95

Z-80* CARD for APPLE

Two computers in one, Z-80 & 6502, more than doubles the power & potential of your Apple, includes Z-80 CPU card, CP/M 2.2, & BASIC-80*
CPX-30800A *A & T* $299.95

8" DISK CONTROLLER

New from Vista Computer, single or double sided, single or double density, compatible with DOS 3.2/3.3, Pascal, & CPM 2.2, Shugart & Qume compatible
IOD-2700A *A & T* $499.95

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)* $1995.00

DISK DRIVES - Micro Sci

Inexpensive disk drives for your Apple

A2 *Direct replacement for Apple Disk II, works with Apple II controller as first or second drive.*
MSM-123101 *Micro Sci A2* $429.95

A40 *40 track drive for Apple II. Improved storage capacity and speed over Apple Brand drives - requires Micro Sci controller.*
IOD-2340A *Micro Sci A40* $399.95

A70 *70 track drive for Apple II. Twice the storage capacity and three times faster than Apple Brand drives - requires Micro Sci controller*
IOD-2370A *Micro Sci A70* $499.95

Micro Sci Controller *Disk controller for up to two Micro Sci A40 or A70 disk drives, DOS 3.2, 3.3, Pascal, and Z-80 SoftCard compatible, includes utility disk and 40/70 track patch.*
IOD-2300A *Micro Sci controller* $95.00

VISION 80 - Vista Computer

80 column x 24 line video card for Apple II, 128 ASCII characters, upper and lower case, 9 x 10 dot matrix with 3 dot descenders, standard data media terminal control codes, CP/M Pascal & Fortran compatible, 50/60 Hz
IOV-2400A *Vista Vision 80* $375.00

AIO, ASIO, APIO - S.S.M.

Parallel & serial interface for your Apple (see Byte pg 11)
IOI-2050K *Par & Ser kit* $139.95
IOI-2050A *Par & Ser A & T* $169.95
IOI-2052K *Serial kit* $89.95
IOI-2052A *Serial A & T* $99.95
IOI-2054K *Parallel kit* $69.95
IOI-2054A *Parallel A & T* $89.95

CPS MULTICARD - Mtn. Computer

Three cards in one! Real time clock - calendar, serial interface, & parallel interface - all on one card.
IOX-2300A *A & T* $199.95

Single Board Computer

Z-80 STARTER KIT - SD Systems

Complete Z-80 microcomputer with RAM, ROM, I/O, keyboard, display, kludge area, manual, & workbook
CPS-30100K *KIT* $299.95
CPS-30100A *A & T* $469.95

SYM-1 - Synertek Systems

Single board computer with 1K of RAM, 4K of ROM, key-pad, LED display, 20ma & cassette interface on board.
CPK-50020A *A & T* $249.95

VIC 20 - Commodore

Complete personal computer with 5K RAM, full color, 61 key keyboard, 4 dual special-function keys, serial ports, cassette port, composite video output (connects to standard color TV set), BASIC language, & expansion port.
COM-VIC20 *VIC-20* .... Under $300.00

PERSONAL COMPUTERS

Also available from Jade - Call for Price and Info

AIM-65, Altos, Apple II, Atari, Commodore, California Computer Sys Hewlett-Packard, Intersystems Jade, NEC, Novell, SD Systems SYM-1, Xerox, and more...

Video Monitors

HI-RES 12" GREEN - Zenith

15 MHz bandwidth, 700 lines/inch, P31 green phosphor, switchable 40 or 80 columns, small, light-weight & portable.
VDM-201201 *List price $150.00* $118.95

12" GREEN SCREEN - NEC

20 MHz, P31 phosphor video monitor with audio, exceptionally high resolution - A fantastic monitor at a very reasonable price
VDM-651200 *Special Sale Price* $199.95

12" COLOR MONITOR - NEC

Hi-res monitor with audio & sculptured case
VDC-651212 *Color Monitor* $479.95
NEC-1202D *RGB color monitor* ... $1045.00

Leedex / Amdek

Reasonably priced video monitors
VDM-801210 *Video 100 12" B&W* .. $139.95
VDM-801230 *Video 100-80 12" B& W* $179.95
VDM-801250 *12" Green Phospor* $169.95
VDC-801310 *13" Color I* $379.95
VDC-801320 *Color II* $895.00
IOV-2300A *DVM board for Apple* .. $199.95

Video Terminals

TELEVIDEO 910

Full featured - inexpensive terminal
VDT-901210 *List 795.00* $695.00

TELEVIDEO 950

VDT-901250 *List $1195.00* $995.00

AMBER SCREEN - Volker Craig

Detachable keyboard, amber on black display, 7 x 9 dot matrix, 10 program function keys, 14 key numeric pad, 12" non-glare screen, 50 to 19,200 baud, direct cursor control, auxiliary bi-directional serial port
VDT-351200 *List $795.00* $645.00

VIEWPIONT - ADDS

Detachable keyboard, serial RS232C interface, baud rates from 110 to 19,200, auxiliary serial output port, 24 x 80 display.
VDT-501210 *Sale Priced* $639.95

DIALOGUE 80 - Ampex

VDT-230080 *List $1195.00* $895.00

Circle 222 on inquiry card.

JADE Computer Products

FREE 1982 CATALOG

Just circle our reader service number on the information request card located near the index.

S-100 CPU Boards

THE BIG Z* - Jade
2 or 4 MHz switchable Z-80 CPU with serial I/O, accomodates 2708, 2716, or 2732 EPROM, baud rates from 75 to 9600*
CPU-30201K *Kit* $139.95
CPU-30201A *A & T* $189.95
CPU-30200B *Bare board* $35.00

2810 Z-80* CPU - Cal Comp Sys
2/4 MHz Z-80A CPU with RS-232C serial I/O port and on board MOSS 2.2 monitor PROM, front panel compatible*
CPU-30400A *A & T* $269.95

CB-2 Z-80 CPU - S.S.M.
2 or 4 MHz Z-80 CPU board with provision for up to 8K of ROM or 4K of RAM on board, extended addressing, IEEE S-100, front panel compatible.
CPU-30300K *Kit* $239.95
CPU-30300A *A & T* $299.95

S-100 PROM Boards

PROM-100 - SD Systems
2708, 2716, 2732 EPROM programmer w/software
MEM-99520K *Kit* $189.95
MEM-99520A *A & T* $249.95

PB-1 - S.S.M.
2708, 2716 EPROM board with built-in programmer
MEM-99510K *Kit* $154.95
MEM-99510A *A & T* $219.95

EPROM BOARD - Jade
16K or 32K uses 2708's or 2716's, 1K boundary
MEM-16230K *Kit* $79.95
MEM-16230A *A & T* $119.95

S-100 Video Boards

VB-3 - S.S.M.
80 characters x 24 lines expandable to 80 x 48 for a full page of text, upper & lower case, 256 user defined symbols, 160 x 192 graphics matrix, memory mapped, has key board input.
IOV-1095K *4 MHz kit* $349.95
IOV-1095A *4 MHz A & T* $439.95
IOV-1096K *80 x 48 upgrade* $39.95

VDB-8024 - SD Systems
80 x 24 I/O mapped video board with keyboard I/O, and on-board Z-80A.*
IOV-1020A *A & T* $459.95

VIDEO BOARD - S.S.M.
64 characters x 16 lines, 128 x 48 matrix for graphics, full upper/lower case ASCII character set, numbers, symbols, and greek letters, normal/reverse/blinking video, S-100.
IOV-1051K *Kit* $149.95
IOV-1051A *A & T* $219.95
IOV-1051B *Bare board* $34.95

S-100 Motherboards

ISO-BUS - Jade
Silent, simple, and on sale - a better motherboard
6 Slot (5¼" x 8⅝")
MBS-061B *Bare board* $19.95
MBS-061K *Kit* $39.95
MBS-061A *A & T* $49.95
12 Slot (9¾" x 8⅝")
MBS-121B *Bare board* $29.95
MBS-121K *Kit* $69.95
MBS-121A *A & T* $89.95
18 Slot (14½" x 8⅝")
MBS-181B *Bare board* $49.95
MBS-181K *Kit* $99.95
MBS-181A *A & T* $139.95

S-100 RAM Boards

MEMORY BANK - Jade
4 MHz, S-100, bankselectable, expandable from 16K to 64K
MEM-99730B *Bare Board* $49.95
MEM-99730K *Kit no RAM* $199.95
MEM-32731K *32K Kit* $239.95
MEM-64733K *64K Kit* $279.95
Assembled & Tested .... add $50.00

64K RAM - Calif Computer Sys
4 MHz bank port / bank byte selectable, extended addressing, 16K bank selectable, PHANTOM line allows memory overlay, 8080 / Z80 / front panel compatible.
MEM-64565A *A & T* $575.00

64K STATIC RAM - Mem Merchant
64K static S-100 RAM card, 4-16K banks, up to 8MHz
MEM-64400A *A & T* $789.95

32K STATIC RAM - Jade
2 or 4 MHz expandable static RAM board uses 2114L's
MEM-16151K *16K 4 MHz kit* $169.95
MEM-32151K *32K 4 MHz kit* $299.95
Assembled & tested .... add $50.00

16K STATIC RAM - Mem Merchant
4 MHz 16K static RAM board, IEEE S-100, bank selectable, Phantom capability, addressable in 4K blocks, "disable-able" in 1K segments, extended addressing, low power
MEM-16171A *A & T* $164.95

S-100 Disk Controllers

DOUBLE-D - Jade
Double density controller with the inside track, on-board Z-80A, printer port, IEEE S-100, can function on an interrupt driven buss*
IOD-1200K *Kit* $299.95
IOD-1200A *A & T* $375.00
IOD-1200B *Bare board* $59.95

DOUBLE DENSITY - Cal Comp Sys
5¼" and 8" disk controller, single or double density, with on-board boot loader ROM, and free CP/M 2.2 and manual set.*
IOD-1300A *A & T* $374.95

S-100 I/O Boards

S.P.I.C. - Jade
Our new I/O card with 2 SIO's, 4 CTC's, and 1 PIO
IOI-1045K *2 CTC's, 1 SIO, 1 PIO* .. $179.95
IOI-1045A *A & T* $239.95
IOI-1046K *4 CTC's, 2 SIO's, 1 PIO* $219.95
IOI-1046A *A & T* $299.95
IOI-1045B *Bare board w/ manual* ... $49.95

I/O-4 - S.S.M.
2 serial I/O ports plus 2 parallel I/O ports
IOI-1010K *Kit* $179.95
IOI-1010A *A & T* $249.95
IOI-1010B *Bare board* $35.00

S-100 Mainframes

MAINFRAME - Cal Comp Sys
12 slot S-100 mainframe with 20 amp power supply
ENC-112105 *Kit* $329.95
ENC-112106 *A & T* $399.95

EPROM ERASER - Spectronics
Ultra-violet EPROM erasers
XME-3100A *With out timer* $69.50
XME-3101 *With timer* $94.50
XME-3200 *Economy Model* $39.95

Disk Drives

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

Dual 8" Subassembly Cabinet
END-000420 *Bare cabinet* $59.95
END-000421 *Cabinet kit* $225.00
END-000431 *A & T* $359.95

8" Disk Drive Subsystems
Single Sided, Double Density
END-000423 *Kit w/2 FD100-8Ds* . $924.95
END-000424 *A & T w/2 FD100-8Ds* $1124.95
END-000433 *Kit w/2 SA-801Rs* ... $999.95
END-000434 *A & T w/2 SA-801Rs* $1195.00

8" Disk Drive Subsystems
Double Sided, Double Density
END-000426 *Kit w/2 DT-8s* $1224.95
END-000427 *A & T w/2 DT-8s* ... $1424.95
END-000436 *Kit w/2 SA-851Rs* .. $1295.00
END-000437 *A & T w/2 SA-851Rs* $1495.00

5¼" Disk Drives

***Shugart SA400L** sngl-sided dbl-density 40 track*
MSM-104000 .. $234.95 ea 2 for **$224.95 ea**

***Shugart SA450** dbl-sided dbl-density 70 track*
MSM-104500 .. $349.95 ea 2 for **$329.95 ea**

***Qume DT-5** dbl-sided dbl-density 80 track*
MSM-750050 .. $359.95 ea 2 for **$349.95 ea**

***MPI B-51** sngl-sided dbl-density 40 track*
MSM-155100 .. $234.95 ea 2 for **$224.95 ea**

***MPI B-52** dbl-sided dbl-density 40 track*
MSM-155200 .. $344.95 ea 2 for **$334.95 ea**

***MPI B-91** sngl-sided dbl-density 77 track*
MSM-155300 .. $369.95 ea 2 for **$359.95 ea**

***MPI B-92** dbl-sided dbl-density 77 track*
MSM-155400 .. $469.95 ea 2 for **$459.95 ea**

8" Disk Drives

***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**

***Qume DT-8** double-sided double-density*
MSF-750080 .. $524.95 ea 2 for **$499.95 ea**

***Siemens FDD 100-8** sngl-sided dbl-density*
MSF-201120 .. $384.95 ea 2 for **$349.95 ea**

BUS PROBE - Jade
S-100 diagnostic analyzer board, dynamic visual display of all 96 IEEE S-100 signals, aids in real time analysis of faulty hardware and software
TSX-200B *Bare Board* $59.95
TSX-200K *Kit* $119.95
TSX-200A *A & T* $149.95

Circle 222 on inquiry card.

SD Systems ExpandoRAM III

256K RAM $879.95

Single User System

SBC-200, 64K ExpandoRAM II, Versafloppy II, CP/M 2.2

$1095.00

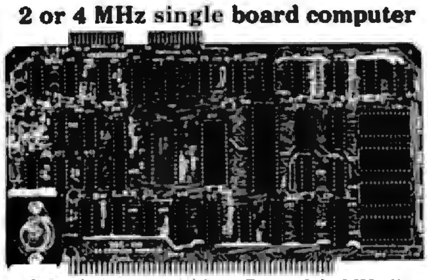
4 MHz Z-80A CPU, 64K RAM, serial I/O port, parallel I/O port, double-density disk controller, CP/M 2.2 disk and manuals, system monitor, control and diagnostic software.

Add $100.00 for upgrade to ExpandoRAM III 64K (expandable to 256K)

-All boards are assembled and tested-

SBC-200

2 or 4 MHz single board computer



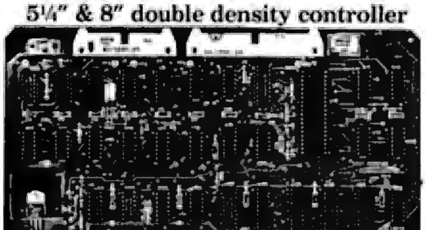
• S-100 bus compatible • Powerful 4MHz Z-80A CPU • Synchronous/asynchronous serial I/O port with RS-232 interface and software programmable baud rates up to 9600 baud • Parallel input and parallel output port • Four channel counter/timer • Fourmaskable, vectored interrupt inputs and a non-maskable interrupt • 1K of on-board RAM • Up to 32K of on-board ROM • System monitor PROM included

The SBC-200 is an excellent CPU board to base a microcomputer system around. With on-board RAM, ROM, and I/O, the SBC-200 allows you to build a powerful three-board system that has the same features found in most five-board microcomputers. The SBC-200 is compatible with both single-user and multi-user systems.

CPU-30200A	*A & T with monitor*	$299.95

Versafloppy II

5¼" & 8" double density controller



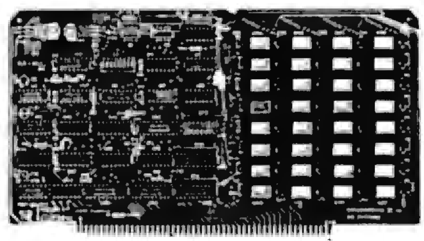
• S-100 bus compatible • IBM 3740 compatible soft sectored format • Controls single and double-sided drives, single or double density, 5¼" and 8" drives in any combination of four simultaneously • Drive select and side select circuitry • Analog phase-locked loop data seperator • Vectored interrupt operation optional • Standard CP/M 2.2 disk operating • Control/diagnostic software PROM included

The Versafloppy II is faster, more stable and more tolerant of bit shift and "jitter" than most controllers. All control and diagnostic software included.

IOD-1160A	*A & T*	$359.95
For CP/M 2.2 and manual set add		$99.95

ExpandoRAM III

64K to 256K expandable RAM board



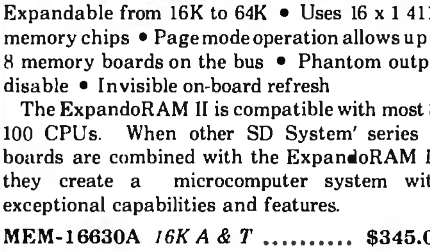
SD Systems has duplicated the famous reliability of their ExpandoRAM I and II boards in the new ExpandoRAM III, a board capable of containing 256K of high speed RAM. Utilizing the new 64K x 1 dymanic RAM chips, you can configure a memory of 64K, 128K, 192K, or 256K, all on one S-100 board. Memory address decoding is done by a programmed bipolar ROM so that the memory map may be dip-switch configured to work with either COSMOS/MPM-type systems or with OASIS-type systems.

Extensive application notes concerning how to operate the ExpandoRAM III with Cromemco, Intersystems, and other popular 4 MHz Z-80 systems are contained in the manual.

MEM-65064A	*64K A & T*	$495.00
MEM-65128A	*128K A & T*	$639.95
MEM-65192A	*192K A & T*	$769.95
MEM-65256A	*256K A & T*	$879.95

ExpandoRAM II

16K to 64K expandable RAM board



• S-100 bus compatible • Up to 4MHz operation • Expandable from 16K to 64K • Uses 16 x 1 4116 memory chips • Page mode operation allows up to 8 memory boards on the bus • Phantom output disable • Invisible on-board refresh

The ExpandoRAM II is compatible with most S-100 CPUs. When other SD System' series II boards are combined with the ExpandoRAM II, they create a microcomputer system with exceptional capabilities and features.

MEM-16630A	*16K A & T*	$345.00
MEM-32631A	*32K A & T*	$365.00
MEM-48632A	*48K A & T*	$385.00
MEM-64633A	*64K A & T*	$399.95

PROM-100

Versatile EPROM Programmer

• S-100 bus compatible • Programs 2708, 2758, 2716, 2732, 2516 EPROMs • DIP switch selection of EPROM type • 25 VDC programming pulse generated on-board • Very fast programming and verification • Zero insertion force socket • Programming software included on 8" diskette

MEM-99520K	*Kit w/software*	$189.95
MEM-99520A	*A & T w/software*	$249.95

Multi-User System

SBC-200, 256K ExpandoRAM III, Versafloppy II, MPC-4 COSMOS Multi-User Operating System, C BASIC II

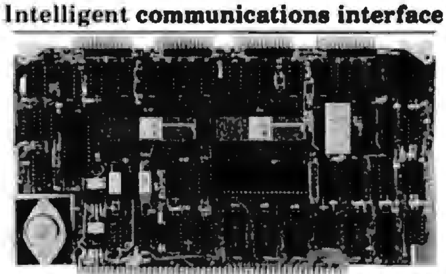
$1995.00

Two Z-80A CPUs (4 MHz), 256K RAM, 5 serial I/O ports with independently programmable baud rates and vectored interrupts, parallel input port, parallel output port, 8 counter/timer channels, real time clock, single and double sided/single or double density disk controller for 5¼" and 8" drives, up to 36K of on-board ROM, CP/M 2.2 compatible COSMOS interrupt driven multi-user disk operating system, allows up to 8 users to run independent jobs concurrently, C BASIC II, control and diagnostic software in PROM included.

-All boards are assembled and tested-

MPC-4

Intelligent communications interface



• Four buffered serial I/O ports • On-board Z-80A processor • Four CTC channels • Independently programmable baud rates • Vectored interrupt capability • Up to 4K of on-board PROM • Up to 2K of on-board RAM • On-board firmware

This is not just another four-port serial I/O board! The on-board processor and firmware provide sufficient intelligence to allow the MPC-4 to handle time consuming I/O tasks, rather than loading down your CPU. To increase overall efficiency, each serial channel has an 80 character input buffer and a 128 character output buffer. The on-board firmware can be modified to make the board SDLC or BISYNC compatible. In combination with SD's COSMOS operating system (which is included with the MPC-4), this board makes a perfect building block for a multi-user system.

IOI-1504A	*A & T with COSMOS*	$495.00

Place Orders Toll Free

Continental U.S.	*Inside California*
800-421-5500	**800-262-1710**

For Technical Inquires or Customer Service call:
213-973-7707

JADE
Computer Products

4901 W. Rosecrans, Hawthorne, Ca 90250

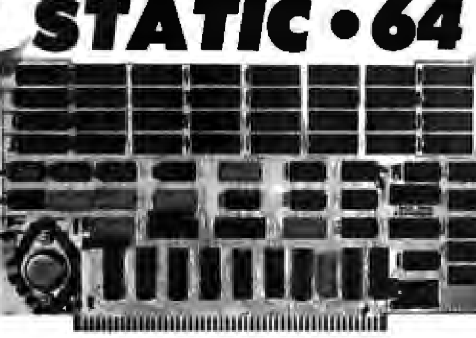
TERMS of SALE: Cash, checks, credit cards, or Purchase Orders from qualified firms and institutions. **Minimum Order $15.00.** California residents add 6% tax. Minimum shipping & handling charge $3.00. Pricing & availibility subject to change

Circle 223 on inquiry card.

California Digital

Post Office Box 3097 B • Torrance, California 90503

California Digital STATIC • 64



RELIABILITY OF STATIC ... PRICE OF DYNAMIC

Sixteen Bit Memory

$595

February Price $850

30% Price Reduction

Utilizing the new Hitachi 6167/2167 ram chip, the Static 64 is the most current technology available is S-100 memory products.
24 bit extended addressing, 8 or 16 bit data paths along with 16 bit request and acknowledge make this unique board completely compatable with the IEEE 696 S-100 buss standard.

The Static 64 has been engineered to allow each 16K segment of memory to be bank selectable supporting multiuser systems. Other selectable features allow the board to fully integrate with all current bank selecting schemes including Cromex and Alpha-Micro. Operates with all 16 bit computers including Seattle Computers. Tecmar and Lomas. Designed for DMA operations at clock frequencies in excess of 10 MHz. Standby power consumption less than one Amp.

To add to the total integrity of the product, each board is subjected to extensive high temperature burn-in and test procedures. CAL-6400

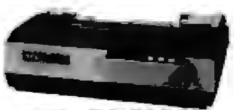
ZENITH $119

GREEN PHOSPHOR MONITOR

The new Zenith ZVM-121 monitor features a P-31 green phosphor tube along with 15 MHz bandwidth.

Switch selectable for 40 and 80 character per line screen formats.

Accepts composite video and is fully compatable with 80 column Apple cards.
VDM-121 20 lbs.



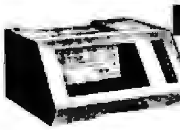
EPSON MX80 — $450

Epson MX80FT friction/tr	$595.00
Epson MX100 132 column	
Graftrax 80 option	70.00
Apple I/O & cable (8131)	129.00
Serial interface (8141)	79.00
Serial Inter., 2K buf. (8151)	145.00
Cable for TRS-80	35.00
IEEE 488 interface (8161)	65.00
Replacement head	45.00
Replacement Ribbon	14.00
Paper 3500 sheets 9 1/2"	35.00

NEC PC-8023A — $535

Dot-matrix, bi-directional, logic-seeking, friction or tractor feed, impact printer. Complete graphics, upper and lower case ASCII, Greek, mathematics long with the ability to print dot graphic screen images directly onto paper.

Proportional spacing and 132 column compressed print make this low cost machine the best value in todays printer market.



PRINTRONIX

P-300 $4500

P-600 $6150

PRINTERS

Epson MX80	PREMX80	$475
Epson MX80FT	PREMX80F	595
Epson MX100	PREMX100	
Anadex 9500	PRA9500	1295
Anadex 9501	PRA9501	1295
Anacom 150	PRA150	1075
IDS Paper Tgr.	PRG460G	1095
IDS Tiger 560	PRG560G	1350
Diablo 630	PRD630	2150
Diablo 1650	PRD1650	2850
Diablo 1640	PRD1640	2496
Datasouth 180	PRD180	1350
Printronix 300	PRP300	4500
Printronix 600	PRP600	6150
NEC/Spinwriter 1	PRN5510ps	2695
NEC/Sm 16K	PRN5516ps	2795
TEC/Starwrit.	PRV300	1395
Okidata 80	PRO80	410
Okidata 82	PRO82	619
Okidata 83	PRO83	895
Teletype 43K	PTT4320K	1095
Texas Ins. 810	PRT810B	1450
Tex.Ins 810C	PRT810C	1795
Centronics 730	PRC730P	529
Centronics 737	PRC737P	695
Centronics 739	PRC739P	795
Centrnx 704-9	PRC704-9	
Centrnx.704-11	PRC704-11	

SYSTEMS

HEWLETT PACKARD
HP 85 COMPUTER
BELOW OUR COST
$2295

apple
48K Memory
$1150

IBM 3101 Display Terminal

IBM Direct Price $1395

California Digital discount price **$1295**

AMPEX DIALOGUE 80

REDUCED PRICE

$795

New from the Ampex Corporation. The Dialogue 80 features removable keyboard, displayable two pages (four optional) dual program keys, half intensity protected fields and status line. Transmits data either block, line or character mode. Excellent value. VDT-D80 shipping 47 lbs.

VIDEO TERMINALS

ADDS Viewpoint	VDT-RVP	595
ADDS Regent 25 numeric cluster	VDT-R25	850
ADDS Regent 30 25th status line	VDT-R30	950
ADDS Regent 40 limited graphics	VDT-R40	1195
ADDS Regent 60 Block mode	VDT-R60	1495
Ampex Dialouge 80 two page,detatch	VDT-D80	
Digital Equipment VT-100	VDT-V100	1595
Digital Equipment VT-132	VDT-V132	1895
IBM 3101-10 character mode green	VDT-3101	1195
IBM 3101-20 block mode	VDT-31012	1395
Visual 200	VDT-V200	995
Televideo 910C (new)	VDT-T910	595
Televideo 912C	VDT-T912	665
Televideo 920C	VDT-T920	745
Televideo 950C detatchable keybd.	VDT-T950	985
Zenith Z-19	VDT-Z-19	

VIDEO MONITORS

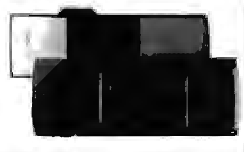
BMC KG-12C 20 MHz P31 green phosphor	$169
NEC gm. 1201	189
Zenith gm ZVM121	119
BMC color composit	339
Zenith color 13"	395
NEC RGB 1202DH	895

EPROM ERASER

Ultra Vilot Products

$65

UVP-11E

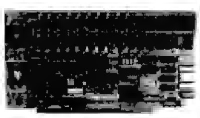


ACCESSORIES FOR THE APPLE COMPUTER

CALIFORNIA COMPUTER SYSTEMS	
Arithmetic Processor 7811 B/C	$319
Asynchronous serial Interface 7710	129
Centronics Interface card 7728	95
12K PROM Module 7114	69
Calender/Clock, Bat. back-up 7424	99
Parallel Interface 7720A	99
Programable Timer 7740A	99
Analog/Digital converter 7470A	99
MICROSOFT PRODUCTS	
Apple to Z-80 CPU card	379
D.C. HAYES PRODUCTS	
Micromodem for Apple	319
COMPUTER STOP PRODUCTS	
Double Vision / 80 Column Video	250
INTERACTIVE STRUCTURES	
16 Channel A/D card AIO/2	275
MOUNTAIN COMPUTER PRODUCTS	
Intro X-10 system for BSR	[illegible]
Intro X-10 card only	[illegible]
16 channel AD/DA 8 bit	[illegible]
Apple Clock battery back-up	[illegible]
Supertalker SD200	[illegible]
ROM Plus with filter	[illegible]
ROM Writer/Programmer	[illegible]
APPLE BRAND PRODUCTS	
Apple Language card	[illegible]
Floppy disk with controller	[illegible]
Floppy disk wit but controller	[illegible]
Apple parallel interface	[illegible]
SSM MICROCOMPUTER	
Dual serial parallel interface AIO	
SORRENTO VALLEY ASSOCIATES	
8" floppy controller (Pascal)	[illegible]

S-100 BOARDS

Assembled • Tested • Burned-in



CPU BOARDS

Calif. Computer 2810A Z-80 DMA, 4MHz	BDC-C2810	$250
Godbout Z-80 24 bit, 4MHz	BDC-GZ80	220
Godbout 8085/8088 dual 16 bit processor	BDC-G88	375
Measurement Systems Z-80 4 serial 2 parallel real time clock, 8 vector	BDC-MZ80	395
SD Systems SBC-200 Z-80 with serial & parallel I/O ports	BDC-SBC2	385
Teletek FDC-1 single board CPU & floppy disk controller plus I/O	BDC-FDC1	695

MAINFRAMES

Calif. Computer 2200A 12 slot & power supply	ENM-C2200	
TEI 12 slot table	ENM-T12	
TEI 22 slot table	ENM-T22	
Godbout mainfrm.	ENM-GMF	

MEMORY BOARDS

Calif. Computer 2065A 64K dyamic memory	BDM-C2065	
Calif. Computer 2016 16K static memory	BDM-C2016	259
Calif. Computer 2032 32K static memory	BDM-C2032	585
Godbout Ram 17 64K static memory 16 bit	BDM-G17	1025
SD Systems Expandoram II 16K dynamic	BDM-EX16	295
64K dynamic	BDM-EX64	375
Measurement Systems DMB6400 for Alpha Micro	BDM-M6400	685

EPROM BOARDS

Digital Research 32K, 2716 proms extra	BDM-DP32	80
SD Systems Prom-100 programmer	BDM-P100	250

FLOPPY DISK CONTROLLER

Calif. Computer 2422A with 2.2 CPM	BDF-C2422	329
Godbout "Disk One" features the NEC 765 controller, DMA arbitration	BDF-GD1	395
Measurement Systems 765 chip, single & double density. Error recovery	BDF-MF	410
SD Systems Versafloppy II double density	BDF-VF2	419
Tarbell D/D	BDF-TF2	439
Morrow Design Disk Jockey I single density	BDF-DJ1	195
Morrow Design Disk Jockey II double density	BDF-DJ2	345

INTERFACE BOARDS

Calif. Computer 2718 I/O 2 serial/2 par'l	BDT-C2718	
Morrow Designs Switchboard 2 serial/4 par'l	BDT-MSB	219
Morrow Designs Multiboard 3 serial/3P, +++	BDT-MMB	275
Godbout Interfacer One 2 serial/2 par'l	BDS-GB1	199
Godbout Interfacer Two 1 serial/3 par'l	BDS-GB2	199

SPECIALITY BOARDS

QT Computer real time clock/calendar	BDS-QCK	139
Artec Elec. Wire wrap prototype board	BDS-AWW	25
Artec Elec. General Purpose proto board	BDS-AGP	25
Godbout Spectrum color board	BDS-GSC	294
D.C. Hayes S-100 Micromodem	BDS-HMI	350
Mullen Products extender board & logic probe kt	BDS-MTB1	49
Mullen Products Opto-contro board kit	BDS-MOC	139

Rotron Muffin Fan

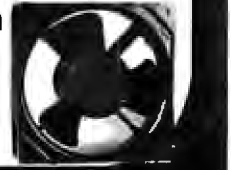
$14.77

$12.00 @ 100
10.50 @ 1000

115 VAC. 7 Watts WR2A1

Factory fresh Muffin fans

NOT pull-outs. EMF-4M



VISA

master charge

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Circle 73 on inquiry card.

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TECHNICAL & CALIFORNIA
(213) 679-9001
TWX 910 325-6212

California Digital

Post Office Box 3097 B • Torrance, California 90503

DISKETTES

FREE PLASTIC LIBRARY CASE INCLUDED WITH THE PURCHASE OF EVERY BOX OF DISKETTES

$24.95

Private labeled for California Digital by one of the most respected producers of magnetic media. Each diskette is certified double density at 40 tracks. To insure extended media life each diskette is manufactured with a reinforced hub-hole. And of course, a plastic library case is included with every box of diskettes. MDD-CDX(5)X10) Please specify computer or required sectors.

Ten boxes $22.75 One hundred boxes $21.50

5¼" DISKETTES WITH LIBRARY CASE

$26.50

Your Choice
SCOTCH
MEMOREX
VERBATIM

	Soft Sector	10 Sector	16 Sector	
SCOTCH	744-0	744-10	744-16	$26.50
MEMOREX	3401	3403	3405	26.50
VERBATIM	525-01	525-10	NA	26.50
DYSAN	104/1	107/1	NA	39.50

Single Side Double Density

DYSAN	104/1D	107/1D	NA	45.00

Double Side Double Density

SCOTCH	745-0	745-10	745-16	42.50
DYSAN	104/2D	107/2D	NA	49.50
DYSAN 96	204/2D	NA	NA	59.50

EIGHT INCH DISKETTES

Single Side Single Density			Single Side Double Density		
SCOTCH	740-0	29.50	SCOTCH	741-0	39.00
MEMOREX	3060	29.50	MEMOREX	3090	35.00
DYSAN	3740/1	39.50	DYSAN	3740/D	57.50
Thirty Two Sector			Double side Double Density		
SCOTCH	740-32	29.50	SCOTCH	743-0	47.50
Scotch Head Cleaning Kits 5¼ & 8"		$24.95	MEMOREX	3114	39.50
Plastic Library Cases 5¼ & 8"		1.95	DYSAN	3740/2D	65.00
Diskette Flip Tubs 10 diskettes 5¼"		24.95			
Diskette Flip Tubs 10 diskettes 8		24.95			

PLEASE PHONE FOR VOLUME PRICING.

BSR SYSTEM X-10

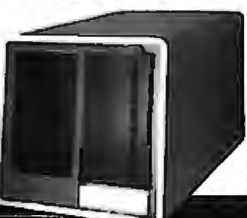
The new BSR timer runs your home just like clockwork. Turns on lamps and appliances while your away from home. Completely compatible with your existing Sym X-10 devices.

BSR Timer eight channel	$65.95	Appliance Module 500 W.	$13.95
Master control console	34.95	Lamp Module 300 Watts	13.95
Ultrasonic Controller	19.95	NEW full control wall switch	14.50

WINCHESTER SUBSYSTEM

$1250

Includes seven megabyte Winchester hard disk, dual enclosure and power supply. Floppy backup drive $199.95 additional.



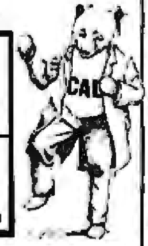
VISA

master charge

Circle 73 on inquiry card.

MEMORY

64K DYNAMIC	16K STATIC
$9.95	$13.95
4164 100-	2167 70ns.
16K DYNAMIC	**2716 EPROM**
$2.10	$4.95
4116 100-$1.85	100-$4.50 1K-$4.00



2732 EPROM SALE $7.95

STATIC

		ea.	32+	100+	1K+
21L02	1K	1.19	1.09	1.05	.99
2114	300ns.	2.95	2.75	2.50	1.99
4044-4	450ns.	4.50	4.19	4.00	3.75
4044-2	250ns.	4.95	4.65	4.50	4.25
6116	16k 24 pin	7.95	7.50	6.75	5.45
2167/6167	20 pin	11.95	10.75	9.65	9.25

EPROM

		ea.	32+	100+	1K+
2708	450ns.	3.95	3.50	3.25	3.00
2716	5V.	4.95	4.00	3.75	3.50
2716	tri-volt	8.50	7.95	7.65	7.25
2732	Intel/Hitac.	7.95	7.50	7.00	6.65
2532	Texas Inst	12.95	11.50	10.00	9.50
2764	64K Eprom	29.95	27.00	25.00	23.50

direct connect MODEM

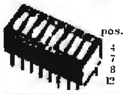
Your Choice **$169**

Direct connect modems eliminate loss of information due to the carbon compression associated with acoustic modems. Choose either of these two great units.

The Universal Data Systems 103LP is switch selectable between answer and originate modes. Fully Bell 103 compatable. Directly connects to the new modular telephone jack. 100% powered from the telephone line. No need to locate modems in proximity to A.C. power recepticle. MOD-103LP 2 pounds.

Novation "D" Cat connects to most of the new "Bell" modular handsets. Ideal for multiple line office telephones. Requires external A.C. power. MOD-DCAT 2 Lb.

SWITCHES



DIP SWITCHES

pos.	ea.	100+	1K+
4	.80	.75	[illegible]
7	.99	.83	[illegible]
8	1.05	.91	[illegible]
12	1.19	.90	[illegible]

TOGGLE

		ea.	100+
7101	on/on	1.19	.98
7103	on/off/on	1.39	1.19
7107	mnt. on	1.49	1.19
7108	mnt. on	1.39	1.19
7205	dpdt mnt	1.55	[illegible]

CONNECTORS

GOLD EDGE CONNECTORS

S-100 .125" centers	each	10+
Imsai solder .250" row	$2.95	$2.50
Imsai wire wrap (TI)	3.95	3.50
Soldtan Hi-Rel. .250"	4.50	4.00
Soldtan Hi-Rel. W/W	5.35	4.90
Soldtan / Altair .140"	4.95	4.70

.156" Centers (standard)		
22/44 Kim Eyelet	2.50	2.15
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	6.60	6.15
43/86 Moto. 6800 W/W	7.00	6.85

INTEGRATED CIRCUIT SOCKETS

	Low Profile each	Low Profile 100+	Wire Wrap each	Wire Wrap 100+
8 pin	$.10	$.09	$.45	$.41
14 pin	.10	.09	.47	.41
16 pin	.12	.11	[illegible]	.45
18 pin	.15	.13	[illegible]	.61
24 pin	.25	.24	[illegible]	.87
40 pin	.45	.40	[illegible]	1.47

"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	1.25	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	8.60	8.00
DD50 hood 2/P	2.60	2.40	2.10

CENTRONICS			
57-30360	[illegible]	6.75	[illegible]

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	5.15	4.90

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NEW OLIVETTI 801 Eight Inch Disk Drive $295

		ONE	TWO	TEN
★ OLIVETTI 801	single	$319	309	295
★ OLIVETTI 802/851	double	425	419	410
SHUGART 801/R	single	395	385	375
SHUGART 851/R	double	525	495	475
QUME DATA TRACK 8	double	525	495	475

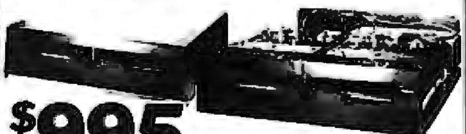
★ The 8" Olivetti drives are aprox. ½" wider than the Shugarts.

Five Inch Disk Drives

OLIVETTI 501/400	single	199	185	175
OLIVETTI 502/451	double	235	225	215

Upon request, all drives are supplied with power connectors and one manual per order.

230 volt 50Hz. 8" add $50.00 per drive.



$995 *Eight Inch Subsystem*

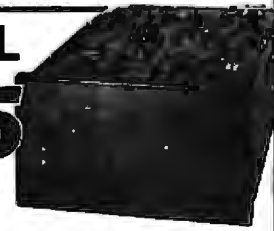
Two Olivetti 801 disk drives with power supply, 4" exhaust fan complete in dual enclosure with all necessary power cables. Documentation included. 50 Lbs. CAL-2801

Signal cable add $35.00 WCA-6500

Same as above but with:

Shugart 801R	MSD2801	$1195	Olivetti 802	CAL2802	$1250
Shugart 851R	MSD2851	1450	Qume DT8	MSD8DT	1450

SPECIAL $895



Volumn Pricing Upon Request

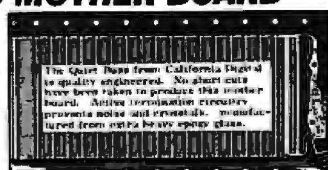
Seagate Compatable 7.5 MEGABYTE Winchester Hard Disk Drive

We have priced this so low that the manufacturer has asked not to use their brand name in our advertising.
Industry standard Seagate plug compatable. Drive fits into the same space as a 5¼" floppy disk drive. CAL-561/2

S-100 MOTHER BOARD

$35

IMSAI
18 Slot
CAL-M18



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15381 CHEMICAL LANE ★ HUNTINGTON BEACH, CA 92649
★ (714) 891-2677 ★

SOFTWARE SOFTWARE SOFTWARE

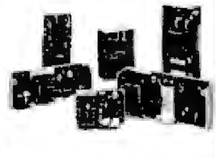
CP/M 2.2 $150
WORDSTAR $250
SUPER VYZ $95

DATA BASE DBII $595
MICROSOFT BASIC 80 $299

CROSSTALK MODEM $150

OPEN FRAME POWER SUPPLIES

DISK POWER SUPPLIES				
PRIAM–SHUGART–CENTURY–MICROPOLIS				
+5V @ 9A	–5V @ .8A	+24V @ 7A	US-384	89.00
SHUGART – SIEMANS – MPI 5¼"				
+5V @ .5A	+12V @ .9A		US-340	33.50
+5V @ 2A	+12V @ 4A		US-323	56.25
SHUGART – SIEMANS – CDC 8"				
+5V @ 1A	–5V @ .5A	+24V @ 1.5A	US-205	52.50
+5V @ 2A	–5V @ .5A	+24V @ 3A	US-206	69.00
+5V @ 3A	–5V @ .6A	+24V @ 5A	US-162	89.00
+5V @ 1.7A	–5V @ 1.5A	+24V @ 2A	US-272	69.00
+5V @ 2A	+12V @ .4A	–12V @ .4A	US-HTAA	37.50



If you can beat these prices we will be truly amazed. OEM's at 500 lot pay more than this. Call or write for full spec. sheets.

COMING NEXT MONTH — HARD DISK!

BREAK THE COST BARRIER!

GRAND OPENING SPECIAL

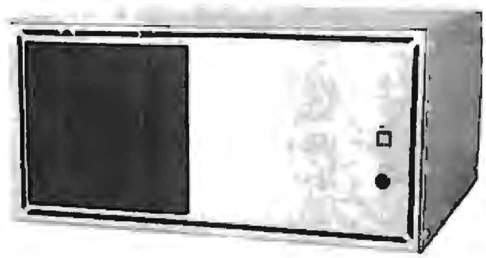
THIS OFFER ONLY GOOD THRU MAY 1982
NOW IS YOUR CHANCE TO GET THAT COMPUTER
LOOK AT THESE FEATURES!

- 4MHZ Z-80 CPU with 2 Programmable Serial and 3 Parallel Ports
- 64K Dynamic Ram w/Extended Addressing to 1MB
- Floppy Disk Controller with WD1795. Runs 8" or 5" Floppys Error Free
- 30 Amp Power Supply with S-100 MOD 12 Slot Mother with Regulated Floppy Supplies as Shown Below
- Tan and Charcoal Sturdy Steel Cabinet with Space for 2 Floppy Drives at Left (8" or 5")

$1750 Retail

ONLY $975.00

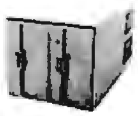
CP/M $150*
MP/M $350
CABLE SET $30

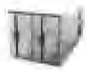


(Less Drives, Cables Pick-up Price)
*CP/M is a Trademark of Digital Research

★ DUAL DRIVE SUBSYSTEMS ★


HORIZONTAL


VERTICLE


MINI

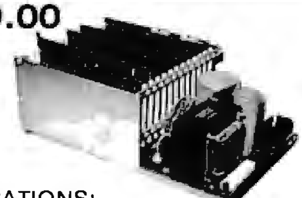
- Power Supply for 2 801/851 DT8 etc.
- 50 Pin Ribbon Cable, 36"
- AC Cord Fuse Internal Wiring

w/2 801R Shugart	$1045.00
w/2 851R Shugart	$1395.00
w/2 QUME DT-8	$1295.00
w/2 MPI B-51	$ 675.00
w/2 MPI B-52	$ 830.00
w/2 MPI B91	$ 850.00
w/2 MPI B92	$ 995.00
w/2 Empty 5"	$ 87.00
w/2 Empty 8"	$ 95.00

★ DELTA PRODUCTS ★

S-100 MOD KIT $199.00

For test or hobby applications complete S-100 12 Slot Sub-System power for up to 4 Floppy Disk Drives.

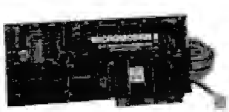


SPECIFICATIONS:

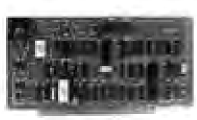
UNREGULATED	REGULATED
• 12 Slots S-100	+5 at 5 Amps
• +8VDC at 30Amps	+24 at 4 Amps
• ±16VDC at 6 Amps	–5 at 1 Amp

DP-CPU	Z-80 4MHZ, Prom 2 Serial 3 Par	**$255**
DP-DSK	WD-1795 MINI and 8"	**$275**
DP-64K	Bank SW Memory up to 1 Meg	**$389**
DP-32K	Static Ram (Kit)	**$199**
DP-MPM	IO MPM Interface Card	**$335**
DP-DTC	Hard Disk and DTC Tape	**$225**
DP-SMS	Hard Disk Controller	**$750**

★ MODEMS ★

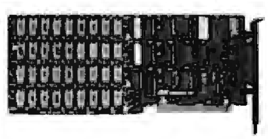


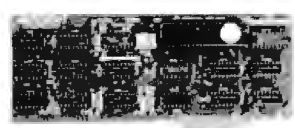
Ask About Our Low Cost Modem Software



Hayes - Micro Modem	**$275.00**
Hayes - Smart Modem	**$250.00**
NOV. - DCAT 300 Baud Direct Con. Ans./Orig.	**$165.00**
NOV. - AUTOCAT Auto/Ans./Orig. Direct Con.	**$235.00**
NOV. - APPLECAT 300/1200 Baud Direct Con.	**$350.00**
PMMI - MM103 300/600 Baud (S-100)	**$359.00**

★ IBM AND APPLE ★





APPLE - 16K Ram Expansion Card, works with Microsoft Basic	**$99.50**
APPLE - Z-80 CPU Direct replacement for Z-80 Softcard	**$149.50**
IBM-PC Ram Expansion Card with 64K (256K available	**$475.00**

Circle 420 on inquiry card.

PRINTERS

- C-ITOH PROWRITER $625.00
- C-ITOH Comet I 9 x 7 Dot Matrix ...$450.00
- C-ITOH Comet II...$810.00 132 Column Printer 9 x7 Dot Matrix
- MPI-88G $725.00
- EPSON MX 80 ......CALL
- EPSON MX 100 .....CALL
- Anadex 9501 ....$1,235.00 Graphic Printer
- OKIDATA 82A $465.00
- Microline 80 ......$329.00

MONITORS

ZENITH VIDEO MONITOR-
ZVM $145.00

AMDEK MONITORS—
AMDEK Color 1 ...$399.00
AMDEK Video 300 .$229.00
w/Green Screen

California Computer Systems

- 2810 CPU Only — $255.00
- 2422 Dsk Cont Only — $330.00
- 2065C 64K Only — $510.00
- 2200A Mainframe Only — $450.00
- CCS Apple Boards Call for prices
- CCS 2200 System Tested and Assembled Only — $1,695.00

★ SPECIAL ★ SPECIAL ★ SPECIAL ★

CCS SYSTEM 2410

FEATURES

- DMA Disk Controller
- 2-Real Time Clocks
- 2-Serial/1-Parrell Port
- Hardware Vectored Interupts
- Supports C/PM, M/PM, OASIS

*****Comes with C/PM*****
only-$2200.00

U.S. MICRO SALES

11 EDISON DRIVE ★ NEW LENOX ★ ILLINOIS 60451
CALL TOLL FREE: 1-800-435-9357 ★ MONDAY thru SATURDAY
(ILLINOIS RESIDENTS CALL: 815-485-4002) ★ 8:00 a.m. to 6:30 p.m.

TERMS: Prepayment — C.O.D. up to $100.00 — M/C Visa
$5.00 Processing and Handling added to each order PLUS
Shipping Charges. Please allow personal check to clear before shipment.
15% Restocking Charge

SSM

CB2-CPU $295.00
MB10A-16K.........$295.00
MB64-64K $845.00
I/05-2SER 3PAR.....$329.00
I/O8-8SER $550.00

Apple

A-I/O II $225.00
A-SI/O $149.00

COMMUNICATIONS PACKAGES

TRACEND I..........$89.00
TRACEND II $149.00

DISK DRIVES

- Shugart 801's — $395.00
- Shugart 851's — $575.00
- Qume DT-8's — $540.00
- Shugart 400's — $255.00
- Tandom 5¼ — $255.00

TERMINALS

- Adds Regent 20 — $570.00
- Televideo 910 — $575.00
- Televideo 912C — $665.00
- Televideo 925C — $740.00
- Televideo 950 — $950.00
- Ampex Dialog 80—$895.00
- Zenith Z19 — $745.00

Zenith data systems

CALL FOR PRICES

FEATURES!

TERMINAL

- Feather Touch Capacitance Keyboard
- 60 Key Standard ASCII
  PLUS + Hex Keypad
  PLUS + 8 Special Function Keys
  PLUS + 20 Screen Editing Keys
- SOROC Type Screen Attribute Set
- Half Intensity

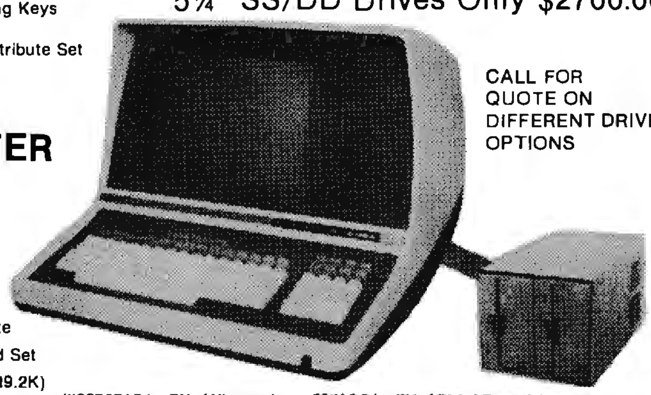
COMPUTER

- 8 Slot S-100
- 64K Dynamic Ram
- 4MHZ Z-80
- Double Density Disk Controller
- Programmable Baud Rate
- Programmable Keyboard Set
- Serial Printer Port (150-19.2K)

S-100-8

INCLUDING CP/M 2.2®
AND WORDSTAR®

WITH: 8" SS/DD Drives Only $2850.00
5¼" SS/DD Drives Only $2700.00



CALL FOR QUOTE ON DIFFERENT DRIVE OPTIONS

WORDSTAR is a TM of Micropro Inc. - CP/M 2.2 is a TM of Digital Research Inc.

Circle 420 on inquiry card.

16K Memory 4116-200ns 8/15.95

ALL MERCHANDISE 100% GUARANTEED! **CALL US FOR VOLUME QUOTES**

EPROMS

			Each	8 pcs
1702	256 x 8	(1ns)	4.95	4.50
2708	1024 x 8	(450ns)	2.99	2.75
2758	1024 x 8	(5V) (450ns)	9.95	8.95
TMS2516	2048 x 8	(5V) (450ns)	6.95	5.95
2716	2048 x 8	(5V) (450ns)	5.50	4.95
2716-1	2048 x 8	(5V) (350ns)	9.00	8.50
TMS2716	2048 x 8	(450ns)	9.95	8.95
TMS2532	4096 x 8	(5V) (450ns)	12.95	11.95
2732	4096 x 8	(5V) (450ns) (200ns)		CALL
2764	8192 x 8	(5V) (450ns)		CALL

DYNAMIC RAMS

				100 pcs
4027	4096 x 1	(250ns)	2.50	2.00
4116-120	16,384 x 1	(120ns)	8/29.95	CALL
4116-150	16,384 x 1	(150ns)	8/18.95	1.95
4116-200	16,384 x 1	(200ns)	8/15.95	1.80
4116-300	16,384 x 1	(300ns)	8/14.95	1.75
4164	64,536 x 1	(200ns)		CALL

STATIC RAMS

				100 pcs
2101	256 x 4	(450ns)	1.95	1.85
2102-1	1024 x 1	(450ns)	.89	.85
21L02-4	1024 x 1	(LP) (450ns)	1.29	1.15
21L02-2	1024 x 1	(LP) (250ns)	1.69	1.55
2111	256 x 4	(450ns)	2.99	2.49
2112	256 x 4	(450ns)	2.99	2.79
2114	1024 x 4	(450ns)	8/16.95	1.95
2114L-2	1024 x 4	(LP) (200ns)	8/19.95	2.35
2114L-3	1024 x 4	(LP) (300ns)	8/18.95	2.25
2114L-4	1024 x 4	(LP) (450ns)	8/17.95	2.10
2147	4096 x 1	(55ns)	9.95	CALL
TMS4044-4	4096 x 1	(450ns)	3.49	3.25
TMS4044-3	4096 x 1	(300ns)	3.99	3.75
TMS40L44-2	4096 x 1	(LP) (200ns)	4.49	4.25
TMM2016	2048 x 8	(200ns) (150ns)		CALL
HM6116	2048 x 8	(200ns) (150ns) (120ns)		CALL

LP = LOW POWER

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				74LS166	2.40	74LS293	1.85
74LS00	.25	74LS85	1.15	74LS168	1.75	74LS295	1.05
74LS01	.25	74LS86	.40	74LS169	1.75	74LS298	1.20
74LS02	.25	74LS90	.65	74LS170	1.75	74LS324	1.75
74LS03	.25	74LS91	.89	74LS173	.80	74LS352	1.55
74LS04	.25	74LS92	.70	74LS174	.95	74LS353	1.55
74LS05	.25	74LS93	.65	74LS175	.95	74LS363	1.35
74LS08	.35	74LS95	.85	74LS181	2.15	74LS364	1.95
74LS10	.25	74LS96	.95	74LS189	9.95	74LS365	.95
74LS11	.35	74LS107	.40	74LS190	1.00	74LS366	.95
74LS12	.35	74LS109	.40	74LS191	1.00	74LS367	.70
74LS13	.45	74LS112	.45	74LS192	.85	74LS368	.70
74LS14	1.00	74LS113	.45	74LS193	.95	74LS373	.99
74LS15	.35	74LS114	.50	74LS194	1.00	74LS374	1.75
74LS20	.25	74LS122	.45	74LS195	.95	74LS377	1.45
74LS21	.35	74LS123	.95	74LS196	.85	74LS378	1.18
74LS22	.25	74LS124	2.99	74LS197	.85	74LS379	1.35
74LS26	.35	74LS125	.95	74LS221	1.20	74LS385	1.90
74LS27	.35	74LS126	.85	74LS240	.99	74LS386	.65
74LS28	.35	74LS132	.75	74LS241	.99	74LS390	1.90
74LS30	.25	74LS136	.55	74LS242	1.85	74LS393	1.90
74LS32	.35	74LS137	.99	74LS243	1.85	74LS395	1.65
74LS33	.55	74LS138	.75	74LS244	.99	74LS399	1.70
74LS37	.55	74LS139	.75	74LS245	1.90	74LS424	2.95
74LS38	.35	74LS145	1.20	74LS247	.76	74LS447	.37
74LS40	.35	74LS147	2.49	74LS248	1.25	74LS490	1.95
74LS42	.55	74LS148	1.35	74LS249	.99	74LS668	1.69
74LS47	.75	74LS151	.75	74LS251	1.30	74LS669	1.89
74LS48	.75	74LS153	.75	74LS253	.85	74LS670	2.20
74LS49	.75	74LS154	2.35	74LS257	.85	74LS674	9.65
74LS51	.25	74LS155	1.15	74LS258	.85	74LS682	3.20
74LS54	.35	74LS156	.95	74LS259	2.85	74LS683	2.30
74LS55	.35	74LS157	.75	74LS260	.65	74LS684	2.40
74LS63	1.25	74LS158	.75	74LS266	.55	74LS685	2.40
74LS73	.40	74LS160	.90	74LS273	1.65	74LS688	2.40
74LS74	.45	74LS161	.95	74LS275	3.35	74LS689	2.40
74LS75	.50	74LS162	.95	74LS279	.55	81LS95	1.69
74LS76	.40	74LS163	.95	74LS280	1.98	81LS96	1.69
74LS78	.50	74LS164	.95	74LS283	1.00	81LS97	1.69
74LS83	.75	74LS165	.95	74LS290	1.25	81LS98	1.69

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74C02	.35	74C901	.80	4020	.95	4099	1.95
74C04	.35	74C902	.85	4021	.95	14409	12.95
74C08	.35	74C903	.85	4022	1.15	14410	12.95
74C10	.35	74C905	10.95	4023	.35	14411	11.95
74C14	1.50	74C906	.95	4024	.75	14412	12.95
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74C160	2.00	4001	.35	4066	.75	4539	1.95
74C161	2.00	4002	.25	4068	.40	4543	2.70
74C162	2.00	4006	.95	4069	.35	4555	.95
76C163	2.00	4007	.29	4070	.35	4556	.95
74C164	2.00	4008	.95	4071	.30	4581	1.95
74C165	2.00	4009	.45	4072	.30	4582	1.95
74C173	2.00	4010	.45	4073	.30	4584	.95
74C174	2.25	4011	.35	4075	.30	4585	.95
74C175	2.25	4012	.25	4076	.95	4702	12.95
74C192	2.25	4013	.45	4078	.30	4724	1.50
74C193	2.25	4014	.95	4081	.30	80C07	.95
74C195	2.25	4015	.95	4082	.30	80C95	.85
74C200	5.75	4016	.45	4085	.95	80C96	.95
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74C373	2.75	4018	.95	4093	.95	80C98	1.20

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SN7401N	.20	SN7473N	.35	SN74157N	.69
SN7402N	.25	SN7474N	.35	SN74160N	.89
SN7403N	.25	SN7475N	.49	SN74161N	.89
SN7404N	.25	SN7476N	.35	SN74162N	.89
SN7405N	.29	SN7479N	5.00	SN74163N	.89
SN7406N	.35	SN7480N	.50	SN74164N	.89
SN7407N	.35	SN7482N	.99	SN74165N	.89
SN7408N	.29	SN7483N	.69	SN74166N	1.25
SN7409N	.29	SN7485N	.89	SN74167N	2.79
SN7410N	.25	SN7486N	.35	SN74170N	1.95
SN7411N	.29	SN7489N	1.75	SN74172N	4.95
SN7412N	.35	SN7490N	.49	SN74173N	1.39
SN7413N	.40	SN7491N	.59	SN74174N	.99
SN7414N	.69	SN7492N	.45	SN74175N	.89
SN7416N	.29	SN7493N	.45	SN74176N	.79
SN7417N	.29	SN7494N	.69	SN74177N	.79
SN7420N	.25	SN7495N	.69	SN74179N	1.49
SN7421N	.29	SN7496N	.69	SN74180N	.79
SN7422N	.45	SN7497N	3.00	SN74181N	2.25
SN7423N	.29	SN74100N	1.49	SN74182N	.79
SN7425N	.29	SN74104N	.89	SN74184N	2.49
SN7426N	.29	SN74105N	.89	SN74185N	2.49
SN7427N	.25	SN74107N	.35	SN74190N	1.25
SN7428N	.49	SN74109N	.39	SN74191N	1.25
SN7430N	.25	SN74116N	1.95	SN74192N	.89
SN7432N	.29	SN74121N	.39	SN74193N	.89
SN7437N	.25	SN74122N	.55	SN74194N	.89
SN7438N	.40	SN74123N	.59	SN74195N	.69
SN7439N	.25	SN74125N	.49	SN74196N	.89
SN7440N	.20	SN74126N	.49	SN74197N	.89
SN7441N	.89	SN74132N	.75	SN74198N	1.49
SN7442N	.59	SN74136N	.75	SN74199N	1.49
SN7443N	1.10	SN74141N	.99	SN74221N	1.25
SN7444N	1.10	SN74142N	3.25	SN74251N	.99
SN7445N	.89	SN74143N	3.49	SN74276N	1.95
SN7446N	.79	SN74144N	3.49	SN74279N	.79
SN7447N	.69	SN74145N	.79	SN74283N	1.49
SN7448N	.79	SN74147N	1.95	SN74284N	3.95
SN7450N	.20	SN74148N	1.29	SN74285N	3.95
SN7451N	.20	SN74150N	1.25	SN74365N	.69
SN7453N	.20	SN74151N	.69	SN74366N	.69
SN7454N	.20	SN74152N	.69	SN74367N	.69
SN7459A	.25	SN74153N	.79	SN74368N	.69
SN7460N	.20	SN74154N	1.25	SN74390N	1.49
SN7470N	.29	SN74155N	.79	SN74393N	1.49

74LS

74LS00	.29	74LS92	.75	74LS192	1.15
74LS01	.29	74LS93	.75	74LS193	1.15
74LS02	.29	74LS95	.99	74LS194	1.15
74LS03	.29	74LS96	1.15	74LS195	1.15
74LS04	.35	74LS107	.45	74LS197	1.19
74LS05	.35	74LS109	.45	74LS221	1.19
74LS08	.35	74LS112	.45	74LS240	1.49
74LS09	.35	74LS113	.49	74LS241	1.49
74LS10	.35	74LS114	.49	74LS242	1.49
74LS11	.39	74LS122	.89	74LS243	1.49
74LS12	.35	74LS123	1.25	74LS244	1.49
74LS13	.59	74LS125	.59	74LS245	2.95
74LS14	.99	74LS126	.59	74LS247	1.19
74LS15	.35	74LS132	.99	74LS248	1.19
74LS20	.35	74LS133	.89	74LS249	1.19
74LS21	.36	74LS136	.49	74LS251	.99
74LS22	.35	74LS138	.89	74LS253	.99
74LS26	.35	74LS139	.89	74LS257	.89
74LS27	.35	74LS151	.89	74LS258	.89
74LS28	.35	74LS153	.89	74LS260	.69
74LS30	.35	74LS154	1.75	74LS266	.69
74LS32	.35	74LS155	.89	74LS273	1.95
74LS33	.59	74LS156	.89	74LS279	.89
74LS37	.45	74LS157	.89	74LS283	.89
74LS38	.39	74LS158	.89	74LS290	.99
74LS40	.35	74LS160	1.15	74LS293	.99
74LS42	.89	74LS161	1.15	74LS298	1.25
74LS47	.89	74LS162	1.15	74LS352	1.29
74LS48	1.15	74LS163	1.15	74LS353	1.29
74LS49	1.15	74LS164	1.15	74LS365	.69
74LS51	.45	74LS165	1.15	74LS366	.69
74LS54	.35	74LS168	1.19	74LS367	.69
74LS55	.36	74LS169	1.19	74LS368	.69
74LS73	.45	74LS170	1.95	74LS373	1.95
74LS74	.45	74LS173	.99	74LS374	1.95
74LS75	.59	74LS174	.99	74LS375	.69
74LS76	.45	74LS175	.99	74LS386	.69
74LS78	.49	74LS181	2.95	74LS390	2.49
74LS83	.89	74LS190	1.25	74LS393	2.49
74LS85	1.25	74LS191	1.25	74LS399	2.49
74LS86	.49			74LS670	2.49
74LS90	.69			81LS95	1.95
				81LS97	1.95

74S

74S00	.45	74S124	3.95	74S243	3.25
74S02	.45	74S133	.55	74S244	3.25
74S03	.45	74S134	.69	74S251	1.45
74S04	.55	74S135	1.19	74S253	1.45
74S05	.55	74S136	1.75	74S257	1.35
74S08	.50	74S138	1.35	74S258	1.35
74S09	.50	74S139	1.35	74S260	.79
74S10	.45	74S140	.79	74S280	2.95
74S11	.45	74S151	1.35	74S287	3.25
74S15	.45	74S153	1.35	74S288	2.75
74S20	.45	74S157	1.35	74S373	3.49
74S22	.45	74S158	1.35	74S374	3.49
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74S65	.50	74S196	1.95	74S570	5.95
74S74	.75	74S240	2.95	74S571	5.95
74S86	.79	74S241	2.95	74S572	9.95
74S112	.79	74S242	3.25	74S573	9.95
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CA3059N	3.25			CA3600N	3.50

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CD4011	.39	CD4049	.49	CD4514	3.95
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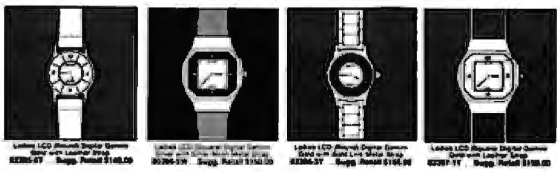

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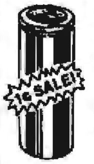
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

COMPUTER GRADE CAPACITORS



MFD	WVDC	PRICE	MFD	WVDC	PRICE	MFD	WVDC	PRICE
[illegible]	[illegible]	[illegible]	10,000	15	[illegible]	24,000	[illegible]	[illegible]
[illegible]	200	2.49	10,000	[illegible]	[illegible]	27,000	10	[illegible]
1,250	3	.99	11,000	[illegible]	[illegible]	32,500	25	4.95
1,500	25	1.95	11,000	[illegible]	[illegible]	40,000	25	5.95
1,500	50	2.95	11,000	[illegible]	[illegible]	43,000	10	[illegible]
2,000	10	2.95	13,000	[illegible]	[illegible]	50,000	20	7.95
2,250	100	[illegible]	14,000	[illegible]	[illegible]	52,000	20	5.95
2,300	33	2.95	14,000	[illegible]	[illegible]	55,000	[illegible]	5.95
2,500	15	[illegible]	16,000	[illegible]	[illegible]	58,000	20	5.95
3,000	25	1.95	20,000	[illegible]	2.95	65,000	10	7.95
3,600	40	[illegible]	20,000	[illegible]	3.95	73,800	5	7.95
4,500	50	[illegible]	21,000	15	[illegible]	80,000	15	9.95
5,500	25	4.49	23,000	7	[illegible]	90,000	10	8.95
6,100	40	2.49	23,000	10	[illegible]	160,000	10	8.95
6,600	50	4.95	23,000	20	3.95	200,000	3	12.95

OVER 200 OTHER VALUES AVAILABLE — CALL OR WRITE FOR YOUR REQUIREMENT

LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100
8 pin LP	.17	.16	.15
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	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL · STANDARD (TIN)

	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD

	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.29	2.09	1.89

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5ea.	10 Ohm / 27 Ohm	12 Ohm / 33 Ohm	15 Ohm / 39 Ohm	18 Ohm / 47 Ohm	22 Ohm / 56 Ohm	50pcs.	$1.95
ASST. 2	5ea.	68 Ohm / 180 Ohm	82 Ohm / 220 Ohm	100 Ohm / 270 Ohm	120 Ohm / 330 Ohm	150 Ohm / 390 Ohm	50pcs.	$1.95
ASST. 3	5ea.	470 Ohm / 1.2K	560 Ohm / 1.5K	680 Ohm / 1.8K	820 Ohm / 2.2K	1K / 2.7K	50pcs.	$1.95
ASST. 4	5ea.	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	50pcs.	$1.95
ASST. 5	5ea.	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	50pcs.	$1.95
ASST. 6	5ea.	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	50pcs.	$1.95
ASST. 7	5ea.	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	50pcs.	$1.95

ASST. 8R Includes Resistor Assts. 1-7 (350 pcs.) $10.95 ea.

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6% Sales Tax
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4/82

INTERSIL

Part No.	Function	Price
7045IPI	CMOS Precision Timer	14.95
7045EV/Kit*	Stopwatch Chip, XTL	24.95
7106CPL	3½ Digit A/D (LCD Drive)	16.95
7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	29.95
7116CPL	3½ Digit A/D LCD Dis. HLD.	18.95
7117CPL	3½ Digit A/D LED Dis. HLD.	17.95
7201IDR	Low Battery Volt Indicator	2.25
7205IPG	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	Stopwatch Chip, XTL	19.95
7206CJPE	Tone Generator	5.15
7206CEV/Kit*	Tone Generator Chip, XTL	12.95
7207AIPD	Oscillator Controller	6.50
7207AEV/Kit*	Freq. Counter Chip, XTL	13.95
7208IPI	Seven Decade Counter	17.95
7209IPA	Clock Generator	3.95
7215IPG	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL	19.95
7216AIJI	8-Digit Univ. Counter C.A.	32.00
7216CIJI	8-Digit Freq. Counter C.A.	26.95
7216DIPI	8-Digit Freq. Counter C.C.	21.95
7217IJI	4-Digit LED Up/Down Counter	12.95
7218CIJI	8-Digit Univ. LED Drive	10.95
7224IPL	LCD 4½ Digit Up Counter DRI	11.25
7226AIJL	8-Digit Univ. Counter	31.95
7226AEV/Kit*	5 Function Counter Chip, XTL	74.95
7240IJE	CMOS Bin Prog. Timer/Counter	4.95
7242IJA	CMOS Divide-by-256 RC Timer	2.05
7250IJE	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	CMOS BCD Prog. Timer/Counter	5.25
7555IPA	CMOS 555 Timer (8 pin)	1.45
7556IPD	CMOS 556 Timer (14 pin)	2.20
7611BCPA	CMOS Op Amp Comparator 5MV	2.25
7612BCPA	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	CMOS Dual Op Amp Comp. 5MV	3.95
7631CPE	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
8038CCPD	Waveform Generator	4.95
8048CCPE	Monolithic Logarithmic Amp	21.60
8069CCQ	50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	Volt Ref/Indicator	2.95
8212CPA	Volt Ref/Indicator	2.95

74C

74C00	.39	74C95	1.59	74C221	1.95
74C02	.39	74C107	1.89	74C240	2.25
74C04	.39	74C151	2.95	74C244	2.25
74C08	.39	74C154	3.95	74C373	2.49
74C10	.39	74C157	2.25	74C374	2.59
74C14	.75	74C160	1.69	74C901	.69
74C20	.39	74C161	1.60	74C903	.69
74C30	.39	74C162	1.49	74C911	10.95
74C42	1.39	74C163	1.69	74C912	10.95
74C48	1.95	74C164	1.59	74C915	1.69
74C73	.79	74C173	1.39	74C917	10.95
74C74	.79	74C174	1.39	74C922	5.49
74C85	1.95	74C175	1.19	74C923	5.75
74C86	.99	74C192	1.69	74C925	7.50
74C89	6.95	74C193	1.69	74C926	7.50
74C90	1.29	74C195	1.59	80C95	.79
74C93	1.29			80C97	.79

LINEAR

LH0002CN	6.85	LM340T-5	1.25	LM702H	.79
LM10CLH	4.50	LM340T-12	1.25	LM703CN	.89
LM11CLH	4.75	LM340T-15	1.25	LM709N	.29
LH0070-0H	4.95	LM341P-5	.75	LM710N	.79
TL071CP	.79	LM341P-12	.75	LM711N	.79
TL072CP	1.39	LM341P-15	.75	LM723N	.69
TL074CN	2.49	LM342P-5	.69	LM733N	1.00
LH0082CD	35.80	LM342P-12	.69	LM739N	1.19
TL082CP	1.19	LM342P-15	.69	LM741CN	.35
TL084CN	2.19	LM348N	1.25	MC1741SCG	3.00
LH0094CD	36.80	LM350K	5.75	LM747N	.79
LM300H	.99	LF351N	.60	LM748N	.59
LM301CN	.35	LF353N	1.00	LM1014N	2.75
LM302H	1.95	LF355N	1.10	LM1310N	1.95
LM304H	1.95	LF356N	1.10	LM1458CN	.59
LM305H	.99	LM358N	1.00	LM1488N	1.25
LM307CN	.45	LM359N	1.79	LM1489N	1.25
LM308CN	1.00	LM370N	4.49	LM1496N	1.95
LM309H	1.95	LM373N	3.25	LM1556V	1.75
LM309K	1.25	LM377N	2.95	LM1800N	2.95
LM310CN	1.75	LM380N	1.25	LM1871N	5.49
LM311/CN	.90	LM381N	1.95	LM1872N	5.49
LM312H	2.49	LM382N	1.79	LM1877N-9	3.25
LM317MP	1.15	LM384N	1.95	LM1889N	3.20
LM317T	1.75	LM386N-3	1.29	LM1896N	1.75
LM317K	3.95	LM387N	1.45	LM2002T	1.49
LM318CN	1.95	LM389N	1.35	LM2877P	2.05
LM319N	1.95	LM392N	.69	LM2878P	2.25
LM320K-5	1.35	LF398N	4.00	LM2896P-1	2.25
LM320K-12	1.35	LM399H	5.00	LM3189N	2.95
LM320K-15	1.35	TL494CN	4.49	LM3900N	.69
LM320T-5	1.25	TL496CP	1.75	LM3905CN	1.25
LM320T-12	1.25	NE510A	6.00	LM3909N	1.15
LM320T-15	1.25	NE529A	4.95	LM3914N	3.95
LM323K	5.95	NE531H	3.95	LM3915N	3.95
LM324N	.99	NE536H	6.00	LM3916N	3.95
LM329DZ	.65	NE540H	6.00	RC4136N	1.25
LM331N	3.95	NE544N	4.95	RC4151NB	3.95
LM334Z	1.30	NE550A	1.30	RC4194TK	6.95
LM335Z	1.40	NE555V	.39	RC4195TK	5.49
LM336Z	1.75	LM556N	.99	LM4500A	3.25
LM337T	1.95	NE564N	3.95	ICL8038B	4.95
LM337MP	1.15	LM565N	1.25	LM13080N	1.29
LM338K	6.95	LM566CN	1.95	LM13600N	1.49
LM339N	.99	LM567V	1.25	75138N	1.95
LM340K-5	1.35	NE570N	4.95	75450N	.89
LM340K-12	1.35			75451CN	.39
LM340K-15	1.35			75492	.89

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
10 pf	.08	.06	.05	.001µF	.08	.06	.05
22 pf	.06	.06	.05	.0047µF	.06	.06	.05
47 pf	.06	.06	.05	.01µF	.06	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.06	.08	.05	.047µF	.09	.07	.06
470 pf	.06	.08	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (Solid) CAPACITORS

.1/35V	.39	.34	.29	1.5/35V	.41	.37	.29
.15/35V	.39	.34	.29	2.2/35V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.56
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.56

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial	1-99	100-499	500+	Radial	1-99	100-499	500+
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.16	.14	.10	.47/50V	.16	.14	.13
3.3/50V	.16	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.16	.14	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.15	.13	.12
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.18	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

Circle 224 on inquiry card.

Circle 10 on inquiry card.

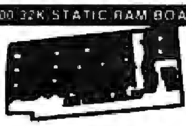
BECKMAN DIGITAL MULTIMETERS

TECH 300 Digital Multimeter	$ 110 00
TECH 310 Digital Multimeter	140 00
TECH 330 Digital Multimeter	169 00
VC-201 Vinyl Carrying Case	10 00
DC-202 Deluxe Carrying Case	24 00
HV-211 High Voltage Probe	35 00
RP-221 RF Probe	35 00
CT-231 AC Current Clamp	42 00
DL-241 Deluxe Test Lead Kit	10 00
TL-242 Square Test Leads	6 00

NLS TOUCH TEST 20

Digital Multimeter	$349 95

S-100 32K STATIC RAM BOARD



2 or 4 MHz Expandable uses 2114L's

16K 4 MHz Kit	$159 95
16K 4MHz A&T	217 95
32K MHz Kit	289 95
★ 32K 4 MHz A&T	★ 339 00
Bare Board	39 95
Bare Bd w/all parts less mem	[illegible]

8080/8085 SUPPORT

8155/8156 I/O	$ 11 95
8755 I/O w/EPROM	44 95
8202 Dyn RAM Cont	34 95
8205/74S 138 Decoder	3 95
8212 8 bit I/O	2 75
8214 Priority Int	5 25
8216 Bus Driver	2 75
8224 Clock Gen	2 95
8224 4 MHz	9 75
8226 Bus Driver	2 95
8T26 Bus Driver	2 95
8228 Sys Con	4 50
8238 Sys Con	5 50
8243 I/O Exp	9 50
8250 Asyn Com	15 95
8251 Prog I/O	6 95
8253 Int Timer	12 95
8255 Prog I/O	4 50
8257 Prog DMA	9 95
8259 Prog Int	9 95
8275 CRT Con	29 95
8279 Prog Keyboard	9 95

Z80 SUPPORT

Z80-PIO	2 5 MHz	$ 6 75
Z80A-PIO	4 0 MHz	9 95
Z80-CTC	2 5 MHz	6 75
Z80A-CTC	4 0 MHz	9 95
Z80-DMA	2 5 MHz	19 95
Z80A-DMA	4 0 MHz	29 95
Z80-SIO/0	2 5 MHz	24 95
Z80A-SIO/0	4 0 MHz	29 95
Z80-SIO/1	2 5 MHz	24 95
Z80A-SIO/1	4 0 MHz	29 95
Z80-SIO/2	2 5 MHz	24 95
Z80A-SIO/2	4 0 MHz	29 95

4K STATIC RAM SELL-OFF

for Z80 based systems

★ Zilog 6104-4 4Kx1 450ns ★ $1 49

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PB-6	$ 19 95
PB-100	21 00
PB-101	28 00
PB-102	34 00
PB-103	59 00
PB-104	77 00
PB-203	130 00
PB-203A	170 00
PB-203A Kit	140 00

PROTO CLIPS

PC-14	14 Pin	$ 3 75
PC-16	16 Pin	3 50
PC-24	24 Pin	8 50
PC-40	40 Pin	13 95

6800 SUPPORT

6810 128x8 RAM	$ 4 75
6820	6 50
6821	6 50
6828 Priority Int	10 75
6834-1 512x8 Eprom	16 95
6845/HD46505 CRT Cont	29 95
6847 Color CRT	29 95
6850ACIA	5 95
6852 Serial Adapter	5 95
6860 Modem	10 95
6862 Modulator	11 95
6871A 1 0MHz OSC	25 95
6880 Bus Driver	2 19
MC68488	19 95
68047	24 95

6520PIA	$ 7 50
6522Mult	11 95
6530-002 003, 004 005	21 95
6532	19 95
6551	19 95

BIPOLAR PROMS

82S23/6330/5600/74S188	$ 4 25
82S115 (512x8) TS	12 95
82S123/5610/74S268 (32x8) TS	4 25
82S126/5603/74S387 (256x4) OC	4 25
82S129/5623/74S287 (256x4) TS	4 25
82S130/5604/74S570 (512x4) OC	6 50
82S131/74S571 (512x4) TS	6 95
82S137/74S573 (1024x4) TS	12 95
82S141/3624/74S474 (512x8) TS	12 95
82S147/74S472 (512x8) TS	12 95
74S471/6309 (256x8) TS	7 95

MOS PROMS

2764 (8Kx8) TS	$89 95
2732 (4Kx8) TS	16 95
2716/2516 5V (2Kx8) TS	8 95
TMS2716 ±5V 12V	17 95
2758 5V (450ns)	7 50
2708 (450ns)	5 75
2708 (650ns)	5 25
1702A	5 75
MM5203AQ	14 50
MM5204Q	9 95

IC SPECIAL PURCHASE

82S09 64x9 RAM	$ 8 95
DP8304 Octal Driver	2 95
DAC86EX D/A Conv	6 95
MC1650 Hi Speed A/D	7 95
SN75136	46
MC10210	89
LM339	79
LM710CN	29
LM711CN	29
78M06	49
79M06	49
74157	49
74161	49
74C74	39
MC14433P 3 5 Digit A/D	13 95
ICL8211 Volt Ref	1 95
LM1850N Gr Fault	3 for 1 00
LM2900N Quad Amp	2 for 1 00
LM2917N Freq to Volt Conv	2 for 1 99
MEM4963 Mosfet Smoke Detector	7 95
27S08 32x8 PROM (IM5600)	2 95
ULN2003A 7ch dr	99
MCM14505 64 bit St RAM	6 95
MOC1003 Opto Cap (4N28)	3 for 1 00
SPX33 Opto Coup	3 for 1 00
IH5045 CMOS Sw DPST	4 50
UA3045 Trans Array	1 25
TR1402A UART	1 95
MK1007 Dyn Mem Shift Reg	3 95
5318 TV Ch Disp Circuit	4 50
8700CJ 8 bit A/D	9 95
7520/25	50
[illegible]	2 for 1 99
MC1372	8 95
MM5298-4A/B	2 95
LM377	1 25
LM380	1 25
LM387	1 25
LM4558	3 for 1 99
RC4136	2 for 1 99
RC4131	2 for 1 99
COM 5027	39 95
COM 5037	49 95
TMS 4060 4K RAM (22 Pin)	1 49
TMS 4050 4K RAM (18 Pin)	1 49
MCM 6604 4K RAM (16 Pin)	1 49

416/4116 16K (16 Pin)	$ 2 49
416 200 ns Set of 8	15 95
4115 8K (16 Pin)	2 49
4050 4Kx1 (18 Pin)	4 95
4060 4Kx1 (22 Pin)	4 95
4096 4Kx1 (16 Pin)	3 95
2104 4Kx1 (16 Pin)	4 75
4027 4Kx1 (16 Pin)/UPD414	4 95
5261	1 95
5262	1 95
5270	4 95
5280	4 95
1103	95
4008L	4 95
6605	7 95
6804	4 95
6602	1 50
64K RAM	9 95

MICROPROCESSORS

Z8001 16 bit to 8Mb	$ 110 00
Z8002 16 bit to 64K	75 00
Z80	9 95
Z80A	11 95
F-8 (3850)	16 95
2650	16 95
CD1802	9 75
8080A	4 75
8080A-4MHz	19 95
8085	14 95
8008-1	14 95
2901	9 90
2901A	14 95
TMS 9900JL	49 95
6502	9 95
6502A	16 95
IM6100	29 95
6800	11 75
6800B 2 0 MHz	19 95
6802P	14 95
8035	14 95
8039	12 95
INS 8073N	34 95
8755	49 95
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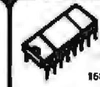

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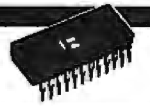

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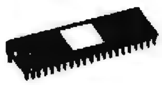

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SN7492N	45	SN74283N	1 40
SN7493N	45	SN74284N	3 90
SN7494N	69	SN74285N	3 90
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74LS00

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74LS08N	28	74LS173N	89
74LS09N	35	74LS174N	89
74LS10N	28	74LS175N	89
74LS11N	39	74LS181N	2 20
74LS12N	33	74LS190N	1 15
74LS13N	47	74LS191N	1 15
74LS14N	95	74LS192N	98
74LS15N	33	74LS193N	98
74LS20N	26	74LS194N	1 15
74LS21N	33	74LS195N	95
74LS22N	33	74LS196N	89
74LS26N	33	74LS197N	89
74LS27N	33	74LS21N	1 15
74LS28N	33	74LS240N	1 69
74LS30N	26	74LS241N	1 69
74LS32N	33	74LS242N	1 69
74LS33N	55	74LS243N	1 69
74LS37N	45	74LS244N	1 49
74LS38N	39	74LS245N	2 20
74LS40N	[illegible]	74LS247N	1 10
74LS42N	79	74LS248N	1 10
74LS47N	79	74LS249N	1 19
74LS48N	95	74LS251N	1 40
74LS51N	26	74LS253N	1 40
74LS54N	29	74LS257N	85
74LS55N	29	74LS258N	98
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74LS92N	75	74LS293N	99
74LS93N	75	74LS295N	1 10
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74LS125N	89	74LS368N	69
74LS126N	52	74LS373N	1 69
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74LS136N	49	74LS375N	69
74LS138N	85	74LS377N	1 95
74LS139N	85	74LS385N	1 95
74LS145N	1 25	74LS386N	65
74LS148N	1 49	74LS390N	1 95
74LS151N	79	74LS393N	1 95
74LS153N	79	74LS395N	1 70
74LS154N	1 70	74LS399N	2 35
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Once again, our BOMB-card mail bin has overflowed with responses to an article on IBM's Personal Computer. "A Closer Look at the IBM Personal Computer" by Gregg Williams outstripped all other articles in the January issue and ran away with first place. Our congratulations to Gregg for a first-rate review. Second-place prize of $50 goes to Jerry Pournelle for his User's Column entitled "Operating Systems, Languages, Statistics, Pirates, and the Lone Wolf." Steve Ciarcia has to settle for third place this month. (Sorry, Steve, but no matter how we counted, you still came up third.)

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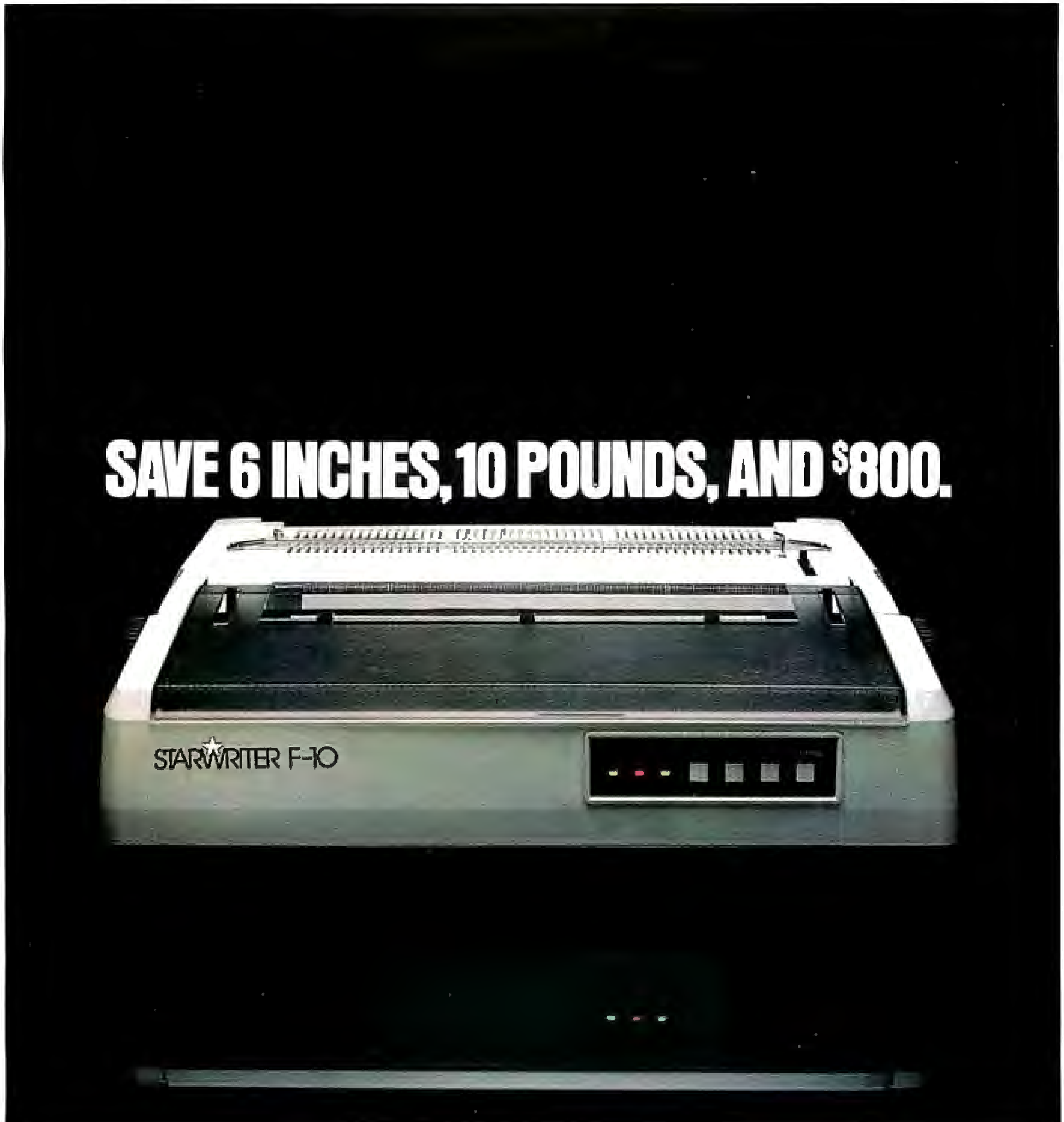

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