BYTE®

the small systems journal

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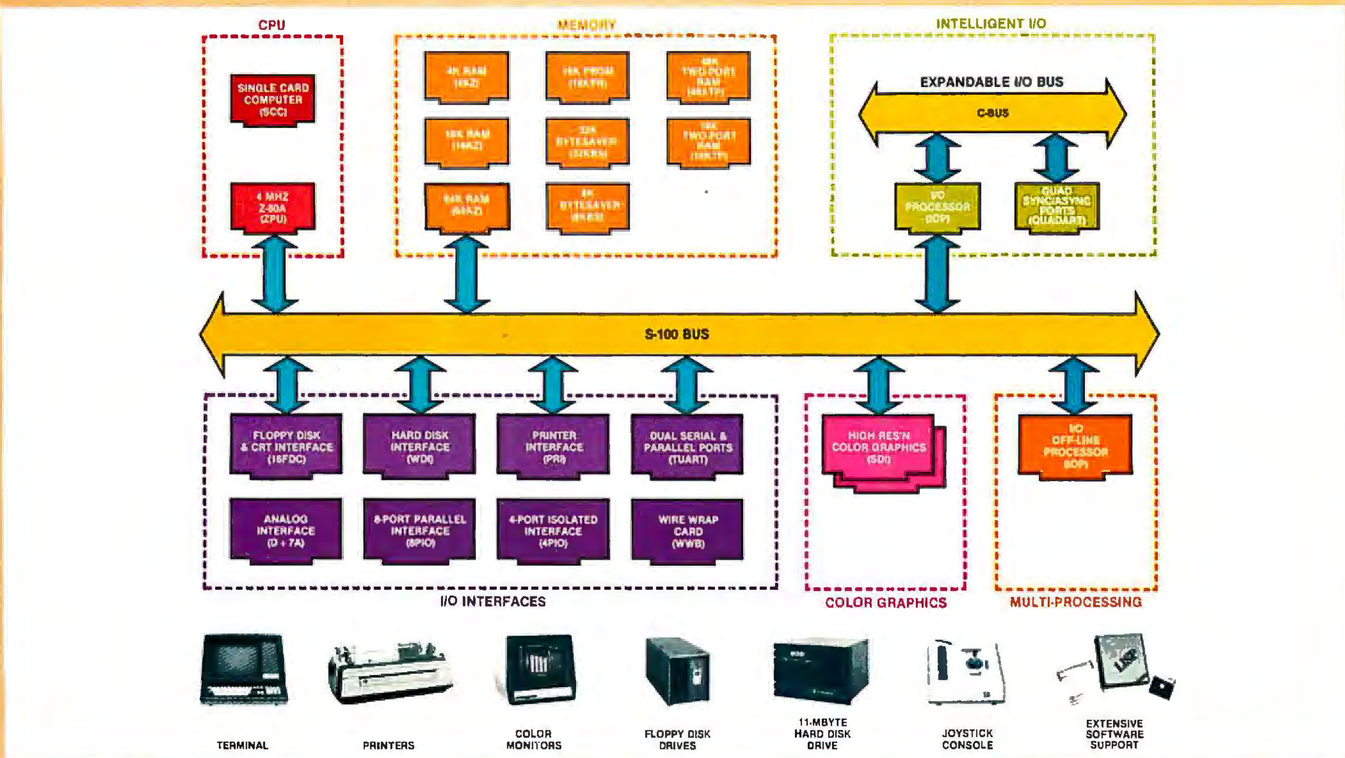

What Cromemco computer card capability can do for you

The above diagram shows in a functional way one of the most complete lines of computer cards in the industry.

Look it over carefully. It could be well worth your while.

These are all cards that plug into our S-100 bus microcomputers.

You can also assemble them into a custom system in convenient Cromemco card cages.

MULTI-PROCESSING AND INTELLIGENT I/O

The range of capabilities and versatility you can draw upon is enormous.

In processors, for example, you have a choice of CPU's including our extremely useful new I/O Processor. This can be used as a satellite processor to do off-line processing, multi-processing, and to form intelligent I/O. It opens the door to a whole new group of applications and tasks. Ask us about it.

HIGH RESOLUTION COLOR GRAPHICS

Again, you can have beautiful high-resolution color graphics with our color graphics interface. You can select from over 4000 colors and have a picture with a resolution at least equal to quality broadcast-TV pictures.

You have an unprecedented selection of memory including our unusual 48K and 16K **two-port** RAMs which allow high-speed color graphics.

LOTS OF STORAGE

These days you often want lots of disk storage. So you can select from our disk controller card which will operate our 5" and 8" floppy disk drives (up to 1.2 megabytes). Or select our WDI interface to operate our 11-megabyte hard disk drives.

POWERFUL SOFTWARE AND PERIPHERAL SUPPORT

There's much more yet you can do with our cards. And, of course, there's an easy way to put them to work in our 8-, 12-, and 21-slot card cages. Our PS8 power supply makes it simple to get the system into operation.

Finally, Cromemco offers you the strongest software support in the industry with languages like FORTRAN, C, COBOL, ASSEMBLER, LISP, BASIC and others. There is also a wide choice from independent vendors.

To top it all off, you can draw from a substantial array of peripherals: terminals, printers, color monitors and disk drives.

CONTACT YOUR CROMEMCO REP

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Contact your Cromemco rep now and get this capability working for you.

CROMEMCO COMPUTER CARDS

- **PROCESSORS** — 4 MHz Z-80 A CPU, single card computer, I/O processor • **MEMORY** — up to 64K including special 48K and 16K two-port RAMS and our very well known BYTESAVERS® with PROM programming capability • **HIGH RESOLUTION COLOR GRAPHICS** — our SDI offers up to 754 x 482 pixel resolution. • **GENERAL PURPOSE INTERFACES** — QUADART four-channel serial communications, TU-ART two-channel parallel and two-channel serial, 8PIO 8-port parallel, 4PIO 4-port isolated parallel, D+7A 7-channel D/A and A/D converter, printer interface, floppy disk controller with RS-232 interface and system diagnostics, wire-wrap and extender cards for your development work.

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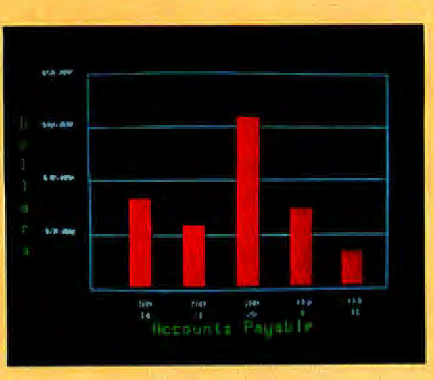
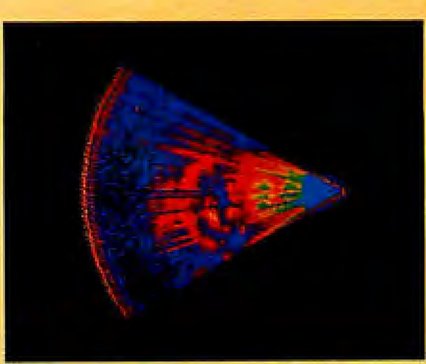
Circle 105 on inquiry card.



Management Information Display



Ultrasonic heart sector scan

High-resolution display with alphanumerics

Get the professional color display that has BASIC/FORTRAN simplicity

LOW-PRICED, TOO

Here's a color display that has everything: professional-level resolution, enormous color range, easy software, NTSC conformance, and low price.

Basically, this new Cromemco Model SDI* is a two-board interface that plugs into any Cromemco computer.

The SDI then maps computer display memory content onto a convenient color monitor to give high-quality, high-resolution displays (756 H x 482 V pixels).

When we say the SDI results in a high-quality professional display, we mean **you can't get higher resolution than this system offers in an** NTSC-conforming display.

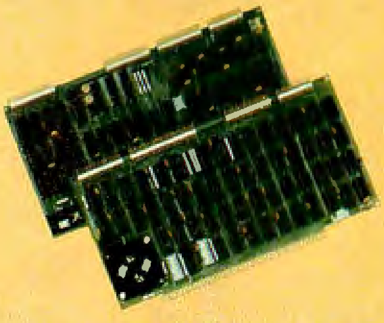
The resolution surpasses that of a color TV picture.

BASIC/FORTRAN programming

Besides its high resolution and low price, the new SDI lets you control with optional Cromemco software packages that use simple BASIC- and FORTRAN-like commands.

Pick any of 16 colors (from a 4096-color palette) with instructions like DEFCLR (c, R, G, B). Or obtain a circle of specified size, location, and color with XCIRC (x, y, r, c).

*U.S. Pat. No. 4121283

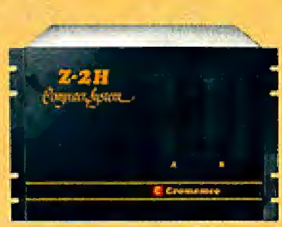


Model SDI High-Resolution Color Graphics Interface

HIGH RESOLUTION

The SDI's high resolution gives a professional-quality display that strictly meets NTSC requirements. You get 756 pixels on every visible line of the NTSC standard display of 482 image lines. Vertical line spacing is 1 pixel.

To achieve the high-quality display, a separate output signal is produced for each of the three component colors (red, green, blue). This yields a sharper image than is possible using an NTSC-composite video signal and color TV set. Full image quality is readily realized with our high-quality RGB Monitor or any conventional red/green/blue monitor common in TV work.



Model SDI plugs into Z-2H 11-megabyte hard disk computer or any Cromemco computer

DISPLAY MEMORY

Along with the SDI we also offer an optional fast and novel **two-port** memory that gives independent high-speed access to the computer memory. The two-port memory stores one full display, permitting fast computer operation even during display.

CONTACT YOUR REP NOW

The Model SDI has been used in scientific work, engineering, business, TV, color graphics, and other areas. It's a good example of how Cromemco keeps computers in the field up to date, since it turns any Cromemco computer into an up-to-date color display computer.

The SDI has still more features that you should be informed about. So contact your Cromemco representative now and see all that the SDI will do for you.

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In The Queue

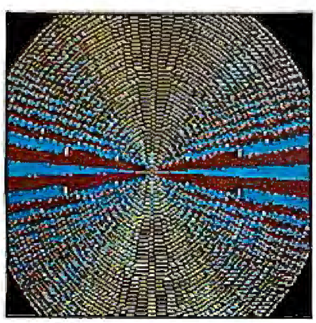
Volume 6, Number 5 May 1981

Features

Reviews

Nucleus

BYTE



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In This Issue

Did you know that the Vikings were notorious pirates? In Robert Tinney's striking cover painting, executed from an original design by Jonathan Graves, the floppy disk is the "sail" that powers the underhanded business of software piracy. Included are several articles on the legal aspects of protecting software from unscrupulous pirates: Chris Morgan's editorial, "How Can We Stop Software Piracy?" (page 6); Christopher Kern's "Washington Tackles the Software Problem" (page 128), and Stephen A Becker's "Legal Protection for Computer Hardware and Software" (page 140).

Other noteworthy articles in this issue include in-depth examinations of the Extended Color BASIC for the TRS-80 Color Computer, the new Commodore VIC microcomputer, and the Epson MX-70 and MX-80 printers. And this issue begins a new occasional feature on microcomputer video games called "BYTE's Arcade."

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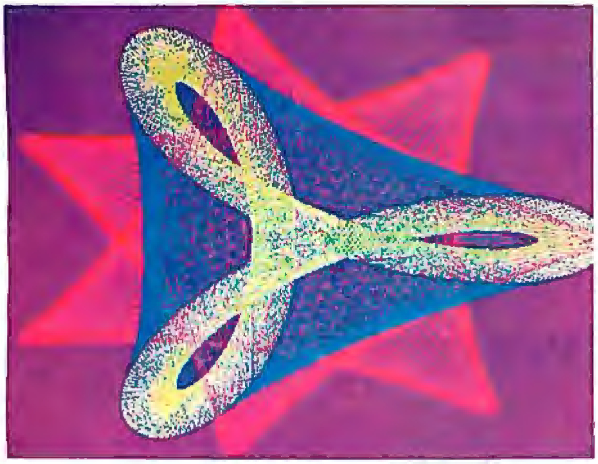
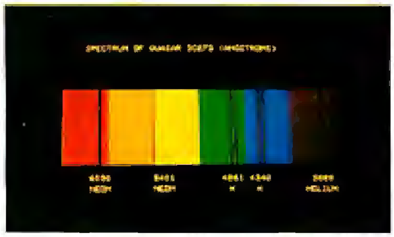


"...stands well above other S-100 graphics displays in its price and performance range."
BYTE, Product Review



"...better monochromatic ...display...."
ELECTRONIC DESIGN, 1981 Technology Forecast

MICROANGELO

HIGH RESOLUTION GRAPHICS SINGLE BOARD COMPUTER

512 x 480 resolution black and white **and** vivid color displays

RS-170 composite or direct drive output

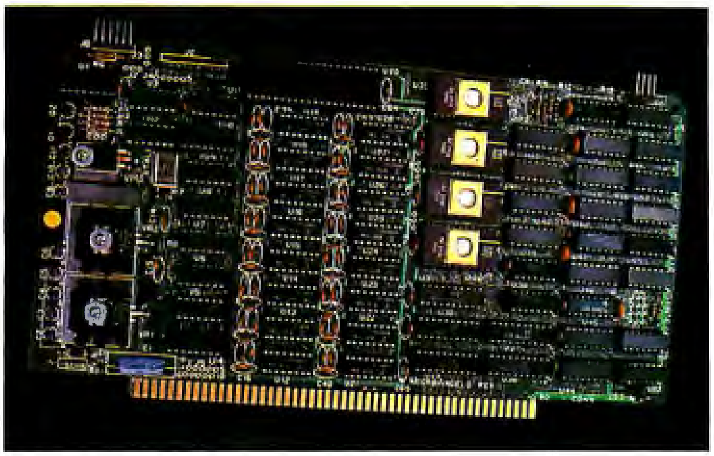
Local or external sync generation

4 Mhz Z80 microprocessor

60 hertz real-time clock

8 level interrupt tie-in

IEEE S100 bus compatible



Light pen interface

Time multiplexed refresh

4K resident Screenware™ Pak I operating system

32K RAM isolated from host address space

High speed communications over parallel bus ports

Screenware™ Pak I

A 4K byte operating system resident in PROM on MicroAngelo™. Pak I emulates an 85 character by 40 line graphics terminal and provides over 40 graphics commands. Provisions exist for user defined character sets and directly callable user extensions to Screenware™ Pak I.

Screenware™ Pak II

An optional software superset of Pak I which adds circle generation, polygon flood, programmable split screen for separate graphics and terminal I/O, relative coordinates, faster vector and character plotting, a macro facility, full UCSD Pascal compatibility, and more.

And now...COLOR!!

The new MicroAngelo™ Palette board treats from 2 to 8 MicroAngelos as "bit planes" at a full 512 x 480 resolution. Up to 256 colors may be chosen from 16.8 million through the programmable color lookup table. Overlays, bit plane precedence, fade-in, fade-out, gray levels, blinking bit plane, and a highly visual color editor are standard.

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Editorial

How Can We Stop Software Piracy?

Chris Morgan, Editor in Chief

Software piracy is rapidly becoming a major problem in the personal computer field. The casual copying of programs by computer hobbyists, although not at the epidemic stage, is frighteningly commonplace. Many people fail to see (or prefer not to see) that the practice is not just illegal—it's *unethical.*

But what about making backup copies of important software? What happens if your small business' direct-mail program "dies"? Without a backup, a businessman's only recourse is to return the disk to the manufacturer and hope it won't take longer than a few weeks to get a replacement. Manufacturers understand the problem, and have designed some floppy-disk-based programs that allow the user to make one backup copy. After this, software "jamming" information is automatically added to the original floppy disk to theoretically prevent additional illegal copies. In practice, though, enterprising software experts can crack the protection mechanisms and make copies at will.

The industry is faced with a dilemma: how does the manufacturer serve the customer's legitimate need to make backup copies, while protecting his expensive software investment? There are two possibilities: put the would-be software pirate at a disadvantage if he makes an illegal copy, or, better still, make it virtually impossible for the pirate to make a copy.

The Persuasion Route

Let me make a not-too-perfect analogy between the software industry and the record industry. When tape recorder sales began to increase during the early 1970s, record industry executives predicted that record sales would plummet because of private off-the-air taping. But, in fact, record sales climbed steadily throughout the decade. Why? My opinion is that when people think of a recording, they think of the entire package: the album artwork, the liner notes—in short, there is more to a recording than the sound coming from a pair of loudspeakers. In much the same vein, there is more to a piece of software than the object code: there is the documentation, for instance.

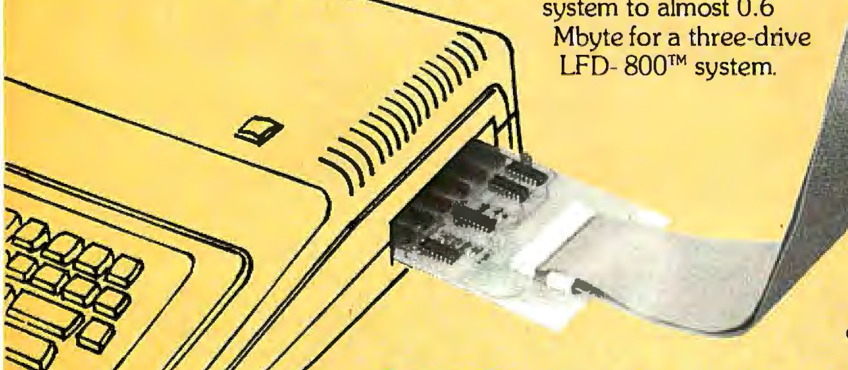
The need to make a copy of the documentation is an additional nuisance for the software pirate. It costs money to make photocopies. Then there's the registration card: legitimate owners of software are often put on mailing lists to receive updates to their programs as well as information about new programs from the manufacturer. A cheap and effective way for manufacturers to fight the pirate is to creatively exploit the latter idea. At the risk of overgeneralization, computer-science people tend to be obsessive-compulsive in their psychological makeup, ie: they hate to miss out on any details about a product they buy—especially a piece of software!

I mentioned earlier that this was a less-than-perfect analogy. The problem is that a $9.95 recording is one thing—a $600 program is quite another. The above-mentioned tactics might help the manufacturer of a $30 or $50 piece of software, but temptation becomes powerful indeed when the price tag reaches three or four figures.

Editorial continued on page 10

Introducing the COLOR CONNECTION™

Plug A TRS-80* Color Computer into the World of System-50™ Computing.



Now you can expand Tandy's exciting new TRS-80* Color Computer using proven System-50 products. Expansion possibilities are limitless. And expansion is easy. Plug one end of the COLOR CONNECTION into the Program Pak* connector of the Color Computer. Plug the other end into a System-50 bus motherboard. Now add the functions you want, selecting from an inventory of standard modules manufactured by competent, long-established firms — from the inventory of solid performers, like Percom Data Company.

Mini-disk storage — today!

Available off-the-shelf for your extended system is Percom's field-proven LFD mini-disk system. The first choice of knowledgeable 680X computerists since 1977, Percom LFD mini-disk systems come complete, ready to plug in and run. File storage capacities range from 102 Kbytes for a one-drive LFD-400™ system to almost 0.6 Mbyte for a three-drive LFD- 800™ system.

Get serious!

For serious computing like word processing add the Percom ELECTRIC WINDOW™. This memory-mapped video display card features instant display updating, software-defined full display formatting — up to 80 characters by 24 lines, an extendable character generator that generates fully-formed upper and lower case characters, and more. The ELECTRIC WINDOW provides either composite or separate sync-video output, and interfaces a standard black-&-white video display monitor.

Beyond 16K

Another option is incremental memory expansion. Add 8-, 16- or 24-Kbytes of static RAM with our M24SS card; 16-, 32- or 48-Kbytes of dynamic RAM with our M48DSS card. The COLOR CONNECTION prevents contention between internal computer memory and external memory.

System Requirements

The COLOR CONNECTION interfaces a TRS-80* Color Computer to a System-50 bus motherboard. Power for the COLOR CONNECTION is obtained from the computer. Power for the extended bus cards must be provided by an external source, such as Percom's System-50 Power Supply. The COLOR CONNECTION provides for disabling the computer internal memory at 8-Kbyte boundaries to prevent contention with external memory.

The COLOR CONNECTION............. $99.95

The right motherboard

Fast mini-disk storage, full-format alphanumerics and memory add-on are obvious expansion possibilities. The optional Percom System-50 Motherboard allows you to consider the less obvious. This seven-slot motherboard not only can be self-extended, but also can be extended with our 30-pin I/O motherboard. The richness of readily available peripheral interface cards provides an uncommon degree of expansion flexibility.

The System-50 (SS-50) bus community. With a TRS-80* Color Computer and the COLOR CONNECTION, it's your world. Enjoy!

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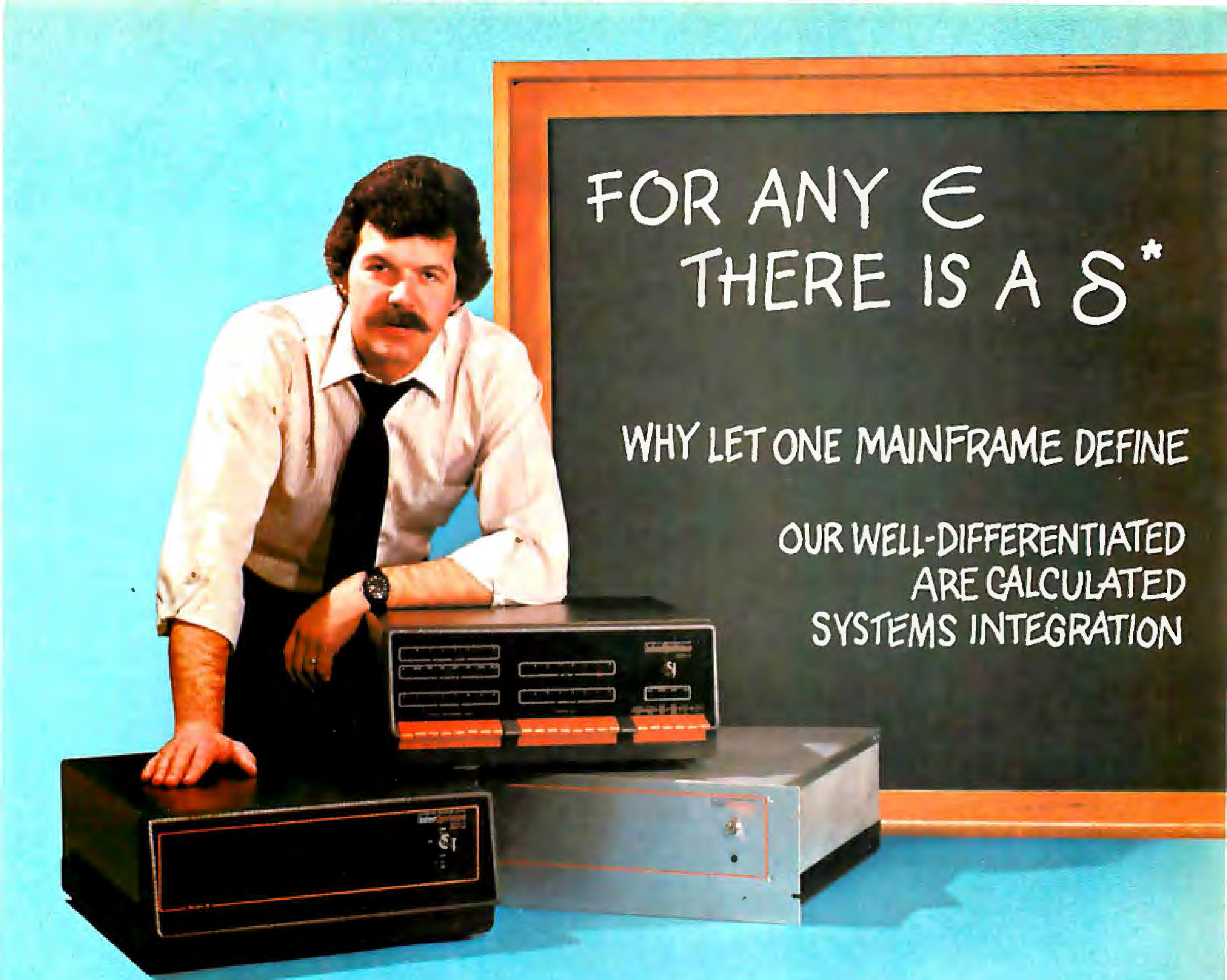
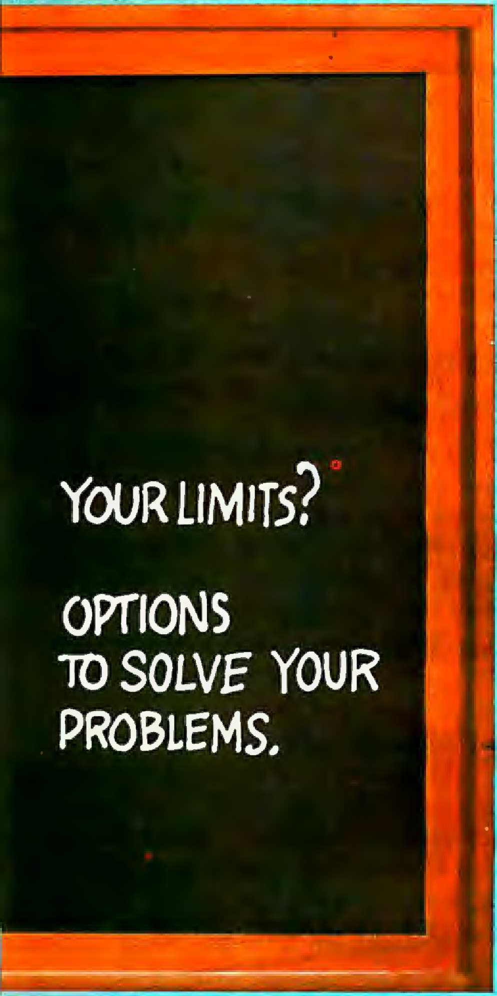

FOR ANY ∈
THERE IS A δ*
WHY LET ONE MAINFRAME DEFINE
OUR WELL-DIFFERENTIATED
ARE CALCULATED
SYSTEMS INTEGRATION

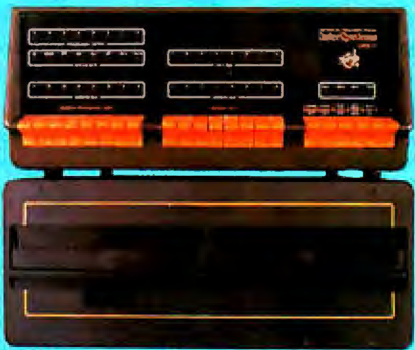


Board level options...

Intersystems mainframe packages, equipped with Series II boards, are operational in both 8 and 16 bit settings and support extended addressing in both I/O and memory space, recognizing 16 bit I/O addresses and 24 bit memory addresses. Just look at these individual features;

- MPU-80—uses a Z-80, 8 vectored interrupt lines and two 4K windows to address up to 1 Megabyte of RAM without bank select.
- 64KDR—sophisticated refresh circuitry allows unlimited DMA and absolutely reliable operation without wait states.
- 6 SI/O — six individually software-controllable serial I/O ports with optional interrupts. Each can run RS 232 at up to 19,200 BAUD, as can our VI/O board.
- VI/O—has two serial ports; two 8-bit parallel output and two 8-bit parallel input ports plus 8 individually controllable command lines and 16 levels of vectored interrupts.
- FDC II—can DMA up to a full track into 16 Megabytes of memory. Optionally generates interrupts and handles up to four 8" floppies.
- MPU-8000 — available with the non-segmented Z-8002†, which directly addresses 64K, or the segmented Z-8001†, which can directly address 8 Megabytes.

Extended systems options...



Interfacing disk drives is not a trivial matter, so when your objectives and resources dictate you spend your energy elsewhere, use our resources to perform the service for you. We can add our disk drive package to any Z-80 or Z-8000 configuration we provide ... again, fully assembled and tested and covered under one warranty.

Or our complete Pascal Development System.

We use it for our own hardware and software development. It includes either table-top mainframe, two 8" floppy disks, 128K RAM, CP/M#, and Intersystems Pascal/Z™ compiler and Cache BIOS™.

THIS SYSTEM IS FAST! Why? Because our ultra-fast Cache BIOS automatically buffers whole tracks, eliminating most disk accesses. This delivers up to three times the throughput of any other floppy-based system we know and is equal to many small hard disk systems.

The system is versatile, too. SET program allows you to change many BIOS parameters and specify control characters to enable special features such as diagnostic output to trace program execution. It can also provide remote I/O to link your system to almost any other computer, large or small.

And it's reliable. The Cache BIOS System runs continuous memory tests when idle, and verifies with a Read after Write and Read after Read.

And the system also includes our Pascal/Z, a true native compiler producing ROMable and Re-entrant code. It features a minimum of extensions chosen for the development of your scientific and business applications. And it's compatible with our native code Pascal for Z-8000, providing a graceful upward path to 16 bit applications. So what you write now is right later.

One choice you won't have to make...

We don't believe you should ever have to sacrifice good technical support to find a good product. We'll back you to the hilt with services like free technical consultation, board-swapping, diagnostic packages, and documentation that gives you all you need to integrate, operate and maintain your system ... right down to schematics of the boards.

Your solution should be clear.

Whether you're integrating for scientific, governmental or commercial applications, Intersystems can provide a Delta for your Epsilon.

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Technological Measures

The ultimate answer is to make it so difficult and costly for the pirate to make copies that the problem goes away. A good first step is to put teeth into software protection laws. The revised copyright act of 1976 had a major impact on phonograph record pirates because of the much more stringent penalties for convicted offenders. You may have noticed the Ⓟ sign on commercial records and tapes: it's an indication that they're protected by the new law. (For further legal background, including information on the latest Supreme Court decisions, see "Washington Tackles the Software Problem," page 128, and "Legal Protection for Computer Hardware and Software," page 140.)

We come next to the most intriguing weapon in our arsenal: hardware "locks" on the software. The concept of the *I.D. ROM* is a recent development now being used, among other places, in conjunction with a program called RCS/Micro Modeller, developed in England by Intelligence (UK) Limited. The program allows a person to use an Apple II computer to create financial planning models and high-resolution color displays featuring pie charts, histograms, and so on. A novel feature of the program is its "electronic slide show" capability: a hand-held control, similar to a slide projector control, plugs into one of the paddle ports of the Apple and allows the user to cycle through an electronic "slide show" on the video screen. Built into the control is a special ROM containing an identification number that is duplicated on the program floppy disk. The program periodically checks for the presence of the I.D. ROM. If it's not found, the program crashes.

This technique puts one more stumbling block in the way of the pirate, and it does not add appreciably to the total cost of the software (the I.D. ROM costs about $20). Alas, there are some experts in Europe who have cracked the code of another I.D. ROM used in conjunction with a program called Wordcraft, which is being distributed by Commodore in England. So the technique, while making it much more difficult to copy software, is not the ultimate answer. Still, I welcome this type of innovative approach to a mind-boggling problem. Readers interested in further information about the RCS/Micro Modeller program (not yet available in the United States) should contact David Low, ACT (Microsoft) Ltd, 5/6 Vicarage Rd, Edgbaston, Birmingham B15 3ES England.

Two of the most promising solutions to the software protection problem come from West Coast inventor Marc Kaufman. He has filed a patent for an "execute-only ROM," a new type of read-only memory which produces a sequence of executable code in the normal manner, but prohibits the user from randomly accessing memory addresses. As Kaufman explains, the user begins execution of the program at a known address. A "secret" executive routine, built into the ROM, contains a table of the legal next steps for every given step in the program. Only those steps listed in the table can be accessed by the user. For example, if the program contains a branch to one of two places, *only* those two places can be examined by the programmer at that time. If a program contains enough branches, it would take an inordinate amount of time for the user to run through every permutation of the program to get a complete listing of the code, even if a computer did the searching. Kaufman is presently working with both hardware vendors and users to develop the idea. An unreadable EPROM is also in the works, enabling the do-it-yourselfer to create secure programs.

Kaufman's second idea is to add a "black box" to a personal computer. Every piece of software would come with a magnetic key (or other type of hard-to-duplicate key) that plugs into the black box and contains a coded I.D. number that matches the I.D. number on the floppy disk. The program resides on the disk in encrypted form. In order to decode the program, the key must be plugged into the box. With this scheme, the user can make as many backup copies as desired, but only one of them can be used at a time. The drawback to such a system is the need for the black box. But if the idea catches on, the price would probably come down. Interested readers can contact Marc Kaufman at Kaufman Research, 14100 Donelson Pl, Los Altos Hills CA 94022.

Stopping the pirate is vital. Piracy has reached near epidemic levels in Europe, where it is not uncommon for an entire computer club numbering in the hundreds to line up their computers and make hundreds of copies of programs from United States manufacturers for the use of the entire club! Then there is the phenomenon of the "software library." Some of them are legitimate, but all too many cavalierly offer copies of programs to their members at a fraction of the retail cost.

Illegitimate copies of programs threaten the fabric of personal computing. The software innovators in our field must be compensated fairly for their work, or we will no longer see the high-quality programs that currently grace the marketplace.

I welcome comments from readers about this all-important issue, and would like to begin a dialog featuring your comments. Please send your thoughts to: Software Protection, c/o BYTE Publications Inc, POB 372, Hancock NH 03449. ■

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Articles which are accepted are purchased with a rate of up to $50 per magazine page, based on technical quality and suitability for BYTE's readership. Each month, the authors of the two leading articles in the reader poll (BYTE's Ongoing Monitor Box or "BOMB") are presented with bonus checks of $100 and $50. Unsolicited materials should be accompanied by full name and address, as well as return postage.

Educational Dialog

As a junior-high-school teacher with several years of experience, I want to call into question some of the underlying assumptions in Seymour Papert's "New Cultures from New Technologies." (See the September 1980 BYTE, page 230.)

Mr Papert seems to believe that children and child-initiated explorations are inherently good and, conversely, that parents, teachers, schools, and their limits and expectations are inherently bad. Also, he seems to believe that all learning can and should be as swift, natural, accurate, and frustration-free as the learning of spoken language, and that learning by rote or rite is without meaning and is harmful to the child.

To the first supposition, I can only reply that there is a time and place to be child-centered, and a time and place to be goal-directed. To the second supposition, language acquisition has little to do with other types of learning—it is a highly specific capability that is "hard-wired" into the brain from birth. Finally, rote and rite learning are common elements in spontaneous children's play, to say nothing of adult culture.

Piagetian learning is at best an unfortunate choice of words on Mr Papert's part, because Piaget did not focus on learning at all. He studied the cognitive processes in children that depended on maturation, not learning, and were indeed highly resistant to any learning experiences he was able to devise. His great contribution to education was to point out that there *are* thresholds and there *are* ceilings to what an immature mind can learn. The insight-oriented "new math" failed in public education for this reason: its proponents were asking grade-school children to perform abstract reasoning, which Piaget terms *formal operations,* before they were ready to do so.

Anyone wishing to teach young children to program computers, regardless of formal language instruction, had better remember a few things: Piagetian formal operations begin in adolescence. It is not safe to assume that a preadolescent is doing what you think he is doing, in the way you think he is doing it, or for the reason you think he is doing it. You ignore Piaget at your own peril.

In summation, no single development is going to revolutionize education, because it is a "soft" field—too many factors are operating already. The computer probably will be the biggest thing ever to hit the field, but not for the reasons Papert thinks.

Charles Heckel
1624 Hillcrest
Glendale CA 91202

Seymour Papert Replies:

I agree with Mr Heckel that one ignores Piaget at one's peril. I have tried not to ignore him. I spent about 5 years working in his center for Genetic Epistemology in Geneva, Switzerland. In my book Mindstorms: Children, Computers and Powerful Ideas, *I argue that our work on Logo is in the spirit of Piaget's* theory *even if it seems to contradict some of his empirical* findings.

I grant that children in many countries have been found to follow a fixed pattern of intellectual development. I grant that psychologists have failed when they tried to change this pattern of development by exposing children to a few hours of special treatment under laboratory conditions. But, I argue in Mindstorms *that the penetration of computers into the lives of children (indeed into the whole culture) will exert a much more massive influence on intellectual development than any experiments in the past. I suggest that it is* possible *that these more massive influences will have correspondingly massive* effects. *I don't see how any of Piaget's experiments could conceivably be held to exclude this possibility.*

In addition to these general issues, there is one specific point of Piagetian interpretation on which I must express disagreement with Mr Heckel. Piaget certainly did not believe, as Mr Heckel asserts, that the acquisition of language "has little to do with" other types of learning or that it is "hard-wired." This sounds more like Noam Chomsky's position against which Piaget argued with increasing vigor in the last years of his life.

Letters

Ada Manual Available

The reference manual for the Ada programming language, July 1980 version, is now available from the Government Printing Office. The supply in the Defense Department's DARPA office (referred to in "BYTELINES," January 1981 BYTE, page 200) is now exhausted. Requests should be sent to:

Superintendent of Documents
US Government Printing Office
Washington DC 20402

Order number: 008-000-00354-8

Cost: $5.50 per copy.

I learned this when I requested information from DARPA about the manual.

Mike Robinson
Rt 4, Box 70
Ringgold GA 30736

Hard Disk to Buy

I was quite amused to read that manufacturers are unable to understand why small hard disks aren't selling as expected. (See "Winchester 8-inch Drives Off to Slow Start," December 1980 "BYTELINES," page 214.) Perhaps the reason could be the typical $5000 to $8000 price tag—more than a little difficult to justify to your wife, mother, girlfriend....

Besides the normal budgetary problems, I have no way to interface a hard disk to my Heath H-8 computer, either in hardware or software. Another problem is that most hard disks are not removable. Imagine the added utility of a drive using an 8- or 14-inch cartridge, holding about 20 megabytes, costing $2000, and removable (so you can take it to your friend's house). Come to think of it, that's a good description of a DEC (Digital Equipment Corporation) RK05 cartridge disk-pack drive.

John F Priebe
4804 Mt Airy Rd
Sylvania OH 43560

Plot: North by Northwest

I found John Beetem's article "Vector Graphics for Raster Displays" enjoyable. (See the October 1980 BYTE, page 286.) But, when I read R H Rae's letter, I had to respond. (See "Intercepting Raster," January 1981 BYTE, page 14.) Beetem's vector-generator routine works beautifully for its intended purpose. But Rae's alternative suggests that there are those who could profit from a little "compuservation" (running faster on fewer bytes).

The routine I use to drive my Houston Instrument Hiplot plotter is a modification of the one that appears in Hiplot brochures (it is actually Algorithm 162 by Fred G Stockton; *Collected Algorithms from ACM*, 1963). I offer it in a minimal BASIC as Houston Instrument did. It assumes that the PRINT statement goes to the Hiplot, which ignores all characters except "p" thru "w," and "y" and "z." "p" means move the pen one increment (0.005 inch) north, "q" northeast, "r" east, and so on to "w" meaning northwest.

```
10 A$="rqvwpsvupqpwtstu"
20 INPUT X,Y
30 PRINT"z":REM PEN DOWN
   COMMAND
40 GOSUB 100
50 PRINT"y":REM PEN UP
   COMMAND
60 GOTO 20
70 REM *** VECTOR GENERATOR
   SUBROUTINE ***
80 REM THIS SUBROUTINE DRAWS
   THE BEST STRAIGHT
90 REM LINE FOR A COORDINATE
   CHANGE OF (X) AND (Y)
100 I=1: IF X<0 THEN X=-X: I=3
110 IF Y<0 THEN Y=-Y: I=I+4
120 IF X<Y THEN T=X: X=Y: Y=T:
    I=I+8
130 E=-X/2: C=0
140 IF C>X-.5 THEN RETURN
150 E=E+Y: IF E>0 THEN E=E-X:
    PRINT MID$(A$,I+1,1):
    GOTO 170
160 PRINT MID$(A$,I,1)
170 C=C+1: GOTO 140
```

This routine is marvelous; no multiplications and only an avoidable right shift in line 130 (the entire routine, including the array and double-precision variable storage, requires less than 130 bytes of 8080 code).

The byte miser in me demanded that I understand this routine. When I found its logic as simple as the routine, I couldn't resist configuring it for screen graphics and animation, turning a printer into a plotter, and tackling the awesome task of massaging my plotter into a super printer.

If it is not too late, Mr Rae, you might consider using Stockton's algorithm for your commercial graphics product.

William A McWorter Jr
Mathematics Department
Ohio State University
Columbus OH 43210

Circle 202 on inquiry card. →

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BYTE's BOMBworks

My December 1980 BYTE did not include the usual Reader's Service and BOMB cards, so here are my December BOMB votes.

My vote for the *best article of the year* is Grady Booch's Micrograph series. (See "Micrograph, Part 1: Developing an Instruction Set for a Raster-Scan Display," November 1980 BYTE, page 64; "Part 2: Video-Display Processor," December 1980 BYTE, page 120; and "Part 3: Software and Operation," January 1981 BYTE, page 238.) I eagerly awaited my January BYTE for the concluding part.

Mr Booch's design was good, but the hardware could have been upgraded for better performance. According to my calculations for the color chip, the Z80 microprocessor is active only 12% of the time with the hardware configuration shown. The Motorola spec sheets give a better hardware implementation: isolate the display memory from the processor memory when the display circuitry is accessing display memory. Such an approach would allow fuller utilization of the Z80, as well as remove response-time problems from the interface to the host computer (ie: lost time when the Z80 is locked out by the display). All in all, Mr Booch's articles were *excellent*!

I had a different opinion of the competing serials on graphics. Alan Grogono's "Graphic Color Slides" articles gave no insight into the more general problem of graphics. (See the November and December 1980 BYTEs, pages 126 and 96, respectively.) Allen Watson's "A Simplified Theory of Video Graphics" presented little if any new information on either hardware or software. (See the November and December 1980 BYTEs, pages 180 and 142, respectively.) He might as well have referred to some of the many articles and books on the television signals (eg: the *TV Typewriter Cookbook* or some such). I rate both of these articles *poor*.

On a more positive note, I enjoyed all of the game reviews and would like to see more for other software packages. These, however, would rate only a *good*, with the exceptions of "On the Road to Adventure"; "Odyssey: The Compleat Apventure"; and "Zork and the Future of Computerized Fantasy Simulations." I rate all of these *excellent*. (See the December 1980 BYTE, pages 158, 90, and 172, respectively.) I'd also place Steve Ciarcia's "Computerized Testing" in that category. (See December 1980 BYTE, page 44.)

Circle 420 on inquiry card. ⟶


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I want to compliment BYTE's Production Director, Nancy Estle, on the layout of BYTE. BYTE articles generally manage to stay in one piece, rather than starting in the front and continuing piecemeal throughout the remainder of the magazine. I would like to see even more segregation between articles and advertising, however. I do not object to the ads, in fact I conscientiously read through them, hoping that I won't miss any new developments. But having to wade through the ads to find article continuations is annoying.

Arthur Throckmorton
5657 S Oak St
Littleton CO 80127

The CBT Is Dead: Long Live the CBT

In regard to Mr James R Boatright's letter in the December 1980 BYTE, the reported demise of the CBT is somewhat exaggerated. (See "The End of the CBT," page 300.) The CBT-1001D DAA (data-access arrangement), though no longer available from Bell, is currently manufactured by Precision Components, Elgin, and Terminal Systems, etc. It is available from many distributors who are typically listed in the yellow pages under "Telephone Equipment & Systems." The CBT is used extensively by manufacturers in the medical-data field.

Please be advised, Mr Boatright, you need not discard your equipment requiring use of CBT, CBS, or other types of DAA.

Carl E Osborne Jr
President
O & J Electronics Inc
4027 Knight Arnold Rd, Suite 105
Memphis TN 38118

More on HP-41C

Congratulations to BYTE and to Bruce D Carbrey for the excellent article on the HP-41C "calcuputer." (See "A Pocket Computer? Sizing up the HP-41C," December 1980 BYTE, page 244.) With a few enhancements, I used the "CODEBREAKER" demonstration-game program over the holidays with my grandchildren. It is a fine example of the capability of the HP-41C.

Circle 274 on inquiry card. →

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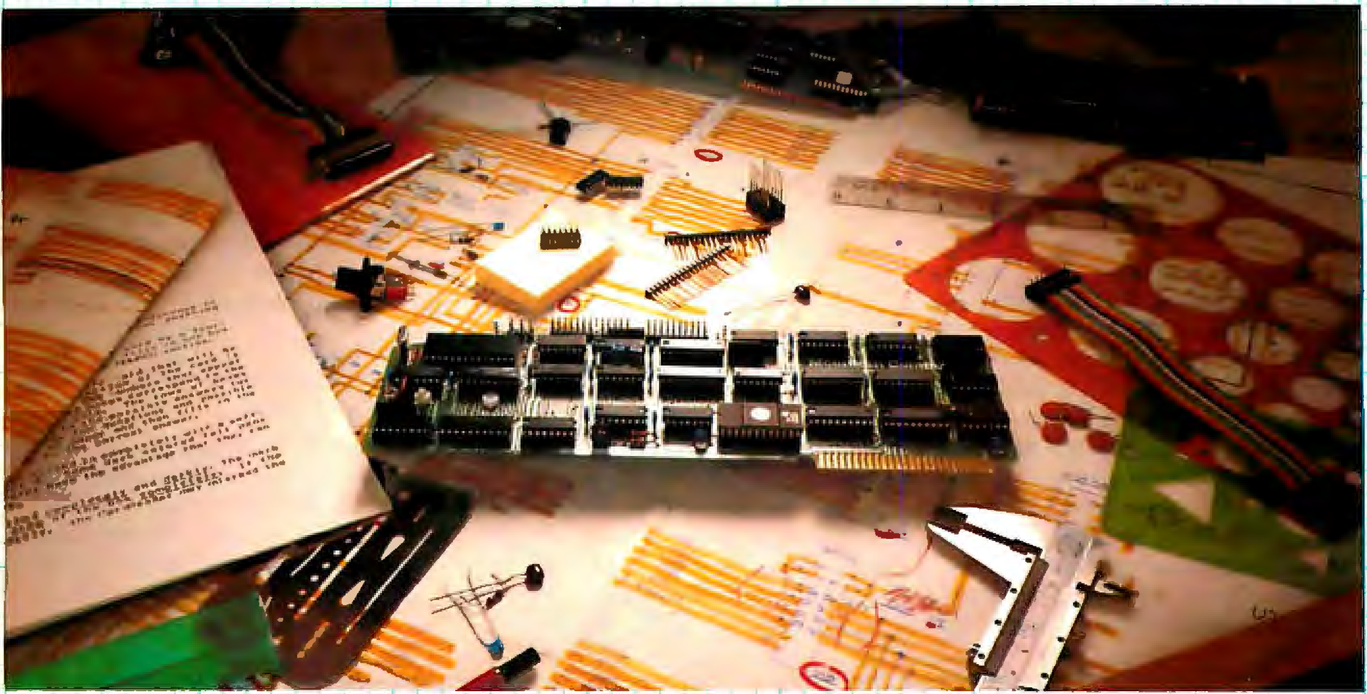

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But just as any program or product can be improved, so can any article. It is most unfortunate that Mr Carbrey failed to mention two important aspects of the HP-41C:

1. The HP-41C continues the use of RPN (reverse Polish notation) logic. Since my first experience with RPN in the 1960s on a Friden CRT desk-top calculator (it used RPN well before Hewlett-Packard), there has been no question that RPN is the *only* way to go. Not just because it may use less keystrokes, but because its logic is unambiguous, straightforward, and simple to remember. This is a most important attribute of the HP-41C!

2. Even more important, Mr Carbrey failed to mention that all Hewlett-Packard programmable calculators, including the HP-41C, are supported by an active, independent user's organization known as the PPC—Personal Programmers Club. (Formerly known as the HP-65 User's Group.) The PPC has no connection with Hewlett-Packard or its Users Library. A periodic publication, the *PPC Calculator Journal*, is available to members only. Club members have discovered that many things can be done with the HP-41C and its predecessors. Although some of these capabilities are not "supported" by Hewlett-Packard, their use can greatly improve almost any program. The club is currently designing a custom ROM (read-only memory) to make these features available to its members.

Anyone seriously using the HP-41C should join the PPC. To get further information, send a 9- by 12-inch stamped, self-addressed envelope with 2 ounces postage to Richard J Nelson, Editor/Publisher *PPC Calculator Journal*, 2541 W Camden Pl, Santa Ana CA 92704. You will receive a sample issue of the *Journal* and further membership information.

B F Wheeler
22 Wilkins Ave
Haddonfield NJ 08033

Chessmate

In the December 1980 BYTE, John Martellaro presented a review of the Sargon II chess-playing program. (See "Sargon II, An Improved Chess-Playing Program for the Apple II," page 114.) He states that it is the first chess program he has seen that sets a trap. He also says that it is the strongest chess program money can buy—dedicated chess-playing devices included. Does this include the Chess Challenger 7 by Fidelity Electronics?

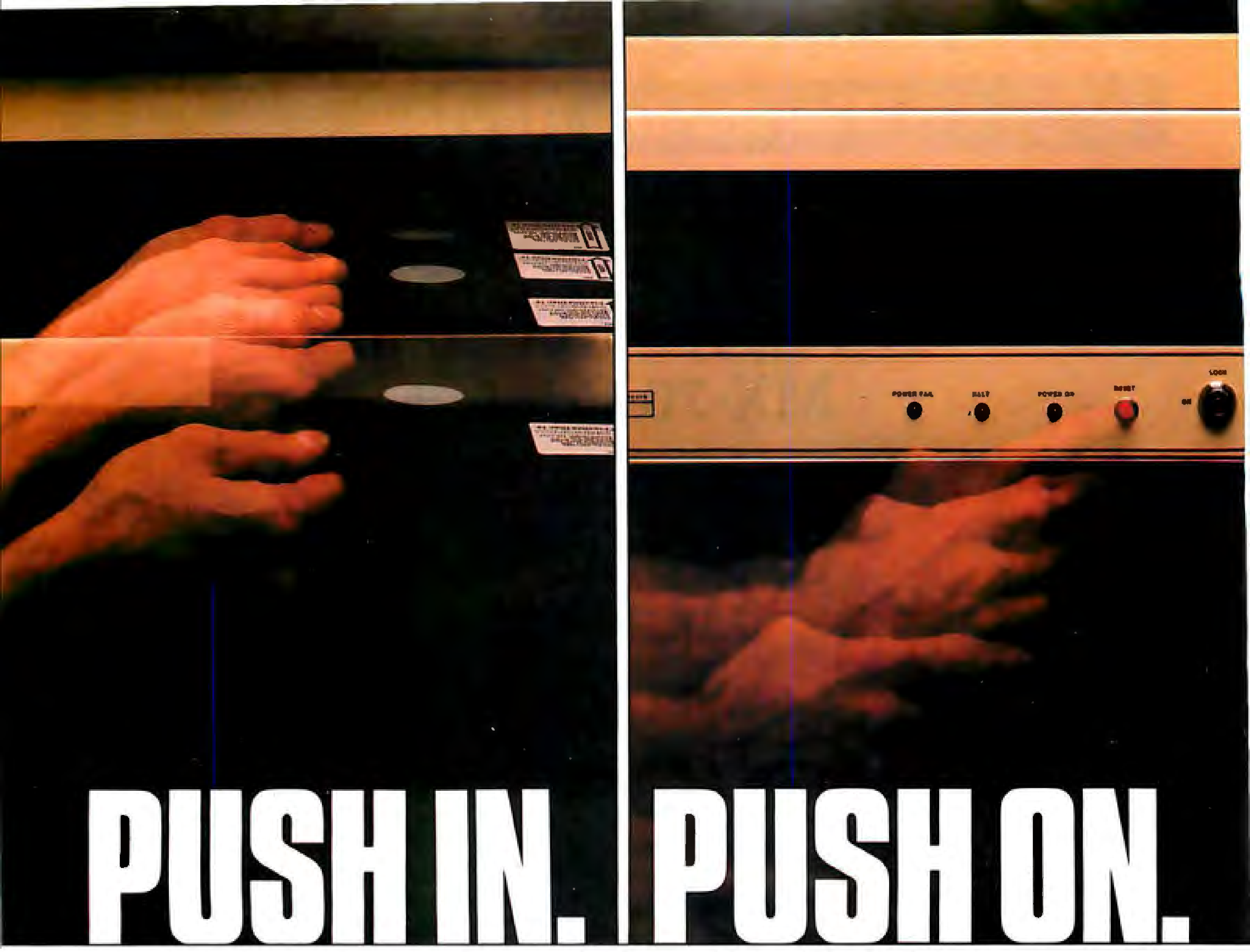
My Chess Challenger 7 on level 7 (tournament level) played exactly the same game as Sargon II, including the trap, through step 12. At step 12, Sargon played Nc3-d5 (N/B3-Q5); Chess Challenger 7 played Qd2-d1 (Q-Q1). My response was Qf6-g6 (Q-KN3), at which point Chess Challenger 7 conceded the game.

I would like to see an entire issue of BYTE devoted to this kind of competition between computers. Does BYTE have such an issue planned?

Tom Disque
Rt 7, Waldrap Dr
Mayfield KY 42066

No such issue is planned, but we will continue to publish reviews of chess programs and playing machines as they come in to us (hint). (See "The Newest Sargon: 2.5" in the January 1981 BYTE, page 208.)

Letters continued on page 268



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Circle 58 on inquiry card.

The Epson MX-80 and MX-70 Printers

Kevin Cohan, Technical Editor

Small system users soon realize that effective programming is difficult without hard copy upon which to make notes, corrections, and general scribblings. However, realization often turns to dismay when the "professional" quality printer carries a price tag larger than that of an otherwise complete popular disk-based microcomputer system. In the past, inexpensive printers (when available) have been slow, unreliable, inconvenient (eg: many require expensive thermal or electrostatic paper), and generally lacking in desirable features. Those users with less than $1000 to spend have been faced with a choice of such a printer or a refurbished IBM Selectric or Teletype ASR33.

Epson Inc has aimed its two new low-priced dot-matrix printers, the MX-80 and the MX-70, squarely at this under-$1000 market (see photo 1). Both have features normally found only in professional printers that are priced accordingly. (Active in the computer printer business in Japan for over fifteen years, Epson has also supplied print heads and mechanisms for such well-known printer manufacturers as Anadex.)

Photo 1: *The Epson MX-70 and MX-80 printers. The MX-70 (left) is a prototype of the final version which has a tan rather than a cream body.*

The MX-80

The more expensive MX-80 printer has so many features that a complete learner's manual accompanies the instruction manual. This manual (written by David A Lien and published for Epson by Compusoft) guides the user through basic setup procedures and also describes the less obvious capabilities of the MX-80: it can do much more than provide hard-copy listings!

Measuring 37.4 cm wide by 30.5 cm deep by 10.7 cm high (14$\frac{7}{10}$ by 12 by 4$\frac{1}{5}$ inches), the MX-80 is not much larger in size than a stack of five or six issues of BYTE. It has a 9-wire print head that prints 96 ASCII (American Standard Code for Information Interchange) characters with lowercase descenders and 64 graphics characters on a 9 by 9 dot matrix, as shown in listing 1. The print head has an estimated life of over 50,000,000 characters, and it can be easily replaced. Print speed is 80 cps (characters per second) bidirectionally, and a long-life print ribbon is contained in an easily removable cartridge.

External features (shown in photo 2) include a metal paper-guide rack, manual paper-advance knob, power switch, Centronics-type 36-pin cable connector, three control pushbuttons, and four green indicator LEDs (light-emitting diodes). In addition, the MX-80 has a tractor-feed paper mechanism and can use three-ply paper (original and two carbon copies). The On-Line pushbutton toggles the printer between on- and off-line modes. The FF (form feed) and LF (line feed) pushbuttons, functional only when the printer is off-line, advance the paper by one form (ie: page length) and one line, respectively. The distance that the paper advances may be changed under software control.

The four LEDs indicate Power, Printer Ready, No Paper, and On-Line. A software-controllable buzzer is located inside the printer case and is activated by a reed switch on the paper guide when the printer runs out of paper. A self-test mode may be activated by turning the printer on while depressing the LF pushbutton; in this mode, all characters provided by internal software are

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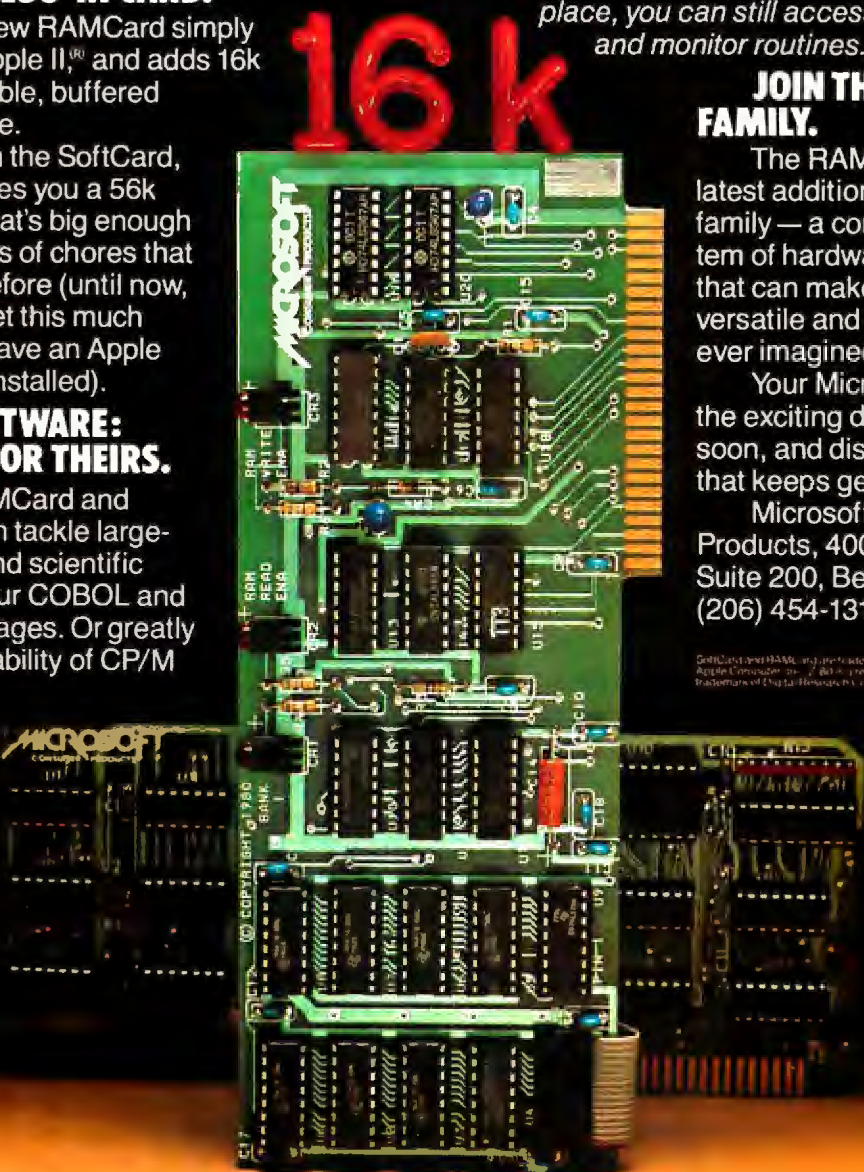

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(2a) (2b)

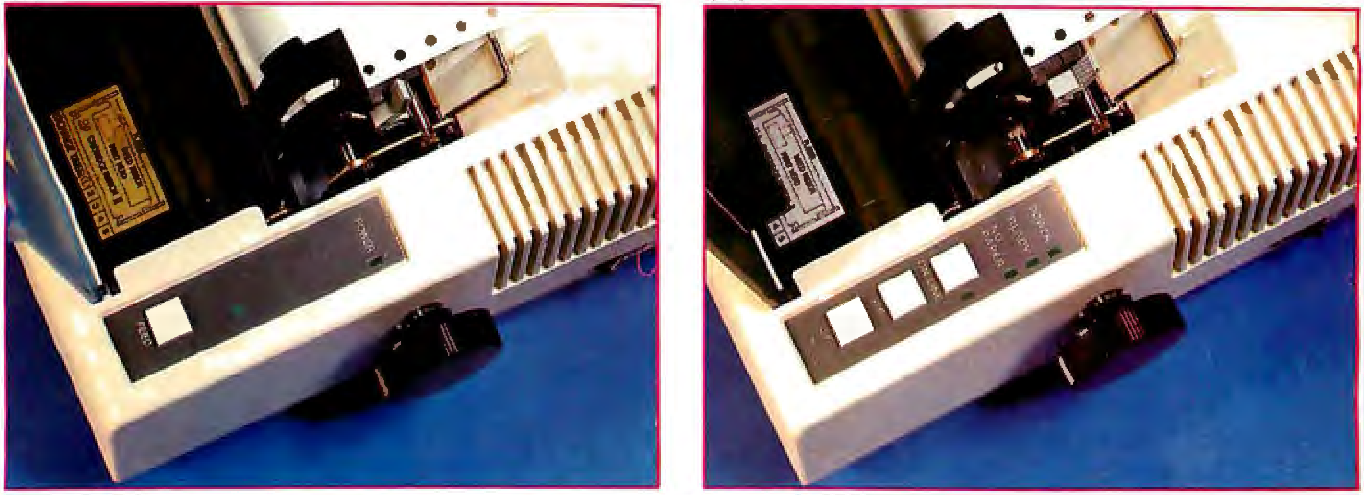


Photo 2: *Control panels for the Epson MX-70 and MX-80 printers. Photo 2a shows the FEED (paper feed) button and the green Power LED (light-emitting diode) on the MX-70. Photo 2b shows the control panel of the MX-80, which has Power, Ready, No Paper, and On-Line LEDs, and On-Line, FF (form feed), and LF (line feed) buttons.*

At a Glance

Name
Epson MX-80

Use
Dot-matrix impact printer

Manufacturer
Epson America Inc
23844 Hawthorne Blvd
Torrence CA 90505
(213) 378-2200

Dimensions
37.4 cm wide by 30.5 cm deep by 10.7 cm high ($14\frac{7}{10}$ by 12 by $4\frac{1}{5}$ inches)

Price
$645

Features
Prints 96 ASCII and 64 graphics characters in a 9 by 9 dot matrix (lowercase letters have descenders); 80 cps bidirectional print speed with end-of-line seeking function (increases average print speed); tractor-feed paper mechanism; prints TRS-80 graphics, Japanese Katakana set, special characters for the US, England, France, and Germany; prints an original and up to two carbon copies; programmable tabs; replaceable print head; and a long-life ribbon cartridge

Additional Hardware
Interface card needed for Apple II

Documentation
MX-80 User's Manual by David A Lien, 22 by 28 cm ($8\frac{1}{2}$ by 11 inches), about 100 pages

Options
TRS-80 cable (about $25); Apple II interface card with cable (about $110); IEEE-488 or serial interface (about $65 each); serial interface with 2 K-byte buffer (about $150); 960 dot-per-line graphics option (about $100)

repeatedly printed out to test the operation of the print head, ribbon guide, and motor mechanisms.

Internally, the MX-80 is a truly intelligent printer that incorporates its own microprocessor: an Intel 8049 single-chip 8-bit processor with 2 K bytes of masked ROM (read-only memory), 128 bytes of programmable memory, and twenty-seven I/O (input/output) lines. This microprocessor coordinates the internal logic and controls the two precision stepper motors. One motor moves the print head, while the other advances the paper. The microprocessor is aware of the position of the print head at any given moment and actively seeks the shortest means of travel to the next print position. This feature, in combination with the bidirectional printing capability, constitutes the logical-seeking function, which increases the effective printing speed and minimizes head-travel time to reduce head wear.

Several options may be selected via two internal DIP (dual in-line pin) switches; these include auto line-feed, a full TRS-80 graphics set or a Japanese Katakana character set, and special characters for the US, England, Germany, and France (see listing 2). This last feature allows the printing of umlauts, accented letters, and other characters that are generally unavailable on personal computer printers.

Under software control, the user may select one of three print densities: 2, 4, or 6.5 characters per centimeter (5, 10, or 16.5 characters per inch), which results in 40, 80, or 132 characters on a line. Line spacing (ie: the distance the paper advances when a line-feed code is transmitted) has a default value of 0.423 cm ($\frac{1}{6}$ inch), but it may be set from 0.035 cm ($\frac{1}{72}$ inch) to 3.00 cm ($1\frac{13}{72}$ inch) in increments of 0.035 cm ($\frac{1}{72}$ inch)—the distance between two wires on the print head. This presents some interesting possibilities.

The number of lines per form defaults to sixty-six but may be set at any whole number less than that. The user may specify up to sixty-four vertical tabs per form and up to 112 horizontal tabs per line. An emphasized character

Listing 1: *ASCII character set as printed on the Epson MX-80 (figure 1a) and the MX-70 (figure 1b) low-cost printers. Note the lack of descenders on lowercase letters in the MX-70 example.*

1a

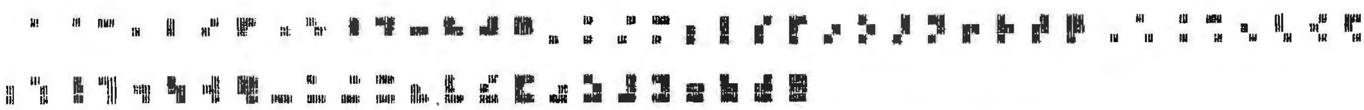
```
  ! " # $ % & ' ( ) * + , - . / 0 1 2 3 4 5 6 7 8 9 : ; < = > ? @ A B C D E F G
H I J K L M N O P Q R S T U V W X Y Z [ \ ] ^ _ ` a b c d e f g h i j k l m n o
p q r s t u v w x y z { | } ~
```

1b

```
  ! " # $ % & ' ( ) * + , - . / 0 1 2 3 4 5 6 7 8 9 : ; < = > ? @ A B C D E F G
H I J K L M N O P Q R S T U V W X Y Z [ \ ] ^ _ ` a b c d e f g h i j k l m n o
p q r s t u v w x y z { | } ~
```

Listing 2: *The MX-80 has several user-selectable font options, including graphics characters that are TRS-80 compatible (2a), Japanese Katakana (2b), and special characters for the US, England, France, and Germany (2c).*

2a



2b

```
 ｡ ｢ ｣ ､ ･ ｦ ｧ ｨ ｩ ｪ ｫ ｬ ｭ ｮ ｯ ｰ ｱ ｲ ｳ ｴ ｵ ｶ ｷ ｸ ｹ ｺ ｻ ｼ ｽ ｾ ｿ ﾀ ﾁ ﾂ ﾃ ﾄ ﾅ ﾆ ﾇ
ﾈ ﾉ ﾊ ﾋ ﾌ ﾍ ﾎ ﾏ ﾐ ﾑ ﾒ ﾓ ﾔ ﾕ ﾖ ﾗ ﾘ ﾙ ﾚ ﾛ ﾜ ﾝ ﾞ ﾟ
```

2c

```
U.S.A:      # @ [ \ ] { | } ~        ENGLAND:     £ @ [ \ ] { | } ~

FRANCE:     # à ° ç § é ù è ¨        GERMANY:     # § Ä Ö Ü ä ö ü ß
```

mode (where each character is overprinted a second time) and a boldface mode (where the paper is advanced 0.0118 cm [1/216 inch] before overprinting) are also available (see listing 3). The printer slows to 40 cps in these special modes.

For a cost of about $650, this is more printer for the money than any other available.

The MX-70

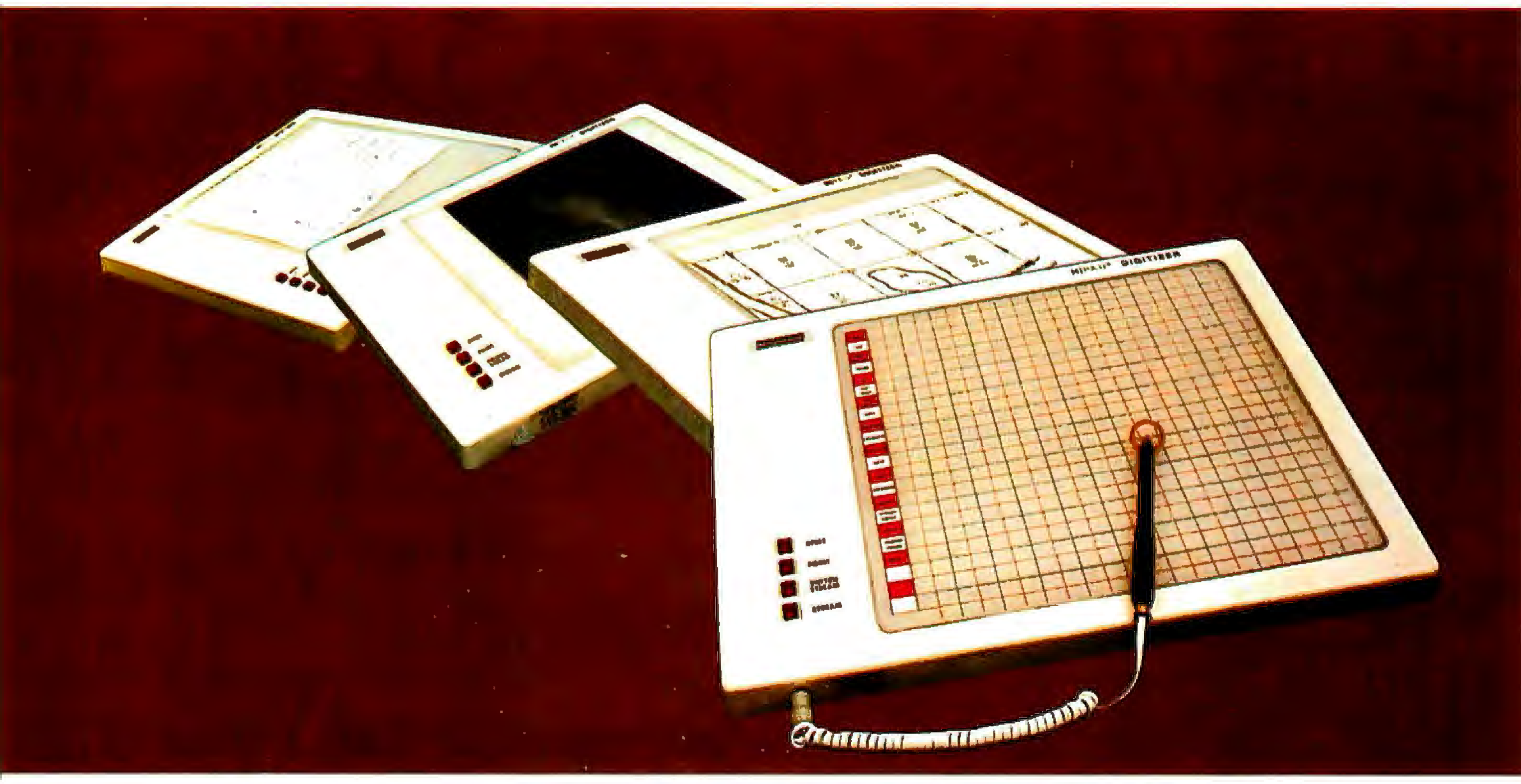
Similar in appearance to the MX-80, but with fewer features, the MX-70 is available for about $200 less (suggested retail price, $449). A 7-wire print head produces characters on a 7 by 5 dot matrix at a rate of 80 cps, but the unit does not offer the bidirectional logical-seeking capabilities of the MX-80. The MX-70 has only one green LED for power indication and only one general paper-advance (line feed that repeats if held down) pushbutton. The MX-70 uses the same self-test mode as the MX-80.

Internal jumpers select one of two character sets and auto-line-feed on or off. The MX-70 may be ordered with either the Japan/USA or the England/Germany special character set in ROM. The user may software-select 40 or 80 characters per line, or a high-resolution graphics mode where binary bit images are directly printed on a 480 by 7 dot per line matrix (ie: the user can print any combination of dots within this graphics density). Line spacing may be from 0.035 cm to 3.00 cm (1/72 inch to 1 13/72 inch). The ability to advance the paper by the distance between two wires on the print head, combined with the high-resolution graphics mode, gives the user an effective resolution of 480 by 792 dots per standard form. The actual form length may be set from 0.424 cm to 51.2 cm (1/6 inch to 20 1/6 inch).

If it seems strange that the MX-70 offers bit-map graphics and the MX-80 doesn't, it will be no surprise for you to learn that by the time this article is printed, Epson will be offering a retrofit option on the MX-80. For about $100, this option will give the MX-80 bit-mapped graphics at either 480 or 960 dots per line: the latter density is twice that of the MX-70.

In this age of runaway inflation...

Look what $795* will buy



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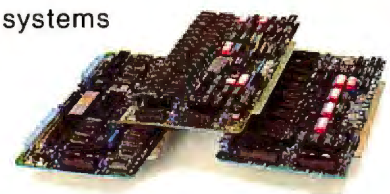

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We challenged our design team to create an innovative yet competitive system utilizing our existing line of field proven, dependable S-100 boards. The result: a highly reliable, quality built, state of the art microcomputer that gives you the cost/performance edge you need to be a leader in your field.

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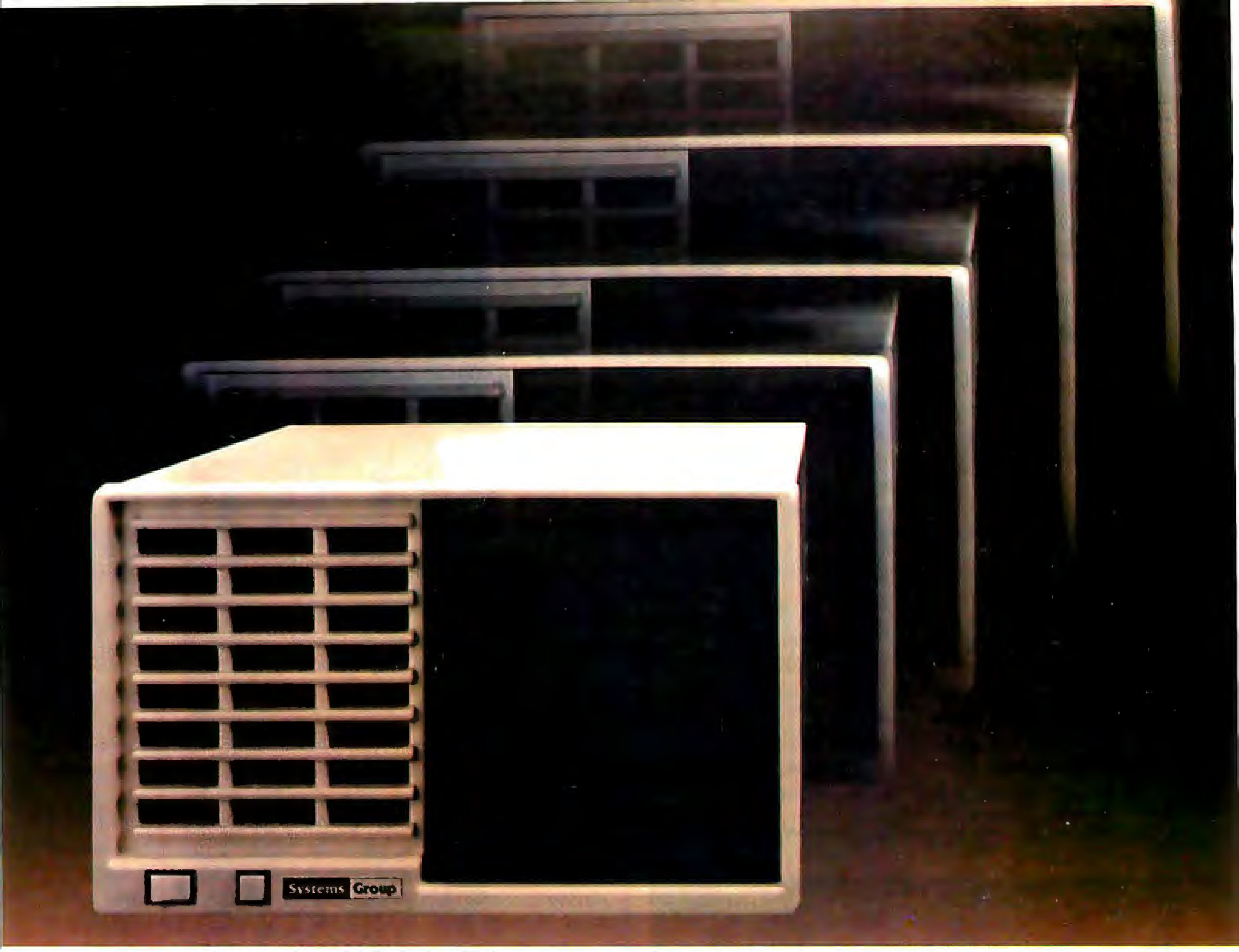

enhanced XIOS. The CP/M based System 2800 provides improved diagnostic reporting capability and increased sector sizes of 1024 bytes yielding disk performance throughput increases up to 400% over standard unblocked systems.

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All operating systems are available in either floppy or hard disk configurations. The disk drive selection includes single or double sided, double density 8-inch floppies with up to 2.52 megabytes of formatted storage per system, expandable to 5.04 megabytes, and an 8-inch 10 megabyte winchester hard disk.

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At a Glance

Name
Epson MX-70

Use
Dot-matrix impact printer

Manufacturer
See "At a Glance" box for Epson MX-80

Dimensions
Same as MX-80

Price
$449

Features
Prints 96 ASCII characters in a 5 by 7 dot matrix; 80 cps print speed; tractor-feed paper mechanism; prints an original and up to two carbon copies; includes a high-resolution graphics mode, replaceable print head, and long-life ribbon cartridge

Additional Hardware
Interface card needed for Apple II

Documentation
MX-70 User's Manual by David A Lien, 22 by 28 cm (8½ by 11 inches), about 80 pages

Options
Choice of either USA/Japan or England/Germany special character sets in ROM; TRS-80 cable (about $25); Apple II interface with cable (about $110)

Listing 3: *The MX-80 features five various character modes (figure 3a), several of which may be combined to produce different effects. The MX-70 has only two character modes (figure 3b), but has a high-resolution graphics mode (not shown) as a standard feature.*

3a

```
STANDARD CHARACTERS

BOLDFACE CHARACTERS

DOUBLE STRIKE CHARACTERS

COMPRESSED CHARACTERS

D O U B L E   W I D T H   C H A R A C T E R S
```

3b

```
REGULAR CHARACTERS

E X P A N D E D   C H A R A C T E R S
```

[**Editor's note:** *I was very pleased with the quality and reliability of both printers, but would like to mention two very small complaints. First, the MX-80 has a piercing alarm tone that sounds for three seconds whenever it receives a "bell" character. This causes some annoyance when the printer is used with an Apple II, which beeps during printing errors and causes the Epson printer to beep. Second, both printers are so quiet when not working (hardly a criticism) and the power-on LED is so small, that it is easy to overlook these indications and leave the printers on overnight....* **GW**]

Interfacing

Both the MX-80 and MX-70 printers communicate through an 8-bit parallel port that is available on a 36-pin Centronics-type cable connector. Some computers require a special interface in order to use the Epson printers, but all necessary interface components are available from Epson Inc. TRS-80 owners may use the standard Radio Shack printer cable, but due to a slight difference in connections, only the official Epson cable allows the separation of the carriage return and line feed characters. This permits the user to underline and overstrike characters, a capability that is not possible with the Radio Shack cable. Apple users will be glad to know that Epson is marketing a special interface card with cable that will plug directly into a peripheral slot in their computer. However, due to a peculiarity of the Apple's video memory, the Apple interface card will not transmit ASCII codes greater than decimal 127, thus preventing use of the MX-80 graphics set. [*Computer Corner of New Jersey, 439 Route 23, Pompton Plains NJ 07444, telephone (201) 835-7080, modifies either the Ep-*

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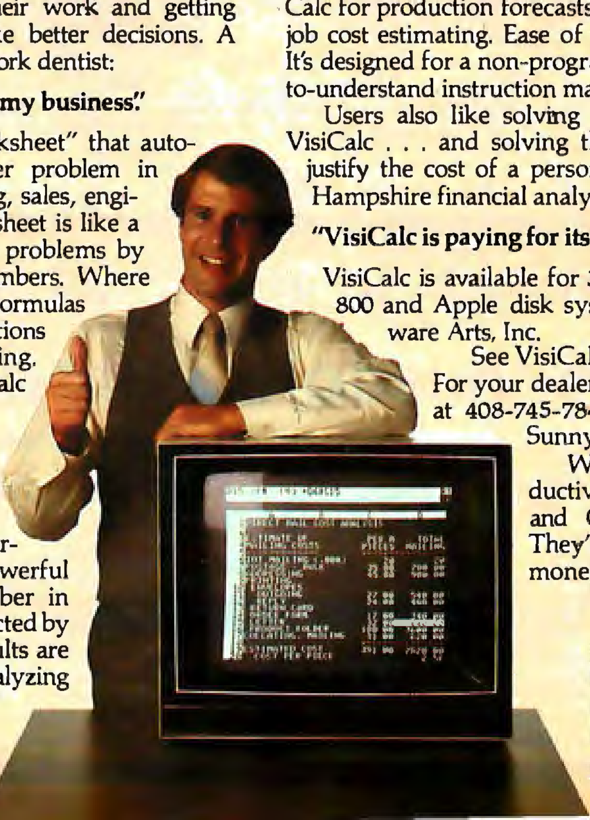

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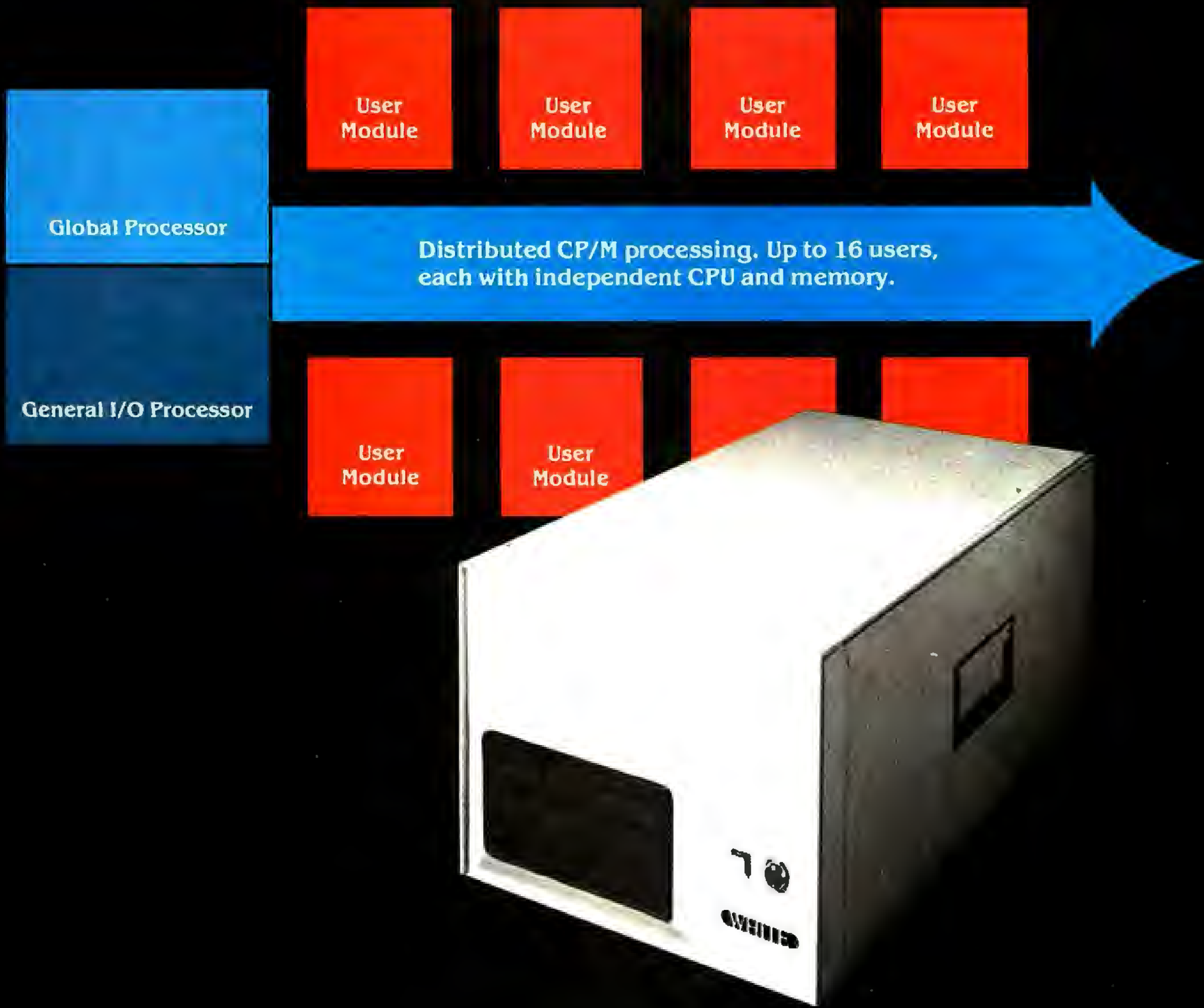
son or the Apple parallel interface cards to allow access to the graphics characters on the MX-80 printer. The modification is simple—the data-bit-7 line to the printer (the line that controls the highest bit of the 8-bit interface) is isolated from the interface board and connected via a wire to one of the annunciator output bits coming from the Apple II game socket. A POKE statement can then toggle this line, causing the MX-80 to print either normal ASCII characters or Epson graphics.... GW]

In addition to the standard TRS-80 cable and Apple II board/cable interfaces, which are available for both printers, the MX-80 will also have the following interfaces: IEEE-488, serial, and buffered serial (which includes a 2 K-byte character buffer). Approximate prices are given in the MX-80 "At a Glance" text box.

Conclusions

• The Epson MX-80, at $645, and the MX-70, at $449, both represent an unprecedented level of performance for the price. Although the low price of the MX-70 is particularly attractive, the added features of the MX-80 make it worth the extra $200. The most important features are the intelligent bidirectional printing (which significantly increases the printing speed) and the 9 by 9 dot matrix for letters (which allows true descenders on lowercase letters like "y" and "g" and results in a more readable text).

• Both printers require tractor-feed paper, which limits the user's choices (eg: standard letterhead stationery can't be used), but also assures precise placement of text on a page. And what other low-cost printer prints on ordinary



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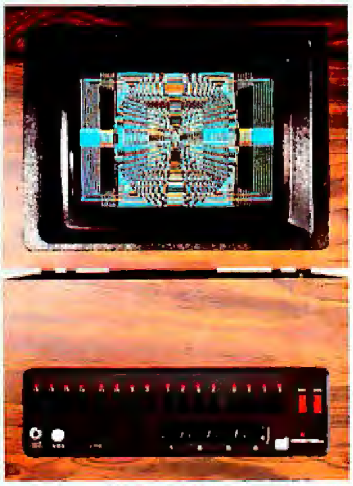
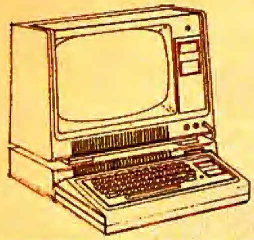


paper (as opposed to thermal or electrostatic) and produces an original as well as up to two carbon copies by using multiple-ply paper? This ability, due to the fact that both are impact printers, is of particular interest to small business users.

In addition, the print head can be changed (recommended after 50,000,000 characters) by the owner, at a cost of about $30. A quieter print head (5 dB quieter than the standard head during printing) is available for about $40. Like the standard replaceable print head, it can be installed by the user.

- Although the MX-70 and the MX-80 share many features, each has its own graphics option. The MX-70 has bit-mapped graphics that permit control over any dot in a 480 by 7 dot array, one 7-dot column at a time. The MX-80, on the other hand, has the same graphics set as the TRS-80, and an option for bit-map graphics.
- Epson America is beginning to enter the US market and has already begun to train many of its distributors and dealers to act as authorized service centers. The three Epson factory centers, located in Dallas, San Francisco, and Great Neck, New York, also provide service—a major consideration when investing in a unit that is mechanical as well as electronic in nature. (The unusual potential of these machines to do more than simple printing has also led to the founding of an independent Epson Users' Group. For more information, contact Frank Barden, Epson Users' Group, c/o 1017 Trollingwood Ln, Raleigh NC 27604.)
- Both the Epson MX-80 and MX-70 offer a variety of features at a price well below that of any comparable printer on the market. These features, the reputation of Epson, and the thorough engineering that is apparent in the two units, allow me to recommend these printers to any personal computer owner. ■

TRS-80* Model I Computer Owners . . .



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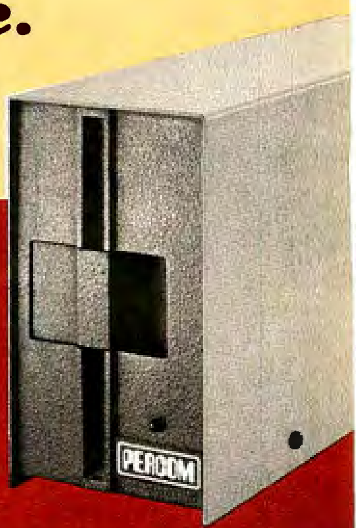

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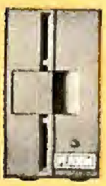
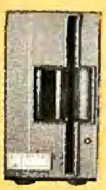


TFD-40 Drives store 180 Kbytes (double-density) or 102 Kbytes (single-density) of formatted data on one side of a 40-track minidiskette. Although economically priced, TFD-40 drives receive the same full Percom quality control measures as TFD-100 and TFD-200 drives.

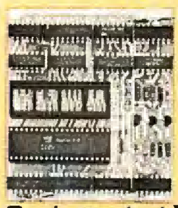
TFD-100™ Drives

TFD-100 drives are "flippy" drives. You store twice the data per minidiskette by using both sides of the disk. TFD-100 drives store 180 Kbytes (double-density) or 102 Kbytes (single-density) **per side**. Under double-density operation, you can store a 70-page document on one minidiskette.

TFD-200™ Drives



TFD-200 drives store 350 Kbytes (double-density) or 197 Kbytes (single-density) on one side of a minidiskette. By comparison, 3740-formatted eight-inch disks store only 256 Kbytes. Enormous on-line storage capacity in a 5" drive, plus proven Percom reliability. That's what you get in a TFD-200.



The DOUBLER™ — This proprietary adapter for the TRS-80* Model I computer packs approximately twice the data on a disk track.

Depending on the type of drive, you can store up to four times as much data — 350 Kbytes — on one side of a minidiskette as you can store using a Tandy standard Model I computer drive.

Easy to install, the DOUBLER merely plugs into the disk controller chip socket of your Expansion Interface. No rewiring. No trace cutting.

And because the DOUBLER reads, writes and formats *either* single- or double-density disks, you can continue to run all of your single-density software, then switch to double-density operation at any convenient time.

Included with the PC card adapter is a TRSDOS*-compatible double-density disk operating system, called DBLDOS™, plus a CONVERT utility that converts files and programs from single- to double-density or double- to single-density format.

Each DOUBLER also includes an on-card high-performance *data separator circuit* which ensures reliable disk read operation.

The DOUBLER works with standard 35-, 40-, 77- and 80-track drives rated for double-density operation.

Note. Opening the Expansion Interface to install the DOUBLER may void Tandy's limited 90-day warranty.

Free software patch with drive purchase. This software patch, called PATCH PAK,™ upgrades TRSDOS* for single-density operation with improved 40- and 77-track drives.

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Extended Color BASIC for the TRS-80 Color Computer

Stan Miastkowski, Technical Editor

Inexpensive and easy-to-use color graphics have been the goal of personal computer makers for a number of years. Although graphics have been available, they've been neither inexpensive nor easy to use. Many of the systems currently on the market require the skills of an experienced machine-language programmer in order to generate high-resolution graphics. Some manufacturers have simplified the process; but, for the most part, generating a full-color graphics display is still a tedious exercise.

Radio Shack has released the first *truly* easy-to-use and inexpensive system that generates full-color graphics. Extended Color BASIC is available for the TRS-80 Color Computer and was developed by Microsoft. In fact, the message:

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SOFT

appears when you turn the Color Computer on. Extended Color BASIC is fast, memory-efficient, and so well designed that anyone (even children) can create graphics shapes in a few minutes. Best of all, it's fun to use and has features that advanced programmers will appreciate.

Getting Into Graphics

If you have a TRS-80 Color Computer, you can add Extended Color BASIC for $99. The computer must be returned to Radio Shack for the modification. Extended Color BASIC also requires 16 K bytes of programmable memory, which, if you don't already have it, adds $119 to the price of modification. The complete Extended Color Computer sells for $599. You'll still need a color monitor—although the family television is still the most popular alternative.

Radio Shack has released the first easy-to-use and inexpensive system that generates full-color high-resolution graphics.

Graphics Modes

Extended Color BASIC has five distinct graphics modes available—two low-resolution, two medium-resolution, and one high-resolution (see table 2). The low- and medium-resolution modes each offer a choice of two-color or four-color modes. When memory space is at a premium, the two-color modes are handy for space conservation. The high-resolution mode has only a two-color mode available. Entering any of the five graphics modes is simple—a PMODE command is the first line of any graphics program. The command is followed by the number (0 thru 4) of the graphics mode you wish to use.

Even though the size of the graphics blocks (or pixels) differ widely in the three main graphics modes, all points are plotted on a 256-by-192 grid (49,152 points). This greatly simplifies matters if you decide to modify any program that uses the graphics modes—if you change the resolution, you don't have to change the parameters of the graphics commands.

Color Combinations

The TRS-80 Color Computer has available a set of nine colors (see table 3). It's interesting to note that the powerful Motorola 6847 Video Display Generator, a key component in the Color Computer, has the capability of displaying a very large number of distinct shades. It's possible to take a look at them by turning on the computer, waiting for the Extended Color BASIC message to appear, and then *rapidly* turning the computer off and on.

Attempting to figure out the color combinations available in each of the

CIRCLE (*x,y*), *r*, c, *hw*, *start*, *end*
Draws a circle, partial circle, or ellipse.
- *x* is the x-coordinate of the circle's centerpoint.
- *y* is the y-coordinate of the circle's centerpoint.
- *r* is the radius of the circle. Each unit is equal to one graphics point on the screen.
- c is a number (0 to 8) which specifies the color of the circle. The number must be one of those specified for the mode/color set combination. If this value is omitted, the foreground color defaults to the previously specified color.
- *hw* is the height/width ratio of the circle (from 1 to 255). If it's omitted, 1 (a perfect circle) is used.
- *start* is the starting point of the circle (from 0 to 1). This is optional and if omitted, 0 is used.
- *end* is the endpoint of the circle (from 0 to 1). If it's omitted, 1 is used.

COLOR *foreground,background*
Sets the foreground and background screen colors within limits specified by the mode/color set combination.
- *foreground* is a color code (0 to 8).
- *background* is the background color (0 to 8).

DRAW *line*
Draws a line (or series of lines) by specifying the direction, angle, and color.
line is a string expression and may include:

Motion Commands
- M = Move the draw position
- U = Up
- D = Down
- L = Left
- R = Right
- E = 45-degree angle
- F = 135-degree angle
- G = 225-degree angle
- H = 315-degree angle
- X = Execute a substring and return

Modes
- C = Color
- A = Angle
- S = Scale

Options
- N = No update of draw position
- B = Blank (no draw, just move)

EDIT
Allows editing of program lines.
- *n*C Changes *n* characters.
- *n*D Deletes *n* characters
- I Allows insertion of new characters.
- H Deletes remainder of line and allows insertion of new characters.
- L Lists current line and continues edit.
- *n*Sc Searches for *n*th occurrence of character c.
- X Extends line.
- SHIFT Escape from subcommand.
- *n* SPACE Moves cursor *n* spaces to the right.
- *n* Moves cursor *n* spaces to the left.

GET *startpoint—endpoint, destination,* G
Places the graphics contents of a specified rectangle within a specified array.
- *startpoint* is the coordinate of the upper-left corner of a rectangle on the screen.
- *endpoint* is the coordinate of the lower-right corner of the same rectangle.
- *destination* is the name of a predefined array that will store the contents of the rectangle. G tells the computer to store the rectangle's contents with full graphic detail.

LINE (*x1,y1*)—(*x2,y2*), *a,b*
Draws (or erases) a line between two specified points. Also draws a box using the coordinates as the opposing corners.
- *x1,y1* is the starting position of the line.
- *x2,y2* is the endpoint of the line.
- *a* is either PSET or PRESET.
- *b* is either B (for box) or BF (for filled box).

PAINT (*x,y*) ,c,*b*
Fills a specified area with a specified color. (The color is limited by the mode/color set combination.)
- *x* is an x-coordinate.
- *y* is a y-coordinate.
- c is the color code (from 0 to 8). The color selected must match one of the colors available in the particular mode/color set combination in use.
- *b* is the border color (0 to 8) at which painting will stop.

PCLEAR *n*
Clears a specified number of memory pages (1536 bytes each) for graphics use.
n is the number of graphics pages (1 to 8).

PCLS *color*
Clears the video display.
color is the number (0 to 8) of one of the colors available for the mode/color set combination in use.
If *color* is omitted, the existing background color is used.

PCOPY *source* TO *destination*
Copies the contents of one memory page to another memory page.
source and *destination* are memory page numbers (1 to 8).

PLAY
Plays music of a specified note (A thru G or 1 thru 12), octave (1 thru 5), volume, note duration, tempo, and pause. It also allows the execution of substrings and will handle the specification of sharps and flats.

PMODE *mode, start-page*
Selects the graphics mode and the memory page on which a program starts.
Mode is the graphics mode (0 to 4). The default value is 2.
Start-page is the number of the graphics page (1 to 8) on which the program will start.

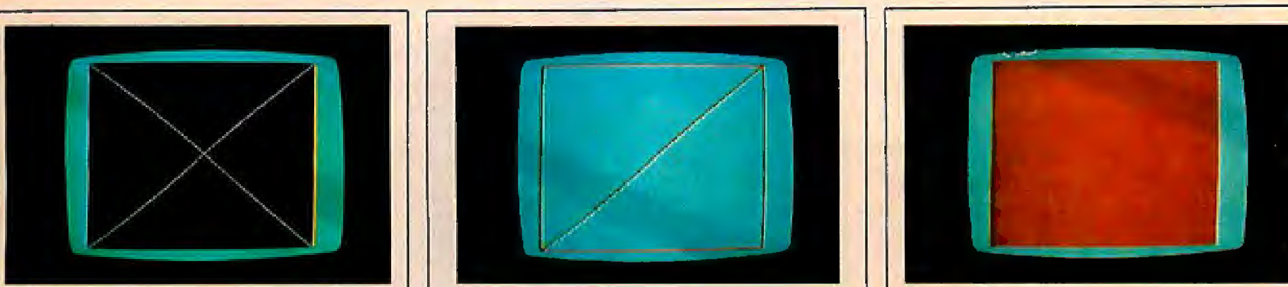
PSET (*x,y*,c)
Turns on selected graphics points.
x is the position on the *x*-axis.
y is the position on the y-axis.
c is the color of the dot (0 to 8).

PRESET (*x,y*)
Turns off graphics points which were turned on by the PSET command.
x is the coordinate on the *x*-axis.
y is the coordinate on the y-axis.

PUT *startpoint—endpoint, source, action*
Places the graphics contents of a rectangle stored in an array by the GET command at a specified position.
- *startpoint* is the coordinate of the upper-left corner of the rectangle.
- *endpoint* is the coordinate of the lower-right corner of the rectangle.
- *source* is the name of a predefined array that contains the data to be written into the rectangle.
- *action* determines how the data is to be written into the rectangle and can be the following:
  - PSET—Sets the points that were set in the original rectangle.
  - PRESET—Resets the points that were set in the original rectangle.
  - AND—Compares the points stored in the original rectangle with the destination rectangle. If both are set, then the screen point will be set; if not, the screen point is reset.
  - OR—Compares the points as above. If either is set, the screen point will remain set.
  - NOT—Reverses the state of each point in the destination rectangle.

SCREEN *type, color set*
Tells the computer whether you want to use a text screen or a graphics screen and selects the color set.
- *type* is either 0 (text screen) or 1 (graphics screen).
- *color set* is either 0 or 1 (see table 4).

Table 1: *Graphics, editing, and music commands available in Extended Color BASIC.*



(a)
```
5  PMODE 4,1
10 PCLS
20 SCREEN 1,1
30 LINE (0,0)-(255,191),PSET
40 LINE (0,191)-(255,0),PSET
50 GOTO 50
```

(b)
```
5  PMODE 1,1
10 PCLS
20 SCREEN 1,1
25 LINE (0,0)-(255,191),PSET,B
30 LINE (0,191)-(255,0),PSET
40 GOTO 40
```

(c)
```
5  PMODE 1,1
10 PCLS
20 SCREEN 1,1
25 LINE (0,0)-(255,191),PSET,BF
30 LINE (0,191)-(255,0),PSET
40 GOTO 40
```

Photo 1: *Three examples of the LINE statement in Extended Color BASIC. Photo 1a shows the high-resolution mode (PMODE 4,1). Photo 1b is the low-resolution mode (PMODE 1,1) and shows that when the suffix "B" is added to the LINE command in line 25, a box is created which uses the endpoint coordinates as opposing corners. Photo 1c shows what happens when the suffix "BF" is added to line 25. A box is created and filled with the foreground color. (Note that the line created by line 30 was drawn, but it's invisible because it's the same color as the filled box.)*

graphics modes is, at first glance, probably the most complicated aspect of using Extended Color BASIC. Choosing what's called the *color set* is done by the SCREEN command. This command has two parameters: The first tells the computer whether you want the graphics mode or text mode. The second parameter selects the color set. This is where things get a bit tricky. The three two-color modes (low-, medium-, and high-resolution) each offer a choice of *either* black and green *or* black and buff. The two four-color modes (low- and medium-resolution) offer color sets of either green/yellow/blue/red or buff/cyan/magenta/orange. None of the graphics modes allow you to use all nine colors at one time.

A further "complication" is the COLOR command, which instructs the computer to use specified foreground/background colors. The specified color codes must be in the allowable color set for the graphics mode you're using (see table 4)—otherwise you'll be greeted with an error message when you attempt to run the program.

Extended Color BASIC divides the available graphics memory into eight pages of 1536 bytes each.

Although all this seems extremely complicated, I found that within a few hours of using Extended Color BASIC, the graphics modes and available color sets became second nature. Besides, the system sets default values for you if you don't want to bother remembering all the combinations at first.

Graphics Pages

Extended Color BASIC divides the available graphics memory into eight *pages* of 1536 bytes each. An optional PCLEAR command can be used in the program to specify the number of pages you want to use. (The default is 4.) A PCOPY command is also available which can copy the contents of one page into another page (as long as the new page was allocated by PCLEAR). In addition, the PMODE command has a second parameter that specifies which page to start the program on.

It doesn't take long to realize that the memory pages offer a number of interesting and creative possibilities. Switching between pages offers the opportunity for limited animation—especially since it's possible to update

PMODE Number	Grid Size	Color Mode	Memory Pages Used
4	256 by 192	Two-color	4
3	128 by 192	Four-color	4
2	128 by 192	Two-color	2
1	128 by 96	Four-color	2
0	128 by 96	Two-color	1

Table 2: *The five graphics modes of Extended Color BASIC (two low-resolution, two medium-resolution, and one high-resolution). All modes are selected by the PMODE command and are mapped onto a 256 by 192 grid.*

Code	Color
0	Black
1	Green
2	Yellow
3	Blue
4	Red
5	Buff
6	Cyan
7	Magenta
8	Orange

Table 3: *Colors available on the TRS-80 Color Computer.*

one page while another is on the screen.

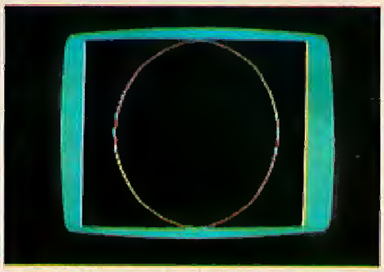
Creating Graphics

Once you get used to the graphics and color modes, using Extended Color BASIC to actually create graphics displays is easy. Although it *is* possible to use the PSET and PRESET commands (the equivalent of the familiar SET and RESET commands found in other TRS-80s), the 50,000 or so graphics points available in the high-resolution mode make the setting of individual points a very time-consuming exercise (although this might be necessary in a few cases).

The people who designed Extended Color BASIC have made it simple—such commands as LINE, CIRCLE, DRAW, and PAINT (see photos) make the creation of very sophisticated shapes an easy job. The most-used commands include:

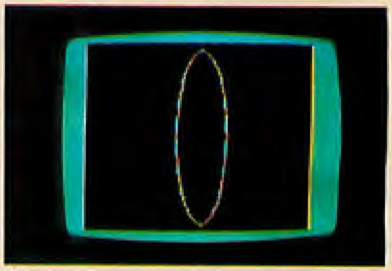
- LINE—Draws a line between two specified sets of coordinates. It will also draw a box and, if desired, fill the box with the foreground color.
- CIRCLE—Draws a circle with a specified radius at a specified coordinate. You also have the option of changing the height/width ratio and drawing only parts of the circle.
- DRAW—Draws a line or series of lines. You specify the direction, angle, and color.
- PAINT—Fills a specified area with a color you pick.
- GET—Places the graphics content of a specified rectangular area of the display within an array.
- PUT—Takes the array used to store the GET information and redraws the graphics within an area that you specify.

(For a complete list of Extended Color BASIC graphics commands, see table 1).



(a)

```
5   PMODE 4,1
10  PCLS
20  SCREEN 1,1
30  CIRCLE (128,96),95
40  GOTO 40
```



(b)

```
5   PMODE 4,1
10  PCLS
20  SCREEN 1,1
30  CIRCLE (128,96),30,,3
40  GOTO 40
```

(c)

```
5   PMODE 4,1
10  PCLS
20  SCREEN 1,1
30  CIRCLE (128,96),30,1,1,.25,.75
40  GOTO 40
```

(d)

```
10  PMODE 4,1
20  PCLS
30  SCREEN 1,0
40  FOR RADIUS = 1 TO 100 STEP 10
50  CIRCLE (128,96),RADIUS
60  NEXT RADIUS
70  GOTO 70
```

Photo 2: *Four variations of Extended Color BASIC's CIRCLE statement, all in the high-resolution graphics mode. Photo 2a is a simple circle with coordinates (128,96) as the centerpoint and 95 graphics blocks as the radius. In photo 2b, the height/width ratio has been specified as 3, creating an oval. The ratio can be specified from 0 to 255. If > 1, the circle is "higher" than it is wide; if < 1, it is wider than it is high. If the ratio is 0, the circle is infinitely higher than it is wide and becomes a straight line. Photo 1c uses the start and finish parameters to specify which part of the circle to draw. Photo 1d uses a single CIRCLE statement and a FOR-NEXT loop to create a bullseye.*

Music

Although fast and easy color graphics is the bread and butter feature of Extended Color BASIC, the system has a number of other strong points, including the ability to perform some pretty fancy music. The non-modified version of the TRS-80 Color Computer (without Extended Color BASIC) allows you to create music by the SOUND command, which gives a range of notes from F_3 to E_7 with a duration of 6/100 to 6/10 seconds. Obviously, there are limitations to this; there is a limited range, each note requires a separate program line, and you have no control over the tempo or volume. Playing all but the most simple tune is a tedious job.

All of those problems have been eliminated in Extended Color BASIC through the use of one powerful command—PLAY. The PLAY command allows you to control the note, octave, duration of notes and pauses, and volume through the use of a single string. You can also execute substrings, making the playing of certain kinds of music a much easier proposition (see listing 1). Notes (over a five-octave range) can be specified by using either the numerals 1 thru 12 or the notes themselves from C to B (including sharps and flats). Duration of notes can be varied from a whole note to a 1/255th note! Thirty-one volume levels can be specified, and tempo and pause-length have a range of

```
5   PMODE 3,1
10  PCLS
20  SCREEN 1,1
30  LINE (0,0)-(255,191),PSET
40  LINE (0,191)-(255,0),PSET
50  CIRCLE (128,96),90
60  PAINT (135,125),8,8
70  GOTO 70
```

Photo 3: *An example of the PAINT statement. The lines and circles shown are in the medium-resolution two-color mode (PMODE 3,1). The PAINT statement in line 60 specifies the beginning point of the painting (135,125), the color choice, and the color number at which the painting will stop.*

PMODE Number	Color Set	Two-Color Combination	Four-Color Combination
4	0	Black/Green	—
	1	Black/Buff	—
3	0	—	Green/Yellow/Blue/Red
	1	—	Buff/Cyan/Magenta/Orange
2	0	Black/Green	—
	1	Black/Buff	—
1	0	—	Green/Yellow/Blue/Red
	1	—	Buff/Cyan/Magenta/Orange
0	0	Black/Green	—
	1	Black/Buff	—

Table 4: *Color combinations (sets) that can be used within Extended Color BASIC. (Color set is the second parameter of the PMODE command.) The two low- and medium-resolution modes each have a two-color and a four-color set available. The single high-resolution mode is two-color and only allows combinations of black/green or black/buff.*

Listing 1: *A demonstration of Extended Color BASIC's music capabilities. Lines 55 thru 80 create six string variables (A$ thru F$) and assign to them note, duration, octave, tempo, and volume-level information. Line 85 assigns string variable X$, a string of commands to execute (X) substrings A$ thru F$. The music is played by the PLAY command in line 90, which calls the nested substrings.*

```
1 '*** BACK TO BACH ***
2 '
5 CLS
10 PRINT @ 96, STRING$(32,"*")
20 PRINT @ 320, STRING$(32,"*")
25 PRINT @ 201, "BACK TO BACH"
40 FOR X = 1 TO 1000: NEXT X
55 A$ = "T6;O2;L2;G;L4;C;D;E;F;L2;G;C;P16;C;"
60 B$="L2;A;L4;F;G;A;B;O3;L2;C;O2;C;P16;C;F;L4;G;
   F;E;D"
65 C$="L2;E;L4;F;E;D;C;L2;O1;B;O2;L4;C;D;E;C"
70 D$="L2;E;L1;D;L2;G;L4;C;D;E;F;L2;G;C;P16;C"
75 E$="L2;A;L4;F;G;A;B;O3;L2;C;O2;C;P16;C;F;L4;G;
   F;E;D"
80 F$="L2;E;L4;F;E;D;C;D;E;L2;F;O1;B;L1;O2;C"
85 X$="XA$;XB$;XC$;XD$;XE$;XF$;"
90 PLAY X$
```

from 1 to 255. If you're musically inclined, you'll find the PLAY command an interesting one, despite the inability to play chords. Even for one not schooled in musical theory, these capabilities are useful for adding sound to program displays, graphics, and animation.

The Added Extras

Extended Color BASIC adds to the TRS-80 Color Computer commands and functions. This makes it substantially the same as the well-known Radio Shack Level II BASIC. After using the non-extended BASIC for a while, it was good to have back such familiar commands as TRON and TROFF (trace on and off), and ON ERROR GOTO. Functions added include PEEK (strangely enough, non-extended color BASIC does have POKE but not PEEK), SQR, EXP, COS, LOG, TAN, and USR.

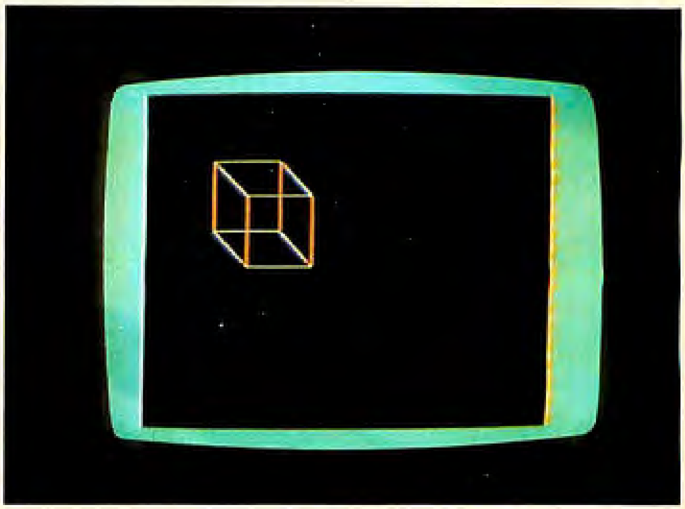
There are a number of differences. Since both extended and non-extended color BASIC use device numbers for I/O (input/output) operations (0 for the keyboard and video screen, −1 for the cassette, and −2 for the printer), OPEN, CLOSE, INPUT, and EOF (end-of-file) statements are available. Therefore, dumping a program to a line printer is done by the PRINT#−2 command instead of LPRINT.

Also, because Extended Color BASIC includes a USR function, it is possible to call machine-language subroutines from BASIC programs (unlike the non-extended version). The technical information appendix of the Extended Color BASIC manual says, "The ROM (read-only memory) contains many subroutines that can be called from machine-language programs." From this statement, you might think that a long list of ROM subroutines would be included. Unfortunately, such is not the case. A total of seven follows, all dealing with cassette, joystick, and keyboard I/O. To be fair, the lack of ROM subroutine information is not Radio Shack's fault—its license with Microsoft prevents publication of such information.

Despite the lack of specific subroutine information, there are three new statements within Extended Color BASIC which are designed to help out the machine-language programmer:

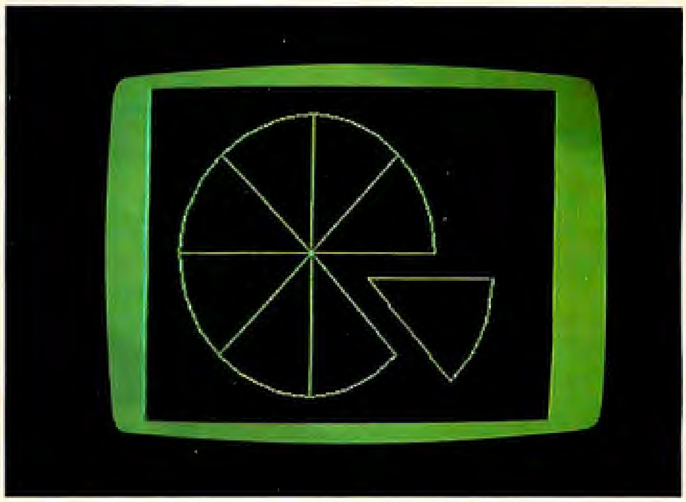
(a)

```
5   PMODE 4,1
10  PCLS
20  SCREEN 1,1
25  DRAW "BM40,80;U40;R40;D40;L40"
30  DRAW "BM+20,20;U40;R40;D40;L40"
40  LINE (60,100)-(40,80),PSET
50  LINE (60,60)-(40,40),PSET
60  LINE (100,60)-(80,40),PSET
70  LINE (100,100)-(80,80),PSET
80  GOTO 80
```



(b)

```
5   PMODE 4,1
10  PCLS
20  SCREEN 1,0
30  DRAW "BM98,96;NU80;NE56;
    NR80;NF56;ND80;NG56;NL80;NH56"
40  CIRCLE (98,96),80,1,1,.125,1
50  CIRCLE (135,110),80,1,1,1,.125
60  LINE (135,110)-(190,167),PSET
70  LINE (135,110)-(235,110),PSET
80  GOTO 80
```



(c)

```
5   PMODE 4,1
10  PCLS
15  SCREEN 1,0
20  DRAW "BM50,50R60D10NL20D20L20NU20L20NU20
    L20U20NR20U10" 'TOP VIEW
25  DRAW"BM50,100R20ND20R20ND20R20D20
    NL20D10L60U10NR20U20" 'FRONT VIEW
30  DRAW "BM150,100R30D30L30U10NE20U20"
    'SIDE VIEW
35  ' OBLIQUE VIEW—LINES 40-60

40  DRAW "BM150,50U5E15R10BF20BD30NR5L20H25U10
45  DRAW "BM150,50U5F8U15R15H8F8L15F8NR15D15F8
    ND10E15NR10H8
50  LINE (175,30)-(200,55),PSET
55  LINE -(200,80),PSET
60  LINE (167,60)-(183,46),PSET
65  GOTO 65
```

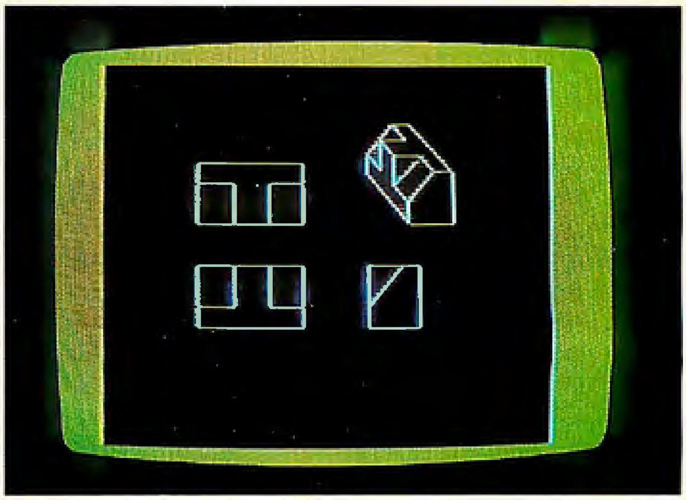
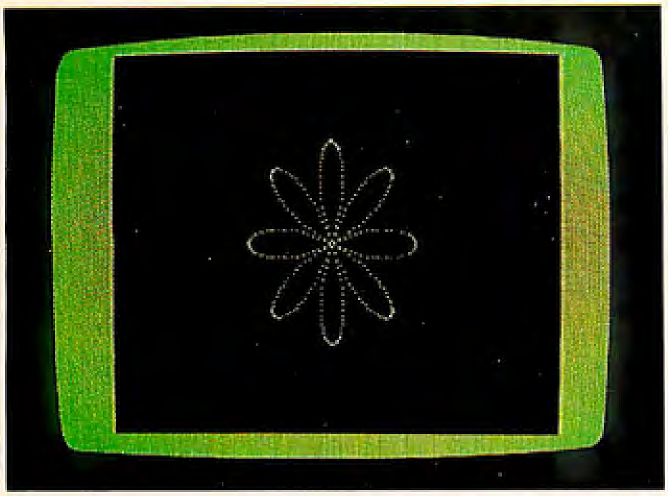
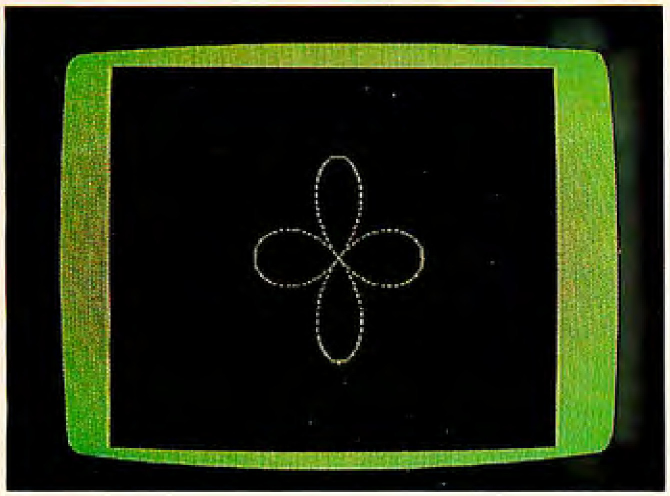


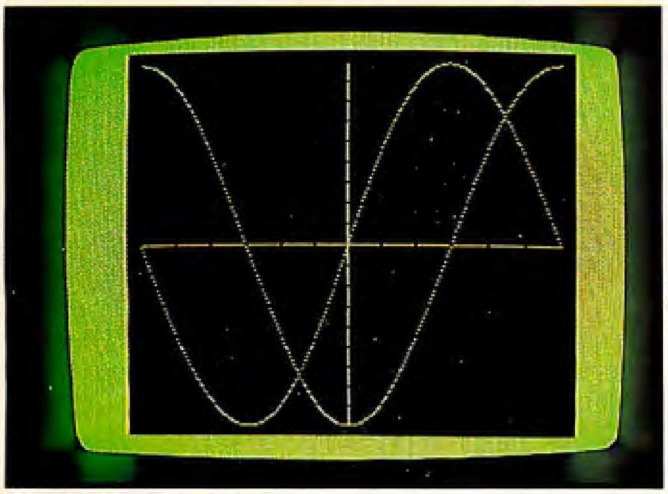
Photo 4: *Three examples of the DRAW statement, which allows you to specify the starting point, direction, angle, and color of a figure. The cube in photo 4a was created by DRAWing two squares (lines 25 and 30) and connecting them with four LINE statements (lines 40 thru 70). Photo 4b is an example of the DRAW statement's "no update" option. Each of the lines radiating from the center of the "pie" is drawn individually, with the computer returning each time to the centerpoint of the circle (98,96). The detached "slice" was created using the CIRCLE statement's start/end parameters and two LINE commands. Photo 4c uses all of the parameters of the DRAW statement to create the four projection studies of a figure.*





(a)

```
5   PCLEAR 8
10  PMODE 4,1
11  PCLS
12  SCREEN 1,0
13  PI = 3.14159
15  A1 = 0: A2 = 2*PI
20  N = 360:A = 50
25  X = (A2-A1)/N
30  FOR I = A1 to A2 STEP X
35  R = A * COS (4*I)
40  X = R *SIN(I)
45  Y = R * COS (I)
50  PSET(128 + X,96 + Y,5)
55  NEXT I
60  GOTO 13
```



(b)

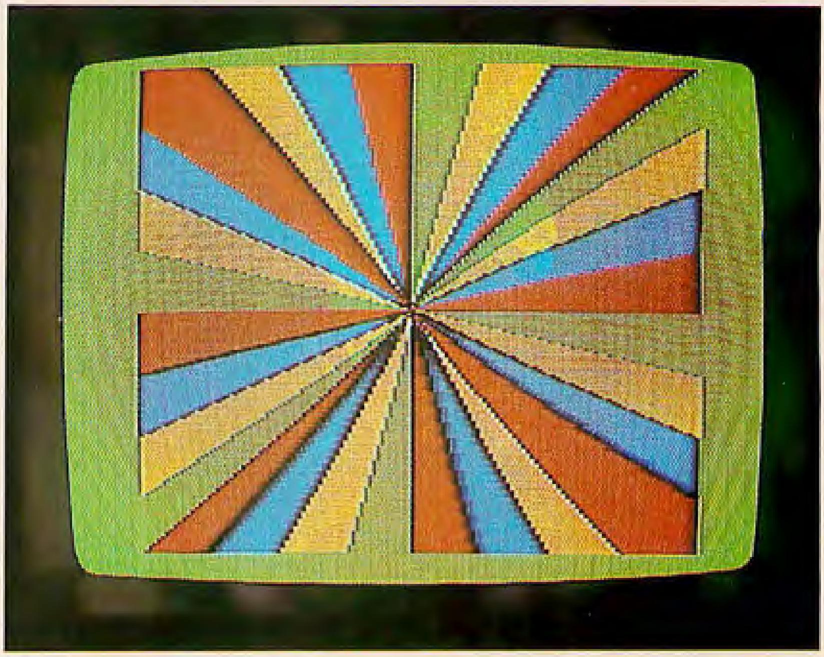
```
10  PMODE 4,1
20  PCLS
30  SCREEN 1,0
40  LINE (127,5)-(127,185),PSET
50  LINE (7,95)-(247,95),PSET
60  FOR XSCALE = 7 TO 247 STEP 20

70  PRESET (XSCALE,95)
80  NEXT XSCALE
90  FOR YSCALE = 5 TO 185 STEP 10
100 PRESET (127,YSCALE)
110 NEXT YSCALE
130 FOR X = -180 TO 180 STEP 1.5
140 AX = X/57.29578
145 XP = X/1.5 + 127
150 F1 = -(SIN(AX)*90) + 95
160 F2 = -(COS(AX)*90) + 95
170 PSET(XP,F1,1): PSET(XP,F2,1)
180 NEXT X
190 GOTO 190
```

Photo 5: *Three high-resolution examples of the use of PSET, SIN, and COS. The eight-leaf clover in photo 5a is changed to a four-leaf clover (photo 5b) by changing the cosine value in line 35 to 2. In photo 5c, the computer uses PSET, SIN, and COS to draw the sine/cosine waves and LINE to draw the x-y axis. Notice that each wave travels 360 degrees (from +180 to −180) and that the x-axis increments 30 degrees at each gradation. This is a good exercise in mapping (scaling down) a program to fit the video display.*

- CLOADM—Loads a machine-language program from cassette. You can also specify a memory offset.
- CSAVEM—Writes a machine-language program to cassette.
- DLOADM—Loads a machine-language program at the speed you specify (300 or 1500 bps [bits per second]).

Advanced programmers should be able to use its speed and efficient use of memory space to avoid the tedium of machine-language programming.

Although a lack of machine-language information might be considered a handicap by some, it is not. One of the most striking features of Extended Color BASIC is that it is *fast*—despite the fact that the microprocessor runs at the relatively slow speed (for computers) of .894 MHz (million cycles per second). It's evident that the 6809E is an extremely powerful microprocessor. Creating graphics by the PSET (point-by-point) method is slow, but the LINE, CIRCLE, DRAW, and PAINT statements are surprisingly fast—obviously calling machine-language subroutines in the Extended Color BASIC ROM.



```
5    PCLEAR 8
50   GOTO 600
60   LINE ((255 - X),(191 - Y)) - (X,Y),PSET

61   J = J + 1:IF J > A THEN J = 0:A = RND(50)
63   RETURN
600  REM ROTATING FAN
601  FOR I = 1 TO 5 STEP 4
602  PMODE 3,1
603  PCLS
604  SCREEN 1,0
605  A = 25:X = 0: Y = 0: J = 0
610  FOR X = 0 TO 254
612  COLOR X/32 + 1,5
615  GOSUB 60: NEXT X
620  FOR Y = 0 TO 190
623  COLOR Y/24 + 1,5
625  GOSUB 60: NEXT Y
630  FOR X = 255 TO 1 STEP -1
633  COLOR X/32 + 1,5
635  GOSUB GO: NEXT X
640  FOR Y = 191 TO 1 STEP -1
643  COLOR Y/24 + 1,5
645  GOSUB 60: NEXT Y
650  NEXT I
660  FOR I = 1 TO 5 STEP 4
670 PMODE 3,1
680  SCREEN 1,0
690  FOR T = 1 TO 30: NEXT T
700  NEXT I
710  GOTO 660
```

Photo 6: *Advanced programming in Extended Color BASIC. The program uses the available parameters of LINE, SCREEN, and COLOR to create a multicolor rotating display.*

The Editor

The color graphics and musical ability of Extended Color BASIC are the most interesting features; however, the addition of a full-feature editor (once again similar to the Level II BASIC editor) will surely be appreciated. It only takes a couple of times of retyping long program lines to correct a single error to convince any programmer that editing capability is not a luxury.

Documentation

As usual, the Radio Shack people have done an outstanding job of providing a manual aimed squarely at the "average" user of Extended Color BASIC (ie: the non-programmer).

Hexadecimal Address	Decimal Address	Contents
0-3FF	0-1023	System Use
0FF	255	Direct Page Memory
3FF	1023	Extended Page Memory
400-5FF	1024-1535	Text Screen Memory
		Graphic Screen Memory
600-BFF	1536-3071	Page 1
C00-11FF	3072-4607	Page 2
1200-17FF	4608-6143	Page 3
1800-1DFF	6144-7679	Page 4
1E00-23FF	7680-9215	Page 5
2400-9FF	9216-2559	Page 6
2A00-2FFF	2560-12287	Page 7
3000-35FF	12288-13823	Page 8
		Program and Variable
3600-3FFF	13824-16383	Storage
8000-9FFF	37768-40959	Extended Color BASIC
A000-BFFF	40960-49151	Color BASIC
C000-FEFF	49152-65279	Cartridge Memory
FF00-FFFF	65280-65535	Input/Output

Table 5: *TRS-80 Color Computer memory map. (Map as shown is with Extended Color BASIC and 16 K bytes of programmable memory installed.)*

Technical Writer Jonathan Erickson has written a manual ("documentation" is a dirty word in the halls of Radio Shack, since they feel it connotes *non*-readability) in Radio Shack's informal, chatty, and *very* readable style. He's also managed to do this without talking down to the reader. Best of all, the material is well organized so that finding specific information is quick and easy.

Summary

Radio Shack's Extended Color BASIC is a breakthrough in color graphics for personal computers. It's fast, easy-to-use, and capable of producing striking graphics. In addition, advanced programmers should be able to use its speed and efficient use of memory space to avoid the tedium of machine-language programming. It lends itself well to the development of games and is also a great way for children to get involved with programming. For experienced programmers, "getting into" the system in order to broaden its features will present a challenge and eventually result in even more exciting graphics.

Extended Color BASIC (in its present form) and the TRS-80 Color Computer system do not readily lend themselves to a professional or business environment. The inability to mix graphics and text on the screen makes it difficult to set up charts and graphs. But better things are coming—Radio Shack will introduce a floppy-disk drive for the Color Computer within a few months and also plans to market a low-cost plotter/printer for the system.

Finally, Extended Color BASIC is the first incarnation of Microsoft's continual development of software dedicated to computer graphics, one of the fastest growing fields of the future. If Extended Color BASIC is an indication of the beginning for personal computers, we can expect amazing products in the years to come.■

At a Glance

Name
Extended Color BASIC

Type of package
Color graphics, music, and BASIC extension

Manufacturer
Radio Shack
1300 One Tandy Ctr
Fort Worth TX 76102

Price
$99 to add to existing TRS-80 Color Computer;
$599 for complete system (less video display)

Format
ROM (read-only memory)

Language used
BASIC

Computer needed
Radio Shack TRS-80 Color Computer with 16 K bytes of programmable memory.

Documentation
"Going Ahead With Extended Color BASIC"
215 pages, 22 by 28 cm (8½ by 11 inches)

Of interest to
Everyone

Additional comments
If Extended Color BASIC is to be added to an existing TRS-80 Color Computer, the unit must be returned to Radio Shack for modification.

The Commodore VIC 20 Microcomputer:
A Low-Cost, High-Performance Consumer Computer

Gregg Williams
Senior Editor

"Why haven't you bought a personal computer yet?" This question will elicit varying responses from people interested in buying one. However, most of them fit into two categories: "They're still too expensive," or "The ones I can afford are not a good long-range investment." There are some good general-purpose microcomputers around, but they're in the $1000 price range. And some computers cost as little as $200; that's certainly the right price, but you know you're sacrificing *something* (quality of materials, expandability, etc) to get such a low price.

The Commodore VIC 20 microcomputer may change all this. It is well constructed, has color, sound, and graphics, and is easy to use. It comes with everything needed to use it (except an ordinary color television set), includes a well-written instruction manual, and is supported by a line of optional extensions, peripherals, and documentation (see figure 1). Looking at a picture of the version selling in Japan (photo 1) might cause you to think $600 would be a fair price. It is, compared to the cost of other units. But it does not cost $600—the VIC 20 retails for $299.95.

The Commodore VIC 20 is well constructed, has color, sound, and graphics, and is easy to use.

Physical Characteristics

The VIC (which stands for Video Interface Computer) is a small unit, about the size of the main (keyboard) component of the Radio Shack TRS-80 Model I. It measures 40.3 by 20.4 by 7.2 cm (15.9 by 8 by 2.8 inches) and is small enough to easily fit on a work desk or a shelf. In fact, it is small enough to fit into a suitcase (along with its external power supply and RF (radio-frequency) modulator), making it usable as a portable personal computer.

The first thing I noticed about the VIC was its keyboard. It is the equal of any personal-computer keyboard in both appearance and performance. This is a remarkable accomplishment, almost unbelievable considering the price of the entire unit. Three of its closest competitors, the Atari 400, the Radio Shack TRS-80 Color Computer, and the Sinclair ZX80, have keyboards that are less than perfect as a result of cost cutting. In this respect, the Commodore VIC 20 stands clearly ahead of its competition.

Photo 2a shows the rear panel of the VIC 20. The long slot on the left is used to plug in memory cartridges, program cartridges, or a VIC Master Control Panel, which allows up to four cartridges to be plugged in. Immediately to the right of the cartridge slot is the TV output socket. The signal from this plug goes directly to a video monitor or through the RF modulator and a TV switch box to a standard television set. (The necessary cable, RF modulator, and switch box are supplied with the VIC.)

The middle (round) connector on the rear panel is a serial interface that drives a single 5-inch floppy disk and a printer. Up to five peripheral devices can be daisy-chained through each other to this connector. The next slot to the right (the short rectangular

Acknowledgment
I would like to thank Ramon Zamora, David Cole, and the rest of the Avalanche Inc staff for their assistance during the writing of this article.

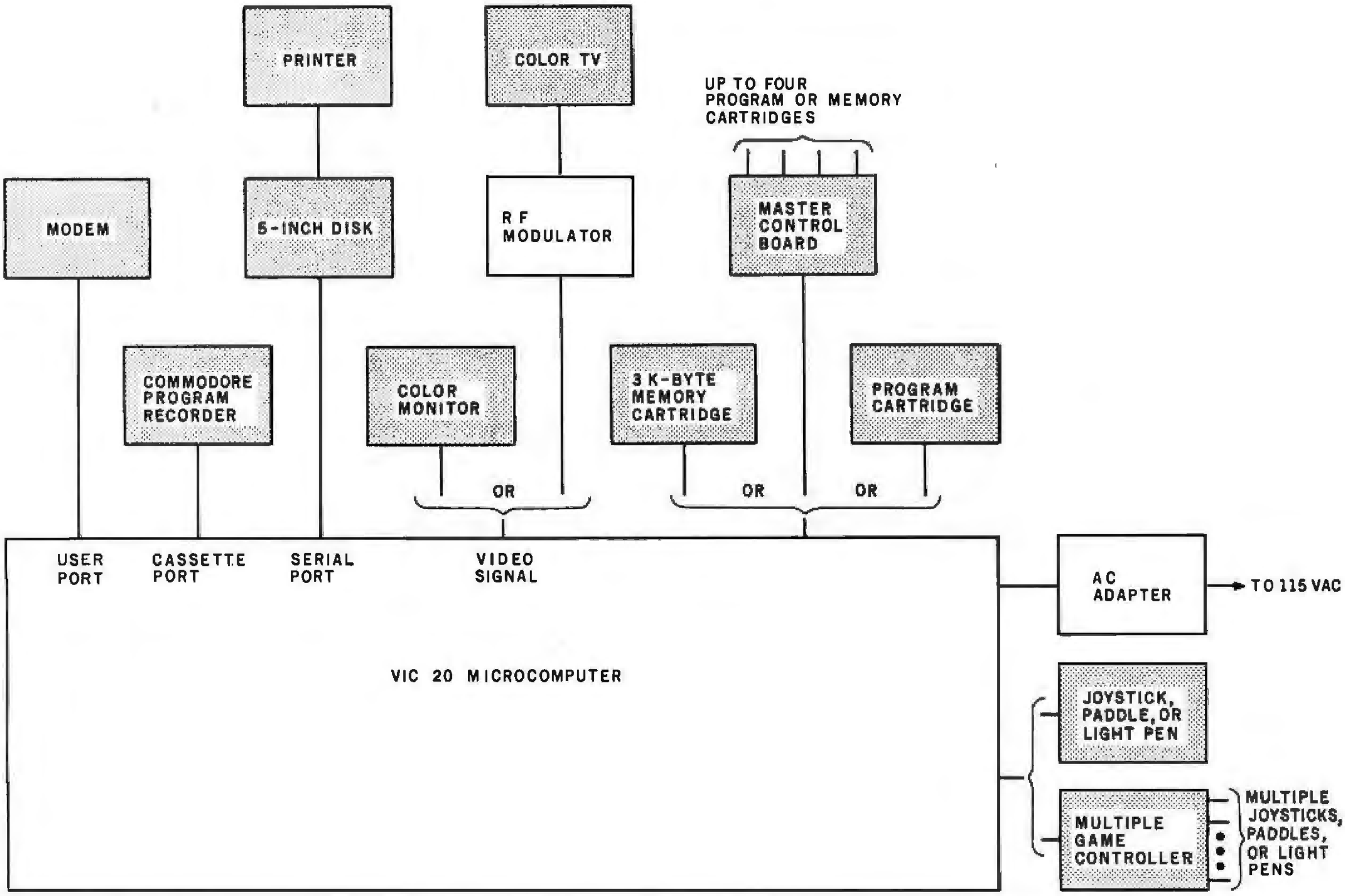


Figure 1: *A block diagram of the Commodore VIC 20 system (shaded components are available at extra cost).*

slot) goes to the VIC cassette recorder (which is available separately). The rightmost slot contains a "user port" that can be connected to a printer, a modem, or one of several other peripheral devices. With an optional RS-232C adapter card, this port can also be used with RS-232C devices.

The left-side panel (see photo 2b) contains (from left to right) a game port, a rocker-type on/off switch, and a socket to receive power from the VIC power supply. The game port, according to Commodore, can accept a joystick, a light pen, a game paddle, or a VIC Multiple Game Controller (which allows several game devices to be connected to the VIC).

Photo 1: *The Commodore VIC 20 microcomputer. This unit, a final prototype based on the Japanese version of the VIC microcomputer, differs from the American model only in the model number.*

When the VIC 20 is turned on, the video display (a color television tuned to channel 3 or 4) stays dark for about three seconds, then shows the display given in photo 3. The VIC display has 23 lines of 22 characters or graphics symbols per line, with cyan (greenish blue) letters on a white background. The active display area in the VIC is delineated by a border of a different color (in photo 3, a cyan border). The border crisply marks the working area of the VIC. For me, it has the psychological effect of making the screen area seem bigger; this is important, since the VIC displays fewer characters per line than any of its competitors.

VIC Graphics

The VIC 20 graphics character set is virtually identical to that of its predecessors, the Commodore PET and CBM (Commodore Business

Machine). The standard VIC can display over sixty graphics symbols, shown on the front faces of most of the keys (see photo 1). Since these symbols are directly available from the keyboard and can be stored in string variables and displayed by PRINT statements, it is easy for even the inexperienced BASIC user to combine these symbols into larger pictures. This character-size building-block approach is used by Atari, Commodore, Ohio Scientific, and Sinclair. It is a good way to generate graphics that are easy to understand and use without having to design a separate graphics mode. Such graphics are better than simply being able to turn on and off coarse graphics blocks (as in the TRS-80 Models I and III and the Color Computer) because character-oriented graphics allow more detailed images (although, unlike the graphics-blocks system, character graphics do not allow full control of the image).

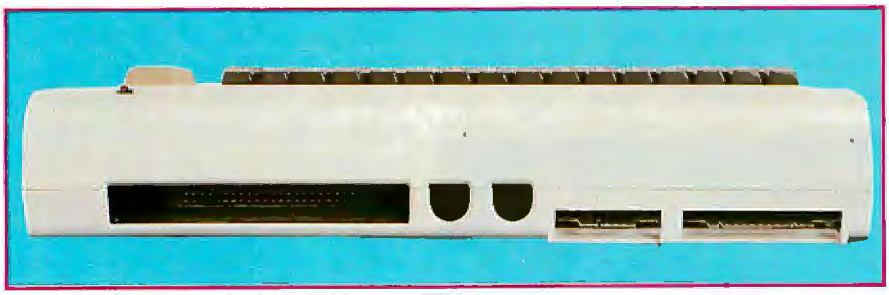
All the graphics characters in the VIC are accessible directly from the keyboard. For characters shown on the fronts of key caps, pressing either shift key or the Commodore key (the key in the lower left corner of the keyboard) causes one of these characters to be displayed. Pressing the Commodore key with a given key causes the character on the left half of the front face to be displayed; pressing either shift key with a given key causes the character on the right half to be displayed.

All the graphics characters in the VIC are accessible directly from the keyboard.

Both uppercase and lowercase characters can be displayed, but you lose access to all the characters on the right half of the key front faces. Toggling between this uppercase/lowercase/graphics mode and the default uppercase/graphics mode is done by pressing the shift key, holding it down, pressing the Commodore key, and releasing both keys. The graphics characters on the left half of the key front faces are still available with lowercase letters. Commodore grouped what it believes are the most useful graphics characters (ones that might be used with lowercase letters in business applications) on the left half of the key front faces.

Finally, the number of graphics characters that can be displayed is doubled because *any* character can be displayed as is or in reverse (see photo 3). This can be done immediately or during program execution. Pressing the RVS ON key (the CTRL key plus the 9 key simultaneously) causes all displayed characters to appear in reverse on the screen. (If you are programming and hit the RVS ON key while defining a character string, a reverse R will appear and subsequent keystrokes will not be reversed. However, when you print that string, the reverse R will not appear but will cause all subsequent characters to be displayed in reverse.) Pressing the RVS OFF key (CTRL plus the 0 key) causes all displayed characters to appear unreversed on the screen. (When included in a character string, the RVS OFF key causes all subsequent characters to be displayed normally; its symbol appears in the character string as a reverse underline.)

(2a)



(2b)

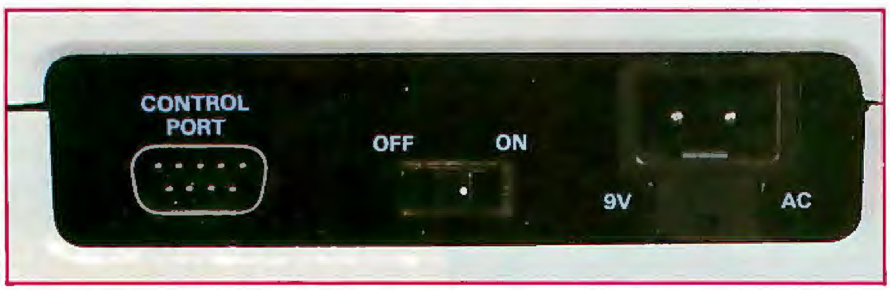


Photo 2: *Connections to the VIC 20 microcomputer. Photo 2a shows the rear panel of the VIC; from left to right are a slot for program cartridges and connections to a television or video monitor, a floppy disk, a Commodore cassette recorder, and a printer or other peripherals. Photo 2b shows a game device port, an ON/OFF rocker switch, and a connector for an external power supply.*

VIC Color

To quote an adage from photography, "If you can't make it good, make it red." There is an element of truth in that—color *does* make things more exciting, and it's always one of the most striking features of a microcomputer video display. The VIC has an impressive color display due largely to the complete control you have over the placement and combination of colors.

The VIC allows you to display normal and reversed characters (including all graphics symbols) in eight colors: black, white, red, cyan, purple, green, dark blue, and yellow. The color of the flashing cursor and all subsequent characters displayed on the video screen is set by simultaneously pressing the CTRL key and the appropriate color key (one of the keys numbered 1 through 8). As described for the RVS ON and

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Photo 3: *The VIC 20 video display immediately after being turned on.*

Photo 4: *The character set of the VIC 20. Any character can be displayed in reverse.*

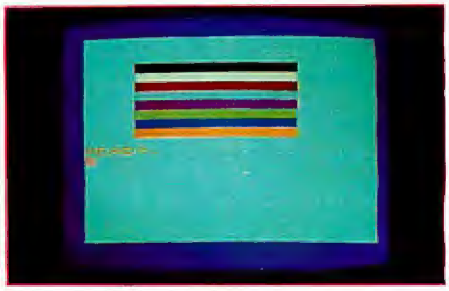

Photo 5: *The eight character colors available on the VIC 20. All characters can be displayed in any of these colors.*

RVS OFF keys, pressing a color key within a character string causes a reverse character to be placed in the string. This tells the VIC not to immediately change the display color, but to change it when that string is printed. Photo 5 shows the eight colors available, each of which is displayed by printing the corresponding color control character followed by a line of reverse spaces (which appear as solid squares of the current color). The computer displays *all* ouput in the current color. In photo 5, since the last color used was yellow, the VIC responds with its end-of-program message in yellow.

The VIC also allows you to change the background color of the working area in the center and the border that surrounds it. Choose from sixteen background colors and eight border colors (ie: 128 background/border combinations). The two are changed by executing (either directly or from a program) the statement:

POKE 36879,X

where X is a value as given in table 1. The background colors can be any of the eight character colors or orange, light orange, pink, light cyan, light purple, light green, light blue, or light yellow. The border colors can be any of the eight character colors.

An unusual thing about the VIC is that the background color can change independently of the character color (other color microcomputers can't do this). Combined with the color and reverse keys, this allows a tremendous amount of control over the video display. Photos 6a and 6b show a run of a program differing only in the value poked to memory location 36,879. Photo 6a shows a light green background and a cyan border; this was accomplished by poking the value 219 to that location. Photo 6b shows a light cyan background and a red border; this was accomplished by poking the value 186 to that location.

Background	Border							
	Black	White	Red	Cyan	Purple	Green	Blue	Yellow
Black	8	9	10	11	12	13	14	15
White	24	25	26	27	28	29	30	31
Red	40	41	42	43	44	45	46	47
Cyan	56	57	58	59	60	61	62	63
Purple	72	73	74	75	76	77	78	79
Green	88	89	90	91	92	93	94	95
Blue	104	105	106	107	108	109	110	111
Yellow	120	121	122	123	124	125	126	127
Orange	136	137	138	139	140	141	142	143
Light orange	152	153	154	155	156	157	158	159
Pink	168	169	170	171	172	173	174	175
Light cyan	184	185	186	187	188	189	190	191
Light purple	200	201	202	203	204	205	206	207
Light green	216	217	218	219	220	221	222	223
Light blue	232	233	234	235	236	237	238	239
Light yellow	248	249	250	251	252	253	254	255

Table 1: *Background and border color combinations in the VIC 20 microcomputer. Poking decimal location 36,879 with the values given in this table gives a video display with the colors shown.*

In addition, notice the two sets of angle brackets on each line. The first set contains an X symbol, a space, and a small square. The second set contains the *reverse* of each of these characters. Notice the role of the background and character colors in these reversed and nonreversed characters. If the background color were changed with those characters on the screen, the characters would assume the new background color but retain the old character color.

Photo 7 contains a listing of the program that produced photo 6b. Several control characters appear in this listing as seemingly arbitrary reverse characters. These are screen-manipulation characters stored for later use because they appear within a character string; if a quote mark had not been previously typed on the same line, the character would have been executed immediately and would not have appeared on the screen. The reverse heart in line 100 is the VIC symbol to clear the screen and put the cursor in the upper left corner. The reverse R and reverse underline in line 110 correspond to the RVS ON and RVS OFF keys, respectively. They cause the three characters between them to be displayed in reverse. The reverse characters in lines 120 through 180 are the result of pressing the corresponding color keys (CTRL plus the keys 1 through 8, respectively). They cause all printed characters to be displayed in the given color, as shown in photo 6b.

The VIC video display is memory-mapped (ie: the contents of the screen are determined by the contents of a given range of memory locations inside the VIC). Because of this, the

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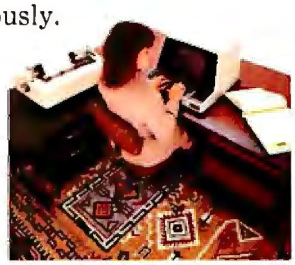

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screen can be directly manipulated by poking values into certain memory locations. Memory locations 7680 through 8185 (decimal) contain the code for a given character; memory locations 38,400 through 38,905 contain the code for the *color* of the respective character. Locations 7600 and 38,400 determine the character in the upper left corner. Locations 7601 and 38,401 determine the character to its right, and so on down to the character in the lower right corner.

VIC Sound and BASIC

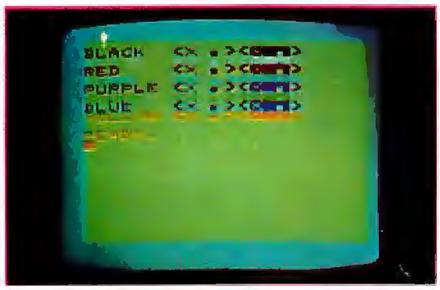
The VIC 20 can produce three independent "voices" of music and one voice of noise through the speaker of the attached television set. Each voice, covering a three-octave range, covers a different part of the audio spectrum. The voices are labeled "tenor," "alto," and "soprano"; they are activated by poking a number between 128 and 254 into locations 36,874 through 36,876. The noise generator is similarly activated at location 36,877, and an overall volume control (which takes values between 0 and 15) is located at 36,878. Table 2 lists important memory locations in the VIC 20. Table 3 lists the values to be poked into the music-voice locations to give a certain musical pitch within the three-octave range of that voice.

VIC BASIC is a version of Microsoft BASIC modified by Commodore. It is a full-blown BASIC with the features found on most microcomputers, allowing the VIC to accept other BASIC programs with little or no modification. A list of BASIC keywords accepted by the VIC is given in table 4. The keywords listed have the standard definitions given by Microsoft BASIC.

The VIC Product Line

Although prices and availability of VIC peripheral devices were not

(6a)



(6b)

Photo 6: *Variations in character, background, and border colors on the VIC 20. Photos 6a and 6b differ only in the value stored in location 32,879, which determines the background color (from sixteen choices) and the border color (from eight choices).*

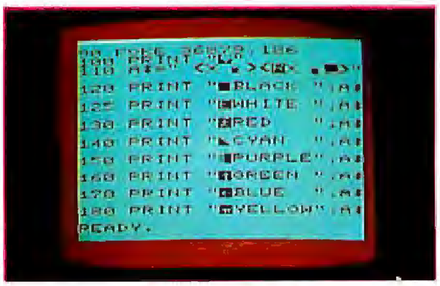


Photo 7: *A VIC BASIC program utilizing color, graphics, and reverse video. This program produces the video display shown in photo 6b. The reverse character before each color word in the PRINT statements is a control character determining the color of everything displayed after it. See the text for details.*

Memory Location (in Decimal)	Use
7680 to 8185	contains character contents of VIC video display; characters are mapped by row, with location 7680 corresponding to the upper left corner of the display
36,874	corresponds to tenor music "voice"; should contain either 0 (for silence) or 128 through 254 (for note; see table 3)
36,875	corresponds to alto music "voice"
36,876	corresponds to soprano music "voice"
36,877	corresponds to a noise-producing "voice"; accepts values of 0 and 128 through 254; higher values give higher-pitched white-noise sounds
36,878	volume control for all music and noise "voices"; effective values are 0 through 15
36,879	control byte for background and border colors; see table 1
38,400 to 38,905	contains character color contents of VIC video display; mapped to video display in the same way as the character contents (see above)

Table 2: *Some important memory locations in the VIC 20 microcomputer.*

Note	Value	Note	Value
C	135	G	215
C#	143	G#	217
D	147	A	219
D#	151	A#	221
E	159	B	223
F	163	C	225
F#	167	C#	227
G	175	D	228
G#	179	D#	229
A	183	E	231
A#	187	F	232
B	191	F#	233
C	195	G	235
C#	199	G#	236
D	201	A	237
D#	203	A#	238
E	207	B	239
F	209	C	240
F#	212	C#	241

Table 3: *Values used in the generation of music on the VIC 20 microcomputer. On the VIC, these values are stored in memory locations 36,874 through 36,876 to generate the appropriate note within the three-octave range of a given music voice.*

definite at press time, Commodore has announced an extensive line of products to be "introduced during and throughout 1981." (By the time you read this, Commodore expects to have the VIC computer itself available through Commodore dealers.) This list of peripheral devices and accessories includes:

• *Memory-expansion products*—Commodore will sell a line of cartridges that add programmable memory to the VIC, increasing the size and complexity of programs that can be run. A 3 K-byte cartridge can be plugged directly into the VIC, and 8 and 16 K-byte cartridges can be plugged in through a Master Control Panel that plugs into the VIC cartridge slot and accepts up to four cartridges. The maximum amount of programmable memory is 32 K bytes.

• *Storage peripherals*—Commodore will sell both a low-cost cassette recorder (although existing Commodore recorders work with the VIC) and a low-cost single 5-inch floppy-disk drive. The disk drive will hold up to 170 K bytes of data.

• *Other peripherals*—These include a dot-matrix printer, joysticks, light pens, game paddles, and a Multiple Game Controller (discussed earlier).

• *Interfaces*—Commodore plans two interfaces for the VIC, a modem and an IEEE-488 bus interface. The modem allows communication with other computers over telephone lines. The IEEE-488 interface allows the VIC (like the PET and CBM machines) to interface with PET peripherals and a wide variety of test instruments and devices that use this standard bus.

• *Firmware*—A wide range of software will be distributed in cartridge form; three firmware cartridges have already been announced. The first, the RS-232C Interface Cartridge, allows you to use the VIC and a modem to communicate with other computers and access information utilities like MicroNet and The Source. The second, the VIC Programming Cartridge, will include a machine-language monitor and a number of utility functions useful during programming; it will also use the four function keys (on the right-hand side of the keyboard) to execute predetermined functions. The third, the VIC Super Expander Cartridge, will add 3 K bytes of programmable memory, a new level of high-resolution graphics, and additional music-related capabilities. The high-resolution graphics (which I have not seen) are said to be excellent (176 rows by 176 columns of graphics dots, also called *pixels*).

• *Documentation*—In addition to the *VIC User's Manual*, supplied with the VIC, Commodore plans a series of book-plus-cartridge packages explaining several aspects of using and programming the VIC. (Documentation is discussed in greater detail later in this article.)

Arithmetic Operators:
ABS, ATN, LET, SGN, INT, SQR, RND, LOG (to base e), EXP (to base e), COS, SIN, TAN, +, −, *, /, ↑(exponentiation), <, >, =

Character Operators:
CHR$, ASC, SPC, TAB, LEN, STR$, VAL, LEFT$, RIGHT$, MID$, + (to concatenate strings)

Control Words:
FOR, TO, STEP, NEXT, GOTO, IF, THEN, GOSUB, RETURN, ON (used with GOTO and GOSUB), WAIT, END, USR

File and I/O Words:
OPEN, CLOSE, INPUT, INPUT#n, PRINT, PRINT#n, GET, READ, DATA, DIM, RESTORE

Command Words:
RUN, STOP, LOAD, SAVE, VERIFY, CONT, LIST, NEW, CLR

Miscellaneous Words:
AND, OR, REM, DEF FNx, FNx, POKE, NOT, FRE, PEEK

Table 4: *A list of VIC BASIC keywords.*

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Human Engineering on the VIC

When the microcomputer industry was smaller, hobbyists put up with about anything in a computer as long as it worked. But now that major corporations are marketing microcomputers for the general public, *human engineering*—the design of systems to make them easy and efficient to use—has become the most important factor in the usability of computer systems. The VIC deserves high marks in human engineering because it is easy to understand and use.

The VIC keyboard is one of the best I've seen. It is well constructed and has a good feel during typing. The key names on the top and front faces of the keys are highly visible and easy to read. In most cases, key functions have been wisely chosen and named. For example, the key used to stop a program from executing is labeled as the RUN/STOP key. Pressing it (instead of the arbitrary control-C combination used by many computers) causes the VIC to stop executing the program and print out the line number where the program was stopped. Use of the CLR/HOME (clear-screen-and-home-cursor-to-upper-left-corner/home-cursor) and INST/DEL (insert/delete

Name of Computer	Atari 400	Commodore **VIC 20**	Ohio Scientific Challenger 1P	Radio Shack TRS-80 Color	Sinclair **ZX80**
Microprocessor used	6502	6502A	6502	6809E	Z80A
System clock frequency	1.8 MHz	slightly more than 1 MHz	1 MHz	slightly less than 1 MHz	3.25 MHz
List price	$499/$630 (two models, 8 K or 16 K)	$399.95	$479	$399	$199.95
Type of keyboard	touch-sensitive flat panel; slightly smaller than normal keyboard	full-size normal keyboard; very good feel	full-size normal keyboard	full-size normal keyboard; keys have feel of calculator buttons (not good)	touch-sensitive flat panel; much smaller than normal keyboard
Amount of programmable memory supplied	8 K or 16 K bytes (see above)	5 K bytes	8 K bytes	4 K bytes	1 K bytes
Maximum programmable memory possible	16 K bytes	32 K bytes	32 K bytes	16 K bytes	16 K bytes
Type of BASIC	full BASIC	full BASIC	full BASIC	limited BASIC (extended BASIC for more sophisticated music and graphics at extra cost)	limited BASIC (extended BASIC available at extra cost)
Video screen size (in characters)	16 rows by 32 columns	23 rows by 22 columns	24 rows by 24 columns or 12 rows by 48 columns	16 rows by 32 columns	24 rows by 32 columns
Lowercase letters available?	yes	yes	yes	accepts lowercase letters but displays uppercase as inverse capitals	no
Color available?	yes	yes	yes, at extra cost ($229 extra)	yes	no
Graphics characters available?	yes; characters available from keyboard	yes; characters available from keyboard	yes; graphics available only through POKE and CHR$ statements	no, but unit color block is ¼ normal character size	yes; characters available from keyboard
High-resolution graphics available?	yes, included (320 by 192 pixels)	yes, at extra cost (176 by 176 pixels)	no	yes, at extra cost (256 by 192 pixels)	no
Music available?	yes, three voices of music; can mix noise with each voice	yes, three voices of music, one of noise	yes, one voice of music (needs external speaker and amplifier)	yes, one voice of music	no
Extensions to BASIC for color, low-resolution graphics, and music?	yes, uses BASIC commands to manipulate all three	no, uses control characters and pokes to manipulate all three	no, uses pokes to manipulate all three	yes, uses BASIC commands to manipulate all three	low-resolution graphics available from keyboard
Uses program cartridges?	yes	yes	no	yes	no
Machine-language monitor included?	no	no	yes	yes	no
Assembly-language assembler available (at extra cost)?	yes	yes	yes	no	no

Table 5: *A comparison of five low-cost microcomputers, including the Commodore VIC20.*

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HP Series 80 Personal Computers for Professionals: HP-85 ($3250*) and HP-83 ($2250*) specifications: 16K RAM expands to 32K, 32K ROM expands to 80K; CRT with integrated graphics; (HP-85 only; built-in thermal printer, cassette tape unit); Software includes VisiCalc™ PLUS, Information Management, Graphics Presentations, Surveying, Data Communications (Spring '81), Statistics, Regression Analysis, Math, Linear Programming, Waveform & Circuit Analysis, BASIC Training. HP peripherals include floppy discs, printers and plotters.

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text) keys is obvious when they have been used a few times.

The RESTORE key performs a valuable function in a computer where so many changes in character, background, and border color are possible. It resets the VIC to its state when it was turned on, except that it leaves the current program in memory (unlike some reset keys). Finally, the four large keys marked "f1/f2" through "f7/f8" have no predefined use but can be used by a programmer (through use of the GET statement) to produce a specific function within the program. By using the shift key, these four keys can trigger up to eight user-defined functions. These keys are also used in some application cartridges to execute predefined functions.

As I mentioned earlier, the VIC video display is well designed. The large letters are easy to read, even on an inexpensive color television, and the border around the active area of the display is restful to the eye. The narrow screen width (22 characters) will be a problem for some users, especially people using programs that need to display large amounts of data. Still, the screen width was a design decision reflecting the intended market, and I think that Commodore made a good decision under the circumstances.

Probably the most unexpected feature of the VIC is that it will be able to exchange both tape and disk files with the Commodore PET and CBM machines. Whether or not the program runs correctly on the other machines depends on whether it contains system-dependent code. For example, a CBM program using the full 80 columns of the CBM video display will not run correctly on the VIC, nor will a program larger than 32 K bytes. The ability to exchange data and programs among machines from the same manufacturer is almost unheard of. One good example of its usefulness is a situation where someone buys several VIC 20s to be used for data entry and feeds the results into a Commodore CBM computer.

I also found the screen-manipulation characters and POKE statements for music easy to use. By manipulating color, graphics, and sound without using any new BASIC keywords, Commodore has achieved two advantages. First, VIC programs are syntactically equivalent to PET programs. Programs can be transferred between machines without syntax errors due to unrecognized keywords; also, Commodore probably developed VIC BASIC faster and at less cost because of its similarity to PET BASIC. Second, VIC BASIC is easier to learn for people who know PET BASIC or another version of Microsoft BASIC.

An interesting thing about the VIC not apparent at first is the lightness of the unit. It literally has fewer components inside than you would expect. This is possible because it is built around a custom "video interface chip" built by MOS Technology for its parent company, Commodore. This integrated circuit handles all the interaction between the 6502 microprocessor (also manufactured by MOS Technology) and the color television (this function is done by a handful of integrated circuits in many other microcomputers). The low component count plus Commodore's ability to manufacture and assemble almost all of the VIC within its own factory account for the lighter weight and extremely low cost of the unit.

One final human-engineering feature of the VIC that will be appreciated by machine-language users and software developers shows Commodore's willingness to learn from hard-earned experience. The developers of VIC BASIC separated a kernel of I/O (input/output) subroutines from the rest of BASIC. They have written these routines as true subroutines and have devised a method for passing parameters to them so they can be used by anyone who wants to develop software for

At a Glance

Name
VIC 20

Manufacturer
Commodore Business Machines
950 Rittenhouse Rd
Norristown PA 19401
(215) 666-7950

Price
$299.95

Dimensions
40.3 by 20.4 by 7.2 cm (15.9 by 8 by 2.8 inches)

Processor name and type
6502, 8-bit

System clock frequency
slightly over 1 MHz

Memory
5 K bytes

Mass storage
cassette recorder or floppy disk optional

Other hardware features
character-size graphics symbols, keyboard, uppercase and lowercase letters, eight-color foreground and sixteen-color background video display, three-part music generator, external RF (radio-frequency) modulator and power supply, built-in serial port

Software included
16 K-byte VIC BASIC in ROM (read-only memory)

Hardware options
cassette recorder, floppy disk, dot-matrix printer, modem, IEEE-488 interface, joystick, light pen, game paddle, extra memory cartridges (up to a total of 32 K bytes), RS-232C adapter

Software options
VIC Programming Cartridge (includes programming utilities and machine-language monitor), VIC Super Expander Cartridge (adds 3 K bytes more memory, high-resolution graphics capability)

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minidisks

the VIC. In addition, all I/O routines called by BASIC are called indirectly through programmable-memory pointers holding the addresses of the true I/O routines; in this way, users can substitute their own I/O routines to be executed in place of those provided within the VIC.

These design decisions (which will be documented to interested parties by Commodore) do two things. First, they encourage the potential software developer to write software for the VIC by eliminating the need to write custom I/O routines. Second, they help isolate the structure of VIC BASIC from some machine-language code that may need to be changed; in this way, Commodore can prevent having several versions of VIC BASIC at some time in the future (a problem that plagued the PET and CBM machines).

Problems and Limitations

The VIC 20 is a very good machine, but it is not without some problems; fortunately, none of them are major.

The juxtaposition of several key pairs on the keyboard is unfortunate. First, the CLR/HOME key is next to the INST/DEL key; while inserting or deleting characters in a BASIC line, you may inadvertently clear the screen or return the cursor to the upper left corner of the screen. More annoying are the reversals of the colon and semicolon keys and the RETURN and RESTORE keys (see photo 1). Touch typists and keyboard users are used to finding these key pairs in different positions (eg: the RETURN key in the same row as the top row of letters). Since the VIC keyboard does not have the layout of previous Commodore machines, it is unfortunate that the keyboard was not laid out in a slightly different way.

Another problem has to do with the music voices. Once a music voice is turned on by the appropriate POKE statement, only poking that location to zero, turning off the sound on the television set, or turning off the computer will shut off the sound. Neither stopping the program that turned on the sound nor typing the keyword

END will stop it. (The Atari 400 has a similar problem, but typing END causes it to silence all sound generators.)

Another problem is shielding against RFI (radio-frequency interference). Although the Federal Communications Commission has passed a set of rules to eventually keep personal computers and similar devices from interfering with television and radio reception, most manufacturers have received extra time to modify their products. In the case of Commodore, only units manufactured after March 1981 must meet the new requirements. I have been told by Commodore that unshielded units will be marked as such. If you live in close proximity to other people, I recommend that you wait for a shielded unit. If you use an unshielded VIC, people nearby may not be able to use radios and televisions while the computer is on.

The most serious problem I found can be avoided with some forethought. The VIC tape recorder, once put into play or record mode, can be started and stopped by the computer. A potential problem occurs when you have just done a LOAD and are about to do a SAVE (to save, for example, a revised version of the program just loaded). When you did the LOAD, the VIC instructed you to press the play button to begin the loading process. When it finished loading the program, it stopped the tape-transport motor but left the play button depressed. If you then give the SAVE command, the VIC initiates the process, even though the record button has not been pressed. (If no recorder buttons are pressed when the SAVE command is given, the VIC instructs you to press both the play and record button, and the recording process occurs without error.) The RUN/STOP key will not abort the loading process, although pressing the RUN/STOP and RESTORE keys will. Still, there are two chances to lose the program: one, not realizing that the program is not being recorded; two, realizing it but turning the VIC off from not knowing that the SAVE command can be aborted and restarted.

One of the most important components of a consumer-oriented microcomputer is its documentation.

Documentation

One of the most important components of a consumer-oriented microcomputer is its documentation. Microcomputer documentation was neglected in the past because it was seen as being too expensive and time-consuming to justify the perceived benefits. Now, however, good documentation can make the difference between the average consumer using or ignoring the same machine. Microcomputer documentation has a heavy burden to carry because of the multiple functions it needs to perform. First, it must tell the user how to unpack the computer, get it running, and use it with prepackaged software. Second, it must guide the user carefully through the first sessions with the computer (because many people still have some uneasiness or fear of computers). Third, it must educate the user about microcomputers in general so its potential for use can be seen. Fourth, it must document the features of the microcomputer in a way that is both complete and easy to understand.

Commodore recognized the need for good documentation. Avalanche Inc (of Palo Alto, California) has been commissioned to produce several books about the VIC. The first, the *VIC User's Manual*, is supplied with the VIC and is a good introduction to the VIC and its features. Its style is informal, friendly, and respectful of the reader's intelligence, but it assumes no previous knowledge of computers. There are illustrated chapters on setting the VIC up and on using its graphics, color, and music. Each feature of the VIC is illustrated with several short programs (5 to 25 lines each), making it

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4401 So. Tamarac Parkway, Denver, CO 80237 (303) 741-1778 easy to begin learning about the computer. Most of the chapters do not rely on material from previous chapters, meaning that the reader can learn about the features in any order.

Avalanche has produced two more books, *Introduction to Computing ...On the VIC* and *Introduction to BASIC Programming...On the VIC.* Both books, part of the Commodore Learning Series, are available at extra cost. They are written in the same friendly style and cover the use of the VIC in greater depth. What makes these books so innovative is that each book is sold with a program cartridge containing longer example programs that are used in the book. This allows the reader to learn from longer programs without the drudgery of having to type them in.

Comparison to Other Computers

Table 5 gives a comparison of five low-cost, consumer-oriented microcomputers: the Atari 400, the Commodore VIC 20, the Ohio Scientific Challenger 1P, the Radio Shack TRS-80 Color, and the Sinclair ZX80. Although the VIC is a very good machine, some of the others have features that may make them the best choice for you. The Atari 400 has the most sophisticated design; it allows detailed video graphics (although they are more difficult to program) and is the logical choice of anyone wanting access to sophisticated arcade-like games. The TRS-80 Color Computer might be the best choice if you want the convenience of getting service and repairs from a Radio Shack store. In any case, the best computer for you depends on your needs and your budget.

Conclusions

- The final verdict on the Commodore VIC 20 is not in yet because of the large amount of hardware and software not yet commercially released. But if the rest of the product line is as good as the VIC 20 microcomputer is, the VIC computer system will be one of the strongest on the market.
- The VIC 20 computer unit is unexcelled as a low-cost, consumer-oriented computer. Even with some of its limitations (eg: screen size of 23 rows by 22 columns, maximum programmable memory of 32 K bytes), it makes an impressive showing against more expensive microcomputers like the Apple II, the Radio Shack TRS-80, and the Atari 800.
- The low cost of the VIC ($299.95) is made possible by a custom computer-to-video interface circuit that replaces several other integrated circuits and by Commodore's manufacturing most of the VIC at in-house factories in Japan.
- The VIC is well designed and easy for the novice to use. A large part of its suitability for first-time users is due to its excellent documentation and attention to human-engineering factors. The unit has some small design flaws, but they are minor. ■

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Steve Ciarcia
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Many of you grew up as I did, taking all your toys apart. In most cases, the wrapping was scarcely off a gift before a screwdriver was skillfully applied to pry it apart.

I haven't changed much over the years. I still take most of my gadgets apart. Five months ago, I bought the Milton-Bradley Big Trak toy tank for use in a project. Instantly, I had the screwdriver and pliers ready to do their job. I unpacked the Big Trak, installed the batteries, placed it on the floor, and pressed the Test button. The tank beeped a few times and executed a preprogrammed test sequence. Everything worked, so I began to disassemble it. The time from my unpacking the box to unscrewing the case wasn't more than a minute and a half.

I took Big Trak apart because I was interested in the motorized mechanism inside the vehicle. I found it an impressive engineering accomplishment that such sophisticated control could be provided with inexpensive motors. My previous experience led me to believe that only industrial-quality DC (direct-current) motors could be controlled so well. It seems that many things have changed since I was a kid: permanent-magnet DC motors aren't what they used to be.

Photo 1: *A PM (permanent-magnet) DC motor can also be used as a generator-type tachometer, or tachometer-generator. When the shaft is turned, a DC current proportional to the speed is produced. In the case shown, a small PM DC motor is secured in a vise, and the shaft is slowly turned (by the belt attached to the shaft and extending to the lower right). The digital voltmeter above the motor indicates the actual generator output voltage. In this case, the shaft is turning at about 150 rpm.*

DC motor *controls* are not the same, either. They are simpler, more accurate, and cheaper. Using DC motors has become relatively easy. It's no longer a black art.

I hope this article discussing the principles of DC motors will dispel your reluctance to experiment with them. First the basics, then some examples of motor use.

What Is a DC Motor?

The DC motor was invented by Michael Faraday early in the nineteenth century. He determined that when a current-carrying conductor is placed in a magnetic field, a force is applied to the conductor, causing it to move. Shown graphically in figure 1, the direction and magnitude of this force are functions of the conductor current and the direction of the magnetic field. Conversely, moving

a conductor through a magnetic field was found to induce a current in the conductor proportional both to the intensity of the field and the velocity of the conductor as it passes through the field.

Faraday found the best way to obtain useful work from this magnetic force. He assembled a rotating disk-shaped conductor within the magnetic field. The resultant force vectors caused the disk to spin. To attach current-carrying leads to the spinning conductor, he used sliding contacts.

These two discoveries became the basis of the DC motor and the DC generator. Eventually, the disk was replaced with many turns of wire placed in deep slots of a laminated iron rotor. This part is the *armature*. The externally applied magnetic field, the *stator field*, was produced by an electromagnet (or a permanent magnet) and the sliding contacts became carbon *brushes* and *commutators*.

The optimum DC-motor configuration has the most conductors in the magnetic field. Maximum force is developed at a right angle to the stator field. Between these positions, the resultant force is a function of the sine of the angles between the two fields. As the rotor turns, the magnetic field rotates with it unless some provision has been made to switch the direction of current flow in individual armature conductors so they maintain the maximum force vector.

This switching is done with a commutator, as shown in figure 2 on page 70. Current flows in through brush A and out through brush B. During clockwise rotation, the current in coils 3 and 6 will have reversed after one sixth of a revolution past the position shown. In fact, after every one sixth of a revolution, the current in two opposite armature conductors changes directions. As a result, the current-flow and field vectors in the armature occupy a fixed position in space independent of rotation of the coils. This provides steady, unidirectional torque.

Motor Classification

DC motors are often classified by the type of stator field used. Fractional-horsepower DC motors using electromagnets to generate the stator field are called "wound-field motors." There are three basic types: series field, shunt field, and compound field. A graphic comparison of speed, torque, and current of these three motors is given in figure 3 on page 72.

Series-field motors provide the greatest torque at start-up because the high initial armature current flows through the stator field as well. As the speed increases, the current decreases. This further increases the speed. If not for internal friction and coil-winding energy losses, this type of motor could theoretically run away under no-load conditions. This type of motor is best used where large starting torques are required, such as automotive propulsion. A schematic representation and speed/torque graph are shown in figure 3a.

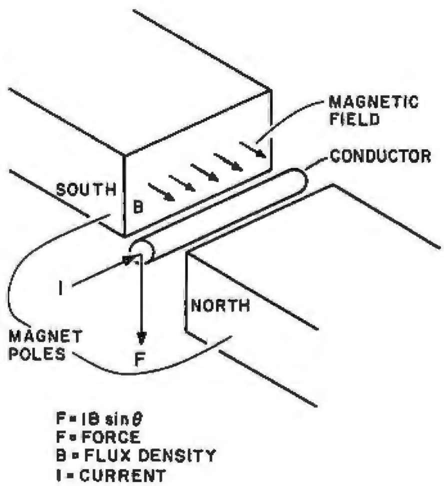


Figure 1: *Simplified diagram of the basic electromagnetic principles behind the DC motor. When a current-carrying conductor is placed in a magnetic field, the conductor feels a mechanical force, F, in the indicated direction, perpendicular to the current and the magnetic field. The force is greatest when the current is flowing perpendicular to the lines of flux ($\theta = 90°$), as shown here. The force is zero if current flows parallel to the lines of flux ($\theta = 0°$).*

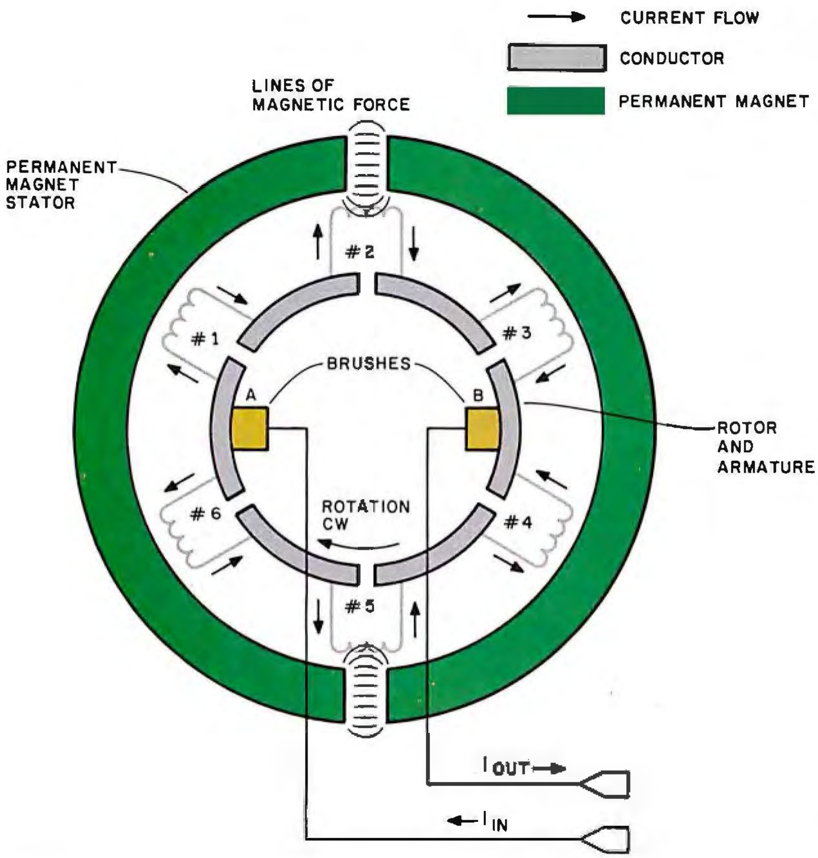


Figure 2: *Internal structure of a typical PM (permanent-magnet) DC motor. Brushes transfer current to the armature coils. As the armature rotates, the brushes contact the assembly at different points, reversing the direction of current flow in the appropriate coils to maintain the electromagnetic force and provide continuing torque.*

Shunt-field motors, shown in figure 3b, have the armature and field coils connected in parallel. The lower-current field winding, used only for creating a magnetic field and not required to carry the heavy armature current, makes this motor popular for fixed-speed applications. Except at start-up, the shunt-field motor has greater torque than the series-field motor for a given speed.

Compound-field motors have both series- and shunt (parallel)- field windings. These motors exhibit high starting torque and relatively flat function curves for speed/torque characteristics. While useful in providing rotation in one direction, this motor is difficult to reverse since connections to *both* windings must be reversed in polarity. Complex switching circuits are required for reversal control.

Permanent-Magnet Motors

In a PM (permanent-magnet) motor, the stator field is produced by a permanent magnet, not an electromagnet. The PM motor has a speed/torque curve that is linear over an extended range, as shown in figure 3d.

The obvious advantage of using a permanent magnet is that it requires no electrical power to generate the stator field. Because the actual electrical-to-mechanical energy conversion takes place in the armature, the major part of the power supplied to the electromagnetic field coil in a wound-field motor is lost as heat. The PM motor requires less power and less cooling.

The PM motor is not new. It has been around for many years and was used in your childhood toys. However, high-power PM motors were very expensive and rarely found in the home. Only recently has the in-

corporation of new ceramic magnet materials made the PM motor practical for low-cost/high-power applications. Previously, most PM motors used *alnico*-alloy magnets, which are susceptible to demagnetization.

The magnet material in all PM motors is magnetized during manufacture by placing it into a strong electromagnetic field. If, later on, the motor is not carefully regulated while in use, high armature currents can produce fields exceeding the original magnetization flux. Consequently, this can demagnetize the stator magnet.

The current at which this phenomenon occurs is approximately seven or eight times the stated normal operating current of the motor. A PM motor with a 3 A current rating would have problems at currents exceeding 24 A. While such values seem

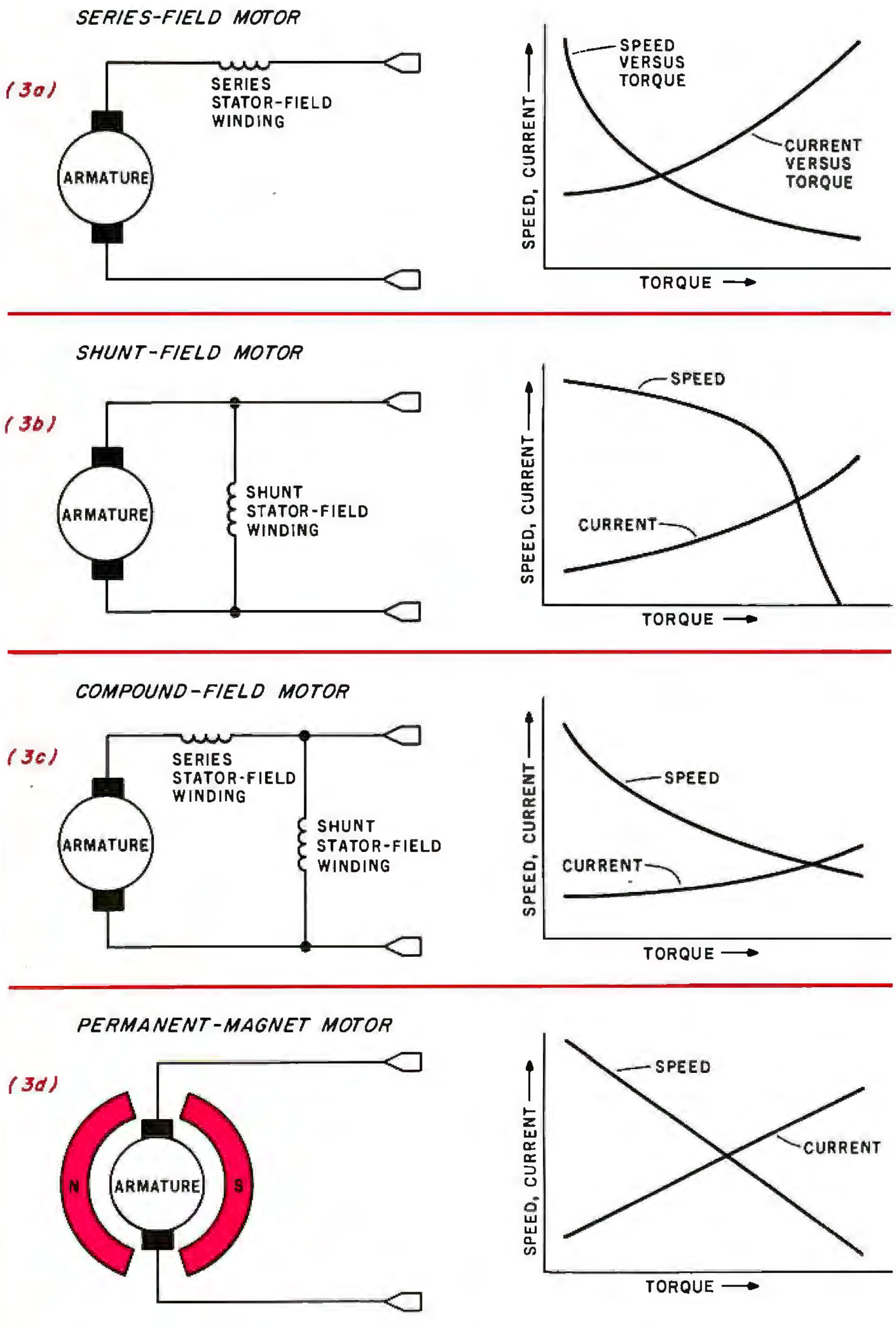
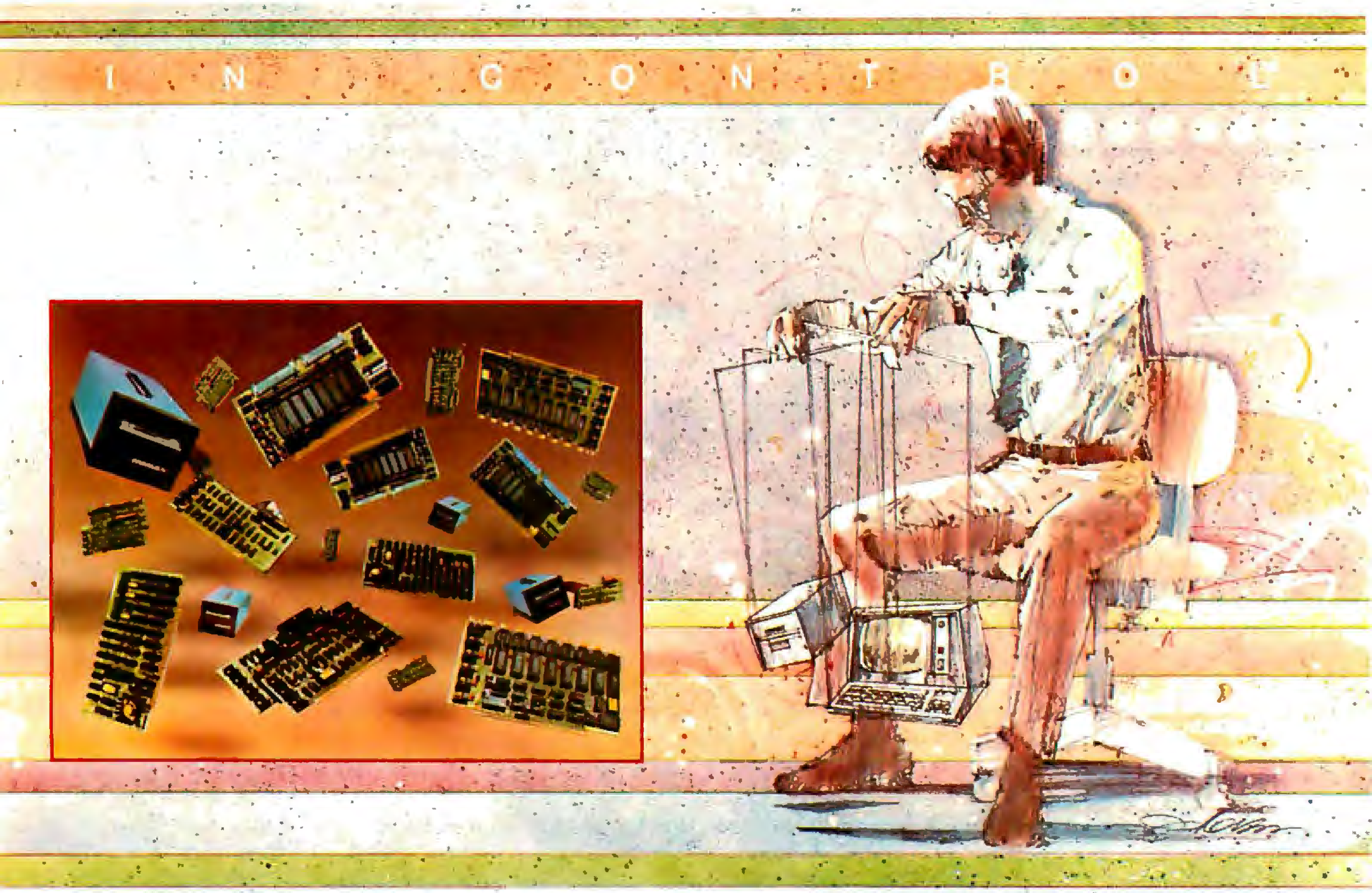


Figure 3: *Different types of DC motors are distinguished by the type of stator field. Three types use an electromagnet to produce the stator field; the fourth uses a permanent magnet. Different methods of connecting windings in the stator electromagnet produce different speed/torque and current/torque function curves.*



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unlikely in normal use, very high currents are often incurred in low-speed, high-torque, pulsed operation. The greatest risk occurs during a high-torque, high-speed, rapid-reverse situation. The sum of the applied voltage and counter EMF (electromotive force) of the motor at the instant of reversal can create excessive current due to relatively low armature resistances. This article primarily covers low-speed PM-motor applications, so this shouldn't be a problem.

Speed Control in PM Motors

Controlling the speed of a PM motor is much easier than controlling a wound-field motor because the speed/torque characteristics are linear. If you apply a fixed voltage to a PM motor, it rotates at a fixed speed. Double the voltage or reduce the torque (load) requirement by half, and the speed increases by a linearly proportional amount.

Therefore, the least complicated speed control is one which adjusts the voltage applied to the armature. This can be physically accomplished using a rheostat, an autotransformer and rectifier, or a linear transistor-amplifier circuit (such as the one shown in figure 4). The objective is to apply a relatively constant current to the armature.

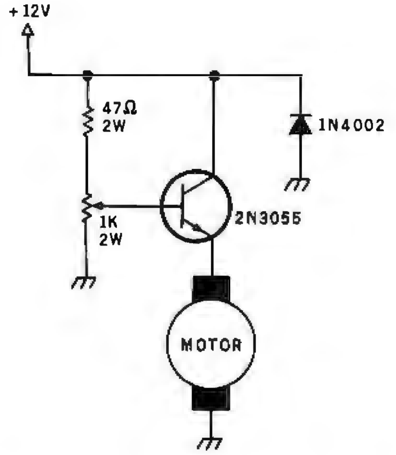

Figure 4: *A simple open-loop linear motor-speed control. Operating the controlling transistor in the linear region of its characteristic curve leads to loss of energy as heat.*

In the case of the linear amplifier, however, considerable power is wasted as heat loss when the control component (here, a transistor) is not fully turned on (saturated). The worst case occurs when high torque is required at low speed. This condition can be overcome by *pulsing* the power to the armature through an on/off switch or a switching amplifier. The resulting average current creates the same effect as the linear amplifier without the power-dissipation problems.

There are three basic types of switching amplifiers used in PM-motor controls: PWM (pulse-width modulation), PFM (pulse-frequency modulation), and SCR (silicon-controlled-rectifier) pulse-width modulation. Essential characteristics of these three forms are shown in figure 5 on page 76.

The *pulse-width-modulated* controller works by switching the full voltage of the DC power supply to the motor on and off at a fixed frequency with a varying duty cycle. At low speeds, the duty cycle is short,

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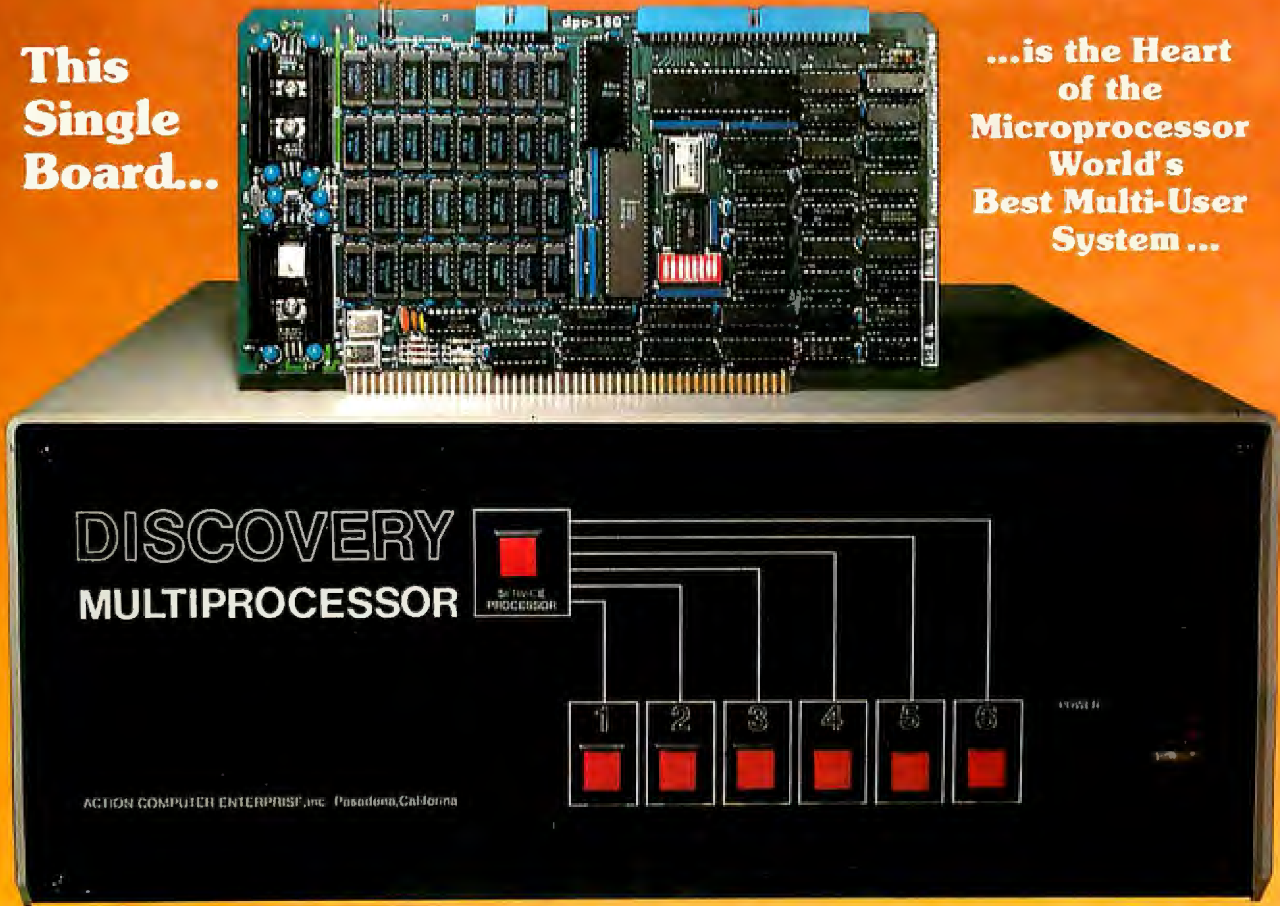

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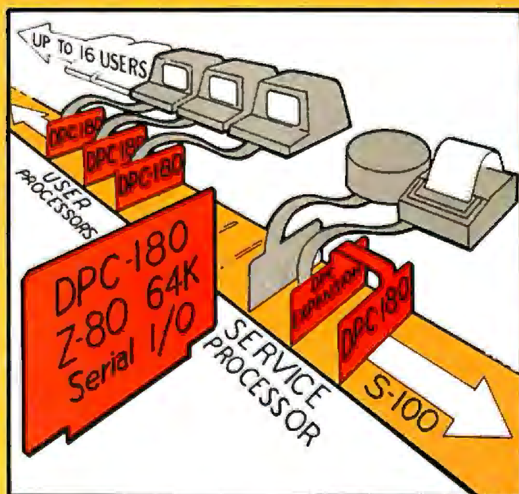

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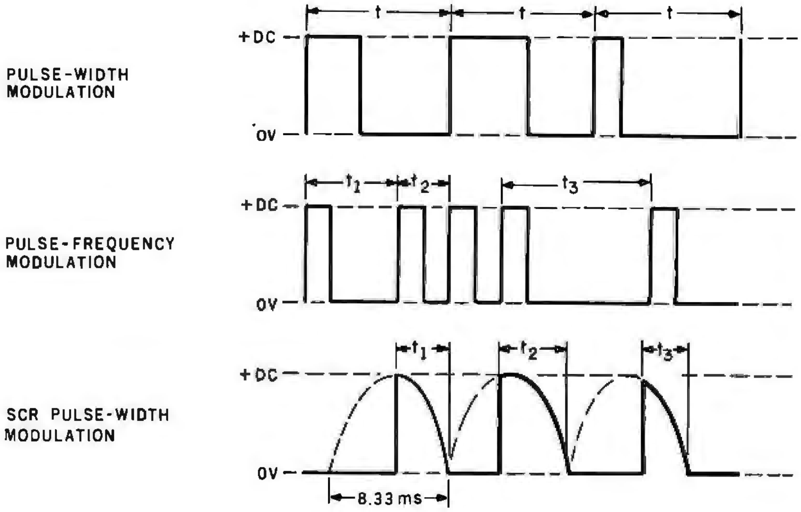

Figure 5: *Comparison of three basic switching-amplifier control-circuit output waveforms. The controlling semiconductors are saturated; the average amount of electrical current transferred to the motor is limited by rapidly cutting the current off and on.*

and the average voltage applied to the armature is low. At high speeds, the duty cycle is much longer, and the average voltage is increased.

The *pulse-frequency-modulated* controller, on the other hand, switches the DC supply on for a fixed period of time at a varying repetition rate. At slow speeds, the switching frequency is low, and the resulting average applied voltage is low. At higher speeds, the pulse width of the applied power is the same, but the switching frequency is increased to raise the average voltage level.

Figures 6 and 7 on page 78 illustrate simple circuits allowing you to experiment with PWM and PFM speed controls. The components and frequencies in the schematics are selected for high-current DC motors such as those found in electric drills. (For use on high-speed/low-torque hobby motors, the frequencies and pulse widths may require adjustment.) In figure 6, 10 to 100% PWM speed control is accomplished by adjusting the duty cycle of a one-shot (monostable multivibrator) triggered from a fixed 100 Hz frequency source. In figure 7, PFM speed control is obtained by varying the frequency of 1 ms pulses applied to the motor.

The third method, using an SCR as the switching element, is a variation on PWM. *SCR speed control* is nearly always used at the power-line frequency (50 or 60 Hz). It functions by changing the firing angle (ie: the point in the waveform where conduction is triggered) between 0 and 180 degrees and applying a specific fraction of each voltage waveform to the motor. At low speeds, the firing time is short, resulting in a low average voltage applied to the motor. At high speeds, the firing time becomes longer, resulting in a higher average voltage.

The SCR controller does not have the precise control resolution of the linear amplifier, but its major advantages are high power-conversion efficiency in the switching mode and low forward-voltage drop. The predominant use of SCRs in fractional-horsepower DC-motor controls is primarily due to the simplicity of the circuitry. A typical wide-range SCR speed-control circuit is shown in schematic form in figure 8 on page 80. Figure 9 illustrates a speed-control circuit which maintains constant speed under varying load conditions.

Closed-Loop Speed Control

The speed-control designs presented so far have been open-loop controllers. They are adequate for setting speeds where torque requirements are constant. For applications where there is a variation in load demand or where constant velocity is required, a closed-loop control system must be

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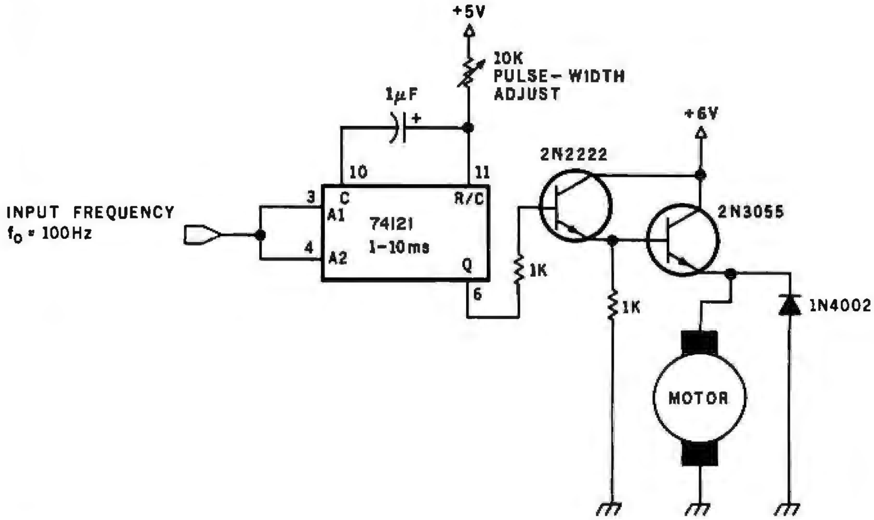

Figure 6: *A simple PWM (pulse-width-modulated) motor-speed control. The duty cycle of the monostable multivibrator (74121) is adjusted by the variable resistor to change the average integrated (in the mathematical sense) electrical current supplied to the motor through the driving transistors. Pin 14 of the 74121 should be connected to +5 V, while pin 7 should be connected to ground. The 2N3055 transistor must be mounted on a heat sink.*

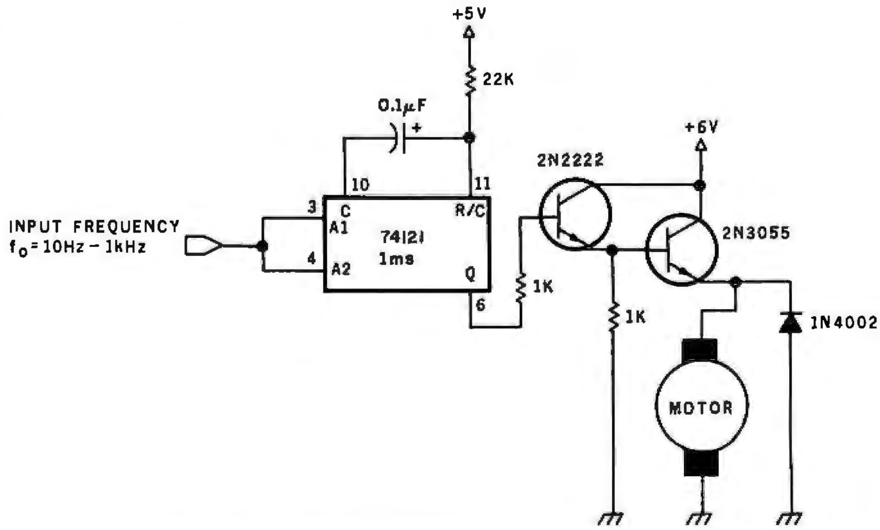

Figure 7: *A simple PFM (pulse-frequency-modulated) motor-speed control. The number of constant-duration pulses supplied to the driving transistors over a given interval controls the speed.*

employed.

Figure 10a on page 84 shows an open-loop controller; figure 10b shows a closed-loop system. Both controllers use an amplification device to drive the motor. The amplifier block can be broadly interpreted to represent any of the driving methods discussed (PWM, linear amplifier, etc). In the open-loop controller, any variation in load demand causes the motor to speed up or slow down.

The basic difference between the open- and closed-loop control methods is that the latter uses a sensor attached to the motor shaft to monitor the actual motor speed. The sensor provides a feedback signal proportional to the shaft's speed. This can be compared with the desired value of the signal (the set point) to find out if the motor is running fast or slow. If the speed is too low, the comparator applies more voltage to the amplifier to bring the speed up. When

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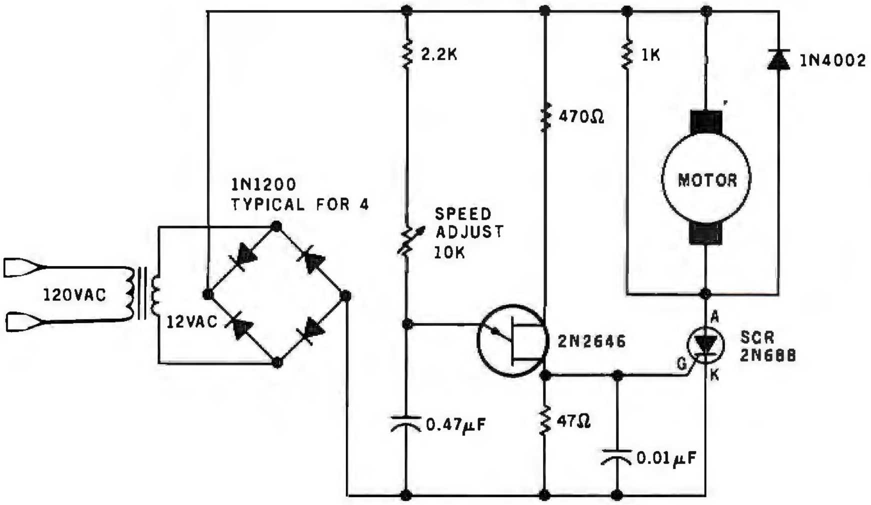

Figure 8: *An SCR- (silicon-controlled rectifier) controlled motor-speed circuit. This method, a variation of PWM (pulse-width modulation), has a wide speed range, high power-conversion efficiency, and low forward-voltage drop across the controlling semiconductor, but not the precise control resolution of a linear-amplifier circuit.*

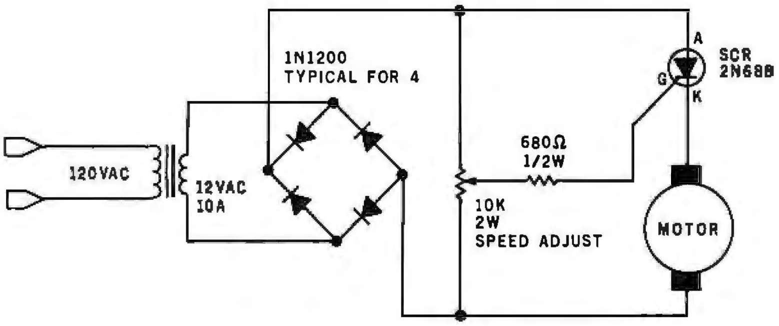

Figure 9: *A second type of SCR-controlled motor-speed control. This design has a limited speed range but maintains constant speed under varying load conditions.*

the speed sensor indicates the speed is too high, the comparator reduces the current to the motor, and the speed drops.

The speed sensor is generally a DC generator. This is nothing more than another PM motor operated in reverse. When the armature is turned, its coils cut through the PM stator-field lines, inducing a current in the armature windings. A motor with a rating of 500 rpm per volt, when used as a generator, produces an output of approximately 4 V if the armature is rotated at 2000 rpm. Such generator-type tachometers (or tachometer-generators) are useful for medium- and high-speed applications when they have a reasonably detectable and steady output. Photo 1 shows a PM motor being used as a generator.

At low speeds, an *incremental encoder* is often used instead of the generator-type tachometer. An incremental encoder generates a pulse when the shaft has rotated through a given angular increment. They are most suitable in low-speed and position-mode controllers. Photo 2 on page 81 shows a simple incremental encoder. More on this later.

Servo Controls

So far, we have discussed open- and closed-loop speed controls. We can turn a potentiometer and set a speed of 2000 rpm on a PWM-controlled motor. We can even attach a tachometer to regulate the speed at this set point. All these controls, however, are scalar and unidirectional. When the speed control is adjusted, we are setting a fixed number of revolutions per minute, rather than attempting to rotate the motor shaft to a particular position or to have it make ten revolutions and stop.

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Operating in Quadrants

The torque/current and torque/speed function curves of figures 3a, 3b, 3c, and 3d on page 72 all lie in the first quadrant of a Cartesian coordinate system. In these graphs, torque and speed are considered positive when the motor's shaft is rotating in the forward direction, and current is positive or negative according to its direction of flow.

During most modes of operation, the curves remain in the first quadrant; only when sudden stopping and reversing take place do the curves enter other quadrants.

For instance, in dynamic braking, the inputs to the armature coils are shorted together. As the motor continues to rotate, the existing magnetic field induces in the coils a counter electromotive force that attempts to produce a field opposing the existing field. The opposition of the two fields produces negative torque and surprisingly fast braking action. The current of this counter electromotive force is negative, and the torque/current function curve momentarily moves into the third quadrant.

providing positive- and negative-output voltages for four-quadrant operation in conjunction with feedback control are discussed, we are no longer talking about mere speed controls, but about *servo systems.* Servo systems are usually configured to provide velocity, position, or torque control, or combined velocity/position control. The definition encompasses all DC-motor applications beyond first-quadrant fixed-speed operation (see the text box above).

The simplest type of servo operation is a forward/reverse motor control. Reversing the rotation on a PM DC motor is accomplished by reversing the polarity of the applied voltage. While this can be done manually by using a switch, in automatic-control systems it is most frequently done with transistors. Two typical circuits are illustrated as schematic diagrams in figures 11a and 11b on page 86. In figure 11a, a forward-control signal turns on transistors Q1 and Q4, routing the current through the motor as shown. A

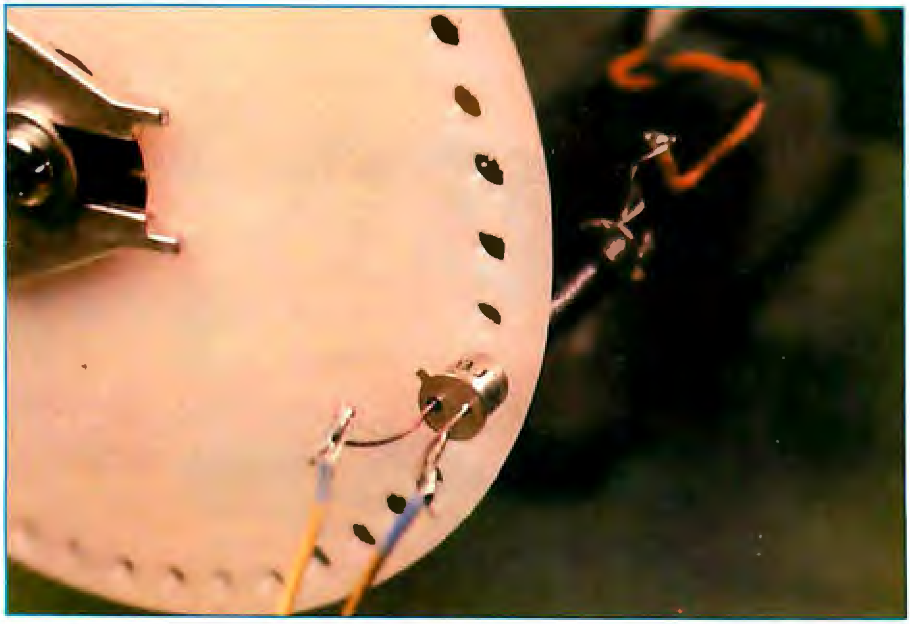

Photo 2: *The most frequently used nongenerator speed-feedback device is the incremental encoder. This is a homemade encoder, consisting of a plastic disk attached to the motor shaft. Around the perimeter of the disk are slots or holes. A light source is placed on one side; a light sensor on the other side. As the shaft turns, the disk interrupts the light seen by the photo sensor and creates a pulsed output with a pulse rate proportional to the speed of the rotation.*

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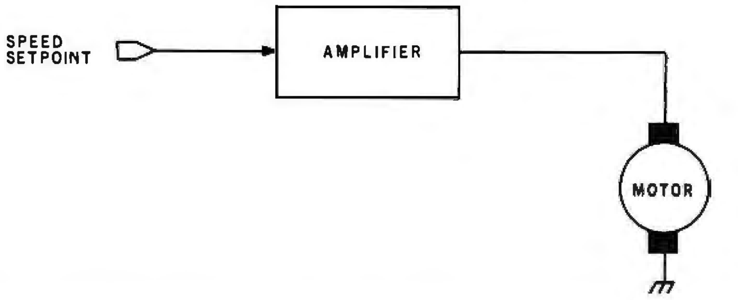

Figure 10a: *Block diagram of an open-loop controller. Variations in mechanical load cause the motor to speed up or slow down.*

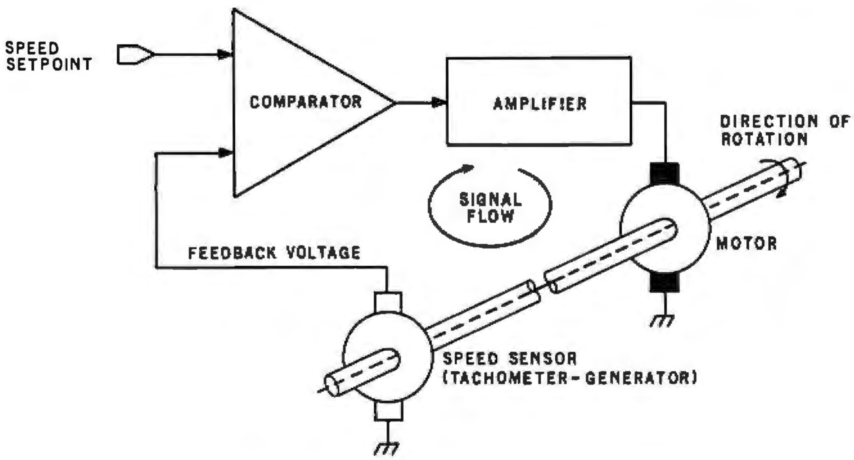

Figure 10b: *Block diagram of a closed-loop controller. The speed sensor detects too-fast or too-slow motion and keeps the motor running without variation in speed over wide variations in load.*

reverse-control signal enables transistors Q2 and Q3 to route the current through the motor in the opposite direction. This circuit, frequently called a *bridge output*, uses only a single DC supply voltage and is generally reserved for use in PWM or PFM controllers. Figure 11b shows a complementary output driver. It is more suitable for linear-control operation, and it requires two opposite-polarity power-supply voltages.

Incremental-Motion Systems

Usually, we don't think of performing positional control with DC motors. Most of our experience has been with 7000 rpm, 3 V PM motors salvaged from toys. However, using special DC motors, it is possible to perform repeatable intermittent or incremental motion. These are the motors generally used in computer-peripheral magnetic-tape transports and line-feed mechanisms. In these, it is frequently necessary to run the motor at fast speeds to achieve high media-slew rates, as well as slow incremental motion. (Stepper motors generally cannot attain the high speeds required.)

The incremental drive is basically a high-performance velocity-controlled

Special DC motors are used in computer peripheral devices where widely varying speeds are needed.

DC-servo system. The incremental motion is obtained by applying variable-amplitude voltage pulses to the input and accelerating the armature for predetermined periods of time. Figure 12 on page 88 shows the control waveforms.

With the system initially at rest, a high positive step voltage, t_1, is applied to the input. This causes the motor to accelerate almost instantaneously. Shortly thereafter, the voltage is reduced to a level, t_2, maintaining constant rotational speed. Some time later, the shaft rotation is stopped by applying a reverse-polarity input, t_3. Attempting to accelerate in the opposite direction causes the motor to brake. The exact timing of these pulses depends upon the specific motor and torque requirements.

The entire process takes only a few milliseconds and may move the armature a fraction of a revolution. This incremental motion is repeatable, enabling practical application. If, for example, it is applied at 100 steps per second while using an incremental encoder for speed control, the motion will appear to be produced by a high-torque stepper motor.

Build a Motorized Platform

Experimenting with incremental-motion controls on permanent-magnet DC motors is not as difficult as you might imagine. Once you discover the capabilities, you may find yourself experimenting with different mechanisms, as I have.

The cheapest high-power low-voltage PM DC motor I found was the one in a hand-held battery-operated drill. The motor I used was from a Black & Decker Model 9001 $^1/_4$-inch cordless drill. This same motor is probably used in a variety of other tools and appliances, possibly hedge trimmers and the like.

The basic unit consists of a power pack (containing a 4.8 V rechargeable nickel-cadmium battery and a charger) and the motor/drill-chuck assembly. The motor/chuck assembly contains the PM motor, reduction gears, and drill chuck.

A major stumbling block in building a transport mechanism that might be used in a robot has been the expense of the motors and gears. In lightweight assemblies, designers often incorporate stepper motors because they are easily controlled and their motion is repeatable. In larger and heavier vehicles, use of stepper motors becomes prohibitively expensive, and alternative drive mechanisms are required.

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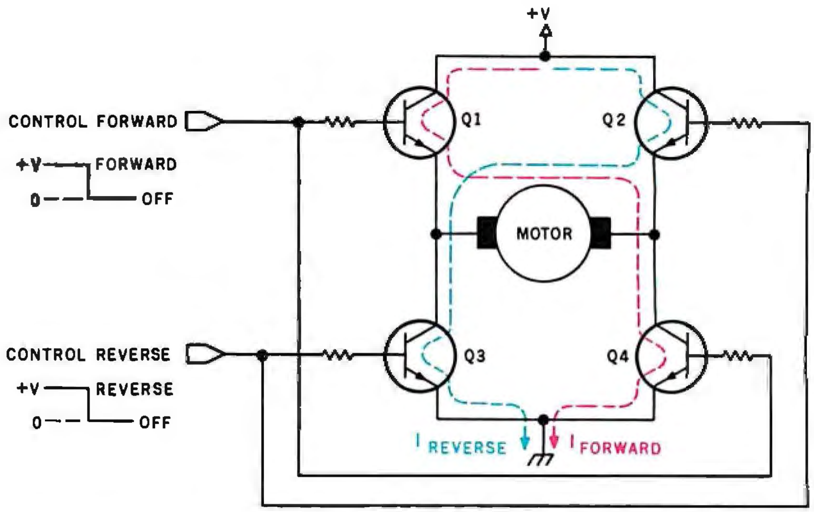

Figure 11a: *One of two basic reversing motor-control circuits. This bridge-type switch uses a single DC supply voltage and is used mostly in PWM or PFM controllers.*

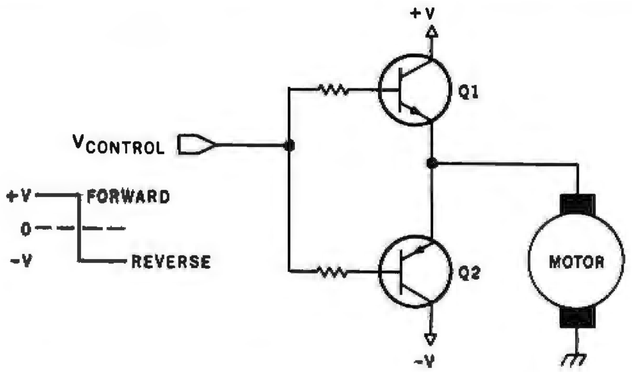

Figure 11b: *A complementary-type reversing circuit. It is more suitable for linear-amplifier control operation, while requiring two opposite-polarity power-supply voltages.*

While I did not intend to build a 300-pound "Son of Robbie," I wanted to experiment with some form of remote-controlled transport. Since the drills contained gear-reduced, low-voltage/high-torque motors and a chuck to attach an axle, it was natural to consider their use. The only problem I envisioned was reducing the nominal 750 rpm motor speed to a fairly constant value around 60 rpm. An incremental-motion controller was the answer.

The result of my experimentation is the motorized platform shown in photos 3, 4, and 5 on pages 90 and 92. A sketch of the major parts is shown in figure 13 on page 88. The platform consists of a T-shaped metal frame with a drive motor on each "arm" and a swivel wheel on the "leg." I designed it in a T shape so the drive motors could provide steering control, as well as forward/backward motion. In a conventional four-wheeled vehicle, this can be accomplished only by turning the axis of two wheels in the direction of the turn. This could not be accommodated in the present mechanism.

With the T shape, steering is like simple rotation. For forward motion, both motors rotate clockwise; for reverse motion, both motors turn counterclockwise. Turns are accomplished by driving the motors in opposite directions. For a right turn, motor A goes clockwise and motor B goes counterclockwise. A left turn, or left rotation, occurs with the opposite settings. The effect is that it rotates in place. Usually, reversing the polarity to the motors is handled through transistor switches, but I found that the voltage drop through the switch-

Text continued on page 90


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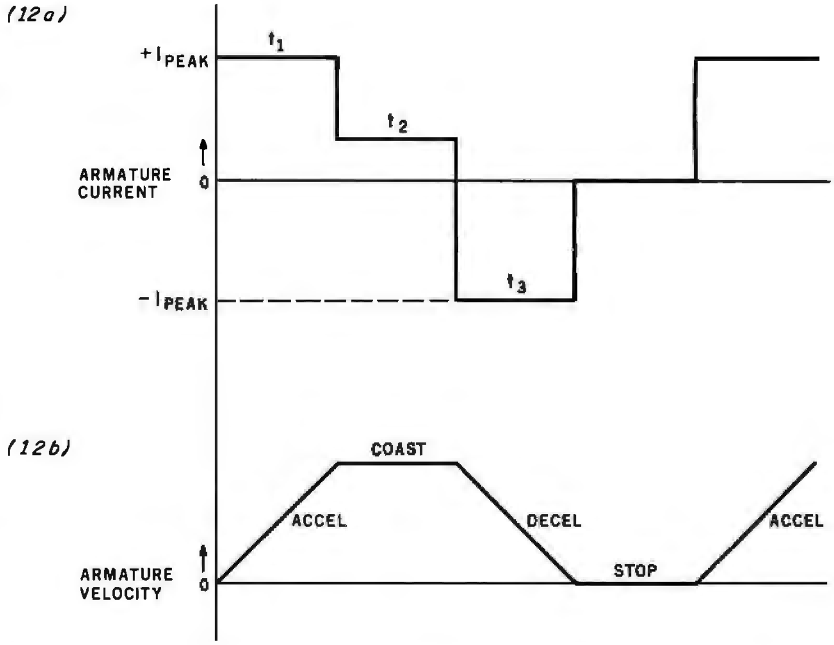
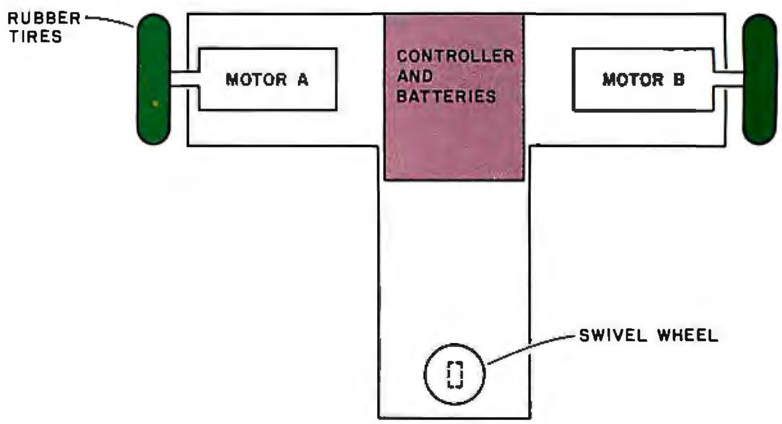
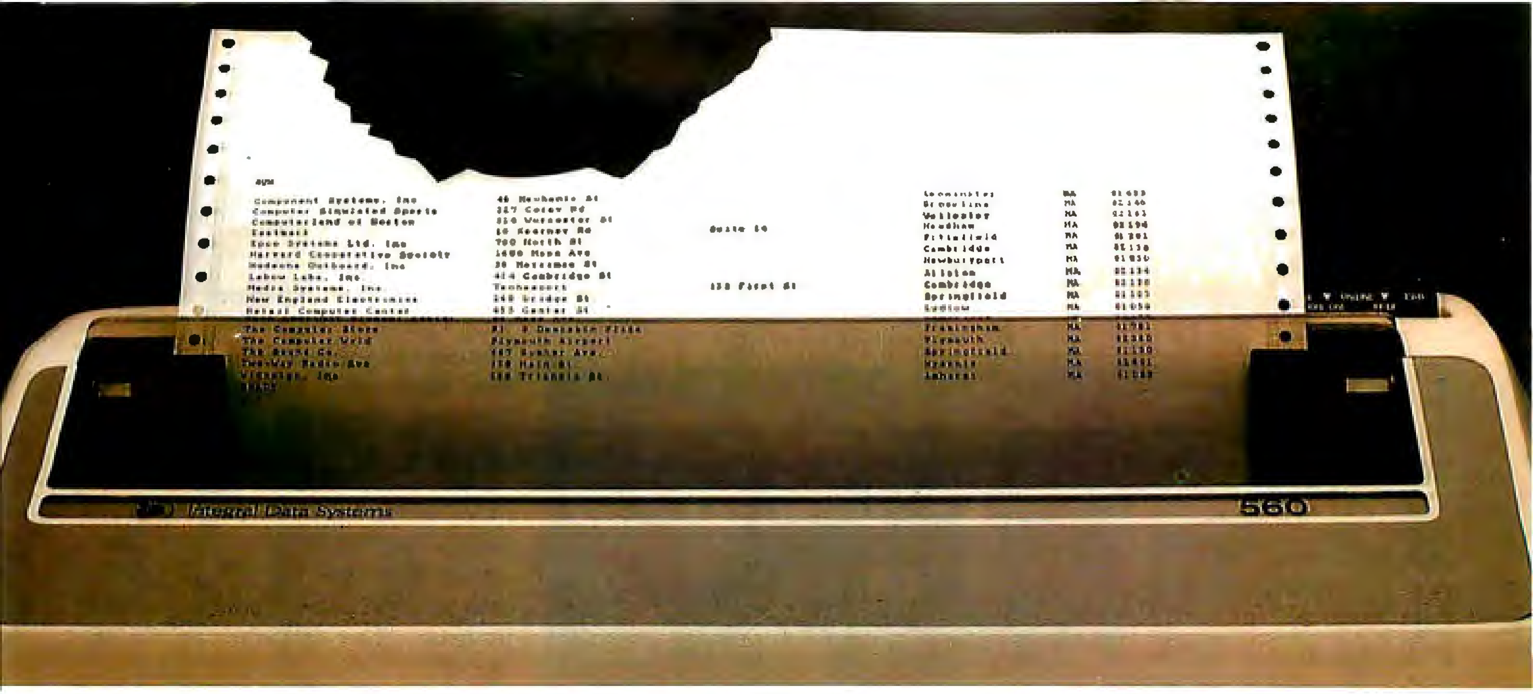


Figure 12: *Precise control can be achieved using incremental-motion controllers. During predetermined periods of time, variable-amplitude voltage pulses are applied to the motor's coils. With the system initially at rest, a high positive step voltage, t_1, is applied to the motor. After motion has begun, the voltage is reduced to a lower continuing value, t_2. When the motor is to be stopped, a negative braking voltage, t_3, is applied.*



	DIRECTION OF ROTATION	
FUNCTION	*MOTOR A*	*MOTOR B*
FORWARD	CW	CW
RIGHT TURN	CW	CCW
LEFT TURN	CCW	CW
BACKWARD	CCW	CCW

Figure 13: *Arrangement of components of the motorized platform. Steering is done in the simplest case by rotation. Both motors turn in the same direction for straight motion, whereas for a turn, one motor turns CW (clockwise) and the other turns CCW (counterclockwise).*



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Text continued from page 86:
ing network was too much in this low-voltage system. Instead, I used relays to switch polarities and enable motion.

The greatest design obstacle was the actual velocity-control system. Even though the drills contained gears, the no-load speed was 750 rpm. With a wheel and axle inserted into the chuck, the platform's uncontrolled speed with no load was 10 feet per second. About 9 inches per second, corresponding to 60 rpm, seemed considerably more manageable.

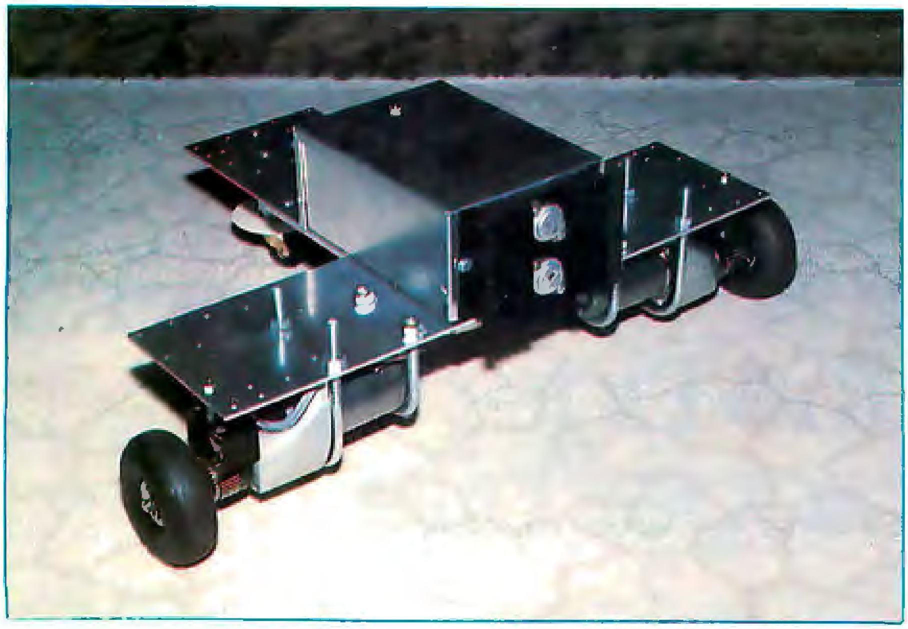

Photo 3: *A simple application of the DC motor controls presented in this article is to build a small mobile motorized platform. This one uses two battery-operated drill motors and a swiveling furniture caster. The T-shaped structure has complete mobility and can turn and pivot, as well as follow a straight line. The large box in the center of the platform contains the two motor controllers, relays, and batteries.*

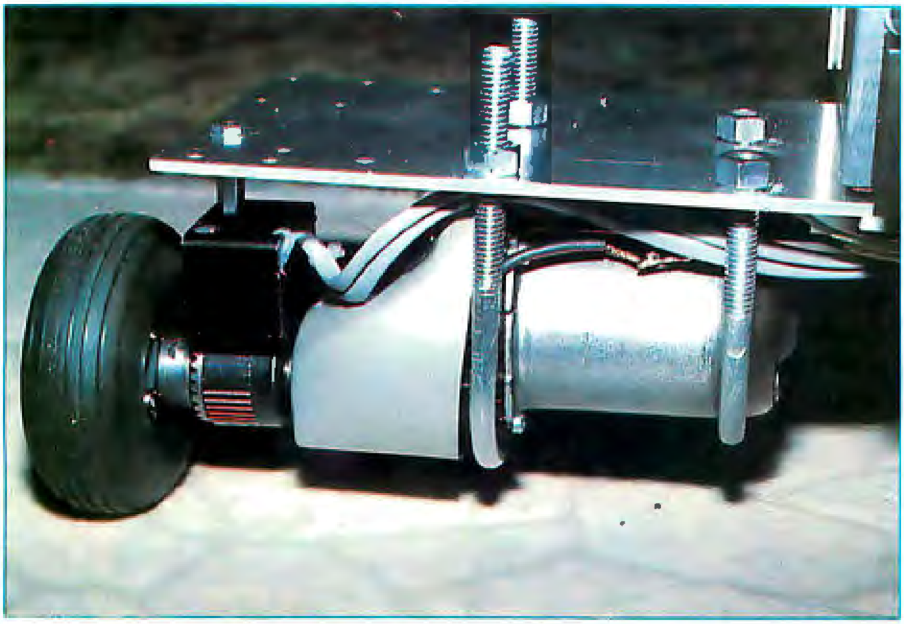

Photo 4: *Close-up of a drive motor on the platform. The motor is from a 4.8 V Black & Decker battery-operated ¼-inch drill. The drill's case and battery pack have been removed. It is secured to the aluminum T-frame with two U bolts. A ⁵⁄₃₂-inch brass rod that serves as an axle is inserted into each drill chuck. The tires are air-filled 3¼-inch diameter rubber tires used on model airplanes.*

To attain this lower speed, an incremental-motion/PWM controller was designed. One controller is required for each motor. The schematic diagram is shown in figure 14 on page 96. Component values were experimentally determined for use with the Black & Decker PM motor specified. Other PM motors may not operate in exactly the same manner.

Basically, the circuit is a closed-loop controller, consisting of a comparator, driver amplifier, and speed-feedback sensor. The desired speed is selected through a ten-turn potentiometer. The set-point voltage so derived is compared to an integrated feedback voltage from an optical incremental encoder. If the speed is too slow, the pulses out of the comparator are made longer. If the speed is too fast, the pulses are cut shorter. A negative voltage applied to the driver input between pulses assures complete turnoff.

The low pulse-frequency rate required to keep the speed at or below 60 rpm results in an incremental-motion condition. The start pulse is at the full DC supply voltage, creating a high-velocity start-up. A reverse-step pulse is not necessary to stop the motor, however, due to the high mechanical load presented to the motor through the gears. They serve to immediately dampen any coasting. The result is smooth, low-speed rotation, in rapid discrete increments, at a predictable constant velocity.

Maintaining constant motor speed is imperative when the motors must run synchronously for forward and backward motion. Turns are not as critical, but you realize what happens when one motor runs faster than another.

The 60 rpm speed is too slow to use a tachometer-generator without considerable complication. Instead, an incremental encoder (shown in photo 6) generates pulses as the wheels turn. Ordinarily, I would have used a slotted or perforated disk interrupting a light beam, but it wouldn't fit in the space available. Instead, I wrapped reflective aluminized tape with black stripes parallel to the axis of rotation around the chuck. An LED (light-

emitting diode) and phototransistor sense the light and dark areas of the tape as the shaft rotates. The greater the number of divisions or stripes per inch, the greater the resolution of the feedback system. While I was able to set the same speed on both motors, more encoder divisions would have been better.

Ideas for Computer Control

This article wouldn't be complete unless I described how my motorized platform can be remotely controlled from the computer. Essentially, it requires three signals controlling one power-on/off relay and two forward/reverse relays (10 A contacts).

Text continued on page 98

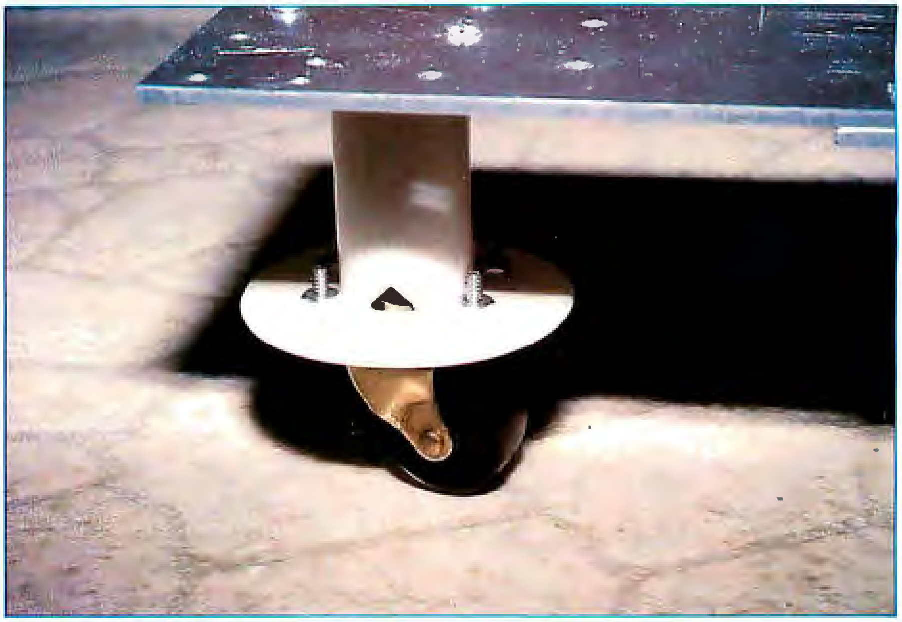

Photo 5: *The rear of the T-frame is supported on a furniture caster. This is a simple scheme allowing motion in any direction.*

Photo 6: *It was nearly impossible to fit the incremental-encoder disk of photo 2 between the motor and the wheel. Instead, a piece of reflective aluminized tape with black stripes was wrapped around the drill chuck. An infrared LED (light-emitting diode) and phototransistor are aimed at the tape so the light is reflected to the sensor. As the shaft turns, the light is interrupted much the same as the disk version.*

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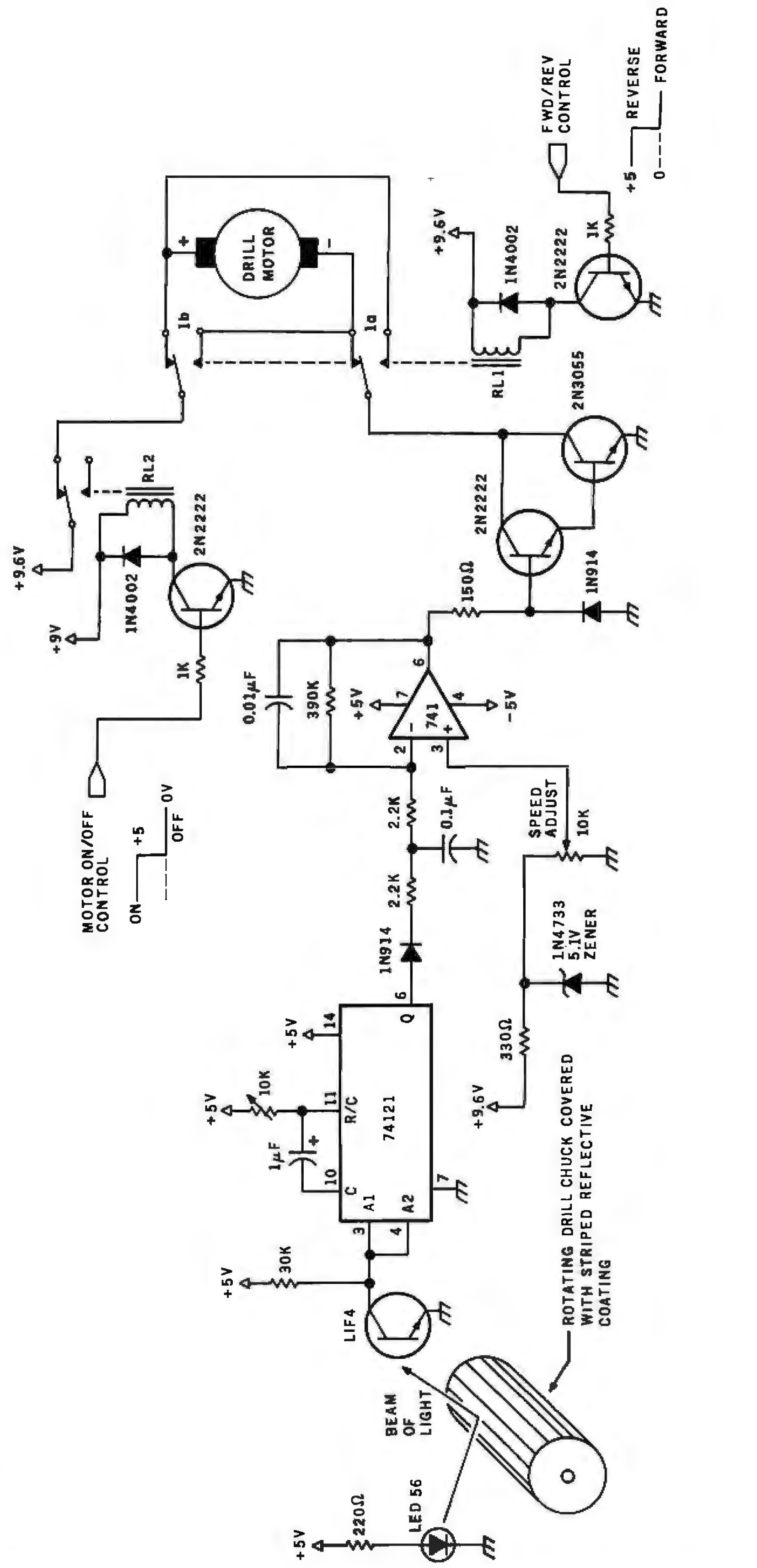

Figure 14: *The motor-control system of the platform, featuring incremental-motion control and reversing capability. Two such circuits were used, one for each motor. Values of the components were experimentally chosen for use with the motor from a Black & Decker Model 9001 portable drill. The 2N3055 transistor must be mounted on a heat sink. The L1F4 phototransistor is made by General Electric.*

Text continued from page 92:
The forward/reverse relays set the intended motor directions, and the power-on/off relay starts both motors. As long as the power is on, the platform goes in the direction set by the two forward/reverse relays.

Computer direction of the relays is accomplished with 3 control-signal bits from a parallel output port. For wireless remote-control operation, the communication control link presented in my article "A Computer-Controlled Tank" (BYTE, February 1981, page 44) can easily be adapted to this task.

In Conclusion

You may never see my contraption again. I don't consider this the start of a serious robot-building project. The total expense for the platform was under $50. It was just an experiment. I had always wanted to try using inexpensive electric-drill motors as servos. While I had mixed success, it did serve as a vehicle for a general article on DC-motor control.

Building the platform was the only way to truly test the theory. I was surprised that the final unit, weighing 10 pounds, had no problems with insufficient driving torque (unfortunately, the small batteries lasted only about 5 minutes in constant use). Even with an additional 5 pounds of payload (a bottle of Hennessy cognac and two heavy BYTEs), it worked well.

I don't expect many of you will try to build a motorized platform. I do, however, anticipate that more of you will consider using permanent-magnet DC motors for future designs where you thought only stepper motors could be used. If you already own a battery-operated drill, connect it to the control circuit of figure 6 or figure 9. You will be surprised at the capabilities it demonstrates.

Next Month:

Add a speech-synthesizer circuit-board assembly to your computer. ■

Editor's Note: *Steve often refers to previous Circuit Cellar articles as reference material for the articles he presents each month. These articles are available in reprint books from BYTE Books, 70 Main St, Peterborough NH 03458.* Ciarcia's Circuit Cellar *covers articles appearing in BYTE from September 1977 thru November 1978.* Ciarcia's Circuit Cellar, Volume II *presents articles from December 1978 thru June 1980.*

Many Circuit Cellar projects are available as kits. To receive a complete list, circle 100 on the Reader Service card.

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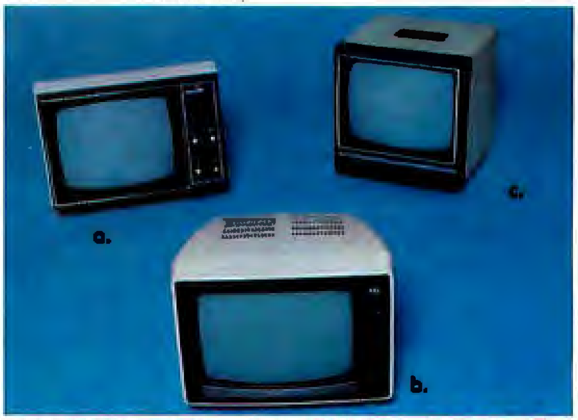

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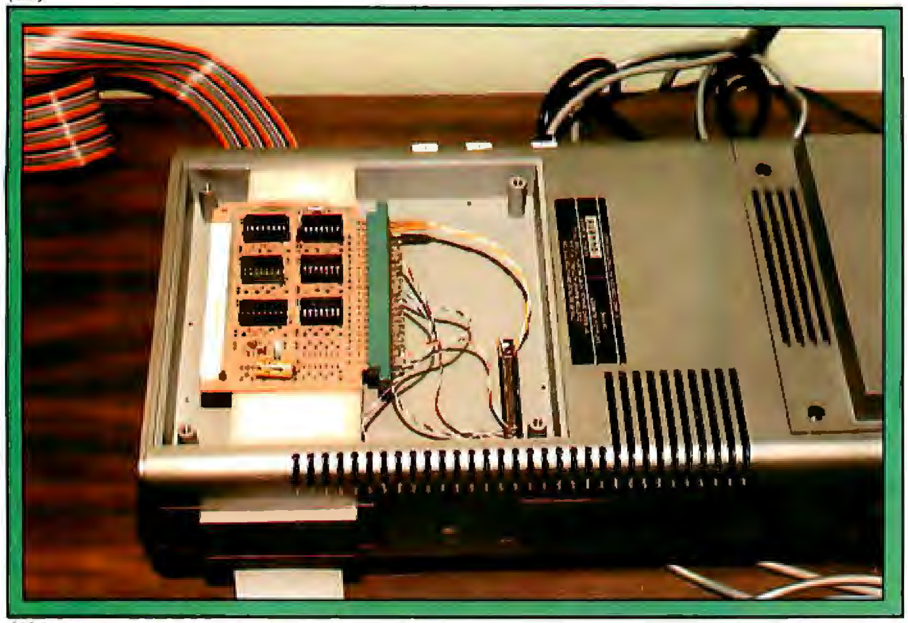


(1b)

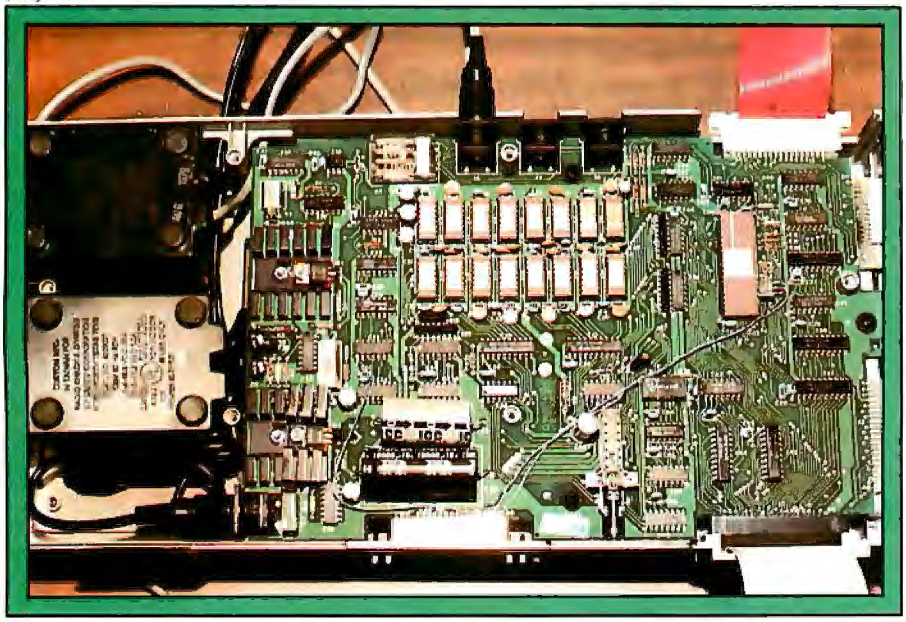


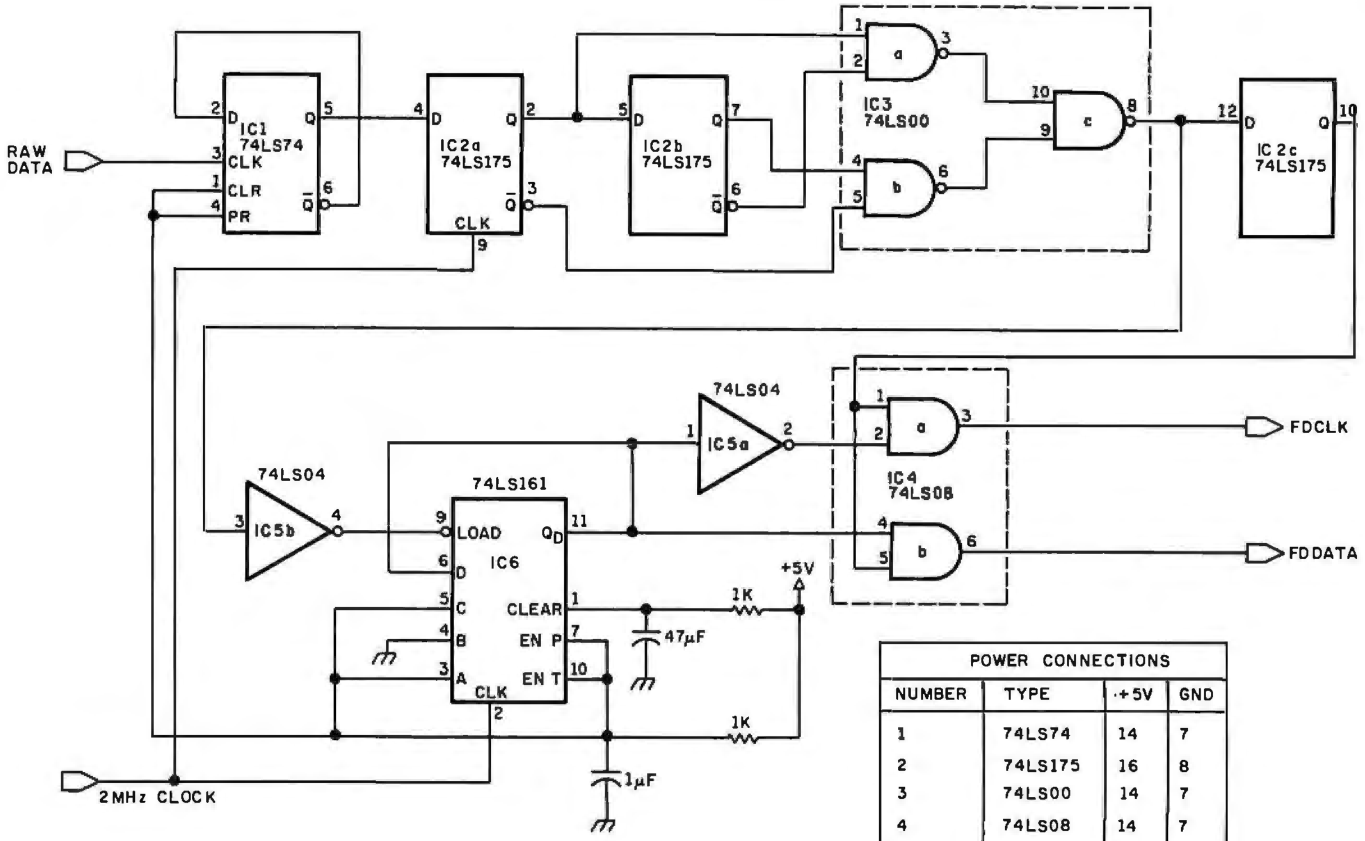
Photo 1: *External data separator circuitry as installed in the Radio Shack TRS-80 Expansion Interface. Most of the integrated circuits can occupy the space intended for the RS-232 interface (photo 1a). Irreversible changes can be avoided by bending a few pins on the FD1771 to obtain the necessary signals (see the wires leading from the FD1771, under the red cable, in photo 1b).*

Ken Kline
3821 Penitencia Creek Rd
San Jose CA 95132

When I first added a floppy-disk drive to my Radio Shack TRS-80 Model I computer, I was very disappointed in its operation. My records indicated that, on the average, I was getting an error for every four disk accesses. These errors were independent of the type of access (ie: they occurred while accessing programs, data files, utilities, and even the bootstrap loading routine). In desperation, I called the Tandy Corporation in Fort Worth, Texas, and was told to use a better grade of disk. I tried this and noticed an improvement (to one error in eight accesses), but the lack of reliability was intolerable.

Discussing my problem with owners of other home computer systems, I came to the conclusion that the FD1771-01 floppy-disk controller part was the culprit. Don't misunderstand, I am not downgrading the FD1771. If you have studied the specifications and application notes of the FD1771 as much as I have you will realize that it is quite a marvelous piece of silicon. However, quoting from Western Digital Corporation's *FD1771-01 Application Notes* (document Number A0104, page 2) "In order to maintain an error rate better than 1 in 10^8, an external data separator is recommended."

The data separator that I finally ended up with is shown schematically in figure 1. It is a modification of one of the external data separators recommended by Western Digital (as



POWER CONNECTIONS			
NUMBER	TYPE	+5V	GND
1	74LS74	14	7
2	74LS175	16	8
3	74LS00	14	7
4	74LS08	14	7
5	74LS04	14	7
6	74LS161	16	8

Figure 1: *External data separator circuitry. This design was developed from one recommended by Western Digital in an applications note for its FD1771. This circuit adds a power-on reset feature.*

shown on page 5 of the same document). After adding the external data separator to my TRS-80, access errors virtually disappeared.

The data separator was constructed on an old printed-circuit board. It already had the voltage and ground connections run to all integrated-circuit-socket positions, and it had edge-card connections. The circuit board now resides in the compartment of the TRS-80 Expansion Interface reserved for the RS-232C interface or other extra circuitry (see photo 1).

This circuit varies from the one in the Western Digital application notes in the use of +5 V on some integrated circuit pins (through a 1 k-ohm pull-up resistor) and a resistor/capacitor network that provides a lag of about 45 ms on the 74LS161 counter's CLEAR input (IC6, pin 1) to insure that it is cleared on power-up.

In order not to make any irreversible changes in the printed-circuit board of the TRS-80 Expansion Interface, the three connections to the FD1771 floppy-disk controller can be made through a 3-pin length of a dip strip, a type of socket. Remove the 1771 from its socket and carefully bend pins 25, 26, and 27 out from their normal position. Then reinsert the 1771 into its socket and push the 3-pin dip strip onto the three pins sticking out.

Pin 25 must be connected to ground when using an external data separator (pin 25 is normally pulled up to +5 V for internal data separation). Pins 26 and 27 are the separated clock and data inputs to the 1771. The raw data from the disk drive to the external data separator is available at pin 8 of integrated circuit Z32 in the Expansion Interface, and the 2 MHz clock signal is picked up at pin 3 of Z25.

All signals are sent to Expansion Interface connector J1 and are available on the internal expansion connector inside the additional circuitry compartment. Ground is available on pins 41 and 42 of that connector, and +5 V is available on pins 39 and 40 (see the right edge of the second page of the Expansion Interface schematic, page 41, in the Radio Shack Expansion Interface manual).

I measured the current required to operate the external data separator (using LS-type integrated circuits) and believe that the 40 mA it draws is certainly less burden on the Expansion Interface power supply than the RS-232C interface that might use this position. ■

BYTE'S ARCADE

Star Raiders

Gregg Williams, Senior Editor

What can you say about a game that takes your breath away? There are not enough superlatives to describe Star Raiders. Just as the VisiCalc software package from Personal Software has enticed many people into buying Apple II computers, I'm sure that the Star Raiders software cartridge from Atari Inc has sold its share of Atari 400 and 800 computers.

Photo 1: *The view from the bridge of the Star Raiders ship during a hyperspace jump. A static photo cannot do justice to the excitement you feel as stars streak by prior to the jump.*

What is Star Raiders? It's a video arcade game that isn't hungry for quarters. I first saw Star Raiders at the West Coast Computer Faire in May 1979, and in the two years that have passed since the first public viewing of the game, no one—I repeat, no one—has created either a home-computer game or a coin-operated video game that is better than Star Raiders. (This fact is even more surprising when you consider the speed with which new standards are set in this industry.)

For the people who haven't seen Star Raiders in action, I'll attempt a brief description. Star Raiders is loosely modeled on the "Star Trek"-type game that has been running on micro- and larger computers for the past eight years. You, as commander of a starship, must search out and destroy all enemy spaceships in the galaxy (which is subdivided into a rectangular array of units called "sectors"). Of course you have only a certain amount of energy, and when you fight an enemy ship that is in the sector you occupy, it can fight back and damage your ship.

Why spend all those quarters on arcade games? With a microcomputer and a few weeks' worth of arcade money, you can enjoy at home microcomputer games that are just as good as (and sometimes identical to) the popular coin-operated video arcade games. BYTE's Arcade is an occasional feature that reviews the best of these fast-action games. If you would like to review or give an opinion of a favorite microcomputer game of this type, please write to: BYTE's Arcade Editor, POB 372, Hancock NH 03449.

Star Raiders is a descendant of this kind of game in the same way that the new pocket computers are descendants of a four-function mechanical adding machine. The many innovations in Star Raiders make you feel that you are actually piloting the spaceship instead of just typing in commands (and endlessly pressing the ubiquitous RETURN key).

Star Raiders has color, sound, and joystick input to make the game more realistic, but the feature that gives it life is its real-time animation. When you patrol a sector, you see a field of stars passing you in all directions, as if you were actually moving through a three-dimensional field of stars. When you steer the ship using your joystick, the stars outside your ship veer realistically in the opposite direction. Enemy ships (called Zylons) appear from above or below, receding in size as they speed past. A battle claxon sounds when you enter a sector containing enemy ships. Attacking Zylons shoot balls of energy at your ship; if they hit, your shields flicker and you hear a destructive crash. And the hyperspace effect (used to

Photo 2: *The Star Raiders Galactic Chart. Each square represents a sector of space. The star symbols represent sectors containing starbases; all other squares marked with symbols represent sectors containing Zylon enemy ships. Your ship is located in the square near the center, marked by a small dot.*

Photo 3: *The view from the bridge during combat. "Star Trek" games were never like this! When you occupy the same sector as enemy ships (here, top and bottom center) their size will increase and decrease as you move toward or away from them.*

At a Glance

Name Star Raiders	**Author** Doug Neubauer
Type Arcade-style game	**Format** Game cartridge
Manufacturer Atari Inc Consumer Division 1195 Borregas Ave Sunnyvale CA 94086 (408) 745-2000	**Language** 6502 machine language **Computer** Atari 400 or 800
Price $59.95	**Documentation** 10 pages, 22 by 28 cm (8½ by 11 inches)

move you from one sector to another) must be seen to be believed!

I could continue to describe the intricacies of Star Raiders, but words cannot evoke the sensation of actually playing the game. To Doug Neubauer of Atari, who wrote Star Raiders, my unbounded thanks. To all software vendors, this is the game you have to surpass to get our attention. And to Atari, I can only say that if you offer us games like this, we can't refuse. ■

Super Nova

Bob Liddil, POB 66, Peterborough NH 03458

Arcade video games are extremely popular throughout the world. It would seem natural, therefore, that these games would take hold in the TRS-80 marketplace, where good graphics programs are in short supply. There is, to be sure, a good deal of mediocrity on the market, such as early versions of Space Invaders. Super Nova, however, is an example of how well a program can be created if its designer takes enough time and care with it.

The instant the program (a standard machine-language system tape) is loaded, Super Nova spins into a stunning

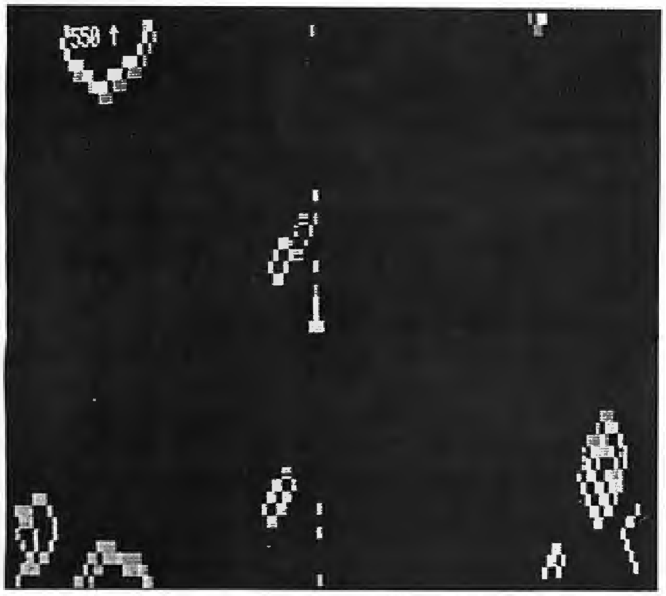


Photo 1: *The Super Nova game in play.*

At a Glance

Name Super Nova **Type** Arcade-style game **Manufacturer** Big Five Software POB 9078-185 Van Nuys CA 91409 **Price** $14.95	**Format** Cassette **Language** Z80 machine code **Computer** TRS-80 Model I with 16 K bytes of memory and Level I or Level II BASIC **Documentation** 1-page insert sheet

three-dimensional starburst display that looks so real it makes you dizzy. The depth of field is absolutely startling. This is the most striking high-speed animation I have ever seen (with the possible exception of the hyperdrive display of Atari's Star Raiders. The graphics work in Super Nova is fast, stunning, and very uncharacteristic of TRS-80 games.

As with its coin-operated counterpart, Atari's Asteroids game, the object of Super Nova is to destroy objects that appear on the screen while avoiding your own destruction. Meteors, of all shapes and sizes, make up the bulk of these targets. When you hit the larger asteroids, they shatter into smaller and smaller chunks, and, if you're lucky or skillful, they finally disintegrate. It should be noted that the supply of meteors is unlimited.

Not content to menace the player with mere rocks hurtling through the void, Super Nova thoughtfully provides missile-firing alien spaceships. Three less-dangerous craft appear when there are six or less meteors on the screen. Two larger ships, worth more as targets, appear when you reach a score of 10,000 points.

Some of the aliens have special shields that allow them to pass harmlessly through meteors. Not so for your fighter—touch something, anything, and you're destroyed. The game ends when you have lost three ships.

Super Nova has a well-thought-out keyboard setup that enhances the playability of the game. Five keys control your ship's action in a fashion similar to the buttons supplied in coin-operated video games. The R and T keys turn the ship counterclockwise and clockwise, respectively. The O key applies engine thrust in whatever direction the ship is pointing, and the P key fires your missiles. Finally, the space bar launches the ship into hyperspace. The keys are located so that you play the game with the first two fingers of each hand touching the keys and either thumb working the space bar.

Super Nova would be an enjoyable game if it had only the features I've described so far, but it offers even more. This game has refinements that distinguish a truly great computer game from a good one. The propulsion formula used to control the behavior of your ship, for example, is Newtonian in nature, closely simulating the actual response you would expect from a real spaceship. Going too fast or too far? Turn your ship in the opposite direction and increase thrust just enough—remember, opposite thrusts cancel each other out—and your ship stops.

The rotation controls (the R and T keys) turn the ship in 45° increments, which is the best you can do with the limited TRS-80 graphics. As a last resort, hitting the space bar throws your ship into hyperspace. So if three large meteors and an enemy ship are converging on you from different directions, this action might save you. I say *might* because a hyperspace jump ends with your ship popping up anywhere on the screen. Since there are obstacles everywhere, you may find yourself in a worse position than when you started.

Game programs that cross my desk receive many a trial, but none is so grave or deadly as 12-year-old Richard's, my young neighbor and resident computer-game buff. With his attention span of less than 5 minutes, he rips through normal TRS-80 games with uncanny speed. His response to Super Nova, however, was an enthusiastic "Excellent!" He stayed with it for 3 hours, until his mother appeared to drag him away for homework. There is no higher recommendation available.

In summation, Super Nova is fast, entertaining, and professional. It is well worth its $14.95 price tag. I fully agree with Richard—Super Nova is excellent! ■

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Tranquility Base

Robin Moore, Warner Hill Rd, RFD 5, Derry NH 03038

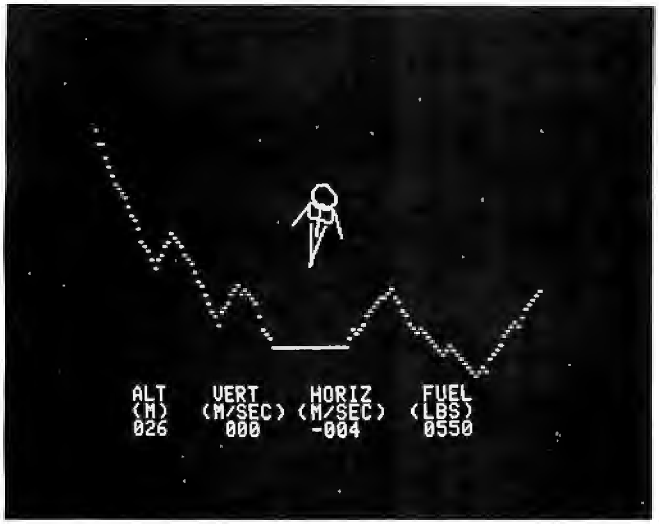

Photo 1: *The Tranquility Base game in progress.*

Bill Budge has written a lunar-lander-style arcade game for the Apple II. Called Tranquility Base, the game uses Apple high-resolution graphics to portray the lunar-lander module and the moonscape below. The player attempts to bring the lunar module out of orbit and land it safely on one of several flat areas on the lunar surface. A fixed amount of fuel is provided, and the score is based on the number and quality of successful landings.

Playing the Game

The game is simple, although not necessarily easy to play. A key is pressed to start the action, and the lunar-lander module appears, orbiting from left to right over a detailed moonscape. The rockets are controlled with the Apple II's game paddle 0, while the "1" and "2" keys on the keyboard adjust the rotational attitude of the lander. Each keypress rotates the ship slightly in one direction or the other. There are no steering rockets, so the lander's horizontal motion must be controlled by rotating the ship and using the main rockets.

It is difficult to make a successful landing. The landing areas are never much larger than the width of the ship, and the rocket control is quite sensitive, so you might cause the ship to take off just as you are gently touching down. If the lunar module touches anything except a flat landing area, it crashes and explodes. Landing too quickly can also cause a crash and an explosion. The score for each successful landing is derived from the horizontal and vertical velocities of the ship when it touches down.

Graphics and Sound

Consistently excellent graphics are a hallmark of Bill Budge's games, and the Tranquility Base graphics are no exception. From the title display that shows the lunar module, moonscape, and starfield (with little apples as planets) to the final module explosion, the graphics are great. The lunar module is nicely detailed, and when it explodes, pieces fly off and tumble in various directions. Even the rocket flame is detailed: it flickers realistically and provides visual feedback by smoothly changing size as the rocket thrust is varied.

When the lunar module orbits off the right edge of the screen, a new section of scenery snaps into view below, and the lander orbits in from the left. Tranquility Base also provides a close-up view of the lander and the moonscape when the lander is a certain distance from the ground: this will help you make a smooth landing. Fuel

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level, horizontal and vertical velocities, and altitude are displayed in text form below the graphics display. This aspect might have been improved by using analog displays simulated with graphics.

Most arcade-type games make extensive use of sound effects to enhance the realism of the simulation. Unfortunately, Tranquility Base takes little advantage of the Apple II's sound capabilities. Sound is used when the lander crashes and explodes, but it is not very realistic. I would have preferred some rocket-motor sounds varying with the thrust level, and perhaps a warning tone to indicate unsafe landing parameters.

At a Glance

Name
Tranquility Base

Type
Arcade-style game

Manufacturer
Stoneware
50 Belvedere
San Rafael CA 94901

Price
$24.95

Author
Bill Budge

Format
5¼-inch floppy disk

Language
6502 machine language

Computer
Apple II or Apple II Plus with one disk and 32 K bytes of memory

Documentation
Instructions in game

Conclusions

- Tranquility Base is a medium-speed lunar-lander-style arcade game with excellent graphics. Like most of Bill Budge's games, it is well done and functions flawlessly.
- The game is fairly difficult to play, enough so that it tends to discourage some new users. After a little practice, however, it becomes more enjoyable and exciting.
- Whether or not Tranquility Base is worth $25 depends on how much you enjoy the game and how often you play. I suggest that you try it out at a local computer store before you make a decision. ■

Asteroids in Space and Planetoids

Oliver Holt
Old Nashua Rd
Amherst NH 03031

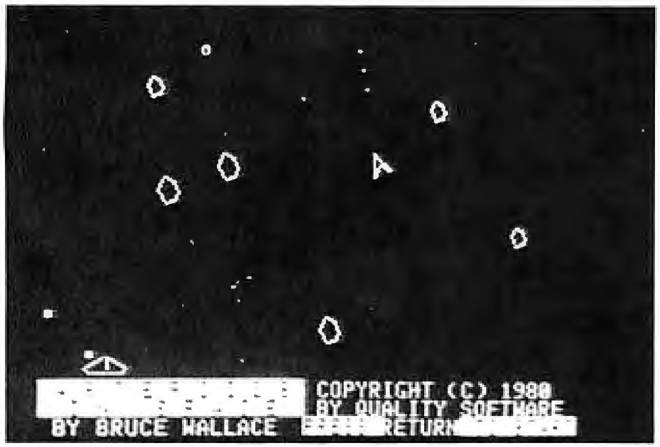

Photo 1: *Asteroids in Space is the title of the Asteroids game for the Apple from Quality Software. It is similar to the actual arcade game; the spaceship is controlled via the game paddles.*

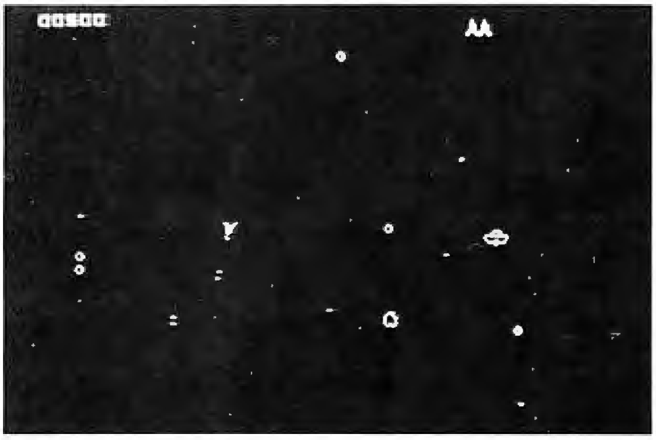

Photo 2: *Planetoids is Adventure International's offering. The use of machine-language programming combined with high-resolution graphics results in smooth action without a jittery picture.*

Asteroids by Atari Inc is certainly one of the most popular arcade games in this country, inspiring people of all ages to deposit their quarters with devotion. Due to this popularity, it was only a matter of time before a home-computer version was developed. Asteroids in Space (by Quality Software, referred to as QS) and Planetoids (by Adventure International, or AI) both closely simulate the Atari game, in which a player must destroy asteroids and alien ships by accurately firing a laser. An off-target laser shot or slow response is fatal. The Apple's high-resolution graphics capabilities allowed the authors to reproduce almost exactly the display features of the original game. Both games skillfully employ realistic sound effects. The two versions use game paddles to control the motion of a spaceship and to fire lasers, but because of differences in the method of control used each game has a unique feel.

Planetoids

On start-up, Planetoids (from AI) displays a menu that includes several levels of play. This menu is part of a HELLO disk program written in both Integer and Applesoft BASIC, allowing use in either an Apple II or an Apple II Plus. The options in this menu give a choice of easy, regular, or hard modes of play, as well as a demo mode to display how the game works.

In the easy mode everything on the screen is very explosive. Every planetoid particle has the potential to destroy your spaceship unless your laser beam gets to the particle first. (Points are based on the number of planetoids you destroy.) The regular mode is supposed to be an emulation of the actual arcade game, but it does not appear to be significantly different from the easy mode. In the hard mode, the planetoids behave differently; they migrate toward your ship as if pulled by gravity. This characteristic becomes particularly annoying when one of your ships is destroyed and you still have other ships left to play. At this point, the planetoids gather around

At a Glance

Name Planetoids	**Language** 6502 machine language (has menu programs in both Integer and Applesoft BASIC)
Type of package Arcade-style game	**Computer needed** Apple II or Apple II Plus with 48 K bytes of memory and one floppy-disk
Manufacturer Adventure International POB 3435 Longwood FL 32750	**Documentation** One page with description of the game; additional instructions in the actual program.
Price $19.95	
Format 5¼-inch floppy disk	

the spot where your next ship will appear, making it difficult to escape without being destroyed. Sometimes your spaceship will reappear directly under a planetoid and explode before you even realize that your ship has (momentarily) returned. When this happens you have no choice but to sit there and watch your spaceships dwindle away with no hope of retaliation.

Planetoids uses one paddle and the keyboard to control the ship. You rotate the paddle to turn the spaceship and press the paddle button to apply thrust. The spaceship will continue to move in the direction it is pointed as long as the button is depressed, but it stops as soon as the button is released. Pressing any key on the keyboard fires a laser in the direction the ship is pointing. However, there is no provision for putting the ship into hyperspace, as in the original coin-operated version.

Asteroids in Space

Quality Software's Asteroids in Space has two choices on start-up, offering either a normal or demo game. When in demo mode, the spaceship randomly moves around in space shooting the laser beam in all directions until the ship itself is destroyed. Watching this can be useful if you have never played this kind of game before, but most users will want to go directly to the normal mode. This mode of play offers separate choices for either normal or fast lasers and asteroids. According to the documentation, higher scores may be obtained with either fast lasers or fast asteroids, or both. The game's difficulty increases, however.

Both game paddles are used to control the action in this version. One paddle controls the movement of the spaceship, rotating it by turning the paddle, and thrusting it by pushing the button. However, this game incorporates momentum into the action of the spaceship, requiring you to use the thrust to slow the ship or to change its direction of movement. [*I have trouble playing this version because I spend all my time trying to stop my ship from moving....***GW**] Unlike the AI game, your ship can move in one direction while it fires in another. Lasers are fired using the game button on the other paddle. This method of control is harder to mentally and physically coordinate, making the game more challenging and frustrating. This game, like Planetoids, does not have the hyperspace feature of the original Atari version.

Scoring for both games is determined by the number of alien spaceships and asteroids (or planetoids) you can destroy. The QS version awards from twenty to thirty points for larger asteroids, more for smaller ones. Alien spaceships are worth up to 300 points. The AI game allows only ten points for the planetoids and up to fifty for the alien ships.

The graphics in both games are very good, very similar to the original arcade game. All the objects move

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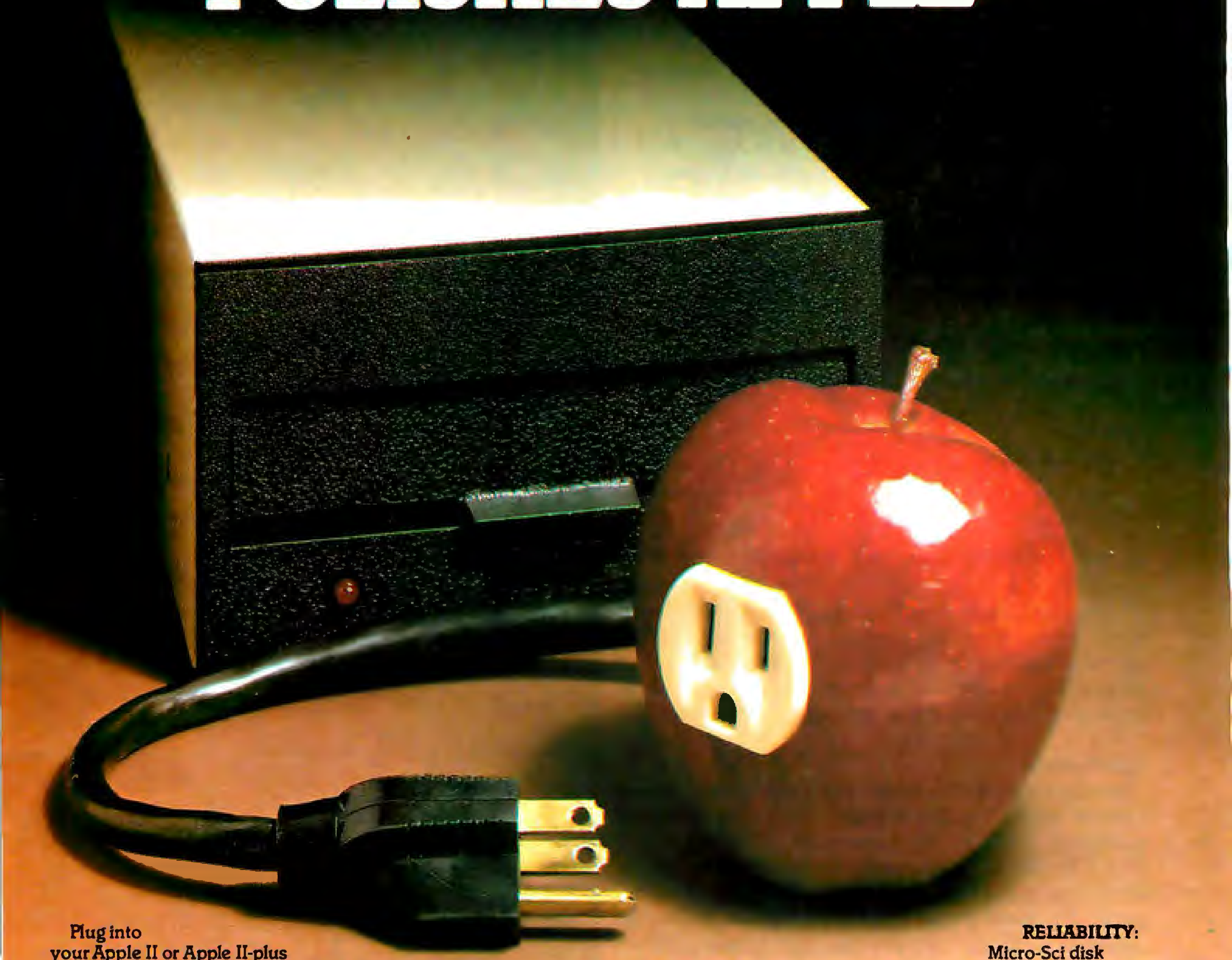

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At a Glance

Name Asteroids in Space	**Language** 6502 machine language
Type of package Arcade-style game	**Computer needed** Apple II or Apple II Plus with 48 K bytes of memory and one floppy-disk drive
Manufacturer Quality Software 6660 Reseda Blvd Suite 105 Reseda CA 91335	**Documentation** One page with description of the game; additional instructions in the actual program.
Price $19.95	
Format 5¼-inch floppy disk	

smoothly without the annoying "jumping" or jitter effect predominant in lower-resolution video games and some of the poorer high-resolution graphics games. Sound effects were also similar to the arcade game, but I felt the QS version to be more realistic and of higher quality. The AI sounds were barely audible over the pounding of the keyboard while I was firing at objects on the screen.

Conclusions

Having played both games, I feel it's difficult to choose between them. The QS version offers different speed variations, while the AI version offers three levels of play. I like the AI version better because it can be slightly easier to play and there are three distinct variations to the game. The more astute game player might prefer the greater physical dexterity and mind/eye coordination required by the QS version. However, the games are different enough to entice most people to own both. ■

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Using Page Two with Apple Pascal Turtle Graphics

Bruce Wallace, 333 Escuela
Ave #316, Mountain View CA 94040

So, you have Pascal up on your Apple and you're ready to use the built-in turtle graphics. One of the first things you probably notice is that the Pascal manuals never mention which high-resolution graphics page you are working with. In fact, the manuals don't even mention that a second page exists. Well, it does. And, it turns out to be fairly simple to use the unit TURTLEGRAPHICS on either page. There are three things to be considered:

1. reserving the page two memory space
2. getting TURTLEGRAPHICS to plot on page two
3. getting the Apple to display page two

Before we get into graphics, we'll need a technique for PEEKing and POKEing. This can be done with the help of the following declarations:

```
TYPE byte = 0..255;
     pab = PACKED ARRAY[0..1] OF byte;
     multitype = RECORD
                 CASE integer OF
                    1 : (int:integer);
                    2 : (ptr:↑pab);
                    3 : (dptr:↑integer)
                 END;
```

A variable declared to be of type "multitype" can be referred to as either an integer or a pointer variable. This leads to the following definitions:

```
PROCEDURE poke(addr:integer; value:byte);
VAR local:multitype;
BEGIN
   local.int := addr;
   local.ptr↑[0] := value
END;

FUNCTION peek(addr:integer):byte;
VAR local:multitype;
BEGIN
   local.int := addr;
   peek := local.ptr↑[0]
END;
```

Now that we can access memory directly, we need to reserve the memory space for high-resolution page two; otherwise, Pascal might try and use it for stack or heap space. The UCSD extension routine RELEASE will do the trick for us. Assume that "save" is declared to be of type "multitype." The code segment:

```
save.int := 24576;
release(save.dptr);
```

will reserve all of low memory up to address hexadecimal 6000 (24 K). This is done once at the beginning of your program.

Next, inform TURTLEGRAPHICS which page it is to use. Do this by placing a 2 or a non-2 value into a particular memory location for page-two or page-one plotting, respectively. A pointer to this location resides as the eighth entry in a pointer table. The table itself is pointed to by the contents of absolute locations 254 and 255 decimal. This leads to the following routine, which sets the page to be plotted on:

```
PROCEDURE setdraw(page1:boolean);
VAR local:multitype;
BEGIN
   local.int := 254;
   local.int := local.dptr↑ + 14;
   IF page1 THEN local.dptr↑ := 1 ELSE
       local.dptr↑ := 2
END;
```

Finally, we must be able to switch the page that Apple is displaying. After we are in the high-resolution mode via a call to GRAFMODE, we simply PEEK or POKE as we would in BASIC. Using the above PEEK or POKE routines, access −16299 or −16300 for page two or page one, respectively.

In general, INITTURTLE only works with page one, and, in fact, it even resets the display mode to page one. Use FILLSCREEN to clear page two. Also, the turtle position is not moved when changing the high-resolution page via "setdraw" above. For example, if you left off plotting at *x*,*y* position 50,50 with an angle of 45°, that's where you will start plotting on the other page.

Armed with these handy code segments, you can now get smooth animation by flipping from page to page. This should open up new possibilities for Apple Pascal graphics users. ■

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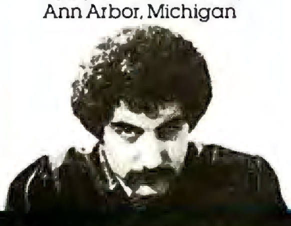

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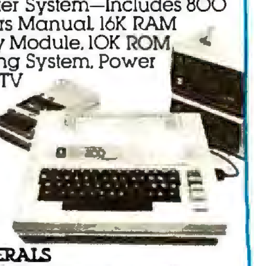

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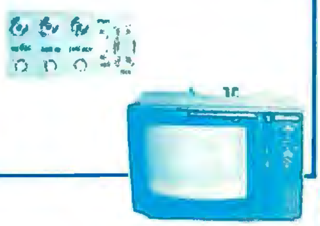

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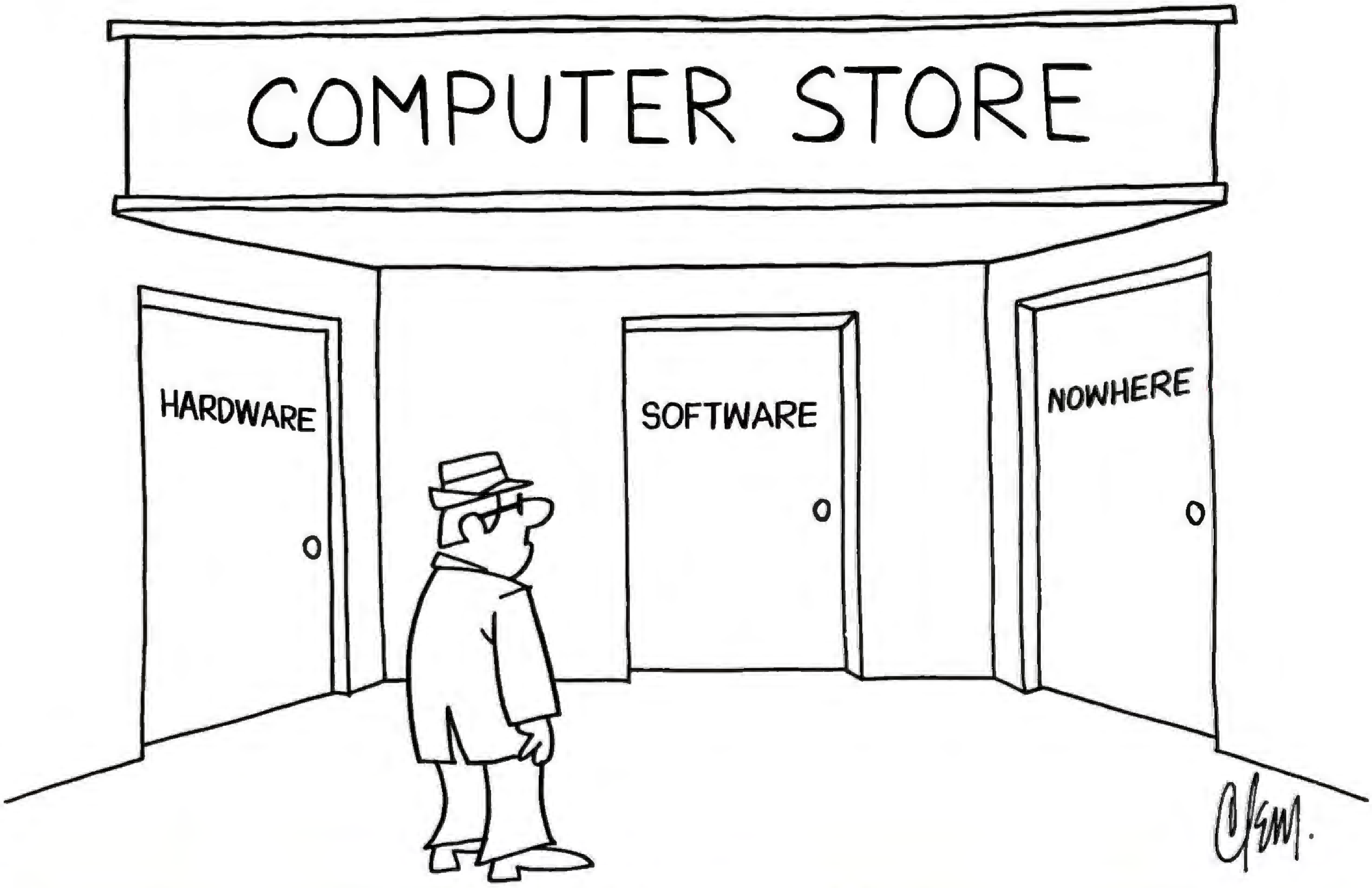

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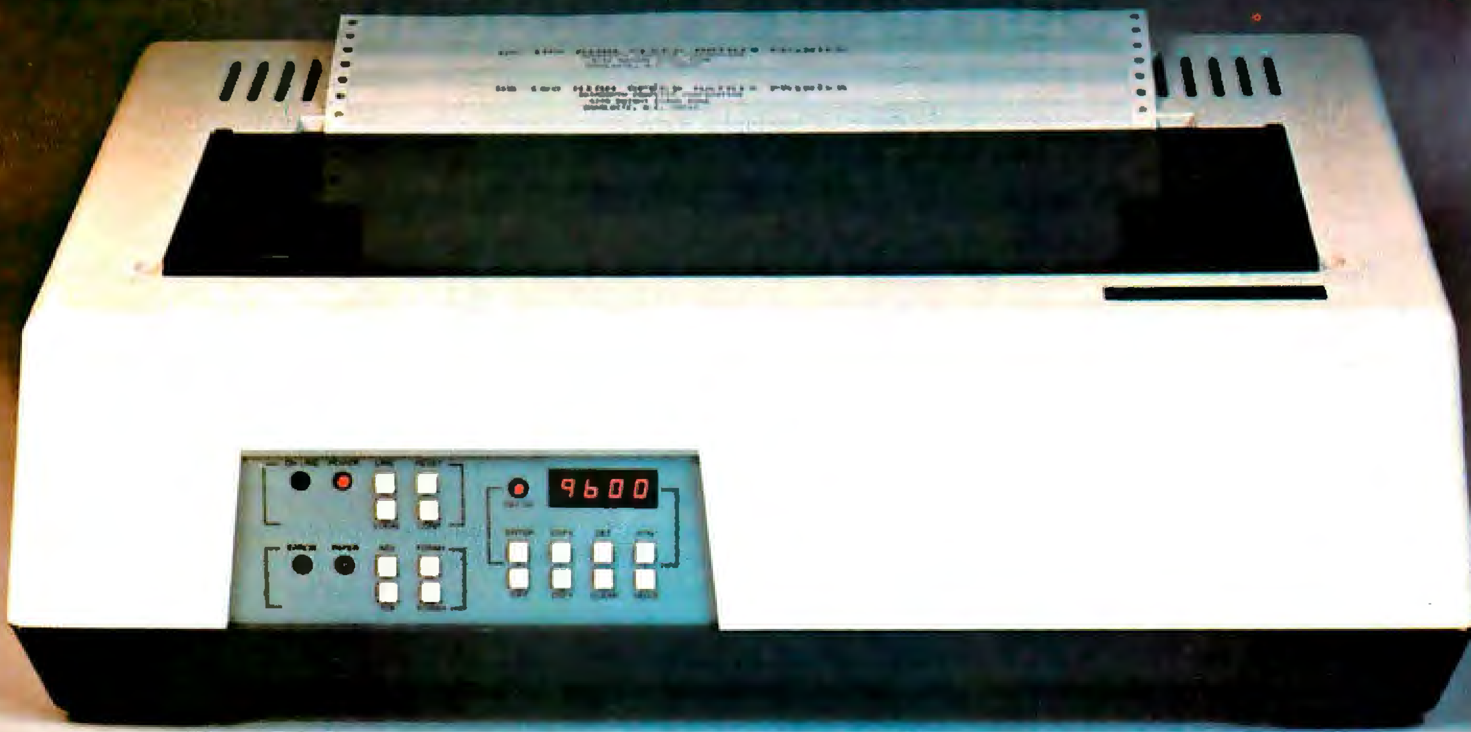

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Washington Tackles the Software Problem

Christopher Kern
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There was a time when a personal computer was nothing more than a microprocessor, some support circuits, a couple of thousand bytes of memory, and a few light-emitting diodes. In those bygone days, "software" consisted of a painstakingly crafted 1280-byte nano-BASIC interpreter, which was stored as perforations in a long, thin strand of paper and loaded into the machine by a device known, quaintly, as a paper-tape reader.

Today, all you have to do to get your new 16-bit, 8 MHz, 12 M byte, 512-by-512 pixel, hand-held color widget going is to break the cellophane. And as long as you haven't managed to clobber the widget's sophisticated mega-tasking, ultra-user operating system, or the various editors, high-level language compilers and interpreters, and powerful application programs that come as standard equipment, you are up and running.

All that fancy software is as much a part of the widget as the hardware that it runs on, and the attempt by the Widgetizer Corporation and others like it to protect their investment in software development is the reason why the courts and Congress now find themselves confronted with the "software problem."

About the Author
Christopher Kern is a lawyer by training, a journalist by trade, and a computer programmer just for the fun of it.

The Software Problem

The software problem actually existed *before* the advent of the microcomputer, but spectacular improvements in microcomputer hardware have increased the demand for sophisticated software. At the same time, reduced production costs for hardware have radically enlarged the computer market, making it increasingly difficult to control software piracy.

Most microcomputer products are based on one of a relatively small set of microprocessors, so it is technically as well as economically practical to copy software, moving it from one hardware environment to another. Within the hobby market, this typically takes the form of one hobbyist copying commercial programs for a few friends. At the least, this is probably a violation of the purchaser's contractual obligation to the software vendor; it is certainly the moral equivalent of larceny. But although this practice is obviously a serious matter for those who sell software to the home market, its relative economic significance is fairly small. The real problem is the commerical duplication—often entirely legal—of software and software-based products for commercial purposes.

The Copyright Problem

When Congress overhauled the nation's copyright laws in 1976, it sidestepped the software problem by failing to specify the extent to which computer programs were eligible for copyright protection. A source listing clearly could be protected by copyright; a listing of a program is, after all, just a text. But what about the program as it appears in other forms? It was not clear whether object code, stored as a series of binary electronic impulses in memory or as magnetic fields on a mass storage device, was also subject to the creator's copyright.

One notorious illustration of the problem involved a microcomputer chess game sold by a Florida company called Data Cash Systems. The Data Cash game appeared on the market in 1977 and sold for $169. A year later, JS & A Group Inc of Chicago introduced a competitive chess game for $99. The program it used was identical to the one used in the Data Cash machine.

Although the two programs were unquestionably the same, Data Cash lost its copyright infringement suit on the grounds that the law, as it then existed, did not protect software in object-code form. The trial court rul-

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Supreme Court Takes a Softer Look at Software

"A claim drawn to subject matter otherwise statutory does not become nonstatutory simply because it uses a mathematical formula, computer program, or digital computer."

Justice William Rehnquist, Majority Decision, *Diamond* v. *Diehr*, March 1981

With this somewhat cryptic remark, the Supreme Court has, in the words of software and patent expert Morton C Jacobs, "removed the shackles from the software innovator." The *Diamond* v. *Diehr* decision (described in the accompanying article) was the culmination of years of court cases involving the patentability of software.

The key word in the above quote is "statutory." According to patent law, an invention is statutory if it is a "process," "machine," "article of manufacture," or "composition of matter." All other inventions are said to be nonstatutory. For example, computer programs or mathematical algorithms are currently considered to be nonstatutory by the court. In the *Diehr* case, the Supreme Court decided for the first time that an invention does not become *ineligible* for a patent simply because of the presence of a computer program in the invention. However, an invention must still fall in a statutory category and must pass the traditional tests for merit: it must be "novel," "useful," and "unobvious."

The court has yet to take the final step and say that software is patentable, but this important decision points in that direction.

Jacobs feels that now small businesses can afford to once again become innovators in the software field. Small-business entrepreneurs need patent protection to raise venture capital to bring their ideas to fruition.

Ruth M Davis, former director of the Center for Computer Services and Technology of the National Bureau of Standards, agrees that "there is a small-business potential to innovate in the software field...the patent system is important in stimulating [this] technological innovation."

The closeness of the 5 to 4 decision in the *Diehr* case has led some observers to conclude that the court is evenly divided on the software issue, but Jacobs is quick to point out that the court is becoming progressively more and more "pro-software" in its recent decisions. Further, the Supreme Court has had the benefit of advice and testimony from computer experts over the years, and the growing sophistication of its decisions reflects this.

Of course, the answers aren't all in yet. For example, what if an enterprising inventor puts a new program in a computer so that he can claim the novelty of the entire machine? This effectively preempts the algorithmic content of the program. The courts have balked at this approach in the past. Even so, the day may soon come when a program residing on a floppy disk will be granted a patent...CM

ing was affirmed by the US Court of Appeals for the Seventh Circuit, and precipitated considerable concern within the data-processing industry. It appeared that in the future, the only realistic defense against software piracy would be strict enforcement of licensing agreements. But a licensing agreement binds only those who are party to it. It has no legal effect on a pirate who obtains the software without signing an agreement.

The copyright problem was resolved by the Computer Software Copyright Act of 1980, which was passed in the waning days of the 96th Congress and signed by President Carter just before he left office. The Act amends the 1976 copyright statute by defining a computer program as "a set of statements or instructions to be used directly or indirectly in a computer to bring about a certain result." The word "directly" refers, of course, to the object code. But while the new copyright law protects both the source statements and the sequence of machine instructions in the program, it does not protect the underlying logic of the program—the operations that the software is designed to perform.

The Patent Problem

The most effective way to prevent unauthorized use of computer programs would be to patent them. A patent would protect the *process* that a program carries out, regardless of its specific form. True, the duration of a patent is short (17 years), but in a rapidly changing industry that disadvantage is only theoretical; for practical purposes, the protection afforded by a patent borders on the absolute.

Several attempts have been made to get the Supreme Court to recognize the patentability of computer software. In *Gottschalk* v. *Benson* (1972), the Court unanimously rejected a patent claim for an algorithm that converted numerical data in binary-coded-decimal form to pure binary. In his opinion for the Court, Justice William O Douglas started with the long-established proposition that "an

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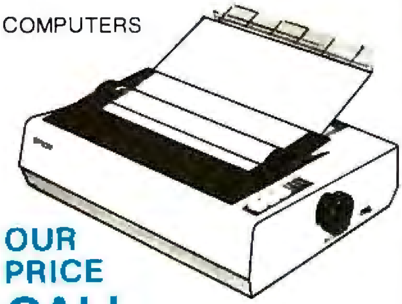

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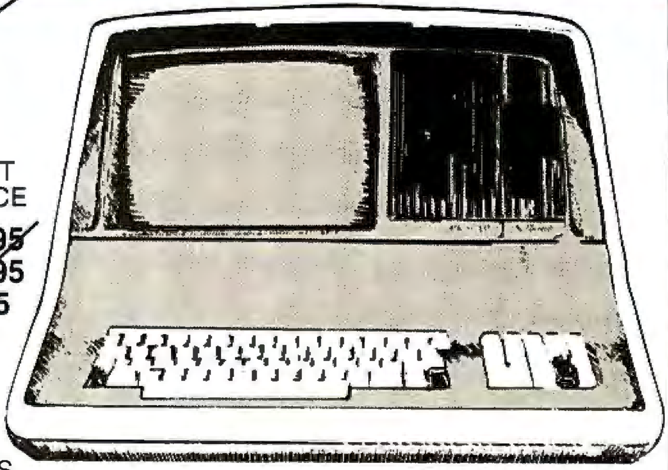

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idea of itself is not patentable," and concluded that granting a patent for the BCD-to-binary algorithm would amount to giving the applicant exclusive ownership of a mathematical abstraction.

At the same time, Douglas disclaimed any intention of foreclosing patent protection for computer programs altogether. He hinted that it would be best if Congress would resolve the issue of patentability of computer software. But his opinion suggested that until Congress acted, the Court would avoid any sweeping ruling on the patent law and allow its interpretation to evolve on a case-by-case basis.

The protection afforded by a patent borders on the absolute.

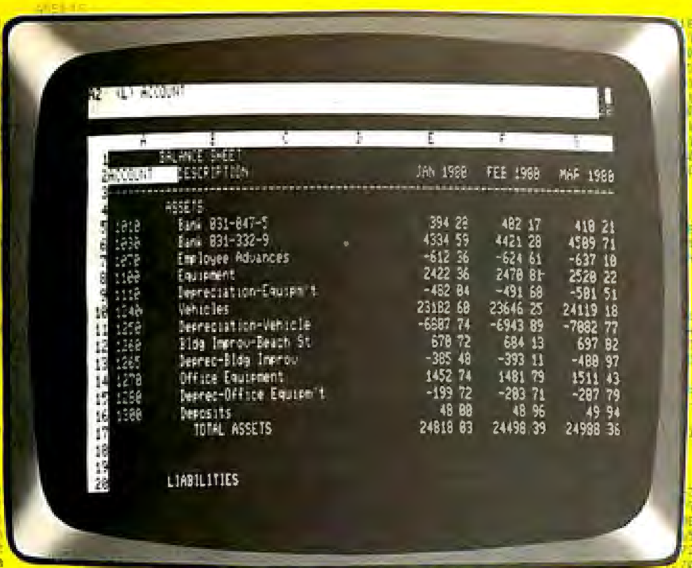
The Flook Decision

A few years later, in *Parker* v. *Flook* (1978), the Supreme Court addressed an attempt to circumvent its ruling that an algorithm could not be patented. The case involved an application for a method of determining when a catalytic conversion process had exceeded certain predefined parameters. A computer program calculated *alarm limits,* which indicated when an inefficient or dangerous condition existed. While the applicant admitted that an algorithm was crucial to the patent application, he argued that he had tied its use to a specific industrial process—the catalytic chemical conversion of hydrocarbons.

The Supreme Court rejected Flook's contention by a vote of 6 to 3, holding that the only novel part of the process was the algorithm embedded in the computer program. The algorithm itself, under *Benson,* was of course not patentable. In his opinion for the Court, Justice John Paul Stevens said that both the chemical and mechanical processes involved were well known, and concluded that the patent application "simply provides a new and presumably better method for calculating alarm limit values." For patent purposes, mathematical algorithms, like laws of nature, were to be treated as though they had previously been known, even though in fact they were newly discovered by the applicant. "Respondent's process is unpatentable," Justice Stevens wrote, "not because it contains a mathematical algorithm, but because once that algorithm is assumed to be within the prior art, the application, considered as a whole, contains no patentable invention."

A Recent Interpretation

Was the *Flook* decision a fluke? Recent cases suggest it may have been. In the case of *Diamond* v. *Chakrabarty* (1980), the Court considered a patent claim for a laboratory-created bacterium. Superficially, computer programs and man-made bacteria have little in common (program bugs belong to a different species). Yet computer software and genetic engineering are alike in two respects: (1) Congress was unaware of either one when it wrote the basic patent



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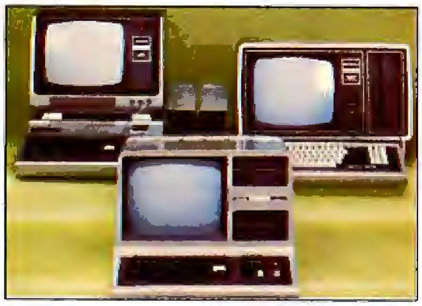

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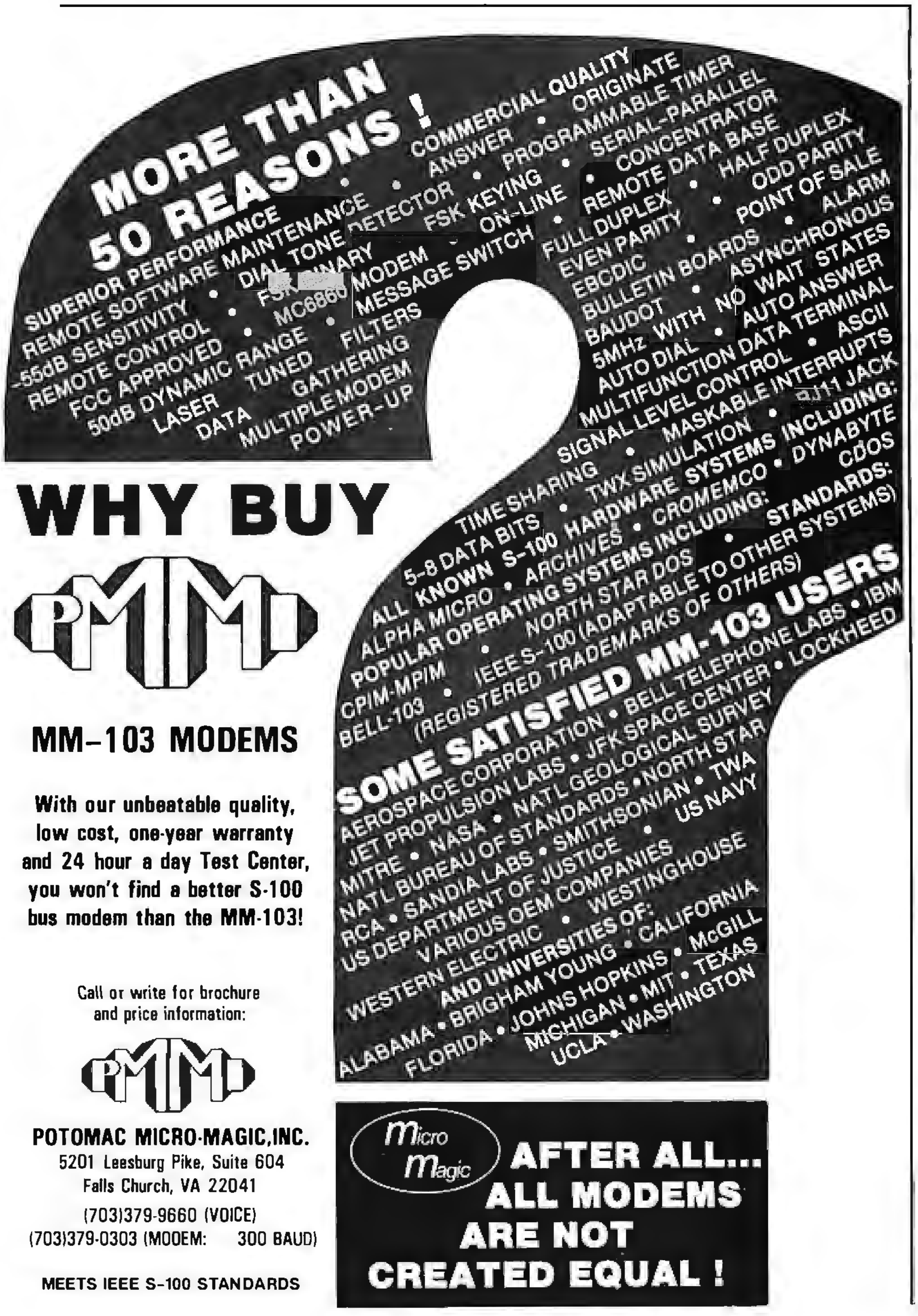
law, which is only slightly changed from the language drafted by Thomas Jefferson in 1793, and (2) both programming and genetic engineering involve the manipulation of coded information which is stored (in one instance, in the electronic or magnetic memory of a computer and, in the other, in the molecular memory of a cell). But a 5 to 4 majority of the Supreme Court ruled in *Chakrabarty* that man-made microorganisms are indeed eligible for patents.

In March of this year, the Court cited its reasoning in *Chakrabarty* as justifying patent eligibility for a process involving a computer program. The case, *Diamond* v. *Diehr*, was also decided by a 5 to 4 vote. The Court ruled that a patent could be granted for a new method of curing synthetic rubber that was designed around a computer program. The program calculated the time required for the curing process by monitoring the temperature inside the curing furnace and continuously updating the time remaining. This allowed the program to stop the process the instant the rubber had been properly cured.



The Justice Department, which opposed the patent application, said that the facts of the *Diehr* case were indistinguishable from those of the *Flook* case. Both patent applications were for industrial processes that were new because of the way they used computer programs. But Justice William Rehnquist, speaking for the Court, said there was a vital difference between *Diehr* and *Flook*. In *Flook*, the algorithm used to calculate alarm limits for the catalytic conversion process was new, but the *idea* of calculating alarm limits was not. In *Diehr*, the entire *process* was new; the essence of the patent application was that no one had ever successfully monitored the temperature inside the furnace and then used a computer program to continuously calculate when to stop the curing process.

Prospects

At this point it is difficult to tell whether or not the Supreme Court is in the process of reversing direction on the issue of software patentability. The most that can be said with any assurance is that the narrow majorities that have decided the recent cases indicate a deep division in the Court. A stinging dissent in the *Diehr* case by Justice Stevens, who was the author of the *Flook* opinion and who opposes any extension of patent protection for software, makes it clear that the debate is a long way from being resolved.

The Court was expected to take the case law one step further in its current term. It had agreed to rule in the case of *Diamond* v. *Bradley*, which involved a patent application for read-only memory routines used in the central processor of a computer for machine control. The Court of Customs and Patent Appeals, which has tended to be well ahead of the Supreme Court in authorizing patent protection for computer programs, held that the application should be granted. The Patent Court ruling was affirmed, but only because Chief Justice Warren Burger removed himself from the case (as is customary, he gave no explanation for his decision not to participate), leaving the other members of the Court evenly divided.

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While such a split leaves the lower court ruling intact, it has no value as legal precedent.

What Does This Mean to Us?

For those of us with a recreational interest in the computer industry, there is little to lose and potentially something to gain from the change Congress has made in the copyright law and the possibility that the Supreme Court will increase the patent protection afforded computer software. True, now that object code is clearly subject to copyright, you will be breaking the law if you copy your commerical BASIC interpreter for a friend. But the added protection provided by the new copyright amendments may encourage more software development, giving experimenters a wider selection of software products. It is even possible that vendors will begin to sell source code for microcomputer system programs (some even withhold information about useful program entry points) because the code will be protected by copyright.

Object code is now clearly subject to copyright laws.

It is not clear to what extent the personal-computer market, a relatively small part of the overall microcomputer market, would be affected by a Supreme Court ruling that would enlarge the patent protection already granted to software-based industrial processes. But I suspect that any change in the patent laws that encourages innovation will increase the industry's interest in sources of innovation—that includes the tinkerers who develop potentially marketable software purely for their own amusement.■

New Technology Clashes With Old Laws

Over the decades, different laws have been developed to protect different kinds of creative works. But computer software is not quite like anything that has preceded it. On the one hand, a software package may be thought of as a work of authorship. On the other hand, it is functionally mechanistic. Things are further complicated by the fact that it has become remarkably easy to copy large amounts of information quickly. Of course, the easier it is to reproduce a protected work, the harder it is to protect it.

The United States Constitution, in listing the powers of Congress, specifies that Congress shall have the power "to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive rights to their respective writings and discoveries" [Article I, Section 8]. Congress has exercised this power by enacting patent and copyright laws.

Patent law is set forth in Title 35 of the United States Code. It affords strong protection, for a period of 17 years, to demonstrably useful, novel, and nonobvious inventions. Whereas copyright is designed to protect the "expression" of an idea or process, a patent is designed to protect inventions, which are products or processes in themselves.

Although patents have been awarded to software, the rigid standards of novelty and nonobviousness have made application difficult.

Similar confusion has existed with regard to the applicability of copyright laws. The disagreement among those caught up in the necessity of applying old laws to new phenomena was brought into focus during the 1970s as Congress attempted to overhaul the 1909 copyright laws.

Concurrent with the activity in Congress, a commission was formed in 1975 to address the copyright problems of data processing. CONTU (the National Commission on New Technological Uses of Copyrighted Works) examined various existing laws that could, presumably, be modified to protect data bases and software. In 1978, CONTU issued its Final Report, *a study that recommended appropr ate changes to the copyright law, based on the results of its research. (*Final Report, *stock number 030-020-00143-8, is available from the US Government Printing Office.)*

Although a new Copyright Act was passed in the fall of 1976 (effective January 1, 1978), Congress decided that the implications of data processing and reproduction technology had to be further clarified before they could be properly reflected in the new law. Accordingly, a stop-gap paragraph was inserted which indicated that the old laws, though ambiguous, still pertained. Subsequent revision (most particularly the Computer Software Copyright Act of 1980) continues to provide inadequate protection.

*An interesting historical parallel to the debate over software protection occurred in 1908, when the Supreme Court held that a piano roll was not a "copy" of music because it was not, for most purposes, h manly readable (*White-Smith Music Publishing Co v. Apollo Co, *209 US 1). For similar reasons, it has been argued that a program in object code lacks communicative potential and might therefore be constitutionally uncopyrightable. But, as CONTU points out, copyright protection has been extended by the courts to such diverse works of authorship as freight tables, interest tables, and lists of similarly meaningless five-letter code "words." These works of authorship, like computer programs, are valued for their utility, rather than their artistic merit.*

Ross Olmsted
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Legal Protection for Computer Hardware and Software

Stephen A Becker
Lowe, King, Price & Becker
Suite 209
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Picture the following:

Tinkering at your home, you develop a program or hardware innovation that, you believe, can be sold for a handsome sum. When you consider marketing your development, justifiable paranoia strikes, as it becomes painfully apparent that an unscrupulous competitor could easily copy your program (by exact reproduction) or hardware (by duplicating the schematic diagram or by employing *reverse engineering*).

Question: How can a hobbyist or small businessman, with limited resources, guarantee that the law will provide protection against such unfair competition?

Answer: There are no guarantees.

Patents, *copyrights*, and *trade secrets* are the three basic forms of legal protection that are primarily applicable to computer-related innovations. Unfortunately, there is no single form of protection for all the different varieties of hardware and software that is entirely satisfactory to the small businessman. In fact, this also applies to large businesses with virtually unlimited resources.

About the Author

Stephen A Becker has a master of science degree in electrical engineering. He has been granted two patents for his work in electronic control systems while working as a research engineer. After obtaining a law degree in 1975, he entered the field of patent law. Attorney Becker specializes in the protection of intellectual property innovations, with particular emphasis on computers, and is a partner in the patent law firm of Lowe, King, Price & Becker.

The following discussion provides some general legal background on a very complex and growing subject. However, I encourage you to confer with a patent attorney (registered with the United States Patent and Trademark Office) who specializes in all forms of intellectual property protection, prior to entering the marketplace. Also remember that this discussion concerns US law only. If you have an international market, professional advice is even more essential.

Patents

Patents provide a formidable protection for innovations that meet the rather stringent legal requirements of patentability. The right to a patent is fragile and can be lost by certain avoidable acts, such as public disclosure or an offer for sale more than one year before the patent is applied for. A patent, once granted, gives the patent owner the exclusive right to make, use, or sell the patented innovation in this country for 17 years. The patent owner has the right to stop others from infringement and collect damages even if the infringer later developed the same invention independently. After the 17-year period has expired, the innovation is considered to be in the public domain and available to all without limitation.

In order to qualify for a patent, the invention must be *new*, *useful*, and *unobvious* in view of existing technology. In fact, before a patent is granted by the United States Patent and Trademark Office, a patent examiner conducts technological research to determine whether the invention is adequately different from the existing technology to merit an award of "Letters Patent." About one dozen patent examiners, who specialize in computer technology, work for The Patent and Trademark Office.

Unfortunately, the procedure of applying for a patent is very expensive. In most cases, a patent attorney or agent must be retained to prepare a patent application and to submit arguments in favor of patentability before the Patent and Trademark Office during the approximately 18-month period of examination. During this time no patent protection exists. Patent rights are created only when a patent is actually issued. Furthermore, there is no guarantee that you will receive a patent. The Patent and Trademark Office may rule that the invention does not qualify for patent protection. They may do this for one of two reasons: because the invention is not the type that patents are designed to protect (eg: mathematical algorithms) or because the invention is simply too close to existing technology to be considered "unobvious."

It is definitely possible to obtain a patent on hardware innovations, such as peripherals, interface circuitry, or construction techniques. There is considerable uncertainty, however, concerning what types of computer software, if any, can be protected by a patent. In 1972 and 1978, Supreme Court litigation between patent applicants and the Patent and Trademark Office resulted in denials of patent protection on programs that

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are essentially mathematical algorithms, such as numerical conversion.

But in more recent cases (in 1980 and 1981) the Supreme Court begged the question of whether or not other types of software may be patentable. The Court of Customs and Patent Appeals (CCPA), which reviews Patent and Trademark Office decisions and is highly regarded for its competence in patent matters, has held that certain other types of software may be patentable. Issuance of patents has been denied by the CCPA only on software that is essentially algorithmic in nature. Thus, it is still unclear what types of software will ultimately be considered patentable if and when that broad issue is considered by the Supreme Court.

On the other hand, the courts have held that inventions are not unpatentable merely because they involve programming. For example, consider a microprocessor-based system that is programmed to operate with an array of sensors to monitor a physical parameter in a unique way and to process sensor-generated data in accordance with a stored program, generating machine-control signals. This system is patentable if it satisfies the three basic criteria of novelty, usefulness, and non-obviousness. Thus, patent protection is available to computer-related innovations involving programming so long as the invention is in the overall system and not solely in the program.

Because the costs involved in obtaining patent protection are high and the law of software protection is still uncertain, I do not recommend patents as an avenue of protection of programming by the personal computer experimenter or small businessman. However, if the invention involves more than just programming (eg: a complete system involving programming, or a new piece of hardware) and there is a significant commercial potential associated with the invention, then Letters Patent should be considered to increase the likelihood of success in the commercial environment.

Copyrights

A copyright is essentially the right of an author to control the copying of his or her work by others. It is applicable to computer software but not hardware. A copyright is easy and inexpensive to obtain. It must include the following comment at the start of the program:

© <name of copyright owner> <date of first publication>,

© John Doe 1979

In order to perfect the copyright, as is necessary before a copyright infringer can be sued, the copyright must be registered with the Copyright Office by filling out a FORM TX. (The address is: United States Copyright Office, Library of Congress, Washington DC 20559.) After you fill it out, mail it with two copies of the program as originally published (or publically disseminated) and a $10 registration fee.

If the program is on magnetic tape or other non-readable form, a printout must also be deposited. Even if you do not register the copyright, you are required to deposit copies with the Copyright Office within three months of the date of first publication of the program with the copyright notice.

As a practical matter, however, there is no penalty for non-deposit in the absence of registration, unless the Copyright Office specifically demands a deposit. Details on software registration can be obtained directly from the United States Copyright Office or from an attorney specializing in intellectual property law.

The term of a copyright extends throughout the lifetime of the author plus 50 years. In the case of a work made for hire, the term is the earlier of two periods: 75 years from the year that the work (ie: program) was published, or 100 years from the year that the program was written.

Although the cost and effort of obtaining a copyright on software are minimal, and although there is virtually no time delay or uncertainty (as in patents), a copyright offers substantially less protection than a patent. First, the copyright covers the "expression" (ie: program listing) of software but not the idea, procedure, or concept underlying the software. A competitor could, for example, use the copyright owner's basic procedure or method of solution without infringing the copyright if a different but equivalent program is developed. Also, the copyright owner is provided no protection against competitors

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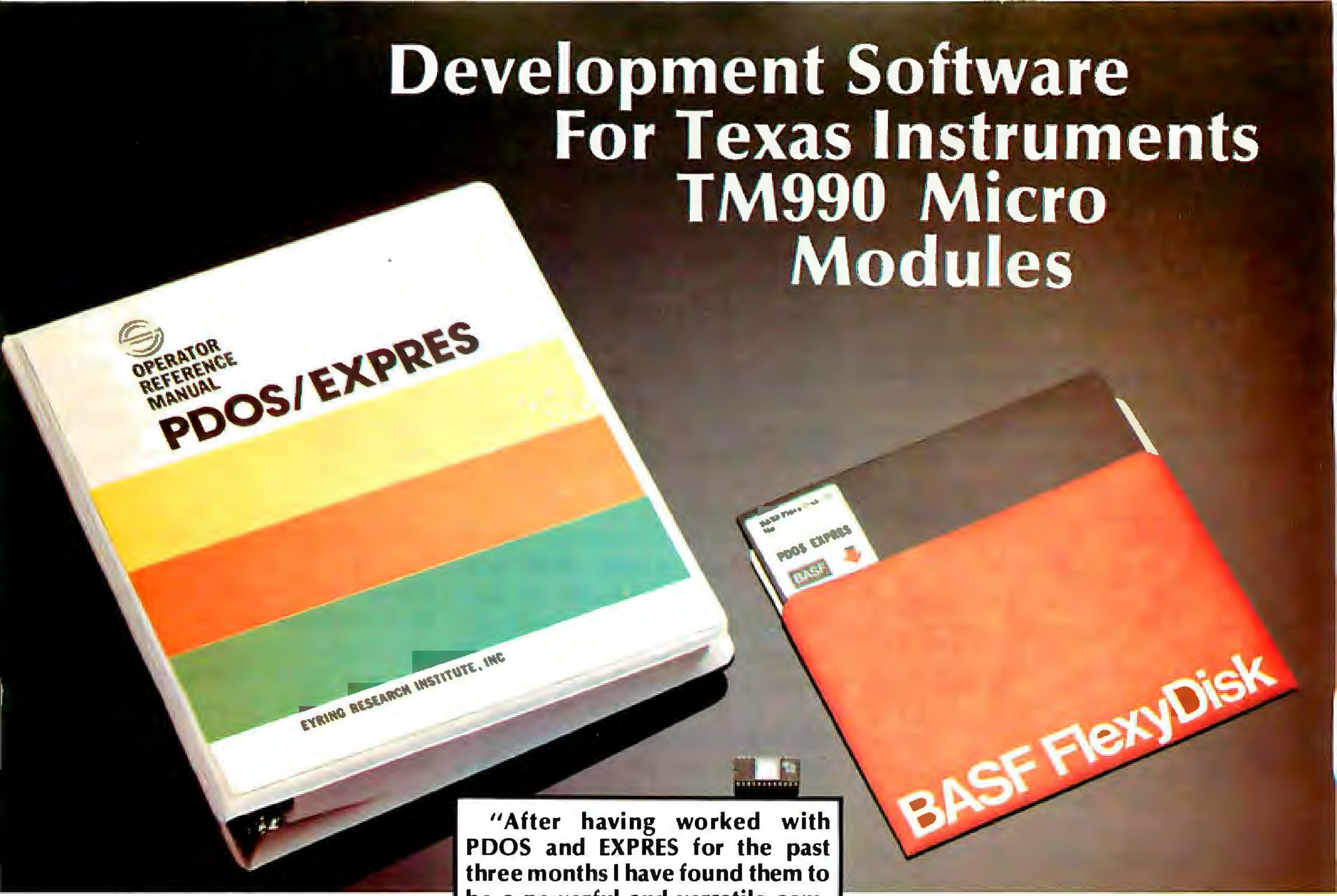

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who independently develop the same program; a copyright offers protection only against actual copying.

This may be enough protection for many computer programs. But the form of expression of a program is often critical and modification of that expression often destroys or substantially reduces its utility. I recommend that programmers routinely include the copyright notice in a comment statement at the start of each program prior to distribution, and postpone registration of the copyright until a lawsuit for copyright infringement is contemplated.

A word of caution concerning copyrights: there is presently some uncertainty whether, and to what extent, computer programming is a proper subject for copyright protection. An early attitude was that programs could not receive copyright protection because they are part of a machine rather than a literary work. Present sentiments, however, are that at least the "expression" of the program should be protectable by copyright. This issue may soon be settled because Congress is expected to consider subcommittee recommendations to amend the Copyright Act.

(Editor's Note: *Source listings are unequivocably covered by copyright laws, but the extent of copyright protection as it is applied to programs in other forms is less clear. For further explanation, and a discussion of Supreme Court rulings regarding software patents, see "Washington Tackles the Software Problem," page 128.)*

Trade Secrets

A trade secret is commonly defined as a formula, process, mechanism, compound, or compilation of data, not patented, but known only to certain individuals using it in business to obtain a commercial advantage. In order for there to be a trade secret that will be enforced by the courts, a secret must exist and there must be a duty on the part of all persons who learn the secret not to disclose it. Confidential relationships are generally established between employers and employees or between businesses cooperating in a technical development by a type of contract known as a confidential disclosure agreement. For example, if you, a small businessman, wish to submit your unpatented innovation to a corporation for evaluation you may request that a corporate officer sign a confidential disclosure agreement. Such an agreement states that the corporation agrees to use your disclosure only for the purpose of evaluation and to disclose it outside the company only with your express written approval. The agreement will require the company to bind all its employees to confidentiality. However, the agreement must not be too restrictive to prevent the company from properly evaluating your innovation. Some companies may not be willing to sign a confidential disclosure agreement and, in fact, may even require you to agree to non-confidentiality before they will review an outside innovation.

A trade secret automatically exists between a patent applicant and the Patent and Trademark Office during the period of examination of the patent application. The Patent and Trademark Office is required by law to maintain the application in secrecy.

The Coca-Cola formula is an example of a successful trade secret which has never been patented and is known only to some internal personnel. For a trade secret to exist the subject matter must, in fact, be maintained in secrecy. But trade secrets are easy to lose. Once the secret becomes public, for example, legal protection is lost. It may become public through your own carelessness or through commonplace and legal competitive means, such as reverse engineering. A trade secret is not lost, however, if a competitor obtains the secret by unfair means, such as industrial espionage. The courts are filled with lawsuits involving piracy of trade secrets—including cases that involve theft of software and data by such means as tapping communication lines.

One advantage of trade secrets, in contrast with either patents or copyrights, is that the trade secret exists as

long as the secret is maintained; it does not expire after a predetermined finite lifetime. There are no formal procedures, applications to fill out, or government fees to pay to establish a trade secret. Furthermore, there are no delays because the trade secret becomes enforceable as soon as it exists.

Unless you are in a position to maintain your software in secrecy and to bind all parties involved in confidentiality by contract, a trade secret is apt to be lost through inadvertence or by acceptable competitive efforts. For example, in the absence of restrictive licensing, there are no legal means to prevent a competitor from purchasing your software for the purpose of reproducing it for sale to his own customers. Of course, if the printout carries the copyright notice and the program is copied by the competitor verbatim, you will have a claim for copyright infringement following registration of your copyright with the Copyright Office.

Trade secret protection is at best very risky and can be lost for any number of reasons both inside and outside your control. In addition, there is some conflict between copyright law and trade-secret law since copyright protection is based upon publication, whereas trade-secret protection prohibits publication. Therefore, care must be taken to indicate that there is no presumption of publication of programs carrying the copyright notice that are distributed under restrictive licenses or confidential disclosure agreements. Even then, once the program is deposited with the Copyright Office, trade-secret protection may be lost.

Protection

The type or types of protection that should be considered for programs and computer-related developments depend upon several factors. These are:

- the nature of the development, that is, whether it is basically a mathematical algorithm of some other type of program or computer-based system merely involving programming
- the commercial importance of the invention
- the commercial lifetime of the invention
- the importance of exclusivity in the marketplace

Patent protection should be considered for hardware, or for computer-based systems, when the novelty involves more than merely the programming, if there is significant commercial potential and there is a commercial lifetime of at least several years.

Software should bear the copyright notice, despite uncertainties in the law, and I even recommend applying the copyright notice to printed-circuit boards to protect direct copying of circuit layouts. Trade secrets should be relied upon only when you are in a position to actually maintain your software or hardware systems in secrecy and bind your employees to secrecy and customers by contract; this is generally not practical where public sales are made. An old practice for maintaining circuitry in secrecy has been to embed the circuitry in epoxy, to prevent reverse engineering by inspection. It may even be necessary to embed small metal particles in the epoxy to prevent inspection by X-ray photography. Obviously, this approach is impractical for the small businessman working in the public market.

Whenever possible, software should be sold under restrictive licenses between you and your customers. Under the license terms, the software remains your property, while the customer is permitted to use it but not reproduce the program for use by others. A patent attorney will be able to draft a restrictive license to meet your particular requirements.

Most patent attorneys are also engineers who specialize in all areas of intellectual property, such as patents, trademarks, copyrights, and trade secrets; they are in a position to develop a portfolio of intellectual property protection suitable to your particular needs. I strongly recommend that you consult one before you attempt to market any product.■

Software Review

Dancing Demon from Radio Shack

Elizabeth Cooper and
Yvon Kolya
POB 22
Peterborough NH 03458

Radio Shack's latest addition to its games line is a fantastic graphics and sound game called Dancing Demon. The author of this well-designed gem is Leo Christopherson—the creator of Snake Eggs and Bee Wary, those wonderfully graphic but nonsensical games.

Dancing Demon is a fairly sophisticated music-generating program which uses carefully synchronized moving graphics and impressive sound.

Written in BASIC, the game places you in the role of agent/operator of an ex-devil called the Dancing Demon. As his agent you must choreograph his dance steps to music you compose.

The documentation is careful to explain that the demon is rather dim-witted and understands only a special code for the music and dance steps. This code assigns one note to each letter of the alphabet. Covering a full two octaves (25 notes total) the "A" key equals low C and the "Y" key is equal to high C. The "Z" key is reserved for rests between notes.

After selecting the demon's music, you are given the opportunity to choose his dance steps. (If you wish, you can select the dance steps first; the order is up to you.) The same simplistic approach is also used for this procedure. The letter "A" represents Step 1, the letter "B" represents Step 2, and so forth to the letter "Z," a total of 26 different steps.

The instructions are clear and to the point; at times, they are clearly geared towards young children.

The program is as easy to understand and the documentation is clearly written. After CLOADing it and typing RUN, you see the main program menu. The menu options are:

1. Compose your own music
2. Create your own dance routine
3. Make the demon perform the pro gram in memory
4. Save your show to tape
5. Load a show from tape
6. Make the demon perform the first preset show
7. Make the demon perform the second preset show

The last two options are usually the first ones chosen. These two opening numbers give a good example of the capabilities of the demon and are quite entertaining.

Continuing up the menu in reverse order, you have the option to LOAD (from tape) a show previously composed, or to save to tape a show you have just perfected. Both of these options are arranged simply so children should experience little difficulty.

Option three lets you play the show currently in memory. You are asked two questions: The first question asks for a speed factor, which determines how fast the music plays, and how fast the demon executes the dance routine. Any number between 1 (super fast) and 255 (very slow) may be entered.

The second question asks how many performances of this routine you wish to see. Again, you may answer with a number between 1 and 255.

After you've answered the questions the screen displays the theater stage, the curtain rises, and the demon starts his performance.

Option two lets you program the dance steps to be used by the demon. The steps have enough variety to be entertaining and yet the differences are subtle enough so that any combination of steps will result in a credible dance routine. Since the steps are designated by letters of the alphabet, you can amuse yourself by typing in actual sentences and watching how these are translated into movements by the demon. You can even type in the words to the song you've just

At a Glance

Name of software package
Dancing Demon

Type of package
Game

Manufacturer
Radio-Shack
1600 Tandy Center
Fort Worth TX 76102

Price
$9.95

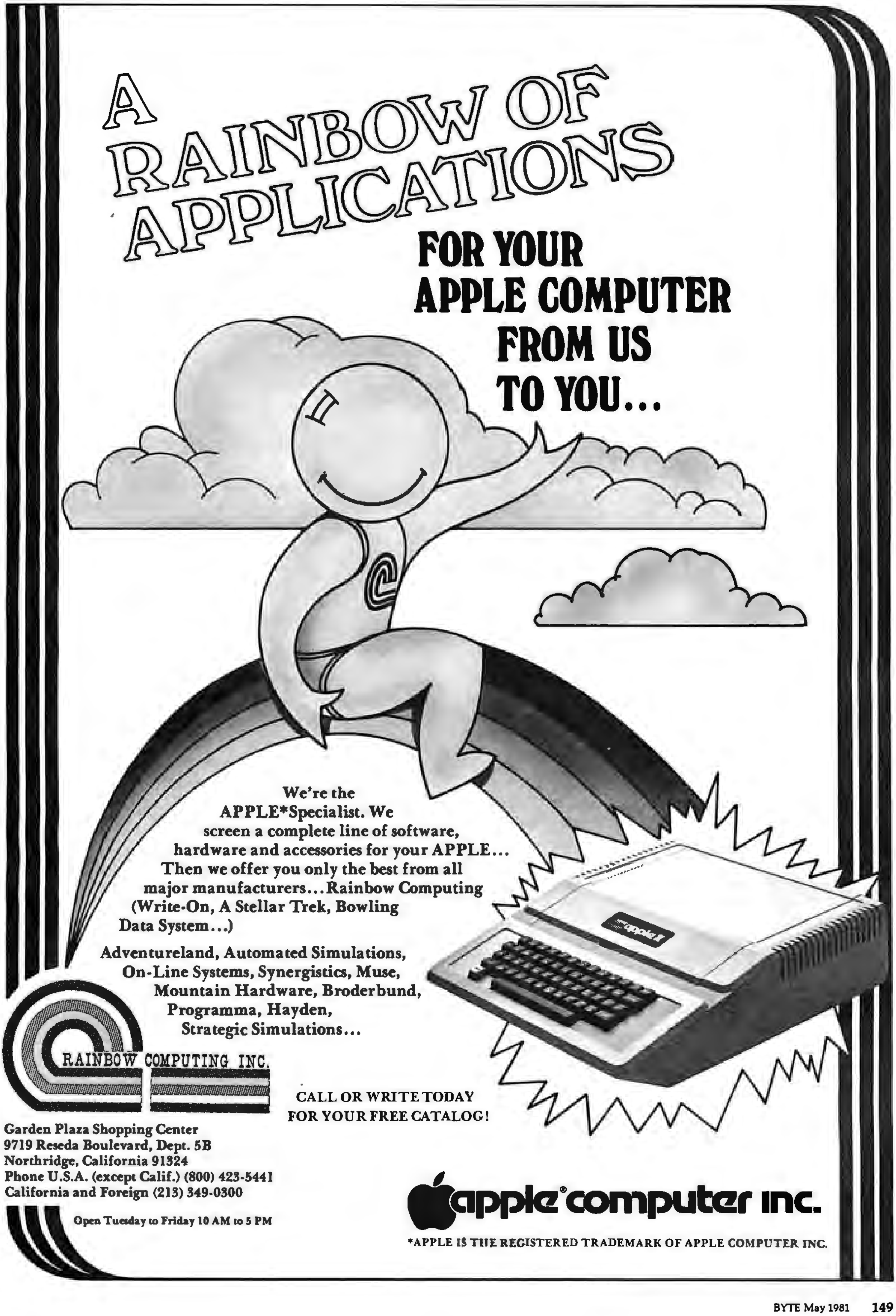
Format
Cassette tape

Language used
BASIC

Computer needed
TRS-80, Level II BASIC, 16 K programmable memory

Documentation
13 pages, 8½ by 11 inches

Of interest to
Children, parents and grown-ups who are kids at heart



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entered into the music section of the program.

One very nice feature is the "preview." By pressing the space bar you can see the demon dance the routine as you have entered it so far. If you don't like it, you can easily change it. The only restriction is that you are limited to a maximum of 248 dance steps in the routine.

Once you're satisfied with the dance routine performed by the demon, you enter it into "permanent" memory by pressing the ENTER key. This also returns you to the main menu. Finally, option number one lets you enter the music to which you want the demon to dance.

While the basic idea of the musical accompaniment seems quite simple, in actuality, it is considerably more difficult to create (or recreate) a musical melody than it is to design a workable dance routine. As with the dance steps, each note is designated by a letter of the alphabet. To include a rest, the "Z" key is used. What's confusing is the fact that there cannot be a direct correspondence between the letters of the keyboard and the letters of the musical scale. This is because the sharps, flats, and octaves (ie: the notes low C, low C#, high C, etc) cannot all be matched to the keyboard letter "C"; instead, they are matched to the keyboard "A," "B," and "M" keys, respectively. Even for someone who already plays music of a more conventional sort, it's like learning an entirely new instrument. For those who read music, a chart matching the keyboard letters to their appropriate places on the musical staff might have been a very welcome addition to the documentation.

Then again, it might be easier to take the advice in the instructions and simply pick out tunes by ear. When you're programming music, each press of a key results in the appropriate note being played, and the appearance of that key's symbol on the sequence list.

To hear the sequence you've input so far, press the space bar. This is an excellent feature, since it is always encouraging to hear your progress up to this point, and it's easier to spot and correct mistakes. As in option two, when you're satisfied with the music sequence, press ENTER to have it added to memory, and to return to the main menu. You are limited to a sequence of 248 notes. There's no need to worry about having the same number of notes as you have dance steps. The music sequence repeats (if necessary) until all of the dance steps in the sequence have been executed.

Conclusions

Dancing Demon, Radio Shack's newest graphics and sound game, is an admirable addition to its game line. It combines an entertaining graphics routine with an equally amusing sound routine (including the clicks from the demon's tap-dance shoes). Because of the unusual combination of sophistication and simplicity, this game could be an excellent means of sparking and fostering the creativity of children.

The game sells for $9.95 and, we feel, it should be purchased by anyone with children. We heartily recommend it. ■

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Wire-Wrapping and Proto-System Techniques

Adolph Mangieri
POB 384
New Kensington PA 15068

The cost of microprocessor, memory, and peripheral devices has plummeted, while the details of computer circuit theory and design have become widely available. In combination, these conditions are enticing a greater number of hobbyists to build and experiment with computer circuits. However, the process of translating published circuits and personal circuit designs into functioning hardware can create unusual problems.

Whether you build a system from the ground up or expand an already-existing system, your initial choice of wiring and prototyping techniques will have a substantial impact on both the effort required and the success of the project. Plugboard systems break a computer system into manageable and easily documented circuit blocks. For rapidity in wiring, assembling, and later modification of the project, wrapped-wire techniques best serve the computer hobbyist.

Wrapped-Wire Connection

A *wrapped-wire* connection is made up of six closely spaced turns of solid copper wire wrapped, under tension, around square, sharp-edged metal posts. Both the wire and wrap-post edges become indented, forming a number of gas-tight contacts with a total resistance of less than three milliohms. An additional turn of the insulated wire at the start of the wrap process prevents wire breakage under conditions of extreme vibration, and also reduces the possibility of a short circuit from the lowest turn of exposed wire to a nearby trace or ground plane on the circuit board.

The wrapped connection is made with a metal tube that has a central hole in one end for a wrap post and a smaller hole (alongside the first) that accepts a piece of wire. In conventional insulated wire wrapping, a piece of wire is cut to length and the ends are stripped of insulation. One end is inserted into the wire hole in the wrapping tool, and the tool is then placed over a wrap post. As the tool is rotated, wire is pulled from the hole at a 90 degree angle and wrapped around the post, creating enough drag and tension to make a good contact. This method requires a separate wire for every connection. It is also possible to connect a number of posts with a single unbroken strand of uninsulated wire— a process known as *chaining*. However, bare-wire chaining is suitable only for installation of ground buses or isolated jumper connections.

Fortunately, *insulated* wire chains can be made with special wrapping tools recently introduced by Vector Electronics.

Wire-Wrapping Tools

The Vector Electronics model P180 Slit-N-Wrap is a high-speed chain-wrapping tool that eliminates wire cutting and stripping. A top-mounted wire spool holds 100 feet of #28 gauge nylon-polyurethane insulated wire (available in four colors). Wire exits the wire hole, and a sharp cutting edge slits the insulation to expose a portion of bare wire as you form the wrapped connection. The tool is supplied with two spools of wire and a P183 chisel knife and wire-forming tool, for routing wire and nipping off the beginning end-tail.

The nylon-polyurethane insulated wire resembles magnet wire, and it may be wrapped around an odd-sized terminal and soldered directly through the insulation. (However, you should exercise caution in avoiding the dragging or binding of wire against sharp wrap-post edges.) The thin but tough wire insulation barely increases wire diameter or stiffness, and as a result, the tool maneuvers smoothly on dense wire-wrap boards.

A similar high-speed tool, the Vector model P184 Tefzel Slit-N-Wrap, chain-wraps #28 gauge Tefzel insulated wire. This tool is supplied with two 50-foot spools of wire in different colors. Tefzel insulation is relatively thick, allowing carefree wire wrapping and eliminating any chance of a short circuit, but the wire also handles somewhat more stiffly. Both Slit-N-Wrap tools must be rotated clockwise to slit the wire insulation, and both wrap their wire type conventionally.

The Vector P160-2A Dual-Way Wrap-N-Strap is a conventional tool that wraps #30, #28, and #26 gauge wire. Bare-wire chaining or strapping is possible by feeding wire down through the hollow handle. The

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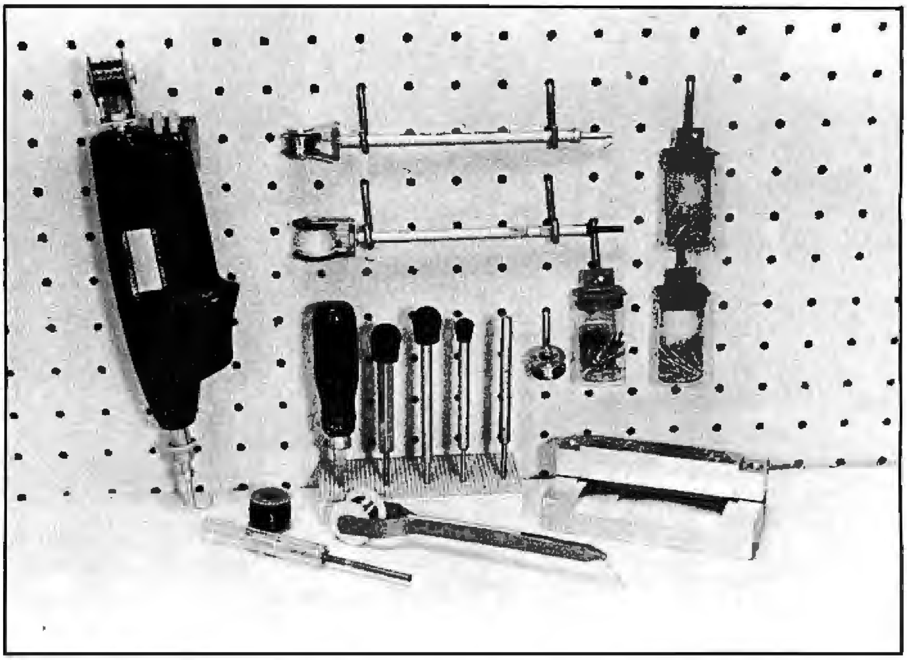

Photo 1: *Available wire-wrapping tools include the Vector P180 Slit-N-Wrap, installed in a P160-4R cordless driver unit (left), the P160-2A-1 Dual-Way Wrap-N-Strap (top center), and the P184-Tefzel Slit-N-Wrap (below). The stand (center) displays five different pin-insertion tools. In the foreground (left to right) are the P160-1A Dual-Way unwrapping tool, P178-1 wiring pencil, and the P187 IDC fixture for assembling IDC ribbon cables.*

P160-2A-1 wrapping tool is a similar instrument, but it has a top-mounted spool to hold the bare wire. Both tools offer a solution to the problem of inserting wire (especially the remaining end of a very short wire) into the wire hole. Each tool has a recessed tip with a cross-slot that allows wire insertion without up-ending the tool or fumbling about on the board. The Vector P160-1A Dual-Way unwrap tool has a retractable hood that catches the unravelled wire when you unwrap a connection.

Even chaining can become tedious if you wrap a large backplane or motherboard, but a powered wrapping tool can make this kind of operation less tiresome. Powered wrappers are versatile hand-held units that contain an electric motor and a hollow main spindle that accepts the handles of various manual Vector tools. These electrical tools can make a single wrap in seconds; chains can be wrapped as quickly as the tool is moved to the next wrap post. However, the powered wrappers are bulkier and less easy to handle when routing wire on a densely populated circuit board. The Vector model P160-4R wrapper (see photo 1) is powered by rechargeable nicad batteries. The newer model P160-4R3 has a hand-fitting pistol grip. The P160-4T1, supplied with the P180 wrapping tool installed, is similar in design, but it operates off 110 V AC lines. The battery-operated P184-4T model, and the line-operated P184-4T1 Electro-Wrappers are supplied with the P184 Tefzel wire-wrapping tool installed.

Another recently developed wiring technique uses a wiring pencil. The pencil dispenses solder-thru insulated wire from a top-mounted wire spool. Instead of wrapping a connection, you simply loop several turns around a terminal and begin to solder. This technique permits assembly of low-profile plugboards with low-profile solder-tail sockets. The Vector model P178-1 wiring pencil dispenses either #36 gauge or #32 gauge solder-thru wire and #30 bare tinned wire. The tool is supplied with one 400-foot bobbin of #36 gauge wire (available in three colors).

Wrap Posts and Accessories

Vector can supply wrap posts in many styles, along with DIP (dual in-line pin) wrap-post sockets of all

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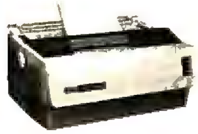

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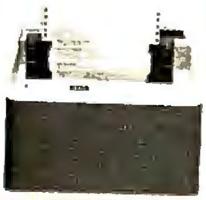

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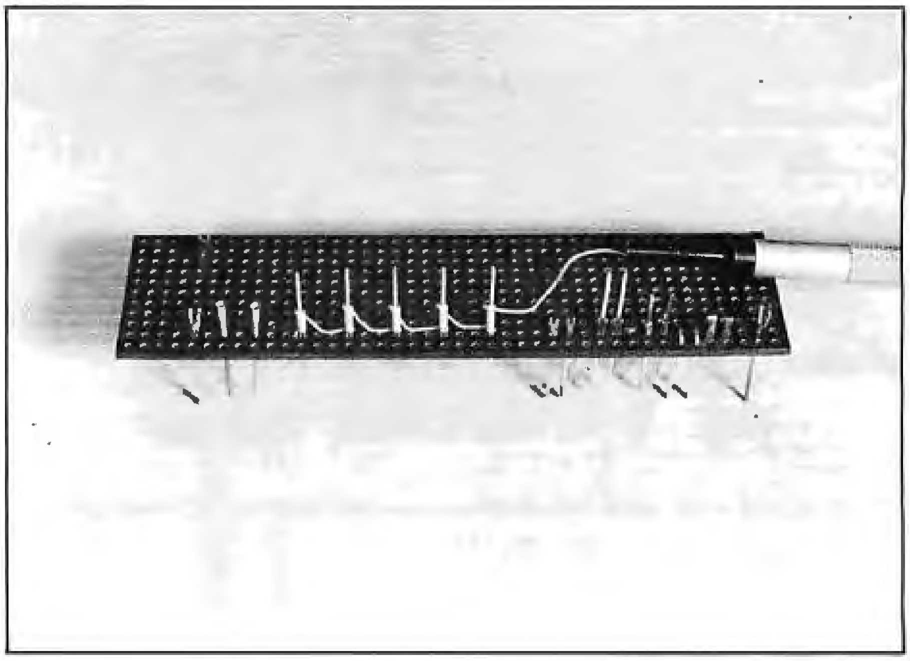

Photo 2: *Rapid assembly of circuit boards demands insulated-wire strapping or chaining techniques, as demonstrated with the P184 Tefzel Slit-N-Wrap tool. The wide variety of board pins shown can handle any wiring situation.*

sizes. At least four pin styles and several pin insertion tools will be needed to assemble a project. Wrap posts are 0.025 inches square (0.64 mm) and are push-fitted into 0.042 inch (1.07 mm) holes. The T-49 Klip Wrap post has a three-way fork (see photo 2) at one end for support of discrete components that may be snapped in place or soldered. You can install this pin with the Vector P156 insertion tool. For soldered installation of discrete components, the T-44 Miniwrap pin has a small slot at one end and is installed with the A13 hand tool. The K-32 J-pin passes through two holes and the short leg is bent to the board. Substitute DIP sockets can be made using these pins.

The Vector T46-5-9 pin is one of several pins that has a crossbar on the shank. The pins are installed with the aid of the P205 insertion tool, and crossbars are aligned to accept female IDC (insulation displacement connector) plugs of ribbon cables. The T46-4-9 pin is similar in design but single-ended, and it passes a card-finger pad or power plane to the other side of the board. Other single-ended board-feed-thru pins include the T46-4 and T51 pins. Typical of a family of pins having no crossbar, the T46-3 double-ended pin is inserted with the P133A insertion tool. Use these pins when the laterally extending crossbar pins create a problem. To assemble sockets for small transistors or integrated circuits, you can use the R31 and R32 socket pins. Use the Vector MB45-20 perforated alignment block to back up the board and assure perpendicular installation of board pins. Photo 2 shows useful pin styles and a sample Tefzel-wire chained connection.

Although the use of Slit-N-Wrap chaining tools reduces time spent forming the wrapped connections, it can be tedious to wire-wrap a circuit that includes hundreds of connections. Much of the time is spent referring to the schematic and plugboard diagrams, locating the pins on the circuit board, forming and routing wires, and correcting wiring errors. A particular circuit board may have markings (eg: socket pin numbers) that can be helpful in wrapping your circuit, but these marks are quickly obscured on a crowded board with hundreds of closely spaced wrap posts. Correcting wiring errors can be time consuming, as the wire in question is often buried under several layers of wires. Make sure that you are properly oriented when you make the connections: it will reduce the

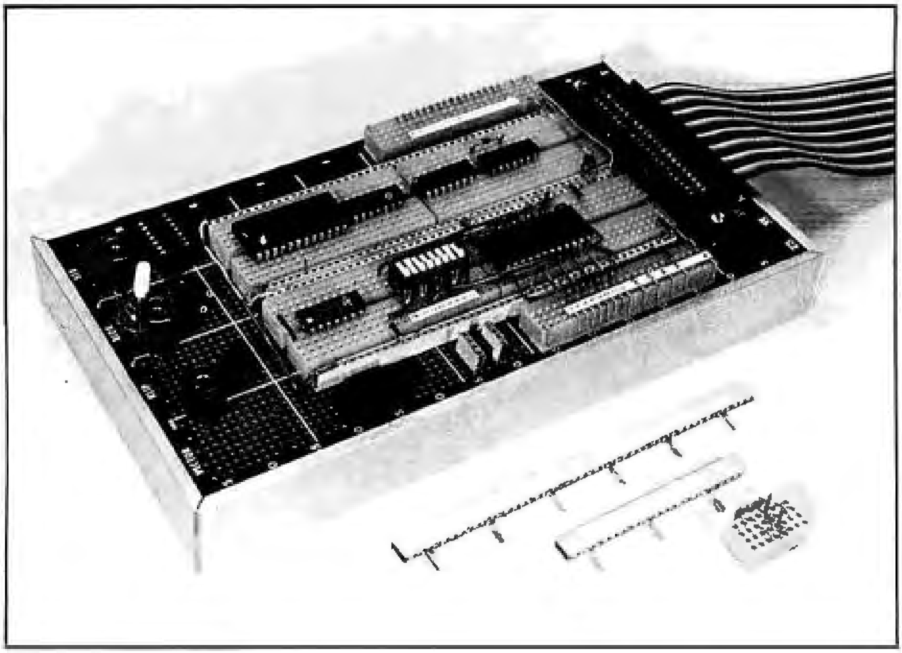

Photo 3: *A DIP (dual in-line package) patchboard or breadboard, such as the Vector 51X patchboard, is indispensable to circuit development. This patchboard is top and bottom wirable and can be easily linked to a computer with an IDC ribbon cable.*

amount of time devoted to the wiring operation.

To install a chained wire-wrap run correctly, push short lengths of insulation over each post as you identify it, then select the best route for the run. You should begin at the end that allows easy removal of the first wire anchor with a chisel knife. Remove the markers as you proceed, taking care to insert the tool on the marked pin. Check the completed wire run for errors before you proceed.

Avoid taut wire runs that can result in wire breakage or bent wrap posts. When removing the tool from a wrap post, use the tip of the wrapping tool or the wire-forming tool to mold the wire to the board. An excellent wire-forming tool can be made from the wooden handle of an artist's paint brush. Sharpen one end in a pencil sharpener and fashion a screwdriver blade at the other end. Use both the wrapping and the wire-forming tools as you form and route wire to the next wrap post. To reduce crosstalk, avoid bundling wire runs, and approach or pass the wire between socket pins perpendicular to the plane of the pin rows. To begin the next wrap, use the forming tool to press the wire to the board: do this slowly, using no down-pressure on the first turn. If you use the P180 wrapping tool, start the wrap slightly above an etched plane. Wire breakage rarely occurs, but it is usually the result of a sudden start on a taut wire.

Pencil Wiring

When you assemble a board that uses solder-tail (low-profile) DIP sockets, use the pencil wiring technique. After you chain-wrap the interconnections, solder the looped turns with a soldering pencil heated to a temperature of 750 degrees F. The heat melts the nylon-polyurethane insulation, which allows the solder to bond the connection. The Vector P178-1 wiring pencil is supplied with #36 gauge solder-thru wire, but spools of #32 gauge solder-thru wire and #30 gauge bare wire can also be used.

Orbit the tip of the wiring pencil around the terminal or socket pin, placing the loops of wire somewhat above the board surface. Due to the additional soldering time required to melt the wire insulation, you should use soldering heatsinks to protect delicate components. If this is not possible, tin a portion of the wire before you form the loops (this premelts the insulation). You can obtain a satisfactory connection by solder-wetting the loops on one side of the terminal or component post: this reduces soldering time.

You can use the Vector P179WS series of plastic wire spacers to route the wire neatly. The wire spacers are push-fitted into the board and have a number of wire-retaining slots top-side. Low-impedance ground circuits may be obtained by running a second or third wire parallel to the first run, or you can pencil-wire the ground bus with Vector W30-4 #30 gauge tinned bare wire. Install discrete components on the T42-1 micro-clips or flea clips.

DIP Patchboard

The DIP patchboard or breadboard is a necessity for developing and verifying circuit designs. The breadboard includes strips and banks of tie points that accept DIP devices, jumper wires, and component leads. Photo 3 shows a Vector 51X DIP patchboard that, with the addition of an IDC 40-conductor ribbon cable, is modified to link up with a TRS-80 computer. Model 51X-GP is similar, but the supporting board has a ground plane. To make a large patchboard, you can install four 51X-GP-2 assemblies in the 43X-4 Multi-Conn chassis. A patchboard (including plugboards) can be assembled on any p-pattern board by inserting the large T66-96 Klip-Bloks, the T45-48 Klip-Bus, and similar components in any pattern. These unique systems can be wired from either side of the board. Wrap posts pass directly through the tie points to the other side.

A good ground system on the patchboard is imperative. Push long wrap posts through all device ground points and chain-wrap the pins on the bottom side to form a ground grid. Bypass the supply line with a 100 μF electrolytic capacitor and a 1.0 μF tantalum capacitor, and bypass the supply pins of all monostables and flip-flops with a 0.1 μF disk capacitor to ground. One bypass capacitor for every pair of DIP packages should suffice for other devices. Use short jumper wires and keep the wires separated. You can measure the current drain of the patchboard with a meter, but be sure to short out or

Circle 393 on inquiry card. →

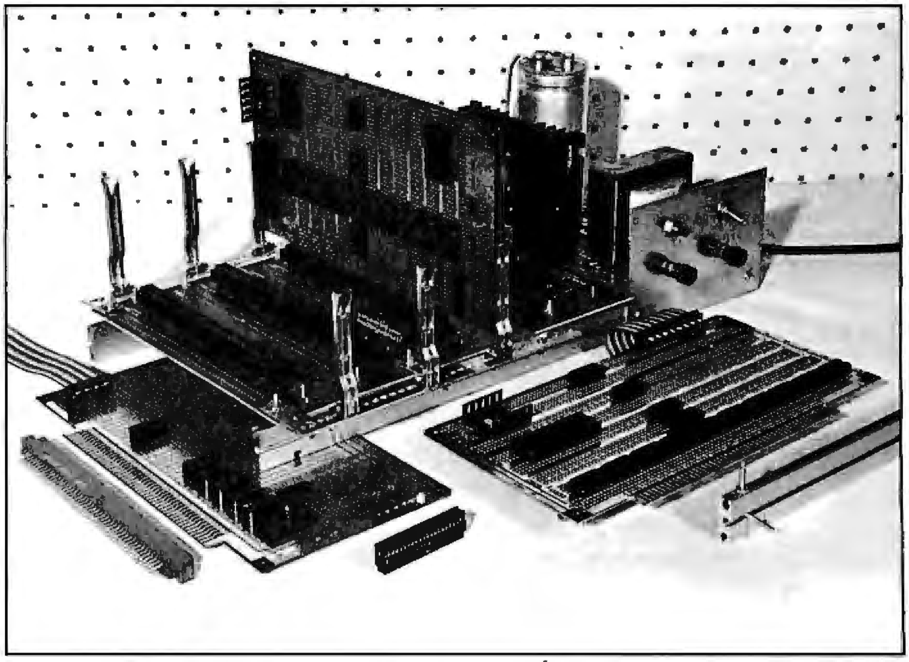

Photo 4: *Low-cost open-frame S-100 bus mainframe uses a Vector 8803 motherboard and T169 T-struts. S-100 prototyping boards include the model 8800V in the mainframe, an 8804 Any-Dip board (right), and the 8802 pad board (left). Shown in the foreground (left to right) are the R681-2 plugboard receptacle, KS2-40 female IDC connector, and T169 T-strut. The power supply (rear) bolts to T-struts supporting the S-100 motherboard.*

remove the meter when you run operating tests.

Plugboard Proto Systems

Plugboard systems for the stand-alone microcomputer or for expansion of an existing system are easily assembled at low cost using Vector card-cage components. You can then add card receptacles to these open-frame systems when needed.

An inexpensive S-100-bus system can be built using the components shown in photo 4, based on the Vector 8803 motherboard. The board accepts eleven Vector RS681-2 card receptacles that are easily soldered to the hot-tinned solder-masked board. A portion of the board includes printed-circuit traces for installation of either active or passive bus terminations.

Install the S-100 motherboard on a pair of Vector T169 T-struts (see photo 4) using the insulating spacers that are supplied, and secure it with SC4-28 hex-head screws (these slide into the strut). The BR27D card guides are mounted on the motherboard, on a length of B63-240 punched mounting plates. There is ample room to the rear for installation of an S-100 mainframe power supply for the stand-alone system. The 8803 motherboard mounts directly on the T-struts of the Vector Pak VP1 and VP2 deluxe table-top microcomputer cabinets. These cabinets include card guides and a mounting plate for the power supply.

For prototyping or the assembly of system components, select from plugboards optimized for wire-wrapping or soldered-wiring techniques. The Vector model 8800V microprocessor board has a number of wide vertical bus bars on both sides that form the ground and supply planes. The connecting zig-zag buses between the bars accept board feed-thru pins. The supplied heatsink mounts on either end of the board which supports two on-card voltage regulators, one of which is prewired to the power plane. Device sockets are mounted vertically, in four rows and twelve columns, with labeled pin numbers. A connector for IDC ribbon cable may be installed at either end of the board. The Vector 8804 Any-Dip board (which is similar to the 8800V model in many respects) accepts

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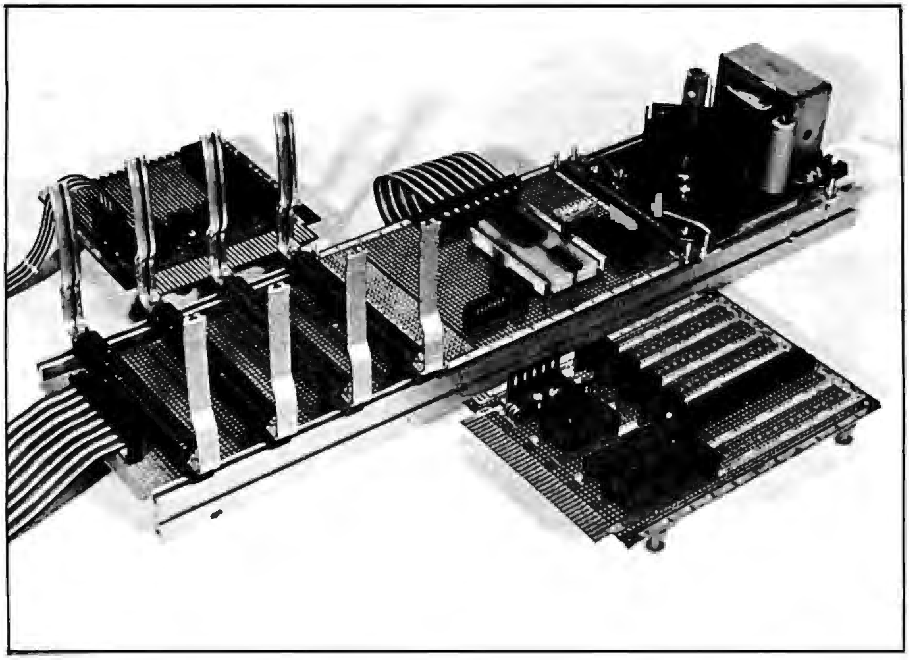

Photo 5: *A system bus with fewer than one hundred lines can also be assembled using standard Vector components. The seventy-two-line combination system pictured here is a typical example. Primary components include the R636-1 receptacles, a 3677-7 clearance ground-plane board on the wire-wrapped backplane, and a Vector 8004 Circboard in the patchboard area. Plugboards include the model 4066-1 ground-plane board (top left) and the 4493 Any-Dip board with opposing power and ground planes. The system is powered by a Jameco model JE200 power supply.*

sockets horizontally, in seven rows and ten columns, and its IDC cable connector resides anywhere along the top edge of the card. With sockets parallel to the card-finger array, this board allows easy wiring of card buffers and memory arrays.

You can choose from four S-100 plugboards that tend to favor point-to-point soldered wiring. The Vector 8801-1 plugboard has no circuit traces apart from card fingers. Sockets and connectors mount in any position, and you can use Vector T107 punched bus strips to assemble low-impedance ground and supply buses. The double-sided 8801 plugboard has one tinned pad per hole that serves as a solderable anchor point for sockets, component wire leads, etc. The double-sided 8802-1 board is similar, but has two holes per pad and vertically mounted sockets. The Vector 8802 board also has two holes per pad, but the holes are plated through to the opposing pad. This unique board favors rapid and reliable anchoring of components, and with minimal risk of pad lifting.

You may find it advantageous to use this prototyping system with a smaller user-defined system bus. Lines from the TRS-80 forty-line bus can be assigned so that you can place ground lines that alternate between signal lines, while retaining the same assignment for normal S-100 bus power-supply lines. Connect the ground on the plugboard, leaving the backplane unaltered. The resulting ground lines shield the signal lines. One prototyping sytem may then serve both the S-100 bus and the foreign bus if you are careful not to plug incompatible cards in simultaneously. The large S-100 boards generally provide more board space per dollar than small cards, but packing a number of smaller system modules on one S-100 card tends to complicate system documentation.

Plugboard systems with a user-defined system bus are easily assembled at low cost and in a manner similar to the assembly of the S-100 system. The system shown in photo 5 uses the R636-1 plugboard receptacle with seventy-two (36/72) contacts and mating BR27-1 card guides. Receptacle wrap posts pass through a length of 3677-7 clearance ground-plane board supporting pin rows so that you can plug in an IDC ribbon cable. To create a work area for a patchboard or other circuit, you can add a Vector 8004 Circboard with clearance ground plane, as shown. Alternatively, you can install the 8002 Circboard with interleaved buses for wire wrapping, the 8801 Circboard with buses and three-hole pads for any wiring method, or the 8803 pad-per-hole Circboard. A Jameco JE200 5 V, 1 A power supply fits the system neatly and powers the combination proto system. Plugboards that mate with this system include the Vector 4493 Any-Dip series and the 4066 series boards.

A system with a fifty-six-line bus can be assembled with the R656 plugboard receptacle and the Vector 4610 series plugboards. If you use the R644-3 receptacle with forty-four bus lines, you can choose from numerous plugboards in the Vector 4412, 3662, 3682, and 4494 board series. The 4609 plugboard can be adapted to the external bus system of the Apple II, PET, or Super-KIM machines, either as an open frame set-up or installed in a Vector card cage using the standard mounting hardware.

Give early consideration to the installation of ribbon cable links. IDC cables are readily available, and they come assembled in assorted lengths and a number of lines. You can also use Vector KS2-20 or KS2-40 female IDC plugs to assemble your own cables. The plugs mate with two rows of T49-5-2 wrap posts installed on p-pattern board. Use the P187 universal IDC fixture or its equivalent to press-fit the IDC connector to KW2-20-type twenty-line ribbon cable (use two lengths side by side on the KS2-40 connector). The IDC cable can be used for the links between the computer and proto-system, between plugboards, and to peripherals. You can also use the DIP-plug ribbon cable with male headers that fit standard DIP sockets of most sizes. It is best to use pre-assembled DIP cable. The Vector DIP interconnects are available in lengths of 12 inches (304 mm) and 24 inches (608 mm), and as single- or double-ended cables

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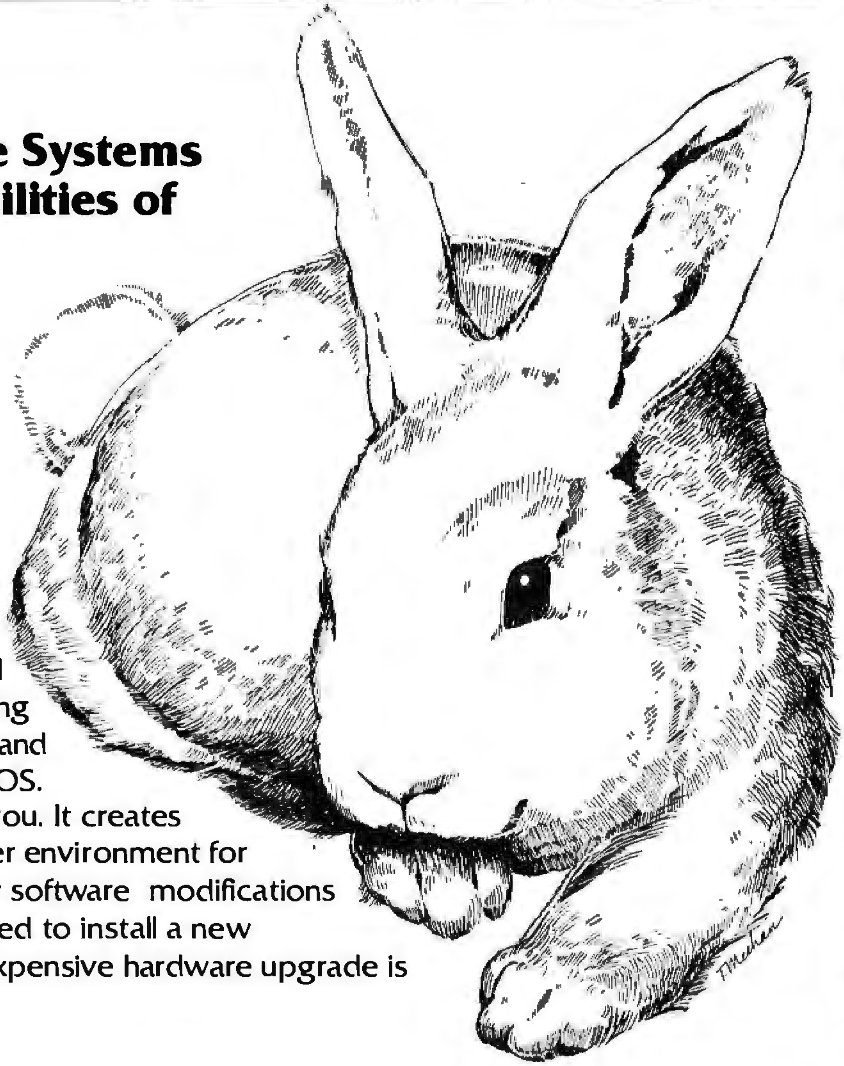

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Bus Terminations

With the aid of a short backplane and short connecting cable to the computer, the plugboard system can usually operate without bus line terminations. However, line terminations reduce line impedances, thereby reducing noise and crosstalk. The line termination consists of pull-up resistors that are placed at one end of the backplane and connected from each signal line to a noiseless regulated-voltage source of 2.6 V to 5.0 V.

The active line termination of the 8803 motherboard is made up of 270-ohm resistors connected to the 2.6 V source. On a pull-down to logic level 0 (approximately 0.4 V), the line termination current is (2.6 − 0.4)/270 (approximately 8 mA), which can be easily handled by standard TTL devices. More than likely, the line drivers of your computer consist of 74LS devices which can drive (sink) 8 mA. This leaves no reserve drive for gates sensing the line, and for this reason you should push-fit the termination resistors on T49 Klip Wrap posts instead of soldering so that you can experiment with lower line-termination currents.

You can conserve supply current by using active line terminations. To obtain line-termination currents of approximately 4, 2, and 1 mA, use 560-ohm, 1100-ohm, and 2200-ohm resistors, respectively. For a smaller system, you can pull up the lines to the 5 V source and compute the termination current based on 5 V.

Plugboard Assembly and Test

Check for errors in the schematic diagram of the circuit, especially in the labeling of device-pin numbers. A pair of diagram sheets are supplied with the Vector plugboards so that you can determine the component and wiring placement for both sides of the board before you begin actual construction. Both sheets should be thoroughly labeled, especially with regard to each of the card fingers connected to the system bus. Observe how the data and address lines are

grouped together in certain areas—it can help you determine the optimum placement of the associated integrated circuits. Use the plugboard itself for the preliminary layout of sockets and other components. Determine the locations of board feed-thru pins and all discrete components: don't wait until after you have begun to wire the board. It's a good idea to include extra ground feed-thru pins and to leave one socket position open near the card fingers for future additions. Draw the socket outlines on both layout sheets, show the positions of feed-thru pins and discrete components, and label them accordingly. Check any prewired card finger or voltage regulator position and make any changes by cutting traces.

Install all board pins, but omit the sockets so that you can use the board backup block. Insert T46-2-9 double-ended wrap posts in all card fingers, driving them in from the copper side of the pad hole. Though pins make excellent electrical contact with the pads, the connection can become erratic if you loosen or rock the pins excessively. Check for continuity with the ohmmeter, and solder if necessary. Many of the wire-wrap-style plugboards are designed to accept the disk bypass capacitor by direct soldering to the etched planes. Install and solder the capacitors before you install the sockets.

Secure the sockets to the board using 5-minute epoxy cement. Press an index card against the tips of the wrap posts associated with the card fingers on the wiring side of the board. Mark and label the impressions with bus assignments, for reference when wiring. Label an unmarked socket position using MS10A pin-marking strips. Begin by chain-wrapping the ground circuits to further reduce ground-return impedance. Wire the supply lines next and, as the last step, install any wiring which may be altered. Record your progress on the schematic diagram as you install and verify each wire run.

Before you install any integrated circuits, use the ohmmeter to verify all wiring topside from card fingers and from socket to socket. Check for

bus- and supply-line short circuits. Insert a milliameter in the power supply line and energize the board. Check voltage-regulator outputs and voltage distribution. With the power off, insert integrated circuits one by one and observe the expected increases in supply current. If all is well, connect the ribbon cable to the proto system and check the voltages at the other end of the cable. Take care that the proto system's power supplies do not feed directly back to your computer!

At this point, the wise experimenter will perform static tests on at least a portion of the board logic (eg: port and memory decoders). Use jumper wires to program the input logic and verify the output. A patchboard with the entire system bus laid out and labeled on Klip Block linked to the system by ribbon cable is a handy aid for conducting static tests. These tests detect wiring and design errors, as well as defective integrated circuits.

Always turn off all power when inserting or removing connectors and plugboards. Connect the untested ribbon cable and proto system to your computer, but do not install the plugboards. If your computer fails to function, look for line shorts. Another possible culprit is the ribbon cable capacitance (or the cable may be picking up noise). Always use very short cables and be prepared to experiment with several lengths. As the final and most crucial test, insert the plugboard in the proto system for dynamic on-line tests. The most frequently encountered problems are the result of wiring errors or omissions, erratic or defective integrated circuits, and contaminated and erratic connectors.

An erratic integrated circuit device is difficult to pinpoint, but it can be forced to reveal itself. Allow the system to warm up thoroughly, and attempt to reproduce the observed erratic behavior. Then, spray each suspected device with integrated-circuit cooler. In many cases, this will temporarily restore the system to normal operation and isolate the troublesome component. Another approach is to substitute suspect integrated circuits with those that you know are reliable.

Once you resolve the frustrating circuit problem, you will gain a far greater understanding of the microprocessor, logic circuits, and test techniques. So start experimenting with computer hardware circuits made simply by wire wrapping and a plugboard system. It will lead to greater enjoyment of your hobby.■

Notice of Omission

Due to a processing error the Lanier Business Products ad which appeared on page 27 of the April Byte had no Reader Service Number.

For more information regarding their "no problem trial offer" circle 475 on the inquiry card in this issue.

Speeding Up TRS-80 Graphics

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Florissant MO 63031

Many TRS-80 owners have probably, at one time or another, experimented with using DATA statements to store graphics information. This method can be highly efficient, but there's a catch. It is possible to store graphics as data in *several* different ways. Which is best?

In this article, we will examine some of the methods of storing a screen image as DATA statements, and, later, of recreating it on the video screen. Listings 1 thru 13 show the evolution of successively complex techniques.

In most cases, we will start with a picture onscreen (as provided by a run of listing 1). Many of the simpler sketching programs for the TRS-80 don't provide any way to store the images to disk, and the screen-reading programs used as examples in this article can be appended to a sketching program that will allow you to save your work. Let's look at the first method of saving screen images.

POINT Graphics

Every cell (graphics point) on the TRS-80 graphics screen can be turned on by a SET statement or turned off by a RESET statement. This method is used in listing 1 to draw a picture on the TRS-80 video screen. Another TRS-80 Level II command, POINT, returns a 1 or 0 based on the value of the cell given by the *x* (column number) and *y* (row number) parameters of the POINT statement.

The easiest way to store the video screen would be to examine and write an (*x*, *y*) number pair for each cell that is shown. Unfortunately, this is both time consuming and wasteful of disk storage. Due to the nature of most drawings, they are more easily approached as a series of horizontal lines; this is done in listing 1 where a horizontal line of cells is SET to screen inside a do-loop that varies the *x* (column) coordinate of the SET statement. We can store each line of cells as a triad of numbers: *y* (row) number, beginning *x* (column) number, and ending *x* (column) number. Then we can later read the triad and recreate the line by executing a SET statement within a do-loop.

By PEEKing the appropriate memory locations, we can represent the contents of the screen as exactly 1024 numbers.

Listing 2 illustrates this process by creating the disk file of triads (lines 11000 thru 11050), closing it (line 11060), then opening it again and recreating the picture from a cleared screen (it does this by reading the disk data file in lines 12000 thru 12020, as discussed above). The data in this data file will be used by listing 3.

Data Files and POKE Graphics

To use these data files in other programs, the disk file of numbers must now be converted to DATA statements. However, you won't have to type them on the keyboard. Listing 3 will read the disk file from listing 2, convert the numbers to DATA statements complete with line numbers, and put them back onto disk in ASCII format, ready to be merged with a BASIC program.

Now that the numbers have been reconfigured as DATA statements, they can be merged with a short program that will use the DATA statements to set the graphics. This method is a bit faster than reading the data from a disk file. Listing 4 includes the DATA statements (lines 1905 thru 1960) generated by listing 3 (which contain the data generated by listing 2). Lines 100 to 130 read the data and set the graphics. Lines 200 to 210 generate hardcopy of the information on the screen for conversion to DATAPOKE statements. Line 300 creates a file and stores the data on disk.

Listing 4 creates (in line 300) a new

Text continued on page 176

Interested readers can call The Software Center at (314) 838-7785.

Listing 1: *TRS-80 graphics program using the traditional SET and RESET graphics.*

```
10 CLS:CLEAR 200
20 FOR X=50 TO 95:Y=12:SET(X,Y):NEXT:FOR Y=13 TO 32:SET(50,Y):SET(95,Y):NEXT
30 FOR X=28 TO 50:Y=22:SET(X,Y):NEXT:Y=22:FOR X=37 TO 43:SET(X,Y):Y=Y-1:NEXT
40 FOR X=44 TO 49:SET(X,Y):Y=14:NEXT:FOR Y=22 TO 29:X=28:SET(X,Y):NEXT:FOR Y=29
TO 30:X=27:SET(X,Y):NEXT:FOR Y=27 TO 28:X=29:SET(X,Y):NEXT:FOR Y=26 TO 27:X=30:S
ET(X,Y):NEXT
50 FOR Y=25 TO 26:X=31:SET(X,Y):NEXT:SET(31,25):FOR X=32 TO 38:Y=24:SET(X,Y):NEX
T:SET(40,23):SET(41,24):SET(46,24):Y=25:FOR X=42 TO 47:SET(X,Y):Y=Y+1:NEXT:FOR Y
=23 TO 30:X=48:SET(X,Y):NEXT
60 Y=25:FOR X=38 TO 44:SET(X,Y):SET(X+1,Y):Y=Y+1:NEXT:FOR X=45 TO76:Y=32:SET(X,Y
):NEXT:Y=31:FOR X=76 TO 83:SET(X,Y):SET(X+1,Y):Y=Y-1:NEXT
70 FOR X=83 TO 90:Y=24:SET(X,Y):NEXT:Y=25:FOR X=90 TO 94:SET(X,Y):SET(X+1,Y):Y=Y
+1:NEXT:FOR X=96 TO 97:Y=31:SET(X,Y):NEXT
80 FOR X=33 TO 36:Y=27:SET(X,Y):NEXT:FOR X=85 TO 88:SET(X,Y):NEXT:FOR Y=30 TO 32
:X=30:SET(X,Y):NEXT:Y=30:FOR X=30 TO 32:SET(X,Y):SET(X+1,Y):Y=Y-1:NEXT
90 Y=28:FOR X=36 TO 38:SET(X,Y):SET(X+1,Y):Y=Y+1:NEXT:Y=32:FOR X=30 TO 33:SET(X,
Y):SET(X+1,Y):Y=Y+1:NEXT:FOR X=33 TO 36:Y=35:SET(X,Y):NEXT
100 Y=34:FOR X=36 TO 38:SET(X,Y):SET(X+1,Y):Y=Y-1:NEXT:FOR Y=30 TO 32:X=39:SET(X
,Y):NEXT:X=34:Y=30:SET(X,Y):SET(X+1,Y):SET(33,31):SET(36,31):X=34:Y=32:SET(X,Y):
SET(X+1,Y)
110 FOR Y=30 TO 32:X=82:SET(X,Y):SET(X+9,Y):NEXT:Y=30:FOR X=82 TO 85:SET(X,Y):SE
T(X+1,Y):Y=Y-1:NEXT:Y=32:FOR X=82 TO 84:SET(X,Y):SET(X+1,Y):Y=Y+1:NEXT:FOR X=85
TO 88:Y=35:SET(X,Y):NEXT
120 Y=34:FOR X=88 TO 90:SET(X,Y):SET(X+1,Y):Y=Y-1:NEXT:Y=28:FOR X=88 TO 90:SET(X
,Y):SET(X+1,Y):Y=Y+1:NEXT:FOR X=86 TO 87:Y=30:SET(X,Y):Y=32:SET(X,Y):NEXT:SET(85
,31):SET(88,31)
130 X=55:Y=15:SET(X,Y):SET(X,Y+1):SET(X+1,Y+2):SET(X+1,Y+3):SET(X+2,Y+4):SET(X+2
,Y+5):SET(X+3,Y+6):SET(X+4,Y+5):SET(X+4,Y+4):SET(X+5,Y+3):SET(X+5,Y+2):SET(X+6,Y
+1):SET(X+6,Y)
140 FOR Y=15 TO 21:X=65:SET(X,Y):NEXT:FOR X=69 TO 73:Y=15:SET(X,Y):NEXT:FOR Y=16
 TO 21:X=71:SET(X,Y):NEXT:FOR X=77 TO 81:Y=15:SET(X,Y):Y=21:SET(X,Y):NEXT:SET(78
,18):FOR Y=15 TO 21:X=77:SET(X,Y):NEXT
150 FOR Y=15 TO 21:X=85:SET(X,Y):NEXT:Y=18:FOR X=86 TO 89:SET(X,Y):Y=Y-1:NEXT:Y=
18:FOR X=86 TO 89:SET(X,Y):Y=Y+1:NEXT
160 FOR Y=24 TO 29:X=55:SET(X,Y):SET(X+4,Y):SET(X+9,Y):NEXT:Y=25:FOR X=60 TO 62:
SET(X,Y):SET(X+1,Y):Y=Y+1:NEXT:
170 FOR Y=25 TO 28:X=68:SET(X,Y):NEXT:FOR X=69 TO 71:Y=24:SET(X,Y):Y=29:SET(X,Y)
:NEXT:SET(72,25):SET(72,28):SET(74,29)
180 FOR X=1 TO 1500:NEXT:PRINT@64,STRING$(60,' '):PRINT@128,STRING$(60,' '):FOR
X=5 TO 125:Y=0:SET(X,Y):SET(X,Y+1):Y=47:SET(X,Y):SET(X,Y-1):NEXT:FOR Y=0 TO 47:X
=5:SET(X,Y):SET(X+1,Y):SET(X+2,Y):NEXT
185 FOR Y=0 TO 47:X=125:SET(X,Y):SET(X-1,Y):SET(X-2,Y):NEXT:FOR X=1 TO 1000:NEXT
```

Listing 2: *Program to read data directly from the screen memory and store it to the disk as numbers representing a series of horizontal lines of graphic dots.*

```
11000 OPEN'O',1,'GRAPHIC/DAT':FORY=0TO47:X=-1
11010 X=X+1:IFX>127THEN11060
11020 IFPOINT(X,Y)=0THEN11010
11030 X1=X
11040 X=X+1:IFX>127ORPOINT(X,Y)=0THENPRINT#1,Y',X1','X:GOTO11010
11050 GOTO11040
11060 NEXTY:CLOSE
12000 OPEN'I',1,'GRAPHIC/DAT':CLS
12010 C=C+1:IFEOF(1)=0THENINPUT#1,Y,X1,X2:FORX=X1TOX2:SET(X,Y):NEXT:GOTO12010
12020 GOTO12020
20000 REM--ORIGINAL GRAPHICS ROUTINE FROM A SKETCH BY
       KARL WILLIAMSON, OVERLAND, MO.  SET AND RESET
       GRAPHICS BY RON BOBO.
20005 REM--ALL OTHER PROGRAMMING IN THIS SERIES BY
      JOHN KNODERER, COMP-U-TRS, 51 FLORISSANT OAKS
      SHOPPING CENTER, FLORISSANT, MO, 63031
20010 REM--LINES 11000 TO 11060 CONVERT SCREEN TO VALUES
      Y, X1 AND X2 AND SEND TO DISK.  FOR USE IN LINE 'FOR
      X=X1 TO X2:SET(X,Y):NEXT'
20020 REM--LINES 12000-12020 TEST THE NUMBERS CREATED BY 11000
65000 'TWO
```

Listing 3: *This routine reads the data file generated by the program in listing 2 (and subsequent listings) and creates an ASCII file containing BASIC DATA statements.*

```
13000 CLEAR9999:OPEN'I',1,'GRAPHIC/DAT':LN=1900:OPEN'O',2,'GRAPHIC/ASC
13010 LN=LN+5:X$=STR$(LN)+' DATA'
13020 IFEOF(1)THENPRINT#2,LEFT$(X$,LEN(X$)-1):PRINTX$CHR$(8):CLOSE:END
13030 INPUT#1,Y:X$=X$+MID$(STR$(Y),2)+',':IFLEN(X$)>237THENPRINT#2,LEFT$(X$,LEN(
X$)-1):PRINTX$CHR$(8):GOTO13010
13040 GOTO13020
13900 REMARK--THIS CONVERTS NUMBERS ON DISK TO BECOME REGULAR BASIC DATA STATEME
NTS WITH A LIMIT OF 240 CHARACTERS PER LINE
65000 'CONVERT
```

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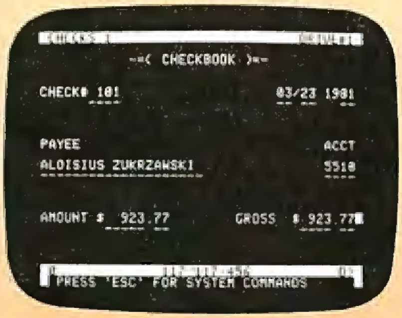

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Listing 4: *Recreation of a graphics picture. This listing shows how the DATA statements generated by listing 3 may be appended to a program that uses them to recreate the original graphics display.*

```
100 ONERRORGOTO120:CLS
110 READY,X1,X2:FORX=X1TOX2:SET(X,Y):NEXT:GOTO110
120 RESUME130
130 ONERRORGOTO0:GOTO 150
150 REMARK--THIS SECTION OF PROGRAM FROM LINE 100TO LINE 130 IS PROGRAM LISTING
NUMBER ZERO THAT WILL RECREATE THE GRAPHIC PICTURE OF LISTING 1.
190 'GOTO300
200 FORI=15360TO16383:LPRINTPEEK(I);:NEXT:RETURN
210 REM--LINE 200 WILL GENERATE HARD COPY OF DATA FOR THE NEXT PROGRAM
300 OPEN"O",2,"DATAPOKE":FORI=15360TO16383:PRINT#2,PEEK(I):NEXT:CLOSE:STOP:REMAR
K THIS LINE WILL OUTPUT TO DISK
1905 DATA0,5,126,1,5,126,2,5,8,2,123,126,3,5,8,3,123,126,4,5,8,4,123,126,5,5,8,5
,123,126,6,5,8,6,123,126,7,5,8,7,123,126,8,5,8,8,123,126,9,5,8,9,123,126,10,5,8,
10,123,126,11,5,8,11,123,126,12,5,8,12,50,96,12,123,126,13,5,8,13,50,51,13,95
1910 DATA96,13,123,126,14,5,8,14,45,51,14,95,96,14,123,126,15,5,8,15,44,45,15,50
,51,15,55,56,15,61,62,15,65,66,15,69,74,15,77,82,15,85,86,15,89,90,15,95,96,15,1
23,126,16,5,8,16,43,44,16,50,51,16,55,56,16,61,62,16,65,66,16,71,72,16,77,78
1915 DATA16,85,86,16,88,89,16,95,96,16,123,126,17,5,8,17,42,43,17,50,51,17,56,57
,17,60,61,17,65,66,17,71,72,17,77,78,17,85,86,17,87,88,17,95,96,17,123,126,18,5,
8,18,41,42,18,50,51,18,56,57,18,60,61,18,65,66,18,71,72,18,77,79,18,85,87,18
1920 DATA95,96,18,123,126,19,5,8,19,40,41,19,50,51,19,57,58,19,59,60,19,65,66,19
,71,72,19,77,78,19,85,86,19,87,88,19,95,96,19,123,126,20,5,8,20,39,40,20,50,51,2
0,57,58,20,59,60,20,65,66,20,71,72,20,77,78,20,85,86,20,88,89,20,95,96,20,123
1925 DATA126,21,5,8,21,38,39,21,50,51,21,58,59,21,65,66,21,71,72,21,77,82,21,85,
86,21,89,90,21,95,96,21,123,126,22,5,8,22,28,51,22,95,96,22,123,126,23,5,8,23,28
,29,23,40,41,23,48,49,23,50,51,23,95,96,23,123,126,24,5,8,24,28,29,24,32,39,24
1930 DATA41,42,24,46,47,24,48,49,24,50,51,24,55,56,24,59,60,24,64,65,24,69,72,24
,83,91,24,95,96,24,123,126,25,5,8,25,28,29,25,31,32,25,38,40,25,42,43,25,48,49,2
5,50,51,25,55,56,25,59,62,25,64,65,25,68,69,25,72,73,25,82,84,25,90,92,25,95
1935 DATA96,25,123,126,26,5,8,26,28,29,26,30,32,26,39,41,26,43,44,26,48,49,26,50
,51,26,55,56,26,59,60,26,61,63,26,64,65,26,68,69,26,81,83,26,91,93,26,95,96,26,1
23,126,27,5,8,27,28,31,27,33,37,27,40,42,27,44,45,27,48,49,27,50,51,27,55,56
1940 DATA27,59,60,27,62,65,27,68,69,27,80,82,27,85,89,27,92,94,27,95,96,27,123,1
26,28,5,8,28,28,30,28,32,34,28,36,38,28,41,43,28,45,46,28,48,49,28,50,51,28,55,5
6,28,59,60,28,64,65,28,68,69,28,72,73,28,79,81,28,84,86,28,88,90,28,93,96,28
1945 DATA123,126,29,5,8,29,27,29,29,31,33,29,37,39,29,42,44,29,46,47,29,48,49,29
,50,51,29,55,56,29,59,60,29,64,65,29,69,72,29,74,75,29,78,80,29,83,85,29,89,91,2
9,94,96,29,123,126,30,5,8,30,27,28,30,30,32,30,34,36,30,38,40,30,43,45,30,47
1950 DATA49,30,50,51,30,77,79,30,82,84,30,86,88,30,90,92,30,95,96,30,123,126,31,
5,8,31,30,31,31,33,34,31,36,37,31,39,40,31,44,46,31,50,51,31,76,78,31,82,83,31,8
5,86,31,88,89,31,91,92,31,95,98,31,123,126,32,5,8,32,30,32,32,34,36,32,38,40
1955 DATA32,45,77,32,82,84,32,86,88,32,90,92,32,95,96,32,123,126,33,5,8,33,31,33
,33,37,39,33,83,85,33,89,91,33,123,126,34,5,8,34,32,34,34,36,38,34,84,86,34,88,9
0,34,123,126,35,5,8,35,33,37,35,85,89,35,123,126,36,5,8,36,123,126,37,5,8,37
1960 DATA123,126,38,5,8,38,123,126,39,5,8,39,123,126,40,5,8,40,123,126,41,5,8,41
,123,126,42,5,8,42,123,126,43,5,8,43,123,126,44,5,8,44,123,126,45,5,8,45,123,126
,46,5,126,47,5,126
65000 'FOUR
```

Text continued from page 171:

data file, DATAPOKE, that represents the screen contents in another way. Actually, the contents of the screen are stored in the TRS-80 memory as 1024 contiguous bytes of memory, each byte representing six graphics cells (two cells wide by three cells high). By PEEKing the appropriate memory locations (decimal 15360 to 16383), we can represent the contents of the screen as exactly 1024 numbers, which are written to the DATAPOKE file, as shown in listing 4.

Now, using the DATAPOKE file just generated and the conversion program in listing 3, we come up with a new set of DATA statements. These are merged with another short routine to produce listing 5, which reads data and POKEs the values into video memory.

To get all of these graphics characters on the screen we are now using 1024 different numbers, with an average of 3 to 4 bytes used per number for storage (including commas). In return for the large amount of memory that is being used, we are only gaining a slight speed advantage over the original program. Let's look for something that will reduce memory usage.

Replacing Blanks with Tabs

Tab characters are stored in TRS-80 Level II BASIC as the value 192 plus the number of spaces to tab to the right. With this knowledge, we can combine a string of spaces into one character of memory by replacing the spaces with a tab character.

Listing 6 uses this information to take a different set of numbers off the screen. The program will generate a new set of numbers that may then be converted to DATA statements using the converison program. To list these same values to a printer, merely remove the END statement from line 660.

Note that in listing 6, the computer was not told to store any of the figures for regular printable charac-

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Listing 5: *This program takes the DATA statements generated by listing 4 and POKEs the information directly into the screen memory.*

```
500 DEFINTI-N:CLS
520 FORI=15360TO16383:READA:POKEI,A:NEXT
530 GOTO 530
550 REM--LINES 500 TO 520 READ DATA STATEMENTS AND POKE THE
VALUES INTO SCREEN MEMORY
1905 DATA32,32,170,191,159,143,143,143,143,143,143,143,143,143,143,143,143,143,1
43,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,1
43,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143
1910 DATA143,143,143,175,191,149,32,32,170,191,149,32,32,32,32,32,32,32,32,32,32
,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,3
2,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,170,191,149,32,32
1915 DATA170,191,149,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32
,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,3
2,32,32,32,32,32,32,32,32,32,170,191,149,32,32,170,191,149,32,32,32,32,32,32
1920 DATA32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32
,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,1
70,191,149,32,32,170,191,149,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32
1925 DATA32,160,176,176,191,131,131,131,131,131,131,131,131,131,131,131,131,131,
131,131,131,131,131,131,131,131,171,149,32,32,32,32,32,32,32,32,32,32,32,32,170,
191,149,32,32,170,191,149,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,184
1930 DATA135,32,32,191,32,138,181,32,186,133,170,149,130,171,151,129,170,151,131
,129,170,181,158,129,32,170,149,32,32,32,32,32,32,32,32,32,32,32,32,170,191,149,
32,32,170,191,149,32,32,32,32,32,32,32,32,32,32,32,32,32,32,160,158,129,32,32
1935 DATA32,191,32,32,171,188,151,32,170,149,32,170,151,32,32,170,159
,180,32,32,170,149,32,32,32,32,32,32,32,32,32,32,32,32,170,191,149,32,32,170,191
,149,32,32,32,32,32,32,32,32,32,188,140,140,140,140,143,188,140,140,140,188,191
1940 DATA32,32,32,131,32,32,130,129,32,130,129,32,130,131,131,129,130,129,130,12
9,32,170,149,32,32,32,32,32,32,32,32,32,32,32,32,170,191,149,32,32,170,191,149,3
2,32,32,32,32,32,32,32,32,191,184,151,131,131,175,182,173,144,131,191,191,32
1945 DATA170,149,170,189,180,191,32,190,131,141,32,32,32,160,190,135,131,131,175
,180,170,149,32,32,32,32,32,32,32,32,32,32,32,32,170,191,149,32,32,170,191,149,3
2,32,32,32,32,32,32,32,160,191,167,190,135,175,180,139,189,155,180,191,191,32
1950 DATA170,149,170,149,131,191,32,175,176,156,176,32,184,159,161,190,135,175,1
80,139,191,149,32,32,32,32,32,32,32,32,32,32,32,32,170,191,149,32,32,170,191,149
,32,32,32,32,32,32,32,32,130,129,191,153,183,157,187,149,130,175,182,179,191
1955 DATA176,176,176,176,176,176,176,176,176,176,176,176,190,135,32,191,153,183,
157,187,149,170,157,132,32,32,32,32,32,32,32,32,32,32,32,170,191,149,32,32,170,1
91,149,32,32,32,32,32,32,32,32,32,32,130,175,180,190,135,32,32,32,32,32,32,32
1960 DATA32,32,32,32,32,32,32,32,32,32,32,32,32,32,130,175,180,190,135,32,32,32,
32,32,32,32,32,32,32,32,32,32,32,32,170,191,149,32,32,170,191,149,32,32,32,32,32
,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32
1965 DATA32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32
,32,170,191,149,32,32,170,191,149,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,3
2,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32
1970 DATA32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,170,191,149,32,32,170,191,
149,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,3
2,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32,32
1975 DATA32,32,32,32,32,170,191,149,32,32,170,191,189,188,188,188,188,188,188,18
8,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,18
8,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188
1980 DATA188,188,188,188,188,188,188,188,188,188,190,191,149
65000 'FIVE
```

Listing 6: *A routine that compresses a string of spaces into a TAB character that represents the number of spaces in the string.*

```
600 OPEN"D",2,"PRINTCHR":L=1:A=PEEK(15360):POKE16383,32:IFA<129THENA=32
610 FORI=15361TO16383:B=PEEK(I):IFB<129THENB=32
620 IFB=AANDA=32THENL=L+1:GOTO660
630 IFB=32THENL=1:C=A:GOSUB690:A=B:GOTO660
640 IFA=32THENC=192+L:GOSUB690:GOTO655
650 C=A:GOSUB690
655 A=B
660 NEXTI:END
690 PRINT#2,C:RETURN
695 REMARK  LINES 600-690 OUTPUT TO DISK, LINES 900-960 OUTPUT TO LINEPRINTER
900 POKE16383,32:L=1:A=PEEK(15360):IFA<129THENA=32
910 FORI=15361TO16383:B=PEEK(I):IFB<129THENB=32
920 IFB=AANDA=32THENL=L+1:GOTO960
930 IFB=32THENL=1:LPRINTA;:A=B:GOTO960
940 IFA=32THENLPRINT192+L;:GOTO955
950 LPRINTA;
955 A=B
960 NEXTI:END
65000 'SIX
```

Listing 7: *Program to display data stored in the compressed format.*

```
800 DEFINTI-N:ONERRORGOTO830:CLS
820 READJ:PRINTCHR$(J);:GOTO820
830 RESUME840
840 POKE 16383,149
850 GOTO 850
```

Listing 7 continued on page 180

ters (such as blanks, letters, or numbers) because these can be more efficiently printed using PRINT statements. If you have both graphics and alphanumeric characters on the screen, the programs shown here will treat alphanumerics as a series of blanks for DATA purposes.

The next routine, listing 7, displays the data from the DATA statements created using listing 3 and the data file from listing 6, PRINTCHR. This routine requires graphics characters on every line. If you go more than sixty-three successive blank spaces, you will get a function error, so we are assuming that graphics will be present on every line.

In the sample data in listing 7, the last item in the DATA statements would give us a function error, so we did not use it in this particular example. Instead, a 149 was POKEd into the space (16383).

One problem that must be solved concerns the method of ending the loop that contains the DATA statements. For example, the three BASIC statements in line 820 of listing 7 are an endless loop that reads an item from the DATA statement and prints it. If we plan to use the same routine for different sets of DATA statements, we need to get the program out of the loop after it has read the last item of data; if we do not, the program will end immediately with an out-of-data error.

There are several ways this problem can be approached. Although tedious, we could count the number of items in the data statements and put the READ statement in a do-loop. We could also append a certain flag value (one that would not otherwise be in a valid list of data) to the end of the data statements and put the READ statement in a loop that stops when it reads the flag value. Instead, we decided to use the ON ERROR GOTO option that is available in Level II BASIC.

In listing 7, the ON ERROR GOTO 830 (in line 800) is executed when the READ tries to read past the last data value. (Without this statement, the program would end.) The RESUME 840 statement at line 830 causes the program to continue, even after what would otherwise be a fatal error. The loop to itself at line 850 allows us to fill the entire video screen with the picture being displayed, without ending the program and scrolling the

Listing 7 continued:

```
1905 DATA194,170,191,159,143,143,143,143,143,143,143,143,143,143,143,143,143,143
,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143
,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143,143
1910 DATA143,143,143,175,191,149,194,170,191,149,248,170,191,149,194,170,191,149
,248,170,191,149,194,170,191,149,248,170,191,149,194,170,191,149,209,160,176,176
,191,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131
1915 DATA131,131,131,171,149,204,170,191,149,194,170,191,149,208,184,135,194,191
,193,138,181,193,186,133,170,149,130,171,151,129,170,151,131,129,170,181,158,129
,193,170,149,204,170,191,149,194,170,191,149,206,160,158,129,195,191,194,171
1920 DATA188,151,193,170,149,193,170,149,193,170,151,194,170,159,180,194,170,149
,204,170,191,149,194,170,191,149,201,188,140,140,140,140,143,188,140,140,140,188
,191,195,131,194,130,129,193,130,129,193,130,131,131,129,130,129,130,129,193
1925 DATA170,149,204,170,191,149,194,170,191,149,201,191,184,151,131,131,175,182
,173,144,131,191,191,193,170,149,170,189,180,191,193,190,131,141,195,160,190,135
,131,131,175,180,170,149,204,170,191,149,194,170,191,149,200,160,191,167,190
1930 DATA135,175,180,139,189,155,180,191,191,193,170,149,170,149,131,191,193,175
,176,156,176,193,184,159,161,190,135,175,180,139,191,149,204,170,191,149,194,170
,191,149,200,130,129,191,153,183,157,187,149,130,175,182,179,191,176,176,176
1935 DATA176,176,176,176,176,176,176,176,176,190,135,193,191,153,183,157,187,149
,170,157,132,203,170,191,149,194,170,191,149,202,130,175,180,190,135,213,130,175
,180,190,135,207,170,191,149,194,170,191,149,248,170,191,149,194,170,191,149
1940 DATA248,170,191,149,194,170,191,149,248,170,191,149,194,170,191,189,188,188
,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188
,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,188
1945 DATA188,188,188,188,188,188,188,188,188,188,188,188,188,188,188,190,191
65000 'SEVEN
```

Listing 8: *Routine to convert the graphics data to strings of characters.*

```
1100 POKE16383,32:OPEN"O",2,"PRINTSTR":L=1:A=PEEK(15360):IFA<129THENA=32
1110 FORI=15361TO16383:B=PEEK(I):IFB<129THENB=32
1120 IFB=ATHENL=L+1:GOTO1160
1130 PRINT#2,L","A:L=1:A=B
1160 NEXTI:END
1170 REMARK--PRINT OUT TO DISK
65000 'EIGHT
```

top two lines off the top of the screen.

Graphics Using STRING$

From an examination of the DATA statements in listing 7 it is apparent that we still have a lot of repetition. This is especially true when we print a straight line or a solid area of graphics. In order to save even further on DATA items and to speed program execution, the DATA may be rearranged to allow the printing of strings of identical characters (in much the same way that we printed a line of "set" graphics points in listing 2).

The STRING$(X,Y) command in Level II BASIC allows us to print X identical characters, each of which has an ASCII value of Y. When reading the video screen with PEEK statements, we will be looking for identical adjacent values. The data we print to a disk file (and later translate to DATA statements) will be a pair of numbers, the first number being the repetition factor and the second being the ASCII value of the character to be repeated. This method has been used to create the data file PRINTSTR in listing 8, and it displays graphics faster than previous methods.

Please note that in each of these programs that use PRINT for output purposes, the very last character on the screen (position 16,383) will not print, so if any SET, RESET, or POKE had been done into this area in the original program, it would be left blank. Your program could remedy this by POKEing 16383 with the proper value.

Listing 9 restores the graphics image to the video screen by reading the data items in the DATA statements (again created by the PRINTSTR file and listing 3). This program reads pairs of data items and prints them using STRING$ in line 1420 to expand the pair of numbers to a string of proper length.

Listing 9 demonstrates that it is possible to extend the number of lines on which graphics are not required. However, they must still be present on at least every fourth line, because the length of each string must be less than or equal to 255, a limitation of Level II BASIC.

Combining Methods

Listing 10 (to create the data file FASTER) and listing 11 (to print the image from the DATA statements) refine the above method by storing a single data item instead of a data pair, when the character being repeated is a space (decimal value 32). Since the

Text continued on page 184

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Listing 9: *Routine to display graphics data converted to strings of characters.*

```
1390 CLEAR 3000
1400 DEFINTI-N:ONERRORGOTO1430:CLS
1420 READI,J:PRINTSTRING$(I,J);:GOTO1420
1430 RESUME1440
1440 POKE 16383,149
1450 GOTO 1450
1905 DATA2,32,1,170,1,191,1,159,56,143,1,175,1,191,1,149,2,32,1,170,1,191,1,149,
56,32,1,170,1,191,1,149,2,32,1,170,1,191,1,149,56,32,1,170,1,191,1,149,2,32,1,17
0,1,191,1,149,56,32,1,170,1,191,1,149,2,32,1,170,1,191,1,149,17,32,1,160,2,176
1910 DATA1,191,21,131,1,171,1,149,12,32,1,170,1,191,1,149,2,32,1,170,1,191,1,149
,16,32,1,184,1,135,2,32,1,191,1,32,1,138,1,181,1,32,1,186,1,133,1,170,1,149,1,13
0,1,171,1,151,1,129,1,170,1,151,1,131,1,129,1,170,1,181,1,158,1,129,1,32,1,170
1915 DATA1,149,12,32,1,170,1,191,1,149,2,32,1,170,1,191,1,149,14,32,1,160,1,158,
1,129,3,32,1,191,2,32,1,171,1,188,1,151,1,32,1,170,1,149,1,32,1,170,1,149,1,32,1
,170,1,151,2,32,1,170,1,159,1,180,2,32,1,170,1,149,12,32,1,170,1,191,1,149,2
1920 DATA32,1,170,1,191,1,149,9,32,1,188,4,140,1,143,1,188,3,140,1,188,1,191,3,3
2,1,131,2,32,1,130,1,129,1,32,1,130,1,129,1,32,1,130,2,131,1,129,1,130,1,129,1,1
30,1,129,1,32,1,170,1,149,12,32,1,170,1,191,1,149,2,32,1,170,1,191,1,149,9,32
1925 DATA1,191,1,184,1,151,2,131,1,175,1,182,1,173,1,144,1,131,2,191,1,32,1,170,
1,149,1,170,1,189,1,180,1,191,1,32,1,190,1,131,1,141,3,32,1,160,1,190,1,135,2,13
1,1,175,1,180,1,170,1,149,12,32,1,170,1,191,1,149,2,32,1,170,1,191,1,149,8,32
1930 DATA1,160,1,191,1,167,1,190,1,135,1,175,1,180,1,139,1,189,1,155,1,180,2,191
,1,32,1,170,1,149,1,170,1,149,1,131,1,191,1,32,1,175,1,176,1,156,1,176,1,32,1,18
4,1,159,1,161,1,190,1,135,1,175,1,180,1,139,1,191,1,149,12,32,1,170,1,191,1,149
1935 DATA2,32,1,170,1,191,1,149,8,32,1,130,1,129,1,191,1,153,1,183,1,157,1,187,1
,149,1,130,1,175,1,182,1,179,1,191,12,176,1,190,1,135,1,32,1,191,1,153,1,183,1,1
57,1,187,1,149,1,170,1,157,1,132,11,32,1,170,1,191,1,149,2,32,1,170,1,191,1,149
1940 DATA10,32,1,130,1,175,1,180,1,190,1,135,21,32,1,130,1,175,1,180,1,190,1,135
,15,32,1,170,1,191,1,149,2,32,1,170,1,191,1,149,56,32,1,170,1,191,1,149,2,32,1,1
70,1,191,1,149,56,32,1,170,1,191,1,149,2,32,1,170,1,191,1,149,56,32,1,170,1,191
1945 DATA1,149,2,32,1,170,1,191,1,189,56,188,1,190,1,191
65000 'NINE
```

Listing 10: *Routine to generate a more compact graphics data file.*

```
1500 POKE16383,32:L=1:A=PEEK(15360):IFA<129THENA=32
1505 OPEN"O",2,"FASTER"
1510 FORI=15361TO16383:B=PEEK(I):IFB<129THENB=32
1520 IFB=ATHENL=L+1:GOTO1560
1530 IFA=32THENLPRINT192+L;ELSELPRINTL;A;
1535 IFA=32THENPRINT#2,192+LELSEPRINT#2,L","A
1540 L=1:A=B
1560 NEXTI:END
1570 REMARK--PROGRAM LISTING NUMBER TEN TO PRINT OUT LISTING FOR NEXT PROGRAM AN
D SEND IT TO DISK
1580 REMARK--IF HARD COPY IS NOT DESIRED, ELIMINATE LINE 1530
65000 'TEN
```

Listing 11: *Routine to display data as created by listing 10.*

```
1690 CLEAR 3000
1700 DEFINTI-N:ONERRORGOTO1730:CLS
1720 READI:IFI<192THENREADJ:PRINTSTRING$(I,J);ELSEPRINTCHR$(I);
1725 GOTO1720
1730 RESUME1740
1740 POKE 16383,149
1745 GOTO 1745
1750 REMARK--PROGRAM NUMBER ELEVEN LINES 1600-1740
1905 DATA194,1,170,1,191,1,159,56,143,1,175,1,191,1,149,194,1,170,1,191,1,149,24
8,1,170,1,191,1,149,194,1,170,1,191,1,149,248,1,170,1,191,1,149,194,1,170,1,191,
1,149,248,1,170,1,191,1,149,194,1,170,1,191,1,149,209,1,160,2,176,1,191,21,131
1910 DATA1,171,1,149,204,1,170,1,191,1,149,194,1,170,1,191,1,149,208,1,184,1,135
,194,1,191,193,1,138,1,181,193,1,186,1,133,1,170,1,149,1,130,1,171,1,151,1,129,1
,170,1,151,1,131,1,129,1,170,1,181,1,158,1,129,193,1,170,1,149,204,1,170,1,191
1915 DATA1,149,194,1,170,1,191,1,149,206,1,160,1,158,1,129,195,1,191,194,1,171,1
,188,1,151,193,1,170,1,149,193,1,170,1,149,193,1,170,1,151,194,1,170,1,159,1,180
,194,1,170,1,149,204,1,170,1,191,1,149,194,1,170,1,191,1,149,201,1,188,4,140
1920 DATA1,143,1,188,3,140,1,188,1,191,195,1,131,194,1,130,1,129,193,1,130,1,129
,193,1,130,2,131,1,129,1,130,1,129,1,130,1,129,193,1,170,1,149,204,1,170,1,191,1
,149,194,1,170,1,191,1,149,201,1,191,1,184,1,151,2,131,1,175,1,182,1,173,1,144
1925 DATA1,131,2,191,193,1,170,1,149,1,170,1,189,1,180,1,191,193,1,190,1,131,1,1
41,195,1,160,1,190,1,135,2,131,1,175,1,180,1,170,1,149,204,1,170,1,191,1,149,194
,1,170,1,191,1,149,200,1,160,1,191,1,167,1,190,1,135,1,175,1,180,1,139,1,189
1930 DATA1,155,1,180,2,191,193,1,170,1,149,1,170,1,149,1,131,1,191,193,1,175,1,1
76,1,156,1,176,193,1,184,1,159,1,161,1,190,1,135,1,175,1,180,1,139,1,191,1,149,2
04,1,170,1,191,1,149,194,1,170,1,191,1,149,200,1,130,1,129,1,191,1,153,1,183
1935 DATA1,157,1,187,1,149,1,130,1,175,1,182,1,179,1,191,12,176,1,190,1,135,193,
1,191,1,153,1,183,1,157,1,187,1,149,1,170,1,157,1,132,203,1,170,1,191,1,149,194,
1,170,1,191,1,149,202,1,130,1,175,1,180,1,190,1,135,213,1,130,1,175,1,180,1,190
1940 DATA1,135,207,1,170,1,191,1,149,194,1,170,1,191,1,149,248,1,170,1,191,1,149
,194,1,170,1,191,1,149,248,1,170,1,191,1,149,194,1,170,1,191,1,149,248,1,170,1,1
91,1,149,194,1,170,1,191,1,189,56,188,1,190,1,191
65000 'ELEVEN
```

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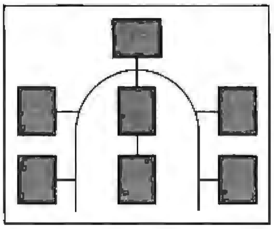

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Listing 12: *Routine that converts screen data to the most compact, fastest form discussed in this article.*

```
1800 POKE16383,149:L=1:A=PEEK(15360):IFA<129THENA=32
1805 OPEN'O',2,'FASTEST'
1810 FORI=15361TO16383:B=PEEK(I):IFB<129THENB=32
1820 IFB=ATHENL=L+1:GOTO1860
1830 IF A=32 THEN PRINT#2,192+L:ELSE IF L=1 PRINT#2,AELSEPRINT#2,L','A
1840 L=1:A=B
1860 NEXTI:END
65000 'TWELVE
```

Listing 13: *Routine to display the compressed data generated by listing 12.*

```
1905 DATA194,170,191,159,56,143,175,191,149,194,170,191,149,248,170,191,149,194,
170,191,149,248,170,191,149,194,170,191,149,248,170,191,149,194,170,191,149,209,
160,2,176,191,21,131,171,149,204,170,191,149,194,170,191,149,208,184,135,194
1910 DATA191,193,138,181,193,186,133,170,149,130,171,151,129,170,151,131,129,170
,181,158,129,193,170,149,204,170,191,149,194,170,191,149,206,160,158,129,195,191
,194,171,188,151,193,170,149,193,170,149,193,170,151,194,170,159,180,194,170
1915 DATA149,204,170,191,149,194,170,191,149,201,188,4,140,143,188,3,140,188,191
,195,131,194,130,129,193,130,129,193,130,2,131,129,130,129,130,129,193,170,149,2
04,170,191,149,194,170,191,149,201,191,184,151,2,131,175,182,173,144,131,2,191
1920 DATA193,170,149,170,189,180,191,193,190,131,141,195,160,190,135,2,131,175,1
80,170,149,204,170,191,149,194,170,191,149,200,160,191,167,190,135,175,180,139,1
89,155,180,2,191,193,170,149,170,149,131,191,193,175,176,156,176,193,184,159
1925 DATA161,190,135,175,180,139,191,149,204,170,191,149,194,170,191,149,200,130
,129,191,153,183,157,187,149,130,175,182,179,191,12,176,190,135,193,191,153,183,
157,187,149,170,157,132,203,170,191,149,194,170,191,149,202,130,175,180,190,135
1930 DATA213,130,175,180,190,135,207,170,191,149,194,170,191,149,248,170,191,149
,194,170,191,149,248,170,191,149,194,170,191,149,248,170,191,149,194,170,191,189
,56,188,190,191
2000 DEFINTI-N:ONERRORGOTO2030:CLS
2020 READI:IFI<129THENREADJ:PRINTSTRING$(I,J);ELSEPRINTCHR$(I);
2025 GOTO2020
2030 RESUME2040
2040 POKE 16383,149
2045 GOTO 2045
2050 REMARK--PROGRAM NUMBER THIRTEEN TO EXECUTE PRINTOUT LINES 1900-2040
65000 'THIRTEEN
```

Text continued from page 180:

tab characters have a decimal value of 193 or greater, listing 11 can distinguish between tab values (to be printed using CHR$) and number pairs (to be printed using STRING$). This gives us a slight improvement in speed over the previous method.

A variation of this program comes to mind, since the number 1 is really not needed when using the STRING$ function. If the length of the string is 1, we can PRINT CHR$(176), instead of using STRING$(1,176) as we would when using a number pair (see line 1910 of listing 11). That being the case, it is possible to rewrite the routine and, by adding one statement, tell the computer to go ahead and print out only 1 character.

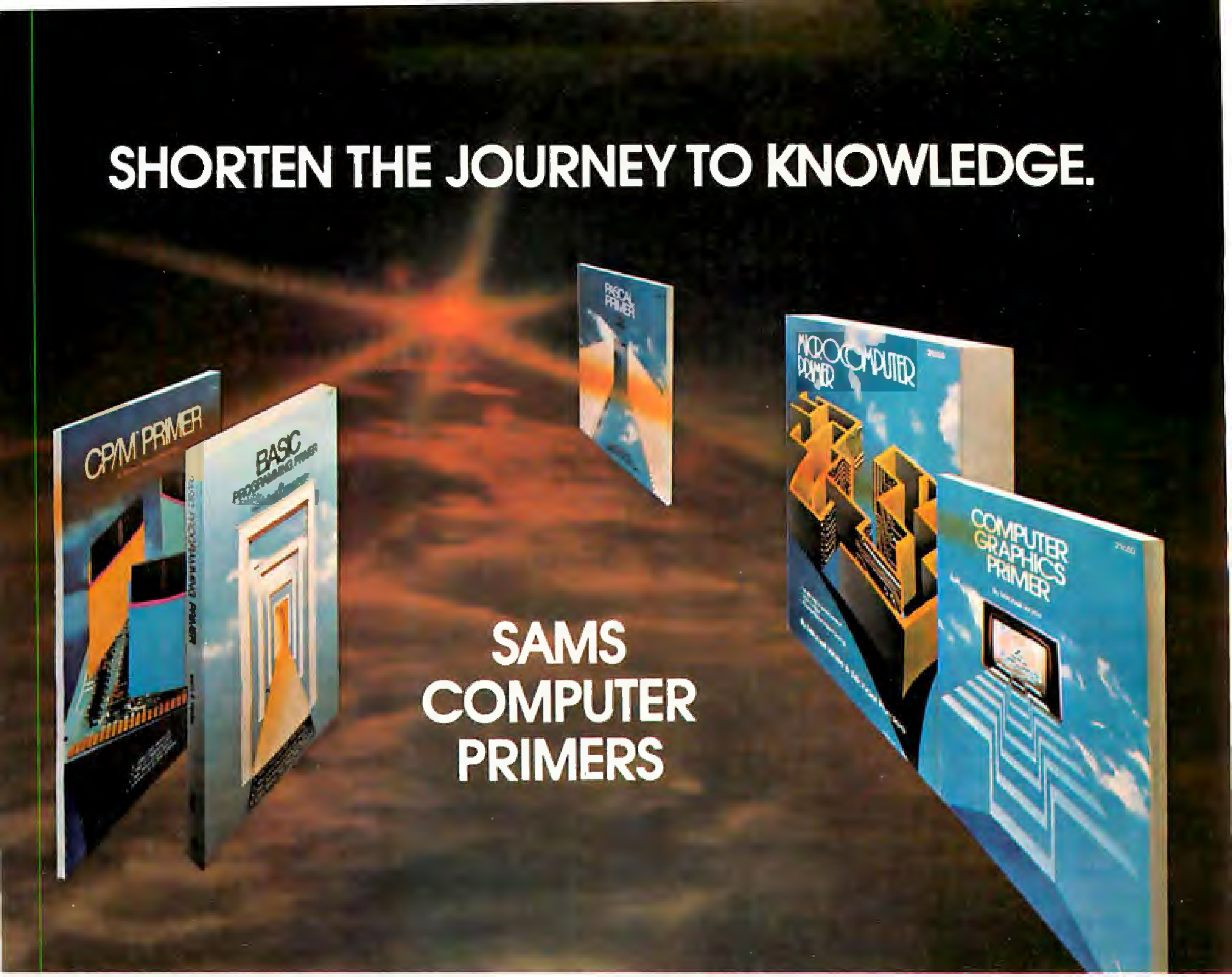
Features of several of these programs may be combined. The space saver, which prints a series of spaces as the value 192 plus the number of spaces (as done in listings 6 and 7), may be combined with printing of a string of graphic characters using STRING$ (see listings 8 and 9). By combining these with the length-1 technique discussed above, we have a slightly more complicated program. It does, however, run a bit faster than its predecessor and uses much less memory in the DATA statements.

The final (and fastest) version of this program is given in listings 12 and 13. Using the three techniques just discussed, listing 12 writes data values out to the data file FASTEST. When this data is converted to DATA statements (by running listing 3), the program in listing 13 (which includes the data statements) uses them to recreate the original picture on the video screen.

Conclusions

These programs serve to illustrate alternative methods of using graphics on the TRS-80 Model I with Level II BASIC. These are not the only techniques that can be used, but are merely our suggestions for ideas you can try in some of your programs.

In some cases you will be sacrificing memory space for printout speed. The decision as to which of these methods is best for your particular program rests solely with you. The easiest way to find out is to put the various routines into programs and experiment with them. ■



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Getting Problem-Solving Advice from a Computer

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Over the last three years, Paul Mellema and I have been at work on EMIL, an interactive computer program that we use to help teach our courses in formal logic. Since June 1979, we have been devoting our efforts to implementing a computerized "copilot" for EMIL that students can call on to solve problems.

The methods used to give our students advice are easily implemented and effective. The approach does not easily fit into the standard categories of educational computing (ie: record keeping, drill and practice, testing, games, simulation, etc). It is an approach that has potential for widespread application. The goal of this program is to help students develop and use skills and strategies needed to creatively solve problems that do not necessarily have only one solution. The program is Socratic in its style, because it asks students leading questions that help them analyze and resolve their difficulties.

In the study of formal logic, students are required to construct formal proofs. A proof is a series of statements leading to a conclusion. Each step of the proof is assumed to be true or derived from previous steps according to the rules of logic. The proof is intended to demonstrate that the conclusion follows logically from the assumptions.

Learning this type of thinking is valuable to students not only because it can lead to a mastery of logic, but because it also gives students experience in the kind of creative problem solving characteristic of mathematics, theoretical science, and many other disciplines and real-life pursuits.

Giving students practice in the creative solution of formal problems is important in education and particularly so in the sciences. Scientific knowledge is too often presented as if it descended from heaven or was created by some form of superhuman intelligence. Very little effort is given to help students appreciate the thinking processes that go into the analysis and solution of scientific problems. There is a tendency to obscure the very human process of trial and error, of trying out strategies, of assessing failures, and of creating better lines of attack, which are all part of scientists' daily life. A course in logic gives students the opportunity to refine their problem-solving skills in an environment where the difficulty of the problems can easily be adjusted to their growing abilities.

In a traditional course in logic, where students' abilities vary widely, those who do not have an initial knack for problem solving are at a serious disadvantage. Even when strategies for proof building are carefully discussed in class, some students invariably complain that they cannot solve a new problem on their own in spite of understanding the lectures. Part of this difficulty is that some students cannot convert verbal explanations of techniques into strategies for dealing with new situations. Their problem is somewhat similar to that of a student driver who has mastered a lecture on how to operate a car, but cannot convert this knowledge into the appropriate series of actions for handling a real car on a real road. Driver training classes overcome this problem by using the guidance of a copilot who helps correct errors while the students practice the task.

Similar sorts of tutoring are very effective for helping students who cannot apply the verbal knowledge about logic to the construction of proofs. If students are asked to "think out loud" while attempting a proof, a gentle nudge here and there often leads to success. If they do not understand the rules or simply have not bothered to learn them, guiding them through a few proofs tends to straighten things out quickly, and it improves confidence and motivation. Just as in teaching most skills, effective methods involve letting students perform given tasks under guidance. Lecturing on the proper procedures and telling students to "go home and do likewise" is relatively ineffective.

About the Author

James Garson is a member of the Department of Information Engineering, University of Illinois at Chicago Circle. This article is a revised version of a paper he delivered to the National Educational Computer Conference, June 1980, in Norfolk VA. The work described was carried out under the National Science Foundation Grant Number SER79-00527. This article does not represent the views of that foundation. Another article by Mr Garson, "The Case Against Multiple Choice," can be found in The Computing Teacher, *February-March 1980, page 29.*

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Of course there are good reasons why tutoring is not widely used in introductory logic courses. These classes are usually quite large, so tutoring simply takes too much of the teacher's time. Besides that, grading formal proofs constructed by students is tedious, so teachers tend to give students relatively few exercises that require them to create such proofs. Even students who do well in logic generally do not get enough practice to develop very much skill. Often the teacher relies on exercises that require a single answer — exercises that ask students to give justifications for the steps of a completed proof. This does familiarize students with the rules, but it gives them no practice in the art of building up a proof.

Enter the Computer

Computers make it possible to simulate the tutoring situation. Students can enter their proofs at the terminal, and the computer can determine whether each line follows from previous lines and describe the difficulty if one does not. If students get lost, the computer can give advice on how to proceed.

In 1976 we wrote a program called EMIL that lets students enter their proofs at the terminal and monitors their progress. The program has been used in a variety of courses at Notre Dame and has recently been adopted at Rutgers University. EMIL has several advantages over other proof-checking programs. First, there are a large number of logic textbooks, each with its own version of the rules of logic. Our program is the only one that lets a teacher supply the program with the set of rules used in his or her class, instead of forcing the use of the text with the set of rules written into the program. Second, the EMIL program is extremely gentle with students' input and generally repairs typing mistakes rather than complaining about them. This is important because many students are unfamiliar both with the terminal keyboard and the notation of logic. Third, the program lets students enter statements at the bottom (ie: end) of the proof so they can work the proof backwards if they desire to do so.

We allow and, in fact, encourage this because effective proof-building requires an analysis not only of the statements already derived, but of the statement to be proved as well. Often the proof can be considerably simplified by using the goal statement as a guide for determining the steps previous to it. Our program allows students to employ such strategies right at the terminal, instead of submitting a finished product to the computer for checking. The fourth advantage of our program is the main topic of this article: since September of 1979 EMIL has been giving students good advice on how to solve problems they find difficult. In this way, it is providing a good portion of what can be offered by a human logic tutor.

Programming Strategies

There are several distinct approaches to designing a computer program that can offer advice on formal proof construction. The first is simply to store a completed version of each proof and a list of comments that are intended to help students who ask for aid in deriving a given line. If the comments prove unhelpful, students can ask to see the next line of the stored proof or, indeed, any number of lines up to and including the entire proof.

This hint approach requires that a completed proof must be stored in the computer with appropriate comments for every problem students will work on. It also presupposes that there is only one reasonable sequence of steps that leads to the conclusion. If students approach a problem in an unusual way, there may not be enough similarity between their proofs and the stored proof for the computer to be of any help. Finally, it presupposes a top-to-bottom pattern of proof construction. But very often, from a given step in a proof, it is not at all apparent how to get to the conclusion. Such strategies must be explained with reference to what happens later in the proof. This sort of hint routine fails to help students appreciate global strategies that require knowledge not just of where the proof has been, but of where it is going. These are generally the most useful strategies.

Another technique is to write a program that allows the computer to generate a solution to students' problems and to recognize certain standard situations during the course of that solution. This strategy eliminates the need for storing a proof with commentary for each problem, since the computer generates its own solutions. But this strategy runs the risk of generating strange proofs that students are unlikely to recapitulate. Also, each formulation of the rules of logic would require its own custom-tailored program for generating proofs. Furthermore, the program to generate comments must be very carefully written to avoid misleading advice. Most importantly, this approach still does not help students to see global strategies; like the stored proof approach, it uses a top-to-bottom pattern of proof construction. So, this approach also confines itself to giving advice only about the next line of the proof.

Another difficulty with both of these approaches to the design for an advice giver is that the program does not attempt to construct advice on the basis of whatever progress the student may have already made on the proof. This tends to discourage invention of novel, yet promising, partial solutions. It can devalue students' creative abilities and lower their self-confidence. It dampens students' engagement in the problem-solving process while reinforcing stereotyped solutions.

Our Approach

The third approach to the design of an advice giver, the one we have adopted, overcomes these problems by paying more attention to the techniques actually used by human logic tutors. One of the main things a human tutor should do is to provide students with effective problem-solving tools for analyzing situations and for breaking problems into simpler subproblems. The same tools can then be applied to these simpler problems. An effective tutor does not give a solution or even pieces of it. Instead, the tutor provides an apprenticeship in the art of asking relevant questions, whose answers lead students to see how problems can be broken down into more manageable parts. Questions like "Can you apply this rule to statements you have already derived?" and "What rule could be used to derive a statement of this type?", when presented in a coherent sequence, are very effective for helping students develop strategies to be used effectively in a wide variety of proof-building problems.

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```
1. 'CAN YOU APPLY MP TO ANY PROVEN LINES' 'Y' 2 'N' 3
   '*ANSWER YES OR NO'
2. 'APPLY MP TO THESE LINES' '*'
3. 'WHAT IS THE MAIN CONNECTIVE OF YOUR GOAL FOR-
MULA?' '&' 4 'V' 5 '->' 6 '*PLEASE ANSWER &, V OR ->'
```

Table 1: *Sample records from the question file of our program that is designed to give advice to students concerning the construction of formal proofs in logic courses.*

to new questions on the basis of the answers. Eventually, the program runs out of questions to ask, and specific advice is given on the basis of the information provided in the previous answers. (The questions can be thought of as being structured in a tree, with the path taken along the branches being determined by the students' answers and the advice for each situation being located at the tip of each branch.)

Programming the question-asking routines for our own advice giver was quite simple. Thus the main focus of our attention has been the creation of a file of questions with real pedagogical merit. Since the questions are not written into the structure of our program, modifying the question tree in response to what we learn about effective advice is a painless process that does not require any programming expertise.

Our question file has a very simple format. (See table 1.) Each record contains the text of a question followed by a list of acceptable answers. Each answer is followed by a number indicating which record to jump to in case the student responds with that answer. The last item in each record begins with a "*" (which indicates that there are no more acceptable answers) and contains text that is printed in case the student does not respond with one of the acceptable answers. Most of the questions we ask are answered with *yes* or *no*, but we found the use of other sorts of answers more convenient for certain questions. The text of the advice to be given is simply stored in the question file followed by "*". This indicates that this pseudoquestion has no acceptable answers, and the program should stop after printing the advice.

Expansion

We have built a number of improvements into this simple program. The first has to do with the fact that the sequence of the questions should vary depending on how much students have learned and how difficult their problems are. Our solution to this problem is to assign each problem a level number and to use this number to route the program to separate question trees for each level we have defined.

The second enhancement is motivated by the fact that we want to mention items in our questions that change during the execution of the program (for example, the last line number finished in the proof or the name of the rule to be used). Obviously the text of the questions in the file cannot mention specific line numbers or rule names. Our solution is to introduce variables that are replaced with the corresponding specific information just before the question is printed. We have adopted a convention that words beginning with "&" are variables, so a line of advice on our question file might read:

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"YOU SHOULD APPLY &RULE TO LINE &GNUM"

This directs the program to fill in the specific information about the rule name and line number, for example:

"YOU SHOULD APPLY MP TO LINE 5"

Although our advice-giving program was running with these two enhancements in September, we were still working on a central portion of the program the following January. We still had to program the most important improvement: the development of subroutines that can answer all the questions posed to students by the program and that can comment on any errors in students' responses. Though students are usually accurate in their responses, they occasionally make mistakes that can result in their receiving bad advice. But this is not the only reason for giving the computer the ability to monitor the correctness of students' responses.

Once students run the advice giver a number of times, they become bored with answering a number of seemingly pointless questions. The questions become pointless not because they are not needed in analyzing proof-construction problems in general, but because a particular portion of the analysis is not needed for the problem being dealt with. When the computer is capable of answering the questions itself, we can decide which questions at particular levels of difficulty should be printed at the terminal, and those the computer should answer for itself by examining the proof being worked on.

Experienced students may resent being asked any questions at all and may prefer the advice giver to merely print specific pieces of advice. However, we believe that for most students who need the advice giver in the first place, posing relevant questions is much more valuable to learning problem-solving skills than is obtaining advice.

Does It Work?

We now have a version of EMIL that answers all the questions it poses. We also have a method for indicating which questions are to be asked under the particular circumstances. There is a need to do more research on how obtrusive the advice giver ought to be in relation to students' progress and cognitive style. However, one of the advantages of our program is that we can easily control the circumstances under which questions are asked. In fact, our program allows the students to suppress the asking of questions if this bothers them.

There is a final reason for programming the computer so that it can answer all the questions: when this is done the program can traverse the question tree on its own and come up with relevant advice. Once advice is available, the program can follow it to construct proofs on its own. Judging from extensive tests of the program, our advice tree turns out to be highly, though not totally, effective for solving logic problems. It is capable of solving over 95% of the problems that we give to our students. This provides us with an important tool for improving our program. By running a large number of problems through our advice giver, we can determine the circumstances under which it is unable to do a proof. Then we use that information to create a more sophisticated version of our question file.

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wide range of applications. It can be used, for example, to help college students with their physics homework, to determine the identity of unknowns in qualitative chemistry, to help medical students learn diagnosis, and even to help people determine what is wrong with their cars or whether they should itemize their deductions. All it takes is a simple program to run the questions and a question file that is carefully constructed to reflect the best strategies that people actually use to solve the kind of problems at issue. Depending on the context of its use, some or all of the enhancements to the basic program we have developed could be used.

It is worth pointing out exactly how our advice-giving program differs from the traditional way in which the multiple-choice format is used in CAI (computer-aided instruction). These differences are not particularly striking from the programmer's point of view. In both cases, programs are designed to ask questions and to select new questions on the basis of the answers. The advice-giving program requires a more elaborate branching structure and may differ in being unable to evaluate responses. But the important differences are the ones that are obvious to the educator: these have to do with the educational goals of the program.

The standard objective for using multiple-choice techniques is to help students learn certain facts. In the case of the advice-giving program, the answers are not part of what is being taught. It is the sequence of questions representing an effective problem-solving strategy that we would like students to master. By repeatedly exposing students to questions that have been proven effective in problem analysis, they learn to develop efficient strategies that can be used over a wide range of problems. The whole process of adopting principles of problem analysis is a valuable exercise of problem-solving skills that can be applied to any domain where creative thinking is required.

We should stress that despite our emphasis on strategy learning as an objective to advice-giving programs, the programs are also effective in giving factual information. From our advice giver, our students learn about the rules of logic, their names, their operation, and their functions in proofs. Also important is that our program helps expose students to this information at the exact times when it is most useful: this is the context when they are most likely to be receptive to learning these facts.

Although the advice-giving program may not look very different from standard multiple-choice "courseware" to the programmer, it has radically different educational goals — the most important of which is the development of problem-solving abilities. Given the simplicity of the programming effort as compared to games and simulations, the advice-giving program is particularly attractive for educators interested in developing students' creativity. ■

Education Forum is an occasional feature in BYTE intended to foster debate about the uses of personal computers *in the* schools and colleges. We encourage reader participation. Contributors should supply their full names and addresses for publication, along with their telephone numbers, which will not be published.

A Chessboard Journey on the TI-59 Programmable Calculator

Michael Gilpin
Michigan Technological University
Houghton MI 49931

KTTOUR-59 (see listing 1) is a program for the Texas Instruments TI-59 that finds *Knight tours* on an 8 by 8 board. (A Knight tour is a journey on a chessboard where the Knight lands on each square exactly once.)

To begin, partition the calculator memory locations into 320 program lines and 90 addressable memory locations by pressing 9, *Op, 17. Then enter the program and press B. This initializes values in registers 00 thru 89 as shown in figure 1. The actual chessboard is represented by registers 11 thru 18, 21 thru 28, . . . 81 thru 88. After setting up this initial configuration, the program returns with the display value 0. Enter the initial square number and press C. The program will then move the Knight at the approximate rate of one move every 33 seconds according to the Rule of Warnsdorf. That is, it will always move the Knight to a square having, at that point in the tour, a minimal number of entrances.

Execution stops with the display value 0 as soon as no additional moves can be found. Pressing D causes the program to flash each move in the format "square.move" (eg: "13.07" means the seventh move was made on square number 13). This allows the user to write down the complete tour on graph paper. If used in conjunction with the Texas Instruments PC-100A printer, a hard copy of the tour is produced using the same format. Then for a dif-

Text continued on page 202

Listing 1: *KTTOUR-59, written for the Texas Instruments TI-59.*

Loc.	Keys	Comments
000	9 STO 50	Start with 9 exits.
003	8 STO 09	Prepare to test 8 jumps.
006	RCL *IND 09 SUM 10	Put KT on test square.
010	SUB 0 91 INV *x=t 0 61	Test for legal move.
017	8 STO 00	Prepare to count exits.
020	1 STO 89	One exit has been found.
023	RCL *IND 00 SUM 10	Put KT on potential exit.
027	SUB 0 91 INV *x=t 0 37	Test for legal exit.
034	1 SUM 89	Increase exit count.
037	*DSZ 0 0 23	Next potential exit.

Listing 1 continued on page 200

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Listing 1 continued:

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041          2    1    +/-  SUM  10                        Return KT to test square.
046          RCL  50   x≷t  RCL  89   *x≥t 0    60         Test for new minimum.
054          STO  50   RCL  10   STO  20                   New minimum and position.
060          *CP
061          *DSZ 9    0    06                             Next test square.
065       2  1    +/-  SUM  10                             Return KT to last square.
070     RCL  10   -    RCL  20   =    *x=t 2    10         Stop if no move possible.
079     RCL  *IND 10   STO  *IND 20   RCL  20
        STO  10   1    SUM  *IND 10                        Move knight.
090 RST                                                    Look for further moves.
091 RCL 10   x≷t  1    0    *x≥t 1    07
        8    9    x≷t  *x≥t 1    07                        Test for correct range.
105 RCL *IND 10   *CP  INV  SUB                            Return 0 for legal move.
109 *LBL B                                                 Prepare board for tour.
        *CMS 8    0    STO  00   8    +/-
        STO  *IND 00   *Op  30   STO  *IND
        00   SUM  00   *DSZ 0    1    18                   Fill border squares.
130     2    STO  01   STO  07   4    STO  03
        STO  05   x²   STO  04   7    STO  02
        STO  06   2    1    +/-  STO  08                   Load jump increments.
153 CLR R/S
155 *LBL C                                                 Make first move.
        STO  10   STO  20   1    STO  *IND 10   RST        Begin search.
165 *LBL D    *Fix 2                                       Display Routine.
169     8    STO  00                                       Prepare row index.
172     8    STO  09                                       Prepare column index.
175          RCL  00   ×    1    0    +    RCL  09
             =    STO  89   +    RCL  *IND 89   ÷
             1    0    0    =    Pause Pause Pause *Prt    Display "square.move".
198     *DSZ 9    1    75   *Adv                           Next column.
203     *DSZ 0    1    72                                  Next row.
207 CLR INV  *Fix R/S
```

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20 -8	21 0	22 0	23 0	24 0	25 0	26 0	27 0	28 0	29 -8
30 -8	31 0	32 0	33 0	34 0	35 0	36 0	37 0	38 0	39 -8
40 -8	41 0	42 0	43 0	44 0	45 0	46 0	47 0	48 0	49 -8
50 -8	51 0	52 0	53 0	54 0	55 0	56 0	57 0	58 0	59 -8
60 -8	61 0	62 0	63 0	64 0	65 0	66 0	67 0	68 0	69 -8
70 -8	71 0	72 0	73 0	74 0	75 0	76 0	77 0	78 0	79 -8
80 -8	81 0	82 0	83 0	84 0	85 0	86 0	87 0	88 0	89 0

Figure 1: *Register initialization assignments. The values are assigned as shown for an 8 by 8 playing area. Usable squares are identified by a zero value; the board size can be reduced by manually assigning nonzero values to eliminate squares.*

11 1	12 20	13 9	14 14	15 3
21 10	22 15	23 2	24 19	25 24
31 21	32 8	33 23	34 4	35 13
41 16	42 11	43 6	44 25	45 18
51 7	52 22	53 17	54 12	55 5

Figure 2: *Example of a reduced-size board. The Knight tour shown here is the result of KTTOUR-59's version of the Rule of Warnsdorf applied to a starting position of 11.*

Text continued from page 198:

ferent tour, press B, enter a new starting position, and proceed as before.

The program execution can be modified to find tours on subsets of the 8 by 8 board. Press B as before. Then enter a nonzero value (say 1) into any square you wish to eliminate before entering the initial square and pressing C. This works since the Knight is not allowed to move to squares containing a nonzero value. For example, press B and then store the value 1 into registers 16, 17, 26, 27, 36, 37, 46, 47, 56, 57, 61 thru 67, and 71 thru 77. Enter the initial position of 11 and press C. The result will be the 5 by 5 tour shown in figure 2. ■

Acknowledgments

M Kraitchik, le Probleme du Cavalier, Gauthiers-Villars et C^IE, Paris, 1927.

Thanks are also due Professor William Woodruff, Grand Rapids, Michigan.

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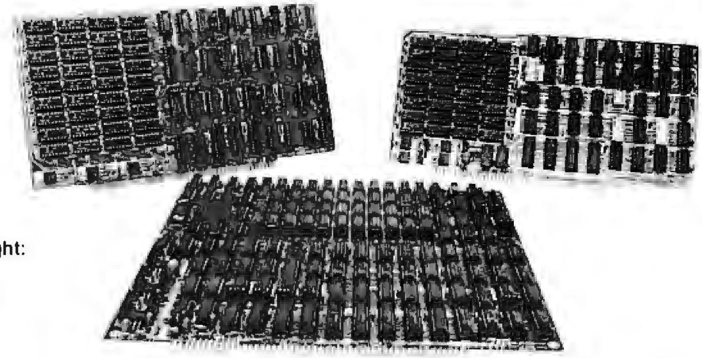

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An Integer Math Package for the 8080

Bruce D Carbrey
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"How can you have a computer that doesn't know how to multiply?" People unfamiliar with microcomputers ask this question incredulously whenever I describe the limitations of arithmetic on my 8080-based system. Of course, if you work in BASIC, you may take arithmetic for granted; but if you are an assembly-language user like myself, you are probably painfully aware of the absence of 16-bit arithmetic on the 8080 microcomputer.

It is quite possible that you need multiple-byte arithmetic routines for your assembly-language programs. If program space is a problem (most floating-point routines use several K bytes of memory), or if 16-bit signed integer arithmetic is sufficient for your needs, then the arithmetic routines given in this article may be of interest. These routines run one order of magnitude faster than full floating-point routines; also, they occupy only 215 bytes, all of which may be in read-only memory if desired.

Two additional routines provide conversion between ASCII (American Standard Code for Information Interchange) decimal character strings and the signed binary notation used by the arithmetic routines. These routines require an additional 175 bytes, including 2 bytes that must be in programmable memory.

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Design of the Arithmetic Routines

The arithmetic routines (given in listing 1) use the HL register pair as a 16-bit wide "accumulator." Subroutines performing *dyadic* operations (ie: those with two operands) expect to find one operand in the HL register pair and the other in the DE register pair. The result is returned in the HL pair. The arithmetic subroutines also set the sign and zero flags to reflect the value of the result returned in the HL register pair. (For example, if the result of an operation is decimal −11034, then the minus flag will be set and the zero flag will be cleared.) The information in the carry flag is invalid and should be ignored. The B, C, D, and E registers are restored by all routines except EDIVMOD (the division routine), which returns the quotient in the HL register pair and the remainder in the DE register pair, with the B and C registers restored.

Internally, values are represented in two's complement form, with the most significant bit acting as a sign bit. (See text box on page 225.) This representation is a simple extension of the 8-bit representation used for normal accumulator operations.

Unfortunately, this also leads to one small anomaly. The smallest representable number is −32,768, but the largest is only +32,767. (See the text box on page 226.) Thus, if you negate the value −32,768, an overflow will result. As a consequence of this fact, you may add or subtract two values that give a result of exactly −32,768, but if you try to multiply or divide two numbers that will yield an answer of exactly −32,768, an overflow will result because the multiply and divide routines work on absolute values internally.

All operations, including the string-to-numeric conversions, will

Text continued on page 226

NO MEMORY PARITY?
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First in Software Technology

Listing 1: *16-bit arithmetic subroutines in 8080 assembly language. The eight routines, which are fully documented in the listing, operate on 16-bit numbers in two's complement form.*

```
                                    ORG      4000H

                         ***********************************************************************
                         *                                                                     *
                         *         ***** EXTENDED ARITHMETIC SUBROUTINES FOR 8080 COMPUTERS *****     *
                         *                                                                     *
                         *         WRITTEN BY BRUCE D. CARBREY       REVISION 0       SEPT., 1977   *
                         *                                                                     *
                         *         THESE ROUTINES EXTEND THE ARITHMETIC CAPABILITIES OF        *
                         *         THE 8080 MICROCOMPUTER TO INCLUDE INTEGER ARITHMETIC        *
                         *         ON SIGNED, 16-BIT QUANTITIES, USING BINARY, TWOS-COMPLEMENT *
                         *         ARITHMETIC.   THE RANGE OF PERMISSABLE VALUES WITHOUT       *
                         *         OVERFLOW IS                                                 *
                         *                    -32767 TO +32767                                 *
                         *                                      DECIMAL.  TO USE A MATH ROUTINE, *
                         *         SIMPLY LOAD THE REGISTER(S) INDICATED WITH THE OPERAND(S),  *
                         *         AND CALL THE APPROPRIATE ROUTINE.  THE ANSWER WILL BE       *
                         *         RETURNED IN THE REGISTER(S) INDICATED.  THE SIGN (S) AND    *
                         *         ZERO (Z) FLAGS WILL BE SET TO REFLECT THE VALUE OF THE      *
                         *         RESULT IN THE SAME WAY AS FOR AN ORDINARY 8-BIT ADD.        *
                         *         LOGIC IS PROVIDED FOR DETECTING OVERFLOW FOR ALL OPERATIONS, *
                         *         WHICH RESULTS IN A CALL TO A ROUTINE NAMED OVERFLOW         *
                         *         ( WHICH IS NOT SUPPLIED SINCE YOU MUST DECIDE WHAT YOU      *
                         *         WANT TO DO IN CASE OF OVERFLOW--- PROBABLY PRINT A MESSAGE  *
                         *         AND JUMP TO YOUR MONITOR).                                  *
                         *                                                                     *
                         *         IN ADDITION TO THE MATH OPERATORS, TWO UTILITY SUBROUTINES  *
                         *         ARE PROVIDED FOR STRING-NUMERIC AND NUMERIC-STRING CONVERSION. *
                         *                                                                     *
                         *         ENTRY      SUBROUTINE FUNCTION                              *
                         *         -----      ---------- --------                              *
                         *                                                                     *
                         *         EADD       (HL) = (HL) + (DE)                               *
                         *         ESUB       (HL) = (HL) - (DE)                               *
                         *         EMULT      (HL) = (HL) * (DE)                               *
                         *         EDIVMOD    (HL) = (HL) / (DE), AND (DE) = (HL) MOD (DE)     *
                         *         ESIGN      SET (S), (Z) FLAG TO REFLECT (HL), LEAVING (HL)  *
                         *                    UNCHANGED.                                       *
                         *         ECMP       SET (S), (Z) FLAGS TO REFLECT (HL) - (DE), LEAVING *
                         *                    (HL) AND (DE) UNCHANGED.                         *
                         *                                                                     *
                         *         DECBIN     CONVERT ASCII CHARACTER STRING REPRESENTING A SIGNED *
                         *                    DECIMAL INTEGER TO A SIGNED BINARY NUMBER.       *
                         *         BINDEC     CONVERT A SIGNED BINARY NUMBER TO AN ASCII STRING *
                         *                    REPRESENTING THE SIGNED DECIMAL VALUE OF THE NUMBER. *
                         *                                                                     *
                         *                                                                     *
                         ***********************************************************************

                           *         MATH PACKAGE EXECUTION TIMES IN MICRO-SECONDS:
                           *
                           *         ROUTINE  TYPICAL  WORST CASE
                           *
                           *         EADD       30        54
                           *         ESUB       50        74
                           *         EMULT     370       517
                           *         EDIVMOD   680      2500
                           *
                           *
                           *         ***** YOU MUST PROVIDE PATCHES TO THESE TWO ROUTINES... *****
                           *
                          OVERFLOW  EQU       0          WHERE TO GO AFTER OVERFLOW
                          CONVERR   EQU       0          WHERE TO GO ON STRING-NUMERIC ERROR
                           *

                         ***********************************************************************
                         *                                                                     *
                         * SUBROUTINE EADD - ADD (HL) TO (DE), RESULT TO (HL)                  *
                         *                                                                     *
                         ***********************************************************************

                           *          (HL) = (HL) + (DE)
                           *         ON RETURN, SIGN, ZERO FLAGS WILL REFLECT RESULT. CY CLEARED.
                           *         A REGISTER CLOBBERED. B, C, D, E REGS RESTORED.
                           *
         4000     7C      EADD      MOV       A,H        TEST IF SIGNS ARE SAME OR DIFFER...
         4001     AA                XRA       D
         4002     E680              ANI       80H
         4004     19                DAD       D          ADD, WITHOUT AFFECTING ZERO FLAG...
         4005     C20E40            JNZ       ESIGN      SKIP OVERFLOW TEST IF SIGNS DIFFER
         4008     1F                RAR                  TEST FOR OVERFLOW BY...
```

Listing 1 continued on page 212


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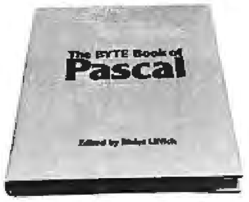

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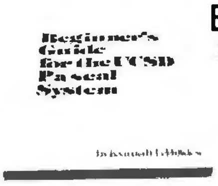

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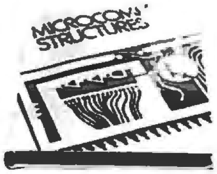

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Listing 1 continued from page 206:

```
4009    AC                XRA     H          ...EXCLUSIVE OR OF CY AND SIGN OF RESULT
400A    17                RAL
400B    DC0000            CC      OVERFLOW   CHECK FOR ARITH OVERFLOW
                  *                          FALL THRU TO .....

                  ***********************************************************************
                  *                                                                     *
                  * SUBROUTINE ESIGN - SET (S), (Z) FLAGS TO REFLECT (HL)               *
                  *                                                                     *
                  ***********************************************************************

                  *
                  *       A REGISTER CLOBBERED, ALL OTHERS RESTORED.
                  *
400E    AF        ESIGN   XRA     A          CLEAR FLAGS
400F    84                ADD     H          SET FLAGS TO REFLECT HI BYTE
4010    C0                RNZ                RETURN IF HI-ORDER BYTE IS NON-0
4011    85                ADD     L          ELSE, SEE IF L IS 0 TOO...
4012    C8                RZ                 AND IF SO, RETURN
4013    AF                XRA     A          ELSE, FORCE FLAGS TO SHOW +
4014    3C                INR     A
4015    C9                RET

                  ***********************************************************************
                  *                                                                     *
                  * SUBROUTINE ESUB - SUBTRACT (DE) FROM (HL), RESULT TO (HL)           *
                  *                                                                     *
                  ***********************************************************************

                  *       (HL) = (HL) - (DE)
                  *       ON RETURN, ZERO, SIGN FLAG REFLECT RESULT. CY CLEARED.
                  *       A REGISTER CLOBBERED. B, C, D, E RESTORED.
                  *
4016    D5        ESUB    PUSH    D
4017    EB                XCHG
4018    CD3040            CALL    COMP2      FORM 2S COMPLEMENT OF SUBTRAHEND...
401B    CD0040            CALL    EADD       ...AND PROCEED AS IN ADDITION
401E    D1                POP     D
401F    C9                RET

                  ***********************************************************************
                  *                                                                     *
                  * ECHS - CHANGE SIGN OF REGISTER (HL)                                 *
                  *                                                                     *
                  ***********************************************************************

                  *       (HL) = -(HL)
                  *       ON RETURN, ZERO, SIGN FLAG REFLECT RESULT.  CY CLEARED.
                  *       A REGISTER CLOBBERED.  B, C, D, E RESTORED.
                  *
4020    7C        ECHS    MOV     A,H
4021    D680              SUI     80H        CHECK FOR THAT ONE NASTY CASE...
4023    C22A40            JNZ     ECHSGO     ...OF (HL) = EXACTLY -32768...
4026    85                ADD     L          ...WHICH CANT BE COMPLEMENTED RIGHT
4027    CC0000            CZ      OVERFLOW   ...AND WHEN DETECTED, ABORT
402A    CD3040  ECHSGO    CALL    COMP2      ELSE, FORM 2S COMPLEMENT IN (HL)
402D    C30E40            JMP     ESIGN      SET FLAGS AND RETURN
                  *
                  *       SUBROUTINE COMP2 - FORM 2S COMPLEMENT OF (HL)
                  *
4030    7C        COMP2   MOV     A,H
4031    2F                CMA
4032    67                MOV     H,A
4033    7D                MOV     A,L
4034    2F                CMA
4035    6F                MOV     L,A
4036    23                INX     H
4037    C9                RET

                  ***********************************************************************
                  *                                                                     *
                  * SUBROUTINE EMULT - MULTIPLY (HL) BY (DE), RESULT TO (HL)            *
                  *                                                                     *
                  ***********************************************************************

                  *       (HL) = (HL) * (DE)
                  *       ON RETURN, ZERO, SIGN FLAG REFLECT RESULT.  CY CLEARED.
```

Listing 1 continued on page 214

Listing 1 continued:

```
                         *          A REGISTER CLOBBERED.  B, C, D, E RESTORED.
                         *
4038    C5      EMULT       PUSH       B
4039    D5                  PUSH       D
403A    CD6F40              CALL       RSLTSIGN  FIND RESULT SIGN, ABS VAL OF OPERANDS
403D    AF                  XRA        A
403E    84                  ADD        H
403F    CA4840              JZ         HLSMALL   BRANCH IF (HL) LESS THAN 8 BITS
4042    AF                  XRA        A
4043    82                  ADD        D         ELSE, OTHER OP MUST BE .LT. 8 BITS...
4044    C40000              CNZ        OVERFLOW  ...OR OVERFLOW WOULD RESULT
4047    EB                  XCHG                 (HL) NOW HAS AN OP WITH .LT. 8 BITS
4048    7D      HLSMALL     MOV        A,L       MOVE 8-BIT OR LESS MULTIPLIER TO A
4049    210000              LXI        H,0       INITIALIZE PARTIAL PRODUCT
404C    37      XMLOOP      STC                  CLEAR CARRY...
404D    3F                  CMC
404E    1F                  RAR                  ROTATE MULTIPLIER RITE OFF END
404F    D25640              JNC        SHIFTOP   IF BIT SHIFTED-OUT WAS 0, SKIP
4052    19                  DAD        D         ELSE, ADD MULTIPLICAND TO PARTIAL PROD.
4053    DC0000              CC         OVERFLOW  ...WHILE CHECKING FOR OVERFLOW
4056    EB      SHIFTOP     XCHG
4057    29                  DAD        H         SHIFT MULTIPLICAND LEFT 1 BIT...
4058    DC0000              CC         OVERFLOW  ...WHILE CHECKING FOR OVERFLOW
405B    EB                  XCHG
405C    B7                  ORA        A
405D    C24C40              JNZ        XMLOOP    BRANCH TO TOP OF LOOP IF MULT IS NON-0
4060    D1                  POP        D         WHEN MULTIPLY DONE, RECALL (DE)
4061    7C      SIGNRCL     MOV        A,H
4062    07                  RLC                  MAKE FINAL OVERFLOW CHECK...
4063    DC0000              CC         OVERFLOW  FOR VALUES BETWEEN32768 AND 65535 INCLUS.
4066    78                  MOV        A,B       THEN RECALL SIGN BYTE
4067    17                  RAL
4068    DC3040              CC         COMP2     CHANGE SIGN OF RESULT IF IT IS TO BE -
406B    C1                  POP        B
406C    C30E40              JMP        ESIGN     SET FLAGS AND RETURN
                         *
                         *          SUBROUTINE RSLTSIGN - COMPUTE SIGN OF RESULT FOR * AND /
                         *
                         *          ON RETURN: (HL) = ABSOLUTE VALUE OF (DE), (DE) = ABS. VAL (HL),
                         *          (B) = SIGN OF RESULT IN MOST SIGNIFICANT BIT.
                         *
406F    44      RSLTSIGN    MOV        B,H       FETCH SIGN BYTE OF 1ST OPERAND
4070    7C                  MOV        A,H       ...TO B AND ALSO TO A...
4071    17                  RAL
4072    DC3040              CC         COMP2     ABSOLUTE VALUE OF (HL)
4075    EB                  XCHG                 2ND OPERAND...
4076    7C                  MOV        A,H       SIGN BYTE TO A...
4077    A8                  XRA        B         RESULTANT SIGN...
4078    47                  MOV        B,A       ...TO MSB OF REG B FOR LATER RECALL
4079    7C                  MOV        A,H       SIGN BYTE OF 2ND OP TO A
407A    17                  RAL
407B    DA3040              JC         COMP2     ABSOLUTE VALUE, THEN RETURN.
407E    C9                  RET


                         ***********************************************************************
                         *                                                                     *
                         * SUB. EDIVMOD - DIVIDE (HL) BY (DE), QUO. TO (HL), REM. TO (DE)      *
                         *                                                                     *
                         ***********************************************************************

                         *          ON CALL: (HL) = DIVIDEND, (DE) = DIVISOR.
                         *          ON RETURN: (HL) = QUOTIENT, (DE) = REMAINDER.
                         *          FLAGS REFLECT VALUE OF QUOTIENT.  CY CLEARED.
                         *          A REGISTER CLOBBERED.  B, C RESTORED.
                         *          REMAINDER IS ALWAYS POSITIVE, REGARDLESS OF SIGN OF OPERANDS.
                         *
407F    C5      EDIVMOD     PUSH       B
4080    AF                  XRA        A         IF DIVISOR = 0...
4081    B3                  ORA        E
4082    B2                  ORA        D
4083    CC0000              CZ         OVERFLOW  ...THEN ABORT
4086    CD6F40              CALL       RSLTSIGN  COMPUTE RESULT SIGN; SWAP DE, HL
4089    7C                  MOV        A,H       INSURE THAT NEITHER OPERAND...
408A    B2                  ORA        D         ...WAS THAT NASTY SPECIAL CASE...
408B    07                  RLC                  ...OF EXACTLY -32768...
408C    DC0000              CC         OVERFLOW  ...AND IF IT WAS, ABORT
408F    C5                  PUSH       B         SAVE RESULT SIGN BYTE
4090    4B                  MOV        C,E       MOVE DIVIDEND ( = REM) TO BC
4091    42                  MOV        B,D
4092    110000              LXI        D,0       INITIALIZE QUOTIENT = 0...
4095    D5                  PUSH       D         ...ON TOP OF STACK (TOS)
4096    EB                  XCHG                 NOW BC = REM, DE=DIV, TOS=QUO
```

Listing 1 continued on page 216

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	NAME	DESCRIPTION
1	RULE78	Interest Apportionment by Rule of the 78's
2	ANNUI	Annuity computation program
3	DATE	Time between dates
4	DAYYEAR	Day of year a particular date falls on
5	LEASEINT	Interest rate on lease
6	BREAKEVN	Breakeven analysis
7	DEPRSL	Straightline depreciation
8	DEPRSY	Sum of the digits depreciation
9	DEPRDB	Declining balance depreciation
10	DEPRDDB	Double declining balance depreciation
11	TAXDEP	Cash flow vs. depreciation tables
12	CHECK2	Prints NEBS checks along with daily register
13	CHECKBK1	Checkbook maintenance program
14	MORTGAGE/A	Mortgage amortization table
15	MULTMON	Computes time needed for money to double, triple, etc.
16	SALVAGE	Determines salvage value of an investment
17	RRVARIN	Rate of return on investment with variable inflows
18	RRCONST	Rate of return on investment with constant inflows
19	EFFECT	Effective interest rate of a loan
20	FVAL	Future value of an investment (compound interest)
21	PVAL	Present value of a future amount
22	LOANPAY	Amount of payment on a loan
23	REGWITH	Equal withdrawals from investment to leave 0 over
24	SIMPDISK	Simple discount analysis
25	DATEVAL	Equivalent & nonequivalent dated values for oblig.
26	ANNUDEF	Present value of deferred annuities
27	MARKUP	% Markup analysis for items
28	SINKFUND	Sinking fund amortization program
29	BONDVAL	Value of a bond
30	DEPLETE	Depletion analysis
31	BLACKSH	Black Scholes options analysis
32	STOCVAL1	Expected return on stock via discounts dividends
33	WARVAL	Value of a warrant
34	BONDVAL2	Value of a bond
35	EPSEST	Estimate of future earnings per share for company
36	BETAALPH	Computes alpha and beta variables for stock
37	SHARPE1	Portfolio selection model-i.e. what stocks to hold
38	OPTWRITE	Option writing computations
39	RTVAL	Value of a right
40	EXPVAL	Expected value analysis
41	BAYES	Bayesian decisions
42	VALPRINF	Value of perfect information
43	VALADINF	Value of additional information
44	UTILITY	Derives utility function
45	SIMPLEX	Linear programming solution by simplex method
46	TRANS	Transportation method for linear programming
47	EOQ	Economic order quantity inventory model
48	QUEUE1	Single server queueing (waiting line) model
49	CVP	Cost-volume-profit analysis
50	CONDPROF	Conditional profit tables
51	OPTLOSS	Opportunity loss tables
52	FQUOQ	Fixed quantity economic order quantity model
53	FQEOWSH	As above but with shortages permitted
54	FQEOQPB	As above but with quantity price breaks
55	QUEUECB	Cost-benefit waiting line analysis
56	NCFANAL	Net cash-flow analysis for simple investment
57	PROFIND	Profitability index of a project
58	CAP1	Cap. Asset Pr. Model analysis of project
59	WACC	Weighted average cost of capital
60	COMPBAL	True rate on loan with compensating bal. required
61	DISCBAL	True rate on discounted loan
62	MERGANAL	Merger analysis computations
63	FINRAT	Financial ratios for a firm
64	NPV	Net present value of project
65	PRINDLAS	Laspeyres price index
66	PRINDPA	Paasche price index
67	SEASIND	Constructs seasonal quantity indices for company
68	TIMETR	Time series analysis linear trend
69	TIMEMOV	Time series analysis moving average trend
70	FUPRINF	Future price estimation with inflation
71	MAILPAC	Mailing list system
72	LETWRT	Letter writing system-links with MAILPAC
73	SORT3	Sorts list of names
74	LABEL1	Shipping label maker
75	LABEL2	Name label maker
76	BUSBUD	DOME business bookkeeping system
77	TIMECLCK	Computes weeks total hours from timeclock info.
78	ACCTPAY	In memory accounts payable system-storage permitted
79	INVOICE	Generate invoice on screen and print on printer
80	INVENT2	In memory inventory control system
81	TELDIR	Computerized telephone directory
82	TIMUSAN	Time use analysis
83	ASSIGN	Use of assignment algorithm for optimal job assign.
84	ACCTREC	In memory accounts receivable system-storage ok
85	TERMSPAY	Compares 3 methods of repayment of loans
86	PAYNET	Computes gross pay required for given net
87	SELLPR	Computes selling price for given after tax amount
88	ARBCOMP	Arbitrage computations
89	DEPRSF	Sinking fund depreciation
90	UPSZONE	Finds UPS zones from zip code
91	ENVELOPE	Types envelope including return address
92	AUTOEXP	Automobile expense analysis
93	INSFILE	Insurance policy file
94	PAYROLL2	In memory payroll system
95	DILANAL	Dilution analysis
96	LOANAFFD	Loan amount a borrower can afford
97	RENTPRCH	Purchase price for rental property
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Listing 1 continued:

```
4097    210100            LXI     H,1         INITIALIZE HOLD = 1
                  *
409A    29        DBLDIV  DAD     H           LEFT SHIFT HOLD
409B    EB                XCHG                NOW BC=REM, DE=HOLD, HL=DIV, TOS=QUO
409C    29                DAD     H           LEFT SHIFT DIV
409D    CDC940            CALL    CMPBH       COMPARE DIV TO REM
40A0    EB                XCHG                NOW BC=REM, DE=DIV, HL=HOLD, TOS=QUO
40A1    D29A40            JNC     DBLDIV      BRANCH BACK IF DIV < REM
40A4    EB                XCHG                DUMMY XCHG TO MAKE LOOP WORK 1ST PASS...
40A5    EB        HALVEDIV XCHG               NOW BC=REM, DE=DIV, HL=HOLD, TOS=QUO
40A6    CDCE40            CALL    DIVBY2      HOLD = HOLD/2 (RITE SHIFT)
40A9    CAC240            JZ      DIVDONE     IF HOLD = 0, WERE DONE
40AC    EB                XCHG                NOW BC=REM, DE=HOLD, HL=DIV, TOS=QUO
40AD    CDCE40            CALL    DIVBY2      RITE SHIFT DIV
40B0    CDC940            CALL    CMPBH       COMPARE DIV TO REM...
40B3    FAA540            JM      HALVEDIV    IF DIV > REM, BRANCH BACK
40B6    79                MOV     A,C         REM = REM - DIV...
40B7    95                SUB     L
40B8    4F                MOV     C,A
40B9    78                MOV     A,B
40BA    9C                SBB     H
40BB    47                MOV     B,A
40BC    E3                XTHL                NOW BC=REM, DE = HOLD, HL=QUO, TOS=DIV
40BD    19                DAD     D           QUO = QUO + HOLD
40BE    E3                XTHL                NOW BC=REM, DE=HOLD, HL=DIV, TOS=QUO
40BF    C3A540            JMP     HALVEDIV    ENDDO.

40C2    E1        DIVDONE POP     H           GET QUOTIENT TO HL
40C3    59                MOV     E,C         MOVE FINAL REM TO DE
40C4    50                MOV     D,B
40C5    C1                POP     B           RECALL SIGN BYTE FOR RESULT
40C6    C36140            JMP     SIGNRCL     COMPUTE FINAL SIGN OF RESULT AND RETURN
                  *
                  *       INTERNAL SUBROUTINE CMPBH - COMPARE BC TO HL...
                  *
40C9    79        CMPBH   MOV     A,C
40CA    95                SUB     L
40CB    78                MOV     A,B
40CC    9C                SBB     H           SIGN, ZERO NOW REFLECT (BC) - (HL)...
40CD    C9                RET
                  *
                  *       INTERNAL SUBROUTINE DIVBY2 - DIVIDE (HL) BY 2 (RITE SHIFT)
                  *       KILLS PSW.  REMAINDER RETURNED IN CY.
                  *
40CE    AF        DIVBY2  XRA     A           CLEAR CY
40CF    7C                MOV     A,H
40D0    1F                RAR
40D1    67                MOV     H,A
40D2    7D                MOV     A,L
40D3    1F                RAR
40D4    6F                MOV     L,A
40D5    B4                ORA     H           SET ZERO FLAG IF BOTH H AND L = 0
40D6    C9                RET


                  **********************************************************************
                  *                                                                    *
                  *  SUBROUTINE DECBIN - CONVERT ASCII DECIMAL TO BINARY NUMBER        *
                  *                                                                    *
                  **********************************************************************

                  *       THIS ROUTINE CONVERTS A STRING OF ASCII CHARACTERS REPRESENTING
                  *       A NUMBER TO A SIGNED 16-BIT NUMBER IN TWOS COMPLEMENT FORM.
                  *       LEGAL RANGE OF CONVERTIBLE VALUES IS -32767 TO +32767.
                  *       LEGAL FORM FOR STRING IS...
                  *
                  *       <BLANKS><SIGN><BLANKS><DIGITS><NON-DIGIT>
                  *
                  *       WHERE  <BLANKS> IS 0 OR MORE BLANKS,
                  *              <SIGN>  IS +, -, OR OMITTED,
                  *              <DIGITS> IS A STRING OF 1 OR MORE NUMERIC DIGITS,
                  *                    REPRESENTING AN INTEGER NOT EXCEEDING 32767.
                  *              <NON-DIGIT> IS ANY NON-DIGIT CHARACTER (E.G., A BLANK).
                  *
                  *       USAGE:
                  *
                  *       ON CALL:
                  *       (DE) = ADDRESS OF START-OF-ASCII STRING TO BE CONVERTED.
                  *       ON RETURN TO CALLING PROGRAM...
                  *       (HL) = RETURNED SIGNED NUMERIC VALUE
                  *       (DE) = ADDRESS OF TERMINAL CHARACTER OF STRING (<NON-DIGIT>)
                  *       SIGN AND ZERO FLAGS WILL BE SET TO REFLECT VALUE IN (HL).
```

Listing 1 continued on page 220

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) **MON-3** and **MON-4** (Howe Software).....Powerful utility programs enabling you to interact directly with your **TRS-80** in MACHINE LANGUAGE.....The monitor comes with complete 40-page instruction manual making it useful for both the beginner and advanced programmer.... simple commands make it easy to use.....functions include DISPLAY, DISASSEMBLE, MOVE and COMPARE, SEARCH, MODIFY, RELOCATE, PRINT, READ and WRITE, UNLOAD, SAVE and READ, INPUT and OUTPUT, SEND and RECEIVE.....MON-3 **$39.95** (for cassette)..... MON-4 **$49.95** (for disk).

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(15) **FAST SORT** (Howe Software).....a series of machine-language subroutines to sort data from BASIC programs.....data may be alphabetic (string) or numeric.....easily interfaced with your BASIC programs (no machine language knowledge is necessary) **$9.95**

(16) **MAILING LIST** (Howe Software).....maintains mailing lists of over 1000 names.....commands allow adding, changing, deleting, and finding names. Sorting is done in machine language subroutine.....labels printed in 1, 2 or 3 columns **$89.95**

(17) **HOME BUDGET** (Howe Software).....combines the maintenance of your checkbook with analysis of your income, expenses and monthly bills. Handles data including bills, income, deposits, checks and debits to your checking account, and cash expenses. Computes checkbook balance, list of unpaid bills, monthly and year-to-date summaries of income and expenses showing income tax deductions.....All output printed on video display or line printer.....comes with complete instructions manual **$49.95***

(18) **SMALL BUSINESS ACCOUNTING** (Howe Software).....Based on the DOME BOOKKEEPING SYSTEM.....keeps track of all income, expenditures and payroll for a small business of up to 16 employees.....income and expenditures can be entered on a daily, weekly or monthly basis..... computes monthly and year to date totals.....manual contains complete instrucitons for customization Cassette version **$29.95**.....Diskette version **$49.95**

(19) **REMODEL-PROLOAD** (Racet Computes).....Renumber program lines.....move statements from one part of a program to another **$34.95**

(20) **GSF** (Racet Computes).....Lightning fast in-memory machine language sort utility that can be made part of your BASIC progams without any machine language knowledge.....includes several other utilities to speed up your BASIC programs.....no machine knowledge necessary to use GSF in your BASIC programs **$30.00**

(21) **DOSORT** (Racet Computes).....includes **GSF** (above).....extends the in memory sort to sorts on multiple disk drives **$45.00***

(22) **COPSYS** (Racet Computes).....allows the user to make copies of machines language cassettes without any knowledge of machine language **$20.00**

(23) **COMRPOC** (Racet Computes).....an auto load program for disk users.....allows the user to insert a diskette into their **MOD-III** and have the computer take over all loading.....load a machine language program, BASIC, RUN a certain program all without pressing a single button .....allows your computer to perform 10, 20, 30 or more functions without pressing a single button **$30.00***

(24) **INFINE BASIC** (Racet Computes).....adds a variety of machine language subroutines to your BASIC programs (without any machine language knowledge).....fastsorts.....matrix operations .....compress and uncompress data.....and more **$60.00**

(25) **INFINITE BUSINESS** (Racet Computes).....an add on package to **INFINITE BASIC**.....adds a variety of routines important to the businessman (increase accuracy of calculations and more) **$30.00**

(26) **DMS** (Racet Computes).....lightning fast machine language sort.....sorts up to 4 disk drives of information **$90.00***

(27) **BLINK** (Racet Computes).....allows you to RUN new programs without losing the variables stored in your previous program.....line many programs together without losing important variables **$30.00***

(28) **KFS-80** (Racet Computes).....now you can use ISAM (Index Sequential Access Files) on your **MOD-III**.....using ISAM in your BASIC programs allows instant access of your items in your data files.....use with mail programs.....inventory programs.....etc. **$100.00***

(29) **MAIL LIST** (Racet Computes).....all routines are in machine language allowing for quick access **$75.00**

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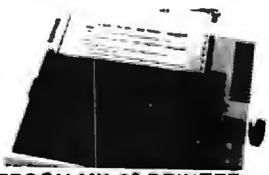

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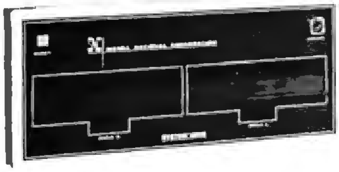
Listing 1 continued:

```
                        *         CY CLEARED. A REGISTER CLOBBERED. B, C RESTORED.
                        *
                        *         NOTES ON METHOD... B REG USED TO HOLD 3 FLAGS...
                        *         BIT 7="-" FLAG = MINUS SIGN ENCOUNTERED
                        *         BIT 6= "SE" FLAG = SIGN ENCOUNTERED
                        *         BIT 0 = "DE" = DIGIT ENCOUNTERED.
                        *
40D7   C5      DECBIN    PUSH    B
40D8   0600              MVI     B,0         INITIALIZE FLAGS -,DE,SE
40DA   210000            LXI     H,0         INITIALIZE RESULT
40DD   1A      AKLOOP    LDAX    D           FETCH NEXT ASCII CHARACTER
40DE   D630              SUI     48          CONVERT CHAR TO BCD DIGIT IF POSSIBLE
40E0   4F                MOV     C,A         SAVE (CHARACTER-48) IN C
40E1   FAFF40            JM      NOTDIGIT    IS IT A DIGIT 0 THRU 9...
40E4   FE0A              CPI     10
40E6   F2FF              JP      NOTDIGIT
40E9   D5                PUSH    D           ...IF SO, SAVE BUFFER POINTER
40EA   110A00            LXI     D,10        ...MULTIPLY PARTIAL RESULT BY 10...
40ED   CD3840            CALL    EMULT       ...(ALSO CHECKING FOR OVERFLOW)...
40F0   1600              MVI     D,0         ...AND ADD IN VALUE OF DIGIT...
40F2   59                MOV     E,C
40F3   CD0040            CALL    EADD        (HL) = (HL)*10 + DIGIT
40F6   D1                POP     D           RECALL BUFFER POINTER
40F7   13                INX     D           BUMP BUFFER POINTER
40F8   3E01              MVI     A,1         ...SET "DIGIT ENCOUNTERED (DE) FLAG...
40FA   B0                ORA     B
40FB   47                MOV     B,A
40FC   C3DD40            JMP     AKLOOP      ...AND WERE READY FOR NEXT CHARACTER
                        *
                        *         COME HERE FOR ANY CHARACTER EXCEPT 0,1,...9
                        *
40FF   79      NOTDIGIT  MOV     A,C         RECALL (CHAR-48)
4100   FEF0              CPI     -16         IS IT A BLANK. SET ZERO FLAG IF SO.
4102   78                MOV     A,B         RECALL FLAGS
4103   0F                RRC                 TEST "DIGIT ENCOUNTERED" FLAG IN CY
4104   DA6140            JC      SIGNRCL     IF DIGITS ENCOUNTERED PRIOR, WERE DONE
4107   C20E41            JNZ     TRYSIGN     ...ELSE, IF NOT BLANK TRY + OR -
410A   13                INX     D           ...ELSE IGNORE LEADING BLANK,
410B   C3DD40            JMP     AKLOOP      AND PROCEED WITH NEXT CHARACTER
410E   78      TRYSIGN   MOV     A,B         TEST "SE" FLAG IN CY
410F   07                RLC
4110   07                RLC
4111   DC0000            CC      CONVERR
4114   79                MOV     A,C         ELSE RECALL (CHAR-48)
4115   FEFD              CPI     -3          IS IT "-"...
4117   C2                JNZ     TRYPLUS     ...IF NOT TRY FOR "+" SIGN...
411A   3EC0              MVI     A,0C0H      ...IF IT IS "-", SET SE AND - FLAG
411C   B0                ORA     B
411D   47                MOV     B,A
411E   13                INX     D           BUMP BUFFER POINTER
411F   C3DD40            JMP     AKLOOP      AND PROCEED WITH NEXT CHARACTER
4122   FEFB    TRYPLUS   CPI     -5          IS IT "+" CHARACTER...
4124   C40000            CNZ     CONVERR     IF NOT ITS AN ERROR
4127   3E40              MVI     A,40H       IF IT IS "+", SET "SE" FLAG
4129   B0                ORA     B
412A   47                MOV     B,A
412B   13                INX     D           BUMP BUFFER POINTER
412C   C3DD40            JMP     AKLOOP      AND PROCEED WITH NEXT CHARACTER
                        *

                        ************************************************************************
                        *                                                                      *
                        * SUBROUTINE BINDEC - CONVERT BINARY NUMBER TO DECIMAL ASCII STRING    *
                        *                                                                      *
                        ************************************************************************

                        *         THIS ROUTINE GENERATES A STRING OF ASCII CHARACTERS
                        *         REPRESENTING A SIGNED DECIMAL INTEGER.  THE STRING IS
                        *         GENERATED LEFT-JUSTIFIED, WITH LEADING ZEROS SUPPRESSED.
                        *         THE STRING WILL OCCUPY FROM 1 TO 6 CHARACTERS DEPENDING ON
                        *         THE SIGN AND MAGNITUDE OF THE NUMBER DESIRED.
                        *         ON CALL: (HL) = SIGNED BINARY NUMBER TO BE CONVERTED.
                        *         (DE) = ADDRESS OF FIRST CHARACTER OF BUFFER WHERE STRING IS
                        *         TO BE GENERATED.
                        *         ON RETURN: (DE) = ADDRESS OF NEXT BYTE AFTER THE STRING
                        *         WHICH WAS GENERATED.  (A) = NUMBER OF CHARACTERS GENERATED.
                        *         B, C, H, L RESTORED.
                        *
412F   C5      BINDEC    PUSH    B
4130   E5                PUSH    H           SAVE HL
4131   010000            LXI     B,0         B=MINUS FLAG, C= DIGIT COUNTER
```

Listing 1 continued on page 222



Reliable/low cost single board design w/Z80 CPU.

Supports 1 to 4 single density floppy disks.

External S100 Bus available for extended adaptability (12 slots).

Four serial RS232 ports (parallel option available).

Random Access Memory: 64K RAM standard.

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Data Storage Power with 0.5 to 96 Megabytes available. The S100 Bus and SMD disk controller access a variety of hard disk systems:

BASF	8, 24, 40 Megabytes (fixed Winchester system)
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CDC	32, 64, 96 Megabytes (fixed Winchester + removable cartridge)

Multiprocessing: Multiple computer boards can be mounted within the System 4000 chassis and each can support a separate user station with its own display terminal and printer. The terminal network is controlled by a master CPU and each slave has the computational speed and memory size necessary to execute sophisticated programs without burdening the other user stations.

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Circle 367 on inquiry card.

Listing 1 continued:

```
402     4134    E5                 PUSH    H
403     4135    29                 DAD     H          PUSH SIGN INTO CY
404     4136    E1                 POP     H          RECALL UN-SHIFTED NO.
405     4137    D24241             JNC     DIV10K     FALL THRU FOR - NUMBER
406     413A    3E2D               MVI     A,45       ASCII MINUS SIGN
407     413C    12                 STAX    D          INTO BUFFER
408     413D    04                 INR     B          SET MINUS FLAG
409     413E    13                 INX     D          AND BUFFER POINTER
410     413F    CD3040             CALL    COMP2      ABSOLUTE VALUE OF NUMBER
411     4142    EB      DIV10K     XCHG               N TO DE, BUFF ADDR TO HL
412     4143    228441             SHLD    BUFADR     SAVE BUFFER ADDRESS
413     4146    EB                 XCHG
414     4147    111027             LXI     D,10000
415     414A    CD6E41             CALL    CNVT1DIG   FIND FIRST DECIMAL DIGIT
416     414D    11E803             LXI     D,1000
417     4150    CD6E41             CALL    CNVT1DIG   SECOND DEC DIGIT...
418     4153    116400             LXI     D,100
419     4156    CD6E41             CALL    CNVT1DIG   THIRD...
420     4159    110A00             LXI     D,10
421     415C    CD6E41             CALL    CNVT1DIG   4TH
422     415F    7D                 MOV     A,L        LAST DIGIT IS FINAL REMAINDER
423     4160    C630               ADI     48         CONVERT TO ASCII CHAR
424     4162    0C                 INR     C
425     4163    2A8441             LHLD    BUFADR     RECALL BUFFER POINTER
426     4166    EB                 XCHG
427     4167    12                 STAX    D          INSTALL LAST CHARACTER INTO BUFFER
428     4168    79                 MOV     A,C        RETURN CHARACTER COUNT IN A REG
429     4169    80                 ADD     B          ...AND ADD 1 FOR MINUS SIGN IF MINUS
430     416A    13                 INX     D          POINT TO NEXT DIGIT IN BUFFER
431     416B    F1                 POP     H          FINAL RESTORE FOR HL
432     416C    C1                 POP     B          RECALL B
433     416D    C9                 RET
434     416E    CD7F40  CNVT1DIG   CALL    EDIVMOD    DIVIDE REMAINDER BY 10**N
435     4171    EB                 XCHG               NEW REM TO HL
436     4172    7B                 MOV     A,E        DIGIT TO A
437     4173    B1                 ORA     C          IF NO NON-ZERO DIGITS SO FAR...
438     4174    C8                 RZ                 ...AND THIS = 0, THEN SUPPRESS LEADING 0
439     4175    7B                 MOV     A,E        ELSE, RECALL DIGIT
440     4176    C630               ADI     48         CONVERT DIGIT TO CHAR
441     4178    0C                 INR     C          UPDATE CHAR COUNTER
442     4179    EB                 XCHG
443     417A    2A8441             LHLD    BUFADR     BUFFER ADDRESS LOAD
444     417D    77                 MOV     M,A        STORE CHAR IN BUFFER
445     417E    23                 INX     H          NEXT CHAR
446     417F    228441             SHLD    BUFADR     SAVE BUFFER POINTER
447     4182    EB                 XCHG
448     4183    C9                 RET

                        ***************************************************************************
                        *                                                                         *
                        * FOLLOWING MUST BE IN READ/WRITE MEMORY...                               *
                        *                                                                         *
                        ***************************************************************************

450     4184            BUFADR     DS      2          TEMPORARY STORAGE FOR POINTER
451     4186                       END
```

```
                                        --- SYMBOLIC CROSS-REFERENCE MAP ---

-SYMBOL-    -VALUE- -R        -DEFINED- -REFERENCED-

AKLOOP       40DD   *A          336       353     364     376     383
BINDEC       412F   *A          399        29
BUFADR       4184   *A          450       412     425     443     446
CHIN         0000                 7        13
CHOUT        0000                 8        27      36
CMPBH        40C9   *A          285       255     264
CNVT1DIG     416E   *A          434       415     417     419     421
COMP2        4030   *A          161       141     156     205     217     224     410
CONVERR      0000               102       368     378
DBLDIV       409A   *A          252       257
DECBIN       40D7   *A          333        20      23
DIVBY2       40CE   *A          294       260     263
DIVDONE      40C2   *A          277       261
DIV10K       4142   *A          411       405
EADD         4000   *A          110       142     347
ECHS         4020   *A          151     *UNUSED
ECHSGO       402A   *A          156       153
EDIVMOD      407F   *A          234       434
EMULT        4038   *A          175        25     344
ESIGN        400E   *A          125       114     157     207
```

Listing 1 continued on page 224

Listing 1 continued:

```
ESUB         4016  *A        139   *UNUSED
HALVEDIV     40A5  *A        259    265    275
HLSMALL      4048  *A        185    180
INBUF        3038  *A         40     12     19
MONITOR      0000              9     35
NOTDIGIT     40FF  *A        357    339    341
OUTBUF       304F  *A         41     28     32
OVERFLOW     0000            101    118    155    183    192    195    202    238    243
RSLTSIGN     406F  *A        214    177    239
SHIFTOP      4056  *A        193    190
SIGNRCL      4061  *A        200    281    361
TEST         3000  *A         12   *UNUSED
TEST1        3003  *A         13     18
TEST2        3010  *A         19     16
TEST3        302F  *A         33     38
TRYPLUS      4122  *A        377    371
TRYSIGN      410E  *A        365    362
XMLOOP       404C  *A        187    198

-COMMON BLOCK-     -L     -

ABSOL               01DF
```


TECHNOLOGY:
AMERICA'S COMPETITIVE EDGE.
Westinghouse addresses the vital role of technology in industry.

Technology is the key to the world marketplace.

If we want to maintain America's competitive edge, we must make better use of present technologies, and encourage new ones.

Most of the firms and countries which have achieved conspicuous success in this world have done so because they possessed some special advantage. They had an edge over their competitors. In recent decades, America's competitive edge has been its technology. Our ability to originate and apply innovative scientific and engineering ideas earned us a commanding lead in the world marketplace.

Things have changed

Unfortunately, that lead has dwindled. America's share of the world's manufactured goods market has eroded over the past 20 years, lost to foreign manufacturers. Not only have they captured part of what had been our share of the world market, but they are now successfully penetrating our own domestic markets.

What happened?

A look at a few statistics helps reveal some of the reasons for our reversals. Take patents. The number of domestic patent applications by Americans has been flat for several years. In contrast, the number of those filed here by foreign countries has been rising every year. In 1978, almost 37 percent of the patents granted went to foreign applicants. Or take the percentage of our Gross National Product going into industrial R&D. Over the past two decades, it has dropped precipitously.

What is needed

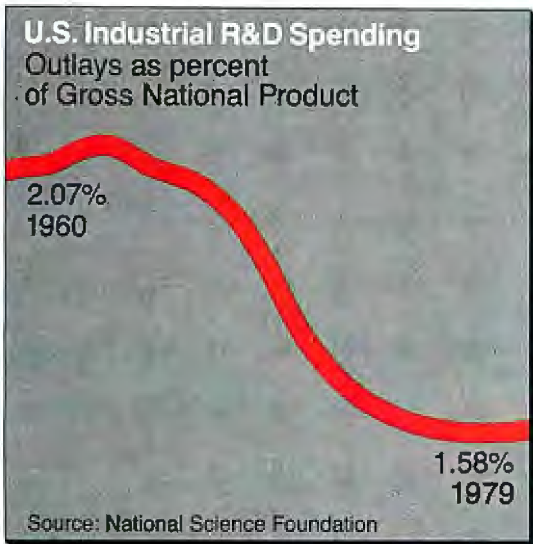
Fortunately, today Westinghouse and other corporations already have technologies which can help America maintain its technological leadership. And these same corporations are hard at work on technologies which can expand America's leadership. The problem lies in implementing those technologies. Because, while the development of new technologies costs a large amount of money, turning them into commercial realities requires far more.

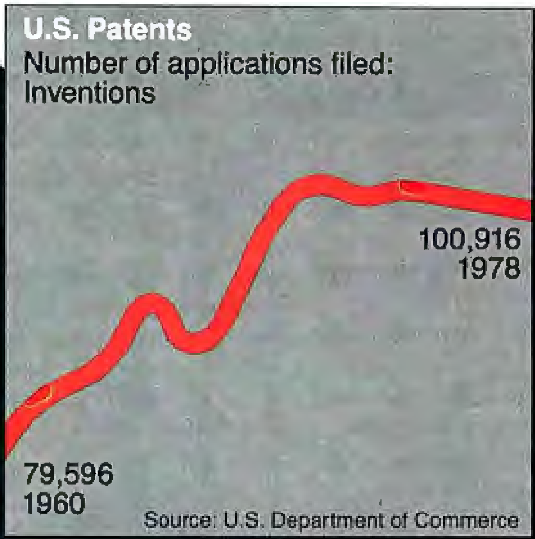
A national commitment

Something else is needed: a united effort by industry, labor and government. Obviously, management should make a greater R&D effort to refine today's technologies, and develop new ones for tomorrow. Employes must realize that their cooperation is vital if America is to remain the most productive nation in the world. And our elected officials need to re-establish a sound economic foundation, because that is basic to all social progress. In particular, tax laws and monetary policy must be structured to allow industry to accumulate capital needed to apply available technologies, and invest in the development of still more advanced ones.

The Westinghouse role

At Westinghouse, we believe technology is vital to our nation, our customers, and our own progress. We're supporting that belief by ambitious R&D programs, by building and modernizing existing facilities, and by introducing innovative methods to improve both our own quality and productivity and that of our customers. Today's proven Westinghouse technologies are focused on key areas such as productivity, services, energy, and America's national security. These existing technologies, together with the ones we are developing for the future, represent our efforts to help maintain this nation's competitive edge. On the following pages are some examples.





In the next five years, Westinghouse plans to invest:

$1 Billion on R&D and $2 Billion applying current technologies in:

- Modernization of existing plants and equipment
- Construction of new plants
- Productivity and quality improvement projects

WESTINGHOUSE TECHNOLOGY APPLIED TO ENERGY

Someday, Westinghouse technology will provide economical electricity from the sun, and clean gas from coal.

The fact that silicon photovoltaic cells can turn sunlight into electric current has been known for some time. The problem is the high cost involved. Westinghouse has invented a new dendritic web process that significantly reduces the cost of producing such cells. As a result, the U.S. Department of Energy's economic cost target now appears achievable. Westinghouse is working with the two largest electrical utilities in California to provide demonstration photovoltaic modules this year.

Advanced energy technologies

Westinghouse is involved in the advanced energy technologies that may play a role in this nation's energy future. For example, on the horizon are promising technologies like iron-nickel, and iron-air high power batteries. Also showing promise are fuel cells that chemically produce electricity. But until solar and other energy technologies become a reality, this nation will depend upon coal and nuclear power for its electricity. Westinghouse is focusing much of its effort on these two areas.

Clean gas from coal

Westinghouse has pioneered in coal gasification technology. Over the last decade we have developed a process to turn coal into a clean gas for power generation, and for industrial or synthetic natural gas applications. The process has the advantage that it can use virtually any type of coal, soft coal or hard coal. The environmental impact is minimal, regardless of the coal's moisture, sulphur, or ash content. With continued technical progress, Westinghouse coal gasification systems can be in commercial operation by the mid-1980's.

Nuclear technology

Nuclear power remains an economical and safe way of producing electricity. Westinghouse leads in the application of nuclear technology to generate electricity. And we are developing an advanced nuclear plant able to make more fuel than it uses.

A segment of silicon ribbon from the Westinghouse dendritic web process

WESTINGHOUSE TECHNOLOGY APPLIED TO SECURITY

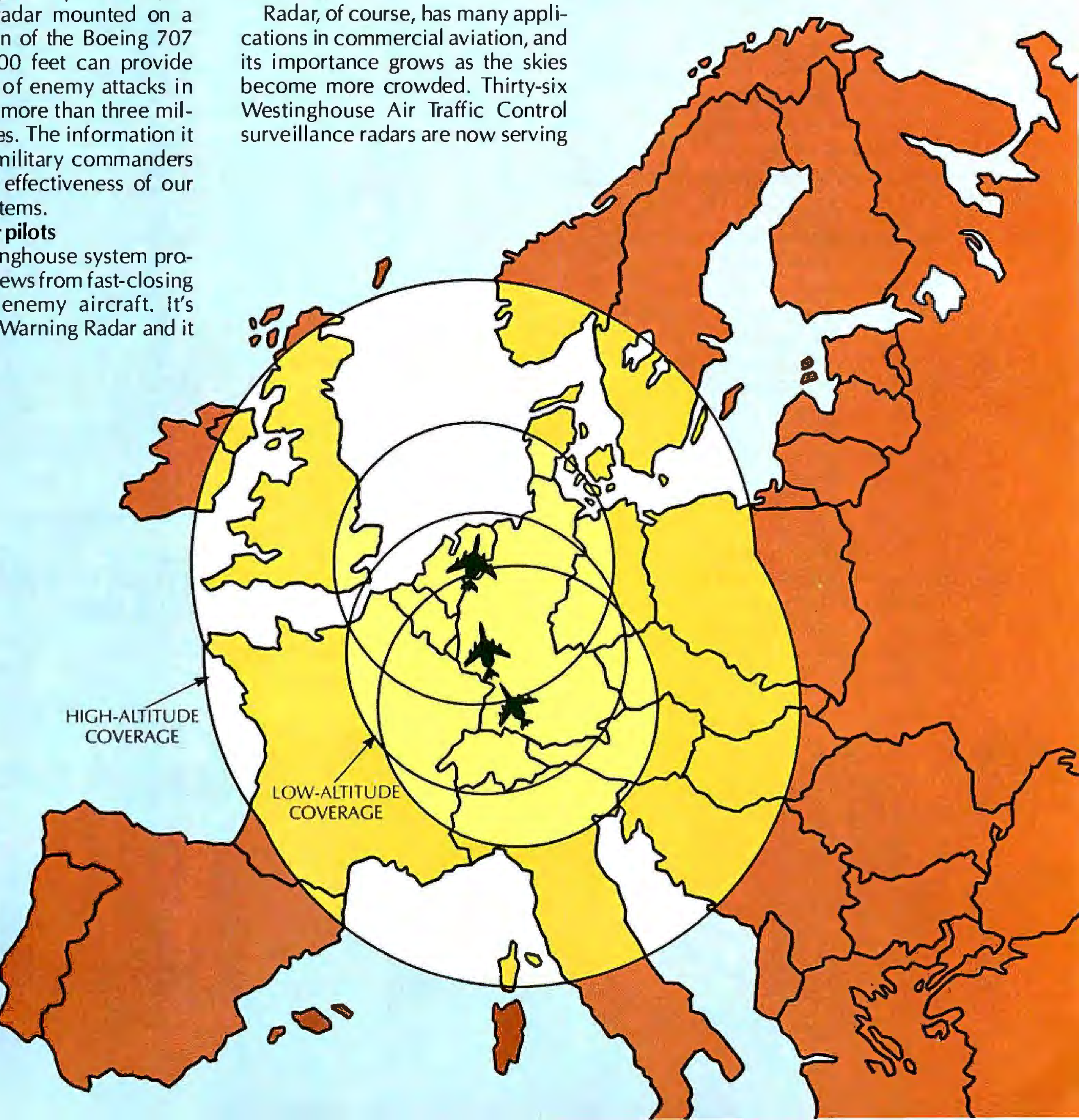
Today, Westinghouse Airborne Radar is one of our first lines of defense around the world.

It's called AWACS, an airborne warning and control system which provides long-range surveillance in an area at least 20 times greater than any surface-based system. It's already in use by our Air Force, and has been adopted by NATO. Just one AWACS radar mounted on a military version of the Boeing 707 flying at 30,000 feet can provide early warning of enemy attacks in an airspace of more than three million cubic miles. The information it helps give to military commanders multiplies the effectiveness of our air defense systems.

New safety for pilots

Another Westinghouse system protects aircraft crews from fast-closing missiles and enemy aircraft. It's called our Tail Warning Radar and it provides the pilot with accurate warnings to take evasive maneuvers. It also automatically triggers appropriate countermeasures. It's able to do all this in a split second, and with a phenomenally low false alarm rate.

Radar, of course, has many applications in commercial aviation, and its importance grows as the skies become more crowded. Thirty-six Westinghouse Air Traffic Control surveillance radars are now serving the FAA, the Switzerland Federal Air Office, and the Canadian Department of National Defense. The FAA uses the radars in some of the nation's most heavily traveled areas. So, nearly all domestic commercial flights come under the surveillance of a Westinghouse radar at some point during their flight.



WESTINGHOUSE TECHNOLOGY APPLIED TO PRODUCTIVITY

How Westinghouse product can increase industrial

How to increase output per hour...
How to eliminate waste...
How to cut energy costs...
Westinghouse has developed products and systems able to provide a wide variety of industries with effective answers.
Here are several of special interest.

The Westinghouse Numa-Logic® Control System

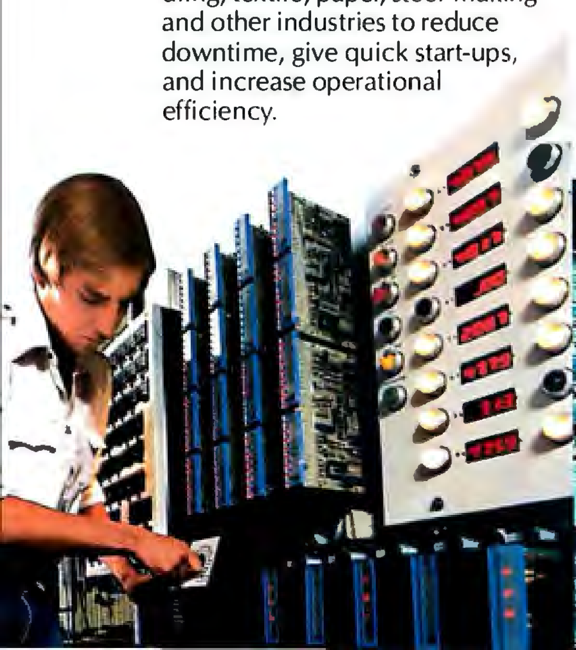
The Westinghouse Numa-Logic solid-state programmable controller uses microprocessor technology to provide more reliable operation for electrical control applications. It can economically replace as few as eight relays. It also has the capability to control the hundreds of sequences required by sophisticated, automated processes. The Westinghouse Numa-Logic system is being used in the machine tool, materials handling, textile, paper, steel-making and other industries to reduce downtime, give quick start-ups, and increase operational efficiency.

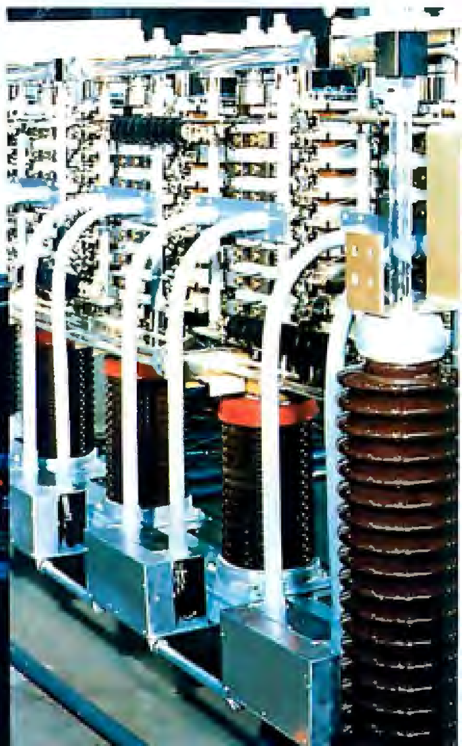
Factory computer systems

Also making major contributions to increased productivity are Westinghouse factory computer systems. They are capable of operating as many as 100 different machine tools simultaneously. They can also provide real time status and performance monitoring at four levels: maintenance, shop supervisor, middle and upper management. In application after application, downtime has been sharply reduced, and actual machine time has been increased up to 55 percent.

Power electronics

Solid-state static VAR generators are a key solution for utility and industrial system line problems because they provide system stability and improve power flow capability. Planning studies at a major utility concluded that 10 transmission lines with static VAR generators could deliver the power ordinarily requiring 16 lines. When it comes to industrial applications such as steel-making, VAR generators can improve the efficiency of power usage by improving the power factor and providing faster arc furnace melt times. One steel producer's productivity increased sufficiently to pay back the nearly $2 million cost of the static VAR generator in 15 months.





and service technologies productivity today.

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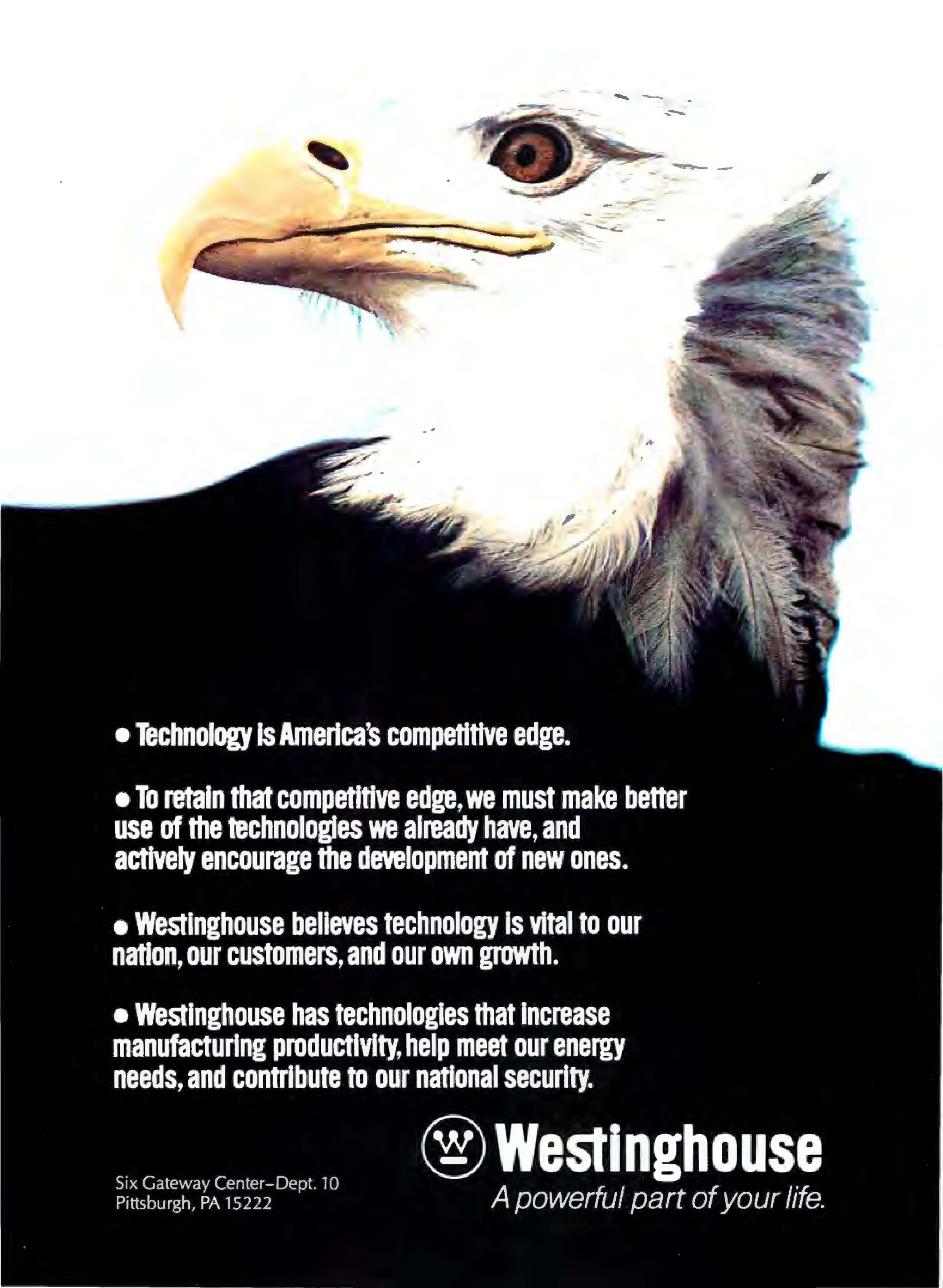
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Listing 2: *Test program for the arithmetic subroutines. This program receives two numbers from the keyboard and displays their product. Note that the user must supply entry points to character input and output routines and to the system monitor (or any other program to be jumped to when this program ends).*

```
                      ******************************************************************************
                      *                                                                            *
                      * TEST PROGRAM DISPLAYS PRODUCT OF 2 NUMBERS ENTERED FROM KEYBOARD           *
                      *                                                                            *
                      ******************************************************************************

                      *         ***** NOTE: YOU MUST SUPPLY THESE 3 ENTRY POINTS: *****
                      *
                      CHIN      EQU     0          SUBROUTINE TO GET KEYBOARD CHAR. IN A REG.
                      CHOUT     EQU     0          SUBROUTINE TO DISPLAY (A) AS ASCII CHAR.
                      MONITOR   EQU     0          ENTRY TO SYSTEM WHEN PROGRAM DONE
                      *
                                ORG     3000H
      3000    213B30  TEST      LXI     H,INBUF    INPUT BUFFER ADDRESS TO HL
      3003    CD0000  TEST1     CALL    CHIN       GET AN ASCII CHARACTER IN A REGISTER
      3006    77                MOV     M,A        STORE CHARACTER INTO BUFFER
      3007    FE0D              CPI     13         AND IF ITS A CARRIAGE RETURN
      3009    CA1030            JZ      TEST2      THEN BRANCH
      300C    23                INX     H          ELSE, ADVANCE TO NEXT BYTE OF BUFFER
      300D    C30330            JMP     TEST1      ...AND CONTINUE
      3010    113B30  TEST2     LXI     D,INBUF    RECALL INPUT BUFFER STARTING ADDRESS
      3013    CDD740            CALL    DECBIN     CONVERT ASCII DECIMAL TO BINARY NUMBER
      3016    E5                PUSH    H          SAVE NUMBER
      3017    13                INX     D          ADDRESS OF START OF SECOND NUMBER STRING
      3018    CDD740            CALL    DECBIN     CONVERT SECOND NUMBER TO BINARY IN HL
      301B    D1                POP     D          RECALL FIRST NUMBER
      301C    CD3840            CALL    EMULT      FIND PRODUCT IN HL
      301F    3E0A              MVI     A,10       ASCII LINE FEED
      3021    CD0000            CALL    CHOUT      START ANSWER ON NEW LINE
      3024    114F              LXI     D,OUTBUF   OUTPUT BUFFER STARTING ADDRESS
      3027    CD2F41            CALL    BINDEC     CONVERT ANSWER TO ASCII STRING
      302A    AF                XRA     A
      302B    12                STAX    D          MARK END-OF-STRING WITH 0-BYTE
      302C    214F30            LXI     H,OUTBUF   RECALL START OF BUFFER
      302F    AF      TEST3     XRA     A
      3030    86                ADO     M          FETCH NEXT CHARACTER
      3031    CA0000            JZ      MONITOR    IF ITS 0-BYTE TERMINATOR, QUIT
      3034    C00000            CALL    CHOUT      ELSE, DISPLAY BYTE
      3037    23                INX     H          ADVANCE BUFFER POINTER
      303B    C32F30            JMP     TEST3

      303B            INBUF     OS      20         INPUT BUFFER FOR 2 NUMBERS
      304F            OUTBUF    DS      10         OUTPUT BUFFER FOR RESULT
```

Two's Complement of Binary Numbers

Two's complement is a method of representing negative numbers in binary radix. It is only one of several methods of negative number representation, but it has the advantage of eliminating subtraction as a separate operation; subtraction can be performed by taking the two's complement of the subtrahend and adding it to the minuend.

The two's complement of a number is found by complementing every bit in the number (changing 1s to 0s and vice versa) and adding 1 to the resulting value. For example, suppose we want to take the two's complement of the number 4 stored as an 8-bit value:

4 in binary is:	*00000100*
complementing each bit:	*11111011*
adding 1:	*1*
—4 in two's complement:	*11111100*

(By the way, the numeral 11111011 is called the one's complement of 4.)

To show that subtraction can be performed using straight binary addition with two's complement, take the example of subtracting 4 from 7:

7 in binary is:	*00000111*
two's complement of 4:	*11111100*
adding, we get:	*1 00000011*

The carry, 1, is thrown away, and the result, 00000011, is decimal 3 in binary.

In two's complement, negative numbers always have a leftmost bit of 1; on the other hand, nonnegative numbers have a leftmost bit of 0. However, the absolute value of a negative number cannot be found by simply evaluating the lower bits; as before, you must complement the number and add 1.

These routines run an order of magnitude faster than full floating-point routines.

Text continued from page 204:
treat values outside the range of −32,768 to +32,767 as an overflow condition.

When an overflow is detected, a call is made to a subroutine called OVERFLOW, which is not provided because you will want to implement it in a manner appropriate to your system. A simple error-processing routine would display an error message and jump to the system monitor. If desired, a more sophisticated error-processing routine could continue processing, because the top of the stack contains the return address to the routine where the overflow was detected. Similarly, you must provide an entry point called CONVERR, which will be called in the event of a string-numeric conversion error.

The string-numeric conversion routine, DECBIN, will convert any legitimate numeric decimal representation, including those with leading blanks or blanks between the sign and the leading digit. It will reject errors including two signs or an illegal character. Any nonnumeric character after the start of the number terminates the conversion, facilitating parsing of free-format data entries. This is illustrated by the sample test program of listing 2, which accepts two numbers on one line and prints their product on the next line.■

The Largest and Smallest Numbers in Two's Complement Notation

Another property of two's complement numbers is that the absolute value of the largest positive number that can be represented is 1 less than the absolute value of the smallest negative number that can be represented. As an example, look at all the possible 3-bit two's complement numbers:

0 is 000; complementing and adding 1 gives 000 (or −0)
1 is 001; complementing and adding 1 gives 111 (or −1)
2 is 010; complementing and adding 1 gives 110 (or −2)
3 is 011; complementing and adding 1 gives 101 (or −3)
−1 is 111; complementing and adding 1 gives 001 (or 1)
−2 is 110; complementing and adding 1 gives 010 (or 2)
−3 is 101; complementing and adding 1 gives 011 (or 3)

But we have one number left over, 100. Inasmuch as the most significant bit is 1, it must be negative. To find its absolute value, take its two's complement:

the number is:	100
complement it:	011
add 1:	1
its two's complement is:	100
which is binary for 4	

Therefore, 100 in two's complement notation must be −4. But notice that, given three bits for the binary representation of signed numbers, there is no way to represent positive 4 in two's complement notation. The largest positive number that can be represented is one less than that.

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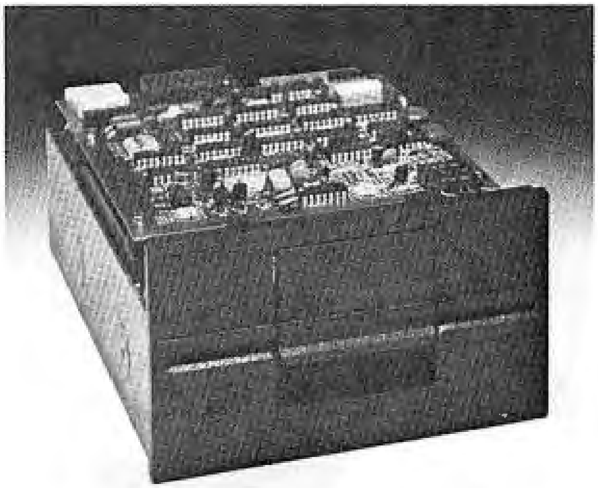

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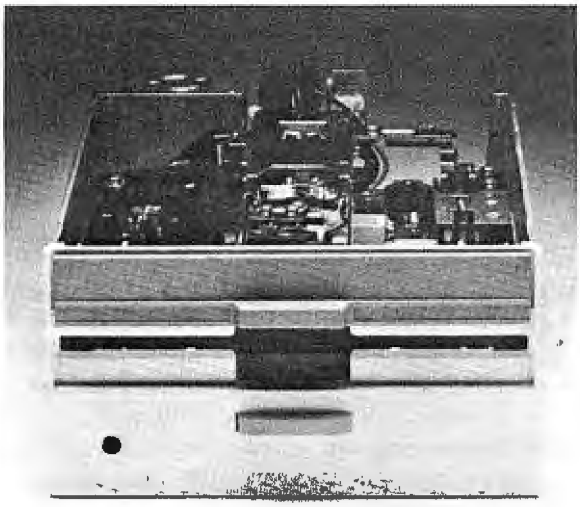

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Print Your Own Bar Codes

UPC Bar Codes With the Centronics 737

John Anderson, 149 Cliffside Dr, Wilmington NC 28403

Hewlett-Packard's introduction of a less-than-$100 bar-code reader will certainly increase interest in bar codes as a viable means of transporting program listings through the printed media. But reading bar codes is not enough. To maximize their usefulness, we must be able to generate them as well: only then will creative applications begin to emerge. There must be numerous instances where keyboard input to small-business data-processing systems can be replaced with bar-code input.

My interest in bar codes arose from a need for simple data entry in an educational application. The problem required easy generation as well as easy reading of bar codes. To generate bar code, you must be able to produce vertical lines and spaces of equal (or approximately equal) width. This can, of course, be done with a plotter or a high-resolution graphics printer. Or, it can be done with a low-cost, dot-matrix, proportional-spacing printer, such as the Centronics 737.

I had a Centronics 737, so I began to experiment with producing bar codes, and found that the printer can be used quite effectively. The Centronics 737 produces a high-density dot-matrix print in the proportional-spacing mode. With the concatenation symbol (|) as the basic vertical bar, the printer can be directed to backspace dot by dot, allowing the compression of vertical bars into a solid bar of variable width.

Text continued on page 276

PAPERBYTE® Bar Codes With Integral Data Systems Printers

Dr G Louis, OB/GYN Dept, St Michael's Hospital, 30 Bond St, Toronto M5B 1W8 Canada

The advent of Hewlett-Packard's low-cost bar-code reader, HEDS-3000, makes it possible to consider software distribution in machine-readable form via the printed page. The bar-code reader (described in Carl Helmers' editorial, "Bar Codes, Revisited...," April 1980 BYTE, page 6) can be interfaced to a computer for slightly more than $100.

This article will describe a program that uses the graphics plotting option of an Integral Data IP-225 (or IDS-440) printer to produce bar code. (The IP-225 sells for about $1000.) The format is the PAPERBYTE® format, described in Ken Budnick's book, *Bar-Code Loader* (Peterborough NH: BYTE Books, 1977).

In graphics mode, the Integral Data printers allow column by column control of the image printed. Each column is 7 dots high, and each dot is controlled by the corresponding bit in the byte of data sent. For example, if you send a question mark (hexadecimal 3F) to the printer while in graphics mode, a vertical bar of 6 dots is printed. If you send a NUL (0), the printer leaves a blank that is 1 dot-width across. This takes care of 0 bits and spaces. One bits (double-width bars) are simply printed as two question marks side by side. The bar-code loader program by Ken Budnick has software filtering to correct dropouts (white spots on the bars) and blotches (black dots in the spaces), and it also proves adequate to deal

Text continued on page 230

Editor's Note: *When we put the Hewlett-Packard HEDS-3000 bar-code wand on the cover of the April 1980 BYTE, we believed that the only major obstacle to the widespread use of bar codes—lack of a reliable wand at an affordable price—had been eliminated. You couldn't make your own bar codes (we thought), but you could read them. In the January 1981 BYTE, we published an article that showed how to make HP-41C bar codes on an expensive Diablo 1650 printer (see "Generating Bar Codes in the Hewlett-Packard Format," by Thomas McNeal, January 1981 BYTE, page 148). But few people have such an expensive printer, and (we thought) most people still couldn't make their own bar codes.*

*We were wrong. The two articles above show two different formats of bar codes produced on two different dot-matrix printers. All of the work is done in the software; the hardware only has to generate a thin vertical bar and place it anywhere on a line. With the proper bar-code reading software, even bar codes made with dot-matrix printers can be consistently and reliably read....*GW

Text continued from column 2, page 228:
with the tiny white spaces left between the dots in the double-width bars. The only restriction is that the printer ribbon *must* be in good condition; otherwise, the contrast between bar and space will not be sufficient for a reliable wand reading.

The program in listing 1 prints bar code from data in memory with start and stop addresses specified by the user. Tiny Pascal as described by K-M Chung and H Yuen (see reference 2) and implemented by me in 8080 assembly language (see reference 4) was used for this routine. Those who are unfamiliar with Pascal should have little difficulty following the algorithm: readability is one of the most important advantages of Pascal. Two minor points may give some trouble to BASIC programmers: percent signs (%) associated with numbers or variables indicate that the number or variable is expressed in hexadecimal, and the CASE X OF... statement is used to choose from among options to be executed depending on the value of X. However, interested readers

Figure 1: *Bar-code representation of part of listing 1, made on an Integral Data Systems IP-225.*

BAR-CODE PRINTER -- SOURCE LIST -- 800624

0000

0015

0029

003E

Listing 1: *Tiny Pascal source listing for a program that will generate printed bar codes from data in memory. Translation into BASIC or assembly language should prove fairly simple, even if the user is unfamiliar with Pascal.*

```
} *** BAR-CODE PRINTER PROGRAM
      FOR INTEGRAL DATA IP-225 (440) WITH GRAPHICS
      BY DR. G. LOUIS
         OB/GYN DEPT., ST. MICHAEL'S HOSPITAL
         30 BOND STREET, TORONTO, CANADA  M5B 1W8
      800501, LAST MODIFIED 800624
}
CONST MAXBAR=400  } MAX UNIT WIDTHS PER FRAME };
      PRINT=%85A  } DIRECTS OUTPUT TO PRINTER };
      NOPRINT=%84C  } NO OUTPUT TO PRINTER };
      DEL=127; CAN=24; FF=12; CR=13; TAB=9; } ASCII CTL }
      PLOT=3; PLTESCAP=3; NORMLPRT=2; } PLOT MODE CTL }
      CPI12=30  } SET PRINTER DENSITY 12 CHAR/IN };
      CPIMAX=31  } SET MAXIMUM DENSITY FOR PLOTTING };
VAR   I  } GENERAL-PURPOSE INDEX },
      IPT  } CHARACTER INPUT },
      ABSFLAG  } TRUE IF ABSOLUTE ADDRESSING CALLED FOR },
      ORIGIN  } ADDRESS OF 1ST BYTE TO BE CODED },
      LASTBYTE  } ADDRESS OF LAST BYTE TO CODE },
      POINTER  } ADDRESS OF NEXT BYTE TO CODE },
      FRAMEID  } VALUE OF ID BYTE OF NEXT FRAME }:
        INTEGER;
      JOBNAME: ARRAY [53] OF INTEGER;
FUNC WFRAME (START,STOP);
  } WRITE ONE FRAME BEGINNING AT START AND ENDING
    AT STOP OR WHEN THE PAGE IS FULL, WHICHEVER IS
    FIRST; RETURN THE ADDRESS OF THE BYTE FOLLOWING
    THE ONE LAST ENCODED }
  CONST SYNC=%96  } FIRST BYTE OF EVERY FRAME };
  VAR   ABSCK  } TRUE IF AN ABSOLUTE ADDRESS IS WANTED },
        BARCNT  } NUMBER OF UNIT WIDTHS IN FRAME },
        CKSUM  } HEX CHECKSUM },
        FRAMELEN  } NUMBER OF BYTES IN FRAME },
        I  } GENERAL-PURPOSE INDEX }:
          INTEGER;
  PROC WBYTE (VALUE);
  } WRITE BAR CODE FOR 8 LSB'S OF "VALUE" }
    VAR BUF, I: INTEGER;
    BEGIN
    BUF := VALUE AND 255;
    FOR I := 1 TO 8 DO BEGIN
      WRITE (SPACE, BAR); IF BUF > 127 THEN WRITE (BAR);
      BUF := (BUF SHL 1) AND 255 END
    END;
  FUNC SCANBYTE (VALUE);
  } RETURN THE NUMBER OF UNIT WIDTHS NEEDED TO WRITE
    BAR CODE FOR 8 LSB'S OF "VALUE" }
    VAR BUF, CNT, I: INTEGER;
    BEGIN
    BUF := VALUE AND 255; CNT := 0;
    FOR I := 1 TO 8 DO BEGIN
      CNT := CNT+2; IF BUF > 127 THEN CNT := CNT+1;
      } ONE SPACE + ONE BAR, + ONE MORE BAR IF BIT IS 1 }
      BUF := (BUF SHL 1) AND 255 END;
    SCANBYTE := CNT END;
  BEGIN  } WFRAME }
  ABSCK := ABSFLAG AND (START <= STOP);
  WRITE (CPI12);
  IF ABSFLAG THEN WRITE (START%)
    ELSE WRITE (START-ORIGIN%);
  WRITE (TAB,CPIMAX,PLOT); WBYTE (SYNC); FRAMELEN := 0;
  IF ABSCK THEN BEGIN
      CKSUM := (START SHR 8) + (START AND 255);
      BARCNT := SCANBYTE (START SHR 8) + SCANBYTE (START)
    END
    ELSE BEGIN CKSUM := 0; BARCNT := 0 END;
  IF START <= STOP THEN REPEAT
    I := MEM [START + FRAMELEN]; CKSUM := CKSUM + I;
    BARCNT := BARCNT + SCANBYTE (I);
    FRAMELEN := FRAMELEN + 1
  UNTIL (BARCNT > MAXBAR-24) OR (START+FRAMELEN = STOP+1);
  IF ABSCK THEN FRAMELEN := FRAMELEN+2;
  CKSUM := 256 - ((CKSUM + FRAMEID + FRAMELEN) AND 255);
  WBYTE (CKSUM); WBYTE (FRAMEID); WBYTE (FRAMELEN);
  IF ABSCK THEN BEGIN
    WBYTE (START SHR 8); WBYTE (START);
    FRAMELEN := FRAMELEN-2 END;
  FOR I := 1 TO FRAMELEN DO
    WBYTE (MEM [START + I - 1]);
  WRITE (SPACE, BAR, PLTESCAP, NORMLPRT, CPI12, CR);
  WFRAME := START + FRAMELEN
  END;
BEGIN  } *** MAIN PROGRAM *** }
CALL (NOPRINT); I := 0;
WRITE (FF,'BAR-CODE PRINTER',CR,CR,'JOB NAME: ');
WHILE I < 53 DO BEGIN
  READ (IPT); CASE IPT OF
    DEL: IF I > 0 THEN BEGIN WRITE (IPT); I := I-1 END;
    CAN: WHILE I > 0 DO BEGIN WRITE (DEL); I := I-1 END
    ELSE BEGIN
      WRITE (IPT); JOBNAME [I] := IPT; I := I+1;
      IF IPT = CR THEN I := 53  } TO GET OUT OF LOOP } END
    END  } CASE }
  END  } WHILE }; JOBNAME [53] := CR;
WRITE (CR,'START ADDRESS: '); READ (ORIGIN%);
WRITE (CR,'END ADDRESS: '); READ (LASTBYTE%);
WRITE (CR,'SPECIFY ABSOLUTE ADDRESSES? ');
REPEAT READ (IPT) UNTIL (IPT = 'Y') OR (IPT = 'N');
WRITE (IPT); ABSFLAG := (IPT='Y');
CALL (PRINT); WRITE (CPI12); I := -1;
REPEAT I := I+1; WRITE (JOBNAME [I])
UNTIL JOBNAME [I] = CR; WRITE (CR);
POINTER := ORIGIN; FRAMEID := 0;
REPEAT
  POINTER := WFRAME (POINTER,LASTBYTE);
  FRAMEID := FRAMEID+1;
  IF (0 = FRAMEID MOD 55) AND (POINTER <= LASTBYTE)
    THEN BEGIN WRITE (FF); I := -1;
    REPEAT I := I+1; WRITE (JOBNAME [I])
    UNTIL JOBNAME [I] = CR; WRITE (CR) END
UNTIL POINTER > LASTBYTE;
POINTER := WFRAME (POINTER,0)  } WRITE EOF FRAME }
WRITE (FF); CALL (NOPRINT)
END. } MAIN PROGRAM }
```

Technical Forum

should find it easy to adapt this routine to their own favorite languages and printers. Figure 1 shows the textually-encoded bar-code representation of a portion of listing 1.

The program need not be used exclusively for software distribution. Transfer of data of any kind between computers with incompatible mass-storage devices is easy if the source computer can create bar code and the recipient can read it. In addition, cheap, compact, archival storage of seldom-used information is possible if the length of files and frequency of use are such that entry via the wand is not unreasonably tedious.

Lest there be any doubt about the suitability of this program for use in software distribution, I will conclude by mentioning a recent experiment. I produced the bar-code listing (partially reproduced in figure 1) and photocopied it on a high-quality electrostatic photocopier. Both the original and the copy were scanned five times with the bar-code wand. I counted the number of passes needed to read each line and calculated the average. For the original and the copy, 1.1 and 1.3 passes with the wand sufficed to obtain a good read. Total time to enter the code ranged from 10 to 15 minutes, but this time could be decreased if a portable drafting tool or a T-square were used instead of a ruler to guide the wand across the page. The most time-consuming step in the entry process involved alignment of the ruler. Clearly, it is perfectly feasible to use this method to distribute machine-readable code on paper. ■

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1. Budnick, K. *Bar Code Loader*. Peterborough NH: BYTE Books, 1977.
2. Chung, K-M and H Yuen. "A Tiny Pascal Compiler, Part 1: The P-Code Interpreter," September 1978 BYTE, page 58. Republished in *The BYTE Book of Pascal*. B W Liffick, editor. Peterborough NH: BYTE Books, 1979, page 59.
3. Helmers, Carl. "Bar Codes, Revisited...," April 1980 BYTE, page 6.
4. Louis, G. "Tiny Pascal in 8080 Assembly Language," July 1979 BYTE, page 174. Republished in *The BYTE Book of Pascal*. Blaise W Liffick, editor. Peterborough NH: BYTE Books, 1979.

BYTE's Bugs

Upside-Down Static Phoneme

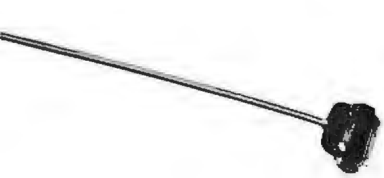
Right in the middle of "Articulate Automata," there's an upside-down vowel spectrum! (See photo 3, page 170, February 1981 BYTE.)

Richard T Gagnon
R T Gagnon Associates
210 W Tienken
Rochester MI 48063

Mr Gagnon is correct: our phoneme spectrum was inverted. Thanks for setting us upright....CM ■

STEP #1. PLUG IT IN.

(THERE IS NO STEP #2.)



APPLE[T.M.]

PET[T.M.]

TRS-80[T.M.]

ETC.

System Notes

Faster BASIC for the Ohio Scientific

John A Sauter, Department of Biochemistry
5426 Med Sci I, University of Michigan, Ann Arbor MI 48109

"I don't believe it! The guy who wrote this program didn't know what he was doing." How many times have you seen a program and said that? Well, I never thought I would say it while looking at the Microsoft multiplication routines written for Ohio Scientific's BASIC.

Multiplication routines written in software are *slow*, especially when accurate to 9 digits. Programmers are always trying to optimize mathematical routines for speed. That's why I was surprised that the main loop for the multiplication routine contained line after line of inefficient instructions.

To comprehend the problem, you need to understand how a software multiplication routine works. For multiplication of large numbers, the process is similar to the longhand method taught in school. The two numbers to be multiplied, the multiplier and the multiplicand, are stored in the floating-point accumulator and the alternate floating-point accumulator, respectively. These accumulators are usually 4 to 5 bytes in length and preferably located in page 0 memory. The low bit of the multiplier is checked to see if it is set: if it is, the multiplicand is added to the product (initially 0); if it is not, no addition occurs.

Next, both the multiplier and the product are shifted 1 bit right (or, alternately, the multiplier is shifted right and the multiplicand is shifted left) and the low bit on the multiplier is checked again. This process is repeated for each bit in the multiplier. Four bytes are required for 9 digits of precision: a great deal of bit shifting must go on. In fact, the bit shifting uses most of the time required for a multiplication routine.

Fortunately, there is a convenient instruction in the 6502 microprocessor for shifting several contiguous bytes 1 bit to the right. The ROR instruction shifts a byte 1 bit to the right, with the carry shifted into the high-order bit, and the low-order bit of the byte shifted into the carry. Successive executions of the ROR instruction on contiguous bytes will shift all of the bytes 1 bit to the right, with the low bit of 1 byte shifting into the high bit of the next.

Listing 1 contains a portion of the Microsoft multiplication routine for the 6502. It is part of the routine that shifts the product 1 bit right. This sequence is repeated four more times in the subroutine, and requires a total time of 85 μs (with a 1 MHz clock rate while assuming

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Listing 1: *Section of the multiplication routine from Microsoft's disk BASIC, written for Ohio Scientific computers. This section can be replaced with a single ROR instruction (ROR $73, where the dollar sign denotes a hexadecimal 73). The replacement accomplishes the same task in much less time.*

```
LOC     CODE      MNEMONIC     TIME (uS)

1946    A9 80     LDA #$00        2
1948    90 02     BCC $194C       3
194A    A9 80     LDA #$80        2
194C    46 73     LSR $73         5
194E    05 73     ORA $73         3
1950    85 73     STA $73         3
```

Listing 2: *Part of a routine accessed by the addition and subtraction routines in Ohio Scientific's disk BASIC. This section can be replaced by the single instruction ROR $02,X.*

```
LOC     CODE      MNEMONIC     TIME (uS)

1854    A9 00     LDA #$00        2
1856    90 02     BCC $185A       3
1858    A9 80     LDA #$80        2
185A    56 02     LSR $02,X       6
185C    15 02     ORA $02,X       4
185E    95 02     STA $02,X       4
```

that, on the average, the instruction at hexadecimal 194A is executed only half of the time). This sequence is also in a loop that is repeated for all 8 bits of a multiplier byte, requiring a time of 680 μs for each subroutine call. Finally, the subroutine is called four (sometimes five) times for each floating-point multiplication. Thus, a total of 2.72 ms is used for each floating-point multiplication. However, the entire listing can be replaced by the single instruction (ROR $73). This instruction requires only 5 μs to execute, for a total time of 800 μs for each floating-point multiplication: a saving of 1.92 ms for each call to the multiplication routine.

My own tests with the changes have indicated that BASIC requires approximately 4.9 ms to complete a floating-point multiplication on a 9-digit number, whereas with the changes, it takes only 3.1 ms. This is an increase in speed of 37%!

Other routines that access the multiplication routines also execute more rapidly. For instance, the logarithm routine takes approximately 34.8 ms to complete a 9-digit logarithm; with the changes, it takes only 21.9 ms. This is also an increase in speed of 37%.

Similar mistakes were found in a section of the normalization routine (starting at hexadecimal 1854) accessed by the addition and subtraction routines (see listing 2). This sequence is repeated two more times. It can all be replaced by the instruction ROR $02,X. Another interesting section of the routine occurs at hexadecimal 1879 (see listing 3). This can be replaced by the instruction ROR A, which takes only 2 μs to execute. The actual increase in speed for the addition and subtraction routines with the changes installed was too difficult to measure since the routines are fairly rapid compared to the BASIC loops and other program segments used to test

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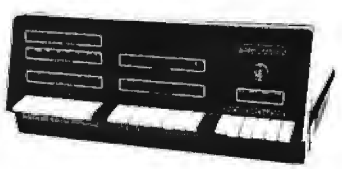

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Listing 3: *Section from the normalization routine used by the addition and subtraction routines in Ohio Scientific's disk BASIC. This section can be replaced by the instruction ROR A.*

```
LOC    CODE     MNEMONIC     TIME (uS)

1879   08       PHP           3
187A   4A       LSR A         2
187B   28       PLP           4
187C   90 02    BCC $1880     3
187E   09 80    ORA #$80      2
1880   C8       INY
```

them. I did notice that BASIC testing loops often executed approximately 10% faster with the changes. I attribute this to the faster addition routine.

I suspected that the division routines would also contain errors, but discovered that the ROL instruction was used wherever it was needed. (The ROR instruction isn't necessary in division.)

I immediately contacted Ohio Scientific and Microsoft to inform them of the problem. Both replied with an explanation that restored my faith in big-name software companies. Apparently, earlier versions of the 6502 microprocessor did not include an ROR instruction, but as customer demand grew, MOS Technology incorporated an ROR instruction in later versions of the 6502. Unfortunately, some of the earlier Ohio Scientific computers had already been sold with the old microprocessor. Therefore, Microsoft wrote its BASIC without any ROR instructions to make the software compatible with the earlier versions of the computer. Listings 1, 2, and 3 are actually macro expansions of the ROR instruction. [*Macros are one-line pseudoinstructions placed in an assembly-language source listing. When processed, they are replaced by a (predefined) set of assembly-language instructions and assembled into machine language....*GW] Microsoft assured me that this was done only for the KIM and Ohio Scientific computers. All other versions of 6502 BASIC were written using the ROR instruction.

For those who have later versions of Ohio Scientific computers and don't have BASIC permanently stored in read-only memory, there is a way to change Ohio Scientific's disk BASIC to use the ROR instruction. If you are using the OS-65D disk operating system, the program in listing 4 will permanently change your BASIC for 8-inch disks. It simply loads a part of the BASIC interpreter into memory, POKEs in the required changes, and stores the changed code back on disk. For 5-inch disks, statement 80 should be changed to read:

80 DISK!"CA 4200=03,1"

and statement 150 should be:

150 DISK!"SA 03,1=4200/8"

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I have not been able to test these changes for the 5-inch systems, and I suggest that you exercise caution in using them. For systems that use the OS-65U operating system, the program in listing 5 should be used to change your BASIC.

Ohio Scientific often boasts of supporting the fastest BASIC of any of the popular personal computers, and it can give you a great sense of satisfaction to make it run even faster. I have run BASIC with these changes for four months and have noticed that all of my programs run faster than before, especially those loaded with mathematical equations. If you decide to incorporate these changes into your system, I suggest that you first try them on an old copy of your operating system to ensure that the changes work on your computer. ■

Listing 4: *Program used with the OS-65D operating system and 8-inch disks. Beginning at hexadecimal location 4800, the program loads a portion of BASIC into memory, then POKEs the appropriate ROR instructions into the mathematical routines and stores the revised BASIC back on the disk.*

```
10 REM DISK BASIC CORRECTION ROUTINE.  OS-65D, 8" DISKS
20 DATA 118,2,118,3,118,4,104,106,200,208,232,24,96
30 DATA 102,115,102,116,102,117,102,118,102,189,152
40 DATA 74,208,214,96
50 REM SET UP TOP OF MEMORY TO $47FF
60 POKE 132,255 : POKE 133,71 : POKE 128,255 : POKE 129,71
70 REM CALL IN A PORTION OF BASIC TO $4800
80 DISK!"CA 4800=04,1"
90 A1=18516 : REM 18516 = $4854
100 A2=18758 : REM 18758 = $4946
110 REM POKE IN THE CORRECTED CODE
120 FOR I=0 TO 12 : READ D : POKE A1+I,D : NEXT I
130 FOR I=0 TO 14 : READ D : POKE A2+I,D : NEXT I
140 REM SAVE THE CORRECTED BASIC BACK ON DISK
150 DISK!"SA 04,1=4800/B"
160 END
```

Listing 5: *Program used with the OS-65U operating system. This program does the same thing as listing 4, but begins at hexadecimal location 7800.*

```
10 REM DISK BASIC CORRECTION ROUTINE.  OS-65U
20 DATA 0,36,0,0,0,2,0,120
30 DATA 118,2,118,3,118,4,104,106,200,208,232,24,96
40 DATA 102,115,102,116,102,117,102,118,102,189,152
50 DATA 74,208,214,96
60 REM SET UP USR FUNCTION AND PUT AND GET ROUTINES
70 POKE 8778,192 : POKE 8779,36
80 POKE 9432,243 :POKE 9433,40
90 POKE 9435,232 : POKE 9436,40
100 REM DISK ADDRESS = $1800 + $0C00, NUMBER OF BYTES = $0200
110 REM RAM ADDRESS = $7800
120 CB=9889 : FOR I=1 TO 8 : READ D : POKE CB+I,D : NEXT I
130 REM CALL IN A PORTION OF BASIC TO $7800
140 ER=USR(0)
160 A1=30804 : REM 30804 = $7854
170 A2=31046 : REM 31046 = $7946
180 REM POKE IN THE CORRECTED CODE
190 FOR I=0 TO 12 : READ D : POKE A1+I,D : NEXT I
200 FOR I=0 TO 14 : READ D : POKE A2+I,D : NEXT I
210 REM SAVE THE CORRECTED BASIC BACK ON DISK
220 ER=USR(1):CLOSE
230 END
```

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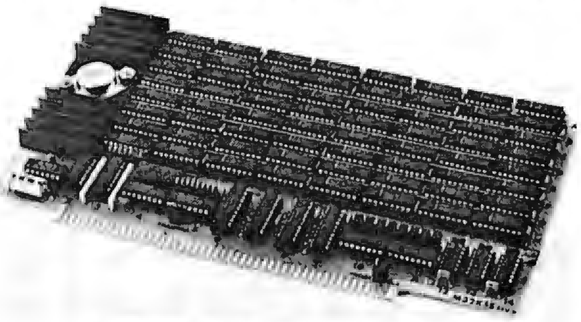

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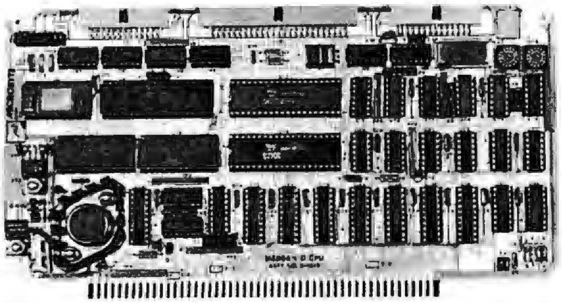

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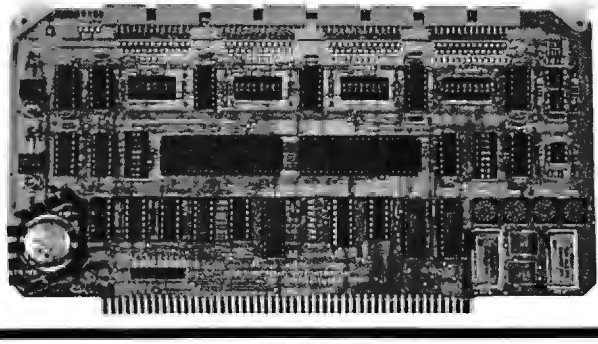

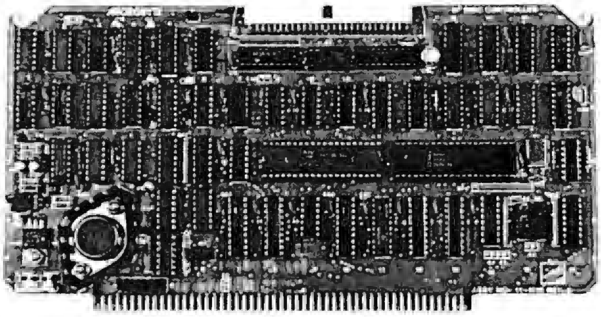

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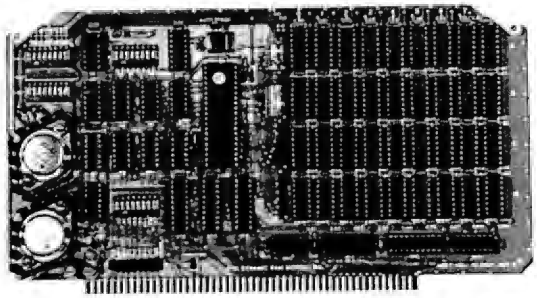

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Principles of Interactive Computer Graphics, 2nd Edition

William M Newman and
Robert F Sproull
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Reviewed by
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Is your computer a glorified scorekeeper? Was zapping your 10,000th Klingon your most creative accomplishment? Perhaps you have tried to do more, to be more creative. However, the books you found were either too simple ("See Dick run the program. Run, Dick, run.") or too technical ("The vectored translation of a quadratic polynomial synthesizing imaginary roots and real constraints utilizing classical fourth-order Runge-Kutta numerical techniques...").

With the second edition of *Principles of Interactive Computer Graphics*, you can explore the special techniques of computer-generated graphics (see page 146 of the December 1977 BYTE for a review of the first edition). The first edition, published in 1973, discussed algorithms and hardware in reference to vector-drawing displays, because these were the most common type of display. At the time, raster-scan displays were available, but programmers mainly used them for data entry and interactive-program preparation. When experimenters needed inexpensive, human-readable output devices for microprocessor-based computers, the raster-scan method was developed for graphics use. Newman and Sproull recognize this and have included a section devoted to the software techniques needed to implement graphics capabilities on raster-scan displays. This section describes angle and line generation, solids generation, interactive computation, hardware, and language implementation.

Another major change is the use of Pascal to describe the algorithms. The first edition used a language called SAIL, which required the inclusion of a user's manual. Because of the wide use of Pascal, today's readers will more easily understand the material presented. Even those whose knowledge of Pascal is limited will comprehend the algorithms with little difficulty.

There are twenty-six chapters arranged in six parts. Part 1 discusses line drawing, point plotting, transformations, windowing, and clipping. This material is applicable to raster-scan and vector-drawing displays. In part 2, emphasis is on graphics packages—that is, groups of subroutines to be invoked by applications programs. Part 3 describes the man-to-machine interface. Here, the authors identify several input devices (keyboards, light pens, tablets, three-dimensional input) and methods to use them. In part 4, the following subjects dealing with raster-scan graphics are covered: fundamentals, solid-area conversion, interactive methods, and hardware.

Three-dimensional graphics techniques are more thoroughly examined in part 5, which includes perspective, shading, curved surfaces, and hidden-line/hidden-surface algorithms. Part 6 brings it all together by outlining various hardware display units, methods of user interfacing, and graphics languages. Two appendices are included. The first is a discussion of matrix- and vector-arithmetic operations; the second, homogeneous coordinate techniques. Many of the clipping, windowing, and transformation techniques require a fundamental knowledge of vector and matrix computation. These two appendices provide that knowledge, as long as you understand mathematical notation.

Although this book still is a basic tool for college- and graduate-level computer science courses, the novice or personal computerist will find it understandable. This book will spark your imagination and challenge your creative abilities. Once that challenge is accepted, zapping Klingons will be a bore.■

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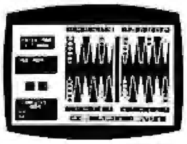

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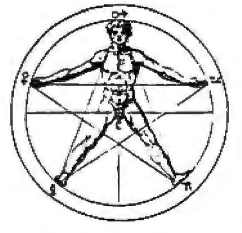

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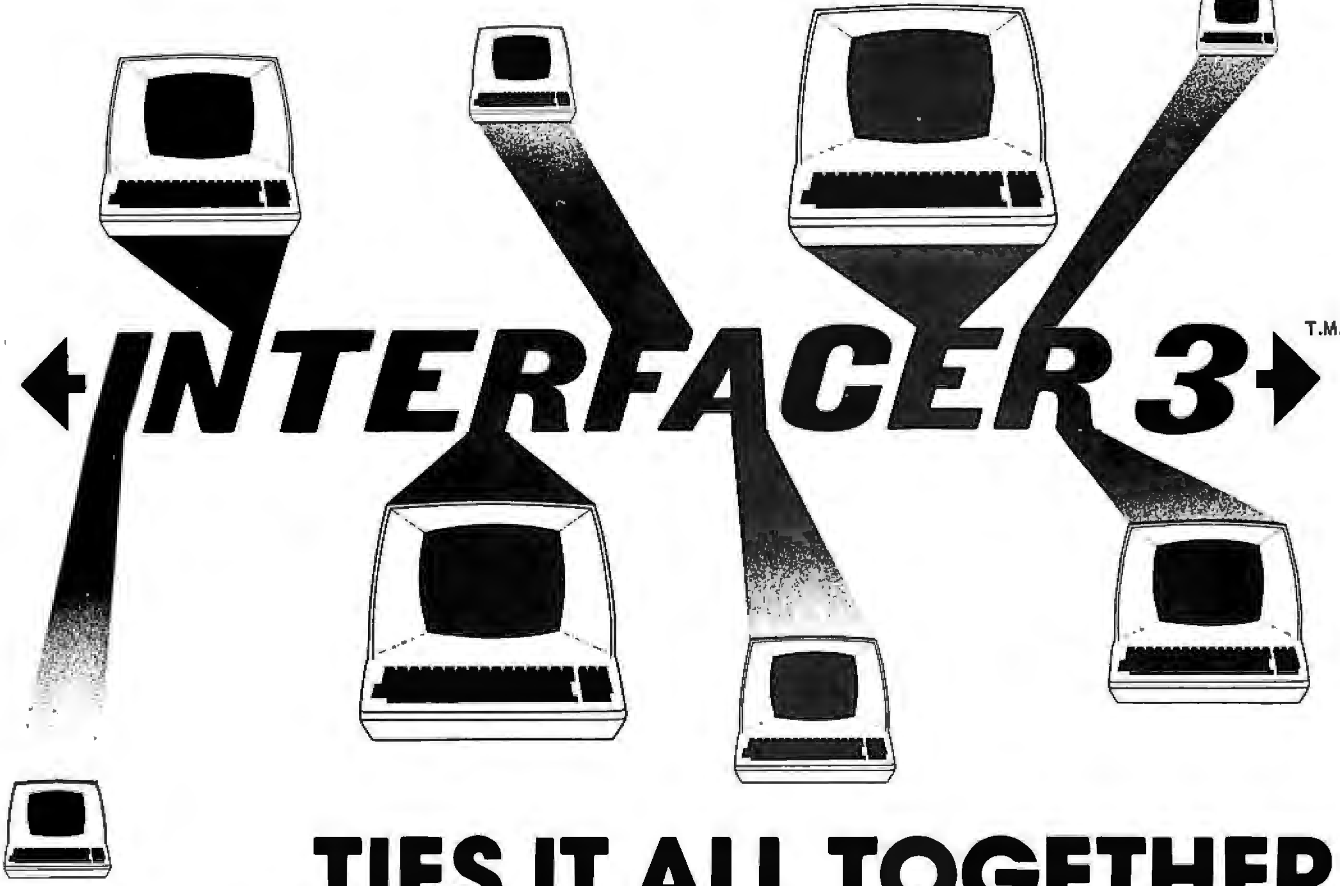

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Software Review

Super STEP

Stanley D Robbins, 249 Willow Ter, Sterling VA 22170

Super STEP is a machine-language utility that works with and is an extension of Radio Shack's T-Bug program. Super STEP allows you to run a machine-language program either by stopping at predefined locations (*breakpoints*) or stopping after each machine-language instruction is executed (*single-stepping*).

The TRS-80 video display shows a great deal of information that is useful during debugging, including the instruction currently executed, the contents of the top 5 bytes of the Z80 stack area, the status of all registers and status flags, and a user-specified area of memory. In addition, much of the information is printed twice in order to show these values before and after execution of the current machine-language instruction. Although it is not evident from the documentation supplied, Super STEP is not merely a utility that interrupts program execution after each instruction: it is a *simulation* (or *model*) that behaves like an actual Z80.

The instruction booklet that accompanies Super STEP creates the first impression—and that impression is not the best. The small type is difficult to read in good

At a Glance

Name
Super STEP Z80 Processor Model

Type
Debugging utility for assembly-language programming (runs as an extension of Radio Shack's T-Bug program)

Manufacturer
Allen Gelder Software
Box 11721
Main Post Office
San Francisco CA 94101

Price
$19.95

Format
Cassette tape

Language
Machine language

Computer
TRS-80 Model I, with Level II BASIC and 16 K bytes of memory

Documentation
Instruction booklet of 16 pages, 11.5 by 14 cm (4½ by 5½ inches)

Audience
Assembly-language programmers

lighting; in reduced lighting (to facilitate reading of the TRS-80 video screen), the type is almost illegible.

The documentation is very detailed, but it took me a long time to fathom some of the obscure terminology. For example, the author, Alan Gelder, refers to "Z80 Processor Models" (plural), while more conventional terminology would refer to different "states" of the same model. An additional, but more aggravating, example occurs when he refers to "the left 1BH columns" and "the right 25H columns" of the TRS-80 video screen. After some thought, I realized that the H at the end of both "1BH" and "25H" referred to hexadecimal notation and that the author intended "1BH columns" to mean "(decimal) 27 columns" (hexadecimal 1B equals decimal 27). The video screen is a *human* interface and, as such, should be described with decimal values, not hexadecimal values.

Based on previous experience with a cassette-only system, I would assume that most (tape-oriented) assembly-language programmers have located their programs in memory to just above the top of the T-Bug program; in this way, they can use T-Bug while debugging their program. Since hexadecimal memory locations 4B00 thru 68FF are occupied by Super STEP, the user would be required to reassemble his programs to a location in memory above hexadecimal location 68FF in order to utilize this product (unless the program is relatively small and resides from hexadecimal locations 4980 to 4AFF). Of course, Allen Gelder Software also provides a product called Super TLEGS; it enables the user to relocate Super STEP (as well as T-Bug) but costs an additional $9.95, bringing the total to $29.90.

The Super STEP program is loaded as follows: load Radio Shack's T-Bug software as a standard "system" tape (from BASIC, type SYSTEM, press the ENTER key, type TBUG, press ENTER, wait for the tape to finish loading); load Super STEP in the same way, using the file name "SPRSTP"; execute the machine-language program by typing a slash followed by the ENTER key (the TRS-80 should respond with a # sign); type S and press the ENTER key. (This procedure is described in the Super STEP booklet.)

At this point, Super STEP fills the video display with information: the right 37 columns fill with a display that shows the current contents of the Z80 (both the prime and unprimed sets of registers), an annotated display of the status byte that shows the flag settings, and some other information. The part of this display that I did understand was very impressive, but I was unable to decipher most of the information in the lower portion. The author describes this display in a photograph on page 3 of the instruction booklet, but his description is neither clear nor thorough.

I then used the T-Bug load (L) command to load a reassembled version (with a new starting address in memory) of the program that I wanted to debug. During the load of a program from tape, Super STEP improves upon the T-Bug loading procedure by displaying the name of the object program on the screen.

(Since Super STEP is an add-on package to Radio Shack's T-Bug program, many of the required commands are explained only in the Radio Shack T-Bug documentation. Consequently, familiarity with the T-Bug program—or at least its documentation—is necessary.)

I displayed a memory location via the memory (M) command. To advance the display to the next location, I depressed the SPACE bar (as directed in the Super STEP instruction booklet), and the equivalent assembly instruction appeared to the right of the first byte of memory I had displayed (a feature that T-Bug doesn't offer); the following byte was then displayed on the following line (as in the normal T-Bug program). To single-step the Super STEP simulation model, depress the SPACE bar repeatedly. This will display memory one byte at a time and update the video display as each instruction is disassembled and executed.

While displaying memory, the semicolon (";") function allows you to view 16 bytes of memory simultaneously, versus the single-byte display of the normal T-Bug program. Another key determines whether this display is in hexadecimal or ASCII. Unfortunately, the display generated on the lefthand side of the video screen sometimes overwrites information on the righthand side. Although this information is correctly updated the next time an instruction is executed, the "garbage" characters remain in the spaces between information fields on the righthand side, making the screen harder to read.

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Exiting the "M(emory)" mode and reentering it at the entry point of my program, I depressed the ":" key to invoke the Super STEP trace function (ie: automatic single-stepping). I then watched my program "execute" for a while, instruction by instruction! The ":" (trace) function more than justifies the inclusion of the word "super" in the name of this product.

An additional feature is the ability to run Super STEP at two different speeds while tracing; at the slow speed, you can see individual instructions as they execute, while at the fast speed, only the registers of the display are readable.

While tracing a program, I found an error in the interaction between the halt ("Z") and trace (":") commands. Use of the "Z" key is supposed to immediately stop the automatic tracing of program execution. It does, but it may stop in the middle of a 2- or 3-byte instruction. The problem at this point was only aesthetic, but when I resumed tracing by pressing the ":" key, Super STEP took the next byte (in the middle of an instruction) and tried to interpret it as the first byte of a new instruction. This can result in the execution of an incorrect Z80 instruction.

A potential annoyance arises in the processing of a CALL or a RST (restart) instruction when tracing or single-stepping a section of a program: if the invoked subroutine is bug-free, it is irritating to slowly single-step through all the subroutine code to get back to the main routine that is being debugged. Super STEP tries to solve that problem via the "*" function. If this function is turned on, CALLs and RSTs will not be followed but will be "directly executed" (ie: the single-stepping is turned off during the execution); if this function is turned off, Super STEP will trace or single-step through all program code. However, this command is inconvenient when you want to step through some subroutines but not others. When I'm single-stepping through some code, I can't turn the "*" function on before a routine I don't want to trace — by the time I see the CALL statement, I've already started single-stepping through the routine.

Some improvements come to mind. I would like to see some indication of interrupt status (enabled or disabled) on the video display. In addition, Super STEP would be greatly improved if the author provided three copies of the software (one each for the 16 K-byte, 32 K-byte, and 48 K-byte versions of the TRS-80) that would load in the top end of the computer's memory. It would be nice if Super STEP could be rewritten to include all of the T-Bug functions: it could then be sold as a stand-alone product. [*On the other hand, the additional time required to add such features is often unavailable to small software companies. If the author did incorporate these features, the necessary increase in price would probably be greater than the cost of T-Bug....*GW]

Conclusions

- One of the most outstanding features of Super STEP is its ability to single-step or trace through *any* Z80 code, even routines in ROM; this power is due to the fact that Super STEP is a software program that simulates the Z80, so it has complete control of any program it is executing.
- On the negative side, the documentation for Super STEP is inadequate. I had to reread the instruction manual and experiment with the software in order to figure out how to use it. Users with less patience or machine-language experience will probably have trouble with this product.
- Overall, I think that the Super STEP package (in conjunction with the Super TLEGS program for an additional $9.95) will be useful to the serious assembly-language programmer with a tape-based TRS-80. Its utility is decreased if you have a disk system (I don't know if you can save it to disk), but it still has some features that the TRSDOS DEBUG program (supplied with the TRS-80 disk operating system) doesn't have. ■

BYTE's Bugs

Problematic Problem Solving

The article entitled "Machine Problem Solving" (November 1980 BYTE, by Peter Frey) has a bug on line 230 of the "Treasure Search" game. (See page 258, listing 1.)

The line should read:

```
230  X$= RIGHT$(STR$
     (B(I),1)):GOSUB 1000
```

Many thanks to those who called us about this typographical error. ■

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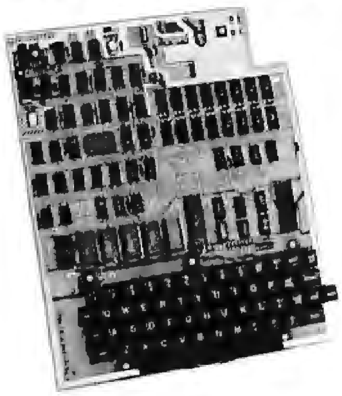

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Wordsmith

Mark Dahmke, 1515 Superior Apt 15, Lincoln NE 68521

The greatest compliment I can give Scion Corporation's Wordsmith is that I am using it to write this review. I have searched long and hard for a word processor that would give me the features and capabilities of a big-system full-screen editor.

I used to do all of my writing on an IBM 370 computer, using a full-screen editor and a batch program that read in my text and formatted it for a high-speed printer. The full-screen editor was adequate, but the batch program was painful to use because you couldn't see the results without running it (over and over). It was like using a compiler instead of an interpreter—you had to wait.

Wordsmith combines the features of a good, full-screen editor (one of the nicest I have used) in a "what you see is what you get" format, thus allowing text to appear on the screen exactly as you want it printed.

Wordsmith Overview

Wordsmith runs on an 8080- or Z80-based microcomputer with either CP/M or North Star disk operating systems. The distribution disk also supplies a customization program that allows the user to define the ASCII codes of the special-function keys, the location of the memory-mapped video display, and the printer interface.

Unlike many other word processors, Wordsmith is page-oriented, ie: page boundaries are maintained in the disk file. Scion's Screensplitter video display has 86 characters per line and 40 lines, but Wordsmith uses the top line as a "scoreboard" to keep track of cursor position (line and column numbers), current page, total number of pages, and the maximum number of pages that can be used within the disk file that is currently open. The file name (fully qualified by the conventions of the operating system in use) is also shown on the scoreboard. The right portion of the scoreboard is used to enter commands. Getting to the command line is easy—just hit Break, or the key you have assigned to that function. The command line then becomes active, shows a cursor, and awaits your input. Hitting Break again terminates command entry and executes the command. If no command is entered (ie: if you hit Break twice without entering a command), nothing will happen. Wordsmith has over seventy commands, not including those used for cursor movement (up, down, left, right, etc).

About the Author

Mark Dahmke is a consulting editor for BYTE magazine. He also operates a computer consulting business called MCD Consulting and is involved in the design of office automation systems. His interests include astronomy, science fiction, writing, and painting.

At a Glance

Software
Wordsmith page-oriented word processor

Use
Word processing

Manufacturer
Scion Corporation
8455-D Tyco Rd
Vienna VA 22180
(703) 827-0888

Price
Wordsmith word processor (CP/M or North Star): $295; Screensplitter video board (86 characters by 40 lines) and firmware: $395. Video subsystem (Wordsmith, Screensplitter board, firmware, 15-inch green-phosphor video monitor, and high-quality word-processor keyboard IBM Selectric II style): $1795

Features
Wordsmith word processor (software) runs with a memory-mapped video display (the Screensplitter) with 86 characters per line and 40 lines. Wordsmith is completely reentrant and is written in 8080 assembly language

Operating System
CP/M 8-inch or North Star 5-inch (single-, double-, or quad-density) floppy-disk formats; also IMDOS, MDOS, CDOS (single-, double-, or quad-density formats)

Hardware
Any S-100 8080- or Z80-based microcomputer. Wordsmith will run in a CP/M system with only 16 K bytes of memory. The Scion Screensplitter memory-mapped video board is required.

Documentation
66-page manual, 21 by 27.5 cm (8½ by 11 inches), for Wordsmith; 70-page manual for Screensplitter (same size)

Firmware
1 K bytes of video-display software in a 2708 EPROM

Audience
Anyone requiring high-quality word-processing capability

Other Features

Wordsmith has many other features that make text entry less tedious. The *tab-stop line* allows you to set up any number of tabs in a given text file. When you enter the ET command, Wordsmith displays a reverse-video line just below the scoreboard. You can place a period wherever you want a tab stop, and Wordsmith will remember the tab-stop line (the line of periods) for each separate disk file. Once set up, the tab stops may be altered by entering the ET command again.

The *hold area* is a reserved area of memory that can be used to save up to an entire screen page (86 characters by 39 lines). Using this feature, any amount of text, from a single word or line to an entire screen page, may be copied to another part of the screen, another page in the file, or another disk file. Many commands are available for copying the held text back to the screen. For example, it may be put down "literally," meaning that it will be placed on the screen just as it was copied from the screen. The PF, or *put-formatted* command, will reformat the

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*Last August, Chris Morgan and I went to Washington DC to see a networked office-automation system that Scion had installed in a congressman's office. The system, called Rosenet, consists of a network of Z80 microcomputers running a modified version of the North Star disk operating system. Each workstation also includes a Wordsmith video subsystem. All workstations are tied to a central microcomputer that maintains data bases and an electronic mail/memo system. The master system also provides printer and dial-up modem services to the workstations, which communicate with the master through RS-232C lines running at 19,200 bits per second....*MCD

text in the hold area to fit a new shape or region of the screen. This allows you to work easily with "newspaper columns."

Up to 20 text *windows* may be defined on each page. Wordsmith keeps track of the windows on each page and the cursor location within each window. This extra information is stored in blocks at the end of the text file, which allows the file to be read in by an assembler or compiler without interference. A window may be any size, from 1 by 2 characters to a whole screen page. This feature is most useful in "cut and paste" operations. When several windows are defined on a page (the screen itself is called the *base window*), you can move from window to window by hitting the Cycle key. This moves you to the next window in the loop, and eventually returns you to the one you started at. When a window is active, it is impossible to type text or move the cursor to a location outside the window. It's like having a miniature screen within a screen. Windows are also useful for setting up *templates*—files with no text, but with a window structure. A template might, for example, be set up to look like a standard letter format with header, body, closing, and so on. It is then a simple matter to fill in the blanks when writing the letter.

A large selection of cursor-movement commands is available, beginning with the obvious: up, down, left, right and home (move to the upper lefthand corner of the window). On the video-subsystem keyboard, typing Shift in combination with one of the cursor-direction keys causes movement of the cursor in increments of eight character positions, instead of one. Also included are: delete to end of line, move to end of line, delete character, backspace, insert blank, insert mode, delete left, and tab.

Line control and movement commands include: insert line, delete line, insert multiple lines, delete multiple lines, center line, hold multiple lines (in hold area), split line and join line, and search line for string.

Among the window control and movement commands are: open window, clear window, set mark, clear marks, open line window, open paragraph window, drop window, drop all windows, cycle (to next window), go to base window, jump window (to new location on screen), illuminate all windows (ie: set to reverse video), change size transparently, change size, fill window (from hold area), adjust window (right justify), hold window, put text literally (from hold area), put text formatted, erase window, search for string, and search and replace string.

Page Control and Movement

Pages may be inserted and deleted, up to the limit of pages allowed in a disk file. When a new file is created (using the new-file command), you must specify the number of pages you require. Other commands include: NP (flip to next page), PP (flip to previous page), PG*n* (go to page *n*), PG+*n* (go forward *n* pages), PG−*n* (go backward *n* pages), IP (insert page), DP (delete page), CP (reread current page off disk), SP (split page into two pages—split at the cursor), JP (join two pages), save and recall page templates (window structures).

Disk-File Management

Files can be created with the NF (new-file) command. For example, the command NF B:TEST-10 will create a file (under CP/M) on the B disk called TEST, with room for ten text pages. The command OF B:TEST will get the old file called TEST from the B disk. The page that was saved in the previous editing session will be redisplayed on the screen. CL (close file) ends an editing session and closes a file. Since text pages are not necessarily in sequential order in a file, the SQ (sequence file) command will sort them into order. (This is not needed for normal operations, except when Wordsmith files are being used to store programs or other information that will subsequently be read by another program, such as an assembler or BASIC compiler.) Other file-level commands include: SRFs (search file for string "s"), SUFs (substitute next occurrence) and SAFs (substitute all occurrences in file).

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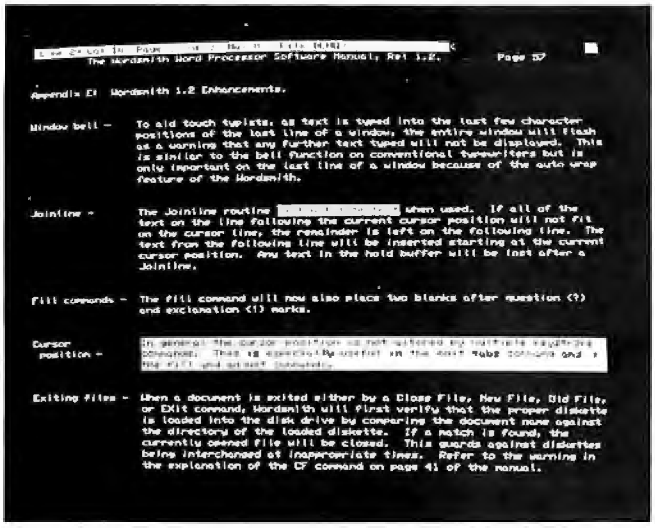

Photo 1: *The Wordsmith word processor as displayed on the Screensplitter video board.*

Printer Control

Scion supplies the intelligent printer interface of your choice. Printers currently supported include the Diablo 1610, 1620, 1650, NEC 1510, 1520, Qume Sprint 5, and any printer that accepts only carriage return, line feed, and form feed as control characters. A printed page may range from 1 to 255 lines in length. The user has control over the top margin, left margin, and number of lines per page. All hard-copy commands (except Type Window) begin printing from the cursor line and proceed through the file. The format for all five commands is:

(*Command*)-(*t*),(*l*),(*h*)

where *t* is the top margin (defaults to 4 lines), *l* is the left margin (defaults to 4 columns), *h* is the number of lines per page (defaults to 50).

If all defaults are used, Wordsmith will format output for an 8½- by 11-inch page. Control-S may be used to temporarily stop printing, and Control-K may be used to abort the print command.

The available printer commands are as follows:

- TCL (type continuous literally): The entire document is printed on the printer, starting on the current page and the current cursor line. Any blank lines at the bottom of a screen page will also be typed.
- TSL (type sheets literally): Wordsmith will pause after printing each page and await a carriage return from the keyboard. This permits use of single sheets of paper (eg: letterhead paper).
- TCC (type continuous compacted): Similar to TCL except that any blank lines at the end of each screen page will be ignored.
- TSC (type sheets compacted): Similar to TCC except that Wordsmith will wait for a carriage return at the end of each page.
- TW (type window): The current window is typed. This command is useful for cut-and-paste operations and for previewing portions of the document prior to final printing.

Wordsmith also allows the definition of page headers and footers. When a header or footer is set up, you may specify where it is to start (on what printed page) and, if page numbers are used, with which number it should begin. The page number will be inserted automatically anywhere in the header or footer where you have typed three pound signs (#) in a row. The page number will be left-justified within this field.

Software Problems

No software product is without its bugs, but Wordsmith is very reliable (it has never caused text to be lost). There are, however, some minor, annoying problems. First, the header and footer commands don't work properly if the default parameters are changed. Second, if no files are open and you issue a save-page command, the program may write over the file pointed to by the FCB (File Control Block) in the CP/M version. Otherwise, Wordsmith performs excellently, and the company, anxious to overcome any bugs, will often give you corrections over the phone (assuming you know 8080 assembly language).

Conclusions

The Wordsmith/Screensplitter combination forms one of the best word processors I have ever used, either on a microcomputer or a large system. The command repertoire is extensive, yet easy to use and learn. Many of its features are not available on word processors of any size or price. ■

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BYTELINES

News and Speculation About Personal Computing

Conducted by Sol Libes

An Apple III Emulation Mode: Axlon Inc is working on a project that will allow an Apple II to run most of the software designed for the Apple III—including the Apple III disk operating system, SOS. The product has its roots in another product recently introduced by Axlon, the Axlon 256 Memory System. The unit consists of an interface card and a card cage that contains up to 256 K bytes of memory. There are separate versions for the Atari and Apple II, and one for the Apple III is in the works. Expressed simply, the unit can exchange 32 K-byte blocks of its memory for the top 32 K bytes in the 48 K machine connected to it.

Special disk-operating-system software included with the unit makes its operation transparent to the user. The hardware/software combination looks to the host computer like a large-capacity disk drive. Program files in the memory of the unit can be run as if they were on floppy disk, and data files can be accessed in both random and serial fashion. There are two advantages to this unit: one, information can be accessed in microseconds (as opposed to milliseconds or longer for floppy-disk drives); and two, the increased main-memory space makes both existing and proposed programs that crowd the current 48 K-byte limit more feasible.

The Sunnyvale, California-based Axlon is working with Apple Computer to finalize the design of the Apple III emulation hardware/software combination. The proposed unit will include the Axlon 256 Memory System, a special hardware board, special software, and an 80-column adapter for the Apple II.

EEPROM Is Coming: Several IC designers are predicting that the EEPROM (electrically erasable programmable read-only memory) will replace the ultraviolet-light EPROM within three to four years and may, perhaps, be used as nonvolatile main memory. Several companies are now putting finishing touches on these devices for introduction later this year. For example, Hitachi has announced the HN48016, a 16 K-bit EEPROM (2 K by 8 bits) that is pin-compatible with the popular 2716 UV-EPROM. It uses the same voltages, takes 10 ms per byte to program, and can be completely erased with a 1-second pulse. Data retention is claimed to be more than ten years. Intel has a similar device called the 2816. Prices and access times are comparable to their EPROM equivalents.

Microsoft Adds Graphics Commands To BASIC: Microsoft is offering OEMs who have hardware graphics capability an enhanced version of the popular BASIC-80 interpreter. The added commands will allow you to create lines, boxes, circles, curves, do object painting and relocation, and save all your work. Seven new commands have been added: CIRCLE, PAINT, GETSET, LINE, DRAW, PUT, and PRESET.

Continuing AMSAT OSCAR Activity: AMSAT, the Radio Amateur Satellite Corporation, has survived the loss of its Phase-IIIA OSCAR satellite. (See "BYTELINES," September 1980 BYTE, page 166.)

Construction of a new Phase-IIIB satellite is underway in Marburg, West Germany; Budapest, Hungary; and Washington DC. AMSAT has scheduled the satellite's launch for February 24, 1982 on a European Space Agency Arriane-booster flight.

As part of its planned use, the satellite will relay computer data by amateur radio operators in personal-computer networks.

For information on how to join AMSAT and receive *Orbit* magazine, write to AMSAT, POB 27, Washington DC 20044.

Details On 32-Bit Microprocessors: Intel released more information on its new 32-bit microprocessor, called the iAPX432. The microprocessor, under development for six years, features an object-oriented architecture that treats high-level entities as elementary software components that can be easily manipulated. These entities include records, queues, tasks, and collections of procedures.

In its simplest form, the microprocessor consists of two integrated circuits. More processors can be added later to obtain multiprocessing without altering software. It is expected that samples will be available in the fall.

$100,000 Computer-Chess Prize Offered: Carnegie-Mellon University (CMU) is offering a prize of $100,000 to the first person to develop a computer program that can defeat the world chess champion. Dr Hans Berliner, a computer scientist at CMU and a former world chess champion, heads the competition-rules committee. He feels that the prize may be won by 1990 or sooner, but certainly no later than the year 2000.

Last year a $1000 CMU prize was won when Jack Gibson, a chess expert, was defeated by Belle, a computer-chess machine developed by Ken Thompson and Dr Joe Condon, researchers at Bell Laboratories, Murray Hill, New Jersey.

Mini-Winchester Update: Five companies have announced 5-inch Winchester drives. The drives' storage capacity ranges from 1.8 to 12.3 megabytes (unformatted), and prices vary from $690 to $1600 (500-unit quantity prices). Most suppliers are now shipping evaluation units to OEMs (original equipment manufacturers), with limited production expected by late summer. Don't expect full production until next year.

The five companies which have already announced mini-Winchester hard disks are Shugart Associates, Seagate Technology, Irwin International, Tandon Magnetics, and New World Computer Company. The price leader appears to be Shugart, with its SA602 3.3-megabyte drive at $660. The maximum storage leader is the 12.3-megabyte

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Formats: 8, NS, MP, SB, TRS2, CDOS

SPELLBINDER™ - $495. Manual alone - $50.

Full feature word processing system with Office Management capabilities. It's special features include ease-of-use by office personnel, flexible print formatting & output, and a powerful macro capability which allows features to be added for the unique requirements of each user. Mail list macro is included for mail merge with form letters.

Requires CP/M & 32K RAM. Formats: 8, NS, MP, CDOS, SB, APPL

SPELL MENU™ - $95. Spellbinder version of Magic Menu.

MCALL™ - $85.

Communications program designed to drive an acoustic coupler. Features include:

- Time sharing Terminal emulation
- Disk file transfer between CP/M computer & Time Sharing Computer in either direction
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AMCALL™ - $95.

Auto-answer, auto dial version of MCALL currently supports IDS 88-modem & Potomac Micro-Magic MM-103 boards.

Requires CP/M. Formats: 8, NS, MP, SB, CDOS

MICROSTAT™ - $250. Manual alone - $25.

Powerful statistical analysis package.

Includes data management sub-system for editing, sorting, ranking, lagging, data file transfers PLUS eleven data transformations (e.g. linear, reciprocal, exponential, etc.)

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- ANOVA (one and two-way)

Requires 48K RAM, NorthStar Basic or CP/M & CBASIC2 or Microsoft Basic 80.

Formats: 8, NS, MP, SB, TRS2, CDOS, APPL

FORMAT CODES: 8 (8" single density IBM soft-sectored) NS (NorthStar DD) MP (Micropolis Mod II/Vector MZ) SB (Superbrain 3.0) CDOS (8" Cromemco CDOS) TRS2 (TRS-80 Mod II) APPL (Apple II)

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Circle 127 on inquiry card.

Model 510 from Irwin. It costs $1500, which includes integral tape-cartridge backup.

TI Improves The 99/4 Home Computer: Texas Instruments is determined to make its TI 99/4 home computer a success. TI has improved the competitive position of the 99/4 by substantial price cuts and software improvements, the two areas in which the machine fared poorly. The new list price for the console is $649.95, a reduction of $300, and the radio-frequency (RF) modulator's price has been reduced from $75 to $50.

TI has introduced a software-development system that includes UCSD Pascal and a ROM (read-only memory) module with an assembly-language debugger. The console has been modified and includes dual floppy-disk drives and RS-232C interfaces. TI has also announced third-party software-incentive programs for software developers. TI plans to introduce extended BASIC and memory-expansion capabilities in the TI 99/4. Regrettably, TI has not seen fit to improve the keyboard or make any substantial hardware improvements other than the addition of memory.

More On Daisy-Wheel Printers: Daisy-wheel printers are the most widely used printers for letter-quality hard copy, but the market is undergoing substantial change. Last year, the number of daisy-wheel-printer manufacturers doubled. More competition meant lower prices and increased performance. The new entries came from Olivetti, Fujitsu, Ricoh, C Itoh, and Pertec. Qume and Diablo still dominate the market, but competitors are broadening their performance range from the traditional 45 to 55 cps (characters per second) to 15 to 80 cps.

The 45 to 55 cps range is dominated by Qume, an ITT subsidiary with 45% of the market, and Diablo, a Xerox subsidiary with 40% of the market. NEC also has a 10% market share, with the other companies dividing the remaining 5%. The prices of these machines should drop about $1000, to $2700 within the next two to three years, and the printer manufacturers will most likely introduce 30 cps versions selling for under $2000. Look for the 30 cps machines by year-end.

Expect a price war between the manufacturers of the lower-speed 15 to 20 cps printers. Prices may drop to $1200 or less by year-end. Those companies at loggerheads in this marketing war are Ricoh (which supplies Tandy), Olivetti, Pertec (which supplies machines made by Triumph-Adler), and C Itoh.

Fujitsu has already demonstrated an 80 cps daisy-wheel printer. Look for it in computer stores this summer. Qume, Diablo, and NEC are expected to introduce 80 cps machines, and some companies are working on 100 cps machines.

Ada On Microcomputers: At a recent ACM/SIGPLAN-sponsored meeting, TeleSoftware demonstrated the new Ada language on a 16-bit microcomputer. The compiler is 50 K bytes, supports run-time utilities, and produces pseudocode that runs directly on a Western Digital Pascal/Ada Microengine system. TeleSoftware said that the Ada code could be converted to the native code of some other microprocessor by use of a simple p-code interpreter (p-code is the machine language executed by the Microengine). Ken Bowles, the developer of UCSD Pascal and founder of TeleSoftware, said the company also intends to provide Ada compilers for 8086-, 68000-, and Z8000-based systems.

Western Digital will manufacture the Pascal/Ada Microengine for $12,750. It will include 128 K bytes of programmable memory, five I/O ports, a 10-slot chassis, video-display terminal, dual floppy-disk drives, and a line printer. The basic system will cost $6210. Western Digital also said that it soon expects to release a hard-disk controller, a cryptographic security module, a distributed multiprogramming operating system, and an X.25 packet-switching and local network product for the processor.

Computer Bulletin Boards Grow In Popularity: There are over 200 CBBS (computer bulletin board systems) in this country and their number grows weekly. Anyone with a terminal, modem, and telephone can access them. (If you use an Apple computer, they are called ABBS.) Most CBBS and ABBS serve as message centers for computer clubs. Some systems distribute software; for this service, a caller needs a computer with modem-driver software for file transfers.

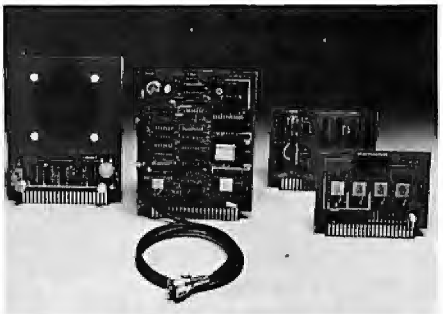
Other bulletin board systems serve special interests (eg: AMRAD's Blind Service CBBS 703-281-2222, the Family Historians' CBBS 703-978-7561, and Aviators' BBS 916-393-4459). For more information on all of these systems and how to access them, call the MAGMEDIA-80 CBBS (415) 573-8768.

Here Come The Japanese: Expect to see several Japanese personal-computer systems in US stores this fall. Most of the systems will compete directly with the Apple II, Commodore PET, and Radio Shack TRS-80. They'll sell for the same price, perhaps slightly less, but offer extra features. NEC (Nippon Electric Company) will market the PC-8001 at the same price as the Apple II. (See "The NEC PC-8001: A New Japanese Personal Computer," by Michael Keith and C P Kocher, January 1981 BYTE, page 72.) Its features will match or exceed the Apple's. Matsushita (known in America as Quasar and Panasonic) and Sharp are also expected to have their systems on dealer shelves this fall. The Z80-based Sharp system is already on sale in England. One English distributor has already adapted CP/M for it.

Shopping Via Computer: Comparison retail shopping by home computer appears to be the wave of the future. One of the first computerized retailers is Comp-U-Card of Stamford, Connecticut. It claims to have 1.5 million members, of which 5000 already have computer I/O capability. To become a member it costs $18 per year, or $9 if you come under a group plan. To access the service's base of more than 30,000 items, you call it either via a toll-free telephone number or a two-way cable TV hookup. Comp-U-Card presents product specifications, price, and delivery charges. You can order any item at a typical savings of 20 to 40% or just use the service to compare prices.

Data-Base Systems Ex-

The VP-111 hobby computer: Start programming for only $99.



New! VP-111 Microcomputer.... $99. Assembled* and tested.

Features:

- RCA 1802 Microprocessor.
- 1K Bytes static RAM.
Expandable on-board to 4K.
Expandable to 32K Bytes total.
- 512 Byte ROM operating system.
- CHIP-8 interpretive language or machine language programmable.
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- Cassette interface—100 Bytes/sec.
- Instruction Manual with 5 video game listings, schematics, CHIP-8, much more!

Ideal for low-cost control applications. Expandable to full VP-711 capability with VP-114 Kit.

*User need only connect cables (included), a 5-volt power supply and speaker.

New low price! VP-711, only.......... $199. Completely assembled and tested.

All the features of the VP-111 plus:

- A total of 2K Bytes static RAM.
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- 8 Bit input port.
- 8 Bit output port.
- I/O port connector.
- System expansion connector.
- Built-in speaker.
- Plastic cover.

Three comprehensive manuals:

- Instruction Manual—20 video game listings, schematics, much more.
- User's Guide—operating instructions and CHIP-8 for the beginner.
- RCA 1802 User's Manual (MPM-201B)—complete 1802 reference guide.

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Add computer power a board at a time.

With easy-to-buy options, the versatile RCA hobby computer means even more excitement. More challenges in graphics, games and control functions. For everyone, from youngster to serious hobbyist.

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Please send me the items indicated.

- ☐ **VP-111** New low cost Microcomputer (See description above) .... $ 99
- ☐ **VP-114** Expansion Kit for VP-111—Includes 3K RAM, I/O Port and connectors $ 76
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- ☐ **VP-44** RAM On-Board Expansion Kit—Four 2114 RAM ICs. Expands VP-711 memory to 4K Bytes .... $ 36
- ☐ **VP-590** Color Board—Adds color. Four background and eight foreground colors .... $ 69
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- ☐ **VP-570** Memory Expansion Board—Plug-in 4K RAM memory .... $ 95
- ☐ **VP-580** Auxillary Keypad—Adds two-player interactive capability. Connects to VP-590 or VP-585 .... $ 20
- ☐ **VP-585** Keypad Interface Board—Interfaces two VP-580 Auxiliary Keypads to VP-111/711 .... $ 15
- ☐ **VP-560** EPROM Board—Interfaces two 2716 EPROMS to VP-111/711 .. $ 34
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- ☐ **VP-611** Keyboard—Same as VP-601 plus 16-key numeric keypad .... $ 89
- ☐ **VP-616** Keyboard—Same as VP-606 plus 16-key numeric keypad $119
- ☐ **VP-620** Cable—Connects VP-601/611 to VP-111/711 .... $ 20
- ☐ **VP-623** Cable—Unterminated for VP-601/611 .... $ 20
- ☐ **VP-626** Connector—Male "D" mates to VP-606/616 .... $ 7
- ☐ **VP-3301** Interactive Data Terminal $369
- ☐ **VP-3303** Interactive Data Terminal with built-in RF output............ $389

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Credit card account No. ______________________
Master Charge Interbank No. __________ Expiration date __________
Signature (required for credit orders): ______________________
Name (please type or print): ______________________
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State & Zip: ______________________ Telephone:( ) __________

Make checks payable to RCA Corp. Prices and specifications are subject to change without notice.

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panding: The need to access reference material has become much easier because of computerized data-base distributors. For example, a lawyer can access the Nexis system from Mead Data Central, 200 Park Ave, New York NY 10017, for a special keyed-word news-search service. The cost is $1 to $1.50 per minute, plus a $300 monthly charge. The initial sign-up charge is $425. There are many lower-cost data-base services catering to the special needs of various professionals.

For information on data-base systems, consult the *Directory of On-Line Data Bases*, published by Cuadra Associates, 1523 Sixth St, Suite 12, Santa Monica CA 90401. The price is $60 per year (four issues).

Computer Makers To Market Private Software: If you develop software for the HP-85 desk-top system in your spare time, Hewlett-Packard has a plan for marketing it. Hewlett-Packard will pay a royalty for the software and offer to sell you a system at a discount. Burroughs has a similar plan.

GM On Robotics Shopping Spree: GM has ordered 25 robots for its transmission-machining lines at its Warren, Michigan, facility. This is the largest undertaking of its kind in the automotive industry. The robots will cost almost $2 million. GM plans to buy as many as 1800 programmable robots between now and 1984.

In a related development, GM will use laser checking devices on its J-car-body assembly lines; the devices will check 20 to 30 points on each car for proper body fit and panel alignment. There will be no contact with the auto during this checking procedure.

AT&T To Enter Computer Market: In a landmark decision, the FCC will allow AT&T (American Telephone & Telegraph) to enter the computer business. The decision requires AT&T to set up a separate subsidiary to offer terminals and computer-enhanced services. Industry pundits speculate that AT&T will position itself to capitalize on the marriage of the telephone and computer technologies.

Used Word-Processor Market Burgeoning: You can save quite a bit of money by buying a used word processor. IBM, Xerox, Lanier, and Vydec systems are becoming available as companies upgrade to newer, more powerful machines. In Minneapolis, Word Systems Inc specializes in selling used word-processor systems, although they are also available through many other dealers.

Extra-Life Printer Ribbons: Replacing printer ribbons is expensive. Here's how to revive worn-out closed-loop ribbons housed in plastic cases: carefully pry open the case without disturbing the ribbon. Spray the ribbon lightly (don't overspray) with an all-purpose lubricant such as WD-40, close the case, and let it stand overnight. The lubricant causes the ink from the moist unused portions of the ribbon to flow down into the dry areas of the ribbon. This renewal process can usually be repeated several times before the ribbon is completely exhausted.

Random News Bits: United States Robots, Conshocken, Pennsylvania, claims to have developed a five-jointed robot arm using seven microprocessors—one for each joint, one for math calculations, and one for overall coordination. The microprocessors do multiprocessing on a shared bus and memory system. ...Toshiba and Hitachi have demonstrated "pocketbook TVs" that typically use 120- by 160-element LCDs (liquid-crystal displays). Matsushita and Hitachi reportedly will introduce products next year using these displays. ...Interested in learning more about possible health hazards associated with CRT (cathode-ray tube) terminals? Then you should get a copy of the 16-page pamphlet entitled *Health Protection for Operators of DCTs/CRTs*. It's published by the New York Committee for Occupational Safety and Health, 32 Union Sq, Rm 404, New York NY 10003 ($1 for individuals; $3 for institutions).

Random Rumors: Apple Computer may put off its plans to build 5-inch Winchester-disk drives for the Apple III and the rumored Apple IV. Apple has reportedly inked a contract for 10,000 six-megabyte ST-506 drives from Seagate Technology. Apple still plans to produce a hard-disk drive for introduction next year. ...It is rumored that Digital Equipment Corporation has developed a single-integrated-circuit version of the PDP-11 and that it exists in prototype form. No production plans have as yet been established. ...There is a lot of talk circulating that Xerox will soon release a version of the Smalltalk programming language and a complete book describing it. Most likely it will be released to universities who presently have the Xerox Alto system (an experimental personal computer). ...*Electronic News* recently reported that IBM and Tandy were holding discussions on the possibility of IBM 3103 video terminals being sold through Radio Shack stores. ...According to a report issued by International Resource Development Inc (IRD) in Norwalk, Connecticut, IBM, Xerox, and Matsushita will introduce typewriters with voice input by 1983. IRD predicts that the typewriters will correctly recognize 93% of "typical business English as spoken by the average executive," and that the unit will have a video screen that displays the spoken words. Corrections and changes can be made on the screen....

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.

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16-BIT OR EXTENDED ADDRESSING — Special circuitry is included to allow memories without IEEE extended addressing to be used in systems with more than 64K (uses PHANTOM).

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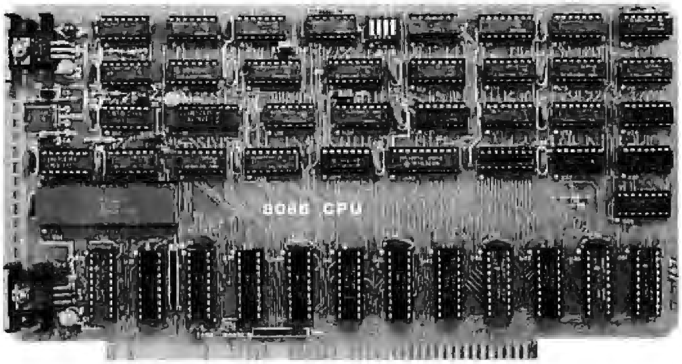
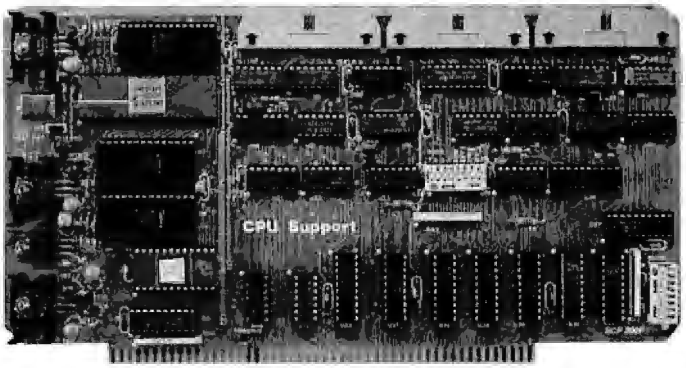
2-CARD CPU SET — Includes serial I/O, parallel I/O, a monitor in 2716 EPROM, a time-of-day clock, and a very flexible and expandable vectored interrupt system.





Price includes 86-DOS™

DEVELOPMENT SOFTWARE — 86-DOS provides a complete package of development software, including editor, assembler, debugger, Z80 to 8086 source code translator, and utilities.

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IT'S THE STANDARD — This BASIC is essentially identical to version 5 of Microsoft's BASIC interpreter, the accepted standard with widely available application programs. Programs distributed in CP/M® format are easily converted to the 86-DOS system. (CP/M is a registered trademark of Digital Research.)

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PRICE: $350 To registered SCP 8086 CPU owner, $500 to others.

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Please specify disk controller from among those supported.

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Continued from page 20:

Resistible Puzzle

John Moore revived the earlier-published problem of creating a network with resistance of 355/113 (a very close approximation to π) with a minimum number of unit-valued resistors. (See the January 1981 BYTE, page 16.) He improved greatly on W Lloyd Milligan's 26-unit solution (see the August 1980 BYTE, page 20) by presenting two 18-unit solutions and asking if anyone could find a solution with 17 or fewer resistors.

By abandoning their continued-fraction method in favor of one based on Diophantine equations (those having positive, non-zero integer solutions), I was able to come up with two different 15-unit solutions. (See figures 1a and 1b.)

I believe these two to be minimal, and essentially the only minimal solutions (ie: except for other solutions created by trivial transpositions of series and parallel elements in one of these resistors) within the class of networks examined by this method and by the continued-fraction method (ie: all simple series-parallel networks).

But there are many more ways to connect a handful of resistors than just in simple series-parallel networks!

I looked for a solution with a bridge as a part of the total network. With the help of a TI-58 programmable calculator, I was able to find a 14-unit solution. (See figures 2 and 3 on page 270.)

Of course, with 12 or 13 resistances to connect together in an arbitrary fashion, much more complicated figures than bridges are possible. Unfortunately, the calculation of resulting network impedance, and the searching through the various configurations, becomes correspondingly complex. I suspect that the 14-unit solution can be improved upon.

David F Smith
3033 Turk Blvd, #3
San Francisco CA 94118

(1a) (1b)

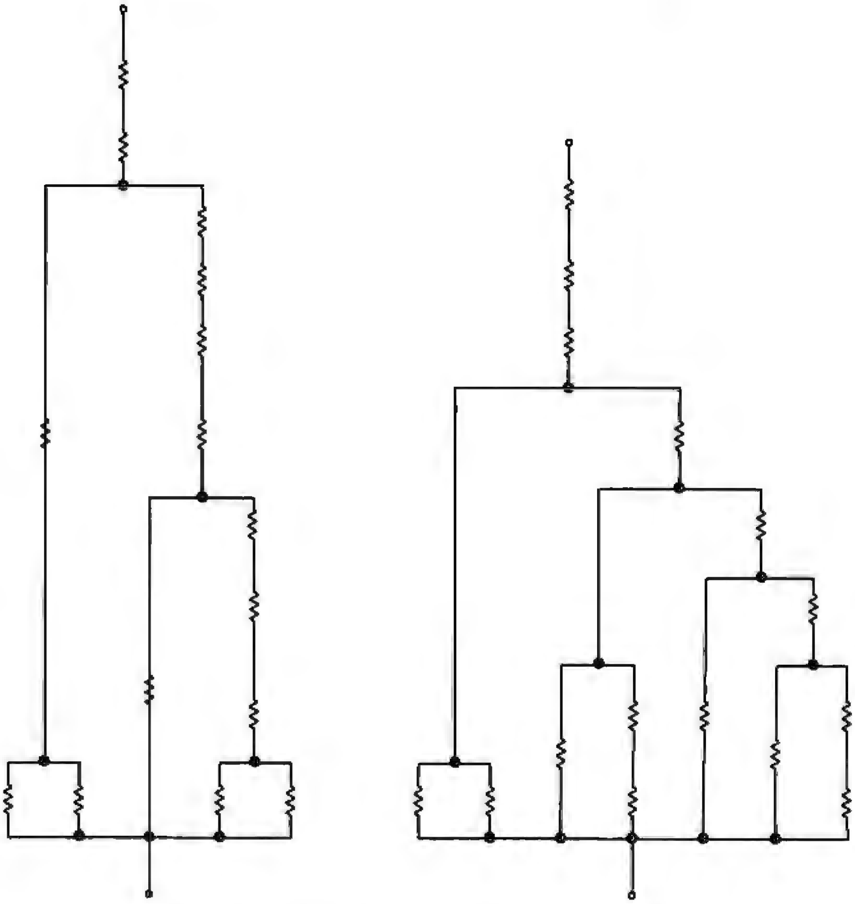

Figure 1: *Two 15-unit networks with* $Z = \frac{355}{113}$

COLLECTOR EDITION
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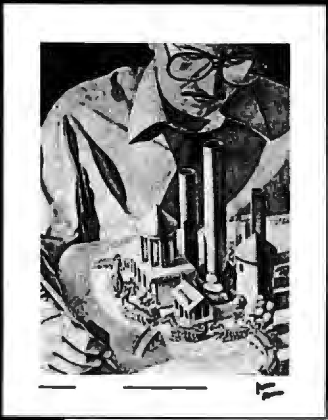
#1



#5

#2

#6

#3

#7

#4

#8

The Byte Covers shown at left are available as Collector Edition Prints. Each full color print is:

- 11" X 14" including a 1½" border.
- Part of an edition strictly limited to only 100 prints.
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___	#5-Computer Engineering	$20
___	#6-Total Eclipse	$20
___	#7-Computer Hardware	$20
___	#8-Perspectives	$20
___	No.'s 1-4	$70
___	No.'s 5-8	$70

Post. & hand. ($3 in US, $6 overseas) $ ______

Total $ ______

☐ I have enclosed check or money order

☐ Visa ☐ MasterCharge

Card # ______

Expiration Date ______

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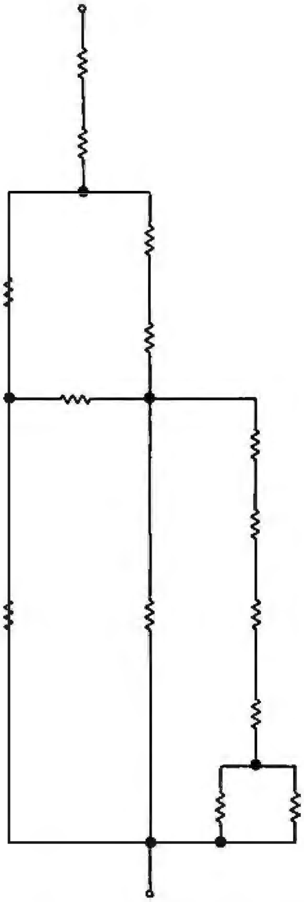
24 HOURS A DAY! 7 DAYS A WEEK!

Figure 2: *A 14-unit network with* $Z = \frac{355}{113}$



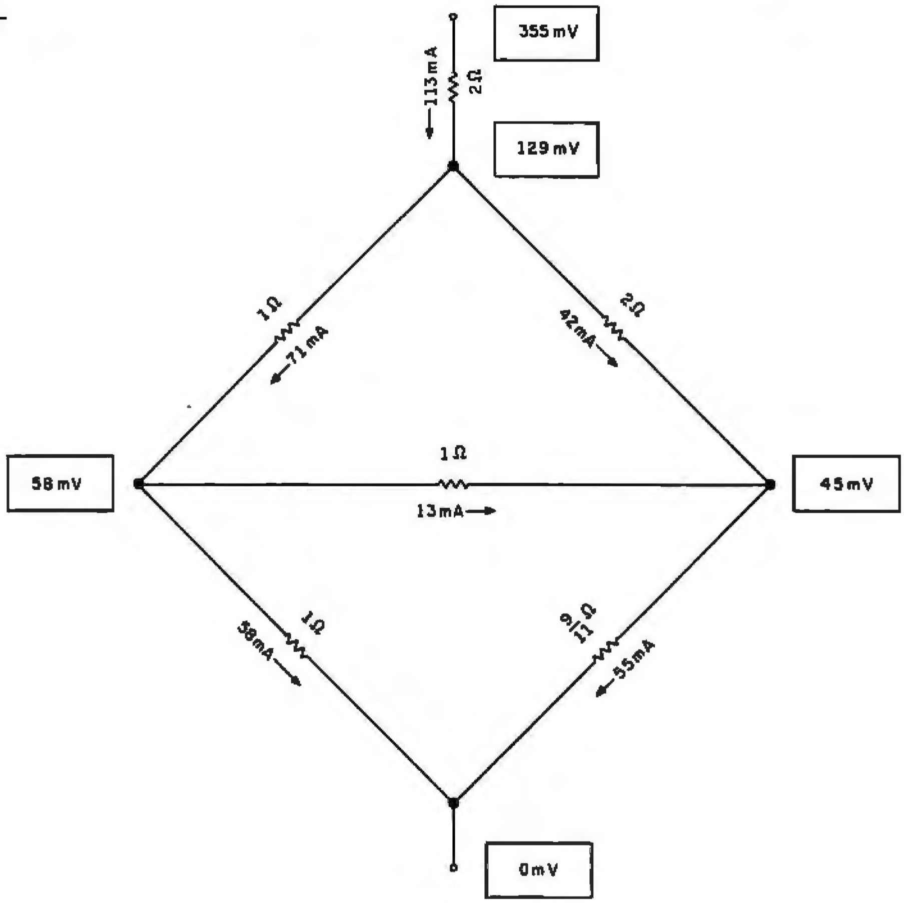


Figure 3: *Voltages and currents in the 14-unit network with 355 mV across it.*

Easier Communication in Two Directions

Mark R Titchener's article "Communications in Two Directions" (June 1980 BYTE, page 96) presents a circuit to communicate bidirectionally on a single line; however, it requires too many components. An easier way to do it is shown in figure 4. This circuit will work for both analog and digital signals. Using standard op-amp theory, it is easily shown that V4 = V2 and V3 = V1. Line impedance can be compensated for by making R0 variable.

R Gupta
Electrical Engineering
University of Auckland
Private Bas, Auckland
New Zealand

Smart Wheelchair Project

Steve Ciarcia's article "Home in on the Range! An Ultrasonic Ranging System" (November 1980 BYTE, page 32) was excellent. I would, however, like to make BYTE readers aware of another project that has incorporated the Polaroid Ultrasonic Ranging technology. The project was funded by the Veterans Administration Rehabilitative Engineering Research and Development Center of Palo Alto, California. The participants, Karen Altman, Rick Epstein, Leslie Gerding, Wayne Ledger, and Dave Parker, were graduate students last year at Stanford Mechanical Engineering.

The objective was to design, develop, and successfully fabricate a "smart" electronic wheelchair. Its construction included ten ultrasonic sensors, eight of which were used to detect approaching obstacles or the presence of a wall on either side of the chair. The remaining sensors were focused on the user's head from two angles.

The chair has many modes of operation: the most important is the head-control mode. Here, the user directs the movements of the chair by head motions. To move the chair forward, the user posi-

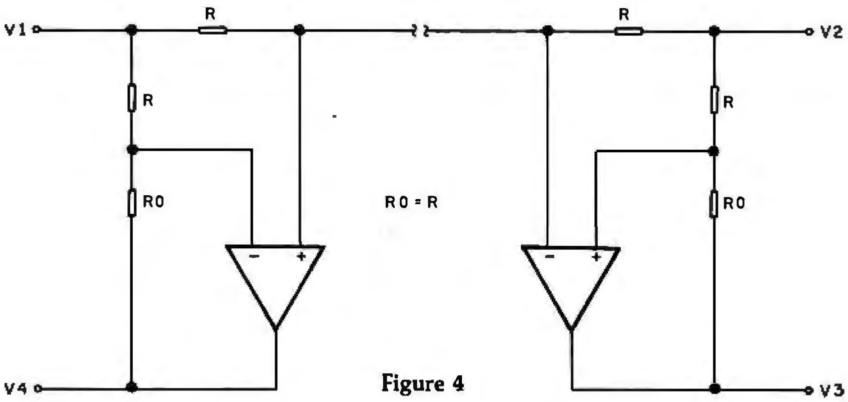


Figure 4

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NOW FOR A LIMITED TIME, THIS SPECIAL OFFER

JOIN SUPER★STAR INTERNATIONAL FOR THE REGULAR YEARLY MEMBERSHIP FEE AND RECEIVE A FREE DISKETTE WITH THE FOLLOWING PROGRAMS:

- "RECOVER", it allows you to recover an erased program
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- "RETURN", it gets you back into a crashed program from CP/M[1]
- the game "OTHELLO".

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tions his or her head toward the front of the chair. Similar operations control the three remaining directions. In effect, the user's head is a proportional-control joystick. One can readily see that this type of noncontacting control would be helpful for people who have no usable arm function.

In operation, the front-facing ultrasound sensors detect the presence of obstacles in the chair's path. When such an obstacle comes within a predetermined distance, the chair automatically slows and stops before running into it. If the "obstacle" moves away, the chair will follow at a fixed distance.

Side sensors serve to detect walls. A mode to "follow that wall" enables a chair to travel parallel to the chosen wall at a fixed distance. Open doorways are detected and passed over, but a discontinuity of more than a few feet disables the wall-following mode and waits for further commands from the user.

A "cruise control" mode does not use any additional sensors, but instead relies on wheel-speed data obtained from two optical shaft encoders. Once in this mode, the chair proceeds at a constant speed and heading despite changes in terrain.

A final mode allows the head to be moved without affecting the chair.

The user initializes the system to the range of his or her head motion by means of a "training" program that instructs the user to center the head, to move it to the left or right, and forward or backward. The program uses this information to calibrate the position/speed algorithm as well as set up a dead band around the user's rest position.

The hardware presently consists of a Z80 microprocessor, 64 K bytes of memory, and an external disk-drive system. Once the program is loaded, the disk is disconnected and the user drives off. The software executive is written in BASIC, with a majority of the actual real-time program coded in machine language and as arithmetic function calls. The listing consumes 40 pages.

The current construction phase will shrink the initial hardware and software configuration by one-third. A final design will capture the features on a single printed-circuit board.

The approach taken in pursuit of the interface between the ultrasound sensors and the microprocessor is considerably different from the method described in Steve's article. Since the Polaroid kits were not available at the time of construction, several new cameras were sacrificed to acquire the parts required. In addition, the computer interface was done not at the EDB level, but at the custom ultrasound board level. To perform a ranging, the computer generates a transmit request pulse via a convenient parallel output bit. The output from the board is then interrogated to start a software timing loop that is terminated by the received echo signal. The number of times the loop is performed gives a fairly precise measure of the range. Dividing this value by an appropriate factor will yield the range in whatever units are required. In the course of the project, a resolution of about a quarter of an inch was obtained over distances ranging from 9 inches to 20 feet (depending on surface characteristics).

Additional information about this ongoing project can be obtained by writing me at the address below.

David L Jaffe
Palo Alto VA Medical Center
Rehabilitative Engineering Research and Development Center
3801 Miranda (153)
Palo Alto CA 94304■

dBASE™ II vs. the Bilge Pumps.

by Hal Pawluk

We all know that bilge pumps suck.

And by now, we've found out—the hard way—that a lot of software seems to work the same way.

So I got pretty excited when I ran across **dBASE II**, an assembly-language relational Database Management System for CP/M. It works! And even a rank beginner like myself got it up and running the first time I sat down with it.

If you're looking for software to deal with your data, too, here are some tips that will help:

Tip #1: Database Management vs. File Handling:

Any list or collection of data is, loosely, a data base, but most of those "data base management" articles in the buzzbooks are really about file handling programs for specific applications. A real Database Management System gives you data and program independence (no reprogramming when data changes), eliminates data duplication and makes it easy to turn data into information.

Tip #2: Assembly Language vs. BASIC:

This one's easy: if you're setting up a DBMS, you're going to be doing a lot of sorting, and Basic sorts are s-l-o-w. Run a benchmark on a Basic system like S*-IV against a relational DBMS like **dBASE II** and you'll see what I mean. (But watch it: I've also seen one extremely slow assembly-language file management system.)

Tip #3: Relational vs. Hierarchal & Network DBMS.

CODASYL-like hierarchal and network systems, around since the 1960's, are being phased out on the big machines so why get stuck with an old-fashioned system for your micro? A relational DBMS like **dBASE II** eliminates the predefined sets, pointers and complex data structures of a CODASYL-type DBMS. And you don't need to be a programmer to use it.

dBASE II vs. everything else.

dBASE II really impressed me.

Written in assembly language (with no need for a host language), it handles up to 65,000 records (up to 32 fields and 1000 bytes each), stores numeric data as packed strings so there are no round-off errors, has a super-fast multiple-key sort, and supports ISAM based on B* trees.

You can use it interactively with English-like commands (DISPLAY 10 PRODUCTS), or program it (so when you've set up the formats, your secretary can do the work). Its report generator and user-definable full screen operations mean that you can even use your existing forms.

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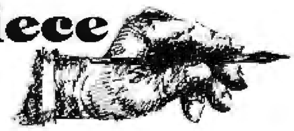

CP/M REGISTERED TRADEMARK DIGITAL RESEARCH

Text continued from page 228:

My application required that I code the 10 decimal digits (0 thru 9). I borrowed the 7-bit-per-digit bar code used in the UPC (Universal Product Code) to represent those digits. [*Note that UPC bar codes, as shown in figure 1, have a different appearance from PAPERBYTE® and other bar-code formats....*GW] Each of the identifiers that is generated consists of 6 digits, thereby allowing the printer to operate close to the left margin. This was a distinct advantage for my application. The dot-backspacing feature of the printer reduces the dot-position counter by the amount the user specifies, returns the carriage to the left margin, and then back to the new position indicated by the pointer. Because of this method of printing, the time required to print a line increases disproportionately with its length. Thus, short lines are desirable.

The following procedure was used to generate bar codes with the Centronics 737:

- Set the proportional-spacing mode on the printer by issuing the command:

```
LPRINT CHR$(27); CHR$(17);
```

This can be done either in, or before running the program, but I suggest doing it in the program to avoid problems that arise in the monospacing mode.

- Read the character codes into a binary array.
- Use the INKEY$ function to enter a character to be printed in bar code. Use the entered value to retrieve the binary code for the character from the array. The 1s and 0s are values of the variable J, and are used as follows in the LPRINT statement:

```
LPRINT CHR$(92 * J + 32);
```

If J=1, then CHR$(124) causes a bar to be printed. If J=0, then CHR$(32) results in a blank space.

- Backspace to the dot position immediately following the one just printed, by issuing the following printer command:

```
LPRINT CHR$(08); CHR$(4);
```

In my application, I placed equivalent Arabic numerals

800218

824009

Figure 1: *Bar codes generated by a Centronics 737 dot-matrix printer and a TRS-80 computer, using the program in listing 1. The program also prints the equivalent Arabic numerals under the code.*

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Listing 1: *Bar-code generator. The program, written for the Radio Shack TRS-80 with Level II BASIC, generates bar codes for the decimal digits 0 thru 9 on a Centronics 737 printer.*

```
10 DIM B(10,7)
20 '
30 '     LOAD THE BINARY ARRAY
40 '
50 FORI=0TO9:FORJ=1TO7:READB(I,J):NEXTJ:NEXTI
60 '
70 '     SET THE PROPORTIONAL SPACING MODE ON THE PRINTER
80 '
90 LPRINTCHR$(27);CHR$(17);
100 '
110 '     BEGIN SIX-DIGIT INPUT LOOP
120 '
130 FORN=1TO6
140 '
150 '     STROBE KEYBOARD FOR AN INPUT DIGIT
160 '
170 Y$=INKEY$:IFY$=""THEN170  ELSEI=VAL(Y$):A$(N)=Y$
180 '
190 '     RETRIEVE BINARY CODE FOR THE DIGIT AND PRINT
200 '     THE BAR CODE REPRESENTATION FOR IT.
210 '
220 FOR K=1TO7:J=B(I,K)
230 LPRINTCHR$(92*J+32);CHR$(08);CHR$(4);:NEXTK:NEXTN
240 '
250 '     PRINT THE ARABIC NUMERALS
260 '
270 LPRINT" ":FORN=1TO6:LPRINTA$(N);:NEXTN
280 '
290 '     BINARY CODE FOR DIGITS 0 - 9
300 '
310 DATA 0,0,0,1,1,0,1
320 DATA 0,0,1,1,0,0,1
330 DATA 0,0,1,0,0,1,1
340 DATA 0,1,1,1,1,0,1
350 DATA 0,1,0,0,0,1,1
360 DATA 0,1,1,0,0,0,1
370 DATA 0,1,0,1,1,1,1
380 DATA 0,1,1,1,0,1,1
390 DATA 0,1,1,0,1,1,1
400 DATA 0,0,0,1,0,1,1
410 END
```

after the 6-digit bar code to allow a quick check of the coded identifier. An example of bar codes generated with the Centronics 737 appears in figure 1.

The program in listing 1 was written for the Radio Shack TRS-80 using Level II BASIC. This is only a sample program that can be modified to suit your taste, but it demonstrates how you can generate bar codes on a low-cost printer. ■

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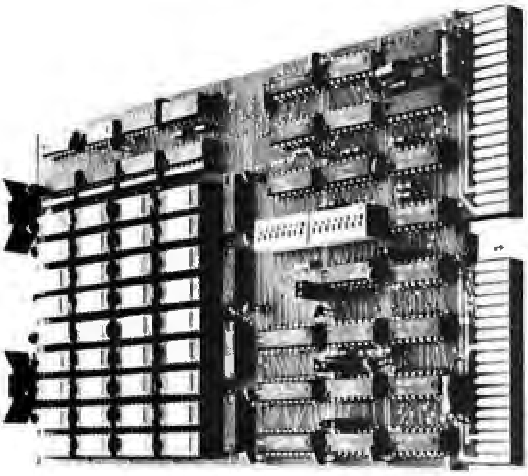

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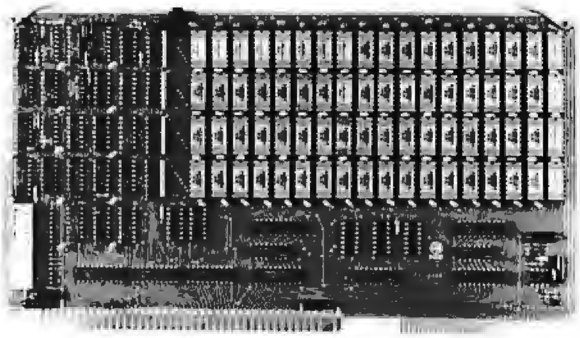

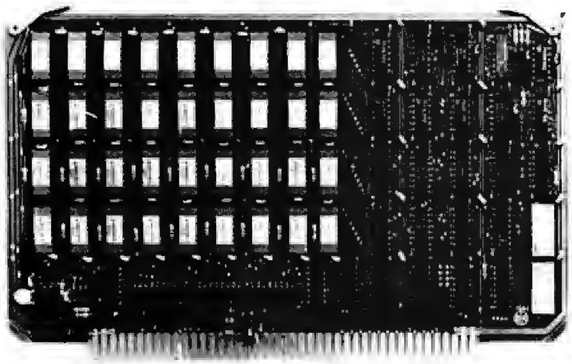

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Using Interrupts on the Apple II System

George M White
Computer Science Department
University of Ottawa
Ottawa, Ontario K1N 6N5 Canada

The designers of the Apple II personal computer made a judicious choice of software/hardware trade-offs. The most important software systems are stored in ROM (read-only memory) at high addresses where they are, for the most part, out of sight. Since the monitor, BASIC interpreter, and miniassembler are stored in ROM, they cannot be destroyed by user programs running out of control, nor can they be altered to produce strange results.

A surprising feature of the Apple II's system software is that it makes little use of the 6502 interrupt system.

A surprising feature of the Apple II's system software is that it makes little use of the interrupt system of the 6502 microprocessor. However, the creators of the monitor have correctly assumed that some users might want to make use of interrupts, so they have provided several facilities to aid the user in doing so. The hardware and software facilities permit the user to write interrupt-service routines and to wire up interrupt generators that easily fit into one or more of the eight I/O (input/output) card slots, conveniently located under the Apple's removable plastic cover.

Interrupt-Service Software

Let's compare interrupt-service routines to program subroutines. In the BASIC language, subroutines are called at a known *location* within a program by a GOSUB statement. The subroutine is not executed (or shouldn't be) until the GOSUB statement is encountered during the course

Acknowledgment

Most of this article was written while the author was enjoying the incomparable hospitalité of L'Institut de Recherche d'Informatique et d'Automatique in Rocquencourt, France.

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of the program. Subroutines are usually written to perform a specific action such as altering values of variables, I/O operations, etc.

Interrupt routines, on the other hand, are called at a specific point in *time*. An interrupt signal arrives, and the interrupt-service routine is called. There is no warning. The signal can arrive at any time, and the program being executed can be interrupted at any point.

The interrupt routine is a program like any other program. It can do everything an ordinary program can do, such as calculate numbers, manipulate strings, ring bells, or print messages on the console. Usually, the interrupt system found on microprocessors is used to control a computer peripheral device or to monitor and control external machinery.

The interrupt system can continuously watch the temperature of a furnace, the condition of a fire or burglar alarm, or the time of day. When something unusual happens, when the temperature goes too high or a burglar alarm sounds, the interrupt system alerts the computer to respond to the unusual condition and perform necessary actions.

However, the writing of such a program is a demanding task. The programmer must be aware of five aspects of interrupts that involve both the hardware and software of the system.

Necessary Conditions

1. *There must be an external device capable of sending an interrupt signal to the computer.*

The smaller systems used by novice BASIC programmers usually do not contain devices capable of generating interrupts. Even if they did, the BASIC language system available is not able to handle them directly, because most versions of BASIC do not recognize that interrupts exist.

The external device that sends the interrupt can be anything external to the processor and memory; it does not have to be physically located outside the computer box itself. Some common devices used as sources of interrupts are real-time clocks, terminals, and other computers. This list is not exhaustive. *Anything* capable of generating an electrical signal—automobile, household appliance, or burglar alarm—can be used as a source of interrupts.

2. *The processor must be capable of receiving and acting upon the interrupt signal.*

This implies not only that the signal must be wired into the computer with all its voltages having the correct values, but also that the processor must be set up to respond to the signal. We shall see later that the 6502 microprocessor can actually ignore some kinds of interrupts if the programmer has told it to ignore them.

Anything capable of generating an electrical signal—automobile, household appliance, or burglar alarm—can be used as a source of interrupts.

3. *The processor must be able to tell which of several possible devices generated the interrupt.*

If there is only one interrupt-generating device wired into the system, there won't be any problem identifying the source of the interrupt when it arrives. But if there are several interrupt sources—all trying to get the attention of the processor—the computer must have some way of telling which interrupt source is responsible for sending the signal, so it can take appropriate action.

4. *The processor must respond to the interrupt by doing something.*

When an interrupt signal arrives and is accepted by the computer, the program must perform an appropriate action (ie: "service" the interrupt). In some cases, this action is very simple, such as printing a character on a terminal. In other cases, the system may have to do something much more complicated, like placing a telephone call, sounding an alarm, or aborting the program it was executing.

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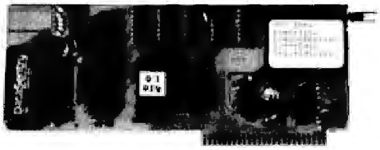

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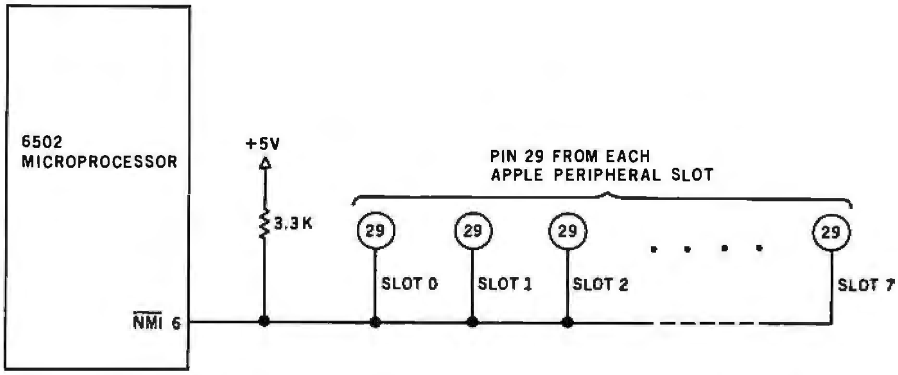

Figure 1: *The 6502 $\overline{NMI}$ signal and the Apple II peripheral slots. The $\overline{NMI}$ signal is connected to pin 29 of each of the slots and is held high by the pull-up resistor shown. An interrupt is generated if the peripheral card in any of the slots presents a low impedance to ground to its pin 29.*

5. *After the service has been performed, the processor usually must return to the interrupted program and continue from the point of interruption.*

When an interrupt signal arrives and is accepted by the computer, the program must perform an appropriate action.

Usually (but not always), the interrupt has interfered with the execution of a program. After the interrupt has been successfully serviced, control should return to the interrupted program or process at the point of interruption without modifying the process in any way. Sometimes this program is nothing other than an endless loop waiting for interrupts to arrive.

Nonmaskable Interrupts

The Apple II has two separate interrupt lines entering its 6502 processor. They work somewhat differently.

Pin number 6 on the 6502 package is an active-low signal input called the *nonmaskable interrupt*, $\overline{NMI}$. It is connected through the printed-circuit board to a pull-up resistor and to pin 29 in each of the eight I/O slots shown in figure 1.

If none of the circuit cards in the slots has anything attached to its pin 29, the potential at the $\overline{NMI}$ input observed by the 6502 is always held high by the pull-up resistor. This is the normal mode of operation. If a low impedance to ground is presented to pin 29 by *any* of the slots, the $\overline{NMI}$ line goes low, causing an interrupt condition to be generated in the 6502. This is the definition of the nonmaskable interrupt. This interrupt can be better understood by examining each of the five aspects presented earlier.

1. Any external device can generate an interrupt by presenting a ground (or low impedance to ground) potential to pin 29 in any of the I/O slots. Thus, the Apple II can have eight different interrupt sources, and they all may decide to interrupt at once.

2. The $\overline{NMI}$ signal is always recognized by the 6502 microprocessor, because it is nonmaskable. (Maskable interrupts will be discussed shortly.)

3. If there is only one device capable of sending the $\overline{NMI}$ signal, there is no question which device sent it. But if there are two or more interrupting devices, a problem arises. The 6502 microprocessor has only a single $\overline{NMI}$ input line, and every $\overline{NMI}$ signal goes there. In the Apple II, the processor can differentiate among several possible sources by *polling* the devices.

Polling is done by asking each device if it sent the interrupt signal or not. A program directs the computer

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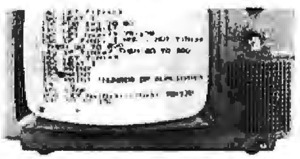

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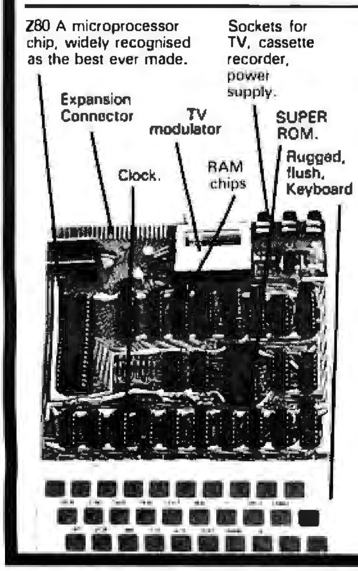

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to examine the status of each device which might have sent the interrupt. The details of this depend greatly on the way the devices are wired up, but in principle some of the 50 lines in the I/O slots can be used by the device to present logical flags or form data buffers. Examination of these signal lines by the program can then determine whether the device in question sent the $\overline{\text{NMI}}$ or not.

Daisy-chain inhibition of interrupts can be provided for in hardware by using control lines INT IN (pin 28) and INT OUT (pin 23) on the I/O slots, which are reserved for such a purpose. Various I/O devices can thereby have different priorities for interrupt servicing.

The Apple II's motherboard contains the wiring that links the boards together. This arrangement is shown in figure 2. Pin 28 (the INT IN line) of slot 0 has no connection, but pin 23 (INT OUT) of slot 0 connects to pin 28 of slot 1. Pin 23 of slot 1 connects to pin 28 of slot 2, and so on, up to slot 7. Pin 23 of slot 7 has no connection.

There are several methods for wiring the daisy chain, but in the most common configuration there is a low impedance (or a direct connection) on each interrupt-using card between INT IN and INT OUT. I/O cards have priority in interrupt service according to their physical position in the I/O slots. Cards in the lower-numbered slots have higher priority, while cards in the higher-numbered slots have lower priority: it is not that the processor will process the I/O functions of the higher-priority cards before dealing with lower-priority cards if interrupts occur at the same time, but that the lower-priority cards are *not permitted* to generate an interrupt signal until the higher-priority device allows it.

In this scheme, *I/O slots must be contiguously filled with cards so a continuous circuit, the daisy chain, is completed between the cards on the INT IN and INT OUT lines.* I/O cards that do not use the interrupt system can be placed between cards that do if the noninterrupting cards have a jumper or connection between the contacts for pins 28 and 23 to maintain circuit continuity.

The highest-priority I/O card must reside in a lower-numbered slot than any other interrupt-generating card. The highest-priority card is special: it is responsible for placing a voltage indicating a high logic condition (usually +5 V) on the INT OUT pin for its slot. The lower-priority cards need not have this capability. They need only have the capability of opening the circuit between the INT IN and INT OUT pins for their slots.

Suppose, for example, that there are interrupt-generating I/O interface cards in slots 5, 6, and 7. The card in slot 5 must be capable of placing a potential of +5 V on the INT OUT connection. The card in slot 6 must

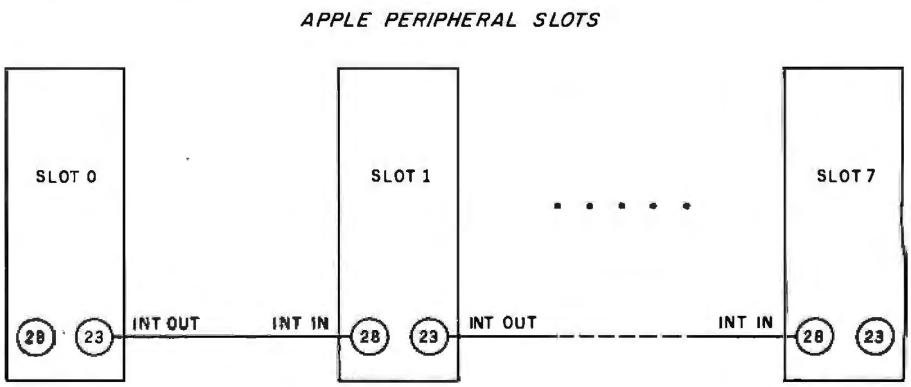

Figure 2: *Using daisy chaining to create a priority system of interrupts. The INT OUT (pin 23 of each slot) and INT IN (pin 28 of each slot) signals are connected to each other to create a daisy chain that is broken by an interrupting slot. A peripheral device is not allowed to generate an interrupt unless it has highest priority or "permission" from higher-priority devices. Peripherals in lower slots have a higher interrupt priority than peripherals in higher slots. See the text for details.*

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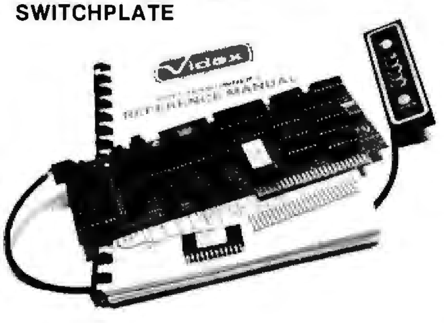

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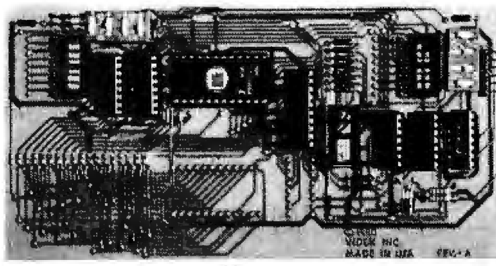

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have a low impedance from INT IN to INT OUT as a normal condition (so the card in slot 7 will be able to "see" the +5 V provided by the card in slot 5), and the cards in both 6 and 7 must be able to detect the absence of the +5 V potential on the INT IN line. The controlling circuitry of the slot-6 and slot-7 cards must recognize the absence of the INT IN high logic level and interpret it as denoting a condition in which the lower-priority cards are not permitted to generate an interrupt.

When the slot-5 device needs to interrupt the processor, it causes a low logic level to be placed on the $\overline{\text{NMI}}$ line, pin 29, as previously described. At the same time, it removes the high logic level from the INT OUT line, pin 23. The slot-6 and slot-7 devices sense the low level on their INT IN pins, and they refrain from issuing an interrupt signal as long as this condition persists.

Meanwhile, the polling software in the processor polls the slot-5 card, as it has been set up to do first; the software polls the I/O cards in order of priority. Finding the slot-5 card needing attention, the software branches to the appropriate interrupt-servicing routine.

When the interrupt routine for the slot-5 device has finished its business, the interrupt condition is cleared, and control returns to the interrupted processing. At this point, the slot-5 card restores the +5 V potential to the INT OUT line, and the slot-6 and slot-7 cards can issue interrupts as necessary.

If the slot-6 card needs to issue an interrupt (and +5 V is present on its INT IN pin), it activates the $\overline{\text{NMI}}$ line in the same way. But because it is not the source of the +5 V on the INT IN/INT OUT path, it merely activates logic to create a high impedance between the INT IN and INT OUT pins for its own slot, thereby preventing the slot-7 device from seeing the +5 V INT IN level. In this way, the slot-6 card asserts its higher interrupt priority over the slot-7 card. When the slot-6 interrupt has been serviced by the processor, the low impedance is restored between the INT IN and INT OUT pins of slot 6, and the +5 V potential propagates once more along the motherboard traces to slot 7.

4. When an interrupt arrives at the 6502, the microprocessor responds by performing the following operations on its stack:

Push program-counter high byte
Push program-counter low byte
Push status register
Jump via hexadecimal FFFA

Thus, the PC (program counter) and the status register are pushed (saved) onto the stack (the high byte of the PC is pushed first, then the lower byte, and, finally, the status register, P). After these stacking operations, the processor executes an indirect jump via hexadecimal memory location FFFA (ie: the location jumped to is the contents of FFFB (high byte) and FFFA (low byte) considered as a 16-bit number). In the Apple II computer, this is a ROM address, and Apple Computer Inc has set its contents to hexadecimal 03FB (remember that the lower byte contains the low-order address). Therefore, the system jumps to hexadecimal location 03FB and starts executing what it finds there. This area contains programmable memory, and it is the user's responsibility to start the interrupt-service routine there. Unfortunately, this area is organized so there are only 3 bytes of memory actually available here. Because of this, the user must store a jump instruction in these 3 bytes that will direct execution to another area of memory, typically to the page beginning at hexadecimal location 0300 or to some higher area such as hexadecimal 0800 or 1000.

Generally, the first instructions in the interrupt-service routine are those to save the present value of the A, X, and Y registers on the stack. After that, the interrupt service is performed, and the A, X, and Y registers are restored. The routine should always be terminated with an RTI (return from interrupt) instruction. This instruction will unstack the status registers and program counter, and execution will continue from the point it had reached just before the occurrence of the interrupt. The inter-

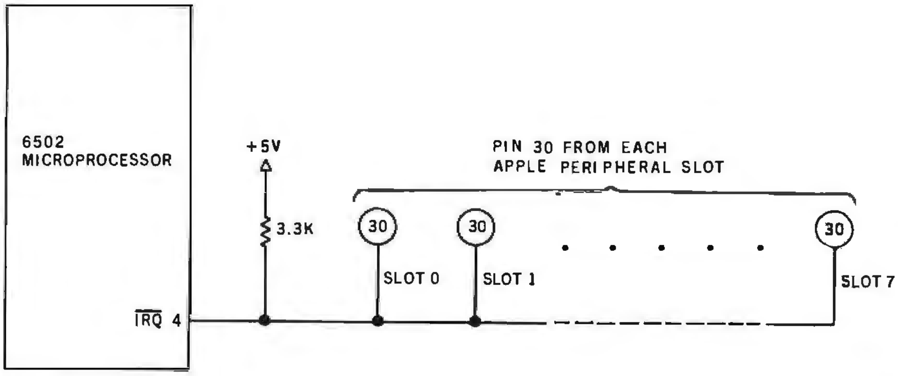

Figure 3: *The 6502 $\overline{IRQ}$ signal and the Apple II peripheral slots. The $\overline{IRQ}$ signal is connected to pin 30 of each of the slots and is held high by the pull-up resistor shown. A maskable interrupt is generated if the peripheral card in any of the slots presents a low impedance to ground to its pin 30.*

rupt-service routine itself must be written very carefully. It must, of course, perform whatever service you wish it to—such as printing a message on the console, ringing a bell, dialing a telephone, or turning on the furnace. But while it is doing these things, the service routine must not disturb any code used by the other routines stored in memory. The stacks should be in exactly the same state upon exit as they were when the service routine began.

5. The RTI instruction at the end of the service routine unstacks the status registers and program counter. This ensures that execution will continue from the point reached just before the arrival of the interrupt. Functionally, it is equivalent to:

Pop status register
Pop program-counter low byte
Pop program-counter high byte
Execute next instruction

Maskable Interrupts

Pin number 4 on the 6502 chip is an input signal called the interrupt request, $\overline{IRQ}$. This is a *maskable* interrupt. In the Apple II, $\overline{IRQ}$ is connected through the printed-circuit board to a pull-up resistor and to each of the eight I/O slots, as shown in figure 3.

This is the same scheme used for the $\overline{NMI}$ except that the interrupt request will not be accepted if the interrupt-disable bit, I, in the status register, P, is set (ie: contains a 1). As before, this interrupt scheme can be better understood by considering the five aspects of interrupts.

1. Any external device can generate an interrupt request by driving pin 30 on any I/O slot to ground potential. Once again, the Apple II can have eight different interrupt sources, and they all may decide to fire at the same time.

2. The 6502 microprocessor will respond to this request only if the interrupt-disable bit, I, in the status register, P, is cleared (ie: bit I must be a 0). This is done by executing a CLI (clear interrupt-disable bit) instruction any time before the arrival of the interrupt request. However, the 6502 will completely ignore the request if bit I has been set by executing an SEI (set interrupt-disable bit) instruction before the arrival of the interrupt.

3. Once again, the microprocessor is unable to determine the source of the interrupt. If there is only one device capable of sending an $\overline{IRQ}$ signal, there is no problem. If more than one device can do this, the same factors apply that were discussed earlier in the section on the nonmaskable interrupt, and polling can be used to determine which device caused the $\overline{IRQ}$.

4. If bit I has been cleared and the $\overline{IRQ}$ signal arrives at the 6502, the following actions occur:

Push program-counter high byte
Push program-counter low byte
Push status register
Jump via hexadecimal FFFE

Text continued on page 294

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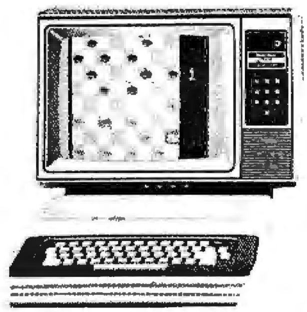

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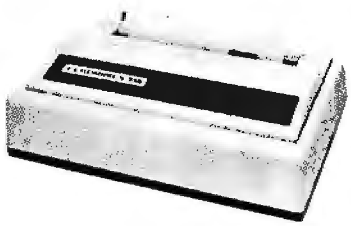

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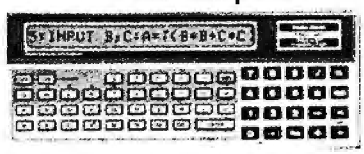

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Listing 1: *Assembly-language routines to test maskable and nonmaskable interrupts. Routines RNMI and RIRQ print the messages "NMI" and "IRQ", respectively, 255 times when the appropriate interrupt is generated. The short routines at hexadecimal 352 (decimal 850) and hexadecimal 354 (decimal 852) are meant to be called from BASIC to enable and disable, respectively, the maskable interrupt. See the text for details on generating the interrupts necessary to test these routines.*

```
                          *TEST OF INTERRUPT SYSTEM
                                .OR    $3FB
03FB-   4C  00 03               JMP    RNMI
03FE-   21  03                  .DA    RIRQ
                                .OR    $300
                          ************************************************
                          *                                              *
                          ***********  ROUTINE   FOR   NMI  ***********
                          *                                              *
                          ************************************************
0300-   48                RNMI  PHA              SAVE REGISTERS
0301-   8A                      TXA
0302-   48                      PHA
0303-   98                      TYA
0304-   48                      PHA
0305-   A2  FF                  LDX    #$FF
0307-   A9  CE            L1    LDA    #$CE      PRINT "N"
0309-   20  ED FD               JSR    $FDED
030C-   A9  CD                  LDA    #$CD      PRINT "M"
030E-   20  ED FD               JSR    $FDED
0311-   A9  C9                  LDA    #$C9      PRINT "I"
0313-   20  ED FD               JSR    $FDED
0316-   CA                      DEX
0317-   E0  00                  CPX    #0
0319-   D0  EC                  BNE    L1
031B-   68                      PLA              RESTORE REGISTERS
031C-   A8                      TAY
031D-   68                      PLA
031E-   AA                      TAX
031F-   68                      PLA
0320-   40                      RTI              GO BACK
                          ************************************************
                          *                                              *
                          ***********  ROUTINE   FOR   IRQ  ***********
                          *                                              *
                          ************************************************
0321-   48                RIRQ  PHA              SAVE REGISTERS
0322-   8A                      TXA
0323-   48                      PHA
0324-   98                      TYA
0325-   48                      PHA
0326-   A2  FF                  LDX    #$FF
0328-   A9  C9            L2    LDA    #$C9      PRINT "I"
032A-   20  ED FD               JSR    $FDED
032D-   A9  D2                  LDA    #$D2      PRINT "R"
032F-   20  ED FD               JSR    $FDED
0332-   A9  D1                  LDA    #$D1      PRINT "Q"
0334-   20  ED FD               JSR    $FDED
0337-   CA                      DEX
0338-   E0  00                  CPX    #0
033A-   D0  EC                  BNE    L2
033C-   68                      PLA              RESTORE REGISTERS
033D-   A8                      TAY
033E-   68                      PLA
033F-   AA                      TAX
0340-   68                      PLA
0341-   40                      RTI              GO BACK
                          ************************************************
                          *                                              *
                          **********  ROUTINES   FOR   BASIC  **********
                          *                                              *
                          ************************************************
                                .OR    850
0352-   58                      CLI              ENABLE INTERRUPTS
0353-   60                      RTS
0354-   78                      SEI              DISABLE INTERRUPTS
0355-   60                      RTS
                                .EN

SYMBOL TABLE

RNMI   0300    L1    0307    RIRQ    0321
L 2    0328
```

Circle 15 on inquiry card. →

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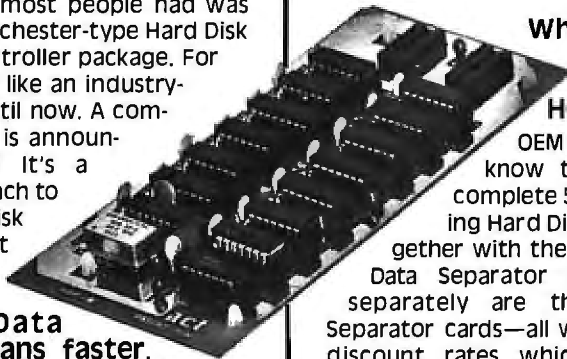

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Text continued from page 290:

As before, the program counter and the status register are placed on the stack, and the processor executes an indirect jump via hexadecimal location FFFE. This is again a ROM area in the Apple II and has been set by Apple Computer Inc to the value hexadecimal FA86 (or FA40 in the autostart version), which is an address in ROM. Thus, the processor starts executing at location FA86 (or FA40), where it finds the following instructions (a "$" indicates a hexadecimal address):

```
STA $45
PLA
PHA
ASL A
ASL A
ASL A
BMI $FA92 or BMI $FA4C
JMP ($03FE)
```

This section of code stores the accumulator at hexadecimal location 45 in page zero and checks to see if the fourth bit in the status register, the "break" bit B, is high or not. An interrupt request, $\overline{\text{IRQ}}$, always forces this bit low, so the BMI instruction never succeeds and finally the indirect jump, JMP ($03FE), is encountered. The hexadecimal address 03FE is in programmable memory, and the writer of the service routine must place the address of the routine here. Note that this is somewhat different from the way in which the $\overline{\text{NMI}}$ request is routed. For the $\overline{\text{IRQ}}$ interrupts, the *address* of the service routine rather than a jump instruction including an address must be stored in the 2 bytes, hexadecimal 03FE and 03FF. Also, remember that the lower byte of the 2-byte address must be stored first.

As before, the registers are usually stacked first, although this time the accumulator can be left alone, since it has already been stored at hexadecimal location 45 by the program in ROM. Then the interrupt service is performed, the registers are restored, and, finally, an RTI is executed.

5. The processor returns to its original program after it encounters the RTI. As before, this instruction will:

Pop status register
Pop program-counter low byte
Pop program-counter high byte
Execute next instruction

In principle, any program in any language can be interrupted by an external signal, and the interrupts can be serviced using the techniques described above. In microprocessor systems such as the Apple II, the interrupted program is usually a BASIC program, and the interrupt-service routines are usually written in assembly language. An example of such a service routine is shown in listing 1. It is assumed that there is only one device capable of generating an interrupt, that the service to be performed consists only of writing a message to the console, and that interrupts will not interrupt themselves.

To test this routine, a BASIC program should be written and executed. When you wish to enable the $\overline{\text{IRQ}}$ signal from your BASIC program, it is only necessary to execute:

```
CALL 850
```

and when you wish to disable the $\overline{\text{IRQ}}$, all you have to do is:

```
CALL 852
```

If you do not have any device in your I/O slots capable of generating an interrupt request, you can easily make one by bending a resistor with a pair of long leads so that the leads are about one-half inch apart. A 100-ohm resistor works well. Then *very carefully* connect pin 29 (for the $\overline{\text{NMI}}$) or pin 30 (for the $\overline{\text{IRQ}}$) through the resistor to the ground pin (pin 26) on any of the I/O slots. This technique is crude but effective, and will generate the interrupt request whenever you wish. The $\overline{\text{NMI}}$ signal will always set the interrupt system in motion, but the $\overline{\text{IRQ}}$ signal will be accepted only if you have executed the BASIC instruction CALL 850.

Once you have mastered the fundamentals of interrupt handling, the number of interrupts that can be serviced and the complexity of the service are limited only by the speed of the interrupting devices and ingenuity of the servicing programs. ■

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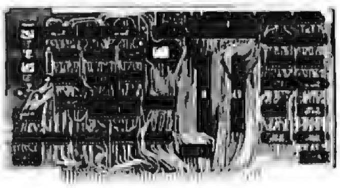

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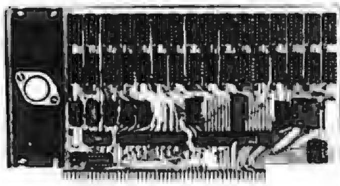

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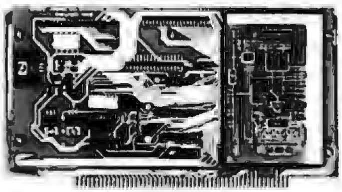

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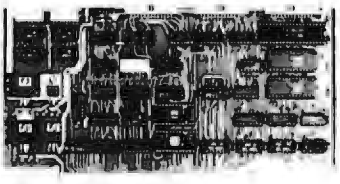

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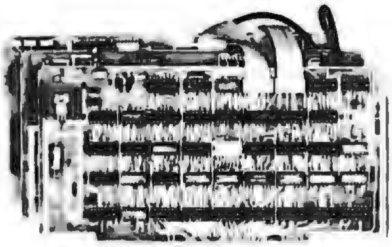

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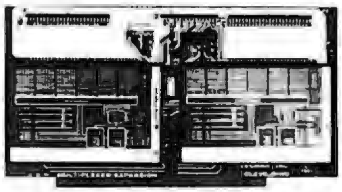

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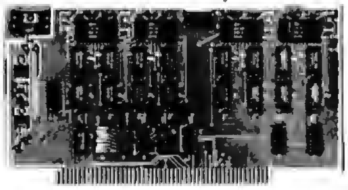

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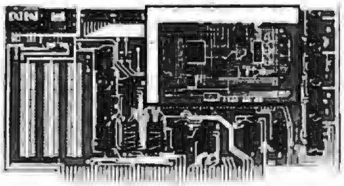

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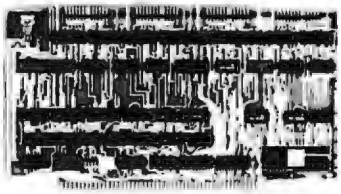

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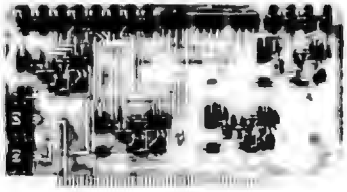

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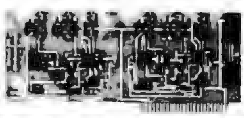

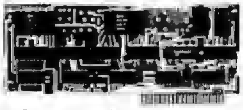

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Digital Plotting with the Apple II Computer

Dr Richard C Hallgren
Department of Biomechanics
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The first attempts to use personal computers in the research laboratory have met with considerable success. Not only are these machines functioning as computational tools, they are also being used with custom interface circuits to digitize analog signals and to process data using routines such as the fast Fourier transform (see "Fast Fourier Transforms on Your Home Computer" by W D Stanley and S J Peterson, on page 14 of the December 1978 BYTE).

In dealing with complex, time-dependent waveforms and their spectrums, it is desirable to display the data as a function of either time or frequency. Plotting is possible with a data terminal such as the DECwriter II, but such methods are lacking when high-resolution plotting is required. The Hiplot digital plotter, manufactured by Houston Instrument, gives the small-system user a cost-effective means of obtaining high-quality digital plots. The plotter uses an 8½- by 11-inch sheet of paper and allows plotting within a 7- by 10-inch boundary. Reversible stepper motors are used to give bidirectional steps of either 200 or 100 steps per inch, amounting to a resolution of 0.005 or 0.01 inches per step. An RS-232C serial interface is a standard feature, which makes connecting the plotter to a computer an easy task.

The Hiplot accepts data in an RS-232C format consisting of 1 start bit, 8 data bits, and 2 stop bits. Since the computer manipulates 8 bits of

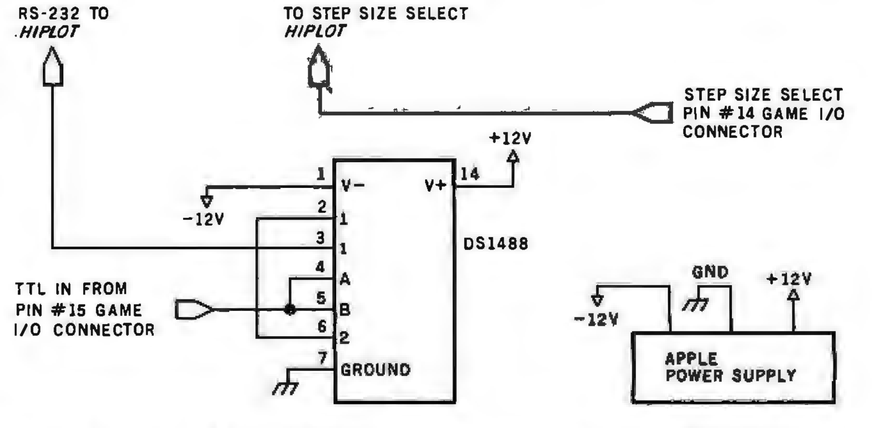

Figure 1: *Schematic of Apple II TTL (transistor-transistor logic) to RS-232C interface utilizing only one line-driver integrated circuit, a DS1488.*

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Listing 1: *6502 machine-language routine to perform functions of a UART (universal asynchronous receiver/transmitter) for transmitting RS-232C serial data through the hardware modification.*

```
8000-   A0 09      LDY   #$09    9 bits (1 start, 8 data)
8002-   18         CLC
8003-   48         PHA           Save data byte
8004-   B0 05      BCS   $800B
8006-   AD 59 C0   LDA   $C059   Output a space
8009-   90 03      BCC   $800E
800B-   AD 58 C0   LDA   $C058   Output a mark
800E-   A9 03      LDA   #$03
8010-   48         PHA
8011-   A9 04      LDA   #$04
8013-   4A         LSR
8014-   90 FD      BCC   $8013                       Delay 1 bit time
8016-   68         PLA
8017-   E9 01      SBC   #$01
8019-   D0 F5      BNE   $8010
801B-   68         PLA           Get data byte
801C-   6A         ROR           Rotate into carry bit
801D-   88         DEY           Decrement bit count
801E-   D0 E3      BNE   $8003   Jump if more data
8020-   A0 02      LDY   #$02    2 stop bits
8022-   AD 38 C0   LDA   $C058   Output a mark
8025-   A9 03      LDA   #$03
8027-   48         PHA
8028-   A9 04      LDA   #$04
802A-   4A         LSR
802B-   90 FD      BCC   $802A                       Delay 1 bit time
802D-   68         PLA
802E-   E9 01      SBC   #$01
8030-   D0 F5      BNE   $8027
8032-   88         DEY           Decrement bit count
8033-   D0 ED      BNE   $8022   Jump if more stop bits
8035-   60         RTS
```

parallel data at a time, we need a method to convert the parallel data to serial data. I decided to implement this conversion in software, instead of using a UART (universal asynchronous receiver/transmitter) to keep the system simple. The only things required are the software routine and a line driver to shift the TTL (transistor-transistor logic) voltage-level output from the Apple II to RS-232C levels for the Hiplot. A DS1488 quad line driver integrated circuit (see figure 1) is mounted on an Apple Hobby/Prototyping board and inserted into expansion slot 6 on the Apple motherboard. The Apple writes data to the line driver by toggling the latch circuit connected to the Apple game-I/O port. Accessing hexadecimal address C059 ("LDA $C059" in listing 1) causes a 1 to be transmitted. Accessing hexadecimal address C058 ("LDA $C058" in listing 1) causes a 0 to be transmitted. (In RS-232C communications, any voltage between +5 V and +15 V is called a *space* and represents a "high" signal or a digital 0; any voltage between −5 V and −15 V is called a *mark* and represents a "low" signal or a digital 1.)

Figure 2 on page 300 shows the flowchart for the software routine that replaces the UART; listing 1 (above) shows the program with comments. To reduce the plotting time to a minimum, I decided to operate the Hiplot at its maximum data rate of 9600 bps (bits per second). Executing the output routine loads the Y register with a count of nine and clears the carry bit. The routine then writes a mark (a digital 1 or a *low* signal) if the carry bit is cleared, or a space (the opposite of mark) if the carry bit is set, and loops for a time period equal to the time spacing between bits. The routine then shifts the data so the most significant bit goes into the carry bit and checks to see if all the data bits have been sent. If not, it loops to process the next bit. Otherwise, it transmits 2 stop bits and returns to the calling program.

Getting to the point where data can be transferred from the Apple to the Hiplot is only the first part of using the plotter. Since the plotter comes with no software, it is necessary to write routines which will generate axis systems and, if desired, alphanumeric characters.

Text continued on page 314

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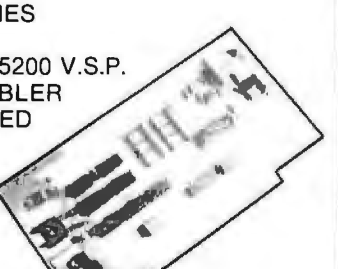

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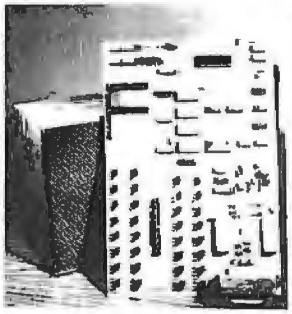
Chip with Data Sheet **$69.00**

$329.

"CONTROL TALKER II"



- ★ 110V 50/60 HZ
- ★ 32 INPUT LINES (TTL)
- ★ 32 10 AMP (50V) OUTPUT LINES
- ★ Z80 BASED SYSTEM
- ★ 8K PROM (SOCKET)
- ★ 1K RAM
- ★ VOICE OUTPUT
- ★ SINGLE BOARD
- ★ STEPPING MOTOR CONTROL (UP TO 8)

Control Talker II can be used to control stepping motors, relays, counters, etc., and support a variety of uses including robotics, telephone dialer, digital access, security, auto drilling, measuring, counting and virtually unlimited applications with added speech output to advise of status etc. Put one to work for you today!

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(Regularly) $808.00)

CALIFORNIA COMPUTER SYSTEMS

Order Number	Our Price
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2032B 32K Static MEM-300NS	640 00
2032C 32K Static MEM-200NS	649 00
2065C 64K Dynamic MEM-200NS	569.00
2116A 16K Static MEM-450NS	257.00
2116B 16K Static MEM-300NS	261.00
2116C 16K Static MEM-200NS	290.00
2116X 16K BD only	67 00
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7470A A/D Converter	97.00
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7712A Serial Synch Bd.	152.00
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7720B Centronic Parallel Interface	99.00
7811B Arithmetic Processor with Diskette	329.00
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VOLTAGE REGULATORS

Part#	Case	Price
78L05	TO92	45
78L12	TO92	.45
78L15	TO92	45
79L05	TO92	65
79L12	TO92	65
79L15	TO92	.65
7805P	TO220	1.20
7812P	TO220	1.20
7815P	TO220	1 20
7905P	TO220	1.25
7912P	TO220	1.25
7915P	TO220	1.25
7805K	TO3	1.50
7812K	TO3	1.50
7815K	TO3	1.50
7905K	TO3	1.60
7912K	TO3	1.60
7915K	TO3	1.60
309H	TO39	95
309K	TO3	1.25
317P	TO220	1.95
317K	TO3	2.95
323K	TO3	5.50
337P	TO220	2.40
337K	TO3	3.80
350K	TO3	5.75

CRYSTALS
(Part# includes frequency in MHZ)

Part#	Price
SY1	5.75
SY1.8432	5.75
SY2	5.75
SY2.4576	5.75
SY3.579	5.75
SY4	4.50
SY5.068	4.50
SY6	4.50
SY6.144	4.50
SY8	4.50
SY10	4.50
SY12	4.50
SY14.31818	4.50
SY15	4.50
SY18	4.50
SY18.432	4.50

CERAMIC DISC CAPACITORS 50V

Value	1 +	25 +	100+
4.7pf	.07	06	04
10pf	.07	.06	.04
22pf	.07	.06	04
33pf	.07	06	04
39pf	07	06	04
47pf	07	.06	04
68pf	.07	.06	.04
100pf	.07	.06	.04
150pf	.07	.06	.04
220pf	.07	.06	04
270pf	07	.06	.04
330pf	07	.06	.04
470pf	07	.06	.04
.001mf	07	06	.04
.0022mf	07	06	.04
.0033mf	.07	.06	.04
.0047mf	.07	06	.04
.01mf	.07	.06	.04
.022mf	.10	.08	.06
.033mf	.10	.08	.06
.047mf	11	.09	.07
.1mf	.14	.12	.10

DIODES
Switching

1N914	12/$1.00
1N4148	12/$1.00

SOCKETS

LOW-PROFILE SOLDER TIN

Part#	1 +	25 +	100+
S8LT	.15	11	08
S14LT	.18	16	14
S16LT	.21	.18	.16
S18LT	26	22	18
S20LT	.31	.26	.20
S22LT	33	.28	.22
S24LT	.35	.29	24
S28LT	.41	.34	.28
S40LT	.53	.47	40

WIRE-WRAP SOLDER TIN

Part#	1 +	25 +	100+
S8WT	.37	33	.30
S14WT	48	43	.39
S16WT	.53	.48	.43
S18WT	61	.55	.50
S20WT	.85	.77	69
S22WT	.89	.80	.72
S24WT	.96	.86	.77
S28WT	1.22	1 11	99
S40WT	1.75	1.57	1 40

WIRE-WRAP GOLD

Part#	1 +	25 +	100 +
S8WG	54	49	44
S14WG	.77	69	.62
S16WG	83	75	.68
S18WG	1.00	.90	.81
S20WG	1.24	1 11	.99
S22WG	1 35	1.22	1.10
S24WG	1.40	1.26	1.13
S28WG	1.78	1.60	1.44
S40WG	2.25	2.03	1 83

SOLID DIPPED TANTALUM CAPACITORS 20%

Value	Volts	1 +	25 +	100+
.1mf	35v	.35	.30	.26
.15mf	35v	.35	.30	.26
.22mf	25v	.35	.30	.26
.33mf	35v	.35	.30	.26
.47mf	35v	.35	30	.26
.68mf	35v	.35	30	26
1mf	35v	.35	.30	.26
1.5mf	35v	.45	.39	.33
2.2mf	35v	.45	.39	.33
3.3mf	35v	.50	.42	.36
4.7mf	25v	50	42	.36
4.7mf	35v	.65	.56	.44
6.8mf	35v	.65	.56	.44
10mf	25v	.85	.72	.61
10mf	35v	1.19	1.00	.84
15mf	25v	1.30	1.09	.92
22mf	25v	1.30	1.09	.92
33mf	25v	1.35	1.12	.95
47mf	25v	1.55	1.29	1.05
100mf	6v	2.95	2.48	2 08

¼ WT & ½ WT CARBON FILM 5% RESISTORS

10	100	1K	10K	100K	1M
11	110	1.1K	11K	110K	1.1M
12	120	1.2K	12K	120K	1.2M
13	130	1.3K	13K	130K	1.3M
15	150	1.5K	15K	150K	1.5M
16	160	1.6K	16K	160K	1.6M
18	180	1.8K	18K	180K	1.8M
20	200	2K	20K	200K	2M
22	220	2.2K	22K	220K	2.2M
24	240	2.4K	24K	240K	2.4M
27	270	2.7K	27K	270K	2.7M
30	300	3K	30K	300K	3M
33	330	3.3K	33K	330K	3.3M
36	360	3.6K	36K	360K	3.6M
39	390	3.9K	39K	390K	3.9M
43	430	4.3K	43K	430K	4.3M
47	470	4.7K	47K	470K	4.7M
51	510	5.1K	51K	510K	5.1M
56	560	5.6K	56K	560K	5.6M
62	620	6.2K	62K	620K	
68	680	6.8K	68K	680K	
75	750	7.5K	75K	750K	
82	820	8.2K	82K	820K	
91	910	9.1K	91K	910K	

MINIMUM ORDER PER TYPE:
5 pcs—any qty 5 pack @ $.25

MINIMUM ORDER PER TYPE:
100 pcs
Price Per 100 Pk:

QTY	¼ WT	½ WT
100 up	$1.70	$1.80
1,000 up	1.50	1.60
5,000 up	1.30	1.40
10,000 up	1.10	1.20

ZENER DIODES
½ WT

Part#	Price
1N5231B	.20
1N5239B	.20
1N5242B	.20
1N5245B	20
1N5248B	.20
1N5250B	.20
1N5252B	.20
1N5255B	.20

1 WT

Part#	Price
1N4733A	.30
1N4739A	.30
1N4742A	.30
1N4744A	.30
1N4746A	.30
1N4747A	.30
1N4749A	.30

POLYESTER CAPACITORS + & – 10% TOLERANCE 50V

Value	1 +	25+	100+
.001mf	.13	.11	.08
.0012mf	.13	.11	.08
.0015mf	.13	.11	.08
.0018mf	.13	.11	.08
.0022mf	.13	.11	.08
.0027mf	.13	.11	.08
.0033mf	.13	.11	.08
.0039mf	.13	.11	.08
.0047mf	.13	.11	.06
.0056mf	.13	.11	.08
.0068mf	.13	.11	.08
.0082mf	.13	.11	.08
.01mf	.13	.11	.08
.012mf	.13	.11	.08
.015mf	.13	.11	.08
.018mf	.14	.12	.09
.022mf	.14	.12	.09
.027mf	.14	.12	.09
.033mf	.14	.12	.09
.039mf	.15	.13	.10
.047mf	.15	.13	.10
.056mf	.16	.13	.10
.068mf	.17	.14	.11
.082mf	.17	.14	.11
.1mf	.18	.15	.12
.12mf	.20	.17	.14
.15mf	.22	.18	.15
.18mf	.24	.20	.16
.22mf	.26	.22	.17
.27mf	.30	.25	.20
.33mf	.33	.28	.23
.39mf	.37	.31	.25
.47mf	.40	.34	.30

TRANSISTORS

2N2219A	$ .35
2N2222A	.25
2N2905A	.30
2N2907A	.25
2N2369A	.25
2N3904	.20
2N3906	.20
PN2222A	.19
PN2907A	.19

RECTIFIERS (1A)

		100+
1N4001	12/1.00	.07
1N4002	12/1.00	.07
1N4003	12/1.00	.07
1N4004	12/1.00	.07
1N4005	10/1.00	.08
1N4006	10/1.00	.08
1N4007	10/1.00	.08

74 LS

Part #	Price	Part #	Price
74LS00	.32	74LS152	79
74LS01	.32	74LS153	.79
74LS02	.32	74LS154	2.05
74LS03	.32	74LS157	1.15
74LS04	.32	74LS158	1.15
74LS05	.32	74LS160	.65
74LS08	.32	74LS161	.85
74LS09	.35	74LS162	.85
74LS10	.36	74LS163	.95
74LS11	36	74LS164	1.10
74LS12	.39	74LS165	1.10
74LS13	.32	74LS166	2.55
74LS14	.65	74LS170	1.90
74LS15	.35	74LS173	1.35
74LS20	.32	74LS174	1.25
74LS21	.36	74LS175	95
74LS22	.36	74LS181	2.35
74LS26	.35	74LS190	1.15
74LS27	.39	74LS191	1.15
74LS28	.37	74LS192	1.15
74LS30	.36	74LS193	1.15
74LS32	.40	74LS194	1.15
74LS37	.38	74LS195	1.15
74LS38	.39	74LS196	.99
74LS40	.38	74LS197	99
74LS42	.95	74LS221	.95
74LS47	1.15	74LS240	1.05
74LS48	1.15	74LS241	1.05
74LS51	.32	74LS242	1.45
74LS54	.38	74LS243	1.45
74LS55	.34	74LS244	1.05
74LS73	.49	74LS245	2.15
74LS74	.49	74LS251	1.29
74LS75	.63	74LS253	.99
74LS76	.55	74LS255	.99
74LS83	.95	74LS257	1.15
74LS85	1.25	74LS258	1.15
74LS86	.55	74LS260	.95
74LS90	.79	74LS261	2.49
74LS92	.75	74LS266	.65
74LS93	.75	74LS273	1.65
74LS95	.99	74LS283	1.05
74LS107	.50	74LS365	.85
74LS109	.50	74LS366	.65
74LS112	.52	74LS367	.65
74LS113	.52	74LS368	.65
74LS114	.52	74LS373	1.65
74LS123	1.05	74LS374	1.45
74LS125	.70	74LS375	.99
74LS126	.70	74LS377	1.15
74LS132	.95	74LS386	.59
74LS136	.53	74LS390	1.75
74LS138	.85	74LS393	1.75
74LS139	.85	81LS95	1.35
74LS148	1.75	81LS96	1.35
74LS151	.79	81LS97	1.35
		81LS98	1.35

4000 CMOS B SERIES ONLY

Part #	Price
4000	.35
4001	.35
4002	.35
4006	1.05
4007	.35
4008	1.15
4009	45
4010	45
4011	.35
4012	.35
4013	.50
4014	65
4015	.75
4016	.55
4017	1.05
4018	.95
4019	55
4020	1.10
4021	1.10
4022	.75
4023	35
4024	.65
4025	.35
4026	1.45
4027	50
4028	.75
4029	1.15
4030	.50
4034	2.55
4035	99
4040	1.15
4041	1 15
4042	1.05
4043	.95
4044	.95
4046	1.15
4047	1.35
4048	.99
4049	.50
4050	.50
4051	1.10
4052	1.10
4053	.65
4060	1.39
4066	39
4068	.35
4069	.35
4070	.39
4071	.39
4072	.39
4073	.39
4075	.39
4076	1.15
4077	.39
4078	.35
4081	.35
4082	.35
4093	.95
4503	.85
4508	2.95
4510	.69
4511	.89
4512	1.10
4514	2.55
4515	2.55
4516	1.25
4518	1.25
4519	.55
4520	1.25
4526	1.65
4527	1.65
4528	1.45

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OEM AND INSTITUTIONAL INQUIRIES INVITED

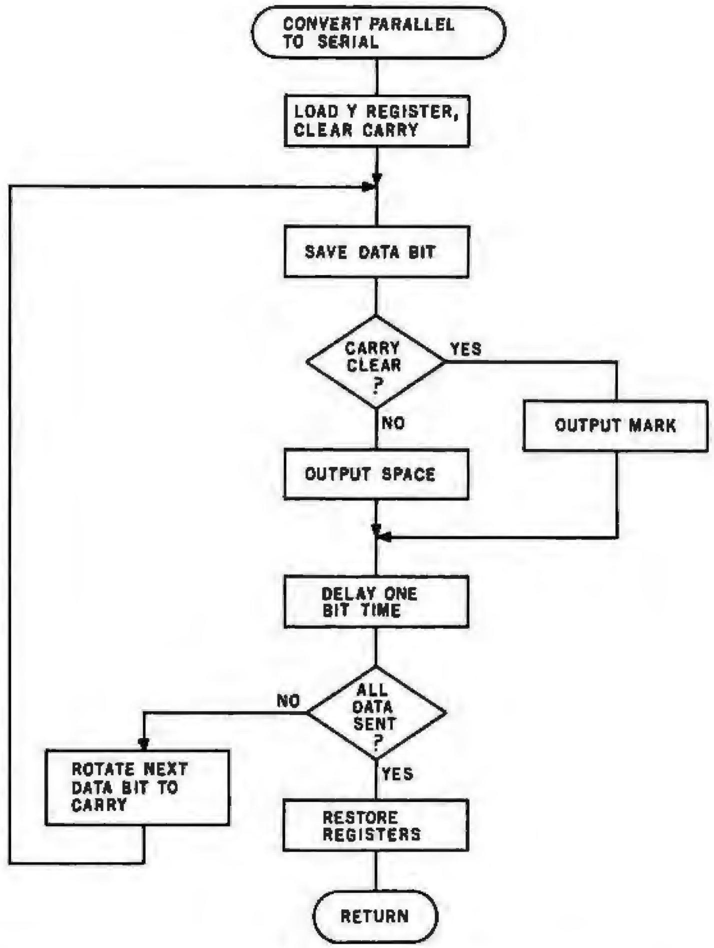
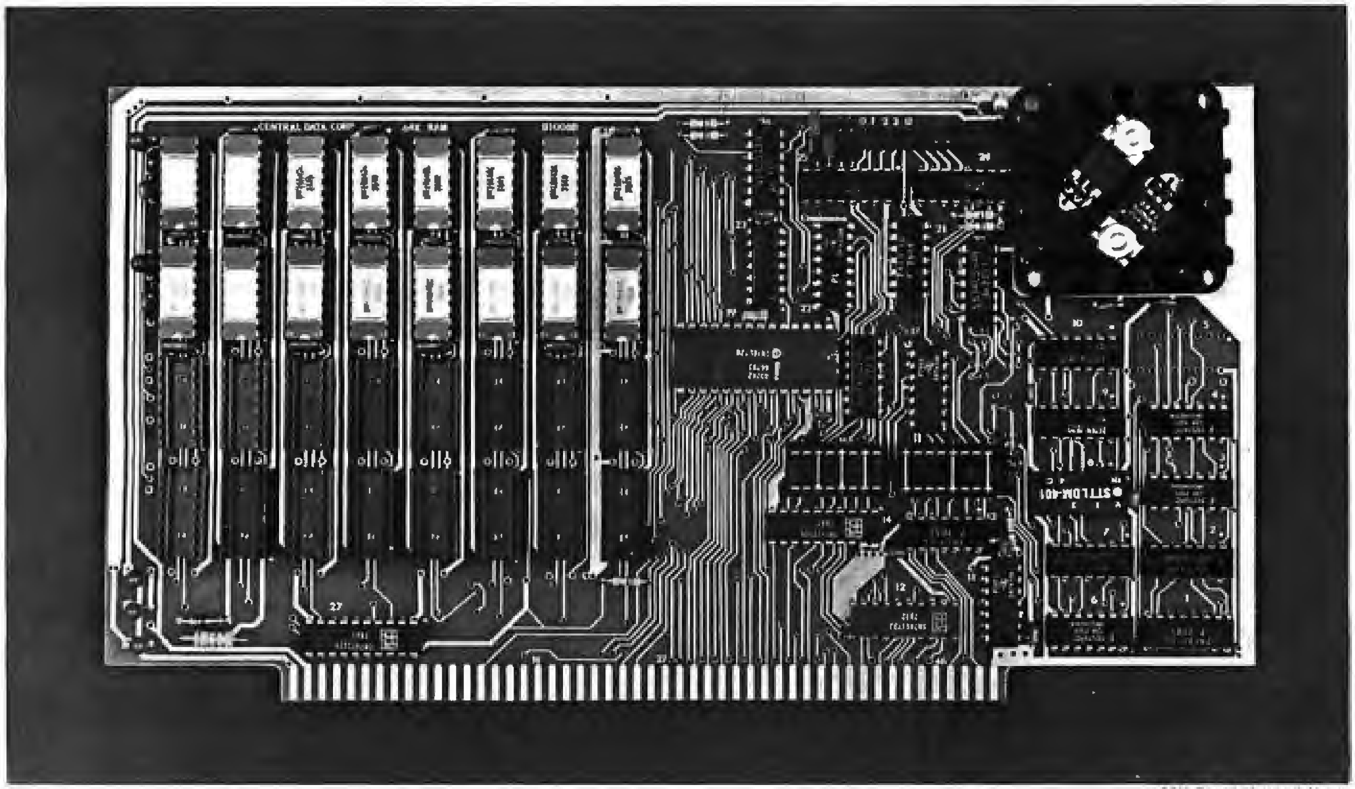


Figure 2: *Flowchart for machine-language software UART in listing 1.*

Listing 2: *Machine-code command generator to select a specified plotter command before calling the UART subroutine.*

```
8038-   48          PHA             Save accumulator
8039-   08          PHP             Save processor status
803A-   A9 70       LDA    #$70     Output 'p'
803C-   20 00 80    JSR    $8000    Jump to parallel to serial conversion
803F-   28          PLP             Restore processor status
8040-   68          PLA             Restore accumulator
8041-   60          RTS             Return
8042-   48          PHA
8043-   08          PHP
8044-   A9 71       LDA    #$71     Output 'q'
8046-   4C 3C 80    JMP    $803C
8049-   48          PHA
804A-   08          PHP
804B-   A9 72       LDA    #$72     Output 'r'
804D-   4C 3C 80    JMP    #803C
8050-   48          PHA
8051-   08          PHP
8052-   A9 73       LDA    #$73     Output 's'
8054-   4C 3C 80    JMP    $803C
8057-   48          PHA
8058-   08          PHP
8059-   A9 74       LDA    #$74     Output 't'
805B-   4C 3C 80    JMP    $803C
805E-   48          PHA
805F-   08          PHP
8060-   A9 75       LDA    #$75     Output 'u'
8062-   4C 3C 80    JMP    $803C
8065-   48          PHA
8066-   08          PHP
```

Listing 2 continued on page 302



32K Board Pictured Above

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	2MHz	4MHz
16K	$249	$259
32K	$375	$395
48K	$500	$530
64K	$625	$665

We have now been shipping our 2MHz dynamic RAM boards for over two years. Hundreds of 4MHz boards have been going out every month since early 1979. Our reliability is proven in the thousands of systems which contain our board. Many quality-minded systems houses across the country and overseas are using our boards for their equipment.

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Deselect around PROMs. Our boards have the important deselect feature which lets you overlap any fixed memory in your system with no interference.

Our features make the board easily used and expanded. You address our boards on 16K boundaries with mini-jumps (small shorting plugs that slide over wire-wrap pins) near the top of the board for easy access. If you want to expand your board after you have purchased it, all that you need to do is add memory. We can supply you with expansion packages ($150-2MHz, $160-4MHz) which include eight RAMs that you can depend on as well as two mini-jumps for addressing. And of course, our board **never** generates wait states.

Low power consumption keeps your computer running cool and reliable. The total power consumption of our 16K board is typically less than 4 watts (+8V @ 300ma, +16V @ 150ma and −16V @ 20ma). Boards with additional memory typically increase power consumption only 1 watt per 16K!

Standard S-100 Interface. Our board is designed to interface with any standard S-100 CPU. All of the timing of the board is independent of the processor chip, and the board is set up for different processors by changing two plugs on the board.

Call or write us today. That will guarantee a fast response with more information on the board. Or make an order — you'll probably have the board in two weeks! **If you're interested, also ask for a catalog on our Z8000 16-bit processor board designed for the MULTIBUS.** All of these products are available to your local dealer, also.

Central Data Corporation, 713 Edgebrook Drive, PO Box 2530, Station A, Champaign, IL 61820. (217) 359-8010

Central Data

Circle 65 on inquiry card.

Listing 2 continued:

```
8067-    A9 76      LDA   #$76    Output 'v'
8069-    4C 3C 80   JMP   $803C
806C-    48         PHA
806D-    08         PHP
806E-    A9 77      LDA   #$77    Output 'w'
8070-    4C 3C 80   JMP   $803C
8073-    48         PHA
8074-    08         PHP
8075-    A9 79      LDA   #$79    Output 'y'
8077-    4C 3C 80   JMP   #803C
807A-    48         PHA
807B-    08         PHP
807C-    A9 7A      LDA   #$7A    Output 'z'
807E-    4C 3C 80   JMP   $803C
```

Listing 3: *BASIC program to produce a plot of the voltage across a charging capacitor.*

```
10  REM  MAIN PROGRAM
12  HOME : VTAB 12
14  PRINT "POSITION PEN IN LOWER LEFT HAND"
16  PRINT "CORNER.  PRESS ANY KEY TO CONTINUE."
18  GET A$
19  HOME
20  GOSUB 1000  REM DRAW X,Y AXIS
30  REM  EXPONENTIAL RISE
32  POKE  -  16293,0  REM SET RESOLUTION TO 200 POINTS PER INCH
34 Z = 0
36  CALL  -  32646:  FOR I = 0 TO 10:  NEXT I  REM PEN DOWN
38  FOR I =  0 TO 8.99 STEP  .005
40 V = 5 *  (1 -  EXP ( - I))  REM FIND CAPACITOR VOLTAGE
42 K =  INT  (200 * V)
44  IF K - Z = 0 THEN GOTO 90  REM NO CHANGE IN PREVIOUS POTENTIAL
46  IF K - Z < 0 THEN GOTO 60  REM POTENTIAL IS DECREASING
48  FOR J = 1 TO (K - Z) REM POTENTIAL IS INCREASING
50  CALL  - 82712  REM MOVE IN +Y DIRECTION
52  NEXT J
54  GOTO 70
60  FOR J = 1 TO (Z - K)
62  CALL  - 32681  REM MOVE IN -Y DIRECTION
64  NEXT J
70 Z = K
90  CALL  - 32695  REM MOVE IN +X DIRECTION
92  NEXT I
94  CALL  - 32653  REM PEN UP
99  END
300  REM  "1"
301  CALL  - 32653:  FOR I = 1 TO 8:  CALL  - 32674:  Next I.
302  CALL  - 32646
304  FOR I = 1 TO 8:  CALL  - 32702:  NEXT I
306  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
308  CALL  - 32653
310  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
312  CALL  - 32646
314  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
316  CALL  - 32653
317  FOR I = 1 TO 8:
318  FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
319  RETURN
320  REM  "2"
321  CALL  - 32653:  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
322  CALL  - 32646
324  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
326  FOR I = 1 TO 13:  CALL  - 32681:  NEXT I
328  FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
330  FOR I = 1 TO 13:  CALL  - 32681:  NEXT I
332  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
334  CALL  - 32653
336  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
337  FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
339  RETURN
```

Listing 3 continued on page 304

OUR TIMING CONTROL UNIT HELPS YOUR COMPUTER KEEP SCORE OF TIME AND DATE.

Power-up or power-down, your computer always knows the time, *exactly*, with Digital Pathway's Timing Control Unit (TCU). Even during extended power interruptions. Rechargeable battery support makes our TCU immune from power failure of any kind. For as long as three months. And an on-board crystal-controlled oscillator ensures supreme accuracy.

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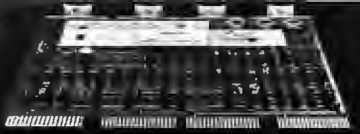

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Listing 3 continued:

```
340  REM  "3"
341  CALL  - 32653:  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
342  CALL  - 32646
344  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
346  FOR I = 1 TO 13:  CALL  - 32681:  NEXT I
348  FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
350  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
352  FOR I = 1 TO 13:  CALL  - 32681:  NEXT I
354  FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
356  CALL  - 32653
357  FOR I = 1 TO 8:  CALL  - 32695:  NEXT I
358  FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
359  RETURN
360  REM  "4"
361  CALL  - 32653:  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
362  CALL  - 32646
364  FOR I = 1 TO 13:  CALL  - 32681:  NEXT I
366  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
368  CALL  - 32653
372  FOR I = 1 TO 13:  CALL  - 32712:  NEXT I
374  CALL  - 32646
376  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
377  CALL  - 32653
378  FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
379  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I:  RETURN
380  REM  "5"
381  CALL  - 32653:  FOR I = 1 TO 8:  CALL  - 32695:  NEXT I
382  CALL  - 32646
384  FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
386  FOR I = 1 TO 13:  CALL  - 32681:  NEXT I
388  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
390  FOR I = 1 TO 14:  CALL  - 32681:  NEXT I
392  FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
394  CALL  - 32653
396  FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
397  FOR I = 1 TO 8:  CALL  - 32695:  NEXT I
399  RETURN
400  REM  "6"
401  CALL  - 32653:  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
402  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
404  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
406  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
408  FOR I = 1 TO 13:  CALL  - 32712:  NEXT I
410  ROR I = 1 TO 16:  CALL  - 32667:  NEXT I
412  CALL  - 32653
414  FOR I = 1 TO 13:  CALL  - 32712:  NEXT I
415  FOR I = 1 TO 8:  CALL  - 32695:  NEXT I
416  RETURN
420  REM  "7"
422  CALL  - 32653
424  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
426  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
428  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
430  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
432  CALL  - 32653
434  FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
436  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
439  RETURN
440  REM  "8"
442  CALL  - 32653
444  FOR I = 1 TO 8:  CALL  - 32695:  NEXT I
445  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
446  FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
448  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
450  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
452  FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
454  CALL  - 32653
456  FOR I = 1 TO 13:  CALL  - 32681:  NEXT I
457  CALL  - 32646
458  FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
460  CALL  - 32653
462  FOR I = 1 TO 8:  CALL  - 32695:  NEXT I
464  FOR I = 1 TO 13:  CALL  - 32712:  NEXT I
469  RETURN
```

Listing 3 continued on page 306

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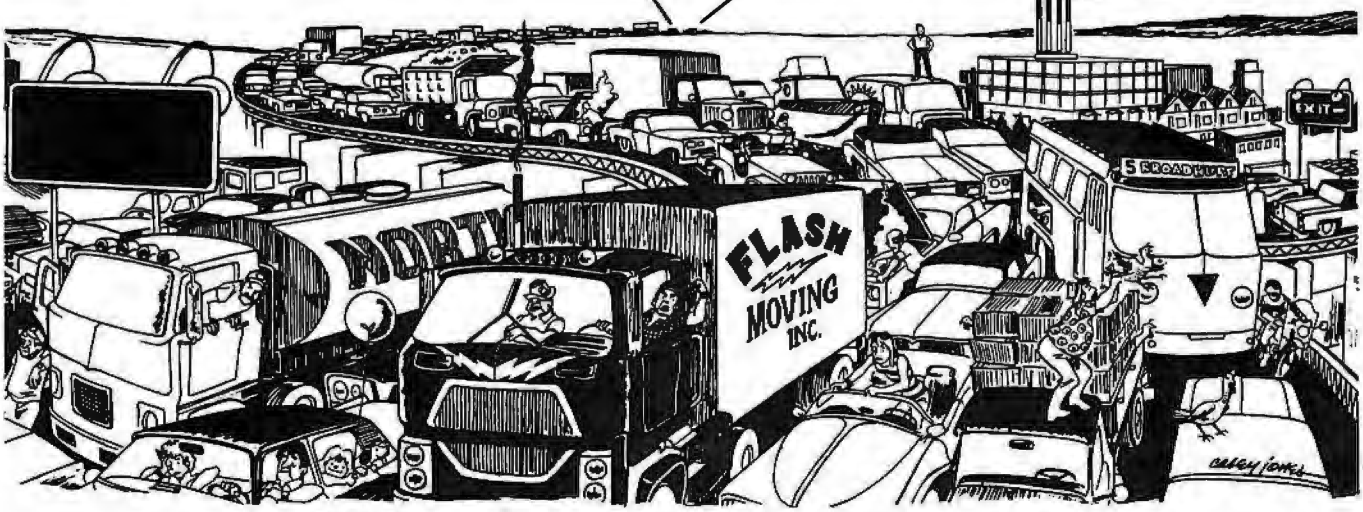
Listing 3 continued:

```
480  REM  "9"
482  CALL  - 32653
483  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
484  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
485  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
486  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
487  CALL  - 32653
488  FOR I = 1 TO 13:  CALL  - 32712:  NEXT I
489  CALL  - 32646
490  FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
492  FOR I = 1 TO 13:  CALL  - 32712:  NEXT I
493  CALL  - 32653
494  FOR I = 1 TO 8:  CALL  - 32695:  NEXT I
499  RETURN
500  REM  "0"
502  CALL  - 32653
504  FOR I = 1 TO 8:  CALL  - 32695:  NEXT I
506  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
508  FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
510  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
512  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
514  FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
516  CALL  - 32653
518  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
519  RETURN
999  END
1000  REM  X AXIS
1010  POKE  - 16294,0:  CALL  - 32653
1012  FOR I = 1 TO 50:  CALL  - 32712:  NEXT I
1014  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1016  FOR I = 1 TO 1000:  CALL  - 34695:  NEXT I
1018  CALL  - 32653
1100  REM  X AXIS SCALE
1110  FOR I = 1 TO 20:  CALL  - 32712:  NEXT I
1112  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1114  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1116  CALL  - 32653
1118  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1120  POKE  - 16293,0
1122  GOSUB 480
1124  POKE  - 16294,0
1126  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1128  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1130  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1132  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1134  CALL  - 32653
1146  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1148  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1150  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1152  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1154  CALL  - 32653
1156  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1158  POKE  - 16293,0
1160  GOSUB 440
1162  POKE  - 16294,0
1164  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1166  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1168  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1170  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1172  CALL  - 32653
1174  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1176  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1178  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1180  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1182  CALL  - 32643
1184  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1186  POKE  - 16293,0
1188  GOSUB 420
1190  POKE  - 16294,0
1192  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1194  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1196  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1198  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1199  CALL  - 32653
```

Listing 3 continued on page 308

"By the time we get out of this traffic, my 6-month auto policy will be up for renewal. And they may raise my rate, too!"

"6 months? Next time, call GEICO and get a 12-month policy."



Unlike most companies, GEICO still offers the 12-month auto policy...a full year's coverage at a low rate. With a choice of convenient payment plans to fit your budget. Up to 9 payments if you wish.

And this is possible because GEICO tries to insure only good drivers. Good drivers are the best inflation-fighters around. You have fewer accidents. You cost us less. So you are one reason we can afford to charge you less.

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NOTE: While you're checking GEICO, why not find out about our rates for homeowner/renter and boatowner coverage. And—even if you do not meet GEICO's auto policy standards—you may still obtain the same quality auto coverage and service from our affiliate, Criterion Insurance Company, at somewhat higher rates. Criterion operates in the District of Columbia and every state except Massachusetts, New Jersey and South Carolina.

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Where good drivers get the low rates they deserve.

Call toll-free **800-841-3000** (8 a.m.-9 a.m. East Coast Time)
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Send to: GEICO & Affiliates, Consumer Information Services, GEICO Center, Macon, GA 31295

Name ______

Address ______ Apt. # ______

City ______ State ______ Zip ______

Employer ______ # Yrs. ______

Govt. or Military Grade ______ Have you previously been insured with GEICO? ☐ Yes ☐ No

Location of car if different from address above:

Car # 1: City ______ State ______

Car # 2: City ______ State ______

Car # 3: City ______ State ______

Name of current insurance co. ______ Month/Year Current Policy Expires ______

List all drivers	M or F	Relation	Age	Marital Status	Occupation	Yrs. lic.	Driver Training		% of Use of Cars			Accidents in Past 5 Years*		Violations in Past 3 Years*		License Suspension*	
							Yes	No	#1	#2	#3	Yes	No	Yes	No	Yes	No
		SELF															

If student away at school, how many miles to school? ______ miles.

	CAR 1	CAR 2	CAR 3
Year & Make			
Model (Nova, Granada, etc.)			
Body type: 2/4 dr. sdn, hardtop, sta. wag			
No. of cylinders			
Est. Annual Mileage			
Days per week driven to work or parking area			
One way driving distance			
Is car used in business (except to/from job)?			

If "yes" explain ______

*For accidents, violations, or license suspension, give dates and complete details, including cost of damages, on a separate sheet.
Check for Information on ☐ Homeowners/Renter's Insurance ☐ Boatowner's Insurance

684

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Not available in New Jersey or Massachusetts.

Circle 166 on inquiry card.

Listing 3 continued:

```
1200  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1202  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1204  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1206  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1208  CALL  - 32653
1210  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1212  POKE  - 16293,0
1214  GOSUB 400
1216  POKE  - 16294,0
1218  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1220  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1222  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1224  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1226  CALL  - 32653
1228  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1230  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1232  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1234  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1236  CALL  - 32653
1238  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1240  POKE  - 16293,0
1242  GOSUB 380
1244  POKE  - 16294,0
1246  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1248  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1250  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1252  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1254  CALL  - 32653
1256  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1258  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1260  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1262  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1264  CALL  - 32653
1266  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1268  POKE  - 16293,0
1270  GOSUB 360
1272  POKE  - 16294,0
1274  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1276  FOR I = 1 TO 38:  CALL  - 32667:  NEXT I
1278  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1280  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1282  CALL  - 32653
1284  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1286  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1288  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1290  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1292  CALL  - 32653
1294  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1296  POKE  - 12394,0
1298  GOSUB 340
1300  POKE  - 16294,0
1302  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1304  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1306  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1308  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1312  FOR I - 1 TO 50:  CALL  - 32667:  NEXT I
1314  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1316  CALL  - 32546:  FOR I = 0 TO 10:  NEXT I
1318  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1320  CALL  - 32653
1322  For I = 1 TO 5:  CALL  - 32681:  NEXT I
1324  POKE  - 16293,0
1326  GOSUB 320
1328  POKE  - 16294,0
1330  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1332  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1334  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1336  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1338  CALL  - 32653
1340  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1342  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1344  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1346  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1348  CALL  - 32653
```

Listing 3 continued on page 310

Listing 3 continued:

```
1350  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1352  POKE  - 16293,0
1354  GOSUB 300
1356  POKE  - 16294,0
1358  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1360  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1362  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1364  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1366  CALL  - 32653
1368  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1370  FOR I = 1 TO 37:  CALL  - 32681:  NEXT I
1372  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1373  REM  Y AXIS
1374  FOR I = 1 to 700:  CALL  - 32712:  NEXT I
1376  FOR I = 1 to 13:  CALL  - 32667:  NEXT I
1378  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1380  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1381  CALL  - 32653
1382  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1384  FOR I = 1 TO 43:  CALL  - 32667:  NEXT I
1386  POKE  - 16293,0
1388  GOSUB 400
1390  POKE  - 16294,0
1392  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1394  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1396  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1398  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1400  CALL  - 32653
1402  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1404  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1406  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1408  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1410  CALL  - 32653
1412  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1414  FOR I = 1 TO 43:  CALL  - 32667:  NEXT I
1416  POKE  - 16293,0
1418  GOSUB 380
1420  POKE  - 16294,0
1422  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1424  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1426  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1428  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1430  CALL  - 32653
1432  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1434  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1436  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1438  FOR I = 0 TO 26:  CALL  - 32695:  NEXT I
1440  CALL  - 32653
1442  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1444  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1446  POKE  - 15293,0
1448  GOSUB
1450  POKE  - 16294,0
1452  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1454  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1456  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1458  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1460  CALL  - 32653
1462  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1464  FOR I = 1 to 33:  CALL  - 32667:  NEXT I
1466  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1468  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1470  CALL  - 32653
1472  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1474  FOR I = 1 TO 43:  CALL  - 32667:  NEXT I
1476  POKE  - 16293,0
1478  GOSUB 340
1480  POKE  - 16294,0
1482  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1484  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1486  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1488  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1490  CALL  - 32653
1492  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
```

Listing 3 continued on page 312

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Circle 341 on inquiry card.

Listing 3 continued:

```
1494  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1496  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1498  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1500  CALL  - 32653
1502  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1504  FOR I = 1 TO 43:  CALL  - 32667:  NEXT I
1506  POKE  - 16293,0
1508  GOSUB 320
1510  POKE  - 16294,0
1512  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1514  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1516  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1518  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1520  CALL  - 32653
1522  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1524  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1526  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1528  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1530  CALL  - 32653
1532  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1534  FOR I = 1 TO 43:  CALL  - 32667:  NEXT I
1536  POKE  - 16293,0
1538  GOSUB 300
1540  POKE  - 16294,0
1542  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1544  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1546  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1548  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1550  CALL  - 32653
1552  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1554  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1556  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1558  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1560  CALL  - 32653
1562  FOR I = 1 TO 26:  CALL  - 32667:  NEXT I
1564  FOR I = 1 TO 100:  CALL  - 32681:  NEXT I
1566  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1568  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1570  CALL  - 32653
1572  FOR I = 1 TO 13:  CALL  - 32667:  NEXT I
1574  FOR I = 1 TO 50:  CALL  - 32712:  NEXT I
1999  RETURN
```

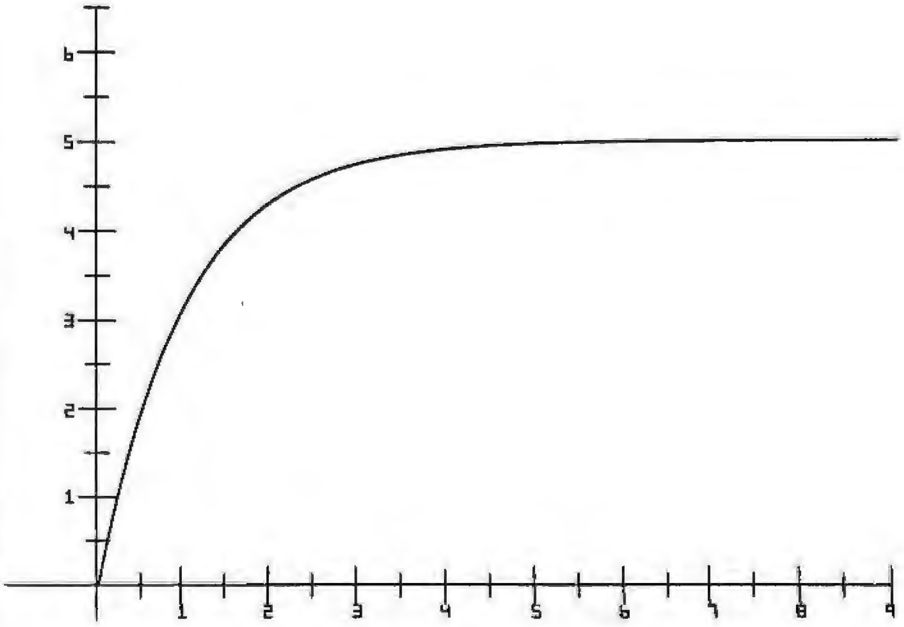

Figure 3: *Sample plot of results obtainable with the information included in this article.*

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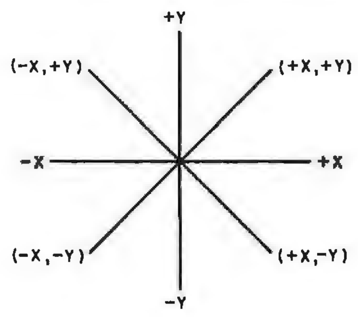

COMMAND	CHARACTER	HEXADECIMAL ADDRESS
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+X,+Y	q	8042
+X	r	8049
+X,−Y	s	8050
−Y	t	8057
−X,−Y	u	805E
−X	v	8065
−X,+Y	w	806C
PEN UP	y	8073
PEN DOWN	z	807A

Table 1: *Chart of plotter pen-movement commands and the vector notation associated with each command.*

Text continued from page 298:

Table 1 shows plotter commands and the vector notation associated with each. Listing 2 on page 300 is a machine-language routine that generates the specified command characters. To execute a given command, a jump is made to the appropriate hexadecimal address, where the proper character is loaded into the accumulator. A call is then made to the parallel-to-serial subroutine, where the command character is transferred from the computer to the plotter.

Results with the digital plotter have been encouraging. Figure 3 on page 312 shows an actual plot made on the plotter. A #0 Rapidograph pen was used to produce a high-quality plot. The plot is a simulation of the voltage drop across a capacitor that is placed in series with a resistor and a fixed voltage source. Figure 4 shows the flowchart of the program, and listing 3 beginning on page 302 shows the program with comments.

At present, the Apple II and Hiplot digital plotter are being used for several projects that include the spectral analysis of breath sounds, muscle voltages, and neural characteristics. The two units working together provide a low-cost, high-quality record of the analysis of scientific data. ■

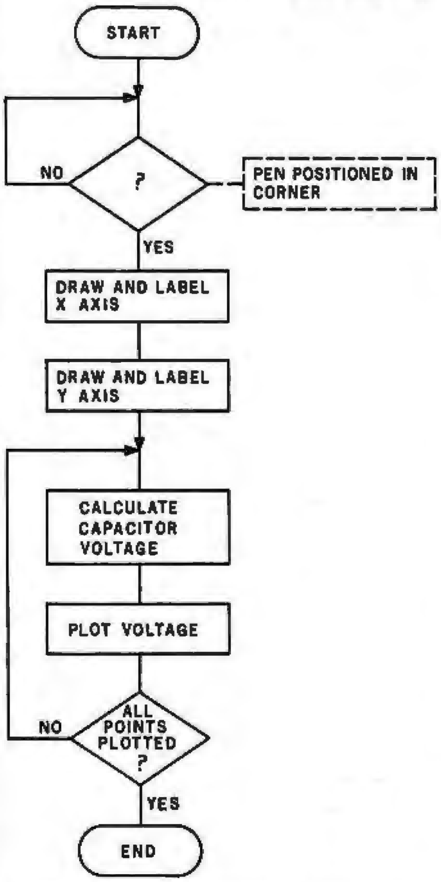

Figure 4: *Flowchart for the BASIC program used to produce figure 3.*

Recursion and Side Effects in Pascal

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University of Massachusetts
Boston Harbor Campus
Boston MA 02125

Two features of Pascal, *recursion* and *side effects,* often cause difficulties for beginners to the language. Although these features appear to address separate issues, they are not unrelated, and for this reason confusion over one often accompanies confusion over the other. Conversely, contemplation of one can assist in an understanding of the other. It is easier to comprehend both issues if you look at the management of variables that results from procedure calls. That will be the focus of this article.

Typically, the concept of recursion is illustrated with simple functions that are better written without recursion. We will adhere to that custom for the standard reason of comprehensibility. Readers who master recursion will find an excellent treatment of the subject (when and when not to use it) in Nikolaus Wirth's *Algorithms + Data Structures = Programs,* listed in the references.

Consider the easy problem of computing the factorial $n! = 1 \times 2 \times \ldots \times n$. Factorial is defined recursively as follows:

$$n! = n(n-1)! \text{ if } n > 1$$
$$n! = 1 \qquad \text{ if } n = 1$$

The following Pascal function computes the factorial function recursively:

```
FUNCTION fac(n: INTEGER): INTEGER;
    BEGIN
        IF n = 1
        THEN fac := 1
        ELSE fac := fac(n - 1)*n
    END
```

Suppose that a main program contains the following calling sequence:

```
m := 3; y := fac(m)
```

The function "fac" is recursive. That is, "fac(3)" will call "fac(2)", which will call "fac(1)". We say that there are three activations of this function, with parameter values of 3, 2, and, finally, 1.

Each activation of a recursive function (or procedure) must have a separate location (called the *stack frame*) for its local variables, parameters, etc. In this way, one activation (say, "fac(2)") does not disturb the contents of another activation (say, "fac(3)"). As each activation begins, a new stack frame is created (or *pushed*) for its local variables. As that activation is completed, its stack frame is destroyed (or *popped*), and control returns to the previous activation. The "current" values of the local variables are then taken from the stack frame of the previous activation, which is now at the bottom of the (downward-growing) stack. [*In a stack, only the item most recently placed there can be accessed. We call this the* top *of the stack if the stack is growing "up." Since the stack in this context is growing "down," we will refer to the item that can be removed as the* bottom *of the stack....*GW]

Snapshots of the stack are shown in figure 1. The global variables "m" and "y" (ie: those declared in the main program) are allocated storage in the stack frame of the main program, which is shown at the top frame of the stack. These variables are not duplicated with each activation of the function. A function or procedure may be able to directly access and modify a global variable. That, as you will see, can lead to surprising results.

Above and between the snapshots of the stack in figure 1 is the fragment of code (plus comments, in braces) which caused the changes to the stack. This information helps specify the time when each snapshot was taken.

At any point in time, there are two currently active frames that are of immediate interest. These two frames contain the values that are currently accessible; they are the top and bottom frames in figure 1. The top frame contains the (global) variables of the main program. The local frames are shown below it, growing downward. The bottom frame is the only local frame that is currently accessible (ie: belongs to the current activation). In addition to local variables, the stack frame contains the value of the function (marked "P" if it is pending further calculations) and the return address (so that control will be transferred back to the correct calling sequence). The

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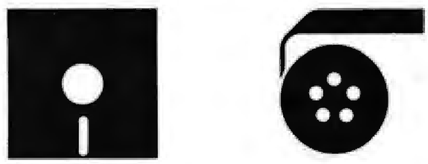

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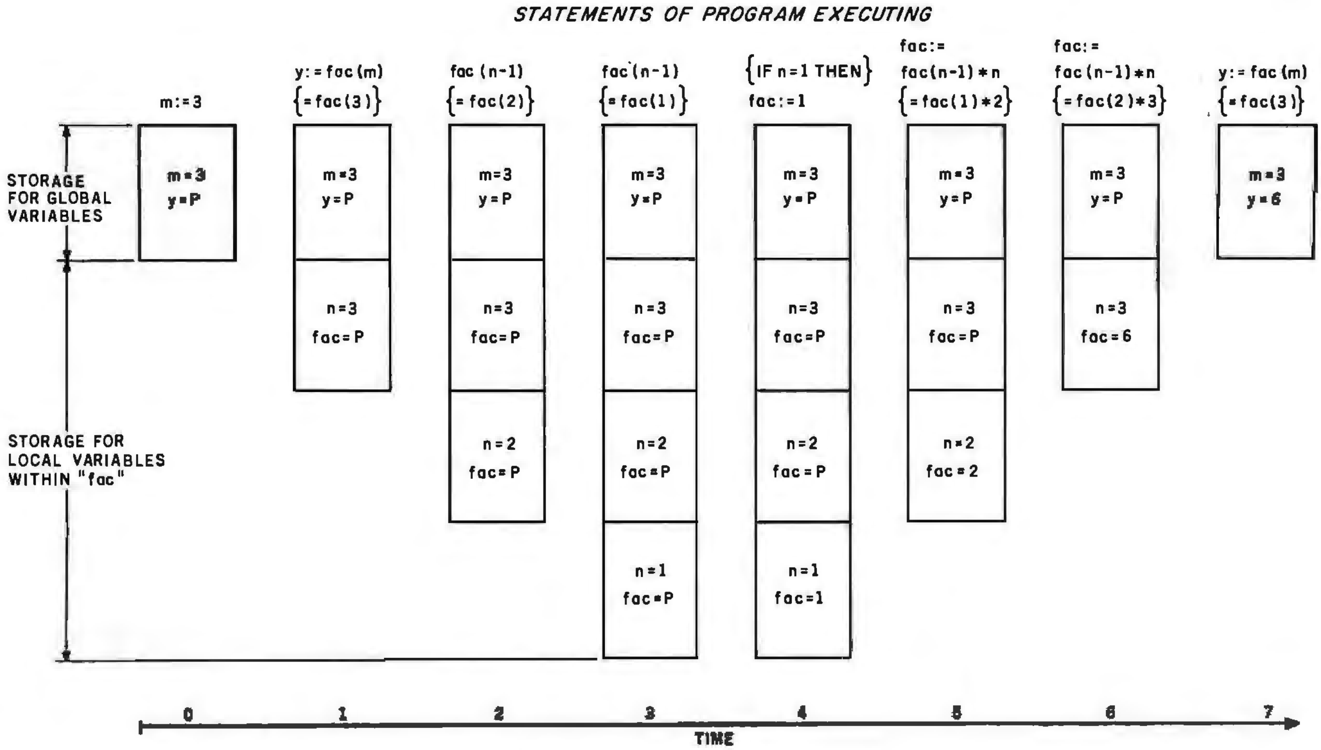


Figure 1: *Execution of the Pascal statements "m := 3; y := fac(m)". The columns of boxes represent the stack at time t=0, 1, 2,...7. The statements above each column indicate the part of the function that is executed to give the stack illustrated below, and the comments in braces are used to clarify the statements being executed. The letter P indicates a pending calculation.*

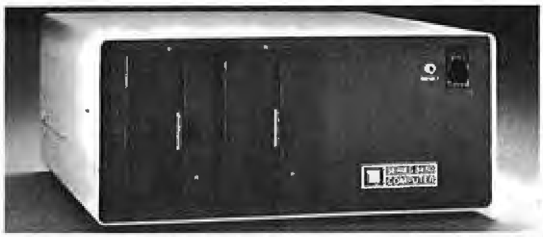
addresses have not been shown in figure 1.

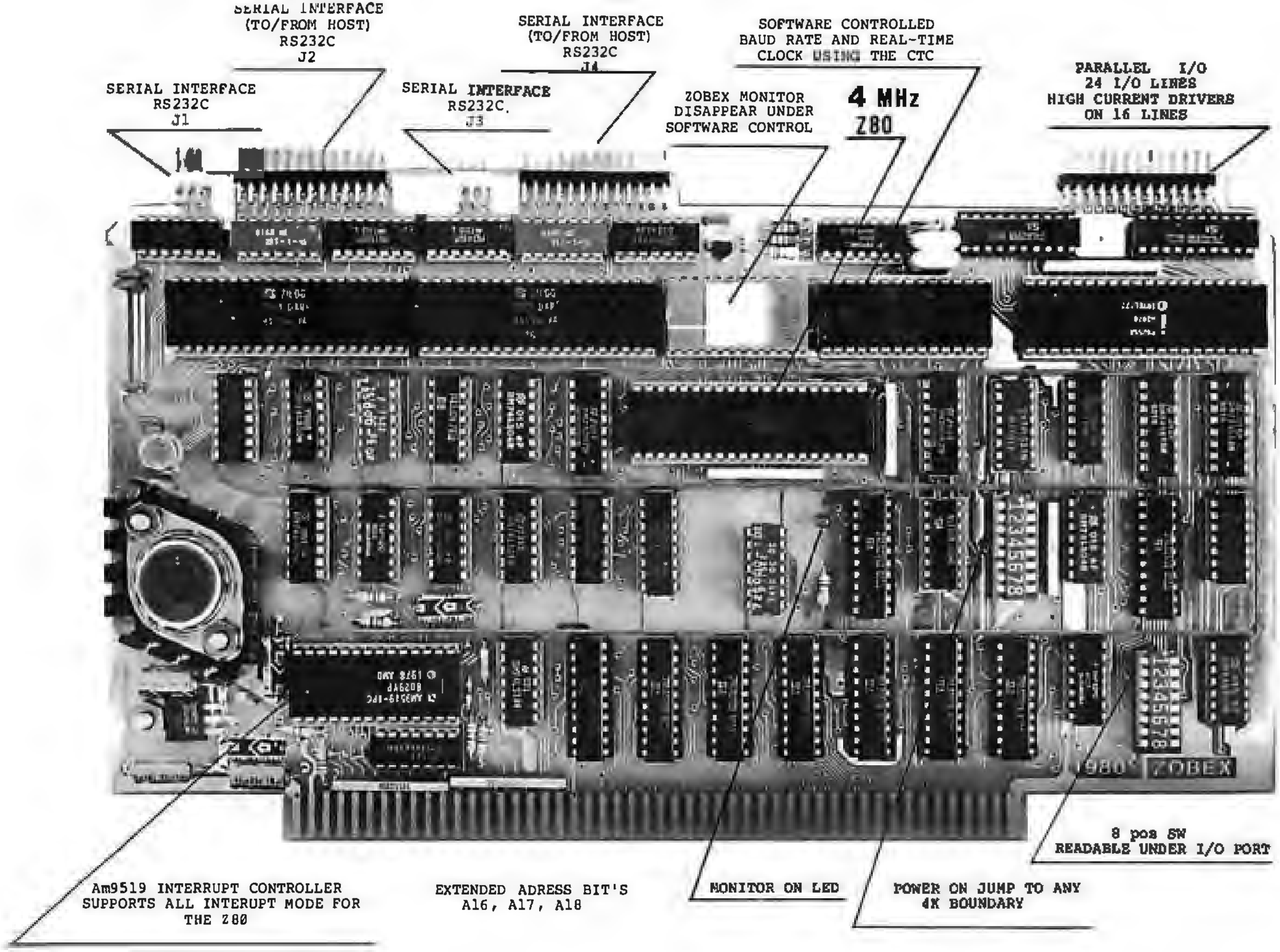
Had the variables "m" or "y" occurred inside "fac" without a new declaration, these variables would be said to be *global* to the function, and then "fac" could access or change their values. When global variables are changed within a function, the function is said to cause *side effects*. Sometimes this is useful, but often it is dangerous, and should be used with caution.

When the program execution begins, the global frame is set up, and soon the variable "m" is assigned the value of 3 (see column 0 in figure 1). When the function call "fac(m)" is reached, a stack frame for "fac" is set up (column 1) below the global frame, and the value, 3, of the argument "m" is assigned the parameter "n" and stored in the local stack frame. (This *call by value* is the default behavior in Pascal. The alternative method of passing values, *variable parameters*, will be discussed shortly.)

Now the value of "fac(n−1)=fac(2)" is required. In order to compute this, the function "fac" is called (recursively), this time with a parameter value of 2. A second local stack frame is set up with n=2 (column 2).

This activation will call "fac(1)", and its frame is set up





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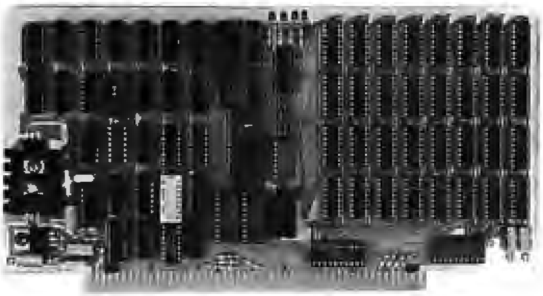

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at the bottom of column 3. Since n=1, this can be evaluated without further recursion: the answer is 1, and is stored in the variable "fac" in column 4. Now the previous invocation of "fac" (with n=2) can complete its work. Its answer is 2×fac(1)=2×1=2, which is assigned to the variable "fac" in column 5 (where the stack frame of "fac(1)" has been popped).

The unwinding process continues as control returns to the previous call of "fac" (with n=3), where the answer can now be computed as fac=3×fac(2)=3×2=6, and stored in column 6. Finally, the answer is assigned to the global variable "y" in column 7.

Applications of Side Effects

Before we see how side effects can lead to unexpected trouble, we should point out that they can be used in many legitimate ways. For example, no useful language can exist without the statement READ(x). It may also be useful to have a function that includes the following code:

```
IF denominator = 0
THEN write('attempt to divide by zero')
ELSE quotient := numerator/denominator
```

The procedures read and write both have side effects—they affect the status of the (global) files input and output.

Another useful application of side effects occurs when each activation of a procedure computes only part of the answer and places it into the appropriate section of a global buffer. When all activations of the procedure have done their jobs, this buffer will contain the entire answer, which can then be worked on. Examples are the recursive algorithms for sorting arrays and for backtracking (see Wirth, Chapter 3 and page 79, listed in the references). This mechanism is not without risk, however, because procedures other than the one intended can inadvertently modify the global variable.

Some languages provide the appropriate mechanism, eg: "own" variables in ALGOL-60 or static storage in PL/I and C. These variables have "local name scope" (ie: they can not be directly accessed from outside the procedure). However, they are allocated storage only once. Thus, like global variables, new copies are not made with each activation of the procedure, so their values are retained from one activation of the procedure to the next. The loss of this feature in Pascal is generally overshadowed by the pleasant fact that Pascal is a simplification of ALGOL-60, whereas PL/I is a "complification."

A Faulty "fac" Function

Now we'll look at a modification of the factorial program, where a variable parameter is used. Although it looks very much like the first version of "fac", you will see that it computes the wrong answer:

```
FUNCTION fac2 (VAR n:INTEGER):INTEGER;
BEGIN
        IF n = 1
        THEN fac2 := 1
        ELSE
        BEGIN
                n := n - 1;
                fac2 := fac2(n) * (n + 1)
        END
END
```

Assume that it is called, as before, by the following sequence:

```
m := 3; y := fac2(m);
```

Note the keyword "VAR" in the function header. A variable parameter in Pascal does not copy the value of its argument onto the stack frame. Instead, a reference (ie: a pointer) to the argument (in this case, the variable "m") is placed on the stack frame. This method is known as "call by reference." There are times when you want to use this method—for example, when a large item like an array or file is a parameter, or when you want to change the value of a global variable. But disaster lurks, as we will indicate shortly.

The argument in a call by reference must also be a variable (see Wirth, page 71). This prohibits a call like "fac2(n−1)", since (n−1) is an expression, not a variable. Therefore, the variable "n" must be decremented in the ELSE clause. This appears to make the same mathematical calculation as in the previous version of the function "fac" because the multiplication is now by (n+1), the original value of n. In fact, it does not.

By having a variable parameter, "fac2" is able to get into the global variable "m" and (if you are not careful) change its value.

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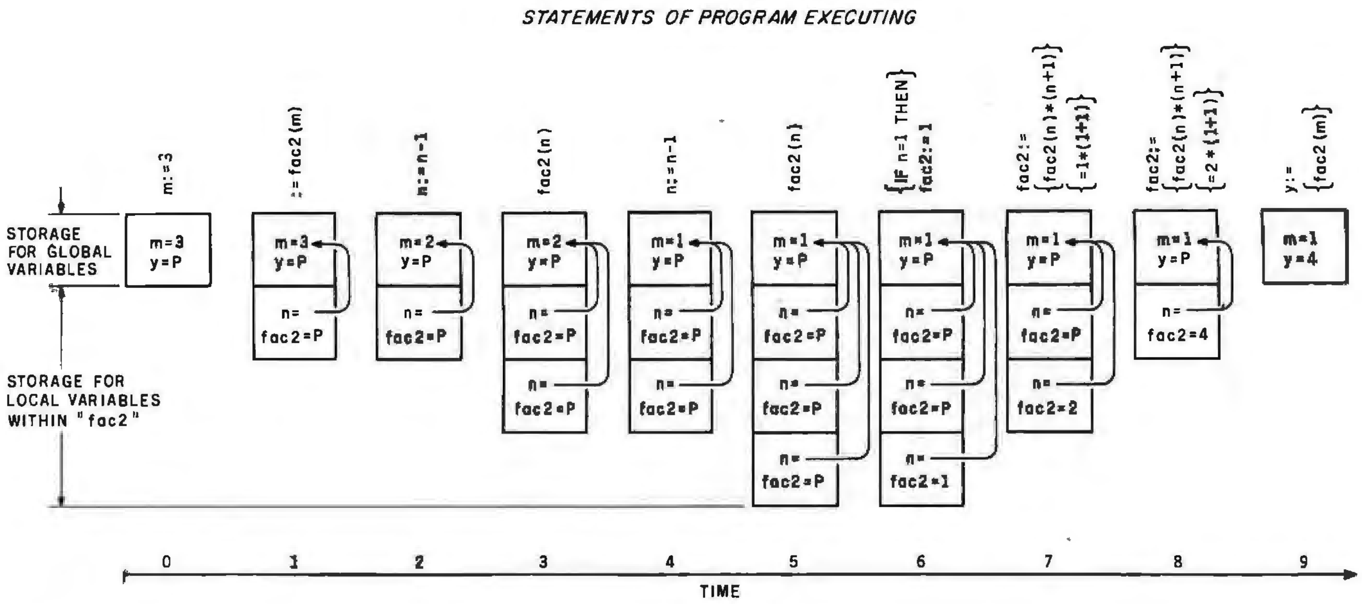

Figure 7: *Execution of the Pascal statements "m := 3; y := fac2(m)". In this case, the variable "n" within the function "fac2" (listed in the text) points to the global variable "m" and can change its value; the arrows from "n" to "m" indicate this relationship.*

Consider the stack diagrams for the function "fac2" (see figure 2). This time, each new instance of "n" gets a pointer to the variable "m" and the code "n := n−1" causes the global variable, "m", to be decremented by 1. Still, no values can be assigned to "fac2" until the stack starts to unwind, and when that happens, the value of "m" has been decreased to 1. Thus the multiplication is always by 2.

As you see, this function is not computing factorials at all, but 2^{m-1}. The problem arises because "fac2" is altering the value of its parameter, a situation to be avoided when not absolutely necessary. After the entire function terminates, the variable "m" will be left at 1, regardless of its initial value. The function "fac2" is exerting a side effect on "m".

Side effects can occur whenever a procedure accesses a global variable either directly or indirectly via a variable parameter. Side effects are avoided by the use of local parameters (declared within the procedure or function) and value parameters. Many side-effect errors are so easy to make and so hard to debug that language designers will prohibit certain dangerous constructs (or encourage the implementors to do so). (See *Pascal User Manual and Report*, page 79, listed in the references.) For example, the use of global variables (or parameters) for the control of "for" loops is prohibited by the CDC implementation of Pascal described in *The Pascal User Manual and Report* (pages 120 and 121, and error messages 155 and 180).

One of the most discomforting difficulties in debugging

Programmers should strive to write code that is clear, correct, verifiable, and easily transported to other implementations.

functions with side effects may occur if f×g is not equal to g×f, at least if "f" or "g" is a function. Consider, for example, the apparently simple modification of the "fac2" function that is made by changing the key line to:

```
fac2 := (n + 1)*fac2(n)
```

The reader is invited to make a stack history as above. Assume that multiplications are performed left to right, and that the stack frame for "fac2" also allocates a location to hold the value of the expression (n+1) until after "fac2(n)" is computed, with the two values then being multiplied. (In practice, values of such expressions may be stored as temporary variables in registers.)

As a result of this single change, "fac2" will compute the correct value of factorial. What is the moral? Whenever the spectre of unplanned side effects rears its ugly head, discovery of the "correct" solution may be a matter of luck (and might depend on the implementation!). In any case, programs are certainly hard to debug whenever f×g and g×f are not equal.

There are, of course, simpler examples that illustrate this phenomenon. Consider the following function:

```
FUNCTION f(VAR i:INTEGER):INTEGER;
BEGIN f := i; i := i + 1 END;
```

This function simply returns the value of its argument, but has the side effect of incrementing that argument.

The following sequence:

```
x := 1; WRITE ( (x + 1)*f(x) );
x := 1; WRITE ( f(x) * (x + 1) );
```

produces a printout of:

```
2     3
```

In this case, the printout (which would have been "2 2" if the order of multiplication had not mattered) vindicates our assumption that multiplication was performed left to right.

The order in which multiplications are performed is (deliberately) left unspecified by the semantics of most programming languages. For example:

```
x := 1; WRITE(x*f(x));
x := 1; WRITE(f(x)*x);
```

produces a printout of:

```
2     2
```

and we must conclude that the value of the expression f(x) is evaluated before the value of the variable "x". This may be done for optimization reasons, in order to minimize register use. Furthermore, an optimizing compiler may choose not to evaluate f(x) at all in an expression like 0*f(x), since the answer is always zero. In that case, any side effects of the function "f" on "x" would not appear.

In short, the results of these examples can very well depend on the implementation! It is bad practice to write this kind of code, and programmers should strive to write code that is clear, correct, verifiable, and easily transported to other implementations. If you can avoid unnecessary side effects, you will be one step closer to this goal. ■

References

1. Jensen, K and N Wirth. *Pascal User Manual and Report.* Springer-Verlag, 1974.
2. Wirth, N. *Algorithms + Data Structures = Programs.* Englewood Cliffs NJ: Prentice-Hall, 1976.

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Debug machine-language programs for 6800 systems using instruction mnemonics.

The disassembler requires less than 1 K bytes of read-only memory, produces symbolic program listings similar to those produced by an assembler, and can be used to produce source code for input to an assembler (for instance, if you need to reassemble a program to incorporate modifications). As an added feature, the disassembler calculates and displays the effective address referenced by relative address mode instructions.

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The disassembler subsystem consists of three main routines: operator interface, disassembler, and an output routine for terminal display of disassembled code. The user can write his own interface and other routines for special applications. Any operator interface routine must set the first (or only) address of code to be disassembled, the number of lines of disassembled code to be produced (128 lines maximum), and the address of an output routine.

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The built-in operator interface is designed for use with video terminals having displays in a format of sixteen lines of thirty-two characters each, although it will work with other types of terminals. Since each line of output is thirty-two characters in length, the interface routine will cause a single page of fifteen lines to be displayed, with the cursor at the bottom of the display (as illustrated in figure 1). A new address can then be entered. If

About the Author

Aillil Ian Halsema has worked as a programmer since 1971. He is now a senior member of the programming staff at Xerox Corporation. He owns a Southwest Technical Products Corporation 6800 system equipped with 16 K bytes of memory, a CT-1024 video terminal, an AC-30 cassette tape interface, and an Okidata CP-110 printer.

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you wish to view the next sequential set of fifteen lines, type a nonhexadecimal character followed by a G. The disassembler executes quickly; it will be input/output (I/O) bound (having to wait for I/O operations to finish) up to terminal data rates of about 3000 bps.

Disassembler Tables

Almost half of the memory space taken up by the disassembler is used for two tables. The larger of the two is the *packed-mnemonic* table. Each entry in this table is 2 bytes long, with entries arranged in ascending operation code order. Those operation codes which are undefined (such as hexadecimal 00) are represented in the table by the FCB pseudo-operation mnemonic. Each entry is formed by dropping the fourth character of the mnemonic (either an A or a B as in LDAA), masking out the 3 high-order bits of each of the remaining characters, and packing them into 16 bits. The high-order bit of the 16 is used as a flag to specify an alternate entry in the smaller table. Note that this method of packing characters is valid only for character codes with the same high-order 3 bits. Numeric and alphabetic ASCII characters cannot be packed together. Figure 2 gives an example of mnemonic packing.

The smaller table is the *format* table. It defines the address mode, the fourth character of the mnemonic symbol, and the number of bytes in the input object code. The format table consists of thirty-two 1-byte entries with two entries for each possible value of the high-order nybble (ie: half-byte) of the input op code. The second entry of a pair is selected when bit 16 is set to the value 1 in the corresponding packed-mnemonic-table entry.

This method of defining formats and mnemonics works for all but three mnemonic symbols. The PSHB, PULB, and BSR op codes are exceptions that must be handled differently in the program. A fourth exception is the FCB pseudo-operation which has its own *format-flags byte* outside of the table.

During execution of the disassembler, the op code is used as an index into the packed-mnemonic table, while the high-order nybble of the op code is multiplied by 2 and is used as an index into the format table. The packed mnemonic is unpacked, and the 3 high-order bits of each character are restored by adding hexadecimal 40 to each 5-bit value. The unpacked ASCII characters are stored in a line buffer along with the fourth character, if any, of the mnemonic.

The operand field is built using format table data indicating the length and address mode of the instruction. If an immediate-mode instruction is being processed, the operand is preceded by a "#" character. If the instruction uses relative addressing, the absolute effective address is calculated and is placed in the comments field of the output buffer. If the instruction uses indexing, the operand is followed by a ",X" sequence. All operands are in hexadecimal. All fields in the line start at fixed locations, making for easier user processing.

Hardware Additions

The hardware cycle counter is connected to side A of the peripheral interface adapter. Figure 3 shows a schematic diagram of this. In my system, a Southwest Technical Products Corp (SwTPC) 6800, the peripheral interface adapter is on an MP-L parallel interface board which is connected to the system reset line. On power-up or reset conditions, data direction register A (DDRA) and I/O register A (IORA) cause logic 1 levels to appear on the MP-L's output lines. If applied directly to the counter, these levels would start the counter running and producing interrupts before the system could properly process them.

To avoid this condition, a 7404 hex inverter is used to complement the load, clear, and enable signals, and to keep the counter halted and cleared following power-up and system reset.

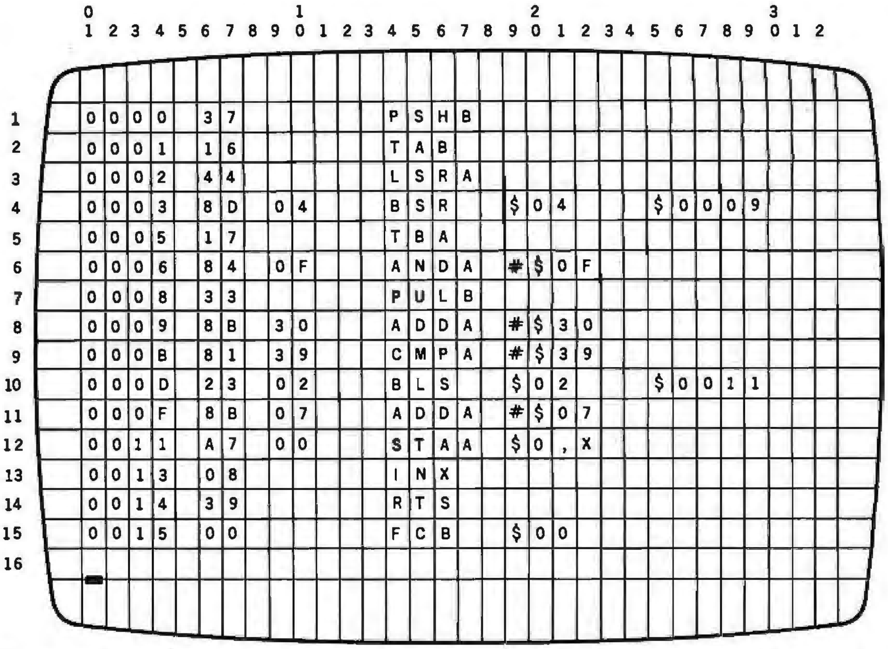

Figure 1: *Example of disassembled code as it appears when output to a video terminal screen.*

```
Mnemonic to be packed:  LDX

ASCII Hexadecimal Representation:  4C 44 58  (0100 1100 0100 0100 0101 1000)
                                                   L         D         X
Deleting the high-order 3 bits:  0 1100 0 0100 1 1000
                                    L      D      X
Collecting the bits in 2 bytes:  00110000 10011000   (30 98)
                       not used ↗   L    D    X
```

Figure 2: *Forming an entry in the packed-mnemonic table. The three high-order bits are stripped from the ASCII representation of each character of the three-letter mnemonic. The 5-bit characters are packed into two 8-bit bytes, with one bit not used. The characters are restored to 8-bit form by adding hexadecimal 40 to the 5-bit value.*

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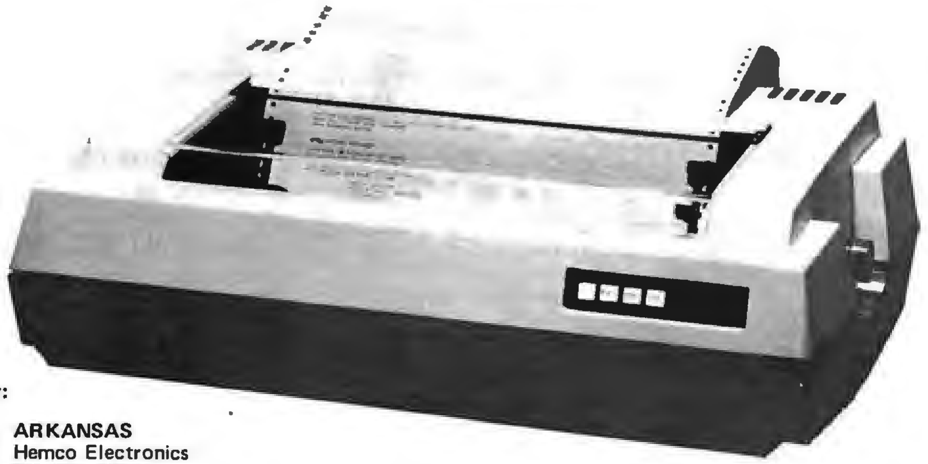

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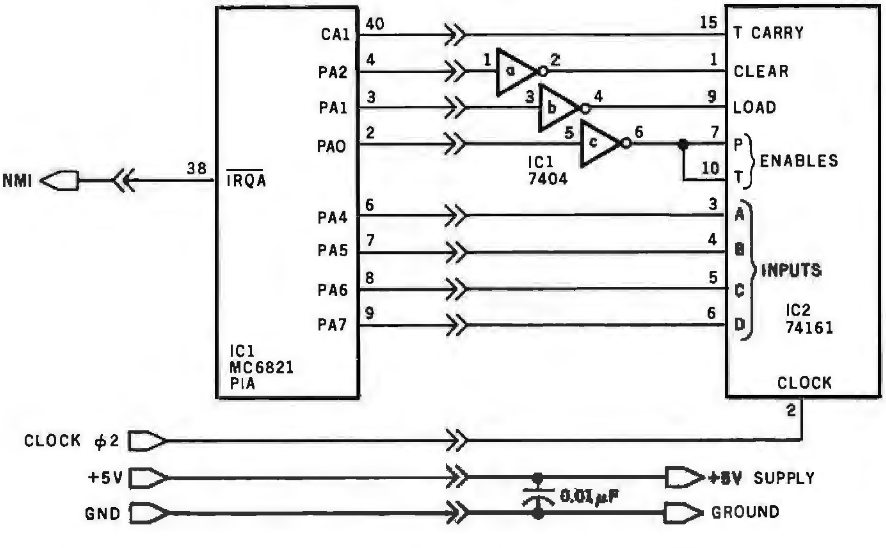

PIA I/O REGISTER A							
7	6	5	4	3	2	1	0
COUNT BIT 3	COUNT BIT 2	COUNT BIT 1	COUNT BIT 0		$\overline{\text{CLEAR}}$	$\overline{\text{LOAD}}$	$\overline{\text{ENABLE}}$

Figure 3: *Schematic diagram of the hardware cycle counter. The DEMONS system uses the nonmaskable interrupt (NMI) in the 6800.*

Number	Type	+5 V	GND
IC1	7404	14	7
IC2	74161	16	8

From the program's viewpoint, the counter clear is off when IORA bit 2 is a 1, counter load is off when IORA bit 1 is a 1, and counter enable is on when IORA bit 0 is 0. IORA bits 4, 5, 6, and 7 are used to output the value to be loaded into the counter, leaving IORA bit 3 unused.

The 74161 device in figure 3 is a 32 MHz synchronous 4-bit counter whose carry output will go high for a period equal to one full machine cycle when a count of 15 is reached. By presetting the counter, the carry output can be made to go high after 1 to 15 clock cycles.

I built the prototype version of the cycle counter on a perforated circuit board and attached it to the MP-L board, which supplies power and clock signals. You can see this mounting technique in photos 1 and 2. This assembly plugs into the motherboard and I/O board slot 3, giving it the hexadecimal address range 800C through 800F. If the cycle counter is to be plugged into some other slot, DEMONS will have to have the new address of IORA patched in at hexadecimal locations 03E9, 03EA, 040B, and 040C. DEMONS uses the nonmaskable interrupt (NMI), so the interrupt-request acknowledge (IRQA) line must be wired to the NMI input on the cycle counter's peripheral interface adapter board.

How the Cycle Counter Works

Upon start-up DEMONS initializes the peripheral interface adapter and loads an initial value of 6 (count 9 phase-2 clock cycles) into the counter. The counter is started and a return from interrupt (RTI) instruction is executed. The counter will reach the terminal count value and toggle the CA1 line one cycle before the RTI instruction completes execution. Upon completion of the RTI instruction, the processor will recognize the interrupt, save the registers in the stack, and transfer control to the DEMONS interrupt routine via the previously set NMI vector address.

DEMONS' interrupt processor will test the cycle counter's peripheral interface adapter control register A to verify that it was entered as a result of a valid interrupt. If the cycle counter did not cause the interrupt, the instruction at hexadecimal location

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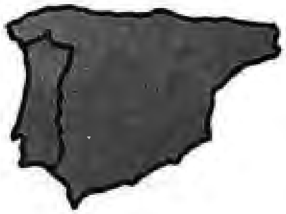

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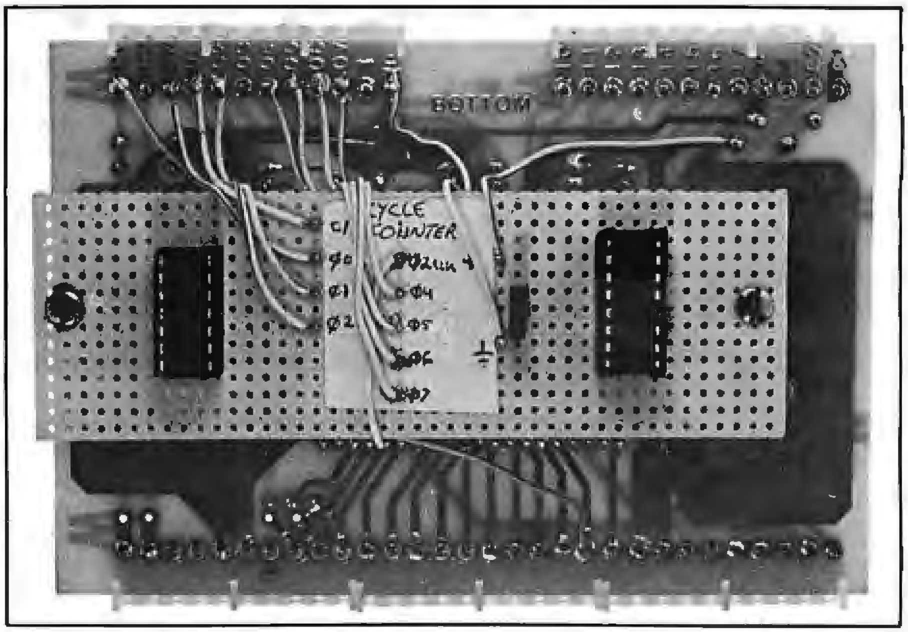

Photo 1: *The cycle-counter circuit was constructed on a small piece of perforated board and mounted on the MP-L parallel interface board inside the SwTPC 6800.*

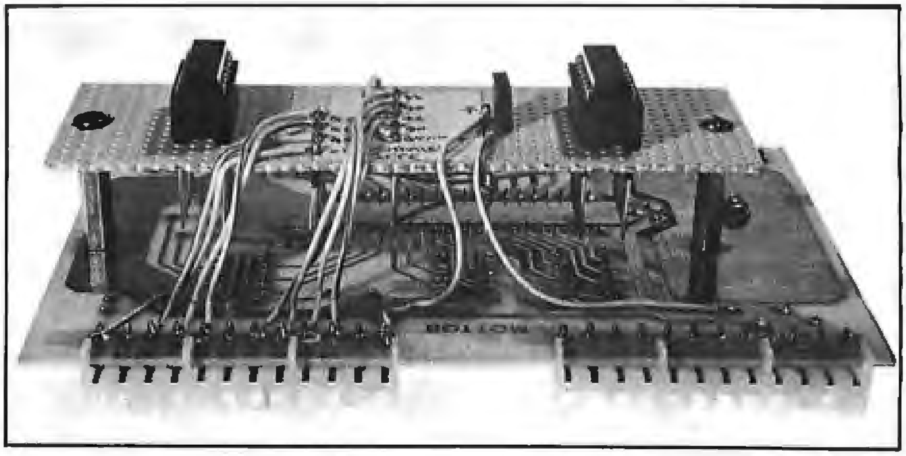

Photo 2: *Shown here is the method of mounting the cycle-counter circuit board.*

0411 will be executed. DEMONS is supplied with three no-operation instructions (NOPs) starting at this address. You should patch DEMONS to jump to another nonmaskable interrupt processing routine if the cycle counter is not the only source of nonmaskable interrupts.

If the interrupt is valid, the counter is halted, cleared, and reloaded with a value of 3. The registers are fetched from the stack and displayed on the terminal along with the next instruction to be executed, in this case the first instruction of the problem program. DEMONS then waits for the user to enter a command. If the *step* command is entered, the counter is started and a return from interrupt (RTI) instruction is executed. Twelve phase-2 ($\phi 2$) clock cycles later, the CA1 line is toggled, producing another nonmaskable interrupt. Since the RTI instruction takes 10 cycles to execute, the interrupt occurs during execution of the first instruction of the program that is being debugged. From this point on, interrupts will occur after the execution of the RTI instruction as *each* instruction of the program being debugged is executed.

Operational Modes

In *step* mode, DEMONS causes a single instruction of the program being debugged to be executed, and then seizes control of operations to

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Command	Description
S.	Step and execute from current address.
S*nnnn*	Set hexadecimal address *nnnn* as the new current address.
T*nnnn*.	Set trace mode and break address *nnnn*. Break count set to 1.
T*nnnn*,11	Set trace mode and break address *nnnn*. Set break count to 11.
C*nn*	Set condition codes to hexadecimal value *nn*.
B*nn*	Set B register to hexadecimal value *nn*.
A*nn*	Set A register to hexadecimal value *nn*.
X*nnnn*	Set X register to hexadecimal value *nnnn*.
R	Display registers.
D.	Display 14 instructions in disassembled form starting at the current address.
D*nnnn*	Display 14 instructions in disassembled form starting at hexadecimal address *nnnn*.
G	Exit from DEMONS and resume problem program execution at the current address.
P*nnnn*,oo oo ...	Patch memory starting at address *nnnn* with the hexadecimal values oo. Terminate entry with a carriage return.

Table 1: *Summary and description of the DEMONS command set.*

Dialogue at Terminal	Comments
*L	Command MIKBUG to load DEMONS from tape.
*G	Start DEMONS execution.
P *1E00*	Tell DEMONS where to start problem program being debugged.
CC B A X E1 00 00 3745	DEMONS displays registers.
1E00 BD 1E45 JSR $1E45	DEMONS displays the next instruction.
: *S.*	Operator commands an instruction step.
CC B A X E1 00 00 3745	DEMONS displays registers.
1E45 37 PSHB	DEMONS displays the next instruction.
:*T1E5F,03*	Enter trace mode.
: *S.*	Start tracing.

Table 2: *Example of a typical user work session with DEMONS, with commentary. Characters in italics have been typed by the user.*

	Simultaneous Interrupts	Processor Action
Early (PK) Mask	NMI and SWI	*treats as IRQ*
	NMI and IRQ	handles NMI first
	IRQ and SWI	handles SWI first
Later Masks	NMI and SWI	handles NMI first
	NMI and IRQ	handles NMI first
	IRQ and SWI	handles IRQ first

Table 3: *Sequence of interrupt handling in the Motorola 6800 microprocessor. Parts produced during early production runs used the PK chip mask, and demonstrate unexpected behavior under certain interrupt conditions, most notably the simultaneous occurrence of a nonmaskable hardware interrupt (NMI) and a software interrupt (SWI). The PK series of 6800 branches to the IRQ (maskable hardware interrupt) vector location whenever this happens. (Parts of the PK series have the letters PK inscribed somewhere on the surface of the package; therefore they may be identified.) Later production runs of the 6800 processor used an improved chip mask, and devices from these later runs handle interrupts in a more logical manner.*

The following rule holds true for all 6800 processors: in the case where the IRQ signal is overruled by one of the other two interrupts, the IRQ may be ignored and lost unless its interrupt signal has been latched. Fortunately, the IRQ signal from the peripheral interface adapter (PIA) is latched.

allow user input. At this point, the user can modify the program; alter the path taken through the program; change the contents of the condition code registers, index register, or either accumulator; display memory content in disassembled form; or enter the trace mode.

In *trace* mode, DEMONS continues to receive control following execution of problem program instructions, but the user is not given control (that is, a chance to input commands) until the *break* address (or breakpoint) is encountered and the break counter is decremented to 0. The user sets the break address and the break count. Once set, these cannot be cleared without going through DEMONS initialization or executing the program being debugged until the break address is encountered N times. The break address entered must always be the address of the op code (ie: first byte) of an instruction byte sequence. Once trace mode is selected, tracing will be started by entry of the step command. Using the trace feature, the user can avoid stepping through long loops and previously debugged code one instruction at a time. Table 1 shows the complete command set of DEMONS; table 2 shows an example of user interaction.

DEMONS may be exited by use of the GO function, which bypasses the counter start-up code, or by activating the system reset line (by hitting the reset switch).

Possible Problems

All debugging monitors have drawbacks; DEMONS is no exception. Since DEMONS relies on having the stack-pointer (SP) register properly set, code which uses the stack pointer as an index register must be bypassed using the step function. Any code that is synchronized with some external process or has critical timing requirements will be delayed by at least 130 machine cycles per instruction, causing possible errors. If a software interrupt (SWI) or regular maskable hardware interrupt (IRQ) occurs simultaneously with the cycle counter's nonmaskable interrupt (NMI), possible vectoring problems may occur. (Table 3 summarizes these effects.) Thus care must be

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I stated that the disassembler executes quickly, and will have to wait for input/output (I/O) operations when using terminals having data rates of up to about 3000 bits per second (bps). I calculated this figure by disassembling 128 instructions and noting the time required to complete this task (T1). The time required for I/O operations (T2) was determined from the following formula:

$$T2 = (C \times L) \times D$$

where:

C is the number of characters per line (32)
L is the number of lines in the test (128)
D is the time required to transmit one character (0.033 seconds at 300 bps)

The processor time required to disassemble the 128 instructions is then:

$$T_p = T1 - T2.$$

The disassembler is no longer I/O bound in speed of execution when $T_p = T2$ for the 128-line test. The system is I/O bound when $T_p < T2$, and is compute bound when $T_p > T2$.

taken when using DEMONS to avoid stepping through software interrupt (SWI) instructions. Likewise, I/O operations involving a regular maskable interrupt (IRQ) may not work correctly every time.

Other Considerations

Several extensions to DEMONS are possible. The *patch* function is not symbolic, but may be made so by using the disassembler tables in reverse and using a subset of the 6800 assembly language restricted to hexadecimal operands. This feature was not included in this version of DEMONS because of the need to avoid using excessive amounts of programmable memory. Another extension could be to allow the entry of multiple addresses for the trace function to compare against. This feature would be useful if a situation arose in which the program under test could take several possible and unpredictable paths.

To use the disassembler in stand-alone mode, control should be passed to hexadecimal location 0000. The disassembler will reply by outputting a blank character to the terminal. Enter the four-digit hexadecimal address of the area of memory whose contents are to be displayed. The disassembler will issue home-up and erase-to-end-of-frame cursor commands to the terminal and will begin displaying lines of disassembled code. When 15 instructions have been displayed, the disassembler will pause awaiting entry of the address of the next area of memory to be displayed. If a nonhexadecimal character is entered, MIKBUG will resume control.

DEMONS is started by transferring control to hexadecimal address 03CC. DEMONS will output the character P to the terminal and await entry of the four-digit hexadecimal address of the program to be debugged. Following entry of this address, the contents of the registers and the next instruction to be executed from the program being debugged will be displayed. DEMONS then issues a colon (:) as a prompt character and awaits entry of a command at the control terminal. If a format error is made while entering a command, DEMONS will output a question mark and again prompt for input.

The most efficient way to use DEMONS is to step through undebugged code a single instruction at a time, patching errors as they are encountered and correcting the contents of the registers when necessary, in an attempt to find as many bugs as possible in a single run. When the number of patches becomes unwieldy, or an unpatchable bug is found, or the last bug is found, only then should you reload the assembler and reassemble the problem program. This technique will reduce the number of times you have to load memory from your mass-storage device and so will increase productivity. ■

Listing 1: *The main debugging routine of DEMONS, assembled in code for the 6800 microprocessor. This program uses the cycle counter, shown in figure 3, to generate interrupts that allow it to take command from the user program.*

```
                                NAM      DEMON
                    *
                    * AUTHOR: A.I. HALSEMA
                    * DATE: 11/08/77
                    * OBJECT MACHINE: SWTPC 6800
                    * PROGRAM NAME: DEMON(S) VERSION 1.0
                    * DEBUG MONITOR (SYMBOLIC) INITIALIZATION
                    *
                    *           THIS ROUTINE READIES THE PIA AND STARTS THE HARDWARE CYCLE
                    *           COUNTER. IT WILL REQUEST THE STARTING ADDRESS OF THE CODE
                    *           TO BE DEBUGGED WITH A 'P' PROMPT. IT ALSO REMOVES TRACE
                    *           SETTINGS.
                                OPT      0
    03CC                        ORG      $03CC
                    *
          A075      XSAV        EQU      $A075                  X-REGISTER SAVE AREA
          A02F      STAK        EQU      $A02F                  DEMON(S) STACK ADDRESS
          A006      NMIV        EQU      $A006                  NMI INTERRUPT VECTOR ADDRESS
          E1D1      OUTEEE      EQU      $E1D1                  OUTPUT CHARACTER ROUTINE
          A078      TFLAG       EQU      $A078                  TRACE ACTIVE FLAG, 1= ACTIVE
          A00C      ADDR        EQU      $A00C                  ADDRESS STORAGE USED BY BADDR
          800C      HCCPIA      EQU      $800C                  CYCLE COUNTER PIA ADDRESS
          A07C      APPND       EQU      $A07C                  APPENDAGE ADDRESS FOR DISASM
          A077      LINES       EQU      $A077                  LINES FOR DISASM TO DISPLAY
          01A4      APP         EQU      $01A4                  APPENDAGE ADDRESS IN DISASM
          E0CA      OUT2HS      EQU      $E0CA                  OUTPUT 2 HEX DIGITS AND SPACE
```

Listing 1 continued on page 338

Listing 1 continued:

```
        E0C8    OUT4HS   EQU    $E0C8         OUTPUT 4 HEX DIGITS AND SPACE
        A079    TADDR    EQU    $A079         TRACE RECOGNITION ADDRESS
        E1AC    INEEE    EQU    $E1AC         CHARACTER INPUT ROUTINE
        E07E    PDATA1   EQU    $E07E         PRINT BLOCK ROUTINE
        0018    NEXTL    EQU    $0018           DISASSEMBLER ENTRY POINT
                *
                * DEMON(S) START-UP ENTRY POINT
                *
03CC 8E A02F START       LDS    #STAK         SET STACK ADDRESS
03CF 7F A078             CLR    TFLAG         RESET TRACE FLAG
03D2 BD 047D UG          JSR    CURL          ISSUE CR/LF
03D5 86 50               LDAA   #'P
03D7 BD E1D1             JSR    OUTEEE        ISSUE PROMPT
03DA BD 0482             JSR    BADDR         GET START OF PROBLEM PROGRAM
03DD 25 F3               BCS    UG            BAD INPUT- TRY AGAIN
03DF BD 0561             JSR    SETAD
03E2 CE 040A             LDX    #INTRP        SET UP NMI VECTOR
03E5 FF A006             STX    NMIV
03E8 CE 800C             LDX    #HCCPIA       INITIALIZE PIA/CYCLE COUNTER
03EB 6F 01               CLR    1,X          SELECT DDRA
03ED 86 FF               LDAA   #$FF         AND SET UP ALL LINES TO OUTPUTS
03EF A7 00               STAA   X
03F1 86 04               LDAA   #$04           SELECT IORA
03F3 A7 01               STAA   1,X
03F5 86 6B               LDAA   #$6B         TURN OFF COUNTER RESET
03F7 A7 00               STAA   X             AND SET INITIAL COUNTER VALUE
03F9 A6 00  SETUP        LDAA   X
03FB 84 F9               ANDA   #$F9         TURN OFF COUNTER LOAD
03FD A7 00               STAA   X
03FF 86 07               LDAA   #$07           ENABLE CA1 INTERRUPT ON LOW TO
0401 A7 01               STAA   1,X          ,HIGH TRANSITIONS
0403 A6 00               LDAA   X
0405 84 F8               ANDA   #$F8         START COUNTER
0407 A7 00               STAA   X
0409 3B                  RTI                  GO TO PROBLEM PROGRAM
                *
                * DEMON(S) INTERRUPT PROCESSOR AND OPERATOR COMMAND DECODING.
                *          ENTERED ONLY UPON OCCURENCE OF NMI INTERRUPT.
                *          LOCATION LABELLED 'USER' ALLOWS FOR PATCHING IN JUMPS
                *          TO FURTHER INTERRUPT PROCESSING IF MORE THAN ONE SOURCE
                *          OF NMI INTERRUPTS IS AVAILABLE.
                *
040A CE 800C INTRP       LDX    #HCCPIA       GET PIA ADDRESS
040D 6D 01               TST    1,X          ,AND CHECK FOR CYCLE COUNTER
040F 2B 03               BMI    MINE           ,INTERRUPT
0411 01     USER         NOP                  PATCH A JUMP TO SOME OTHER NMI
0412 01                  NOP                  ,PROCESS HERE, BECAUSE THIS
0413 01                  NOP                  ,INTERRUPT IS NOT FROM CYCLES.
0414 86 04  MINE         LDAA   #$04           DISABLE COUNTER INTERRUPTS
0416 A7 01               STAA   1,X
0418 86 3F               LDAA   #$3F          STOP COUNTER
041A A7 00               STAA   X
041C 86 3B               LDAA   #$3B          RESET COUNTER- SET LOAD VALUE
041E A7 00               STAA   X              , TO 3
0420 A6 00               LDAA   X              DUMMY READ TO INSURE NMI OFF
0422 30                  TSX
0423 EE 05               LDX    5,X          GET ADDRESS OF NEXT INSTRUCTION
0425 FF A00C             STX    ADDR         SET ADDRESS FOR DISASSEMBLER
0428 7D A078             TST    TFLAG         TRACE MODE RUNNING?
042B 27 0A               BEQ    NOT           IF NOT- BRANCH
042D BC A079             CPX    TADDR         TRACE FLAG SET- TEST ADDRESS
0430 26 52               BNE    NOPE          BRANCH IF WRONG ADDRESS
0432 7A A078             DEC    TFLAG         ADDRESSES ARE EQUAL- COUNT HIT
0435 26 4D               BNE    NOPE          IF NOT ZERO- GO TRACE SOME MORE
0437 86 01  NOT          LDAA   #$01           SET NUMBER OF LINES FOR DISASM
0439 B7 A077             STAA   LINES
043C 8D 2B               BSR    REGS          DO A CR LF AND DISPLAY REGISTERS
043E BD 056E             JSR    SHOLIN        DISPLAY INSTRUCTION
0441 86 3A  COMON        LDAA   #':           GET COMMAND- ISSUE PROMPT
0443 BD E1D1             JSR    OUTEEE
0446 BD E1AC             JSR    INEEE          GET INPUT
0449 CE 0578             LDX    #COMTAB       GET COMMAND TABLE ADDRESS
044C E6 00  TEST         LDAB   X             GET RECOGNITION CHARACTER
044E 11                  CBA                  SAME AS INPUT?
044F 26 04               BNE    MORE          IF NOT- GO LOOK AGAIN
0451 EE 01               LDX    1,X         EQUAL- GET CURRENT ADDRESS
0453 6E 00               JMP    X             GO DO IT TO IT
                *
0455 5D     MORE         TSTB                 FOUND END OF TABLE?
0456 27 05               BEQ    BAD           YES- TELL OPERATOR
0458 08                  INX                  NO- POINT TO NEXT ENTRY IN TABLE
0459 08                  INX
045A 08                  INX
045B 20 EF               BRA    TEST          AND GO TEST IT
                * INPUT IS BAD- TELL OPERATOR AND GIVE HIM ANOTHER CHANCE TO DO IT RIGHT
045D 86 3F  BAD          LDAA   #'?           DISPLAY QUESTION MARK
045F BD E1D1             JSR    OUTEEE
0462 8D 19  NEXT1        BSR    CURL          DO CARRIAGE RETURN/LINE FEED
0464 20 DB               BRA    COMON         AND GO TRY AGAIN
```

Listing 1 continued on page 340

Listing 1 continued:

```
                      *
                      *
                      * REGS- DISPLAY REGISTERS
                      *
0466 8D 15      REGS       BSR      CURL               DO CR/LF
0468 CE 059A               LDX      #CCL               DISPLAY 'CC B A X' CRLF
046B BD E07E               JSR      PDATA1
046E 30                    TSX                         GET STACK ADDRESS
046F 08                    INX                         CORRECT FOR REGS RETURN ADDRESS
0470 08                    INX
0471 BD E0CA               JSR      OUT2HS             DISPLAY CC
0474 BD E0CA               JSR      OUT2HS             DISPLAY B
0477 BD E0CA               JSR      OUT2HS             DISPLAY A
047A BD E0C8               JSR      OUT4HS             DISPLAY X
047D CE 05A4    CURL       LDX      #CRLF              DO CARRIAGE RETURN/LINE FEED
0480 BD E07E               JSR      PDATA1
0483 39                    RTS                         EXIT
                      *
0484 CE 800C    NOPE       LDX      #HCCPIA            GET PIA ADDRESS
0487 7E 03F9               JMP      SETUP              GO START COUNTER AND EXECUTE
                      *
                      * GET HEX INPUT
                      *
048A BD E1AC    INHEX      JSR      INEEE               GO GET CHARACTER
048D 80 30                 SUBA     #$30               HEX?
048F 2B 10                 BMI      BADHEX             NO- JUMP
0491 81 09                 CMPA     #$09                BETWEEN 0 AND $09?
0493 2F 0A                 BLE      OKHEX              YES- OK
0495 81 11                 CMPA     #$11              A OR GREATER?
0497 2B 08                 BMI      BADHEX             NO- ERROR
0499 81 16                 CMPA     #$16              F OR LESS?
049B 2E 04                 BGT      BADHEX             NO- ERROR
049D 80 07                 SUBA     #$07                ADJUST FOR A THROUGH F VALUES
049F 0C         OKHEX      CLC                         CLEAR ERROR FLAG
04A0 39                    RTS                         EXIT
04A1 0D         BADHEX     SEC
04A2 39                    RTS
                      *
                      *GET ONE BYTE OF HEX INPUT- EXIT WITH DIGIT IN A AND CARRY CLEAR IF OK.
                      *
04A3 8D E5      BYTE       BSR      INHEX              GET A DIGIT
04A5 25 0A                 BCS      BADB               BAD- NOT HEX- JUMP
04A7 48                    ASLA                        MOST SIGNIFICANT DIGIT, SO LEFT
04A8 48                    ASLA                        , JUSTIFY IT
04A9 48                    ASLA                        ,
04AA 48                    ASLA                        ,
04AB 16                    TAB                         , AND SAVE IN B-REGISTER
04AC 8D DC                 BSR      INHEX              GET LEAST SIGNIFICANT DIGIT
04AE 25 01                 BCS      BADB               IF INPUT IS BAD- JUMP
04B0 1B                    ABA                         COMBINE BOTH IN A
04B1 39         BADB       RTS                         EXIT
                      *
                      * BADDR- BUILD ADDRESS, RESULT IN $A00C AND X IF GOOD, ELSE CARRY SET.
                      *
04B2 8D EF      BADDR      BSR      BYTE               GET HEX BYTE
04B4 25 0D                 BCS      ADBAD              JUMP IF BAD
04B6 B7 A00C               STAA     ADDR               SAVE BYTE
04B9 8D E8                 BSR      BYTE               GET SECOND BYTE
04BB 25 06                 BCS      ADBAD              JUMP IF BAD
04BD B7 A00D               STAA     ADDR+1             SAVE IT
04C0 FE A00C               LDX      ADDR               GET IN X
04C3 39         ADBAD      RTS                         EXIT
                      *
                      * TRACE PROCESSING, COMMAND FORMAT: TXXXX, OR TXXXX,NN
                      *                             WHERE T IS THE COMMAND CHARACTER
                      *                                    XXXX IS A FOUR-DIGIT HEX ADDRESS
                      *                                    NN IS A TWO  DIGIT TRAP COUNT=$7F MAX.
                      *            TRACE MODE IS SET WITH THIS COMMAND, STEP COMMAND STARTS RUN.
                      *            THE PROBLEM PROGRAM WILL RUN UNTIL DEMON(S) HAS ENCOUNTERED
                      *            ADDRESS XXXX NN TIMES, WHEN IT WILL RETURN OPERATOR CONTROL.
                      *            ADDRESS XXXX MUST BE THE ADDRESS OF THE FIRST BYTE OF AN INSTRUCTION.
                      *            NOTE THAT ZERO IS A DISALLOWED VALUE FOR NN IN INPUT.
                      *            TXXXX. FORM SETS NN TO 01 AUTOMATICALLY.
04C4 8D EC      TRACE      BSR      BADDR              GO GET TRACE ADDRESS
04C6 25 95                 BCS      BAD                BAD INPUT
04C8 FF A079               STX      TADDR
04CB BD E1AC               JSR      INEEE               GET PERIOD OR COMMA
04CE 81 2E                 CMPA     #'.                PERIOD?
04D0 27 0F                 BEQ      SETONE             YES- SET TFLAG TO ONE
04D2 81 2C                 CMPA     #',                COMMA?
04D4 26 87                 BNE      BAD                NO- BAD INPUT
04D6 8D CB                 BSR      BYTE               IT IS COMMA- GET LOOP COUNT
04D8 25 83                 BCS      BAD
04DA 27 81                 BEQ      BAD
04DC B7 A078    SETT       STAA     TFLAG              SET IN TRACE FLAG
04DF 20 81      NEXT2      BRA      NEXT1              GO GET A COMMAND
04E1 86 01      SETONE     LDAA     #$01
04E3 20 F7                 BRA      SETT
```

Listing 1 continued on page 342

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Listing 1 continued:

```
                * STEP COMMAND PROCESSING, CAUSES TRANSFER OF CONTROL TO ADDRESS.
                *                 COMMAND FORMAT: SXXXX OR S,
                *                        WHERE XXXX IS A FOUR DIGIT HEX ADDRESS.
                *                 SXXXX FORM SETS NEW CURRENT ADDRESS
                *                 S, FORM STARTS RUN AT CURRENT ADDRESS.
                *
04E5 8D CB      STEP      BSR     BADDR            GO GET ADDRESS
04E7 25 98                BCS     NOPE             IF NOT HEX- ASSUME PERIOD
04E9 8D 76                BSR     SETAD            ELSE PUT ADDRESS IN STACK
04EB 7E 0437              JMP     NOT              DISPLAY AND GET NEXT COMMAND
04EE 01                   NOP
04EF 01                   NOP
04F0 01                   NOP
04F1 01                   NOP
                * GO COMMAND PROCESSING, CAUSES EXIT FROM DEMON(S) WITH CYCLE COUNTER
                *                       HALTED, USE WHEN FINISHED WITH DEBUGGING.
                *                       CONTROL IS PASSED TO THE CURRENT ADDRESS REACHED
                *                       WHILE STEPPING OR TRACING.
04F2 3B         GO        RTI                      EXIT FROM DEMON(S)
                * DISPLAY COMMAND PROCESSING, DISPLAYS 15 INSTRUCTIONS FROM MEMORY IN
                *                            DISASSEMBLED FORM,
                *                            COMMAND FORMS: DXXXX OR D,
                *                                   WHERE XXXX IS A 4 DIGIT HEX ADDRESS
                *                            D, CAUSES DISPLAY TO START WITH THE CURRENT
                *                            INSTRUCTION
04F3 7E 045D    DAB       JMP     BAD
04F6 86 0E      DISPLA    LDAA    #$0E             SET UP LINES FOR DISASM
04F8 B7 A077              STAA    LINES
04FB 8D B5                BSR     BADDR            GET ADDRESS
04FD 24 06                BCC     SHOW             IF NO ERROR ON ENTRY- BRANCH
04FF 30                   TSX                      GET ADDRESS FROM STACK
0500 EE 05                LDX     5,X
0502 FF A00C              STX     ADDR             ,AND SET FOR DISASSEMBLER
0505 86 10      SHOW      LDAA    #$10              HOME UP
0507 BD E101              JSR     OUTEEE
050A 8D 62                BSR     SHOLIN           GO DISPLAY INSTRUCTION
050C 20 D1                BRA     NEXT2            GET ANOTHER COMMAND
                * REGISTER DISPLAY, THE REGISTERS IN THE STACK ARE DISPLAYED,
                *                 COMMAND FORM: R
                *
050E BD 0466    SHOREG    JSR     REGS             DISPLAY REGISTERS
0511 7E 0441    BACKUP    JMP     COMON            GO GET ANOTHE COMMAND
                *
                * SUPPORT SUBROUTINE- GET INPUT AND PREPARE X REGISTER
                *
0514 8D 8D      BYN       BSR     BYTE             GET INPUT BYTE
0516 25 04                BCS     GAG              BAD VALUE?
0518 30                   TSX                      SET VALUE IN STACK
0519 08                   INX                      ADJUST ADDRESS FOR BEING IN A SUBROUTINE
051A 08                   INX
051B 39                   RTS
051C 31         GAG       INS
051D 31                   INS
051E 20 D3                BRA     DAB
                *
                * SET CONDITION CODE REGISTER. COMMAND FORM: CXX
                *                            WHERE XX IS A 2-DIGIT HEX VALUE THAT
                *                            THE CC REGISTER IN THE STACK WILL BE SET
                *                            TO.
                *
0520 8D F2      RSETC     BSR     BYN              GET INPUT BYTE
0522 A7 00      SETREG    STAA    X
0524 20 B9                BRA     NEXT2            GO GET ANOTHER COMMAND
                *
                * SET B-REGISTER,  COMMAND FORM: BXX
                *
0526 8D EC      RSETB     BSR     BYN              GET INPUT BYTE
0528 08         BSETS     INX
0529 20 F7                BRA     SETREG
                *
                * SET A-REGISTER,  COMMAND FORM: AXX
                *
052B 8D E7      RSETA     BSR     BYN
052D 08                   INX
052E 20 F8                BRA     BSETS
                * SET X-REGISTER,  COMMAND FORMAT: XNNNN
                *                  WHERE NNNN IS A 4-DIGIT HEX VALUE
                *
0530 BD 04B2    RSETX     JSR     BADDR            GET 4 DIGITS
0533 25 BE                BCS     DAB              BAD INPUT?
0535 30                   TSX                      NO- GET STACK ADDRESS
0536 09                   DEX                      SET X VALUE IN STACK
0537 09                   DEX
0538 09                   DEX
0539 8D 28                BSR     SETS
```

Listing 1 continued on page 344

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INTERNATIONAL MICRO SYSTEMS

For details on our demo special, contact us at:
8425 Quivira Road, Lenexa, Kansas 66215
Phone: (913) 888-8330

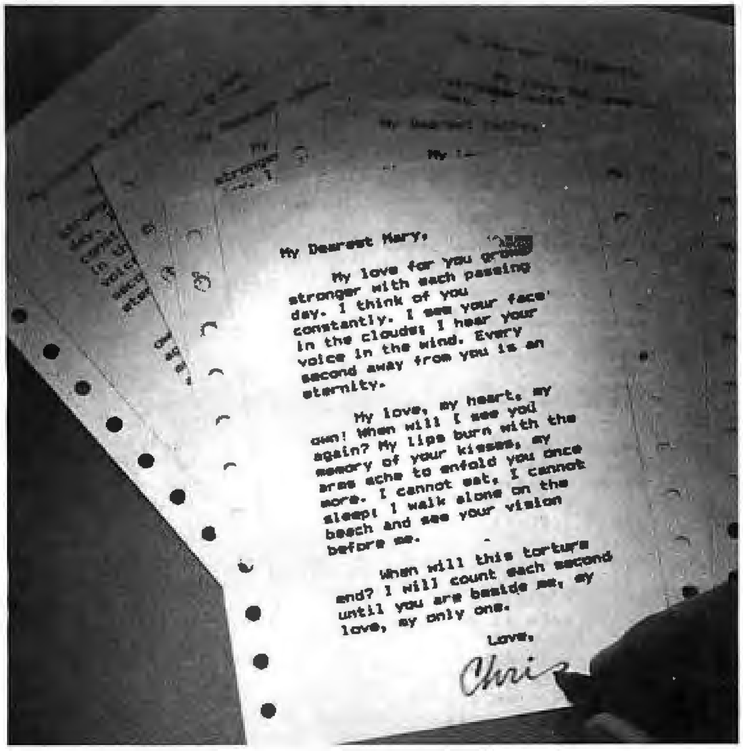
Circle 201 on inquiry card.

Listing 1 continued:

```
0538 20 A2   NEXT3    BRA    NEXT2
                      * PATCH COMMAND PROCESSOR, COMMAND FORMAT: PXXXX,NN NN NN ....(CR)
                      *                         WHERE XXXX IS A 4-DIGIT HEX ADDRESS
                      *                         AND NN IS A 2-DIGIT HEX VALUE
                      *       ENTER AS MANY 2 DIGIT VALUES AS NEEDED, THEN TERMINATE STRING
                      *       WITH A CARRIAGE RETURN, EACH NN VALUE IS PLACED IN MEMORY AS
                      *       IT IS ENTERED, UNLESS AN ERROR IS MADE, THEN THE NN VALUE
                      *       CONTAINING THE ERROR IS REJECTED AND IS NOT STORED.
                      *
053D BD 04B2 PATCH    JSR    BADDR              GET ADDRESS
0540 25 B1            BCS    DAH                JUMP IF NOT HEX
0542 FF A075 GETMOR   STX    XSAV               SAVE X FOR LATER
0545 BD 04A3 GETS     JSR    BYTE               GET 2 DIGIT VALUE
0548 25 0D            BCS    WHAT               JUMP IF NOT HEX
054A FE A075          LDX    XSAV               RESTORE X
054D A7 00            STAA   X                  .AND STORE THE VALUE
054F 08               INX                       POINT TO NEXT LOCATION
0550 86 20            LDAA   #'                 SPACE BETWEEN INPUTS
0552 BD E1D1          JSR    OUTEEE
0555 20 EB            BRA    GETMOR             GO GET MORE INPUT
0557 88 DD   WHAT     EORA   #$DD              INPUT NOT HEX- CARRIAGE CODE?
0559 27 E0            BEQ    NEXT3              JUMP IF YES
055B 88 21            EORA   #$21              COMMA?
055D 27 E6            BEQ    GETS               JUMP IF YES
055F 20 92            BRA    DAH                .ELSE ERROR IF NOT
                      *
                      * SUPPORT SUBROUTINE- MOVE ADDRESS INTO STACK
                      *
0561 30      SETAD    TSX                       PUT THE ADDRESS IN THE STACK
0562 08               INX
0563 B6 A00C SETS     LDAA   ADDR
0566 A7 06            STAA   6,X
0568 B6 A00D          LDAA   ADDR+1
056B A7 07            STAA   7,X
056D 39               RTS
                      *
                      * SUPPORT SUBROUTINE- SET APPENDAGE ADDRESS AND CALL DISASSEMBLER
                      *
056E CE 01A4 SHOLIN   LDX    #APP               SET APPENDAGE FOR DISASSEMBLER
0571 FF A07C          STX    APPND
0574 BD 0018          JSR    NEXTL              GO TO DISASSEMBLER
0577 39               RTS
                      * COMMAND TABLE, EACH ENTRY IS 3 BYTES LONG, THE FIRST BYTE IS THE ASCII
                      *            COMMAND CHARACTER, THE NEXT 2 BYTES ARE THE PROCESS
                      *            ADDRESS, THE TABLE IS TERMINATED WITH A BYTE OF ZEROS.
                      *
0578 53      COMTAB   FCC    /S/                STEP COMMAND
0579 04E5             FDB    STEP
057B 54               FCC    /T/                TRACE COMMAND
057C 04C4             FDB    TRACE
057E 52               FCC    /R/                REGISTER DISPLAY
057F 050E             FDB    SHOREG
0581 47               FCC    /G/                GO COMMAND
0582 04F2             FDB    GO
0584 44               FCC    /D/                DISPLAY COMMAND
0585 04F6             FDB    DISPLA
0587 43               FCC    /C/                SET CONDITION CODES
0588 0520             FDB    RSETC
058A 41               FCC    /A/                SET A-REGISTER
058B 052B             FDB    RSETA
058D 42               FCC    /B/                SET B-REGISTER
058E 0526             FDB    RSETB
0590 58               FCC    /X/                SET X-REGISTER
0591 0530             FDB    RSETX
0593 50               FCC    /P/                PATCH
0594 053D             FDB    PATCH
0596 00               FCB    0,0,0              SPACE FOR PATCHING AN ENTRY
0597 00
0598 00
0599 00               FCB    0                  END OF TABLE
                      * REGISTER IDENTIFICATION
059A 43      CCL      FCC    /CC B  A  X/       REGISTER ID LINE
059B 43
059C 20
059D 42
059E 20
059F 20
05A0 41
05A1 20
05A2 20
05A3 58
05A4 0D      CRLF     FCB    $0D,$0A,4          CARRIAGE RETURN/LINE FEED
05A5 0A
05A6 04
                      END
```

Listing 2 starts on page 346
Listing 3 is on page 358

We're known for our fine print.



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The type you get out of most printers you wouldn't send to your maiden aunt, much less use for your *important* correspondence. And up to now, in order to get a dot matrix hardcopy you could really call correspondence quality, you had to spend on the high side of a thousand bucks.

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For starters, it features the world's first *disposable* print head—after it's printed between 50 and 100-million characters, just throw it away. A new one costs less than $30 and you can change it yourself with one hand. Plus, the MX-80 prints bidirectionally and 80 CPS with a logical seeking function to minimize print head travel time and maximize throughput. Finally—and this is the best part—you can buy an MX-80 right now for less than $650.

And that's what we call a lot of fine print for the money.

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Circle 152 on inquiry card.

Listing 2: *The disassembler routine included as part of DEMONS. The packed-mnemonic table and format table occupy much space.*

```
                                NAM     DISASM
                          *
                          * AUTHOR: A.I. HALSEMA
                          * DATE: 10-28-1977
                          * OBJECT MACHINE: SWTPC 6800
                          * PROGRAM NAME: DISASSEMBLER VERSION 1.1
                          *
                                OPT     0
0000                            ORG     $0000
          E047      BADDR       EQU     $E047
          A00C      ADDR        EQU     $A00C
          E07E      PDATA1      EQU     $E07E
                          *
                          * OPERATOR INTERFACE
                          *
0000 BD E047 START      JSR     BADDR           GET DUMP ADDRESS FROM OPERATOR VIA MIKBUG
0003 86 0F              LDAA    #15             SET # OF LINES TO DUMP
0005 B7 A077            STAA    LINES
0008 CE 0169            LDX     #ERASE          ERASE CRT SCREEN
000B BD E07E            JSR     PDATA1
000E CE 01A4            LDX     #APP            SET APPENDAGE ROUTINE ADDRESS
0011 FF A07C            STX     APPND
0014 8D 02              BSR     NEXTL
0016 20 E8              BRA     START
                          * DISASSEMBLER, ENTER WITH DISPLAY START ADDRESS AT $A00C,
                          *       NUMBER OF LINES TO DISPLAY AT LABEL 'LINES',
                          *     SET ADDRESS OF APPENDAGE ROUTINE AT A07C
                          *       ENTER VIA JSR,
                          *     EACH TIME A LINE IS READY, APPENDAGE RECIEVES CONTROL VIA JSR, RETURN VIA RTS,
                          *       EXIT WITH $A00C CONTAINING ADDRESS OF NEXT
                          *       INSTRUCTION, LOCATION $A04A CONTAINING 32
                          *       BYTES OF ASCII TEXT TERMINATED BY CR,LF,04,
                          *       LOCATION 'LINES' WILL CONTAIN ZERO,
0018 FE A00C NEXTL      LDX     ADDR            GET ADDRESS OF DATA
001B A6 00              LDAA    X               GET DATA BYTE
001D CE A06B            LDX     #WORKA
0020 A7 03              STAA    BYTE,X          SAVE IT
0022 5F                 CLRB                    NOW MULTIPLY BY 2
0023 48                 ASLA
0024 59                 ROLB
0025 AB 02              ADDA    TAD+1,X         ADD MNEMONIC TABLE ADDRESS
0027 E9 01              ADCB    TAD,X
0029 A7 07              STAA    BASE+1,X        SAV THE DISPLACEMENT INTO TABLE
002B E7 06              STAB    BASE,X
002D A6 03              LDAA    BYTE,X          GET HIGH ORDER NYBBLE
002F 44                 LSRA
0030 44                 LSRA                    RIGHT JUSTIFY IT
0031 44                 LSRA                    AND MULTIPLY BY 2
0032 84 FE              ANDA    #$FE
0034 5F                 CLRB
0035 AB 05              ADDA    FAD+1,X         ADD BASE OF FLAG TABLE
0037 E9 04              ADCB    FAD,X
0039 A7 09              STAA    FLAGA+1,X       SET POINTER INTO FLAG TABLE
003B E7 08              STAB    FLAGA,X
003D CE A04A            LDX     #LINE           BLANK THE DISPLAY LINE
0040 C6 1B              LDAB    #27
0042 86 20              LDAA    #$20
0044 A7 04   BLOP       STAA    4,X
0046 08                 INX
0047 5A                 DECB
0048 26 FA              BNE     BLOP
004A 86 04              LDAA    #4              SET EOL MARKER
004C A7 05              STAA    5,X
004E CE 0D0A            LDX     #$0D0A          SET CRLF IN LINE
0051 FF A068            STX     LINE+30
0054 FE A071            LDX     WBAS            GET THE PACKED MNEMONIC
0057 A6 00              LDAA    X               AND EXPAND INTO DISPLAY LINE
0059 84 7F              ANDA    #$7F
005B E6 01              LDAB    1,X
005D 44                 LSRA
005E 56                 RORB
005F 44                 LSRA
0060 56                 RORB
0061 8B 40              ADDA    #$40
0063 B7 A058            STAA    OPER
0066 54                 LSRB
0067 54                 LSRB
0068 54                 LSRB
0069 CB 40              ADDB    #$40
006B F7 A059            STAB    OPER+1
006E A6 01              LDAA    1,X
0070 84 1F              ANDA    #$1F
0072 8B 40              ADDA    #$40
0074 B7 A05A            STAA    OPER+2
0077 A6 00              LDAA    X               GET HI BYTE AGAIN
0079 81 18              CMPA    #$18            TEST FOR FCB MNEMONIC
007B 26 05              BNE     NFC             NOT FCB
007D CE 03CB            LDX     #FFLAG          IS FCB- SET FCB FLAG ADDRESS
0080 20 26              BRA     OFF
```

Listing 2 continued on page 348

When Eight Is Not Enough: CP/M-86™ and CBASIC/86™

"In 1977 Compiler Systems, Inc. introduced CBASIC™ as a CP/M® programming language. It quickly became the most widely used BASIC dialect. Since then CBASIC has been adapted for use on systems supporting MP/M™ and TRSDOS."

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—Gordon Eubanks, CSI president

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Sierra Madre, CA 91024, (213) 355-1063

Listing 2 continued:

```
                    **********************************************
0082 F6 A06E NFC            LDAB     WBYT              TEST FOR EXCEPTIONS
0085 C1 37                  CMPB     #$37              PULB?
0087 26 05                  BNE      TPSH
0089 CE 03B5                LDX      #PULB
008C 20 1A                  BRA      OFF
008E C1 33   TPSH           CMPB     #$33              PSHB?
0090 26 05                  BNE      TBSR
0092 CE 03B5                LDX      #PULB
0095 20 11                  BRA      OFF
0097 C8 8D   TBSR           EORB     #$8D              BSR?
0099 26 05                  BNE      SET
009B CE 03AF                LDX      #BSR
009E 20 08                  BRA      OFF
                    **********************************************
        00A0 SET            EQU      *
00A0 FE A073                LDX      WFLG              GET FLAG ADDRESS
00A3 85 80                  BITA     #$80              TEST FLAG BIT
00A5 27 01                  BEQ      OFF               BIT IS OFF
00A7 08                     INX                        BIT IS ON- POINT TO 2ND FLAG
00A8 A6 00   OFF            LDAA     X                 GET THE FLAG
00AA B7 A06B                STAA     FLAGD             ,AND SAVE IT
00AD CE A04A                LDX      #AADR             POINT ASCII ADDRESS IN LINE
00B0 B6 A00C                LDAA     ADDR              GET CURRENT ADDRESS
00B3 8D 2A                  BSR      CVASC             CONVERT TO ASCII
00B5 B6 A00D                LDAA     ADDR+1            SAME FOR LOW BYTE
00B8 8D 25                  BSR      CVASC
00BA B6 A06E                LDAA     WBYT              GET CURRENT BYTE
00BD 08                     INX                        LEAVE SPACE BETWEEN ADDR,+ DATA
00BE 8D 1F                  BSR      CVASC             CURRENT BYTE TO ASCII
00C0 F6 A06B                LDAB     FLAGD             GET FLAG DATA
00C3 C4 03                  ANDB     #$3               SAVE ONLY INSTRUCTION LENGTH
00C5 F7 A07B                STAB     SIZE              SAVE IT
00C8 08                     INX
00C9 FF A075 CLOP           STX      XSAV              SAVE POINTER INTO DISPLAY LINE
00CC FE A00C                LDX      ADDR              GET DATA ADDRESS
00CF 08                     INX
00D0 5A                     DECB                       COUNT BYTES
00D1 27 10                  BEQ      NMR               NO MORE
00D3 A6 00                  LDAA     X                 GET DATA
00D5 FF A00C                STX      ADDR
00D8 FE A075                LDX      XSAV
00DB 8D 02                  BSR      CVASC             AND PUT IN DISPLAY LINE AS OBJ.
00DD 20 EA                  BRA      CLOP
00DF 7E 018C CVASC          JMP      TOASC
00E2 FF A00C NMR            STX      ADDR              X NOW POINTS TO NEXT DATA
00E5 B6 A06B                LDAA     FLAGD             GET FLAG DATA
00E8 85 40                  BITA     #$40              SET REGISTER A?
00EA 27 07                  BEQ      NOTA              NO
00EC 86 41                  LDAA     #'A               YES- ADD TO ASCII MNEMONIC
00EE B7 A05B SETR           STAA     OPER+3
00F1 20 08                  BRA      FORM
00F3 85 80   NOTA           BITA     #$80              SET REGISTER B?
00F5 27 04                  BEQ      FORM              NO- NO REGISTER SYMBOL
00F7 86 42                  LDAA     #'B               YES
00F9 20 F3                  BRA      SETR
00FB CE A05E FORM           LDX      #ARG              POINT ARGUMENT POSITION IN LINE
00FE B6 A06B                LDAA     FLAGD             GET FORMAT CODE
0101 44                     LSRA
0102 44                     LSRA
0103 84 07                  ANDA     #7
0105 27 0F                  BEQ      DISPLY            INHERENT FORMAT
0107 4A                     DECA
0108 27 1A                  BEQ      REL               RELATIVE FORMAT
010A 4A                     DECA
010B 27 3D                  BEQ      IND               INDEXED FORMAT
010D 4A                     DECA
010E 27 46                  BEQ      IMM               IMMEDIATE FORMAT
0110 80 03                  SUBA     #3                FCB?
0112 27 49                  BEQ      FCBFR
0114 8D 57   DOMV           BSR      SETM              NONE OF THE ABOVE- MUST BE EXTENDED OR DIRECT
0116 FE A07C DISPLY         LDX      APPND             GET APPENDAGE ROUTINE ADDRESS
0119 AD 00                  JSR      X
011B 7A A077                DEC      LINES             COUNT LINES
011E 27 03                  BEQ      FIN               ALL DONE?
0120 7E 0018                JMP      NEXTL             NO- DO NEXT LINE
0123 39              FIN    RTS                 GO AWAIT NEXT COMMAND
                    * FORMAT ARGUMENT FIELD FOR A RELATIVE INSTRUCTION
0124 8D 47   REL            BSR      SETM              SET S AND MOVE BYTES
0126 FE A00C                LDX      ADDR              POINT TO DATA
0129 09                     DEX
012A 4F                     CLRA                       CALCULATE EFFECTIVE ADDRESS OF
012B E6 00                  LDAB     X                  RELATIVE INSTRUCTION
012D 2A 01                  BPL      POS
012F 43                     COMA
0130 FB A00D POS            ADDB     ADDR+1
0133 B9 A00C                ADCA     ADDR
0136 01                     NOP
0137 01                     NOP
0138 01                     NOP
0139 CE A064                LDX      #ABS+1
013C 8D 4E                  BSR      TOASC
```

Listing 2 continued on page 350

Listing 2 continued:

```
013E 17                 TBA
013F 01                 NOP
0140 01                 NOP
0141 8D 49              BSR     TOASC
0143 86 24              LDAA    #'$
0145 B7 A063            STAA    ABS
0148 20 CC              BRA     DISPLY
                * FORMAT ARGUMENT FIELD FOR AN INDEXED INSTRUCTION
014A 8D 21      IND     BSR     SETM                 SET $ AND MOVE BYTES
014C 86 2C              LDAA    #',                  APPEND ,X TO FIELD
014E A7 01              STAA    1,X
0150 86 58              LDAA    #'X
0152 A7 02              STAA    2,X
0154 20 C0              BRA     DISPLY
                * FORMAT ARGUMENT FIELD FOR AN IMMEDIATE INSTRUCTION
0156 86 23      IMM     LDAA    #'#                  PRECEED FIELD WITH A #
0158 A7 00              STAA    X
015A 08                 INX
015B 20 B7              BRA     DOMV
                * FORMAT ARGUMENT FIELD FOR AN FCB PSEUDO
015D 86 24      FCBFR   LDAA    #'$                MOVE DATA FOR FCB
015F A7 00              STAA    X
0161 FE A04F            LDX     LINE+5
0164 FF A05F            STX     ARG+1
0167 20 AD              BRA     DISPLY
0169 10         ERASE   FCB     $10,$16,$04
016A 16
016B 04
016C 01                 NOP
                * GENERAL ARGUMENT FIELD FORMATTING
016D 86 24      SETM    LDAA    #'$.                 SET DOLLAR SIGN
016F A7 00              STAA    X
0171 BF A073            STS     WFLG                 PREPARE TO MOVE BYTES
0174 8E A051            LDS     #LINE+7
0177 F6 A07B            LDAB    SIZE               GET OBJECT INPUT SIZE
017A C1 03              CMPB    #3                 IF SIZE= 3, MOVE 4 BYTES OF ASCII
017C 26 01              BNE     DLOOP
017E 5C                 INCB
017F 08         DLOOP   INX
0180 32                 PULA
0181 A7 00              STAA    X
0183 5A                 DECB
0184 26 F9              BNE     DLOOP
0186 BE A073            LDS     WFLG               RESTORE SP
0189 39                 RTS
018A 01                 NOP
018B 01                 NOP
                * CONVERT CONTENTS OF A TO ASCII AND STORE AT ADDRESS POINTED TO BY X,
                * RETURN WITH X INCREMENTED AND B UNCHANGED.
018C 37         TOASC   PSHB                       SAVE B
018D 16                 TAB                        COPY A
018E 44                 LSRA                       GET LEFT NYBBL
018F 44                 LSRA
0190 44                 LSRA
0191 44                 LSRA
0192 8D 04              BSR     ASC                CONVERT TO ASCII AND STORE
0194 17                 TBA
0195 84 0F              ANDA    #$F                GET RIGHT NYBBL
0197 33                 PULB                      RESTORE B
0198 8B 30      ASC     ADDA    #$30               CONVERT A DIGIT TO ASCII
019A 81 39              CMPA    #$39
019C 23 02              BLS     OU
019E 8B 07              ADDA    #$7
01A0 A7 00      OU      STAA    X
01A2 08                 INX
01A3 39                 RTS
                * APPENDAGE FOR LINE DISPLAY
01A4 CE A04A    APP     LDX     #LINE                GET ADDRESS OF TEXT.
01A7 BD E07E            JSR     PDATA1             DISPLAY THE LINE
01AA 39                 RTS
                *
                * PACKED MNEMONIC TABLE
                *
                *  MNEMONICS (ALPHA ONLY) ARE TRUNCATED TO THE 5 LOW ORDER BITS
                *  AND STORED 3 IN 16 BITS.  THE HIGH ORDER BIT OF THE 16 IS USED
                *  AS A FLAG WHICH, IF SET, INDICATES THAT THE SECOND FORMAT FLAG
                *  BYTE OF A PAIR SHOULD BE USED.
01AB 1862       MTAB    FDB     $1862                FCB     00
01AD 39F0               FDB     $39F0                NOP     01
01AF 1862               FDB     $1862                FCB     02
01B1 1862               FDB     $1862                FCB     03
01B3 1862               FDB     $1862                FCB     04
01B5 1862               FDB     $1862                FCB     05
01B7 5030               FDB     $5030                TAP     06
01B9 5201               FDB     $5201                TPA     07
01BB 25D8               FDB     $25D8                INX     08
01BD 1088               FDB     $1088                DEX     09
01BF 0D96               FDB     $0D96                CLV     0A
01C1 4CB6               FDB     $4CB6                SEV     0B
01C3 0D83               FDB     $0D83                CLC     0C
01C5 4CA3               FDB     $4CA3                SEC     0D
```

Listing 2 continued on page 352

☆☆

4MHZ, DOUBLE DENSITY, COLOR & B/W GRAPHICS . . THE LNW80 COMPUTER

COMPARE THE FEATURES AND PERFORMANCE

FEATURES	LNW80	PMC-80**	TRS-80* MODEL III
PROCESSOR	4.0 MHZ	1.8 MHZ	2.0 MHZ
LEVEL II BASIC INTERP.	YES	YES	LEVEL III BASIC
TRS80 MODEL 1 LEVEL II COMPATIBLE	YES	YES	NO
48K BYTES RAM	YES	YES	YES
CASSETTE BAUD RATE	500/1000	500	500/1500
FLOPPY DISK CONTROLLER	SINGLE/ DOUBLE	SINGLE	SINGLE/ DOUBLE
SERIAL RS232 PORT	YES	YES	YES
PRINTER PORT	YES	YES	YES
REAL TIME CLOCK	YES	YES	YES
24 X 80 CHARACTERS	YES	NO	NO
VIDEO MONITOR	YES	YES	YES
UPPER AND LOWER CASE	YES	OPTIONAL	YES
REVERSE VIDEO	YES	NO	NO
KEYBOARD	63 KEY	53 KEY	53 KEY
NUMERIC KEY PAD	YES	NO	YES
B/W GRAPHICS, 128 X 48	YES	YES	YES
HI-RESOLUTION B/W GRAPHICS, 480 X 192	YES	NO	NO
HI-RESOLUTION COLOR GRAPHICS (NTSC), 128 X 192 IN 8 COLORS	YES	NO	NO
HI-RESOLUTION COLOR GRAPHICS (RGB), 384 X 192 IN 8 COLORS	OPTIONAL	NO	NO
WARRANTY	6 MONTHS	90 DAYS	90 DAYS
TOTAL SYSTEM PRICE	$1,664.00	$1,840.00	$2,187.00
LESS MONITOR AND DISK DRIVE	$1,200.00	$1,375.00	---

When you've compared the features of an LNW80 Computer, you'll quickly understand why the LNW80 is the ultimate TRS80 software compatible system. LNW RESEARCH offers the most complete microcomputer system at an outstanding low price.
We back up our product with an unconventional 6 month warranty and a 10 days full refund policy, less shipping charges.

LNW80 Computer $1,200.00
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* TRS80 Product of Tandy Corporation.
** PMC Product of Personal Microcomputer, Inc.

LNW80

- BARE PRINTED CIRCUIT BOARD & MANUAL $89.95

The LNW80 - A high-speed color computer totally compatible with the TRS-80*. The LNW80 gives you the edge in satisfying your computation needs in business, scientific and personal computation. With performance of 4 MHz, Z80A CPU, you'll achieve performance of over twice the processing speed of a TRS-80*. This means you'll get the performance that is comparable to the most expensive microcomputer with the compatibility to the world's most popular computer (TRS-80*) resulting in the widest software base.

FEATURES:
- TRS-80 Model 1 Level II Software Compatible
- High Resolution Graphics
  - RGB Output - 384 x 192 in 8 Colors
  - NTSC Video or RF MOD - 128 x 192 in 8 Colors
  - Black and White - 480 x 192
- 4 MHz CPU
- 500/1000 Baud Cassette
- Upper and Lower Case
- 16K Bytes RAM, 12K Bytes ROM
- Solder Masked and Silkscreened

LNW SYSTEM EXPANSION

- BARE PRINTED CIRCUIT BOARD AND MANUAL $69.95
WITH GOLD CONNECTORS $84.95

The System Expansion will allow you to expand your LNW80, TRS-80*, or PMC-80** to a complete computer system that is still totally software compatible with the TRS-80* Model 1 Level II.

FEATURES:
- 32K Bytes Memory
- 5" Floppy Controller
- Serial RS232 120ma I/O
- Parallel Printer
- Real Time Clock
- Screen Printer Bus
- On Board Power Supply
- Solder Masked and Silkscreened

KEYBOARD

LNW80 KEYBOARD KIT $84.95

The Keyboard Kit contains a 63 key plus a 10 key, P.C. board, and remaining components.

LNDoubler

- Assembled and Tested $149.00

Double-density disk storage for the LNW Research's "System Expansion" or the Tandy's "Expansion Interface". The LNDoubler™ is totally software compatible with any double density software generated for the Percom's Doubler***. The LNDoubler™ provides the following outstanding features.

- Store up to 350K bytes on a single 5" disk
- Single and double density data separation
- Precision write precompensation circuit
- Software switch between single and double density
- Hardware override into single density only
- Easy plug in installation requiring no etch cuts, jumpers or soldering
- 35, 40, 77, 80 track 5" disk operation
- 120 day parts and labor Warranty

*** Doubler is a product of Percom Data Company, Inc.

DOS PLUS 3.2D $95.00

Micro Systems software's double density disk operating system. This operating system contains all the outstanding features of a well developed DOS, with ease in useability.

LNW DATA SEPERATOR

- Assembled and Tested $17.95

The LNW Data Separator provides you with a reliable and inexpensive means of solving your disk data read error problems for your 5" single density drives. Compatible with both the LNW System Expansion and Tandy's Expansion Interface. Some soldering is required.

CASE

LNW80 CASE $84.95

The streamline design of this metal case will house the LNW80, LWN System Expansion, LNW80 Keyboard, power supply and fan, LNDoubler™, or LNW Data Separator. This kit includes all the hardware to mount all of the above. Add $12.00 for shipping

PARTS AVAILABLE FROM LNW RESERARCH
4116 - 200ns RAM
6 chip set $26.00
8 chip set $33.50
16 chip set $64.00
24 chip set $94.00
32 chip set $124.00

- LNW80 "Start up parts set" LNW80-1 . . . . $82.00
- LNW80 "Video parts set" LNW80-2 . . . . $31.00
- LNW80 Transformer LNW80-3 . . . . $18.00
- LNW80 Keyboard cable LNW80-4 . . . . $16.00
- 40 Pin computer to expansion cable $15.00
- System Expansion Transformer $19.00
- Floppy Controller (FD1771) and UART (TR1602) . . . $30.00

LNW RESEARCH
C O R P O R A T I O N
14661–C MYFORD RD.
TUSTIN CA. 92680

Circle 219 on inquiry card.

VISA & MASTER CHARGE ACCEPTED Add $3.00 for shipping
ORDERS & INFO. NO. 714-552-8946
SERVICE NO. 714-641-8850

Listing 2 continued:

```
01C7 0D89    FDB   $0D89    CLI     0E
01C9 4CA9    FDB   $4CA9    SEI     0F
01CB 4C41    FDB   $4C41    SBA     10
01CD 0C41    FDB   $0C41    CBA     11
01CF 1862    FDB   $1862    FCB     12
01D1 1862    FDB   $1862    FCB     13
01D3 1862    FDB   $1862    FCB     14
01D5 1862    FDB   $1862    FCB     15
01D7 5022    FDB   $5022    TAB     16
01D9 5041    FDB   $5041    TBA     17
01DB 1862    FDB   $1862    FCB     18
01DD 1021    FDB   $1021    DAA     19
01DF 1862    FDB   $1862    FCB     1A
01E1 0441    FDB   $0441    ABA     1B
01E3 1862    FDB   $1862    FCB     1C
01E5 1862    FDB   $1862    FCB     1D
01E7 1862    FDB   $1862    FCB     1E
01E9 1862    FDB   $1862    FCB     1F
01EB 0A41    FDB   $0A41    BRA     20
01ED 1862    FDB   $1862    FCB     21
01EF 0909    FDB   $0909    BHI     22
01F1 0993    FDB   $0993    BLS     23
01F3 0863    FDB   $0863    BCC     24
01F5 0873    FDB   $0873    BCS     25
01F7 09C5    FDB   $09C5    BNE     26
01F9 08B1    FDB   $08B1    BEQ     27
01FB 0AC3    FDB   $0AC3    BVC     28
01FD 0AD3    FDB   $0AD3    BVS     29
01FF 0A0C    FDB   $0A0C    BPL     2A
0201 09A9    FDB   $09A9    BMI     2B
0203 08E5    FDB   $08E5    BGE     2C
0205 0994    FDB   $0994    BLT     2D
0207 08F4    FDB   $08F4    BGT     2E
0209 0985    FDB   $0985    BLE     2F
020B 5278    FDB   $5278    TSX     30
020D 25D3    FDB   $25D3    INS     31
020F C2AC    FDB   $C2AC    PUL A   32
0211 42AC    FDB   $42AC    PUL B   33   EXCEPTION
0213 10B3    FDB   $10B3    DES     34
0215 5313    FDB   $5313    TXS     35
0217 C268    FDB   $C268    PSH A   36
0219 4268    FDB   $4268    PSH B   37   EXCEPTION
021B 1862    FDB   $1862    FCB     38
021D 4A93    FDB   $4A93    RTS     39
021F 1862    FDB   $1862    FCB     3A
0221 4A89    FDB   $4A89    RTI     3B
0223 1862    FDB   $1862    FCB     3C
0225 1862    FDB   $1862    FCB     3D
0227 5C29    FDB   $5C29    WAI     3E
0229 4EE9    FDB   $4EE9    SWI     3F
022B 38A7    FDB   $38A7    NEG A   40
022D 1862    FDB   $1862    FCB     41
022F 1862    FDB   $1862    FCB     42
0231 0DED    FDB   $0DED    COM A   43
0233 3272    FDB   $3272    LSR A   44
0235 1862    FDB   $1862    FCB     45
0237 49F2    FDB   $49F2    ROR A   46
0239 0672    FDB   $0672    ASR A   47
023B 066C    FDB   $066C    ASL A   48
023D 49EC    FDB   $49EC    ROL A   49
023F 10A3    FDB   $10A3    DEC A   4A
0241 1862    FDB   $1862    FCB     4B
0243 25C3    FDB   $25C3    INC A   4C
0245 5274    FDB   $5274    TST A   4D
0247 1862    FDB   $1862    FCB     4E
0249 0D92    FDB   $0D92    CLR A   4F
024B 38A7    FDB   $38A7    NEG B   50
024D 1862    FDB   $1862    FCB     51
024F 1862    FDB   $1862    FCB     52
0251 0DED    FDB   $0DED    COM B   53
0253 3272    FDB   $3272    LSR B   54
0255 1862    FDB   $1862    FCB     55
0257 49F2    FDB   $49F2    ROR B   56
0259 0672    FDB   $0672    ASR B   57
025B 066C    FDB   $066C    ASL B   58
025D 49EC    FDB   $49EC    ROL B   59
025F 10A3    FDB   $10A3    DEC B   5A
0261 1862    FDB   $1862    FCB     5B
0263 25C3    FDB   $25C3    INC B   5C
0265 5274    FDB   $5274    TST B   5D
0267 1862    FDB   $1862    FCB     5E
0269 0D92    FDB   $0D92    CLR B   5F
026B 38A7    FDB   $38A7    NEG,X   60
026D 1862    FDB   $1862    FCB     61
026F 1862    FDB   $1862    FCB     62
0271 0DED    FDB   $0DED    COM,X   63
0273 3272    FDB   $3272    LSR,X   64
0275 1862    FDB   $1862    FCB     65
0277 49F2    FDB   $49F2    ROR,X   66
0279 0672    FDB   $0672    ASR,X   67
027B 066C    FDB   $066C    ASL,X   68
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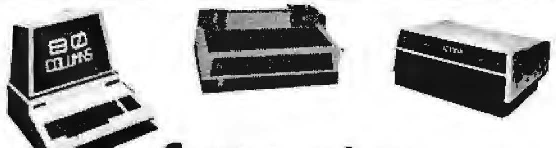
Listing 2 continued on page 354

NEECO

. . . Why not buy from the best?



commodore

4008 (8K RAM - 40 Column)	$ 795
16K "B" (16K RAM - 40 Column)	995
32K "B"(32K RAM - 40 Column)	995
32K "N" (32K RAM - 40 Column)	1295
4032 "B" (32K RAM 4.0 Basic - 40 Column)	1295
4032 "N"(32K RAM 4.0 Basic - 40 Column)	1295
4016 "B" (16K RAM 4.0 Basic - 40 Column)	995
4016 "N" (16K RAM 4.0 Basic - 40 Column)	995
2022 Tractor Printer	795
4040 Dual Disk (340 2.0 DOS)	1295
8050 Dual Disk (1 Meg, 2.0 DOS)	1795
8010 IEEE Modem	395
CZN Cassette	95
PET - IEEE Cable	40
IEEE-IEEE Cable	50

INTERTEC DATA SYSTEMS

32K Superbrain (360K Disk Storage), CP/M*	$2995
64K Superbrain (360 Disk Storage), CP/M*	3150
64K Quad Density Superbrain (700K Disk Storage), CP/M*	3995

ATARI COMPUTER SYSTEMS

ATARI 400 (8K RAM)	$499.00
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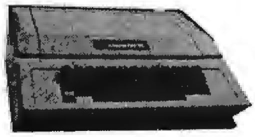
ATARI 800 (16K RAM)	1,080.00
ATARI 410 RECORDER	89.95
ATARI 810 DISK DRIVE	599.95

NEECO also carries all available ATARI software

ALTOS COMPUTER SYSTEMS

	RAM	DISK	
ACS 8000-IS	64K	250K	$2840
ACS 8000-28	64K	500K	3500
ACS 8000-1	64K	500K	3840
ACS 8000-2	64K	1M	4500
ACS 8000-4	64K	2M	5600
ACS 8000-5	64K	1M	5990
ACS 8000-6 Mul2 - Multi-User			
(14.5 M-Winchester)	112K	1M	10,670
(29 M-Winchester)	112K	1M	11,870
ACS 8000-6 Mul4 Multi-User			
(14.5 M-Winchester)	208K	1M	11,960
(29 M Winchester)	208K	1M	13,160

apple computer Authorized Dealer



16K APPLE II+	$1330
32K " II+	1430
48K " II+	1530
APPLE DISK w/3.3 DOS	650
APPLE DRIVE Only	495

APPLE III in Stock!!

128K, with Monitor and Info Analystpak 4740

EPSON PRINTER MX-80

80 Columns, 9x9 Dot Matrix
Bidirectional Printing .. $645

Interface Cards

8140 (RS-232)	$55
8161 (IEEE 488)	55
8131 (Apple Card)	85
8230 (Apple Cable)	25
8220 (TRS-80 Cable)	35

PROFESSIONAL SOFTWARE

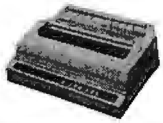
WordPro I (8K)	$29.95
WordPro III (40 Col.) 16K	199.95
WordPro III+ Enhanced Version	295.00
WordPro IV 80 Col., 32K	375.00
WordPro IV+ Enhanced Version	450.00

Multi-Cluster for Commodore Systems.

Allows 3 CPU's (Expandable to 8) to access a single Commodore Disk.

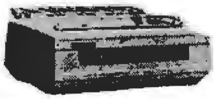
Multi-Cluster .... $795 (3 CPU's)
Each Additional CPU $199 (up to 8)

DIABLO 630



45 CPS, Letter Quality
RS-232 Port $2,710
Tractor Option 250

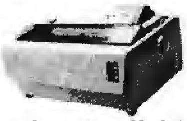
NEC Spinwriter



5530 (Parallel)	$3055
5510 (Serial)	3055
5520 (KSR-Serial)	3415
TRACTOR OPTION	225

55 CPS
Letter Quality
High Reliability

C. ITOH Starwriter



Serial or Parallel $1995

FP 1500
25 CPs,
Letter
Quality

NEECO

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NEECO Order Lines: (617) 449-1760

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NEECO Order Lines: (617) 449-1760

Listing 2 continued:

```
027D 49EC      FDB   $49EC      ROL,X   69
027F 10A3      FDB   $10A3      DEC,X   6A
0281 1862      FDB   $1862      FCB     6B
0283 25C3      FDB   $25C3      INC,X   6C
0285 5274      FDB   $5274      TST,X   6D
0287 29B0      FDB   $29B0      JMP,X   6E
0289 0D92      FDB   $0D92      CLR,X   6F
028B 38A7      FDB   $38A7      NEG     70
028D 1862      FDB   $1862      FCB     71
028F 1862      FDB   $1862      FCB     72
0291 0DED      FDB   $0DED      COM     73
0293 3272      FDB   $3272      LSR     74
0295 1862      FDB   $1862      FCB     75
0297 49F2      FDB   $49F2      ROR     76
0299 0672      FDB   $0672      ASR     77
029B 066C      FDB   $066C      ASL     78
029D 49EC      FDB   $49EC      ROL     79
029F 10A3      FDB   $10A3      DEC     7A
02A1 1862      FDB   $1862      FCB     7B
02A3 25C3      FDB   $25C3      INC     7C
02A5 5274      FDB   $5274      TST     7D
02A7 29B0      FDB   $29B0      JMP     7E
02A9 0D92      FDB   $0D92      CLR     7F
02AB 4EA2      FDB   $4EA2      SUB A   80
02AD 0DB0      FDB   $0DB0      CMP A   81
02AF 4C43      FDB   $4C43      SBC A   82
02B1 1862      FDB   $1862      FCB     83
02B3 05C4      FDB   $05C4      AND A   84
02B5 0934      FDB   $0934      BIT A   85
02B7 3081      FDB   $3081      LDA A   86
02B9 1862      FDB   $1862      FCB     87
02BB 15F2      FDB   $15F2      EOR A   88
02BD 0483      FDB   $0483      ADC A   89
02BF 3E41      FDB   $3E41      ORA A   8A
02C1 0484      FDB   $0484      ADD A   8B
02C3 8E18      FDB   $8E18      CPX     8C
02C5 0A72      FDB   $0A72      BSR     8D      EXCEPTION
02C7 B093      FDB   $B093      LDS     8E
02C9 1862      FDB   $1862      FCB     8F
02CB 4EA2      FDB   $4EA2      SUB A   90
02CD 0DB0      FDB   $0DB0      CMP A   91
02CF 4C43      FDB   $4C43      SBC A   92
02D1 1862      FDB   $1862      FCB     93
02D3 05C4      FDB   $05C4      AND A   94
02D5 0934      FDB   $0934      BIT A   95
02D7 3081      FDB   $3081      LDA A   96
02D9 4E81      FDB   $4E81      STA A   97
02DB 15F2      FDB   $15F2      EOR A   98
02DD 0483      FDB   $0483      ADC A   99
02DF 3E41      FDB   $3E41      ORA A   9A
02E1 0484      FDB   $0484      ADD A   9B
02E3 8E18      FDB   $8E18      CPX     9C
02E5 1862      FDB   $1862      FCB     9D
02E7 B093      FDB   $B093      LDS     9E
02E9 CE93      FDB   $CE93      STS     9F
02EB 4EA2      FDB   $4EA2      SUBA,X  A0
02ED 0DB0      FDB   $0DB0      CMPA,X  A1
02EF 4C43      FDB   $4C43      SBCA,X  A2
02F1 1862      FDB   $1862      FCB     A3
02F3 05C4      FDB   $05C4      ANDA,X  A4
02F5 0934      FDB   $0934      BITA,X  A5
02F7 3081      FDB   $3081      LDAA,X  A6
02F9 4E81      FDB   $4E81      STAA,X  A7
02FB 15F2      FDB   $15F2      EORA,X  A8
02FD 0483      FDB   $0483      ADCA,X  A9
02FF 3E41      FDB   $3E41      ORAA,X  AA
0301 0484      FDB   $0484      ADDA,X  AB
0303 8E18      FDB   $8E18      CPX,X   AC
0305 AA72      FDB   $AA72      JSR,X   AD
0307 B093      FDB   $B093      LDS,X   AE
0309 CE93      FDB   $CE93      STS,X   AF
030B 4EA2      FDB   $4EA2      SUBA    B0
030D 0DB0      FDB   $0DB0      CMPA    B1
030F 4C43      FDB   $4C43      SBCA    B2
0311 1862      FDB   $1862      FCB     B3
0313 05C4      FDB   $05C4      ANDA    B4
0315 0934      FDB   $0934      BITA    B5
0317 3081      FDB   $3081      LDAA    B6
0319 4E81      FDB   $4E81      STAA    B7
031B 15F2      FDB   $15F2      EORA    B8
031D 0483      FDB   $0483      ADCA    B9
031F 3E41      FDB   $3E41      ORAA    BA
0321 0484      FDB   $0484      ADDA    BB
0323 8E18      FDB   $8E18      CPX     BC
0325 AA72      FDB   $AA72      JSR     BD
0327 B093      FDB   $B093      LDS     BE
0329 CE93      FDB   $CE93      STS     BF
032B 4EA2      FDB   $4EA2      SUBB    C0
032D 0DB0      FDB   $0DB0      CMPB    C1
032F 4C43      FDB   $4C43      SBCB    C2
0331 1862      FDB   $1862      FCB     C3
```

Listing 2 continued on page 356

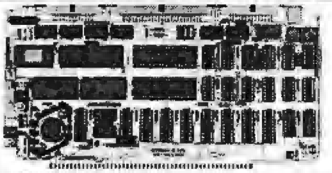
asap computer products, inc.

NEW LOCATION
1198 E. Willow Street
Signal Hill, CA 90806
Toll Free (800) 421-7701 Outside Calif.
(213) 595-6431 Inside Calif.

ORDERING INFO
Name, address, phone
Ship By: UPS or Mail
Shipping Chrg. Add $2.50 up to 2 lbs. (UPS Blue)
U.S. Mail Add $1.50 (U.S. Only)
($25.00 Minimum Order)

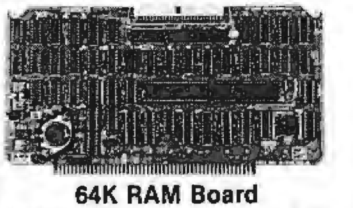
TERMS
We Accept Cash, Check, Money Orders, Visa & Master Charge
(U.S. Funds Only)
Tax: 6% Calif. Res.
COD's & Terms Available on Approval (School PO's Accepted)

MICROBYTE S-100 BOARDS



Z-80A/I-O $349.00
Assembled & Tested
Optional Monitor Program $50.00

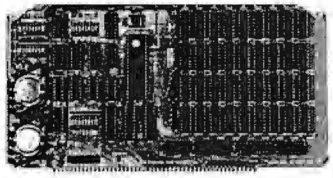
- A completesingleboard Z-80A CPU with serial/parallel interface
- Fully compatible with the proposed IEEE S-100 Bus Standard
- Z-80A CPU (4MHz version of the Z-80)
- 158 instructions—superset of and upward compatible from the 8080's 78 instructions
- Upto4K of on board Eprom with optional Z-80monitor program — 1K(2708), 2K(2716) or 4K(2732)
- Full vectored interrupt capability — 8 bit with MNI (1 bit)
- 2MHz or 4MHz operation is jumper selectable
- Selectable auto-wait state insertion for extending M1*, MREQ*, IORQ* and/or on board ROM
- Dual RS-232 serial I/O ports using the Z80A-DART with individual baud rateselection (from50-19,200baud)
- Up to 24 bit parallel I/O port—fully programmable Intel 8255A



MICROBYTE

- Fully S100 bus compatible
- 64K x 8 bit dynamic RAM
- Low power
  - + 8VDC @ 700 ma
  - + 16VDC @ 100 ma
  - − 16VDC @ 25ma
- Built in-parity with LED indicator and vector interrupt
- Memory addressable in four 16K banks
- Hidden refresh
- Gold contacts for high reliability
- 72-hour Burn-in
- Memory mappedvia DIP switch
- Built-in programmable write-protect
- Programmable control portfor parity and bank control
- Alpha-Micro Compatible

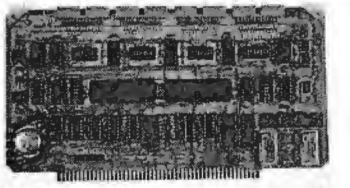
64K RAM Board
Assembled & Tested *Call for Price*



MICROBYTE

- DMA to within 16M byte of memory
- State-of-the-art NEC765LSI Controller
- IEEE-S100 compatible
- DMA arbitration allows useof multiple boards within a system
- PLL data recovery fortotally reliable operation
- Write pre-compswitched at mid-disc for reliable doubledensity operation
- Supports upto four (4) drives
- Power On, Power Off or Reset de-selects drivestoavoid damaging files
- Drive deselect Time Out, deselect drivesnot in use
- Single or doublesided operation
- Single density/double density operation
- 8" standard drives
- Separate V_{CC} supply for data recov-eryto eliminate possible noise problems

Disc Controller $389.00
Assembled & Tested
CPM Available (Optional)



MICROBYTE

- Quad RS-232C Serial Ports One 20mA Current Loop Port
- Fully IEEE S-100 Bus Compatible
- Asynchronous Communications with Z80A-Dart(TM) or Synchronous Communicationswith Z80A-SIO/0(TM)
- Full Set of Modem Control Signals, including RI (Ring Indicator)
- EasilyConfigurable to Any Type of Terminal Interface
- I/O Servicing Environments: (1) Polled; (2) Bus Vector, (3)Z80 Mode 2 Vector
- Off-Board Interrupt Daisy Chain Capability
- Special Receive Conditions: (1) Framing Error; (2)Parity Error, (3) Receiver Overrun Error
- Baud Rates Selected Individually from 50 Baud to 300K Baud
- 72 Hour Burn-In

I/O Board $289.00
Assembled & Tested
Cables Available (Optional)

INFLATION FIGHTER

4116's (200 ns.)
Apple, TRS-80, Heath
8 for $22.00

16- 49	$2.60
50- 99	$2.50
100-499	$2.40
500 Up	$2.25

2114 L-2/200 NS

1-16	$3.60 ea.
17-49	$3.40 ea.
50-99	$3.25 ea.
100-499	$3.00 ea.
500 Up	$2.85 ea.

COMPONENTS

74LS240	1.25 ea.
74LS241	1.10 ea.
74LS244	1.25 ea.
74LS373	1.25 ea.
74LS374	1.25 ea.
8T245	1.45 ea.

S.D. SYSTEM / S-100 BOARDS

EXPANDORAM I 2MHz DYNAMIC RAM BOARD KITS	16K	$239.00
	32K	$265.00
	48K	$289.00
	64K	$315.00
EXPANDO RAM II 4MHz DYNAMIC RAM BOARD KITS	16K	$250.00
	32K	$275.00
	48K	$300.00
	64K	$325.00

SBC-100 KIT $299.00
2.5 MHz/Z-80 CPU WITH SERIAL & PARALLEL I/O PORTS

SBC-200 KIT $325.00
4MHz/Z-80 CPU WITH SERIAL & PARALLEL I/O PORTS

VDB-8024 KIT $380.00
80x24 I/O MAPPED VIDEO BOARD WITH KEYBOARD I/O

VERSAFLOPPY I KIT $250.00
DISK CONTROLLER FOR 8" & 5¼" DRIVES
S-100 BUS COMPATIBLE

VERSAFLOPPY II KIT $350.00
NEW DOUBLE DENSITY DISK CONTROLLER FOR 8" & 5¼" DRIVES

PROM-100 KIT $210.00
S—100/EPROM PROGRAMMER FOR 2708, 2716, 2732, 2758 & 2516(TI)

ALL BOARDS ARE AVAILABLE (ASSEMBLED & TESTED)
CALL FOR PRICE & DELIVERY

SYSTEM SOFTWARE AVAILABLE ON REQUEST

CALIFORNIA COMPUTER®

2032	32K STATIC RAM BRD.
2065	64K DYNAMIC RAM BD.
2116	16K STATIC RAM BD.
2200	MAINFRAME
2422	DISK CONTROLLER
2501	MOTHERBOARD
2710	4-PORT SERIAL I/O
2718	2 SER. PORT & 2 PAR.
2720	4-PORT PARALLEL I/O
2802	6502 CPU BOARD
2810	Z-80 CPU BOARD
7114A	12K ROM/PROM BD.
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Circle 33 on inquiry card.

Listing 2 continued:

```
0333 05C4          FDB   $05C4           ANDB    C4
0335 0934          FDB   $0934           BITB    C5
0337 3081          FDB   $3081           LDAB    C6
0339 1862          FDB   $1862           FCB     C7
033B 15F2          FDB   $15F2           EORB    C8
033D 0483          FDB   $0483           ADCB    C9
033F 3E41          FDB   $3E41           ORAB    CA
0341 0484          FDB   $0484           ADDB    CB
0343 1862          FDB   $1862           FCB     CC
0345 1862          FDB   $1862           FCB     CD
0347 B098          FDB   $B098           LDX     CE
0349 1862          FDB   $1862           FCB     CF
034B 4EA2          FDB   $4EA2           SUBB    D0
034D 00B0          FDB   $00B0           CMPB    D1
034F 4C43          FDB   $4C43           SBCB    D2
0351 1862          FDB   $1862           FCB     D3
0353 05C4          FDB   $05C4           ANDB    D4
0355 0934          FDB   $0934           BITB    D5
0357 3081          FDB   $3081           LDAB    D6
0359 4E81          FDB   $4E81           STAB    D7
035B 15F2          FDB   $15F2           EORB    D8
035D 0483          FDB   $0483           ADCB    D9
035F 3E41          FDB   $3E41           ORAB    DA
0361 0484          FDB   $0484           ADDB    DB
0363 1862          FDB   $1862           FCB     DC
0365 1862          FDB   $1862           FCB     DD
0367 B098          FDB   $B098           LDX     DE
0369 CE98          FDB   $CE98           STX     DF
036B 4EA2          FDB   $4EA2           SUBB,X  E0
036D 00B0          FDB   $00B0           CMPB,X  E1
036F 4C43          FDB   $4C43           SBCB,X  E2
0371 1862          FDB   $1862           FCB     E3
0373 05C4          FDB   $05C4           ANDB,X  E4
0375 0934          FDB   $0934           BITB,X  E5
0377 3081          FDB   $3081           LDAB,X  E6
0379 4E81          FDB   $4E81           STAB,X  E7
037B 15F2          FDB   $15F2           EORB,X  E8
037D 0483          FDB   $0483           ADCB,X  E9
037F 3E41          FDB   $3E41           ORAB,X  EA
0381 0484          FDB   $0484           ADDB,X  EB
0383 1862          FDB   $1862           FCB     EC
0385 1862          FDB   $1862           FCB     ED
0387 B098          FDB   $B098           LDX,X   EE
0389 CE98          FDB   $CE98           STX,X   EF
038B 4EA2          FDB   $4EA2           SUBB    F0
038D 00B0          FDB   $00B0           CMPB    F1
038F 4C43          FDB   $4C43           SBCB    F2
0391 1862          FDB   $1862           FCB     F3
0393 05C4          FDB   $05C4           ANDB    F4
0395 0934          FDB   $0934           BITB    F5
0397 3081          FDB   $3081           LDAB    F6
0399 4E81          FDB   $4E81           STAB    F7
039B 15F2          FDB   $15F2           EORB    F8
039D 0483          FDB   $0483           ADCB    F9
039F 3E41          FDB   $3E41           ORAB    FA
03A1 0484          FDB   $0484           ADDB    FB
03A3 1862          FDB   $1862           FCB     FC
03A5 1862          FDB   $1862           FCB     FD
03A7 B098          FDB   $B098           LDX     FE
03A9 CE98          FDB   $CE98           STX     FF
              *
              *          FORMAT FLAGS
              *
              *   FLAGS ARE 1 BYTE LONG AND ARRANGED IN PAIRS.
              *   BIT: 76543210
              *        RR-FFFSS
              *   WHERE: RR= REGISTER CODE, 0=NONE, 1=A, 2=B
              *          FFF= ADDRESS MODE, 0=INHERENT, 1=RELATIVE, 2=INDEXED
              *                        3=IMMEDIATE, 4=EXTENDED, 5=DIRECT
              *                        6= NONE (FCB PSEUDO)
              *         SS= SIZE OF INSTRUCTION IN BYTES.
              *
03AB 01       FTAB FCB   $01             00-0F   INHERENT
03AC 00            FCB   0
03AD 01            FCB   $01             10-1F   INHERENT
03AE 00            FCB   0
03AF 06       BSR  FCB   $06             20-2F   RELATIVE (USED BY BSR)
03B0 00            FCB   0
03B1 01            FCB   $01             30-3F   INHERENT
03B2 41            FCB   $41             PULA AND PSHA
03B3 41            FCB   $41             40-4F   INHERENT
03B4 00            FCB   0
03B5 81       PULB FCB   $81             50-5F   INHERENT (USED BY PULB)
03B6 00            FCB   0
03B7 0A            FCB   $0A             60-6F   INDEXEXED
03B8 00            FCB   0
03B9 13            FCB   $13             70-7F   EXTENDED
03BA 00            FCB   0
03BB 4E            FCB   $4E             80-8F           IMMEDIATE
03BC 0F            FCB   $0F             CPX,LDS
```

Listing 2 continued on page 358

NOT ANYMORE!

No this isn't a "Hard Disk". We used to call it that, sometimes. But somebody muddied the water.

"Hard Disk", unfortunately, now calls something else to mind. That little bitty guy with no backup capability and no way of switching media? It's a "Hard Disk" to work with, all right, in business applications. Some even say "Impossible Disk".

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Circle 61 on inquiry card.

Listing 2 continued:

```
03BD 56                FCB   $56        90-9F              DIRECT
03BE 16                FCB   $16        CPX,LDS,STS
03BF 4A                FCB   $4A        A0-AF              INDEXED
03C0 0A                FCB   $0A        CPX,JSR,LDS,STS
03C1 53                FCB   $53        B0-BF              EXTENDED
03C2 13                FCB   $13        CPX,,JSR,LDS,STS
03C3 8E                FCB   $8E        C0-CF              IMMEDIATE
03C4 0F                FCB   $0F        LDX
03C5 96                FCB   $96        D0-DF              DIRECT
03C6 16                FCB   $16        LDX,STX
03C7 8A                FCB   $8A        E0-EF              INDEXED
03C8 0A                FCB   $0A        LDX,STX
03C9 93                FCB   $93        F0-FF              EXTENDED
03CA 13                FCB   $13        LDX,STX
                *
03CB 19         FFLAG  FCB   $19        FCB FLAGS
                *
A04A                   ORG   $A04A
A04A 20         LINE   RMB   32
A06A 04                FCB   04
     A06B       WORKA  EQU   *
A06B CE 01AB    FLAGD  LDX   #MTAB      MNEMONIC TABLE BASE
     A06C       WTAD   EQU   FLAGD+1
A06E CE 03AB    WBYT   LDX   #FTAB      FLAG TABLE BASE
     A06F       WFAD   EQU   WBYT+1
A071 0000       WBAS   FDB   0
A073 0000       WFLG   FDB   0
A075 0000       XSAV   FDB   0
A077 00         LINES  FCB   0
     03         BYTE   EQU   WBYT-WORKA
     01         TAD    EQU   WTAD-WORKA
     06         BASE   EQU   WBAS-WORKA
     04         FAD    EQU   WFAD-WORKA
     08         FLAGA  EQU   WFLG-WORKA
     A04A       AADR   EQU   LINE
     A058       OPER   EQU   LINE+13     MNEMONIC POSITION
     A063       ABS    EQU   LINE+24    ABS. ADDRESS FOR RELATIVE MODES
     A05E       ARG    EQU   LINE+19    ARGUMENT POSITION
A078 00                FCB   0,0,0
A07B 00         SIZE   FCB   0
A07C 0000       APPND  FDB   00         COMPLETION APPENDAGE ADDRESS
                       END
```


Listing 3: *Cross-references for symbols used in the disassembler source code of listing 2.*

```
        =
APP    =01A4   000E
APPND  =A07C   0011   0116
ASC    =0198   0192
BLUP   =0044   0048
BSR    =03AF   009B
CLOP   =00C9   000D
CVASC  =00DF   0063   0088   00BE   00DB
DISPL  =0116   0105   0148   0154   0167
DLOOP  =017F   017C   0184
DUMV   =0114   015B
ERASE  =0169   0008
FCBFR  =015D   0112
FFLAG  =03CB   007D
FIN    =0123   011E
FLAGD  =A06B   00AA   00C0   00E5   00FE
FORM   =00FB   00F1   00F5
FTAB   =03AB   A06E
IMM    =0156   010E
IND    =014A   010B
LINE   =A04A   003D   0051   0161   0174   01A4
LINES  =A077   0005   0118
MTAB   =01AB   A06B
NEXTL  =0018   0014   0120
NFC    =0082   007B
NMR    =00E2   00D1
NOTA   =00F3   00EA
OFF    =00A8   0080   008C   0095   009E   00A5
OU     =01A0   019C
POS    =0130   012D
PULB   =03B5   0089   0092
REL    =0124   0108
SETM   =016D   0114   0124   014A
SETR   =00EE   00F9
SIZE   =A07B   00C5   0177
START  =0000   0016
TBSR   =0097   0090
TOASC  =018C   00DF   013C   0141
TPSH   =008E   0087
WBAS   =A071   0054
WBYT   =A06E   00BA
WFLG   =A073   00A0   0171   0186
XSAV   =A075   00C9   00D8
```

■

Build a Super Simple Floppy-Disk Interface, Part 1

James Nicholson and Roger Camp
1046 Gaskill
Ames IA 50010

For personal-computer users, a floppy-disk system represents the ultimate in mass storage because of its speed and capacity. The floppy-disk controller described in this article provides all the capabilities found in commercial systems, yet it is simple and economical because it requires only ten integrated circuits. Fundamental software will be provided (in the second part of this article) to control and perform data transfers, and discussion of file structuring and alternate hardware will give the experimenter ideas for improvements.

This system uses the FD400, an 8-inch floppy-disk drive manufactured by the Pertec Computer Corporation, and the popular Western Digital 1771 floppy-disk controller integrated circuit (which allows such special features as variable block size, soft sectoring, IBM compatibility, and much more). Although the specifics shown are for microcomputers based on the MOS Technology 6502 microprocessor, the controller could be adapted to other microprocessors with some care at a few crucial points. The 6502 offers some speed advantages and a programming ease not afforded by the others.

Fundamentals

The data recorded on floppy disks is logically arranged in concentric rings called *tracks*, with each track composed of blocks of data called *sectors*. The computer must be able to tell where a sector begins, and there are two ways of doing this. Each sector can be distinguished by its position relative to holes punched in the disk (this is called *hard sectoring*), or it can be distinguished by special sequences of information recorded on the disk (*soft sectoring*). In either case, the disk has one hole that is used as an index to signal the start of the first sector on all tracks.

This controller is simple and economical because it requires only ten integrated circuits.

The most common 8-inch floppy-disk format provides for 77 tracks of 26 sectors each, with 128 bytes recorded in each sector. The address of each sector, in the form of a track number (0 through 76) and a sector number (1 through 26), is recorded on the disk at the start of the sector itself.

The disk drive has two motors: one that spins the disk at 360 rpm (revolutions per minute), and one that moves the head from track to track on command. Each drive also has a printed-circuit board to control both motors. The inputs and outputs of this circuit board (see figure 1) follow a standard set by Shugart Associates, manufacturer of one of the first popular floppy-disk drives.

A single pulse on either the STEP-IN line or the STEP-OUT line moves the head one track toward the center of the disk (track 76) or toward the

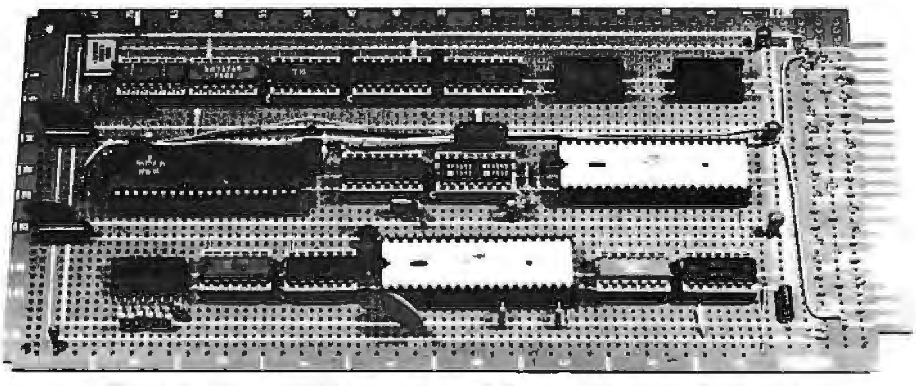
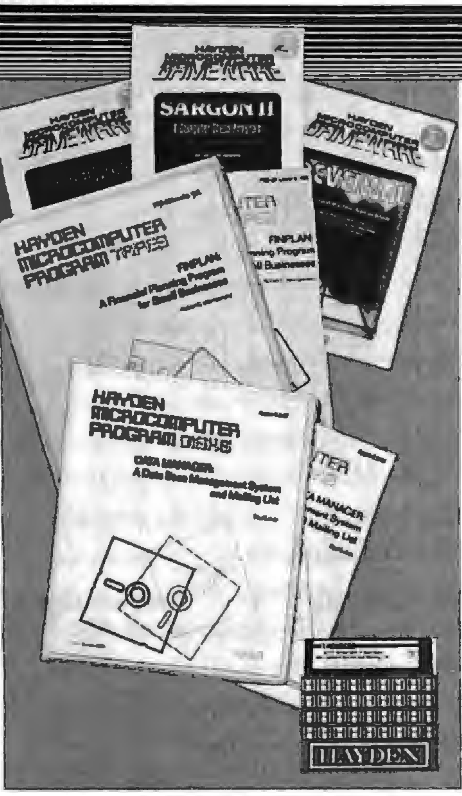


Photo 1: *The authors' wire-wrapped floppy-disk controller board.*

About the Authors

Roger Camp is a Professor of Electrical Engineering at Iowa State University. He is the author of several technical papers and patents, and his most recent book is Micro-Processor Systems Engineering.

James Nicholson, currently Project Manager, Business Recovery Planning, has been involved in large data-center activities for Donnelley Marketing. He has designed and built several microcomputer systems in the last five years.



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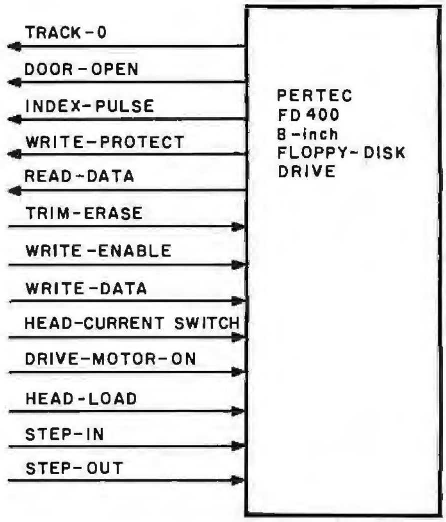

Figure 1: *Input and output lines available for controlling a Pertec FD400 8-inch floppy-disk drive. These signals are the same as those found on any Shugart-compatible drive, so nearly any drive may be substituted for the FD400.*

outside (track 0), respectively. When the head is positioned over track 0, the outermost track, the TRACK-0 output is activated. To turn on the spindle motor, the DRIVE-ON input must be activated, and the disk door in the front of the drive must be closed (this deactivates the DOOR-OPEN output line). As the disk rotates, a photoelectric sensor in the drive detects the index hole in the disk; this generates the INDEX signal that allows the system to begin counting sectors at the first one.

To read data, the HEAD-LOAD line is activated to force the head to contact the rotating disk surface. A mixture of data and clock bits are then detected and amplified by the drive's electronics; these appear as logic levels on the DATA-READ output at the rate of 250 K-bits per second.

To write data on the disk, the head must be loaded, the WRITE-ENABLE line must be activated, and the data must be sent to the drive on the WRITE-DATA line. (This must occur with very specific timing.) If the WRITE-PROTECT output has been activated, the drive has detected the presence of a write-protect notch in the disk's envelope.

Obviously, communication at this level between a disk drive and a microcomputer is possible but not desirable. The microcomputer would spend much of its time catering to the needs of the disk rather than computing. The purpose of the FD1771 (actually a microprocessor in its own right) is to act as a high-level communications interface between the two.

When instructed to *seek* (move the head) to track 30, the 1771 will generate the appropriate number of STEP-IN or STEP-OUT pulses to move the head from its current position, wherever it may be, to track 30. Another example of the 1771's capabilities is the process of reading a specific sector: the 1771 will search a given track for the proper sector address; when located, the data following the address is transferred to the microprocessor. Simultaneously, the 1771 can maintain synchronization with the disk drive and check for errors. Therefore, using the 1771 floppy-disk controller circuit results in a greatly simplified hardware and software design.

Software must be an integral part of the design of any computer subsystem—a subroutine of about 256 bytes is required to communicate the proper commands to the disk controller. Additional software is required to handle complex data-file structures (this software and various structuring techniques will be discussed in part 2 of this article).

Disk Format

Figure 2 schematically describes the format of recorded data on a soft-sectored disk. The pulse generated by the index hole passing the sensor provides a physical reference point to determine the beginning and the end of a track. The diagram represents 16 256-byte sectors (the authors' choice for format) rather than the usual 26

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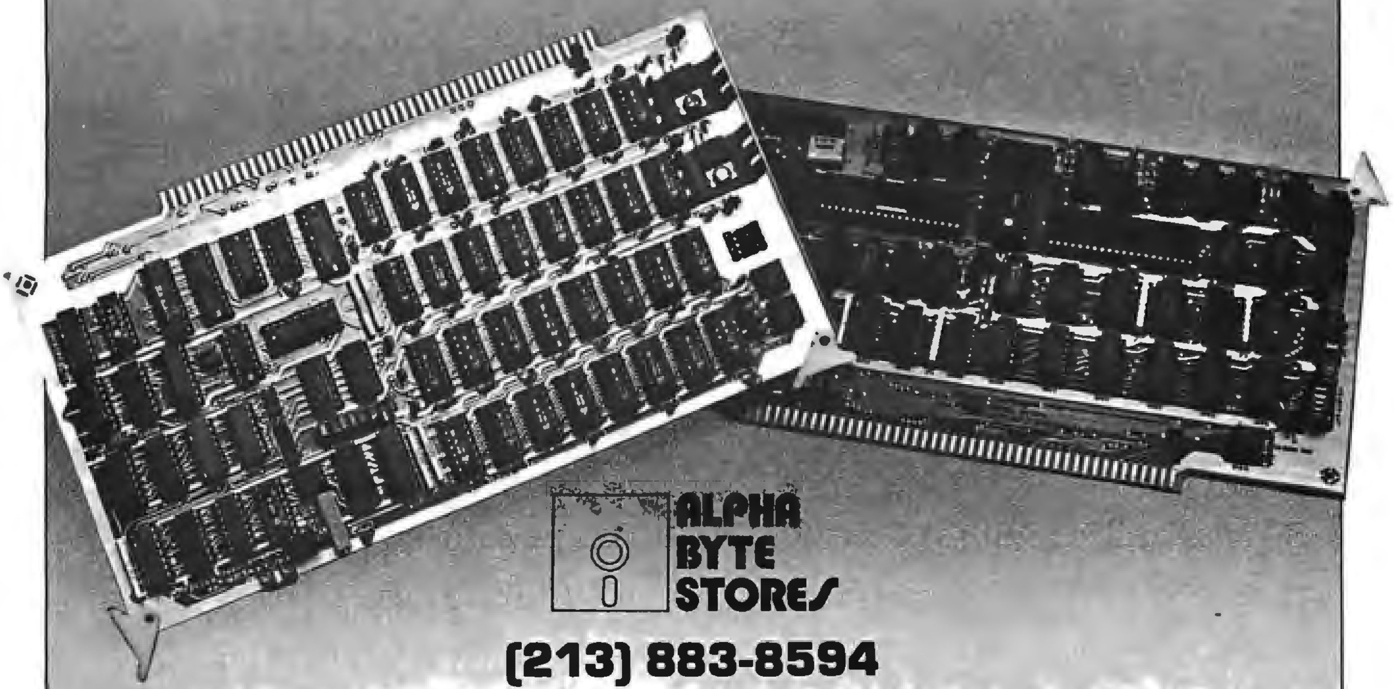

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sectors containing 128 bytes.

The disk rotates once every 166.67 ms, which allows the drive to read 41,665 bits of information; that is, a byte every 32 μs. Each track contains 5208 bytes (divided into data and control bytes), as well as gaps between sectors. (The gaps are required to allow sufficient time to turn write-head current on and off without destroying valid data.)

The IAM (index-address mark) that provides a recorded indication of the beginning of the track has 16 sectors recorded after it. The sectors consist of two records: the ID (identification record) and the DATA (data record). The ID contains information on the track number and the sector number of the DATA that follows. Each of the records begins with an AM (address mark). In addition, each record is ended with a 2-byte CRC (cyclic-redundancy-check) code.

Each byte of data recorded on the disk consists of interleaved clock and data bits. The clock bits convey information used for synchronization and for the identification of AMs. AMs always have clock bits corresponding to hexadecimal C7 (D7 in the case of the IAM); all other bytes of information have clock bits corresponding to hexadecimal FF. In other words, some clock bits are omitted in AMs. This scheme allows the data bits of a data-address mark (hexadecimal FB) to be distinguished from a hexadecimal FB recorded as data.

Figure 2 also illustrates that these data and clock bits are recorded as a single stream. When reading from the disk, the 1771 separates the data and clock bits (although our system uses discrete components to achieve greater reliability).

As a general rule, the larger the sector, the greater the total amount of data that can be recorded on one disk. This is due to the reduced amount of area necessary for gaps and indexing information. Using 16 256-byte sectors, 315,392 bytes of data can be recorded. The usual configuration of 256-byte sectors allows tracks with only 15 sectors; however, it has been found that sufficient space is available to reliably record 16 sectors.

Western Digital's 1771 Floppy-Disk Controller

This device is essentially a microprocessor dedicated to the specific task of controlling disk drives (see figure 3). It has five programmable registers and accepts a number of commands through various combinations of them. For economic reasons, there is a desire to connect multiple drives to a single 1771, but, since the device "remembers" the track the head was last positioned to, switching from one drive to another would place an added burden on the driving software. A case can be made for complete duplication of the controller electronics for each disk drive.

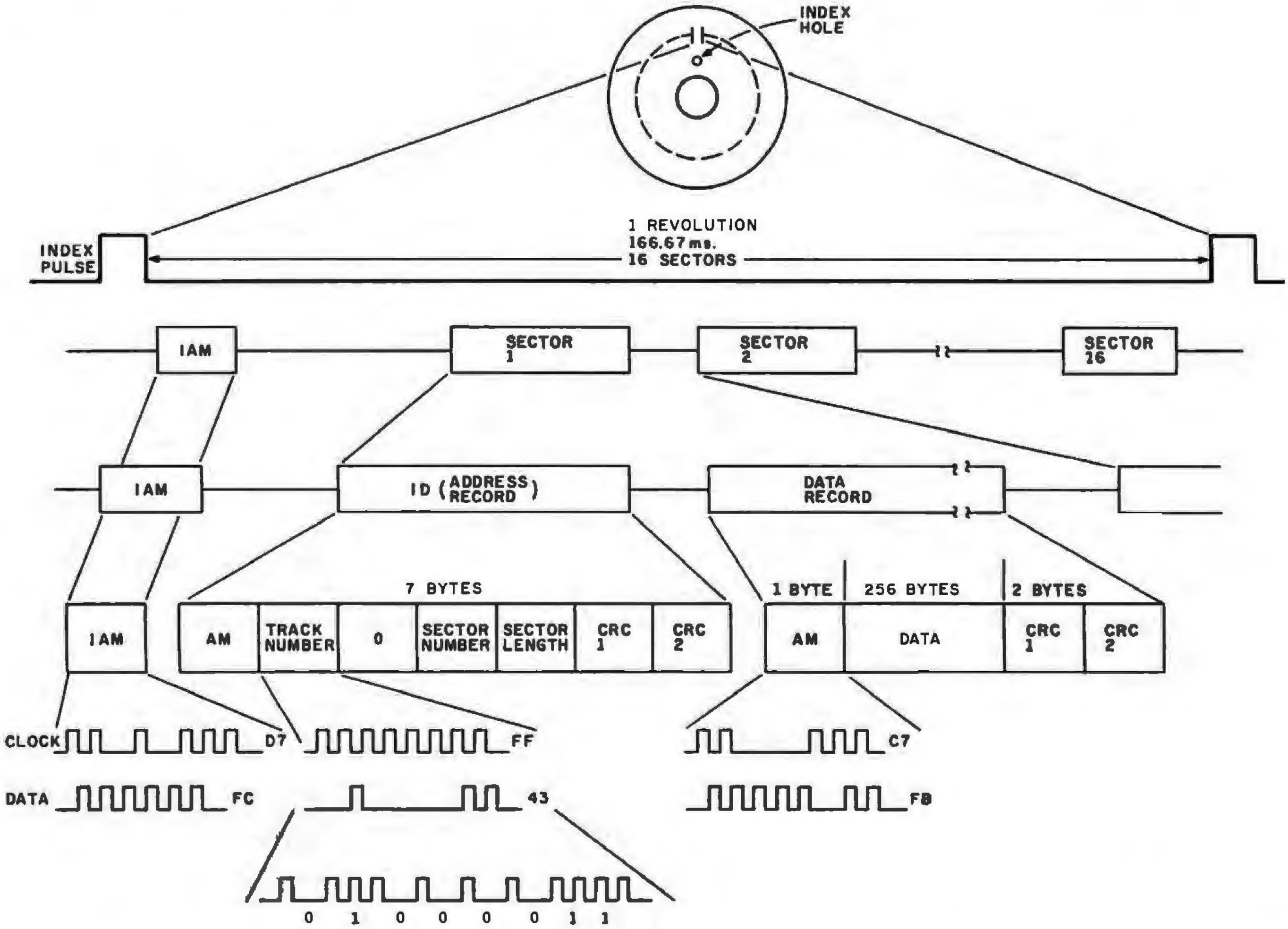


Figure 2: *The format of recorded data on one track of a soft-sectored floppy-disk drive. The IAM (index-address mark) marks the beginning of each track. See the text for details.*

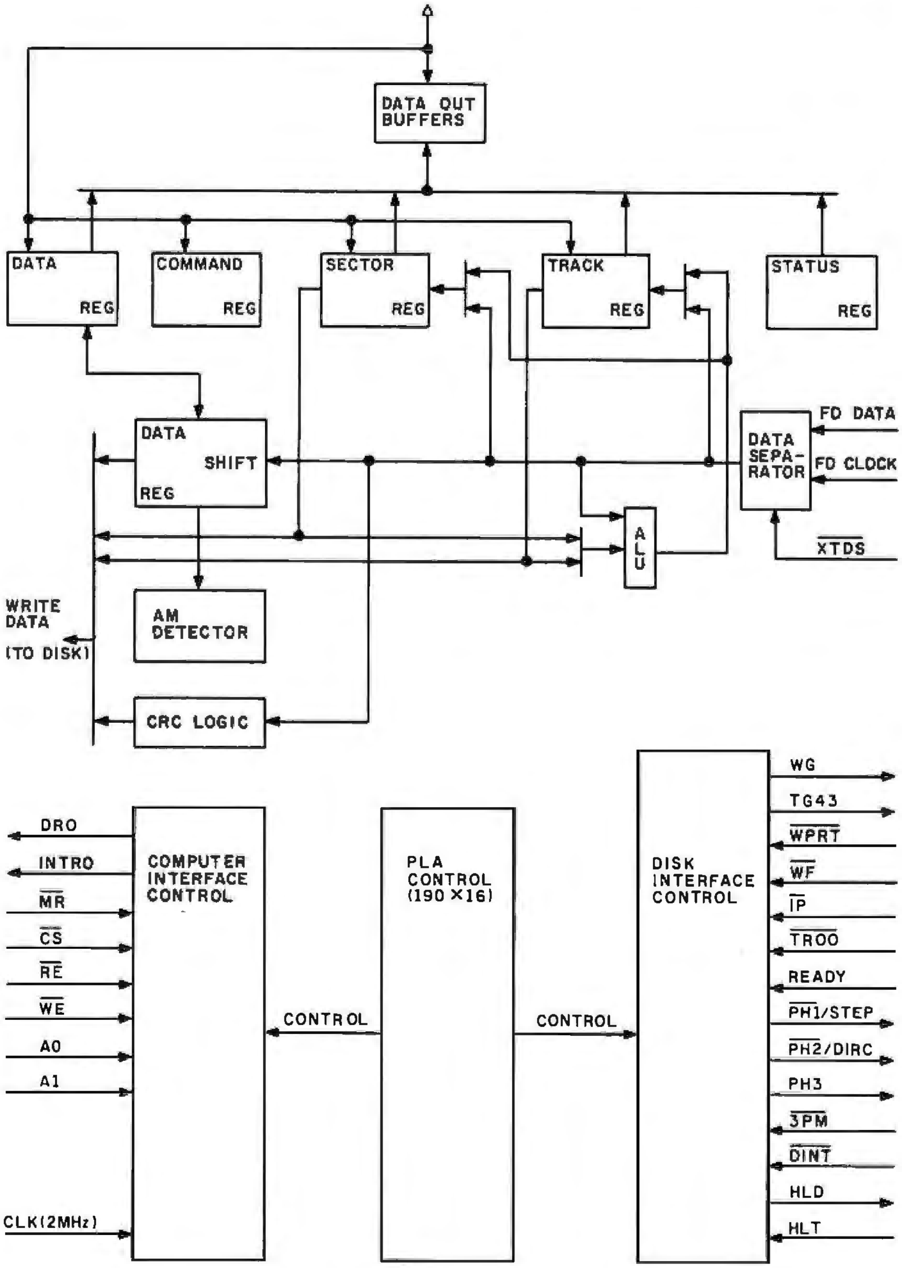
The registers in the 1771 that can be programmed by the user are the data, track, sector, and command registers—there is also a status register that can be read from but not written to. These 8-bit registers form the basis for software control of any disk drive:

- Data register: In disk-reading operations, this register receives 8 bits of data in parallel from the disk via the shift register. The data is held until the computer can accept it, allowing the shift register to be ready for the next byte. During disk-writing operations, 8 bits of data are transferred in parallel from the computer to this register and held until they can be accepted by the shift register for transfer to the disk. When executing the seek command, the data register holds the address of the desired track.
- Track register: This register holds the track number of the current head position. The value is incremented by one for every track the head is stepped in (toward track 76), and decremented by one for every track the head is stepped out (toward track 0). The contents of the register are compared with the track number recorded in the ID field of sectors on the disk.
- Sector register: During read or write operations, the contents of this 8-bit register are compared with the sector number recorded in the ID field of sectors on the disk. The contents should not be changed while the device is busy.
- Command register: This register holds the command currently being executed. The register should not be loaded while the 1771 is busy unless the current command is to be overridden (this action causes an interrupt to be generated). The eleven commands understood by the 1771 are divided into four types, shown in table 1, according to the way their flag bits are defined.
- Status register: Information about the status of the controller can be read from this register. The meaning of the status bits may change depending on the current command.

Registers are accessed by placing the proper logic levels on the A0, A1, $\overline{RE}$, and $\overline{WE}$ lines, as shown in table 2. Other logic levels in the 1771 perform functions to:

- Generate and check the 16-bit CRC code
- Increment, decrement, and compare register values
- Detect ID, data, and index-address marks
- Provide control signals based on an external 2.0 MHz clock

A typical disk operation includes the following steps. First, the soft-



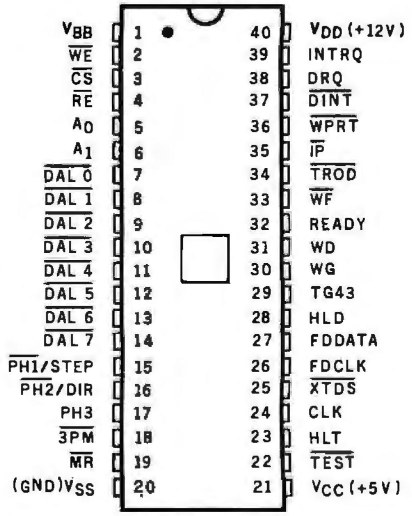


Figure 3: *Internal architecture and pinout diagram of the Western Digital FD1771 floppy-disk controller. The four programmable registers and eleven commands of the 1771 allow any microprocessor to control a disk subsystem using high-level instructions, thus removing a significant burden from the disk-driving software. See table 1 for a summary of the commands.*

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TYPE	COMMAND	7	6	5	4	3	2	1	0
		BITS							
I	Restore	0	0	0	0	h	V	r_1	r_0
I	Seek	0	0	0	1	h	V	r_1	r_0
I	Step	0	0	1	u	h	V	r_1	r_0
I	Step In	0	1	0	u	h	V	r_1	r_0
I	Step Out	0	1	1	u	h	V	r_1	r_0
II	Read Command	1	0	0	m	b	E	0	0
II	Write Command	1	0	1	m	b	E	a_1	a_0
III	Read Address	1	1	0	0	0	1	0	0
III	Read Track	1	1	1	0	0	1	0	$\overline{s}$
III	Write Track	1	1	1	1	0	1	0	0
IV	Force Interrupt	1	1	0	1	I_3	I_2	I_1	I_0

(a)

BIT VALUES FOR TYPE 1

h = Head Load flag (Bit 3)
- h = 1, Load head at beginning
- h = 0, Do not load head at beginning

V = Verify flag (Bit 2)
- V = 1, Verify on last track
- V = 0, No verify

r_1r_0 = Stepping motor rate (Bits 1 through 0)
- r_1r_0 = 11 gives 40 ms step time

u = Update flag (Bit 4)
- u = 1, Update track register
- u = 0, No update

(b)

BIT VALUES FOR TYPE II

m = Multiple Record flag (Bit 4)
- m = 0, Single record
- m = 1, Multiple records

b = Block length flag (Bit 3)
- b = 1, IBM format (128 to 1024 bytes)
- b = 0, Non-IBM format (16 to 4096 bytes)

a_1a_0 = Data Address Mark (Bits 1 through 0)
- a_1a_0 = 00, FB (Data Mark)
- a_1a_0 = 01, FA (User defined)
- a_1a_0 = 10, F9 (User defined)
- a_1a_0 = 11, F8 (Deleted Data Mark)

(c)

BIT VALUES FOR TYPE III

$\overline{s}$ = Synchronize flag (Bit 0)
- $\overline{s}$ = 0, Synchronize to Address Mark
- $\overline{s}$ = 1, Do not synchronize to Address Mark

(d)

BIT VALUES FOR TYPE IV

I_0 thru I_3 = Interrupt Condition flags (Bits 3 through 0)
- I_0 = 1, Not Ready to Ready transition
- I_1 = 1, Ready to Not Ready transition
- I_2 = 1, Index pulse
- I_3 = 1, Immediate interrupt

E = Enable HLD and 10 ms Delay
- E = 1, Enable HLD, HLT and 10 ms delay
- E = 0, Head is assumed engaged and there is no 10 ms delay

(e)

Table 1: *The high-level instructions of the FD1771 disk formatter/controller device. When one of the instructions defined by table 1a is loaded into the command register of the FD1771, the FD1771 executes one or a series of actions. Bits represented by a letter within a command are defined in the bit-value tables for that type of instruction, tables 1b through 1e.*

ware coordinating the disk operation checks to see if the controller is busy from the last command. If it is not, the software writes the desired command into the command register. If data is to be transferred as each byte is assembled (or disassembled) by the shift register, the controller sends a DRQ (*data request*) signal. When the operation is completed, the controller sends an INTRQ (*interrupt request*) signal. The status register can then be checked by the controlling software for seek, write protect, busy, or CRC errors.

Controller Hardware

The schematic diagram for the floppy-disk controller is given in figure 4. In addition to the 1771 and the 6520 PIA (peripheral interface adapter), circuitry is included for read/write control, clock and data bit separation, head loading, and inversion of various signals as required by the FD400 disk drive.

Three gates convert the DIR (direction) and STEP signals from the 1771 into the STEP-IN and STEP-OUT signals needed by the FD400 disk drive. The HEAD-LOAD signal is conditioned by a simple one-shot (monostable multivibrator) and an inverter; this guarantees a fixed 40 ms pause allowing the head to load and settle. Once the interval has passed, a signal is sent to the 1771 to acknowledge the fact.

The data-separator and clock circuit was designed by Steve Christiansen of Iowa State University. This circuit contains four of the ten integrated circuits in the system. (If the disk drive you intend to use has sepa-

A1	A0	Register Affected During Read ($\overline{RE}$ = 0, $\overline{WE}$ = 1)	Register Affected During Write ($\overline{RE}$ = 1, $\overline{WE}$ = 0)
0	0	Status Register	Command Register
0	1	Track Register	Track Register
1	0	Sector Register	Sector Register
1	1	Data Register	Data Register

Table 2: *Access to registers within the Western Digital FD1771 disk formatter/controller device. The FD1771 has five internal registers: command, data, sector, status, and track. A given register is read or written by placing the appropriate values on lines A1 and A0 and pulling down either the READ-ENABLE (RE) line for a read operation, or the WRITE-ENABLE (WE) line for a write operation. The sector and track registers specify the sector and track when these parameters are needed by a given command byte. The command register, when filled, causes one of eleven high-level instructions to be executed (see table 1). Data passes between the computer and the disk drive through the data register. After a command has been executed by the FD1771, the status register must be read before another command can be executed.*

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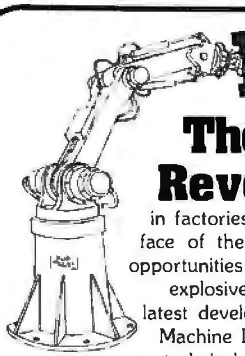

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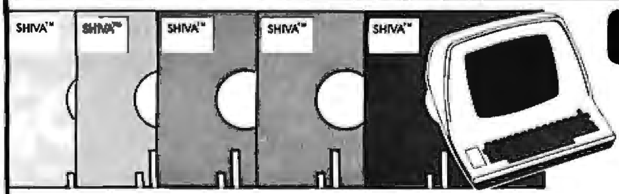

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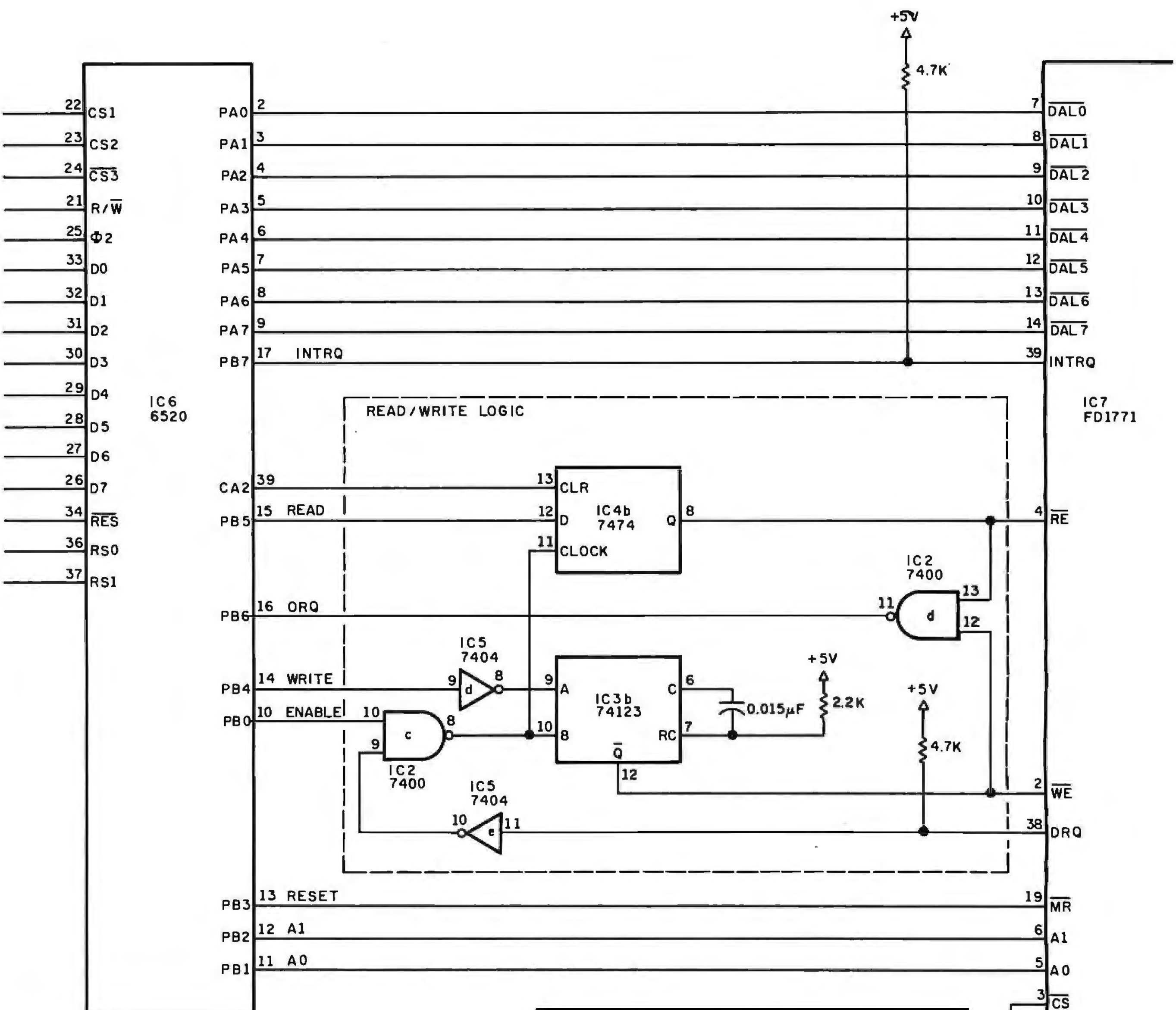


Figure 4a: *Schematic diagram of the computer-interface side of the floppy-disk controller. The 6520 PIA (peripheral interface adapter) LSI (large-scale integration) device simplifies the circuitry so that only ten integrated circuits are needed for the complete controller system. The additional logic devices are used to provide the read and write signals expected by the 1771. See figure 4b on page 372 for the rest of the diagram.*

Number	Type	+5 V	GND	−5 V	+12 V
IC1	7404	14	7		
IC2	7400	14	7		
IC3	74123	16	8		
IC4	7474	14	7		
IC5	7404	14	7		
IC6	6520	20	1		
IC7	FD1771	21	20	1	40
IC8	74193	16	8		
IC9	74193	16	8		
IC10	7402	14	7		

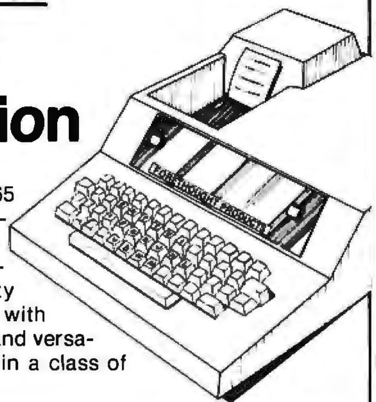
rated clock and data signals, you may be able to eliminate some of the circuitry shown. Remember that the 1771 requires a 2.0 MHz clock.)

The clock part of this circuit is a conventional TTL (transistor-transistor logic) crystal oscillator which also drives a divide-by-two stage to produce the 2.0 MHz clock signal. The data-separator part of the circuit inverts the raw signal from the disk drive and gates it out as data or clock information, depending on the state of the QD output of IC9.

There is a certain difficulty in determining, from a serial-bit stream, which bits are clock and which data (the two are interleaved, and some of the clock bits may be missing). The solution relies on the fact that, at most, three clock pulses will be omitted; if four in a row are omitted, the data and clock outputs are switched by the external data-separator circuit.

The read/write circuitry is very compact and plays a major role in the simplicity of the system. It is a subtle solution to a timing problem; the obvious approach of using the outputs of the 6520 to control RE and WE (the read- and write-enable lines) as input for the DRQ (data-request line) is too slow. The indicated circuitry using the ENABLE line causes each DRQ signal to automatically generate another RE or WE signal as required.

The 6520 has 20 programmable I/O (input/output) pins (see figure 5),



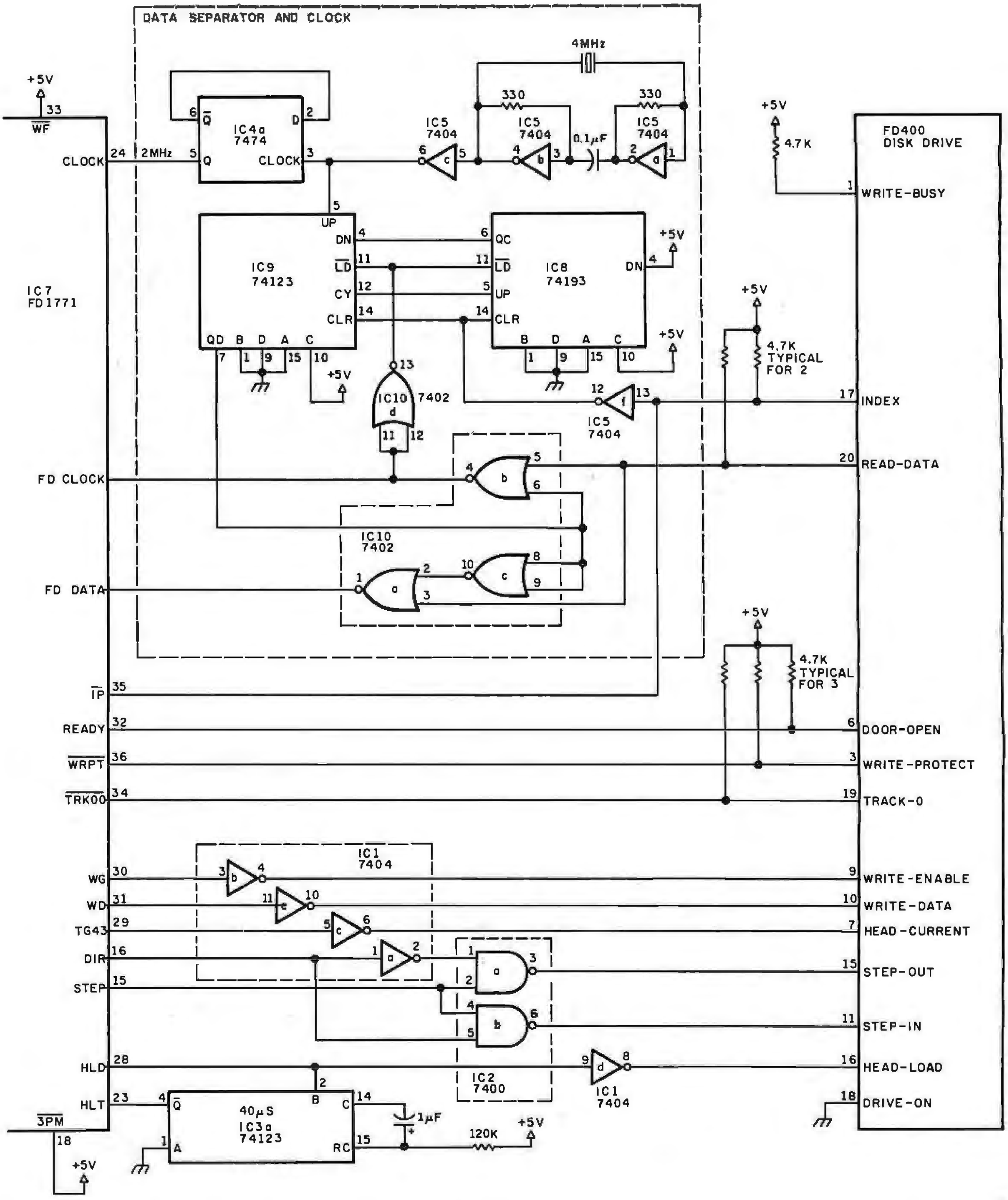


Figure 4b: *Schematic diagram of the drive-interface side of the floppy-disk controller. Clock signals and minor control functions are provided for by the additional circuitry, as well as the separation of recorded data from recorded synchronization pulses.*

of which only 17 are used in this system to interface with the 1771. The A port is programmed as eight bidirectional data lines, and is connected to the 1771's data lines, while the B port pins are programmed as necessary to provide control lines. The data lines of the 6520 can be connected to like lines on the microprocessor, while its three device-select lines can be connected to match whatever address-decoding scheme is appropriate. The

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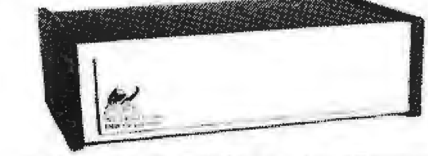

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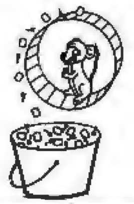

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1	0	0	X	1	Write into ORB
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Control Register Bit Designations

	7	6	5 4 3	2	1 0
CRA	*IRQA1*	*IRQA2*	*CA2 Control*	*DDRA Access*	*CA1 Control*
CRB	*IRQB1*	*IRQB2*	*CB2 Control*	*DDRB Access*	*CB1 Control*

Control of CA2 Output Modes

Bit 5	*CRA Bit 4*	*Bit 3*	*Mode*	*Description*
1	0	0	"Handshake" on Read	CA2 is set high on an active transition of the CA1 interrupt input signal and set low by a microprocessor "read A data" operation. This allows positive control of data transfers from the peripheral device to the microprocessor.
1	0	1	Pulse Output	CA2 goes low for one cycle after a "read A data" operation. This pulse can be used to signal the peripheral device that data was taken.
1	1	0	Manual Output	CA2 set low
1	1	1	Manual Output	CA2 set high

Table 3: *Control codes for the 6520. This device offers 20 pins that may be programmed (either individually or in groups) as input, output, or bidirectional lines.*

6520 controls and modes are listed in table 3.

Construction Notes

The prototype floppy-disk controller was built on a Vector 3677 wire-wrap board (see photo 1). There are no special layout considerations, but adequate power supply bypassing must be observed (i.e., 0.1 μf capacitors across the supply and ground pins of each integrated circuit). A 16-pin DIP (dual in-line package) socket is used to connect the controller to a ribbon cable from the disk drive (use proper terminations).

Debugging

The read/write circuit can be debugged by using a microcomputer. Move the DRQ input (IC5, pin 11 in figure 4) from the 1771 to a convenient 6520 output. With the microcomputer running a diagnostic program, check to see that the $\overline{WE}$ pulse (IC3, pin 12 in figure 4) is about 14 μs.

The data separator can be checked by using a single-pulse input signal in

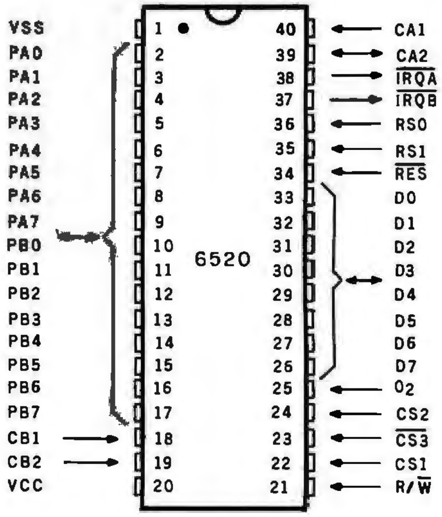

Figure 5: *Pin description of the MOS Technology 6520 PIA. Use of this particular device allows easy interfacing of a disk controller to a 6502-based computer. One I/O port handles control signals; the other is used to transfer parallel bytes of data.*

lieu of the 4.0 MHz crystal oscillator signal. The output of IC9 should count through the full range of 0 through 15, starting at 4, while IC8 should count from 4 through 8.

The INTRQ and DRQ signals were connected to PB6 and PB7 of the 6520 because powerful testing instructions are available for these pins. If problems occur in this area, these instructions will come in handy.

Testimonials

This system has been built by several people and has been proven to work with minimal debugging, using wire-wrap, Slit-N-Wrap, and Super Strip techniques. The circuits are not the simplest possible; we have interfaced a 5-inch disk drive to the KIM and AIM systems using only three integrated circuits. The newer versions of the 1771, which allow the controller to be connected directly to data and address buses, do not need a 6520; but there is a case for isolating the microcomputer from the disk controller through a 6520. Whatever route you choose, this basic design will provide reliable, trouble-free operation.

In Part 2, next month, we will look at the software needed to use this controller. ■

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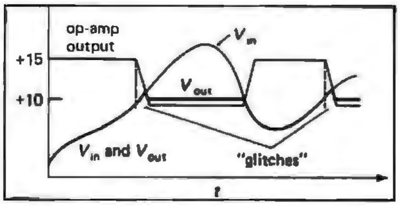

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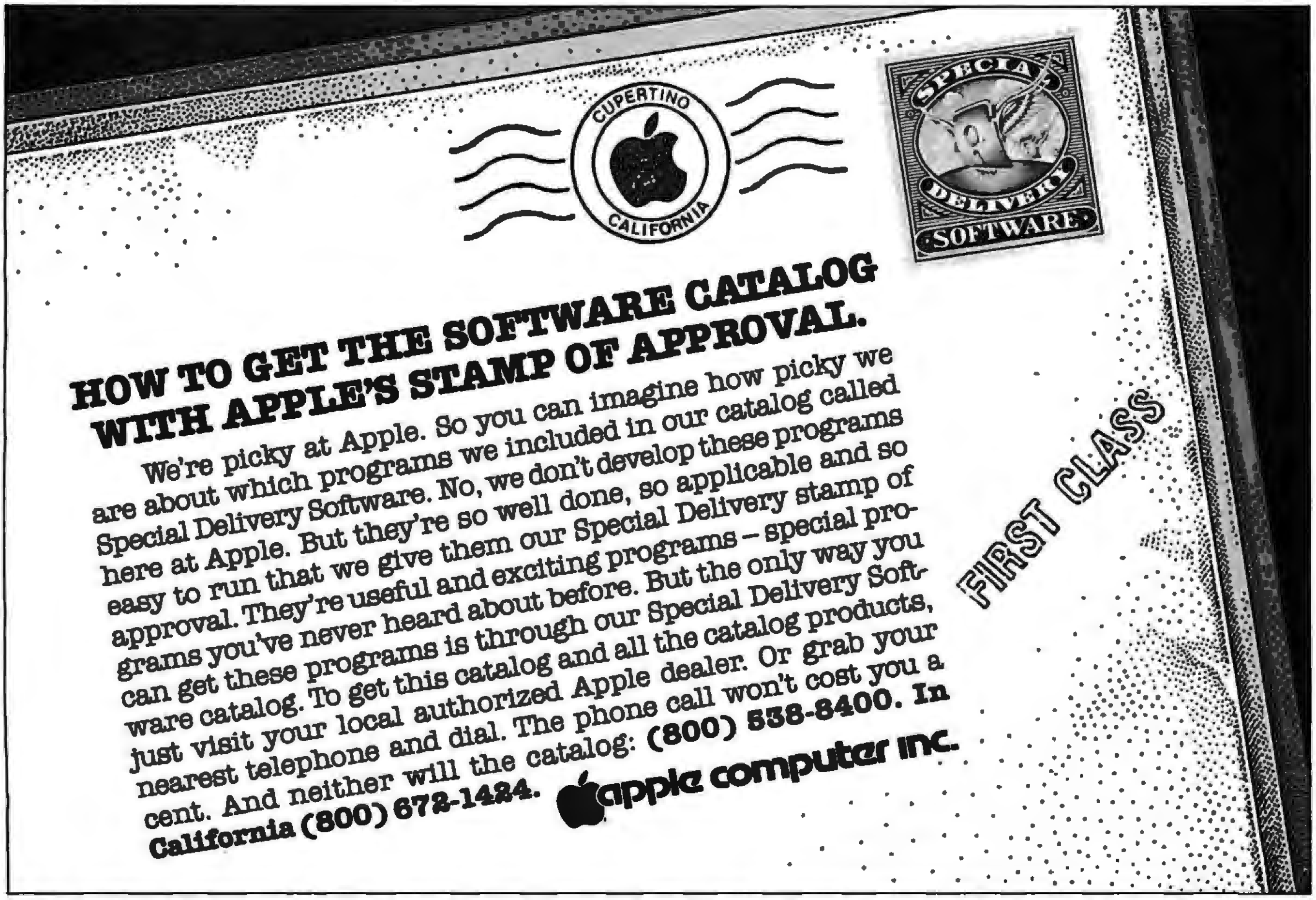

Favorite Benchmarks and Other Programs

In the July 1980 BYTE, Carl Helmers wrote a Technical Forum entitled "Some More on Performance Evaluation" (page 216), in which he requested readers to send in benchmark routines that are "appropriate to the typical language and operating-system environment of the contemporary small computer." The following submission from David I Wilcox, of Mansfield, Pennsylvania, is one of the most noteworthy.

While in college, I was shown a simple way to calculate the number of decimal digits a computer retains in its internal representation of floating-point numbers. If:

$$A = 1./3.$$

then, by computing:

$$\text{abs}(\log_{10}(\text{abs}(1.-(A+A+A))))$$

the number of digits of accuracy is obtained.

The choice of 1./3. is deliberate because it is an infinitely repeating rational number in the binary-number system. Therefore, a difference between 1. and the sum $A+A+A$ must exist in any attempt to represent 1./3. with a finite number of bits.

If the machine does not have the common logarithm function available, then compute:

$$1./(\text{abs}(1.-(A+A+A)))$$

The number of digits of accuracy is approximately the exponent of the result expressed in scientific notation. Better yet, use a calculator or math tables to find the common logarithm of the result.

The number of digits of accuracy available generally depends on both the machine and the language. This method offers a quick, in-the-store check of the actual number of digits used by a given system to represent floating-point numbers.

However, other letters we received bearing the "Favorite Benchmarks" title contained still more programs written in Pascal or BASIC that shaved minutes or seconds from the prime-number-generating program used as a benchmark in Carl Helmers's article. Although we appreciate the attempt at participation represented by these letters, they missed the point expressed by Carl Helmers in that article: "...the goal of the exercise was not to code the most efficient algorithm. It was, rather, to code an algorithm that takes a measurable amount of time while performing a certain group of calculations." The same algorithm (preferably embedded in a common computer language) can then be run on several computers and the times compared as performance indices of the respective language/machine combinations.

For example, the benchmark given by David Wilcox, above, results in a number (calculated in this case, not timed with a stopwatch) that can be used to compare, say, an Atari 400 with a Commodore PET; the comparison being made is one of digits of accuracy.

One prime-number-generating benchmark sent to us gave two times, one for execution of the program using a video terminal and another using a printer. In my opinion, such a benchmark confuses the issue under consideration (computer speed in generating a given set of prime numbers). Unless a benchmark is trying to measure the efficiency of a given computer in displaying *numbers, the interval being timed should end as soon as the first display is printed. This assumes, as was done in the prime-number benchmark, that all results are stored and the printing is done after the computation being measured has finished. In fact, I sometimes bracket the part of the program being measured with print statements that say BEGIN TIMING and END TIMING. This allows me to isolate the function being evaluated....***GW**■

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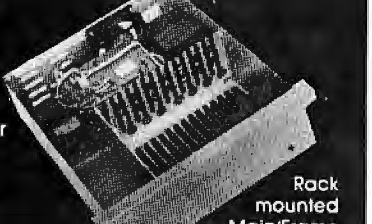

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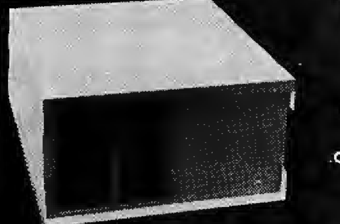

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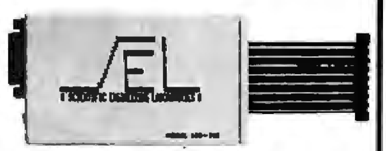

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Book Reviews

Travels in Computerland, or Incompatibilities & Interfaces

by Ben Ross Schneider Jr
Reading MA:
Addison-Wesley
Publishing Company

1974, Softcover, $6.50

Reviewed by
Jonathan Jacky
6551 5th Ave NE
Seattle WA 98115

How many seemingly impractical projects have been attempted only because someone thought, "That should be a trivial exercise for a computer"? So it seemed to theater historian Ben Ross Schneider Jr, when he proposed organizing a data base from *The London Stage*, an eleven-volume, 8000-page calendar of eighteenth-century theater performances. As Schneider envisioned, "It would be like having an index to every kind of thing in the book, only the computer would even turn the pages and take notes for you."

As he became involved in the project, Schneider soon realized that what is conceivable for the computer is sometimes not easily accomplished. He learned that the system which saves the scholar months of repetitive clerical work may well require several times that much effort to get running. Schneider recounts his experience in *Travels in Computerland*, an entertaining book that gives a true-to-life case study illustrating information-retrieval techniques. It is the best account of an ambitious computing project I have read.

Schneider describes the problems of creating a computer-accessible data base from source text intended for human readers. He intended his data bank to produce, for example, listings of every role an actor played during his career. That meant sorting all the entries in *The London Stage* by actor—but *The London Stage* was not arranged by actor; it consisted of theater programs arranged chronologically. Each program included many items: titles, roles, actors... To enable the computer to identify each item, they must be clearly delimited and follow each other in undeviating order.

Schneider believed that the syntax and typography of *The London Stage* satisfied these conditions, but programmer Will Daland recognized otherwise: "Too much variation," he explained. "A computer can't tolerate as much ambiguity as a human... The human being uses an immense store of experience to resolve ambiguities."

So they faced the mammoth task of recopying the entire text to better reveal its contents to the machine.

"The structure of *The London Stage*, which we had to describe before we could analyze it by machine, continually evaded us. To retrieve what was in it we had to know what kinds of things were in it and how this information was arranged. It was like nature itself. We always thought we knew more about it than we actually did."

Eventually they found the precise form in which the text would be presented to the computer, but only after Schneider learned to view his specialty from a new perspective. At one point he was startled when Daland, in trying to allow for all conceivable possibilities, suggested a plausible variation in eighteenth-century casting practices that had never occurred to Schneider. He recalls: "This episode is an example of how computer methods, by imposing logic, increase one's comprehension of one's subject. And that is why Will, who never studied it for an hour, could teach me something about theater history."

The book vividly conveys the day-to-day feel of the project. The reader shares Schneider's dismay when, as deadlines approach and seemingly banal practical problems threaten to scuttle the project, the drama scholar must become a reluctant expert in the countless technical aspects of computing.

Because this work was done in the premicroprocessor era (about ten years ago), some of the problems seem very dated; inestimable difficulty resulted when terminals capable of producing lower-case characters proved to be unavailable. Other problems are perennially familiar; Schneider ruefully recalls the time invested in "persuading data-processing firms to meet declared standards, and explaining to sales representatives what their products were." In a final, ironic twist, humanist Schneider realizes that his achievement is poorly accepted and little understood by fellow scholars because he neglected to communicate effectively with them.

This book should be required reading for anyone planning to apply a computer to an intricate real-world activity, be it business or research. The nature of Schneider's project, his unusual perspective and lively writing, and particularly his vivid characterizations and keen appreciation of the way personalities shape projects, recommend the book to those on the fringes of the computing world. *Travels in Computerland, or Incompatibilities & Interfaces* is especially relevant to those technologically innocent people who think that computers are for doing math, and wonder how anyone could think a machine can help him appreciate a work of art.■

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Circle 454 on inquiry card.

Circle 9 on inquiry card.

Ask BYTE

Conducted by Steve Ciarcia

Here's LED In Your Display

Dear Steve,

I enjoyed your article "Self-Refreshing LED Graphics Display" (October 1979 BYTE, page 58), and think I can use such an output display. My present system is a KIM-1 computer with an 8 K-byte memory board. I use the KIM-1's keypad and LED display for input and output, but I'm having difficulty expanding the display board.

Your design is an 8 by 16 display, but I would like to expand that to 8 by 64; then I could have a small amount of alphanumerics and graphics.

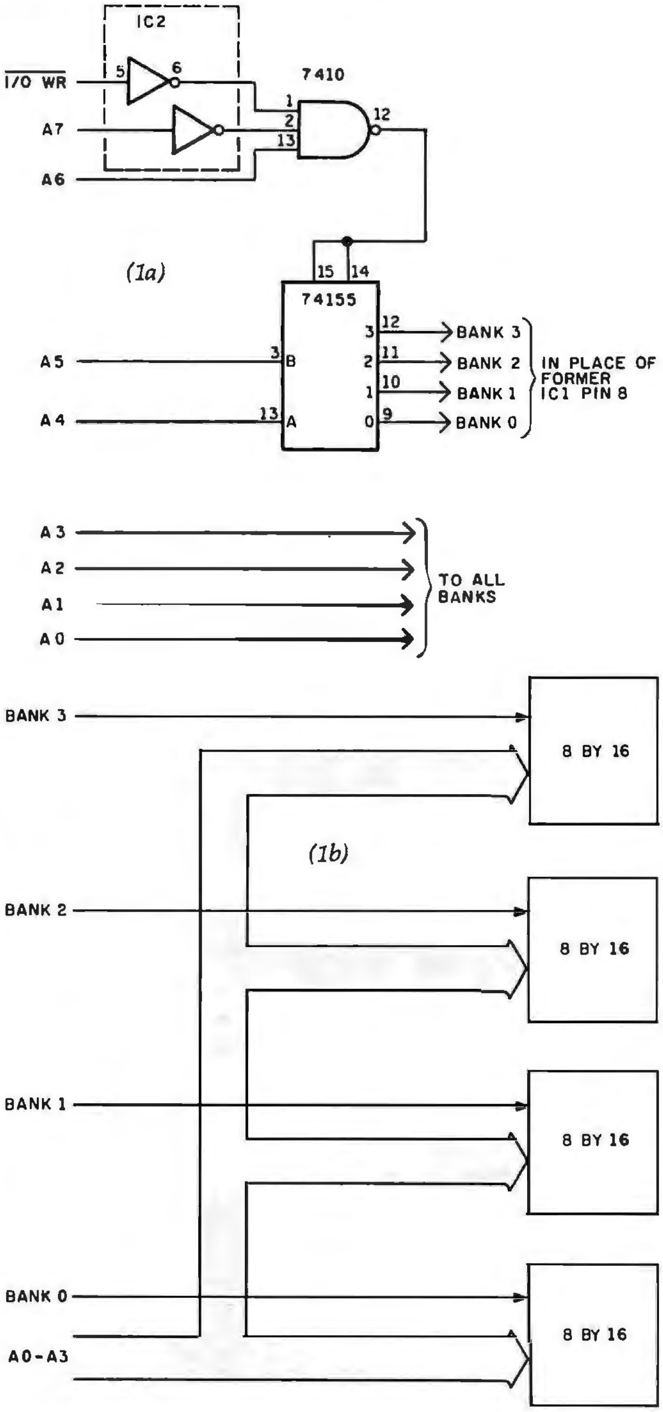
Near the end of your article, you mentioned that to expand on your design, simply add more memory and column decoders. Please be more specific. Would I have to use six address lines, and spread this out over four 74154 1-of-16 decoders? I assume a total of eight 7489 memory devices would be needed. How do I tie this stuff together? Would this affect the refresh and scan rates? Could I substitute LS-type logic circuits in your design?

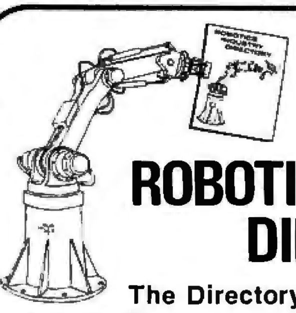
Charlie Timbers

There are several ways to expand the basic 8 by 16 display into an 8 by 64. The easiest thing to do is to make four of the basic units, then change the addressing to be four blocks of sixteen, for a total of sixty-four 8-bit output ports. To accomplish this, the address decoding presently done by IC1 and IC2 must be changed. Figures 1a and 1b should help.

*You can use LS TTL (transistor-transistor logic) devices for those integrated circuits that have an equivalent. Some don't. ...***Steve**

Figure 1





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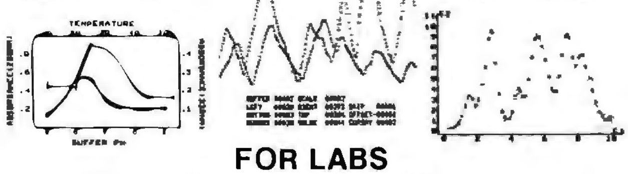

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Circle 25 on inquiry card.

One Shall Be Two

Dear Steve,

We use Maxell MD1 single-sided 5-inch floppy disks on our Apple II. We noticed that the disks have a head-access slot on both sides, so we decided to experiment. We cut a write-enable notch on the opposite edge, and, to our surprise, we were able to write a full 16 sectors on the other side of a single-sided disk. A scan of the disk showed the written data to be in good shape and no physically damaged areas. So, what is the difference between single-sided and double-sided disks—and why purchase a double-sided disk at the extra cost?

Michael Berch
John Oswalt
Berkeley CA

The answer to your question involves how disks are manufactured and tested, rather than any physical difference between them. Both sides of a disk are usually capable of data storage, but, on a single-sided disk, only one is guaranteed.

When a disk is made, it is tested for data retention. This means writing data (usually at a higher density than you will ultimately use) onto the disk and reading it back. If all goes well, the disk is certified. On double-sided disks, both sides are checked and certified.

As a matter of economics, some manufacturers do not bother to check more than what is required to meet production schedules. For example, if 100,000 disks are made and 10,000 must be certified as double sided, the manufacturer may stop testing both sides after getting 10,000 good ones. This often requires checking 15,000 disks to get the 10,000 that pass. Most often, the 5000 rejects end up in the single-sided

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stock (presuming that one side was good). The remaining 85,000 are only checked for one good side.

In your case, one of the following situations may exist:

1. Both sides were checked, but the manufacturer decided to put the disk in a single-sided envelope anyway.
2. The second side was untested by the manufacturer.
3. The second side failed the manufacturer's data test, and the disk could only be certified as single sided.

In the first case, you are handed a golden opportunity. Cut another access hole and use the other side. In the second and third cases, you are playing the odds. Of course, all three are merely conjecture, since the manufacturer doesn't specify the performance capabilities of the uncertified side.

*I suggest that you only use the modified disks for noncritical storage. While it may appear that your experiment has always worked in the disks you've tried, this may be more of a testimonial to the quality of that particular manufacturer's product than a general axiom for all disk users. ...***Steve**

RF Substitute?

Dear Steve,

I've been thinking about buying either an Apple II or an OSI C4P. While saving money and trying to make my decision, I ordered an Interact computer from Manu-Tronics. Each of these devices needs either a monitor or a television set with an RF (radio-frequency) modulator. Since I already have a videocassette recorder, can I hook the device into the video input jack of the cassette recorder and use its built-in RF modulator (channel 3 for

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Circle 72 on inquiry card.

my area) for my display?
John Ramler
Alexandria VA

I was hoping someone would ask that question.

Videocassette recorders have an input jack that is normally intended for use with a TV camera. In general, a camera has a 1-volt peak-to-peak output signal into a 75-ohm load. Most computers with a straight video output try to conform to this specification, so they should be compatible.

To make sure, I connected the output of an Apple II to the camera input of a Magnavox videocassette recorder. The camera/tuner and VTR/TV switches were set to camera and VTR, respectively. In my opinion, it worked well. However, it was necessary to reduce the TV's color-control setting to keep the letters from running together. Once adjusted properly, it made a satisfactory monitor.

An additional benefit of this technique is that you can record anything on the screen. ...Steve

Simple Case Conversion

Dear Steve,

I read Roger L Degler's "A Lowercase to Uppercase Converter," and it seems I have a similar problem. (See the September 1980 BYTE, page 326.) I own an uppercase-only keyboard, but I would like to use lowercase on my video-interface board. Is there some sort of uppercase-to-lowercase converter I could put between my keyboard and video board and still have an operational shift key? I'm sure many BYTE readers have the same problem.

Andrew Meyer
White Plains NY

To get lowercase codes from a keyboard that has uppercase-only output, it is necessary to make the fifth bit high (assuming 7-bit ASCII code), so that an "A" (1000001) becomes an "a" (1100001), and so on.

If your keyboard output is DTL (diode-transistor logic), RTL (resistor-transistor logic), or TTL (transistor-transistor logic), it can be modified a number of ways. One method is the way Roger Degler suggested in his article. Another way, simpler but much less sophisticated, is shown in figure 2. You'll note that pressing the "shift key" causes bit 5 to be high. ...Steve

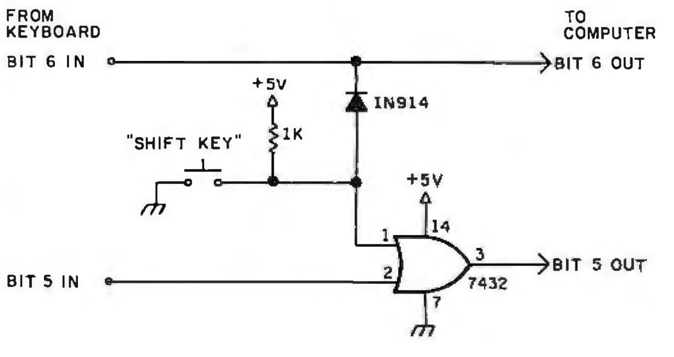

Figure 2

Circle 67 on inquiry card.

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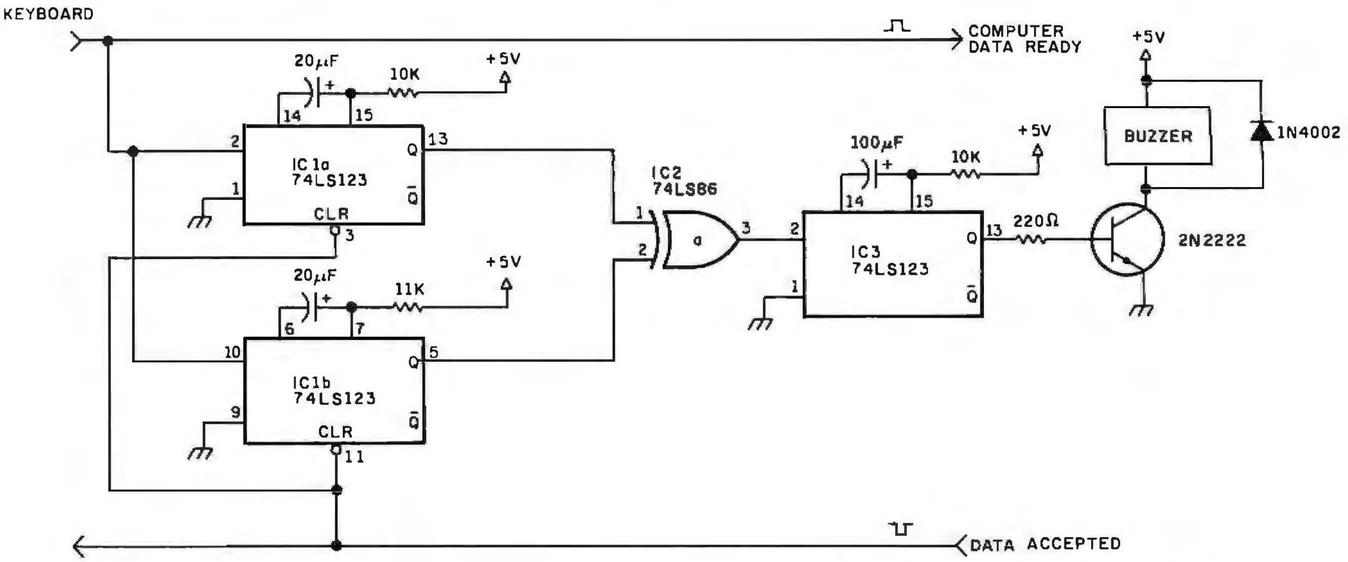

Figure 3

IC Number	Type	+5V	GND
IC1	74LS123	16	8
IC2	74LS86	14	7
IC3	74LS123	16	8

Where'd You Get Those Beepers?

Dear Steve,

I'm connecting a keyboard to a parallel port. I need a simple circuit that beeps if a pulse does not happen on the Data Accepted line within a set period of time after the pulse on the Data Ready line.

Can you help me?

David Smith
North Bergen NJ

There are many ways to design the circuit you want. One method is shown in figure 3. This circuit uses three monostable multivibrators and an Exclusive-OR gate to detect the missing Data Accepted pulse. When a key is pressed, the resulting Data Ready strobe fires IC 1a and IC 1b. IC 1a is "set" for the longest time you will allow before signaling a missing Data Accepted pulse (perhaps 50 ms). IC 1b is set a few microseconds to a few milliseconds longer than 1a (it only has to be 50 ns longer).

When these two one-shots fire, they open a timing window for the Data Accepted strobe. If it is received within the period allowed by 1a, then 1a and 1b are reset (no beep). If, however, no Data Accepted pulse is received, 1a will time-out before 1b. The opposite logic outputs of the two one-shots are then sensed by an Exclusive-OR, IC 2, which fires IC 3. IC 3 is a one-shot set for 200 ms and connected to a beeper. As long as the Data Accepted pulse is received within 50 milliseconds, you should never hear it.... **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:

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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.

Software Received

Apple

Astro-Scope, horoscope for the Apple II. Floppy disk, $30. Astro-Graphics Services Inc, POB 28, Orleans MA 02653.

E, Applesoft editing utility for the Apple II Plus. Cassette, $14.95. Apollo Software Company, 318 Harvard St, Suite 10, Brookline MA 02146.

Electronics I, electronics-design application programs for the Apple II. Floppy disk, $29.95. Howard W Sams & Company Inc, 4300 W 62nd St, POB 558, Indianapolis IN 46268.

Electronics II, electronics-design programs for the Apple II. Floppy disk, $29.95. Howard W Sams & Company Inc (see above).

Electronics III, electronics-design programs for the Apple II. Floppy disk, $29.95. Howard W Sams & Company Inc (see above).

Masterdos, disk customizing programs for the Apple II Plus. Floppy disk, $29.95. Masterworks Software Inc POB 7000-285, Rolling Hills Estates CA 90274.

Micro-Painter, color drawing program for the Apple II. Floppy disk, $34.95. Datasoft Inc, 16606 Schoenborn St, Sepulveda CA 91343.

1981 Tax Preparer, IRS tax-preparation aid for the Apple II. Floppy disk, $99. Howard Software Services, 7722 Hosford Ave, Los Angeles CA 90045.

Reversal, graphics strategy game for the Apple II (plays Othello, a trademark of CBS Inc). Floppy disk, $34.95. Hayden Book Company Inc, 50 Essex St, Rochelle Park NJ 07662.

Sex-O-Scope, horoscope for the Apple II. Floppy disk, $30. Astro-Graphics Services Inc (see above).

TRS-80

Active Filter Design,

Software Received

electronic-design program for the TRS-80. Cassette, $24.95. Howard W Sams & Company Inc, 4300 W 62nd St, POB 558, Indianapolis IN 46268.

Arcade-80, arcade-like graphics game for the TRS-80. Floppy disk, $24.95. Datasoft Inc, 16606 Schoenborn St, Sepulveda CA 91343.

Cosmic Fighter, graphics arcade game for the TRS-80. Cassette, $17.95. Big Five Software, POB 9078, Van Nuys CA 91409.

Descriptive Statistics & Regression Analysis, statistics package for the TRS-80. Cassette, $24.95. Howard W Sams & Company Inc (see above).

Football Classics, graphics strategy game for the TRS-80. Floppy disk, $24.95. Datasoft Inc (see above).

Genealogy, genealogy program for the TRS-80 Model II. Eight-inch floppy disk, $250. John J Armstrong, 3700 Whispering Pine Rd #47B, Mobile AL 36608.

Iago, graphics strategy game for the TRS-80 (plays Othello, a trademark of CBS Inc). Cassette, $19.95. Datasoft Inc (see above).

Plotting Graphs for Line Printer, graphing program for the TRS-80. Cassette, $24.95. Howard W Sams & Company Inc (see above).

Plotting Graphs for Video Display, graphing program for the TRS-80. Cassette, $24.95. Howard W Sams & Company Inc (see above).

Real-Estate, real-estate program for the TRS-80 Pocket Computer. Cassette, $24.95. Radio Shack, 1300 One Tandy Center, Ft Worth TX 76102.

Other Computers

Atari Character Generator, graphics utility for the Atari 400 and 800. Cassette, $15.95. Datasoft Inc, 16606 Schoenborn St, Sepulveda CA 91343.

C Compiler Version 1.4, programming language for the CP/M system. Eight-inch floppy disk, $145. B D Software, Cambridge MA 02139 (distributed by Lifeboat Associates, 1651 Third Ave, New York NY 10028).

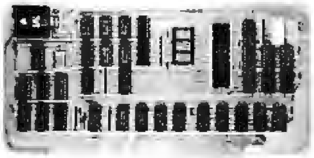
Chest of Classics, collection of games for the Sinclair ZX80. Cassette, $9.95. Lamo-Lem Labs, POB 2382, La Jolla CA 92038.

MINCE Version 2.4, word processor for the CP/M system. Eight-inch floppy disk, $125. Mark of the Unicorn, POB 423, Arlington MA 02174.

Telelink I, terminal program for the Atari 400 and 800. Program cartridge, $19.95. Atari Inc, POB 427, Sunnyvale CA 94086. ■

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. Companies sending software packages must include the suggested list price of the packages and (where appropriate) the alternate forms in which they are available.



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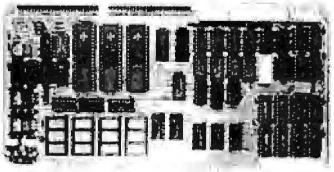

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Books Received

AIM-65, Laboratory Manual and Study Guide, Leo J Scanlon. Somerset NJ: John Wiley & Sons Inc, 1981; 21.5 by 28 cm, 179 pages; softcover, ISBN 0-471-06488-2, $7.95.

APL-Stat, James B Ramsey and Gerald L Musgrave. Belmont CA: Lifetime Learning Publications, 1981; 21.5 by 28 cm, 356 pages; softcover, ISBN 0-534-97985-8, $14.95. Solutions manual for above $3.95.

Apple Machine Language, Don Inman and Kurt Inman. Reston VA: Reston Publishing Company Inc, 1981; 16 by 24 cm, 296 pages; hardcover, ISBN 0-8359-0231-5, $9.95.

The Calculator Afloat, Captain Henry H Shufeldt, USNR (retired) and Kenneth E Newcomer. Annapolis MD: Naval Institute Press, 1980; 16 by 23.5 cm, 225 pages; hardcover, ISBN 0-87021-116-1, $16.95.

Computers in Society, Donald H Sanders. New York: McGraw-Hill Book Company, 1981; 19.5 by 24 cm, 622 pages; hardcover, ISBN 0-07-054672-X, $16.95.

Disassembled Handbook for TRS-80, Volume III, Robert M Richardson. Chautauqua NY: Richcraft Engineering Ltd, 1981; 24 by 28 cm, 239 pages; softcover, ISBN-none, $18.

Electric Machines and Transformers, Leonard R Anderson. Reston VA: Reston Publishing Company Inc, 1981; 18.5 by 24 cm, 305 pages; hardcover, ISBN 0-8359-1615-4, $18.95.

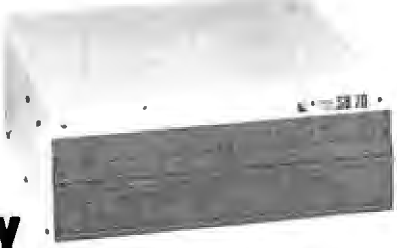
Experimentation with Microprocessor Applications, Thomas W Davis. Reston VA: Reston Publishing Company Inc, 1981; 17.5 by 23.5 cm, 237 pages; softcover, ISBN 0-8359-1812-2, $9.95.

Fifty BASIC Exercises, J P Lamoitier. Berkeley CA: Sybex, 1981; 18 by 23 cm, 253 pages; softcover, ISBN 0-89588-056-3, $12.95.

FORTRAN IV, Second Edition, J Friedmann, P

Circle 71 on inquiry card.

SB/70



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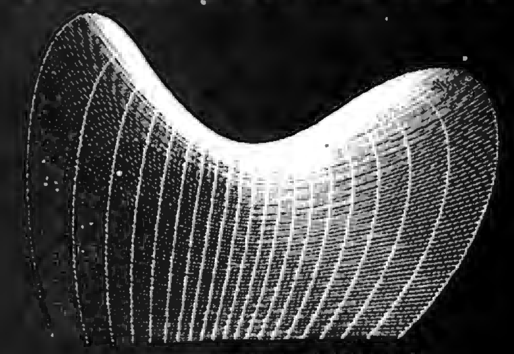
S-100 GRAPHICS



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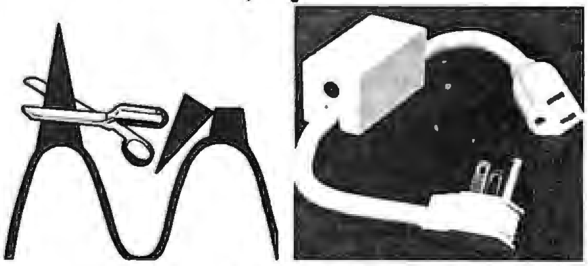

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Greenberg, and A Hoffberg. Somerset NJ: John Wiley & Sons Inc, 1981; 17 by 25.5 cm, 499 pages; softcover, ISBN 0-471-07771-2, $10.95.

Fundamental Structures of Computer Science, W A Wulf, M Shaw, P N Hilfinger and L Flon. Reading MA: Addison-Wesley Publishing, 1981; 17 by 24.5 cm, 621 pages; hardcover, ISBN 0-201-08725-1, $21.95.

H-8 Programming for Beginners, Don Inman and Bob Albrecht. Portland OR: Dilithium Press, 1980; 13.5 by 21.5 cm, 194 pages; softcover, ISBN 0-918398-17-7, $8.95.

LISP, P H Winston and B K P Horn. Reading MA: Addison-Wesley Publishing, 1981; 16 by 23.5 cm, 430 pages; softcover, ISBN 0-201-08329-9, $13.95.

Multinational Computer Nets, Richard H Veith. Lexington MA: Lexington Books, 1981; 16.5 by 23.5 cm, 133 pages; hardcover, ISBN 0-669-04092-4, $18.95.

Problem-Solving and Structured Programming in Pascal, Elliot B Koffman. Reading MA: Addison-Wesley Publishing, 1981; 16 by 23 cm, 483 pages; softcover, ISBN 0-201-03893-5, $13.95.

Programmer's Guide to LISP, Ken Tracton. Blue Ridge Summit PA: Tab Books Inc, 1980; 13 by 21 cm, 210 pages, softcover, ISBN 0-8306-1045-6, $6.95; hardcover. ISBN 0-8306-9761-6, $10.95.

Protocols & Techniques for Data Communication Networks, Franklin F Kuo, editor. Englewood Cliffs NJ: Prentice-Hall Inc, 1981; 18.5 by 24 cm, 468 pages; hardcover, ISBN 0-13-731729-8, $29.95.

The Small Computer in Small Business, A Guide to Selection and Use, Brian R Smith. Brattleboro VT: Stephen Greene Press, 1981; 16 by 23.5 cm, 143 pages; hardcover, ISBN 0-8289-0407-3, $12.50.

Small Computers for the Small Businessman, Nicholas Rosa and Sharon Rosa. Portland OR: Dilithium Press, 1980; 14 by 21 cm, 301

pages; softcover, ISBN 0-918398-31-2, $12.95.

33 Challenging Computer Games for TRS-80/Apple/PET, David Chance. Blue Ridge Summit PA: Tab Books Inc, 1981; 13 by 21 cm, 256 pages; softcover, ISBN 0-8306-1275-0, $7.95; hardcover, ISBN 0-8306-9703-9, $14.95.

Troubleshooting Solid-State Circuits, G Loveday and A Seidman. Somerset NJ: John Wiley & Sons Inc, 1981; 23.5 by 19 cm, 110 pages; softcover, ISBN 0-471-08371-2, $7.95.

Understanding Computer Systems, Harold W Lawson, Jr. Linkoping, Sweden: Harold W Lawson Jr, 1979; 20.5 by 29 cm, 150 pages; softcover, ISBN 91-7372-222-9, $15.25.

Understanding Microprocessors, Lloyd Rich. Reston VA: Reston Publishing Company Inc, 1981; 16 by 23.5 cm, 296 pages; hardcover, ISBN 0-8359-8057-X, $17.95.

Without Me You're Nothing, The Essential Guide to Home Computers, Frank Herbert with Max Barnard. New York: Simon and Schuster, 1980; 16.5 by 24 cm, 304 pages; hardcover, ISBN 0-671-41287-6, $14.95.

Word Processing, Rod Van Uchelen. New York: Van Nostrand Reinhold Company, 1981; 20.5 by 23.5 cm, 128 pages; softcover, ISBN 0-442-28646-5, $7.95.■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

Clubs and Newsletters

Microcomputers in Planning Association

This group is dedicated to using micrcomputers in the field of planning. The emphasis is on the use of microcomputers for physical or social planning, in public agencies, academia, or private firms. The dues are $10 per year, which includes a bimonthly newsletter.

For further details, contact the group at 1204 People's Bldg, 60 Monroe at Ionia, Grand Rapids MI 49503, (616) 454-9375.

MP/M Users Group

MAPS is an MP/M users group that publishes a quarterly newsletter called *MAPS Digest*. The newsletter contains application reports, compatibility issues, MP/M support product reviews, and problem areas and solutions discovered by MP/M users. Members receive a list of programs in the MAPS software library and can participate in the MAPS bulletin-board service. Contact Digiac Corporation, Commercial Products Division, 175 Engineers Rd, Smithtown NY 11787, (516) 273-8600.

Monadnock Computer Society

The Monadnock Computer Society meets on the first Thursday of each month at the Keene State College Library in Keene, New Hampshire. Club members own and use the most popular microcomputers on the market. The club is actively seeking information from other organizations. *MCS Output*, a monthly

newsletter, is available. Contact Doug Scribner, POB 405, Keene NH 03431, (603) 352-5558.

Computer Neophyte Newsletter

ComputerTalk Associates, publisher of *ComputerTalk for the Pharmacist*, has introduced a monthly newsletter for first-time buyers and users of small-business computers. The newsletter covers software, hardware, legal issues, new products, and it gives advice on what to look for when purchasing a computer. It is designed for readers with no prior background in electronic data processing. Subscriptions are available for $35 per year from ComputerTalk Associates, Whitpain Office Campus, 1750 Walton Rd, Blue Bell PA 19422, (215) 825-4918.

TRS-80 Users Group of Delaware

If you live in the Delaware Valley area, there's a users group that would like to hear from you. For more information on the group and its activities, contact Tim J Ihde, 1116 Piper Rd, Wilmington DE 19803, (302) 478-7415.

PDP-8 Users Software Exchange

There's a free software exchange service for DEC (Digital Equipment Corporation) PDP-8 users. The service allows users to submit their software for exchange credits that can be used to obtain any software listed in the *Quarterly Software Exchange Bulletin*. Also available is the electronic magazine *Digital Digest*. Contact PDP-8 Software Exchange, 3169 Holcomb Bridge Rd, Suite 307,

Clubs and Newsletters

Department 1019, Norcross GA 30071, (404) 447-4736.

Computernews for Dentists

This monthly 4-page newsletter contains information about computers, developments in technology, and explanations of components. The newsletter shows dentists how the computer can help in their work, especially in management. *Computernews for Dentists* is published by Praxis Computer Inc, 431 St Paul St, St Catherines, Ontario, L2R 3N4, Canada, (416) 688-2611.

MICRO

MICRO (Midwest Interactive Computer Organization) meets on the second Saturday of each month. Dues are $15 per year. Members own Apple, TRS-80, OSI, TI 99/4, KIM, Technico, and other makes of computers. Contact MICRO at 1520 W Capitol Dr, Appleton WI 54911.

The Aurora Computer Society

The Aurora Computer Society meets on the second Wednesday of each month at the Holyrood School, 7920 94th Ave, Edmonton, Alberta, at 7:30 PM. The group is involved in computer-to-amateur radio interfacing and BASIC classes. Members own PET, TRS-80, SwTPC, and other kinds of microcomputers. A monthly magazine, *Intercom 80*, features technical articles and news of the Society. They are interested in communicating with other groups. Contact Bob Huntingford, POB 4342 South Edmonton, Alberta; or Bill Gillespie, 10129 90th St, Edmonton, Alberta, T5H 1R5, Canada.■

A File Catalog System for UCSD Pascal

Edward Heyman
300 Center Hill Rd
Centerville DE 19807

It doesn't take long to accumulate a large number of disks with assorted software, particularly if you insist on a reasonable amount of backup. Finding a program you worked on two months ago can be a problem without some type of file organization. Ward Christenson provided the CP/M world with that organization in his UCAT disk catalog system. I'd be lost without it.

As my collection of UCSD Pascal files grew I needed a system similar to UCAT to cope with the problem. Hence, I created CATALOG (see listing 1). Written in Pascal, it does all the things that UCAT does as fast or faster than UCAT (even though UCAT is written in assembly language). A new directory can be merged into a 600-entry catalog in about 30 seconds. A search for a file in a 600-entry catalog takes less than a second. A 600-entry catalog uses about thirty-six blocks, as does the backup file. The program code file and pointer file use another twenty blocks for a total of ninety-two blocks.

What CATALOG Does

CATALOG maintains a file of records in which each record is similar to a UCSD Pascal directory entry. The record contains the name of the volume, the file name, the type of file, the date the file was last changed, and the length of the file. CATALOG gets the records directly from a volume directory during UPDATE. Once the CATALOG file is filled with records you can locate a file with the SEARCH command.

Being lazy, I like to have my machine do as much of my work as possible, so I've added a few bells and whistles to the essential features.

Using CATALOG

For the CATALOG program to work, the files MASTCAT.DATA and CAT.POINT.DATA must be on Drive five. If they are not, the program asks if you want to create them. The first time the program is run you must respond with a "Y" to the prompts for file creation before you can proceed.

Thereafter, executing CATALOG will bring forth the command line:

CATALOG→S)earch D)isplay B)ackup U)pdate R)emove Q)uit.

The S Command

Entering "S" will put the program in the Search mode with the prompt:

ENTER THE NAME OF FILE TO BE FOUND→

Uppercase must be used for the file name. Wild-card searches can be made by replacing the wild-card section with "=". For example, the following entries may be made to find CATALOG.TEXT:

CATALOG.TEXT
CAT=
=LOG.TEXT

The directory of an entire volume can be obtained by typing the name of the volume followed by ":".

Entering file name FREE.SPACE will display a list of all the cataloged volumes, the available space, and the most recent date of catalog update of each volume.

The output of the Search command can be directed to the printer by typing "< " before the name of the file to be searched.

The D Command

Entering "D" in response to the main prompt line will display the entire catalog in alphabetical order.

The B Command

Entering "B" in response to the main prompt line will display all files that exist on only one volume (all files that do not have a backup). The routine checks only for the same file name; therefore, files with the same name but different dates are considered to be backed up.

The U Command

A response of "U" to the main prompt line will activate the update routine, which will produce the prompt:

ENTER UNIT NUMBER CONTAINING UPDATE VOLUME→

If UNIT 5 is selected, the catalog file will be updated with the contents of the volume containing the catalog files (with the exception of MASTCAT.DATA). For all other volumes UNIT 4 should be used.

The update procedure will first rename the main catalog file (MASTCAT.DATA) to BACKCAT.DATA and then read the directory for the volume on the selected unit and create a file name FREE.SPACE with the unused space on the volume. It will then sort the files by alphabetical order and merge the volume list with the catalog file (MASTCAT.DATA) and at the same time create the pointer file (CAT.POINT.DATA.).

While merging, any file names added will be displayed on the console terminal and any files that were previously on the volume but were removed will be removed from the master file and displayed as having been deleted. After completion, the number of entries in both the main and backup files will be displayed.

The beauty of Pascal is its self-documenting features—the program should not be difficult to follow.

The R Command

Entering an "R" in response to the main prompt will invoke the prompt line:

ENTER NAME OF VOLUME TO BE REMOVED→

Entering a volume name and a carriage return will cause all entries in the main catalog file for the selected volume to be removed from the file and to be listed on the terminal.

The Q Command

To leave CATALOG enter "Q". UNIT 4 will be checked to see if it contains the booted system volume; if not, a prompt to insert the original system volume will be displayed on the terminal before the program is exited (to prevent a system crash).

How the Program Works

The beauty of Pascal is its self-documenting features—the program should not be difficult to follow.

Since most systems will not have sufficient memory to hold a copy of both the old (BACKCAT.DATA) and the new catalog (MASTCAT.DATA) at one time, the files are read in and written out in sections. OCAT and NCAT are arrays that hold the records read from the old file and the records to be written to the new file, respectively. The size of these arrays is determined by the constant MAXREC. MAXREC should be adjusted to suit your memory size. NREC and OREC are variables associated with the number of records read or records written during the current read or write. DREC is associated with the number of records in the directory. OTOTREC and NTOTREC are the total records read or written to or from a file.

In order to speed the action of the SEARCH command a pointer file is created during UPDATE. The index to the pointers are the characters "A" to "Z". The array holding the pointers is called DEXRAY and is stored on disk in the file CAT.POINT.DATA. The pointer list is created by calls to the procedure SETDEX. It is written to file by procedure WRITEDEX and read into array DEXRAY by procedure READDEX.

Procedure BACKUP checks to see if the file name of a record is unequal to its predecessor and successor. If it is, it is not backed up. Since the array is not large enough to hold all of the catalog file, provisions must be made to compare the last entry in one array with the first entry in the next array. The Boolean variables PASS and UNBACK are used for this purpose.

To simplify the logic of procedure MERGE, several IF statements as well as the CASE statement have been used. The problem may be stated as follows:

- If the current directory record file name is less than the current old catalog record file name, insert the directory record in the new catalog and increment the new file pointer (NREC) and the directory pointer (D).
- If the current directory record file name is equal to the current old catalog record file name, check the volume names. If the current directory record volume name is less than the old catalog record volume name, insert the directory record and increment the new catalog (NREC) and the directory (D) pointers. If the current directory record volume name is equal to the old catalog record volume file name, insert the directory record and increment NREC, OREC, and D. If the directory record volume name is greater than the old file record name, insert the old catalog record into the new catalog and increment the new catalog and old catalog pointers.
- If the current directory record file name is greater than the old catalog record file name, insert the old catalog record in the new catalog and increment the new catalog pointer and the old catalog pointer. If the directory record volume name is equal to the old file record volume name, do not enter the record in the new catalog, and simply increment the old catalog pointer.

I hope that you will find CATALOG useful in keeping track of your files and programs. ■

Listing 1: *A disk catalog system for UCSD Pascal. This program maintains a file of records in which each record is similar to a UCSD Pascal directory. Each record contains the name of the volume, the file name, the type of file, the date the file was last changed, and the length of the file.*

```
(*$S+*)(*L CONSOLE:*)(*L PRINTER:*)(*L CAT.PRN.TEXT*)

PROGRAM CATALOG;

(* written by edward heyman    *)
(* 300 center hill road        *)
(* centerville delaware 19807 *)

CONST
        BLANKS = '                 ';
        MAXREC=200;
        MAXREC_1=201;
        NFILENAME='#5:MASTCAT.DATA';
        OFILENAME='#5:BACKCAT.DATA';
        PFILENAME='#5:CAT.POINT.DATA';
        CLEARSCREEN=12;

TYPE

     DATE_RECORD = PACKED RECORD
                        MONTH: 0..12;
                        DAY: 0..31;
                        YEAR: 0..100
                   END;

     DIR_SIZE = 0..77;
     VOL_ID = STRING[7];
     FILE_ID = STRING[15];
     FILE_TYPE = (UNTYPED,XDISK,CODE,TEXT,
                  INFO,DATA,GRAF,FOTO,SECUREDIR);
     DIR_RECORD = RECORD
                       FIRST_BLOCK: INTEGER;
                       LAST_BLOCK: INTEGER;
```

Listing 1 continued on page 411

Listing 1 continued:

```
                    CASE DIR_FILE_KIND:FILE_TYPE OF
                      SECUREDIR,UNTYPED:
                                        (DIR_VOL_NAME:VOL_ID;
                                         ZERO_BLOCK,
                                         NUM_OF_FILES,
                                         TOTAL_BLOCKS:INTEGER;
                                         LAST_BOOT:DATE_RECORD);
                      XDISK,CODE,TEXT,INFO,DATA,
                      GRAF,FOTO:
                                (DIR_FILE_NAME:FILE_ID;
                                 LASTBYTE:1..512;
                                 DIR_FILE_DATE:DATE_RECORD)
                  END;

      CATALOG_RECORD=PACKED RECORD
                    VOL_NAME:VOL_ID;
                    FILE_NAME:FILE_ID;
                    FILE_KIND:FILE_TYPE;
                    FILE_DATE:DATE_RECORD;
                    FILE_SIZE:0..988;
              END;

      DIRECTORY = ARRAY[DIR_SIZE] OF DIR_RECORD;
      CATARRAY = ARRAY [0..MAXREC] OF CATALOG_RECORD;
      FILEN = STRING[20];
      RECNUM = 0..MAXREC_1;
      INDEX = 'A'..'Z';
      INDEXARRAY = ARRAY [INDEX ] OF INTEGER;

VAR

         NREC,NLREC,OREC,OLREC,DREC,DLREC:RECNUM;
         NTOTREC,OTOTREC:0..2047;
         REMOV,NFILEEND,OFILEEND,DONE:BOOLEAN;
         CH:CHAR;
         DEX: INDEX;
         DEXRAY : INDEXARRAY;
         P : FILE OF CHAR;         {used to switch from console to printer}
         VOL,TEST,SYSTEMVOLUME:VOL_ID;
         CATFILE,OCATFILE,NCATFILE:FILE OF CATALOG_RECORD;
         NCAT,OCAT:CATARRAY;
```

Listing 1 continued on page 412

Listing 1 continued:

```
FUNCTION LOOKUP(FN:FILEN):BOOLEAN;FORWARD;

SEGMENT PROCEDURE INITIALIZE;
  VAR
        I:RECNUM;
        CAT:CATARRAY;
        DEXFILE:FILE OF INDEXARRAY;
  BEGIN
    IF (NOT LOOKUP(NFILENAME))
      THEN BEGIN
             WRITELN('THERE IS NO FILE NAMED ',NFILENAME,' ON THIS DISK');
             WRITELN('DO YOU WANT TO CREATE A ',NFILENAME,'  {Y/N}');
             REPEAT
               READ(CH)
             UNTIL (CH IN ['Y','y','N','n']);
             IF ((CH<>'Y') AND (CH<>'y')) THEN EXIT(CATALOG);
             writeln('FILLING ARRAY[0]');
             WITH CAT[0] DO
               BEGIN
                 VOL_NAME:='        ';
                 FILE_NAME:='               ';
                 FILE_KIND:=UNTYPED;
                 FILE_DATE.MONTH:=0;
                 FILE_DATE.DAY:=0;
                 FILE_DATE.YEAR:=0;
                 FILE_SIZE:=0;
               END;
             FOR I:=1 TO MAXREC DO CAT[I]:=CAT[0];
             writeln('ARRAY IS FILLED');
             REWRITE(CATFILE,NFILENAME);
               FOR I:=0 TO MAXREC DO
                 BEGIN
                   CATFILE^:=CAT[I];
                   PUT(CATFILE);
                 END;{for I}
             CLOSE(CATFILE,LOCK)
           END{if}
      ELSE WRITELN('THE FILE ',NFILENAME,' ALREADY EXITS ON THIS VOLUME ');
```

Listing 1 continued on page 413

Listing 1 continued:

```
   IF NOT LOOKUP(PFILENAME)
     THEN BEGIN
             WRITELN('THERE IS NO FILE NAMED ',PFILENAME,' ON THIS DISK');
             WRITELN('DO YOU WANT TO CREATE A ',PFILENAME,'  {Y/N}');
             REPEAT
               READ(CH)
              UNTIL (CH IN ['Y','y','N','n']);
              IF ((CH<>'Y') AND (CH<>'y')) THEN EXIT(CATALOG);
              FOR DEX:='A' TO 'Z' DO DEXRAY[DEX]:=0;
              REWRITE(DEXFILE,PFILENAME);
              DEXFILE^:=DEXRAY;
              PUT(DEXFILE);
              CLOSE(DEXFILE,LOCK);
              WRITELN(PFILENAME,' WRITTEN TO DISK')
              END{if}
       ELSE WRITELN('FILE ',PFILENAME,' EXISTS');
END;{init}




FUNCTION LOOKUP;
{returns TRUE if filename present FALSE if not}
    VAR
          IOR:0..15;
    BEGIN
      {$I-}
      RESET(CATFILE,FN);
      IOR:=IORESULT;
      CLOSE(CATFILE);
      {$I+}
      IF (IOR=0)
          THEN LOOKUP:=TRUE
          ELSE BEGIN
                 LOOKUP:=FALSE;
                 IF(IOR<>10) THEN WRITELN('IORESULT FOR ',FN,' IS ',IOR);
          END;{else}
    END;{lookup}
```

Listing 1 continued on page 414

Listing 1 continued:

```
PROCEDURE WAIT;
  BEGIN
    GOTOXY(10,24);
    WRITE('PRESS SPACE BAR TO CONTINUE');
    READ(CH)
  END;{wait}

PROCEDURE MEM(PN:STRING);
  BEGIN
      writeln('MEMORY AVAILABLE AT PROCEDURE ',PN,' = ',MEMAVAIL);
  END;



PROCEDURE GET_SYS_VOL(VAR VOL:VOL_ID);
{sets name of volume in drive 4}
  VAR
      I,J: INTEGER;
      SPS:STRING[16];
      AVOL:VOL_ID;
      DIR: DIRECTORY;
  BEGIN
    UNITREAD(4,DIR[0],2048,2);
    VOL:=DIR[0].DIR_VOL_NAME;

    SPS:=COPY(BLANKS,1,7-LENGTH(VOL));
    AVOL:=CONCAT(VOL,SPS);
  END;{set_sys_vol}

PROCEDURE READDEX;
{reads the file of pointers to the first occurrence of each letter in the alpha
  VAR
      DEXFILE : FILE OF INDEXARRAY;
  BEGIN
    RESET(DEXFILE,PFILENAME);
    DEXRAY:=DEXFILE^;
    GET(DEXFILE);
       CLOSE(DEXFILE);
  END;{readdex}

PROCEDURE ENTER_VOL_NAME;
  VAR
        SPS:VOL_ID;
```

Listing 1 continued on page 415

Listing 1 continued:

```
  BEGIN
    VOL:='        ';
    REPEAT
      WRITE(CHR(CLEARSCREEN));
      WRITE('ENTER NAME OF VOLUME TO BE REMOVED --> ');
      READLN(VOL);
    UNTIL (LENGTH(VOL)<=8);
    IF (POS(':',VOL)<>0) THEN DELETE(VOL,POS(':',VOL),1);
    SPS:=COPY(BLANKS,1,7-LENGTH(VOL));
    VOL:=CONCAT(VOL,SPS);
    WRITELN(VOL,'!');
    DREC:=0
  END;{enter_vol_name}


PROCEDURE PRINT_DATE (REC:DATE_RECORD);
{prints date to console or printer}
BEGIN
 WITH REC DO
   BEGIN
      WRITE(P,DAY:3,'-');
        CASE MONTH OF
          1: WRITE(P,'Jan');
          2: WRITE(P,'Feb');
          3: WRITE(P,'Mar');
          4: WRITE(P,'Apr');
          5: WRITE(P,'May');
          6: WRITE(P,'Jun');
          7: WRITE(P,'Jul');
          8: WRITE(P,'Aug');
          9: WRITE(P,'Sep');
          10: WRITE(P,'Oct');
          11: WRITE(P,'Nov');
          12: WRITE(P,'Dec');
        END;{case}
        WRITE(P,'-',YEAR:2,' ':3);
     END;{with}
   END;{print_date}
```

Listing 1 continued on page 416

Listing 1 continued:

```
PROCEDURE PRINT_KIND(FILE_KIND:FILE_TYPE);
{prints file type to console or printer}
   BEGIN
     CASE FILE_KIND OF
        XDISK: WRITE(P,'Bad block');
        CODE:  WRITE(P,'Code file');
        TEXT:  WRITE(P,'Text file');
        INFO:  WRITE(P,'Info file');
        DATA:  WRITE(P,'Data file');
        GRAF:  WRITE(P,'Graf file');
        FOTO:  WRITE(P,'Foto file');
      END; { case }
   END;{print_kind}

 PROCEDURE PRINT_RECORD(CAT1:CATALOG_RECORD);
 {prints record to console or printer}
     BEGIN
       WITH CAT1 DO
         BEGIN
           WRITE(P,FILE_NAME,'   ':18-LENGTH(FILE_NAME));
           WRITE(P,VOL_NAME,' ':8-LENGTH(VOL_NAME));
           WRITE(P,FILE_SIZE:4);
           PRINT_DATE(FILE_DATE);
           PRINT_KIND(FILE_KIND);
           WRITELN(P);
         END;{with}
     END;{print_record}

 PROCEDURE READ_NEW_CAT;
 {reads NREC records or to eof from NCATFILE}
   VAR
         I:RECNUM;
   BEGIN
     I:=1;NREC:=0;
     GET(NCATFILE);
     WHILE (NOT EOF(NCATFILE)) DO
         BEGIN
           NCAT[I]:=NCATFILE^;
           IF ((NCAT[I].VOL_NAME='        '))
             THEN BEGIN
                    NREC:=I-1;
                    NTOTREC:=NTOTREC+NREC;
                    NFILEEND:=TRUE;
                    EXIT(READ_NEW_CAT);
                  END;{if}
```

Listing 1 continued on page 417

Listing 1 continued:

```
          IF (I=NLREC)
             THEN BEGIN
                   NREC:=I;
                   NTOTREC:=NTOTREC+I;
                   EXIT(READ_NEW_CAT);
                  END;{if}
          I:=I+1;
          GET(NCATFILE);
        END;{while}
      NREC:=I-1;
      NTOTREC:=NTOTREC+NREC;
      NFILEEND:=TRUE;
  END;{nreadcat}

PROCEDURE READ_OLD_CAT;
{reads OREC records or to eof from OCATFILE}

VAR
      I:RECNUM;
BEGIN
  I:=1;OREC:=0;
  GET(OCATFILE);
  WHILE (NOT EOF(OCATFILE)) DO
      BEGIN
        OCAT[I]:=OCATFILE^;
        IF ((OCAT[I].VOL_NAME='        '))
          THEN BEGIN
                 OREC:=I-1;
                 OTOTREC:=OTOTREC+OREC;
                 OFILEEND:=TRUE;
                 EXIT(READ_OLD_CAT);
               END;{if}
        IF (I=OLREC)
          THEN BEGIN
                 OREC:=I;
                 OTOTREC:=OTOTREC+I;
                 EXIT(READ_OLD_CAT);
               END;{if}
        I:=I+1;
        GET(OCATFILE);
      END;{while}
    OREC:=I-1;
    OTOTREC:=OTOTREC+OREC;
    OFILEEND:=TRUE;
END;{readcat}
```

Listing 1 continued on page 418

Listing 1 continued:

```
PROCEDURE WRITECAT;
{writes NREC records to NCATFILE}
  VAR
        I:RECNUM;
  BEGIN
    IF (NTOTREC=0) THEN WITH NCAT[0] do
                        BEGIN
                          VOL_NAME:='        ';
                          FILE_NAME:='               ';
                          FILE_KIND:=UNTYPED;
                          FILE_DATE.MONTH:=0;
                          FILE_DATE.DAY:=0;
                          FILE_DATE.YEAR:=0;
                          FILE_SIZE:=0;
                          NCATFILE^:=NCAT[0];
                          PUT(NCATFILE);
                        END;
    FOR I:=1 TO NREC DO
      BEGIN
        NCATFILE^:=NCAT[I];
        PUT(NCATFILE);
        WRITE('.');
      END;
    WRITELN;
    NTOTREC:=NTOTREC+NREC;
    NREC:=0;
    IF DONE THEN CLOSE(NCATFILE,LOCK);
  END;{writecat}
PROCEDURE DISPLAY;
{writes the entire MASTCAT.DAT file to the console}
   VAR
         I:RECNUM;
   BEGIN
    REWRITE(P,'CONSOLE:');
    IF ( LOOKUP(NFILENAME))
      THEN BEGIN
             NREC:=0;
             RESET(NCATFILE,NFILENAME);
             REPEAT
               READ_NEW_CAT;
               FOR I:=1 TO NREC DO PRINT_RECORD(NCAT[I]);
             UNTIL NFILEEND;
```

Listing 1 continued on page 419

Listing 1 continued:

```
                CLOSE(NCATFILE);
                WAIT;
              END{then}
              ELSE WRITELN(NFILENAME,' NOT PRESENT');
       WRITELN('MASTCAT CONTAINS  ',NTOTREC,' RECORDS');
       CLOSE(F);
       WAIT;
   END;{display }

PROCEDURE BACKUP;
{compares file names and reports files without backup}
   VAR
         PASS,UNBACK:BOOLEAN;
         N:RECNUM;
   BEGIN
     PASS:=FALSE;UNBACK:=FALSE;
     REWRITE(P,'CONSOLE:');
     IF ( LOOKUP(NFILENAME))
         THEN BEGIN
                WRITE(CHR(CLEARSCREEN));
                WRITELN('THE FOLLOWING FILES ARE NOT BACKED UP');
                RESET(NCATFILE,NFILENAME);
                REPEAT
                  IF (PASS AND UNBACK)
                      THEN IF (NCAT[0].FILE_NAME<>NCAT[1].FILE_NAME)
                               THEN PRINT_RECORD(NCAT[0]);
                  READ_NEW_CAT;
                  FOR N:=1 TO NREC-1 DO
                     IF ((NCAT[N].FILE_NAME <> NCAT[N-1].FILE_NAME) AND
                           (NCAT[N].FILE_NAME <> NCAT[N+1].FILE_NAME))
                                  THEN PRINT_RECORD(NCAT[N]);
                  PASS:=TRUE;
                  IF (NCAT[NREC].FILE_NAME <> NCAT[NREC-1].FILE_NAME)
                          THEN UNBACK:=TRUE;
                  NCAT[0]:=NCAT[NREC];
                  IF (NFILEEND AND UNBACK) THEN PRINT_RECORD(NCAT[NREC]);
                UNTIL NFILEEND;
                CLOSE(NCATFILE);
             END{if}
         ELSE WRITELN(NFILENAME,' NOT PRESENT');
      CLOSE(P);
      WAIT;
   END;{backup}
```

Listing 1 continued on page 420

Listing 1 continued:

```
PROCEDURE UPDATE;

VAR
        DCAT : ARRAY [DIR_SIZE] OF CATALOG_RECORD;
        RN:RECNUM;

  PROCEDURE RENAME;         {changes name of MASTCAT.DATA to BACKCAT.DATA}
    VAR
          I:INTEGER;
          SPS:STRING[16];
          VOL,AVOL:VOL_ID;
          DIR:DIRECTORY;
    BEGIN
      UNITREAD(5,DIR[0],2048,2);
      VOL:=DIR[0].DIR_VOL_NAME;
      SPS:=COPY(BLANKS,1,7-LENGTH(VOL));
      AVOL:=CONCAT(VOL,SPS);
      FOR I:=1 TO DIR[0].NUM_OF_FILES DO
          WITH DIR[I] DO
            IF (DIR_FILE_NAME='MASTCAT.DATA')
              THEN DIR_FILE_NAME:='BACKCAT.DATA';
      UNITWRITE(5,DIR[0],2048,2);
    END;{rename}


  PROCEDURE WRITEDEX;
  {writes a file of pointers to the first occurrence of each letter in the alpha
    VAR
        DEXFILE : FILE OF INDEXARRAY;
    BEGIN
      REWRITE(DEXFILE,PFILENAME);
      DEXFILE^:=DEXRAY;
      PUT(DEXFILE);
      CLOSE(DEXFILE,LOCK);
    END;{writedex}

  PROCEDURE SORT;
  {sorts the directory file in alphabetical order}
    VAR
          I:RECNUM;
          BUF:CATALOG_RECORD;         {holds record during exchange}
          FLAG:BOOLEAN;               {FALSE if an exchange made during pass}
```

Listing 1 continued on page 421

Listing 1 continued:

```
    BEGIN
      WRITELN('SORTING ',DREC,' RECORDS');
      REPEAT
        FLAG:=TRUE;
        FOR I:=DREC DOWNTO 2 DO
           IF (DCAT[I].FILE_NAME < DCAT[I-1].FILE_NAME) THEN
              BEGIN        {exchange routine}
                BUF:=DCAT[I];
                DCAT[I]:=DCAT[I-1];
                DCAT[I-1]:=BUF;
                FLAG:=FALSE;
              END;{if}
       WRITE('.');
       UNTIL FLAG;
       WRITELN;
       WRITELN('DONE SORTING');
    END;{sort}

PROCEDURE GETDIR;
{reads directory of update volume and puts it in DCAT}
  VAR
      DIRX:DIRECTORY;
      UNITNUM,I: INTEGER;
      CHBUF : char;
      VOL:VOL_ID;
      SPS:STRING[16];
      BLOCKS_USED:0..988;


  BEGIN
  BLOCKS_USED:=10;         {assumes duplicate directories}
  DREC:=0;
    MEM('GETDIR');
    repeat
      WRITE('Enter unit number for required directory --> ');
      READLN(UNITNUM);
      WRITELN
    until unitnum in [ 4 .. 5 ];
    UNITREAD(UNITNUM,DIRX[0],2048,2);            {read directory into array DIF
    IF IORESULT <> 0
      THEN
        BEGIN
          WRITELN('Unit not online');
          EXIT(CATALOG);
        END;
```

Listing 1 continued on page 422

Listing 1 continued:

```
  VOL:=DIRX[0].DIR_VOL_NAME;
  SPS:=COPY(BLANKS,1,7-LENGTH(VOL));   {put VOL in consistent format}
  VOL:=CONCAT(VOL,SPS);
  FOR I:=1 TO DIRX[0].NUM_OF_FILES DO          {move directory to DCAT}
    BEGIN
      WITH DIRX[I] DO
        BEGIN
          IF LENGTH(DIR_FILE_NAME)>0
            THEN
              BEGIN
                DREC:=DREC+1;
                WITH DCAT[DREC] DO
                  BEGIN
                    VOL_NAME:=VOL;
                    FILE_NAME:=DIR_FILE_NAME;
                    SPS:=COPY(BLANKS,1,15-LENGTH(FILE_NAME));
                    FILE_NAME:=CONCAT(FILE_NAME,SPS);
                    FILE_KIND:=DIR_FILE_KIND;
                    FILE_DATE:=DIR_FILE_DATE;
                    FILE_SIZE:=LAST_BLOCK-FIRST_BLOCK;
                    BLOCKS_USED:=BLOCKS_USED+FILE_SIZE;
                  END;{with}
              END;{if length}
        END;{with dirx}
    END;{for}
{create entry with name FREE.SPACE containing the unused space on the volume}
      DREC:=DREC+1;
      WITH DCAT[DREC] DO
```

Listing 1 continued on page 423

Listing 1 continued:

```
        BEGIN
          VOL_NAME:=VOL;
          FILE_NAME:='FREE.SPACE';
          SPS:=COPY(BLANKS,1,15-LENGTH(FILE_NAME));
          FILE_NAME:=CONCAT(FILE_NAME,SPS);
          FILE_KIND:=INFO;
          FILE_DATE:=DIRX[0].LAST_BOOT;
          FILE_SIZE:=DIRX[0].TOTAL_BLOCKS-BLOCKS_USED;
        END;{with}
  END;{setdir}


  PROCEDURE SETDEX;
  {if first occurance of file name with DEX as first letter then
                                 put record number in DEXRAY and increment DEX}
   BEGIN
     IF NCAT[NREC].FILE_NAME[1] >= DEX
     {have we reached or exceeded the next index?}
         THEN BEGIN
                IF NCAT[NREC].FILE_NAME[1] > DEX
                   THEN REPEAT          {fills dexray to the next valid index}
                          DEXRAY[DEX]:=0;
                          IF DEX='Z' THEN EXIT(SETDEX);
                          DEX:=SUCC(DEX);
                        UNTIL (NCAT[NREC].FILE_NAME[1] = DEX);
                DEXRAY[DEX]:=NTOTREC+NREC;
                IF DEX='Z' THEN EXIT(SETDEX);
                DEX:=SUCC(DEX);
              END;{if}
    END;{setdex}

  PROCEDURE MERGE;
  {merges DCAT with OCAT to form NCAT}
    VAR
          X,Y,Z:1..33;
          CONTINUE:BOOLEAN;
          OO,O,D:RECNUM;
    BEGIN
      DEX:='A';                 {set first match char for index at 'A'}
      O:=OREC;
      OREC:=1;
      D:=1;
                                {REMOV is true if volume to be deleted}
      IF (NOT REMOV) THEN VOL:=DCAT[1].VOL_NAME;
                                {DREC+1 is 1 more than the number of files in DCAT}
       WHILE (D < DREC+1) DO
        BEGIN
          WITH DCAT[D] DO
            BEGIN{with}
              IF (FILE_NAME < OCAT[OREC].FILE_NAME)
                  THEN X:=10
                  ELSE IF (FILE_NAME = OCAT[OREC].FILE_NAME)
                          THEN X:=20
                          ELSE X:=30;

              IF (VOL_NAME < OCAT[OREC].VOL_NAME)
                    THEN Y:=1
                    ELSE IF (VOL_NAME = OCAT[OREC].VOL_NAME)
                            THEN Y:=2
                            ELSE Y:=3;

                Z:=X+Y;
                IF ((OREC=0) or (OREC>O)) THEN Z:=11;
```

Listing 1 continued on page 424

Listing 1 continued:

```
            CASE Z OF
                11,12,13,21 : BEGIN       {add record to NCAT from DCAT}
                                NREC:=NREC+1;
                                NCAT[NREC]:=DCAT[D];
                                D:=D+1;                        {increment D}
                                WRITE('ADD    ',NCAT[NREC].FILE_NAME:18);
                                WRITELN(NCAT[NREC].VOL_NAME:10)
                              END;

                22          : BEGIN           {add record to NCAT from DCAT}
                                NREC:=NREC+1;
                                NCAT[NREC]:=DCAT[D];
                                OREC:=OREC+1;             {increment OREC}
                                D:=D+1                    {increment D}
                              END;

                23,31,33    : BEGIN           {add record to NCAT from OCAT}
                                NREC:=NREC+1;
                                NCAT[NREC]:=OCAT[OREC];
                                OREC:=OREC+1;             {increment OREC}
                              END;

                32          : BEGIN              {do not add record to NCAT}
                                WRITE('DELETE ',OCAT[OREC].FILE_NAME:18);
                                WRITELN(OCAT[OREC].VOL_NAME:10);
                                OREC:=OREC+1;             {increment OREC}
                              END;
            END;{case of Z}
         SETDEX;          {check poniter index}
       END;{with}
    IF (NREC=NLREC) THEN WRITECAT;      {NLREC is the max array size}
    IF ((OREC>OLREC) AND (NOT OFILEEND)) {if you are out of OCAT get some more}
         THEN BEGIN
              READ_OLD_CAT;
              O:=OREC;
              OREC:=1;
            END;{if}
  END;{while}            {DCAT is empty}
REPEAT                   {get whats left of OCAT}
  CONTINUE:=FALSE;
  IF (OREC<=O)
       THEN FOR OO:=OREC TO O DO
              IF (OCAT[OO].VOL_NAME <> VOL)
                  THEN BEGIN
                         NREC:=NREC+1;
                         NCAT[NREC]:=OCAT[OO];
                         IF (NREC=NLREC) THEN WRITECAT;
                         SETDEX;
                       END{then}
                  ELSE BEGIN
                        WRITE('DELETE ',OCAT[OO].FILE_NAME:18);
                        WRITELN(OCAT[OO].VOL_NAME:10)
                      END;{else}
  IF (NOT OFILEEND) THEN BEGIN          {if you are out of OCAT get some more}
                       READ_OLD_CAT;
                       O:=OREC;
                       OREC:=1;
                       CONTINUE:=TRUE;
                     END;{if}
UNTIL (NOT CONTINUE);
IF (DEX <'Z')
  THEN FOR CH:=DEX TO 'Z' DO DEXRAY[CH]:=DEXRAY[PRED(DEX)];
```

Listing 1 continued on page 425

Listing 1 continued:

```
 DONE:=TRUE;
 WRITECAT;
 WRITEDEX;
END;{match}

BEGIN{update}
  REWRITE(P,'CONSOLE:');
  IF LOOKUP(OFILENAME)
      THEN BEGIN
             RESET(OCATFILE,OFILENAME);
             CLOSE(OCATFILE,PURGE);                 {remove old BACKCAT}
           END;{if}
  RENAME;                                            {MASTCAT --> BACKCAT}
  IF (NOT REMOV)
             THEN BEGIN
                    GETDIR;
                    SORT;
                    FOR RN:=1 TO DREC DO PRINT_RECORD(DCAT[RN]);
                  END;{if}
  IF LOOKUP(OFILENAME)
        THEN BEGIN
               RESET(OCATFILE,OFILENAME);
               READ_OLD_CAT;
             END{if}
        ELSE OREC:=0;
  REWRITE(NCATFILE,NFILENAME);
  NREC:=0;
  MERGE;
  CLOSE(OCATFILE);
  CLOSE(P);
  WRITELN('BACKCAT CONTAINS  ',OTOTREC,' RECORDS');
  WRITELN('MASTCAT CONTAINS  ',NTOTREC,' RECORDS');
  CLOSE(NCATFILE,LOCK);
  WAIT;
END;{update}


PROCEDURE SEARCH;
    VAR
        STOP,FOUND:BOOLEAN;
        TAR1,TAR2:CHAR;
        START:INTEGER;
        WILDCARD:0..16;
        CAT:CATALOG_RECORD;
        TARGET,SPS:STRING;

   PROCEDURE LONGSEARCH;
   {search used when alphabetical pointer cannot be used }
 VAR
           N:RECNUM;

 BEGIN
  DELETE(TARGET,1,1);                    {remove wildcard char}
  writeln(TARGET);
  REPEAT
    READ_NEW_CAT;
    FOR N:=1 TO NREC DO IF POS(TARGET,NCAT[N].FILE_NAME) <> 0
                           THEN PRINT_RECORD(NCAT[N]);
  UNTIL (NFILEEND);
  CLOSE(NCATFILE);
  WAIT;
```

Listing 1 continued on page 426

Listing 1 continued:

```
        CLOSE(P);
        EXIT(SEARCH)
      END;{longsearch}

     PROCEDURE SEARCH_FOR_VOLUME;
      VAR
                 BLKS,SPS:STRING[7];
                 N:RECNUM;

      BEGIN
        BLKS:='       ';
        DELETE(TARGET,POS(':',TARGET),1);
        SPS:=COPY(BLKS,1,7-LENGTH(TARGET));
        TARGET:=CONCAT(TARGET,SPS);
        writeln(TARGET);
        REPEAT
          READ_NEW_CAT;
          FOR N:=1 TO NREC DO
            IF (NCAT[N].VOL_NAME=TARGET) THEN PRINT_RECORD(NCAT[N]);
        UNTIL (NFILEEND);
        CLOSE(NCATFILE);
        WAIT;
        CLOSE(P);
        EXIT(SEARCH)
      END;{vsearch}

BEGIN{search}
  STOP:=FALSE;FOUND:=FALSE;
  REPEAT
    WRITE('ENTER NAME OF FILE TO BE FOUND--> ');
    READLN(TARGET);
    IF(LENGTH(TARGET)>16) THEN WRITELN('NAME TOO LONG ');
  UNTIL (LENGTH(TARGET)<=16);
  IF (POS('<',TARGET)=1)      {'<' sends output to printer}
           THEN BEGIN
                  DELETE(TARGET,1,1);
                  REWRITE(P,'PRINTER:');
                END{if}
           ELSE REWRITE(P,'CONSOLE:');
  RESET(NCATFILE,NFILENAME);
  IF (POS(':',TARGET)<>0) THEN SEARCH_FOR_VOLUME;
  WILDCARD:=POS('=',TARGET);
  IF (WILDCARD = 1) THEN LONGSEARCH;
  IF (WILDCARD > 1) THEN TARGET:=COPY(TARGET,1,WILDCARD-1);
  TAR1:=TARGET[1];                {TAR1 used to set pointer from DEXRAY}
  IF (WILDCARD <> 2)              {TAR2 used to end search}
       THEN TAR2:=TARGET[2]
       ELSE TAR2:='z';
IF (TAR1 < 'A')
    THEN START:=0
    ELSE IF (TAR1 > 'Z')
          THEN START:=DEXRAY['Z']
          ELSE START:=DEXRAY[TAR1];
SEEK(NCATFILE,START);
GET(NCATFILE);
REPEAT
  CAT:=NCATFILE^;
  IF ((WILDCARD = 0) AND (POS(TARGET,CAT.FILE_NAME) = 1))
                                   THEN BEGIN
                                     PRINT_RECORD(CAT);
                                     FOUND:=TRUE;
                                   END;
```

Listing 1 continued on page 427

Listing 1 continued:

```
    IF ((WILDCARD > 1) AND (POS(TARGET,CAT.FILE_NAME) >= 1))
                                                       THEN BEGIN
                                                         PRINT_RECORD(CAT);
                                                         FOUND:=TRUE;
                                                       END;

    IF ((CAT.FILE_NAME[1] > TAR1 ) OR (CAT.FILE_NAME[2] > TAR2))
                    THEN STOP:=TRUE;
    GET(NCATFILE);
  UNTIL (STOP OR EOF(NCATFILE));
  IF (NOT FOUND) THEN WRITELN('FILE ',TARGET,' NOT FOUND');
  CLOSE(NCATFILE);
  CLOSE(P);
  WAIT
END;{SEARCH}



BEGIN {main}
  IF ((NOT LOOKUP(NFILENAME)) OR (NOT LOOKUP(PFILENAME))) THEN INITIALIZE;
  GET_SYS_VOL(SYSTEMVOLUME);     {record system volume name for rebooting}
  DLREC:=MAXREC;OLREC:=MAXREC;NLREC:=MAXREC;
  READDEX;                    {load the pointer array}
  REPEAT
    REMOV:=FALSE;NFILEEND:=FALSE;OFILEEND:=FALSE;DONE:=FALSE;
    NREC:=0;OREC:=0;DREC:=0;
    NTOTREC:=0;OTOTREC:=0;
    VOL:='          ';
    REPEAT
      WRITE(CHR(CLEARSCREEN));
      MEM('MAIN');
      WRITE('CATALOG -->  S)earch D)isplay B)ackup U)pdate R)emove Q)uit');
      READ(KEYBOARD,CH);
      WRITELN;
    UNTIL (CH IN ['R','r','B','b','U','u','S','s','D','d','Q','q']);
    CASE CH OF
         'U','u' : UPDATE;

         'S','s' : SEARCH;

         'D','d' : DISPLAY;

         'R','r' : BEGIN

                     REMOV:=TRUE;
                     ENTER_VOL_NAME;
                     UPDATE
                   END;{case of R}

         'B','b' : BACKUP;


         'Q','q' : REPEAT
                     GET_SYS_VOL(TEST);
                     IF (TEST=SYSTEMVOLUME)
                          THEN EXIT(CATALOG)
                          ELSE WRITELN('INSERT SYSTEM DISK AND PRESS RETURN');
                     READLN(CH)
                   UNTIL CH='P';

       END;{case}
  UNTIL (CH IN ['Q','q']);
END.
```

Market Report for Software Writers

The 1981 Software Writers Market lists more than 1800 firms that will market and distribute programs developed by independent software writers. The report outlines the usual procedures you must take to contact one of these firms with information about a program. If a firm deems that a program has market potential, it will enter into an agreement with you, market the software, and either pay you a royalty based on sales or buy the rights to the program for exclusive use.

The 1981 Software Writers Market provides addresses and telephone numbers of key contact people in service bureaus, hardware manufacturers, mail-order distributors, book publishers, computer magazines, consulting companies, and more than 1500 retail computer stores. It explains how companies market software, what kinds of software they seek, how you are dealt with, royalty rates, and contract details. The price for *The 1981 Software Writers Market* is $45 (with updates offered).

For complete details, contact Kern Publications, 190 Duck Hill Rd, Duxbury MA 02332, (617) 934-0445.

Computer Literacy Kits for Schools

More than 700 Apple dealers in the US and Canada are participating in the Apple Seed program, which provides qualifying elementary and high school students with computer-course materials. Under the program, Apple Computer will donate a $500 bonus kit of course materials to junior and senior high schools which qualify as "start-up" schools and which buy a 32 K-byte Apple computer with at least one disk drive. Schools that are initiating computer education curricula and schools that are expanding ongoing computer education programs with additional Apple systems are welcomed under the plan.

The Apple Seed kit contains a computer-literacy program for teachers and a course for students, including tutorial materials in BASIC for classes with up to 25 students. Books on microcomputers and systems, computer components for informational purposes, computer literacy programs, an Applesoft BASIC tutorial, and an educational-software directory are incorporated within the course materials. Systems must be purchased from an authorized Apple dealer before July 31, 1981. The offer is limited to one set of materials per school.

For complete details on the Apple Seed computer-literacy program, contact Apple Computer, 10260 Bandley Dr, Cupertino CA 95014.

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Programming Quickies

Printf for the C Function Library

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Washington DC 20024

One of the most-used functions in the standard library for the C programming environment is printf, the formatting print function. Printf accepts character, string, and numeric values as arguments and sends them to the standard output (normally the user's console) according to a specified format. It is used both as the main way to provide a program's output to the console and as a way of testing variable values during debugging. Its control-format string may specify that numerical values be represented in hexadecimal, octal, or decimal notation, that right or left justification be employed, and that arguments be printed in a given field width or restricted to a limited precision.

Although present versions of the BDS C compiler for the 8080 CP/M operating system have the standard printf function, earlier versions had a more primitive version of printf. If you have a version that *cannot* print numerical data in octal, does not permit precision to be specified to limit the length of a string, and only left justifies, the program shown in listing 1 will add all the standard features and a few new ones.

Except for the features that apply only to floating-point and long numerical data, this program conforms to the specifications for printf in Kernighan and Ritchie's *The C Programming Language* (Prentice-Hall, 1978). It is simple to adapt printf to other languages, so long as they permit functions, procedures, and subroutines with a variable number of arguments.

Functions compiled with the BDS C compiler find their arguments along an array of vectors stored at location BASE + 0x3f7, where BASE is the base address of the CP/M operating system for the particular machine being used (and "0x3f7" is C's idiosyncratic notation for hexadecimal 3F7). Up to twenty-four arguments are allowed. Because printf doesn't know in advance how many arguments will be needed as interpretation of the control format proceeds, and because the same function-argument vector will be used by subordinate functions called by printf, all the arguments are collected at the outset and stored in local argument array, "localarg[]." This is the one feature of the function that is specific to the BDS compiler. Note that because the control format is passed to printf as a formal parameter, the processing of the remaining arguments begins at FARGV + 2.

Listing 2 shows a sample run and a demonstration program that exercises printf by printing a series of integers in various notations and by printing a string in various

Text continued on page 434

Listing 1: *This is a program for adding a full-featured printf function to some early versions of C compilers. These earlier versions did not allow the printing of numerical data in octal, and did not permit precision to be specified to limit the length of a string; they allowed only left justification. Two new functions which are called by printf have been added: "Nbase" converts a binary integer into a digit string in the requested radix; "Nspoct" does the same for split octal.*

```
#define BASE             0x4200   /* CP/M base address */
#define FARGV            0x3f7    /* BDS C compiler argument vector */

printf(control)
char *control;
{
        char c, *ps, rjustify, s[17], zerofill;
        int *args, k, localarg[23], prcisn, slen, width;

        /* copy arguments from function argument vector */
        for (k = 0, args = BASE + FARGV + 2; k < 23; ++k, ++args)
                localarg[k] = *args;
        args = localarg;

        while (c = *control++)

                /* check for conversion specification */
                if (c == '%') {

                        /* check for various options */

                        if ((c = *control) == '-') {
                                rjustify = 0;
                                c = *control++;
                        }
                        else
                                rjustify = 1;

                        if (c == '0')
                                zerofill = 1;
                        else
                                zerofill = 0;

                        width = 0;
                        while (isdigit(c = tolower(*control++)))
                                width = 10*width + c - '0';

                        if (c == '.') {
                                prcisn = 0;
                                while (isdigit(c = tolower(*control++)))
                                        prcisn = 10*prcisn + c - '0';
                        }
                        else
                                prcisn = 32767;

                        /* process conversion characters */
                        switch (c) {
                        case 'b':
                                ps = nbase(*args++, 2, s);
                                break;
                        case 'o':
                                ps = nbase(*args++, 8, s);
```

Listing 1 continued on page 432

Listing 1 continued:

```
                        break;
                case 'd':
                        if (*args < 0) {
                                ps = nbase(-*args++, 10, s);
                                *--ps = '-';
                        }
                        else
                                ps = nbase(*args++, 10, s);
                        break;
                case 'u':
                        ps = nbase(*args++, 10, s);
                        break;
                case 'x':
                        ps = nbase(*args++, 16, s);
                        break;
                case 'o':
                        ps = nspoct(*args++, s);
                        break;
                case 's':
                        ps = *args++;
                        break;
                case 'c':
                        c = *args++;
                default:
                        *(ps = s) = c;
                        s[1] = '\0';
                }

                k = strlen(ps);
                slen = k > prcisn ? prcisn : k;

                if (rjustify)
                        while (width-- > slen)
                                if (zerofill)
                                        putchar('0');
                                else
                                        putchar(' ');

                for (k = 1; *ps && k <= prcisn; ++k)
                        putchar(*ps++);

                if (!rjustify)
                        while (width-- > slen)
                                putchar(' ');
        }
        else
                putchar(c);
nbase(n, base, s)
unsigned n, base;
char *s;
{
        int d;

        *(s += 16) = '\0';
        if (n == 0)
```

Listing 1 continued on page 433

Listing 1 continued:

```
                    *--s = '0';
        else
                    while (n > 0) {
                            *--s = (d = n%base) + (d < 10 ? '0' : 55);
                            n /= base;
                    }
        return s;
}




nspoct(n, s)
unsigned n;
char s[];
{
        int d; d = 16384;
        char *ps; ps = s;

        while (d > 0) {
                *ps++ = n/d + '0';
                n %= d;
                if (d == 256) {
                        d = 64;
                        *ps++ = '.';
                }
                else
                        d /= 8;
        }
        *ps = '\0';
        return s;
}
```

Listing 2: *Listing and sample run of a demonstration program which exercises the printf function.*

```
A>TYPE PRINTX.C

main()
{
        unsigned i;
        char *string; string = "hello, world";

        for (i = 1; i <= 16384; i *= 2) {
                printf("dec: %5d  oct: %6o  sploct: %q   ", i, i, i);
                printf("hex: %4x  bin: %016b\n", i, i);
        }

        printf("\n");
        printf(":%10s:\n", string);
        printf(":%-10s:\n", string);
        printf(":%20s:\n", string);
        printf(":%-20s:\n", string);
        printf(":%20.10s:\n", string);
```

Listing 2 continued on page 434

Listing 2 continued:

```
printf(":%-20.10s:\n", string);
printf(":%.10s:\n", string);
}

A>PRINTX

dec:      1  oct:      1  sploct: 000.001  hex:    1  bin: 0000000000000001
dec:      2  oct:      2  sploct: 000.002  hex:    2  bin: 0000000000000010
dec:      4  oct:      4  sploct: 000.004  hex:    4  bin: 0000000000000100
dec:      8  oct:     10  sploct: 000.010  hex:    8  bin: 0000000000001000
dec:     16  oct:     20  sploct: 000.020  hex:   10  bin: 0000000000010000
dec:     32  oct:     40  sploct: 000.040  hex:   20  bin: 0000000000100000
dec:     64  oct:    100  sploct: 000.100  hex:   40  bin: 0000000001000000
dec:    128  oct:    200  sploct: 000.200  hex:   80  bin: 0000000010000000
dec:    256  oct:    400  sploct: 001.000  hex:  100  bin: 0000000100000000
dec:    512  oct:   1000  sploct: 002.000  hex:  200  bin: 0000001000000000
dec:   1024  oct:   2000  sploct: 004.000  hex:  400  bin: 0000010000000000
dec:   2048  oct:   4000  sploct: 010.000  hex:  800  bin: 0000100000000000
dec:   4096  oct:  10000  sploct: 020.000  hex: 1000  bin: 0001000000000000
dec:   8192  oct:  20000  sploct: 040.000  hex: 2000  bin: 0010000000000000
dec:  16384  oct:  40000  sploct: 100.000  hex: 4000  bin: 0100000000000000

:hello, world:
:hello, world:
:        hello, world:
:hello, world        :
:          hello, wor:
:hello, wor          :
:hello, wor:

A>
```

Text continued from page 430:
combinations of justification, field width, and precision (the ":" serves to delimit the field). Calls to printf take the form:

printf(control, argument 1, argument 2, ...)

where "control" is a format string composed of text interspersed with conversion specifications—one for each argument.

Each conversion specification begins with the "%" character and ends with a conversion character indicating the format to be used in printing the corresponding argument (character, string, or number). The standard conversion characters "d" (decimal notation), "u" (unsigned decimal), "o" (octal), "x" (hexadecimal), "c" (character), and "s" (string), are supported. I have added two others not specified in Kernighan and Ritchie's book: "b" (binary notation), which is especially useful for debugging programs that use bitwise logical operators, and "q" (split octal), because the front panel of my Heath H-8 computer has a split-octal display.

A number of options may be specified between the "%" character, which introduces the conversion specification, and the conversion character. A minus sign (−) indicates that left justification (instead of the default right justification) is requested. A digit string indicates the field width; a number that fails to fill the width will be padded on the left or right, as necessary. If the field width is specified with a leading zero, a right-justified number will be padded with zeros instead of blanks, so an 8-bit binary number can be printed as 00100101 instead of 100101. A period followed by another digit string indicates the precision, the maximum field width in which an argument is to be printed; this is primarily useful for truncating strings that exceed the permissible line length.

This version of printf uses four other standard C library functions: "tolower(character)," which converts its argument to lowercase if it isn't lowercase already; "isdigit(character)," which returns true (not zero) if its argument is a digit and false (zero) otherwise; "putchar (character)," which outputs a character to the console; and "strlen(pointer to string)," which returns the length of the string its argument points to.

Two other functions, called by printf and independently useful additions to the standard library, are also included (see listing 1). "Nbase(number, base, pointer to array in which to store result)" converts a binary integer to a digit string of the requested number base. "Nspoct (number, string pointer)" does the same (with leading zeros, and a "." separating the 2 bytes) for the special case of split octal.■

Numerical Methods in Data Analysis

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In engineering research and design work, it is often necessary to determine analytically from a given set of n pairs of discrete data a function which best represents the dependence of one parameter (X) upon the other (Y). Moreover, other characteristics of the obtained function represent this dependence, such as information about its stationary (maximum or minimum) point and its roots, that is, values of X which make Y equal to zero.

Calling on our mathematical background, we know that most continuous functions with defined derivatives may be expressed in a form of a polynomial:

$$Y = a_0 + a_1X + a_2X^2 + a_3X^3 + \ldots + a_mX^m$$

where m is the degree of the polynomial and $a_0, a_1, \ldots, a_m$ are the coefficients.

For a given set of n pairs of data, there is usually a polynomial of degree m with corresponding coefficients $a_0, a_1, \ldots, a_m$ which will approximately describe the general continuous relationship between the two parameters X and Y. The error incurred in obtaining this polynomial will usually be minimal when m is sufficiently large and useful values of Xs and Ys are in the neighborhood of the range $[(X_1, Y_1), (X_n, Y_n)]$ where $X_1 < X_2 < \ldots < X_n$.

By definition, the stationary point of a function is the point at which the dependent parameter Y attains a local maximum or minimum value. This stationary value of the variable X may be obtained by solving the equation $Y' = 0$, or:

$$a_1 + 2a_2X + 3a_3X^2 + \ldots + ma_mX^{m-1} = 0$$

The determination of function $Y = f(X)$ may be done by curve fitting, which requires solving a large set of simultaneous linear equations. The Gauss-Jordan elimination method may be utilized to solve these simultaneous equations. Once the function $f(X)$ is obtained, the values of quantity X for which $f(X)$ equals zero may be calculated by the Newton-Raphson method, which is one of the various numerical methods for obtaining the roots of a continuous differentiable function.

Because many calculations will be performed repetitively, these tasks will be conveniently handled by a digital computer utilizing its ability for high-speed calculations. A scientific high-level language, such as FORTRAN IV, is a suitable language for the development of a computer program for use in this application.

This article will briefly review the principle of curve fitting, the Gauss-Jordan elimination technique, and the Newton-Raphson method. Included is a computer program written in FORTRAN IV with corresponding flowchart and explanations. Examples of practical engineering problems in different fields are also presented.

Curve Fitting: Method of Least Squares

In fitting a curve through the points representing $(X_1, Y_1), \ldots, (X_n, Y_n)$, we employ a mathematical principle that yields a *best-fit curve*: the method of least squares. This method utilizes the laws of probability in obtaining the most probable values for a given set of observations of independent and dependent parameters. According to this method, the coefficients $a_0, a_1, \ldots, a_m$ of a polynomial of degree m may be determined from the following $m+1$ simultaneous equations:

$$\begin{aligned} c_{11}a_0 + c_{12}a_1 + c_{13}a_2 + \ldots + c_{1[m+1]}a_m &= b_1 \\ c_{21}a_0 + c_{22}a_1 + c_{23}a_2 + \ldots + c_{2[m+1]}a_m &= b_2 \\ \vdots \\ c_{[m+1]1}a_0 + c_{[m+1]2}a_1 + \ldots + c_{[m+1][m+1]}a_m &= b_{[m+1]} \end{aligned} \quad (1)$$

where:

$$b_i = \sum^{n} x^{i-1}y$$
$$c_{ij} = \sum^{n} x^{i+j-2}$$

About the Author

Toan C Nguyen is a registered professional engineer in the state of California and a member of the American Society of Mechanical Engineers. He has a master's degree in mechanical engineering from the University of Southern California.

Mr Nguyen has devoted much of his time to the application of computer programming in solving engineering problems. He is presently a senior engineer with the Pipe Hanger Division of ITT Grinnell Corporation.

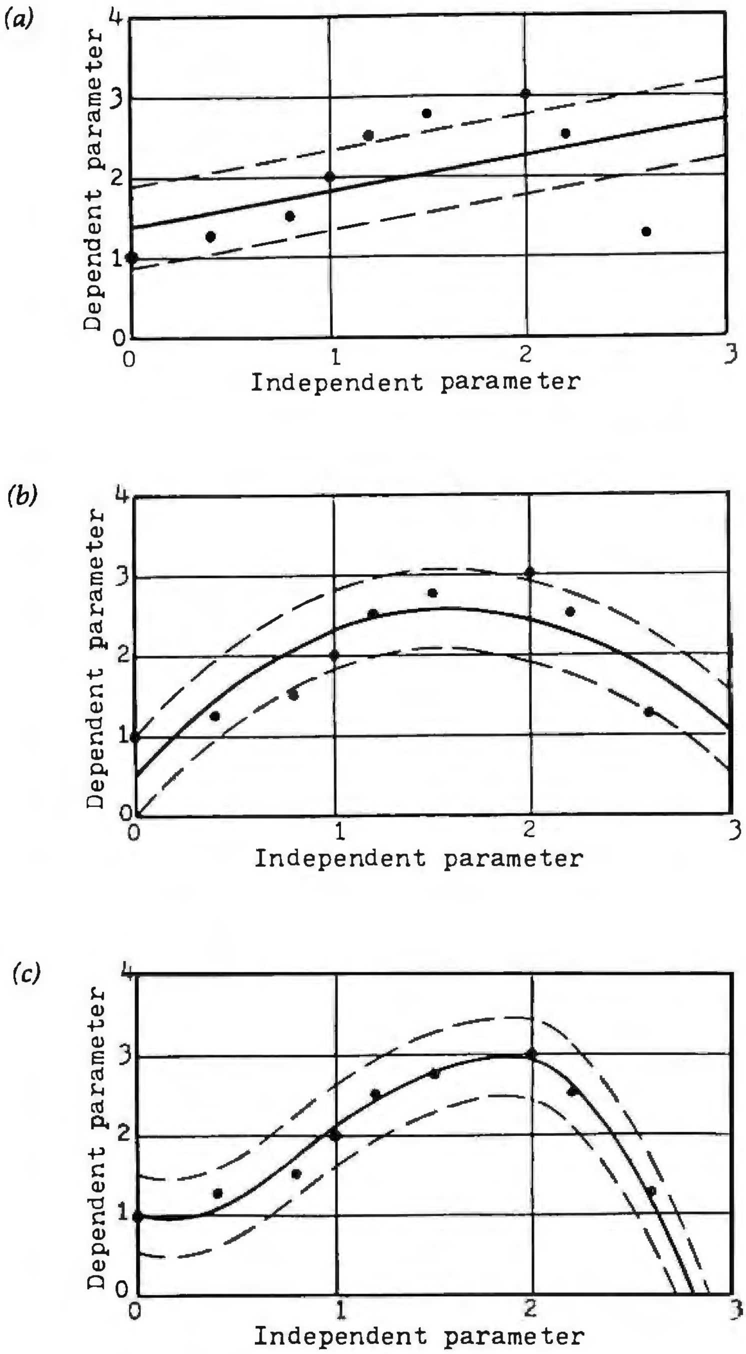


Figure 1: *A representation of the least-squares curve-fitting method. In (a) we see the first-degree curve, which is not acceptable because the uncertainty envelope does not contain all the data points. The figure in (b) shows the second-degree curve, which is not acceptable for the same reason as (a). The third-degree curve is illustrated in figure (c). Here we can observe that the uncertainty envelope does contain all the data points and is, therefore, the desired degree of the least-squares polynomial.*

and the summations $\sum^{n}$ are performed from 1 to n, the number of pairs of data.

Most engineering data is taken with an uncertainty margin. This margin may be expressed as an absolute deviation or as a relative deviation, such as 50 ± 0.5 inches and 50 inches ±1%, respectively. Therefore, when the uncertainty envelope has the most probable least-squares curve as its center line, it also has to cover all the given data points. This condition is illustrated in figure 1.

We usually start with a least-squares equation of relatively low degree and then check to see if all data points fall inside the uncertainty envelope before proceeding to the next higher degree least-squares equation. The process will continue until the uncertainty requirements are satisfied.

Gauss-Jordan Elimination Method

After all the summations of the set of simultaneous equations in equation (1) are calculated, our next step is to solve the set of simultaneous equations for $a_0, a_1, \ldots, a_m$. Although there are numerous techniques to handle this task, the method presented here is the Gauss-Jordan elimination method. The reason for using this method in-

Variable Definitions

FORTRAN Variable	Definition
A (M)	a_m, the mth coefficient of a least-squares polynomial
C (I,J)	c_{ij}, element at ith row and jth column of the augmented matrix of the set of $m+1$ simultaneous equations to be solved for $a_0, \ldots, a_m$
ERR	$\lvert f(X_n)/f'(X_n) \rvert$, absolute value of the nth incurring error in the determination of X for which $f(X)=0$ by Newton-Raphson method
ERROR	ϵ, general term for allowable error (at the beginning of the iteration process) or resulting error (at the end of the process) in the determination of $X_{Y=0}$ and X_{STA}, used in subroutine NEWRAP
ERT	$\epsilon_{Y=0}$, allowable error in the determination of $X_{Y=0}$
EROOT	Error in the determination of $X_{Y=0}$ (before calling subroutine NEWRAP: allowable error; after: resulting error)
ESTN	ϵ_{STA}, allowable error in the determination of X_{STA}
ESTATN	Error in the determination of X_{STA} (before calling subroutine NEWRAP: allowable error; after: resulting error)
I	DO loop index
ICHANG	String input specifying the name of the particular variable of which the value is to be changed
ICONTI	String input (YES or NO) to continue or to stop the process of changing values of some variables
IROOT	Code indicating whether the calculation of $X_{Y=0}$ is needed or not (0: No, 1: Yes)
ISTATN	Code indicating whether the calculation of X_{STA} is needed or not (0: No, 1: Yes)
IUNCER	Code indicating whether the uncertainty is entered as absolute or relative value (0: absolute, 1: relative)
J	DO loop index
K	DO loop index
KPLUS	K+1
LROOT	ROOT, string variable for printout purpose
LSTAT	STATN, string variable for printout purpose
M	DO loop index
MDEG	m, degree of the least-squares polynomial to be fitted through the given set of data, used as the first trial
MDEGRE	Incrementing m, starting from MDEG to a maximum of 10
MMINUS	M−1
MPLUS1	MDEGRE+1
MPLUS2	MDEGRE+2
N	DO loop index for loop which calculates root of $f(X)=0$
NCODE	Code used before subroutine NEWRAP is called to indicate whether the calculation will be for $X_{Y=0}$ or X_{STA} (1: for $X_{Y=0}$, 2: for X_{STA})
NEWTON	Code used in subroutine NEWRAP having the same function as NCODE; its value is transmitted from main program
NITERA	Before the iteration process: maximum allowable number of iterations, transmitted from main program; after the iteration process: actual number of iterations used to obtain the required accuracy ϵ (this new value will be returned to main program)
NMINUS	N−1
NPAIRS	Number of pairs of data
NPLUS	N+1
NRERUN	Code to direct the calculation flow to the beginning of the program (NRERUN=1) or only to the portion computing $X_{Y=0}$ and X_{STA} (NRERUN=0)
NROOT	Similar to NITERA, except that it is in main program and is used primarily for calculating $X_{Y=0}$
NSTATN	Similar to NITERA, except that it is in main program and is used primarily for calculating X_{STA}
SUM	Σs, summations representing b_i or c_{ij}
UNCERT	Uncertainty margin, may be entered as absolute or relative value
UNMARG	Uncertainty margin, calculated from the given UNCERT and IUNCER, and is converted into an absolute value
X(N)	Xs, data entered as independent parameters
X0	Before the iteration process: initial approximation of X_n, transmitted from main program; after the iteration process: obtained value of X_n which satisfies the required accuracy (this new value will be returned to main program)
XS(N)	X_n, nth value of iterated X in Newton-Raphson formula
XRT1	Similar to X0, except that it is in main program and is used primarily for calculating $X_{Y=0}$
XSTN1	Similar to X0, except that it is in main program and is used primarily for calculating X_{STA}
Y(N)	Ys, data entered as dependent parameters
YDEN	$f'(X_n)$, denominator value in Newton-Raphson formula
YNUM	$f(X_n)$, numerator value in Newton-Raphson formula
YOFX	Y(X), value of Y corresponding to a given value of X

Listing 1: *FORTRAN listing of the program CURFIT that solves the least-squares polynomial for the entered pairs of data X(n) and Y(n). Some language features used here differ from standard FORTRAN.*

```
 PROGRAM CURFIT (INPUT,OUTPUT)
 DIMENSION X(100),Y(100),A(11),C(11,12)
 COMMON/BLOCK/A,MPLUS1,MPLUS2
*****
***** DATA STATEMENTS
*****
 DATA NPAIRS,MDEG,IUNCER,UNCERT,IROOT,XRT1,ERT,ISTATN,XSTN1,ESTN/
+10,1,0,.1,1,-1.,.001,1,0.,.001
+/,X/
+-2.,-1.5,-1.,0.,1.,2.,2.5,3.,4.,5.
+/,Y/
+-25.1,-6.9,3.1,5.,-6.9,-21.,-25.,-25.1,-7.,45.
+/
*****
***** FORMAT STATEMENTS
*****
 10 FORMAT (//2X,12HTHE DESIRED ,I2,47H-TH DEGREE LEAST-SQUARES EQUATION HA
+S A FORM OF ,/5X,14HY(X) = SUM OF ,I2,19H-TERMS OF A(I)*X**I,5X,12HI = 0,1
+,...,  ,I2,//20X,1HI,5X,4HA(I),/19X,3H---,2X,8H--------,/)
 20 FORMAT (19X,I2,3X,F8.3)
 30 FORMAT (//2X,6HAFTER ,I2,35H ITERATIONS, THE OBTAINED VALUE OF ,A6,3H I
+S ,F8.3,7H GIVING,/12HAN ERROR OF ,F8.5,2X,33HIF YOU WANT TO TRY NEW VALUE
+S OF ,A6,11H AND ERROR,,/45HENTER THEM IN THAT ORDER; IF NOT, ENTER 0.,0.)
 40 FORMAT (/2X,6HAFTER ,I2,35H ITERATIONS, THE OBTAINED VALUE OF ,A6,4H IS
+ ,F8.3)
 50 FORMAT (//2X,*DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, E
+RT, ESTN,*,/1X,*XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)*)
 60 FORMAT (/2X,*ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN IT
+S NEW VALUE*)
 70 FORMAT (/2X,*ANY MORE VARIABLES TO BE CHANGED ?*)
 80 FORMAT (//2X,*ALTHOUGH A *,I2,*-TH DEGREE LEAST SQUARES CURVE HAS BEEN
+FITTED THROUGH THE*,/1X,*GIVEN SET OF DATA, THE SPECIFIED UNCERTAINTY MARG
+IN IS NOT YET SATISFIED*)
 90 FORMAT (2X,*THE CORRESPONDING VALUE OF Y(XSTATN) IS *,F8.3)
 100 FORMAT (//2X,*THE SPECIFIED DEGREE OF THE LEAST SQUARES EQUATION IS =>
+ THE NUMBER*,/1X,*OF PAIRS OF DATA. REENTER MDEG (< NPAIRS )*)
*****
***** DEFINITIONS OF SOME VARIABLES
*****
 LROOT=5HXROOT
 LSTAT=6HXSTATN
 110 MDEGRE=MDEG
 112 EROOT=ERT
 ESTATN=ESTN
 115 IF (MDEGRE.LT.NPAIRS) GO TO 120
 PRINT 100
 READ,MDEG
 GO TO 110
 120 NROOT=NSTATN=20
 MPLUS1=MDEGRE+1
 MPLUS2=MDEGRE+2
*****
***** DETERMINATION OF ALL SUMMATIONS IN THE SET OF M+1 SIMULTANEOUS EQNS.
*****
 DO 210 I=1,MPLUS1
 DO 200 J=1,MPLUS2
 SUM=0.
 DO 220  N=1,NPAIRS
 IF (J.NE.MPLUS2) SUM=SUM+X(N)**(I+J-2)
 IF (J.EQ.MPLUS2) SUM=SUM+Y(N)*X(N)**(I-1)
 220 CONTINUE
 C(I,J)=SUM
 200 CONTINUE
 210 CONTINUE
*****
***** DETERMINATION OF COEF. A0,...,AM OF THE M-TH DEGREE LEAST-SQUARES
*****     POLYNOMIAL BY GAUSS-JORDAN ELIMINATION METHOD
*****
 DO 330 K=1,MPLUS1
 KPLUS=K+1
 DO 300 J=KPLUS,MPLUS2
 C(K,J)=C(K,J)/C(K,K)
 300 CONTINUE
 DO 320 I=1,MPLUS1
 IF (I.EQ.K) GO TO 320
 DO 310 J=KPLUS,MPLUS2
 C(I,J)=C(I,J)-C(I,K)*C(K,J)
 310 CONTINUE
 320 CONTINUE
 330 CONTINUE
*****
***** CHECK FOR UNCERTAINTY REQUIREMENTS
*****
 DO 410 N=1,NPAIRS
 YOFX=0.
 DO 400 M=1,MPLUS1
 A(M)=C(M,MPLUS2)
 YOFX=YOFX+A(M)*X(N)**(M-1)
 400 CONTINUE
 IF (IUNCER.NE.1) UNMARG = UNCERT
 IF (IUNCER.EQ.1) UNMARG = ABS(UNCERT*YOFX)
 IF (ABS(Y(N)-YOFX).LE.UNMARG) GO TO 410
 MDEGRE=MDEGRE+1
 IF (MDEGRE.LT.NPAIRS.AND.MDEGRE.LE.10) GO TO 112
 MDEGRE=MDEGRE-1
 PRINT 80,MDEGRE
 GO TO 700
 410 CONTINUE
*****
***** PRINT-OUT OF COEF. A0,...,AM OF THE OBTAINED M-TH DEGREE
*****     LEAST SQUARES EQUATION
*****
 PRINT 10,MDEGRE,MPLUS1,MDEGRE
 DO 500 M=1,MPLUS1
 MMINUS=M-1
 PRINT 20,MMINUS,A(M)
 500 CONTINUE
*****
***** CALCULATION OF VALUES OF XROOT OR XSTA
*****
 IF (MDEGRE.EQ.1) IROOT=0
 550 IF (IROOT.NE.1.AND.ISTATN.NE.1) GO TO 700
 IF (IROOT.NE.1) GO TO 620
 600 NCODE = 1
 CALL NEWRAP (XRT1,EROOT,NROOT,NCODE)
 IF (NROOT.LT.20) GO TO 610
 PRINT 30,NROOT,LROOT,XRT1,EROOT,LROOT
 READ,XRT1,ERT
 EROOT=ERT
 IF (XRT1.EQ.0..AND.EROOT.EQ.0.) GO TO 620
 GO TO 600
 610 PRINT 40,NROOT,LROOT,XRT1
 620 IF (ISTATN.NE.1) GO TO 700
 630 NCODE = 2
 CALL NEWRAP (XSTN1,ESTATN,NSTATN,NCODE)
 IF (NSTATN.LT.20) GO TO 640
 PRINT 30,NSTATN,LSTAT,XSTN1,ESTATN,LSTAT
 READ,XSTN1,ESTN
 ESTATN=ESTN
 IF (XSTN1.EQ.0..AND.ESTATN.EQ.0.) GO TO 700
 GO TO 630
 640 PRINT 40,NSTATN,LSTAT,XSTN1
 YOFX=0.
 DO 650 M=1,MPLUS1
 YOFX=YOFX+C(M,MPLUS2)*XSTN1**(M-1)
 650 CONTINUE
 PRINT 90,YOFX
*****
***** CHANGING VALUES OF SOME VARIABLES
*****
 700 PRINT 50
 READ,ICONTI
 IF (ICONTI.EQ.2HNO) GO TO 800
 NRERUN=0
 710 PRINT 60
 READ,ICHANG
 IF (ICHANG.EQ.4HMDEG) READ,MDEG
 IF (ICHANG.EQ.6HUNCERT) READ,UNCERT
 IF (ICHANG.EQ.3HERT) READ,ERT
 IF (ICHANG.EQ.4HESTN) READ,ESTN
 IF (ICHANG.EQ.4HXRT1) READ,XRT1
 IF (ICHANG.EQ.5HXSTN1) READ,XSTN1
 IF (ICHANG.EQ.6HIUNCER) READ,IUNCER
 IF (ICHANG.EQ.5HIROOT) READ,IROOT
 IF (ICHANG.EQ.6HISTATN) READ,ISTATN
 NROOT=NSTATN=20
 EROOT=ERT
 ESTATN=ESTN
 IF (ICHANG.EQ.4HMDEG.OR.ICHANG.EQ.6HUNCERT.OR.ICHANG.EQ.IUNCER) NRERUN=1
 PRINT 70
 READ,ICONTI
 IF (ICONTI.EQ.3HYES) GO TO 710
 IF (NRERUN.EQ.1) GO TO 110
 GO TO 550
 800 STOP
 END
*****
***** CALCULATION OF ROOT OF F(X)=0., AT THE NEIGHBORHOOD OF X=X0,
*****     BY NEWTON-RAPHSON METHOD
*****
 SUBROUTINE NEWRAP (X0,ERROR,NITERA,NEWTON)
 DIMENSION XS(21),A(11)
 COMMON/BLOCK/A,MPLUS1,MPLUS2
 XS(1)=X0
 IF (X0.EQ.0.) XS(1)=X0=.0001
 DO 950 N=1,NITERA
 NPLUS=N+1
 NMINUS=N-1
 910 YNUM=YDEN=0.
 DO 930 I=1,MPLUS1
 IF (NEWTON.EQ.2) GO TO 920
 YNUM=YNUM+A(I)*XS(N)**(I-1)
 YDEN=YDEN+(I-1)*A(I)*XS(N)**(I-2)
 GO TO 930
 920 YNUM=YNUM+(I-1)*A(I)*XS(N)**(I-2)
 YDEN=YDEN+(I-1)*(I-2)*A(I)*XS(N)**(I-3)
 930 CONTINUE
 IF (YDEN.NE.0.) GO TO 940
 XS(N)=(XS(N)+XS(NMINUS))/2.
 GO TO 910
 940 ERR=ABS(YNUM/YDEN)
 IF (ERR.LE.ERROR) GO TO 960
 XS(NPLUS)=XS(N)-YNUM/YDEN
 950 CONTINUE
 X0=XS(NPLUS)
 GO TO 970
 960 X0=XS(N)-YNUM/YDEN
 970 ERROR=ERR
 NITERA=N
 RETURN
 END
READY.
```

stead of Cramer's rule is that it proves to be a simpler and a less time-consuming procedure, especially when the system to be solved has more than three simultaneous linear equations.

This method is a combination of the Gaussian forward and backward eliminations. The forward elimination consists of the following steps:

- Elimination of a_0 from the second and succeeding equations by dividing the first equation by c_{11}; multiplying the modified equation respectively by $c_{21}, c_{31}, \ldots, c_{(m+1)1}$; and then subtracting the obtained equations respectively from the second, third, ..., $(m+1)$th equations. The resulting set of equations is of the form:

$$
\begin{array}{l}
a_0 + c'_{12}a_1 + c'_{13}a_2 + \ldots + c'_{1(m+1)}\,a_m = b'_1 \\
\qquad c'_{22}a_1 + c'_{23}a_2 + \ldots + c'_{2(m+1)}\,a_m = b'_2 \\
\qquad \vdots \\
\qquad c'_{(m+1)2}a_1 + \ldots + c'_{(m+1)(m+1)}a_m = b'_{(m+1)}
\end{array}
\qquad (2)
$$

• Elimination of a_1 from the third and succeeding equations by dividing the second equation in the set of equations in (2) by c'_{22}; multiplying the modified equation respectively by $c'_{32}, c'_{42}, \ldots, c'_{[m+1]2}$; and then subtracting the obtained equations respectively from the third, fourth, . . . , $(m+1)$th equations.
• The elimination process continues until the system is of the form:

$$\begin{aligned} a_0 + c'_{12}a_1 + c'_{13}a_2 + \ldots + c'_{1[m+1]}a_m &= b'_1 \\ a_1 + c''_{23}a_2 + \ldots + c''_{2[m+1]}a_m &= b''_2 \\ &\vdots \\ c^{\{m+1\}}_{[m+1][m+1]}\, a_m &= b^{\{m+1\}}_{[m+1]} \end{aligned} \qquad (3)$$

The backward substitution process may now be used to find the values for all a_i in the reverse order. The value of a_m is calculated from the last equation in equation set (3) and is substituted in the next-to-last equation to solve for a_{m-1}, etc.

In the Gauss-Jordan elimination method, the last procedure (backward substitution process) is replaced by the elimination of a_i, starting from the second step, not only from the $(i+2)$th and succeeding equations, as previously mentioned, but also from all preceding equations, (from the first to the ith equation). Thus, at the end of the process, the final set of equations is of the form:

$$\begin{aligned} a_0 &= b'_1 \\ a_1 &= b''_2 \\ &\vdots \\ a_m &= b^{\{m+1\}}_{[m+1]} \end{aligned} \qquad (4)$$

As we notice, the values of $a_0, a_1, \ldots, a_m$ are obtained directly from equation set (4) as $b'_1, b''_2, \ldots, b^{\{m+1\}}_{[m+1]}$.

One remark about this method is that the values $c_{11}, c'_{22}, \ldots$ must be different from zero to make all divisions meaningful. If this is not the case for some equations, these equations may be rearranged with others which have nonzero values of c.

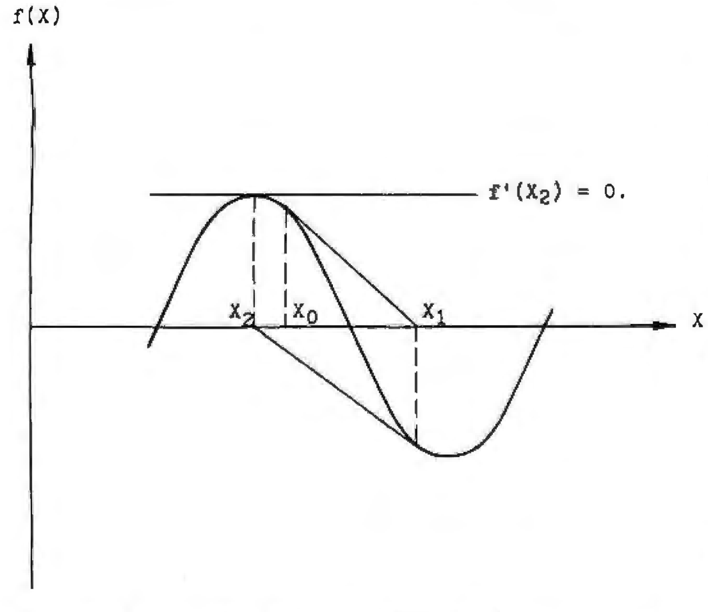


Figure 2: *An example of a function $f(X)$ that is not monotonically increasing or decreasing. This is clearly an undesirable situation for application of the Newton-Raphson method as the successive approximations diverge rather than converge on the desired root of the equation.*

Newton-Raphson Method

So far, utilizing the preceding techniques, we are able to determine for a given set of n pairs of data, a best-fit curve which is represented by the polynomial:

$$Y = a_0 + a_1X + a_2X^2 + \ldots + a_mX^m$$

The roots of $Y(X)=0$ and the X-coordinates of the stationary points (referred to as X_{sta}) are determined by the following equations:

$$\begin{aligned} Y &= a_0 + a_1X + a_2X^2 + \ldots + a_mX^m = 0 \\ Y' &= a_1 + 2a_2X + 3a_3X^2 + \ldots + ma_mX^{m-1} = 0 \end{aligned}$$

As long as $Y(X)$ has first and second defined derivatives and the equations $Y(X) = 0$ and $Y'(X) = 0$ are solvable, the values of $X_{Y=0}$ and X_{STA} may be calculated by using the well-known Newton-Raphson method.

This is an iteration process in which successive approximations are made in accordance with the formula

$$X_{n+1} = X_n - \frac{f(X_n)}{f'(X_n)} \qquad n = 1,2, \ldots$$

For rapid convergence, the initial approximation X_0 should be in the neighborhood of the desired root of the equation $f(X)$ and such that $f'(X) \neq 0$. This value of X_0 may be obtained with the aid of a rough sketch or tabulation of $f(X)$ versus X.

The iteration process continues with converging X_{n+1} until the required accuracy ϵ is obtained, that is

$$|X_{n+1} - X_n| \leq \epsilon \text{ or } |f(X_n)/f'(X_n)| \leq \epsilon$$

When $f(X)$ is not a monotonically increasing or decreasing function, or when there is a point of inflection in the interval $[X_1, X_2]$, the Newton-Raphson method may cause difficulties. In this case, X_{n+1} may tend to diverge or $f'(X_n)$ may happen to be very small or equal to zero, as illustrated in figure 2. A new value of X_n should be reassigned to avoid additional unnecessary iterations or to make $f'(X_n) \neq 0$. This may be accomplished by taking the average of that particular X_n and the previous value X_{n-1} (that is, $(X_n)_{new} = (X_n + X_{n-1})/2$).

Application of this method to our problem yields:

$$(X_{Y=0})_{n+1} = (X_{Y=0})_n - \frac{Y[(X_{Y=0})_n]}{Y'[(X_{Y=0})_n]}, \quad \left| \frac{Y[(X_{Y=0})_n]}{Y'[(X_{Y=0})_n]} \right| \leq \epsilon_{Y=0}$$

$$(X_{STA})_{n+1} = (X_{STA})_n - \frac{Y'[(X_{STA})_n]}{Y''[(X_{STA})_n]}, \quad \left| \frac{Y'[(X_{STA})_n]}{Y''[(X_{STA})_n]} \right| \leq \epsilon_{STA}$$

Computer Program

The program is written in an interactive manner for use with a timesharing system. To provide flexibility and ease of execution, some of the variables of the program

Listing 2: *Sample execution of the program CURFIT.*

```
00170+10,1,0,.1,1,-1.,.001,1,0.,.001
00190+-2.,-1.5,-1.,0.,1.,2.,2.5,3.,4.,5.
00210+-25.1,-6.9,3.1,5.,-6.9,-21.,-25.,-25.1,-7.,45.

RUN

PROGRAM   CURFIT


  THE DESIRED  3-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  4-TERMS OF A(I)*X**I      I = 0,1,..., 3

                      I      A(I)
                     ---    ------

                      0       5.090
                      1      -7.010
                      2      -7.028
                      3       2.005

  AFTER  4 ITERATIONS, THE OBTAINED VALUE OF XROOT  IS    -1.195

  AFTER  4 ITERATIONS, THE OBTAINED VALUE OF XSTATN IS     -.422
  THE CORRESPONDING VALUE OF Y(XSTATN) IS    6.646


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? XRT1
? 0.

  ANY MORE VARIABLES TO BE CHANGED ?
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? XSTN1
? 2.5

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  AFTER  4 ITERATIONS, THE OBTAINED VALUE OF XROOT  IS      .506

  AFTER  3 ITERATIONS, THE OBTAINED VALUE OF XSTATN IS     2.759
  THE CORRESPONDING VALUE OF Y(XSTATN) IS  -25.629


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? XRT1
? 4.

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  AFTER  3 ITERATIONS, THE OBTAINED VALUE OF XROOT  IS     4.194

  AFTER  1 ITERATIONS, THE OBTAINED VALUE OF XSTATN IS     2.759
  THE CORRESPONDING VALUE OF Y(XSTATN) IS  -25.629


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? NO
    STOP
```

Listing 3: *Application of the program CURFIT to a chemical engineering problem.*

```
00170+6,2,1,.005,0,0.,0.,0,0.,0.
00190+5.,10.,20.,30.,40.,45.
00210+18.24,18.56,19.03,19.42,19.74,19.89
RUN


PROGRAM   CURFIT


  THE DESIRED  2-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  3-TERMS OF A(I)*X**I      I = 0,1,..., 2

                      I      A(I)
                     ---    ------

                      0      17.960
                      1        .062
                      2       -.000

  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .002

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  THE DESIRED  2-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  3-TERMS OF A(I)*X**I      I = 0,1,..., 2

                      I      A(I)
                     ---    ------

                      0      17.960
                      1        .062
                      2       -.000

  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .001

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  THE DESIRED  3-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  4-TERMS OF A(I)*X**I      I = 0,1,..., 3

                      I      A(I)
                     ---    ------

                      0      17.894
                      1        .076
                      2       -.001
                      3        .000

  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? NO
    STOP
```

may be modified directly at the terminal in response to those questions printed by the program (see listing 2).

General Features

The program allows the user to:

- Enter up to 100 pairs of data.
- Enter the uncertainty margin as an absolute or relative value.
- Specify the magnitudes of the accuracy margins $\epsilon_{Y=0}$ and ϵ_{STA} required in the calculation of $X_{Y=0}$ and X_{STA}.
- Determine the least-squares polynomial and the values of $X_{Y=0}$ and X_{STA}.
- Initialize the iteration for finding the least-squares polynomial with any degree which, in the user's opinion, may be the desired one. This option eliminates unnecessary calculations resulting from the choice of the first degree as the initial trial.
- Modify information or values of variables after the completion of the first run. These variables include the lowest desired degree of the least-squares polynomial *m*, the uncertainty margin, the initially guessed values of $X_{Y=0}$ and of the abscissa of the stationary point X_{STA} (this is helpful when the least-squares function in question has more than one value of $X_{Y=0}$ or X_{STA} in the range under consideration), and desired accuracy margins $\epsilon_{Y=0}$ and ϵ_{STA}. (This option may be repeated as many times as the user wishes.)
- Monitor when the Newton-Raphson iteration process does not converge or does not give the required values of $X_{Y=0}$ or X_{STA} the desired accuracy so that a new value of $\epsilon_{Y=0}$ or ϵ_{STA} may be entered.

Flowchart and Program Listing

A detailed flowchart and the complete program listing are given in figure 3 and listing 1 respectively. The structure of the flowchart is relatively straightforward and should be reviewed along with those definitions or explanations given in the variable-definition text box on page 437.

- Input: the input data is arranged in three groups of DATA statements in the program listing. The first group contains the values for NPAIRS, MDEG, IUNCER, UNCERT, IROOT, XRT1, ERT, ISTATN, XSTN1, and

Figure 3: *Detailed flowchart of the program CURFIT.*

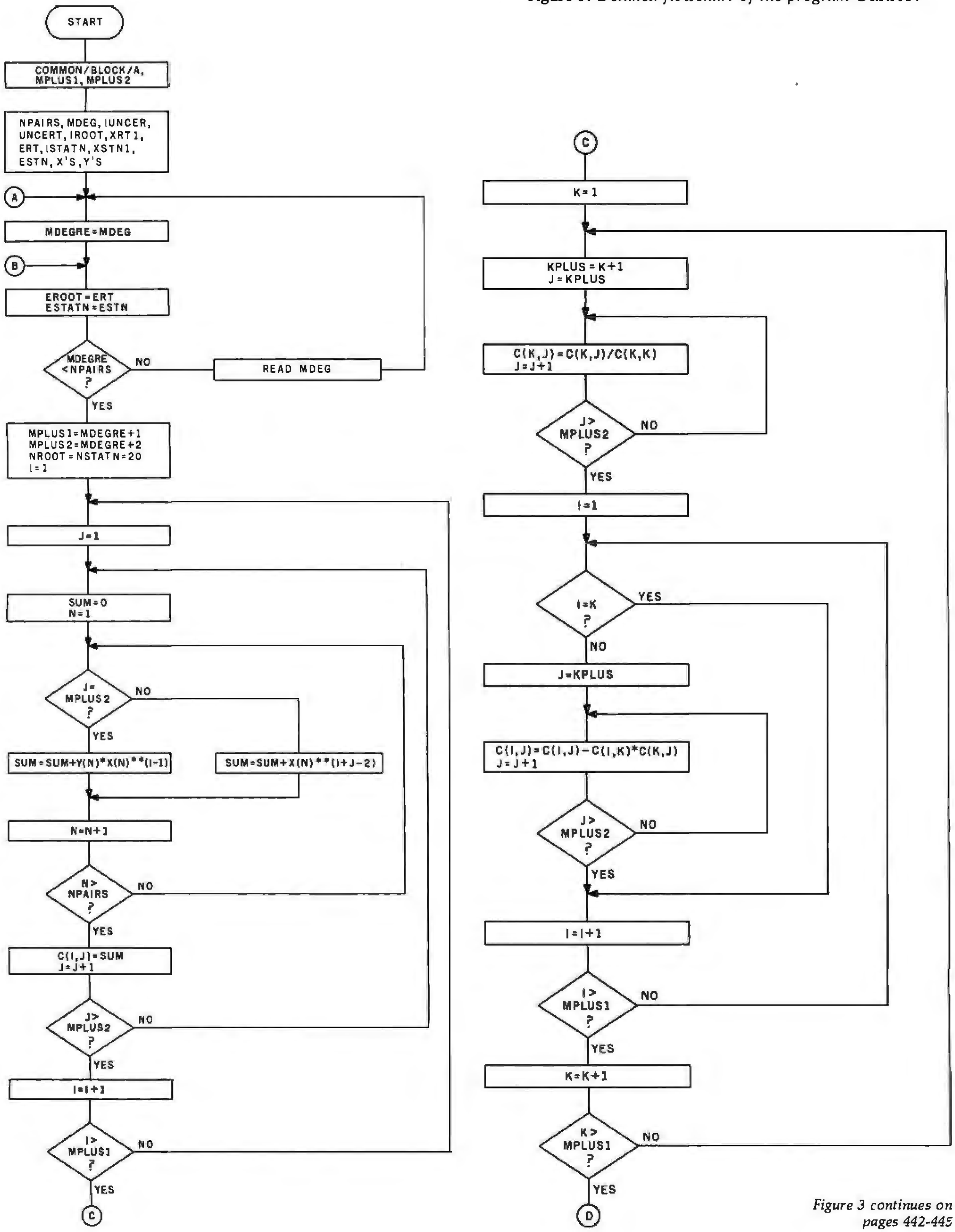


Figure 3 continues on pages 442-445

ESTN. The second group contains the n values for the independent points X_n, or X (NPAIRS). The third group contains the n values for the dependent points Y_n, or Y(NPAIRS). These statements are modified to accommodate different data.

- Output: the results consist of the degree of the sought-for least-squares polynomial and a set of calculated values, which are printed in two columns, representing the ith subscript and corresponding a_i in the representation $Y(X) = \sum_{0}^{m} a_i \times X^i$.

Sample Run

Assuming that the following set of 10 pairs of data is given:

i	1	2	3	4	5	6	7	8	9	10
X(i)	-2.0	-1.5	-1.0	0.0	1.0	2.0	2.5	3.0	4.0	5.0
Y(i)	-25.1	-6.9	3.1	5.0	-6.9	-21.0	-25.0	-25.1	-7.0	45.0

Figure 3 continued:

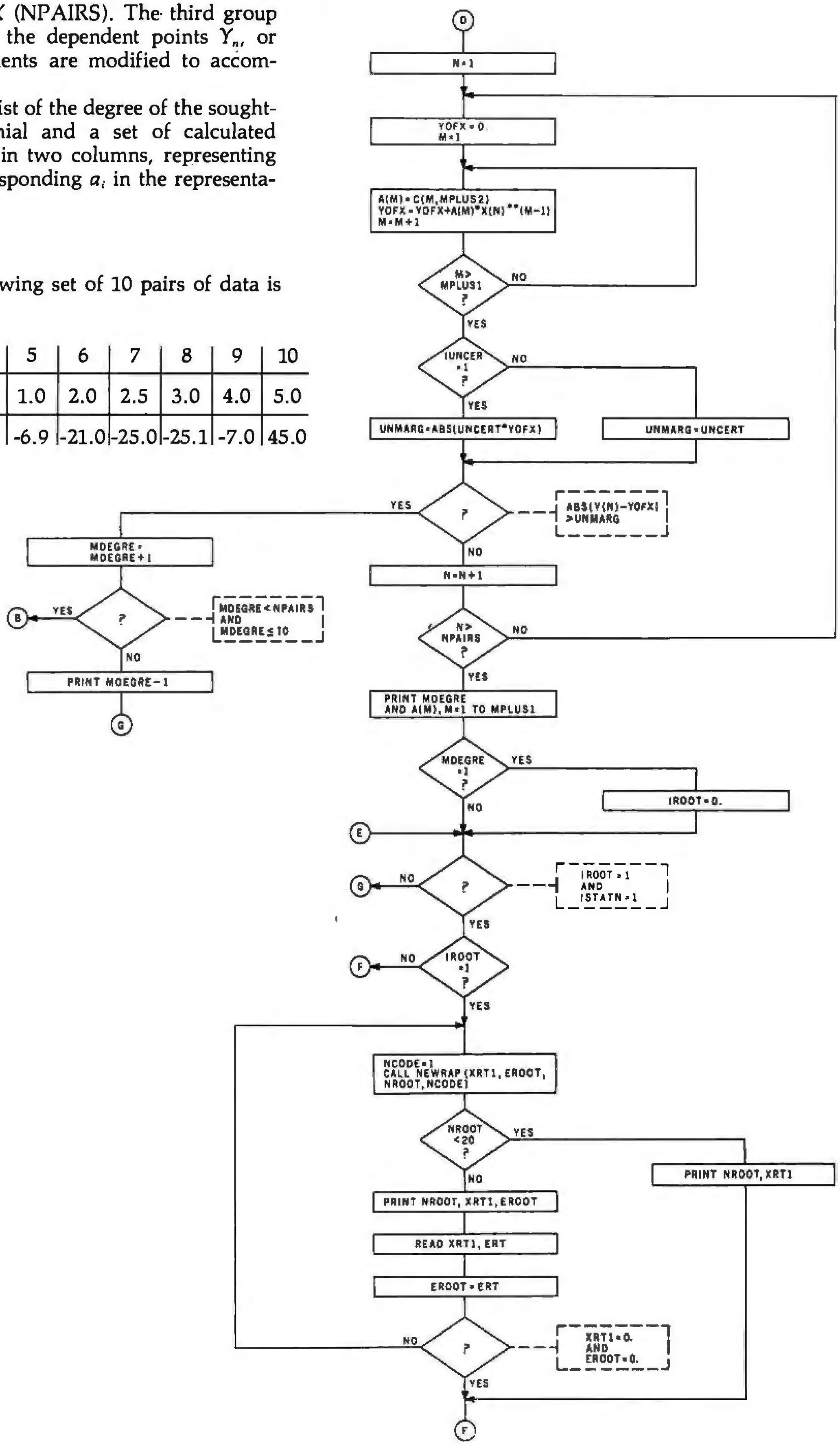


Figure 3 continued:

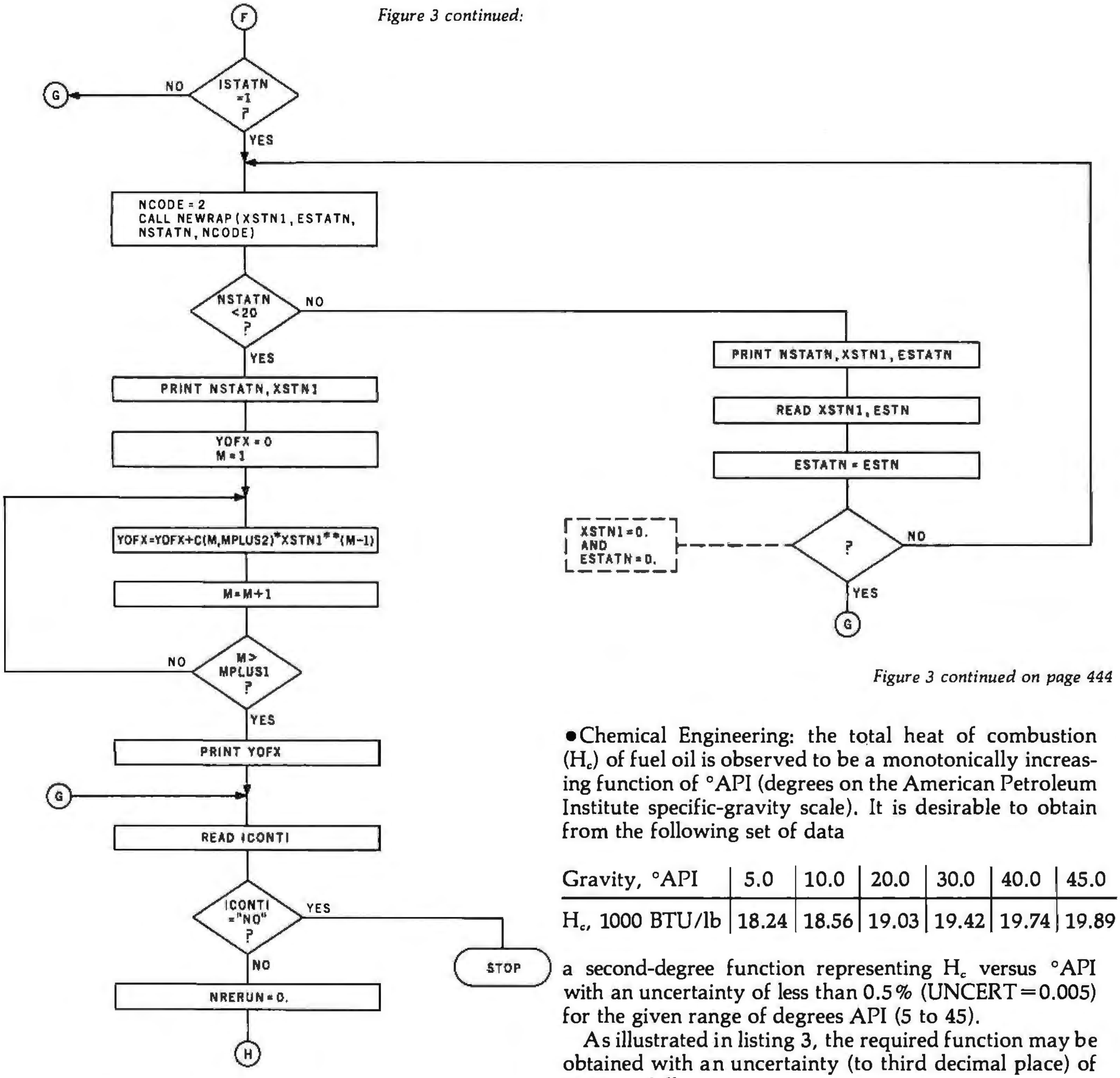


Figure 3 continued on page 444

We are going to use the program CURFIT to determine the continuous relationship between quantities X and Y as well as all values of $X_{Y=0}$ and X_{STA}. A quick look at the foregoing tabulation reveals that, in the specified range of Xs (-2.0 to 5.0), there are:

- three distinct values of $X_{Y=0}$ between $[X(2),X(3)]$, $[X(4),X(5)]$, and $[X(9),X(10)]$ due to the change in signs of corresponding pairs of $Y(i)$s
- two stationary points of which the maximum one is in the neighborhood of pair number 4 and the minimum near pair number 8.

Listing 2 illustrates some possible inputs and outputs for this particular example.

Application to Some Engineering Problems

The applications of the program CURFIT to engineering problems are innumerable. Here are a few simple examples of these applications:

- Chemical Engineering: the total heat of combustion (H_c) of fuel oil is observed to be a monotonically increasing function of °API (degrees on the American Petroleum Institute specific-gravity scale). It is desirable to obtain from the following set of data

Gravity, °API	5.0	10.0	20.0	30.0	40.0	45.0
H_c, 1000 BTU/lb	18.24	18.56	19.03	19.42	19.74	19.89

a second-degree function representing H_c versus °API with an uncertainty of less than 0.5% (UNCERT=0.005) for the given range of degrees API (5 to 45).

As illustrated in listing 3, the required function may be obtained with an uncertainty (to third decimal place) of 0.2% as follows:

$$H_c = 17.960 + .062(°API) - \text{negligible term } (°API)^2, \pm 0.2\%$$

To obtain an uncertainty of 0.1%, a third-degree function will be required, as shown in the last portion of the listing.

- Civil Engineering: in an experiment determining the compressive stress-strain diagram of a concrete mix of cement, sand, and gravel (mix proportion by volume is 1, 2, and 4, respectively), the following data is observed (a kip is a 1000-pound load):

unit strain ϵ (10^{-3} inch/inch)	0.1	0.2	0.3	0.5	0.6	0.8	1.0
unit stress σ (kips /inch^2)	0.44	0.82	1.21	1.78	2.08	2.54	2.83

Listing 4: *Application of the program CURFIT to a civil engineering problem.*

```
00170+7,2,0,.02,0,0.,0.,0,0.,0.
00190+.1,.2,.3,.5,.6,.8,1.
00210+.44,.82,1.21,1.78,2.08,2.54,2.83
RUN

PROGRAM   CURFIT


  THE DESIRED  6-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
      Y(X) = SUM OF  7-TERMS OF A(I)*X**I      I = 0,1,..., 6

                    I      A(I)
                   ---   -------

                    0        .641
                    1      -8.762
                    2      95.608
                    3    -333.314
                    4     573.012
                    5    -477.630
                    6     153.274


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? NO
     STOP
```

Listing 5: *Application of the program CURFIT to an electrical engineering problem.*

```
00170+5,1,1,.001,0,0.,0.,0,0.,0.
00190+50.,55.,60.,70.,75.
00210+239.2,243.1,247.,254.9,258.8
RUN

PROGRAM   CURFIT


  THE DESIRED  1-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
      Y(X) = SUM OF  2-TERMS OF A(I)*X**I      I = 0,1,..., 1

                    I      A(I)
                   ---   -------

                    0    199.937
                    1       .785


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .0005

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  THE DESIRED  1-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
      Y(X) = SUM OF  2-TERMS OF A(I)*X**I      I = 0,1,..., 1

                    I      A(I)
                   ---   -------

                    0    199.937
                    1       .785


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .0001

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  THE DESIRED  3-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
      Y(X) = SUM OF  4-TERMS OF A(I)*X**I      I = 0,1,..., 3

                    I      A(I)
                   ---   -------

                    0    207.832
                    1       .405
                    2       .006
                    3     -.000


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? NO
     STOP
```

Figure 3 continued:

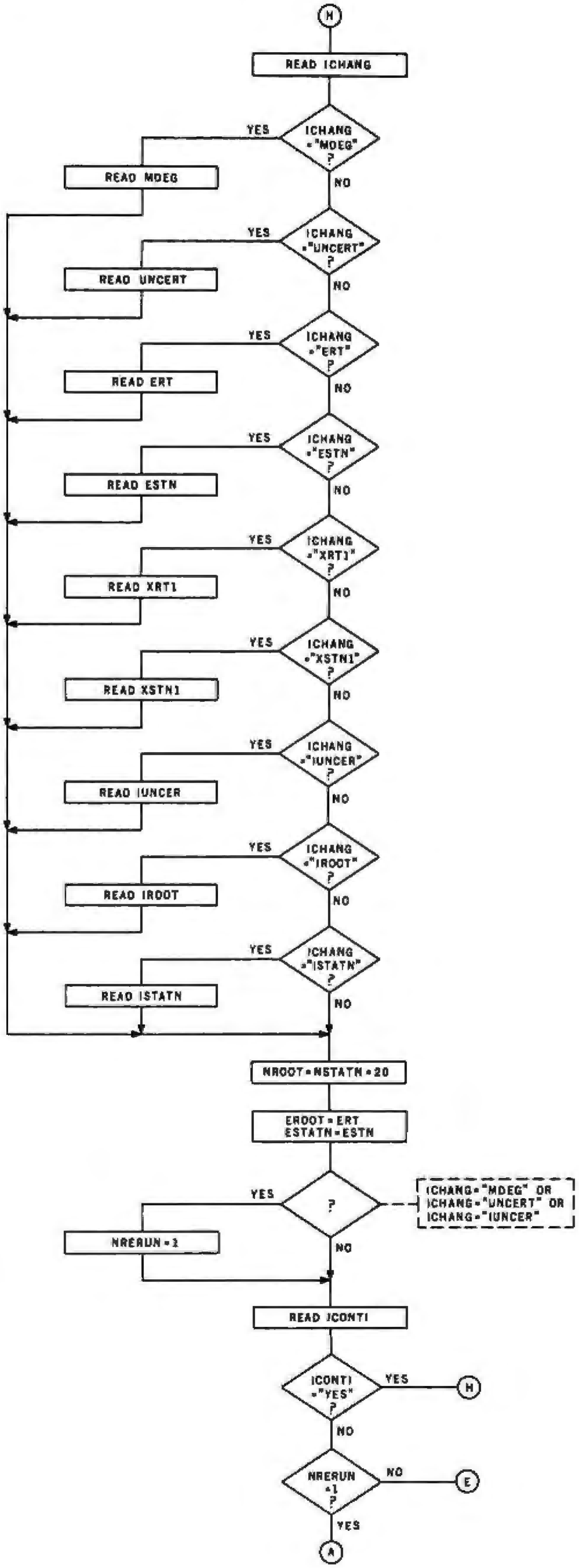
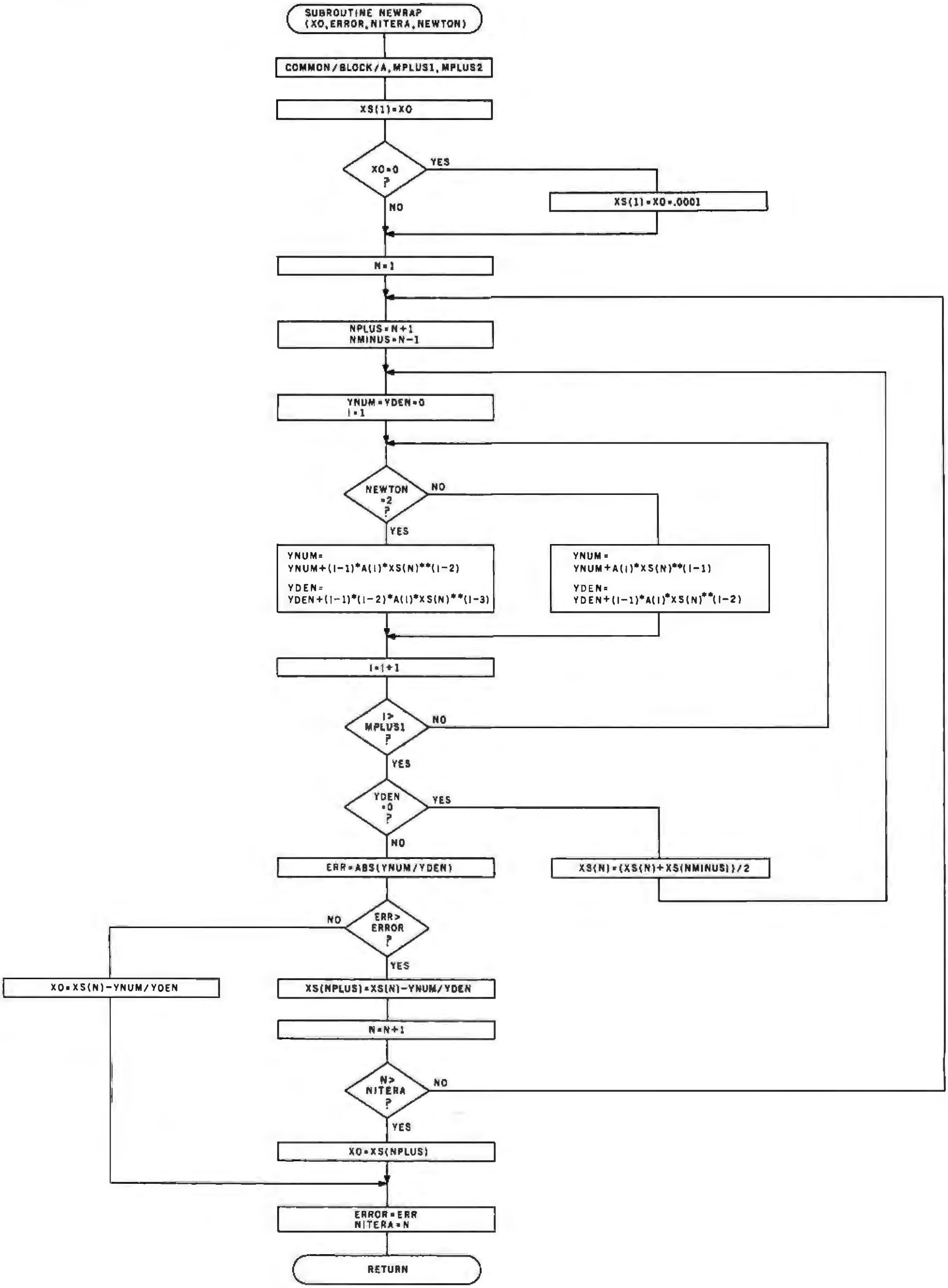


Figure 3 continued:



Deflection (inches)	10.8	21.6	27.0	37.8	48.6	64.8	81.0	86.4	97.2	108.0
Load (pounds)	74.0	117.0	132.0	145.0	150.0	152.0	168.0	183.0	226.0	300.0

Table 1: *Data collected when determining the load/deflection characteristics of a bevel spring, supported and loaded at the edges. The program execution in listing 6 will generate the best-fit curve for all points.*

For a required absolute uncertainty of ±0.02 kips/inch², from listing 4 we know that a sixth-degree polynomial representing σ versus ϵ is obtained as follows:

$$\sigma = 0.641 - 8.762\epsilon + 95.608\epsilon^2 - 333.314\epsilon^3 + 573.012\epsilon^4 - 477.63\epsilon^5 + 153.274\epsilon^6$$

Listing 6: *Application of the program CURFIT to a mechanical engineering problem.*

```
00170+10,2,1,.03,0,0.,0.,0,0.,0.
00190+10.8,21.6,27.,37.8,48.6,64.8,81.,86.4,97.2,108.
00210+74.,117.,132.,145.,150.,152.,168.,183.,226.,300.
RUN

PROGRAM   CURFIT


  THE DESIRED  3-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  4-TERMS OF A(I)*X**I       I = 0,1,..., 3

                    I      A(I)
                   ---   --------

                    0      1.164
                    1      8.261
                    2      -.153
                    3       .001

  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .01

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  THE DESIRED  3-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  4-TERMS OF A(I)*X**I       I = 0,1,..., 3

                    I      A(I)
                   ---   --------

                    0      1.164
                    1      8.261
                    2      -.153
                    3       .001

  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .005

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  THE DESIRED  8-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  9-TERMS OF A(I)*X**I       I = 0,1,..., 8

                    I      A(I)
                   --    ------

                    0    178.423
                    1    -32.937
                    2      3.555
                    3      -.172
                    4       .005
                    5      -.000
                    6       .000
                    7      -.000
                    8       .000

  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? NO
   STOP
```

•Electrical Engineering: in an electrical testing laboratory, a technician obtains the following set of data for the determination of resistance R_o at 0°C and temperature coefficient of resistance α of a conductor.

T, °C	50.0	55.0	60.0	70.0	75.0
R_T, ohms	239.2	243.1	247.0	254.9	258.8

Listing 5 gives the following results:

$$R_T = R_o(1 + \alpha T) = 199.937 + 0.785T, \pm 0.05\%$$
$$\text{or } R_o = 199.937 \text{ ohms}$$
$$\alpha = 0.785/199.937 = 0.00393\ (°\text{C})^{-1}$$

This value of α indicates that the conductor is made of platinum.

•Mechanical Engineering: the data observed in the determination of the load/deflection characteristics of a bevel spring, supported and loaded at its edges, is illustrated in table 1.

As shown in listing 6, for an uncertainty of 1%, a third-degree polynomial is determined as follows, where D is the deflection:

$$\text{Load} = 1.164 + 8.261(D) - 0.153(D)^2 + 0.001(D)^3$$

An eighth-degree polynomial will be required for an uncertainty of 0.5%.■

Glossary

Gauss-Jordan elimination: *This mathematical algorithm is a means of solving a system of simultaneous equations. It proves to be most effective when the system to be solved has more than three simultaneous linear equations. The procedure itself involves the simplification of a matrix formed from the coefficients of the system of simultaneous equations. This method is also referred to as the Gaussian reduction method.*

Newton-Raphson method: *A mathematical technique which employs an iteration process in which successive approximations are made to determine the roots of a polynomial equation. These successive approximations are calculated from the following formula:*

$$X_{n+1} = X_n - \frac{f(X_n)}{f'(X_n)}$$

Cramer's Rule: *An approach to solving a system of simultaneous equations involving the use of determinants. This method is most desirable when dealing with a small system of equations.*

Event Queue

May 1981

May-June
Data-Processing Courses, the Hartford Graduate Center, Hartford CT. For information on these courses, contact the Hartford Graduate Center, Attn: Don Florek, 275 Windsor St, Hartford CT 06120, (203) 549-3600, ext 252.

May-June
Workshops from the National Institute for Management Research, various cities throughout the US. Wordprocessing implementation and supervision and automated office implementation workshops are to be held. The weekend courses are $395 and $495, with discounts available for attendance at two or three workshops. Contact Department C—Wordprocessingfeb2, NIMR Seminars, POB 3727, Santa Monica CA 90403, (213) 450-0500.

May-July
Courses from Integrated Computer Systems Inc, various cites throughout the US. Courses on computer network design and protocols, multiple micro- and minicomputer systems, and fiber-optics communications systems are to be held. The fees for these 3- to 4-day courses range from $695 to $795. Contact Integrated Computer Systems Inc, 3304 Pico Blvd, POB 5339, Santa Monica CA 90405, (213) 450-2060.

May-July
Courses from Zilog, various cities throughout the US. An introduction to microprocessors; the Z80, Z8, and Z8000 family of components; PLZ/SYS programming; development systems; and other topics concerning Zilog products are covered in these courses. Fees range from $150 to $595. For a schedule of times and places, contact Zilog, 10340 Bubb Rd, Cupertino CA 95014, (408) 446-4666, ext 5586.

May 1-2
The Third Annual Computers in Education Conference, Seattle Pacific University, Seattle WA. This conference will feature panel discussions, workshops, and exhibits. Special emphasis will be placed on the use of microcomputers in elementary and high schools. Contact Jerry Johnson, Seattle Pacific University, Seattle WA 98119.

May 4-7
National Computer Conference, McCormick Pl, Chicago IL. Approximately 90,000 people are expected to attend this year's National Computer Conference (NCC). The use of robots and artificial intelligence will be among the program sessions at the Personal Computing Festival during the NCC. This will be the first time that personal-computing exhibits

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, 70 Main St, Peterborough NH 03458. 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.

have joined the rest of the conference in the main exhibit area. Over thirty technical sessions will be held. All major companies will be represented. Contact the American Federation of Information Processing Societies Inc, POB 9658, 1815 N Lynn St, Arlington VA 22209, (703) 558-3617.

May 5-8
INTELCOM 81/Paris, Paris, France. INTELCOM (International Telecommunications and Computer Conference and Exhibition) 81/Paris is part of a program to promote an international dialog on vital subjects in the telecommunications field. This conference attempts to guide the evolution of the computer and its technology by combining the efforts of private companies, government, and equipment users.

For information about attending, presenting a paper, or exhibiting at INTELCOM 81/Paris, contact the Conference Affairs Group, Horizon House, 610 Washington St, Dedham MA 02026, (800) 225-9977; in Massachusetts (617) 326-8220.

May 7-8
The Eighth Annual Computer Show, Valley Plaza Midland, Midland MI. This show is being sponsored by the Saginaw Valley Chapter of the Data Processing Management Association. It will feature data processing software and hardware, computer peripherals and equipment, forms, supplies, graphics equipment, and educational services. Contact Don Seidel, DPMA, Saginaw Valley Chapter, University Center MI 48710, (517) 790-4220.

May 11-13
Custom Integrated Circuits Conference, CICC'81, Americana Hotel, Rochester NY. The CICC aims to bring together designers, producers, and users of custom integrated circuits to discuss recent developments and future directions in the field. Papers will be read on applications, algorithm-implementing integrated circuits, fabrication techniques, interfaces and interconnects, computer-aided design, and testing and qualification. Contact Dr Rajinder Khosla, General Chairman, Research Laboratories, B-81, Eastman Kodak Company, Rochester NY 14650, (716) 722-2525.

May 11-13
Fourth Annual Rosen Research Personal-Computer Forum, Playboy Resort, Lake Geneva WI. This forum features guest speakers from all the major personal-computer hardware and software companies. The Rosen Forum is one of the most prestigious and important seminars in the industry. The registration fee for this 3-day session is $295. For further details, contact Rosen Research Inc, 200 Park Ave, New York NY 10166, (212) 586-3530.

May 11-13
The Thirty-First Electronic Components Conference,

Colony Square Hotel, Atlanta GA. Papers will be read on semiconductor-processing technology, optoelectronic devices, manufacturing technology, materials, hybrid microcircuits, discrete components, interconnections, reliability, and connectors. Contact T G Grau, Bell Laboratories, Whippany Rd, Rm 3B-312, Whippany NJ 07981; or Electronic Industries Association, 2001 Eye St NW, Washington DC 20006.

May 14-16

The Tenth ASIS Mid-Year Meeting, Fort Lewis College, Durango CO. The American Society for Information Science's (ASIS's) theme for this year's meeting is "Using Information." Among the topics to be addressed are user studies, decision making, organizational change, government, education, management, access to information, and designing information systems for use. For information, contact ASIS, 1010 16th St NW, Washington DC 20036, (202) 659-3644.

May 16

Introduction to Pascal, Princeton NJ. The Princeton, New Jersey, chapter of the ACM (Association for Computing Machinery) is sponsoring this seminar. Contact Ronald Orcutt, EDUCOM, POB 364, Princeton NJ 08540; or Bill Hafstad, (201) 457-4055.

May 17-20

Expo '81, Loew's Anatole Hotel, Dallas TX. Expo '81 is a combination of exhibits and technical sessions. The exhibits cover everything from graphics systems to industrial computer-control systems. The technical sessions range from tool design, design engineering, and robotics to numerical control. For more information, contact Numerical Control Society, 519 Zenith Dr, Glenview IL 60025, (312) 297-5010.

May 20-22

Joint Conference on Easier and More Productive Use of Computing Systems, University of Michigan, Ann Arbor MI. This conference intends to combine the insights of the social sciences, humanities, computer science, and human-factors engineering. Contact Gregory A Marks, 4258 Institute for Social Research, University of Michigan, Ann Arbor MI 48106, (313) 763-3482.

May 20-22

Videotex '81, Royal York Hotel, Toronto, Ontario, Canada. Videotext information systems allow users to call up information, make reservations, pay bills, exchange electronic mail, read an electronic newspaper, shop, and play video games. This conference will review videotext developments in Europe, Japan, and North and South America. Demonstrations of videotext systems will be given. Seminars on standards, legal aspects, and economic issues will be featured. Contact Videotex '81, 316 Lonsdale Rd, Suite 3, Toronto, Ontario, M4V 1X4, Canada, (416) 598-1981.

May 21-23

Annual Conference of the Educational Computing Organization of Ontario, Sheraton Centre and the Ontario Institute for Studies in Education, Toronto, Ontario, Canada. Exhibits on the use of computers in schools and discussions on how to locate suitable educational materials will be featured. Contact the Conference Office, OISE, 252 Bloor St W, Toronto, Ontario, M5S 1V6, Canada.

May 22-24

National TRS-80 Microcomputer Show, Statler Exposition Center, New York NY. Exhibits from over 100 manufacturers, distributors, and retailers of equipment for the TRS-80 Models I, II, and III, and Color and Pocket computers, will be featured. Seminars and talks will be held at the show. Contact Kengore Corporation, 3001 Rt 27, Franklin Park NJ 08823, (201) 297-6918.

May 26-29

Office Korea 81, Korea Exhibition Center, Seoul, South Korea. Exhibitors will come from the United States, Japan, the United Kingdom, and South Korea. Computers, copiers, facsimile systems, and office equipment and supplies will be presented. Further information may be obtained from Clapp & Poliak International, 7315 Wisconsin Ave, Washington DC 20014, (301) 657-3090.

May 30

Amateur Fair, Minnesota State Fairgrounds, St Paul MN. Exhibits, prizes, and booths are featured at this swapfest for computer hobbyists. Contact the Amateur Fair, POB 30054, St Paul MN 55175.

June 1981

June 6-9

Atlanta Small Computer Show, Atlanta Hilton, Atlanta GA. Producers of small computers, peripherals, supplies, and services will be exhibiting at this show. Business owners, corporate and government executives, data-processing managers, doctors, lawyers, and other professionals are expected to attend. Obtain additional information from The Atlanta Small Computer Show, 4060 Janice Dr, Suite C-1, East Point GA 30344, (404) 767-9798.

June 9-11

Understanding and Using Computer Graphics, Chicago IL. This seminar covers the latest in graphic-system technology, including hardware, software, and applications. Contact Bob Sanzo, Frost & Sullivan Inc, 106 Fulton St, New York NY 10038, (212) 233-1080.

June 14-18

The Second National Conference of the National Computer Graphics Association, Baltimore Convention Center, Baltimore MD. Computer-graphics demonstrations, exhibits, and workshops will be held. Contact the National Computer Graphics Association Inc, 2033 M Street NW, Suite 330, Washington DC 20036, (202) 466-5895.

June 16-18

NEPCON East '81, New York Coliseum, New York NY. This exposition is aimed at engineers, prototype developers, production specialists, and testing personnel. Technical programs will be presented. Contact Industrial & Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606, (312) 263-4866.

June 17-19
National Educational Computing Conference, North Texas State University, Denton TX. This conference will provide a forum for individuals and institutions interested in educational computing. Computer literacy, computer education for teachers, and computers in education are some of the topics to be covered. Contact Dr Jim Poirot, NECC-81 General Chairman, Computer Sciences Department, North Texas State University, Denton TX 76203.

May 29-31
The Sixth Annual Computerfest, Franklin University, Columbus OH. Talks on robots and calculators will be featured. Microcomputers and small-business systems will be presented. This show is being sponsored by the Midwest Affiliation of Computer Clubs and Franklin University. Contact Computerfest '81, Paul Pittenger, 215 Delhi Ave, Apt J, Columbus OH 43202, (614) 224-6237.

June 23-25
Comdex/Spring, Madison Square Garden and the New York Statler Hotel, New York NY. Computer and computer-related manufacturers, systems houses, computer retailers, dealers, distributors, manufacturers' representatives, commercial OEMs (original equipment manufacturers), and other related businesses will be exhibiting. Contact The Interface Group, 160 Speen St, Framingham MA 01701, (800) 225-4620; in Massachusetts, (617) 879-4502.

June 29-July 1
The Nineteenth Annual Meeting of the Association for Computational Linguistics, Stanford University, Stanford CA. Syntax, parsing, and sentence generation, computational semantics, discourse analysis and speech acts, speech analysis and synthesis, machine and machine-aided translation, and mathematical foundations of computational linguistics are some of the topics that will be discussed. Contact Don Walker, Artificial Intelligence Center, SRI International, Menlo Park CA 94025, (415) 326-6200, ext 3071.

July 1981

July 29-31
The 1981 Microcomputer Show, Wembley Conference Centre, London, England. Seminars on microcomputer applications in business, production, and education will be presented. Topics for conference sessions include hardware availability, software packages and development, automatic test equipment, robotics, and process control. Exhibits from major European and American manufacturers will be featured. Contact TMAC, 680 Beach St, Suite 428, San Francisco CA 94109, (800) 227-3477; in California, (415) 474-3000.■

Technical Forum

Build a Noise-Based Random Number Generator

Terry Mayhugh, 11632 Midhurst Dr, Concord TN 37922

At some time, nearly every programmer finds it necessary to generate random numbers. If a card dealer is being simulated, or a Klingon scanner display is being created, the RND function available in most versions of BASIC may be adequate. However, the pseudorandom sequence generated by RND can bomb in critical applications where a truly random number sequence is needed. Truly random numbers are extremely difficult to generate, especially within a nonrandom machine such as a computer.

The best that can be accomplished purely by software is the generation of finite-length sequences that appear to be random. However, the actual members may be related to specific calculations recently completed by the computer. Such complications will contaminate the results of signal-recovery simulations or digital-filter problems. Even a computer card game may be biased by a previous bet. Ideally, the actual random number generation should be done outside the computer.

Figure 1 is a block diagram of a simple generator capable of producing *truly random* sequences of any length. A free-running oscillator, running asynchronous

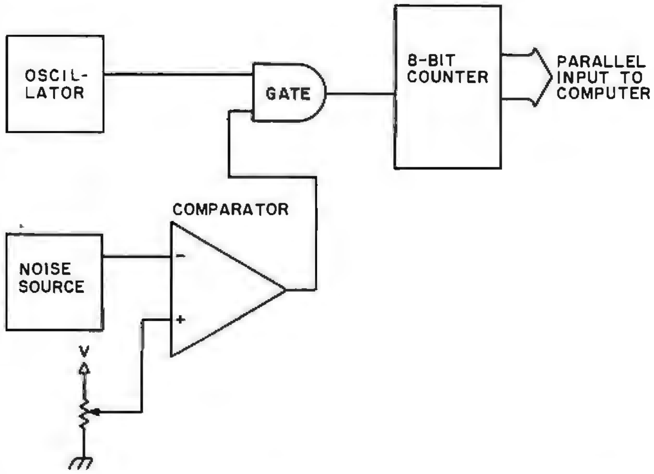


Figure 1: *Block diagram of a generator that produces true random numbers. Through pulses created by the random-noise source, the free-running oscillator is gated to the 8-bit binary counter. Since the instantaneous amplitude of the voltage from the noise source is unpredictable, the width and arrival of the gate pulse generated by the comparator are also random. Therefore, the 8 bits available from the counter are truly random.*

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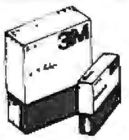

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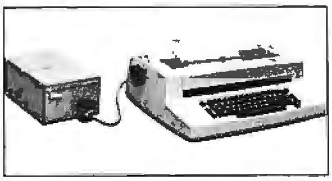

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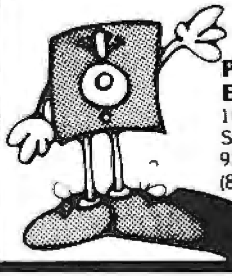

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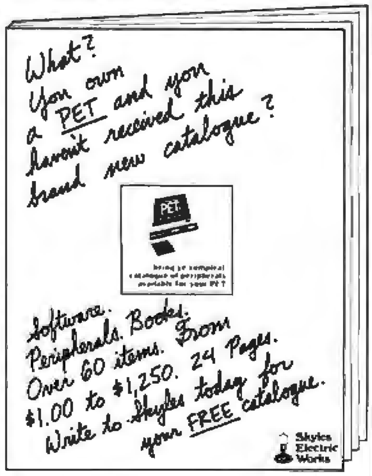

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Mountain View, CA 94041

Circle 368 on inquiry card.

to the microprocessor clock in the computer is gated to an 8-bit binary counter through pulses created by a random-noise source. Since the instantaneous amplitude of the voltage from the noise source is not predictable, the width and the time of arrival of the gate pulse generated by the comparator are unpredictable. The sequence of numbers available from the counter is truly random (if you do not try to sample them at an excessively high rate). For the component values shown in figure 2, there should be no problem in any microprocessor application.

The numbers generated by this technique are uniformly distributed; any number in the set of all possible numbers (0 thru 255) has the same probability of occurring. The mean or expected value of the distribution lies at the center of the set of all possible numbers.

Circuit Description

The noise of zener diode D1 is amplified by IC4 and IC5, which are configured as high-gain wideband amplifiers. The amplified noise from IC5 is compared with the DC wiper voltage of R18 at the input of comparator IC6. A logic level is generated at the comparator output and is used to gate on and off a TTL (transistor-transistor logic) oscillator (IC2), which runs free at about 3 MHz. A cascaded dual 4-bit binary counter (IC3) is clocked by this oscillator.

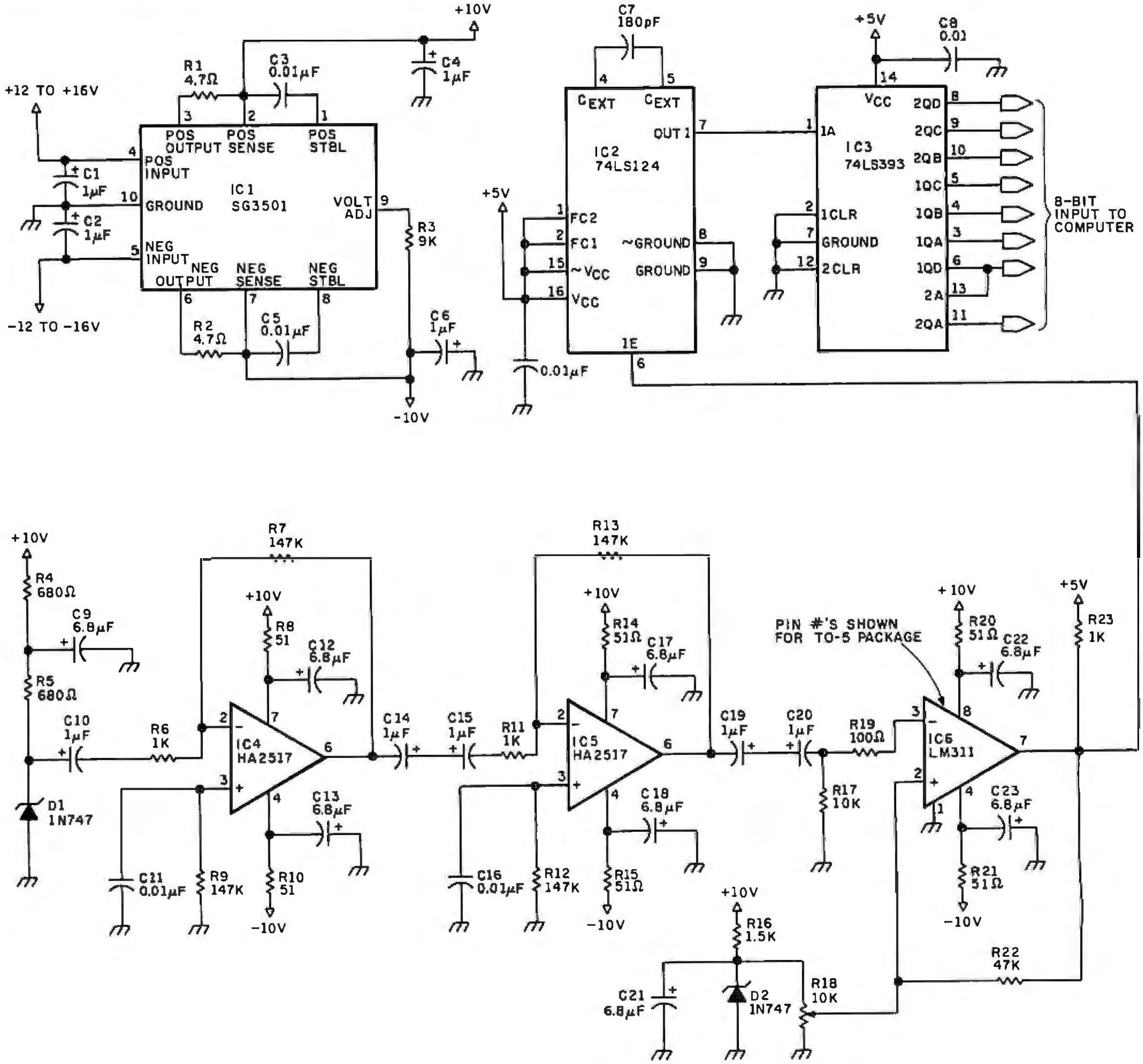

Figure 2: *Schematic diagram of the random number generator described in this article. The noise of D1 is amplified by IC4 and IC5. The amplified noise from IC5 is compared with the DC wiper voltage of R18 at the comparator input of IC6. The level generated at the comparator input gates IC2 (running at about 3 MHz). The oscillator is clocked by IC3 (a cascaded 4-bit binary counter). The circuit should be shielded. Pin numbers shown for IC1 (Silicon General 3501) are those for a TO-5 package.*

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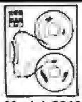

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Parts List

IC1 Silicon General SG3501 dual regulator
IC2 74LS124 oscillator
IC3 74LS393 dual 4-bit counter
IC4, IC5 Harris HA2517 op-amp
IC6 LM311 comparator

R1, R2 4.7 ohm 1/4 W 5% CC (carbon composition)
R4, R5 680 ohm 1/4 W 5% CC
R8,R10,R14,R15,R20,R21 51 ohm 1/4 W 5% CC
R17 10 k-ohm 1/4 W 5% CC
R19 100 ohm 1/4 W 5% CC
R22 47 k-ohm 1/4 W 5% CC
R23 1 k-ohm 1/4 W 5% CC
R16 1.5 k-ohm 1/4 W 5% CC
R3 9.00 k-ohm 1/8 W 1% mF
R6, R11 1.00 k-ohm 1/8 W 1% mF
R7,R9,R12,R13 147 k-ohm 1/8 W mF
R18 10 k-ohm miniature 10-turn potentiometer

C1,C2,C4,C6,C10,C14,C15,C19,C20 1 μF 25 V tantalum
C9,C12,C13,C17,C18,C21,C22,C23 6.8 μF 25 V tantalum
C3,C5,C8,C11,C16 0.01 μF disc ceramic
C7 180 pF disc ceramic
D1, D2 IN747 zener diode

Table 1: *Parts list for the circuit shown in figure 2.*

A great deal of power-supply decoupling and isolation is used in the analog section of the generator. This is necessary to avoid picking up the 60 Hz power signal or any other periodic power-supply noise that could destroy the randomness of this circuit.

The circuit should be constructed within a shielded enclosure to avoid RF (radio frequency) or other interference that could cause a periodic output from IC6. The ±12 V supply in my SwTPC 6800/2 (actually ±14 V) has an unacceptable amount of 60 Hz ripple for this application, so a dual IC regulator (IC1) regulates this voltage to a clean ±10 V for the analog electronics.

Alignment of the generator is relatively simple if an oscilloscope is available. R18 is adjusted while viewing the waveform at pin 7 of IC2. This potentiometer should be adjusted until the waveform at pin 7 spends an equal amount of time in its high and low status. That is, the brightness of the scope trace should be adjusted for uniform brightness at its top and bottom edges. If no scope is available, set the potentiometer for 50 to 100 mV at the wiper.

The eight counter bits may be connected in any order to the eight lines of the parallel port of the computer. In my particular application the port is read with a load-accumulator instruction when a number is needed. No strobe or handshaking is used.

A Gaussian, or normal, distribution can also be created using this uniform generator. Using what statisticians call the Central Limit Theorem, a normal distribution can be created by averaging several random numbers of any other type distribution. I have found that a convenient and sufficient number of samples in most cases is 64. Averaging multiples of 2 maintains maximum speed because the division in the averaging process can be done with simple accumulator shifts. Of course, speed is sacrificed with this method because only one normally distributed number is created for every 64 uniform numbers generated. ■

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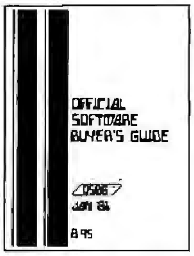

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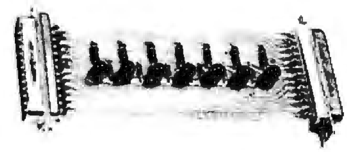

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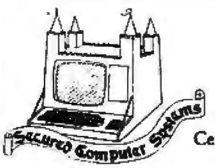

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Fast Fourier Comes Back

Alastair Roxburgh, 50 Maitland St, Dunedin, New Zealand

The program "Fast Fourier for the M6800," by Richard H Lord (February 1979 BYTE, page 108), contains an overflow bug that I discovered while testing a version of the program written for the 8080 processor. (See listing 1.) After the exact nature of the fault was ascertained, a theoretical explanation for it was easy to find. The problem concerns the maximum two's-complement value allowed before scaling commences. The 6800 program requires that any data point outside the range of $-64 <$ data < 64 be scaled down before the next pass. Scaling divides all data values by 2. However, during passes 2 thru 8 it is quite possible for the results of arithmetic operations to exceed the 8-bit two's-complement-number range of $-128 \leq$ data < 127. The reason for this can be seen by referring to lines 205 and 215 in the original program. These lines yield:

$$RM' = RM + RN*COS(X) + IN*SIN(X)$$

Letting RM=RN=IN=M, the maximum data value, then:

$$RM' = M*(1 + COS(X) + SIN(X)).$$

The maximum value of RM' is then M times the maximum value of 1 + COS(X) + SIN(X). This maximum value occurs at an angle of 45°, given by TAN(X) = 1.

Thus, the maximum value of RM' is $M(1 + \sqrt{2})$ or approximately (2.414)M. Letting RM' = 127 (the maximum positive 8-bit two's-complement-data value), then $M = INT(127/(1 + \sqrt{2})) = 52$.

Thus, the data should be scaled before *each* pass if any point exceeds the range $-52 \leq$ data ≤ 52. It makes little difference to the spectra whether the relational operators here are greater-than-or-equal or merely just greater-than. The 6800 program should be amended accordingly:

```
00268     CMP A     # $CC     (-52)
00270     CMP A     # $34      (52)
```

The test program that uncovered the overflow error used program-generated square waves with a period of six data points (equivalent to 10.667 Hz using a sampling rate of 64 Hz). Every amplitude from 128 ± 127 down to 128 ± 1 was tested and the power spectra, as well as SCLFCT, were printed out (requiring approximately three hours at 110 bits per second).

Each transform in the 8080 program takes 3.6 seconds to compute with a 2 MHz processor clock. The power calculation is fast, because a lookup table is used.

When FFTs (fast Fourier transforms) are computed on a minicomputer that has sophisticated error-trapping hardware, the usual practice is not to perform any pre-scaling, but instead to allow arithmetic overflow to occur, do a software interrupt to a scaling routine, and return. This way, fewer scalings of all the data are required, yielding results with the maximum possible numerical precision. The 6800 can detect two's-complement overflows and can efficiently perform (two's complement) arithmetic shifts to scale the data, but it does not have an automatic overflow trap. The advantage of slightly better numerical results would be outweighed by the time required to call an overflow-checking subroutine after most arithmetic operations. The 8080 is even worse off; it has neither a two's-complement-overflow indicator nor a single-instruction equivalent of the 6800's ASR.

Text continued on page 460

Listing 1: *The 8080 version of the fast Fourier transform program originally written for the 6800 processor by Richard Lord. In this version, Mr Roxburgh has corrected an overflow problem that he discovered and diagnosed in the original version.*

```
0000                ;; F A S T   F O U R I E R   T R A N S F O R M.
0000                ;; = = = =   = = = = = = =   = = = = = = = = =
0000                ;;ORIGINAL:- M6800 FFT BYTE FEB 1979.
0000                ;;8080 VERSION BY:- ALASTAIR ROXBURGH.
0000                ;;DATE:- 4 OCT 1979.
0000                ;;256 POINT IN-PLACE COMPLEX FOURIER TRANSFORM.
0000                ;;INPUT DATA UNSIGNED WITH ZERO = 80H.
0000                ;;COMPLEX OUTPUT SIGNED (2'S COMP.).
0000                ;;REAL OUTPUT (POWER OR AMPLITUDE) UNSIGNED.
0000                ;;
0000                ;
0000                SQADR  EQU   9F00H   ;2'S COMP. SQU. TABLE.
0000                STADR  EQU   9F00H   ;2'S COMP. SINE TABLE.
0000                ;
0000                       ORG   8300H
8300                RLPT1  DS    2       ;REAL PTR 1.
8302                RLPT2  DS    2       ;REAL PTR 2.
8304                IMPT1  DS    2       ;IMAG. PTR 1.
8306                IMPT2  DS    2       ;IMAG. PTR 2.
8308                SINPT  DS    2       ;SINE TABLE PTR.
830A                CELCT  DS    1       ;CELL CTR.
830B                CELNUM DS    1       ;NO. OF CELLS.
830C                PAIRNM DS    1       ;PAIRS PER CELL.
830D                CELDIS DS    1       ;SPAN BETWEEN PAIRS.
830E                DELTA  DS    1       ;ANGLE INCREMENT.
830F                SCLFCT DS    1       ;MULTIPLY OUTPUT AMPLITUDE
8310                                     ; BY 2↑SCLFCT.
8310                SINE   DS    1
8311                COSINE DS    1
8312                TREAL  DS    1
8313                TIMAG  DS    1
8314                ;
8314                       ORG   8400H
8400                INPD   DS    256     ;INPUT DATA BUFF.
8500                REAL   DS    256     ;"REAL" BUFF.
8600                IMAG   DS    256     ;"IMAG" BUFF.
8700                ;
8700                       ORG   877FH
877F                PABUF  DS    180     ;POWER/AMPLITUDE SPECTRUM.
8800                ;
8800                       ORG   8000H
8000                ;;
8000                ;;TEST FFT PROGRAM.
8000                ;;
8000 CD D5 81              CALL  WAVE    ;GET TEST SIGNAL.
8003 CD 0C 80              CALL  FFT     ;FORM COMPLEX SPECTRUM.
8006 CD AE 81              CALL  POWER   ;CONVERT COMPLEX SPECTRUM
8009                                     ; TO 128 PT POWER SPECTRUM.
8009                      ;CALL  MAGNI   ;CONVERT COMPLEX SPECTRUM
8009                                     ; TO 128 PT AMPLITUDE SPECTRUM
8009 C3 F4 AF              JMP   0AFF4H  ;RETURN TO BMCOS.
800C                ;
800C                ;;
800C                ;;INITIALISE DATA AREAS.
800C                ;;
800C 3E 00          FFT:   MVI   A,0
800E 32 0F 83              STA   SCLFCT
8011                ;
8011                ;CLEAR IMAG. ARRAY.
8011 21 00 86       CLEAR:LXI    H,IMAG
8014 36 00          CLR1:  MVI   M,0
8016 2C                    INR   L
8017 C2 14 80              JNZ   CLR1
801A                ;
801A                ;MOVE INPUT DATA INTO REAL ARRAY.
801A                ;DE=SOURCE, HL=DEST.
801A 11 00 84       MOVE:  LXI   D,INPD
801D 21 00 85              LXI   H,REAL
8020 1A             MOV1:  LDAX  D
8021 D6 80                 SUI   80H     ;CONVERT TO 2'S COMPLEMENT.
8023 77                    MOV   M,A
8024 1C                    INR   E
8025 2C                    INR   L
8026 C2 20 80              JNZ   MOV1
8029                ;;
8029                ;;PRE-TRANSFORM BIT SWAP.
8029                ;;
8029 11 00 85              LXI   D,REAL
802C 21 00 85              LXI   H,REAL
802F 06 08          BITREV:MVI   B,8     ;SET BIT CTR.
8031 7D                    MOV   A,L     ;LOW-ORDER BITS OF RLPT1.
8032 1F             BRV1:  RAR           ;MOVE LS BIT OF RLPT1
8033 4F                    MOV   C,A     ; INTO CY & SHIFT
8034 7B                    MOV   A,E
8035 17                    RAL           ; IN REVERSE ORDER BACK
8036 5F                    MOV   E,A     ; INTO RLPT2.
8037 79                    MOV   A,C
8038 05                    DCR   B
8039 C2 32 80              JNZ   BRV1
803C 7D                    MOV   A,L
803D BB                    CMP   E       ;COMPARE VALS, & IF
803E DA 46 80              JC    SWP1    ; SAME, DON'T SWAP.
8041 4E             SWAP:  MOV   C,M     ;GET VAL 1 INTO C.
8042 1A                    LDAX  D       ;GET VAL 2 INTO A.
8043 77                    MOV   M,A     ;STORE IN SWAPPED ORDER.
8044 79                    MOV   A,C
8045 12                    STAX  D
8046 2C             SWP1:  INR   L
8047 C2 2F 80              JNZ   BITREV
804A                ;;
804A                ;;FFT FIRST PASS.
804A                ;;
804A CD 4B 81       PASS1:CALL   SCALE   ;SCALE IF DATA OVER-RANGE.
804D 21 00 85              LXI   H,REAL
8050 7E             PA1:   MOV   A,M     ;GET RM.
8051 4F                    MOV   C,A     ;SAVE RM.
8052 2C                    INR   L
8053 46                    MOV   B,M     ;GET RN TOO.
8054 2D                    DCR   L
8055 80                    ADD   B       ;RM' = RM+RN.
8056 77                    MOV   M,A     ;STORE NEW RM'.
8057 79                    MOV   A,C     ;RETRIEVE RM.
8058 90                    SUB   B       ;RN' = RM-RN.
8059 2C                    INR   L
805A 77                    MOV   M,A     ;STORE RN'.
805B 2C                    INR   L       ;NEW PAIR.
805C C2 50 80              JNZ   PA1
805F                ;;
805F                ;;COMPUTATION OF FFT. PASS 2 THRU N.
805F                ;;
805F 3E 40          FPASS:MVI    A,64    ;SET UP PARAMETERS
8061 32 0B 83              STA   CELNUM  ; FOR NO. OF CELLS,
8064 32 0E 83              STA   DELTA   ; ANGLE,
8067 3E 02                 MVI   A,2     ; & FOR
8069 32 0C 83              STA   PAIRNM  ; PAIRS/CELL.
806C 32 0D 83              STA   CELDIS  ;SPAN BETWEEN PAIRS.
806F CD 4B 81       NPASS:CALL   SCALE   ;KEEP DATA IN RANGE.
8072 3A 0B 83              LDA   CELNUM  ;GET NO. OF CELLS &
8075 32 0A 83              STA   CELCT   ; PUT INTO CELL CTR.
8078 21 00 85              LXI   H,REAL
807B 22 00 83              SHLD  RLPT1
807E 22 02 83              SHLD  RLPT2
8081 21 00 86              LXI   H,IMAG
8084 22 04 83              SHLD  IMPT1
8087 22 06 83              SHLD  IMPT2
808A 21 00 9F       NCELL:LXI    H,STADR
808D 22 08 83              SHLD  SINPT
8090 3A 0C 83              LDA   PAIRNM  ;GET PAIRS/CELL CTR.
8093 47                    MOV   B,A
8094 21 0D 83       NC1:   LXI   H,CELDIS
8097 3A 00 83              LDA   RLPT1   ;PTR 1 LSBY.
809A 86                    ADD   M       ;ADD PAIR OFFSET.
809B 32 02 83              STA   RLPT2   ;SET UP BOTH
809E 32 06 83              STA   IMPT2   ; 2ND PTRS.
80A1 C5                    PUSH  B       ;SAVE PAIR CTR.
80A2 2A 08 83              LHLD  SINPT
80A5 7E                    MOV   A,M     ;GET SINE OF ANGLE
80A6 32 10 83              STA   SINE    ; & SAVE.
80A9 3E 40                 MVI   A,64    ;ADD COSINE OFFSET
80AB 85                    ADD   L       ; MODULO 256.
80AC 6F                    MOV   L,A
80AD 7E                    MOV   A,M     ;GET COSINE OF ANGLE
80AE 32 11 83              STA   COSINE  ; & SAVE.
80B1 2A 02 83              LHLD  RLPT2   ;GET REAL PTR 2.
80B4 4E                    MOV   C,M     ;GET RN.
80B5 C5                    PUSH  B       ;SAVE RN.
80B6 3A 11 83              LDA   COSINE  ;GET COSINE.
80B9 CD 7B 81              CALL  MPY     ;A = RN*COS(Z).
80BC 32 12 83              STA   TREAL   ;SAVE PRODUCT.
80BF C1                    POP   B       ;GET RN.
80C0 3A 10 83              LDA   SINE
80C3 CD 7B 81              CALL  MPY     ;A = RN*SIN(Z).
80C6 32 13 83              STA   TIMAG   ;SAVE PRODUCT.
80C9 2A 06 83              LHLD  IMPT2
80CC 4E                    MOV   C,M     ;GET IN.
80CD C5                    PUSH  B       ;SAVE IN.
80CE 3A 10 83              LDA   SINE
80D1 CD 7B 81              CALL  MPY     ;A = IN*SIN(Z).
80D4 21 12 83              LXI   H,TREAL
80D7 86                    ADD   M
80D8 77                    MOV   M,A     ;TR = RN*COS + IN*SIN.
80D9 C1                    POP   B       ;GET IN.
80DA 3A 11 83              LDA   COSINE
80DD CD 7B 81              CALL  MPY     ;A = IN*COS(Z).
80E0 21 13 83              LXI   H,TIMAG
80E3 96                    SUB   M
80E4 77                    MOV   M,A     ;TI = IN*COS - RN*SIN.
80E5                ;
80E5 2A 00 83              LHLD  RLPT1
80E8 7E                    MOV   A,M     ;GET RM.
80E9 4F                    MOV   C,A     ;SAVE RM.
80EA 3A 12 83              LDA   TREAL
80ED 81                    ADD   C
80EE 77                    MOV   M,A     ;RM' = RM+TR.
80EF 79                    MOV   A,C     ;GET RM.
80F0 21 12 83              LXI   H,TREAL
80F3 96                    SUB   M
80F4 2A 02 83              LHLD  RLPT2
80F7 77                    MOV   M,A     ;RN' = RM-TR.
80F8                ;
80F8 2A 04 83              LHLD  IMPT1
80FB 7E                    MOV   A,M     ;GET IM
80FC 4F                    MOV   C,A     ;SAVE IM.
80FD 3A 13 83              LDA   TIMAG
8100 81                    ADD   C
8101 77                    MOV   M,A     ;IM' = IM+TI.
8102 79                    MOV   A,C     ;GET IM.
8103 21 13 83              LXI   H,TIMAG
8106 96                    SUB   M
8107 2A 06 83              LHLD  IMPT2
810A 77                    MOV   M,A     ;IN' = IM-TI.
810B                ;
810B 21 08 83              LXI   H,SINPT
810E 3A 0E 83              LDA   DELTA
8111 86                    ADD   M       ;INCR. PTR ANGLE BY DELTA.
8112 77                    MOV   M,A
8113 21 00 83              LXI   H,RLPT1
8116 34                    INR   M
8117 21 04 83              LXI   H,IMPT1
811A 34                    INR   M
811B C1                    POP   B
811C 05                    DCR   B       ;DECREMENT PAIR CTR.
811D C2 94 80              JNZ   NC1
8120                ;;;;
8120 21 00 83              LXI   H,RLPT1 ;GET PTRS &
8123 3A 0D 83              LDA   CELDIS
8126 86                    ADD   M       ; ADD CELL OFFSET.
8127 77                    MOV   M,A
8128 32 04 83              STA   IMPT1
812B 21 0A 83              LXI   H,CELCT
812E 35                    DCR   M       ;DECR. CELL CTR.
812F C2 8A 80              JNZ   NCELL
8132                ;;
8132                ;;CHANGE PARAMETERS FOR NEXT PASS.
8132                ;;
8132 21 0B 83       NP1:   LXI   H,CELNUM
```

Listing 1 continued on page 460

Listing 1 continued:

```
8135 7E          2300         MOV  A,M
8136 A7          2310         ANA  A      ;CLEAR CY & SHIFT
8137 1F          2320         RAR         ; RIGHT TO HALVE NO. CELLS.
8138 B7          2330         ORA  A      ;SET FLAGS.
8139 77          2340         MOV  M,A
813A C8          2350         RZ          ;OUT OF CELLS -> ***FINISH***.
813B 23          2360         INX  H      ;PAIRNM.
813C 7E          2370         MOV  A,M
813D 87          2380         ADD  A      ;TWICE AS MANY PAIRS.
813E 77          2390         MOV  M,A
813F 23          2400         INX  H      ;CELDIS.
8140 7E          2410         MOV  A,M
8141 87          2420         ADD  A      ;TWICE AS FAR APART.
8142 77          2430         MOV  M,A
8143 23          2440         INX  H      ;DELTA.
8144 7E          2450         MOV  A,M
8145 A7          2460         ANA  A      ;CLEAR CY & SHIFT
8146 1F          2470         RAR         ; RIGHT TO HALVE THE ANGLE.
8147 77          2480         MOV  M,A
8148 C3 6F 80    2490         JMP  NPASS
814B             2500 ;;
814B             2510 ;;SCALE OVER-RANGE DATA.
814B             2520 ;;
814B             2530 ;SCALE REAL & IMAG IF -52 > ANY DATA >= 52.
814B             2540 ;NO REGISTERS PRESERVED.
814B 01 00 85    2550 SCALE:LXI  B,REAL ;SET UP TABLE PTR.
814E 11 FF FF    2560         LXI  D,-1
8151 21 FF 01    2570         LXI  H,512-1 ;NO. OF PTS - 1.
8154 0A          2580 SCL2:  LDAX B      ;GET DATA.
8155 03          2590         INX  B      ;BUMP PTR.
8156 FE CC       2600         CPI  -52    ;TEST LOWER LIMIT.
8158 D2 60 81    2610         JNC  SCL3   ;SKIP TO NEXT PT.
815B FE 34       2620         CPI  52     ;TEST UPPER LIMIT.
815D D2 65 81    2630         JNC  SCL4   ;SCALE ALL IF OUT OF RANGE.
8160 19          2640 SCL3:  DAD  D      ;TEST NEXT PT.
8161 DA 54 81    2650         JC   SCL2
8164 C9          2660         RET         ;DONE TESTING.
8165 21 0F 83    2670 SCL4:  LXI  H,SCLFCT
8168 34          2680         INR  M      ;BUMP SCALE FACTOR COUNT.
8169 01 00 85    2690         LXI  B,REAL ;SET UP TABLE PTR.
816C 21 FF 01    2700         LXI  H,512-1 ;NO. OF PTS - 1.
816F 0A          2710 SCL6:  LDAX B      ;GET DATA.
8170 FE 80       2720         CPI  80H    ; TEST SIGN &
8172 3F          2730         CMC         ; EXTEND IT TO CY.
8173 1F          2740         RAR         ;DIVIDE BY 2.
8174 02          2750         STAX B      ;RETURN DATA TO TABLE.
8175 03          2760         INX  B      ;BUMP PTR.
8176 19          2770         DAD  D      ;NEXT PT.
8177 DA 6F 81    2780         JC   SCL6
817A C9          2790         RET         ;DONE SCALING.
817B             2800 ;;
817B             2810 ;;SIGNED MULTIPLY ROUTINE.
817B             2820 ;;
817B             2830 ;EXTERNAL REG. USAGE:-  A <- (C*A)/128.
817B             2840 ;INTERNAL REG. USAGE:-
817B             2850 ; HL = PRODUCT        (MSBY,LSBY).
817B             2860 ; DE = MULTIPLICAND.
817B             2870 ; BC = MULTIPLIER.
817B             2880 ;NO REGISTERS PRESERVED.
817B 5F          2890 MPY:   MOV  E,A    ;PUT ARG1 INTO MULTIPLICAND.
817C             2900                     ;ARG2 ALREADY IN MULTIPLIER.
817C AF          2910         XRA  A
817D 47          2920         MOV  B,A    ;CLEAR MSBY'S.
817E 57          2930         MOV  D,A
817F 67          2940         MOV  H,A    ;CLEAR PRODUCT.
8180 6F          2950         MOV  L,A
8181 7B          2960         MOV  A,E    ;GET LSBY OF MULTIPLICAND.
8182 FE 00       2970         CPI  0
8184 F2 8A 81    2980         JP   MPY1   ;NEGATIVE MULTIPLICAND?
8187 7A          2990         MOV  A,D
8188 2F          3000         CMA         ;EXTEND SIGN TO MSBY.
8189 57          3010         MOV  D,A
818A 79          3020 MPY1:  MOV  A,C    ;GET LSBY OF MULTIPLIER.
818B FE 00       3030         CPI  0
818D F2 93 81    3040         JP   MPY2   ;NEGATIVE MULTIPLIER?
8190 78          3050         MOV  A,B
8191 2F          3060         CMA         ;EXTEND NEG TO MSBY.
8192 47          3070         MOV  B,A
8193 3E 0F       3080 MPY2:  MVI  A,15   ;SET ITERATION CTR
8195 F5          3090 MPY3:  PUSH PSW    ; & SAVE.
8196             3100         ;ARITH. SHIFT MULTIPLIER RIGHT (BC).
8196 78          3110         MOV  A,B
8197 FE 80       3120         CPI  80H
8199 3F          3130         CMC         ;MAKE CY = MSBIT.
819A 1F          3140         RAR
819B 47          3150         MOV  B,A
819C 79          3160         MOV  A,C
819D 1F          3170         RAR         ;LSBIT->CY.
819E 4F          3180         MOV  C,A
819F             3190         ;TEST MULTIPLIER LSBIT & IF SET,
819F             3200         ; ADD MULTIPLICAND TO PARTIAL PRODUCT.
819F D2 A3 81    3210         JNC  MPY4
81A2 19          3220         DAD  D
81A3             3230         ;ARITH. SHIFT MULTIPLICAND LEFT (DE).
81A3 EB          3240 MPY4:  XCHG        ;SWAP MULTIPLIER & PROD.
81A4 29          3250         DAD  H      ;SHIFT LEFT.
81A5 EB          3260         XCHG        ;RESTORE REGS.
81A6             3270         ;CHECK LOOP CTR.
81A6 F1          3280         POP  PSW
81A7 3D          3290         DCR  A      ;DECREMENT COUNT.
81A8 C2 95 81    3300         JNZ  MPY3
81AB             3310         ;DIVIDE 16-BIT PRODUCT BY 128 SO THAT
81AB             3320         ; SINE & COSINE AMPLITUDE = UNITY.
81AB 29          3330         DAD  H      ;SHIFT-IN MSBIT OF
81AC 7C          3340         MOV  A,H    ; LSBYTE & RETURN IN A.
81AD C9          3350         RET
81AE             3360 ;;
81AE             3370 ;;POWER CALCULATION.
81AE             3380 ;;
81AE             3390 ;NO REGISTERS PRESERVED.
81AE 06 9E       3400 POWER:MVI  B,>SQADR
81B0 21 00 85    3410         LXI  H,REAL
81B3 11 7F 87    3420         LXI  D,PABUF
81B6 4E          3430 PWR1:  MOV  C,M    ;C=REAL.
81B7 0A          3440         LDAX B      ;A=(REAL↑2)/64.
81B8 12          3450         STAX D      ;STORE.
81B9 2C          3460         INR  L
81BA 1C          3470         INR  E
81BB C2 B6 81    3480         JNZ  PWR1
81BE 21 00 86    3490         LXI  H,IMAG ;RESET PTRS.
81C1 11 7F 87    3500         LXI  D,PABUF
81C4 4E          3510 PWR2:  MOV  C,M    ;C=IMAG.
81C5 0A          3520         LDAX B      ;A=(IMAG↑2)/64.
81C6 EB          3530         XCHG
81C7 86          3540         ADD  M      ;A=(REAL↑2 + IMAG↑2)/64.
81C8 D2 CD 81    3550         JNC  $+2
81CB 3E FF       3560         MVI  A,0FFH ;A SATURATES AT 0FFH.
81CD 77          3570         MOV  M,A    ;STORE POWER.
81CE EB          3580         XCHG
81CF 2C          3590         INR  L
81D0 1C          3600         INR  E
81D1 C2 C4 81    3610         JNZ  PWR2
81D4 C9          3620         RET
81D5             3630 ;;
81D5             3640 ;;FILL INPD WITH 10.666 HZ. SQUARE WAVE.
81D5             3650 ;;
81D5 21 00 84    3660 WAVE:  LXI  H,INPD
81D8 0E 2B       3670         MVI  C,43
81DA CD EA 81    3680 WAVE2:CALL LO
81DD CD E5 81    3690         CALL HI
81E0 0D          3700         DCR  C
81E1 C2 DA 81    3710         JNZ  WAVE2
81E4 C9          3720         RET
81E5             3730         ;
81E5             3740 ABC    EQU  117
81E5             3750 MID    EQU  128
81E5 3E F5       3760 HI:    MVI  A,MID+ABC
81E7 C3 EC 81    3770         JMP  $+2
81EA 3E 0B       3780 LO:    MVI  A,MID-ABC
81EC 06 03       3790         MVI  B,3
81EE 77          3800 WAVE3:MOV  M,A
81EF 23          3810         INX  H
81F0 05          3820         DCR  B
81F1 C2 EE 81    3830         JNZ  WAVE3
81F4 C9          3840         RET
81F5             3850         $

ABC     0075     3740  3760  3780
BITRE   802F     0830  1020
BRV1    8032     0850  0920
CELCT   830A     0210  1320  2230
CELDI   830D     0240  1290  1430  2190
CELNU   830B     0220  1250  1310  2290
CLEAR   8011     0630
CLR1    8014     0640  0660
COSIN   8311     0290  1560  1600  1760
DELTA   830E     0250  1260  2070
FFT     800C     0460  0590
FPASS   805F     1240
HI      81E5     3690  3760
IMAG    8600     0370  0630  1360  3490
IMPT1   8304     0180  1370  1940  2120  2220
IMPT2   8306     0190  1380  1470  1670  2030
INPD    8400     0350  0700  3660
LO      81EA     3680  3780
MID     0080     3750  3760  3780
MOV1    8020     0720  0770
MOVE    801A     0700
MPY     817B     1610  1650  1710  1770  2890
MPY1    818A     2980  3020
MPY2    8193     3040  3080
MPY3    8195     3090  3300
MPY4    81A3     3210  3240
NC1     8094     1430  2160
NCELL   808A     1390  2250
NP1     8132     2290
NPASS   806F     1300  2490
PA1     8050     1080  1200
PABUF   877F     0385  3420  3500
PAIRN   830C     0230  1280  1410
PASS1   804A     1060
POWER   81AE     0470  3400
PWR1    81B6     3430  3480
PWR2    81C4     3510  3610
REAL    8500     0360  0710  0810  0820  1070  1330  2550  2690  3410
RLPT1   8300     0160  1340  1440  1820  2100  2180
RLPT2   8302     0170  1350  1460  1570  1910
SCALE   814B     1060  1300  2550
SCL2    8154     2580  2650
SCL3    8160     2610  2640
SCL4    8165     2630  2670
SCL6    816F     2710  2780
SCLFC   830F     0260  0600  2670
SINE    8310     0280  1510  1640  1700
SINPT   8308     0200  1400  1490  2060
SQADR   9E00     0120  3400
STADR   9F00     0130  1390
SWAP    8041     0960
SWP1    8046     0950  1010
TIMAG   8313     0310  1660  1730  1970  2010
TREAL   8312     0300  1620  1720  1850  1890
WAVE    81D5     0430  3660
WAVE2   81DA     3680  3710
WAVE3   81EE     3800  3830
```

Text continued from page 458:

I intend to write a subroutine to compute amplitude spectra following the method pointed out by Bob Leedom. (See "Approximation Makes a Magnitude of Difference," June 1979 BYTE, page 188.) This routine does not appear in listing 1, except as a comment.

Pass 1 of the FFT requires a trivial amount of computer arithmetic. Pass 2 is fairly trivial too, since sine and cosine have only the values −1, 0, and 1. Therefore, a simple way to increase the speed of the program would be to largely duplicate the coding of passes 2 thru *N* (inserting constants instead of variables and using a new sine/cosine table {0,1,0,−1,0 }, etc). A special multiply subroutine could be used for this: a subroutine that can multiply only by 0, 1, or −1, but do it very quickly. This could shave up to one second off the transform time.

Listing 2: *Object-code listing in hexadecimal format of the assembly-language program given in listing 1. The /BC at the end of this listing is a checksum of the whole code.*

```
8000 CD D5 81 CD 0C 80 CD AE 81 C3 E4 AF 3E 00 32 0F
8010 83 21 00 86 36 00 2C C2 14 80 11 00 84 21 00 85
8020 1A D6 80 77 1C 2C C2 20 80 11 00 85 21 00 85 06
8030 08 7D 1F 4F 7B 17 5F 79 05 C2 32 80 7D BB DA 46
8040 80 4E 1A 77 79 12 2C C2 2F 80 CD 4B 81 21 00 85
8050 7E 4F 2C 46 2D 80 77 79 90 2C 77 2C C2 50 80 3E
8060 40 32 0B 83 32 0E 83 3E 02 32 0C 83 32 0D 83 CD
8070 4B 81 3A 0B 83 32 0A 83 21 00 85 22 00 83 22 02
8080 83 21 00 86 22 04 83 22 06 83 21 00 9F 22 08 83
8090 3A 0C 83 47 21 0D 83 3A 00 83 86 32 02 83 32 06
80A0 83 C5 2A 08 83 7E 32 10 83 3E 40 85 6F 7E 32 11
80B0 83 2A 02 83 4E C5 3A 11 83 CD 7B 81 32 12 83 C1
80C0 3A 10 83 CD 7B 81 32 13 83 2A 06 83 4E C5 3A 10
80D0 83 CD 7B 81 21 12 83 86 77 C1 3A 11 83 CD 7B 81
80E0 21 13 83 96 77 2A 00 83 7E 4F 3A 12 83 81 77 79
80F0 21 12 83 96 2A 02 83 77 2A 04 83 7E 4F 3A 13 83
8100 81 77 79 21 13 83 96 2A 06 83 77 21 08 83 3A 0E
8110 83 86 77 21 00 83 34 21 04 83 34 C1 05 C2 94 80
8120 21 00 83 3A 0D 83 86 77 32 04 83 21 0A 83 35 C2
8130 8A 80 21 0B 83 7E A7 1F B7 77 C8 23 7E 87 77 23
8140 7E 87 77 23 7E A7 1F 77 C3 6F 80 01 00 85 11 FF
8150 FF 21 FF 01 0A 03 FE CC D2 60 81 FE 34 D2 65 81
8160 19 DA 54 81 C9 21 0F 83 34 01 00 85 21 FF 01 0A
8170 FE 80 3F 1F 02 03 19 DA 6F 81 C9 5F AF 47 57 67
8180 6F 7B FE 00 F2 8A 81 7A 2F 57 79 FE 00 F2 93 81
8190 78 2F 47 3E 0F F5 78 FE 80 3F 1F 47 79 1F 4F D2
81A0 A3 81 19 EB 29 EB F1 3D C2 95 81 29 7C C9 06 9E
81B0 21 00 85 11 7F 87 4E 0A 12 2C 1C C2 B6 81 21 00
81C0 86 11 7F 87 4F 0A EB 86 D2 CD 81 3E FF 77 EB 2C
81D0 1C C2 C4 81 C9 21 00 84 0E 2B CD EA 81 CD E5 81
81E0 0D C2 DA 81 C9 3E F5 C3 FC 81 3E 0B 06 03 77 23
81F0 05 C2 EE 81 C9 /BC
```

Listing 3: *Listing in hexadecimal format of the two's-complement square table and sine table used by the FFT program.*

```
9E00 00 00 00 00 00 00 01 01 01 01 02 02 02 03 03 04
9E10 04 05 05 06 06 07 08 08 09 0A 0B 0B 0C 0D 0E 0F
9E20 10 11 12 13 14 15 17 18 19 1A 1C 1D 1F 20 21 23
9E30 24 26 27 29 2A 2C 2E 2F 31 33 35 36 38 3A 3C 3E
9E40 40 42 44 46 48 4A 4D 4F 51 53 56 58 5A 5D 5F 62
9E50 64 67 69 6C 6E 71 74 76 79 7C 7F 81 84 87 8A 8D
9E60 90 93 96 99 9C 9F A3 A6 A9 AC B0 B3 B6 BA BD C1
9E70 C4 C8 CB CF D2 D6 DA DD E1 E5 E9 EC F0 F4 F8 FC
9E80 FF FC F8 F4 F0 EC E9 E5 E1 DD DA D6 D2 CF CB C8
9E90 C4 C1 BD BA B6 B3 B0 AC A9 A6 A3 9F 9C 99 96 93
9EA0 90 8D 8A 87 84 81 7F 7C 79 76 74 71 6E 6C 69 67
9EB0 64 62 5F 5D 5A 58 56 53 51 4F 4D 4A 48 46 44 42
9EC0 40 3E 3C 3A 38 36 35 33 31 2F 2E 2C 2A 29 27 26
9ED0 24 23 21 20 1E 1D 1C 1A 19 18 17 15 14 13 12 11
9EE0 10 0F 0E 0D 0C 0B 0B 0A 09 08 08 07 06 06 05 05
9EF0 04 04 03 03 02 02 02 01 01 01 01 00 00 00 00 00
9F00 00 03 06 09 0C 10 13 16 19 1C 1F 22 25 28 2B 2E
9F10 31 33 36 39 3C 3F 41 44 47 49 4C 4E 51 53 55 58
9F20 5A 5C 5E 60 62 64 66 68 6A 6B 6D 6F 70 71 73 74
9F30 75 76 78 79 7A 7A 7B 7C 7D 7D 7E 7E 7E 7F 7F 7F
9F40 7F 7F 7F 7F 7E 7E 7E 7D 7D 7C 7B 7A 7A 79 78 76
9F50 75 74 73 71 70 6F 6D 6B 6A 68 66 64 62 60 5E 5C
9F60 5A 58 55 53 51 4E 4C 49 47 44 41 3F 3C 39 36 33
9F70 31 2E 2B 28 25 22 1F 1C 19 16 13 10 0C 09 06 03
9F80 00 FD FA F7 F4 F0 ED EA E7 E4 E1 DE DB D8 D5 D2
9F90 CF CD CA C7 C4 C1 BF BC B9 B7 B4 B2 AF AD AB A8
9FA0 A6 A4 A2 A0 9E 9C 9A 98 96 95 93 91 90 8F 8D 8C
9FB0 8B 8A 88 87 86 86 85 84 83 83 82 82 82 81 81 81
9FC0 81 81 81 81 82 82 82 83 83 84 85 86 86 87 88 8A
9FD0 8B 8C 8D 8F 90 91 93 95 96 98 9A 9C 9E A0 A2 A4
9FF0 A6 A8 AB AD AF B2 B4 B7 B9 BC BF C1 C4 C7 CA CD
9FF0 CF D2 D5 D8 DB DE E1 E4 E7 EA ED F0 F4 F7 FA FD
     /5F
```

The 8080 program in listing 1 has been dumped out in hexadecimal format with checksum and appears in listing 2. The sine and square tables appear in listing 3. The equations used to define the tables are:

Two's-complement square table:

- Table entries are unsigned 0 thru 255
- Table index I = 0 thru 127 (two's complement 0 thru 127)
  Table (I) = INT (((I ↑ 2)/64) +0.5)
- Table index 129 thru 255 (two's complement −127 thru −1)
  Table (I) = INT ((((256 −I) ↑ 2)/64) + 0.5)
- Table index 128 ('two's-complement−128)
  Table (128) = 255 (not exact value of 256)

Two's-complement sine table:

- Table index I runs from 0 thru 255
- Table (I) = INT(0.5 + 127*SIN((I)*2*PI/256))
  where PI = 3.1416

An optimization of the 6800 FFT would be to replace lines 285 thru 287 inclusive by the single instruction ASR A. This has been incorporated into the 8080 program, but it makes a negligible difference because there is no single 8080 instruction equivalent of the 6800 ASR A instruction (arithmetic shift right, A accumulator). The test power spectrum produced by the 8080 FFT program is printed out in listing 4.

Listing 4: *Test power spectrum produced by the 8080 FFT program in listing 1. The waveform is a square wave with a period of six data points. The first byte is 0 frequency.*

```
877F 01 01 01 01 00 01 00 00 00 00 00 01 00 01 00 00
878F 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
879F 00 00 00 00 00 00 01 01 02 03 10 3C 03 01 01 00
87AF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87BF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87CF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87DF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87EF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87FF 13 /72
```

Richard Lord Replies

Mr Roxburgh is indeed correct about the possibility of overflow with my scaling routine. I tried slowly increasing the amplitude of a square-wave input and discovered that for amplitude pairs of ± hexadecimal 1B, 1F; 33, 3F; and 6A, 6E the algorithm produces overflow artifacts. This did not show up in initial testing because integral binary amplitudes (10, 20, 40) were used. The scaling routine immediately fixes these values before overflow has a chance to occur. For sampled audio, this overflow has undoubtedly introduced errors. Insertion of new limits, as Mr Roxburgh proposed, fixed the overflow problem so that the FFT yields correct results at all amplitudes. My thanks to Mr Roxburgh for pointing this out. I hope that this has not created too many difficulties for anyone who has been using the FFT previous to this discovery.

*Many letters have come to me in response to this article and the response has been very gratifying. Most of the letters have been requests for the 6502 verison which I never got around to writing. (At this time I'd be more inclined to try a 6809 version.) Quite a few readers suggested great improvements to the "sum of absolute values" method, and one letter pointed out that the SIN table is actually a −1*SIN yielding inverted imaginary terms. All these improvements are greatly appreciated.* ■

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Circle 236 on inquiry card.

What's New?

SYSTEMS

Handy Pocket Computer Uses BASIC

Sharp Corporation will announce the introduction of its PC-1211 Pocket Computer into the American market at this month's National Computer Conference (NCC). Measuring only 17.5 by 7 by 1.5 cm (6⅞ by 2¾ by 1⅗₂ inches), the battery-powered PC-1211 contains BASIC in ROM (read-only memory). A 24-character LCD (liquid-crystal display) can be used to show program lines, prompt the user for input from the keyboard, or display results. The unit's typewriter-like keyboard includes a calculator-type keypad. The PC-1211's memory can hold up to 1424 program steps and 26 data variables, or program memory can be used for data (eight steps are equivalent to one variable). Information in memory is retained even when the power is off due to a memory safeguard circuit.

The PC-1211 uses a reservable key system, making it possible to assign a key for a frequently used function or command. Reserved keys provide one-key recall during both manual calculation and programming. In addition, a definable key system fixes 18 programs for each key, allowing the user to recall and run each program at the touch of the proper key. Transparent templates that fit over the keyboard portion of the unit are included to allow labeling of reserved and defined keys.

The BASIC interpreter has the more common BASIC commands and functions, as well as DEBUG, PRINT USING, BEEP, ASN (arcsine), ACN (arccosine), EXP (e^x), and more. Editing functions allow left and right cursor shifting, insertions and deletions, and scrolling up or down. Subroutines and FOR...NEXT loops can be stacked to four levels, and 15 levels of parentheses can be maintained. An 80-character input buffer and multiple statements per line allow easy program entry. A ten-digit mantissa and two-digit exponent are used in all calculations. Four mercury batteries provide approximately 300 hours of operation, thanks to the automatic power-off feature. An applications manual containing 134 programs in ten application areas such as math, statistics, civil engineering, and electrical is included. Each program is accompanied by a description of how it works and a complete list of variable assignments. A beginner's BASIC book is also included in the package.

Also being introduced at NCC are two peripherals for the PC-1211. The CE-121 Cassette Interface allows programs, key assignments, and data to be saved or loaded to or from a cassette-tape recorder. For hard-copy output, Sharp has the CE-122 Printer/Cassette Interface. In addition to the cassette-interface functions, the CE-122 features a 16-character dot-matrix printer capable of printing one line per second. The unit is powered by a rechargeable nickel-cadmium battery and includes a battery indicator that flashes when the battery becomes low.

The PC-1211 will have a suggested retail price of $249. The CE-121 and the CE-122 will have suggested retail prices of $49 and $149, respectively.

The PC-1211 has been previously sold by Radio Shack as the TRS-80 Pocket Computer.

For more information on the PC-1211 Pocket Computer, the CE-121 Cassette Interface, or the CE-122 Printer/Cassette Interface, contact Sharp Electronics Corporation, 10 Keystone Pl, Paramus NJ 07652, (201) 265-5600.

Circle 500 on inquiry card.

Master Controller Board

The Master Controller Board is a Z80-based single-board computer that can be customized for each application. Customization is accomplished by inserting various ROMs (read-only memories), programmable memories, and control integrated circuits as needed. All the I/O (input/output) circuits are mapped into both memory and I/O address space. The board provides three ROM/EPROM (erasable programmable ROM) sockets for up to 12 K bytes of mixed ROM/EPROM. Also included are 2 K bytes of programmable memory, provision for up to 72 lines of parallel I/O, a keyboard controller, and an integrated circuit that provides two serial I/O ports. Two counter/timers and an arithmetic circuit can be added. The Master Controller Board costs $49.95 for a bare board, $99.95 for the minimum kit, and $199.95 assembled. Other options are available. Contact R W Electronics, 3165 N Clybourn, Chicago IL 60618, (312) 248-2480.

Circle 501 on inquiry card.

What's New?

PERIPHERALS

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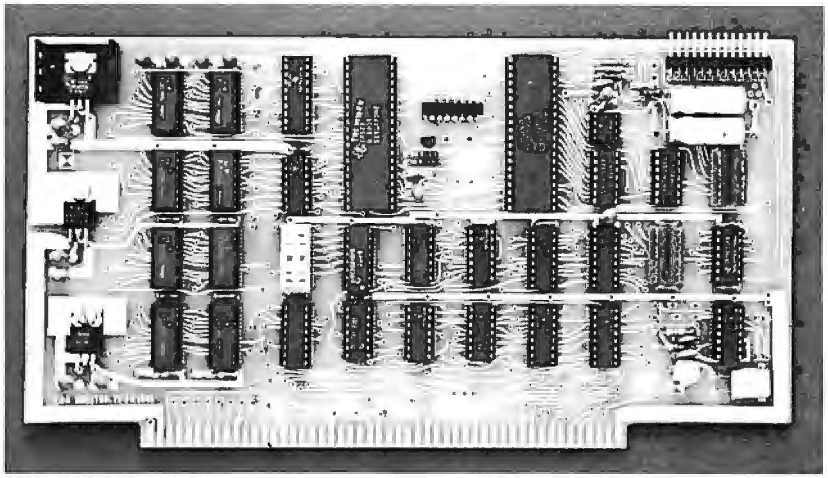


The Color Video Processor and Programmable Sound Generator board can create color graphics and sound. It contains 16 K bytes of I/O- (input/output) mapped video memory and allows graphics or text to be superimposed over an external video input. Using 16 colors with 35 display planes, a three-dimensional effect can be obtained. In addition, the board has three programmable square-wave tone generators and two 8-bit programmable I/O ports. The graphics mode features 256 by 192 dot resolution. The board also allows real-time interrupts. The tone generators feature envelope generation over a range of 12 octaves. The single-board color video and sound generator uses the Texas Instruments TMS9918A Video Display Processor and the General Instrument AY-3-8910 Programmable Sound Generator, and is compatible with Z80, 8085, and 8080 microprocessors on S-100 bus systems. Documentation includes programming examples and test routines. It is available for $475 assembled and tested or $375 in kit form. Contact Electronic Design Associates, POB 94055, Houston TX 77018, (713) 999-2255.

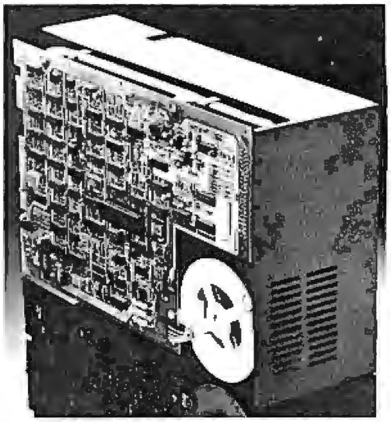
Circle 502 on inquiry card.

Q2000—Family of Hard-Disk Drives

The Q2000 series of 8-inch fixed-hard-disk drives are compatible with Shugart's SA1000 disk drives, but offer 10-, 20-, and 30-megabyte unformatted capacities. This is achieved by using a special head-positioning technique. The Q2000 family features a 4.34-megabit-per-second transfer rate, an average latency of 10 ms, and access times of 15 ms track-to-track, 100 ms maximum, and 50 to 60 ms average. Maximum recording density is 6600 bits per inch, and track density is 345 tracks per inch. Rotational speed is 3000 rpm (revolutions per minute). Soft-sectoring is offered.

In OEM (original equipment manufacturer) quantities of 500 per year, pricing is $1200 for the 10-megabyte Q2010, $1500 for the 20-megabyte Q2020, and $1800 for the 30-megabyte Q2030. For more information, contact Quantum Corporation, 2150 Bering Dr, San Jose CA 95131, (408) 262-1100.

Circle 503 on inquiry card.



What's New?

PUBLICATIONS

Inside BASIC Games

Inside BASIC Games, by Richard Mateosian, uses games as a framework for teaching BASIC programming. Eight games, ranging from simple arithmetic to complex matching games, are described and analyzed so that readers can learn how to design their own programs, as well as play the game. The games are written for most microcomputers. Inside BASIC Games is a Sybex publication, and it costs $13.95. Contact Sybex Inc, 2344 6th St, Berkeley CA 94710, (415) 848-8233.

Circle 504 on inquiry card.

Microcomputer Software Catalog

Creative Discount Software has released its Winter-Spring Software Catalog for the TRS-80, TI-99/4, and the Apple II and the Apple II Plus microcomputers. The catalog features professional, educational, and business software at discounts of up to 30%. Medical and dental office-management systems are also available. For your free copy, request catalog number 47B, from Creative Discount Software, 256 S Robertson, Suite 2156, Beverly Hills CA 90211, (800) 824-7888; in Alaska and Hawaii, (800) 824-7919; in California, (800) 852-7777. Ask for operator 831.

Circle 505 on inquiry card.

Solutions from Serendipity

Serendipity Software Solutions features commercial-application software packages designed for Z80 and 8080/8085-based microcomputers operating under CP/M. Among the products featured in the catalog are general-ledger accounting, commercial accounts receivable and payable, payroll, inventory control for retailers and manufacturers, and professional client billing. There is a $1 handling charge for the catalog. Contact Serendipity Systems Inc, 225 Elmira Rd, Ithaca NY 14850, (607) 277-4889.

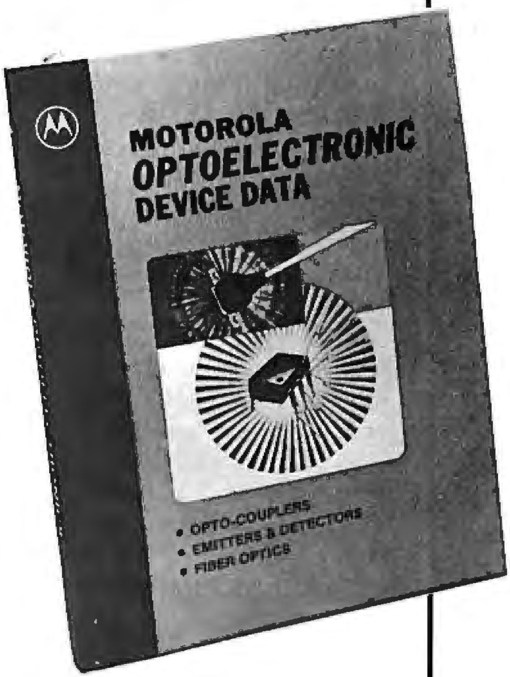
Circle 506 on inquiry card.

Supercap Series Catalog

NEC Electron's Supercap catalog includes specifications, dimensions, applications, discharge characteristics, and lists of features for high-capacitance Supercap memory-backup devices. The Supercaps supply capacitances of up to 1 F [yes, one farad...**RSS**]. They feature a slow rate of discharge and can provide very low currents for approximately one week. The catalog is free from the Product Marketing Manager for Capacitors, NEC Electron Inc, 252 Humboldt Ct, Sunnyvale CA 94086, (408) 745-6520.

Circle 507 on inquiry card.

Optoelectronics and Fiber-Optics Manual



A 286-page optoelectronics and fiber-optics data manual has been published by Motorola Semiconductor Products Inc. The manual provides device data sheets, selector guides, cross-references, and applications information. The manual includes gallium-arsenide infrared emitters, silicon detectors, opto-coupler/isolators, the family of opto-triac drivers, and Motorola's SCR (silicon-controlled rectifier) couplers.

The manual's fiber-optic section is intended principally to address fiber-optic communications systems in the computer, industrial controls, medical electronics, consumer, and automotive applications.

The data book, Mototola Optoelectronics Device Data, costs $3.25. It is available from Motorola Semiconductor Products Inc, POB 20912, Phoenix AZ 85036, (602) 244-4306.

Circle 508 on inquiry card.

What's New?

SOFTWARE

Two New Products from Commodore

Ozz—The Information Wizard lets users design data-management and retrieval systems. Ozz was created for the Commodore CBM 8032 microcomputer. The program allows users to set up formats, store information, perform calculations and global searches, design forms and documents, analyze information, and access files.

Wordcraft 80 is a word-processing program designed for the 8032 system. Wordcraft 80 offers variable page layouts of up to 117 characters by 98 lines; screen display of finished-format documents; tabs, indentations, decimal tabs, columns; automatic centering and right-margin justification; automatic pagination, headers, and trailers; deletion and insertion of text; transfer of text from one page to another; merging of form letters with name/address files; handling of single sheets or continuous-form paper; sub- and superscripts; and automatic underlining and emboldening of text.

For more information on both products, contact Commodore Business Machines Inc, 950 Rittenhouse Rd, Norristown PA 19403, (215) 666-7950.

Circle 509 on inquiry card.

Atari Graphic Editor

Plot & Draw is a cassette-based graphics-generation and editing package that creates graphics in three colors plus a background. Video drawings can be created and saved on cassette. It requires an Atari computer with 8 K bytes of programmble memory and a joystick. The price is $18 from Mosaic Electronics, POB 748, Oregon City OR 97045.

Circle 510 on inquiry card.

The Voice

The Voice gives the Apple II or the Apple II Plus the power of speech. The Voice's built-in vocabulary allows expression of many combinations of phrases, or the user can enter his own vocabulary and make the 48 K-byte Apple say anything. Floppy disks store up to 80 words or phrases that can later be sorted for quick reference. The Voice allows any BASIC program to speak by using PRINT statements. The price is $39.95, from Muse Software, 330 N Charles St, Baltimore MD 21201, (301) 659-7212.

Circle 511 on inquiry card.

FORTH-79 for the Apple

MicroMotion's FORTH-79 conforms to the International FORTH-79 standard. It is suited for data acquisition, process control, animation, and video games.

FORTH-79 comes with a screen editor and macroassembler, and vocabularies for strings, double-precision integers, low-resolution graphics, and modem communications. The operating system allows for multiple disk drives and is 13- or 16-sector disk compatible. It runs on a 48 K-byte Apple II or Apple II Plus. FORTH-79 can be obtained for $89.95 from MicroMotion 12077 Wilshire Blvd, Suite 506, Los Angeles CA 90025, (213) 821-4340.

Circle 512 on inquiry card.

A Stellar Trek

This high-resolution color version of the Star Trek game runs on the Apple II. Three different Klingon opponents and the Romulan Star Empire are pitted against the user. Users have many command prerogatives, including movement throughout the galaxy, use of starship weaponry, maintenance of energy reserves, repair of damage, and more. A Stellar Trek requires 48 K bytes of memory and Applesoft BASIC in ROM (read-only memory). The price is $24.95 on floppy disk. Contact Rainbow Computing, 9719 Reseda Blvd, Northridge CA 91324, (213) 349-5560.

Circle 513 on inquiry card.

Combine Hard Disks and the TRS-80

HDOS-2 is a hard-disk operating system designed to be used with TRSDOS 1.2 on the TRS-80 Model II. The advantage of this software is that it allows a Corvus hard-disk drive to be interfaced with existing software with only minor changes to the programs. HDOS-2 requires 1 K bytes of memory and allows use of multiple drives. The system costs $125. Contact Computer Program Associates, 15076 Beltway Dr, Dallas TX 75234, (214) 233-2039.

Circle 514 on inquiry card.

TFORTH

TFORTH is a fig- (FORTH Interest Group) standard version of FORTH, extended for the TRS-80. It contains an operating system, assembler, text editor, floating-point mathematics package, I/O (input/output) package, graphics links into TRS-80 BASIC, and a phoneme assembler to support voice synthesizers. TFORTH is supplied on 5-inch floppy disks for $130. Contact Advanced Technology Corporation, 1617 Euclid Ave, Knoxville TN 37921, (615) 525-1632.

Circle 515 on inquiry card.

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ANADEX 9500/9501, up to 200 cps, high resolution dot		$1349
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Microline 83, bidirectional, 120 cps, uses 15" paper		$995
TI-810, 150 cps, Basic		$1695
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NNC 80W w/.5MB floppy, 8.4MB hard disc, (OASIS optional)	$6693
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VISA

What's New?

SOFTWARE

Link the TRS-80 with Other Systems

The Super-Host program allows any type of system to communicate with the TRS-80 Model I microcomputer. The program will configure itself to run under TRSDOS, NEWDOS 2.1, or NEWDOS-80. It keeps track of the date and time, even after reboot or system resets. One function of the program protects the user's own and any foreign system from unwanted control codes. Another feature allows users to customize transmissions to conform to other systems' standards and block out characters that might affect those systems.

Super-Host is a menu-driven program, so users can set up all system parameters. Other features are its lowercase driver, uppercase lock for incoming data, and independent uppercase lock on outgoing data. It has user-programmable nulls and line feed. TRS-80 computers with a printer can be programmed to maintain a printed record of callers who have accessed the system.

Super-Host is available for $29.95 from Programs Unlimited, POB 265, Jericho NY 11753, (516) 997-8668.

Circle 516 on inquiry card.

FORTH for Atari

This FORTH system for the Atari 400 and 800 computers requires a minimum of 16 K bytes of programmable memory. The disk-based system has a screen editor and the capability to review and modify disk contents. Included with the program package is dictionary documentation and a customization guide. The system costs $50. For further information, contact Pink Noise Studios, 1411 Center St, Oakland CA 94607, (415) 465-1212.

Circle 517 on inquiry card.

Softstuff Software from Heath

Heath's utility and applications programs in the Softstuff line include the General Ledger II on a floppy disk for use with the HDOS operating system or Heath's version of the CP/M operating system. The price for the program is $124.95. The Small Business Inventory program for HDOS systems is $69.95. The CBASIC language, a disk-based, noninteractive language with pseudocode compiler and run-time interpreter for CP/M systems is priced at $110. The BDS C compiler includes a linking loader, a library containing file I/O (input/output) and floating-point functions, and a library manager. The C compiler runs on CP/M systems and is priced at $119.95.

The Softstuff product line also offers the Microsoft MACRO-80 package, a full-screen editor, a sort program, and a network system. For more information on Softstuff programs, contact Heath Company, Department 350-670, Benton Harbor MI 49022, (616) 982-3210.

Circle 518 on inquiry card.

Software for Law Offices

Law-1 is a time-management and billing system for the legal professional. It features system and program security, client/matter and attorney reporting, accounts-receivable ledgers, ageing analysis, pre-billing worksheets, invoicing, and automatic file backup, and it performs other-than-standard inquiries.

Law-1 is written in CBASIC for CP/M-based systems. It comprises 38 applications packages. The system is parameter driven and can support floppy- and hard-disk configurations. Different terminals are supported. A demonstration package is available for $75, and the single-user package price is $800. For further information, contact Microcon Inc, POB 805, Amherst NH 03031, (603) 673-0230.

Circle 519 on inquiry card.

Learn Trigonometry on the Compucolor II

Using a circular functions approach to trigonometry, these teaching programs provide experiences with radian measure, sine function development, graphing the sums of functions, drill with identities, and polar graphs. All programs encourage the user to explore functions under computer guidance, to recognize identities, and to notice patterns. Program listings are included, so users can create additional variations and drills. This disk for the Compucolor or Intecolor computers requires a 64- by 32-character screen with 127 by 127 color blocks in low- and high-resolution graphics. It is available for $29.95 from Metra Instruments Inc, 2056 Bering Dr, San Jose CA 95131, (408) 297-8530.

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Circle 89 on inquiry card.

What's New?

SYSTEMS

MT500 System

The MT500 microcomputer provides data- and word-processing capabilities for business and scientific applications. The MT500 features a video display, a Z80A microprocessor, the CP/M operating system, 64 K bytes of programmable memory, two 500 K-byte 5-inch floppy-disk drives, and a keyboard. Printers and modems can be attached. The MT500 has a suggested price of less than $6000. For details, contact Maatra Corporation, 1835 W Shryer Ave, Roseville MN 55113, (612) 631-3555.

Circle 521 on inquiry card.

Memory-Mapped S-100 Video Board

The VB3 is a memory-mapped board with a video-display system for S-100 computers. The display can be programmed for up to forty-eight 80-character lines featuring upper- and lowercase letters with true descenders. The VB3 features user-programmable fonts, low intensity, reverse and inverted video, and added print functions such as underscore, strike-through, thin line, or dot graphics. While the VB3 is memory mapped, it occupies memory-address space only when activated.

Software for the VB3 includes a CP/M-compatible driver routine and a terminal-simulator routine. Software controller timing, top and bottom margins, horizontal position, one level of gray, blinking and blank-out character and cursor features are offered. The VB3 video board costs $654.

For further information, contact SSM Microcomputer Products Inc, 2190 Paragon Dr, San Jose CA 95131, (408) 946-7400.

Circle 522 on inquiry card.

HP-83 from Hewlett-Packard

The HP-83 microcomputer is designed for business and technical professionals. The HP-83 is identical to Hewlett-Packard's HP-85 except that it does not have a built-in tape-cartridge drive and thermal printer. The HP-83 has a high-resolution video display, keyboard, enhanced BASIC, and graphics capabilities. Floppy-disk drives and printers can be interfaced to the unit. A data-base system, graphics software, a communications program, and a graphics digitizing tablet are some of the software and peripheral packages devel-

oped for the machine. The HP-83 has a list price of $2250. For more information, contact Inquiries Manager, Hewlett-Packard Company, 1507 Page Mill Rd, Palo Alto CA 94304, (415) 857-1501.

Circle 523 on inquiry card.

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.

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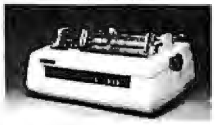

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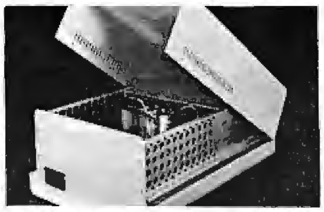

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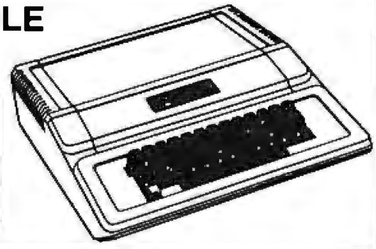

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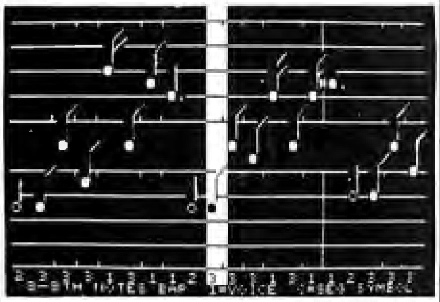

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Z80-DMA	22.25	4006	1.39	4055	3.95	4553	3.50	74LS03	.28	74LS123	1.19	74LS249	1.69
Z80A-DMA	27.75	4007	.29	4056	2.95	4555	.75	74LS04	.39	74LS125	1.35	74LS251	1.79
Z80-S10/0	24.95	4008	1.39	4059	9.95	4556	.75	74LS05	.28	74LS126	.89	74LS253	.98
Z80A-S10/0	29.95	4009	.49	4060	1.39	4581	1.99	74LS08	.39	74LS132	.79	74LS257	.98
Z80-S10/1	24.95	4010	.49	4066	.75	4582	1.01	74LS09	.39	74LS136	.59	74LS258	.98
Z80A-S10/1	29.95	4011	.35	4068	.35	4584	.55	74LS10	.28	74LS138	.89	74LS259	2.95
Z80-S10/2	24.95	4012	.29	4069	.35	4585	.99	74LS11	.39	74LS139	.89	74LS260	.69
Z80A-S10/2	29.95	4013	.49	4070	.49	4702	9.95	74LS12	.39	74LS145	1.25	74LS261	2.49
3205	3.45	4014	1.39	4071	.35	74C00	.39	74LS13	.47	74LS148	1.49	74LS266	.59
3242	10.00	4015	1.15	4072	.35	74C02	.39	74LS14	1.25	74LS151	.79	74LS273	1.75
8155	11.25	4016	.59	4073	.35	74C04	.39	74LS15	.39	74LS153	.79	74LS275	4.40
8185	29.95	4017	1.19	4075	.35	74C08	.49	74LS20	.26	74LS155	1.19	74LS279	.59
8185-2	39.95	4018	.99	4076	1.29	74C10	.49	74LS21	.38	74LS156	.99	74LS283	1.10
8202	45.00	4019	.49	4078	.35	74C14	1.65	74LS22	.38	74LS157	.99	74LS290	1.29
8205	3.45	4020	1.19	4081	.35	74C20	.39	74LS26	.39	74LS158	.75	74LS293	1.95
8212	2.00	4021	1.19	4082	.35	74C30	.39	74LS27	.39	74LS160	.98	74LS295	1.10
8214	3.95	4022	1.15	4085	1.95	74C32	.99	74LS28	.39	74LS161	1.15	74LS298	1.29
8216	1.85	4023	.38	4086	.79	74C42	1.85	74LS30	.26	74LS162	.98	74LS324	1.75
8224	2.65	4024	.79	4093	.99	74C48	2.39	74LS32	.39	74LS163	.98	74LS347	1.95
8226	1.85	4025	.38	4099	2.25	74C73	.85	74LS37	.79	74LS164	1.19	74LS348	1.95
8228	5.00	4026	2.50	4104	1.99	74C74	.85	74LS38	.39	74LS165	.89	74LS352	1.65
8238	5.45	4027	.65	4501	.39	74C85	2.49	74LS42	.79	74LS166	2.49	74LS353	1.65
8243	4.65	4028	.85	4502	1.65	74C89	4.95	74LS47	.79	74LS170	1.99	74LS363	1.49
8251A	5.55	4029	1.29	4503	.69	74C90	1.85	74LS48	.79	74LS173	.89	74LS365	.99
8253	9.85	4030	.45	4505	8.95	74C93	1.85	74LS51	.26	74LS174	.99	74LS366	.99
8255A	5.40	4031	3.25	4506	.75	74C95	1.85	74LS54	.35	74LS175	.99	74LS367	.73
8255A-5	5.40	4032	2.15	4507	.95	74C107	1.19	74LS55	.35	74LS181	2.20	74LS368	.73
8257	9.25	4033	2.15	4508	3.95	74C151	2.49	74LS73	.45	74LS190	1.15	74LS373	2.75
8257-5	9.25	4034	3.25	4510	1.39	74C154	3.50	74LS74	.59	74LS191	1.15	74LS374	2.75
8259A	7.30	4035	.95	4511	1.39	74C157	2.10	74LS75	.68	74LS192	.98	74LS375	.69
8271	60.00	4037	1.95	4512	1.39	74C160	2.39	74LS76	.45	74LS193	.98	74LS377	1.95
8275	32.95	4040	1.29	4514	3.95	74C161	2.30	74LS78	.65	74LS194	1.15	74LS385	1.95
8279	10.80	4041	1.25	4515	3.95	74163	2.39	74LS83	.99	74LS195	.95	74LS386	.65
8279-5	10.80	4042	.95	4516	1.69	74164	2.39	74LS85	1.19	74LS196	.89	74LS390	1.95
8282	6.70	4043	.85	4519	.99	74173	2.59	74LS86	.45	74LS197	.89	74LS393	1.95
8283	6.70	4044	.85	4520	1.39	74174	2.75	74LS90	.75	74LS221	1.49	74LS395	1.70
8284	5.85	4046	1.75	4522	.99	74C175	2.75	74LS92	.75	74LS240	1.95	74LS399	2.95
8286	6.70	4047	1.25	4526	1.15	74C192	2.39	74LS93	.75	74LS241	1.90	74LS424	2.95
8287	6.70	4048	.99	4527	1.75	74C193	2.39	74LS95	.88	74LS242	1.95	74LS668	1.75
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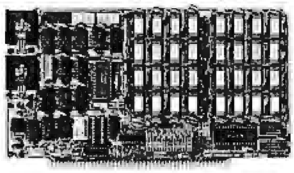

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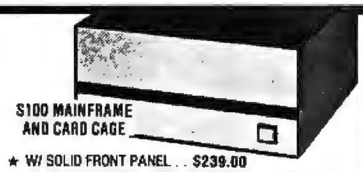

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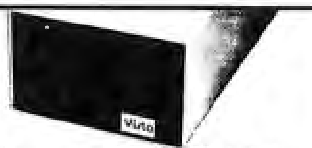

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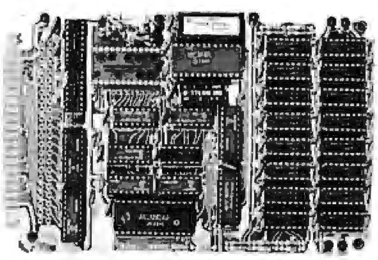

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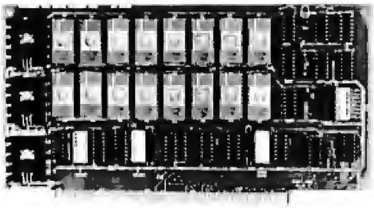

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USES 2716's

Blank PC Board - $34

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SPECIAL: 2716 EPROM's (450 NS) Are $11.95 EA. With Above Kit.

KIT FEATURES:
1. Uses +5V only 2716 (2Kx8) EPROM's.
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3. IEEE S-100 Compatible.
4. Addressable as two independent 16K blocks.
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6. On board wait state circuitry if needed.
7. Any or all EPROM locations can be disabled.
8. Double sided PC board, solder-masked, silk-screened.
9. Gold plated contact fingers.
10. Unselected EPROM's automatically powered down for low power.
11. Fully buffered and bypassed.
12. Easy and quick to assemble.

32K SS-50 RAM

$379.00 KIT

For 2MHZ Add $10

Blank PC Board $50

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Support IC's and Caps $19.95

Complete Socket Set $21.00

Fully Assembled, Tested, Burned In Add $30

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At Last! An affordable 32K Static RAM with full 6809 Capability.

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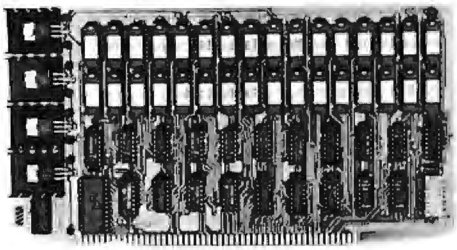

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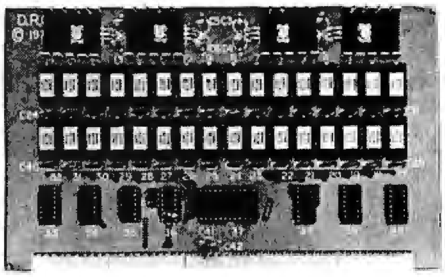

FOR SWTPC 6800 BUSS!

ASSEMBLED AND TESTED - $35

KIT FEATURES:
1. Addressable on 16K Boundaries
2. Uses 2114 Static Ram
3. Fully Bypassed
4. Double sided PC Board. Solder mask and silk screened layout
5. All Parts and Sockets included
6. Low Power: Under 1.5 Amps Typical

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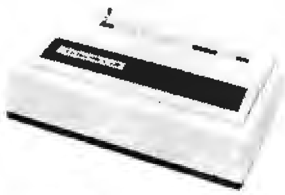

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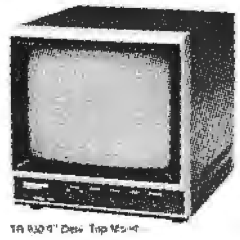

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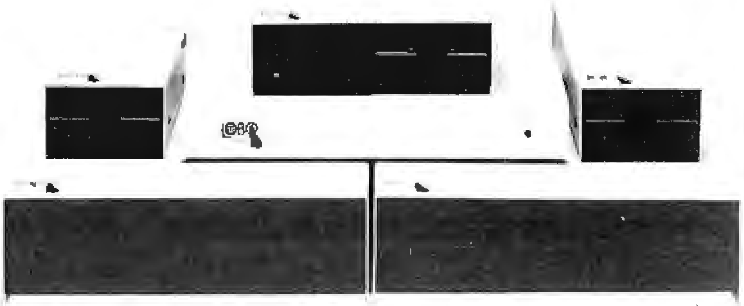

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5101CA	One SA850 in cabinet w/power, DDC* Controller, cable and manual $1759
5202CA	Two SA850 in cabinet w/power, DDC* Controller, cable and manual $2364
LCA-22	Double Density Controller only $599

S-100 BASED COMPUTERS

MODEL NO.	DESCRIPTION
4101C	SA400 in cabinet w/power $369
8212C	Two SA801 in cabinet w/power $1329
5212C	Two SA851 in cabinet w/power $1799

GENERAL

MODEL NO.	DESCRIPTION
8212C	Two SA801 in cabinet w/power $1329
5212C	Two SA851 in cabinet w/power $1799

TRS80

MODEL NO.	DESCRIPTION
4101C	SA400 in cabinet w/power $369
8101C II	One SA800 in cabinet w/power for Mod. II $909
8202C II	Two SA800 in cabinet w/power for Mod. II $1349
LX80	Double-density expansion interface $641
RS232	Dual Serial Port Option $75

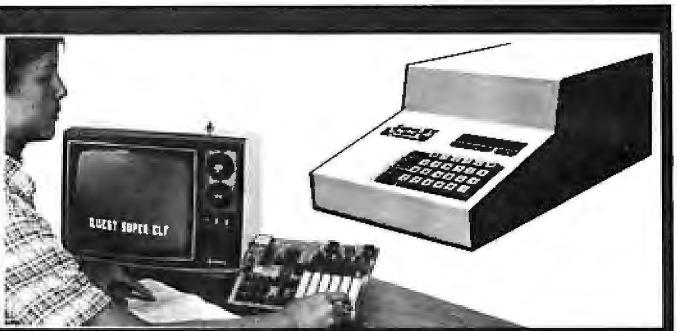
JR INVENTORY CO.,

P.O. Box 185, Santa Ynez, Ca., 93460
(805) 688-8781

Quest ELECTRONICS

P.O. Box 4430X
Santa Clara, CA 95054
Will calls: 2322 Walsh Ave.
(408) 988-1640 TWX 910-338-2139

Same day shipment. First line parts only. Factory tested. Guaranteed money back. Quality IC's and other components at factory prices.



INTEGRATED CIRCUITS

7400TTL	
7400N	.19
7402N	.20
7404N	.25
7409N	.27
7410N	.25
7414N	.70
7420N	.25
7422N	.39
7430N	.25
7442N	.58
7445N	.82
7447N	.63
7448N	.77
7450N	.25
7474N	.35
7475N	.49
7485N	.88
7489N	1.70
7490N	.43
7492N	.43
7493N	.43
7495N	.69
74100N	1.35
74107N	.35
74121N	.34
74123N	.59
74125N	.45
74145N	.77
74150N	1.20
74151N	.69
74154N	1.25
74157N	.69
74161N	.87
74162N	.85
74163N	.87
74174N	.96
74175N	.85
74190N	1.15
74192N	.87
74193N	.85
74221N	1.25
74298N	1.65
74365N	.75
74366N	.75
74367N	.75

74LS00 TTL	
74LS00N	.29
74LS02N	.29
74LS04N	.35
74LS05N	.25
74LS08N	.35
74LS10N	.35
74LS13N	.55
74LS14N	1.00
74LS20N	.35
74LS22N	.35
74LS28N	.35
74LS30N	.35
74LS33N	.60
74LS38N	.50
74LS74N	.45
74LS75N	.65
74LS90N	.60
74LS93N	.75
74LS95N	1.00
74LS107N	.45
74LS112N	.45
74LS113N	.45
74LS132N	.89
74LS136N	.50
74LS151N	.75
74LS155N	.79
74LS157N	1.10
74LS162N	1.10
74LS163N	1.10
74LS174N	1.15
74LS190N	1.25
74LS221N	1.25
74LS258N	1.00
74LS367N	.89

LINEAR	
CA3045	.90
CA3046	1.10
CA3081	1.80
CA3082	1.90
CA3089	3.40
LM301AN/AH	.35
LM305H	.87
LM307N	.35
LM308N	1.00
LM309K	1.25
LM311H/N	.90
LM317T	1.65
LM317K	3.75
LM318	1.50
LM320K-5	1.35
LM320K-12	1.35
LM320K-15	1.35
LM320T-5	.95
LM320T-8	.95
LM320T-12	.95
LM320T-15	.95
LM323K-5	5.95
LM324N	1.00
LM339N	1.00
LM340K-5	1.35
LM340K-8	1.35
LM340K-12	1.35
LM340K-15	1.35
LM340K-24	1.35
LM340T-5	.85
LM340T-8	.85
LM340T-12	.85
LM340T-15	.85
LM340T-18	.85
LM340T-24	.85
LM350	5.50
LM377	2.95
LM379	5.00
LM380N	1.00
LM381	1.60
LM382	1.60
LM709H	.59
LM723H/N	.50
LM733H	.85
LM741CH	.35
LM741N	.38
LM747H/N	.75
LM748N	.50
LM1303N	1.75
LM1304	1.10
LM1305	1.27
LM1307	2.00
LM1310	1.95
LM1458	.55
LM1812	7.50
LM1889	3.00
LM2111	1.75
LM2902	2.25
LM3900N	.60
LM3905	1.75
LM3909N	.95
MC1458V	.55
NE550N	1.35
NE555V	.39
NE556A	.85
NE565A	1.00
NE566V	1.50
NE567V	1.00
NE570B	4.75
78L05	.60
78L08	.60
78M05	.85
75108	1.75
75491CN	.50
75492CN	.55
75494CN	.89

A to D CONVERTER	
8038B	4.50
8700CJ	13.95
8701CN	22.00
8750CJ	13.95
LD130	9.95
9400CJV/F	7.40
ICL7103	9.50
ICL7107	14.25

CMOS	
CD4000	.25
CD4001	.35
CD4002	.35
CD4006	1.10
CD4007	.35
CD4008	1.20
CD4009	.45
CD4010	.45
CD4011	.35
CD4012	.28
CD4013	.47
CD4014	1.25
CD4015	1.00
CD4016	.55
CD4017	1.05
CD4018	.94
CD4019	.45
CD4020	1.02
CD4021	1.35
CD4022	1.10
CD4023	.28
CD4024	.75
CD4025	.28
CD4026	2.50
CD4027	.66
CD4028	.85
CD4029	1.35
CD4030	.45
CD4035	1.00
CD4040	1.35
CD4042	.85
CD4043	.85
CD4044	.85
CD4046	1.67
CD4049	.45
CD4050	.60
CD4051	1.13
CD4060	1.42
CD4066	.71
CD4068	.40
CD4069	.40
CD4070	.50
CD4071	.45
CD4072	.45
CD4073	.45
CD4075	.45
CD4076	1.45
CD4078	.40
CD4081	.35
CD4082	.35
CD4116	.47
CD4490	5.50
CD4507	1.00
CD4508	2.85
CD4510	1.00
CD4511	.94
CD4515	2.52
CD4516	1.10
CD4518	1.50
CD4520	1.02
CD4527	1.51
CD4528	1.60
CD4553	3.50
CD4566	2.45
CD4583	2.35
CD4585	1.10
CD40192	3.00
74C00	.35
74C04	.40
74C10	.35
74C14	.89
74C20	.35
74C30	.35
74C48	1.95
74C74	.85
74C76	1.25
74C90	1.25
74C93	1.25
74C154	3.50
74C160	2.75
74C175	1.35
74C192	1.65
74C221	1.90
74C905	6.00
74C906	.75
74C914	1.95
74C922	5.00
74C923	5.50
74C925	7.50
74C926	6.95
74C927	6.95

INTERFACE	
8095	.65
8096	.65
8097	.65
8098	.65
8T09	1.25
8T10	4.50
8T13	3.00
8T20	5.50
8T23	3.10
8T24	3.50
8T25	3.20
8T26	1.69
8T28	2.75
8T97	1.69
8T98	1.69

MOS/MEMORY RAM	
2101-1	3.85
2102-1	.95
2102AL-4	1.45
2102AN-2L	1.65
2104A-4	4.95
2107B-4	3.75
2111-1	3.75
2112-2	3.95
2114	3.75
2114L 300ns	4.25
2114L 450ns	4.00
4116 200ns	4.50
8/4116 200ns	26.95
MM5262	.40
MM5280	3.00
MM5320	9.95
MM5330	5.94
PD411D-3	4.00
PD411D-4	5.00
P5101L	8.95
4200A	9.95
82S25	2.90
91L02A	1.50
HD0165-5	6.95
MM57100	4.50
GIAY38500-1	9.95
MCM66751A	9.95
9368	3.50
4100	10.00
416	16.00

CLOCKS	
MM5311	5.50
MM5312	4.80
MM5314	3.90
MM5369	2.10
MM5841	14.45
MM5865	7.95
CT7010	8.95
CT7015	6.95
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7207	7.50
7208	15.95
7209	4.95
DS0026CN	3.75
DS0056CN	3.75
MM53104	2.50

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6504	9.95
6522	9.95
6800	6.95
6802	11.95
6820	4.95
6850	5.95
8080A	3.95
8085	12.95
8086	75.00
Z80	9.95
Z80A	11.95
8212	2.90
8214	3.95
8216	3.50
8224	3.45
8228	4.95
8251	6.95
8253	15.00
8255	5.75
8257	10.95
8259	14.95
1802CP plas.	13.95
1802DP plas.	17.95
1861P	9.50
CDP1802CD	28.95
CDP1802D	35.00
CDP1816P	7.95

UART/FIFO	
AY5-1013	5.50
AY5-1014	7.50
3341	6.95

PROM	
1702A	4.95
2708	6.10
2716T1	18.00
2716 5 Volt	10.50
8/2716 5 Volt	89.00
2732	29.50
2758	19.50
8741A	55.00
8748	55.00
8748-8	55.00
8755A	55.00
N82S23	2.95
N82S123	6.50
N82S126	3.75
N82S129	8.50
N82S131	8.50
N82S136	8.75
N82S137	8.75
DM8577	2.90
8223	2.90

CONNECTORS	
30 pin edge	2.50
44 pin edge	2.75
86 pin edge	4.00
100pin edge	4.50
100 pin edge WW	5.25

IC SOCKETS

Solder Tin Low Profile PIN	1 UP	PIN	1 UP
8	.15	22	.30
14	.14	24	.35
16	.16	28	.42
18	.27	36	.58
20	.29	40	.57

2 level 14 pin ww .20

WIRE WRAP LEVEL 3 PIN		PIN	
14	.46	24	.93
16	.49	28	1.00
18	.67	40	1.59

CRYSTALS	
1 MHz	4.50
2 MHz	4.50
4 MHz	4.25
5 MHz	4.25
10 MHz	4.25
18 MHz	3.90
20 MHz	3.90
32 MHz	3.90
32768 Hz	4.00
1.8432 MHz	4.50
3.5795 MHz	1.20
2.0100 MHz	1.95
2.097152 MHz	4.50
2.4576 MHz	4.50
3.2768 MHz	4.50
5.0688 MHz	4.50
5.185 MHz	4.50
5.7143 MHz	4.25
6.5536 MHz	4.25
14.31818 MHz	4.25
18.432 MHz	4.50
22.1184 MHz	4.50

KEYBOARD ENCODERS	
AY5-2376	$12.50
AY5-3600	17.95
AY5-9100	10.50
AY5-9200	16.50
74C922	5.50
74C923	5.50
HD0165-5	6.95
AY5-9400	10.50

D Connectors RS232	
DB25P	3.62
DB25S	5.20
Cover	1.50
DE9S	1.95
DA15P	2.10
DA15S	3.10
Complete Set	9.50

Hickok 3½ Digit LED multimeter	89.95
Stopwatch Kit	26.95
Auto Clock Kit	17.95
Digital Clock Kit	14.95

8K/16K Eprom Kit (less PROMS)	$89.00
Motherboard	$39.00
Extender Board	$15.00

RESISTORS ¼ watt 5%
10 per type .03
25 per type .025
100 per type .015
1000per type .012
350 piece pack 5 pertype 6.75
½ watt 5% per type .05

Televideo Terminal
Model 912 $785.00
Model 920 $885.00

Tiny Basic Experimenters Kit $10.00

KEYBOARDS	
56 key ASCII keyboard kit	$67.50
Fully assembled	77.50
53 key ASCII keyboard kit	60.00
Fully assembled	70.00
Enclosure Plastic	14.95
Metal Enclosure	29.95

LEDS	
Red TO18	.15
Green, Yellow TO18	.20
Jumbo Red	.20
Green, Orange, Yellow Jumbo	.25
Clipilite LED Mounting Clips	8/$1.25

(specify red, amber, green, yellow, clear)

CONTINENTAL SPECIALTIES in stock
Complete line of breadboard test equip.
MAX-100 8 digit Freq. Ctr. $149.95

OK WIRE WRAP TOOLS in stock
Portable Multimeter $18.00
Complete line of AP Products in stock.

SPECIAL PRODUCTS	
MM5865 Stopwatch Timer with 10 pg spec	9.00
PC board	7.50
Switches Mom. Pushbutton	.27
3 pos slide	.25
Encoder HD0165-5	6.95
Paratronics	
Model 10 Trigger Expander Kit	$229.00
Model 150 Bus Grabber Kit	$369.00
Clock Calendar Kit	$23.95
2.5 MHz Frequency Counter Kit	$37.50
30 MHz Frequency Counter Kit	$47.75

TRANSFORMERS	
6V 300 ma	3.25
12 Volt 300 ma transformer	1.25
12.6V CT 600 ma	3.75
12V 250 ma wall plug	2.95
12V CT 250 ma wall plug	3.75
24V CT 100 ma	3.95
10V 1.2 amp wall plug	4.85
12V 6 amp	12.95
12V 500 ma wall plug	4.75
12V 1 amp wall plug	6.50
10/15VAC 8/16VA wall plug	9.75

DISPLAY LEDS			
MAN1	CA	270	2.90
MAN3	CC	125	.39
MAN72/74	CA/CA	300	1.00
DL704	CC	300	1.25
DL707/DL707R	CA	300	1.00
DL727/728	CA/CC	500	1.90
DL747/750	CA/CC	600	1.95
FND359	CC	357	.70
FND500/507	CC/CA	500	1.35
FND503/510	CC/CA	500	.90
FND800/807	CC/CA	800	2.20
3 digit Bubble			.60
10 digit display			1.25
7520 Clairex photocells			.39
TIL311 Hex			9.50
MAN3640	CC	.30	1.10
MAN4610	CA	.40	1.20
MAN4640	CA	.40	1.20
MAN4710	CA	.40	.95
MAN4740	CC	.40	1.20
MAN6640	CC	.56	2.95
MAN6710	CA	.60	1.35
MAN6740	CC	.60	1.35
MA1092A, C, E			8.95
MA1012A			8.95
102P3 transformer			2.25
MA1012A Transformer			2.25

DIP Switches	
4-position	$ .95
5-position	1.00
6-position	1.00
7-position	1.00
8-position	1.05

Complete line of Hobby-Blox solderless breadboards in stock.
1C Starter Pack $5.95
Discrete Component Starter Pack $6.57

RCA Cosmac 1802 Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the Super Elf for so little money. The Super Elf is a small single board computer that does many big things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded** with **additional memory, Full Basic, ASCII Keyboards, video character generation, etc.**

Before you buy another small computer, see if it includes the following features: ROM monitor; State and Mode displays; Single step; Optional address displays; Power Supply; Audio Amplifier and Speaker; Fully socketed for all IC's; Real cost of in warranty repairs; Full documentation.

The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest** address and data bus displays **before, during** and **after** executing instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

An RCA 1861 **video graphics** chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a **speaker system** included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, wait, input, memory protect, monitor select** and **single step.** Large, on board displays provide output and optional **high** and **low address.** There is a 44 pin standard connector slot for PC cards and a 50 pin connector slot for the Quest Super Expansion Board. Power supply and sockets for **all** IC's are included in the price plus a detailed 127 pg. instruction manual which now includes over 40 pgs. of software info. including a series of lessons to help get you started and a music program and graphics target game. Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and R&D.

Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95, High address option $8.95, Low address option $9.95. Custom Cabinet** with drilled and labelled plexiglass front panel **$24.95.** All metal Expansion Cabinet, painted and silk screened, with room for 5 S-100 boards and power supply **$57.00. NiCad Battery Memory Saver Kit $6.95.** All kits and options also completely assembled and tested.

Questdata, a software publication for 1802 computer users is available by subscription for $12.00 per 12 issues. Single issues $1.50. Issues 1-12 bound $16.50.

Tiny Basic Cassette **$10.00,** on ROM **$38.00,** original Elf kit board **$14.95. 1802 software;** Moews Video Graphics **$3.50.** Games and Music **$3.00,** Chip 8 Interpreter **$5.50.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow **you** to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface.** Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf.** The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed.** EPROM can be used for the monitor and TinyBasic or other purposes. **A 1K Super ROM Monitor $19.95** is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software, (relocatable cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. If you have the **Super Expansion Board** and **Super Monitor** the monitor is up and running at the push of a button.

Other on board options include **Parallel Input and Output Ports with full handshake.** They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set** with ribbon cable is available at $15.25 for easy connection between the **Super Elf** and the **Super Expansion Board.**

Power Supply Kit for the complete system (see Multi-volt Power Supply).

Quest Super Basic V5.0

A new enhanced version of **Super Basic** now available. Quest was the first company worldwide to ship a full size Basic for 1802 Systems. A complete function **Super Basic** by **Ron Cenker** including floating point capability with scientific notation (number range $\pm.17E^{38}$), 32 bit integer ±2 billion; multi dim arrays, string arrays; string manipulation; cassette I/O; save and load, basic, data and machine language programs; and over 75 statements, functions and operations.

New improved faster version including **re-number** and essentially **unlimited variables.** Also, an exclusive user expandable command library.

Serial and Parallel I/O included.

Super Basic on Cassette $55.00.

PROM Eraser

assembled. 25 PROM capacity **$37.50** (with timer **$69.50**). 6 PROM capacity OSHA/UL version **$69.50** (with timer **$94.50**).

Z80 Microcomputer

16 bit I/O, 2 MHz clock, 2K RAM, ROM Breadboard space. Excellent for control. Bare Board **$28.50.** Full Kit **$99.00.** Monitor **$20.00.** Power Supply Kit **$35.00. Tiny Basic $30.00**

S-100 Computer Boards

8K Static Godbout Econo IIA Kit	149.00
16K Static Godbout Econo XIV Kit	269.00
24K Static Godbout Econo XX-24 Kit	414.00
32K Static Godbout Econo XX-32 Kit	537.00
16K Dynamic RAM Kit	289.00
32K Dynamic RAM Kit	328.00
64K Dynamic RAM Kit	399.00
Video Interface Kit	**$139.00**

80 IC Update Master Manual $39.00

Comp. IC data selector, 2700 pg. master reference guide. Over 51,000 cross references. Free update service through 1980. Domestic postage $3.50.

Modem Kit $60.00

State of the art, orig., answer. No tuning necessary. 103 compatible 300 baud. Inexpensive acoustic coupler plans included. Bd. only $17.00.

LRC 7000+Printer $389.00

40/20 column dot matrix impact, std. paper. Interface all personal computers.

64/40/32/20 version **$405.00.** Optional cables available.

LRC 7000 printer interface cable for Super Elf with software $35.00

NiCad Battery Fixer/Charger Kit

Opens shorted cells that won't hold a charge and then charges them up, all in one kit w/full parts and instructions. **$7.95**

Rockwell AIM 65 Computer

6502 based single board with full ASCII keyboard and 20 column thermal printer. 20 char. alphanumeric display, ROM monitor, fully expandable. **$405.00.** 4K version **$450.00.** 4K Assembler **$85.00,** 8K Basic Interpreter **$100.00.**

Special small power supply for AIM65 assem. in frame **$54.00.** Complete AIM65 in thin briefcase with power supply **$499.00.** Molded plastic enclosure to fit both AIM65 and power supply **$47.50.** Special Package Price: 4K AIM, 8K Basic, power supply, cabinet **$625.00.**

AIM65/KIM/VIM/Super Elf 44 pin expansion board; 3 female and 1 male bus. Board plus 3 connectors **$22.95.**

60 Hz Crystal Time Base Kit $4.40

Converts digital clocks from AC line frequency to crystal time base. Outstanding accuracy.

Video Modulator Kit $9.95

Convert TV set into a high quality monitor w/o affecting usage. Comp. kit w/full instruc.

Multi-volt Computer Power Supply

8v 5 amp, ±18v .5 amp, 5v 1.5 amp, −5v .5 amp, 12v .5 amp, −12v option. ±5v, ±12v are regulated. Basic Kit **$29.95.** Kit with chassis and all hardware **$43.95.** Add $4.00 shipping. Kit of hardware **$14.00.** Woodgrain case **$10.00.** $1.50 shipping.

Ohio Scientific Computers

C1P Series 2 **$455.00.** Like an Apple at less than half the price! C1PMF Series 2 **$1199.00.** Minifloppy version with additional RAM/ROM. Complete software and peripherals available. Send for free brochure.

Gremlin Color Video Kit $69.95

32 x 16 alpha/numerics and graphics; up to 8 colors with 6847 chip; 1K RAM at E000. Plugs into Super Elf 44 pin bus. No high res. graphics. On board RF Modulator Kit **$4.95**

1802 16K Dynamic RAM Kit $149.00

Expandable to 32K. Hidden refresh w/clocks up to 4 MHz w/no wait states. Addl. 16K RAM **$63.00**

Tiny Basic Extended on Cassette $15.00
(added commands include Stringy, Array, Cassette I/O etc.) S-100 4-Slot Expansion $ 9.95
Super Monitor VI.I Source Listing $15.00

Elf II Adapter Kit $24.95

Plugs into Elf II providing Super Elf 44 and 50 pin plus S-100 bus expansion. (With Super Expansion). High and low address displays, state and mode LED's optional **$18.00.**

Super Color S-100 Video Kit $129.95

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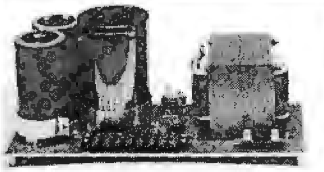
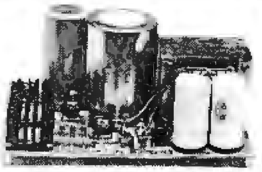


KIT 1, 2 & 3 For S-100

R3 For Three 8" or 5¼" Disk Drives



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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ITEM	USED FOR	@ + 8 Vdc	@ − 9 Vdc	@ + 16 Vdc	@ − 16 Vdc	@ + 28 Vdc	SIZE W × D × H	PRICE
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KIT 2	SYSTEM SOURCE	25A	———	3A	3A	—	12" × 5" × 4⅞"	59.95
KIT 3	DISK SYSTEM	15A	1A	2A	2A	4A	14" × 6" × 4⅞"	67.95

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T_3	110/120	2 × 8 Vac, 15A	28 Vac, CT, 2.5A	48 Vac, CT, 2A	3¾" × 4⅜" × 3⅛"	29.95
T_4	110/120	2 × 8 Vac, 6A	28 Vac, CT, 1.5A	48 Vac, CT, 3A	3¾" × 3⅝" × 3⅛"	22.95
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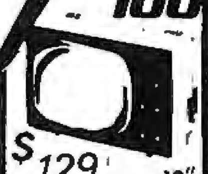
video 100



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74LS26	.49	74LS175	75
74LS27	26	74LS190	75
74LS30	28	74LS193	96
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74LS38	32	74LS196	85
74LS42	65	74LS221	140
74LS48	.78	74LS240	165
74LS51	25	74LS241	165
74LS54	.35	74LS243	145
74LS74	38	74LS244	145
74LS75	60	74LS245	2 25
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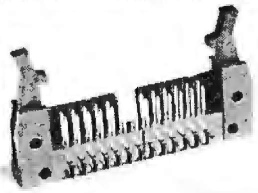

Pins	PC Mounting		Wire Wrap	
10	IDH10SR	.80	IDH10WR	1.75
20	IDH20SR	1.25	IDH20WR	2.75
26	IDH26SR	1.85	IDH26WR	3.60
34	IDS34SR	2.15	IDH34WR	4.15
40	IDH40SR	2.50	IDH40WR	4.90
50	IDH50SR	3.15	IDH50WR	6.15

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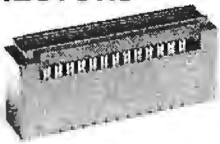
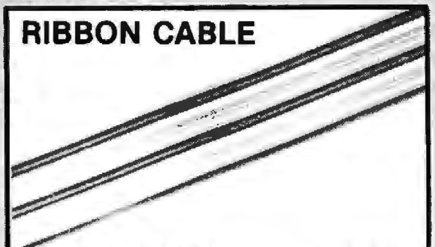
CARD EDGE CONNECTORS



Pins	Part No.	
10	IDE10	3.25
20	IDE20	3.50
26	IDE26	4.05
34	IDE34	4.85
40	IDE40	5.65
50	IDE50	5.90

RIBBON CABLE



Conductors:	Solid Color 10 ft.	Solid Color 100 ft.	Color Coded 10 ft.	Color Coded 100 ft.
10	2.90	17.00	4.00	30.00
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16	3.70	27.20	5.60	48.00
20	4.40	34.00	7.00	60.00
24	5.00	40.80	8.00	72.00
26	5.40	44.20	8.60	78.00
34	6.80	57.80	11.00	102.00
40	7.80	68.00	13.00	120.00
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Female	DB255	3.00
Hood	DB25C	1.10
INSULATION DISPLACEMENT		
Male	IDC25P	4.95
Female	IDC255	5.25
Hood	IDC25C	1.35

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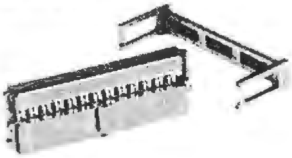
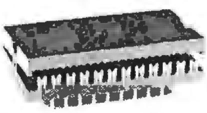


Pins	Part No.		Stain Relief
10	IDS10	1.25	.25
20	IDS20	2.02	.25
26	IDS26	2.65	.25
34	IDS34	3.50	.25
40	IDS40	4.05	.25
50	IDS50	5.06	.25

CABLE PLUGS



Pins	Part No.	
14	IDP14	1.25
16	IDP16	1.40
24	IDP24	2.25
40	IDP40	3.65

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3.0"	1.30	3.86	6.78	7.0"	1.99	6.76	12.44
3.5"	1.37	4.15	7.37	7.5"	2.08	7.07	13.09
4.0"	1.42	4.44	7.94	8.0"	2.14	7.38	13.73
4.5"	1.48	4.74	8.54	8.5"	2.18	7.69	14.36
5.0"	1.54	5.04	9.13	9.0"	2.24	8.11	15.01
5.5"	1.58	5.38	9.72	9.5"	2.30	8.32	15.65
6.0"	1.65	5.66	10.31	10.0"	2.39	8.71	16.28

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500	3½"	250	6"
500	4"	100	6½"
250	4½"	100	7"

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500	3"	500	5"
500	3½"	500	5½"
500	4"	500	6"

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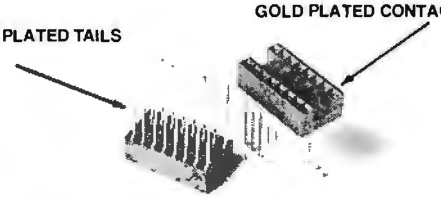

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16	26	.51	13.26
18	23	.70	16.10
20	21	.87	18.27
22	19	.94	17.86
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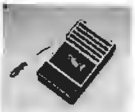

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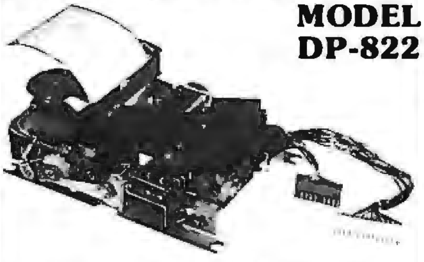

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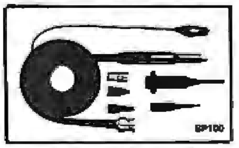

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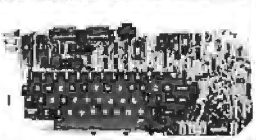

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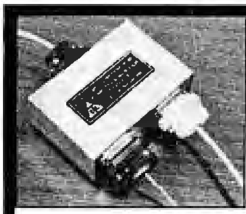

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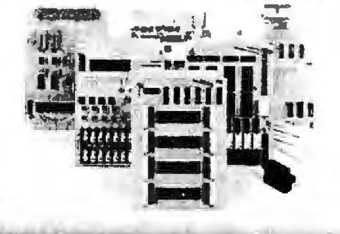

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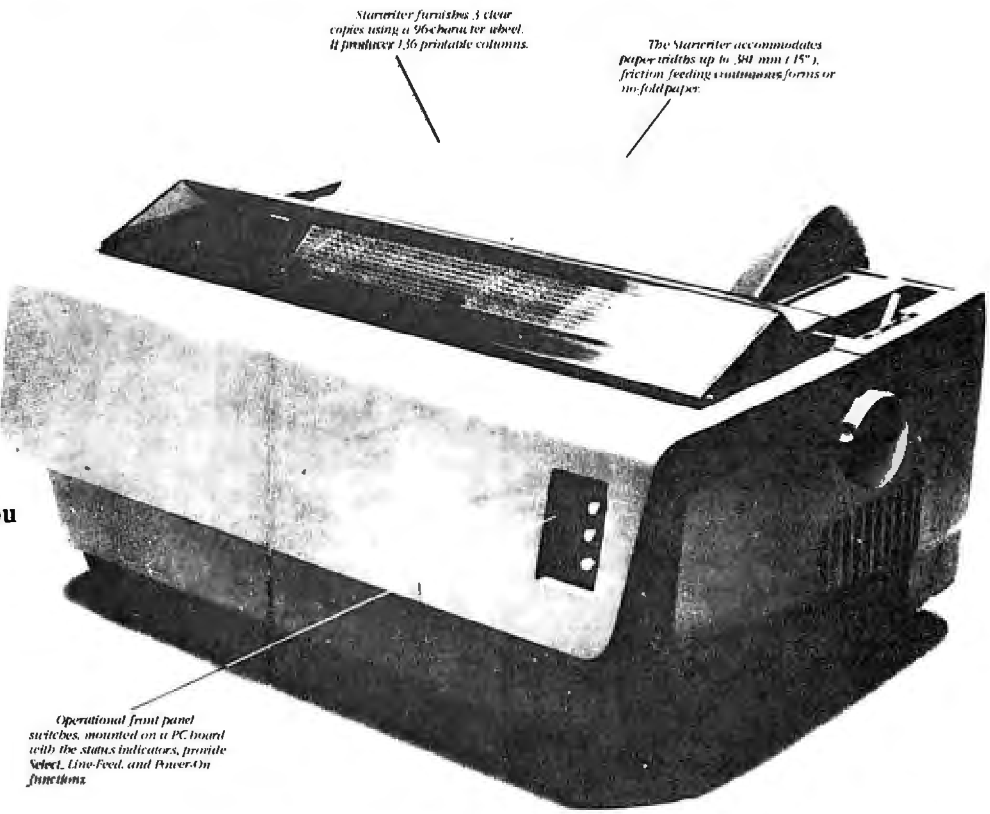

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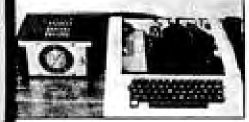

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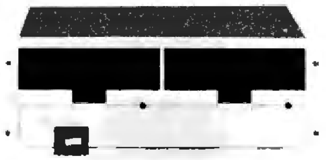

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LM318v	1.49	LM733	.98	75451v	.39
LM323k	4.95	LM741v	.29	MC1330v	1.89
LM324	.59	LM747	.79	MC1350v	1.29
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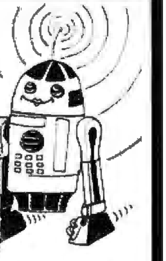

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SN7401N	.22	SN74125N	.39
SN7402N	.22	SN74126N	.44
SN7403N	.22	SN74128N	.59
SN7404N	.22	SN74132N	.69
SN7405N	.23	SN74136N	.95
SN7406N	.23	SN74139N	.95
SN7407N	.23	SN74141N	.69
SN7408N	.26	SN74142N	2.95
SN7409N	.23	SN74143N	2.95
SN7410N	.22	SN74144N	2.95
SN7411N	.29	SN74145N	.62
SN7412N	.29	SN74147N	1.95
SN7413N	.39	SN74148N	1.20
SN7414N	.59	SN74150N	.99
SN7416N	.29	SN74151N	.67
SN7417N	.29	SN74152N	.67
SN7420N	.22	SN74153N	.67
SN7421N	.35	SN74154N	1.19
SN7422N	.29	SN74155N	.82
SN7423N	.29	SN74156N	.89
SN7425N	.29	SN74157N	.69
SN7426N	.29	SN74158N	1.65
SN7427N	.29	SN74160N	.95
SN7429N	.45	SN74161N	.95
SN7430N	.23	SN74162N	.89
SN7432N	.29	SN74163N	.87
SN7437N	.29	SN74164N	.97
SN7438N	.29	SN74165N	.97
SN7439N	.29	SN74166N	1.20
SN7440N	.24	SN74167N	1.95
SN7441N	.79	SN74170N	1.69
SN7442N	.57	SN74172N	5.95
SN7443N	.79	SN74173N	.79
SN7444N	.79	SN74174N	.89
SN7445N	.79	SN74175N	.89
SN7446N	.79	SN74176N	.85
SN7447N	.59	SN74177N	.85
SN7448N	.79	SN74179N	1.80
SN7450N	.23	SN74180N	.75
SN7451N	.23	SN74181N	1.75
SN7453N	.23	SN74182N	.75
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SN7473N	.38	SN74191N	1.15
SN7474N	.36	SN74192N	.85
SN7475N	.38	SN74193N	.85
SN7476N	.36	SN74194N	.85
SN7479N	4.60	SN74195N	.85
SN7480N	.59	SN74196N	.85
SN7481N	1.10	SN74197N	.85
SN7482N	1.10	SN74198N	1.39
SN7483N	.55	SN74199N	1.39
SN7485N	.65	SN74221N	1.39
SN7486N	.39	SN74251N	.95
SN7489N	1.75	SN74273N	1.05
SN7490N	.39	SN74279N	.89
SN7491N	.65	SN74263N	2.15
SN7492N	.52	SN74284N	3.90
SN7493N	.49	SN74285N	3.90
SN7494N	.72	SN74290N	1.25
SN7495N	.65	SN74298N	.95
SN7496N	.72	SN74365N	.68
SN7497N	3.10	SN74366N	.68
SN74100N	.99	SN74367N	.79
SN74107N	.32	SN74368N	.79
SN74109N	.53	SN74390N	1.90
SN74116N	1.95	SN74393N	1.90
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CD4014	1.39	CD4502	1.65
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CD4021	1.19	CD4511	1.39
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CD4023	.38	CD4515	3.95
CD4024	.79	CD4516	1.69
CD4025	.38	CD4518	1.39
CD4027	.65	CD4520	1.39
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CD4029	1.29	CD4556	.99
CD4030	.45	CD4566	2.25
CD4031	3.25	74C00	.39
CD4032	2.15	74C02	.39
CD4034	3.25	74C04	.39
CD4035	.95	74C08	.49
CD4037	1.95	74C10	.49
CD4040	1.29	74C14	1.65
CD4041	1.25	74C20	.39
CD4042	.95	74C30	.39
CD4043	.85	74C32	.99
CD4044	.85	74C42	1.85
CD4046	1.75	74C48	2.39
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CD4051	1.10	74C90	1.85
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CD4060	1.39	74C157	2.10
CD4066	.75	74C160	2.39
CD4069	.35	74C161	2.30
CD4070	.49	74C163	2.39
CD4071	.35	74C164	2.39
CD4072	.35	74C173	2.59
CD4073	.35	74C174	2.75
CD4075	.35	74C175	2.75
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CD4085	1.95	MM80C95	1.50
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74LS00N	.35	74LS164N	1.19
74LS01N	.28	74LS165N	.89
74LS02N	.28	74LS166N	2.48
74LS03N	.28	74LS168N	1.89
74LS04N	.39	74LS169N	1.89
74LS05N	.28	74LS170N	1.99
74LS08N	.39	74LS173N	.89
74LS09N	.39	74LS174N	.99
74LS10N	.2	74LS175N	.99
74LS11N	.39	74LS181N	2.20
74LS12N	.39	74LS190N	1.15
74LS13N	.47	74LS191N	1.15
74LS14N	1.25	74LS192N	.98
74LS15N	.39	74LS193N	.98
74LS20N	.26	74LS194N	1.15
74LS21N	.38	74LS195N	.95
74LS22N	.38	74LS196N	.89
74LS26N	.39	74LS197N	.89
74LS27N	.39	74LS221N	1.49
74LS28N	.39	74LS240N	1.95
74LS30N	.26	74LS241N	1.90
74LS32N	.39	74LS242N	1.95
74LS37N	.79	74LS243N	1.95
74LS38N	.79	74LS244N	1.95
74LS40N	.26	74LS245N	4.95
74LS42N	.79	74LS247N	1.10
74LS47N	.79	74LS248N	1.10
74LS48N	.79	74LS249N	1.69
74LS51N	.26	74LS251N	1.79
74LS54N	.35	74LS253N	.98
74LS55N	.35	74LS257N	.98
74LS73N	.45	74LS258N	.98
74LS74N	.59	74LS259N	2.95
74LS75N	.68	74LS260N	.69
74LS76N	.45	74LS261N	2.49
74LS78N	.65	74LS266N	.59
74LS83AN	.99	74LS273N	1.75
74LS85N	1.19	74LS275N	4.40
74LS86N	.45	74LS279N	.59
74LS90N	.75	74LS283N	1.10
74LS92N	.75	74LS290N	1.29
74LS93N	.75	74LS293N	1.95
74LS95N	.88	74LS295N	1.10
74LS96N	.98	74LS298N	1.29
74LS107N	.45	74LS324N	1.75
74LS109N	.45	74LS347N	1.95
74LS112N	.49	74LS348N	1.95
74LS113N	.49	74LS352N	1.65
74LS114N	.55	74LS353N	1.65
74LS122N	.55	74LS363N	1.49
74LS123N	1.19	74LS365N	.99
74LS124N	1.35	74LS366N	.99
74LS125N	.89	74LS367N	.73
74LS126N	.89	74LS368N	.73
74LS132N	.79	74LS373N	2.75
74LS136N	.59	74LS374N	2.75
74LS138N	.89	74LS375N	.69
74LS139N	.89	74LS377N	1.95
74LS145N	1.25	74LS385N	1.95
74LS148N	1.49	74LS386N	.65
74LS151N	.79	74LS390N	1.95
74LS153N	.79	74LS393N	1.95
74LS154N	2.49	74LS395N	1.70
74LS155N	1.19	74LS399N	2.95
74LS156N	.99	74LS424N	2.95
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74LS158N	.75	74LS670N	2.29
74LS160N	.98	81LS95N	1.99
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LM305H	.89	LM1850N	.95
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LM739N	1.15	SN75453N	.49
LM741CN/H	.33	SN75454N	.49
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DL-241 Deluxe Test Lead Kit	$10
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Model LP-3 High Speed Logic Probe	77.00
Model LPK-1 Logic Probe Kit	21.95
Model LTC-1, LTC-2 Logical Analysis Kits	220/250

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24 Pin Clip	PC-24	$9.50
40 Pin Clip	PC-40	$14.95

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PB-100	18.00	PB-203	97.00
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- Apple III Option A: Apple III 96K, Information Analyst Package, 12" B/W Monitor $3995.00
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3 ASTEROIDS $29.95
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SYM-1	6502	239.00	Add 39.95	AIM65	6502	375.00	Add 49.95
[illegible]	Z80	409.00	N/A	Cosmac Vip	1802	199.00	Inc.

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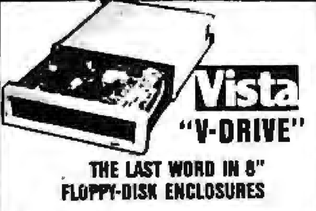

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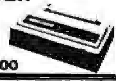

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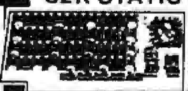

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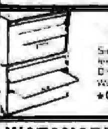

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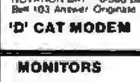

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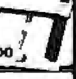

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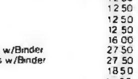

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AM9517 DMA Controller	18.95
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Z80-CTC	2.5 MHz	8.75
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Z80-SIO/1	2.5 MHz	35.95
Z80A-SIO/1	4.0 MHz	39.40
Z80-SIO/2	2.5 MHz	35.95
Z80-SIO/2	4.0 MHz	39.40

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2732	44.95
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KEYBOARD ENCODERS

AY5-2376	13.75
AY5-3600	13.75
HD0165	9.95
74C922	9.95
74C923	9.95

STATIC RAMS

	1-24	25-99	100
21L02 450ns (SALE 2102 .89)	1.30	1.25	.99
21L02 250ns	1.59	1.55	1.15
2111	3.75	3.65	3.55
2112-1	2.95	2.85	2.65
2101-1	2.90	2.70	2.55
2114L-250ns (4045)	6.50	5.95	5.50
2114L-450ns (4048)	5.50	5.25	4.75
4044 250 ns	8.95	7.50	6.90
4044 450ns	5.95	5.95	4.75
EMM4200A	9.75	8.75	7.95
EMM4402	7.85	7.25	6.25
AMD9140/41	10.95	10.25	9.75
AMD9130-31	12.85	11.95	10.75
1101	1.95	1.75	1.25
P2125/93425 (45ns)	9.45	8.35	8.25
6518 1K x 1 CMOS	7.95	7.95	7.25
2147 Low Power 4K Static	19.95	18.95	16.95
93415	9.95	9.95	8.50
TMS4046	11.95	10.95	10.50

DYNAMIC RAMS

416/4116 16K (16 Pin)	8.75
Set of 8 416's	49.95
4115 8K (16 Pin)	6.95
4050 4K x 1 (18 Pin)	4.95
4060 4K x 1 (22 Pin)	4.95
4096 4K x 1 (16 Pin)	3.95
2104 4K x 1 (16 Pin)	4.75
4027 4K x 1 (16 Pin)	4.95

5261	1.95	64K RAMS $159.95	1103	1.95
5262	1.95		4008L	4.95
5270	4.95		6605	7.95
5280	4.95		6604	4.95
5290	12.45		6002	1.50

SOCKETS

# Pins	Lo-Pro Soldertail	Wire Wrap 3 Level Tin	Wire Wrap 3 Level Gold
8	15	32	45
14	19	36	59
16	20	38	62
18	24	59	84
20	29	69	99
22	24	79	1.10
24	38	85	1.20
28	43	1.10	1.49
36	58	1.25	1.69
40	60	1.40	1.89

ZERO INSERTION FORCE

LED READOUTS

Part No	Size	Color	Descr/Option	Price
DL704	300	Red	Comm Cathode	99
DL707	300	Red	Comm Anode	99
FND357	357	Red	Comm Cathode	99
FND501	500	Red	Comm Cathode (+1)	99
FND503(500)	500	Red	Comm Cathode	99
FND507(510)	500	Red	Comm Anode	99
FND508	500	Red	Comm Anode (+1)	99
FND530	500	Green	Comm Cathode	1.49
FND550	500	Orange	Comm Cathode	1.49
FND803(800)	800	Red	Comm Cathode	1.75
FND807(810)	800	Red	Comm Anode	1.75
HP5082-7340	600	Red	4 x 7 Hexidecimal	20.95
HP5082-7300	600	Red	4 x 7 Sgl Digit RHD	18.95
HP5082-7731	300	Red	Comm Anode	75
TIL305		Red	Array 5 x 7	7.95
TIL308	270	Red	Numerical Display	10.95
TIL309	270	Red	Numerical Display	9.95
TIL311	270	Red	4 x 7 Hexidecimal	10.95
MAN2A	320	Red	Array	5.95
MAN10A	270	Red	Alpha Numeric	8.95
XAN3061	300	Red	Comm Anode Right DP	1.25
XAN3062	300	Red	Comm Anode Left DP	1.25
XAN3063	300	Red	Overflow CA Left DP	1.25
XAN3064	300	Red	Comm Cathode Right DP	1.25
XAN3051	300	Green	Comm Anode Right DP	1.99
XAN3052	300	Green	Comm Anode Left DP	1.99
XAN3053	300	Green	Overflow CA Left DP	1.99
XAN3054	300	Green	Comm Cathode Right DP	1.99
XAN3081	300	Yellow	Comm Anode Right DP	2.10
XAN3082	300	Yellow	Comm Anode Left DP	2.10
XAN3083	300	Yellow	Overflow CA Left DP	2.10
XAN3084	300	Yellow	Comm Cathode Right DP	2.10

IC SPECIAL PURCHASE

LF 13508 JFET Analog Multi 8 bit	8.95
ICM 7045 Precision StopWatch	23.95
CMOS LED Stopwatch/Timer	19.95
ICM 7207 Oscillator Controller	7.50
Seven Decade Counter	18.95
ICM 7209 Clock Generator	6.95
ICL 7107 3½ Digit A/D (LED)	14.95
MC14433P 3½ Digit A/D Converter	13.85
ICL 8211 Voltage Reference	1.95
LM 1850N Ground Fault IC	3/1.00
LM 2900N Quad Amplifier	2/1.00
LM 2917N Freq. to Volt Conv	2/1.99
AY-3-3550 4½ digit DMM	24.95
AY-5-3507 40MHz DVM	9.95
MEM 4963 Mostel Smoke Detector	11.95
27S08 32 x 8 Prom (IM 5600)	2.95
G115M 6 channel Mostel	1.49
ULN 2003A 7 channel Driver	99
2101AL-4	1.95
MCM 14505 64 bit Static Ram	6.95
MOC 1003 (4N28) Opto Coupler	3/1.00
SPX33 Opto Coupler	3/1.00
IH 5045 CMOS Switch DBST	4.50
VA3045 Trans. Array	1.25
TR 1402A UART	1.95
MR 1007 Dyn. Mem. Shift Reg.	3.95
5736 Calc. Con Circuit	2/1.99
5763 Calc. Con Circuit	1.95
5318 TV Ch Disp Circuit	4.50
8080A 8 Bit CPU	4.95
82S21 32 x 2 Static RAM	2/1.99
8700 CJ 8 Bit A/D	9.95
2758 5V-2708 EPROM	12.95
MM5280/VPD 411/C2 107/TMS 4060/ 4Kx1 Dynamic 22 Pin RAM	1.75
6604/VPD 414/4027/2660/MK 4096/ 4Kx1 Dynamic 16 Pin	1.95
New National Clock Tip MM 58167 Real Time	19.95

7520 25	50	LM 387	1.2[illegible]
1488/1489	2/1.99	LM 3302	3/1.99
MK5014 Calc	3/1.99	LM 4558	3/1.99
LM323K	4.95	RC4136	2/1.99
MC1372	8.95	RC 4131	2/1.99
MM5298-4A/B	2.95	COM 5027	39.95
LM 377	1.25	COM 5037	49.95
LM380	1.25	DAC100	15.95

VERBATIM DISKETTES

100% CERTIFIED ERROR-FREE!

● 35 TRACKS DOUBLE DENSITY SINGLE-SIDED 5¼

TYPE	DESCRIPTION	PRICE BOX 10
525-01	Soft Sectored TRS80 etc	$29.95
525-10	10 Hole Hard NS Apple etc	$29.95
525-16	16 Hole Hard Micropolis	$29.95
● 40 & 77 TRACK DOUBLE DENSITY – SINGLE SIDED 5¼ W/HUB REINFORCEMENT RING		
577-01	Soft Sectored TRS 80 etc	$37.25
577-10	10 Hole Hard NS Apple etc	37.25
577-16	16 Hole Hard Micropolis	37.25
● 40 TRACKS DOUBLE SIDED, DOUBLE DENSITY 5¼		
550-01	Soft Sectored SA 450 MPI 52	$39.95
550-10	10 Hole Hard BASF WANGCO	$39.95
550-16	16 Hole Hard Micropolis	$39.95
● 8" 100% CERTIFIED DISKETTES		
FD800-01	Soft Single Density 3740	$33.50
FD800-32	32 Hard Single Density Shug	33.50
FD802-01	Soft Double Density 3740	44.80
FD850-01	Soft Double Sided Double Density 3740	49.80

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WE ALSO STOCK DYSAN-CALL

FLOPPY DISK I/O

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uPd372 Nec Floppy	49.95
1781 Dual Floppy	29.95
1791-01 Dual Floppy	36.95
uPd765 Floppy	49.95

A/D CONVERTERS

8700 8 bit Binary	13.50
8701 10 bit Binary	22.00
8703 8 bit TS	13.50
9400 Volt to Freq Conv	7.25
8750 3½ Digit BCD	13.95
1408L6 6 bit	3.95
1408L8 8 bit	5.95
DAC01 D to A	5.95
DAC08	9.95
DAC 100	15.95

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AY38515 Color Converter	2.95
AY38603-1 RoadraceGame	8.95
AY38606-1 Wipeout Game	9.50
AY38607-1 Shooting Gallery	8.95
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MM5320/21 TV Synch Gen	9.95
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MM57100 NSC Color TV	6.95
MM57104 ClockGen	3.75
RF Modulator w/Audio	8.95
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8038 Function Gen	3.95
MC4024VCO	2.95
LM566VCO	1.95
XR2206 Function Generator	5.25

SHIFT REGISTERS

MM500H Dual25	.50
MM5056N Dual 256	2.95
MM5060N Dual 128	2.95
2510A Dual 100	1.95
2847 Quad80	4.95
3341 Dual80	4.95
3351 40 x 9 FIFO	17.95
3357 Quad80	6.95
9403 16 x 4 FIFO	24.95
9408 10 Bit Sequencer	9.95
3347	5.95

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CTS206-2	1.75	CTS206-7	1.75
CTS206-4	1.75	CTS206-8	1.95
CTS206-5	1.75	CTS206-9	1.95
CTS206-6	1.75	CTS206-10	1.95

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DB25P (RS232)	3.25
DB25S Female	3.75
Hood	1.25
Set w/Hood. Sale	$7.50
22/44 W/W, S/T, KIM	2.95
43/86 W/W, S/T, MOT	6.50
50/100 S-100 Connector w/w	4.95
50/100 S-100 Connector s/t	3.95

NAKED PC

S-100 Sound Board	$34.95
Z-80 CPU/(Ithaca)	34.95
8080A CPU	34.95
16K Static RAM (2114)	29.95
32K Static RAM (2114)	39.95
8K Eprom (2708)	24.95
1702 Eprom Board	30.00
2708/2716 Eprom	34.95
Realtime Clock	34.95
ACP Proto Bd. (3M Conn)	27.95
Vector 8800 Proto	22.20
Vector 8803 11 slot MB	29.95
ACP Extender w/Conn.	18.95
13 Slot MotherBoard (WMC)	32.95
9 Slot MotherBoard (WMC)	29.95
8 Slot Mother (Expandable)	34.95
Proc-Tech Bare Boards	CALL
WMC Floppy PCB	34.95
Floppy PCB (8" SHUGART)	39.95
S100 (AY5-8910) Sound Bd	34.95
Apple Sound Bd	24.95

COMPUTER SPECIALS

DISCOUNTS!

	LIST	SALE
Apple II Plus w/16K		1150.
PET 2001-16N	995	795.
ExidySorcerer w/16K		1099
Cromemco Sys III	6990	6290.
Horizon I w/32K		CALL
Pascal Microengine	1995.	1595.
IPSI 1620 Diablo RO	3295	2695
Anadex DP 8000	995	875.
Centronics Micro S-1	595	525
Soroc IQ 120	995	795
Teletype Model 43	1349	1150.
HiPlot Plotter	1085	899
HiPlot Digitizer	795	735
Intertube II	895	784.
Atari 800	999.	825.
Atari 400	549	449.
TI 99/4	1150	1025.
Leedex 12" Monitor	169.	149.
Centronics 737	995	899.
Trencom T-100	375	349.
Trencom T-200	595.	525
Sanyo 9" Monitor	220.	169
Sanyo 15" Monitor	295	249
Sanyo 13" Monitor		395.

SOCKET SPECIALS

14 Pin w/w-2L	$ .35
20 Pin w/w-2L	.75
18 Pin s/t	.15
22 Pin s/t	.15
14 Pins/t	100/12.00
16 Pin s/t	100/13.00

Call for volume pricing.

TERMS: Use check, M/C, VISA, AMEX, CB, or COD. COD requires 25% deposit. Charge Orders please include expiration date. Foreign pay U.S. Funds. Order by phone, mail or TWX. MINIMUM $10.00. Please include magazine issue and phone no. SHIPPING, U.S.A. add $2.00 for first 2 lbs. For surface add 30¢ for additional lbs. For air add 70¢ for additional lbs. FOREIGN Add 10% shipping and handling. COD's $1.85 extra. Not responsible for typos. Some items subject to prior sale. We reserve the right to limit quantities, some items subject to precious metal adder. Retail pricing may vary from Mail Order. We reserve the right to substitute manufacturer.

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Santa Ana, CA 92705 TWX: 910-595-1565

Circle 7 on inquiry card.

Circle 208 on inquiry card.

U.S. MICRO SALES

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SAVE!

(MINIMUM ORDER $10.00)

This is ABSOLUTELY the LOWEST PRICE EVER for a Hi Speed (300 NS) LO-LO Power 32K RAM. 4K by 1 Chips are organized in Selectable Banks.

* *Extended Address Lines A16 - A17*
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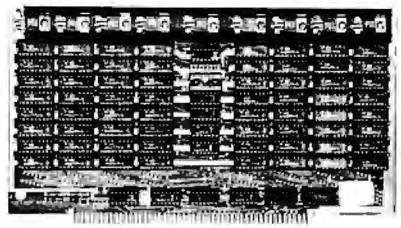
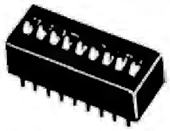
* *9 Regulators*

$299
(KIT)

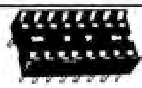


SCHOOLS

DIP SWITCHES



POS.	PRC.
4	.88
5	.92
6	.95
7	.99
8	1.05
9	1.15
10	1.19



PINS	PC	WW
8	.10	.26
14	.13	.29
16	.16	.32
18	.18	.34
20	.22	.38
24	.32	.48
28	.34	.50
40	.45	.61

AMP - Need we say more? There is a difference in sockets! These aren't the lowest prices you can find. But, if you've been"burned" before by bad connections in your computer, a few pennies for the best is worth it!

RESISTORS .02 ea!

(100 PACK) ¼W

1.0	75	2.7K	22K	220K
4.7	100	3.3K	24K	330K
6.8	150	3.9K	27K	470K
10	220	4.7K	33K	680K
15	330	6.8K	39K	1M
22	470	10K	47K	1.5M
27	680	12K	68K	2.2M
33	1K	15K	100K	4.7M
47	1.5K	18K	150K	10M
68	2.2K	20K		

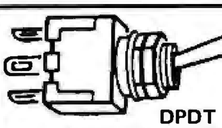
WIRE WRAP WIRE

Packed in 500 Lot Bundles
(Length includes 2" x 1" Strip)
Color — R, Bu, G, Y, Bk, W

50 ft. $1.65 - 100 ft. $3.00 - 500 ft. $9.50

2.5—3.25	4.0—3.75	6.0—4.75
3.0—3.35	4.5—4.00	7.0—5.00
3.5—3.50	5.0—4.50	8.0—5.50
		10.0—6.50

OK WIRE WRAP TOOL $5.95



6 Amps 125 VAC
7 Amps 30 VDC

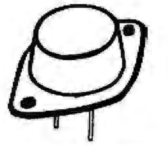
$1.25 ea.

DPDT STANDARD TOGGLE

ST21 (ON-NONE-ON)
ST22 (ON-OFF-ON)
ST23 (MOM ON-OFF-MOM ON)
ST24 (ON-OFF-MOM ON)
ST25 (ON-NONE-MOM-ON)
ST26 (ON-ON-ON)

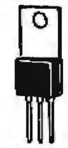
HOBBIEST

LM323K 5V. 3A. REGULATOR



$5.50

TAB MOUNT



7805	+5V	1A
7905	−5V	1A
7812	+12V	1A
7912	−12V	1A

HEAT SINKS 49¢

$1.25

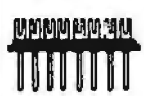
♦ GOLD ♦

S-100-CONNECTOR

TI or Better

SOLDER TAIL	WIRE WRAP
$2.50	**$3.25**

DIP PLUGS



PART#	PINS	PRICE
08DP	8	.40
14DP	14	.55
16DP	16	.58
24DP	24	.95
40DP	40	1.50

Socket and Dip Plug priced based on gold not exceeding $700 per ounce.

CONNECTORS

DUAL ROW .100 PINS	PRICE	CARD EDGE PINS	PRICE
20	2.35	20	3.35
26	3.00	26	3.80
34	3.85	34	4.65
40	4.50	40	5.50
50	5.50	50	5.90

RIBBON — 20 to 34 @ 1.00 ft.
40 & 50 @ 1.30 ft.

CRIMPING 2.00 / CONNECTOR

OEM'S

Z-80-A

$6.95

4MHZ Beastie with extra instructions!

Z-80 SUPPORT

CTC — $6.55
SIO — $25.50
PIO — $6.50
DMA — $18.75

All 4MHZ (who wants 2MHZ?)

74LSXX

74LS00	.33	74LS107	.59	74LS221	2.95
74LS01	.33	74LS109	.59	74LS240	2.95
74LS02	.33	74LS112	.59	74LS241	2.49
74LS03	.33	74LS113	.59	74LS242	1.95
74LS04	.59	74LS114	.49	74LS243	1.95
74LS05	.39	74LS122	.59	74LS244	2.95
74LS06	.39	74LS123	1.19	74LS245	8.95
74LS07	.39	74LS124	1.49	74LS247	1.19
74LS08	.59	74LS125	.89	74LS248	1.19
74LS09	.39	74LS126	.89	74LS249	1.69
74LS10	.29	74LS132	.79	74LS251	1.79
74LS11	.39	74LS133	1.19	74LS253	.95
74LS12	.39	74LS136	.69	74LS257	1.95
74LS13	.69	74LS138	.99	74LS258	1.95
74LS14	1.25	74LS139	.99	74LS259	2.95
74LS15	.49	74LS145	1.25	74LS260	.75
74LS20	1.95	74LS148	1.49	74LS266	1.15
74LS21	3.7	74LS151	.79	74LS273	1.75
74LS22	.29	74LS154	2.49	74LS275	4.39
74LS26	.39	74LS155	1.49	74LS279	.79
74LS27	.49	74LS156	1.49	74LS283	1.49
74LS28	.39	74LS157	1.49	74LS289	5.75
74LS30	.49	74LS158	1.49	74LS290	1.29
74LS32	.95	74LS160	.75	74LS293	1.95
74LS33	1.95	74LS161	1.99	74LS295	1.95
74LS37	.75	74LS162	1.25	74LS298	1.29
74LS38	.39	74LS163	1.25	74LS324	1.75
74LS40	.25	74LS164	2.15	74LS352	1.65
74LS42	1.39	74LS165	1.49	74LS353	1.65
74LS47	.79	74LS166	2.49	74LS365	.95
74LS48	.79	74LS168	2.95	74LS366	.79
74LS35	.25	74LS169	1.95	74LS367	.99
74LS54	.25	74LS170	1.95	74LS368	.99
74LS55	.70	74LS173	1.25	74LS373	2.95
74LS73	.79	74LS174	1.49	74LS374	3.95
74LS74	.59	74LS175	1.49	74LS377	1.95
74LS75	.79	74LS181	2.15	74LS378	1.95
74LS76	.79	74LS189	6.95	74LS379	1.95
74LS78	.49	74LS190	.99	74LS386	.59
74LS83	.95	74LS191	1.95	74LS390	1.95
74LS85	1.49	74LS192	1.95	74LS393	1.95
74LS86	.95	74LS193	1.95	74LS395	1.95
74LS90	.75	74LS194	1.49	74LS490	4.95
74LS92	.75	74LS195	.95	74LS668	1.69
74LS93	.95	74LS196	.95	74LS669	1.89
74LS95	1.29	74LS197	1.95	74LS670	3.55
74LS96	1.29				

Circle 418 on inquiry card.

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Fully compatible with **TRS-80, APPLE II, and S-100**

MPI MODEL B51 $321
TRS-80 plug-in compatible 5.25" single headed 40 track drive. Comes complete with case and power supply. **90 DAY WARRANTY.**

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(No Case or Power Supply)

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MPI MODEL 51	40 tracks, 5 ms.	$254
MPI MODEL 52	Double headed, 80 tracks	$299
MPI MODEL 91	80 tracks	$299
MPI MODEL 92	160 Tracks, Double headed	$399

5.25" POWER SUPPLIES WITH CASE

STANDARD MINI DISK POWER SUPPLY WITH CASE	$80
DELUXE MINI DISK POWER SUPPLY w/CASE & extender card	$131
DUAL MINI DISK POWER SUPPLY w/CASE	$121
DISK DRIVE EXTENDER CABLE	$16

DRIVE CABLES

1 DRIVE TRS-80 CABLE	$24
2 DRIVE TRS-80 CABLE	$29
3 DRIVE TRS-80 CABLE	$35
4 DRIVE TRS-80 CABLE	$40

We'll make any cable! Call us with specs.

THE DOUBLER by PERCOM DATA $203
Double density controller for **TRS-80 Model I.** With data separator. (Use your **PERCOM DISCOUNT** coupon)
DATA SEPARATOR by Percom Data $29
Stops read errors on inner tracks.

SOFTWARE

NEWDOS (40 Track)	$49
NEWDOS + (40Track)	$99
NEWDOS 80	$139
MICROSOFT FORTRAN	$85
Z80 Softcard	$305
Super Utility	$49
Make 80	$14
Electric Pencil (disk)	$130

10% off all **RADIO SHACK** software

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(Prices per box of 10)

		VERBATIM	SYNCOM (NEW)	MEMOREX
5 1/4"	Single sided, single density	$31	$35	$28
	Single sided, double density	$40	$39	$32
	Double sided, single density	$48	N/A	N/A
	Double sided, double density	$48	$52	$40
8"	Single sided, single density	$41	$31	$33
	Single sided, double density	$51	$40	$41
	Double sided, single density	$61	$49	$55
	Double sided, double density	$61	$49	$50

When ordering diskettes, please give us your make and model number of computer or disk drive, or give us the brand and part number of the diskettes you are currently using.

5 1/4" **LIBRARY CASE** holds 10 disks	$3.95
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Refills also available!

16k MEMORY KITS 200 ns $39.00
NEC UPD416C-2 prime dynamic RAM. Compatible with TRS-80, APPLE, or any computer specifying 4116 dynamic RAM.

HOW TO ORDER:
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BY CHECK: Call in your order then send us a cashiers check or money order. This way we can have your order waiting for you when your check arrives. Personal checks require 10-14 days to clear.
BY CREDIT CARD: Just have your **MASTER CHARGE** or **VISA** or **AMERICAN EXPRESS** handy, we'll do the rest.
MAIL ORDERS: NEW ADDRESS 1467 South Michigan Ave., Chicago, IL 60605.
ALL MAIL ORDERS: Send your **NAME** and **STREET ADDRESS** (we ship UPS), **CITY, STATE, ZIP CODE AND TELEPHONE NUMBER** along with your order.
BY CHECK: Include a cashiers check or money order with your order. Personal checks require 10-14 days to clear. For your safety, mail your order via insured mail. **BETTER SAFE THAN SORRY.**
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SHIPPING INFORMATION: We pay all UPS ground service charges (USA only, BLUE LABEL EXTRA) on all items except those denoted with an asterisk (*). (*) items must go airfreight or truck and can be sent freight collect.
FOREIGN ORDERS WELCOME, CALL OR WRITE.
ALL orders F.O.B. Chicago, Il.

WARRANTY INFORMATION: All Equipment carries a 90 day parts and labor warranty, unless otherwise noted. Warranty repair or replacement will be provided at no charge, excluding shipping costs. **10 DAY MONEY BACK GUARANTEE:** If within ten days you return merchandise in new and re-saleable condition we will refund your original purchase price. All refunds, exchanges or repairs include original cartons, packaging, and manuals and be in new and re-saleable condition and accompanied by your original invoice. A 10% re-stocking fee may be charged on returns at our discretion.
Not responsible for typographical errors
Prices subject to change without notice
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What is Jade doing in San Diego?

We've opened a new retail store. To celebrate this latest addition to our family we've reduced our prices on products from SSM, SD Systems, CCS, our own line, as well as our best selling printers, disk drives, and modems. Help us celebrate and we'll help you save money.

PROMS

2708 *450ns*	6.25
10 for $4.90 ea	
2716 *12.5v*	9.95
2716 *5v*	9.95
10 for $7.95 ea	
2532 *5v*	25.00
2732 *5v*	25.00
2758 *5v*	9.95

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21L02A *4 MHz*	1.50
2114L *2 MHz*	3.50
2114LA *4 MHz*	3.75
4116	3.50
4164 *64K x1*	39.95
5257 *2 MHz*	6.75
5257A *4 MHz*	7.25
MK4118	17.95

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AY3-1014A	8.25
TR1602B	5.25
TMS6011	5.95
IM6402	9.00

SUPPORT DEVICES

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8214	4.65
8216	2.95
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8226	3.85
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8243	8.00
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6809	39.95
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Z-80 SUPPORT

3881 *PIO*	8.75
3881-4 *PIO 4 MHz*	12.95
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Novation Cat Modem

300 baud, answer and originate

(We have only 700 availible at this special price)

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D-CAT 300 baud, direct connect modem

IOM-5201A *Special sale price* **$189.00**

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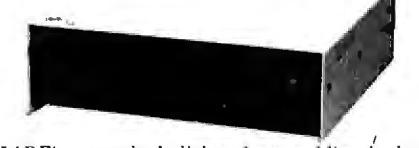
IOM-5230A *Special sale price* **$239.95**

MICROMODEM - D.C. Hayes

Auto answer/dial modem card for Apple or S-100

IOM-2010A *Apple modem* **$349.95**
IOM-1100A *S-100 modem* **$375.00**

Disk Drives



JADE's new dual disk sub-assemblies include: ***Handsome** metal cabinet with **proportionally balanced** air flow system, **assembled & tested** dual drive power supply, **quiet whisper type** cooling fan, power-cable kit, lighted power switch, approved fuse assembly, line cord, **Never-Mar** rubber feet, and all necessary hardware to mount 2-8" disk drives - it's **all American made, guaranteed for six months**, and it's in stock!*

Dual 8" Sub-Assembly Cabinet

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Single sided, double density disk drive sub-system

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END-000427 *A & T w/2 8" drives* **$1695.00**

8" DISK DRIVES

Highly reliable double density floppy disk drives

Shugart 801R single sided, double density

MSF-10801R *SA-801R* **$425.00**
Special Sale Price .... ***2 for $790.00***

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MSF-10851R *SA-851R* **$595.00**
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MSF-201120 *6 mo warranty* **$385.00**
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Qume Datatrak 8 double sided, double density

MSF-750080 *SA-851R compatible* .. **$599.95**
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JADE DISK PACKAGE

Double density controller, two 8" double density floppy disk drives, CP/M2.2 (configured for controller), hardware and software manuals, boot PROM, cabinet, power supply, fan, & cables

Special package price **$1395.00**

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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.

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16K RAM Card - Microsoft

(There is life after 48K)

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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*

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Real time clock w/battery back-up

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23% more storage, 8 times faster, 40 track with free patch, 120 day warranty, includes case, power supply, and cable

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The ultimate program for your Apple II

SFA-24101005M *Complete package* **$139.95**

PRINTER INTERFACE - C.C.S.

Centronics type I/O card w/ firmware

IOI-2041A *A & T* **$99.95**

AIO, ASIO, APIO - S.S.M.

Parallel & serial interface for your Apple (see Byte pg 11)

IOI-2050K *Par & Ser kit* **$129.95**
IOI-2050A *Par & Ser A & T* **$159.95**
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**

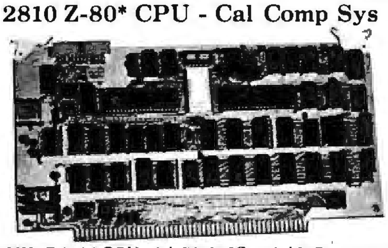
A488 - S.S.M.

IEEE 488 controller, uses simple basic commands, includes firmware and cable, 1 year guarantee, (see April Byte pg 11)

IOX-7488A *A & T* **$399.95**

S-100 CPU

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

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* $145.00
CPU-30201A *A & T* $199.00
CPU-30200B *Bare board* $35.00

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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* $199.95
CPU-30300A *A & T* $239.95

SBC-200 - SD Systems

4 MHz Z-80 CPU with serial & parallel I/O ports, up to 8K of on-board PROM, software programmable baud rate generator, 1K of on-board RAM, Z-80 CTC.*

CPC-30200K *Kit* $339.95
CPC-30200A *Jade A & T* $399.95

S-100 Disk Controller

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 *8" A & T* $389.95
IOD-1205A *5¼" A & T* $389.95
IOD-1200B *Bare board* $65.00

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* $369.95

VERSAFLOPPY II - SD Systems

New double density controller for both 8" & 5¼"

IOD-1160K *Kit* $379.95
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S-100 Video

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* $345.00
IOV-1095A *4 MHz A & T* $395.95
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-1020K *Kit* $399.95
IOV-1020A *Jade A & T* $459.95

VIDEO BOARD - Jade

64 characters x 16 lines, 7 x 9 dot matrix, full upper/lower case ASCII character set, numbers, symbols, and greek letters, normal/reverse/blinking video, S-100.

IOV-1050K *Kit* $99.95
IOV-1050A *A & T* $125.00
IOV-1050B *Bare board* $19.95

MAINFRAME - Cal Comp Sys

12 slot S-100 mainframe with 20 amp power supply

ENC-112106 *A & T* $429.95

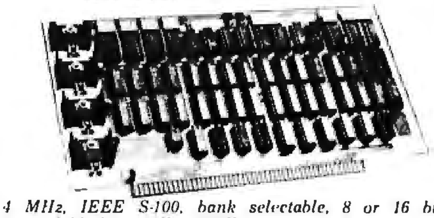
ASCII KEYBOARDS - Microswitch

58 key plus numeric pad and control keys

KBA-99058 *A & T* $39.95

S-100 Memory

MEMORY BANK - Jade



4 MHz, IEEE S-100, bank selectable, 8 or 16 bit, expandable from 16K to 256K

MEM-99730B *Bare board* $55.00
MEM-99730K *Kit, no RAM* $219.95
MEM-16730K *16K kit* $249.95
MEM-32731K *32K kit* $289.95
MEM-48732K *48K kit* $324.95
MEM-64733K *64K kit* $359.95
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 / Z-80 / front panel compatible.

MEM-64565A *A & T* $575.00

EXPANDORAM II - S D Systems

4 MHz RAM board expandable from 16K to 64K

MEM-16630K *16K kit* $275.95
MEM-32631K *32K kit* $295.95
MEM-48632K *48K kit* $315.95
MEM-64633K *64K kit* $335.95
Assembled & tested .... add $50.00

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 - Cal Comp Sys

2 or 4 MHz 16K static RAM board, IEEE S-100, bank selectable, Phantom capability, addressable in 4K blocks

MEM-16160A *16K 2 MHz A & T* ... $286.95
MEM-16162A *16K 4 MHz A & T* ... $289.95
MEM-16160B *Bare board* $50.00

PB-1 - S.S.M.

2708, 2716 EPROM board with built-in programmer

MEM-99510K *Kit* $139.95
MEM-99510A *A & T* $199.95

PROM-100 - SD Systems

2708, 2716, 2732, 2758, & 2516 EPROM programmer

MEM-99520K *Kit* $219.95
MEM-99520A *Jade A & T* $269.95

S-100 I/O

I/O-4 - S.S.M.

2 serial I/O ports plus 2 parallel I/O ports

IOI-1010K *Kit* $159.95
IOI-1010A *A & T* $219.95
IOI-1010B *Bare board* $35.00

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* .. $199.00
IOI-1045A *A & T* $259.00
IOI-1046K *4 CTC's, 2 SIO's, 1 PIO* $259.00
IOI-1046A *A & T* $319.00
IOI-1045B *Bare board w/ manual* ... $59.95
IOI-1045D *Manual only* $20.00

Software

CP/M 2.2 - Digital Research

Latest & most powerful release of CP/M

SFC-52506000D *Manual set* $24.95
SFC-52506000M *5¼" disk & manual* $149.95
SFC-52506000F *8" disk & manual* $149.95

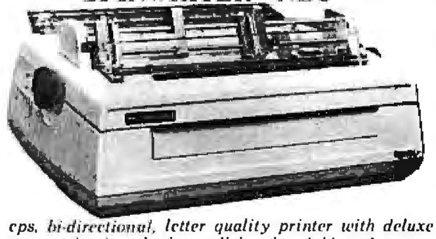
SDOS - SD Systems

DOS, CBASIC-2, Z-80 assembler/editor/linker*

SFX-55001000D *Manual set* $24.95
SFX-55001002M *5¼" disks & man* $199.95
SFX-55001006F *8" disk & manual* $199.95

Printers

SPINWRITER - NEC



65 cps, bi-directional, letter quality printer with deluxe tractor mechanism, both parallel and serial interfaces on-board, 16K buffer, ribbon, print thimble, graphics, micro-space justification, data cable, and self test/diagnostic ROM.

PRD-55511 *without 16K buffer* ... $2795.00
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MX-80 - Epson

132 column, 9 x 9 dot matrix, multiple fonts

PRM-27080 *Save $100.00* .... Call

MX-70

PRM-27070 With Graftrax II .... Call
Interface for Apple $110.00

CENTRONICS 737-1

9 x N dot matrix, letter quality, proportional spacing

PRM-15737 *Parallel* $725.00
With interface for Apple $825.00

Single Board Computers

Z-80* STARTER KIT - SD Systems

Complete Z-80 computer with RAM, ROM, I/O, display, keyboard, manual, and kluge area.*

CPS-30010K *Kit* $369.95
CPS-30010A *Jade A & T* $459.95

AIM-65 - Rockwell

6502 computer with alphanumeric display, printer, & keyboard, and complete instructional manuals

CPK-50165 *1K AIM* $449.95
CPK-50465 *4K AIM* $499.95
SFK-74600008E *8K BASIC ROM* ... $99.95
SFK-64600004E *4K assembler ROM* ... $84.95
PSX-030A *Power supply* $64.95
ENX-000002 *Enclosure* $54.95

4K AIM, 8K BASIC, power supply, & enclosure

Special package price $675.00

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Bargain prices on magnificent magnetic media

5¼" single sided, single density, box of 10

MMD-5110103 *Soft sector* $27.95
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5¼" double sided, double density, box of 10

MMD-5220103 *Soft sector* $39.95

8" single sided, single density, box of 10

MMD-8110103 *Soft sector* $33.95

8" single sided, double density, box of 10

MMD-8120103 *Soft sector* $39.95

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MMD-8220103 *Soft sector* $49.95

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19" rack mountable, adjustable, holds 21 cards

VCT-CCK100 *Anodized Al* $47.95

Metal cage with card guides & fan mounting

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Circle 207 on inquiry card.

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MEMOREX 8"DISKETTES

$25 WITH FREE LIBRARY CASE

Recently the Memorex Corporation had a cancellation on a contract for a truck load of eight inch diskettes. California Digital was fortunate to be offered this load of prime magnetic media.

These diskettes are "UNBRANDED" but are guaranteed first quality Memorex Brand. (#3060 single den.)

Like all diskettes sold by California Digital, a library case is supplied free with the purchase of every box.

This offer is subject to remaining inventory on hand.

SUPER BUY

World's Best Selling Printer

EPSON MX80

Immediate Delivery

Only $475

Correspondence quality printing.
A lot of printers costing a lot more can't touch the MX-80's performance. It gives you a choice of 40, 80, 66 or 132 columns of printing in as many as four distinct printing density modes, a total of twelve different combinations which can accommodate nearly any printing requirement.

Bidirectional printing. Logical seeking of shortest lines. 80 CPS. 64 graphics characters. Forms handling. The list of standard features goes on and on. The fact is that there are few printers that can compete with the MX-80 at ANY price. And none—ZERO—in its extraordinarily affordable price range.

ABCDEFGHIJKLMNOPQRSTUVWXYZABCDEFGHIJ

NEW

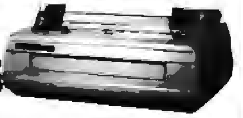
from INTEGRAL DATA

460 Paper Tiger

with GRAPHICS **$1150**

The 460 Paper Tiger uses a dot matrix character formation technique in which the placement of the dots overlap both horizontally and vertically to achieve a correspondence quality printing.
The printer's nine-wire print head uses staggered needle rows to create the vertically overlapping dots. The head is driven bi-directionally under microprocessor control by a stepper motor driven mechanism.
"Two-K" buffer allows the printer to accept the entire content of a 1,920 character CRT screen. With graphics suggested retail price $1,395 27 lbs. PRG-460G

NEC Spinwriter 5510P/S $2795



The word processing quality Spinwriter prints at speeds upto 55 characters per second. The Model 5510 P/S is supplied with both parallel and RS-232 serial interfaces. Also included is the tractor feed mechanism, along with print thimble and ribbon. PRA-5510PS 70 lbs.
Keyboard (KSR) Model 5520 P/S available $2095. PRN-5520PS 75 lbs.

TEC V-300 Word Processing

DaisyWheel Printer

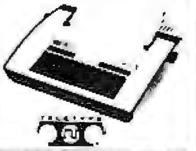
$1595

Finally a reasonably priced letter quality printer... Bi-directional printing at 25 characters per second. Full 136 print positions wide. Proportional spacing 1/120" horizontal, 1/48" vertical.
Uses standard Diablo brand interchangable daisy print wheels.
Intel 8085 CPU microprocessor controlled. Interfaces via Centronics parallel connector. Shipping 58 lbs. PRV-300.

TELETYPE® MODEL 43

4320 KEYBOARD MODELS

TTL serial output	AAA	$ 995
RS232 serial	AAK	1050
Friction 80 column	AAE	1100
Friction 80 RS232	AAL	1195
Bell 103 Modem	AAB	1495



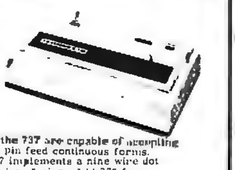
Ultra-Violet Products UVS 11-E

UV EPROM ERASER

$65

CENTRONICS

730	$595
737	$750



Both the Centronics 730 and the 737 are capable of accepting standard office letterhead or pin feed continuous forms. For higher resolution the 737 implements a nine wire dot matrix print head. Parallel interfacing. Add $65 for RS232. PRC-730P (S). PRC-737P (S) 17 lbs.

IBM 3101 Display Terminal

IBM Direct Price $1295

California Digital discount price $1195

AMPEX DIALOGUE 80 CRT TERMINAL

$995

New from the Ampex Corporation: The Dialogue 80 features [illegible] VDT-D80 [illegible]

VIDEO TERMINALS

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
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Digital Equipment VT-100	VDT-V100	1595
Digital Equipment VT-132	VDT-V132	1895
Direct VP-800A emulator	VDT-P800	call
Hazeltine 1410	VDT-H1410	750
Hazeltine 1420	VDT-H1420	795
Hazeltine 1500	VDT-H1500	850
Hazeltine 1510	VDT-H1510	1025
Hazeltine 1520	VDT-H1520	1225
Hewlett Packard 2621A	VDT-HP21A	
Hewlett Packard 2621P	VDT-HP21P	
IBM 3101-10 character mode green	VDT-3101	1195
IBM 3101-20 block mode	VDT-31012	1395
Lear Seigler 3A upper case only	VDT-L3A	850
Lear Seigler ADM5	VDT-L5	945
Lear Seigler ADM31	VDT-L31	1385
Lear Seigler ADM42	VDT-L42	1995
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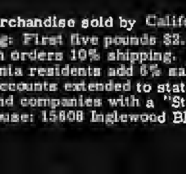
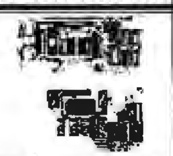
Soroc IQ 140 detatchable keyboard	VDT-Q140	1150
Televideo 912C	VDT-T912	665
Televideo 920C	VDT-T920	745
Televideo 950C detatchable keybd.	VDT-T950	985
Zenith Z-19	VDT-Z-19	735

VIDEO MONITORS



BMC KG12C 18MHz P-31 grn phosphor	$259
Leedex/Amdek 12"100	129
Leedex 100 green	169
Leedex 100-80	197
Hitachi color 13"	389
Zenith color 13"	379
NEC green phosphor	219
Panasonic color 10"	
Sanyo 9" BW	149
Sanyo 12" green phos.	235
Sanyo 15" BW	259
Sanyo 13" color	419

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	80
Calender/Clock, Bat. back-up 7424	110
Parallel Interface 7720A	99
Programable Timer 7740A	89
Analog/Digital converter 7470A	99
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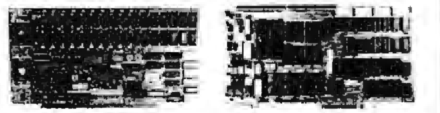
Apple to Z-80 CPU card	379
D. C. HAYES PRODUCTS	
Micromodem for Apple	319
COMPUTER STOP PRODUCTS	
Double Vision / 80 Column Video	250
INTERACTIVE STRUCTURES	
16 Channel A/D card AIO/2	275

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 without 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	239
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
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Calif. Computer 2200A 12 slot & power supply	ENM-C2200	349
TEI 12 slot table	ENM-T12	495
TEI 22 slot table	ENM-T22	650
Godbout mainfrm.	ENM-GMF	
MEMORY BOARDS		
Calif. Computer 2065A 64K dyamic memery	BDM-C2065	$420
Calif. Computer 2016 16K static memory	BDM-C2016	259
Calif. Computer 2032 32K static memory	BDM-C2032	385
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	99
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	419
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
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QT Computer real time clock/calendar	BDS-QCK	135
Artec Elec. Wire wrap prototype board	BDS-AWW	25
Artec Elec. General Purpose proto board	BDS-AGP	25
Godbout Spectrum color board	BDS-GSC	295
D. C. Hayes S-100 Micromodem	BDS-HMI	350
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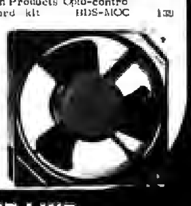

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Circle 57 on inquiry card.

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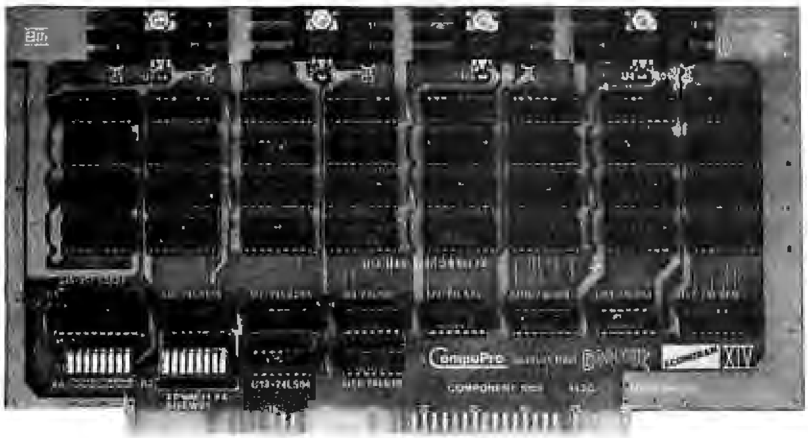

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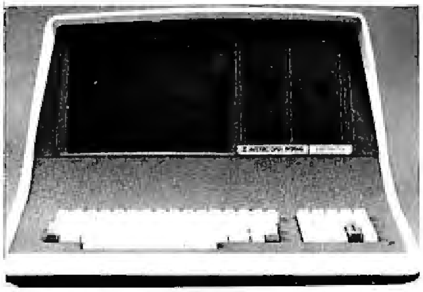

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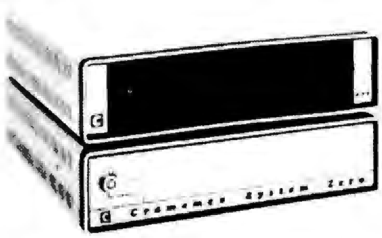

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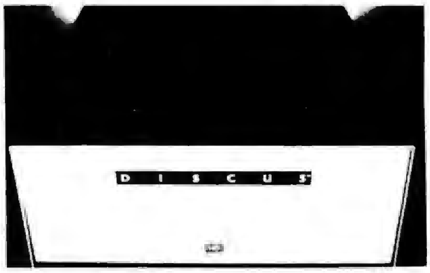

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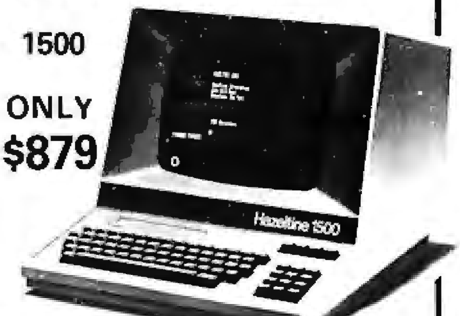

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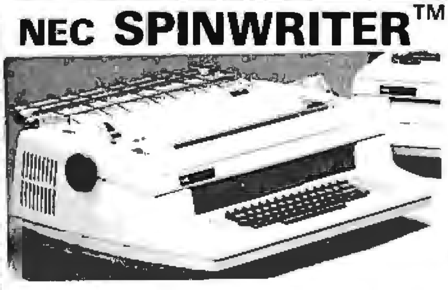

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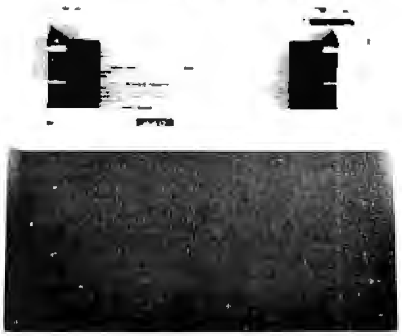

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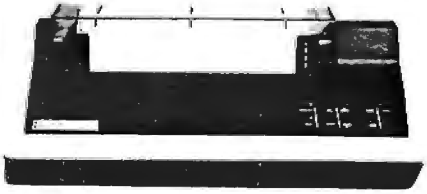

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These notices are free of charge and will be printed one time only on a space available basis. Notices can be accepted from individuals or bona fide computer users clubs only. We can engage in no correspondence on these and your confirmation of placement is appearance in an issue of BYTE.

Please note that it may take three or four months for an ad to appear in the magazine.

FOR SALE: Pascal microengine, Western Digital WD90 (includes factory power supply and cabinet). High-speed UCSD Pascal computer with 64 K memory, single- and dual-density 8-inch floppy software, and all documentation. $1200 plus shipping. Dave Werner, (212) 998-3929.

FOR SALE: GE Terminet 300 ASCII terminal with digital cassette, adjustable tractors, 10-15-30 cps, paper out, etc. Letter-like quality, not dot-matrix. Also, GE acoustic coupled modem (Bell 103). All in excellent condition. Execute commands from disk file with Command Processor software. Includes RTC, printer formatting, dynamic I/O reconfiguration, plus fifteen more commands for North Star Disk (Horizon). Please send SASE. Rich Adamson, 7310 Adams, Lincoln NE 68507, (402) 464-0718.

FOR SALE: Hazeltine 1500 CRT; $700, Hazeltine 1520 CRT; $1100, DEC LA-36; $1250, Omnitech acoustic coupler; $150, Novation CAT acoustic coupler; $150. Above items less than three years old and working. 200 new vacuum tubes; $300, 55 new Calectro & Lafayette panel meters; $165. Buyer pays shipping. Charles B Wall, Rte 3 Wingate, Clarksville TN 37040, (615) 552-2199.

FOR SALE: Twenty-four conductor (shielded coax) computer grade cable, ½-inch O/D vinyl clad bundle. Ideal for low-noise interfaces. Conductors appear to be silver plated and dielectric is teflon. SASE brings conductor sample. $0.95/foot plus postage and handling. Maximum of thirty foot lengths. Also, wanted: rack-mount multidrive 8-inch floppy-disk system. Jim Beistle, POB 501, Gilbert AR 72636, (501) 439-2305.

FOR SALE: SwTPC Model MP-68. All working with documentation, PIA, and 4 K programmable memory; $200. Two 4 K programmable memory boards; $75 each. 8 K programmable memory board with boundary switch; $150. Two MPS serial interfaces; $35 each. MP-LA parallel interface; $35. AC-30 dual cassette interface; $75. $600 takes it all. Herbert Friedman, POB 153, Malverne NY 11565, (516) 481-2717.

FOR SALE: Digital Group TVC-F 512-character video programmable memory/1.1 Kbaud audio-cassette board with all documentation. Assembled and in perfect working order. Also, listings for Z80 operating system, and documentation and listing for EDFORM1 text editor. All for $95 including UPS shipping, or make offer. Martin Tobias, POB 3766, Nashua NH 03061, (603) 889-0901.

FOR SALE: Texas Instruments TI-59 and PC-100 print cradle with all documentation and manuals. In mint condition; $150 or trade for HP-97. Also, HP-67/97 Stat Pac 1, ME1, EE1, CE1, Surveying, Navigation, and Business Decisions Pac; all for $50. Charlie Truax, 2862 King Edward Dr, El Dorado Hills CA 95630, (916) 933-3478 evenings.

FOR SALE: Extra paper, 14- and 8½-inch widths. $15 a box or trade for a TRS-80 disk drive. Van, (616) 429-6788.

FOR SALE: Perkin-Elmer letter-quality printer. KSR, 110 to 300 bps, good condition, switch-selectable U/C or full ASCII, half or full duplex, RS-232C. Bill Touchstone, (216) 333-3114 9:30 AM to 5 PM weekdays.

FOR SALE: 150 lpm Centronics P1 printer (same as Radio Shack Quick Print) with cable to a TRS-80. Excellent condition, $265 (50% of list). D E Johnson, RD 2, Box 197, Corning NY 14830, (607) 524-6740.

FOR SALE: IBM Selectric remote I/O terminal, with ASCII conversion, RS-232, as sold by Worldwide for $645. Fully checked out with manual. Best offer over $400. Steven Mather-Lees, 6 Holly Ln, Hudson NH 03051.

FOR SALE: Antique computer system. 1954 Royal McBee LGP-30, 800 lbs, desk size. 6.5- by 7-inch magnetic drum memory holds 4096 words, 32 bits per word. 113 electron tubes, 1450 diodes, and 34 plug-in cards. Two Friden Flexowriters, paper-tape punch, and plotter. Internal CRT for display in registers. Best offer over $5000. Richard Petras, (215) 356-6637.

FOR SALE: Kilobaud Microcomputing issue #6 (June 1977) through issue #18 (June 1978) in very good condition. Complete, some marks. Best offer. Daniel O Dye Jr, 4861 Gray St, Denver CO 80212.

FOR SALE: IBM 3767 communications terminal. Excellent condition, with forms feeder and cables. Make offer, will sacrifice. Barney Lejeune, POB 3935, Lafayette LA 70502.

FOR SALE: SD Systems VDB-8024 video board; $275. Selectric typewriter, Model 73, with Micromation S-100 interface; $500. Sanyo 15-inch video monitor; $150. Cromemco 8 K Bytesaver with 2708 programmer for S-100; $75. Processor Technology 3P+S parallel/serial I/O board, S-100; $50. Keytronics keyboard with numeric keypad and enclosure; $175. SwTPC KBD-5 keyboard with enclosure; $30. George East, 38 Edwin St, Randolph MA 02368, (617) 963-2265.

FOR SALE: Centronics 730 7 by 7 matrix printer, same as RS Line Printer II. Almost new, in perfect working condition. $560. Also, adapter port when no EI for $20. G Kish, 227 W Meadow Rd, Rockaway NJ 07866, (201) 627-0052 evenings.

FOR SALE: Heathkit H-19, smart video terminal, assembled and tested; $700. Heathkit H-14, microprocessor-based printer, assembled; $700. SD Systems Expandoram 48 K, assembled and tested; $300. Jade Double-D, double-density, 5-inch or 8-inch floppy-disk controller with cable for 8-inch drive, assembled; $350. Everything includes documentation, manuals, schematics, etc. James Gerber, 12850 Kern Rd, Mishawaka IN 46544, (219) 259-9929.

FOR SALE: One almost new CAT/Novation modem, works very well; $100. One almost new Apple II disk drive with DOS 3.3 controller; $425 or best offer. Jon Taute, 2314 S 40th St, Omaha NE 68105, (402) 556-6695 evenings only.

FOR SALE: Z80 computer: 4 K programmable memory, monitor, keyboard, readout-cassette interface. EPROM programmer with sixteen I/O ports S-100; $325. State logic analyzer: 16-bit input, 5 MHz, 16 LED, 4 hexadecimal readout edge clocking, forward and backward stepping; $390. 6809 computer: monitor, Editor/Assembler, RS-232, sixteen I/O ports, timer, cassette interface; $400. Mitra Gopaul, 3 Weymouth Ave, Toronto Ontario, M4C 1R6 Canada, (416) 698-4405.

FOR SALE: Three Godbout memory boards with 8 K. Fully assembled and tested. All for $280 or $95 each. TI SR-52 calculator with PC-100 printer. $260. SSM V81 video board. Fully assembled and tested. $100. I pay shipping. Chuck Terra, 8415 Bird Run, Missouri City TX 77489, (713) 437-1242 after 4 PM.

FOR SALE: Execuport 300 portable terminal. Hard copy, built-in acoustic coupler, carrying case. Can also be used as printer. $600 plus shipping. M A Graziano, (203) 563-5750 after 9 PM.

FOR SALE: Teletype Model ASR33 in mint condition. Used as a system console, upgraded to a CRT. Will sell for best offer. David Wong, 1916 Grand Conc, New York NY 10457, (212) 294-8087 evenings.

FOR SALE: North Star 48 K double-density, two serial ports, one parallel output and one parallel input port, two 5-inch DD disks; $3100. Intertube II, reverse video, dual intensity, extra RS-232 port, absolute addressing, protected data mode, line drawing graphics, 25 by 80, keypad; $650. L A Ludden, 30 Blanchard Rd, Marlton NJ 08053.

FOR SALE: 64 K Digital Group (Bytemaster) complete system, with Oasis 5.4, in perfect condition. Only $2500. S E Rudlin, 4600 Grove Ave, Richmond VA 232_9, (804) 353-1000.

FOR SALE: S-100 boards: Biotech CGS-808 color graphics with 6847 and 4 MHz 8085 processor on board; $275, Bytesaver I; $75, Polly (VTI) video-display board, 16 by 64 characters with graphics symbols; $60, Cromemco JS-1 joystick; $50. Edward March Jr, 2093 Fox Ln, Des Plaines IL 60018, (312) 635-7625 home, (312) 541-7300 work.

FOR SALE: NCR Model 761 cassette deck (Phillips-type). Computer controllable play, record, fast forward, reversed; $250. E J Haas, 3448 S Marcella Ave, Stow OH 44224.

FOR SALE: 8800B 18-slot mainframe; $400. MITS 3203 dual-disk drive; $800. MITS 16MCS 16 K static-memory card; $200. MITS 32-sector disk controller; $600. Pertec FD-410 drives; $300. 88-2SIO serial interface card; $200. QUME Sprint Micro 3 interface card; $200. 88-Prom 1702 prom programmer for 8800B; $150. LA-36 DECwriter II; $800. Gene Friesen, 6435 Colby, Lincoln NE 68505, (402) 467-1903.

FOR SALE: Netronics ELF II boards. Two 4 K programmable memories. Each $72, both $135. Giant Mon and I/O board; $30. Full BASIC (EPROM) board; $120. All for $260. All boards are wired and tested. Robert Foltz, 1911 Mulford Ave, Bronx NY 10461, (212) 863-0964 after 6 PM ET.

FOR SALE: These items by Percom: Data Separator; $15, Microdos (OS-80 version 1.14); $15, Patchpak; $4.50. All complete with manuals. Add $1 for shipping and handling. Albert Nijenhuis, 4310 Osage, Philadelphia PA 19104, (215) 222-1279.

FOR SALE: Altair 8800b computer with 32 K memory, one serial I/O port, ACR cassette-interface board, 2 K PROM board, MBL and DBL bootstrap PROMs, 3202 dual 8-inch disk drive and controller, Lear-Siegler ADM3A video-display terminal, Altair (Microsoft) cassette 8 K BASIC, cassette Extended BASIC, Disk Extended BASIC, and Altair disk operating system. All in perfect condition. Original value over $7300. Asking $4380 or reasonable offer. B Verner, 11404 Woodland Dr, Lutherville MD 21093, (301) 828-8422 evenings.

FOR SALE: Houston Instrument 11- by 11-inch bitpad. James Kientz, RR #1, Wamego KS 66547, (913) 532-3722.

WANTED: Tax-deductible donations are urgently needed. We are engaged in many building and maintenance projects and need CB radios, antennas, lighting apparatus, microscope attachments, and video equipment. Paul Oravis c/o Queen Anne School, 14111 Oak Grove Rd, Upper Marlboro MD 20870.

FOR SALE: Manuals, schematics, and spare boards for Sanders Associates Model 720 Data Display System. Jeff Weger, 614 Willowood Dr, Apt 209, Carol Stream IL 60187.

FOR SALE: IMSAI multiple I/O (MIO) board. Two parallel ports, one serial port, one control port, and a Tarbell tape-cassette interface plus two cables and documentation. Best offer. Eric Aronson, N64 W26611 Hillcrest Cir, Sussex WI 53089, (414) 246-3518 evenings.

BOMB

BYTE's Ongoing Monitor Box

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February BOMB Falls on Tank

Steve Ciarcia captured first place in the voting with "A Computer-Controlled Tank" (page 44), a description of his effort at wireless remote control. He will receive the $100 prize.

James C Anderson took second place with "An Extremely Low-Cost Computer Voice Response System" (page 36), the lead article in our issue theme of "The Computer and Voice Synthesis." He wins the $50 second-place prize.

Third place was shared by Mark Zimmermann, who wrote "A Beginner's Guide to Spectral Analysis, Part 1" (page 68), and Roger Mikel, who contributed "A/D and D/A Conversion—An Inexpensive Approach" (page 312).

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20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520	540	560	580	600	620	640	660	680	700

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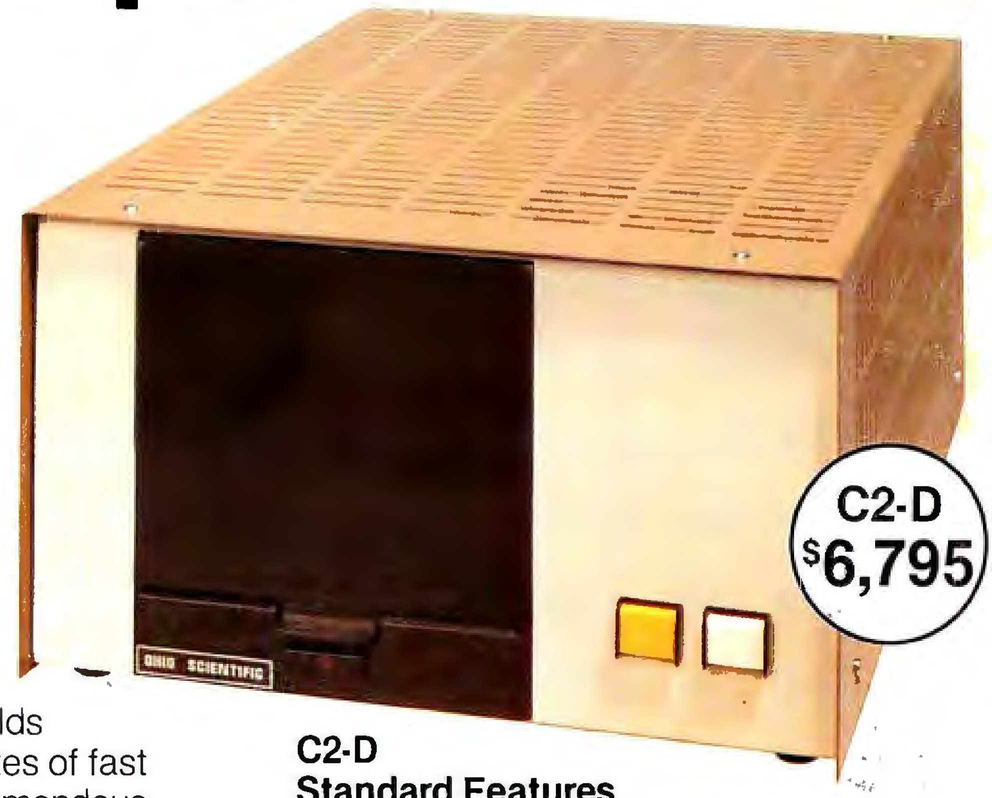

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