

# BYTE

the small systems journal

MAY 1981 Vol. 6 No. 5  
\$2.50 in US/\$2.95 in Canada

A McGraw-Hill Publication



**SOFTWARE PIRACY**

**ROBERT  
ST. JAMES**



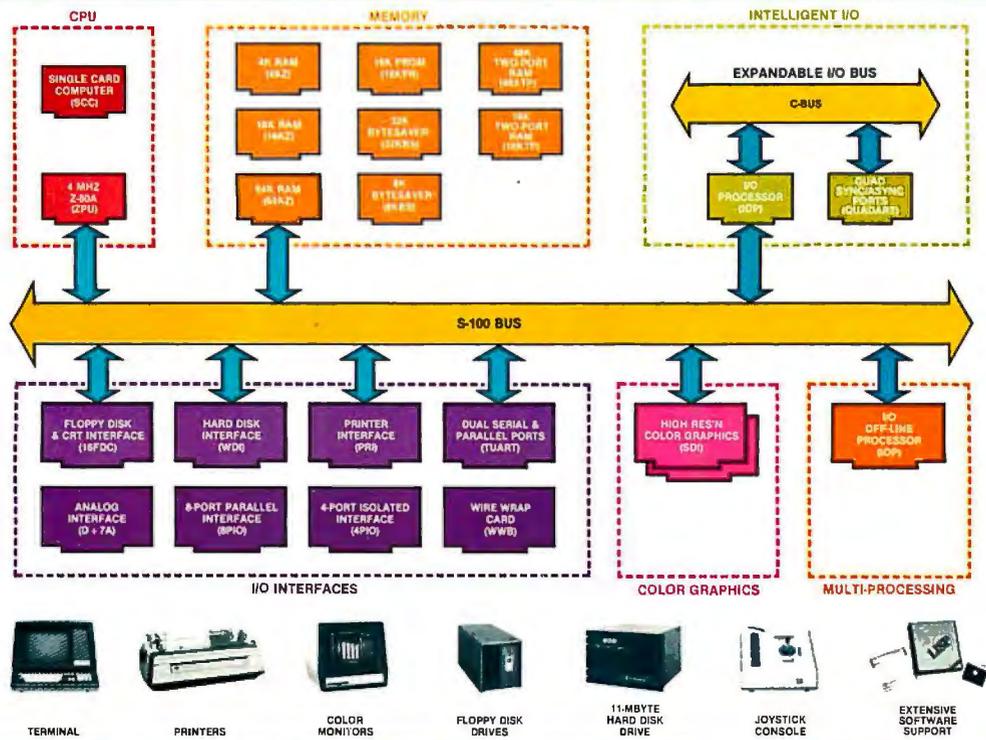
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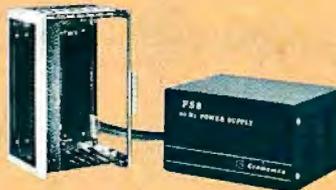
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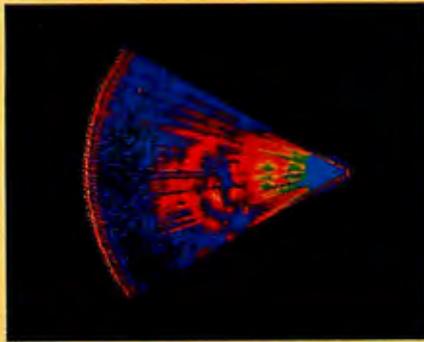
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High-resolution display with alphanumeric

## Get the professional color display that has BASIC/FORTRAN simplicity

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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.

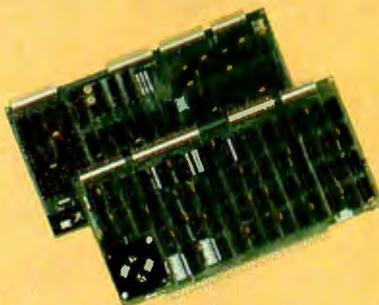
The resolution surpasses that of a color TV picture.

### 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

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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.

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

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### 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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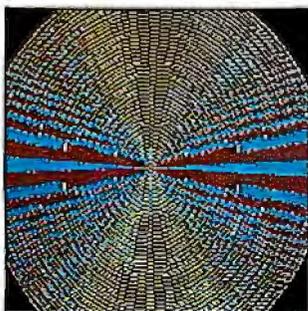
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## BYTE



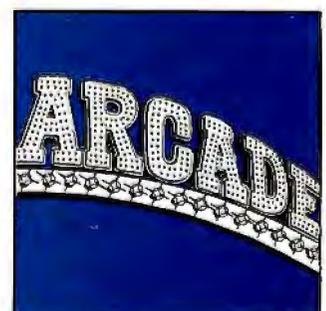
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## In This Issue

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."

BYTE is published monthly by BYTE Publications Inc, 70 Main St, Peterborough NH 03458, phone (603) 924-9281, a wholly-owned subsidiary of McGraw-Hill, Inc. Address subscriptions, change of address, USPS Form 3579, and fulfillment questions to BYTE Subscriptions, POB 590, Martinsville NJ 08836. Controlled circulation postage paid at Waseca, Minnesota 56093 - USPS Publication No. 528890 (ISSN 0360-5280). Canadian second class registration number 9321. Subscriptions are \$19 for one year, \$34 for two years, and \$49 for three years in the USA and its possessions. In Canada and Mexico, \$21 for one year, \$38 for two years, \$55 for three years. \$43 for one year air delivery to Europe. \$35 surface delivery elsewhere. Air delivery to selected areas at additional rates upon request. Single copy price is \$2.50 in the USA and its possessions, \$2.95 in Canada and Mexico. \$4.00 in Europe, and \$4.50 elsewhere. Foreign subscriptions and sales should be remitted in United States funds drawn on a US bank. Printed in United States of America.

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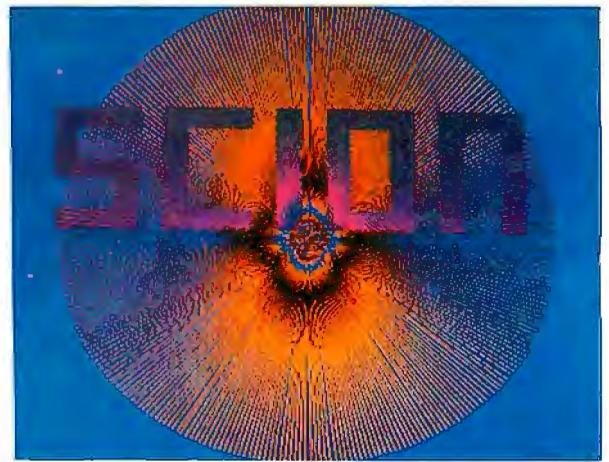
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BYTE, Product Review



"...better monochromatic display..."

ELECTRONIC DESIGN, 1981 Technology Forecast

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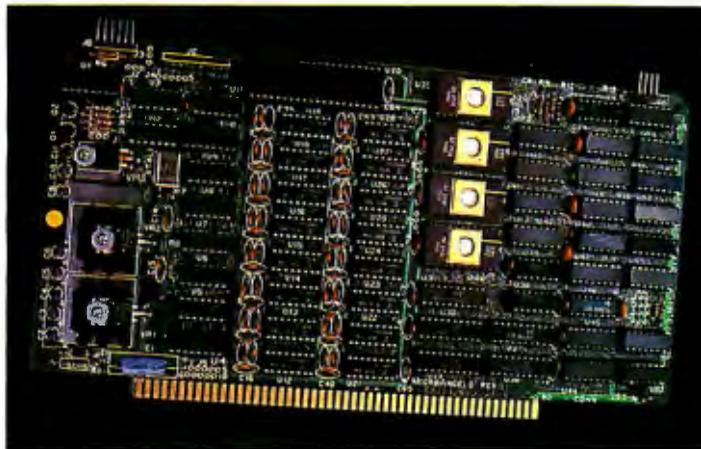
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4K resident Screenware™ Pak I operating system

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High speed communications over parallel bus ports

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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.

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**MILESTONE** requires 48K RAM & CP/M. Also available for Apple Pascal or UCSD Pascal Operating System. Formats: 8" single density IBM soft-sectored, NorthStar DD, Micropolis Mod II, Superbrain 3.0, Apple II. Price is \$295. Manual alone—\$30. Add \$7.00 for shipping.

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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.

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### 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**

Quality Percom products are available at Percom dealers nationwide. Call toll-free, 1-800-527-1592, for the address of your nearest dealer, or to order direct from Percom.

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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.

### 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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- Front Panelless desk top model—a lower cost option for OEM or other turnkey operations which do not require the extra capability of our Front Panel.
- Rack Mount version — features a heavy gauge frame designed to fit into standard 19" racks. CVT power supply for brown out immunity is standard.

\*In Calculus, a fundamental statement in the definition of limit; interpreted here to imply: "For your integration problem, Intersystems has a solution."

† Registered trademark of Zilog, Inc.

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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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# Letters

## 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" in-

to 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.*

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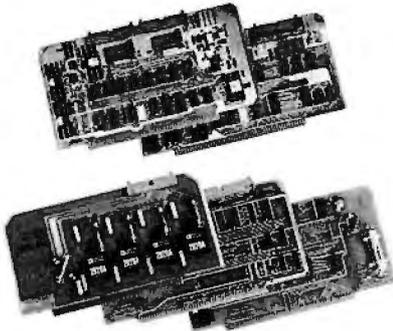
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## Letters

### 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 beautiful-

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

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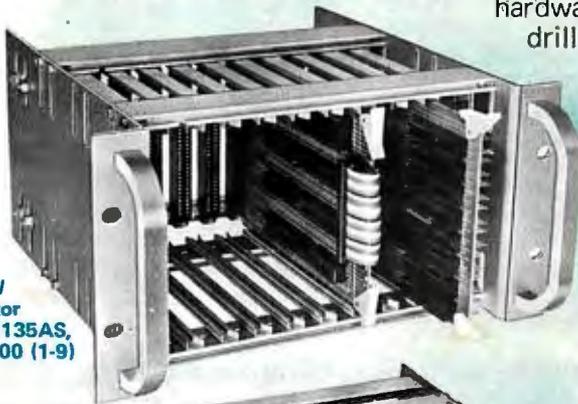
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## BYTE's BOMBworks

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.

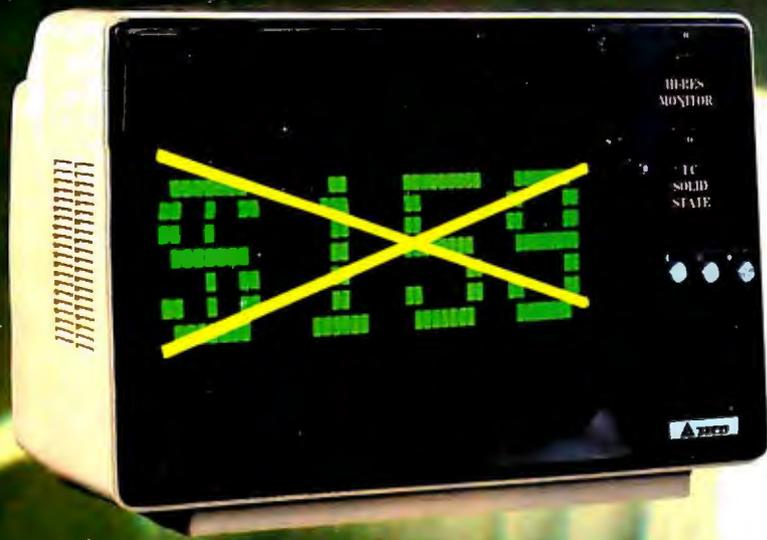
Mr Booch's design was good, but the hardware could have been upgraded for better performance. According to my calculations for the color chip, the Z80 microprocessor is active only 12% of the time with the hardware configuration shown. The Motorola spec sheets give a better hardware implementation: isolate 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 Adventure"; 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.)

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\*\*Model VP-3303 with built-in RF modulator—\$389.  
\*Suggested user price. Monitor and modem not included.

# RCA

Circle 350 on inquiry card.

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.

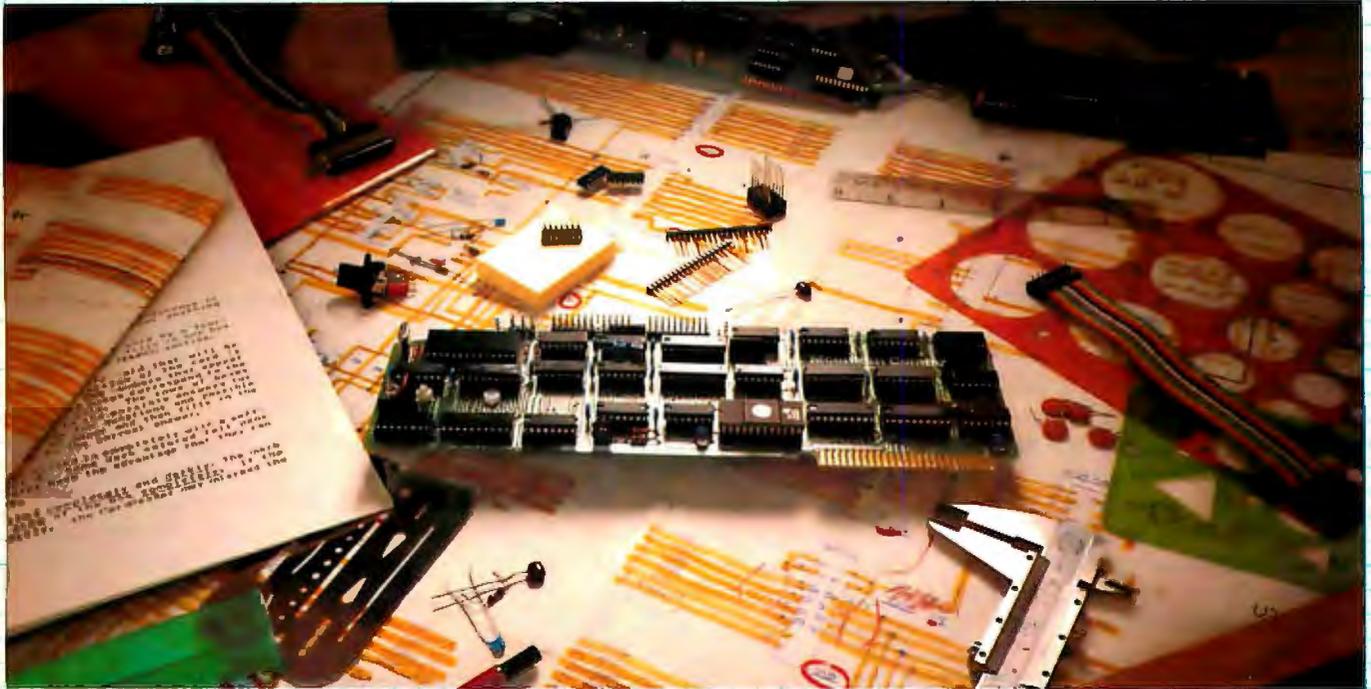
Carl E Osborne Jr  
President  
O & J Electronics Inc  
4027 Knight Arnold Rd, Suite 105  
Memphis TN 38118

## 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 "CODE-BREAKER" 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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## Letters

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

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### 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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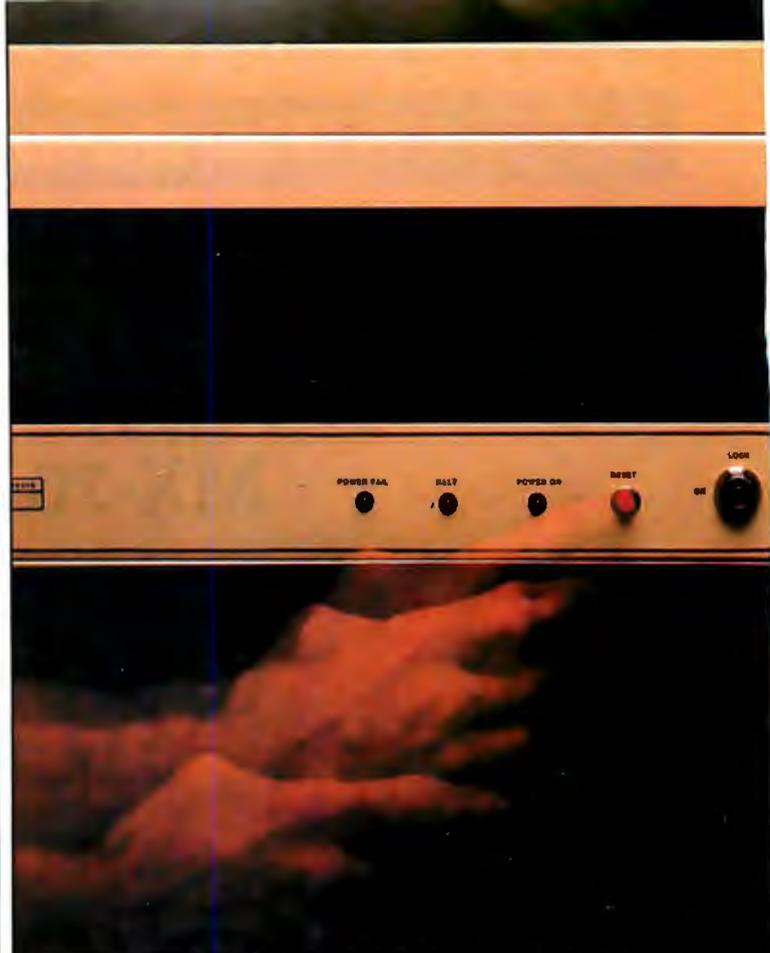
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## The Epson MX-80 and MX-70 Printers

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 $\frac{1}{16}$  by 12 by 4 $\frac{1}{8}$  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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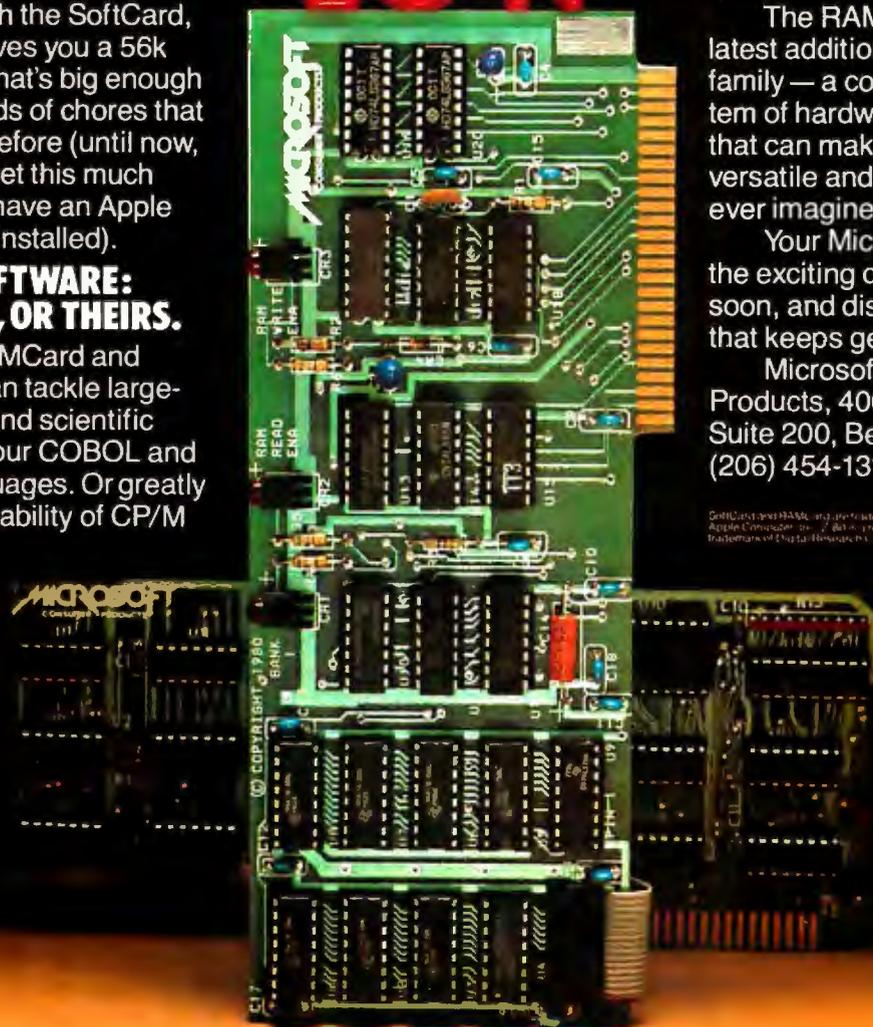
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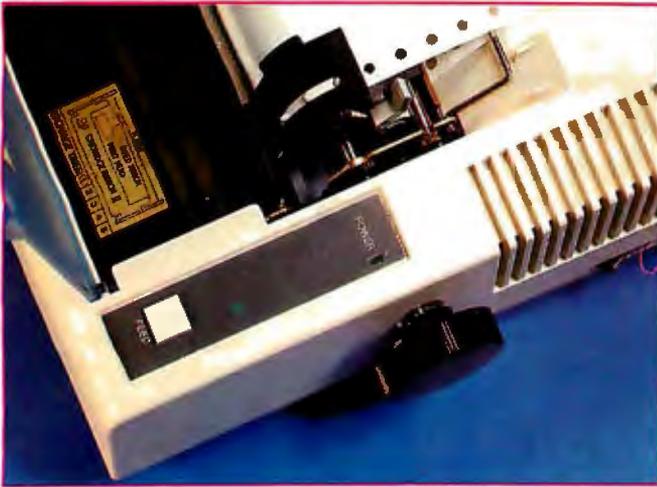
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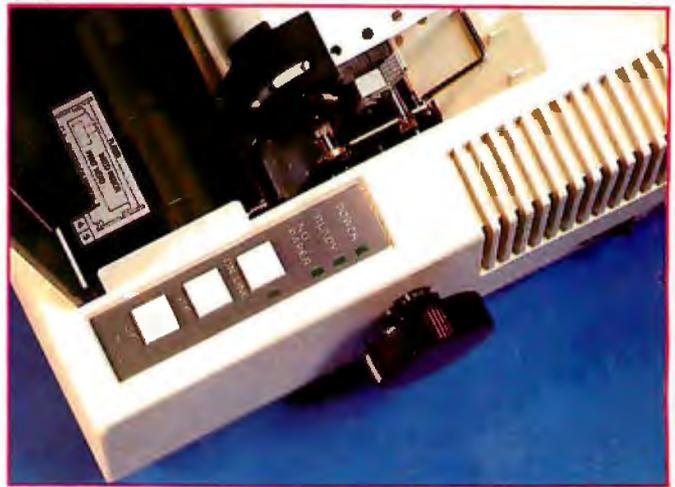
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(2a)



(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 $\frac{1}{10}$  by 12 by 4 $\frac{1}{8}$  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 ( $\frac{1}{8}$  inch) to 3.00 cm (1 $\frac{1}{2}$  inch) in increments of 0.035 cm ( $\frac{1}{8}$  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

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Model 22	\$650.00	1	\$650.00
Model 23	\$675.00	1	\$675.00
Model 24	\$700.00	1	\$700.00
Model 25	\$725.00	1	\$725.00
Model 26	\$750.00	1	\$750.00
Model 27	\$775.00	1	\$775.00
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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

DOUBLE WIDTH CHARACTERS

3b

REGULAR CHARACTERS

EXPANDED CHARACTERS

**[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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A financial VP in Massachusetts is cutting the time it takes to prepare month-end reports from three days to three hours.

A California company is replacing most of its time-share computer service with a personal computer and VisiCalc, saving at least \$30,000 the first year.

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VisiCalc displays an "electronic worksheet" that automatically calculates nearly any number problem in finance, business management, marketing, sales, engineering and other areas. The huge worksheet is like a blank ledger sheet or matrix. You input problems by typing in titles, headings and your numbers. Where you need calculations, type in simple formulas (+, -, ×, ÷) or insert built-in functions such as net present value and averaging. As quickly as you type it in, VisiCalc calculates and displays the results.

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That response comes from a Utah businessman using VisiCalc for production forecasts, financial report ratio analysis and job cost estimating. Ease of use is VisiCalc's best-liked feature. It's designed for a non-programmer, and has an extensive, easy-to-understand instruction manual.

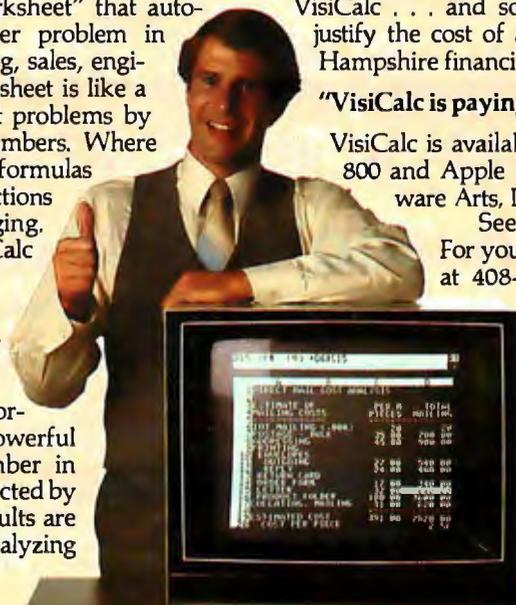
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son or the Apple parallel interface cards to allow access to the graphics characters on the MX-80 printer. The modification is simple—the data-bit-7 line to the printer (the line that controls the highest bit of the 8-bit interface) is isolated from 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]

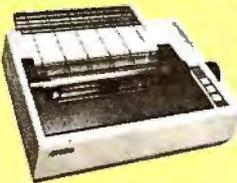
In addition to the standard TRS-80 cable and Apple II board/cable interfaces, which are available for both printers, the MX-80 will also have the following interfaces: IEEE-488, serial, and buffered serial (which includes a 2 K-byte character buffer). Approximate prices are given in the MX-80 "At a Glance" 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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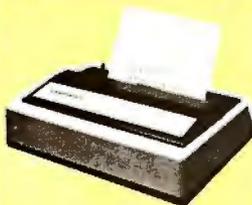
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Okidata M-83	\$919

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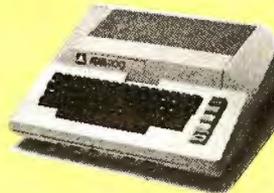
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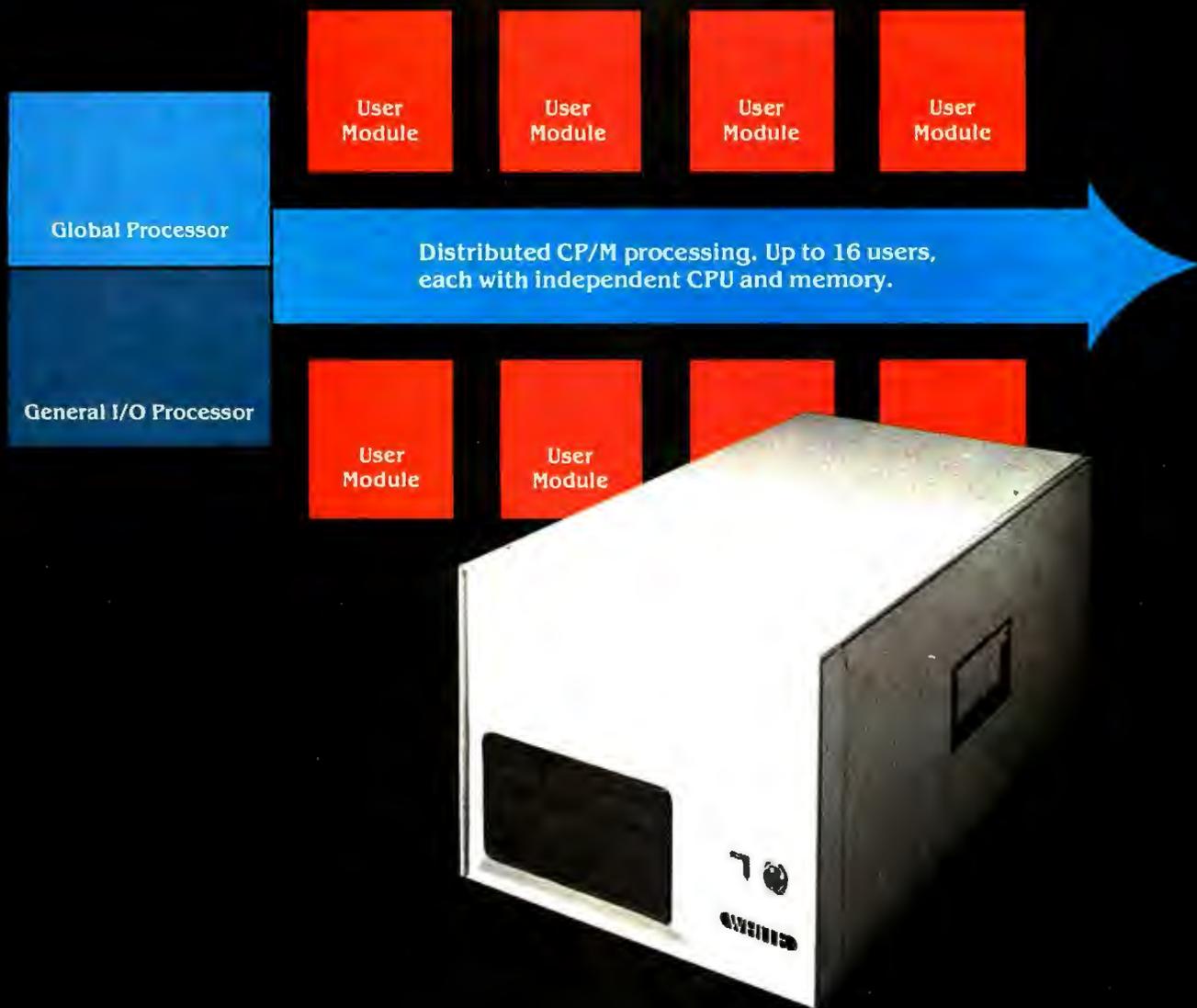
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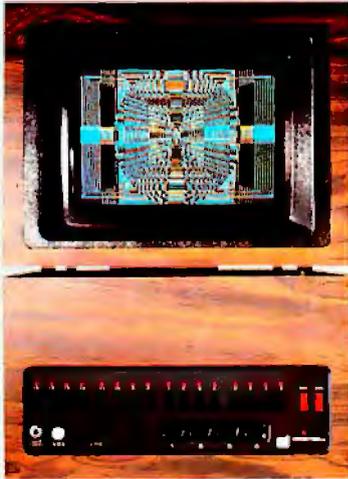
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paper (as opposed to thermal or electrostatic) and produces an original as well as up to two carbon copies by using multiple-ply paper? This ability, due to the fact that both are impact printers, is of particular interest to small business users.

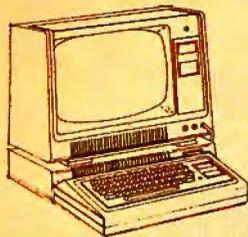
In addition, the print head can be changed (recommended after 50,000,000 characters) by the owner, at a cost of about \$30. A quieter print head (5 dB quieter than the standard head during printing) is available for about \$40. Like the standard replaceable print head, it can be installed by the user.

• 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. ■

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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.



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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.

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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.

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# Extended Color BASIC for the TRS-80 Color Computer

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Stan Miastkowski, Technical Editor

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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:

EXTENDED COLOR BASIC 1.0  
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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.

*nC* Changes *n* characters.

*nD* 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.

*nSc* 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 pre-defined 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 pre-defined 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.

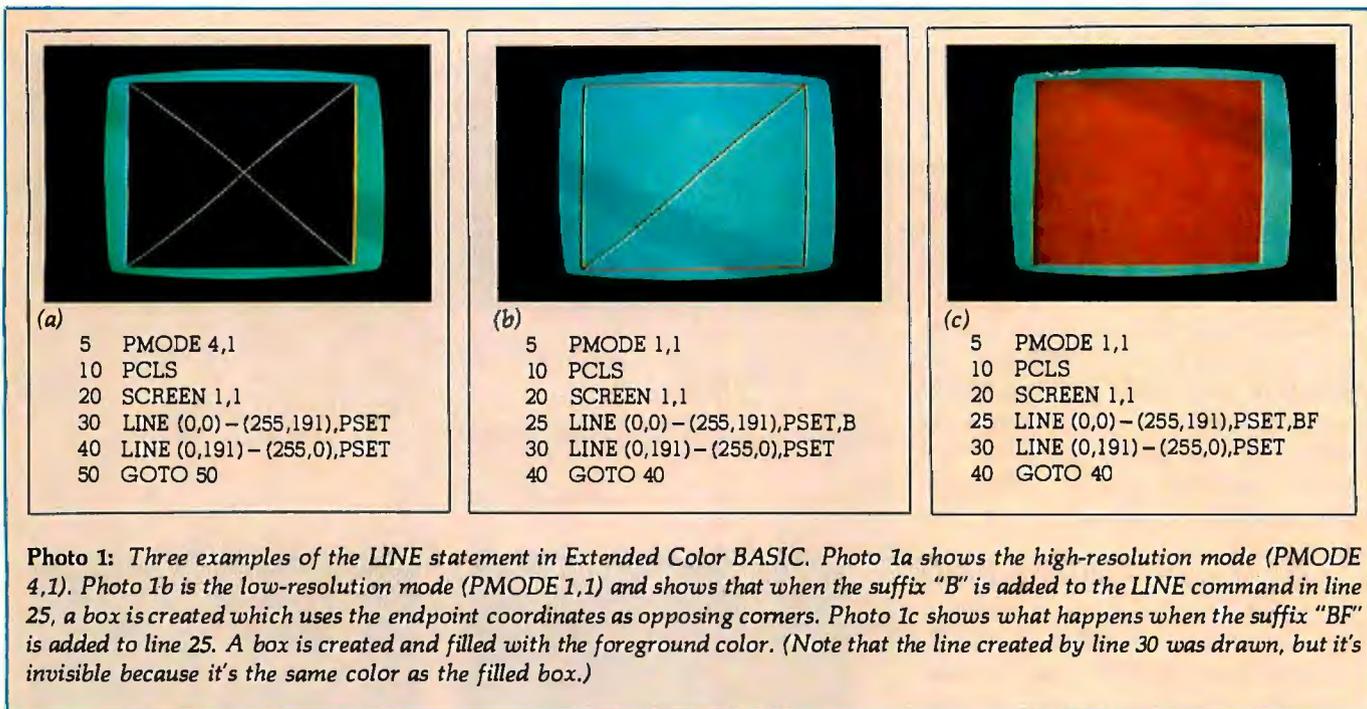
**SCREEN** *type, color set*

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.



**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).

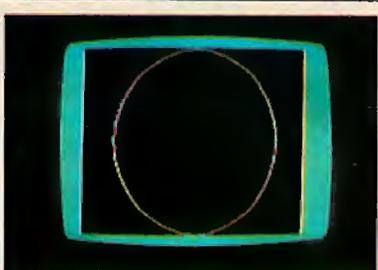
The people who designed Extended Color BASIC have made it simple—such commands as LINE, CIRCLE, DRAW, and PAINT (see photos) make the creation of very sophisticated shapes an easy job. The most-used commands include:

- **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).

### 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

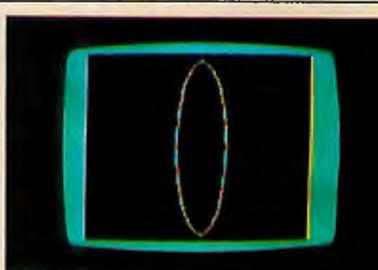


(a)

```

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

```

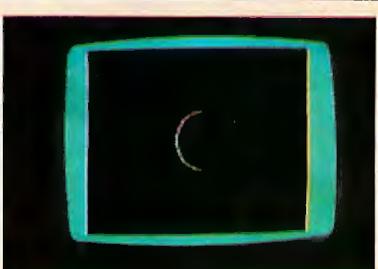


(b)

```

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

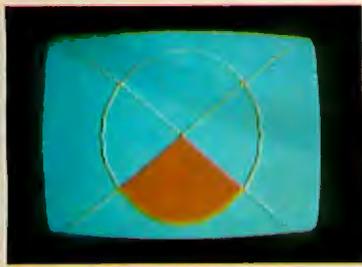
```

**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.

Color Computer (without Extended Color BASIC) allows you to create music by the SOUND command, which gives a range of notes from F<sub>3</sub> to E<sub>7</sub>, 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 com-

mand 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.

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

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

**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;02;L2;G;L4;C;D;E;F;L2;G;C;P16;C;"
60 B$ = "L2;A;L4;F;G;A;B;03;L2;C;02;C;P16;C;F;L4;G;
   F;E;D"
65 C$ = "L2;E;L4;F;E;D;C;L2;01;B;02;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;03;L2;C;02;C;P16;C;F;L4;G;
   F;E;D"
80 F$ = "L2;E;L4;F;E;D;C;D;E;L2;F;01;B;L1;02;C"
85 X$ = "XA$;XB$;XC$;XD$;XE$;XF$;"
90 PLAY X$

```

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 pro-

grams." 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.

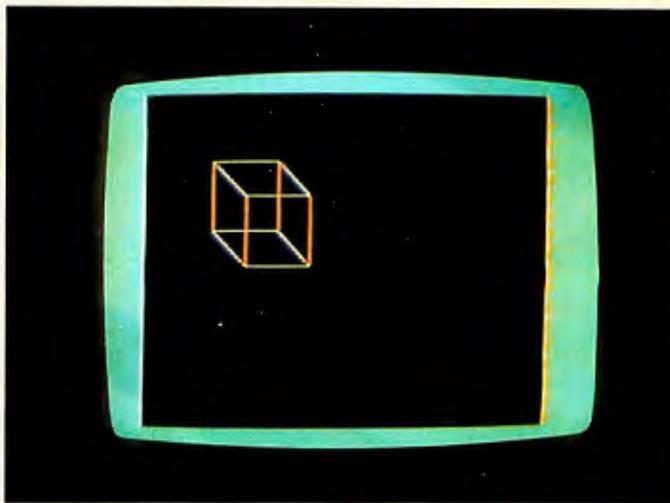
Despite the lack of specific subroutine information, there are three new statements within Extended Color BASIC which are designed to help out the machine-language programmer:

```

5  PMODE 4,1
10 PCLS
20 SCREEN 1,1
25 DRAW "BM40,80;U40;R40;D40;L40"
30 DRAW "EM + 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

```

(a)

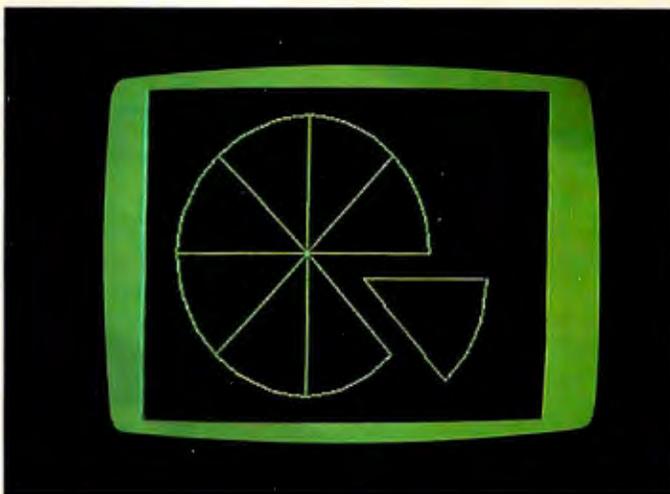


```

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,.125
60 LINE (135,110)-(190,167),PSET
70 LINE (135,110)-(235,110),PSET
80 GOTO 80

```

(b)



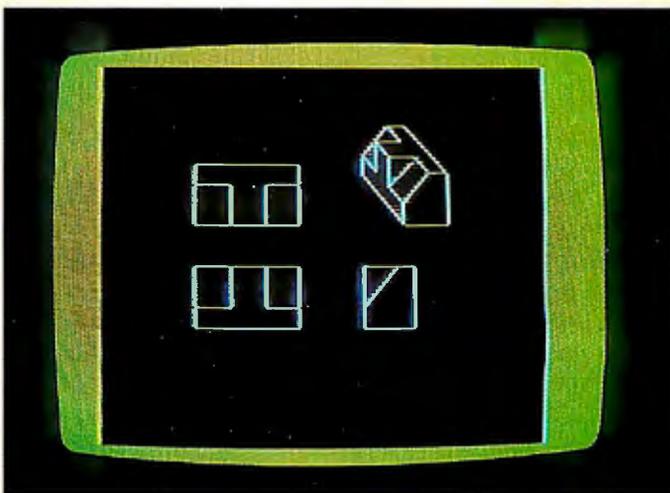
```

5  PMODE 4,1
10 PCLS
15 SCREEN 1,0
20 DRAW "BM50,50R60D10NL20D20L20NU20L20U20NR20U10" 'TOP VIEW
25 DRAW "BM50,100R20ND20R20ND20R20D20
NL20D10L60U10NR20U20" 'FRONT VIEW
30 DRAW "BM150,100R30D30L30U10NE20U20"
'SIDE VIEW
35 ' OBLIQUE VIEW—LINES 40-60

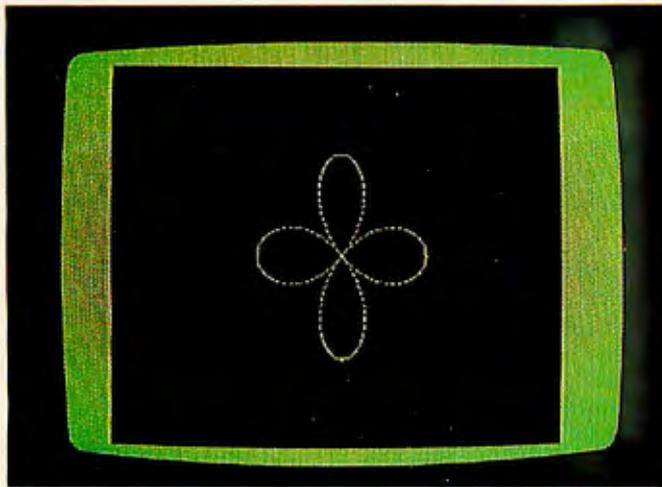
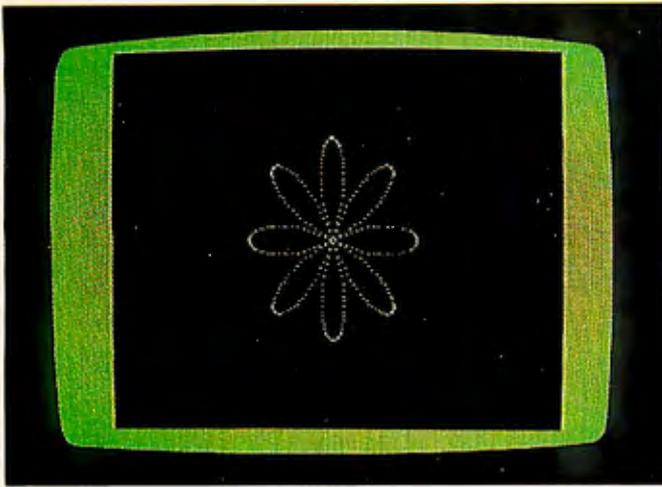
40 DRAW "BM150,50U5E15R10BF20BD30NR5L20H25U10
45 DRAW "BM150,50U5F8U15R15H8F8L15F8NR15D15F8
ND10E15NR10H8
50 LINE (175,30)-(200,55),PSET
55 LINE -(200,80),PSET
60 LINE (167,60)-(183,46),PSET
65 GOTO 65

```

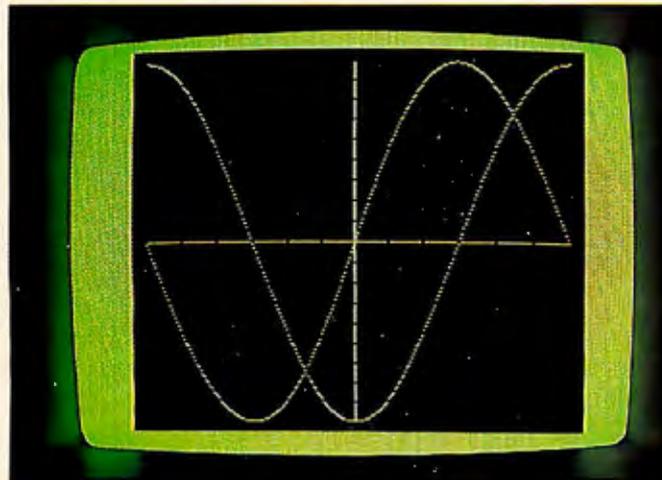
(c)



**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.**

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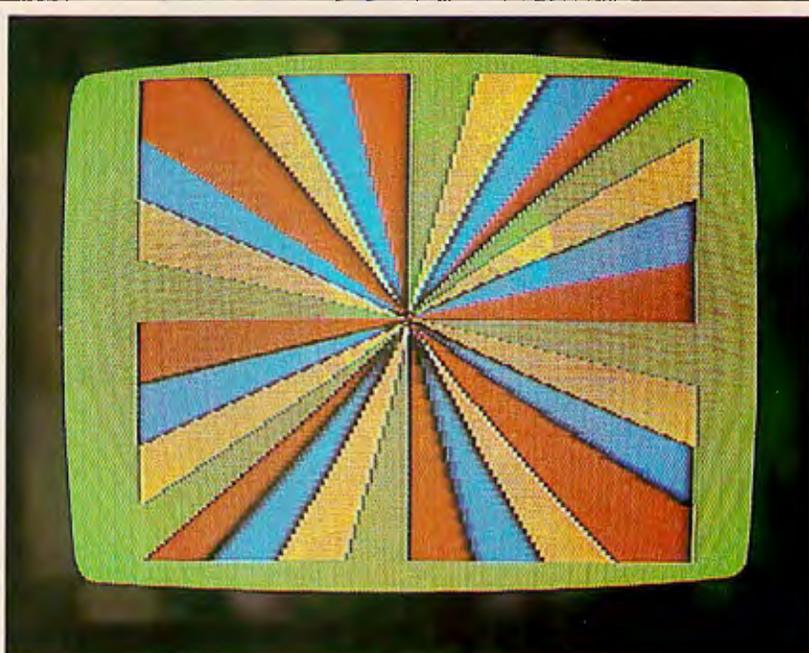
Although a lack of machine-language information might be considered a handicap by some, it is not. One of the most striking features of Extended Color BASIC is that it is *fast*—despite the fact that the microprocessor runs at the relatively slow speed (for computers) of .894 MHz (million cycles per 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.

### 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).



```

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.*

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-FE00	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

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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.

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**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

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## 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.

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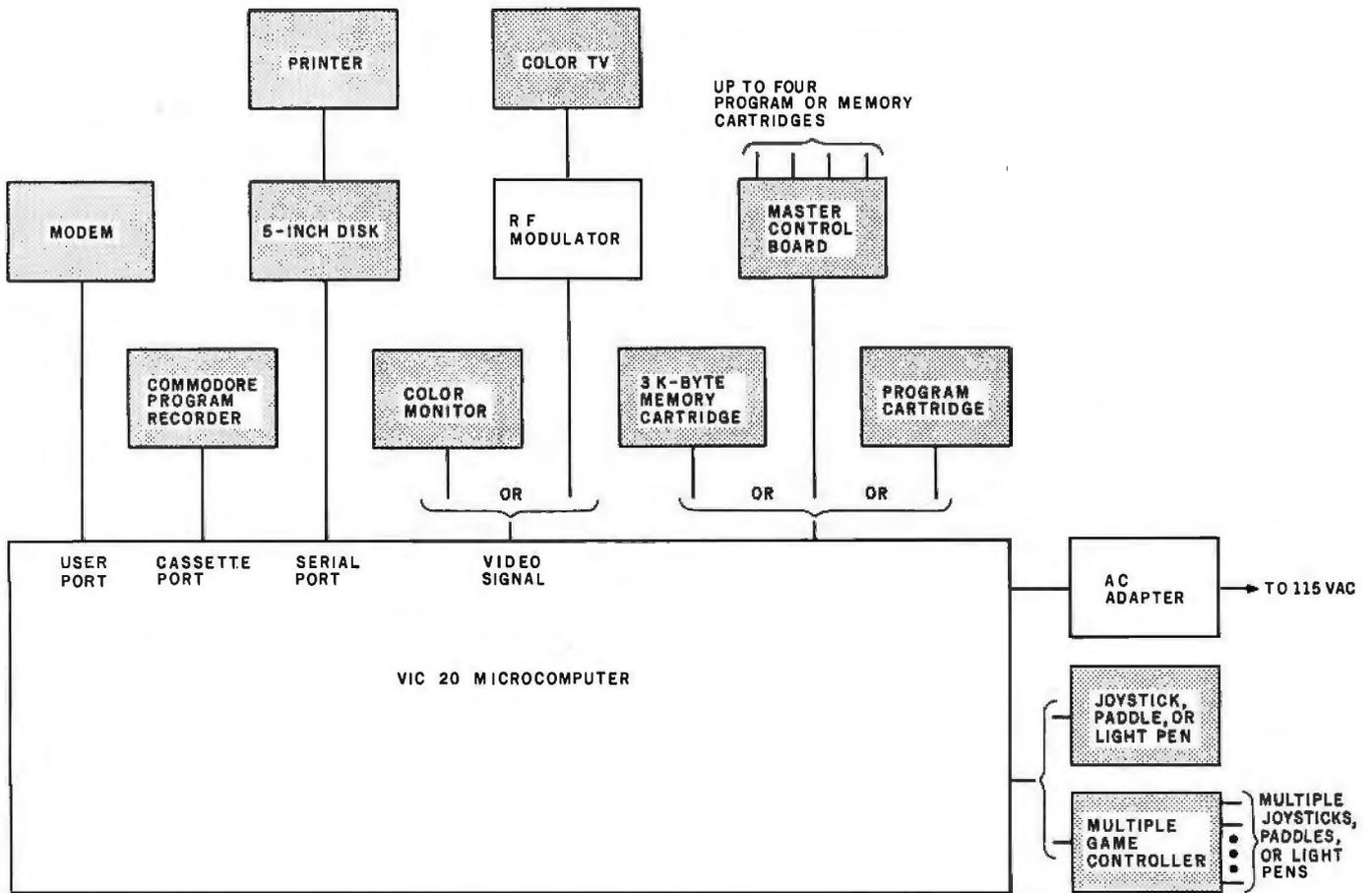


Figure 1: A block diagram of the Commodore VIC 20 system (shaded components are available at extra cost).

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).

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



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.

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.

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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.

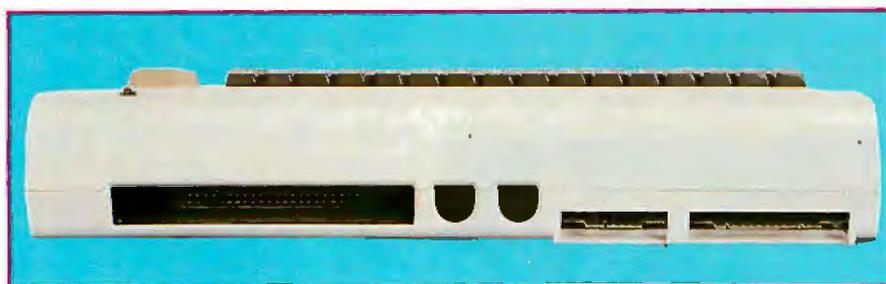
Finally, the number of graphics characters that can be displayed is doubled because *any* character can be displayed as is or in reverse (see photo 3). This can be done immediately or during program execution. Pressing the RVS ON key (the CTRL key plus the 9 key simultaneously) causes all displayed characters 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.)

### VIC Color

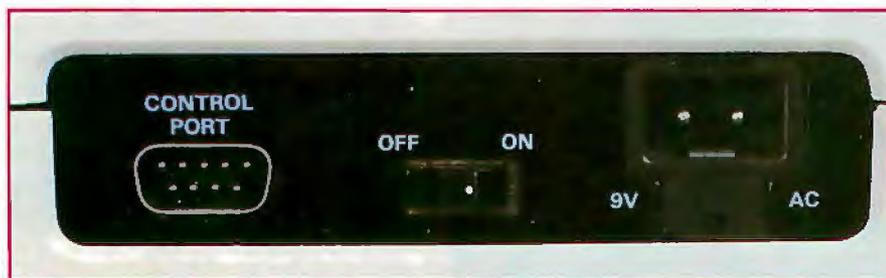
To quote an adage from photography, "If you can't make it good, make it red." There is an element of truth in that—color *does* make things more exciting, and it's always one of the most striking features of a microcomputer video display. The VIC has an impressive color display due largely to the complete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

(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.

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

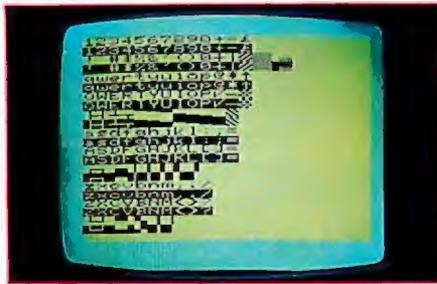


Photo 4: The character set of the VIC 20. Any character can be displayed in reverse.

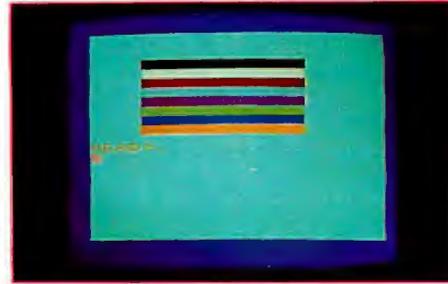


Photo 5: The eight character colors available on the VIC 20. All characters can be displayed in any of these colors.

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* output 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.

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 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

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.

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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.

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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 car-

tridges. 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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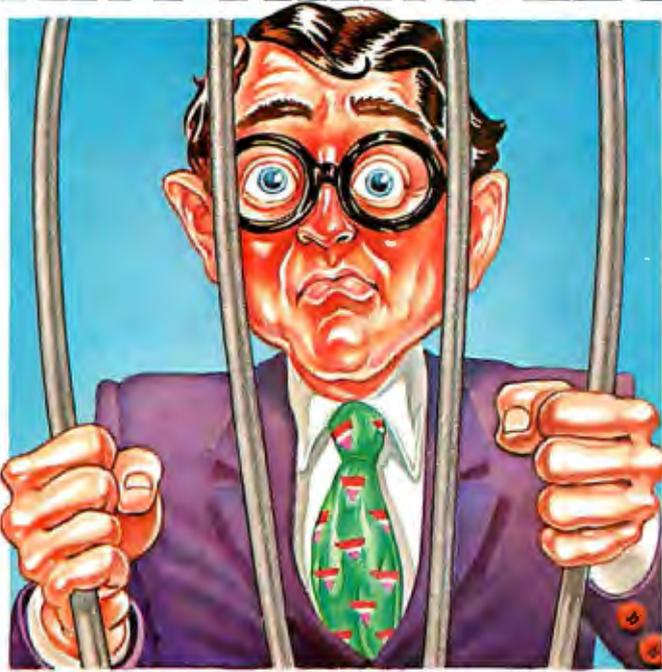
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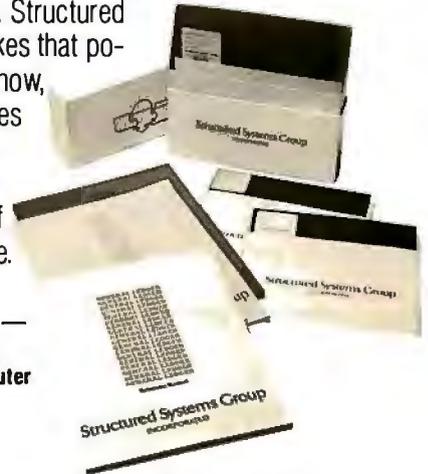
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## Human Engineering on the VIC

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.

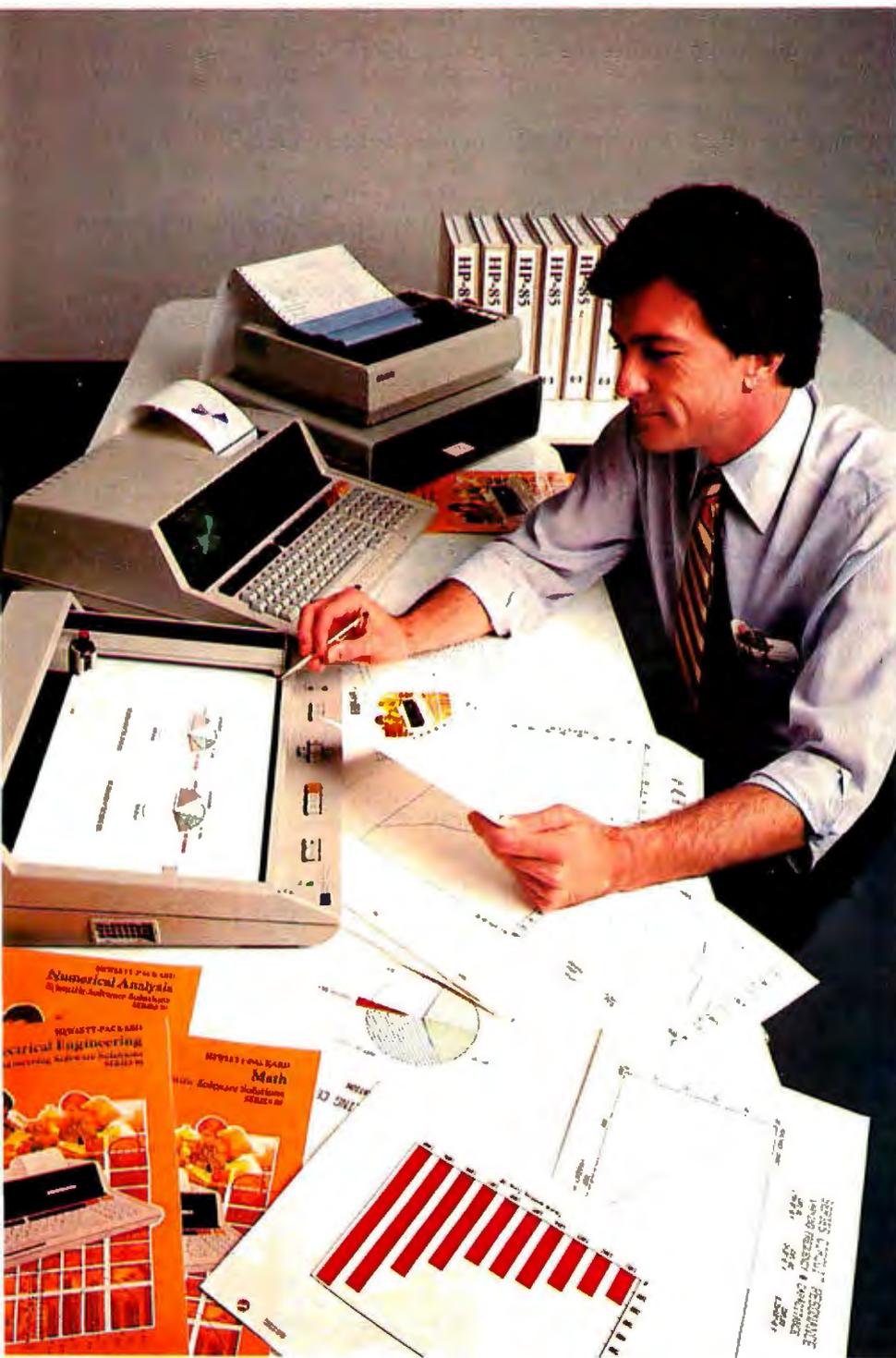
The VIC keyboard is one of the best I've seen. It is well constructed and has a good feel during typing. The key names on the top and front faces of the keys are highly visible and easy to read. In most cases, key functions have been wisely chosen and named. For example, the key

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 1/4 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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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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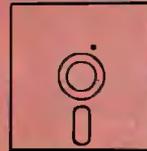
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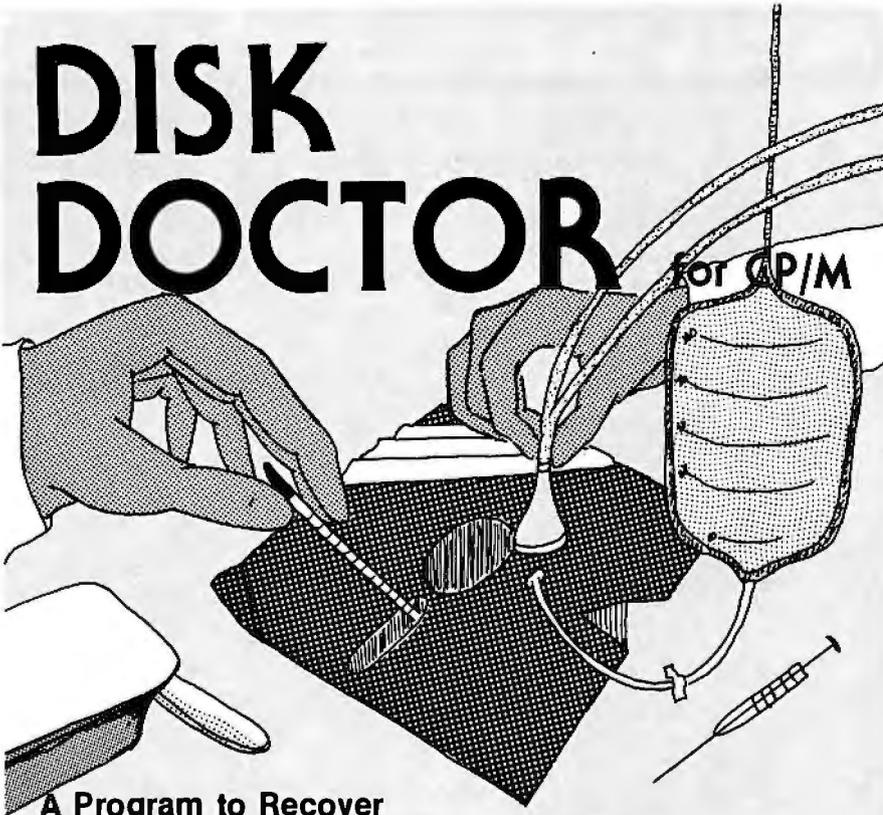
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the VIC. In addition, all I/O routines called by BASIC are called indirectly through programmable-memory pointers holding the addresses of the true I/O routines; in this way, users can substitute their own I/O routines to be executed in place of those 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).

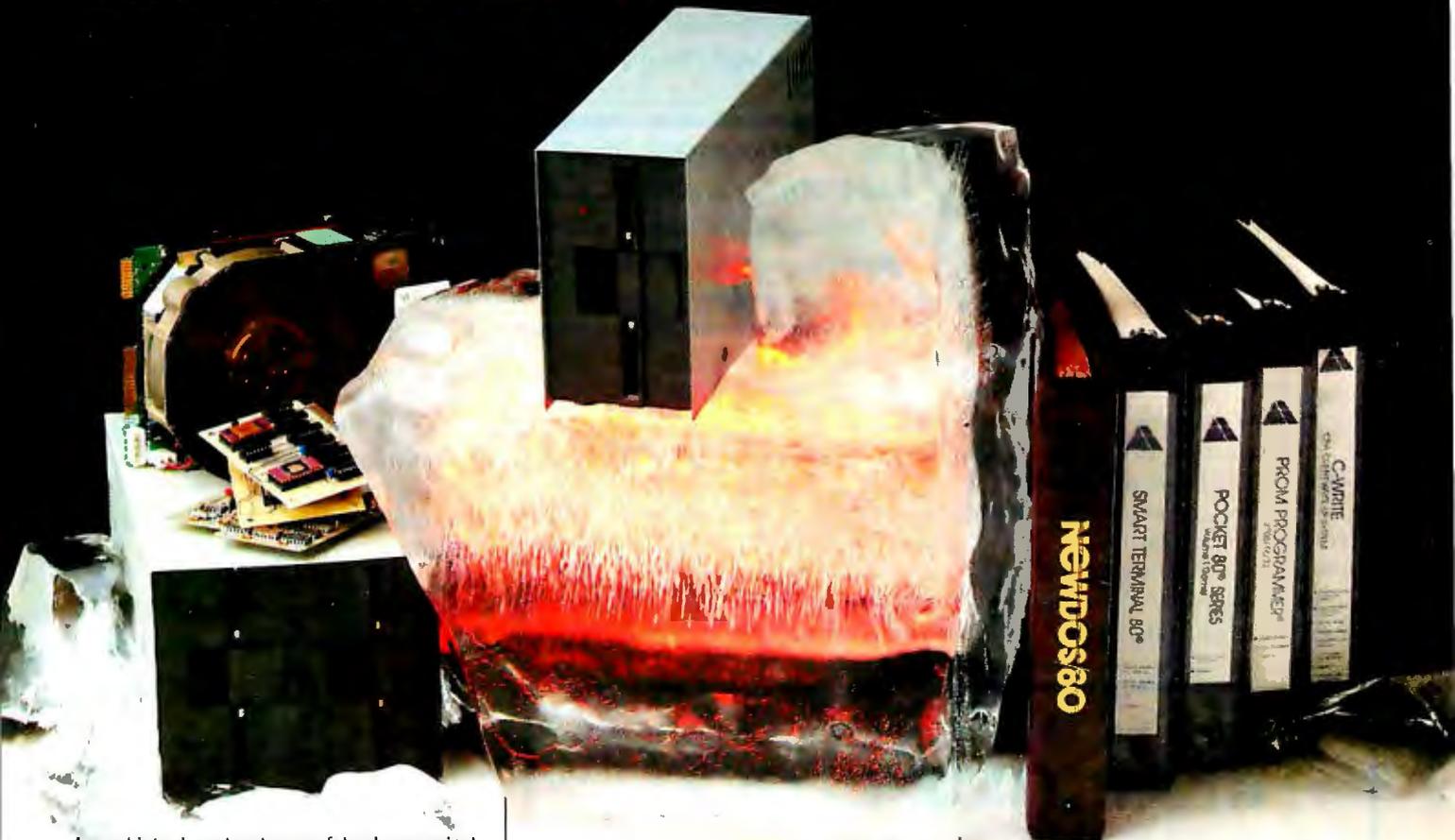
## Problems and Limitations

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

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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

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

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 pro-

cess 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.

**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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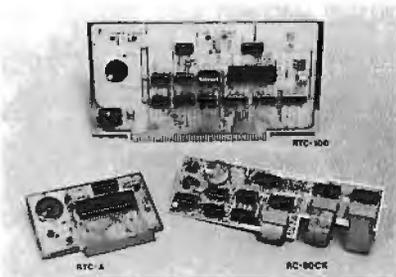
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easy to begin learning about the computer. Most of the chapters do not rely on material from previous chapters, meaning that the reader can learn about the features in any order.

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. ■

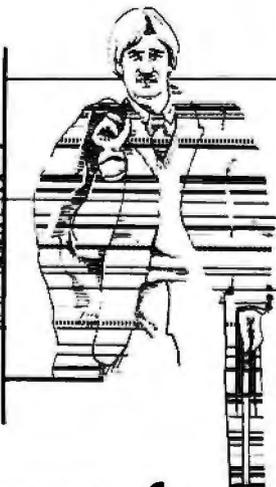
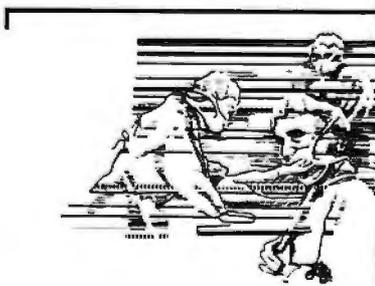
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## DC Motor Controls Build a Motorized Platform

Steve Ciarcia  
POB 582  
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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 pre-programmed 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

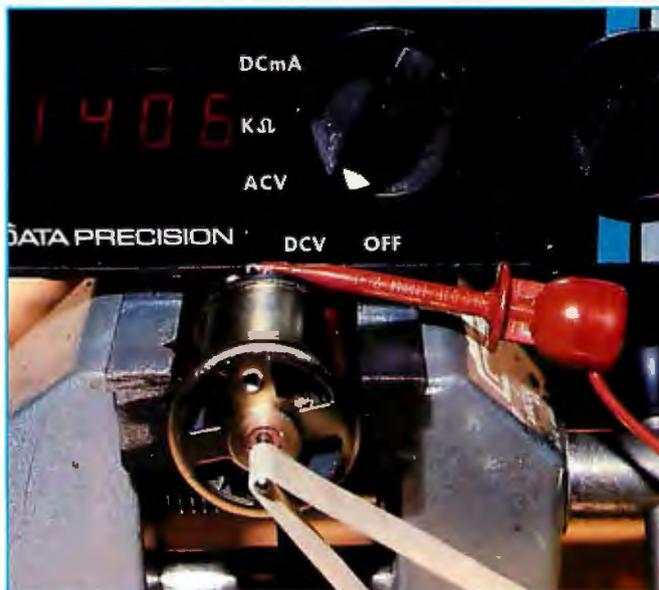
things have changed since I was a kid: permanent-magnet DC motors aren't what they used to be.

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



**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.



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In VEDIT, the screen continuously displays the region of the file being edited, a status line and cursor. Changes are made by first moving the cursor to the text you wish to change. You can then overtype, insert any amount of new text or hit a function key. These changes are immediately reflected on the screen and become the changes to the file.

VEDIT has the features you need, including searching, file handling, text move and macros, plus it has many special features. Like an 'UNDO' key which undoes the changes you mistakenly made to a screen line. The Indent and Undent Keys allow automatic indenting for use with structured programming languages such as Pascal and PL/I. The disk write error recovery lets you delete files or even insert another disk should you run out of disk space during an edit session. And you have the ability to insert a specified line range of another file anywhere in the text. Disk access is very fast and VEDIT uses less than 12K of memory. The extensive 70 page, clearly written manual has sections for both the beginning and experienced user.

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Included is a setup program which allows you to easily customize many parameters in VEDIT, including the keyboard

layout for all cursor and function keys, screen size, default tab positions, scrolling methods and much more. This setup program requires no programming knowledge or 'patches', but simply prompts you to press a key or enter a parameter.

The CRT version supports all terminals by allowing you to select during setup which terminal VEDIT will run on. Features such as line insert and delete, reverse scroll, status line and reverse video are used on 'smart' terminals. The memory mapped version supports bank select and a hardware cursor such as on the SSM VB3. Special function keys on terminals such as the H19, Televideo 920C and IBM 3101, and keyboards producing 8 bit codes or escape sequences are also supported.

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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.

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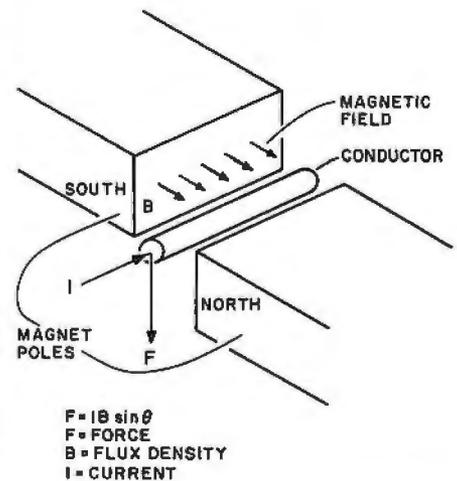


Figure 1: Simplified diagram of the basic electromagnetic principles behind the DC motor. When a current-carrying conductor is placed in a magnetic field, the conductor feels a mechanical force,  $F$ , in the indicated direction, perpendicular to the current and the magnetic field. The force is greatest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



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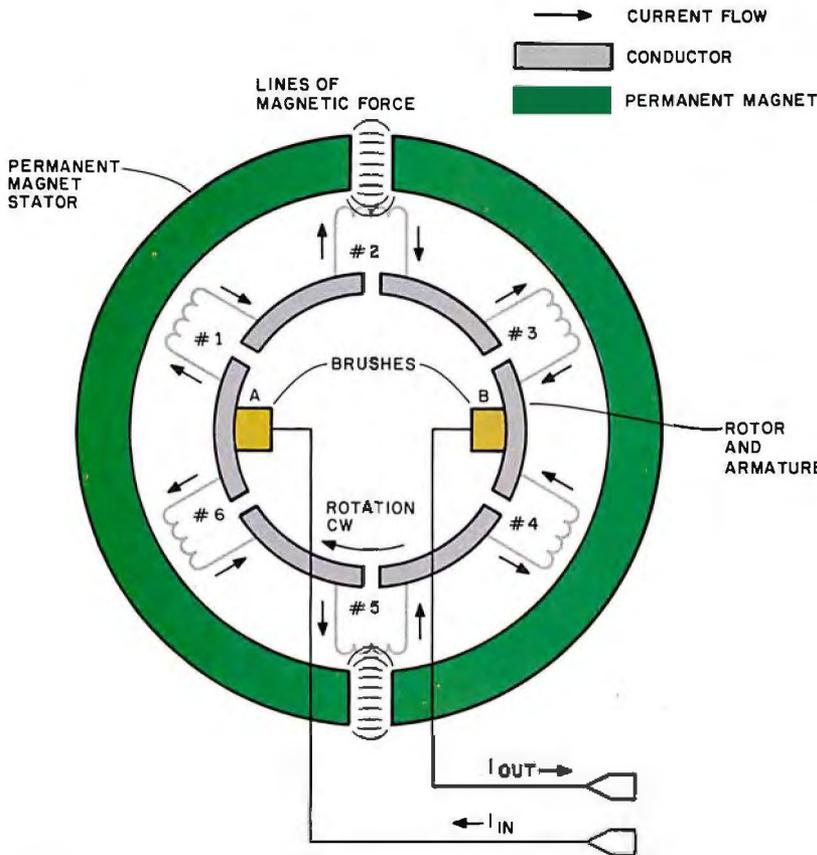
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**Figure 2:** Internal structure of a typical PM (permanent-magnet) DC motor. Brushes transfer current to the armature coils. As the armature rotates, the brushes contact the assembly at different points, reversing the direction of current flow in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

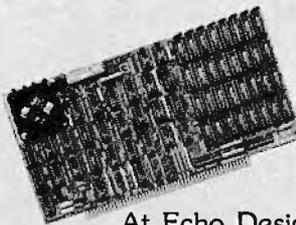
Compound-field motors have both series- and shunt (parallel)- field windings. These motors exhibit high starting torque and relatively flat function curves for speed/torque characteristics. While useful in providing rotation in one direction, this motor is difficult to reverse since connections to *both*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



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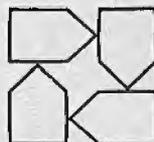
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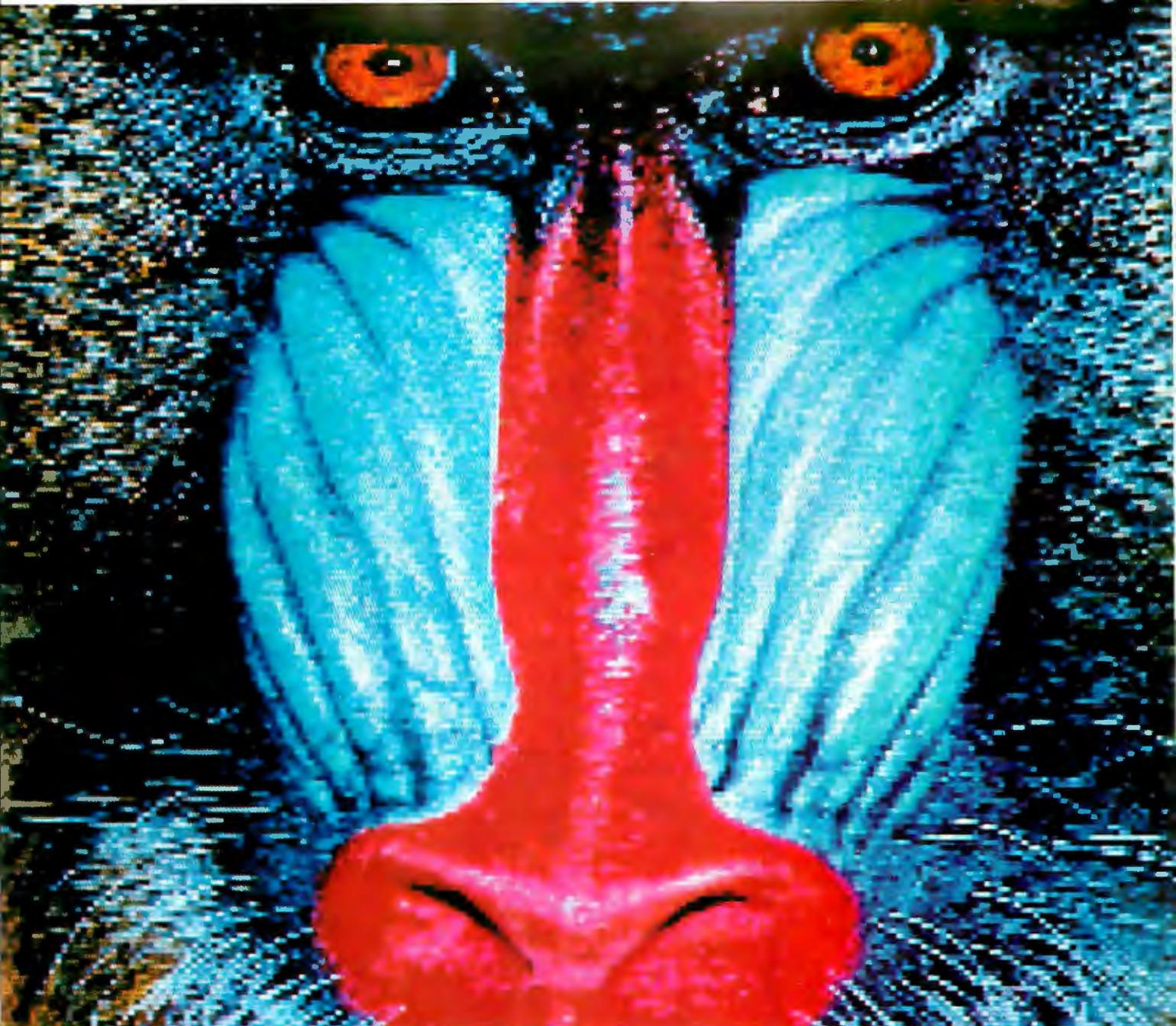
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corporation of new ceramic magnet materials made the PM motor practical for low-cost/high-power applications. Previously, most PM motors used *alnico*-alloy magnets, which are susceptible to demagnetization.

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

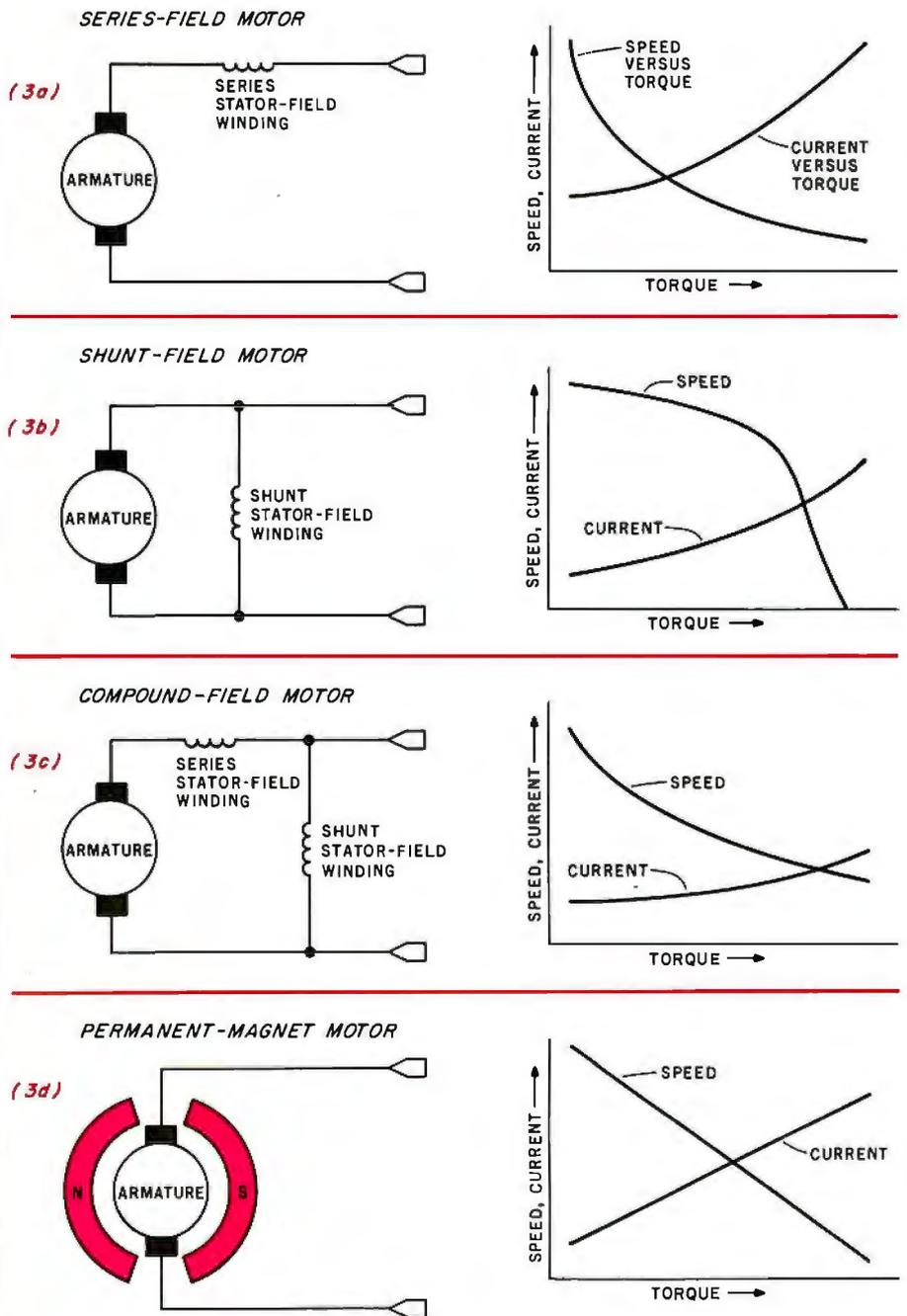
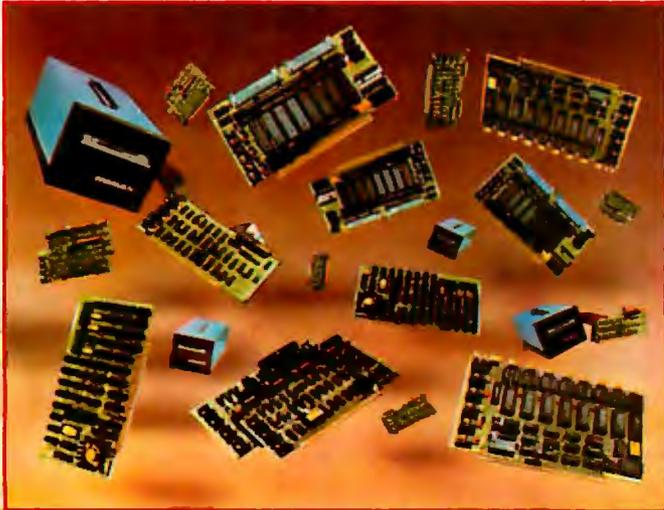


Figure 3: Different types of DC motors are distinguished by the type of stator field. Three types use an electromagnet to produce the stator field; the fourth uses a permanent magnet. Different methods of connecting windings in the stator electromagnet produce different speed/torque and current/torque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

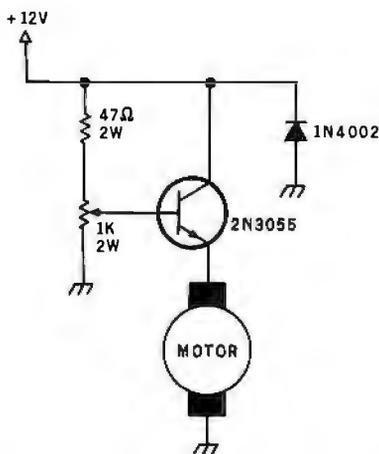


Figure 4: A simple open-loop linear motor-speed control. Operating the controlling transistor in the linear region of its characteristic curve leads to loss of energy as heat.

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.

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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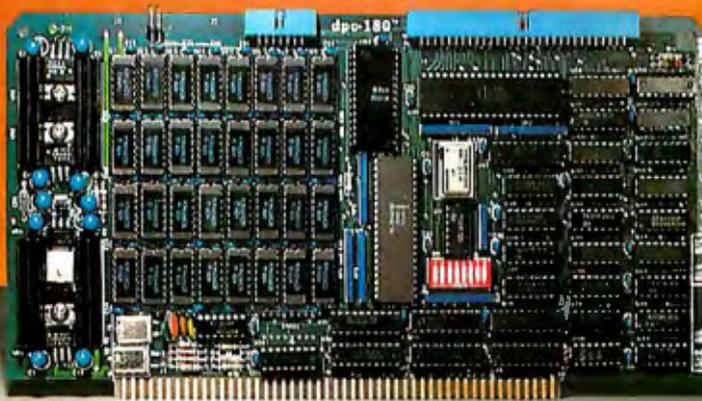
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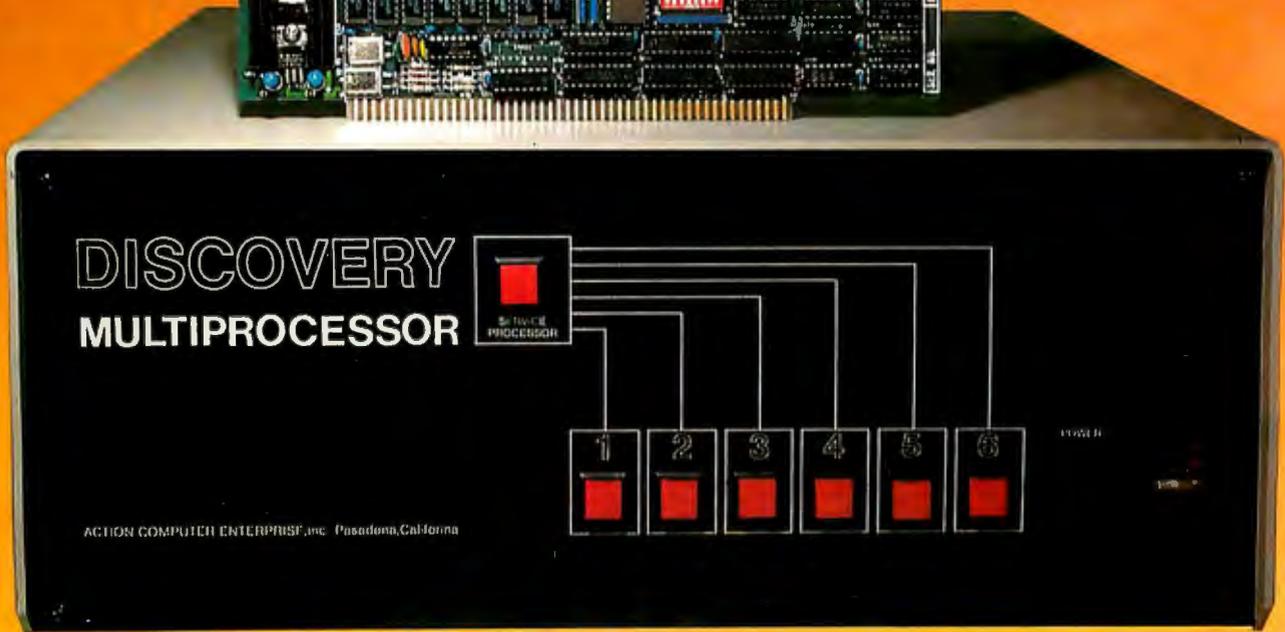
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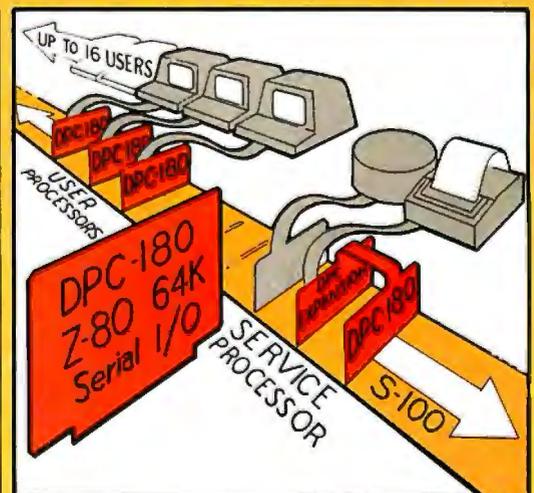
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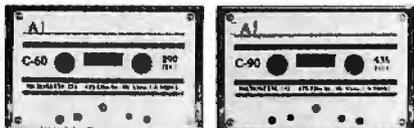
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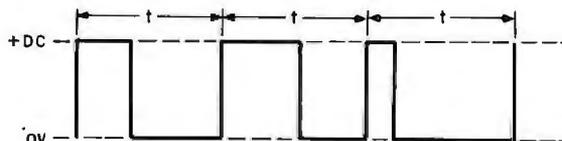
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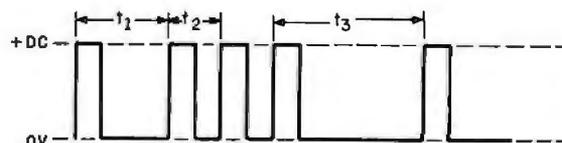
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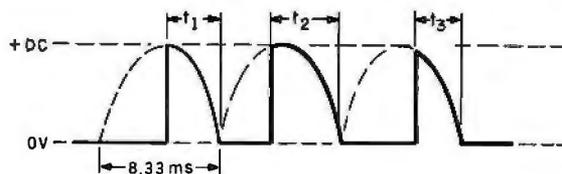


Figure 5: Comparison of three basic switching-amplifier control-circuit output waveforms. The controlling semiconductors are saturated; the average amount of electrical current transferred to the motor is limited by rapidly cutting the current off and on.

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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six	fifty	60hertz	tone	flow	less	over	star	h	y
seven	sixty	20ms	silence	fuel	lesser	parenthesis	start	i	z
eight	seventy	40ms	silence	gallon	limit	percent	stop	j	
nine	eighty	80ms	silence	go	low	please	than	k	
ten	ninety	160ms	silence	gram	lower	plus	the	l	
eleven	hundred	320ms	silence	great	mark	point	time	m	
twelve	thousand	centi	greater	meter	pound	try	n		
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fourteen	zero	comma	high	mili	rate	voil	p		
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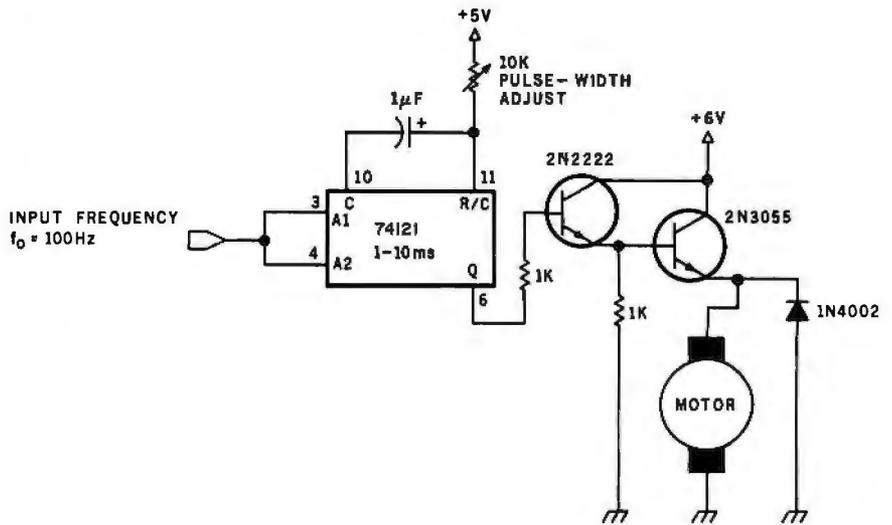


Figure 6: A simple PWM (pulse-width-modulated) motor-speed control. The duty cycle of the monostable multivibrator (74121) is adjusted by the variable resistor to change the average integrated (in the mathematical sense) electrical current supplied to the motor through the driving transistors. Pin 14 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.

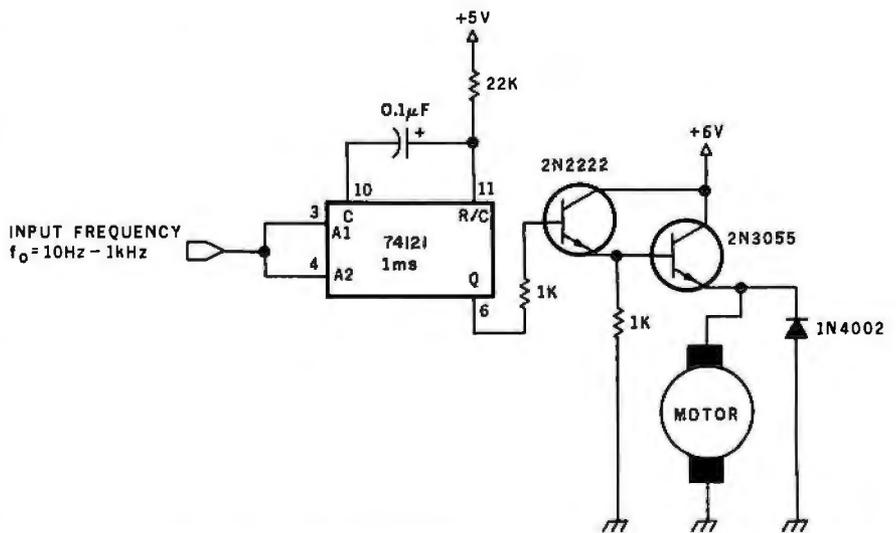


Figure 7: A simple PFM (pulse-frequency-modulated) motor-speed control. The number of constant-duration pulses supplied to the driving transistors over a given interval controls the speed.

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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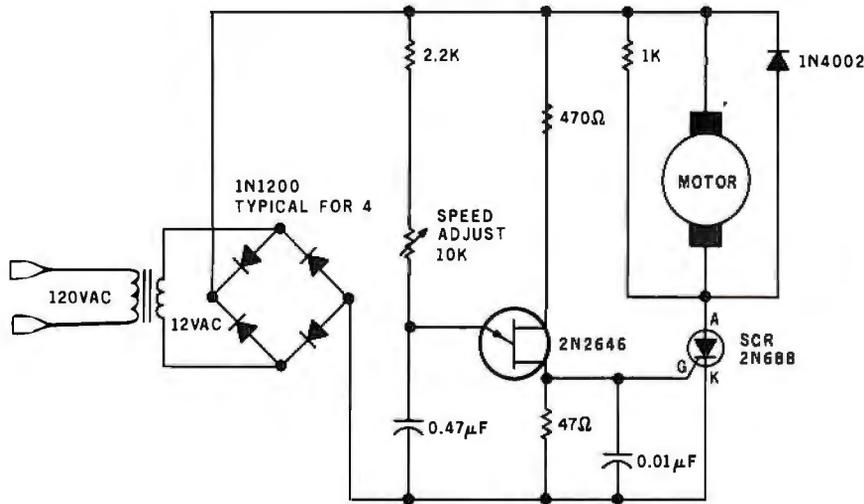
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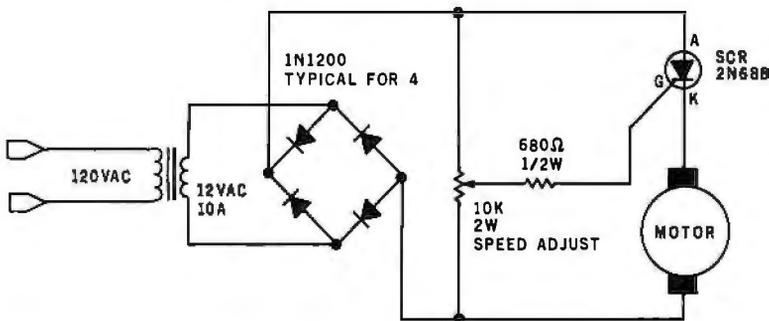
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**Figure 8:** An SCR- (silicon-controlled rectifier) controlled motor-speed circuit. This method, a variation of PWM (pulse-width modulation), has a wide speed range, high power-conversion efficiency, and low forward-voltage drop across the controlling 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 in-

cremental 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.

When control systems capable of

### 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 opera-

tion 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

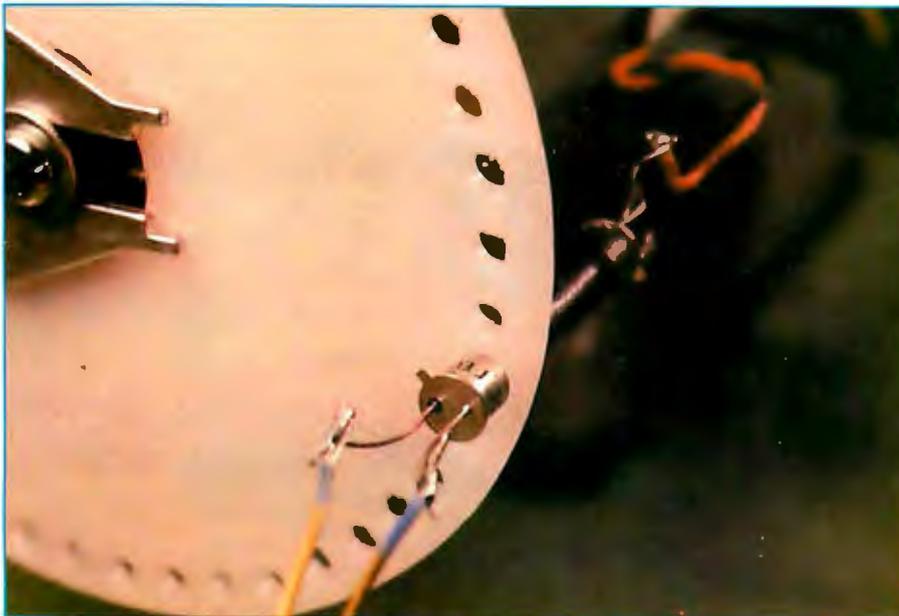


Photo 2: The most frequently used nongenerator speed-feedback device is the incremental encoder. This is a homemade encoder, consisting of a plastic disk attached to the motor shaft. Around the perimeter of the disk are slots or holes. A light source is placed on one side; a light sensor on the other 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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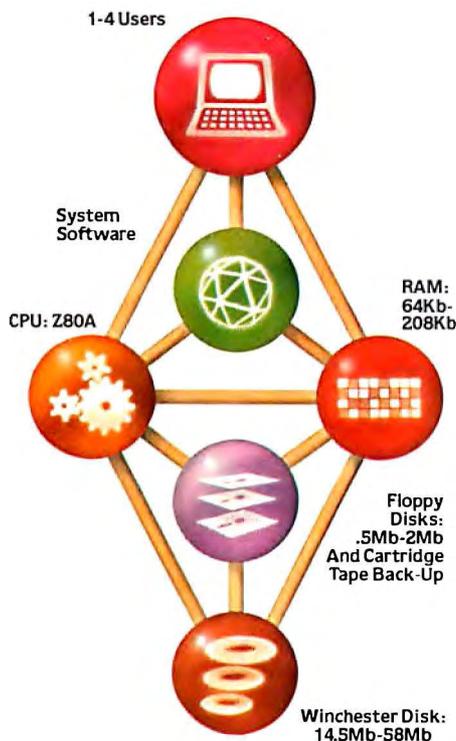
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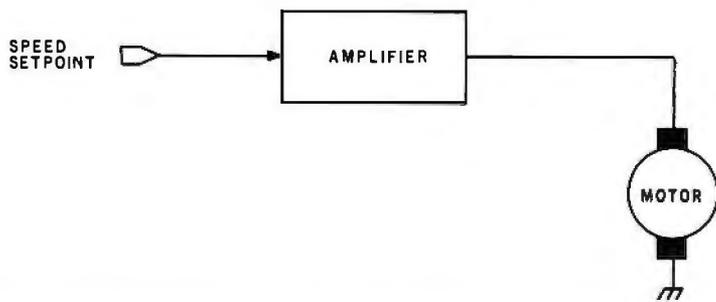


Figure 10a: Block diagram of an open-loop controller. Variations in mechanical load cause the motor to speed up or slow down.

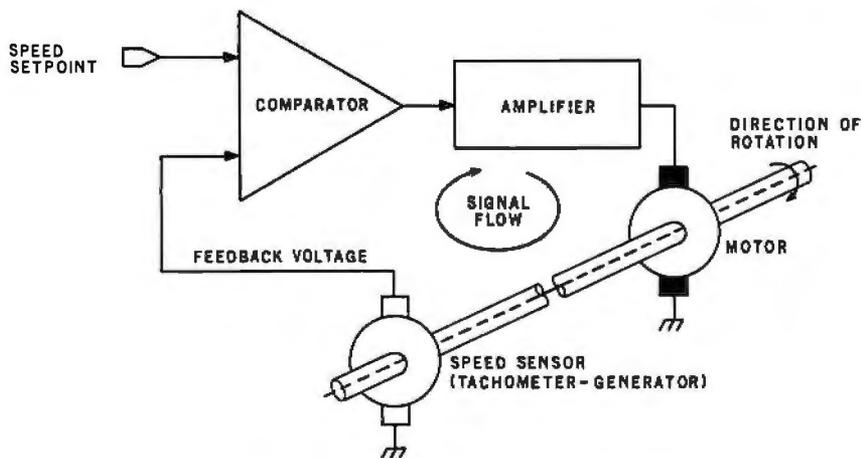


Figure 10b: Block diagram of a closed-loop controller. The speed sensor detects too-fast or too-slow motion and keeps the motor running without variation in speed over wide variations in load.

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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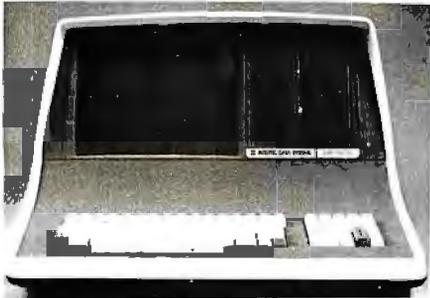
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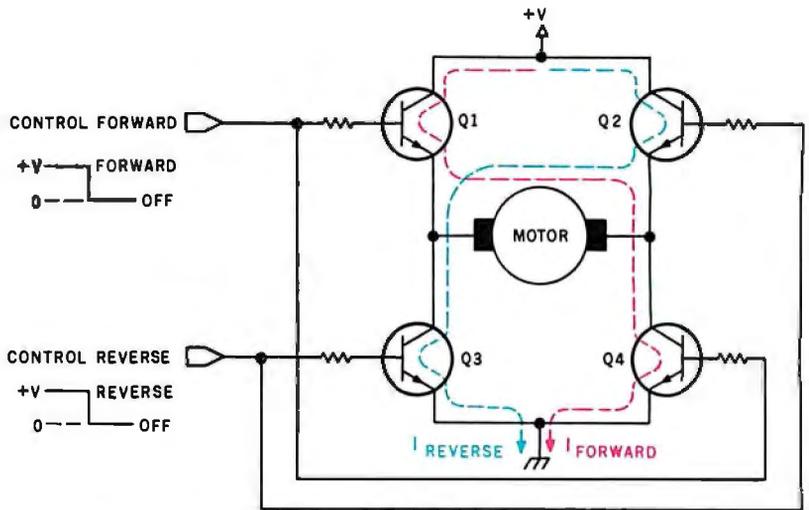


Figure 11a: One of two basic reversing motor-control circuits. This bridge-type switch uses a single DC supply voltage and is used mostly in PWM or PFM controllers.

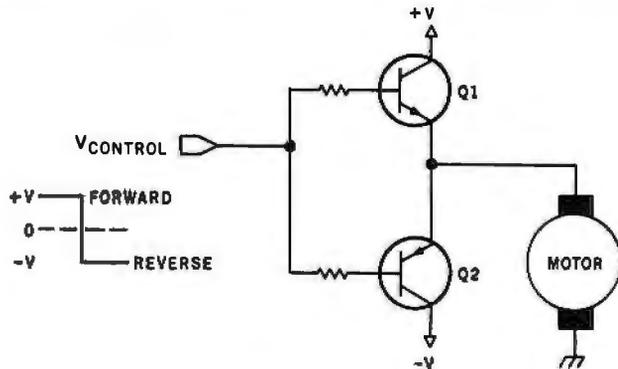


Figure 11b: A complementary-type reversing circuit. It is more suitable for linear-amplifier control operation, while requiring two opposite-polarity power-supply voltages.

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 con-

trol, 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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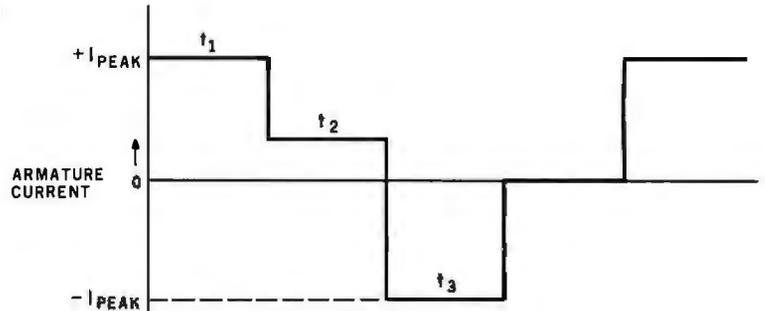
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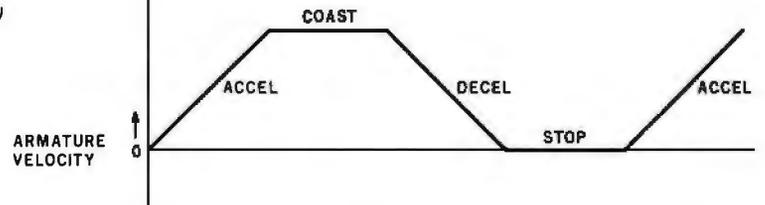
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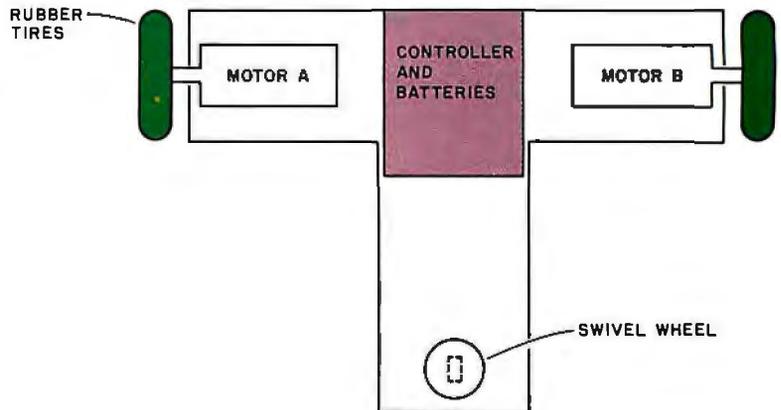
(12a)



(12b)

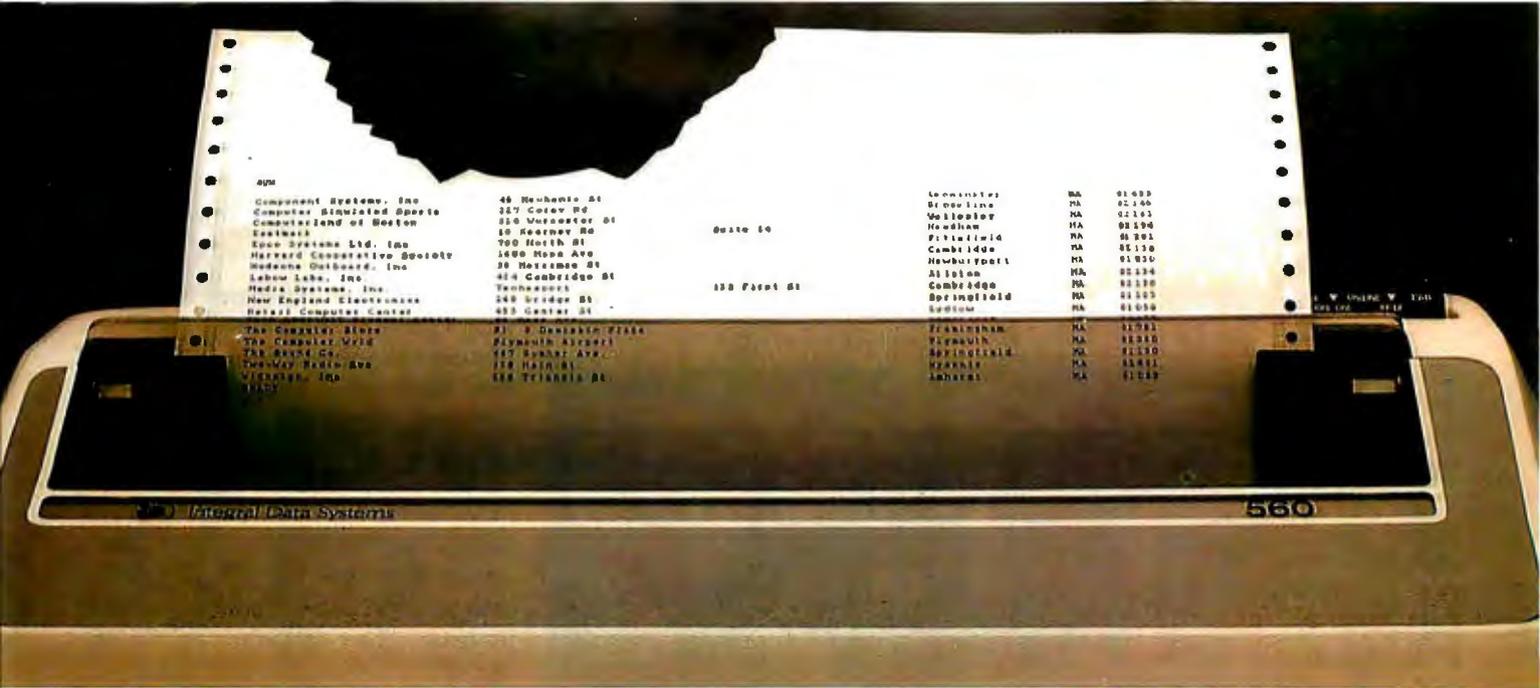


**Figure 12:** Precise control can be achieved using incremental-motion controllers. During predetermined periods of time, variable-amplitude voltage pulses are applied to the motor's coils. With the system initially at rest, a high positive step voltage,  $t_1$ , is applied to the motor. After motion 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.



FUNCTION	DIRECTION OF ROTATION	
	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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# Paper Tiger 560

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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.

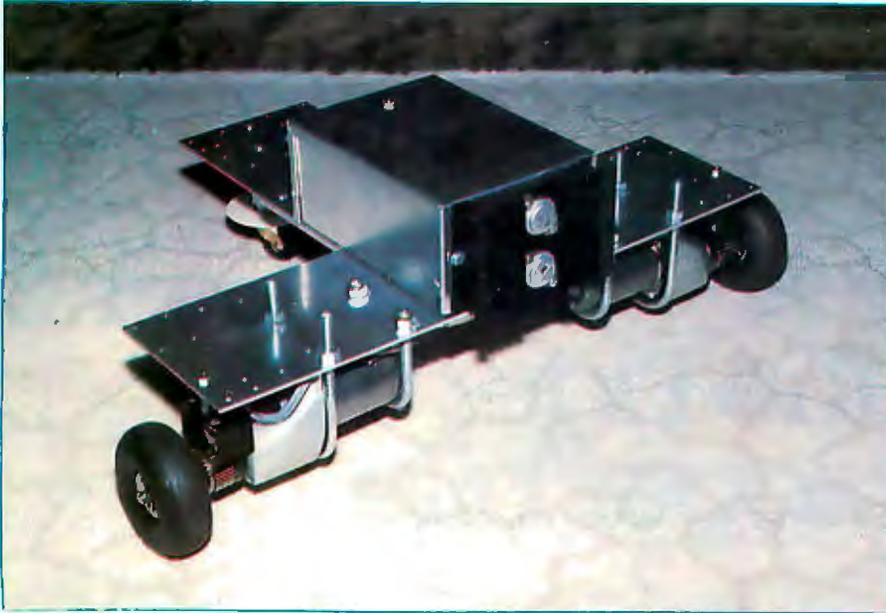
To attain this lower speed, an incremental-motion/PWM controller was designed. One controller is required for each motor. The schematic diagram is shown in figure 14 on page 96. Component values were experimentally determined for use with the Black & Decker PM motor specified. Other PM motors may not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

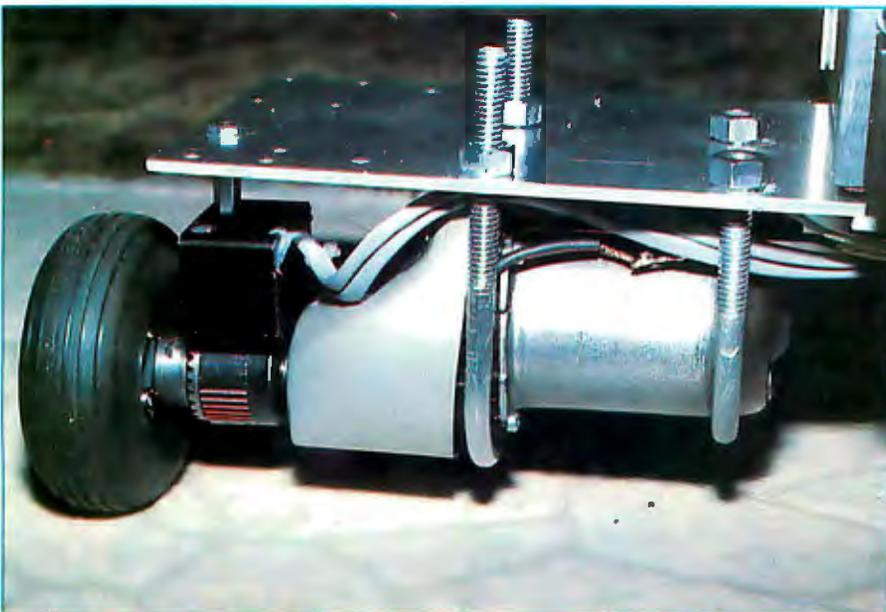
The low pulse-frequency rate required to keep the speed at or below 60 rpm results in an incremental-motion condition. The start pulse is at the full DC supply voltage, creating a high-velocity start-up. A reverse-step pulse is not necessary to stop the motor, however, due to the high mechanical load 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-



**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  $\frac{1}{4}$ -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  $\frac{1}{2}$ -inch brass rod that serves as an axle is inserted into each drill chuck. The tires are air-filled  $3\frac{3}{4}$ -inch diameter rubber tires used on model airplanes.

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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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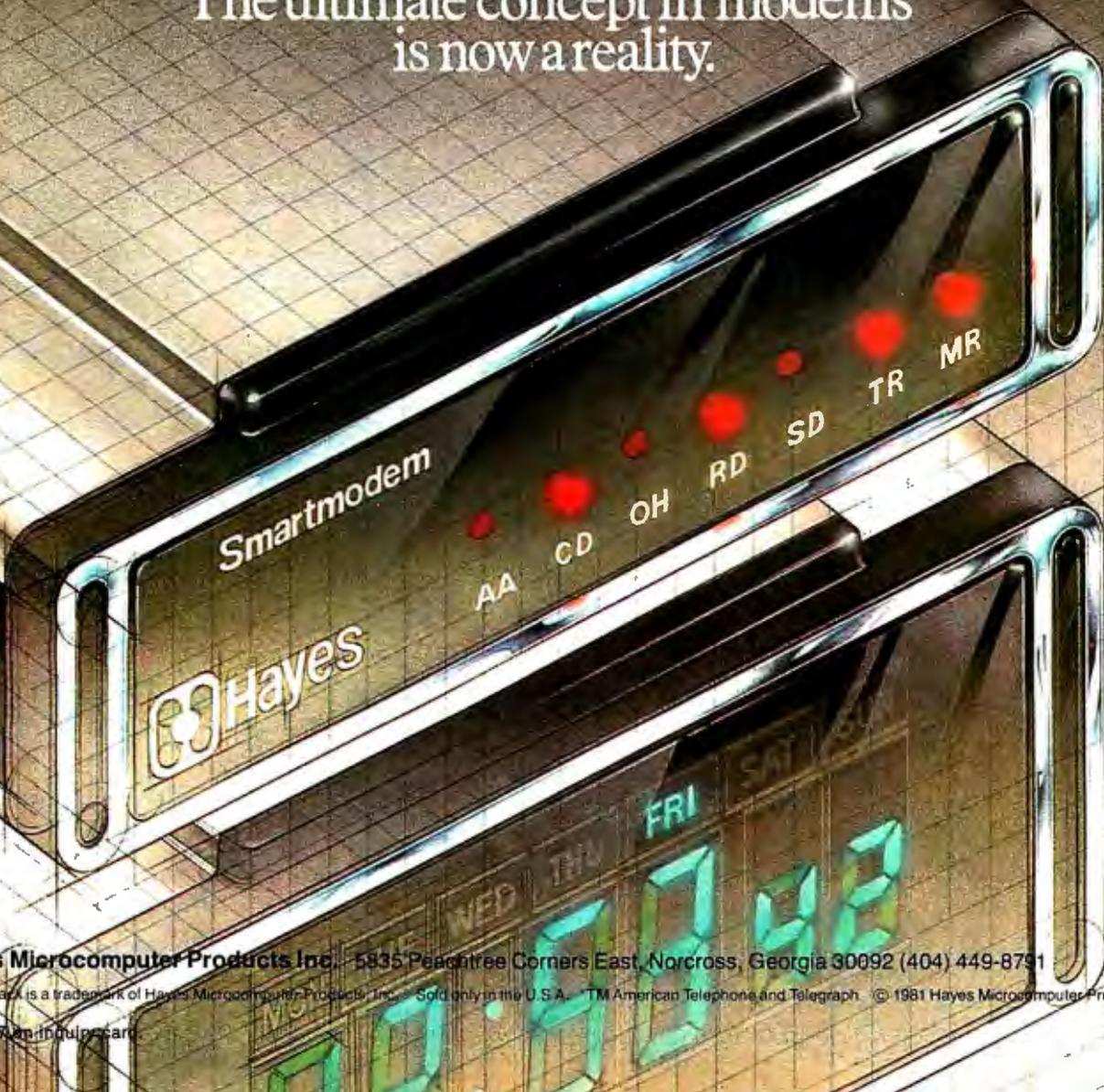
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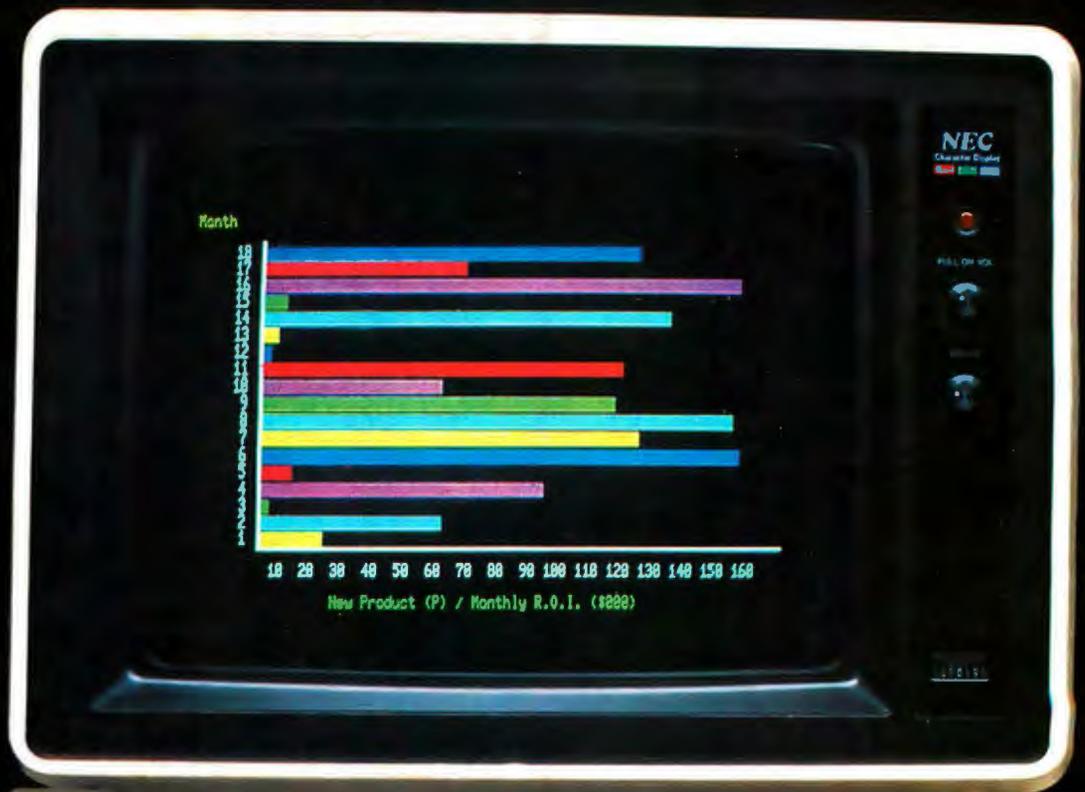
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Text continued from page 92:

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 (unfor-

tunately, 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.

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**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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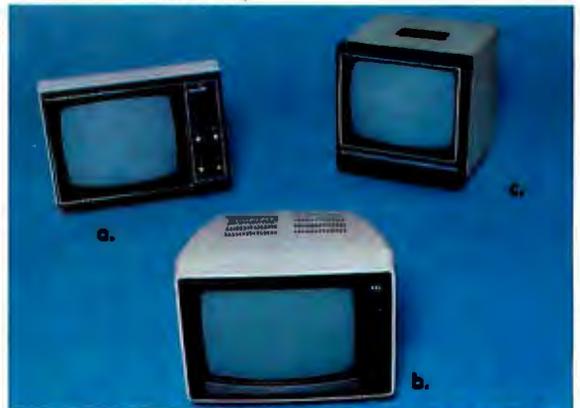


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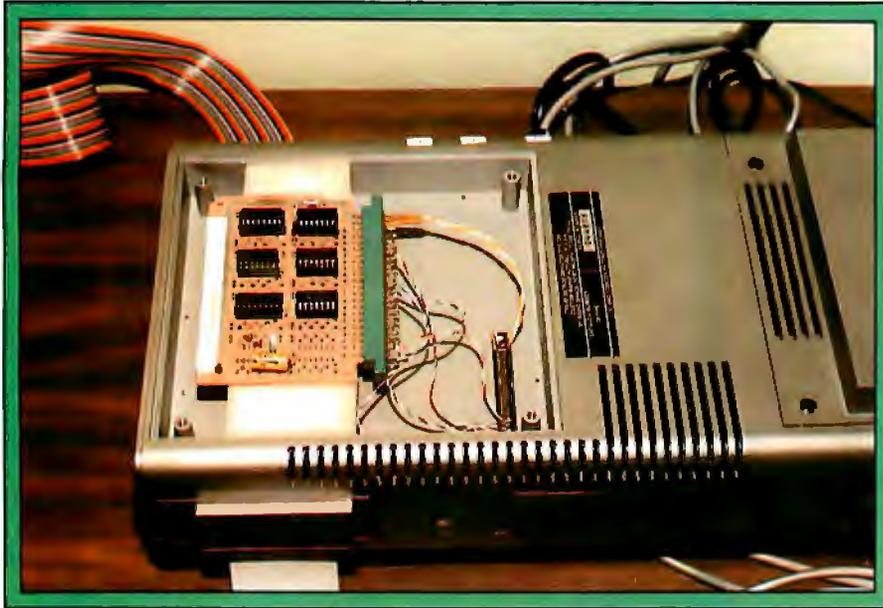
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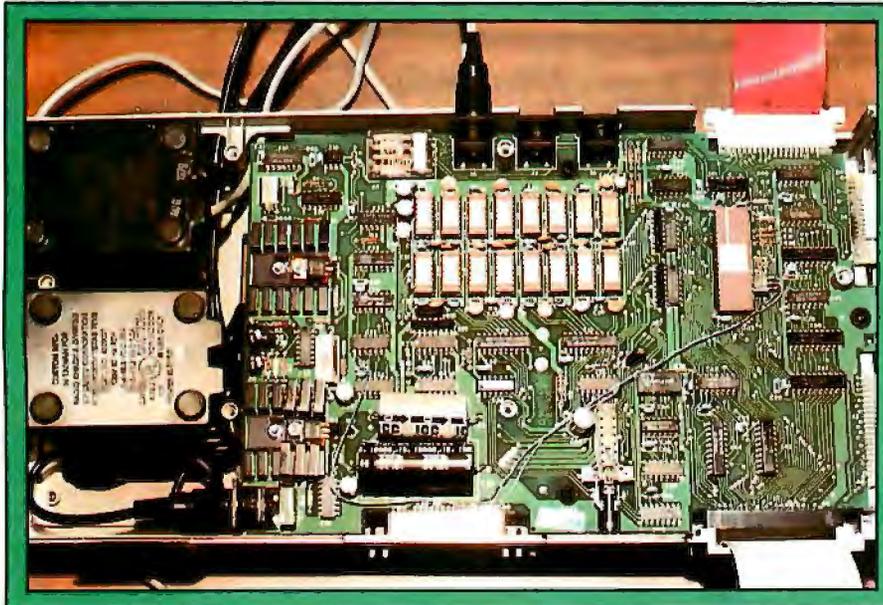
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## Improve TRS-80 Disk Operation Add an External Data Separator

(1a)



(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  $10^6$ , 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

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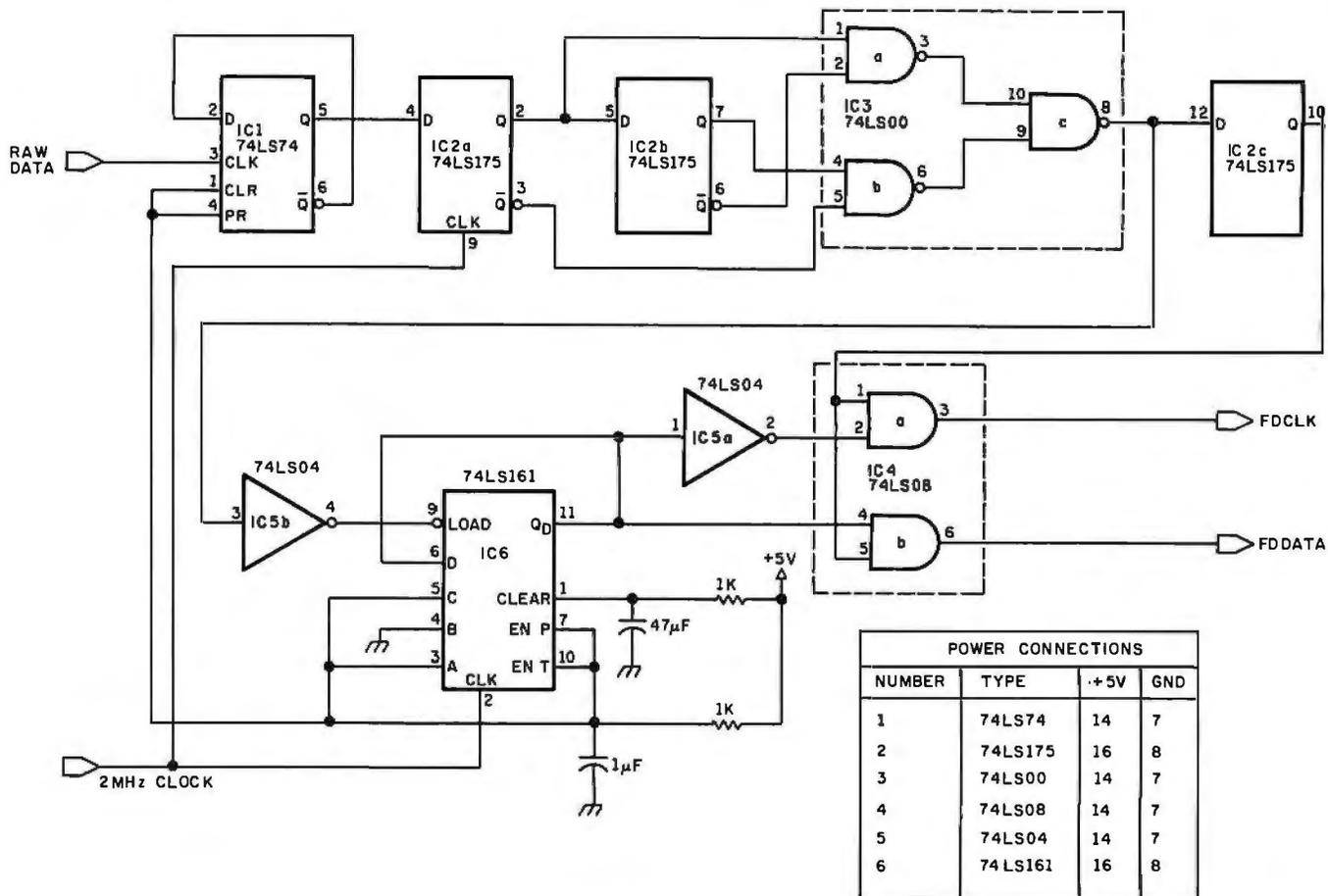
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**Figure 1:** External data separator circuitry. This design was developed from one recommended by Western Digital in an applications note for its FD1771. This circuit adds a power-on reset feature.

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.

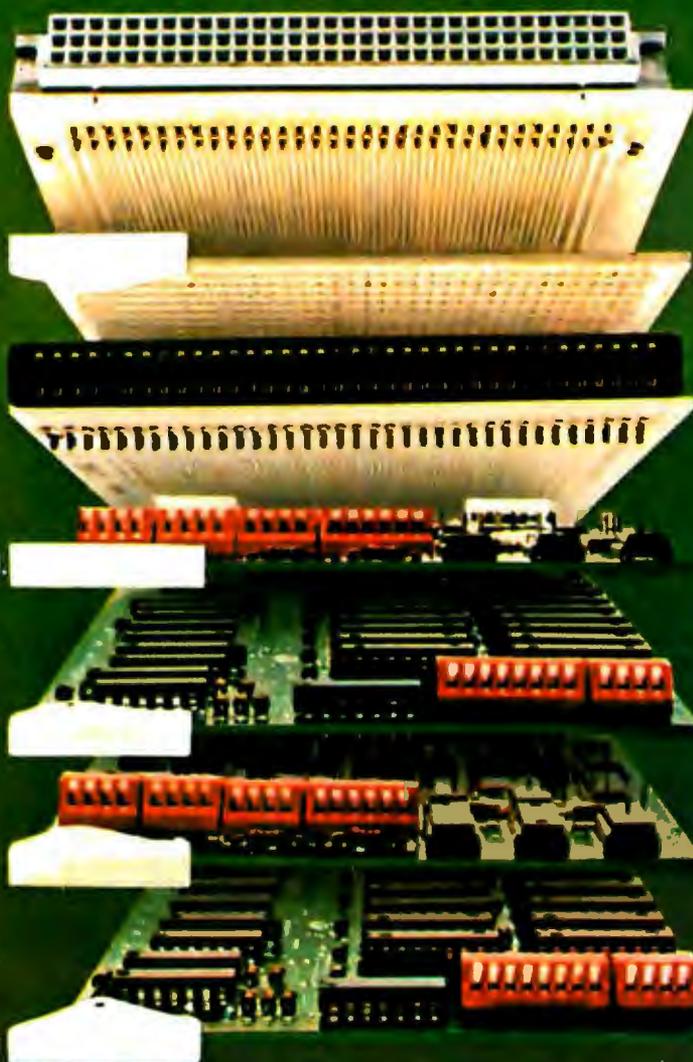
Pin 25 must be connected to ground when using an external data separator (pin 25 is normally pulled up to +5 V for internal data separation). Pins 26 and 27 are the separated clock and data inputs to the 1771. The raw data from the disk drive to the external data separator is avail-

able 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. ■

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## 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.

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



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.

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.

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

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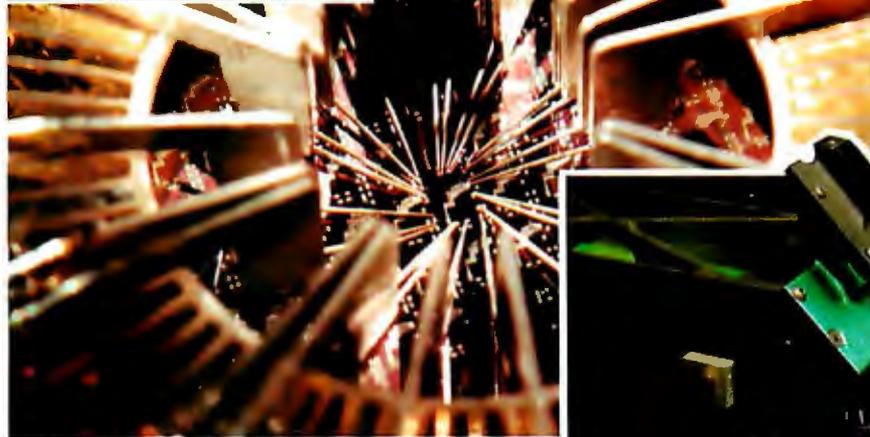
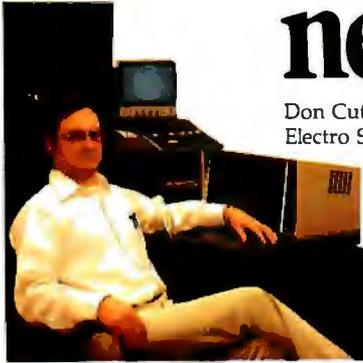
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Left: Pascal-1 controls ESI's laser trimming system. The laser repairs semiconductor memory chips, replacing faulty cells with alternates.

Below: ESI dominates the industry in the computer-controlled laser adjustment of microcircuits. Pascal-1 programming flexibility gives ESI access to many different markets.



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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

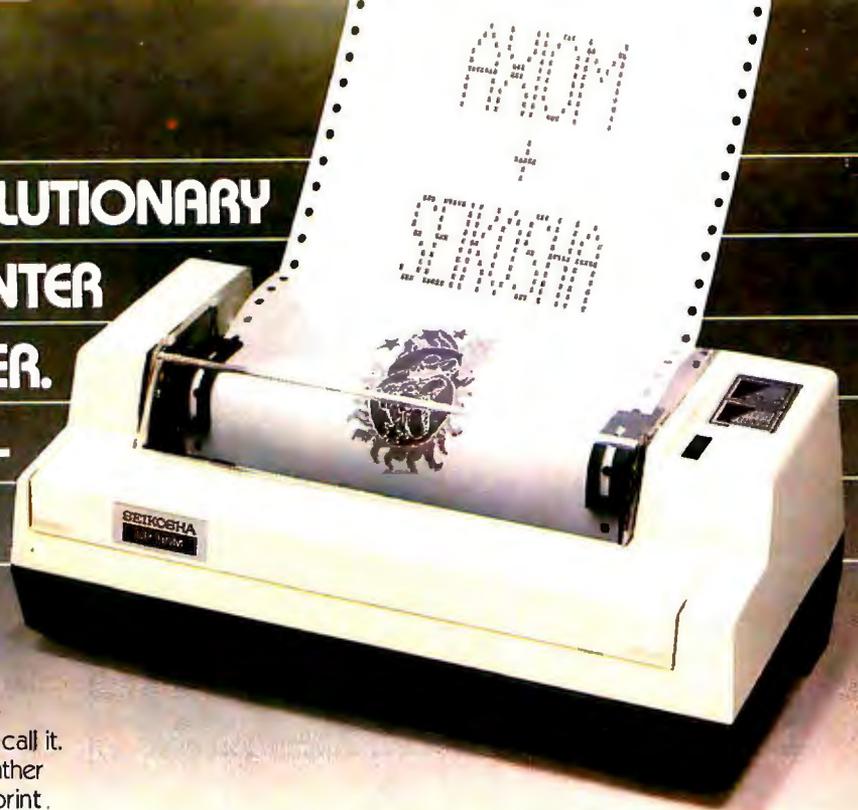
Bob Liddil, POB 66, Peterborough NH 03458

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

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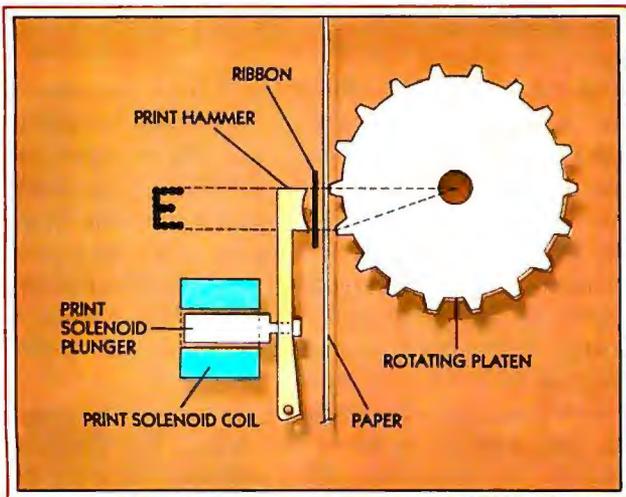
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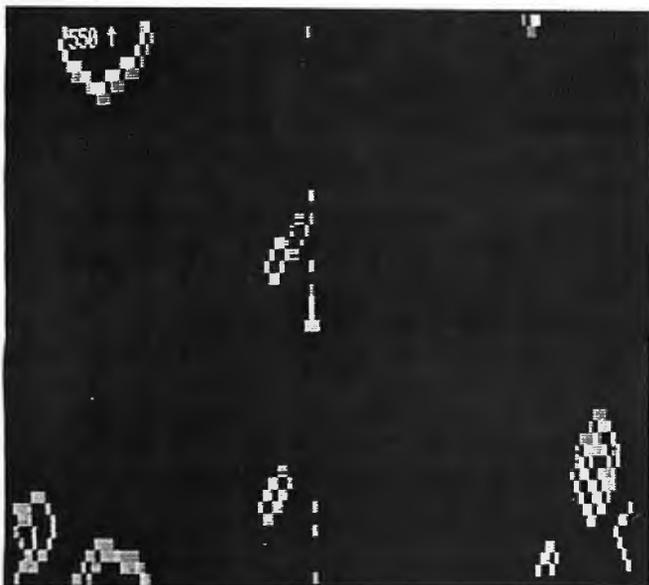


Photo 1: *The Super Nova game in play.*

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

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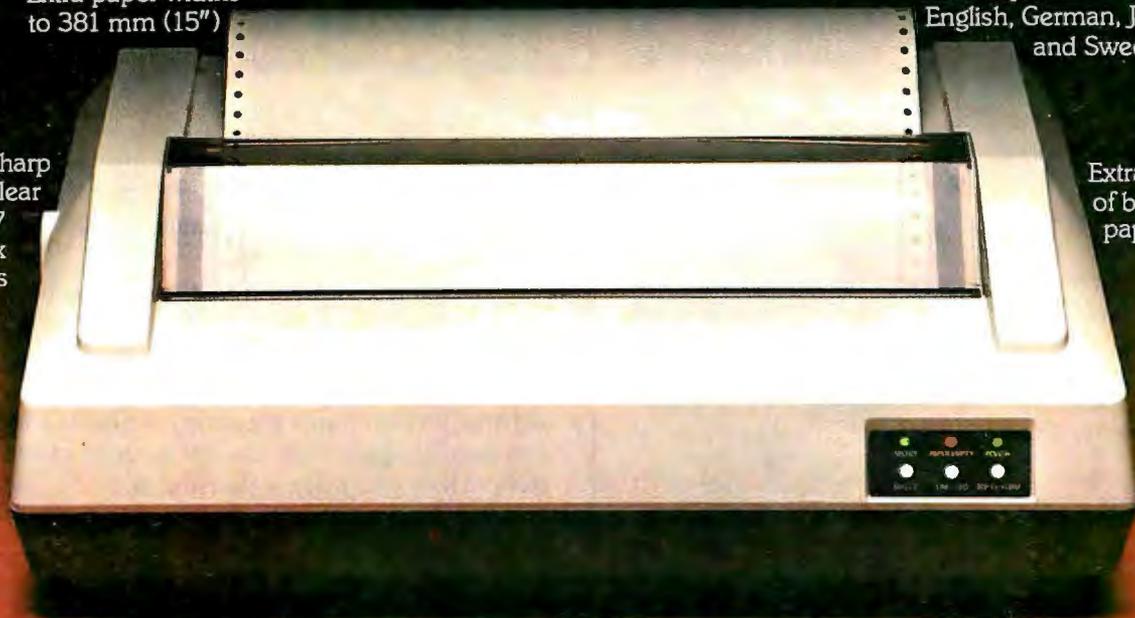
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level, horizontal and vertical velocities, and altitude are displayed in text form below the graphics display. This aspect might have been improved by using analog dis-

plays 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.

### 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. ■

### At a Glance

<b>Name</b> Tranquility Base	<b>Format</b> 5¼-inch floppy disk
<b>Type</b> Arcade-style game	<b>Language</b> 6502 machine language
<b>Manufacturer</b> Stoneware 50 Belvedere San Rafael CA 94901	<b>Computer</b> Apple II or Apple II Plus with one disk and 32 K bytes of memory
<b>Price</b> \$24.95	<b>Documentation</b> Instructions in game
<b>Author</b> Bill Budge	

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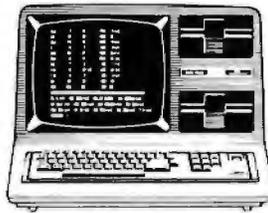
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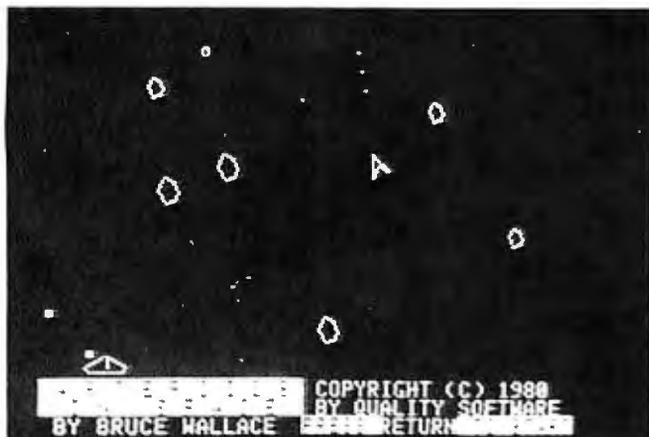
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# Asteroids in Space and Planetoids

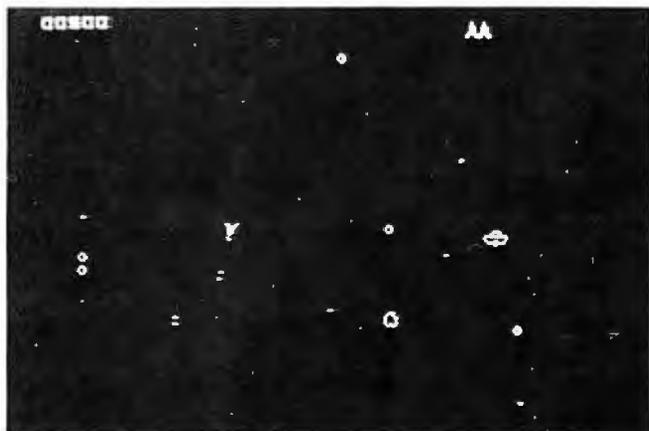
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Oliver Holt  
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**Photo 1:** *Asteroids in Space* is the title of the *Asteroids* game for the Apple from Quality Software. It is similar to the actual arcade game; the spaceship is controlled via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

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**At a Glance**

**Name**  
Planetoids

**Language**  
6502 machine language  
(has inenu programs in both Integer and Applesoft BASIC)

**Type of package**  
Arcade-style game

**Manufacturer**  
Adventure  
International  
POB 3435  
Longwood FL 32750

**Computer needed**  
Apple II or Apple II  
Plus with 48 K bytes of memory and one floppy-disk

**Price**  
\$19.95

**Documentation**  
One page with description of the game; additional instructions in the actual program.

**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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### At a Glance

**Name**  
Asteroids in Space

**Type of package**  
Arcade-style game

**Manufacturer**  
Quality Software  
6660 Reseda Blvd  
Suite 105  
Reseda CA 91335

**Price**  
\$19.95

**Format**  
5¼-inch floppy disk

**Language**  
6502 machine language

**Computer needed**  
Apple II or Apple II  
Plus with 48 K bytes  
of memory and one  
floppy-disk drive

**Documentation**  
One page with descrip-  
tion of the game; addi-  
tional instructions in  
the actual program.

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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# Programming Quickies

## 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:1pab);
3 : (dptr:1integer)
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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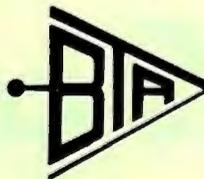


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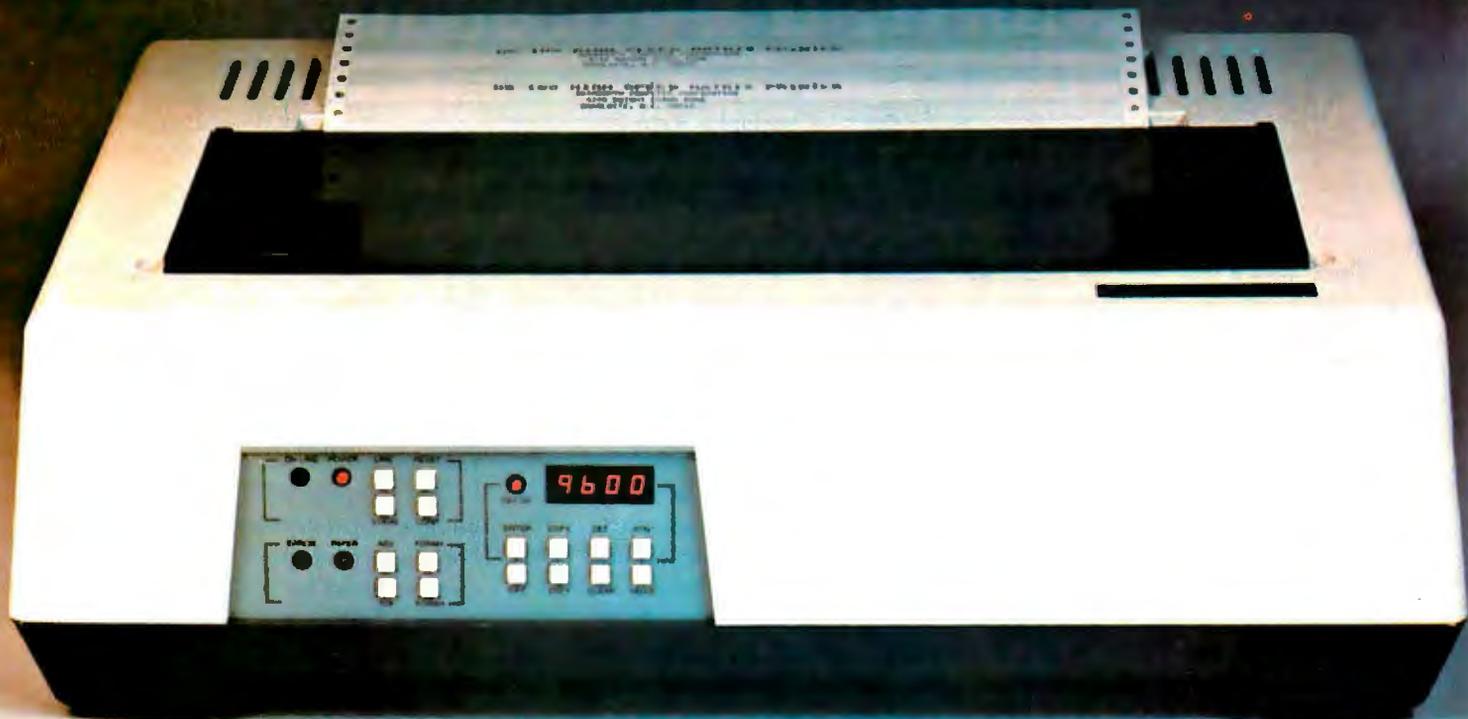
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# Washington Tackles the Software Problem

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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."

## 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 commercial 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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### About the Author

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

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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 stat-

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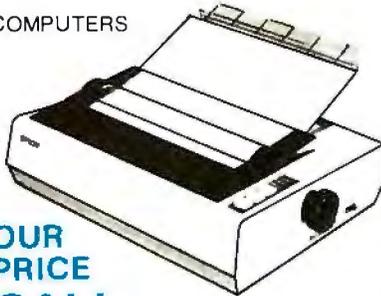
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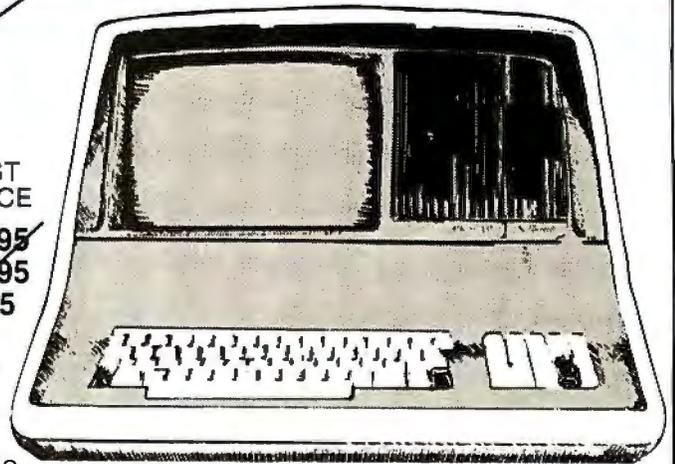
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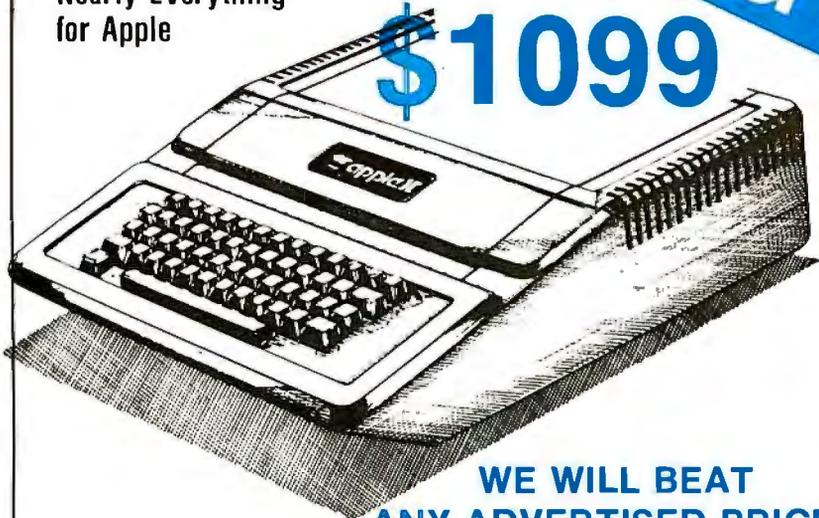
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idea of itself is not patentable," and concluded that granting a patent for the BCD-to-binary algorithm would amount to giving the applicant exclusive ownership of a mathematical abstraction.

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

## The protection afforded by a patent borders on the ab- solute.

ruling on the patent law and allow its interpretation to evolve on a case-by-case basis.

### The Flook Decision

A few years later, in *Parker v. Flook* (1978), the Supreme Court ad-

dressed 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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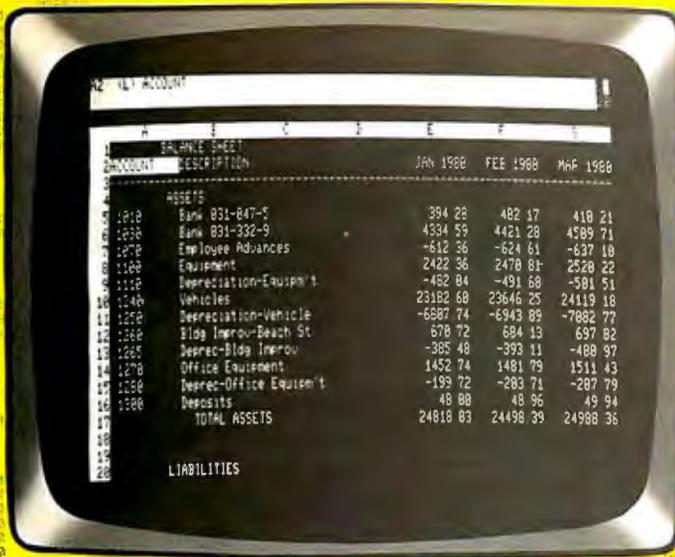
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law, which is only slightly changed from the language drafted by Thomas Jefferson in 1793, and (2) both programming and genetic engineering involve the manipulation of coded information which is stored (in one instance, in the electronic or magnetic 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 commercial BASIC interpreter

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## Object code is now clearly subject to copyright laws.

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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.

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 non-obvious 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 non-obviousness 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 appropriate 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.*

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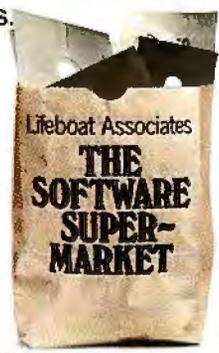
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Answer: There are no guarantees.

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## 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 re-

search 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:

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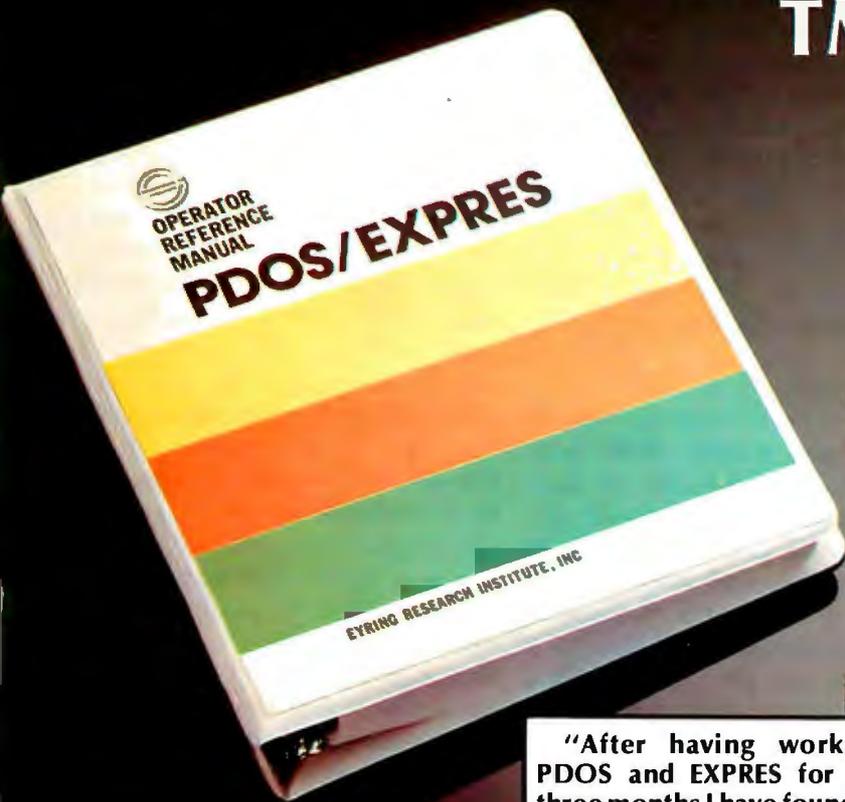
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who independently develop the same program; a copyright offers protection only against actual copying.

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 copy-

right. 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 unequivocally 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

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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. ■

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## GENERAL INSTRUMENT

## 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 program 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  
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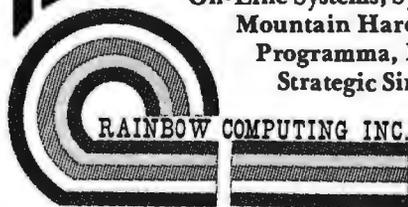
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entered into the music section of the program.

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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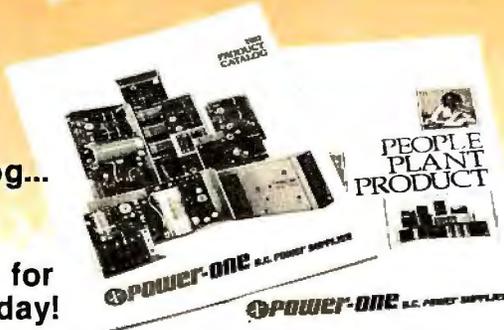
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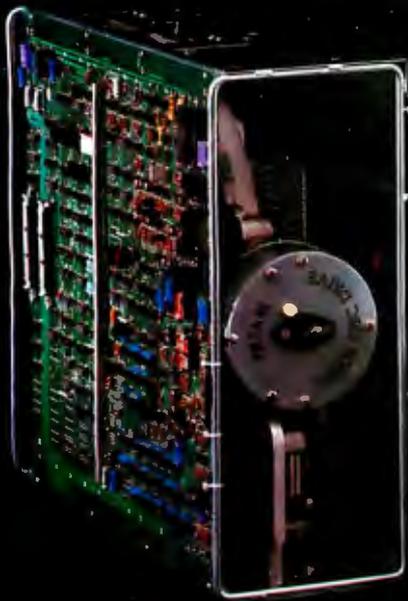
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# Wire-Wrapping and Proto-System Techniques

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Adolph Mangieri  
POB 384  
New Kensington PA 15068

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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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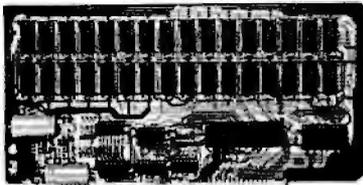
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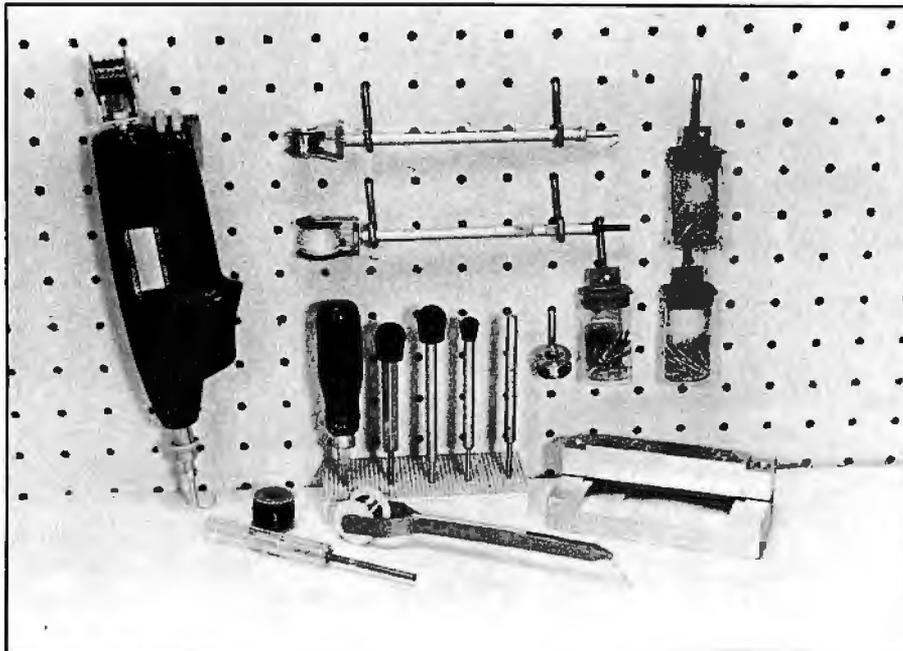
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**Photo 1:** Available wire-wrapping tools include the Vector P180 Slit-N-Wrap, installed in a P160-4R cordless driver unit (left), the P160-2A-1 Dual-Way Wrap-N-Strap (top center), and the P184-Tefzel Slit-N-Wrap (below). The stand (center) displays 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).

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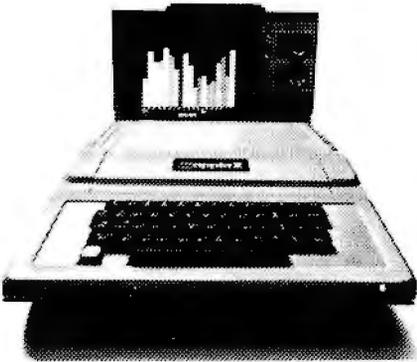
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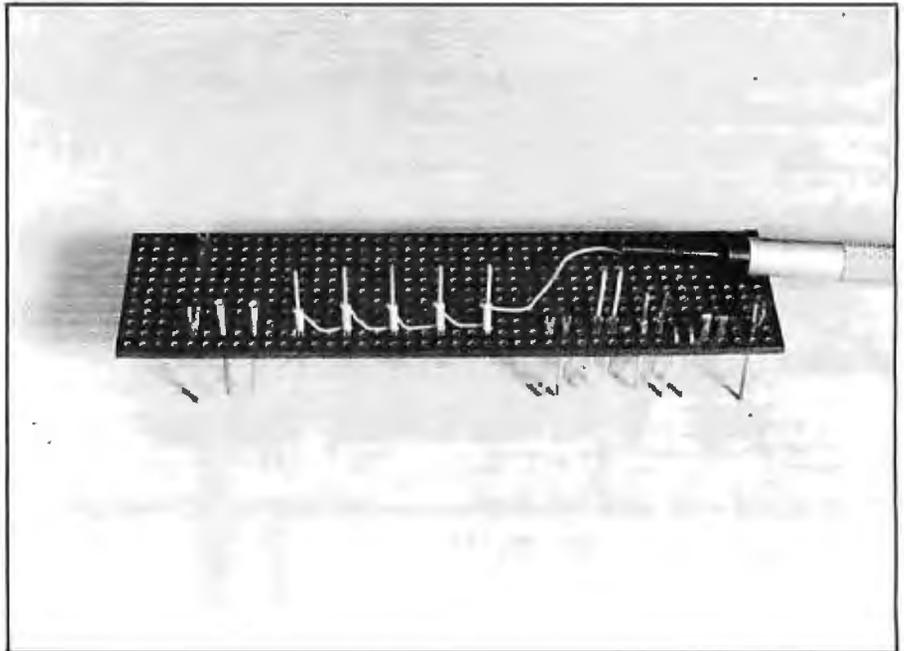


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*Photo 2: Rapid assembly of circuit boards demands insulated-wire strapping or chaining techniques, as demonstrated with the P184 Tefzel Slit-N-Wrap tool. The wide variety of board pins shown can handle any wiring situation.*

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

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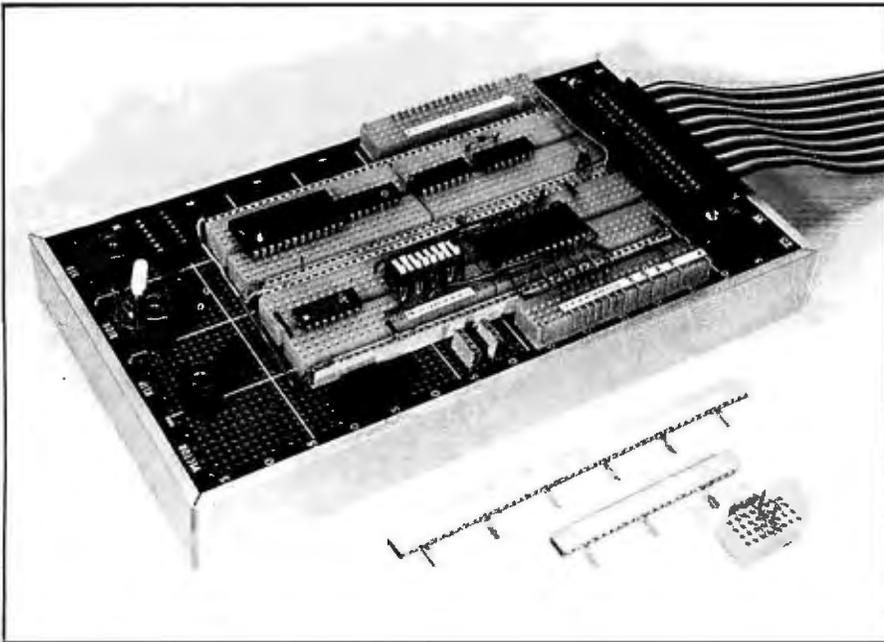
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**Photo 3:** A DIP (dual in-line package) patchboard or breadboard, such as the Vector 51X patchboard, is indispensable to circuit development. This patchboard is top and bottom wirable and can be easily linked to a computer with an IDC ribbon cable.

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 pre-melts 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.

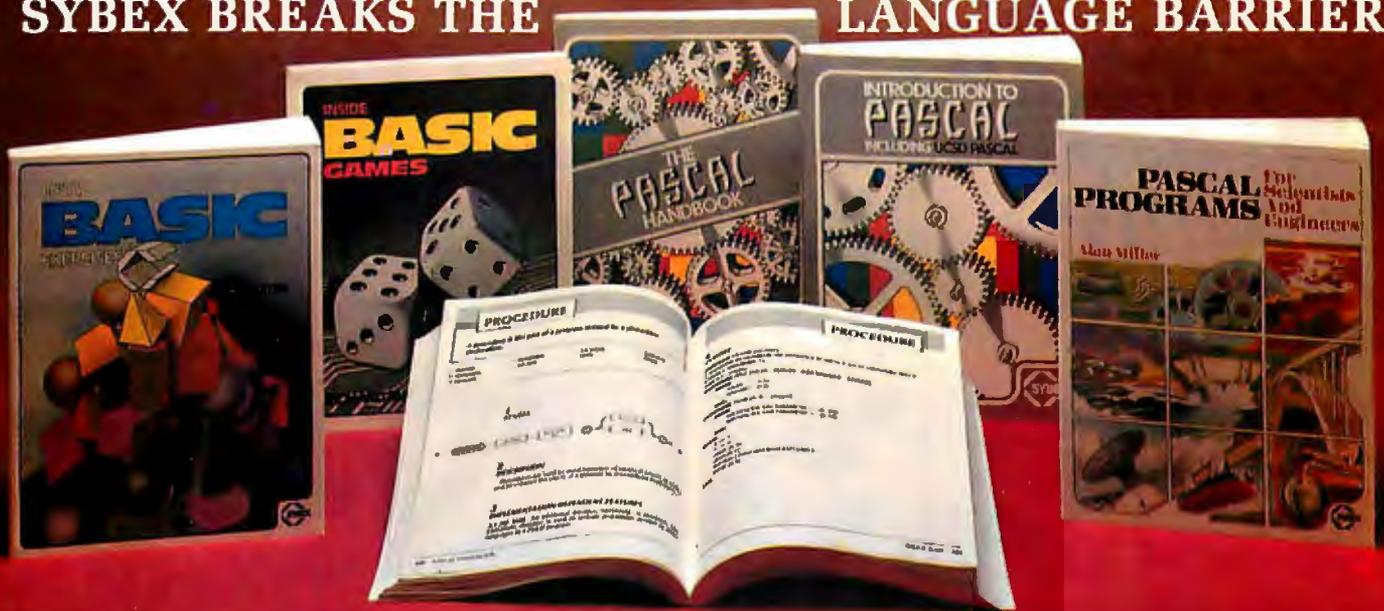
### DIP Patchboard

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  $\mu$ F electrolytic capacitor and a 1.0  $\mu$ F tantalum capacitor, and bypass the supply pins of all monostables and flip-flops with a 0.1  $\mu$ F 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

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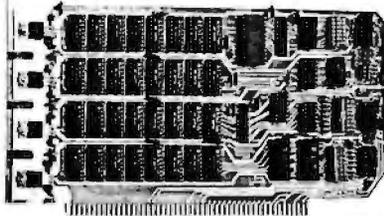
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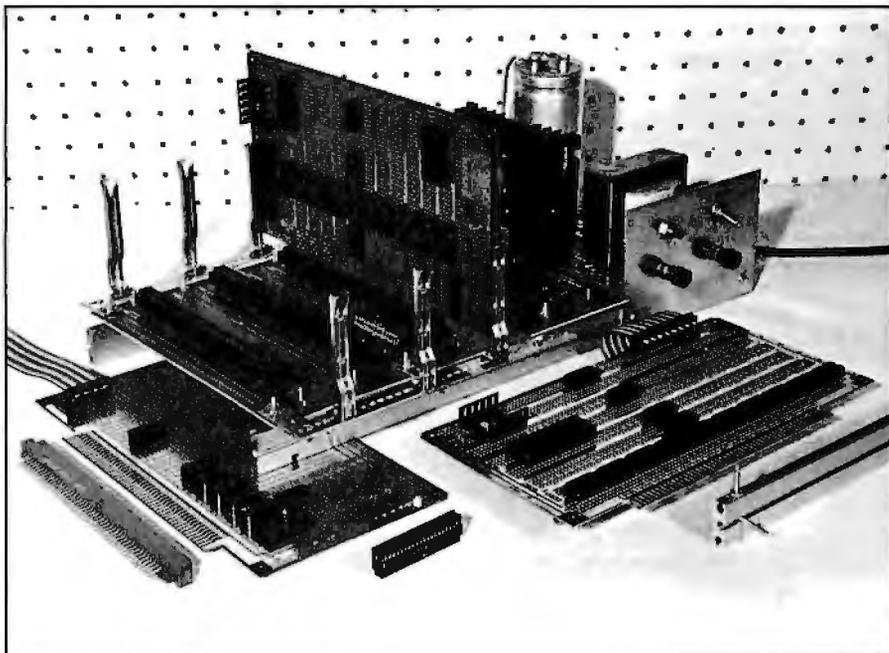
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**Photo 4:** Low-cost open-frame S-100 bus mainframe uses a Vector 8803 motherboard and T169 T-struts. S-100 prototyping boards include the model 8800V in the mainframe, an 8804 Any-Dip board (right), and the 8802 pad board (left). Shown in the foreground (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.

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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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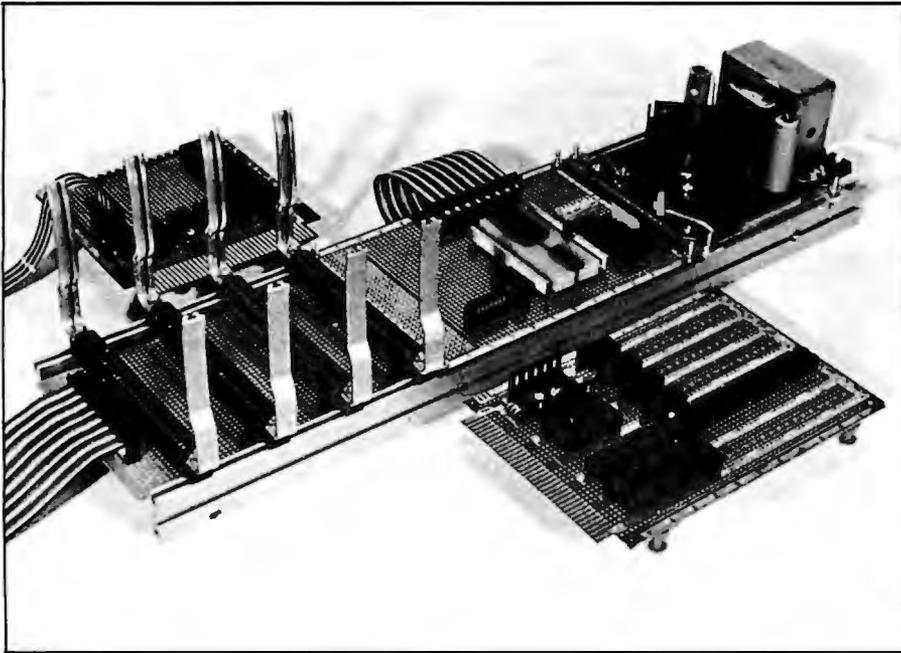
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**Photo 5:** A system bus with fewer than one hundred lines can also be assembled using standard Vector components. The seventy-two-line combination system pictured here is a typical example. Primary components include the R636-1 receptacles, a 3677-7 clearance ground-plane board on the wire-wrapped backplane, and a Vector 8004 Circ-board 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 system 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

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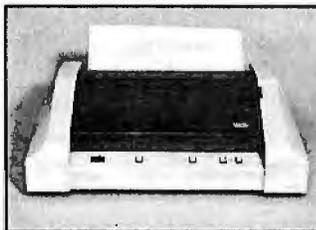
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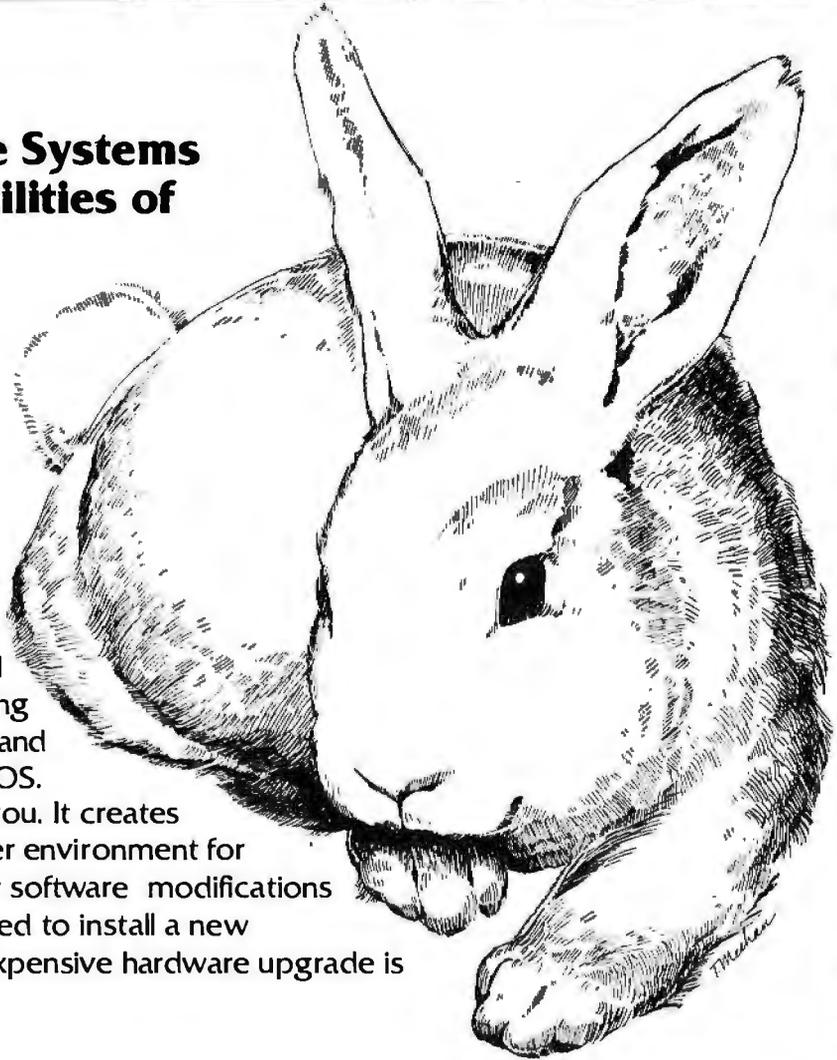
through a length of 3677-7 clearance ground-plane board supporting pin rows so that you can plug in an IDC ribbon cable. To create a work area for a patchboard or other circuit, you can add a Vector 8004 Circboard with clearance ground plane, as shown. Alternatively, you can install the 8002 Circboard 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 plug-board 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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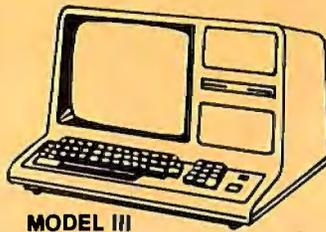
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that fit 14-, 16-, or 24-pin DIP sockets.

## 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

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4012	25 4043 100 4515 195 74C151 175
4013	37 4046 75 4518 100 74C160 120
4014	37 4046 75 4518 100 74C160 120
4015	65 4049 45 4520 70 74C163 115
4016	45 4053 110 74C164 120 74C165 120
4017	70 4061 80 74C100 27 74C174 130
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7419	-17 74107	35 74194	-79
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7426	33 74122	39 74195	-85
7427	35 74123	42 74196	-85
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74LS07	27 74LS158	-100
74LS10	25 74LS159	-100
74LS11	27 74LS160	-100
74LS12	35 74LS161	-100
74LS13	35 74LS162	-100
74LS14	35 74LS163	-100
74LS15	35 74LS164	-100
74LS16	35 74LS165	-100
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74LS18	35 74LS167	-100
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74LS25	35 74LS174	-100
74LS26	35 74LS175	-100
74LS27	35 74LS176	-100
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bus- and supply-line short circuits. Insert a millimeter 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 in-

serting 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. ■

You can extend the usefulness and data entry speed of your TRS-80 by giving it the graphics and menu capabilities of the Bit Pad One digitizer.

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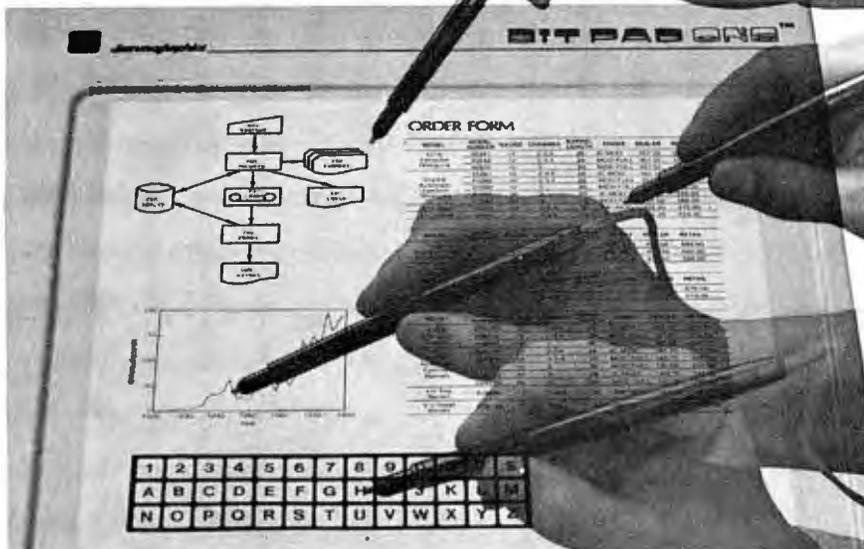
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### Notice of Omission

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

---

Ronald Bobo  
3246 Gravois  
St Louis MO 63118

John Knoderer  
The Software Center  
51 Florissant Oaks Shopping Ctr  
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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

---

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

---

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.

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*

---

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Maximum record size (bytes)	1020	<b>4064</b>	Up to 9 lines of column titles	YES <b>Yes(16)</b>
Maximum number of fields/record	100	<b>999</b>	Up to 9 lines for each record	YES <b>Yes(16)</b>
Handles files with more than one diskette of data	YES	<b>Yes</b>	Maximum number of fields per report	100 <b>999</b>
Custom disk operating system (DOS) for faster data retrieval and program chaining	YES	<b>No</b>	Code fields - store short codes, print long descriptions	YES <b>Yes</b>
User-designed screen formats	YES	<b>No</b>	Comment lines and footnotes	YES <b>Yes</b>
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Ten field types, including dollar/cents, phone & social security number, date, etc.	YES	<b>Yes(15)</b>	Summary only reports	YES <b>Yes</b>
Automatic data compaction for increased disk storage capacity	YES	<b>Yes</b>		
Wild card, partial string, range and Boolean search capabilities	YES	<b>Yes</b>		
Dynamic prompting (tm) - lists all available functions on screen—no need for quick reference card	YES	<b>Yes</b>		
Password file protection	YES	<b>Yes</b>		
Four function calculator mode	YES	<b>Yes</b>		
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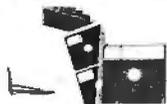
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**Listing 1: TRS-80 graphics program using the traditional SET and RESET graphics.**

```

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 TO 76: 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): S
ET(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 150: 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=0 TO 47: X=-1
11010 X=X+1: IFX>127 THEN 11060
11020 IFPOINT(X, Y)=0 THEN 11010
11030 X1=X
11040 X=X+1: IFX>127 OR POINT(X, Y)=0 THEN PRINT#1, Y, "X1", "X: GOTO 11010
11050 GOTO 11040
11060 NEXT Y: CLOSE
12000 OPEN" I", 1, "GRAPHIC/DAT": CLS
12010 C=C+1: IFEOF(1)=0 THEN INPUT#1, Y, X1, X2: FOR X=X1 TO X2: SET(X, Y): NEXT: GOTO 12010
12020 GOTO 12020
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 KNOEDERER, 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 CLEAR 9999: OPEN" I", 1, "GRAPHIC/DAT": LN=1900: OPEN" O", 2, "GRAPHIC/ASC
13010 LN=LN+5: X$=STR$(LN)+" DATA"
13020 IFEOF(1) THEN PRINT#2, LEFT$(X$, LEN(X$)-1): PRINT#CHR$(8): CLOSE: END
13030 INPUT#1, Y: X$=X$+MID$(STR$(Y), 2)+": IFLEN(X$)>237 THEN PRINT#2, LEFT$(X$, LEN(
X$)-1): PRINT#CHR$(8): GOTO 13010
13040 GOTO 13020
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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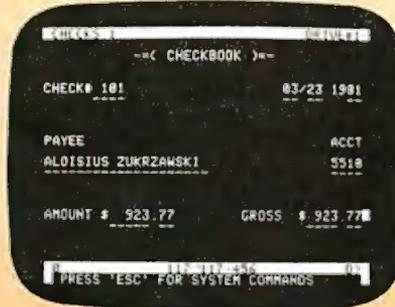
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### Notice of Omission

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.

**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
,29,23,40,41,23,48,49,23,50,51,23,95,96,23,123,126,24,5,8,24,28,29,24,33,39,24
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
9,94,96,29,123,126,30,5,8,30,27,28,30,30,32,30,34,36,30,38,40,30,43,40,37
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 conversion 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 9: Routine to display graphics data converted to strings of characters.

```

1390 CLEAR 3000
1400 DEFINTI-N:QNERRORGOTO1430: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'0',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+L:ELSEPRINT#2,L', 'A
1540 L=1:A=B
1540 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:QNERRORGOTO1730: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
91,195,1,160,1,190,1,135,2,131,1,175,1,180,1,170,1,149,204,1,170,1,191,1,149,194
,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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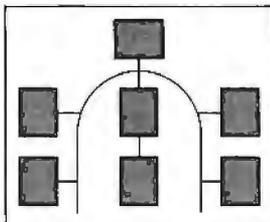
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**Listing 12:** Routine that converts screen data to the most compact, fastest form discussed in this article.

```
1800 POKE16383,149:L=1:A=PEEK(15360):IF A<129 THEN A=32
1805 OPEN"O",2,"FASTEST"
1810 FOR I=15361 TO 16383:B=PEEK(I):IF B<129 THEN B=32
1820 IF B=ATHEN L=L+1:GOTO 1860
1830 IF A=32 THEN PRINT#2,192+L:ELSE IF L=1 PRINT#2,ELSEPRINT#2,L',A
1840 L=1:A=B
1860 NEXT I: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
,129,191,153,183,157,187,149,130,175,182,179,191,2,176,190,135,193,191,153,183,
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 DEFINITION:ONERRORGOTO2030:CLS
2020 READ I:IFI<129 THEN READ J: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.

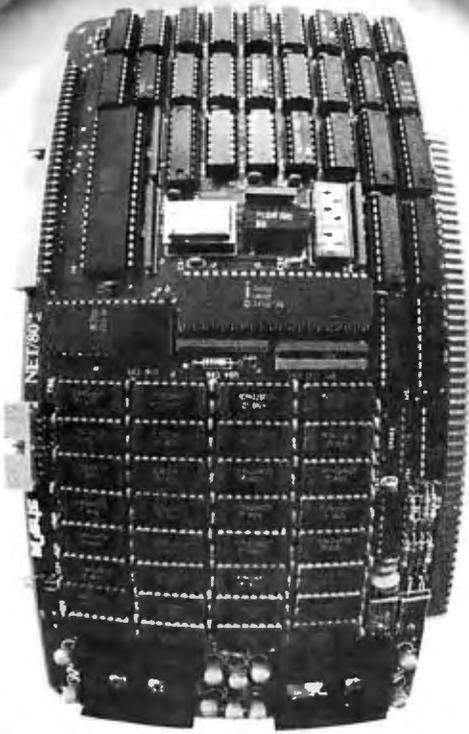
We allow and, in fact, encourage this because effective proof-building requires an analysis not only of the statements already derived, but of the statement to be proved as well. Often the proof can be considerably simplified by using the goal statement as a guide for determining the steps previous to 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.

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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.

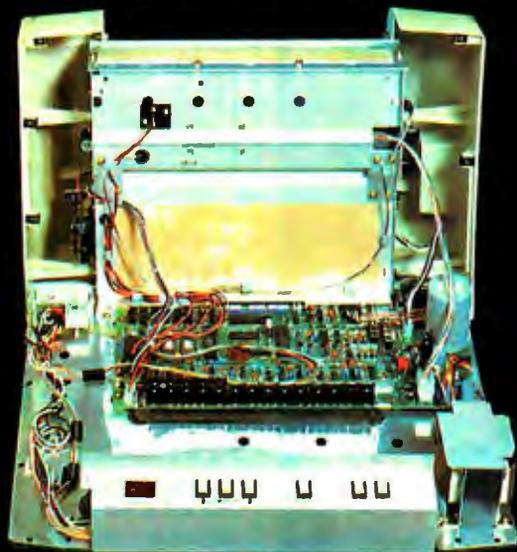
### Our Approach

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.

The central function of our advice-giving program is simply to ask students leading questions and then branch

Circle 23 on inquiry card. →

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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 FORMULA?' '&' 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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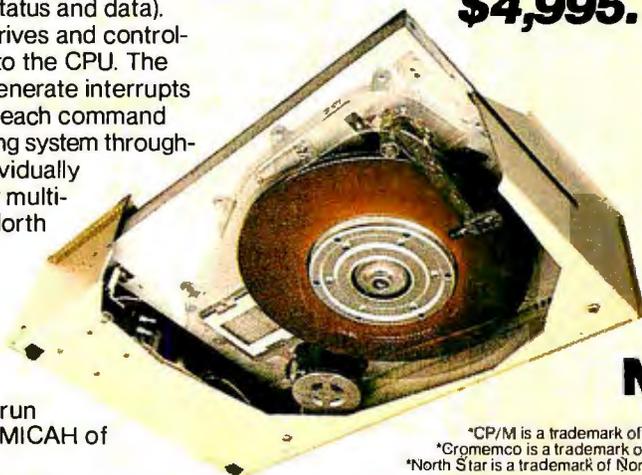
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"YOU SHOULD APPLY &RULE TO LINE &GNUM"

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.

This approach to giving computerized advice has a



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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.

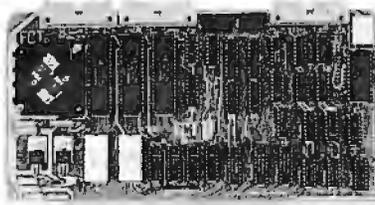
We should stress that despite our emphasis on strategy learning as an objective to advice-giving programs, the programs are also effective in giving factual information. From our advice giver, our students learn about the rules of logic, their names, their operation, and their functions in proofs. Also 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.

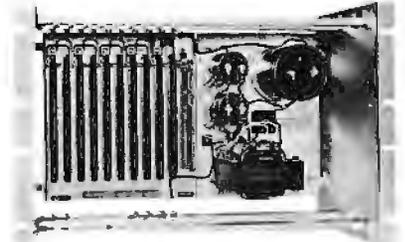
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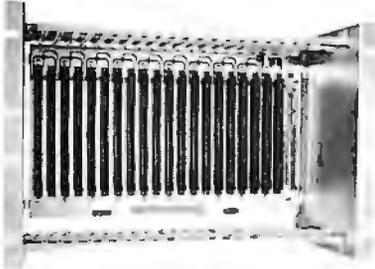


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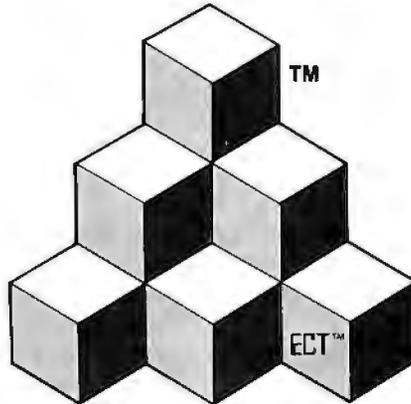


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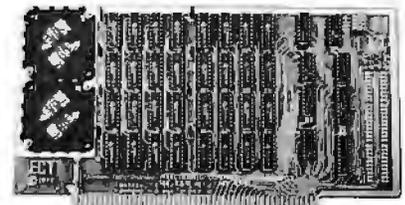
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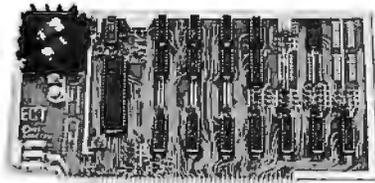


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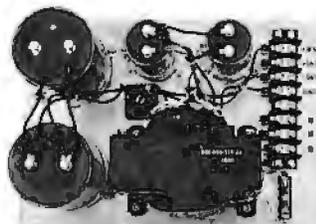


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## A Chessboard Journey on the TI-59 Programmable Calculator

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
00G	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:

041		2	1	+/-	SUM	10									Return KT to test square.
046		RCL	50	$x^2$	RCL	89	$*x \geq t$	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	$x^2$	1	0	$*x \geq t$	1	07							
		8	9	$x^2$	$*x \geq t$	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	$x^2$	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	x	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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00	01	02	03	04	05	06	07	08	09
0	2	7	4	16	4	7	2	-21	-8
10	11	12	13	14	15	16	17	18	19
-8	0	0	0	0	0	0	0	0	-8
20	21	22	23	24	25	26	27	28	29
-8	0	0	0	0	0	0	0	0	-8
30	31	32	33	34	35	36	37	38	39
-8	0	0	0	0	0	0	0	0	-8
40	41	42	43	44	45	46	47	48	49
-8	0	0	0	0	0	0	0	0	-8
50	51	52	53	54	55	56	57	58	59
-8	0	0	0	0	0	0	0	0	-8
60	61	62	63	64	65	66	67	68	69
-8	0	0	0	0	0	0	0	0	-8
70	71	72	73	74	75	76	77	78	79
-8	0	0	0	0	0	0	0	0	-8
80	81	82	83	84	85	86	87	88	89
-8	0	0	0	0	0	0	0	0	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	12	13	14	15
1	20	9	14	3
21	22	23	24	25
10	15	2	19	24
31	32	33	34	35
21	8	23	4	13
41	42	43	44	45
16	11	6	25	18
51	52	53	54	55
7	22	17	12	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<sup>ie</sup>, Paris, 1927.

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

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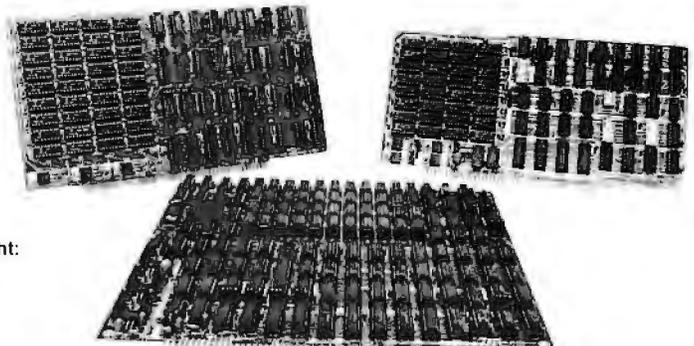
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# An Integer Math Package for the 8080

---

Bruce D Carbrey  
109 Bucknell Trl  
Hopatcong NJ 07843

---

"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.

---

**Improve your  
8080-based personal  
computer by adding  
these 16-bit arithmetic  
routines.**

---

## 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 ig-

nored. 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? Good luck!



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**Operations:** All standard operations plus string comparisons, assignments, and .XOR.

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**Statements:** ANSI 1966 standard with multiple statement lines.

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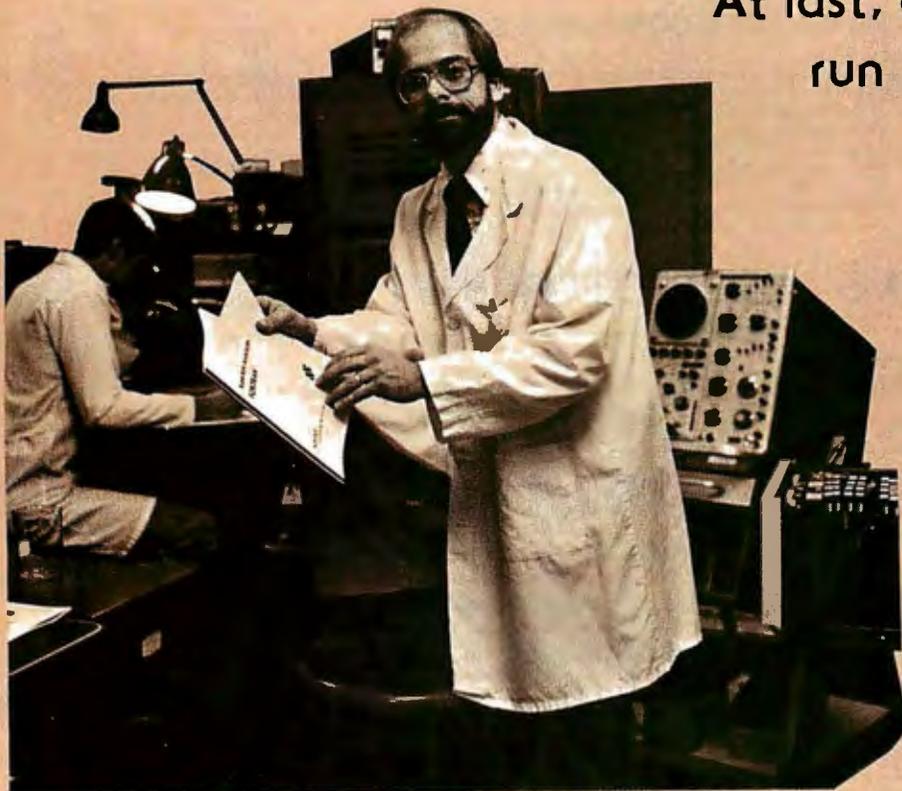
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Listing 1: 16-bit arithmetic subroutines in 8080 assembly language. The eight routines, which are fully documented in the listing, operate on 16-bit numbers in two's complement form.

43

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.
*
*****
```

89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99  
100  
101  
102  
103

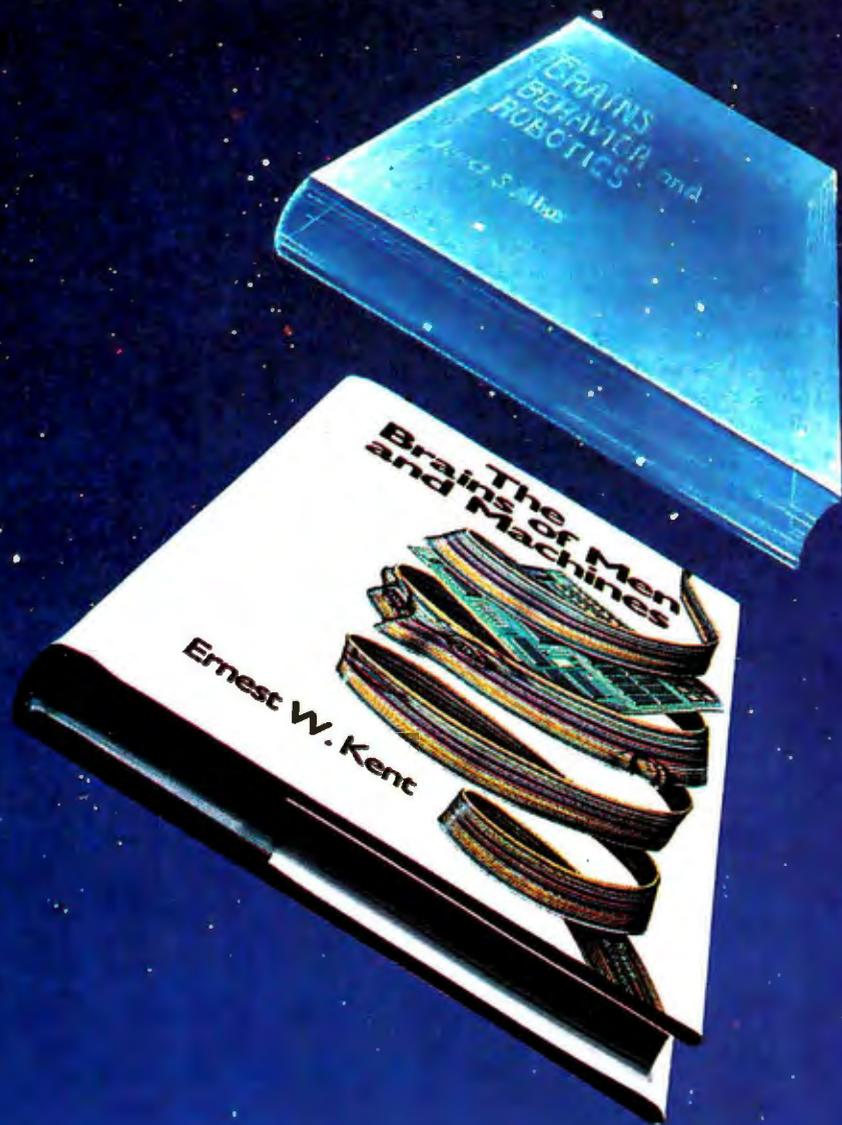
```
*      MATH PACKAGE EXECUTION TIMES IN MICRO-SECONDS:
*
*      ROUTINE  TYPICAL  WORST CASE
*
*      EADD     30        54
*      ESUB     50        74
*      EMULT    370       517
*      EDIVMOD  680       2500
*
*      ***** YOU MUST PROVIDE PATCHES TO THESE TWO ROUTINES... *****
*
*      OVERFLOW 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)
*
*****
```

106  
107  
108  
109  
110  
111  
112  
113  
114  
115

```
*      (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
*      4005  C20E40 JNZ  ESIGN  ADD, WITHOUT AFFECTING ZERO FLAG...
*      4008  1F      RAR      SKIP OVERFLOW TEST IF SIGNS DIFFER
*                               TEST FOR OVERFLOW BY...
```

Listing 1 continued on page 212



# KNOW THYSELF

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John Whitney is on the Faculty in the Department of Art at the University of California, Los Angeles.

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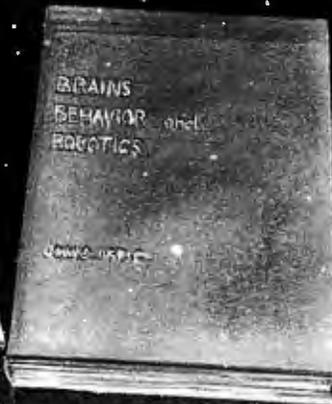
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Scott Kim is a doctoral student in Computer Science at Stanford University and is a concert pianist and composer.

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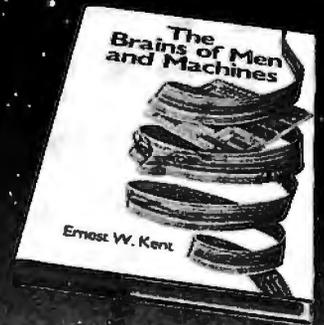
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Listing 1 continued from page 206:

```

116      4009      AC          XRA      H          ...EXCLUSIVE OR OF CY AND SIGN OF RESULT
117      400A      17          RAL
118      400B      DC0000      CC          OVERFLOW CHECK FOR ARITH OVERFLOW
119                                     *          FALL THRU TO .....

```

```

*****
*
* SUBROUTINE ESIGN - SET (S), (Z) FLAGS TO REFLECT (HL)
*
*****

```

```

122      *
123      *          A REGISTER CLOBBERED, ALL OTHERS RESTORED.
124      *
125      400E      AF          ESIGN      XRA      A          CLEAR FLAGS
126      400F      B4          ADD      H          SET FLAGS TO REFLECT HI BYTE
127      4010      C0          RNZ
128      4011      B5          ADD      L          RETURN IF HI-ORDER BYTE IS NON-0
129      4012      C8          RZ          ELSE, SEE IF L IS 0 TOO...
130      4013      AF          XRA      A          AND IF SO, RETURN
131      4014      3C          INR      A          ELSE, FORCE FLAGS TO SHOW *
132      4015      C9          RET

```

```

*****
*
* SUBROUTINE ESUB - SUBTRACT (DE) FROM (HL), RESULT TO (HL)
*
*****

```

```

135      *          (HL) = (HL) - (DE)
136      *          ON RETURN, ZERO, SIGN FLAG REFLECT RESULT. CY CLEARED.
137      *          A REGISTER CLOBBERED. B, C, D, E RESTORED.
138      *
139      4016      D5          ESUB      PUSH     D
140      4017      EB          XCHG
141      4018      CD3040      CALL     COMP2  FORM 2S COMPLEMENT OF SUBTRAHEND...
142      401B      CD0040      CALL     EADD   ...AND PROCEED AS IN ADDITION
143      401E      D1          POP      D
144      401F      C9          RET

```

```

*****
*
* ECHS - CHANGE SIGN OF REGISTER (HL)
*
*****

```

```

147      *          (HL) = -(HL)
148      *          ON RETURN, ZERO, SIGN FLAG REFLECT RESULT. CY CLEARED.
149      *          A REGISTER CLOBBERED. B, C, D, E RESTORED.
150      *
151      4020      7C          ECHS      MOV     A,H
152      4021      D680      SUI     80H   CHECK FOR THAT ONE NASTY CASE...
153      4023      C22A40      JNZ     ECHSGO  ...OF (HL) = EXACTLY -32768...
154      4026      85          ADD     L     ...WHICH CANT BE COMPLEMENTED RIGHT
155      4027      CC0000      CZ     OVERFLOW  ...AND WHEN DETECTED, ABORT
156      402A      CD3040      ECHSGO   CALL    COMP2  ELSE, FORM 2S COMPLEMENT IN (HL)
157      402D      C30E40      JMP     ESIGN  SET FLAGS AND RETURN
158      *
159      *          SUBROUTINE COMP2 - FORM 2S COMPLEMENT OF (HL)
160      *
161      4030      7C          COMP2     MOV     A,H
162      4031      2F          CMA
163      4032      67          MOV     H,A
164      4033      7D          MOV     A,L
165      4034      2F          CMA
166      4035      6F          MOV     L,A
167      4036      23          INX     H
168      4037      C9          RET

```

```

*****
*
* SUBROUTINE EMULT - MULTIPLY (HL) BY (DE), RESULT TO (HL)
*
*****

```

```

171      *          (HL) = (HL) * (DE)
172      *          ON RETURN, ZERO, SIGN FLAG REFLECT RESULT. CY CLEARED.

```

Listing 1 continued on page 214

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Listing 1 continued:

```

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174          *
175      4038      C5      EMULT      PUSH      B
176      4039      05      PUSH      D
177      403A      CD6F40  CALL      RSLTSIGN  FIND RESULT SIGN, ABS VAL OF OPERANDS
178      403D      AF      XRA      A
179      403E      84      ADD      H
180      403F      CA4840  JZ      HLSMALL  BRANCH IF (HL) LESS THAN 8 BITS
181      4042      AF      XRA      A
182      4043      82      ADD      D      ELSE, OTHER OP MUST BE .LT. 8 BITS...
183      4044      C40000  CNZ     OVERFLOW  ...OR OVERFLOW WOULD RESULT
184      4047      EB      XCHG     (HL) NOW HAS AN OP WITH .LT. 8 BITS
185      4048      7D      HLSMALL  MOV      A,L     MOVE 8-BIT OR LESS MULTIPLIER TO A
186      4049      210000  LXI     H,0     INITIALIZE PARTIAL PRODUCT
187      404C      37      XMLONP   STC      CLEAR CARRY...
188      404D      3F      CMC
189      404E      1F      RAR
190      404F      D25640  JNC     SHIFTOP  ROTATE MULTIPLIER RITE OFF END
191      4052      19      DAD     D      IF BIT SHIFTED-OUT WAS 0, SKIP
192      4053      DC0000  CC     OVERFLOW  ELSE, ADD MULTIPLICAND TO PARTIAL PROD.
193      4056      EB      SHIFTOP  XCHG     ...WHILE CHECKING FOR OVERFLOW
194      4057      29      DAD     H      SHIFT MULTIPLICAND LEFT 1 BIT...
195      4058      DC0000  CC     OVERFLOW  ...WHILE CHECKING FOR OVERFLOW
196      405B      EB      XCHG
197      405C      87      ORA      A
198      405D      C24C40  JNZ     XMLOOP   BRANCH TO TOP OF LOOP IF MULT IS NON-0
199      4060      D1      POP     D      WHEN MULTIPLY DONE, RECALL (DE)
200      4061      7C      SIGNRCL  MOV     A,H
201      4062      07      RLC
202      4063      DC0000  CC     OVERFLOW  MAKE FINAL OVERFLOW CHECK...
203      4066      78      MOV     A,B     FOR VALUES BETWEEN 32768 AND 65535 INCLUS.
204      4067      17      RAL
205      4068      DC3040  CC     COMP2    CHANGE SIGN OF RESULT IF IT IS TO BE -
206      406B      C1      POP     B
207      406C      C30E40  JMP     ESIGN   SET FLAGS AND RETURN
208          *
209          *          SUBROUTINE RSLTSIGN - COMPUTE SIGN OF RESULT FOR * AND /
210          *
211          *          ON RETURN: (HL) = ABSOLUTE VALUE OF (DE), (DE) = ABS. VAL (HL),
212          *          (B) = SIGN OF RESULT IN MOST SIGNIFICANT BIT.
213          *
214      406F      44      RSLTSIGN  MOV     B,H     FETCH SIGN BYTE OF 1ST OPERAND
215      4070      7C      MDV     A,H     ...TO B AND ALSO TO A...
216      4071      17      RAL
217      4072      DC3040  CC     COMP2    ABSOLUTE VALUE OF (HL)
218      4075      EB      XCHG     2ND OPERAND...
219      4076      7C      MOV     A,H     SIGN BYTE TO A...
220      4077      A8      XRA     B      RESULTANT SIGN...
221      4078      47      MOV     B,A     ...TO MSB OF REG B FOR LATER RECALL
222      4079      7C      MOV     A,H     SIGN BYTE OF 2ND OP TO A
223      407A      17      RAL
224      407B      DA3040  JC     COMP2    ABSOLUTE VALUE, THEN RETURN.
225      407E      C9      RET

```

```

*****
*
* SUB. EDIVMOD - DIVIDE (HL) BY (DE), QUO. TO (HL), REM. TO (DE)
*
*****

```

```

228          *          ON CALL: (HL) = DIVIDEND, (DE) = DIVISOR.
229          *          ON RETURN: (HL) = QUOTIENT, (DE) = REMAINDER.
230          *          FLAGS REFLECT VALUE OF QUOTIENT.  CY CLEARED.
231          *          A REGISTER CLOBBERED.  B, C RESTORED.
232          *          REMAINDER IS ALWAYS POSITIVE, REGARDLESS OF SIGN OF OPERANDS.
233          *
234      407F      C5      EDIVMOD   PUSH     B
235      4080      AF      XRA      A      IF DIVISOR = 0...
236      4081      83      ORA      E
237      4082      92      ORA      D
238      4083      CC0000  CZ     OVERFLOW  ...THEN ABORT
239      4086      CD6F40  CALL   RSLTSIGN  COMPUTE RESULT SIGN; SWAP DE, HL
240      4089      7C      MDV     A,H     INSURE THAT NEITHER OPERAND...
241      408A      B2      ORA      D      ...WAS THAT NASTY SPECIAL CASE...
242      408B      07      RLC
243      408C      DC0000  CC     OVERFLOW  ...OF EXACTLY -32768...
244      408F      C5      PUSH     B      ...AND IF IT WAS, ABORT
245      4090      4B      MOV     C,E     SAVE RESULT SIGN BYTE
246      4091      42      MDV     B,D     MOVE DIVIDEND ( = REM) TO BC
247      4092      110000  LXI     D,0     INITIALIZE QUOTIENT = 0...
248      4095      D5      PUSH     D      ...ON TOP OF STACK (TOS)
249      4096      EB      XCHG

```

Listing 1 continued on page 216

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6 BREAKEVN	Breakeven analysis	64 NPV	Net present value of project
7 DEPRSL	Straightline depreciation	65 PRINDLAS	Laspeyres price index
8 DEPRSY	Sum of the digits depreciation	66 PRINDPA	Paasche price index
9 DEPRDB	Declining balance depreciation	67 SEASIND	Constructs seasonal quantity indices for company
10 DEPRDDB	Double declining balance depreciation	68 TIMETR	Time series analysis linear trend
11 TAXDEP	Cash flow vs. depreciation tables	69 TIMEMOV	Time series analysis moving average trend
12 CHECK2	Prints NEBS checks along with daily register	70 FUPRINF	Future price estimation with inflation
13 CHECKBK1	Checkbook maintenance program	71 MAILPAC	Mailing list system
14 MORTGAGE/A	Mortgage amortization table	72 LETWRT	Letter writing system-links with MAILPAC
15 MULTMON	Computes time needed for money to double, triple, etc.	73 SORT3	Sorts list of names
16 SALVAGE	Determines salvage value of an investment	74 LABEL1	Shipping label maker
17 RRVARIN	Rate of return on investment with variable inflows	75 LABEL2	Name label maker
18 RRCONST	Rate of return on investment with constant inflows	76 BUSBUD	HOME business bookkeeping system
19 EFFECT	Effective interest rate of a loan	77 TIMECLK	Computes weeks total hours from timeclock info.
20 FVAL	Future value of an investment (compound interest)	78 ACCTPAY	In memory accounts payable system-storage permitted
21 PVAL	Present value of a future amount	79 INVOICE	Generate invoice on screen and print on printer
22 LOANPAY	Amount of payment on a loan	80 INVENT2	In memory inventory control system
23 REGWITH	Equal withdrawals from investment to leave 0 over	81 TELDIR	Computerized telephone directory
24 SIMPDISK	Simple discount analysis	82 TIMUSAN	Time use analysis
25 DATEVAL	Equivalent & nonequivalent dated values for oblig.	83 ASSIGN	Use of assignment algorithm for optimal job assign.
26 ANNUDEF	Present value of deferred annuities	84 ACCTREC	In memory accounts receivable system-storage ok
27 MARKUP	% Markup analysis for items	85 TERMSPAY	Compares 3 methods of repayment of loans
28 SINKFUND	Sinking fund amortization program	86 PAYNET	Computes gross pay required for given net
29 BONDVAL	Value of a bond	87 SELLPR	Computes selling price for given after tax amount
30 DEplete	Depletion analysis	88 ARBCOMP	Arbitrage computations
31 BLACKSH	Black Scholes options analysis	89 DEPRSF	Sinking fund depreciation
32 STOCVAL1	Expected return on stock via discounts dividends	90 UPSZONE	Finds UPS zones from zip code
33 WARVAL	Value of a warrant	91 ENVELOPE	Types envelope including return address
34 BONDVAL2	Value of a bond	92 ACTOEXP	Automobile expense analysis
35 EPSEST	Estimate of future earnings per share for company	93 INSFIL	Insurance policy file
36 BETAALPH	Computes alpha and beta variables for stock	94 PAYROLL2	In memory payroll system
37 SHARPEI	Portfolio selection model-i.e. what stocks to hold	95 DILANAL	Dilution analysis
38 OPTWRITE	Option writing computations	96 LOANAFFD	Loan amount a borrower can afford
39 RTVAL	Value of a right	97 RENTPRCH	Purchase price for rental property
40 EXPVAL	Expected value analysis	98 SALELEAS	Sale-leaseback analysis
41 BAYES	Bayesian decisions	99 RRCONVBD	Investor's rate of return on convertible bond
42 VALPRINF	Value of perfect information	100 PORTVAL9	Stock market portfolio storage-valuation program
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 CONDPFROF	Conditional profit tables		
51 OPTLOSS	Opportunity loss tables		
52 FQOQQ	Fixed quantity economic order quantity model		

NAME	DESCRIPTION
53 FQEOWSH	As above but with shortages permitted
54 FQEQQPB	As above but with quantity price breaks
55 QJUECEB	Cost-benefit waiting line analysis
56 NCFANAL	Net cash-flow analysis for simple investment
57 PROFIND	Profitability index of a project
58 CAPI	Cap. Asset Pr. Model analysis of project

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Listing 1 continued:

```

250 4097 210100 LXI H,1 INITIALIZE HOLD = 1
251 *
252 409A 29 DBLDIV DAD H LEFT SHIFT HOLD
253 409B EB XCHG NOW BC=REM, DE=HOLD, HL=DIV, TOS=QUO
254 409C 29 DAD H LEFT SHIFT DIV
255 409D CDC940 CALL .CMPBH COMPARE DIV TO REM
256 40A0 EB XCHG NOW BC=REM, DE=DIV, HL=HOLD, TOS=QUO
257 40A1 D29A40 JNC DBLDIV BRANCH BACK IF DIV < REM
258 40A4 EB XCHG DUMMY XCHG TO MAKE LOOP WORK 1ST PASS...
259 40A5 EB HALVFDIV XCHG NOW BC=REM, DE=DIV, HL=HOLD, TOS=QUO
260 40A6 CDCE40 CALL DIVBY2 HOLD = HOLD/2 (RITE SHIFT)
261 40A9 CAC240 JZ DIVDONE IF HOLD = 0, WERE DONE
262 40AC EB XCHG NOW BC=REM, DE=HOLD, HL=DIV, TOS=QUO
263 40AD CDCE40 CALL DIVBY2 RITE SHIFT DIV
264 40B0 CDC940 CALL CMPBH COMPARE DIV TO REM...
265 40B3 FAAS40 JM HALVEDIV IF DIV > REM, BRANCH BACK
266 40B6 79 MOV A,C REM = REM - DIV...
267 40B7 95 SUB L
268 40B8 4F MOV C,A
269 40B9 78 MOV A,B
270 40BA 9C SBB H
271 40BB 47 MOV B,A
272 40BC E3 XTHL NOW BC=REM, DE = HOLD, HL=QUO, TOS=DIV
273 40BD 19 DAD D QUO = QUO + HOLD
274 40BE E3 XTHL NOW BC=REM, DE=HOLD, HL=DIV, TOS=QUO
275 40BF C3A540 JMP HALVEDIV ENODO.

277 40C2 E1 DIVDONE POP H GET QUOTIENT TO HL
278 40C3 59 MOV E,C MOVE FINAL REM TO DE
279 40C4 50 MOV D,B
280 40C5 C1 POP B RECALL SIGN BYTE FOR RESULT
281 40C6 C36140 JMP SIGNRCL COMPUTE FINAL SIGN OF RESULT AND RETURN
282 *
283 * INTERNAL SUBROUTINE CMPBH - COMPARE BC TO HL...
284 *
285 40C9 79 CMPBH MOV A,C
286 40CA 95 SUB L
287 40CB 78 MOV A,B
288 40CC 9C SBB H SIGN, ZERO NOW REFLECT (BC) - (HL)...
289 40CD C9 RET
290 *
291 * INTERNAL SUBROUTINE DIVBY2 - DIVIDE (HL) BY 2 (RITE SHIFT)
292 * KILLS PSW. REMAINDER RETURNED IN CY.
293 *
294 40CE AF DIVBY2 XRA A CLEAR CY
295 40CF 7C MOV A,H
296 40D0 1F RAR
297 40D1 67 MOV H,A
298 40D2 7D MOV A,L
299 40D3 1F RAR
300 40D4 6F MOV L,A
301 40D5 B4 ORA H SET ZERO FLAG IF BOTH H AND L = 0
302 40D6 C9 RET

```

```

*****
*
* SUBROUTINE DECBIN - CONVERT ASCII DECIMAL TO BINARY NUMBER
*
*****

```

```

305 * THIS ROUTINE CONVERTS A STRING OF ASCII CHARACTERS REPRESENTING
306 * A NUMBER TO A SIGNED 16-BIT NUMBER IN TWOS COMPLEMENT FORM.
307 * LEGAL RANGE OF CONVERTIBLE VALUES IS -32767 TO +32767.
308 * LEGAL FORM FOR STRING IS...
309 *
310 * <BLANKS><SIGN><BLANKS><DIGITS><NON-DIGIT>
311 *
312 * WHERE <BLANKS> IS 0 OR MORE BLANKS,
313 * <SIGN> IS +, -, OR OMITTED,
314 * <DIGITS> IS A STRING OF 1 OR MORE NUMERIC DIGITS,
315 * REPRESENTING AN INTEGER NOT EXCEEDING 32767.
316 * <NON-DIGIT> IS ANY NON-DIGIT CHARACTER (E.G., A BLANK).
317 *
318 * USAGE:
319 *
320 * ON CALL:
321 * (DE) = ADDRESS OF START-OF-ASCII STRING TO BE CONVERTED.
322 * ON RETURN TO CALLING PROGRAM...
323 * (HL) = RETURNED SIGNED NUMERIC VALUE
324 * (DE) = ADDRESS OF TERMINAL CHARACTER OF STRING (<NON-DIGIT>)
325 * SIGN AND ZERO FLAGS WILL BE SET TO REFLECT VALUE IN (HL).

```

Listing 1 continued on page 220

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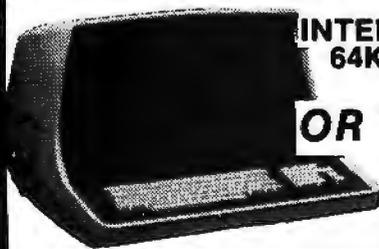
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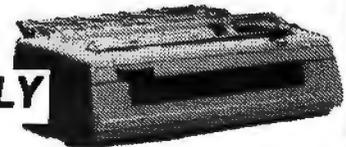
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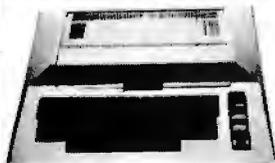
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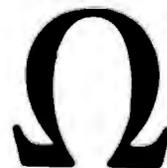
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Listing 1 continued:

```

326          *          CY CLEARED. A REGISTER CLOBBERED. B, C RESTORED.
327          *
328          *          NOTES ON METHOD... B REG USED TO HOLD 3 FLAGS...
329          *          BIT 7="-" FLAG = MINUS SIGN ENCOUNTERED
330          *          BIT 6= "SE" FLAG = SIGN ENCOUNTERED
331          *          BIT 0 = "DE" = DIGIT ENCOUNTERED.
332          *
333      40D7      C5      DECBIN      PUSH      B
334      40D8      0600      MVI      B,0          INITIALIZE FLAGS -,DE,SE
335      40DA      210000     LXI      H,0          INITIALIZE RESULT
336      40DD      1A          AKLOOP     LDAX      D          FETCH NEXT ASCII CHARACTER
337      40DE      D630      SUI      48          CONVERT CHAR TO BCD DIGIT IF POSSIBLE
338      40E0      4F          MOV      C,A          SAVE (CHARACTER-48) IN C
339      40E1      FAFF40     JM      NOTDIGIT     IS IT A DIGIT 0 THRU 9...
340      40E4      FE0A      CPI      10
341      40E6      F2FF      JP      NOTDIGIT
342      40E9      D5          PUSH      D          ...IF SO, SAVE BUFFER POINTER
343      40EA      110A00     LXI      D,10        ...MULTIPLY PARTIAL RESULT BY 10...
344      40ED      CD3840     CALL     EMULT        ... (ALSO CHECKING FOR OVERFLOW)...
345      40F0      1600      MVI      D,0          ...AND ADD IN VALUE OF DIGIT...
346      40F2      59          MOV      E,C
347      40F3      CD0040     CALL     EADD        (HL) = (HL)*10 + DIGIT
348      40F6      D1          POP      D          RECALL BUFFER POINTER
349      40F7      13          INX      D          BUMP BUFFER POINTER
350      40F8      3E01      MVI      A,1          ...SET "DIGIT ENCOUNTERED (DE) FLAG...
351      40FA      R0          ORA      B
352      40FB      47          MOV      B,A
353      40FC      C3DD40     JMP      AKLOOP      ...AND WERE READY FOR NEXT CHARACTER
354          *
355          *          COME HERE FOR ANY CHARACTER EXCEPT 0,1,...9
356          *
357      40FF      79          NOTDIGIT  MOV      A,C          RECALL (CHAR-48)
358      4100      FEFO      CPI      -16         IS IT A BLANK. SET ZERO FLAG IF SO.
359      4102      78          MOV      A,B          RECALL FLAGS
360      4103      0F          RRC          TEST "DIGIT ENCOUNTERED" FLAG IN CY
361      4104      DA6140     JC      SIGNRCL      IF DIGITS ENCOUNTERED PRIOR, WERE DONE
362      4107      C20E41     JNZ      TRYSIGN     ...ELSE, IF NOT BLANK TRY + OR -
363      410A      13          INX      D          ...ELSE IGNORE LEADING BLANK,
364      410B      C3DD40     JMP      AKLOOP      AND PROCEED WITH NEXT CHARACTER
365      410E      78          TRYSIGN  MOV      A,B          TEST "SE" FLAG IN CY
366      410F      07          RLC
367      4110      07          RLC
368      4111      DC0000     CC          CONVERR
369      4114      79          MOV      A,C          ELSE RECALL (CHAR-48)
370      4115      FEFD      CPI      -3          IS IT "-"...
371      4117      C2          JNZ      TRYPLUS     ...IF NOT TRY FOR "+" SIGN...
372      411A      3EC0      MVI      A,0C0H      ...IF IT IS "-", SET SE AND - FLAG
373      411C      R0          ORA      B
374      411D      47          MDV      B,A
375      411E      13          INX      D          BUMP BUFFER POINTER
376      411F      C3DD40     JMP      AKLOOP      AND PROCEED WITH NEXT CHARACTER
377      4122      FEFB      TRYPUS  CPI      -5          IS IT "+" CHARACTER...
378      4124      C40000     CNZ      CONVERR     IF NOT ITS AN ERROR
379      4127      3E40      MVI      A,40H       IF IT IS "+", SET "SE" FLAG
380      4129      80          ORA      B
381      412A      47          MOV      B,A
382      412B      13          INX      D          BUMP BUFFER POINTER
383      412C      C3DD40     JMP      AKLOOP      AND PROCEED WITH NEXT CHARACTER
384          *

```

```

*****
*
* SUBROUTINE BINDEC - CONVERT BINARY NUMBER TO DECIMAL ASCII STRING
*
*****

```

```

387          *          THIS ROUTINE GENERATES A STRING OF ASCII CHARACTERS
388          *          REPRESENTING A SIGNED DECIMAL INTEGER. THE STRING IS
389          *          GENERATED LEFT-JUSTIFIED, WITH LEADING ZEROS SUPPRESSED.
390          *          THE STRING WILL OCCUPY FROM 1 TO 6 CHARACTERS DEPENDING ON
391          *          THE SIGN AND MAGNITUDE OF THE NUMBER DESIRED.
392          *          ON CALL: (HL) = SIGNED BINARY NUMBER TO BE CONVERTED.
393          *          (DE) = ADDRESS OF FIRST CHARACTER OF BUFFER WHERE STRING IS
394          *          TO BE GENERATED.
395          *          ON RETURN: (DE) = ADDRESS OF NEXT BYTE AFTER THE STRING
396          *          WHICH WAS GENERATED. (A) = NUMBER OF CHARACTERS GENERATED.
397          *          B, C, H, L RESTORED.
398          *
399      412F      C5      BINDEC      PUSH      B
400      4130      E5      PUSH      H          SAVE HL
401      4131      010000     LXI      B,0          B=MINUS FLAG, C= DIGIT COUNTER

```

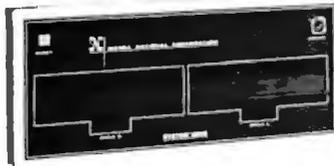
Listing 1 continued on page 222

# the SIERRA PACKAGE

SYSTEM  
3000

SYSTEM  
4000

SOFTWARE  
SUPPORT



**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.

Data Communications: Integrated modem or any RS232 compatible external modem.



**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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Listing 1 continued:

```

402      4134      E5          PUSH      H
403      4135      29          DAD       H          PUSH SIGN INTO CY
404      4136      F1          POP       H          RECALL UN-SHIFTED NO.
405      4137      024241    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      90          ADD     B          ...AND ADD 1 FOR MINUS SIGN IF MINUS
430      416A      13          INX     D          POINT TO NEXT DIGIT IN BUFFER
431      4168      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      R1          ORA     C          IF NO NON-ZERO DIGITS SO FAR...
438      4174      C8          RZ
439      4175      7B          MOV     A,E        ...AND THIS = 0, THEN SUPPRESS LEADING 0
440      4176      C630      ADI     48         ELSE, RECALL DIGIT
441      4178      0C          INR     C          CONVERT DIGIT TO CHAR
442      4179      EB          XCHG     UPDATE CHAR COUNTER
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
CNV1DIG	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
DEC8IN	40D7	*A	333	20 23
DIV8Y2	40CE	*A	294	260 263
DIVDONE	40C2	*A	277	261
DIV10K	4142	*A	411	405
EADD	4000	*A	110	142 347
ECMS	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

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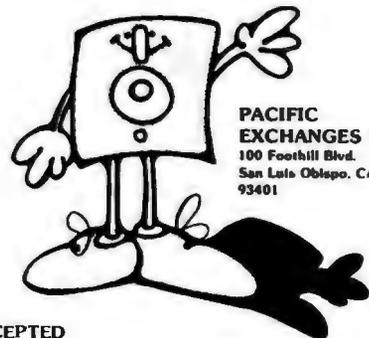


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Listing 1 continued:

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											
XMLLOOP	404C	*A	187	198											
-COMMON BLOCK-		-L	-												
ABSOL			01DF												

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# **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 tech-

nologies 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**

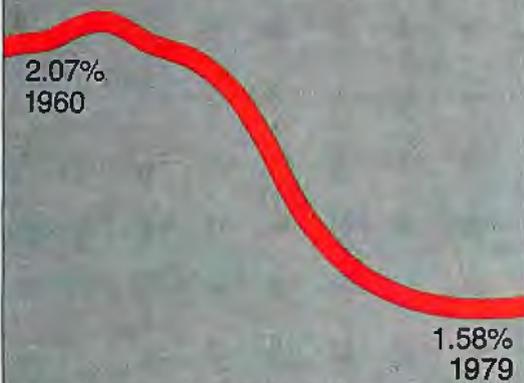
Something else is needed: a united effort by industry, labor and government. Obviously, management should make a greater R&D effort to refine today's technologies, and develop new ones for tomorrow. Employees must realize that their cooperation is vital if America is to remain the most productive nation 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.

### U.S. Industrial R&D Spending

Outlays as percent  
of Gross National Product



Source: National Science Foundation

### U.S. Patents

Number of applications filed:  
Inventions



Source: U.S. Department of Commerce

### U.S. Exports

Percent share manufactured goods  
from 15 major countries  
excluding exports to U.S.



Source: U.S. Department of Commerce

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.

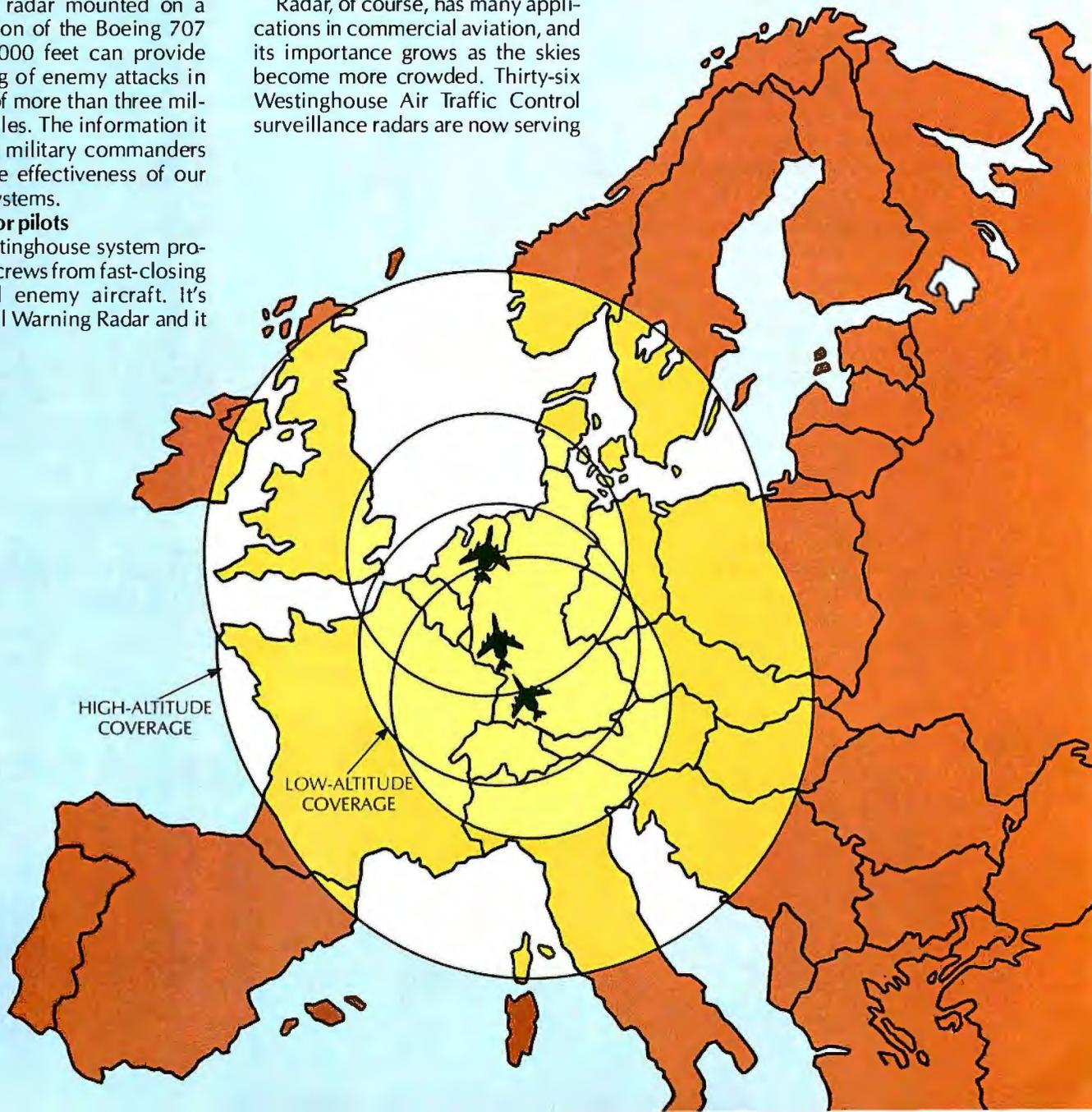
#### New safety for pilots

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**

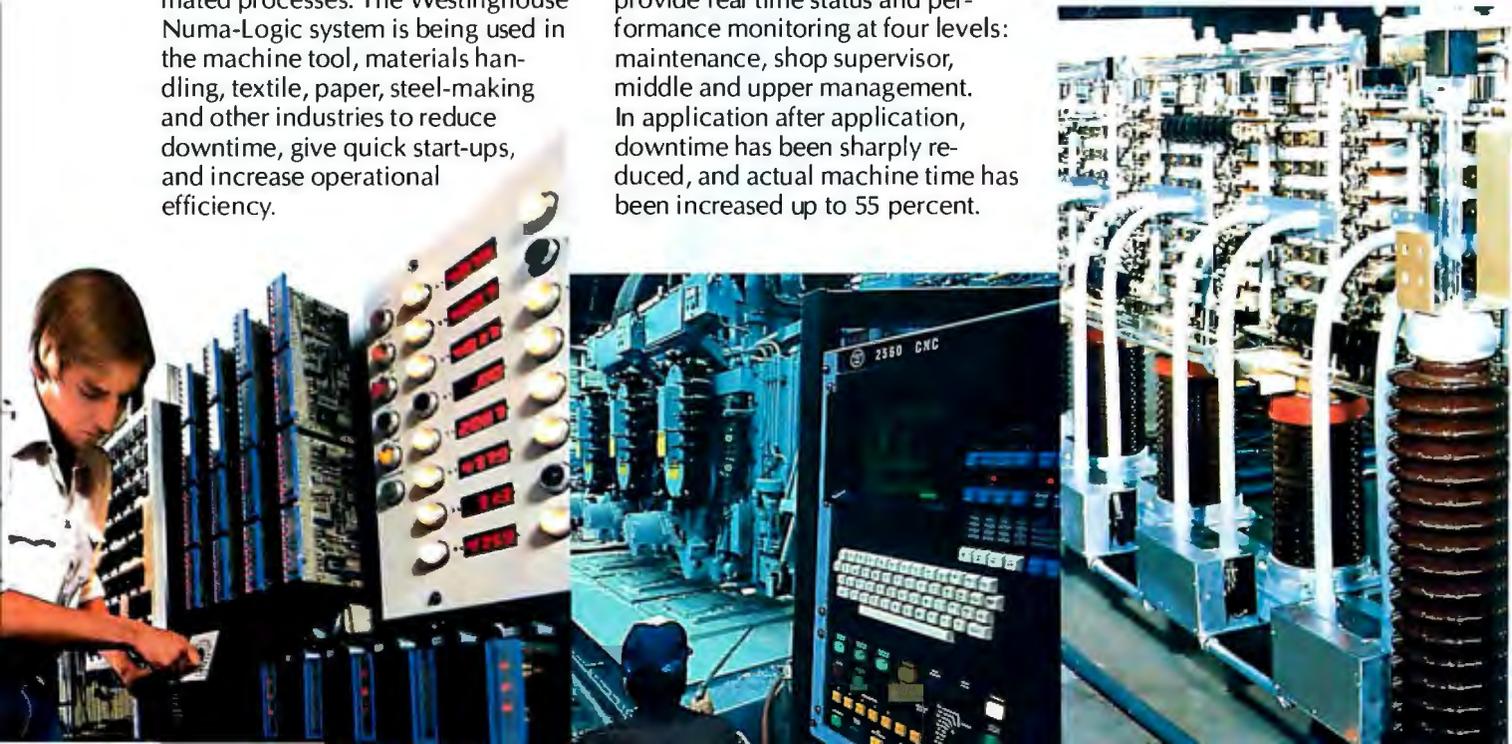
The Westinghouse Numa-Logic solid-state programmable controller uses microprocessor technology to provide more reliable operation for electrical control applications. It can economically replace as few as eight relays. It also has the capability to control the hundreds of sequences required by sophisticated, 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.

## Applied Plasma Systems

Because of the skyrocketing costs of fossil fuels used to supply process heat or chemical reactions, many firms are searching for alternatives. The Westinghouse Applied Plasma Systems can efficiently fire high temperature industrial processes, and serve as a central heating device for a myriad of applications such as chemical processes, metals treating, and combustion replacement. This technology is already providing an efficient answer for blast furnaces and direct reduction iron-making processes. It uses a high temperature gas stream to transmit heat. Studies on the upgrading of existing blast furnace facilities demonstrate up to an 80 percent increase in the capacity of the facilities through the application of Applied Plasma Systems.

*How to minimize downtime... As machines grow more complex, keeping them running takes specialists. To help you maximize productivity, Westinghouse can provide the same technological expertise in services as it does in products.*

## **A remarkable worldwide service network**

Because Westinghouse engineers, tests, and builds complex products and systems, we have the special skills, trained personnel, and necessary tools to maintain such equipment best; or to repair it in the least amount of time. Available to help you with either maintenance or repair are hundreds of trained Westinghouse field service engineers and specialist mechanics who use the most sophisticated on-site testing and repair equipment. And backing them up is a vast network of repair facilities.

Whether Westinghouse built it or not, we can service and repair almost anything from escalators and elevators, to steam turbines and nuclear power plants. Westinghouse can do an operation analysis and recommend an upgrading program, we can train your operators and service personnel, or we can do continuous monitoring of various operations. Whatever is needed.

Experience has taught us that a regularly planned and scheduled maintenance program greatly increases uptime and saves money. Westinghouse is equipped to provide programmed maintenance on a plant-wide basis. During scheduled shutdowns, a crew of Westinghouse field engineers and technicians can move in to do a complete analysis and top-to-bottom overhaul of your entire facilities.



- 
- **Technology is America's competitive edge.**
  - **To retain that competitive edge, we must make better use of the technologies we already have, and actively encourage the development of new ones.**
  - **Westinghouse believes technology is vital to our nation, our customers, and our own growth.**
  - **Westinghouse has technologies that increase manufacturing productivity, help meet our energy needs, and contribute to our national security.**

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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
*
*****

5          *          ***** NOTE: YOU MUST SUPPLY THESE 3 ENTRY POINTS: *****
6          *
7          CHIN      EQU      0          SUBROUTINE TO GET KEYBOARD CHAR. IN A REG.
8          CHOUT     EQU      0          SUBROUTINE TO DISPLAY (A) AS ASCII CHAR.
9          MONITOR   EQU      0          ENTRY TO SYSTEM WHEN PROGRAM DONE
10         *
11         *          ORG      3000H
12         3000      213830 TEST      LXI      H,INBUF      INPUT BUFFER ADDRESS TO HL
13         3003      CD0000 TEST1    CALL     CHIN      GET AN ASCII CHARACTER IN A REGISTER
14         3006      77              MOV      M,A          STORE CHARACTER INTO BUFFER
15         3007      FE0D             CPI      13         AND IF ITS A CARRIAGE RETURN
16         3009      CA1030           JZ       TEST2     THEN BRANCH
17         300C      23              INX     H          ELSE, ADVANCE TO NEXT BYTE OF BUFFER
18         300D      C30330           JMP     TEST1     ...AND CONTINUE
19         3010      113830 TEST2    LXI      D,INBUF   RECALL INPUT BUFFER STARTING ADDRESS
20         3013      CDD740           CALL    DECBIN    CONVERT ASCII DECIMAL TO BINARY NUMBER
21         3016      E5              PUSH   H          SAVE NUMBER
22         3017      13              INX     D         ADDRESS OF START OF SECOND NUMBER STRING
23         3018      CDD740           CALL    DECBIN    CONVERT SECOND NUMBER TO BINARY IN HL
24         301B      D1              POP     D         RECALL FIRST NUMBER
25         301C      CD3840           CALL    EMULT     FIND PRODUCT IN HL
26         301F      3E6A             MVI    A,10      ASCII LINE FEED
27         3021      CD0000           CALL    CHOUT    START ANSWER ON NEW LINE
28         3024      114F             LXI    D,OUTBUF  OUTPUT BUFFER STARTING ADDRESS
29         3027      CD2F41           CALL    BINDEC   CONVERT ANSWER TO ASCII STRING
30         302A      AF              XRA    A         MARK END-OF-STRING WITH 0-BYTE
31         302B      12              STAX   D         MARK END-OF-STRING WITH 0-BYTE
32         302C      214F30           LXI    H,OUTBUF  RECALL START OF BUFFER
33         302F      AF              XRA    A         MARK END-OF-STRING WITH 0-BYTE
34         3030      86              ADO    M         MARK END-OF-STRING WITH 0-BYTE
35         3031      CA0000           JZ     MONITOR   IF ITS 0-BYTE TERMINATOR, QUIT
36         3034      C00000           CALL   CHOUT    ELSE, DISPLAY BYTE
37         3037      23              INX    H         ADVANCE BUFFER POINTER
38         303B      C32F30           JMP    TEST3
39
40         303B      INBUF      OS      20          INPUT BUFFER FOR 2 NUMBERS
41         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: 0000100  
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: 0000111  
two's complement of 4: 11111100  
adding, we get: 1 0000011

The carry, 1, is thrown away, and the result, 0000011, is decimal 3 in binary.

In two's complement, negative numbers always have a leftmost bit of 1; on the other hand, non-negative 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 represen-

tation, 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. ■

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CHANGE	DISPLAY	REORG
COMBINE	EMPTY	RESTART
COMPARE	ENTER	SAVE
COMPUTE	FORMAT	SELECT
COPY	HELP	SET
DATE	JOIN	SORT
DBMS	LIST	STAX
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DEGROUP	POST	TERM
DELETE	PRINT	TITLE
DESTROY	PROJECT	UPDATE
DIC	READ	WRITE

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### 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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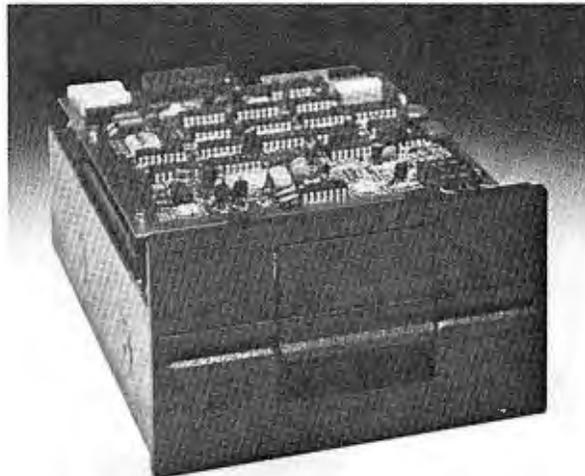
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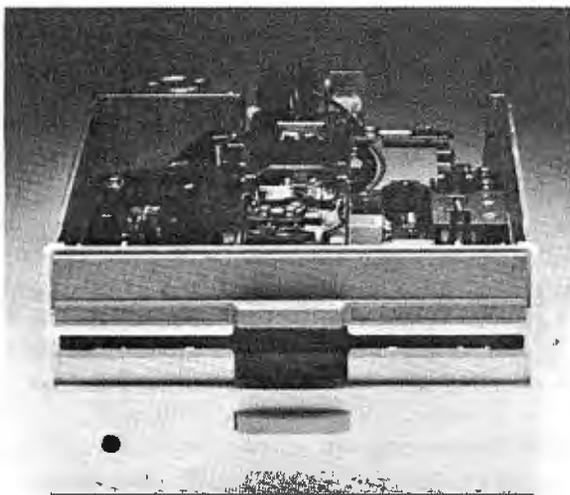
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## Print Your Own Bar Codes

### 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

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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.

```

0010 ) *** BAR-CODE PRINTER PROGRAM
0020 FOR INTEGRAL DATA IP-225 (440) WITH GRAPHICS
0030 BY DR. G. LOUIS
0040   OB/GYN DEPT., ST. MICHAEL'S HOSPITAL
0050   30 BOND STREET, TORONTO, CANADA M5B 1W8
0060   800501, LAST MODIFIED 800624
0070 )
0080 CONST MAXBAR=400 ) MAX UNIT WIDTHS PER FRAME );
0090 PRINT=Z85A ) DIRECTS OUTPUT TO PRINTER );
0100 NOPRINT=Z84C ) NO OUTPUT TO PRINTER );
0110 DEL=127; CAN=24; FF=12; CR=13; TAB=9; ) ASCII CTL );
0120 PLOT=3; PLTESCAP=3; NORMLPRT=2; ) PLOT MODE CTL );
0130 CPI12=30 ) SET PRINTER DENSITY 12 CHAR/IN );
0140 CPIMAX=31 ) SET MAXIMUM DENSITY FOR PLOTTING );
0150
0160 VAR I ) GENERAL-PURPOSE INDEX );
0170 IPT ) CHARACTER INPUT );
0180 ABSFLAG ) TRUE IF ABSOLUTE ADDRESSING CALLED FOR );
0190 ORIGIN ) ADDRESS OF 1ST BYTE TO BE CODED );
0200 LASTBYTE ) ADDRESS OF LAST BYTE TO CODE );
0210 POINTER ) ADDRESS OF NEXT BYTE TO CODE );
0220 FRAMEID ) VALUE OF ID BYTE OF NEXT FRAME );
0230 ) INTEGER;
0240 ) JOBNAME: ARRAY [53] OF INTEGER;
0250
0260 FUNC WFRAME (START,STOP);
0270 ) WRITE ONE FRAME BEGINNING AT START AND ENDING
0280 ) AT STOP OR WHEN THE PAGE IS FULL, WHICHEVER IS
0290 ) FIRST; RETURN THE ADDRESS OF THE BYTE FOLLOWING
0300 ) THE ONE LAST ENCODED );
0310 CONST SYNC=Z96 ) FIRST BYTE OF EVERY FRAME );
0320 VAR ARSCK ) TRUE IF AN ABSOLUTE ADDRESS IS WANTED );
0330 ) BARCNT ) NUMBER OF UNIT WIDTHS IN FRAME );
0340 ) CKSUM ) HEX CHECKSUM OF BYTES IN FRAME );
0350 ) FRAMELEN ) NUMBER OF BYTES IN FRAME );
0360 ) I ) GENERAL-PURPOSE INDEX );
0370 ) INTEGER;
0380
0390 PROC WBYTE (VALUE);
0400 ) WRITE BAR CODE FOR 8 LSB'S OF "VALUE" );
0410 VAR BUF, I: INTEGER;
0420 BEGIN
0430 BUF := VALUE AND 255;
0440 FOR I := 1 TO 8 DO BEGIN
0450   WRITE (SPACE, BAR); IF BUF > 127 THEN WRITE (BAR);
0460   BUF := (BUF SHL 1) AND 255 END
0470 END;
0480
0490 FUNC SCANBYTE (VALUE);
0500 ) RETURN THE NUMBER OF UNIT WIDTHS NEEDED TO WRITE
0510 ) BAR CODE FOR 8 LSB'S OF "VALUE" );
0520 VAR BUF, CNT, I: INTEGER;
0530 BEGIN
0540 BUF := VALUE AND 255; CNT := 0;
0550 FOR I := 1 TO 8 DO BEGIN
0560   CNT := CNT+2; IF BUF > 127 THEN CNT := CNT+1;

```

```

0570   ) ONE SPACE + ONE BAR, + ONE MORE BAR IF BIT IS 1 );
0580   BUF := (BUF SHL 1) AND 255 END;
0590   SCANBYTE := CNT END;
0600
0610 BEGIN ) WFRAME );
0620 ABSCK := ABSFLAG AND (START << STOP);
0630 WRITE (CPI12);
0640 IF ABSFLAG THEN WRITE (STARTX);
0650 ELSE WRITE (START-ORIGINX);
0660 WRITE (TAB,CPIMAX,PLOT); WBYTE (SYNC); FRAMELEN := 0;
0670 IF ABSCK THEN BEGIN
0680   CKSUM := (START SHR 8) + (START AND 255);
0690   BARCNT := SCANBYTE (START SHR 8) + SCANBYTE (START);
0700 END
0710 ELSE BEGIN CKSUM := 0; BARCNT := 0 END;
0720 IF START <= STOP THEN REPEAT
0730   I := MEM [START + FRAMELEN]; CKSUM := CKSUM + I;
0740   BARCNT := BARCNT + SCANBYTE (I);
0750   FRAMELEN := FRAMELEN + 1
0760 UNTIL (BARCNT > MAXBAR-24) OR (START+FRAMELEN = STOP+1);
0770 IF ABSCK THEN FRAMELEN := FRAMELEN+2;
0780 CKSUM := 256 - ((CKSUM + FRAMEID + FRAMELEN) AND 255);
0790 WBYTE (CKSUM); WBYTE (FRAMEID); WBYTE (FRAMELEN);
0800 IF ABSCK THEN BEGIN
0810   WBYTE (START SHR 8); WBYTE (START);
0820   FRAMELEN := FRAMELEN-2 END;
0830 FOR I := 1 TO FRAMELEN DO
0840   WBYTE (MEM [START + I - 1]);
0850 WRITE (SPACE, BAR, PLTESCAP, NORMLPRT, CPI12, CR);
0860 WFRAME := START + FRAMELEN
0870 END;
0880
0890 BEGIN ) *** MAIN PROGRAM *** );
0900 CALL (NOPRINT); I := 0;
0910 WRITE (FF, 'BAR-CODE PRINTER', CR, CR, 'JOB NAME: ');
0920 WHILE I < 53 DO BEGIN
0930   READ (IPT); CASE IPT OF
0940     DEL: IF I > 0 THEN BEGIN WRITE (IPT); I := I-1 END;
0950     CAN: WHILE I > 0 DO BEGIN WRITE (DEL); I := I-1 END
0960     ELSE BEGIN
0970       WRITE (IPT); JOBNAME [I] := IPT; I := I+1;
0980       IF IPT = CR THEN I := 53 ) TO GET OUT OF LOOP ) END
0990     END ) CASE );
1000 END ) WHILE ); JOBNAME [53] := CR;
1010 WRITE (CR, 'START ADDRESS: '); READ (ORIGINX);
1020 WRITE (CR, 'END ADDRESS: '); READ (LASTBYTEX);
1030 WRITE (CR, 'SPECIFY ABSOLUTE ADDRESSES? ');
1040 REPEAT READ (IPT) UNTIL (IPT = 'Y') OR (IPT = 'N');
1050 WRITE (IPT); ABSFLAG := (IPT='Y');
1060 CALL (PRINT); WRITE (CPI12); I := -1;
1070 REPEAT I := I+1; WRITE (JOBNAME [I]);
1080 UNTIL JOBNAME [I] = CR; WRITE (CR);
1090 POINTER := ORIGIN; FRAMEID := 0;
1100 REPEAT
1110   POINTER := WFRAME (POINTER, LASTBYTE);
1120   FRAMEID := FRAMEID+1;
1130   IF (0 = FRAMEID MOD 55) AND (POINTER <= LASTBYTE)
1140     THEN BEGIN WRITE (FF); I := -1;
1150     REPEAT I := I+1; WRITE (JOBNAME [I]);
1160     UNTIL JOBNAME [I] = CR; WRITE (CR) END
1170 UNTIL POINTER > LASTBYTE;
1180 POINTER := WFRAME (POINTER, 0) ) WRITE EOF FRAME );
1190 WRITE (FF); CALL (NOPRINT);
1200 END. ) MAIN PROGRAM );

```



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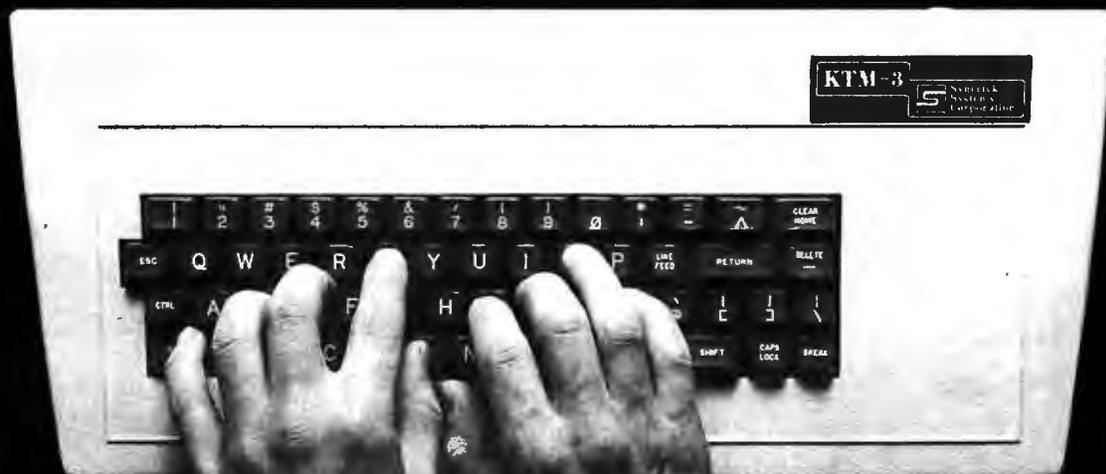
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**Technical Forum**

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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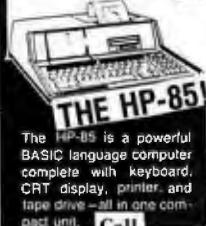
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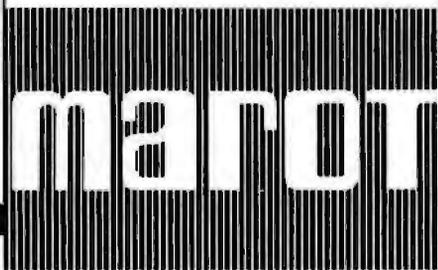
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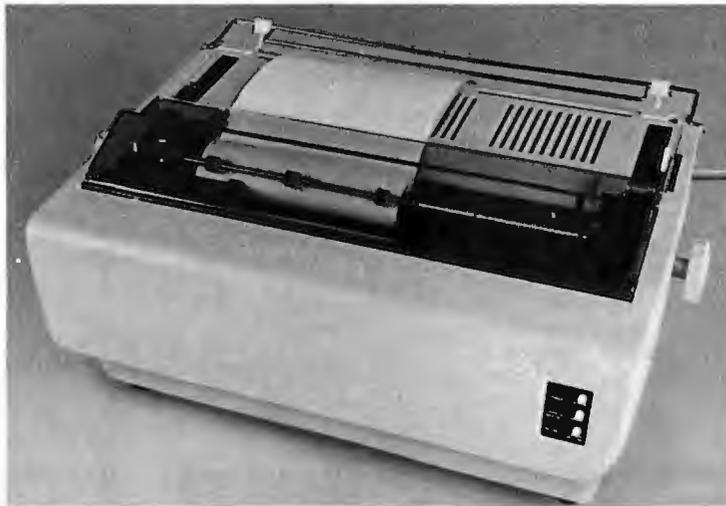
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## System Notes

### 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  $\mu$ s (with a 1 MHz clock rate while assuming

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## System Notes

**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

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  $\mu$ s 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  $\mu$ s to execute, for a total time of 800  $\mu$ s 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%!

**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

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  $\mu$ s 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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## System Notes

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	CB	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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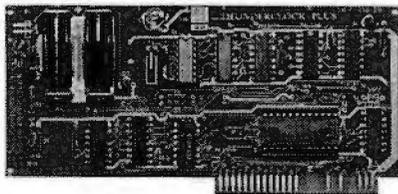
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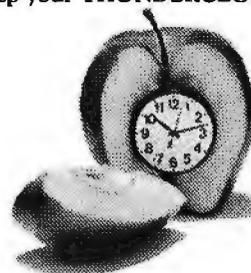
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## System Notes

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. ■

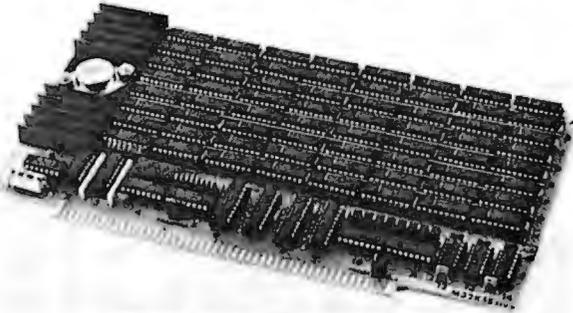
*Listing 4: Program used with the OS-65D operating system and 8-inch disks. Beginning at hexadecimal location 4800, the program loads a portion of BASIC into memory, then POKEs the appropriate ROR instructions into the mathematical routines and stores the revised BASIC back on the disk.*

```
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.*

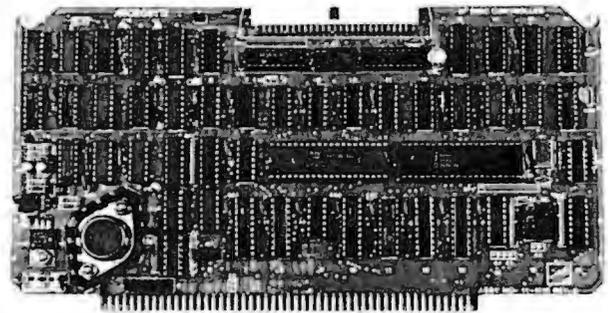
```
10 REM DISK BASIC CORRECTION ROUTINE. OS-65U
20 DATA 0,36,0,0,0,2,0,120
30 DATA 118,2,118,3,118,4,104,106,200,208,232,24,96
40 DATA 102,115,102,116,102,117,102,118,102,189,152
50 DATA 74,208,214,96
60 REM SET UP USR FUNCTION AND PUT AND GET ROUTINES
70 POKE 8778,192 : POKE 8779,36
80 POKE 9432,243 : 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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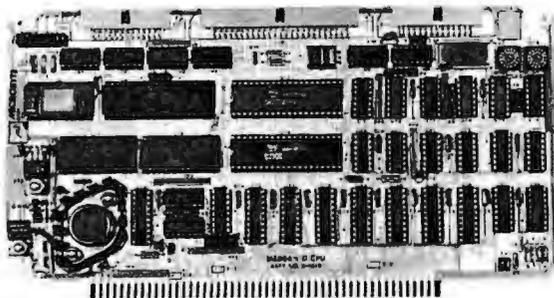
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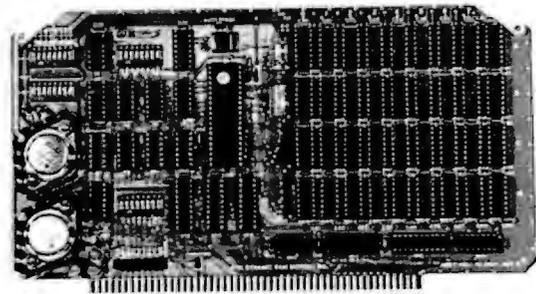
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- Separate V<sub>CC</sub> supply for data recovery to eliminate possible noise problems



## Z-80A I/O

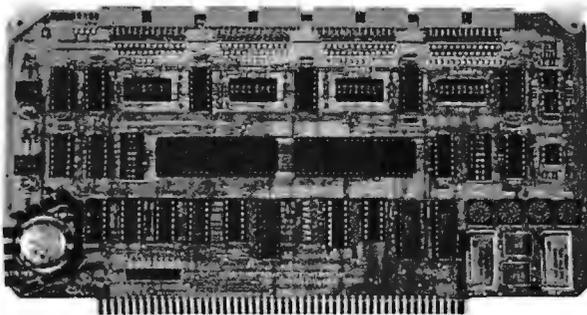
- A complete single board Z-80A CPU with serial/parallel interface
- Fully compatible with the proposed IEEE S-100 Bus Standard
- Z-80A CPU (4MHz version of the Z-80)
- 158 instructions—superset of and upward compatible from the 8080's 78 instructions
- Up to 4K of on board Eprom with optional Z-80 monitor program — 1K(2708), 2K(2716) or 4K(2732)
- Full vectored interrupt capability
- 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 rate selection (16 baud rates from 50-19,200 baud)
- Up to 24 bit parallel I/O port—fully programmable Intel 8255A
- Up to 8 separate counter/timers using 2 Z-80A CTC



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- Fully S-100 bus compatible/Alpha Micro compatible
- 64K x 8 bit dynamic RAM
- Low power: + 8VDC @ 700 ma  
+ 16VDC @ 100 ma  
- 16VDC @ 25 ma
- Built-in-parity with LED indicator and vector Interrupt
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- 72-hour Burn-in
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- 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

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# Book Reviews

## Principles of Interactive Computer Graphics, 2nd Edition

William M Newman and Robert F Sproull  
McGraw-Hill, 1979  
541 pages, hardcover  
\$25.95

Reviewed by  
Richard L Emery  
559 Taos Ct  
Saginaw TX 76179

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 vec-

tored 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 micropro-

cessor-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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# Software for the Apple II and Apple II Plus\*

## BENEATH APPLE DOS

A Technical Manual

By Don Worth and Pieter Lechner

Become an expert on the intricacies of Apple's DOS (Disk Operating System). BENEATH APPLE DOS is the perfect companion to Apple's DOS 3.3 Manual. Containing eight chapters, three appendices, a glossary, an index, and over 160 pages, this manual will serve to completely fill in the many gaps left by Apple's DOS 3.3 Manual. Written for Apple users with DOS 3.3, 3.2 or earlier versions, any Apple disk user would welcome having this carefully written manual at his fingertips.

LEARN . . .

- How DOS 3.3 differs from other DOS versions.
- How disks are protected.
- How to reconstruct a damaged diskette CATALOG.
- How tracks are formatted.
- How to use the disk directly, without DOS.
- How to call DOS's file manager.
- How every routine in DOS works.
- How to customize DOS to your needs.
- How to overcome DISK I/O ERRORS.
- About the "secret" file types — S and R.

INCLUDES . . .

- Large quantities of excellent diagrams and tables.
- Source listings of useful disk utilities.
- Glossary of over 150 technical terms.
- Exhaustive description of DOS program logic.
- Handy reference card.
- Useful patches to DOS.
- Many programming examples.

Book - \$19.95

## CROSS-REF by Jim Aalto

Applesoft programmers will be delighted to have this cross reference utility program in their "tool kit" of software aids. What can CROSS-REF do to speed and facilitate your Applesoft program development? Consider these functions:

VARIABLE CROSS REFERENCE	LINE CROSS REFERENCE
FIND VARIABLE	FIND LINE NUMBER
REPLACE VARIABLE	VARIABLE ONLY LISTING
	LINE ONLY LISTING

Features that make CROSS-REF easy to use include:

- Written in machine language, occupies less than 3K.
- Resides passively in memory while DOS or Applesoft is active.
- Can be loaded with your Applesoft program already resident.
- Very fast — a VARIABLE CROSS REFERENCE for a 16K Applesoft program can start printing in 5 seconds.
- Contains printer format controls and headers for documentation.
- Prints English language error messages.

Cassette - \$22.95    Diskette - \$24.95

LINKER

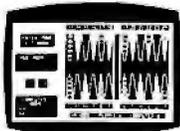
## LINKER by Don Worth.

Turn your Apple II or Apple II Plus into a powerful and productive software development machine with this superb linking loader/editor package. LINKER does the following and much more:

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Linker works with virtually any assembler for the Apple II. Requires 32K of RAM and one disk drive.

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Manual Only - \$19.95



## FASTGAMMON™ By Bob Christiansen.

Sound, hi res, color, and musical cartoons have helped make this the most popular backgammon playing game for the Apple II. But don't let these entertaining features fool you — FASTGAMMON plays serious backgammon. Runs on any Apple II with at least 24K of RAM.

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## METEORIDS IN SPACE™

By Bruce Wallace

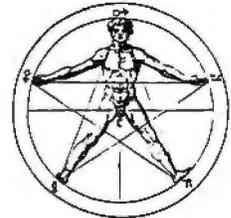
We have taken our popular space game, formerly called Asteroids in Space, and made some important improvements. To accent these improvements we have given it a new name — METEORIDS IN SPACE. Your space ship travels through a shower of deadly meteoroids. If your ship is hit, it will be destroyed, so you use your laser gun to blast the meteoroids. Big meteoroids shatter into smaller meteoroids when hit, and the smaller ones are usually faster and just as deadly. From time to time you will encounter an alien space ship whose mission is to destroy you, so you'd better destroy it first. All the action is displayed in fast, smooth, high resolution graphics, accompanied by sound effects. You now can control your ship using one of two options — the Apple game paddles or the keyboard. One of the game paddle buttons controls the laser fire. In METEORIDS IN SPACE, the spaceship's velocity gradually decreases unless more thrust is applied, adding an element of control. Also new to this version is a hyperspace feature — translate instantly to another spot in the galaxy. The game is over when five of your ships have been destroyed. An additional ship is added for every 10,000 points you score. Runs on any Apple II with at least 32K of RAM and one disk drive.

Diskette - \$19.95



## ASTROAPPLE™ by Bob Male.

Your Apple computer becomes your astrologer, generating horoscopes and forecasts based on the computed positions of the heavenly bodies. This program offers a delightful and stimulating way to entertain friends. ASTROAPPLE produces natal horoscopes (birth charts) for each person based on his or her birth data. Any two people may be compared for physical, emotional, and intellectual compatibility. The program is written in Applesoft BASIC with machine language subroutines. It requires either RAM or ROM Applesoft and at least 32K of memory.



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## FRACAS™ by Stuart Smith.

A fantastic adventure game like no other! Up to eight players can participate in FRACAS at the same time. Journey in the land of FAROPH, searching for hidden treasure while warding off all sorts of unfriendly and dangerous creatures. You and your friends can compete with each other or you can join forces and gang up on the monsters. Your location is presented graphically and sound effects enliven the battles. Save your adventure on diskette or cassette and continue it at some other time. Both integer BASIC and Applesoft versions included. Requires at least 32K of RAM.

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Also by Don Worth . . .

## BENEATH APPLE MANOR — Adventure. Uses Integer BASIC.

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## BABBLE - Fun with words, sound, and graphics.

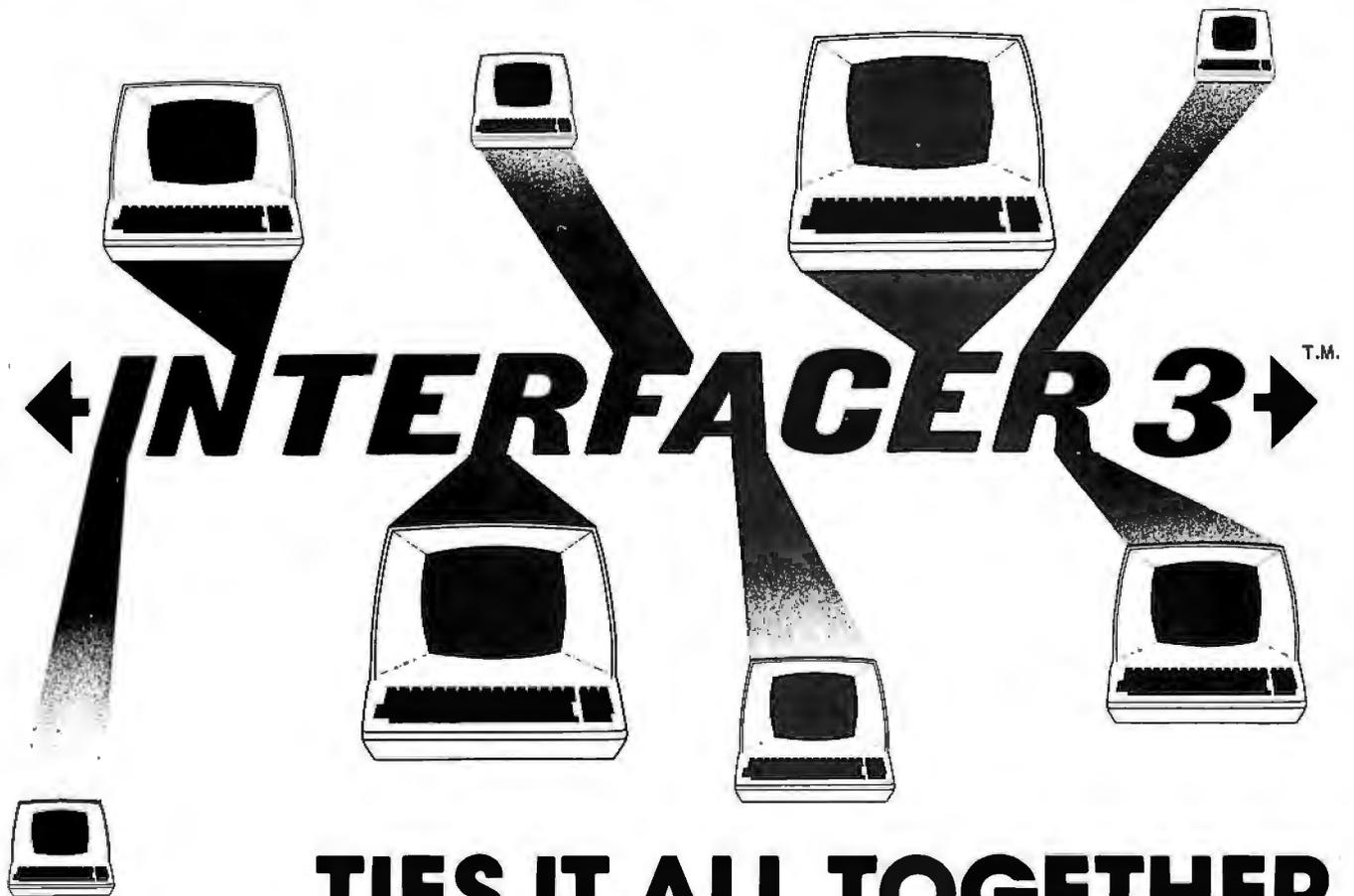
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16K RAM 20-16 (extended addressing and bank select)	\$319	\$399	\$479
24K RAM 20-24 (extended addressing and bank select)	\$429	\$539	\$629
32K RAM 20-32 (extended addressing and bank select)	\$559	\$699	\$799

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Most CompuPro products are available in Unkit form. Assembled/Tested, or qualified under the high-reliability Certified System Component (CSC) program (200 hour burn-in, more). Note: Unkits are not intended for novices, as de-bugging may be required due to problems such as IC infant mortality. Factory service is available for Unkits at a flat service charge.

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Also available: **COMPUTER ENCLOSURE 1**. Same as above, but less power supply and motherboard. \$289 desk top, \$329 rack mount.

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8 Bit CPU 8085 . . . . . \$235 Unkit, \$325 A/T, \$425 CSC.  
16/8 Bit CPU 8085/88 . . . . . \$295 Unkit, \$425 A/T (both operate at 5MHz); \$525 CSC (with 5 MHz 8085, 6 MHz 8088).

## SOFTWARE

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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

<b>Name</b> Super STEP Z80 Processor Model	<b>Format</b> Cassette tape
<b>Type</b> Debugging utility for assembly-language programming (runs as an extension of Radio Shack's T-Bug program)	<b>Language</b> Machine language
<b>Manufacturer</b> Allen Gelder Software Box 11721 Main Post Office San Francisco CA 94101	<b>Computer</b> TRS-80 Model I, with Level II BASIC and 16 K bytes of memory
<b>Price</b> \$19.95	<b>Documentation</b> Instruction booklet of 16 pages, 11.5 by 14 cm (4½ by 5½ inches)
	<b>Audience</b> Assembly-language programmers

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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.

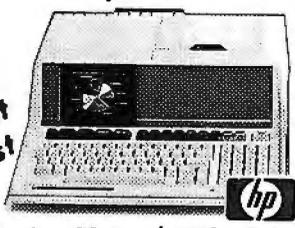
Some improvements come to mind. I would like to see some indication of interrupt status (enabled or disabled) on the video display. In addition, Super STEP would be greatly improved if the author provided three copies of the software (one each for the 16 K-byte, 32 K-byte, and 48 K-byte versions of the 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. ■

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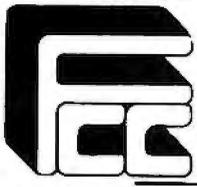
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BYTE's Bugs

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Problematic  
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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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## 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 im-

possible 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), PGn (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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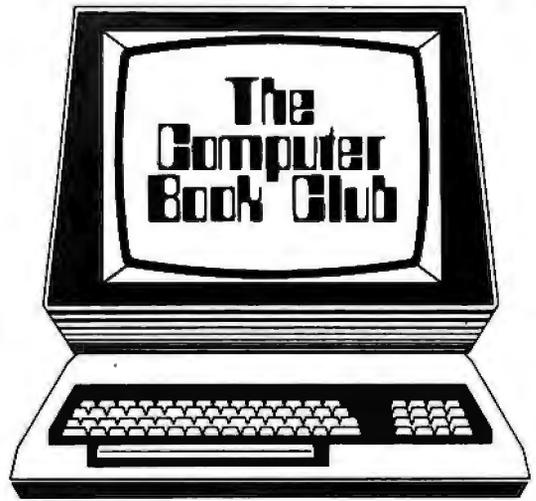
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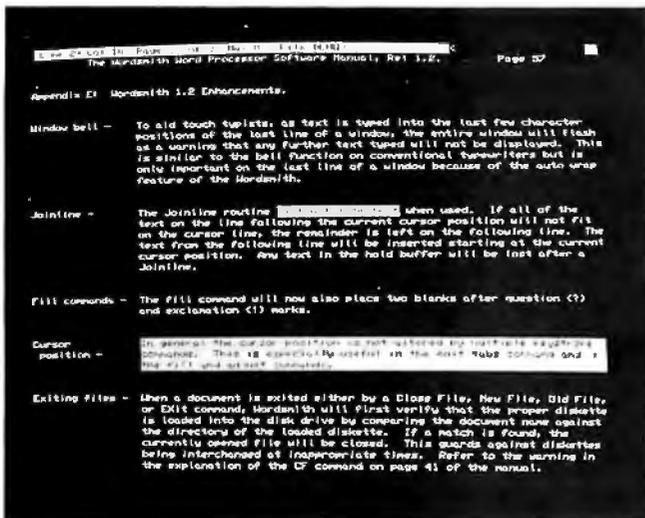


Photo 1: The Wordsmith word processor as displayed on the Screensplitter video board.

## 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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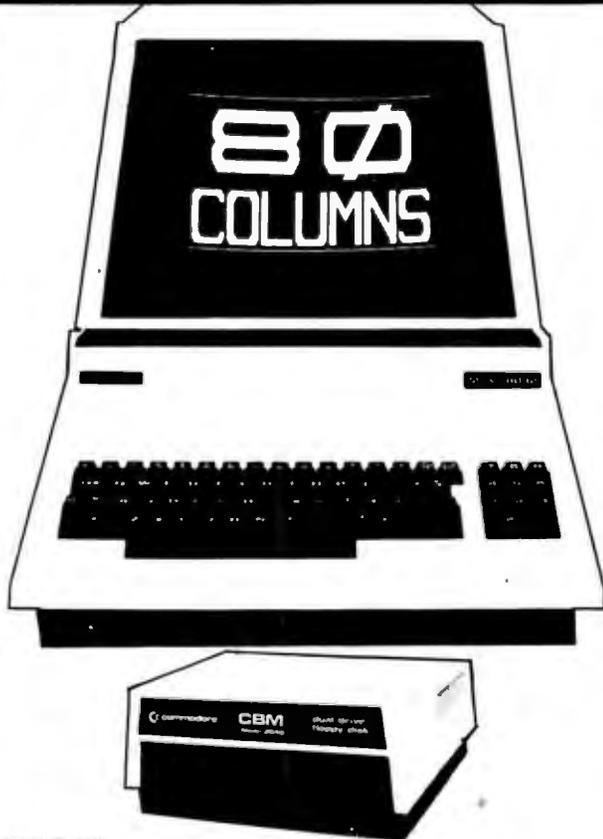
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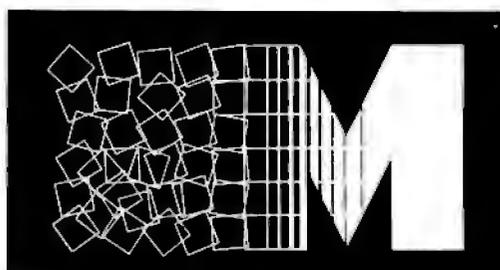
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But cost-effective designs and efficient manufacturing operations weren't enough. Computer retailers can make up to a \$250 markup on the foreign models. Could we hold to a \$299 list price and give the dealer enough incentive to sell the Bytewriter-1? No way. We had to try a more direct approach.

## YOUR BUY DECISION - DEALER OR MAIL ORDER

There are some very good reasons to buy your first computer through a dealer. There is a certain amount of hand-holding required when you decide to buy a personal computer. This is one of the main functions of the retail computer store. And most of them perform this function very well.

But why would anyone want to buy add-on equipment through a dealer? If you find a product that has been designed for and tested with your particular computer, you can safely bypass the computer dealer. You can have the best of both worlds. You can save money by buying direct from the manufacturer, and you can be certain that your new device will work when you get it.

We've done extensive testing with the most popular computers - the TRS-80, the Apple II, and the Atari 400 and 800. If you own one of these computers, we guarantee you won't have any interface problems with the Bytewriter-1.

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Atari 400 & 800 are trademarks of Atari, Inc.  
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## FOUR THINGS YOU SHOULD KNOW BEFORE YOU BUY THIS PRINTER

We don't want any unhappy customers. We'd like you to know the limitations of our printer, as well as its advantages. There are some differences between the Bytewriter-1 and the higher priced printers you may be looking at:

- 1) The Bytewriter-1 takes single sheet and roll paper only. No pin feed paper.
- 2) We've used a 7-wire print head. No fancy lower case descenders.
- 3) There aren't any software frills in the Bytewriter-1, like VFU controls. However, if your main interest is getting software listings or printing letters, you won't care. And, with a bit of ingenuity, you can provide VFU functions in your own programs.
- 4) You can't go into a computer store and pick up a Bytewriter-1. They're sold direct only by MICROTEK.

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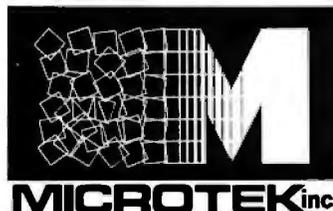
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## News and Speculation About Personal Computing

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.

### **E**EPROM 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 non-volatile 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.

### **M**icrosoft 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.

### **C**ontinuing AMSAT OSCAR Activity:

AMSAT,

the Radio Amateur Satellite Corporation, has survived the loss of its Phase-IIIA OSCAR satellite. (See "BYTE LINES," 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 Ariane-boosted 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.

### **D**etails 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.

### **M**ini-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

# SOFTWARE SOFTWARE DIGITAL MARKETING DIGITAL MARKETING

May 1981

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**MILESTONE™** - \$295. Manual alone - \$30.  
"Critical path" network analysis program for scheduling manpower, dollars and time to maximize productivity.

An interactive project management program that runs under CP/M and can relate together different skills, hourly pay rates and projects to maximize efficiency. MILESTONE could be used to track paper flow, build a computer, check a salesman's performance, or build a bridge. MILESTONE can be used by executives, engineers, managers, and small businessmen to:

- Find the critical tasks which can't be delayed.
- Discover which tasks are not time critical.
- See how manpower and expenses vary versus time.
- Investigate tradeoffs between manpower, dollars and time.
- Communicate plans to others using a printed project schedule.
- Change details of the project and immediately see the results on the screen.

Requires 48K RAM and CP/M. Also available for Apple Pascal or UCSD Pascal Operating Systems.

Formats: 8, NS, MP, CDOS, SB, TRS2, APPL

**DATEBOOK II™** - \$295. Manual alone \$25.

- NOW SCHEDULES APPOINTMENTS FOR UP TO 27 DIFFERENT PEOPLE
- IMPROVED FILE STRUCTURE ALLOWS APPOINTMENTS UP TO ONE YEAR
- Replaces your office appointment calendar
- Searches for openings that fit time of day, day of week & day of year constraints
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- Copies of day's appointments can be quickly printed
- Copies of day's appointments can be quickly printed

Requires 48K RAM and CP/M. Also available for Apple Pascal or UCSD Pascal Operating Systems.

Formats: 8, NS, MP, CDOS, SB, APPL, TRS2

**baZic™** - \$150. Manual alone - \$25.  
Written entirely in Z80™ code baZic runs as much as 30% faster than NorthStar™ BASIC. With minor exceptions, it is 100% compatible with existing NorthStar BASIC programs. Can be used on any Z80-based microcomputer operating under either CP/M or NorthStar DOS. baZic adds new functions to assist in screen formatting, as well as features to simplify programming, e.g. APPEND command/statement, ON GOSUB, cursor-addressable PRINT, etc.

Requires Z80 CPU, CP/M or NorthStar DOS. Formats: 8, NS, MP, SB, TRS2, APPL

**MAGIC WAND™** - \$395. Manual alone - \$35.  
Word Processing System

- Full screen text editing
- Full text formatting commands
- Merging with external data files
- Variables
- Conditional commands
- True proportional printing
- Specify disk format, terminal and printer.

Turns Magic Wand into a humkey system. Allows move from EDIT to PRINT, backup of files or disks, system status, etc. from menu without returning to CP/M 2.x

Requires 56K RAM, CP/M and Magic Wand.  
Formats: 8, NS, MP, SB, TRS2, APPL

**SPECIAL OFFER: Magic Wand, Magic Menu & Spellguard - \$750.**

**PASCAL/M™** - \$225. Manual alone - \$20.  
CP/M™ compatible language for 8080/8085 CPUs, supports full Jensen & Wirth plus 45 extensions to Standard Pascal including Random access files, 40 segment procedures & 16 bit BCD real type. NOW INCLUDES symbolic debugger which features trapping on stores, examining and changing variables and tracing of program execution.

Requires CP/M & 64K RAM. Formats: 8, NS, CDOS, APPL, TRS2

**PASCAL/M for 8086/88™** - \$270.  
Manual alone - \$20.  
All features of Pascal/M for the 8086 and 8088 processors running under the 8086/88 version of CP/M.

Requires CP/M-86™ & 128K RAM. Format: 8

**TRANS 86™** - \$125. Manual alone - \$20.  
8086/88 Translator for existing 8080/8085 programs. The new source code can be easily edited and assembled using ACT II to produce hex code which can be executed by 8088/88. Emphasizes the extensions and features available in the 8086/88.

Requires CP/M and 32K RAM  
Formats: 8, NS, CDOS, APPL

**ACT I™** - \$125. Manual alone - \$15.  
CP/M compatible macro assembler for Z80, 8080/85, 6502 & 6800.

One assembler that supports all major 8 bit micros. ACT features include full macro capabilities, comprehensive pseudo-ops, link-file structures, cross reference map, and algebraic expression processor. Requires 24K RAM & CP/M.

**ACT II™** - \$175. Manual alone - \$20.  
CP/M 2.x compatible cross assembler for 8086/88

**ACT III™** - \$125. Manual alone - \$20.  
CP/M 2.x compatible cross assembler for 6809.

**ACT I and ACT II together™** - \$225.  
Formats: 8, NS, CDOS, MP/M, TRS2, APPL

**PEARL™** The application software generator  
Pearl asks questions that a programmer would have to answer to code the system. You answer the questions & Pearl uses built-in logic to construct both subroutines & mainline programs. The system then compiles & executes your program code.

- Level 1: For Personal Computing - \$130./\$35.
- Level 2: The Business Assistant - \$350./\$35.
- Level 3: Adv. Software Develop. - \$650./\$50.

Requires CP/M and CBASIC2. Formats: 8, NS, MP, SB, TRS2

**CBASIC2™** - \$120.  
Industry standard intermediate code compiler with run-time interpreter. Features include chaining, integer & external precision arithmetic.

**ULTRASORT-II™** - \$175.  
The sort/merge/select utility for CBASIC2 written in assembly language. Can be loaded by CBASIC2 during run-time; also can be used as a stand-alone utility. NOW also supports Basic 80™ & the Microsoft Basic Compiler.

**FABSTM™** - \$175. Manual alone - \$20.  
Fast Access Btree Structure. Key sequential multi-path balanced tree structure. Faster than ISAM. Can be loaded by CBASIC2 during run-time. NOW also supports Microsoft Fortran-80™ and S-Basic™.

Requires CP/M. Formats: 8, NS, MP, SB, TRS2, CDOS

**COPYWRITER™** \$395. Manual alone - \$35.  
A powerful CP/M Word Processing System which includes a fast screen editor and is exceptionally easy to learn and use. Copywriter supports both vertical and horizontal scrolling for 132 column printers. File size is limited only by disk size. The print formatting program allows control over output word processing files, and permits the insertion of variable data into form letters. Full proportional printing is also supported.

**MAILING LIST™** - \$195. Manual alone - \$35.  
An integrated mailing list system which can select any range of zip codes for printing; select which fields to fill into merge; select by title, position or department within a company. Output can sort for bulk mailings by state and zip code.

Copywriter Screen Editor alone - \$195.  
**COPYPROOF™** - \$295. Manual alone - \$35.  
Copywriter version of Spellguard.

**DICTION I™** - \$95.  
22,000 dictionary words not included in Copyproof or Spellguard. Compatible with any word processor using Spellguard.

**DICTION II™** - \$195.  
40,000 more words not included in Diction I. Copyproof or Spellguard.

Copywriter System requires 60K RAM & CP/M. Formats: 8, SB

**SPELLGUARD™** - \$295. Manual alone - \$20.  
20,000+ word dictionary containing commonly used words that find spelling & typographical errors in text files. Allows review of all 10,000 words/min.

Requires CP/M, 48K RAM & Magic Wand, WordStar™ or Spellbinder™  
Formats: 8, NS, MP, SB, TRS2, CDOS

**SPELLBINDER™** - \$495. Manual alone - \$50.  
Full feature word processing system with Office Management capabilities. Its 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:

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- Disk file transfer between CP/M computer & Time Sharing Computer in either direction
- Disk file transfer between two CP/M computers with error detection and correction

**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, tagging, data file transfers PLUS eleven data transformations (e.g. linear, reciprocal, exponential, etc.)
- Frequency distributions, 8 probability distributions
- Multiple regression, correction analysis
- Time series
- Crosstabs/Chi-Square, non-parametrics
- Factorials, permutations, combinations
- Scatterplots
- 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

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Model 510 from Irwin. It costs \$1500, which includes integral tape-cartridge backup.

**T****I 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.

**M****ore 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.

**A****da 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 pseudo-code 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.

**C****omputer 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.

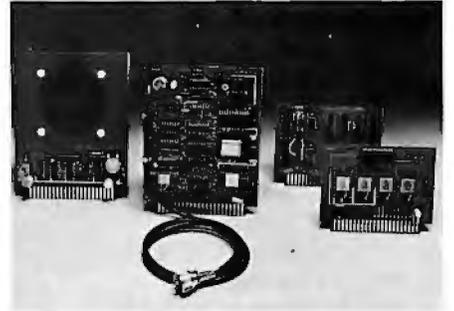
Other bulletin board systems serve special interests (eg: AMRAD's Blind Service CBBS 703-281-2222, the Family Historians' CBBS 703-978-7561, and Aviators' BBS 916-393-4459). For more information on all of these systems and how to access them, call the MAG-MEDIA-80 CBBS (415) 573-8768.

**H****ere 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.

**S****hopping 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.

**D****ata-Base Systems Ex-**

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- VP-565** EPROM Programmer Board—Programs 2716 EPROMs. With software ..... **\$ 99**
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- VP-601** Keyboard—128-character ASCII encoded alphanumeric 8-bit parallel output ..... **\$ 69**
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  - 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**
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  - VP-626** Connector—Male "D" mates to VP-606/616 ..... **\$ 7**
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Make checks payable to RCA Corp. Prices and specifications are subject to change without notice.

**panding:** The need to access reference material has become much easier because of computerized database 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 database 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).

**C**omputer 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.

**G**M 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.

**A**T&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.

**U**sed 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.

**E**xtra-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.

**R**andom 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).

**R**andom 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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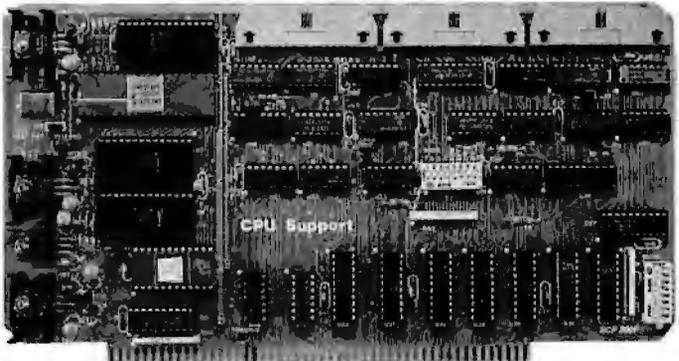
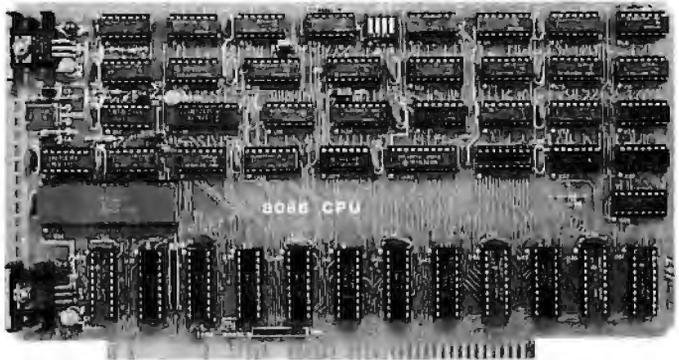
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## Letters

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  $\pi$ ) 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

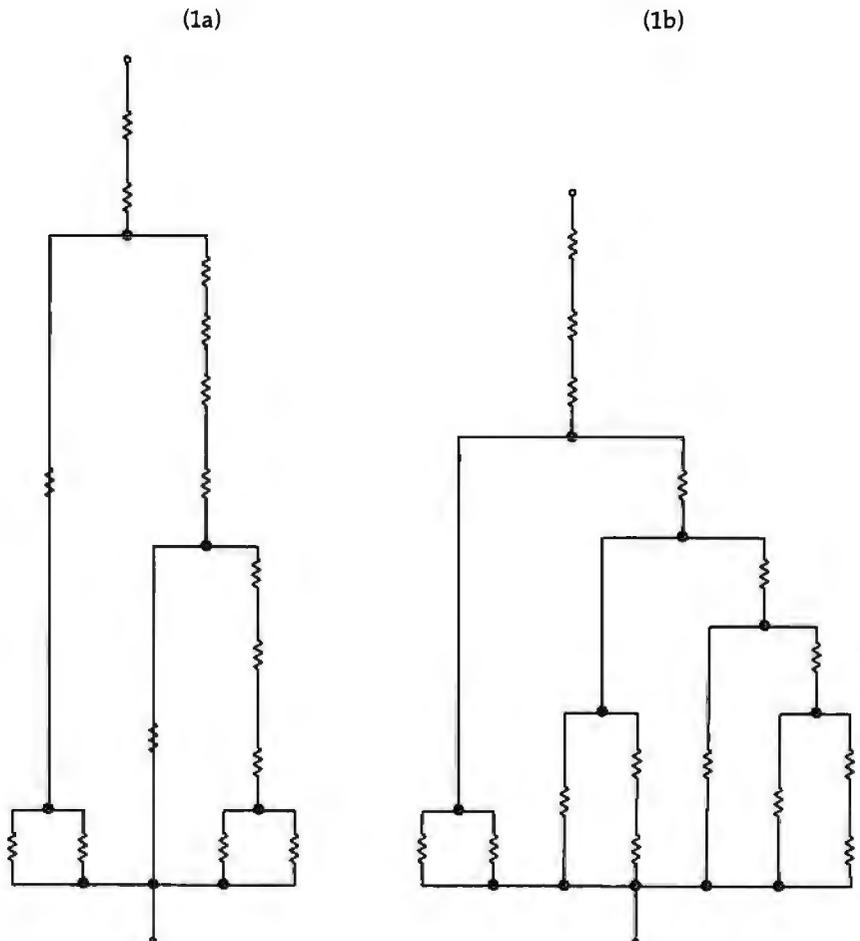


Figure 1: Two 15-unit networks with  $Z = \frac{355}{113}$

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Figure 2: A 14-unit network with  $Z = \frac{355}{113}$

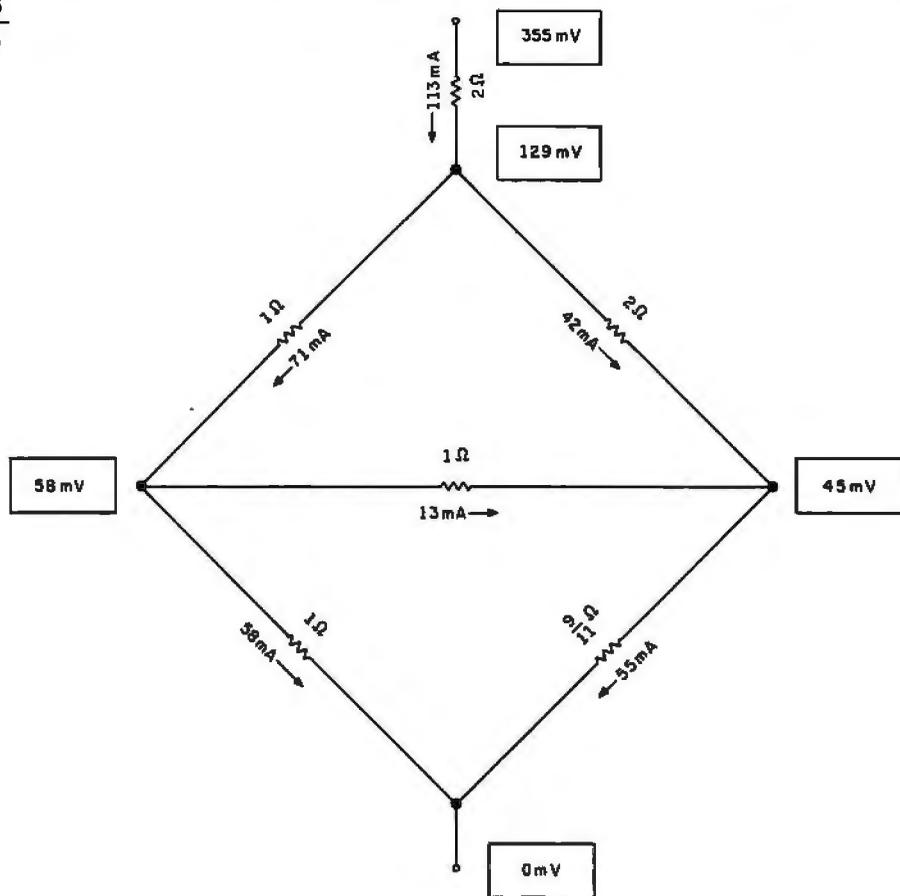
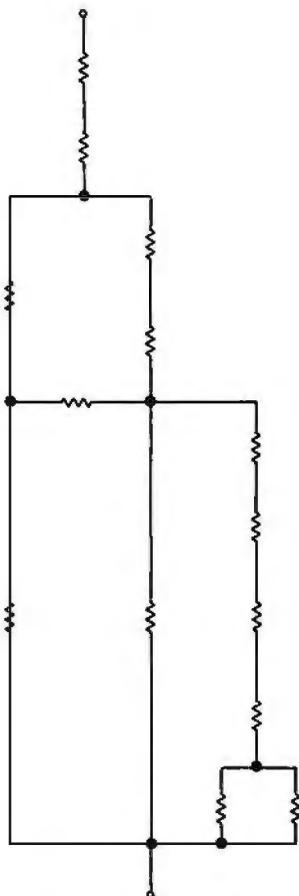


Figure 3: Voltages and currents in the 14-unit network with 355 mV across it.

**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  $V_4 = V_2$  and  $V_3 = V_1$ . Line impedance can

be compensated for by making  $R_0$  variable.

R Gupta  
 Electrical Engineering  
 University of Auckland  
 Private Bas, Auckland  
 New Zealand

**Smart Wheelchair Project**

Steve Ciarcia's article "Home in on the

Rangel 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-

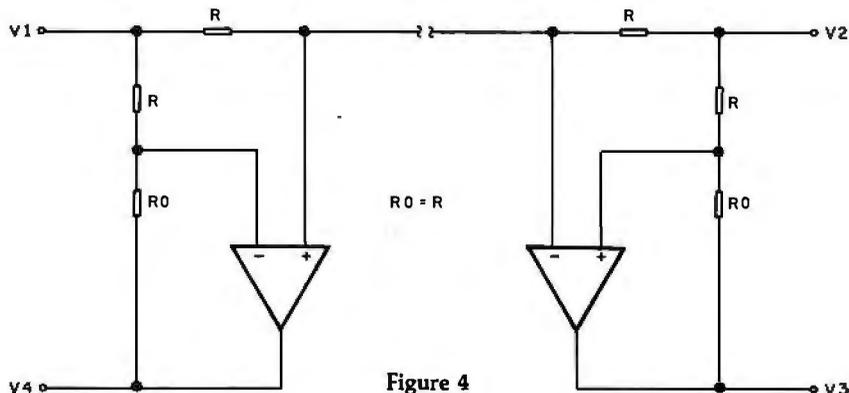


Figure 4

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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**

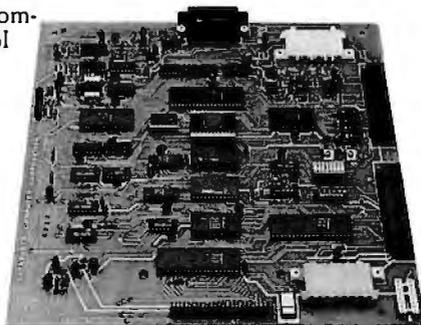


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# dBASE™ II vs. the Bilge Pumps.

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. Hierarchical & Network DBMS.

CODASYL-like hierarchical 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 pre-defined 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.

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## Technical Forum

*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 PAPER-BYTE® 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.

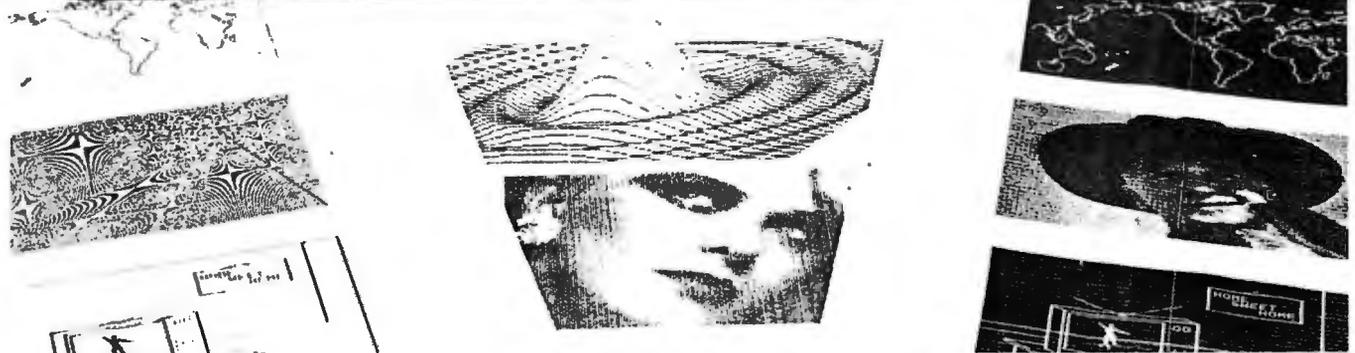
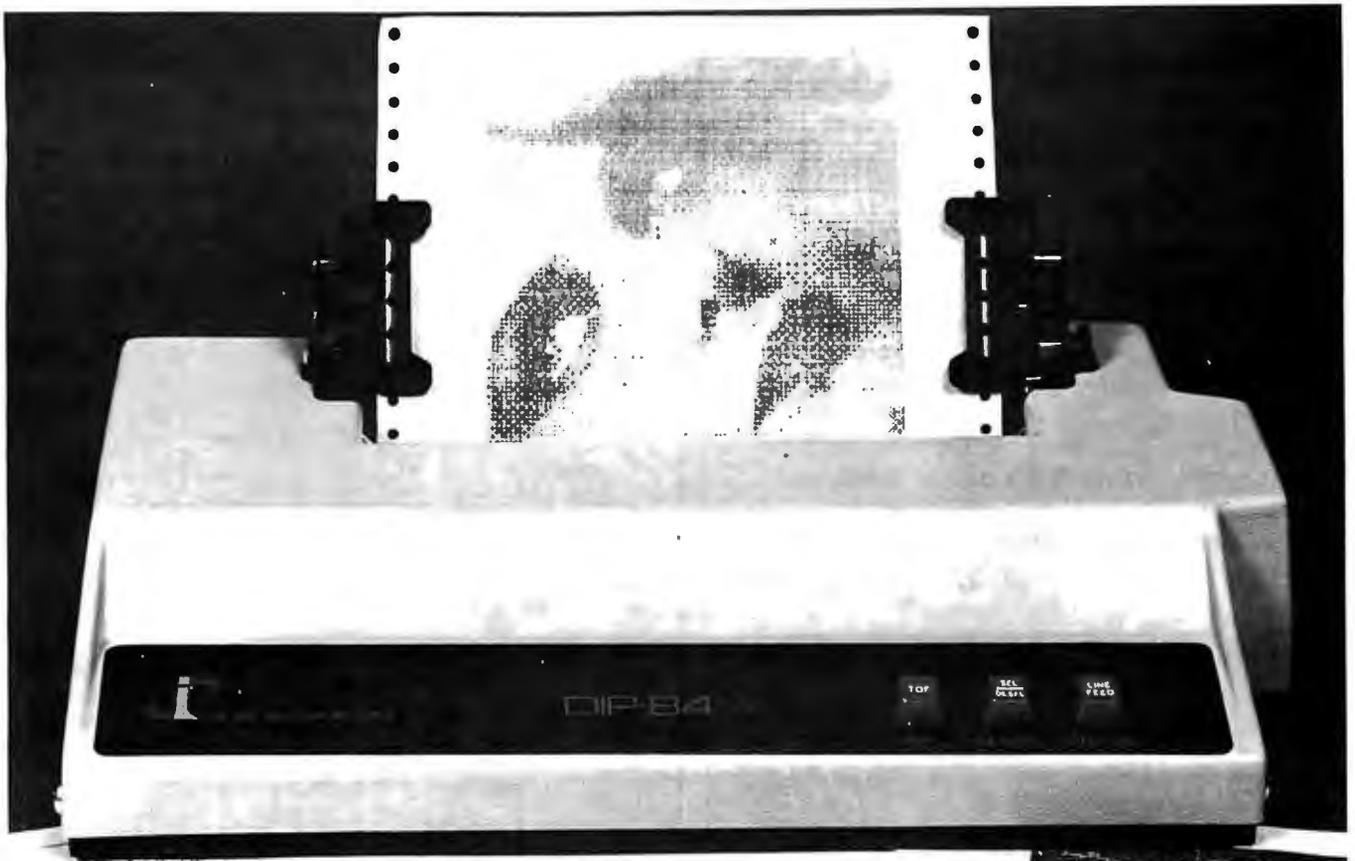
- Backspace to the dot position immediately following the one just printed, by issuing the following printer command:

```
LPRINT CHR$(08); CHR$(4);
```

In my application, I placed equivalent Arabic numerals



**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.

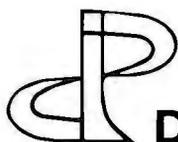


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## Technical Forum

**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$=INKEY$:IF Y$="" THEN 170 ELSE I=VAL(Y$):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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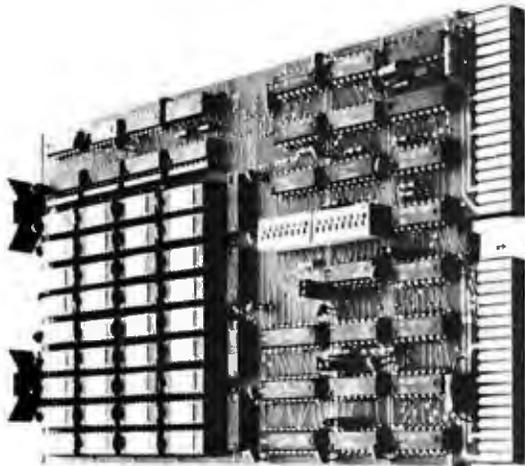
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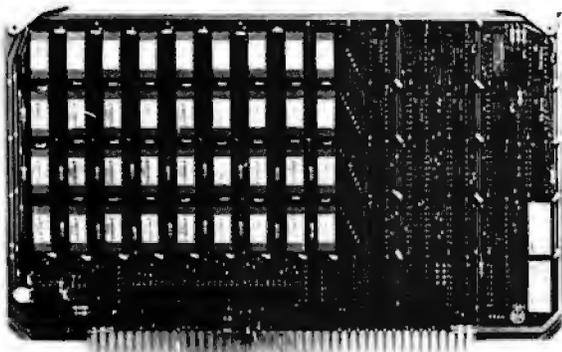
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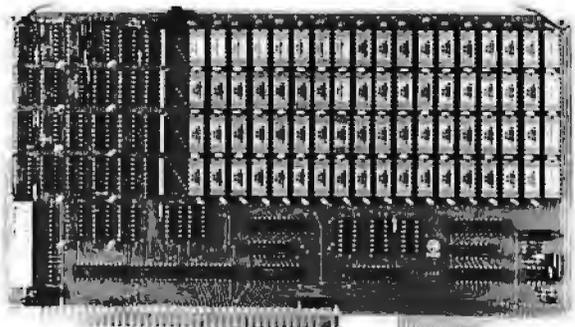
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# Using Interrupts on the Apple II System

---

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

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.

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

### 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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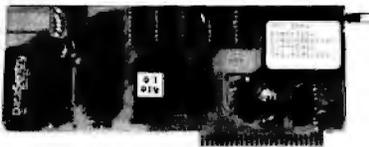


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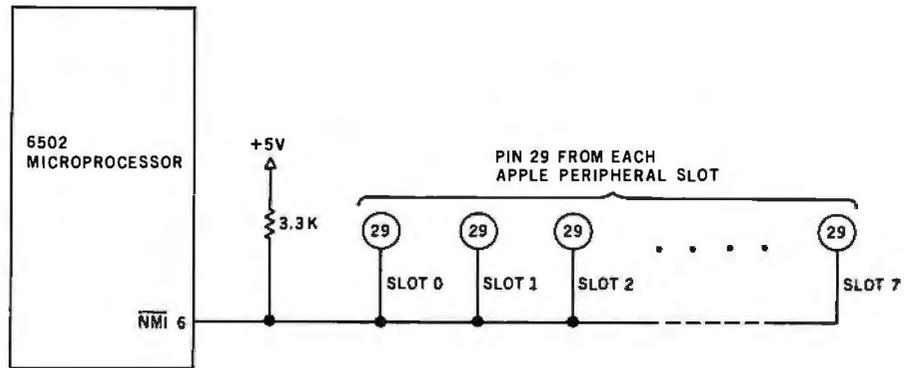


Figure 1: The 6502  $\overline{NMI}$  signal and the Apple II peripheral slots. The  $\overline{NMI}$  signal is connected to pin 29 of each of the slots and is held high by the pull-up resistor shown. An interrupt is generated if the peripheral card in any of the slots presents a low impedance to ground 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 non-maskable interrupt. This interrupt can be better understood by examining each of the five aspects presented earlier.

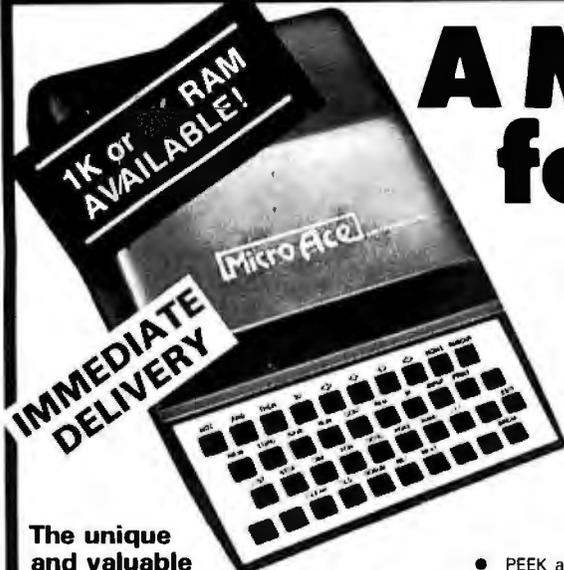
1. Any external device can generate an interrupt by presenting a ground (or low impedance to ground) potential to pin 29 in any of the I/O slots. Thus, the Apple II can have eight different interrupt sources, and they all may decide to interrupt at once.

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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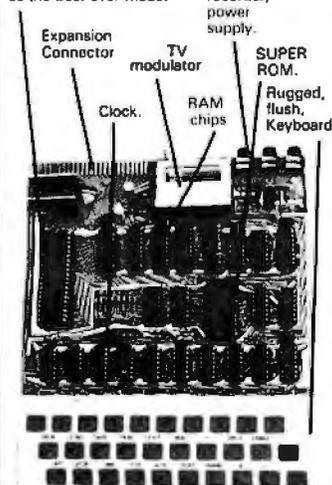
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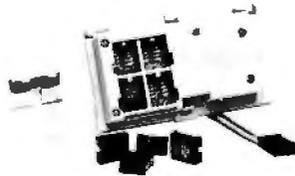
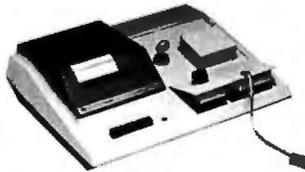
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to examine the status of each device which might have sent the interrupt. The details of this depend greatly on the way the devices are wired up, but in principle some of the 50 lines in the I/O slots can be used by the device to present logical flags or form data buffers. Examination of these signal lines by the program can then determine whether the device in question sent the 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,

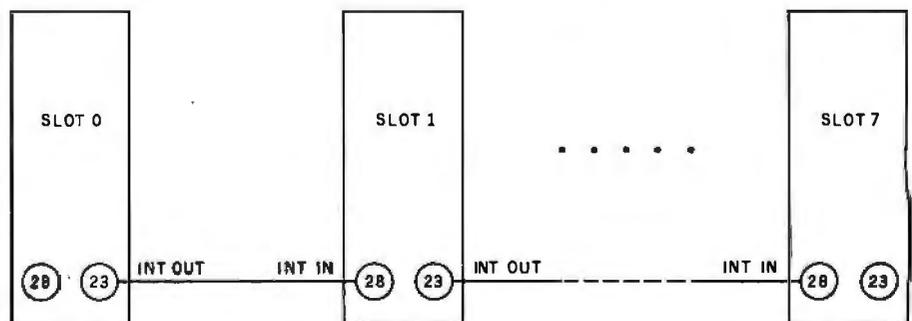
while cards in the higher-numbered slots have lower priority; it is not that the processor will process the I/O functions of the higher-priority cards before dealing with lower-priority cards if interrupts occur at the same time, but that the lower-priority cards are *not permitted* to generate an interrupt 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

APPLE PERIPHERAL SLOTS



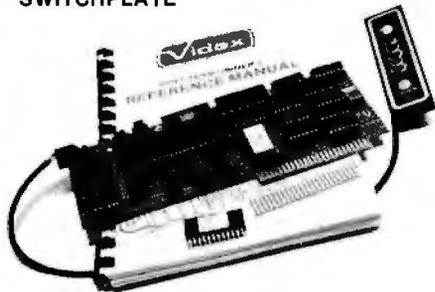
**Figure 2:** Using daisy chaining to create a priority system of interrupts. The INT OUT (pin 23 of each slot) and INT IN (pin 28 of each slot) signals are connected to each other to create a daisy chain that is broken by an interrupting slot. A peripheral device is not allowed to generate an interrupt 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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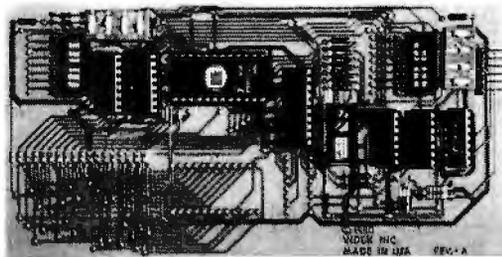
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have a low impedance from INT IN to INT OUT as a normal condition (so the card in slot 7 will be able to "see" the +5 V provided by the card in slot 5), and the cards in both 6 and 7 must be able to detect the absence of the +5 V potential on the INT 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 program-mable 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-

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This handy program allows North Star users to maintain a specialized data base of all files and programs. In the stack of disks which invariably accumulates, DFILE is easy to set up and use. It will organize your disks to provide efficient locating of the desired file or program.
- GRAFIX (TRS-80 only)** Price: \$12.95 Cassette/\$16.95 Diskette  
This unique program allows you to easily create graphics directly from the keyboard. You "draw" your figure using the program's extensive cursor controls. Once the figure is made, it is automatically appended to your BASIC program as a string variable. Draw a "happy face", call it HS and then print it from your program using PRINT HS! This is a very easy way to create and save graphics.
- TIDY (TRS-80 only)** Price: \$10.95 Cassette/\$14.95 Diskette  
TIDY is an assembly language program which allows you to remember the lines in your BASIC programs. TIDY also removes unnecessary spaces and REMARK statements. The result is a compacted BASIC program which uses much less memory space and executes significantly faster. Once loaded, TIDY remains in memory; you may load any number of BASIC programs without having to reload TIDY!

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- DATA SMOOTHER (Not available for ATARI)** Price: \$14.95 Cassette/\$18.95 Diskette  
This special data smoothing program may be used to rapidly derive useful information from noisy business and engineering data which are equally spaced. The software features choice in degree and range of fit, as well as smoothed first and second derivative calculation. Also included is automatic plotting of the input data and smoothed results.
- FOURIER ANALYZER (Available for all computers)** Price: \$14.95 Cassette/\$18.95 Diskette  
Use this program to examine the frequency spectra of limited duration signals. The program features automatic scaling and plotting of the input data and results. Practical applications include the analysis of complicated patterns in such fields as electronics, communications and business.
- TFA (Transfer Function Analyzer)** Price: \$19.95 Cassette/\$23.95 Diskette  
This is a special software package which may be used to evaluate the transfer functions of systems such as hi-fi amplifiers and filters by examining their response to pulsed inputs. TFA is a major modification of FOURIER ANALYZER and contains an engineering-oriented decibel versus log-frequency plot as well as data editing features. Whereas FOURIER ANALYZER is designed for educational and scientific use, TFA is an engineering tool. Available for all computers.
- HARMONIC ANALYZER (Available for all computers)** Price: \$24.95 Cassette/\$28.95 Diskette  
HARMONIC ANALYZER was designed for the spectrum analysis of repetitive waveforms. Features include data file generation, editing and storage/retrieval as well as data and spectrum plotting. One particularly unique facility is that the input data need not be equally spaced in time. The original data is stored and a cubic spline interpolation is used to create the data file required by the FFT algorithm.
- FOURIER ANALYZER, TFA and HARMONIC ANALYZER may be purchased together for a combined price of \$44.95 (three cassettes) and \$56.95 (three diskettes).
- REGRESSION I (Available for all computers)** Price: \$19.95 Cassette/\$23.95 Diskette  
REGRESSION I is a unique and exceptionally versatile one-dimensional least squares "polynomial" curve fitting program. Features include very high accuracy; an automatic degree determination option; an extensive internal library of fitting functions; data editing; automatic data and curve plotting; a statistical analysis (eg: standard deviation, correlation coefficient, etc.) and much more. In addition, new fits may be tried without reentering the data. REGRESSION I is certainly the cornerstone program in any data analysis software library.
- REGRESSION II (PARAFIT) (Available for all computers)** Price: \$19.95 Cassette/\$23.95 Diskette  
PARAFIT is designed to handle those cases in which the parameters are embedded (possibly nonlinearly) in the fitting function. The user simply enters the functional form, including the parameters (A(1), A(2), etc.) as one or more BASIC statement lines. Data and results may be manipulated and plotted as with REGRESSION I. Use REGRESSION I for polynomial fitting, and PARAFIT for those complicated functions.
- MULTILINEAR REGRESSION (MLR) (Available for all computers)** Price: \$24.95 Cassette/\$28.95 Diskette  
MLR is a professional software package for analyzing data sets containing two or more linearly independent variables. Besides performing the basic regression calculation, this program also provides easy to use data entry, storage, retrieval and editing functions. In addition, the user may interpolate the solution by supplying values for the independent variables. The number of variables and data size is limited only by the available memory.
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- BASIC SCIENTIFIC SUBROUTINES, Volume 1 (Not available for ATARI)**  
DYNACOMP is the exclusive distributor for the software keyed to the text BASIC Scientific Subroutines, Volume 1 by F. Ruckdeschel (see the BYTE/McGraw-Hill advertisement in BYTE magazine, January 1981). These subroutines have been assembled according to chapter, including with each collection is a menu program which selects and demonstrates each subroutine.
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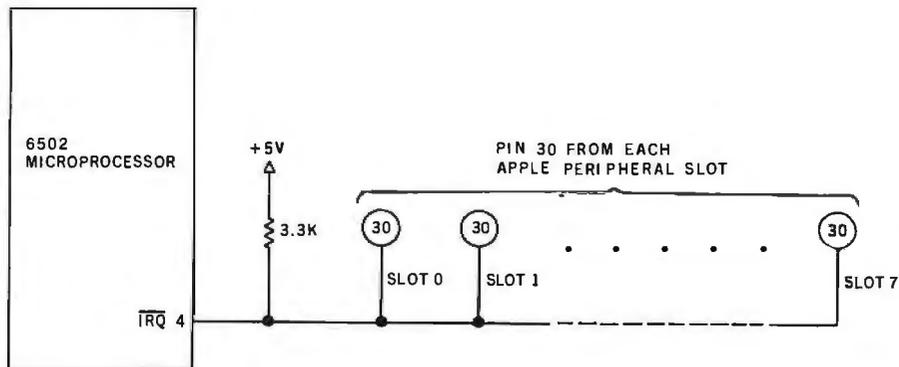


Figure 3: The 6502  $\overline{IRQ}$  signal and the Apple II peripheral slots. The  $\overline{IRQ}$  signal is connected to pin 30 of each of the slots and is held high by the pull-up resistor shown. A maskable interrupt is generated if the peripheral card in any of the slots presents a low impedance 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 FFFF

Text continued on page 294

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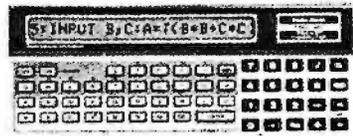
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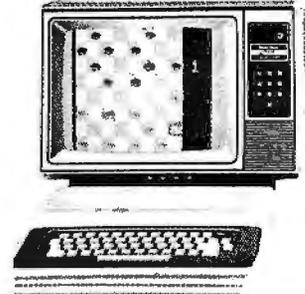
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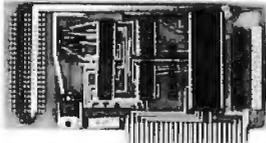


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**Listing 1: Assembly-language routines to test maskable and nonmaskable interrupts.** Routines RNMI and RIRQ print the messages "NMI" and "IRQ", respectively, 255 times when the appropriate interrupt is generated. The short routines at hexadecimal 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.

```

1000 *TEST OF INTERRUPT SYSTEM
1010 .OR $3FB
1020 JMP RNMI
1030 .DA RIRQ
1040 .OR $300
.....
1060 *
1070 ***** ROUTINE FOR NMI *****
1080 *
.....
1090
0300- 48 1100 RNMI PHA SAVE REGISTERS
0301- 8A 1110 TXA
0302- 48 1120 PHA
0303- 98 1130 TYA
0304- 48 1140 PHA
0305- A2 FF 1150 LDX #$FF
0307- A9 CE 1160 L1 LDA #$SCE PRINT "N"
0309- 20 ED FD 1170 JSR $FDED
030C- A9 CD 1180 LDA #$CD PRINT "M"
030E- 20 ED FD 1190 JSR $FDED
0311- A9 C9 1200 LDA #$C9 PRINT "I"
0313- 20 ED FD 1210 JSR $FDED
0316- CA 1220 DEX
0317- E0 00 1230 CPX #0
0319- D0 EC 1240 BNE L1
031B- 68 1250 PLA RESTORE REGISTERS
031C- A8 1260 TAY
031D- 68 1270 PLA
031E- AA 1280 TAX
031F- 68 1290 PLA
0320- 40 1300 RTI GO BACK
.....
1310 *
1320 *
1330 ***** ROUTINE FOR IRQ *****
1340 *
.....
1350
0321- 48 1360 RIRQ PHA SAVE REGISTERS
0322- 8A 1370 TXA
0323- 48 1380 PHA
0324- 98 1390 TYA
0325- 48 1400 PHA
0326- A2 FF 1410 LDX #$FF
0328- A9 C9 1420 L2 LDA #$C9 PRINT "I"
032A- 20 ED FD 1430 JSR $FDED
032D- A9 D2 1440 LDA #$D2 PRINT "R"
032F- 20 ED FD 1450 JSR $FDED
0332- A9 D1 1460 LDA #$D1 PRINT "Q"
0334- 20 ED FD 1470 JSR $FDED
0337- CA 1480 DEX
0338- E0 00 1490 CPX #0
033A- D0 EC 1500 BNE L2
033C- 68 1510 PLA RESTORE REGISTERS
033D- A8 1520 TAY
033E- 68 1530 PLA
033F- AA 1540 TAX
0340- 68 1550 PLA
0341- 40 1560 RTI GO BACK
.....
1570 *
1580 *
1590 ***** ROUTINES FOR BASIC *****
1600 *
.....
1610
1620 .OR 850
0352- 58 1630 CLI ENABLE INTERRUPTS
0353- 60 1640 RTS
0354- 78 1650 SEI DISABLE INTERRUPTS
0355- 60 1660 RTS
1670 .EN

```

SYMBOL TABLE

RNMI	0300	L1	0307	RIRQ	0321
L 2	0328				

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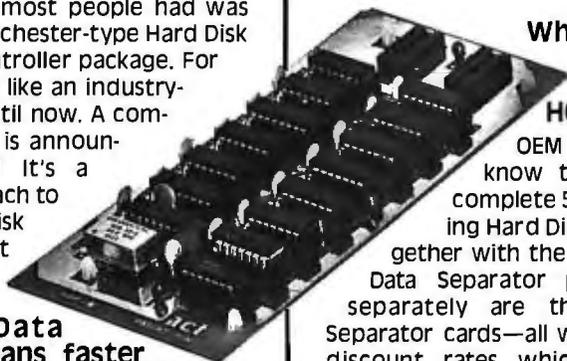
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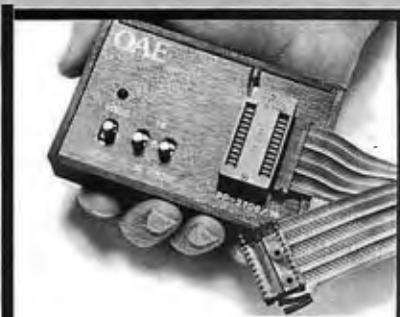
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Text continued from page 290:

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,  $\overline{IRQ}$ , 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  $\overline{NMI}$  request is routed. For the  $\overline{IRQ}$  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  $\overline{IRQ}$  signal from your BASIC program, it is only necessary to execute:

CALL 850

and when you wish to disable the  $\overline{IRQ}$ , 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  $\overline{NMI}$ ) or pin 30 (for the  $\overline{IRQ}$ ) 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  $\overline{NMI}$  signal will always set the interrupt system in motion, but the  $\overline{IRQ}$  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. ■

# 16 BIT 8086 MICRO SYSTEM

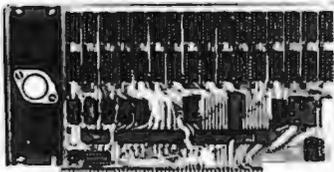
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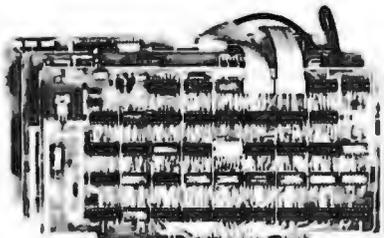
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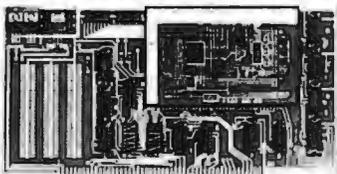
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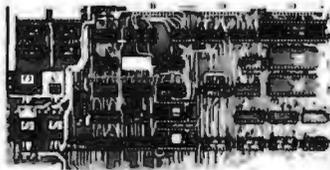
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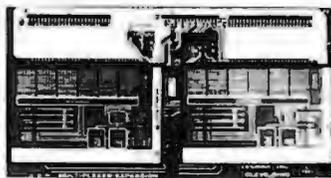
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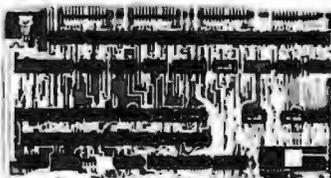
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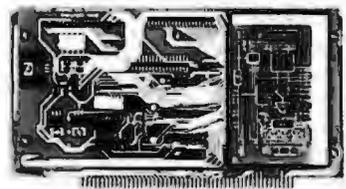
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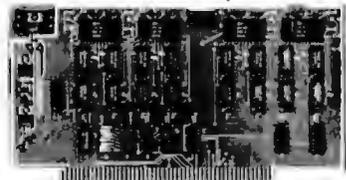
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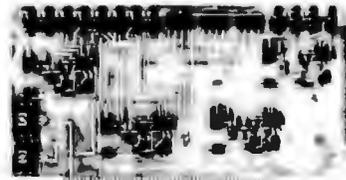
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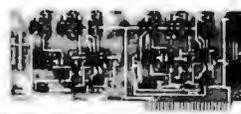
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1 parallel output port



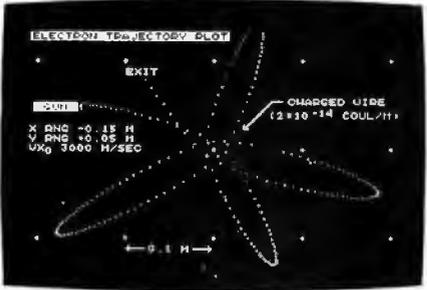
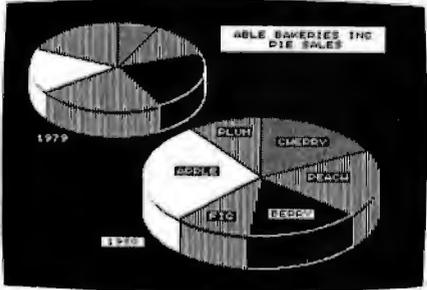
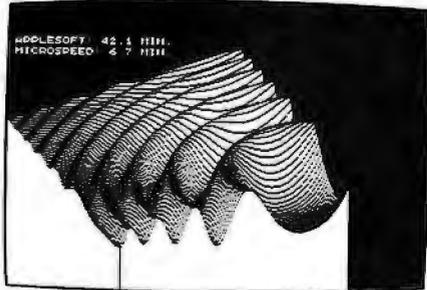
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# Digital Plotting with the Apple II Computer

Dr Richard C Hallgren  
 Department of Biomechanics  
 Michigan State University  
 East Lansing MI 48824

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

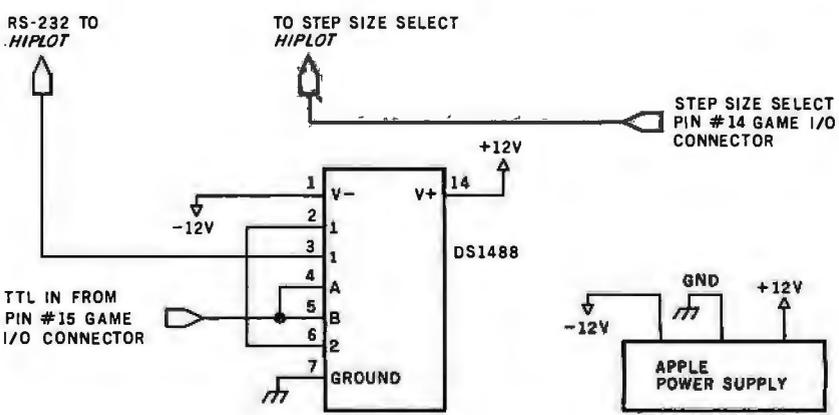


Figure 1: Schematic of Apple II TTL (transistor-transistor logic) to RS-232C interface utilizing only one line-driver integrated circuit, a DS1488.

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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 flow-chart 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*

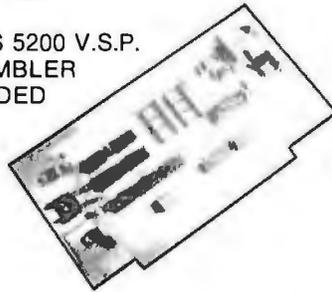
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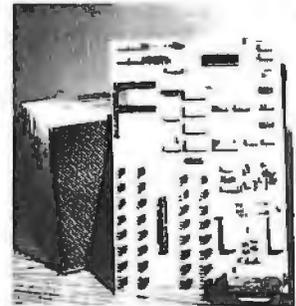
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60pf	.07	.06	.04
100pf	.07	.06	.04
150pf	.07	.06	.04
220pf	.07	.06	.04
270pf	.07	.06	.04
330pf	.07	.06	.04
470pf	.07	.06	.04
.001mf	.07	.06	.04
.0022mf	.07	.06	.04
.0033mf	.07	.06	.04
.0047mf	.07	.06	.04
.01mf	.07	.06	.04
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.60mf	35v	.35	.30	.26
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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
6.0mf	35v	.65	.56	.44
10mf	25v	.85	.72	.61
10mf	35v	1.19	1.00	.84
15mf	25v	1.30	1.09	.92
25mf	25v	1.30	1.09	.92
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1N4027	12/10.00	.06
1N4028	12/10.00	.06
1N4029	12/10.00	.06
1N4030	12/10.00	.06
1N4031	12/10.00	.06
1N4032	12/10.00	.06
1N4033	12/10.00	.06
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1N4035	12/10.00	.06
1N4036	12/10.00	.06
1N4037	12/10.00	.06
1N4038	12/10.00	.06
1N4039	12/10.00	.06
1N4040	12/10.00	.06
1N4041	12/10.00	.06
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Switching	1N814	12S1100
1N4148	12S1100	

### SOCKETS

#### LOW-PROFILE SOLDER TIN

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SBLT	.18	.16	.08
S141L	.18	.16	.14
S151L	.21	.18	.16
S181L	.29	.22	.18
S201L	.31	.26	.20
S221L	.33	.28	.22
S241L	.35	.29	.24
S281L	.41	.34	.28
S401L	.53	.47	.40

#### WIRE-WRAP SOLDER TIN

Part#	1+	25+	100+
S8WT	.37	.33	.30
S14WT	.53	.48	.43
S16WT	.61	.56	.50
S20WT	.85	.77	.69
S24WT	.95	.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	.87	.79	.68
S20WG	1.00	.90	.81
S24WG	1.24	1.11	.99
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S40WG	2.25	2.03	1.83

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.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	.08
.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

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PN2222A	.19
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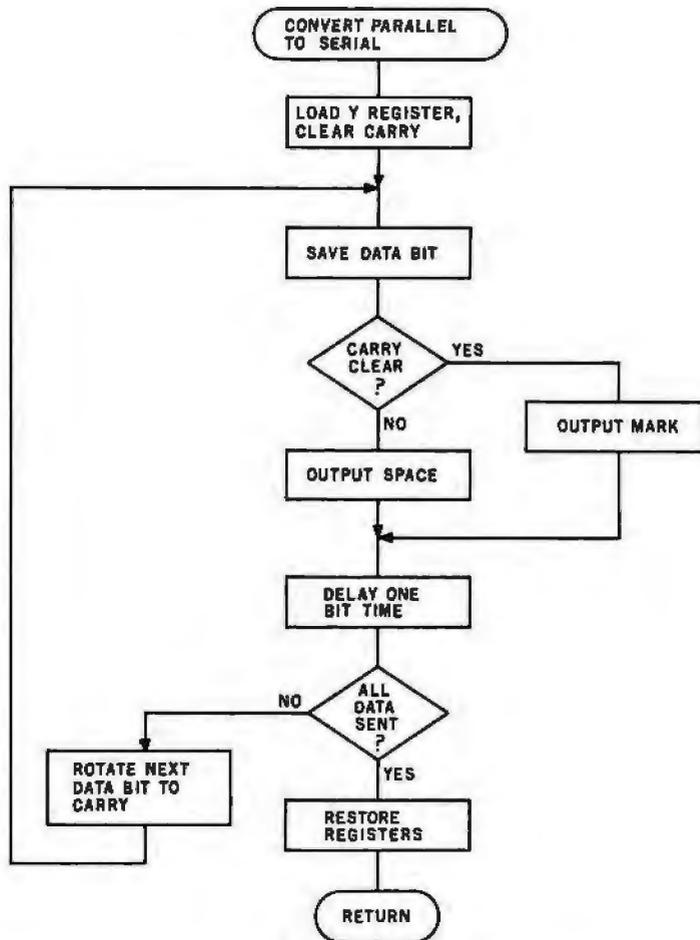
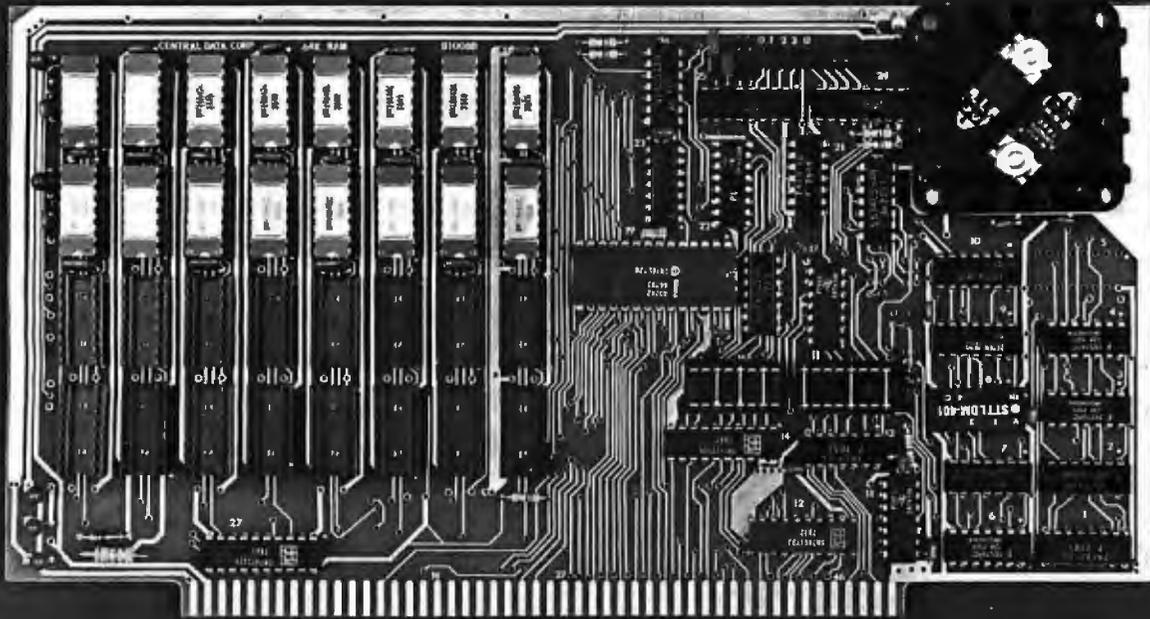


Figure 2: Flowchart for machine-language software UART in listing 1.

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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*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*

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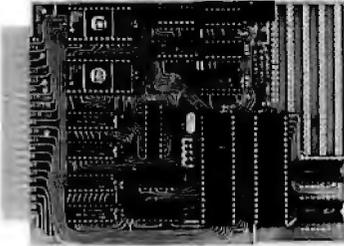
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- Parallel I/O ports available at on-board sockets
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### SOFTWARE FEATURES

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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 FOR 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
    
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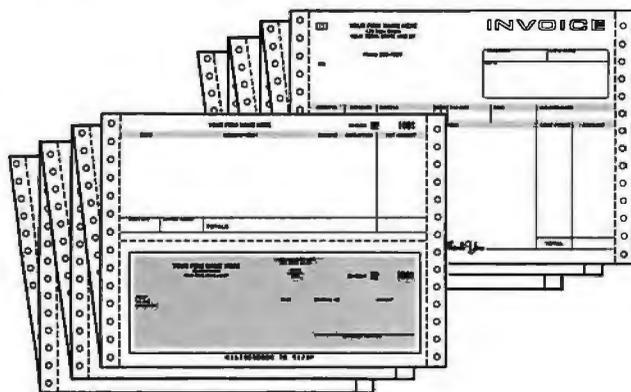
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with continuous business forms  
for small computer systems

Each kit contains samples, programming guides, flyers, prices and order forms for checks, invoices, statements, envelopes, stock paper and labels to fit almost every computer system.

- Available in quantities of 500, 1,000, 2,000, 4,000, 6,000
- Low Prices (500 checks only \$32.50)



- **FAST SERVICE** — It is our policy to ship within 6 working days following our receipt of your order.
- **MONEY BACK GUARANTEE** — If for any reason you are not completely satisfied, your money will be promptly refunded.

Fast Service by mail or . . .PHONE TOLL FREE

**1 + 800-225-9550**

Mass. residents 1 + 800-922-8560

8:30 a.m. to 5:00 p.m. Eastern Time Monday — Friday

Please Ship FREE Kit To: CODE 460

Name \_\_\_\_\_

Company \_\_\_\_\_

Street \_\_\_\_\_

City, State and Zip \_\_\_\_\_

Phone \_\_\_\_\_

Computer make & model \_\_\_\_\_

**Neb's  
Computer Forms**

78 Hollis Street, Groton, Mass. 01450  
A division of New England Business Service, Inc.

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

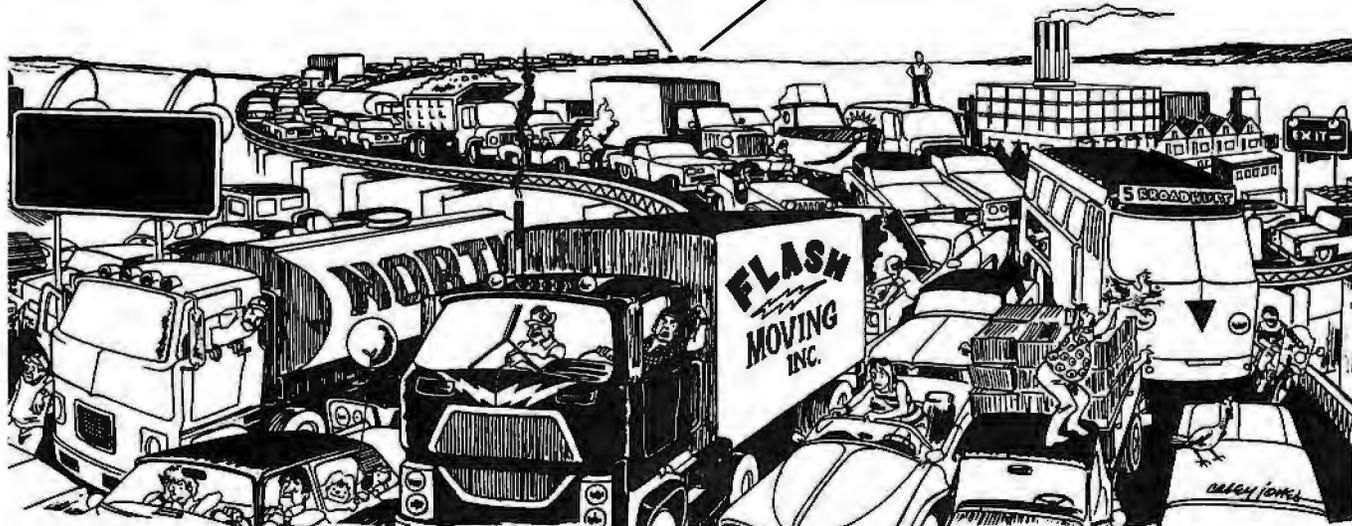
```

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.

"Good" doesn't mean "perfect." Even good drivers may occasionally have an accident. That doesn't necessarily bar you from GEICO... or from being renewed once you're a GEICO policyholder.

If you call, you'll talk directly to a GEICO sales insurance counselor, not a salesman. So there's no pressure. And no extra sales expense to inflate the cost.

GEICO has been saving money for good drivers since 1936. Today, nearly 1,500,000 people are satisfied GEICO policyholders. And that makes GEICO the 5th largest of the more than 1,000 stock companies insuring autos in the U.S.

GEICO has fast and efficient claim service with toll-free and collect-call telephone numbers throughout the U.S. So if you have to report an accident or loss, you can call our claim adjusters immediately. We also have

over 3,500 claim representatives countrywide to assist in handling your claim if necessary.

**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.

**GEICO**  
Where good drivers get the low rates they deserve.

Call toll-free **800-841-3000** (8 a.m.-9 a.m. East Coast Time)  
In Georgia call toll-free 800-342-2800 or mail coupon. No obligation. No salesman will call.

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 \_\_\_\_\_

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)?			

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															

\*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

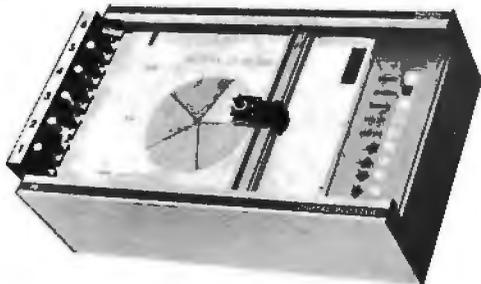
GEICO and Affiliates, Corporate Headquarters: Washington, D.C. 20076

Not available in New Jersey or Massachusetts.

# houston instrument

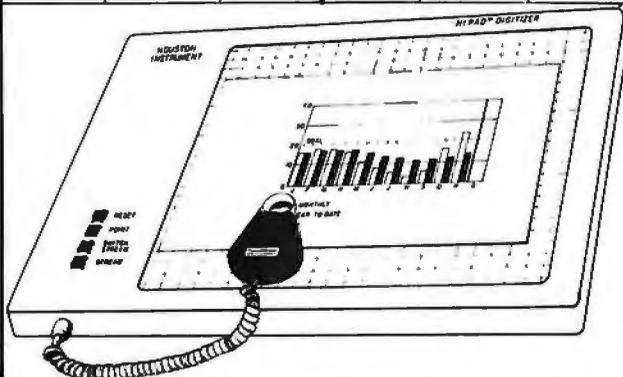
## FROM COMPUTERS TO GO

A six pen plotter option is now available for shipment with the Houston Instrument DMP series of plotters. Now you can produce graphs or charts in black, red, blue, green, violet, orange and optional brown. With the addition of the \$395 six pen option, the DMP-2 through the DMP-7 series of plotters, becomes the only line of multi-color plotters starting under \$1,500.



Digital plotters for the Apple, Atari, PET, PMC-80, TRS-80 or other systems with RS-232C or Centronics data source.

8 1/2" x 11"	STANDARD	6 COLOR	11" x 17"	STANDARD	6 COLOR
DMP-2	\$1085.00	\$1480.00	DMP-5	\$1685.00	\$2080.00
DMP-3	\$1250.00	\$1645.00	DMP-6	\$1850.00	\$2245.00
DMP-4	\$1385.00	\$1780.00	DMP-7	\$1985.00	\$2380.00



The Houston Instrument HI PAD Digitizers for the Apple, Atari, PET, PMC-80, TRS-80 or other systems with RS-232C or Centronics data source. The HI PAD Digitizer is an input device that converts graphic information into digital values. The HI PAD comes completely assembled and ready to use, with an RS-232C and parallel interface integrated for convenient interfacing to your minicomputer or microcomputer based system. It is priced at only \$795.00.

## SOFTWARE TO GO

presents

THE EVANS BUSINESS SYSTEM; a user-definable data-management system emphasizing rapid access to individual records for the APPLE II. Requires 48K, 1 disk drive, ROM or RAM Applesoft. (written by Al Evans)

### USE THE BUSINESS SYSTEM FOR:

Rolodex Emulation	Catalogs	Fantasy Game Characters
Financial Records	Lab Test Results	Any Application Requiring
Real Estate Locator	Bibliographies	Fast, Cross-referenced
Grade Books	Names and Addresses	Random Access to Formatted
		Information

RETRIEVAL TIME: Average less than 5 seconds for any of 1000 records. NUMBER OF FIELDS: defined by user. RECORD LENGTH: Defined by user. FILE SIZE: Determined by record length and disk capacity. Keyfield(s): Specified by user.

### INTRODUCTORY OFFER

You can get the EVANS BUSINESS SYSTEM software package for \$99.95, or \$15.00 for a demo copy (creditable towards the package purchase.)

## COMPUTERS TO GO

(a division of C.T.G Corp.)

2000 Guadalupe Austin, TX 78705

(512) 472 8926 9A.M.-10 P.M., M.-Sat.

DEALER INQUIRIES INVITED

### 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

# COMPUTERS—TERMINALS—MODEMS!

## MODEMS AND COUPLERS

Connect your Apple, TRS-80 or any other computer or terminal to the phone lines!

Penril



**Penril  
300/1200**

Penril 300/1200—Bell 212A style ..... \$799  
Bell 212A style. 1200 baud and 300 baud. Manual originate, auto-answer. Full duplex. RS232. Direct connect to phone lines via RJ11C standard extension phone voice jack. 1 year warranty.



**U.S. Robotics  
USR-330A  
Bell 103/113 style  
USR-330D  
Bell 103/113 style**

USR-330D ..... \$339

Bell 103/113 style. 330 baud. Manual originate, auto-answer. Half/full duplex. RS232. 1 year warranty. Direct connect to phone lines via RJ11C standard extension phone voice jack.

USR-330A ..... \$399  
Same as USR-330D but includes auto-dial capability.



**U.S. Robotics  
The  
Phone Link  
Acoustic  
Modem**

Bell 103/113 style ..... \$179  
300 baud. Sleek, low profile. Originate and answer capability. Half/full duplex. Self-test. RS232. Light displays for On, Carrier, Test, Send Data, Receive Data. 15 oz.

Digital Equipment Corporation



**DEC VT100**

DEC VT100 ... \$1668

Detachable keyboard. Separate numeric keypad with function keys. Business forms character set. Reverse video. Selectable double-size characters. Bidirectional smooth-scrolling. 80 cols or 132 cols. Split screen. Settable tabs. Line drawing graphic characters. Status line. Key-Click.

**CRT's**

Perkin-Elmer  
Corporation



**Superowl 1251**

Perkin-Elmer Superowl 1251 ..... \$1564  
Intelligent, editing CRT. Detachable keyboard. 32 fully programmable function keys. Intelligent printer part. Business forms character set. Block mode. Protected fields. Blinking fields. Numeric fields. Reverse video. Half intensity. Polling. Down line loading of options. Remote control of all options by host computer. Settable tabs. Status line. Separate numeric keypad. Transparent mode.

Perkin-Elmer Corporation



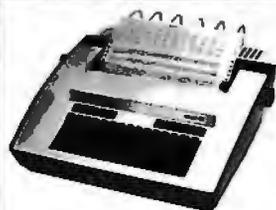
**Bantam 550B .... \$694**  
Compact. Silent. Upper/lower case. 80th col. wrap-around. Bell. Integrated numeric pad. Printer port. Transparent mode. Editing features. Tabbing.

**Bantam 550E...\$755**  
Same as 550B plus separate numeric keypad and cursor direction keys.

**Bantam 550S ..... \$879**  
Same as 550E plus block mode. 8 function keys, and protected fields, reverse video fields, half intensity fields, blinking fields.

## HARDCOPY TERMINALS

## & PRINTERS



**Teletype  
Model 43**

Teletype  
Corporation

Teletype Model 43 KSR with RS232 and Connector Cable ..... \$999  
30 CPS. Dot matrix. 132cols. True descenders on lower case. Excellent print quality for dot matrix printer. Pin feed.



**DEC LA120**

Digital Equipment  
Corporation

DEC LA120 ... \$2388

180 CPS. Dot matrix. Upper/lower case. 1K buffer. Designed for 1200 baud communications. 30 character answerback message. Adjustable line spacing. Adjustable character sizes including double sized characters. Settable horizontal and vertical tabs. Top-of-form capability. RS232.



**DEC LA34DA ... \$939**

30 CPS. Dot matrix. Upper/lower case. 4 character sizes. Up to 217 cols per line. 6 lines per inch settings. Friction feed. Settable tabs. RS232.

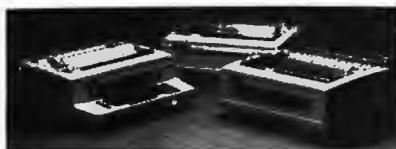
**DEC LA34AA ..... \$1095**  
30 CPS. Dot matrix. Upper/lower case. 8 character sizes including double size characters. 6 lines per inch settings. Up to 217 cols per line. Friction feed. Settable horizontal and vertical tabs. Top-of-form capability.

**Options for LA34AA and LA34DA**

Tractor Feed Mechanism ..... \$114  
Numeric Keypad w/ Function Keys .. \$69  
Pedestal ..... \$100  
Paper Out Sensor ..... \$25  
APL Capability with APL Keycaps .. \$499  
2K Buffer with Text Editor and 1200 Baud Communications Capability ..... \$499

NEC Corporation

**NEC Spinwriter 5510 & 5520**



5520 KSR Spinwriter ..... \$3088  
55 CPS. Impact printer. Selectric print quality. Changeable print fonts. 110, 300 and 1200 baud data rate. Numeric keypad. Friction and tractor feed.

5510 Spinwriter ..... \$2754  
55 CPS. Impact printer. Selectric print quality. Changeable print fonts. 110, 300 and 1200 baud data rate. Friction and tractor feed.



Perkin-Elmer  
Corporation

**Pussycat 650/655  
CRT Screen Printer**

650/655 Pussycat CRT Screen Printer. \$899  
100 CPS. Extremely compact and quiet. 110 to 9600 baud rate. 2K buffer. Ideal for producing rapid, reliable hardcopy of your CRT screen display. Can be added to any CRT with our interface option.

Leasing rates and lease/purchase plan information is available on request.

All equipment is shipped with a 10 day money back guarantee.

We offer full service, on site maintenance plans on all equipment.

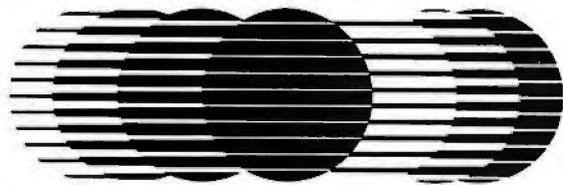
All equipment in stock.



**U.S. ROBOTICS INC.**  
203 N. WABASH SUITE 1716 CHICAGO, ILL 60601

SALES  
GENERAL OFFICES  
SERVICE

(312) 346-5650  
(312) 346-5651  
(312) 733-0497



# HOBBYWORLD ELECTRONICS, INC.

19511 Business Center Drive, Dept B-5  
Northridge, California, 91324

## MAY SPECIALS

**16K Memory \$29.00**  
**Add-On** (Includes Shipping)

for TRS-80®, Apple® and Exidy®  
*Everything you need to upgrade your system.*

Cat No.	Description
1156	For the TRS-80 Keyboard Unit
1156A	For TRS-80 Exp. Interface (prior to 4/1/79)
1156B	For the TRS-80 Exp. Interface (after 4/1/79)
1156C	Apple II
1156D	Exidy Sorcerer

## Verbatim Diskettes



**\$26.00/Box**

(Includes Shipping)

- Datalife Formula
- Single Sided, Double Density
- 10 Diskettes per Box

Cat No.	Description	Use for
1147	Soft Sector	TRS-80, Apple, ATARI
1148	10 Hole, Hard Sector	North Star
1149	16 Hole, Hard Sector	Micropolis

### HOW TO ORDER

Order by phone or by mail. Pay by check, Visa, MasterCard, or C.O.D. (C.O.D. add \$1.40 add'l.) Charge orders: Include Card No. and Expiration Date.

**Toll Free (outside Calif):**  
**(800) 423-5387**  
**Calif & Outside USA:**  
**(213) 886-9200**

*Watch for our new name, HW ELECTRONICS, appearing in our ads next month. We've changed our name because at HW, computers are more than just a hobby.*

### 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

# ALL THESE FEATURES... IN THIS SMALL SPACE... AT THIS LOW PRICE!

## 4,695

Greater computer power . . . fewer separate components . . . larger capability . . . simpler to operate . . . modular maintenance . . .

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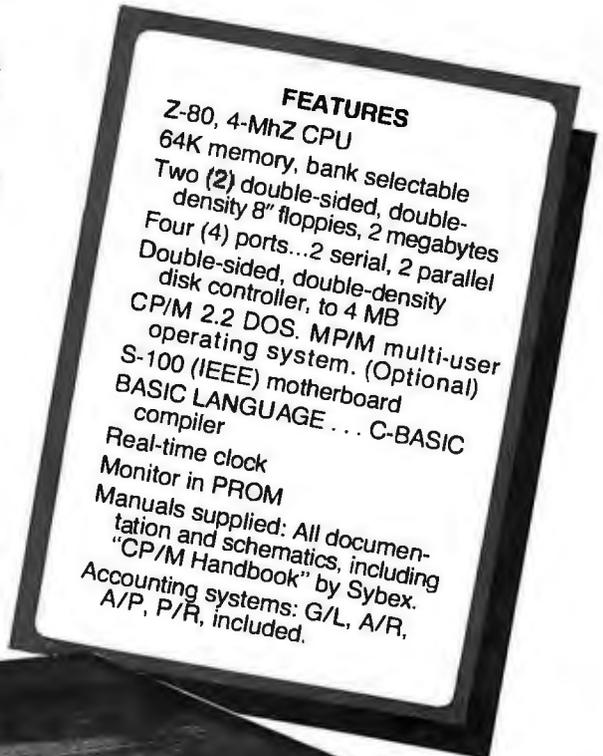
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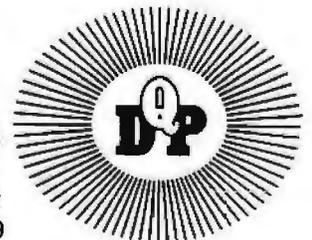
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Listing 3 continued:

```
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
```

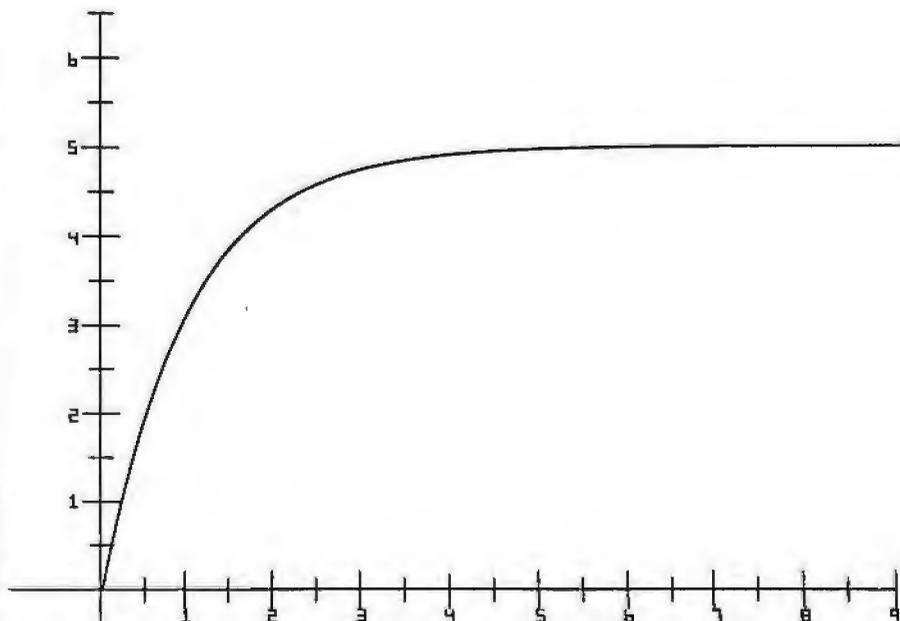


Figure 3: Sample plot of results obtainable with the information included in this article.

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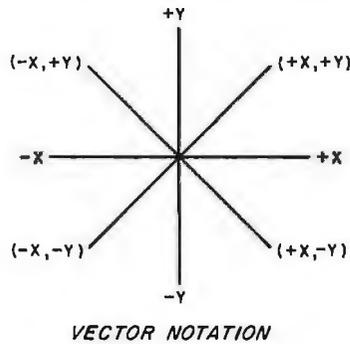
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-X	v	8065
-X,+Y	w	806C
PEN UP	y	8073
PEN DOWN	z	807A

Table 1: Chart of plotter pen-movement commands and the vector notation associated with each command.

Text continued from page 298:

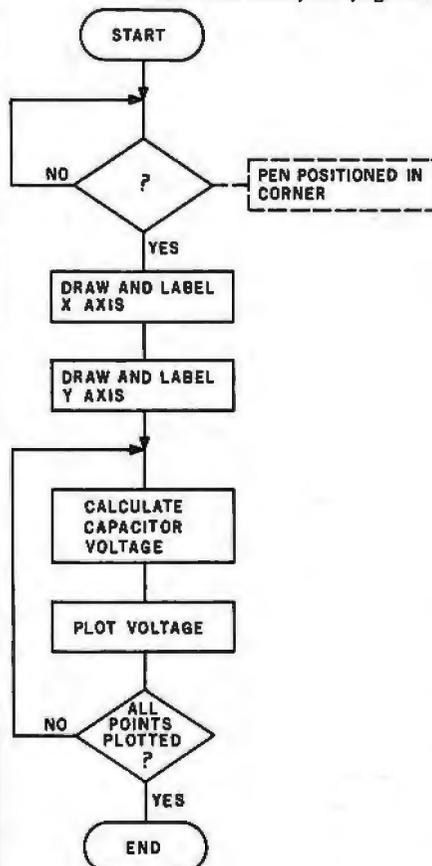


Figure 4: Flowchart for the BASIC program used to produce figure 3.

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. ■

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# Recursion and Side Effects in Pascal

---

Robert Morris and James Perchik  
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  $n! = 1 \times 2 \times \dots \times n$ . Factorial is defined recursively as follows:

$$\begin{aligned} n! &= n(n-1)! \text{ if } n > 1 \\ n! &= 1 \quad \quad \quad \text{if } n = 1 \end{aligned}$$

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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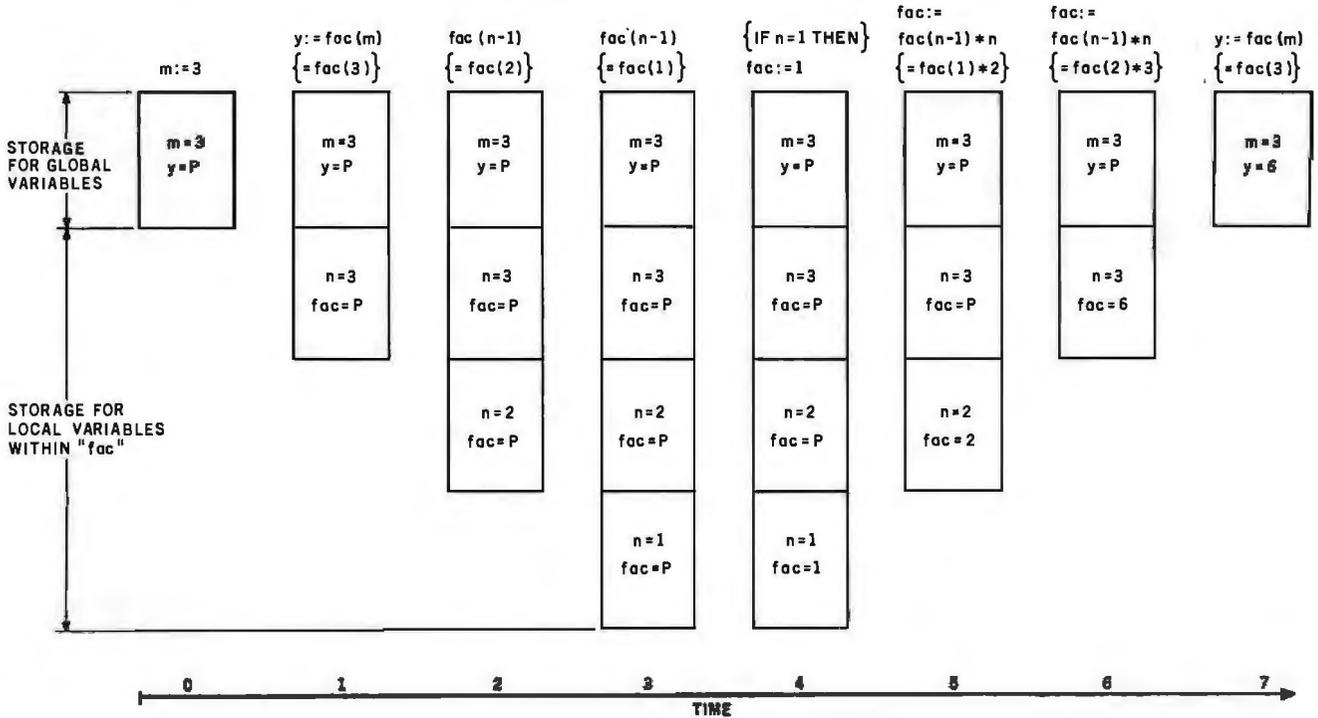


Figure 1: Execution of the Pascal statements "m := 3; y := fac(m)". The columns of boxes represent the stack at time t=0, 1, 2,...7. The statements above each column indicate the part of the function that is executed to give the stack illustrated below, and the comments in braces are used to clarify the statements being executed. The letter P indicates a pending calculation.

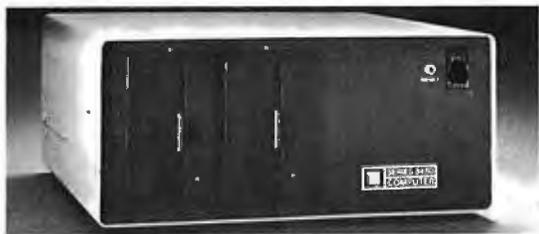
addresses have not been shown in figure 1. Had the variables "m" or "y" occurred inside "fac" without a new declaration, these variables would be said to be *global* to the function, and then "fac" could access or change their values. When global variables are changed within a function, the function 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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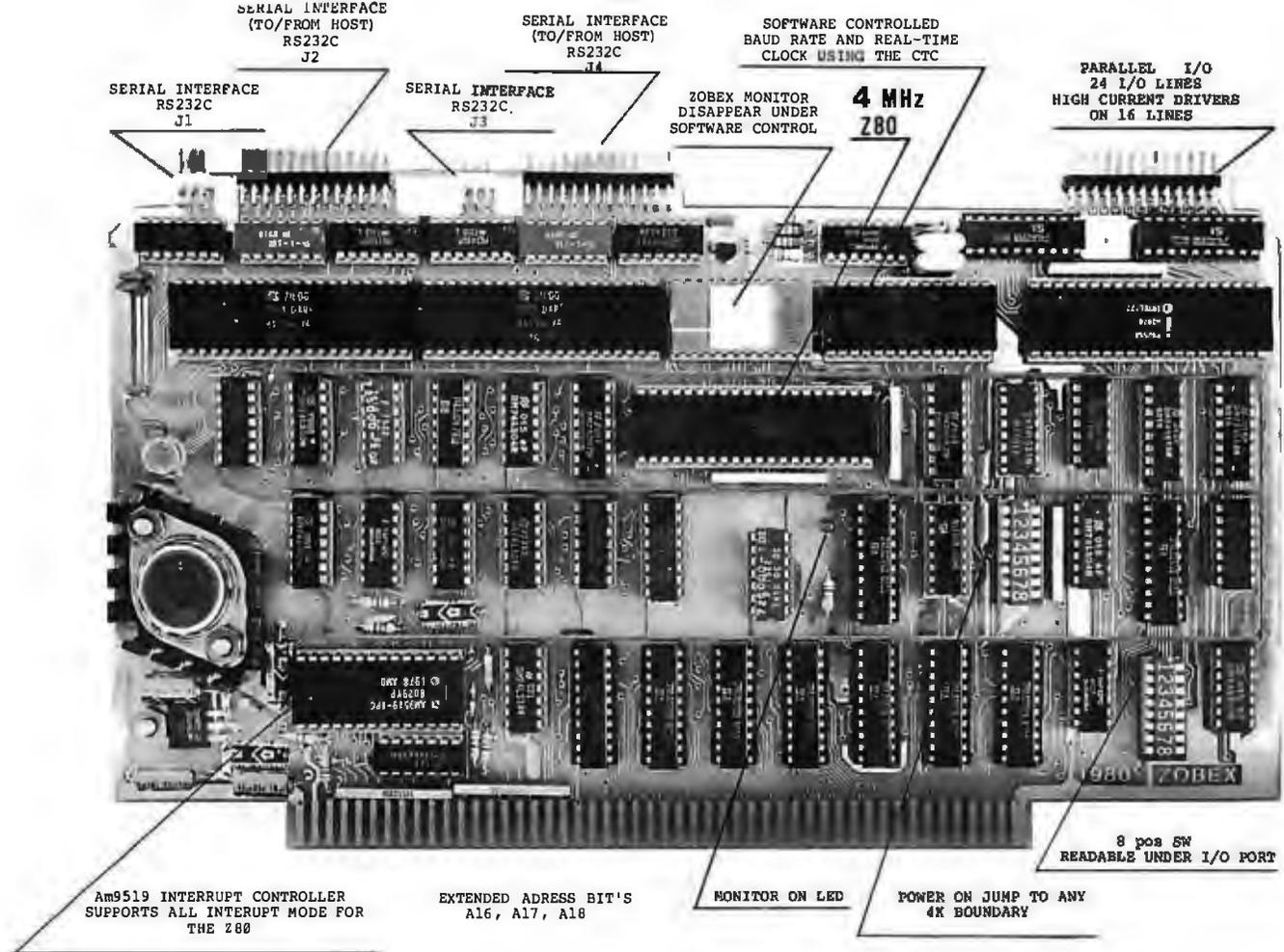
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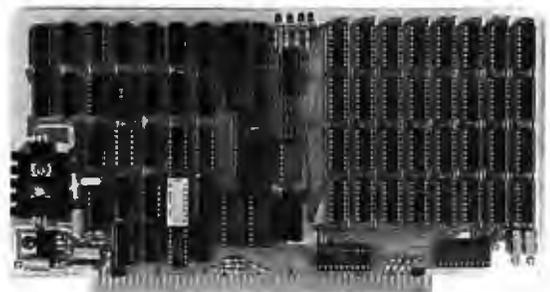
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at the bottom of column 3. Since  $n=1$ , this can be evaluated without further recursion: the answer is 1, and is stored in the variable "fac" in column 4. Now the previous invocation of "fac" (with  $n=2$ ) can complete its work. Its answer is  $2 \times \text{fac}(1) = 2 \times 1 = 2$ , 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  $\text{fac} = 3 \times \text{fac}(2) = 3 \times 2 = 6$ , 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 "complication."

### 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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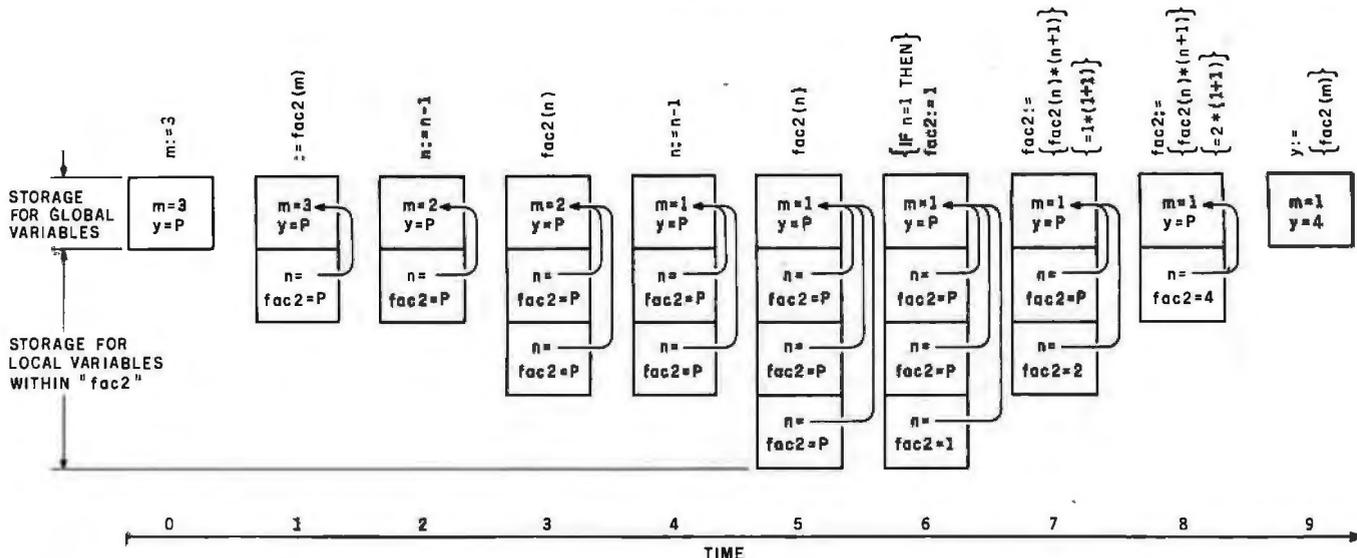


Figure 7: Execution of the Pascal statements `m := 3; y := fac2(m)`. In this case, the variable "n" within the function "fac2" (listed in the text) points to the global variable "m" and can change its value; the arrows from "n" to "m" indicate this relationship.

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 discomfoting difficulties in debugging

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**Programmers should strive to write code that is clear, correct, verifiable, and easily transported to other implementations.**

functions with side effects may occur if  $f \times g$  is not equal to  $g \times f$ , 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  $f \times g$  and  $g \times f$  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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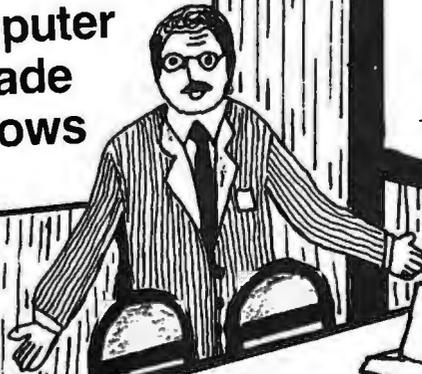
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### About the Author

*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

	0			1			2			3													
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	
1	0	0	0	0	3	7				P	S	H	B										
2	0	0	0	1	1	6				T	A	B											
3	0	0	0	2	4	4				L	S	R	A										
4	0	0	0	3	8	D	0	4		B	S	R		\$	0	4			\$	0	0	0	9
5	0	0	0	5	1	7				T	B	A											
6	0	0	0	6	8	4	0	F		A	N	D	A	#	\$	0	F						
7	0	0	0	8	3	3				P	U	L	B										
8	0	0	0	9	8	B	3	0		A	D	D	A	#	\$	3	0						
9	0	0	0	B	8	1	3	9		C	M	P	A	#	\$	3	9						
10	0	0	0	D	2	3	0	2		B	L	S		\$	0	2			\$	0	0	1	1
11	0	0	0	F	8	B	0	7		A	D	D	A	#	\$	0	7						
12	0	0	1	1	A	7	0	0		S	T	A	A	\$	0	,	X						
13	0	0	1	3	0	8				I	N	X											
14	0	0	1	4	3	9				R	T	S											
15	0	0	1	5	0	0				F	C	B		\$	0	0							
16																							

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)  
L D X  
 not used ↗

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.

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.

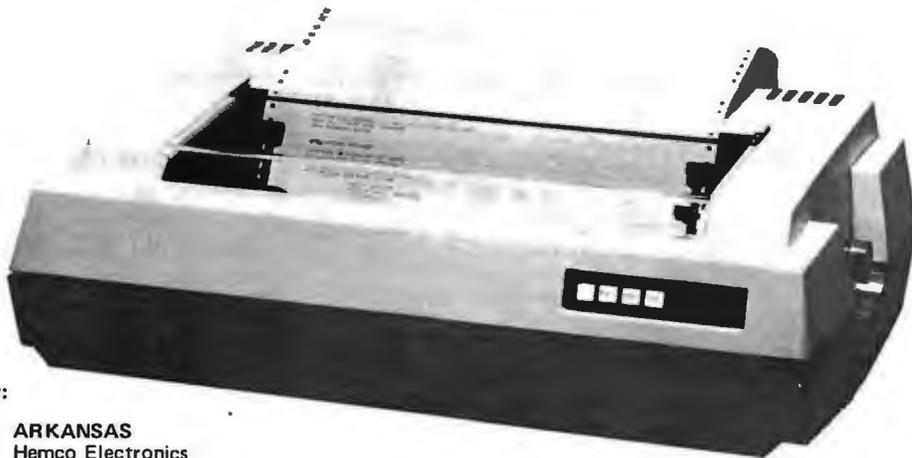
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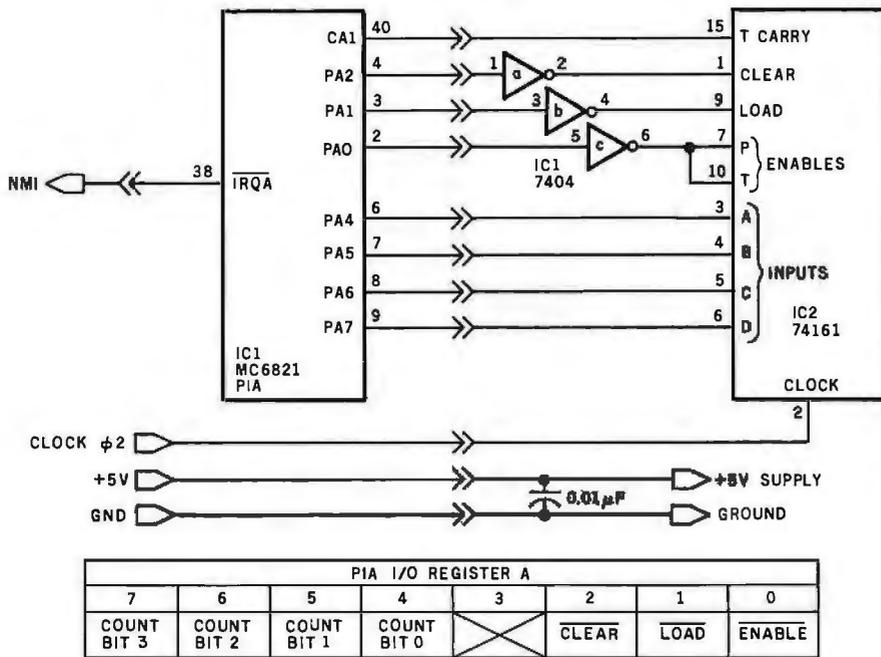


Figure 3: Schematic diagram of the hardware cycle counter. The DEMONS system uses the nonmaskable interrupt (NMI) in the 6800.

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 non-maskable 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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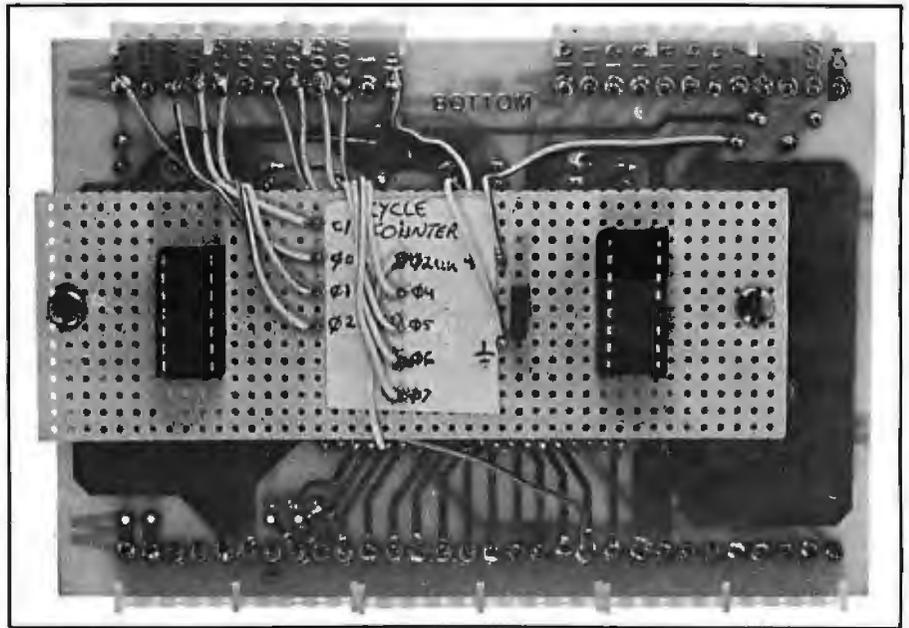


Photo 1: The cycle-counter circuit was constructed on a small piece of perforated board and mounted on the MP-L parallel interface board inside the SwTPC 6800.

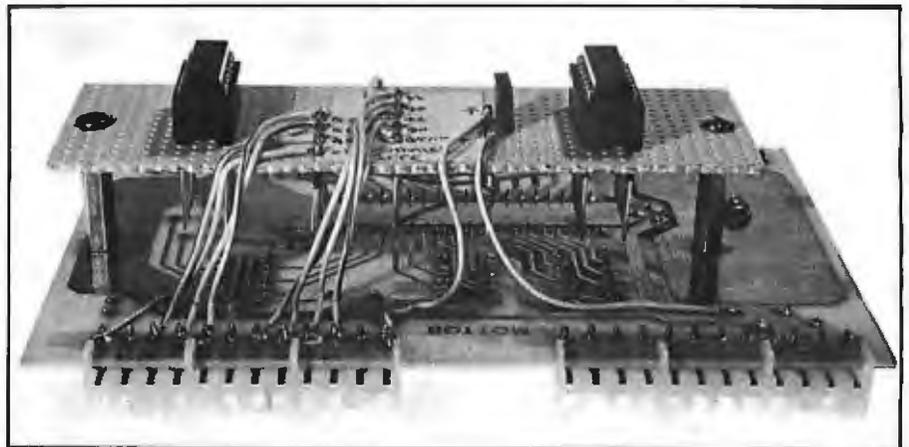


Photo 2: Shown here is the method of mounting the cycle-counter circuit board.

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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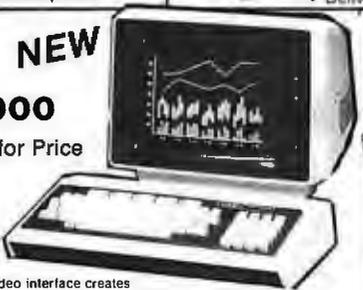
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Command	Description
S.	Step and execute from current address.
Snnnn	Set hexadecimal address <i>nnnn</i> as the new current address.
Tnnnn.	Set trace mode and break address <i>nnnn</i> . Break count set to 1.
Tnnnn,11	Set trace mode and break address <i>nnnn</i> . Set break count to 11.
Cnn	Set condition codes to hexadecimal value <i>nn</i> .
Bnn	Set B register to hexadecimal value <i>nn</i> .
Ann	Set A register to hexadecimal value <i>nn</i> .
Xnnnn	Set X register to hexadecimal value <i>nnnn</i> .
R	Display registers.
D.	Display 14 instructions in disassembled form starting at the current address.
Dnnnn	Display 14 instructions in disassembled form starting at hexadecimal address <i>nnnn</i> .
G	Exit from DEMONS and resume problem program execution at the current address.
Pnnnn,oo oo ...	Patch memory starting at address <i>nnnn</i> 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	DEMONS displays registers.
E1 00 00 3745	
1E00 BD 1E45 JSR \$1E45	DEMONS displays the next instruction.
: S.	Operator commands an instruction step.
CC B A X	DEMONS displays registers.
E1 00 00 3745	
1E45 37 PSWB	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	$\left\{ \begin{array}{l} \text{NMI and SWI} \\ \text{NMI and IRQ} \\ \text{IRQ and SWI} \end{array} \right.$	<i>treats as IRQ</i> handles NMI first handles SWI first
Later Masks	$\left\{ \begin{array}{l} \text{NMI and SWI} \\ \text{NMI and IRQ} \\ \text{IRQ and SWI} \end{array} \right.$	handles NMI first handles NMI first 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:

$$T_2 = (C \times L) \times D$$

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:

$$T_p = T_1 - T_2.$$

The disassembler is no longer I/O bound in speed of execution when  $T_p = T_2$  for the 128-line test. The system is I/O bound when  $T_p < T_2$ , and is compute bound when  $T_p > T_2$ .

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.

```

00100                                NAM    DEMON
00200                                *
00300                                * AUTHOR: A.I. HALSEMA
00400                                * DATE: 11/08/77
00500                                * OBJECT MACHINE: SWTPC 6800
00600                                * PROGRAM NAME: DEMON(S) VERSION 1.0
00700                                * DEBUG MONITOR (SYMBOLIC) INITIALIZATION
00800                                *
00900                                *
01000                                * THIS ROUTINE READIES THE PIA AND STARTS THE HARDWARE CYCLE
01100                                * COUNTER. IT WILL REQUEST THE STARTING ADDRESS OF THE CODE
01200                                * TO BE DEBUGGED WITH A 'P' PROMPT, IT ALSO REMOVES TRACE
01300                                * SETTINGS,
01400                                * UPT    0
01500                                *
01600                                *
01700                                *
01800                                *
01900                                *
02000                                *
02100                                *
02200                                *
02300                                *
02400                                *
02500                                *
02600                                *
03CC                                ORG    $03CC
                                *
                                X=REGISTER SAVE AREA
                                DEMON(S) STACK ADDRESS
                                NMI INTERRUPT VECTOR ADDRESS
                                OUTPUT CHARACTER ROUTINE
                                TRACE ACTIVE FLAG, 1= ACTIVE
                                ADDRESS STORAGE USED BY BALDR
                                CYCLE COUNTER PIA ADDRESS
                                APPENDAGE ADDRESS FOR DISASM
                                LINES FOR DISASM TO DISPLAY
                                APPENDAGE ADDRESS IN DISASM
                                OUTPUT 2 HEX DIGITS AND SPACE
                                *
                                XSAV    EQU    $A075
                                STAK    EQU    $A02F
                                NMIV    EQU    $A006
                                EID1    EQU    $E1D1
                                TFLAG    EQU    $A078
                                ADDR    EQU    $A00C
                                HCCPIA    EQU    $800C
                                APPND    EQU    $A07C
                                LINES    EQU    $A077
                                APP    EQU    $01A4
                                OUT2HS    EQU    $E0CA

```

Listing 1 continued on page 338

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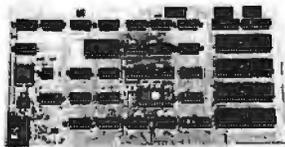
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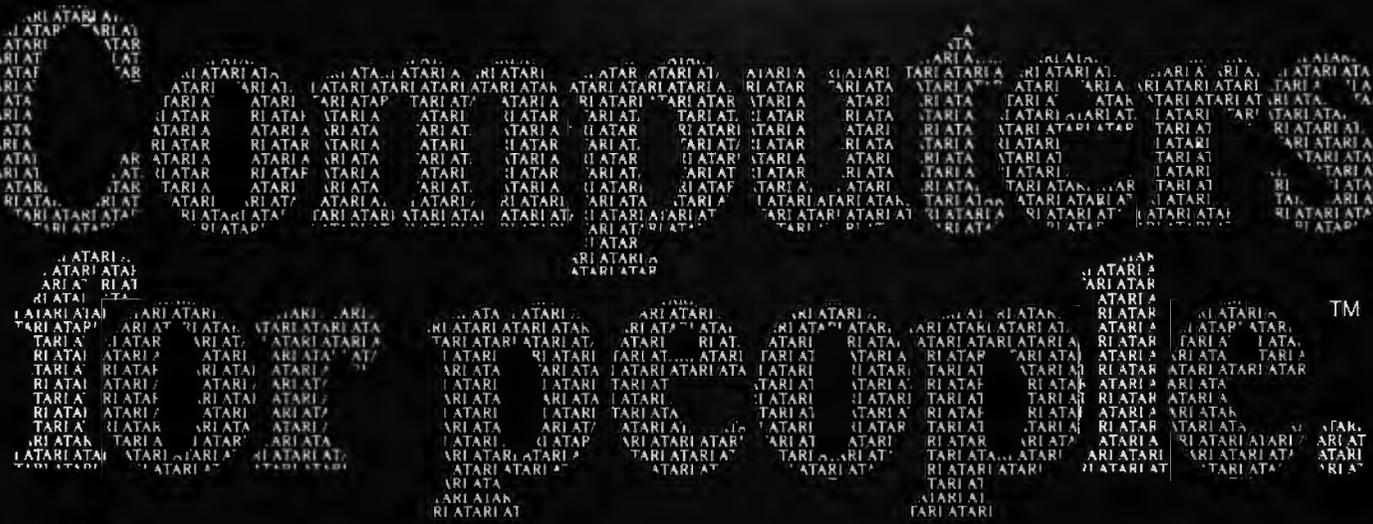
Listing 1 continued:

```

02700      E0C8      OUT4HS      EQU      $E0C8      OUTPUT 4 HEX DIGITS AND SPACE
02800      A079      TADDR       EQU      $A079      TRACE RECOGNITION ADDRESS
02900      E1AC      INEE       EQU      $E1AC      CHARACTER INPUT ROUTINE
03000      E07E      PDATA1    EQU      $E07E      PRINT BLOCK ROUTINE
03100      0018      NEXTL      EQU      $0018      DISASSEMBLER ENTRY POINT
03200
03300      *
03400      * DEMON(S) START-UP ENTRY POINT
03500      03CC      8E      A02F      START      LDS      #STAK      SET STACK ADDRESS
03600      03CF      7F      A078      CLR      TFLAG      RESET TRACE FLAG
03700      03D2      8D      047D      UG        JSR      CURL       ISSUE CR/LF
03800      03D5      86      50      LDAA     #1P        #1P
03900      03D7      8D      E1D1      JSR      QUTEEE     ISSUE PROMPT
04000      03DA      8D      0482      JSR      BADUP     GET START OF PROBLEM PROGRAM
04100      03DD      25      F3      BCS     UG        BAD INPUT= TRY AGAIN
04200      03DF      8D      0561      JSR      SETAD     SETAD
04300      03E2      CE      040A      LDX     #INTRP     SET UP NMI VECTOR
04400      03E5      FF      A006      STX     NMLV     NMLV
04500      03E8      CE      800C      LDX     #CCPIA    INITIALIZE PIA/CYCLE COUNTER
04600      03EB      6F      01      CLR     1,X      SELECT DDFA
04700      03ED      66      FF      LDAA     #SFF     AND SET UP ALL LINES TO OUTPUTS
04800      03EF      A7      00      STAA    X        X
04900      03F1      86      04      LDAA     #S04     SELECT IORA
05000      03F3      A7      01      STAA    1,X      1,X
05100      03F5      86      68      LDAA     #S65     TURN OFF COUNTER RESET
05200      03F7      A7      00      STAA    X        AND SET INITIAL COUNTER VALUE
05300      03F9      A6      00      LDAA     X        X
05400      03FB      84      F9      ANDA    #SF9     TURN OFF COUNTER LOAD
05500      03FD      A7      00      STAA    X        X
05600      03FF      86      07      LDAA     #S07     #S07
05700      0401      A7      01      STAA    1,X      ENABLE CA1 INTERRUPT ON LOW TO
05800      0403      A6      00      LDAA     X        HIGH TRANSITIONS
05900      0405      84      F8      ANDA    #SFR     START COUNTER
06000      0407      A7      00      STAA    X        X
06100      0409      38      HTJ     HTJ     GO TO PROBLEM PROGRAM
06200
06300      *
06400      * DEMON(S) INTERRUPT PROCESSOR AND OPERATOR COMMAND DECODING.
06500      * ENTERED ONLY UPON OCCURENCE OF NMI INTERRUPT.
06600      * LOCATION LABELLED 'USER' ALLOWS FOR PATCHING IN JUMPS
06700      * TO FURTHER INTERRUPT PROCESSING IF MORE THAN ONE SOURCE
06800      * OF NMI INTERRUPTS IS AVAILABLE.
06900      040A      CE      800C      INTRP    LDX     #CCPIA    GET PIA ADDRESS
07000      040D      6D      01      TST     1,X      AND CHECK FOR CYCLE COUNTER
07100      040F      28      03      BMI     MINE     .INTERRUPT
07200      0411      01      USER    NOP      PATCH A JUMP TO SOME OTHER NMI
07300      0412      01      NOP     NOP     .PROCESS HERE, BECAUSE THIS
07400      0413      01      NOP     NOP     .INTERRUPT IS NOT FROM CYCLES,
07500      0414      86      04      LDAA     #S04     DISABLE COUNTER INTERRUPTS
07600      0416      A7      01      STAA    1,X      1,X
07700      0418      86      3F      LDAA     #S3F     STOP COUNTER
07800      041A      A7      00      STAA    X        X
07900      041C      86      38      LDAA     #S35     RESET COUNTER= SFT LOAD VALUE
08000      041E      A7      00      STAA    X        . TO 3
08100      0420      A6      00      LDAA     X        DUMMY READ TO INSURE NMI OFF
08200      0422      30      TSX     TSX     TSX
08300      0423      EE      05      LDX     5,X      GET ADDRESS OF NEXT INSTRUCTION
08400      0425      FF      A00C      STX     ADDR     SET ADDRESS FOR DISASSEMBLER
08500      0428      7D      A078      TST     TFLAG    TRACE MODE RUNNING?
08600      042B      27      0A      BEQ     NOT     IF NOT= BRANCH
08700      042D      8C      A079      CPX     TADDR    TRACE FLAG SFT= TEST ADDRESS
08800      0430      26      52      BNE     NONE     BRANCH IF WRONG ADDRESS
08900      0432      7A      A078      DEC     TFLAG    ADDRESSES ARE EQUAL= COUNT HIT
09000      0435      26      4D      BNE     NONE     IF NOT ZERO= GO TRACE SOME MORE
09100      0437      86      01      LDAA     #S01     SET NUMBER OF LINES FOR DISASM
09200      0439      A7      A077      STAA    LINES   LINES
09300      043C      8D      28      BSR     REGS     DO A CR LF AND DISPLAY REGISTERS
09400      043E      8D      056E      JSR     SHOLIN  DISPLAY INSTRUCTION
09500      0441      86      3A      LDAA     #1I     GET COMMAND= ISSUE PROMPT
09600      0443      8D      E1D1      JSR     QUTEEE  #1I
09700      0446      8D      E1AC      JSR     INEE    GET INPUT
09800      0449      CE      0578      LDX     #COMTAB  GET COMMAND TABLE ADDRESS
09900      044C      E6      00      LDAB    X        GET RECOGNITION CHARACTER
10000      044E      11      CBA     CBA     SAME AS INPUT?
10100      044F      26      04      BNE     MORE    IF NOT= GO LOOK AGAIN
10200      0451      EE      01      LDX     1,X      EQUA= GET CURRENT ADDRESS
10300      0453      6E      00      JMP     X        GO DO IT TO IT
10400
10500      0455      50      NONE    TSTR    TSTR    FOUND END OF TABLE?
10600      0456      27      05      BEQ     BAD     YES= TELL OPERATOR
10700      0458      08      INX     INX     NO= POINT TO NEXT ENTRY IN TABLE
10800      0459      08      INX     INX     INX
10900      045A      08      INX     INX     INX
11000      045B      20      EF      BRA     TEST    AND GO TEST IT
11100      * INPUT IS
11200      045D      86      3F      BAD     1,0AA #1I TELL OPERATOR AND GIVE HIM ANOTHER CHANCE TO DO IT RIGHT
11300      045F      8D      E1D1      JSR     QUTEEE DISPLAY QUESTION MARK
11400      0462      8D      19      NEXT1  BSR     CURL   DO CARRIAGE RETURN/LINE FEED
11500      0464      20      DB     BRA     CONGN  AND GO TRY AGAIN

```

Listing 1 continued on page 340



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Listing 1 continued:

```

11600
11700
11800
11900
12000 0466 8D 15 REGS      RSP      CUHL      DO CR/LF
12100 0468 CE 059A        LDX      #CCL      DISPLAY 'CC B A X' CRLF
12200 046B 8D E07E        JSR      PDATA1
12300 046E 30              TSX
12400 046F 08              LNX      GET STACK ADDRESS
12500 0470 08              LNX      CORRECT FOR REGS RETURN ADDRESS
12600 0471 8D E0CA        JSR      OUT2HS   DISPLAY CC
12700 0474 8D E0CA        JSR      OUT2HS   DISPLAY B
12800 0477 8D E0CA        JSR      OUT2HS   DISPLAY A
12900 047A 8D E0C8        JSR      OUT4HS   DISPLAY X
13000 047D CE 05A4 CURL    LDX      #CRLF    DO CARRIAGE RETURN/LINE FEED
13100 0480 8D E07E        JSR      PDATA1
13200 0483 39              RTS      EXIT
13300
13400 0484 CE 800C NOPE    LDX      #HCCPIA  GET PIA ADDRESS
13500 0487 7E 03F9        JMP      SETUP    GO START COUNTER AND EXECUTE
13600
13700
13800
13900 048A 8D E1AC        INHEX    JSR      INEE     GO GET CHARACTER
14000 048D 80 30          SUBA     #830     HEX?
14100 048F 2B 10          BMI     BADHEX   NO= JUMP
14200 0491 81 09          CMPA    #809     BETWEEN 0 AND 809?
14300 0493 2F 0A          BLE     OKHEX   YES= OK
14400 0495 81 11          CMPA    #811     A OR GREATER?
14500 0497 2B 08          BMI     BADHEX   NO= ERROR
14600 0499 81 16          CMPA    #816     F OR LESS?
14700 049B 2E 04          BGT     BADHEX   NO= ERROR
14800 049D 80 07          SUBA    #807     ADJUST FOR A THROUGH F VALUES
14900 049F 0C          OKHEX    CLC      CLEAR ERROR FLAG
15000 04A0 39              RTS      EXIT
15100 04A1 0D          BADHEX   SEC
15200 04A2 39              RTS
15300
15400
15500
15600 04A3 8D E5        BYTE     BSR      INHEX   GET A DIGIT
15700 04A5 25 0A        BCS     BADB     BAD= NOT HEX= JUMP
15800 04A7 48          ASLA    MOST SIGNIFICANT DIGIT, SO LEFT
15900 04A8 48          ASLA    , JUSTIFY IT
16000 04A9 48          ASLA
16100 04AA 48          ASLA
16200 04AB 16          TAB
16300 04AC 8D DC        BSR     INHEX   , AND SAVE IN B-REGISTER
16400 04AE 25 01        BCS     BADB     GET LEAST SIGNIFICANT DIGIT
16500 04B0 18          ARA    IF INPUT IS BAD= JUMP
16600 04B1 39          BADB    RTS      COMBINE BOTH IN A
16700
16800
16900
17000 04B2 8D EF        BADDR   BSR      BYTE     GET HEX BYTE
17100 04B4 25 00        BCS     ADHAD   JUMP IF BAD
17200 04B6 87 A00C      STAA   ADDR    SAVE BYTE
17300 04B9 8D E8        BSR    BYTE    GET SECOND BYTE
17400 04BB 25 06        BCS     ADHAD   JUMP IF BAD
17500 04BD 87 A00D      STAA   ADDR+1  SAVE IT
17600 04C0 FF A00C      LDX    ADDR    GET IN X
17700 04C3 39          ADBAD   RTS      EXIT
17800
17900
18000
18100
18200
18300
18400
18500
18600
18700
18800
18900 04C4 8D EC        TRACE   BSR      BADDR   GO GET TRACE ADDRESS
19000 04C6 25 95        BCS     RAD     RAD INPUT
19100 04C8 FF A079      STX    TADDR
19200 04CB 8D E1AC      JSR    INKEE   GET PERIOD OR COMMA
19300 04CE 81 2E        CMPA   #1      PERIOD?
19400 04D0 27 0F        BEQ    SETONE  YES= SET TFLAG TO ONE
19500 04D2 81 2C        CMPA   #1      COMMA?
19600 04D4 26 87        BNE    RAD     NO= RAD INPUT
19700 04D6 8D CB        BSR    BYTE    IT IS COMMA= GET LOOP COUNT
19800 04D8 25 83        BCS     RAD
19900 04DA 27 F1        BEQ    RAD
20000 04DC 87 A078      STAA   TFLAG   SET IN TRACE FLAG
20100 04DF 20 81        NEXT2  BRA     NEXT1  GO GET A COMMAND
20200 04E1 86 01        SETONE LDAA   #S01
20300 04E3 20 F7        BRA    SETT

```

Listing 1 continued on page 342

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Listing 1 continued:

```

20400      * STEP COMMAND PROCESSING, CAUSES TRANSFER OF CONTROL TO ADDRESS,
20500      *          COMMAND FORMAT: SXXXX OR S,
20600      *          WHERE XXXX IS A FOUR DIGIT HEX ADDRESS,
20700      *          SXXXX FORM SETS NEW CURRENT ADDRESS
20800      *          S, FORM STARTS RUN AT CURRENT ADDRESS,
20900      *
21000 04E5 8D C8 STEP      BSR      BADDR      GO GET ADDRESS
21100      04E7 25 98      BCS      NOPE      IF NOT HEX= ASSUME PERIOD
21200      04E9 8D 76      BSR      SETAD     ELSE PUT ADDRESS IN STACK
21300      04EB 7E J437    JMP      NOT      DISPLAY AND GET NEXT COMMAND
21400      04EE 01          NOP
21500      04EF 01          NOP
21600      04F0 01          NOP
21700      04F1 01          NOP
21800      * GO COMMAND PROCESSING, CAUSES EXIT FROM DEMON(S) WITH CYCLE COUNTER
21900      *          HALTED, USE WHEN FINISHED WITH DEBUGGING,
22000      *          CONTROL IS PASSED TO THE CURRENT ADDRESS REACHED
22100      *          WHILE STEPPING OR TRACING,
22200      *          EXIT FROM DEMON(S)
22300 04F2 3H GN          RTI          * DISPLAY COMMAND PROCESSING, DISPLAYS 15 INSTRUCTIONS FROM MEMORY IN
22400      *          DISASSEMBLED FORM,
22500      *          COMMAND FORMS: DXXXX OR D,
22600      *          WHERE XXXX IS A 4 DIGIT HEX ADDRESS
22700      *          D, CAUSES DISPLAY TO START WITH THE CURRENT
22800      *          INSTRUCTION
22900      04F3 7E 045D DAB      JMP      BAD      SET UP LINES FOR DISASM
23000      04F6 86 0E DISPLA   LDAA     #SUE
23100      04F8 87 A077      STAA    LINES
23200      04FB 8D 85        BSR     BADDR     GET ADDRESS
23300      04FD 24 06        RCC     SHOW      IF NO ERROR ON ENTRY= BRANCH
23400      04FF 30          TSX     GET ADDRESS FROM STACK
23500      0500 FE 05        LDX     5,X
23600      0502 FF ADDC      STX     ADDR     ,AND SET FOR DISASSEMBLER
23700      0505 86 10 SHDW    LDAA     #S10    HOME IP
23800      0507 8D E101     JSR     OUTREE
23900      050A 8D 62      BSR     SHOLIN   GO DISPLAY INSTRUCTION
24000      050C 20 D1      BRA     NEXT2    GET ANOTHER COMMAND
24100      * REGISTER DISPLAY, THE REGISTERS IN THE STACK ARE DISPLAYED,
24200      *          COMMAND FORM: R
24300      *
24400      050E 8D 0466 SHOREG   JSR     REGS     DISPLAY REGISTERS
24500      0511 7E 0441 HACKUP   JMP     COMMON   GO GET ANOTHER COMMAND
24600      *
24700      * SUPPORT SUBROUTINE= GET INPUT AND PREPARE X REGISTER
24800      *
24900      0514 8D 8D      RYN     BSR     BYTE   GET INPUT BYTE
25000      0516 25 04      BCS     GAG     BAD VALUE?
25100      0518 30          TSX     SET VALUE IN STACK
25200      0519 08          INX     ADJUST ADDRESS FOR BEING IN A SUBROUTINE
25300      051A 08          INX
25400      051B 39          RTS     GAG
25500      051C 31          INS
25600      051D 31          INS
25700      051E 20 D3      BRA     DAB
25800      *
25900      * SET CONDITION CODE REGISTER, COMMAND FORM: CXX
26000      *          WHERE XX IS A 2-DIGIT HEX VALUE THAT
26100      *          THE CC REGISTER IN THE STACK WILL BE SET
26200      *          TO,
26300      *
26400      0520 8D F2      RSETC   BSR     BYN     GET INPUT BYTE
26500      0522 A7 00      SETREG  STAA    X
26600      0524 20 B9      BRA     NEXT2    GO GET ANOTHER COMMAND
26700      *
26800      * SET B-REGISTER, COMMAND FORM: BXX
26900      *
27000      0526 8D EC      RSETB   BSR     BYN     GET INPUT BYTE
27100      0528 08          BSETS   INX
27200      0529 20 F7      BRA     SETREG
27300      *
27400      * SET A-REGISTER, COMMAND FORM: AXX
27500      *
27600      052B 8D E7      RSETA   BSR     BYN
27700      052D 08          INX
27800      052E 20 FB      BRA     BSETS
27900      * SET X-REGISTER, COMMAND FORMAT: XNNNN
28000      *          WHERE NNNN IS A 4-DIGIT HEX VALUE
28100      *
28200      0530 8D 04B2 RSETX   JSR     BADDR     GET 4 DIGITS
28300      0533 25 BE      BCS     DAB      BAD INPUT?
28400      0535 30          TSX     NO= GET STACK ADDRESS
28500      0536 09          DEX     SET X VALUE IN STACK
28600      0537 09          DEX
28700      0538 09          DEX
28800      0539 8D 28      BSR     SETS

```

Listing 1 continued on page 344

DEALERS: By now you know that it takes . . . . .

# SOFTWARE TO SELL COMPUTERS

and International Micro Systems can provide you with the largest selection of quality business applications ever developed for the microcomputer industry.

If you are just looking for a G.L., A/P, and Payroll, you can find them in a dozen ads in this magazine. But there's a much bigger market for micros out there than that. Where can you find a fully interfaced Wholesale/Retail Distribution System? How about Manufacturing Inventory Control including Production Scheduling & Control. See that one anywhere else? Maybe your market is Medical/Dental and IMS has the full systems there too. You can't sell computers without software and IMS has the finest selection of software available for you. Each system has been developed by the IMS professional staff and we support what we sell.

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we put all the software shown below in your office or store ready to demo to your prospects and we include the promotional material and our unique video sales presentation to help you move systems. Give us a call or drop us a card and let us show you what selling business systems should be all about.

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- Job Costing
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- Insurance Forms

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- Inventory Control
- Invoicing & Receivables
- Salesman Comm. Reporting
- Backorder Management

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- Finished Goods Inventory Mgmt.
- Parts Inventory Mgmt.
- Parts Purchasing & Receiving
- Bill of Material
- Production Scheduling



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Phone: (913) 888-8330

Listing 1 continued:

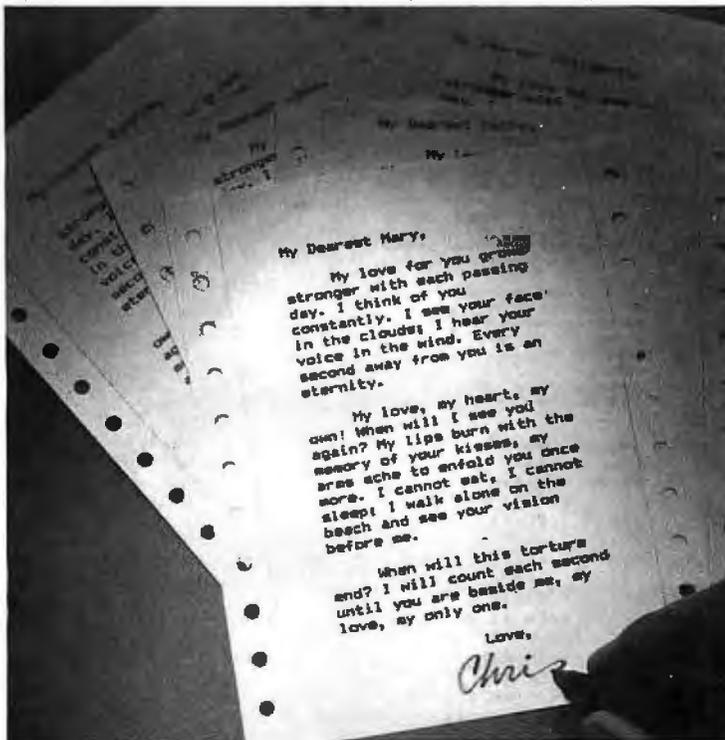
```

28900 053B 20 A2 NEXT3 BRA NEXT2
29000 * PATCH COMMAND PROCESSOR, COMMAND FORMAT: PXXXX,NN NN NN ... (CR)
29100 * WHERE XXXX IS A 4-DIGIT HEX ADDRESS
29200 * AND NN IS A 2-DIGIT HEX VALUE
29300 *
29400 * ENTER AS MANY 2 DIGIT VALUES AS NEEDED, THEN TERMINATE STRING
29500 * WITH A CARRIAGE RETURN, EACH NN VALUE IS PLACED IN MEMORY AS
29600 * IT IS ENTERED, UNLESS AN ERROR IS MADE, THEN THE NN VALUE
29700 * CONTAINING THE ERROR IS REJECTED AND IS NOT STORED.
29800 *
29800 053D 8D 04B2 PATCH JSR BADDR GET ADDRESS
29900 0540 25 R1 RCS DAB JUMP IF NOT HEX
30000 0542 FF A075 GETMDR STX XSAV SAVE X FOR LATER
30100 0545 8D 04A3 GETS JSR BYTE GET 2 DIGIT VALUE
30200 0548 25 0D RCS WHAT JUMP IF NOT HEX
30300 054A FF A075 LDX XSAV RESTORE X
30400 054D A7 00 STAA X AND STORE THE VALUE
30500 054F 08 INX PRINT TO NEXT LOCATION
30600 0550 86 20 LDAA #1 SPACE BETWEEN INPUTS
30700 0552 8D E1D1 JSR OUTDEF
30800 0555 20 ER HRA GETMDR GO GET MORE INPUT
30900 0557 88 D1 WHAT EORA #8DD INPUT NOT HEX= CARRIAGE CODE?
31000 0559 27 E0 BEW NEXT3 JUMP IF YES
31100 055B 88 21 EORA #821 COMMA?
31200 055D 27 E6 BEW GETS JUMP IF YES
31300 055F 20 92 BWA DAB ELSE ERROR IF NOT
31400 *
31500 * SUPPORT SUBROUTINE= MOVE ADDRESS INTO STACK
31600 *
31700 0561 30 SETAB TSX PUT THE ADDRESS IN THE STACK
31800 0562 08 INX
31900 0563 B6 A00C SETS LDAA ADDR
32000 0566 A7 06 STAA 6,X
32100 0568 B6 A00D LDAA ADDR+1
32200 056B A7 07 STAA 7,X
32300 056D 39 RTS
32400 *
32500 * SUPPORT SUBROUTINE= SET APPENDAGE ADDRESS AND CALL DISASSEMBLER
32600 *
32700 056E CE 01A4 SHJLIN LDX #APP SET APPENDAGE FOR DISASSEMBLER
32800 0571 FF A07C STX APPND
32900 0574 8D 0018 JSR NEXTL GO TO DISASSEMBLER
33000 0577 39 HIS
33100 *
33200 * COMMAND TABLE, EACH ENTRY IS 3 BYTES LONG, THE FIRST BYTE IS THE ASCII
33300 * COMMAND CHARACTER, THE NEXT 2 BYTES ARE THE PROCESS
33400 * ADDRESS, THE TABLE IS TERMINATED WITH A BYTE OF ZERO.
33500 *
33500 0578 53 COMTAB FCC /S/ STEP COMMAND
33600 0579 04E5 FDB STEP
33700 057B 54 FCC /T/ TRACE COMMAND
33800 057C 04C4 FDB TRACE
33900 057E 52 FCC /R/ REGISTER DISPLAY
34000 057F 050E FDB SHUREG
34100 0581 47 FCC /G/ GO COMMAND
34200 0582 04F2 FDB GO
34300 0584 44 FCC /D/ DISPLAY COMMAND
34400 0585 04F6 FDB DISPLA
34500 0587 43 FCC /C/ SET CONDITION CODES
34600 0588 0520 FDB RSETC
34700 058A 41 FCC /A/ SET A=REGISTER
34800 058B 0528 FDB RSETA
34900 058D 42 FCC /B/ SET B=REGISTER
35000 058E 0526 FDB RSETB
35100 0590 58 FCC /X/ SET X=REGISTER
35200 0591 0530 FDB RSETX
35300 0593 50 FCC /P/ PATCH
35400 0594 053D FDB PATCH
35500 0596 00 FCB 0,0,0 SPACE FOR PATCHING AN ENTRY
35600 0597 00
35700 0598 00
35800 0599 00
35900 * REGISTER
36000 059A 43 CCL FCC 0 IDENTIFICATION
36100 059B 43 FCC /CC B A X/ REGISTER ID LINE
36200 059C 20
36300 059D 42
36400 059E 20
36500 059F 20
36600 05A0 41
36700 05A1 20
36800 05A2 20
36900 05A3 58
37000 05A4 0D CRLF FCB #0D,#0A,#4 CARRIAGE RETURN/LINE FEED
37100 05A5 0A
37200 05A6 04
37300 END

```

Listing 2 starts on page 346  
Listing 3 is on page 358

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fine print.



# Epson.

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.

Not any more.

The Epson MX-80 challenges any dot matrix printer anywhere to match our type at our price. Or even come close.

Our emphasized print mode gives you a tack-sharp, clean, easy-to-read face with true descenders—at a fraction of the price of daisy wheel printers. We give you a user-defined choice of twelve different weights and sizes of letters in 40, 80, 66 or 132 columns. We give you adjustable tractors so you can do anything from labels to memos to manuscripts. Fast and clean.

But if you think print quality is the only thing we have

to sell, you're wrong. The MX-80 may be the most revolutionary printer to come out in the past ten years.

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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EPSON AMERICA, INC.

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Listing 2: The disassembler routine included as part of DEMONS. The packed-mnemonic table and format table occupy much space.

```

00100          NAM      DISASM
00200          *
00300          * AUTHOR: A.I. HALSEMA
00400          * DATE: 10-28-1977
00500          * OBJECT MACHINE: SWTPC 6800
00600          * PROGRAM NAME: DISASSEMBLER VERSION 1.1
00700          *
00800          OPT      0
00900          0000    ORG      $0000
01000          E047    BADDR    EQU    $E047
01100          A00C    ADDR     EQU    $A00C
01200          E07E    PCDATA1  EQU    $E07E
01300          *
01400          * OPERATOR INTERFACE
01500          *
01600          0000 BD E047 START JSR    BADDR      GET DUMP ADDRESS FROM OPERATOR VIA MIKBUG
01700          0003 86 0F LDAA    #15          SET # OF LINES TO DUMP
01800          0005 87 A077 STAA   LINES
01900          0008 CE 0169 LDX    #ERASE     ERASE CRT SCREEN
02000          000B BD E07E JSR    PCDATA1
02100          000E CE 01A4 LDX    #APP          SET APPENDAGE ROUTINE ADDRESS
02200          0011 FF A07C STX    APPND
02300          0014 8D 02 BSR    NEXTL
02400          0016 20 E8 BRA     START
02500          * DISASSEMBLER. ENTER WITH DISPLAY START ADDRESS AT $A00C.
02600          * NUMBER OF LINES TO DISPLAY AT LABEL 'LINES'.
02700          * SET ADDRESS OF APPENDAGE ROUTINE AT A07C
02800          * ENTER VIA JSR.
02900          * EACH TIME A LINE IS READY, APPENDAGE RECEIVES CONTROL VIA JSR. RETURN VIA RTS.
03000          * EXIT WITH $A00C CONTAINING ADDRESS OF NEXT
03100          * INSTRUCTION, LOCATION $A04A CONTAINING 32
03200          * BYTES OF ASCII TEXT TERMINATED BY CR,LF,04.
03300          * LOCATION 'LINES' WILL CONTAIN ZERO.
03400          0018 FE A00C NEXTL LDX    ADDR      GET ADDRESS OF DATA
03500          001B A6 00 LDAA    X          GET DATA BYTE
03600          001D CE A06B LDX    #WORKA
03700          0020 A7 03 STAA   BYTE,X    SAVE IT
03800          0022 5F CLR    #0
03900          0023 48 ASLA   #0          NOW MULTIPLY BY 2
04000          0024 59 ROL    #0
04100          0025 AB 02 ADDA   TAD+1,X    ADD MNEMONIC TABLE ADDRESS
04200          0027 E9 01 ADCH  TAD,X
04300          0029 A7 07 STAA   BASE+1,X  SAV THE DISPLACEMENT INTO TABLE
04400          002B E7 06 STAR  BASE,X
04500          002D A6 03 LDAA   BYTE,X    GET HIGH ORDER BYTE
04600          002F 44 LSRA   #0
04700          0030 44 LSRA   #0          RIGHT JUSTIFY IT
04800          0031 44 LSRA   #0          AND MULTIPLY BY 2
04900          0032 44 FE ANDA   #FE
05000          0034 5F CLR    #0
05100          0035 AB 05 ADDA   FAD+1,X    ADD BASE OF FLAG TABLE
05200          0037 E9 04 ADCH  FAD,X
05300          0039 A7 09 STAA   FLAGA+1,X  SET POINTER INTO FLAG TABLE
05400          003B E7 08 STAR  FLAGA,X
05500          003D CE A04A LDX    #LINE
05600          0040 C6 1B LDAA   #27
05700          0042 86 20 LDAA   #520
05800          0044 A7 04 BLOP  STAA   4,X
05900          0046 0F INX    #0
06000          0047 5A DECB  #0
06100          0048 26 FA BNE    BLOP
06200          004A 86 04 LDAA   #4          SET EOL MARKER
06300          004C A7 05 STAA   5,X
06400          004E CE 000A LDX    #SOD0A    SET CRLF IN LINE
06500          0051 FF A06B STX    LINE+30
06600          0054 FE A071 LDX    #BAS
06700          0057 A6 00 LDAA   #BAS
06800          0059 44 7F ANDA   #57F
06900          005B E6 01 LDAB  1,X
07000          005D 44 LSRA   #0
07100          005E 56 RORB  #0
07200          005F 44 LSRA   #0
07300          0060 56 RORB  #0
07400          0061 8B 40 ADDA   #540
07500          0063 87 A05B STAA   OPER
07600          0066 54 LSRB  #0
07700          0067 54 LSRB  #0
07800          0068 54 LSRB  #0
07900          0069 CB 40 ADDB  #540
08000          006B F7 A059 STAB  OPER+1
08100          006E A6 01 LDAA   1,X
08200          0070 84 1F ANDA   #51F
08300          0072 88 40 ADDA   #540
08400          0074 B7 A05A STAA  OPER+2
08500          0077 A6 00 LDAA   X
08600          0079 81 1B CMPA  #51B
08700          007B 26 05 BNE   #FCB
08800          007D CE 03CB LDX   #FLAG
08900          0080 20 26 BRA    OFF
IS FCB= SET FCB FLAG ADDRESS

```

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."*

*"At Compiler Systems we learned the lessons of the past well. So well, that in the relatively short time we've been in the software business, we managed to make history ourselves. In fact, CBASIC is the standard for CP/M-based business systems."*

— Gordon Eubanks, CSI president

Today CSI offers CBASIC/86 designed for 16-bit microcomputer-based systems running under CP/M-86. CBASIC/86, now available worldwide, is based on concepts first used by CBASIC including such business-oriented features as: BCD arithmetic with fourteen-digit precision; full format control of printed reports; random and sequential records of any length (not limited to 256 bytes); aids to structured design, i.e. multiple line functions and control structures as well as excellent file-handling and stringing capabilities.

But perhaps the best of CBASIC/86 becomes clear when you're using it. To learn more about CSI's commitment to support CBASIC/86 and CP/M-86 call (213) 355-1063 and discuss putting CBASIC/86 on your system.

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OEMs contact us for pricing

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Sierra Madre, CA 91024, (213) 355-1063

Circle 431 on inquiry card.

Listing 2 continued:

```

09000 *****
09100 0082 F6 A06E NFC LDAB WBYT TEST FOR EXCEPTIONS
09200 0085 C1 37 CMPB #S37 PULB?
09300 0087 26 05 BNE TPSH
09400 0089 CE 03B5 LDX #PULB
09500 008C 20 1A BRA OFF
09600 008E C1 33 TPSH CMPB #S33 PSHB?
09700 0090 26 05 BNE TBSR
09800 0092 CE 03B5 LDX #PULB
09900 0095 20 11 BRA OFF
10000 0097 C8 8D TBSR EORB #S8D BSR?
10100 0099 26 05 BNE SET
10200 009B CE 03AF LDX #BSR
10300 009E 20 08 BRA OFF
10400 *****
10500 00A0 SET EQU *
10600 00A0 FE A073 LDAB WFLG GET FLAG ADDRESS
10700 00A3 85 80 BITA #S80 TEST FLAG BIT
10800 00A5 27 01 BEQ OFF BIT IS OFF
10900 00A7 08 INX BIT IS ON= POINT TO 2ND FLAG
11000 00A8 A6 00 UFF LDAA X GET THE FLAG
11100 00AA B7 A06B STAA FLAGD ,AND SAVE IT
11200 00AD CE A04A LDX #ADDR POINT ASCII ADDRESS IN LINE
11300 00B0 B6 A00C LDAA ADDR GET CURRENT ADDRESS
11400 00B3 8D 2A BSR CVASC CONVERT TO ASCII
11500 00B5 B6 A00D LDAA ADDR+1 SAME FOR LOW BYTE
11600 00B8 8D 25 BSR CVASC
11700 00BA B6 A06E LDAA WBYT
11800 00BD 08 INX GET CURRENT BYTE
11900 00BE 8D 1F BSR CVASC LEAVE SPACE BETWEEN ADDR,+ DATA
12000 00C0 F6 A06B LDAB FLAGD CURRENT BYTE TO ASCII
12100 00C3 C4 03 ANDB #S3 GET FLAG DATA
12200 00C5 F7 A07B STAB SIZE SAVE ONLY INSTRUCTION LENGTH
12300 00C8 08 INX SAVE IT
12400 00C9 FF A075 CLOP STX XSAV SAVE POINTER INTO DISPLAY LINE
12500 00CC FE A00C LDX ADDR GET DATA ADDRESS
12600 00CF 08 INX
12700 00D0 5A DECB COUNT BYTES
12800 00D1 27 10 BEQ NMR NO MORE
12900 00D3 A6 00 LDAA X GET DATA
13000 00D5 FF A00C STX ADDR
13100 00D8 FE A075 LDX XSAV
13200 00DB 8D 02 BSR CVASC AND PUT IN DISPLAY LINE AS OBJ.
13300 00DD 20 EA BRA CLOP
13400 00DF 7E 018C CVASC JMP TOASC
13500 00E2 FF A00C NMR STX ADDR X NOW POINTS TO NEXT DATA
13600 00E5 B6 A06B LDAA FLAGD GET FLAG DATA
13700 00E8 85 40 BITA #S40 SET REGISTER A?
13800 00EA 27 07 BEQ NOTA NO
13900 00EC 86 41 LDAA #1A YES= ADD TO ASCII MNEMONIC
14000 00EE B7 A05B SETR STAA OPER+3
14100 00F1 20 08 BRA FORM
14200 00F3 85 80 NOTA BITA #S80 SET REGISTER B?
14300 00F5 27 04 BEQ FORM NO= NO REGISTER SYMROL
14400 00F7 86 42 LDAA #1B YES
14500 00F9 20 F3 BKA SETR
14600 00FB CE A05E FORM LDX #ARG POINT ARGUMENT POSITION IN LINE
14700 00FE 86 A06B LDAA FLAGD GET FORMAT CODE
14800 0101 44 LSRA
14900 0102 44 LSRA
15000 0103 84 07 ANDA #7
15100 0105 27 0F BEQ DISPLY INHERENT FORMAT
15200 0107 4A DECA
15300 0108 27 1A BEQ REL RELATIVE FORMAT
15400 010A 4A DECA
15500 010B 27 3D BEQ IND INDEXED FORMAT
15600 010D 4A DECA
15700 010E 27 46 BEQ IMM IMMEDIATE FORMAT
15800 0110 80 03 SUBA #3 FCB?
15900 0112 27 49 BEQ FCBFR
16000 0114 8D 57 DOMV BSR SETM NONE OF THE ABOVE= MUST BE EXTENDED OR DIRECT
16100 0116 FE A07C DISPLY LDX APPND GET APPENDAGE ROUTINE ADDRESS
16200 0119 AD 00 JSR X
16300 011B 7A A077 DEC LINES COUNT LINES
16400 011E 27 03 BEQ FIN ALL DONE?
16500 0120 7E 0018 JMP NEXTL NO= DO NEXT LINE
16600 0123 39 FIN RTS GO AWAII NEXT COMMAND
16700 * FORMAT ARGUMENT FIELD FOR A RELATIVE INSTRUCTION
16800 0124 8D 47 REL BSR SETM SET S AND MOVE BYTES
16900 0126 FE A00C LDX ADDR POINT TO DATA
17000 0129 09 DEX
17100 012A 4F CLRA CALCULATE EFFECTIVE ADDRESS OF
17200 012B E6 00 LDAB X RELATIVE INSTRUCTION
17300 012D 2A 01 BPL POS
17400 012F 43 COMA
17500 0130 FH A0#D POS ADDR ADDR+1
17600 0133 B9 A00C ADCA ADDR
17700 0136 01 NOP
17800 0137 01 NOP
17900 0138 01 NOP
18000 0139 CE A064 LDX #ABS+1
18100 013C 8D 4E BSR TOASC

```

Listing 2 continued on page 350

# PMC-80 Expanded



## Use all standard peripherals and existing software

When you buy PMC-80 you get hardware and software compatibility with the most popular microcomputer system in the world—that means thousands of disk and cassette based programs and all kinds of peripherals are instantly available!

PMC-80 has configurations that give the computer enthusiast a way to grow from a STARTER system in affordable increments. Begin at a low \$675 for the basic 16K level II system and grow to the complete 48K memory system pictured above with two floppy disks for less than \$3000.

FASTLOAD option inputs short programs as fast as "disk" from ordinary,

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PMC-80 COMMUNICATOR option provides interface to modems and parallel port printers. Take your pick of peripherals for communication with electronic bulletin boards and low cost timeshare services via phone lines from your home or business.

PMC-80 EXPANDER option provides the most powerful configuration with a total of 48K memory, provision for 4 mini-floppies, printer interface, RS-232C communications interface, plus a slot for the popular S-100 boards.

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Listing 2 continued:

```

18200 013E 17          TBA
18300 013F 01          NOP
18400 0140 01          NOP
18500 0141 8D 49      BSR      TOASC
18600 0143 86 24      LDAA     #'S
18700 0145 87 A063    STAA     ARS
18800 0148 20 CC      BRA      DISPLY
18900
19000 014A 8D 21      INX      BSR      SETM      SETI $ AND MOVE BYTES
19100 014C 86 2C      LDAA     #'I,      APPEND ,X TO FIELD
19200 014E A7 01      STAA     1,X
19300 0150 86 5H      LDAA     #'X
19400 0152 A7 02      STAA     2,X
19500 0154 20 C0      BRA      DISPLY
19600
19700 0156 86 23      IMM     LDAA     #'#      PRECEED FIELD WITH A #
19800 0158 A7 00      STAA     X
19900 015A 08          INX
20000 015B 20 B7      BRA      DMV
20100
20200 015D 86 24      * FORMAT ARGUMENT FIELD FOR AN INDEXED INSTRUCTION
20300 015F A7 00      FCHFR   LDAA     #'6      MOVE DATA FOR FCB
20400 0161 FE A04F     STAA     X
20500 0164 FF A05F     LDX     LINE+5
20600 0167 20 AD      STX     ARG+1
20700 0169 10          BRA      DISPLY
20800 016A 16          ERASE   FCB     $10,$16,$04
20900 016B 04
21000 016C 01          NOP
21100
21200 016D 86 24      * GENERAL ARGUMENT FIELD FORMATTING
21300 016F A7 00      SETM   LDAA     #'$      SET DOLLAR SIGN
21400 0171 BF A073    STAA     X
21500 0174 8E A051    STS     WFLG     PREPARE TO MOVE BYTES
21600 0177 F6 A07B    LDS     #LINE+7
21700 017A C1 03      LDAR    SIZE     GET OBJECT INPUT SIZE
21800 017C 26 01      CMPR    #3       IF SIZE= 3, MOVE 4 BYTES OF ASCII
21900 017E 5C          BNE     DLOOP
22000 017F 08          INCB
22100 0180 32          DLOOP  INX
22200 0181 A7 00      PULA
22300 0183 5A          STAA     X
22400 0184 26 F9      DECB
22500 0186 BE A073    BNE     DLOOP
22600 0189 39          LDS     WFLG     RESTORE SP
22700 018A 01          RTS
22800 018B 01          NOP
22900
23000
23100 018C 37          * CONVERT CONTENTS OF A TO ASCII AND STORE AT ADDRESS POINTED TO BY X,
23200 018D 16          * RETURN WITH X INCREMENTED AND B UNCHANGED.
23300 018E 44          TOASC  PSHR     SAVE B
23400 018F 44          TAB     COPY A
23500 0190 44          LSRA   GET LEFT NYBBL
23600 0191 44          LSRA
23700 0192 8D 04      BSR     ASC      CONVERT TO ASCII AND STORE
23800 0194 17          TRA
23900 0195 84 0F      ANDA   #'F
24000 0197 33          PULR   GET RIGHT NYBBL
24100 0198 8B 30      ASC    ADDA   #'30   RESTORE B
24200 019A 81 39      CMPA   #'39   CONVERT A DIGIT TO ASCII
24300 019C 23 02      BLS    OU
24400 019E 8B 07      ADDA   #'7
24500 01A0 A7 00      OU     STAA     X
24600 01A2 08          INX
24700 01A3 39          RTS
24800
24900 01A4 CE A04A     APP    LDX     #LINE   GET ADDRESS OF TEXT.
25000 01A7 BD E07E     JSR    PDATA1     DISPLAY THE LINE
25100 01AA 39
25200
25300
25400
25500
25600
25700
25800
25900 01AB 1862     * MNEMONICS (ALPHA ONLY) ARE TRUNCATED TO THE 5 LOW ORDER BITS
26000 01AD 39F0     * AND STORED 3 IN 16 BITS, THE HIGH ORDER BIT OF THE 16 IS USED
26100 01AF 1862     * AS A FLAG WHICH, IF SET, INDICATES THAT THE SECOND FORMAT FLAG
26200 01B1 1862     * BYTE OF A PAIR SHOULD BE USED.
26300 01B3 1862     MTAB  FDB     $1862     FCB     00
26400 01B5 1862     FDB     $1862     FCB     01
26500 01B7 5030     FDB     $5030     FCB     02
26600 01B9 5201     FDB     $5201     FCB     03
26700 01BB 25D8     FDB     $25D8     FCB     04
26800 01BD 10B8     FDB     $10B8     FCB     05
26900 01BF 0D96     FDB     $0D96     FCB     06
27000 01C1 4CB6     FDB     $4CB6     FCB     07
27100 01C3 0D83     FDB     $0D83     FCB     08
27200 01C5 4CA3     FDB     $4CA3     FCB     09

```

Listing 2 continued on page 352

# 4MHZ, DOUBLE DENSITY, COLOR & B/W GRAPHICS . . THE LNWB80 COMPUTER



When you've compared the features of an LNWB80 Computer, you'll quickly understand why the LNWB80 is the ultimate TRS80 software compatible system. LNWB 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.

LNWB80 Computer . . . . . \$1,200.00  
 LNWB80 Computer w/B&W Monitor & one 5" Drive . . . . . \$1,664.00  
 All orders must be prepaid, CA residents please include 6% sales tax.  
 Shipping and handling charge of \$15.00 must be included with every order.  
 \* TRS80 Product of Tandy Corporation.  
 \*\* PMC Product of Personal Microcomputer, Inc.

## COMPARE THE FEATURES AND PERFORMANCE

FEATURES	LNWB80	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 I 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 8/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	---

## LNWB80

- BARE PRINTED CIRCUIT BOARD & MANUAL . . . . . \$89.95

The LNWB80 - A high-speed color computer totally compatible with the TRS-80\*. The LNWB80 gives you the edge in satisfying your computation needs in business, scientific and personal computation. With performance of 4 MHz, 280A 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 I 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

## LNWB SYSTEM EXPANSION

- BARE PRINTED CIRCUIT BOARD AND MANUAL . . . . . \$69.95  
 WITH GOLD CONNECTORS . . . . . \$84.95

The System Expansion will allow you to expand your LNWB80, TRS-80\*, or PMC-80\*\* to a complete computer system that is still totally software compatible with the TRS-80\* Model I 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

LNWB80 KEYBOARD KIT . . . . . \$84.95

The Keyboard Kit contains a 63 key plus a 10 key, P.C. board, and remaining components.

## LNWDoubler

- Assembled and Tested . . . . . \$149.00

Double-density disk storage for the LNWB Research's "System Expansion" or the Tandy's "Expansion Interface". The LNWDoubler™ is totally software compatible with any double density software generated for the Percom's Doubler\*\*\*. The LNWDoubler™ 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.

## LNWB DATA SEPARATOR

- Assembled and Tested . . . . . \$17.95

The LNWB 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 LNWB System Expansion and Tandy's Expansion Interface. Some soldering is required.

## CASE

LNWB80 CASE . . . . . \$84.95

The streamline design of this metal case will house the LNWB80, LNWB System Expansion, LNWB80 Keyboard, power supply and fan, LNWDoubler™, or LNWB Data Separator. This kit includes all the hardware to mount all of the above. Add \$12.00 for shipping

## PARTS AVAILABLE FROM LNWB RESEARCH:

- 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
- LNWB "Start up parts set" LNWB0-1 . . . . . \$82.00
- LNWB "Video parts set" LNWB0-2 . . . . . \$31.00
- LNWB Transformer LNWB0-3 . . . . . \$18.00
- LNWB Keyboard cable LNWB0-4 . . . . . \$16.00
- 40 Pin computer to expansion cable . . . . . \$15.00
- System Expansion Transformer . . . . . \$19.00
- Floppy Controller (FD1771) and UART (TR1602) . . . . . \$30.00

Circle 219 on inquiry card.

**LNWB RESEARCH**  
 CORPORATION  
 14661-C MYFORD RD.  
 TUSTIN CA. 92680

VISA & MASTER CHARGE ORDERS & INFO. NO. 714-552-8946  
 ACCEPTED Add \$3.00 for shipping SERVICE NO. 714-641-8850

Listing 2 continued:

27300	01C7	0D89	FDB	80D89	CLI	0E	
27400	01C9	4CA9	FDB	84CA9	SEI	0F	
27500	01CB	4C41	FDB	84C41	SMA	10	
27600	01CD	0C41	FDB	80C41	CBA	11	
27700	01CF	1862	FDB	81862	FCB	12	
27800	01D1	1862	FDB	81862	FCB	13	
27900	01D3	1862	FDB	81862	FCB	14	
28000	01D5	1862	FDB	81862	FCB	15	
28100	01D7	5022	FDB	85022	TAB	16	
28200	01D9	5041	FDB	85041	TRA	17	
28300	01DB	1862	FDB	81862	FCB	18	
28400	01DD	1021	FDB	81021	DAA	19	
28500	01DF	1862	FDB	81862	FCH	1A	
28600	01E1	0441	FDB	80441	ABA	1B	
28700	01E3	1862	FDB	81862	FCB	1C	
28800	01E5	1862	FDB	81862	FCB	1D	
28900	01E7	1862	FDB	81862	FCB	1E	
29000	01E9	1862	FDB	81862	FCB	1F	
29100	01EB	0A41	FDB	80A41	BRA	20	
29200	01ED	1862	FDB	81862	FCB	21	
29300	01EF	0909	FDB	80909	BHI	22	
29400	01F1	0993	FDB	80993	BLS	23	
29500	01F3	0863	FDB	80863	BCC	24	
29600	01F5	0873	FDB	80873	BCS	25	
29700	01F7	09C5	FDB	809C5	BNE	26	
29800	01F9	0881	FDB	808B1	BEQ	27	
29900	01FB	0AC3	FDB	80AC3	BVC	28	
30000	01FD	0AD3	FDB	80AD3	BVS	29	
30100	01FF	0A0C	FDB	80A0C	RPL	2A	
30200	0201	09A9	FDB	809A9	BMI	2B	
30300	0203	08E5	FDB	808E5	BGE	2C	
30400	0205	0994	FDB	80994	BLT	2D	
30500	0207	08F4	FDB	808F4	HGT	2E	
30600	0209	0985	FDB	80985	BLE	2F	
30700	020B	5278	FDB	85278	TSX	30	
30800	020D	25D3	FDB	825D3	INS	31	
30900	020F	C2AC	FDB	8C2AC	PUL A	32	
31000	0211	42AC	FDB	842AC	PUL B	33	EXCEPTION
31100	0213	10B3	FDB	810B3	DES	34	
31200	0215	5313	FDB	85313	TXS	35	
31300	0217	C268	FDB	8C268	PSH A	36	
31400	0219	4268	FDB	84268	PSH B	37	EXCEPTION
31500	021B	1862	FDB	81862	FCB	38	
31600	021D	4A93	FDB	84A93	HTS	39	
31700	021F	1862	FDB	81862	FCB	3A	
31800	0221	4A89	FDB	84A89	RTI	3B	
31900	0223	1862	FDB	81862	FCB	3C	
32000	0225	1862	FDB	81862	FCB	3D	
32100	0227	5C29	FDB	85C29	WAI	3E	
32200	0229	4EE9	FDB	84EE9	SWI	3F	
32300	022B	38A7	FDB	838A7	NEG A	40	
32400	022D	1862	FDB	81862	FCB	41	
32500	022F	1862	FDB	81862	FCB	42	
32600	0231	0DE0	FDB	80DE0	COM A	43	
32700	0233	3272	FDB	83272	LSP A	44	
32800	0235	1862	FDB	81862	FCB	45	
32900	0237	49F2	FDB	849F2	ROR A	46	
33000	0239	0672	FDB	80672	ASR A	47	
33100	023B	066C	FDB	8066C	ASL A	48	
33200	023D	49EC	FDB	849EC	ROL A	49	
33300	023F	10A3	FDB	810A3	DEC A	4A	
33400	0241	1862	FDB	81862	FCB	4B	
33500	0243	25C3	FDB	825C3	INC A	4C	
33600	0245	5274	FDB	85274	TST A	4D	
33700	0247	1862	FDB	81862	FCB	4E	
33800	0249	0D92	FDB	80D92	CLR A	4F	
33900	024B	38A7	FDB	838A7	NEG B	50	
34000	024D	1862	FDB	81862	FCB	51	
34100	024F	1862	FDB	81862	FCB	52	
34200	0251	0DE0	FDB	80DE0	COM B	53	
34300	0253	3272	FDB	83272	LSP B	54	
34400	0255	1862	FDB	81862	FCB	55	
34500	0257	49F2	FDB	849F2	ROR B	56	
34600	0259	0672	FDB	80672	ASR B	57	
34700	025B	066C	FDB	8066C	ASL B	58	
34800	025D	49EC	FDB	849EC	ROL B	59	
34900	025F	10A3	FDB	810A3	DEC B	5A	
35000	0261	1862	FDB	81862	FCB	5B	
35100	0263	25C3	FDB	825C3	INC B	5C	
35200	0265	5274	FDB	85274	TST B	5D	
35300	0267	1862	FDB	81862	FCB	5E	
35400	0269	0D92	FDB	80D92	CLR B	5F	
35500	026B	38A7	FDB	838A7	NEG,X	60	
35600	026D	1862	FDB	81862	FCB	61	
35700	026F	1862	FDB	81862	FCB	62	
35800	0271	0DE0	FDB	80DE0	COM,X	63	
35900	0273	3272	FDB	83272	LSR,X	64	
36000	0275	1862	FDB	81862	FCH	65	
36100	0277	49F2	FDB	849F2	ROR,X	66	
36200	0279	0672	FDB	80672	ASR,X	67	
36300	027B	066C	FDB	8066C	ASL,X	68	

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

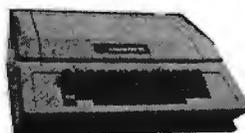


ATARI 400 (8K RAM) .....	\$499.00
ATARI 400 (16K RAM) .....	630.00
ATARI 800 (16K RAM) .....	1,080.00
ATARI 410 RECORDER .....	89.95
ATARI 810 DISK DRIVE .....	599.95

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
<b>ACS 8000-6 Mul2 - Multi-User</b>			
(14.5 M-Winchester)	112K	1M	10,670
(29 M-Winchester)	112K	1M	11,870
<b>ACS 8000-6 Mul4 Multi-User</b>			
(14.5 M-Winchester)	208K	1M	11,960
(29 M Winchester)	208K	1M	13,160



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 .....

## 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

Listing 2 continued:

36400	027D	49EC	FDB	849EC	ROL,X	69
36500	027F	10A3	FDB	810A3	DEC,X	6A
36600	0281	1862	FDB	81862	FCB	6B
36700	0283	25C3	FDB	825C3	INC,X	6C
36800	0285	5274	FDB	85274	TST,X	6D
36900	0287	29B0	FDB	829B0	JMP,X	6E
37000	0289	0D92	FDB	80D92	CLR,X	6F
37100	028B	38A7	FDB	838A7	NEG	70
37200	028D	1862	FDB	81862	FCB	71
37300	028F	1862	FDB	81862	FCB	72
37400	0291	0DED	FDB	80DED	COM	73
37500	0293	3272	FDB	83272	LSR	74
37600	0295	1862	FDB	81862	FCB	75
37700	0297	49F2	FDB	849F2	ROR	76
37800	0299	0672	FDB	80672	ASR	77
37900	029B	066C	FDB	8066C	ASL	78
38000	029D	49EC	FDB	849EC	ROL	79
38100	029F	10A3	FDB	810A3	DEC	7A
38200	02A1	1862	FDB	81862	FCB	7B
38300	02A3	25C3	FDB	825C3	INC	7C
38400	02A5	5274	FDB	85274	TST	7D
38500	02A7	29B0	FDB	829B0	JMP	7E
38600	02A9	0D92	FDB	80D92	CLR	7F
38700	02AB	4EA2	FDB	84EA2	SUB A	80
38800	02AD	0DB0	FDB	80DB0	CMP A	81
38900	02AF	4C43	FDB	84C43	SBC A	82
39000	02B1	1862	FDB	81862	FCB	83
39100	02B3	05C4	FDB	805C4	AND A	84
39200	02B5	0934	FDB	80934	BIT A	85
39300	02B7	3081	FDB	83081	LDA A	86
39400	02B9	1862	FDB	81862	FCB	87
39500	02BB	15F2	FDB	815F2	EDR A	88
39600	02BD	0483	FDB	80483	ADC A	89
39700	02BF	3E41	FDB	83E41	ORA A	8A
39800	02C1	0484	FDB	80484	ADD A	8B
39900	02C3	8E18	FDB	88E18	CPX	8C
40000	02C5	0A72	FDB	80A72	BSR	8D
40100	02C7	B093	FDB	8B093	LDS	8E
40200	02C9	1862	FDB	81862	FCB	8F
40300	02CB	4EA2	FDB	84EA2	SUB A	90
40400	02CD	0DB0	FDB	80DB0	CMP A	91
40500	02CF	4C43	FDB	84C43	SBC A	92
40600	02D1	1862	FDB	81862	FCB	93
40700	02D3	05C4	FDB	805C4	AND A	94
40800	02D5	0934	FDB	80934	BIT A	95
40900	02D7	3081	FDB	83081	LDA A	96
41000	02D9	4E81	FDB	84E81	STA A	97
41100	02DB	15F2	FDB	815F2	EDR A	98
41200	02DD	0483	FDB	80483	ADC A	99
41300	02DF	3E41	FDB	83E41	ORA A	9A
41400	02E1	0484	FDB	80484	ADD A	9B
41500	02E3	8E18	FDB	88E18	CPX	9C
41600	02E5	1862	FDB	81862	FCB	9D
41700	02E7	B093	FDB	8B093	LDS	9E
41800	02E9	CE93	FDB	8CE93	STS	9F
41900	02EB	4EA2	FDB	84EA2	SUBA,X	A0
42000	02ED	0DB0	FDB	80DB0	CMPA,X	A1
42100	02EF	4C43	FDB	84C43	SBCA,X	A2
42200	02F1	1862	FDB	81862	FCB	A3
42300	02F3	05C4	FDB	805C4	ANDA,X	A4
42400	02F5	0934	FDB	80934	BITA,X	A5
42500	02F7	3081	FDB	83081	LDAA,X	A6
42600	02F9	4E81	FDB	84E81	STAA,X	A7
42700	02FB	15F2	FDB	815F2	EDRA,X	A8
42800	02FD	0483	FDB	80483	ADCA,X	A9
42900	02FF	3E41	FDB	83E41	ORAA,X	AA
43000	0301	0484	FDB	80484	ADDA,X	AB
43100	0303	8E18	FDB	88E18	CPX,X	AC
43200	0305	AA72	FDB	8AA72	JSR,X	AD
43300	0307	B093	FDB	8B093	LDS,X	AE
43400	0309	CE93	FDB	8CE93	STS,X	AF
43500	030B	4EA2	FDB	84EA2	SUBA	B0
43600	030D	0DB0	FDB	80DB0	CMPA	B1
43700	030F	4C43	FDB	84C43	SBCA	B2
43800	0311	1862	FDB	81862	FCB	B3
43900	0313	05C4	FDB	805C4	ANDA	B4
44000	0315	0934	FDB	80934	HITA	B5
44100	0317	3081	FDB	83081	LDAA	B6
44200	0319	4E81	FDB	84E81	STAA	B7
44300	031B	15F2	FDB	815F2	EDRA	B8
44400	031D	0483	FDB	80483	ADCA	B9
44500	031F	3E41	FDB	83E41	ORAA	BA
44600	0321	0484	FDB	80484	ADDA	BB
44700	0323	8E18	FDB	88E18	CPX	BC
44800	0325	AA72	FDB	8AA72	JSR	BD
44900	0327	B093	FDB	8B093	LDS	BE
45000	0329	CE93	FDB	8CE93	STS	BF
45100	032B	4EA2	FDB	84EA2	SUBB	C0
45200	032D	0DB0	FDB	80DB0	CMPB	C1
45300	032F	4C43	FDB	84C43	SBCB	C2
45400	0331	1862	FDB	81862	FCB	C3

EXCEPTION

Listing 2 continued on page 356

## NEW LOCATION

1198 E. Willow Street  
Signal Hill, CA 90806

Toll Free (800) 421-7701 Outside Calif.  
(213) 595-6431 Inside Calif.

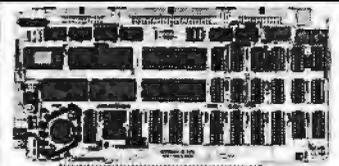
## ORDERING INFO

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.  
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## MICROBYTE S-100 BOARDS



**Z-80A/I-O**  
Assembled & Tested  
Optional Monitor Program \$50.00

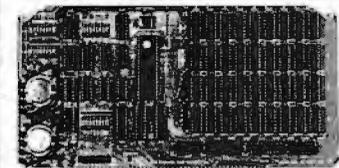
- A complete single board Z80A CPU with serial/parallel interface
- Fully compatible with the proposed IEEE S-100 Bus Standard
- Z80A CPU (4MHz version of the Z80)
- 16B instructions—super set of and upward compatible from the 8080's 76 instructions
- Optional on board Eprom with optional Z80 monitor program — (K1770B, 2K2716) or (K42732)
- Full received interrupt capability — 8 bit with MBI (I bit)
- 2MHz or 4MHz operation in jumper selectable
- Selectable auto-wait state interface for extending M1\*, MREQ\*, IORQ\* and/or on board ROM
- Dual RS-232 serial I/O ports using the 280A DART with individual baud rate selection from 50-19,200 baud
- Up to 24 bit parallel I/O port—fully programmable Intel 825A



**64K RAM Board**  
Assembled & Tested Call for Price

**MICROBYTE**

- Fully S-100 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
- 7/2 Hour Burn-in
- Memory mapped via DIP switch
- Built-in programmable write protect
- Programmable control port parity and bank control
- Also more Compatible



**Disc Controller**  
Assembled & Tested  
CPM Available (Optional)

**MICROBYTE**

- DMA to within 16M byte in memory
- State-of-the-art NEC765LSI Controller
- IEEE-5100 compatible
- DMA arbitration allows use of multiple boards within a system
- PLL data recovery for totally reliable operation
- Writes pre-compensated 4 mid-disc for reliable double density operation
- Supports up to four 41 drives
- Power On, Power Off or Reset de-selects drives to avoid damaging files
- Drive detected Time Out, de-select drives not in use
- Single or double sided operation
- Single density/variable density operation
- 41 standard drives
- Separate Vcc supply for data recovery eliminate possible noise problems



**I/O Board**  
Assembled & Tested  
Cables Available (Optional)

**MICROBYTE**

- Quad RS-232C Serial Ports One 20mA Current Loop Port
- Fully IEEE S-100 Bus Compatible
- Asynchronous Communications with 280A DART or Synchronous Communications with 280A SIO or SIO-DMA
- Full Set of Modem Control Signals including RI (Ring Indicator)
- Easily Configurable to Any Type of Terminal Interface
- I/O Servicing Environments: (1) Poled; (2) Bus Vector; (3) Mode 2 Vector
- Off-Board Interrupt Daisy Chain Capability
- Special Receive Conditions: (1) Framing Error; (2) Parity Error; (3) Receiver Overrun Error
- Bad Rates Selected Individually from 50 Baud to 300K Baud
- 72 Hour Burn-in

## INFLATION FIGHTER

**4116's (200 ns.)**  
Apple, TRS-80, Heath  
8 for \$22<sup>00</sup>

16-49	\$2.60
50-99	\$2.50
100-999	\$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.
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## 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.

## 2708/450 NS

**\$5.25 ea.**  
OR  
**8/\$40.<sup>00</sup>**

## 2716/5 VOLT

**\$8.00 ea.**  
450 NS.  
Major Manufacturer

## MICROPROCESSORS

8080A	\$ 2.50
Z80A	\$ 8.95
Z80A CTC	\$ 7.95
Z80A DART	\$13.95
Z80A SIO	\$24.95
8255 AC5	\$ 5.95
8257 AC5	\$ 8.95
8224	\$ 2.75

## REGULATORS

320T5 .. .80	340T5 .. .70
320T12 .. .80	340T12 .. .75
78L12 .. .	25

## RS-232 CONNECTORS

DB25P DB25S	
1-9	2.90 3.80
10-24	2.75 3.70
25 Up	2.40 3.60

Data Phone Hood 1.00

## S.D. SYSTEM / S-100 BOARDS

<b>EXPANDORAM I</b>	16K	\$239.00
<b>2MHz DYNAMIC RAM BOARD</b>	32K	\$265.00
<b>RAM BOARD KITS</b>	48K	\$289.00
	64K	\$315.00
<b>EXPANDO RAM II</b>	16K	\$250.00
<b>4MHz DYNAMIC RAM BOARD</b>	32K	\$275.00
<b>RAM BOARD KITS</b>	48K	\$300.00
	64K	\$325.00
<b>SBC-100 KIT</b>		\$299.00
2.5 MHz Z-80 CPU WITH SERIAL & PARALLEL I/O PORTS		
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<b>VDB-8024 KIT</b>		\$380.00
80x24 I/O MAPPED VIDEO BOARD WITH KEYBOARD I/O		

<b>VERSAFLOPPY I KIT</b>	\$250.00
DISK CONTROLLER FOR 8" & 5 1/4" DRIVES	
S-100 BUS COMPATIBLE	
<b>VERSAFLOPPY II KIT</b>	\$350.00
NEW DOUBLE DENSITY DISK CONTROLLER FOR 8" & 5 1/4" DRIVES	
<b>PROM-100 KIT</b>	\$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.
7424A	CALENDAR CLOCK BD.
7440A	PROGRAMMABLE TIMER
7470	A/D CONVERTER
7710A	SERIAL SYNCH. BOARD
7712A	SERIAL SYNCH. BOARD
7720A	PARALLEL INTERFACE
7728A	CENTRONICS INTERFACE

**CALL FOR PRICE & DELIVERY**

## CAPACITORS

**.1 @ 12 Volt Ceramic 8c ea.**  
OR  
**100/\$7.00**

**CONNECTORS**

**100 PIN IMSAI GOLD/S-100 SOLDER TAIL \$2.40 ea.**  
OR  
**10/\$2.25 ea.**

**LO-PRO SOCKETS**

1-99	100 Up
14 PIN	.10 .09
16 PIN	.12 .11
18 PIN	.15 .13
20 PIN	.23 .21
24 PIN	.26 .24
28 PIN	.30 .28
40 PIN	.40 .38

(BURNDY/TIN SOLDER TAIL)

## ATARI 800

(NEW 16K VERSION)

- COMPUTER CONSOLE •OPERATORS MANUAL
- ATARI BASIC 8K RAM •RF MODULATOR
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- ALPHANUMERIC KEYS •ADDED OPTIONS PLUS 4 FUNCTION KEYS •JOYSTICKS
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- GRAMMING CASSETTE (NO CHARGE)

**CALL FOR PRICE**  
10% OFF SOFTWARE WITH PURCHASE

## ATARI OPTIONAL ACCESSORIES

MODEL #	DESCRIPTION	PRICE
810	Disk Drive System	\$ 499.00
815	Disk Drive System	\$1199.00
820	40-col. Dot Matrix Printer	\$ 349.00
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830	Acoustic Modem	\$ 159.00
850	Interface Module	\$ 175.00
CX853	16K RAM Module	\$ 140.00
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Description	Price
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Telexlink I	\$19.95
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300 BAUD, AUTO ANSWER/ACUSTIC  
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12" B&W \$129.00

**SANYO VM5012**  
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**AMDEK**  
13" Color \$375.00  
**IN STOCK**

## PRINTERS

**CENTRONICS 737-1**

**ANADEX DP8000**

**ANADEX DP9500**

**ANADEX DP9501**

**TEXAS INST 810**

**BASE 2 800 MST**

**CALL FOR PRICE & DELIVERY**

## QUME DT-8 DISK DRIVE

- Double-sided/Single-Double Density
- IBM-compatible/1.2 Mbytes/Disk
- Fast — 3 ms. Track to Track
- 154 Tracks/Daisy Chain 4 Drives
- ISO Standard Write Protect
- Programmable Door Lock

**CALL FOR PRICE & DELIVERY**

## DISKETTES

Part #	Price Box of 10
Verbatim 5 1/4" (soft)	MD525-01 \$26.50
Scotch 5 1/4" (soft)	744-0 \$33.00
Scotch 5 1/4" (10-sec)	744-10 \$33.00
Scotch 5 1/4" (16-sec)	744-16 \$33.00
Memorex 5 1/4" (soft)	3421 \$24.00
Scotch 8" DS (soft)	743-0 \$49.95
Maxell 8" DS/DD	FD-2D \$65.00

## SHUGART

SA 801R

8" Sgl.-Sided, Sgl./Dbl.  
Density Disk Drive  
Call for Price & Delivery

## New 16K RAM

MODULE FOR  
ATARI 800 Computer Systems  
**\$89.95 each**  
1 YEAR WARRANTY

## MAINFRAME & DISK DRIVE CABINETS from INTEGRAND

**MODEL X5 — Desktop Mainframe — 5 Cards — Small Power Supply** \$200  
Cabinet size: 9 4/8" x 16" d x 7 5/8" h. Cabinet painted dove grey, front panel is black. No optional color! 5-position motherboard, 5 connectors installed, card cage with all guides. Reset switch on front panel. Power switch, 4 DB25 cutouts, 1 BNC mounting hole, 70CFM fan, EMI filter, 5' power cord, line fuse, and clamped flat cable exit on rear panel. P75 power supply (-4-8@10A, +16@1.5A, -16@1.5A). Power supply is a removable module.

**MODEL 700D — Horizontal Desktop Disk/Cover — 2 Eight Inch Drives — Drives Horizontal** \$250  
Cabinet size: 20" w x 23" d x 7 5/8" h. Cabinet painted dove grey, front panel is black. Mounting for 2 eight-inch Shugart SABOR Floppy Disk Drives (or mechanical equivalent). Drive mounting brackets supplied. Drives not supplied. 70CFM fan, 5' three-wire line cord, power switch, line fuse, EMI filter and clamped flat cable exit on rear panel. P794 power supply: +5@4A, +24@5A-6A peak, -5@ 75A. All voltages regulated. Power supply is a removable module.

**MODEL 800D — Desktop Main/Frame — 15 Cards — Standard Power Supply** \$255  
Cabinet size: 17" w x 20 5/8" d x 7 5/8" h. Cabinet painted dove grey, front panel is black (other color schemes optional), 15-position IEEE compatible motherboard (will accept TB01 terminator kit, optional), card cage with all guides. Reset switch on front panel. Power switch, 8 DB25 cutouts, 2 BNC mounting holes, 70CFM fan, EMI filter, 5' power cord, line fuse, and clamped flat cable exit on rear panel. P800 power supply (-4-8@10A, +16@3A, -16@3A). Power supply is a removable module. Motherboard connectors optional.

**MODEL 700US — Vertical Desktop Disk/Cover — 2 Eight Inch Drives — Drives Vertical** \$250  
Cabinet size: 13 5/8" x 23" d x 11" h. Cabinet painted dove grey, front panel is black. Mounting for 2 eight-inch Shugart SABOR Floppy Disk Drives (or mechanical equivalent). Drive mounting brackets supplied. Drives not supplied. 70CFM fan, 5' three-wire line cord, power switch, line fuse, EMI filter and clamped flat cable exit on rear panel. P794 power supply: +5@4A, +24@5A-6A peak, -5@ 75A. All voltages regulated. Power supply is a removable module.

Listing 2 continued:

45500	0333	05C4	FDB	805C4	ANDB	C4
45600	0335	0934	FDB	80934	HLDB	C5
45700	0337	3081	FDB	83081	LDAB	C6
45800	0339	1862	FDB	81862	FCB	C7
45900	033B	15F2	FDB	815F2	EORB	C8
46000	033D	0483	FDB	80483	ADCB	C9
46100	033F	3E41	FDB	83E41	ORAB	CA
46200	0341	0484	FDB	80484	ADDB	CB
46300	0343	1862	FDB	81862	FCB	CC
46400	0345	1862	FDB	81862	FCB	CD
46500	0347	8098	FDB	88098	LDB	CE
46600	0349	1862	FDB	81862	FCB	CF
46700	034B	4EA2	FDB	84EA2	SURB	DO
46800	034D	00B0	FDB	800B0	CMFB	D1
46900	034F	4C43	FDB	84C43	SBCB	D2
47000	0351	1862	FDB	81862	FCB	D3
47100	0353	05C4	FDB	805C4	ANDB	D4
47200	0355	0934	FDB	80934	BITB	D5
47300	0357	3081	FDB	83081	LDAB	D6
47400	0359	4E81	FDB	84E81	STAB	D7
47500	035B	15F2	FDB	815F2	EORB	D8
47600	035D	0483	FDB	80483	ADCB	D9
47700	035F	3E41	FDB	83E41	ORAB	DA
47800	0361	0484	FDB	80484	ADDB	DB
47900	0363	1862	FDB	81862	FCB	DC
48000	0365	1862	FDB	81862	FCB	DD
48100	0367	8098	FDB	88098	LDB	DE
48200	0369	CE98	FDB	8CE98	STX	DF
48300	036B	4EA2	FDB	84EA2	SUBB,X	E0
48400	036D	00B0	FDB	800B0	CMFB,X	E1
48500	036F	4C43	FDB	84C43	SBCB,X	E2
48600	0371	1862	FDB	81862	FCB	E3
48700	0373	05C4	FDB	805C4	ANDB,X	E4
48800	0375	0934	FDB	80934	BITB,X	E5
48900	0377	3081	FDB	83081	LDAB,X	E6
49000	0379	4E81	FDB	84E81	STAB,X	E7
49100	037B	15F2	FDB	815F2	EORB,X	E8
49200	037D	0483	FDB	80483	ADCB,X	E9
49300	037F	3E41	FDB	83E41	ORAB,X	EA
49400	0381	0484	FDB	80484	ADDB,X	EB
49500	0383	1862	FDB	81862	FCB	EC
49600	0385	1862	FDB	81862	FCB	ED
49700	0387	8098	FDB	88098	LDB,X	EE
49800	0389	CE98	FDB	8CE98	STX,X	EF
49900	038B	4EA2	FDB	84EA2	SUBB	F0
50000	038D	00B0	FDB	800B0	CMFB	F1
50100	038F	4C43	FDB	84C43	SBCB	F2
50200	0391	1862	FDB	81862	FCB	F3
50300	0393	05C4	FDB	805C4	ANDB	F4
50400	0395	0934	FDB	80934	BITB	F5
50500	0397	3081	FDB	83081	LDAB	F6
50600	0399	4E81	FDB	84E81	STAB	F7
50700	039B	15F2	FDB	815F2	EORB	F8
50800	039D	0483	FDB	80483	ADCB	F9
50900	039F	3E41	FDB	83E41	ORAB	FA
51000	03A1	0484	FDB	80484	ADDB	FB
51100	03A3	1862	FDB	81862	FCB	FC
51200	03A5	1862	FDB	81862	FCB	FD
51300	03A7	8098	FDB	88098	LDB	FE
51400	03A9	CE98	FDB	8CE98	STX	FF
51500			*			
51600			*	FORMAT FLAGS		
51700			*			
51800			*	FLAGS ARE 1 BYTE LONG AND ARRANGED IN PAIRS,		
51900			*	MI: 72543210		
52000			*	PH=FFFFS		
52100			*	WHERE: R= REGISTER CODE, 0=NONE, 1=A, 2=B		
52200			*	FFF= ADDRESS MODE, 0=IMMEDIATE, 1=RELATIVE, 2=INDEXED		
52300			*	3=IMMEDIATE, 4=EXTENDED, 5=IMPRCI		
52400			*	6= NONE (FOR PSEUDO)		
52500			*	RS= SIZE OF INSTRUCTION IN BYTES.		
52600			*			
52700	03AB	01	YTAB	FCB	801	00=0F INHERENT
52800	03AC	00		FCB	0	
52900	03AD	01		FCB	801	10=1F INHERENT
53000	03AE	00		FCB	0	
53100	03AF	06	NSK	FCB	806	20=2F RELATIVE (USED BY BSR)
53200	03B0	00		FCB	0	
53300	03B1	01		FCB	801	30=3F INHERENT
53400	03B2	41		FCB	841	PULA AND PSHA
53500	03B3	41		FCB	841	40=4F INHERENT
53600	03B4	00		FCB	0	
53700	03B5	81	PULB	FCB	881	50=5F INHERENT (USED BY PULB)
53800	03B6	00		FCB	0	
53900	03B7	0A		FCB	80A	60=6F INDEXED
54000	03B8	00		FCB	0	
54100	03B9	13		FCB	813	70=7F EXTENDED
54200	03BA	00		FCB	0	
54300	03BB	4E		FCB	84E	80=8F IMMEDIATE
54400	03BC	0F		FCB	80F	CPX, LDB

Listing 2 continued on page 358

# NO IT ISN'T!!



## 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".

We'd like to avoid confusion between our Cameo database solution and the one that doesn't work so well. The Cameo DC-500 subsystem employs a decade-proven **cartridge** disk. Our backup capability is built in, and takes four minutes. The ability to switch applications (by exchanging the removable cartridge) means you can use your computer for more kinds of work. A ten megabyte (5 fixed + 5 removable) subsystem costs \$5995, for your **TRS-80\* (Mod. I or II), Apple\*, Heath H89<sup>TM</sup>, or S-100** computer.

So call us "The **Cartridge Disk** Guys", please, and call us soon. We'll show you the **really** cost-effective solution to microcomputer database storage.



**AMEO** ELECTRONICS INC.

1626 CLEMENTINE ANAHEIM, CA 92802

(714) 535-1682

\* TRS-80 is a registered trademark of the Tandy Corp. \* Apple is a registered trademark of Apple Corp.

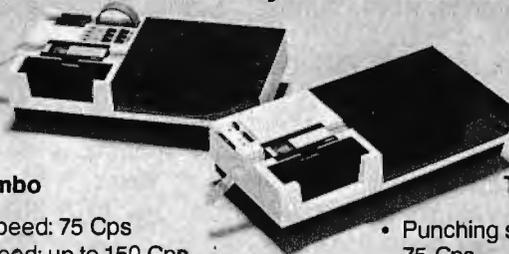
Listing 2 continued:

54500	03BD	5b	FCH	85b	90=9F	DIRECT
54600	03BE	16	FCH	81b	CPX,LDS,STS	
54700	03BF	4A	FCH	84A	A0=AF	INDEXED
54800	03C0	0A	FCH	80A	CPX,JSR,LDS,STS	
54900	03C1	53	FCH	853	B0=BF	EXTENDED
55000	03C2	13	FCH	813	CPX,,JSR,LDS,STS	
55100	03C3	HE	FCH	8HE	CO=CF	IMMEDIATE
55200	03C4	0F	FCH	80F	LDX	
55300	03C5	9b	FCH	89b	U0=UF	DIRECT
55400	03C6	16	FCH	816	LDX,STX	
55500	03C7	HA	FCH	84A	B0=BF	INDEXED
55600	03C8	0A	FCH	80A	LDX,STX	
55700	03C9	93	FCH	893	F0=FF	EXTENDED
55800	03CA	13	FCH	813	LDX,STX	
55900						
56000	03CB	19	FFLAG	FCH	819	FCH FLAGS
56100			*			
56200	A04A		OPG	8A04A		
56300	A04A	20	LINE	RMR	32	
56400	A06A	04		FCH	04	
56500	A06B		WORKA	EQU	*	
56600	A06B	CE 01AB	FLAGD	LDX	#MTAB	MNEMONIC TABLE BASE
56700	A06C		WTAD	EQU	FLAGD+1	
56800	A06E	CE 03AB	WRYT	LDX	#FTAB	FLAG TABLE BASE
56900	A06F		WPAD	EQU	WRYT+1	
57000	A071	0000	WBAS	FDB	0	
57100	A073	0000	WFLG	FDB	0	
57200	A075	0000	XSAV	FDB	0	
57300	A077	00	LINES	FCH	0	
57400	03		BYTE	EQU	WRYT=WORKA	
57500	01		TAD	EQU	WTAD=WORKA	
57600	06		BASE	EQU	WBAS=WORKA	
57700	04		FAD	EQU	WPAD=WORKA	
57800	08		FLAGA	EQU	WFLG=WORKA	
57900	A04A		AADK	EQU	LINE	
58000	A058		UPER	EQU	LINE+13	MNEMONIC POSITION
58100	A063		ABS	EQU	LINE+24	ABS. ADDRESS FOR RELATIVE MODES
58200	A05E		ARG	EQU	LINE+19	ARGUMENT POSITION
58300	A078	00		FCH	0,0,0	
58400	A07B	00	SIZE	FCH	0	
58500	A07C	0000	APPND	FDB	00	COMPLETION APPENDAGE ADDRESS
58600			END			

# Choice

GNT Makes a Tape Punch Station and a Tape Reader/Punch Combination.

Both are small, quiet, and economical. One of them will fit your needs exactly.



### The 4601 Combo

- Punching speed: 75 Cps
- Reading speed: up to 150 Cps
- RS-232-C serial interface
- Utilizes all types of Mylar® and paper tape
- Reliability: MTBF 100 million characters

### The 3601 Punch

- Punching speed: 50 or 75 Cps
- RS-232-C serial interface
- Utilizes all types of Mylar® and paper tape
- Reliability: MTBF 100 million characters

Contact your local dealer or call for complete specifications.

See us at NCC — Booth 3004

## GNT AUTOMATIC INC.

1560 Trapelo Road, Waltham, MA 02154 (617) 890-3305 Telex: 923318

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	0098			
CLUP	=00C9	00DD			
CYASC	=00DF	00B3	0088	009E	00D8
DISPL	=0116	0105	0144	0154	0167
DLOOP	=017F	017C	0184		
DUMY	=0114	015B			
ERASE	=0169	0108			
FCRFR	=015D	0112			
FFLAG	=03CB	007D			
FIN	=0123	011E			
FLAGD	=A06B	03AA	00C0	00E5	00FE
FDRM	=00FB	00F1	00F5		
FTAB	=03A8	A06E			
IMM	=0156	010E			
IND	=014A	0108			
LINE	=A04A	003D	0051	0161	0174 01A4
LINES	=A077	0005	011B		
MTAB	=01AB	A06B			
NEXTL	=0018	0014	0120		
NFC	=0082	0078			
NMR	=00E2	00D1			
NOTA	=00F3	00EA			
OFF	=00A8	0080	008C	0095	009E 00A5
OU	=01A0	019C			
POS	=0130	012D			
PULR	=03B5	0089	0092		
REL	=0124	0108			
SETM	=0160	0114	0124	014A	
SETR	=00EE	00F9			
SIZE	=A07B	00C5	0177		
START	=0000	0016			
TBSR	=0097	0090			
TIASC	=018C	00DF	013C	0141	
TPSH	=008E	0087			
WBAS	=A071	0054			
WBYT	=A06E	00BA			
WFLG	=A073	00A0	0171	0186	
XSAV	=A075	00C9	00D8		

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# Build a Super Simple Floppy-Disk Interface, Part 1

---

James Nicholson and Roger Camp  
1046 Gaskill  
Ames IA 50010

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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

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.

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

---

**This controller is simple and economical because it requires only ten integrated circuits.**

---

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

---

## 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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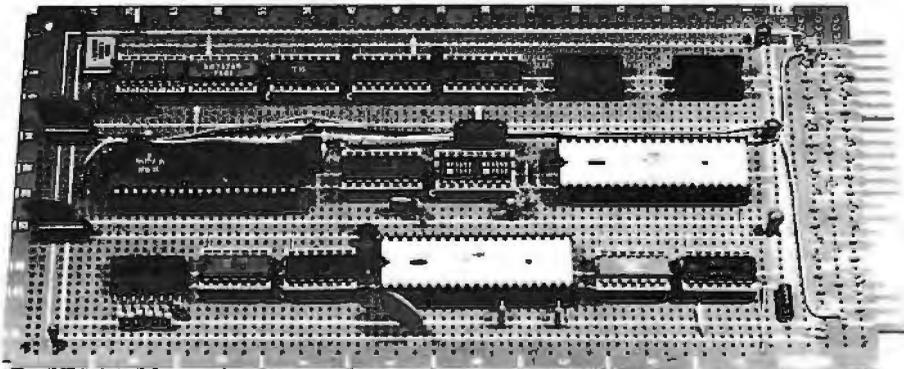


Photo 1: The authors' wire-wrapped floppy-disk controller board.

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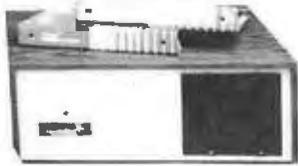
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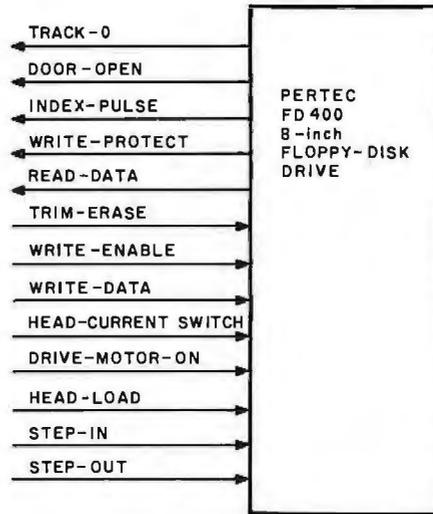


Figure 1: Input and output lines available for controlling a Pertec FD400 8-inch floppy-disk drive. These signals are the same as those found on any Shugart-compatible drive, so nearly any drive may be substituted for the FD400.

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 com-

munications 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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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  $\mu$ s. 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 micro-processor 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.

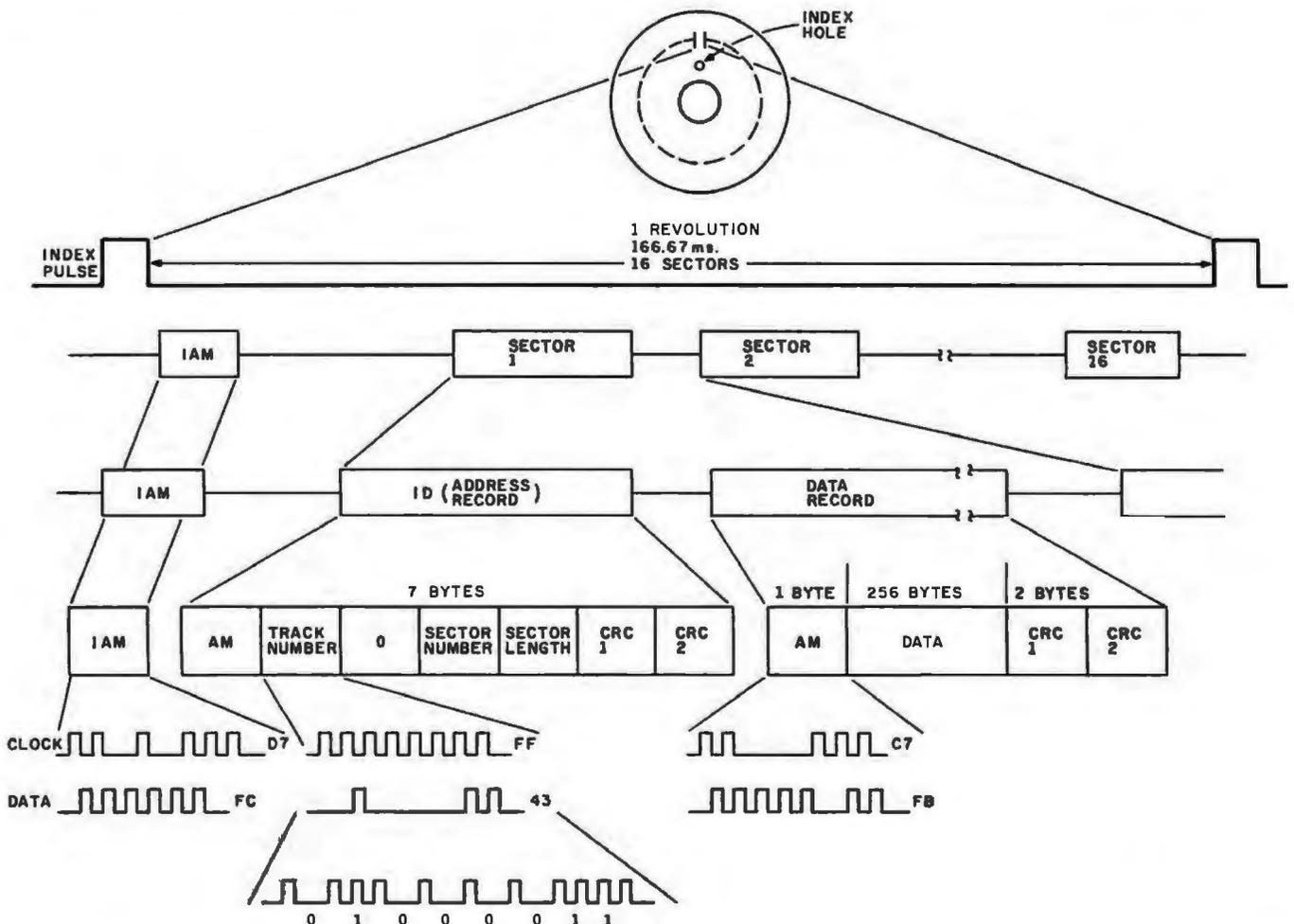


Figure 2: The format of recorded data on one track of a soft-sectored floppy-disk drive. The IAM (index-address mark) marks the beginning of each track. See the text for details.

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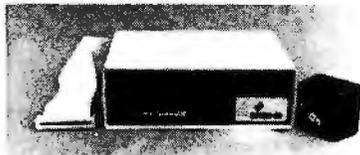
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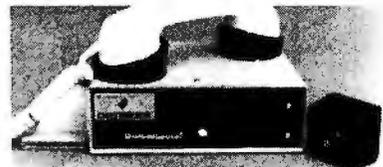
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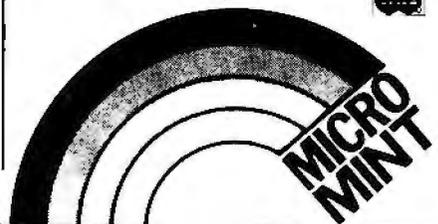
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The registers in the 1771 that can be programmed by the user are the data, track, sector, and command registers—there is also a status register that can be read from but not written to. These 8-bit registers form the basis for software control of any 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, RE, and 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-

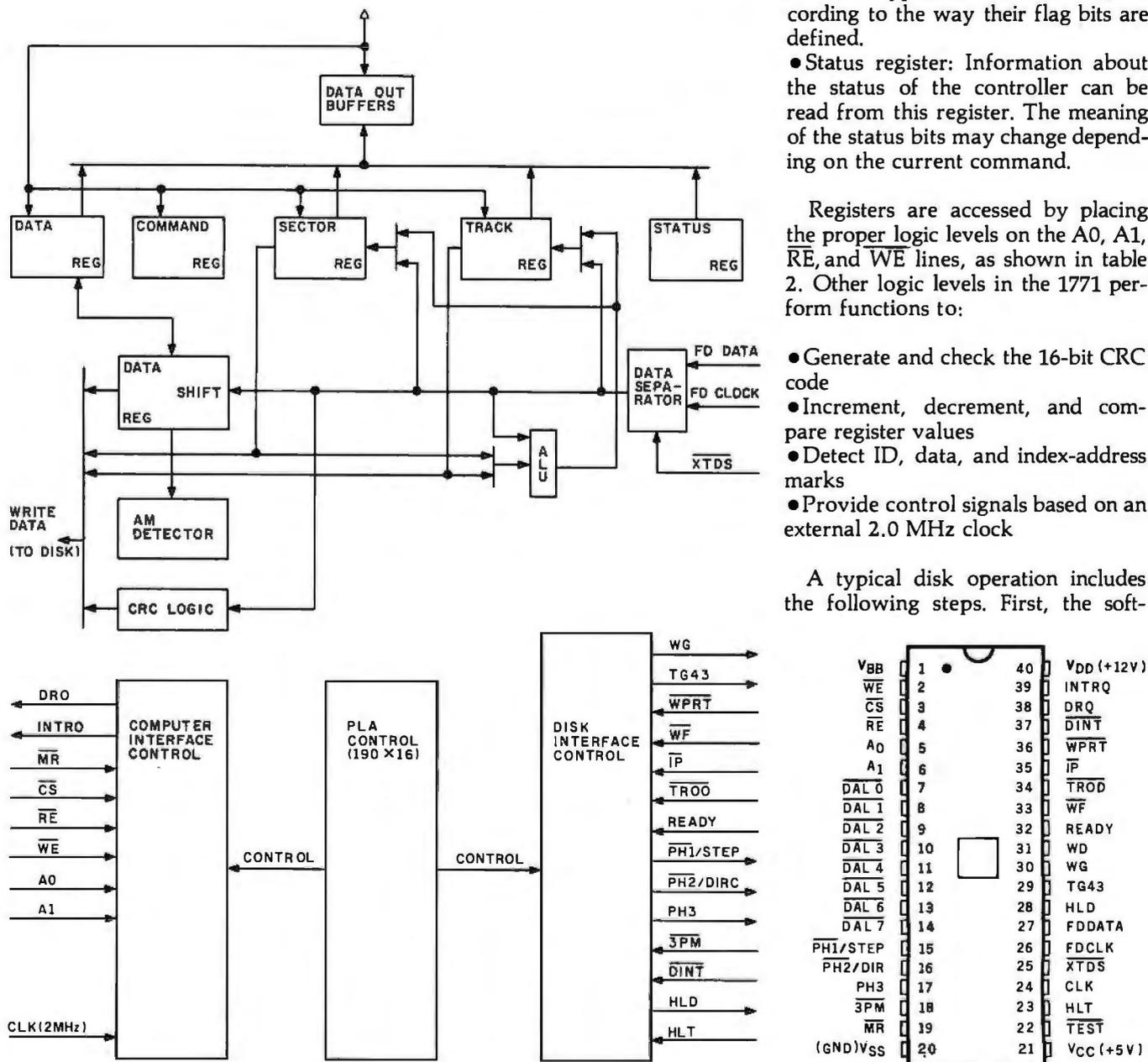


Figure 3: Internal architecture and pinout diagram of the Western Digital FD1771 floppy-disk controller. The four programmable registers and eleven commands of the 1771 allow any microprocessor to control a disk subsystem using high-level instructions, thus removing a significant burden from the disk-driving software. See table 1 for a summary of the commands.



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TYPE	COMMAND	BITS							
		7	6	5	4	3	2	1	0
I	Restore	0	0	0	0	h	V	r <sub>1</sub>	r <sub>0</sub>
I	Seek	0	0	0	1	h	V	r <sub>1</sub>	r <sub>0</sub>
I	Step	0	0	1	u	h	V	r <sub>1</sub>	r <sub>0</sub>
I	Step In	0	1	0	u	h	V	r <sub>1</sub>	r <sub>0</sub>
I	Step Out	0	1	1	u	h	V	r <sub>1</sub>	r <sub>0</sub>
II	Read Command	1	0	0	m	b	E	0	0
II	Write Command	1	0	1	m	b	E	a <sub>1</sub>	a <sub>0</sub>
III	Read Address	1	1	0	0	0	1	0	0
III	Read Track	1	1	1	0	0	1	0	s
III	Write Track	1	1	1	1	0	1	0	0
IV	Force Interrupt	1	1	0	1	l <sub>3</sub>	l <sub>2</sub>	l <sub>1</sub>	l <sub>0</sub>

(a)

## BIT VALUES FOR TYPE I

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<sub>1</sub>r<sub>0</sub> = Stepping motor rate (Bits 1 through 0)r<sub>1</sub>r<sub>0</sub> = 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<sub>1</sub>a<sub>0</sub> = Data Address Mark (Bits 1 through 0)a<sub>1</sub>a<sub>0</sub> = 00, FB (Data Mark)a<sub>1</sub>a<sub>0</sub> = 01, FA (User defined)a<sub>1</sub>a<sub>0</sub> = 10, F9 (User defined)a<sub>1</sub>a<sub>0</sub> = 11, F8 (Deleted Data Mark)

(c)

## BIT VALUES FOR TYPE III

s = Synchronize flag (Bit 0)

s = 0, Synchronize to Address Mark

s = 1, Do not synchronize to Address Mark

(d)

## BIT VALUES FOR TYPE IV

l<sub>0</sub> thru l<sub>3</sub> = Interrupt Condition flags (Bits 3 through 0)l<sub>0</sub> = 1, Not Ready to Ready transitionl<sub>1</sub> = 1, Ready to Not Ready transitionl<sub>2</sub> = 1, Index pulsel<sub>3</sub> = 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 (RE = 0, WE = 1)	Register Affected During Write (RE = 1, 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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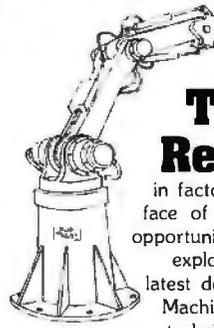
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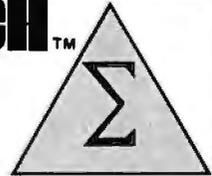
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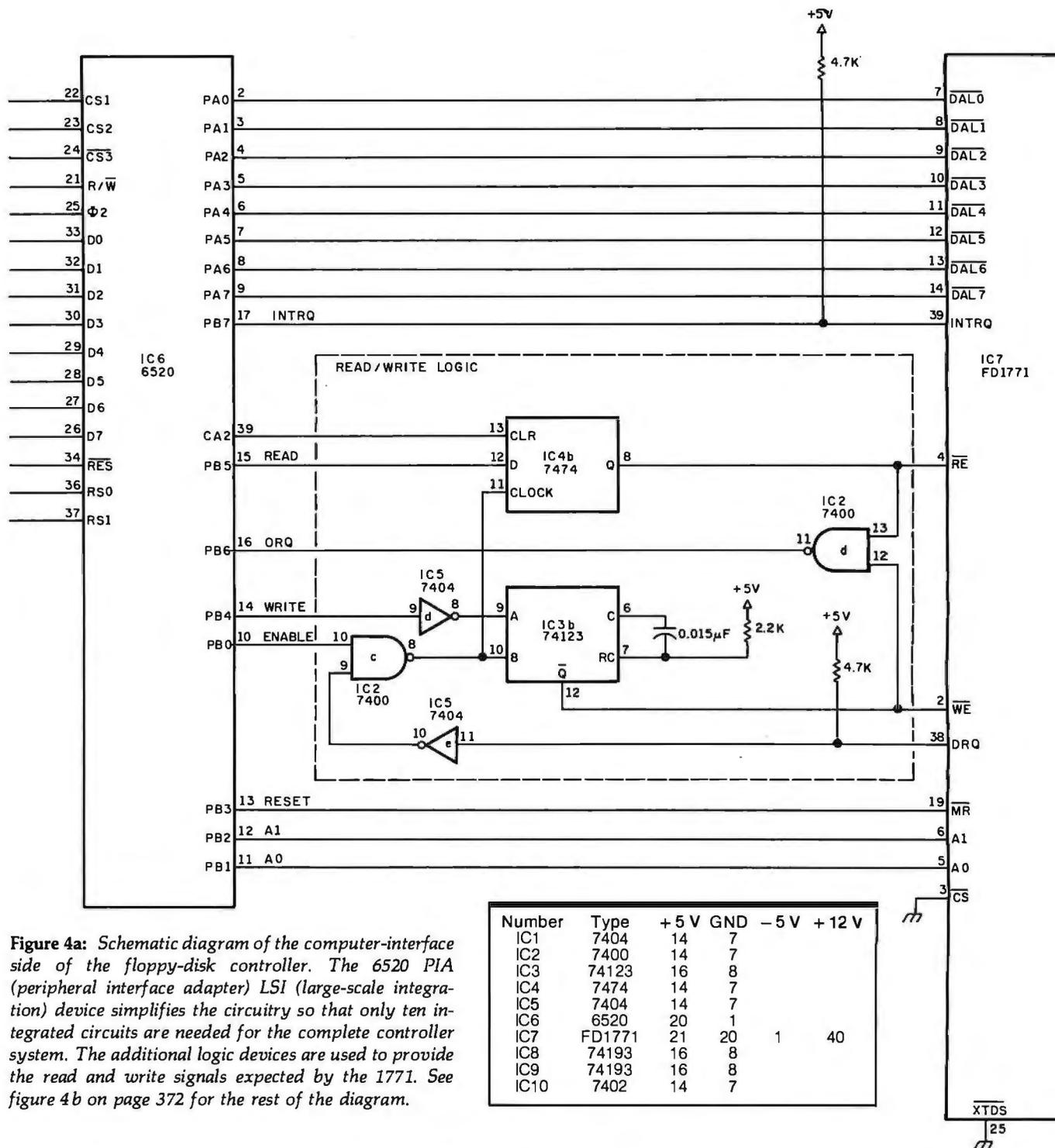
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**Figure 4a:** Schematic diagram of the computer-interface side of the floppy-disk controller. The 6520 PIA (peripheral interface adapter) LSI (large-scale integration) device simplifies the circuitry so that only ten integrated circuits are needed 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.

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.

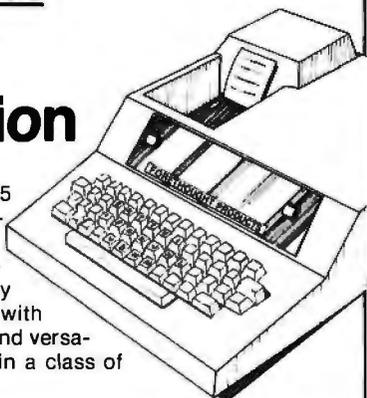
There is a certain difficulty in determining, from a serial-bit stream, which bits are clock and which data (the two are interleaved, and some of the clock bits may be missing). The solution relies on the fact that, at most, three clock pulses will be omitted; if four in a row are omitted, the data and 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),

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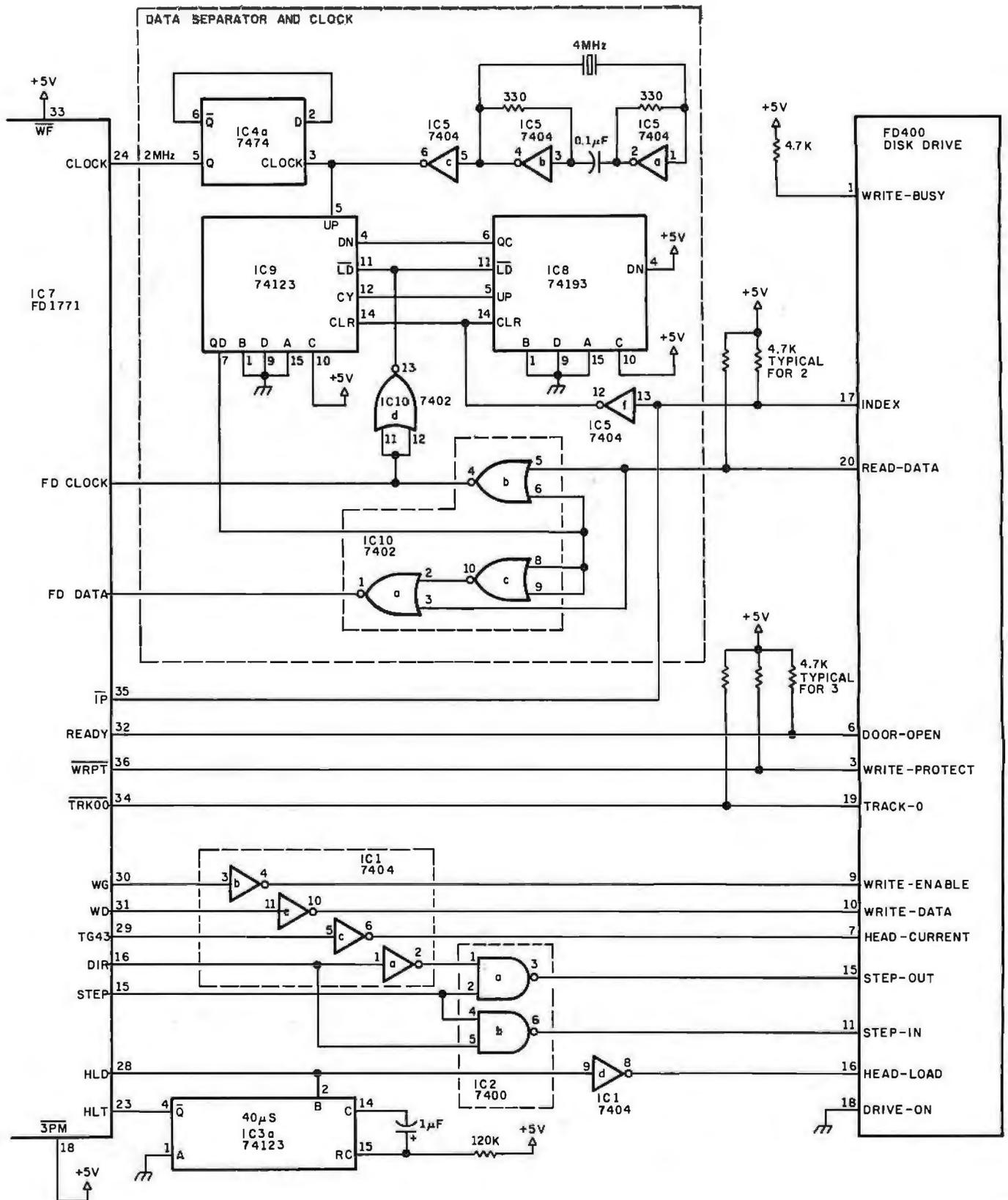


Figure 4b: Schematic diagram of the drive-interface side of the floppy-disk controller. Clock signals and minor control functions are provided for by the additional circuitry, as well as the separation of recorded data from recorded synchronization pulses.

of which only 17 are used in this system to interface with the 7771. The A port is programmed as eight bidirectional data lines, and is connected to

the 7771'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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0	0	X	0	X	Read or Write, DDRA
0	0	0	1	X	Write into ORA
0	0	1	1	X	Read from A-side input pins
0	1	X	X	X	Read or Write CRA
1	0	X	X	0	Read or Write DDRB
1	0	0	X	1	Write into ORB
1	0	1	X	1	Read from B-side input pins
1	1	X	X	X	Read or Write CRB

X = don't care

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			DDRBB Access	CB1 Control	

Control of CA2 Output Modes					
Bit 5	CRA Bit 4	Bit 3	Mode	CA2	Description
1	0	0	"Handshake" on Read	CA2 set high	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	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.

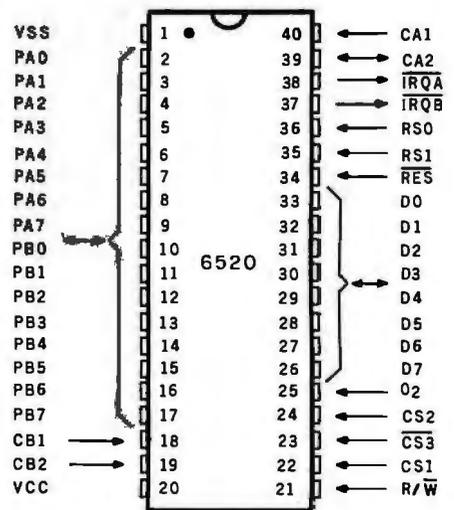
The data separator can be checked by using a single-pulse input signal in

### 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 WE pulse (IC3, pin 12 in figure 4) is about 14 µs.



**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.

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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 con-

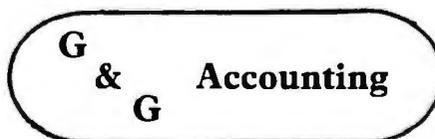
troller through a 6520. Whatever route you choose, this basic design will provide reliable, trouble-free operation.

In Part 2, next month, we will look at the software needed to use this controller. ■

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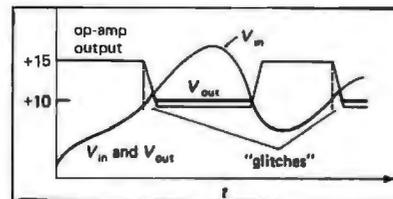
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## Favorite Benchmarks and Other Programs

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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## 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

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why Will, who never studied it for an hour, could teach me something about theater history."

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Because this work was done in the pre-microprocessor 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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# 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 alphanumeric 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

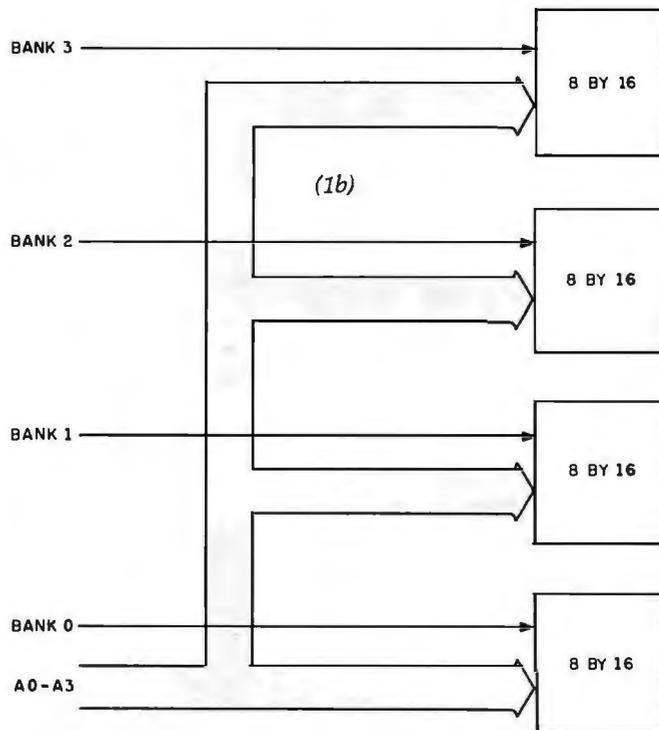
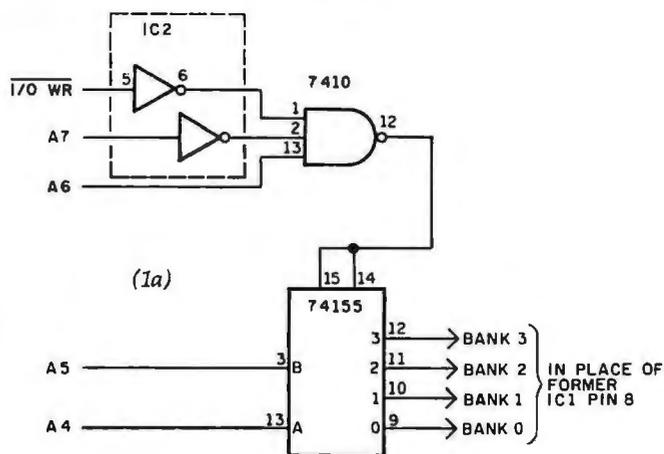
*There are several ways to expand the basic 8 by 16 display into an 8 by 64. The easiest thing to do is to make four of the basic units, then change the addressing to be*

*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



## Model EP-2A-87 EPROM Programmer NEW - CRT ENTRY MODE



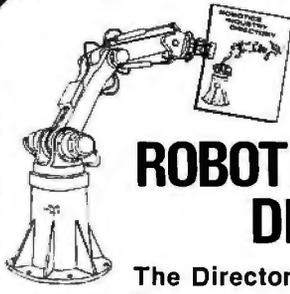
The Model EP-2A-87 EPROM Programmer has an RS-232 compatible interface and includes a 2K or 4K buffer. During the ON-LINE mode, another computer can download to the buffer. Only two easy-to-implement commands are available to an external computer. (Load

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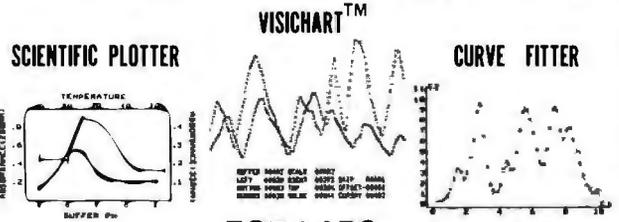
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Michael Berch  
John Oswalt  
Berkeley CA

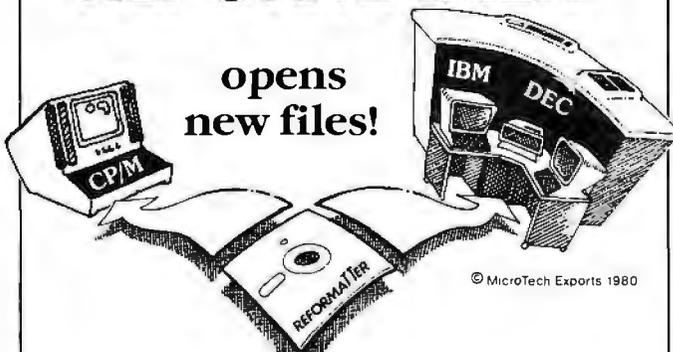
*The answer to your question involves how disks are manufactured and tested, rather than any physical difference between them. Both sides of a disk are usually capable of data storage, but, on a single-sided disk, only one is guaranteed.*

*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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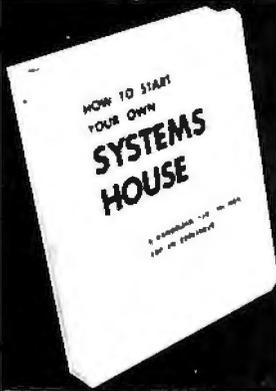
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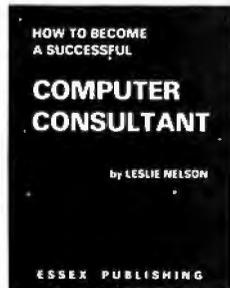
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training users and providing maintenance and support. It also contains sample software contracts that have been used in actual software transactions. Also included are tips on how to negotiate with a large corporation, ways of avoiding personal liability, techniques for obtaining free computer time and hints on how to run a free-lance software business while holding a full-time job.

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3rd edition, June 1980  
Writing and selling computer programs as an independent is a business where • you can get started quickly, with little capital investment • you can do it full time or part time • the potential profits are almost limitless. Since the demand for computer software of all kinds is growing at an explosive rate, the conditions for the small entrepreneur are outstanding.

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The book will guide you step by step through the process of marketing, advertising, negotiating a contract, installing software,

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 non-critical 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?

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## Ask BYTE

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

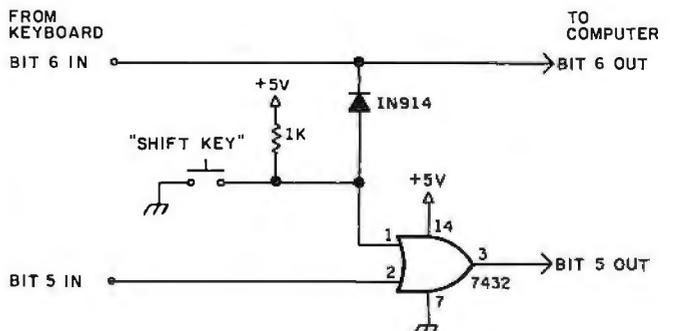


Figure 2

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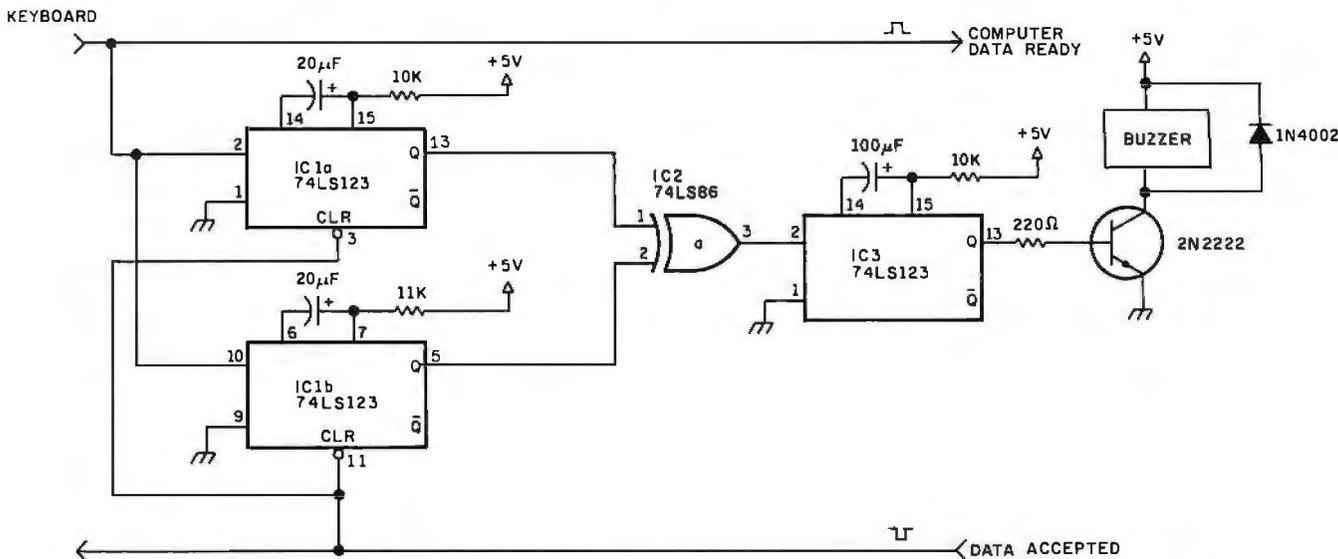


Figure 3

IC Number	Type	+5V	GND
IC1	74LS123	16	8
IC2	74LS86	14	7
IC3	74LS123	16	8

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David Smith  
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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

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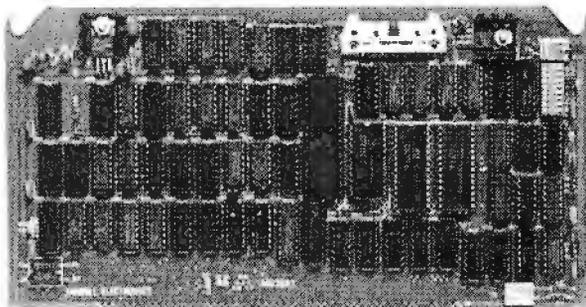
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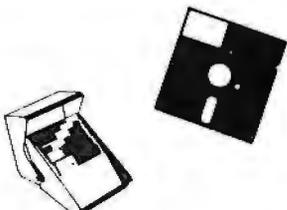
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**Astro-Scope**, horoscope for the Apple II. Floppy disk, \$30. Astro-Graphics Services Inc, POB 28, Orleans MA 02653.

**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).

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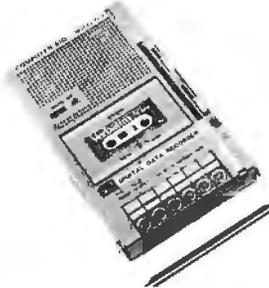
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Z80 Softcard trademark of Microsoft, Inc.

## 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.



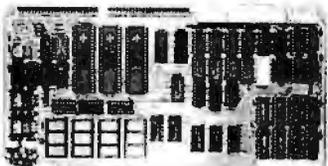
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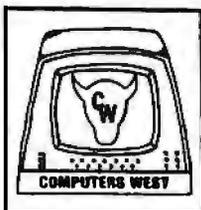
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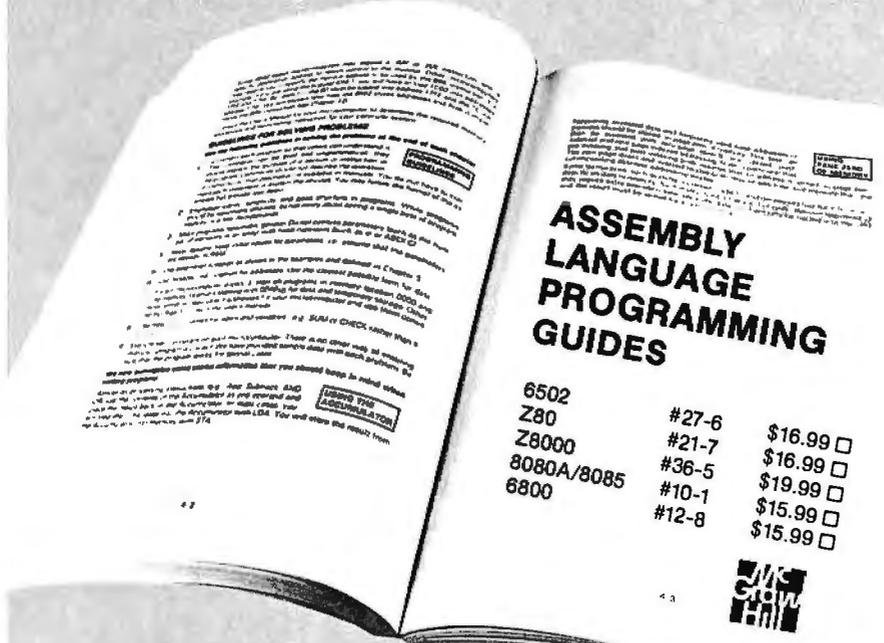
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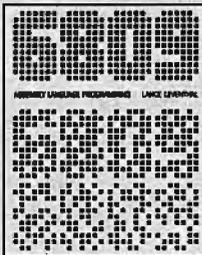
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## Books Received

*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.

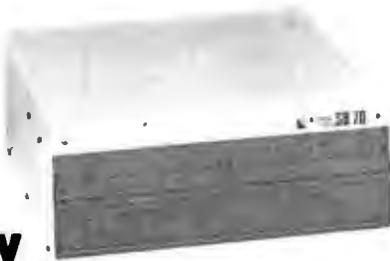
*Experimentation with Microprocessor Applications*, Thomas W Davis. Reston VA: Reston Publishing Company Inc, 1981; 17.5 by 23.5 cm, 237 pages; softcover, ISBN 0-8359-1812-2, \$9.95.

*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

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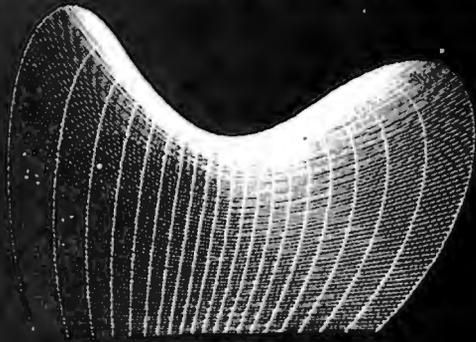
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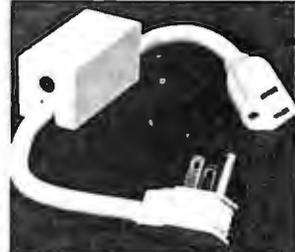
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Greenberg, and A Hoffberg. Somerset NJ: John Wiley & Sons Inc, 1981; 17 by 25.5 cm, 499 pages; softcover, ISBN 0-471-07771-2, \$10.95.

*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.

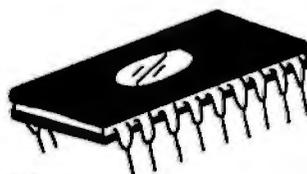
*Programmer's Guide to LISP*, Ken Tracton. Blue Ridge Summit PA: Tab Books Inc, 1980; 13 by 21 cm, 210 pages, softcover, ISBN 0-8306-1045-6, \$6.95; hardcover, ISBN 0-8306-9761-6, \$10.95.

*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

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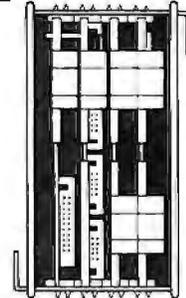
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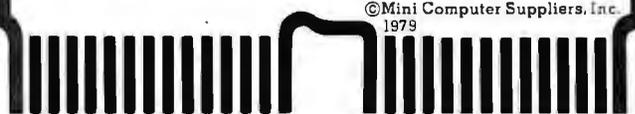
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*Troubleshooting Solid-State Circuits*, G Loveday and A Seidman. Somerset NJ: John Wiley & Sons Inc, 1981; 23.5 by 19 cm, 110 pages; softcover, ISBN 0-471-08371-2, \$7.95.

*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.

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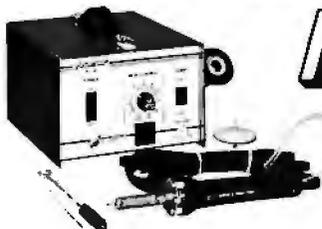
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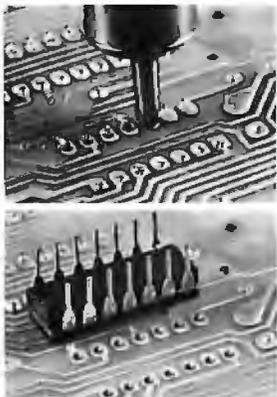
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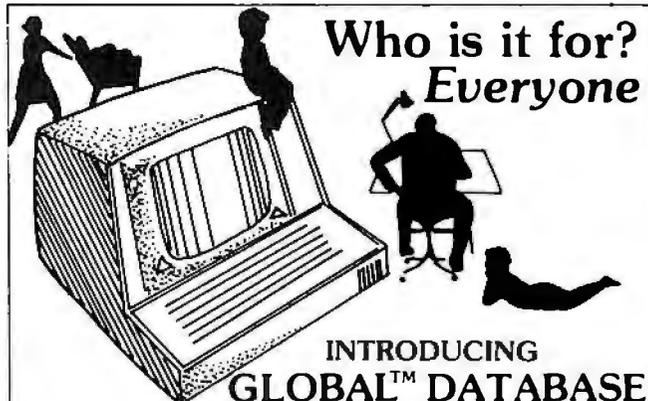
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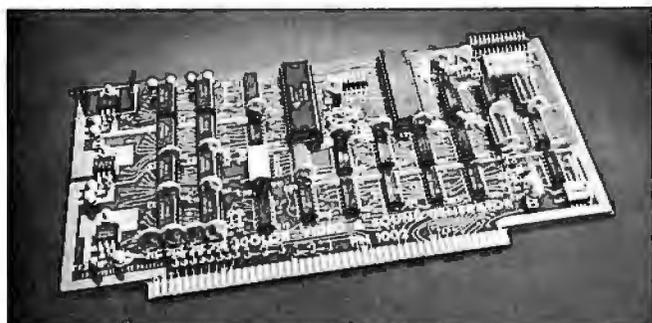
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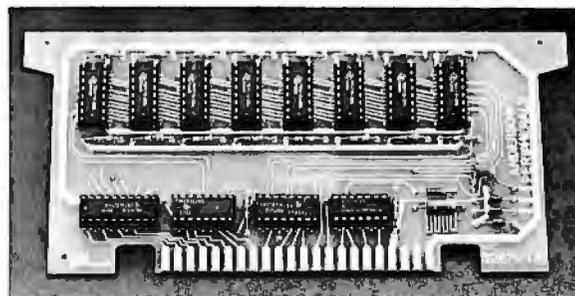
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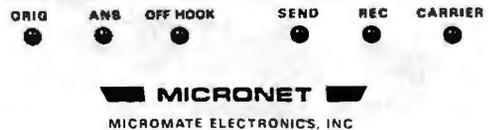
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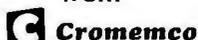
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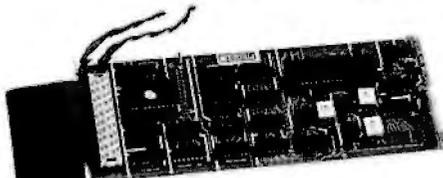
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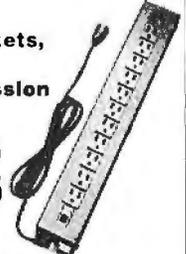
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# A File Catalog System for UCSD Pascal

---

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)update  
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

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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+)}{CL CONSOLE;}{CL PRINTER;}{CL 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,SECUREDIRE);
    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,OFIEND,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

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Listing 1 continued:

```
FUNCTION LOOKUP(FN:FILENAME):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 EXISTS ON THIS VOLUME ');
```

Listing 1 continued on page 413

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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

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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;

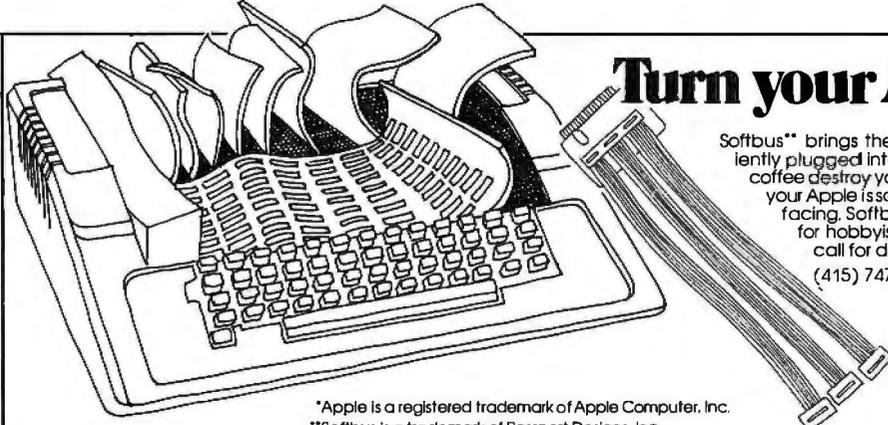
PROCEDURE GET_SYS_VOL(VAR VOL:VOL_ID);
{sets name of volume in drive 4}
  VAR
    I,J: INTEGER;
    SPS:STRING[16];
    AVOL:VOL_ID;
    DIR: DIRECTORY;
  BEGIN
    UNITREAD(4,DIR[0],2048,2);
    VOL:=DIR[0].DIR_VOL_NAME;

    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



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\*Apple is a registered trademark of Apple Computer, Inc.  
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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);
  SFS:=COPY(BLANKS,1,7-LENGTH(VOL));
  VOL:=CONCAT(VOL,SFS);
  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

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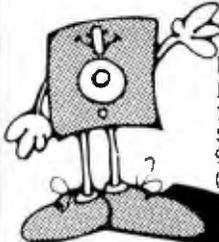
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Listing 1 continued:

```
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
      NCATLIJ:=NCATFILE^;
      IF ((NCATLIJ.VOL_NAME=' '))
        THEN BEGIN
          NREC:=I-1;
          NTOTREC:=NTOTREC+NREC;
          NFILEEND:=TRUE;
          EXIT(READ_NEW_CAT);
        END;{if}
```

Listing 1 continued on page 417



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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

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\*TRS-80 is a trademark of Tandy Corp.

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

## **Bower-Stewart & Associates** SOFTWARE AND HARDWARE DESIGN

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Listing 1 continued:

```
        CLOSE(NCATFILE);
        WAIT;
    END(then);
    ELSE WRITELN(NFILENAME,' NOT PRESENT');
    WRITELN('MASTCAT CONTAINS ',NTOTREC,' RECORDS');
    CLOSE(P);
    WAIT;
END;(display)

PROCEDURE BACKUP;
(comparas 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[N].FILE_NAME<>NCAT[1].FILE_NAME)
                        THEN PRINT_RECORD(NCAT[1]);
                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

## UCSD p-System\* for the INTERTEC SUPERBRAIN<sup>TM</sup>

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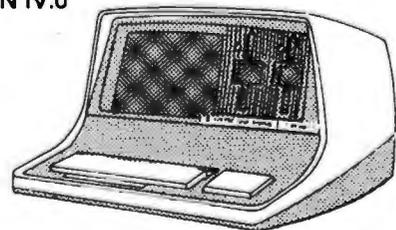
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Listing 1 continued:

```
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,DIRCOJ,2048,2);
    VOL:=DIRCOJ.DIR_VOL_NAME;
    SPS:=COPY(BLANKS,1,7-LENGTH(VOL));
    AVOL:=CONCAT(VOL,SPS);
    FOR I:=1 TO DIRCOJ.NUM_OF_FILES DO
        WITH DIRC[I] DO
            IF (DIR_FILE_NAME='MASTCAT.DATA')
                THEN DIR_FILE_NAME:='BACKCAT.DATA';
    UNITWRITE(5,DIRCOJ,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

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Listing 1 continued:

```
BEGIN
  WRITELN('SORTING ',DREC,' RECORDS');
  REPEAT
    FLAG:=TRUE;
    FOR I:=DREC DOWNTO 2 DO
      IF (DCATCI,FILE_NAME < DCATCI-1,FILE_NAME) THEN
        BEGIN
          {exchange routine}
          BUF:=DCATCI;
          DCATCI:=DCATCI-1;
          DCATCI-1:=BUF;
          FLAG:=FALSE;
        END;{cif}
    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 DIR}
IF IORESULT <> 0
  THEN
  BEGIN
    WRITELN('Unit not online');
    EXIT(CATALOG);
  END;
```

Listing 1 continued on page 422



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```

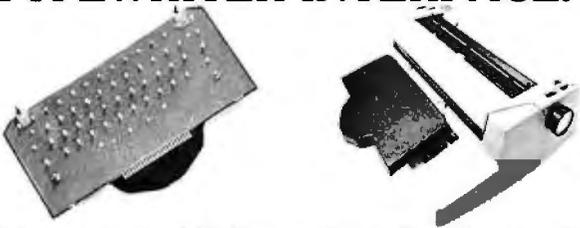
VOL:=DIRXC0J,DIR_VOL_NAME;
SPS:=COPY(BLANKS,1,7-LENGTH(VOL)); {put VOL in consistent format}
VOL:=CONCAT(VOL,SPS);
FOR I:=1 TO DIRXC0J.NUM_OF_FILES DO {move directory to DCAT}
  BEGIN
    WITH DIRXC0J DO
      BEGIN
        IF LENGTH(DIR_FILE_NAME)>0
          THEN
            BEGIN
              DREC:=DREC+1;
              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}
        DREC:=DREC+1;
        WITH DCAT(DREC) DO

```

{create entry with name FREE.SPACE containing the unused space on the volume}

Listing 1 continued on page 423

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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:=DIRXC0J, LAST_BOOT;
  FILE_SIZE:=DIRXC0J, TOTAL_BLOCKS-BLOCKS_USED;
END;{with}
END;{setdir}

PROCEDURE SETDEX;
{if first occurrence 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;
  DREC:=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>0)) THEN Z:=11;
    END;
  END;
END;
```

Listing 1 continued on page 424

```

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 pointer 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          {set whats left of OCAT}
  CONTINUE:=FALSE;
  IF (OREC<=0)
    THEN FOR OO:=OREC TO 0 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(DCATRN);
    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 reboots}
DLREC:=MAXREC;OLREC:=MAXREC;NLREC:=MAXREC;
READDEX; {load the pointer array}
REPEAT
    REMOV:=FALSE;NFILEEND:=FALSE;OFILEEND:=FALSE;IDONE:=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;
```

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*The 1981 Software Writers Market* provides addresses and telephone numbers of key contact people in service bureaus, hardware manufac-

turers, 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.

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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*

## Programming Quizzes

**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], precis, 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 == '.') {
                precis = 0;
                while (isdigit(c = tolower(*control++)))
                    precis = 10*precis + c - '0';
            }
            else
                precis = 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

## Programming Quickies

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 'q':
        ps = nsfoc(*args++, s);
        break;
    case 's':
        ps = *args++;
        break;
    case 'c':
        c = *args++;
    default:
        *(ps = s) = c;
        s[1] = '\0';
}

k = strlen(ps);
slen = k > precisn ? precisn : k;

if (rjustify)
    while (width-- > slen)
        if (zerofill)
            putchar('0');
        else
            putchar(' ');

for (k = 1; *ps && k <= precisn; ++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

## Programming Quickies

---

Listing 1 continued:

```
        *--s = '0';
else
    while (n > 0) {
        *--s = (d = n%base) + (d < 10 ? '0' : 55);
        n /= base;
    }
return s;
}
```

```
nspect(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 s%loct: %a ", 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

## Programming Quickies

Listing 2 continued:

```
printf(":%Z-20.10s:\n", string);
printf(":%Z.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:	000000000010000
dec:	32	oct:	40	sploct:	000.040	hex:	20	bin:	000000000100000
dec:	64	oct:	100	sploct:	000.100	hex:	40	bin:	000000001000000
dec:	128	oct:	200	sploct:	000.200	hex:	80	bin:	000000010000000
dec:	256	oct:	400	sploct:	001.000	hex:	100	bin:	000000010000000
dec:	512	oct:	1000	sploct:	002.000	hex:	200	bin:	000000100000000
dec:	1024	oct:	2000	sploct:	004.000	hex:	400	bin:	000001000000000
dec:	2048	oct:	4000	sploct:	010.000	hex:	800	bin:	000010000000000
dec:	4096	oct:	10000	sploct:	020.000	hex:	1000	bin:	000100000000000
dec:	8192	oct:	20000	sploct:	040.000	hex:	2000	bin:	001000000000000
dec:	16384	oct:	40000	sploct:	100.000	hex:	4000	bin:	010000000000000

```
: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. "Nspect(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:

$$Y = a_0 + a_1X + a_2X^2 + a_3X^3 + \dots + a_mX^m$$

where  $m$  is the degree of the polynomial and  $a_0, a_1, \dots, a_m$  are the coefficients.

For a given set of  $n$  pairs of data, there is usually a polynomial of degree  $m$  with corresponding coefficients  $a_0, a_1, \dots, a_m$  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  $X$ s and  $Y$ s are in the neighborhood of the range  $[(X_1, Y_1), (X_n, Y_n)]$  where  $X_1 < X_2 < \dots < X_n$ .

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:

$$a_1 + 2a_2X + 3a_3X^2 + \dots + ma_mX^{m-1} = 0$$

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  $(X_1, Y_1), \dots, (X_n, Y_n)$ , 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  $a_0, a_1, \dots, a_m$  of a polynomial of degree  $m$  may be determined from the following  $m+1$  simultaneous equations:

$$\begin{aligned} c_{11}a_0 + c_{12}a_1 + c_{13}a_2 + \dots + c_{1[m+1]}a_m &= b_1 \\ c_{21}a_0 + c_{22}a_1 + c_{23}a_2 + \dots + c_{2[m+1]}a_m &= b_2 \\ \vdots & \vdots \\ c_{[m+1]1}a_0 + c_{[m+1]2}a_1 + \dots + c_{[m+1][m+1]}a_m &= b_{[m+1]} \end{aligned} \quad (1)$$

where:

$$b_i = \sum x^{i-1}y$$

$$c_{ij} = \sum x^{i+j-2}$$

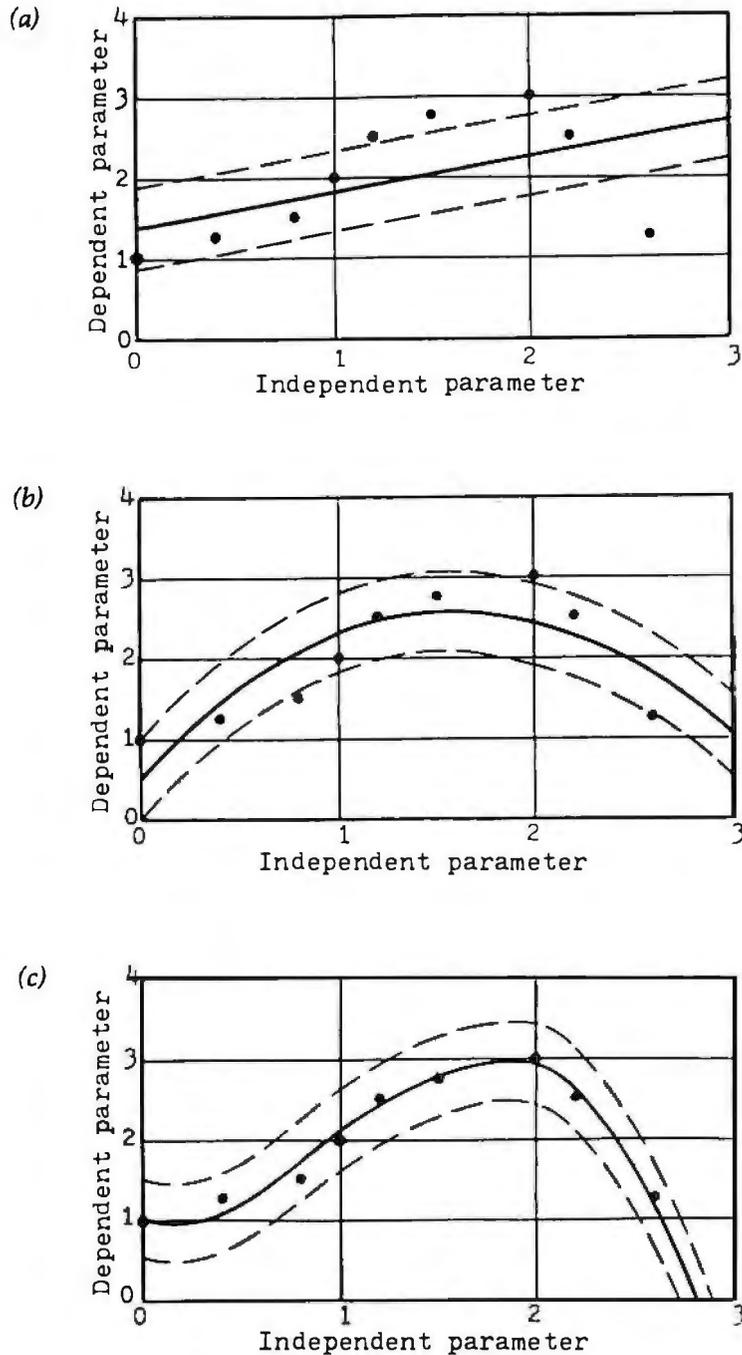
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### About the Author

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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.

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**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  $50 \pm 0.5$  inches and  $50$  inches  $\pm 1\%$ , 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  $a_0, a_1, \dots, a_m$ . 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		
		N	DO loop index for loop which calculates root of $f(X)=0$
A (M)	$a_m$ , the mth coefficient of a least-squares polynomial	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 $X_{STA}$ )
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 $a_0, \dots, a_m$	NEWTON	Code used in subroutine NEWRAP having the same function as NCODE; its value is transmitted from main program
ERR	$ f(X_n)/f'(X_n) $ , absolute value of the nth incurring error in the determination of X for which $f(X)=0$ by Newton-Raphson method	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 $\epsilon$ (this new value will be returned to main program)
ERROR	$\epsilon$ , 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	NMINUS	$N-1$
ERT	$\epsilon_{Y=0}$ , allowable error in the determination of $X_{Y=0}$	NPAIRS	Number of pairs of data
EROOT	Error in the determination of $X_{Y=0}$ (before calling subroutine NEWRAP: allowable error; after: resulting error)	NPLUS	$N+1$
ESTN	$\epsilon_{STA}$ , allowable error in the determination of $X_{STA}$	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)
ESTATN	Error in the determination of $X_{STA}$ (before calling subroutine NEWRAP: allowable error; after: resulting error)	NROOT	Similar to NITERA, except that it is in main program and is used primarily for calculating $X_{Y=0}$
I	DO loop index	NSTATN	Similar to NITERA, except that it is in main program and is used primarily for calculating $X_{STA}$
ICHANG	String input specifying the name of the particular variable of which the value is to be changed	SUM	$\Sigma s$ , summations representing $b_i$ or $c_{ij}$
ICONTI	String input (YES or NO) to continue or to stop the process of changing values of some variables	UNCERT	Uncertainty margin, may be entered as absolute or relative value
IROOT	Code indicating whether the calculation of $X_{Y=0}$ is needed or not (0: No, 1: Yes)	UNMARG	Uncertainty margin, calculated from the given UNCERT and IUNCER, and is converted into an absolute value
ISTATN	Code indicating whether the calculation of $X_{STA}$ is needed or not (0: No, 1: Yes)	X(N)	$X_s$ , data entered as independent parameters
IUNCER	Code indicating whether the uncertainty is entered as absolute or relative value (0: absolute, 1: relative)	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)
J	DO loop index	XS(N)	$X_n$ , nth value of iterated X in Newton-Raphson formula
K	DO loop index	XRT1	Similar to X0, except that it is in main program and is used primarily for calculating $X_{Y=0}$
KPLUS	$K+1$	XSTN1	Similar to X0, except that it is in main program and is used primarily for calculating $X_{STA}$
LROOT	ROOT, string variable for printout purpose	Y(N)	$Y_s$ , data entered as dependent parameters
LSTAT	STATN, string variable for printout purpose	YDEN	$f'(X_n)$ , denominator value in Newton-Raphson formula
M	DO loop index	YNUM	$f(X_n)$ , numerator value in Newton-Raphson formula
MDEG	$m$ , degree of the least-squares polynomial to be fitted through the given set of data, used as the first trial	YOFX	$Y(X)$ , value of Y corresponding to a given value of X
MDEGRE	Incrementing $m$ , starting from MDEG to a maximum of 10		
MMINUS	$M-1$		
MPLUS1	$MDEGRE+1$		
MPLUS2	$MDEGRE+2$		

**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.**

```

00100 PROGRAM CURFIT (INPUT,OUTPUT)
00110 DIMENSION X(100),Y(100),A(11),C(11,12)
00120 CDHMON/BLOCK/A,MPLUS1,MPLUS2
00130*****
00140***** DATA STATEMENTS
00150*****
00160 DATA NPAIRS,MDEG,UNCERT,UNCERT,IROOT,XRT1,ERT,ISTATN,XSTN1,ESTN/
00170+10,1,0,,1,1,-1,,.001,1,0,,.001
00180+/,X/
00190+2,-1,5,-1,,0,,1,,2,,2,5,3,4,,5,
00200+/,Y/
00210+-25,1,-6,9,3,1,5,-6,9,-21,-25,-25,1,-7,,45,
00220+/
00230***** FORMAT STATEMENTS
00250*****
00260 10 FORMAT (//2X,12HTHE DESIRED ,I2,47H-TH DEGREE LEAST-SQUARES EQUATION HA
00270+S A FORM OF ,/5X,14HY(X) = SUM OF ,I2,19H-TERMS OF A(I)*X**I,5X,12HI = 0,1
00280+... , I2//20X,1HI,5X,4HA(I),/19X,3H----,2X,8H-----//)
00290 20 FORMAT (19X,I2,3X,F8,3)
00300 30 FORMAT (//2X,6HAFTER ,I2,35H ITERATIONS, THE OBTAINED VALUE OF ,A6,3H I
00310+S ,F8,3,7H GIVING ,/12HAN ERROR OF ,F8,5,2X,33HIF YOU WANT TO TRY NEW VALUE
00320+S OF ,A6,11H AND ERROR,,/45HENTER THEM IN THAT ORDER; IF NOT, ENTER 0,0,.)
00330 40 FORMAT (/2X,6HAFTER ,I2,35H ITERATIONS, THE OBTAINED VALUE OF ,A6,4H IS
00340+ ,F8,3)
00350 50 FORMAT (//2X,*DD YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, E
00360+RT, ESTN*,/1X,*XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)*
00370 60 FORMAT (/2X,*ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN IT
00380+S NEW VALUE)
00390 70 FORMAT (/2X,*ANY MORE VARIABLES TO BE CHANGED ?*)
00400 80 FORMAT (//2X,*ALTHOUGH A ,I2,2-H DEGREE LEAST SQUARES CURVE HAS BEEN
00410+FITTED THROUGH THE ,/1X,*GIVEN SET OF DATA, THE SPECIFIED UNCERTAINTY MARG
00420+IN IS NOT YET SATISFIED*)
00430 90 FORMAT (2X,*THE CORRESPONDING VALUE OF Y(XSTATN) IS ,F8,3)
00440 100 FORMAT (//2X,*THE SPECIFIED DEGREE OF THE LEAST SQUARES EQUATION IS =>
00450+ THE NUMBER ,/1X,*OF PAIRS OF DATA, REENTER MDEG (< NPAIRS *)
00460*****
00470***** DEFINITIONS OF SOME VARIABLES
00480*****
00490 LROOT=5HXROOT
00500 LSTAT=6HXSTATN
00510 110 MDEG=MDEG
00520 112 EROOT=ERT
00530 ESTATN=ESTN
00540 115 IF (MDEG.LE.LT.NPAIRS) GO TO 120
00550 PRINT 100
00560 READ,MDEG
00570 GO TO 110
00580 120 NROOT=NSTATN=20
00590 MPLUS1=MDEG+1
00600 MPLUS2=MDEG+2
00610*****
00620***** DETERMINATION OF ALL SUMMATIONS IN THE SET OF M+1 SIMULTANEOUS EQNS.
00630*****
00640 DO 210 I=1,MPLUS1
00650 DO 200 J=1,MPLUS2
00660 SUM=0,
00670 DO 220 N=1,NPAIRS
00680 IF (J.NE.MPLUS2) SUM=SUM+X(N)**(I+J-2)
00690 IF (J.EQ.MPLUS2) SUM=SUM+Y(N)*X(N)**(I-1)
00700 220 CONTINUE
00710 C(I,J)=SUM
00720 200 CONTINUE
00730 210 CONTINUE
00740*****
00750***** DETERMINATION OF COEF. A0, ..., AM OF THE M-TH DEGREE LEAST-SQUARES
00760***** POLYNOMIAL BY GAUSS-JORDAN ELIMINATION METHOD
00770*****
00780 DO 330 K=1,MPLUS1
00790 KPLUS=K+1
00800 DO 300 J=KPLUS,MPLUS2
00810 C(K,J)=C(K,J)/C(K,K)
00820 300 CONTINUE
00830 DO 320 I=1,MPLUS1
00840 IF (I.EQ.K) GO TO 320
00850 DO 310 J=MPLUS1,MPLUS2
00860 C(I,J)=C(I,J)-C(I,K)*C(K,J)
00870 310 CONTINUE
00880 320 CONTINUE
00890 330 CONTINUE
00900*****
00910***** CHECK FOR UNCERTAINTY REQUIREMENTS
00920*****
00930 DO 410 N=1,NPAIRS
00940 YDFX=0,
00950 DO 400 M=1,MPLUS1
00960 A(M)=C(M,MPLUS2)
00970 YDFX=YDFX+(M)*X(N)**(M-1)
00980 400 CONTINUE
00990 IF (IUNCER.NE.1) UNMARG = UNCERT
01000 IF (IUNCER.EQ.1) UNMARG = ABS(UNCERT*YDFX)
01010 IF (ABS(Y(N)-YDFX).LE.UNMARG) GO TO 410
01020 MDEG=MDEG+1
01030 IF (MDEG.LE.LT.NPAIRS.AND.I.MDEG.LE.10) GO TO 112
01040 MDEG=MDEG-1
01050 PRINT 80,MDEG
01060 GO TO 700
01070 410 CONTINUE
01080*****
01090***** PRINT-OUT OF COEF. A0, ..., AM OF THE OBTAINED M-TH DEGREE
01100***** LEAST SQUARES EQUATION
01110*****
01120 PRINT 10,MDEG,MPLUS1,MDEG
01130 DO 500 M=1,MPLUS1
01140 MMINUS=M-1
01150 PRINT 20,MMINUS,A(M)
01160 500 CONTINUE
01170*****
01180***** CALCULATION OF VALUES OF X:ROOT OR XSTA
01190*****
01200 IF (MDEG.EQ.1) IROOT=0
01210 550 IF (IROOT.NE.1.AND.ISTATN.NE.1) GO TO 700
01220 IF (IROOT.NE.1) GO TO 620
01230 600 NCODE = 1
01240 CALL NEWRAF (XRT1,ERDOT,NROOT,NCODE)
01250 IF (NROOT.LT.20) GO TO 610
01260 PRINT 30,NROOT,LROOT,XRT1,ERDOT,LROOT
01270 READ,XRT1,ERT
01280 EROOT=ERT
01290 IF (XRT1.EQ.0..AND.ERDOT.EQ.0.) GO TO 620
01300 GO TO 600
01310 610 PRINT 40,NROOT,LROOT,XRT1
01320 620 IF (ISTATN.NE.1) GO TO 700
01330 630 NCODE = 2
01340 CALL NEWRAF (XSTN1,ESTATN,NSTATN,NCODE)
01350 IF (NSTATN.LT.20) GO TO 640
01360 PRINT 30,NSTATN,LSTAT,XSTN1,ESTATN,LSTAT
01370 READ,XSTN1,ESTN
01380 ESTATN=ESTN
01390 IF (XSTN1.EQ.0..AND.ESTATN.EQ.0.) GO TO 700
01400 GO TO 630
01410 640 PRINT 40,NSTATN,LSTAT,XSTN1
01420 YDFX=0,
01430 DO 650 M=1,MPLUS1
01440 YDFX=YDFX+(M)*XSTN1**(M-1)
01450 650 CONTINUE
01460 PRINT 90,YDFX
01470*****
01480***** CHANGING VALUES OF SOME VARIABLES
01490*****
01500 700 PRINT 30
01510 READ,ICONTI
01520 IF (ICONTI.EQ.2HND) GO TO 800
01530 NRERUN=0
01540 710 PRINT 60
01550 READ,ICHANG
01560 IF (ICHANG.EQ.4HMDEG) READ,MDEG
01570 IF (ICHANG.EQ.6HUNCERT) READ,UNCERT
01580 IF (ICHANG.EQ.3HERT) READ,ERT
01590 IF (ICHANG.EQ.4HESTN) READ,ESTN
01600 IF (ICHANG.EQ.4HXRT1) READ,XRT1
01610 IF (ICHANG.EQ.5HXSTN1) READ,XSTN1
01620 IF (ICHANG.EQ.6HIUNCER) READ,IUNCER
01630 IF (ICHANG.EQ.6HIROOT) READ,IROOT
01640 IF (ICHANG.EQ.6HISTATN) READ,ISTATN
01450 NROOT=NSTATN=20
01460 EROOT=ERT
01670 ESTATN=ESTN
01680 IF (ICHANG.EQ.4HMDEG.OR.ICHANG.EQ.6HUNCERT.OR.ICHANG.EQ.UNCERT) NRERUN=1
01690 PRINT 70
01700 READ,ICONTI
01710 IF (ICONTI.EQ.3HYES) GO TO 710
01720 IF (NRERUN.EQ.1) GO TO 110
01730 GO TO 550
01740 800 STOP
01750 END
01760*****
01770***** CALCULATION OF ROOT OF F(X)=0, AT THE NEIGHBORHOOD OF X=X0,
01780***** BY NEWTON-RAPHSON METHOD
01790*****
01800 SUBROUTINE NEWRAF (X0,ERROR,NITERA,NEWTON)
01810 DIMENSION XS(21),A(11)
01820 COMMON/BLOCK/A,MPLUS1,MPLUS2
01830 XS(1)=X0
01840 IF (X0.EQ.0.) XS(1)=X0+.0001
01850 DO 950 N=1,NITERA
01860 NPLUS=N+1
01870 MMINUS=N-1
01880 910 YNUM=YDEN=0,
01890 DO 930 I=1,MPLUS1
01900 IF (NEWTON.EQ.2) GO TO 920
01910 YNUM=YNUM+A(I)*XS(N)**(I-1)
01920 YDEN=YDEN+(I-1)*A(I)*XS(N)**(I-2)
01930 GO TO 930
01940 920 YNUM=YNUM+(I-1)*A(I)*XS(N)**(I-2)
01950 YDEN=YDEN+(I-1)*(I-2)*A(I)*XS(N)**(I-3)
01960 930 CONTINUE
01970 IF (YDEN.NE.0.) GO TO 940
01980 XS(N)=(XS(N)+XS(MMINUS))/2,
01990 GO TO 910
02000 940 ERR=ABS(YNUM/YDEN)
02010 IF (ERR.LE.ERROR) GO TO 960
02020 XS(NPLUS)=XS(N)-YNUM/YDEN
02030 950 CONTINUE
02040 X0=XS(NPLUS)
02050 GO TO 970
02060 960 X0=XS(N)-YNUM/YDEN
02070 970 ERROR=ERR
02080 NITERA=N
02090 RETURN
02100 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  $c_{21}$ ,  $c_{31}$ , . . . ,  $c_{m+11}$ ;

and then subtracting the obtained equations respectively from the second, third, . . . ,  $(m+1)$ th equations. The resulting set of equations is of the form:

$$\begin{aligned}
 a_0 + c'_{12}a_1 + c'_{13}a_2 + \dots + c'_{1m+1}a_m &= b'_1 \\
 c'_{22}a_1 + c'_{23}a_2 + \dots + c'_{2m+1}a_m &= b'_2 \\
 &\vdots \\
 c'_{m+12}a_1 + \dots + c'_{m+1m+1}a_m &= b'_{m+1}
 \end{aligned} \tag{2}$$

• 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  $c'_{32}, c'_{42}, \dots, c'_{[m+1]2}$ ; and then subtracting the obtained equations respectively from the third, fourth,  $\dots$ ,  $(m+1)$ th equations.

• The elimination process continues until the system is of the form:

$$\begin{aligned} a_0 + c'_{12}a_1 + c'_{13}a_2 + \dots + c'_{1[m+1]}a_m &= b'_1 \\ a_1 + c'_{23}a_2 + \dots + c'_{2[m+1]}a_m &= b'_2 \\ &\vdots \\ &\vdots \\ c'_{[m+1]} a_m &= b'_{[m+1]} \end{aligned} \quad (3)$$

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  $i$ th equation). Thus, at the end of the process, the final set of equations is of the form:

$$\begin{aligned} a_0 &= b'_1 \\ a_1 &= b'_2 \\ &\vdots \\ &\vdots \\ a_m &= b'_{[m+1]} \end{aligned} \quad (4)$$

As we notice, the values of  $a_0, a_1, \dots, a_m$  are obtained

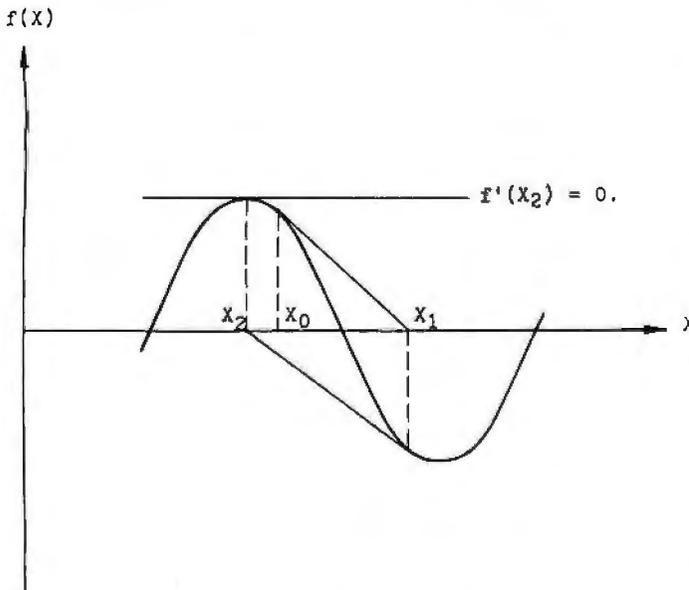


Figure 2: An example of a function  $f(X)$  that is not monotonically increasing or decreasing. This is clearly an undesirable situation for application of the Newton-Raphson method as the successive approximations diverge rather than converge on the desired root of the equation.

directly from equation set (4) as  $b'_1, b'_2, \dots, b'_{[m+1]}$ .

One remark about this method is that the values  $c_{11}, c'_{22}, \dots$  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  $c$ .

### 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:

$$Y = a_0 + a_1X + a_2X^2 + \dots + a_mX^m$$

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:

$$\begin{aligned} Y &= a_0 + a_1X + a_2X^2 + \dots + a_mX^m = 0 \\ Y' &= a_1 + 2a_2X + 3a_3X^2 + \dots + ma_mX^{m-1} = 0 \end{aligned}$$

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

$$X_{n+1} = X_n - \frac{f(X_n)}{f'(X_n)} \quad n = 1, 2, \dots$$

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  $\epsilon$  is obtained, that is

$$|X_{n+1} - X_n| \leq \epsilon \quad \text{or} \quad |f(X_n)/f'(X_n)| \leq \epsilon$$

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:

$$\begin{aligned} (X_{Y=0})_{n+1} &= (X_{Y=0})_n - \frac{Y[(X_{Y=0})_n]}{Y'[(X_{Y=0})_n]}, \quad \left| \frac{Y[(X_{Y=0})_n]}{Y'[(X_{Y=0})_n]} \right| \leq \epsilon_{Y=0} \\ (X_{STA})_{n+1} &= (X_{STA})_n - \frac{Y'[(X_{STA})_n]}{Y''[(X_{STA})_n]}, \quad \left| \frac{Y'[(X_{STA})_n]}{Y''[(X_{STA})_n]} \right| \leq \epsilon_{STA} \end{aligned}$$

### 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   5.070
      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  -4.22
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,.,24,18,56,19,03,19,42,19,74,19,09
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  $\epsilon_{ST_A}$  required in the calculation of  $X_{Y=0}$  and  $X_{ST_A}$ .
- Determine the least-squares polynomial and the values of  $X_{Y=0}$  and  $X_{ST_A}$ .
- 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  $X_{ST_A}$  (this

is helpful when the least-squares function in question has more than one value of  $X_{Y=0}$  or  $X_{ST_A}$  in the range under consideration), and desired accuracy margins  $\epsilon_{Y=0}$  and  $\epsilon_{ST_A}$ . (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  $X_{ST_A}$  the desired accuracy so that a new value of  $\epsilon_{Y=0}$  or  $\epsilon_{ST_A}$  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.

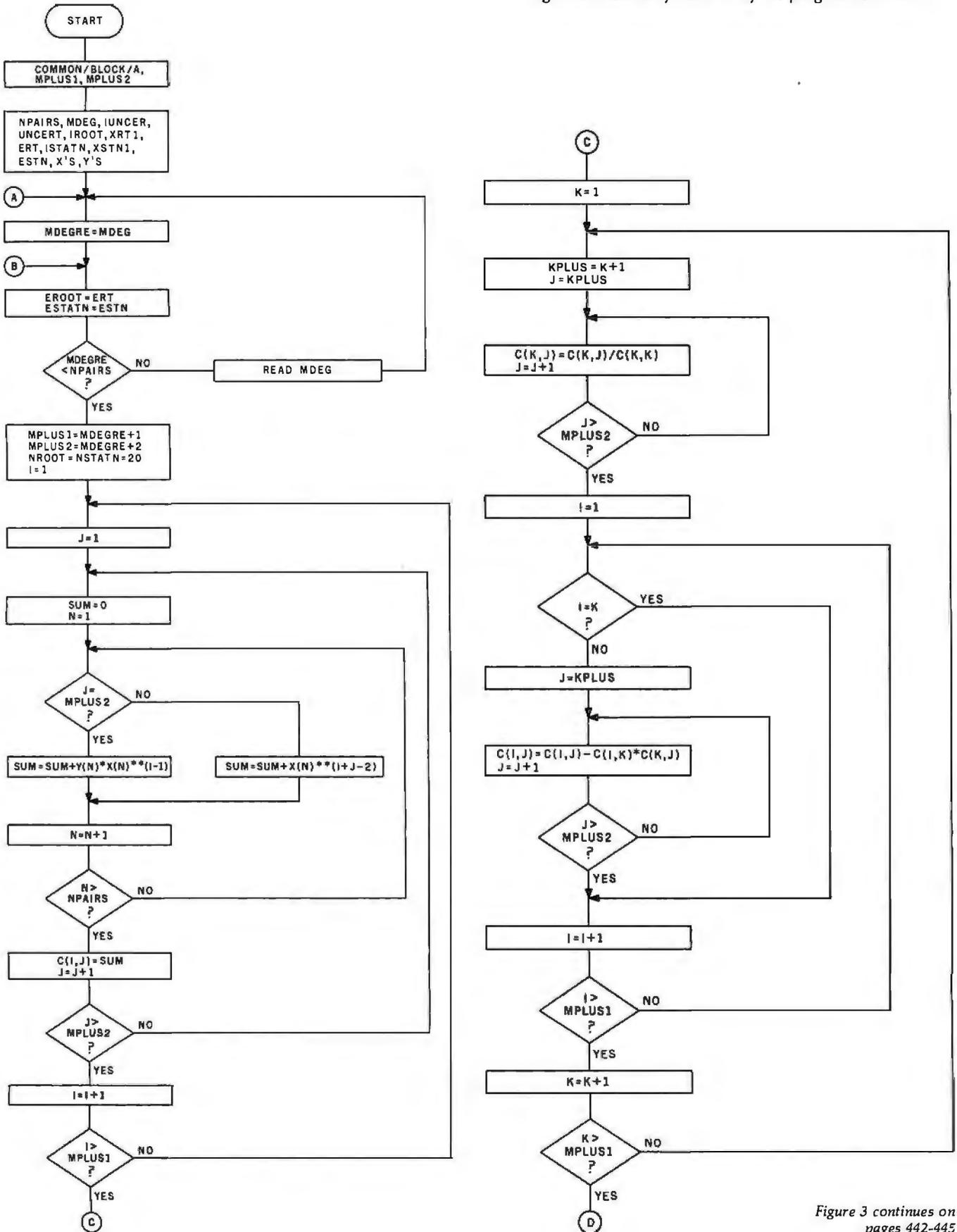


Figure 3 continues on pages 442-445

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  $i$ th 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

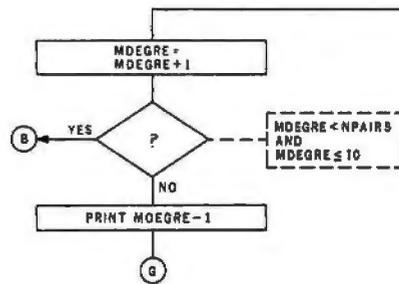


Figure 3 continued:

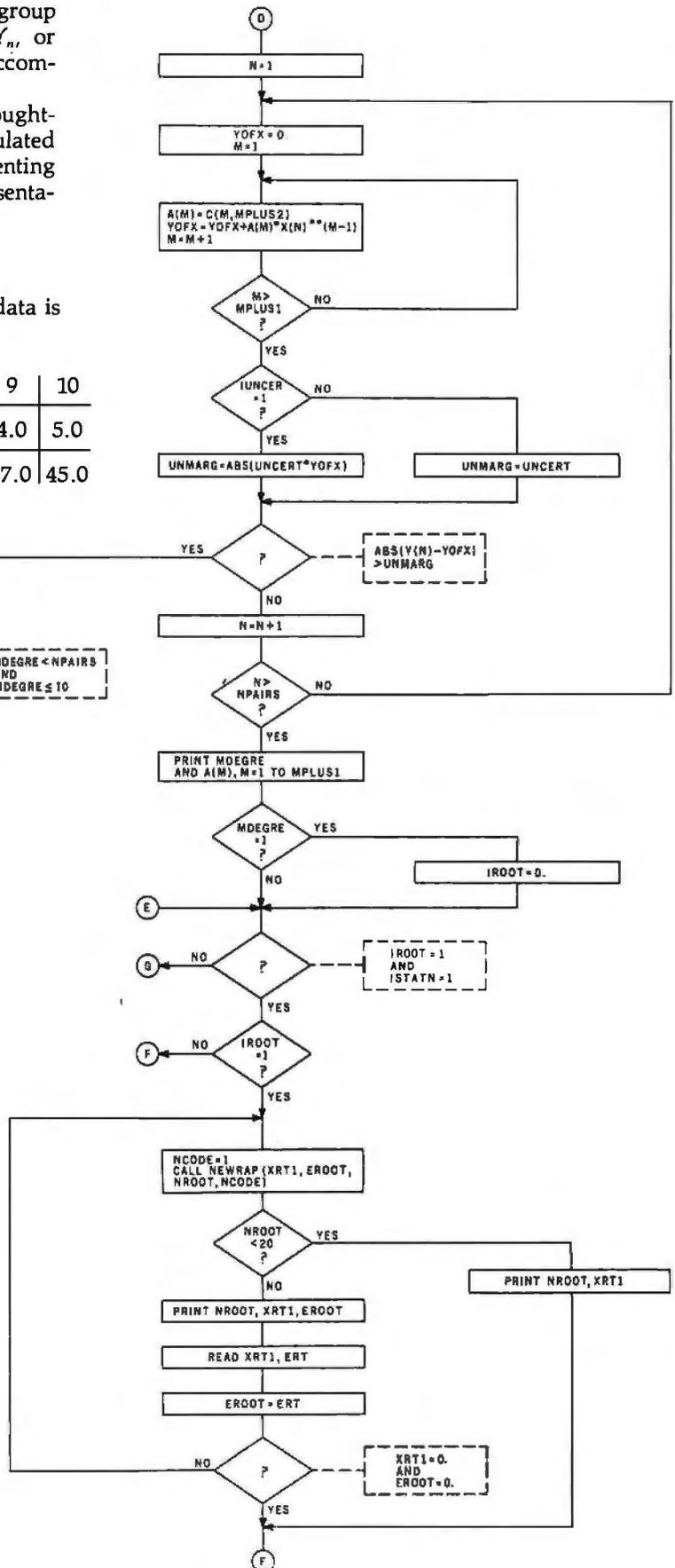


Figure 3 continued:

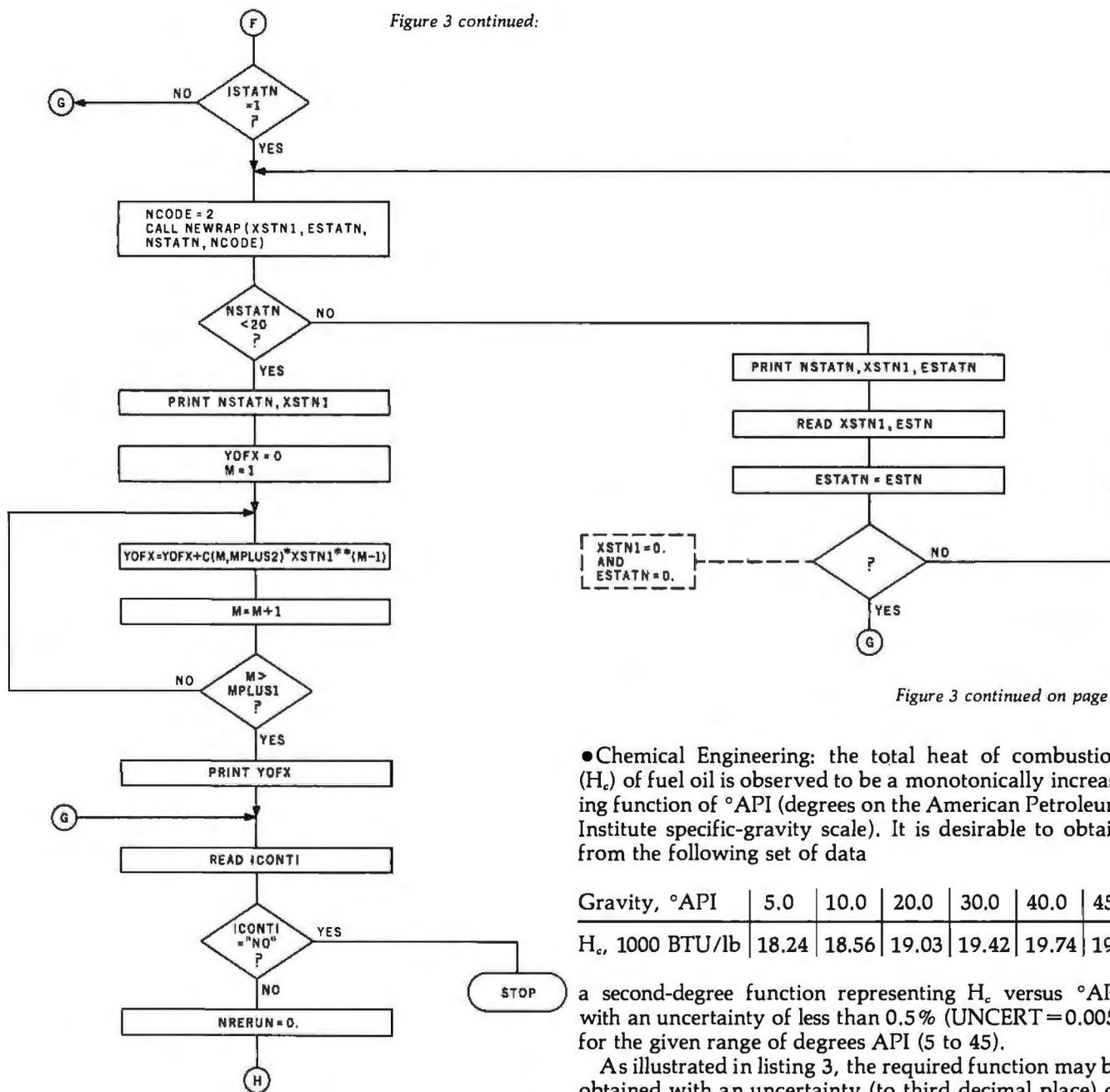


Figure 3 continued on page 444

•Chemical Engineering: the total heat of combustion ( $H_c$ ) of fuel oil is observed to be a monotonically increasing function of  $^{\circ}\text{API}$  (degrees on the American Petroleum Institute specific-gravity scale). It is desirable to obtain from the following set of data

Gravity, $^{\circ}\text{API}$	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  $^{\circ}\text{API}$  with an uncertainty of less than 0.5% ( $\text{UNCERT} = 0.005$ ) 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:

$$H_c = 17.960 + .062(^{\circ}\text{API}) - \text{negligible term} \\ (^{\circ}\text{API})^2, \pm 0.2\%$$

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 $\epsilon$ ( $10^{-3}$ inch/inch)	0.1	0.2	0.3	0.5	0.6	0.8	1.0
unit stress $\sigma$ (kips /inch $^2$ )	0.44	0.82	1.21	1.78	2.08	2.54	2.83

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  $X_s$  (-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.

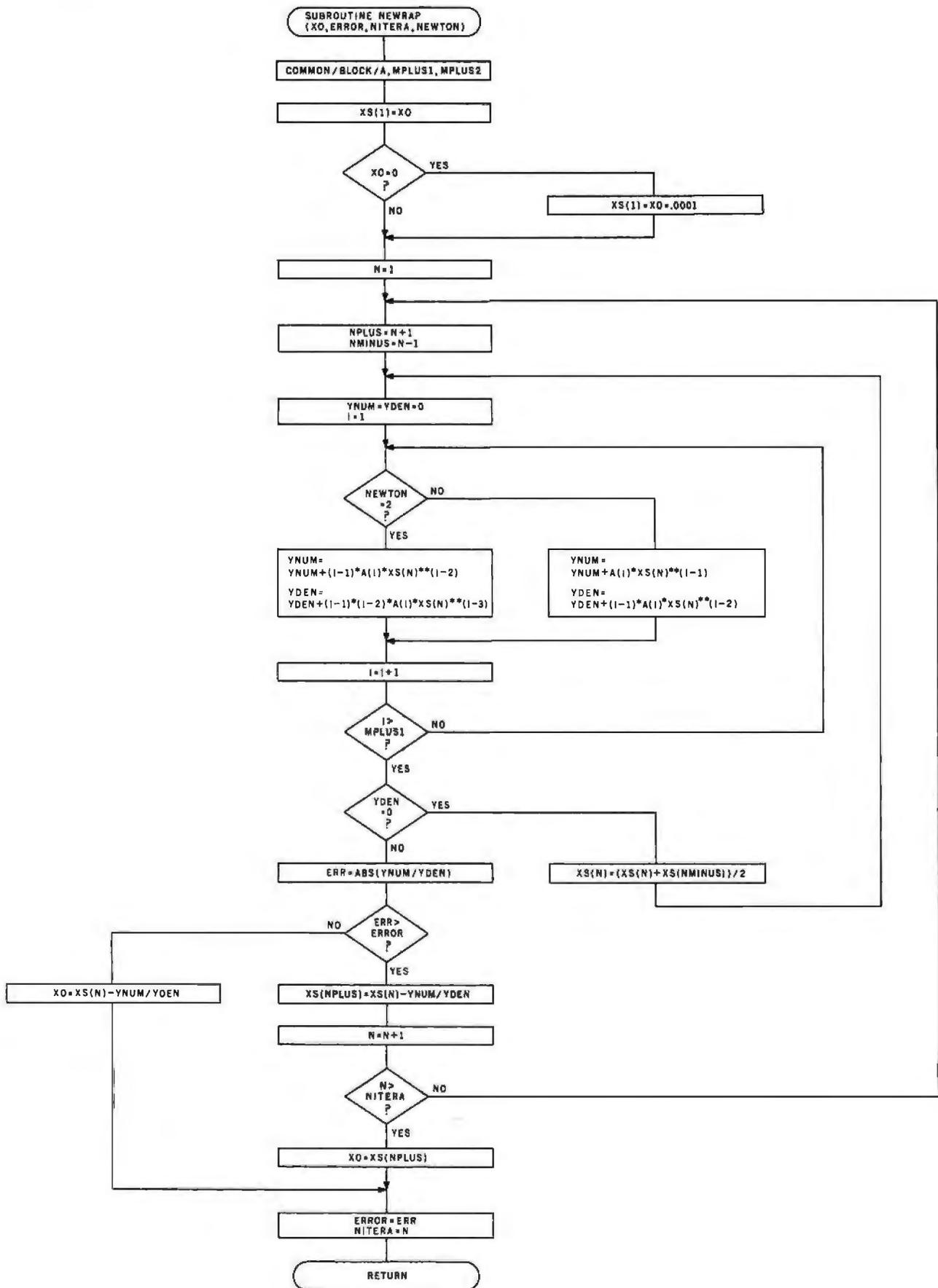
Listing 2 illustrates some possible inputs and outputs for this particular example.

### 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:



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  $\pm 0.02$  kips/inch<sup>2</sup>, from listing 4 we know that a sixth-degree polynomial representing  $\sigma$  versus  $\epsilon$  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,.03,0,0,0,0,0,0,0.
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<sup>I</sup> 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<sup>I</sup> 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<sup>I</sup> I = 0,1,...,8

I	A(I)
0	128.423
1	-32.917
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

• **Electrical Engineering:** in an electrical testing laboratory, a technician obtains the following set of data for the determination of resistance  $R_0$  at 0°C and temperature coefficient of resistance  $\alpha$  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:

$$R_T = R_0(1 + \alpha T) = 199.937 + 0.785T, \pm 0.05\% \\ \text{or } R_0 = 199.937 \text{ ohms} \\ \alpha = 0.785/199.937 = 0.00393 (\text{°C})^{-1}$$

This value of  $\alpha$  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. Word-processing 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 cities 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.

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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 Mid-

land, 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.

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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,

## Event Queue

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 Num-

erical 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. Videotex 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.

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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, On-

tario, 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

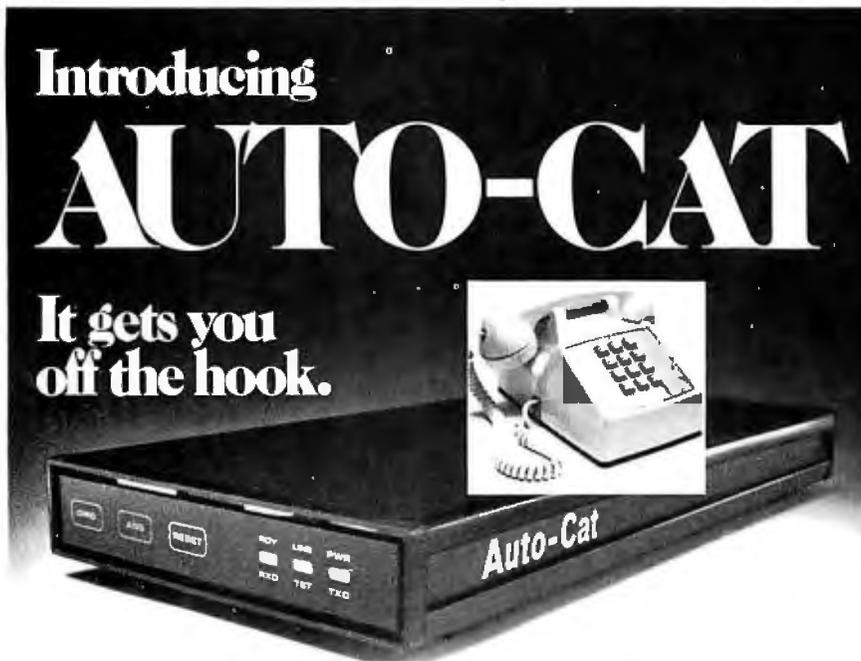
**Understanding and Using Computer Graphics**, Chicago IL. This seminar covers the latest in graphic-system technology, including hardware, software, and applications. Contact Bob Sanzo, Frost & Sullivan Inc, 106 Fulton St, New York NY 10038, (212) 233-1080.

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



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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. ■



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# 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

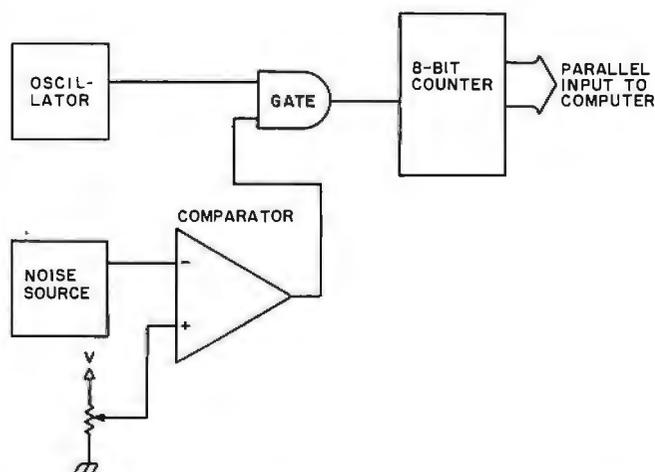


Figure 1: Block diagram of a generator that produces true random numbers. Through pulses created by the random-noise source, the free-running oscillator is gated to the 8-bit binary counter. Since the instantaneous amplitude of the voltage from the noise source is unpredictable, the width and arrival 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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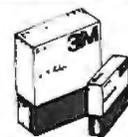
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## Technical Forum

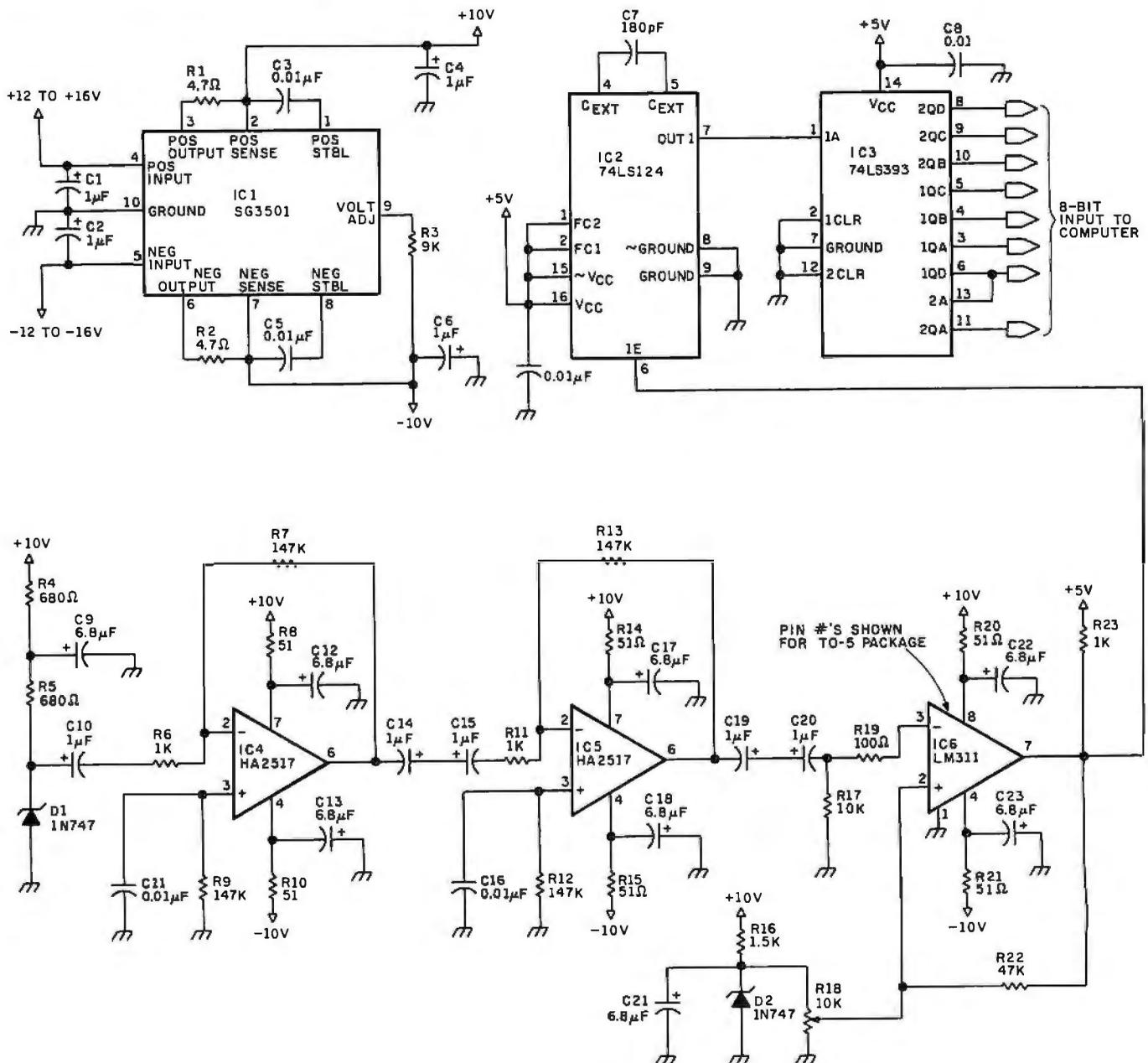
to the microprocessor clock in the computer is gated to an 8-bit binary counter through pulses created by a random-noise source. Since the instantaneous amplitude of the voltage from the noise source is not predictable, the width and the time of arrival of the gate pulse generated by the comparator are 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 occur-

ring. 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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## 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  $-64 < \text{data} < 64$  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  $-128 \leq \text{data} < 127$ . 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  $45^\circ$ , 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  $M = \text{INT}(127 / (1 + \sqrt{2})) = 52$ .

Thus, the data should be scaled before *each* pass if any point exceeds the range  $-52 \leq \text{data} \leq 52$ . 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  $128 \pm 127$  down to  $128 \pm 1$  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*



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**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      0010      FAST FOURIER TRANSFORM.
0000      0020      ;=====
0000      0030      ;ORIGINAL:- MARCO FFT PYTF FFD 1979.
0000      0040      ;8080 VERSION BY:- ALASTAIR ROXBURGH.
0000      0050      ;DATE:- 4 OCT 1979.
0000      0060      ;256 POINT IN-PLACE COMPLEX FOURIER TRANSFORM.
0000      0070      ;INPUT DATA UNSIGNED WITH ZERO = RMH.
0000      0080      ;COMPLEX OUTPUT SIGNED (2'S COMP.).
0000      0090      ;REAL OUTPUT (POWER OR AMPLITUDE) UNSIGNED.
0000      0100      ;
0000      0110      ;
0000      0120      SQRD EQU 9F00H ;2'S COMP. SQR. TABLE.
0000      0130      STADR EQU 9F00H ;2'S COMP. SINE TABLE.
0000      0140      ;
0000      0150      ORG 8300H
0000      0160      RLPT1 DS 2 ;REAL PTR 1.
0000      0170      RLPT2 DS 2 ;REAL PTR 2.
0000      0180      IMPT1 DS 2 ;IMAG. PTR 1.
0000      0190      IMPT2 DS 2 ;IMAG. PTR 2.
0000      0200      SINPT DS 2 ;SINE TABLE PTR.
0000      0210      CFLCT DS 1 ;CFL. CTR.
0000      0220      CFLNUM DS 1 ;NO. OF CELLS.
0000      0230      PAIRNM DS 1 ;PAIRS PER CELL.
0000      0240      CFLDIS DS 1 ;SPAN BETWEEN PAIRS.
0000      0250      DFLTA DS 1 ;ANGLE INCREMENT.
0000      0260      SCLFCT DS 1 ;MULTIPLY OUTPUT AMPLITUDE
0000      0270      ; BY 1/SCLFCT.
0000      0280      SINE DS 1
0000      0290      COSINE DS 1
0000      0300      RFAL DS 1
0000      0310      TIMAG DS 1
0000      0320      ;
0000      0330      ORG 8400H
0000      0350      INPD DS 256 ;INPUT DATA BUFF.
0000      0360      RFAL DS 256 ;"REAL" BUFF.
0000      0370      IMAG DS 256 ;"IMAG" BUFF.
0000      0380      ;
0000      0390      ORG 877FH
0000      0400      0395      PARUF DS 190 ;POWER/AMPLITUDE SPECTRUM.
0000      0410      ;
0000      0420      ORG 8800H
0000      0430      ;
0000      0440      ;FAST FFT PROGRAM.
0000      0450      ;
0000      0460      CALL WAVF ;GET FAST SIGNAL.
0000      0470      CALL FFT ;FORM COMPLEX SPECTRUM.
0000      0480      CALL POWER ;CONVERT COMPLEX SPECTRUM
0000      0490      ; TO 128 BIT POWER SPECTRUM.
0000      0500      ;CALL MAGNI ;CONVERT COMPLEX SPECTRUM
0000      0510      ; TO 128 BIT AMPLITUDE SPECTRUM
0000      0520      JMP DAVEFH ;RETURN TO BMCDS.
0000      0530      ;
0000      0540      ;
0000      0550      ;
0000      0560      ;
0000      0570      ;INITIALISE DATA AREAS.
0000      0580      ;
0000      0590      FTT: MVI A,0
0000      0600      STA SCLFCT
0000      0610      ;
0000      0620      CLEAR IMAG. ARRAY.
0000      0630      CLR: LXI H,IMAG
0000      0640      CLR: MVI M,0
0000      0650      INR L
0000      0660      JNZ CLR1
0000      0670      ;
0000      0680      ;MOVE INPUT DATA INTO REAL ARRAY.
0000      0690      ;SOURCE: HL=DFST.
0000      0700      MOVF: LXI D,INPD
0000      0710      MOVF: LXI H,RFAL
0000      0720      MOV: LDAX D
0000      0730      SUI RMH ;CONVERT TO 2'S COMPLEMENT.
0000      0740      MOV M,A
0000      0750      INR F
0000      0760      INR I
0000      0770      JNZ MOVF1
0000      0780      ;
0000      0790      ;PUF-TRANSFORM BIT SWAP.
0000      0800      ;
0000      0810      LXI D,RFAL
0000      0820      LXI H,RFAL
0000      0830      DITRFV:MVI R,R ;SFT BIT CTR.
0000      0840      MOV A,L ;LOW-ORDER BITS OF RLPT1.
0000      0850      RRV1: RAR ;MOVE LS BIT OF RLPT1
0000      0860      MOV C,A ; INTO CY & SHIFT
0000      0870      MOV A,F
0000      0880      RAL ; IN REVERSE ORDER PACK
0000      0890      MOV F,A ; INTO RLPT2.
0000      0900      MOV A,C
0000      0910      DCR R
0000      0920      JNZ RRV1
0000      0930      MOV A,L
0000      0940      CXP F ;CROSSPAR VALS, & IF
0000      0950      JC SWP1 ;SAMP. DON'T SWAP.
0000      0960      SWAP: MOV C,M ;GET VAL 1 INTO C.
0000      0970      LXI D,0 ;GET VAL 2 INTO A.
0000      0980      MOV M,A ;STORE IN SWAPPED ORDER.
0000      0990      MOV A,C
0000      1000      STAX D
0000      1010      SWP1: INR L
0000      1020      JNZ DITRFV
0000      1030      ;
0000      1040      ;FFT FIRST PASS.
0000      1050      ;
0000      1060      PASS1:CALL SCALF ;SCALF IF DATA OVR-RANGE.
0000      1070      LXI H,REAL
0000      1080      PA1: MOV A,M ;GET RM.
0000      1090      MOV C,A ;SAVE RM.
0000      1100      INR L
0000      1110      MOV B,M ;GET RM TOO.
0000      1120      DCR L
0000      1130      ADD R ;RM' = RM+RM.
0000      1140      MOV M,A ;STORE NEW RM'.
0000      1150      MOV A,C ;GETRIFUE RM.
0000      1160      SUB R ;RM' = RM-RM.
0000      1170      INR L
0000      1180      MOV M,A ;STORE RM'.
0000      1190      ;
0000      1200      ;
0000      1210      ;
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Listing 1 continued:

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R135 7F      2300  MOV  A,M
R136 A7      2310  ANA  A      ;CLEAR CY & SHIFT
R137 1F      2320  RAR      ; RIGHT TO HALVE NO. CFFLS.
R138 07      2330  DRA  A      ;SFT FLAGS.
R139 77      2340  MOV  M,A
R140 0A      2350  RZ      ;OUT OF CELLS -> ***FINISH***.
R141 0A      2360  INX  H      ;PAIRM.
R142 03      2370  MOV  A,M
R143 07      2380  ADD  A      ;TWICF AS MANY PAIRS.
R144 7F      2390  MOV  M,A
R145 23      2400  INX  H      ;CPLDIS.
R146 7F      2410  MOV  A,M
R147 87      2420  ADD  A      ;TWICF AS FAR APART.
R148 77      2430  MOV  M,A
R149 23      2440  INX  H      ;DELTA.
R150 7F      2450  MOV  A,M
R151 A7      2460  ANA  A      ;CLEAR CY & SHIFT
R152 1F      2470  RAR      ; RIGHT TO HALVE THE ANGLE.
R153 77      2480  MOV  M,A
R154 C3 6F 80 2490  JMP  NPASS
R155 77      2500  ;
R156 77      2510  ;SCALF OVER-RANGE DATA.
R157 77      2520  ;
R158 77      2530  ;SCALF REAL & IMAG IF -SP > ANY DATA == SP.
R159 77      2540  ;NO REGISTERS PRESERVED.
R160 01 00 05 2550  SCALF: LXI  D,REAL ;SET UP TABLE PTR.
R161 11 FF FF 2560  LXI  D,-1
R162 21 FF 01 2570  LXI  H,512-1 ;NO. OF PTS - 1.
R163 0A 2580  SCL2: LDAX P      ;GET DATA.
R164 03 2590  INX  P      ;PUMP PTR.
R165 FF CC 2600  CPI  -52 ;TEST LOWER LIMIT.
R166 0A 60 81 2610  JNC  SCL3 ;SKIP TO NEXT PT.
R167 FF 34 2620  CPI  52 ;TEST UPPER LIMIT.
R168 0A 65 81 2630  JNC  SCL4 ;SCALF ALL IF OUT OF RANGE.
R169 19 2640  SCL3: DAD  D      ;NEXT PT.
R170 DA 54 81 2650  JC  SCL2
R171 C3 2660  RET      ;DONE TESTING.
R172 21 0F 83 2670  SCL4: LXI  H,SCL2F
R173 0A 2680  INR  Y      ;PUMP SCALE FACTOR COUNT.
R174 01 00 85 2690  LXI  H,REAL ;SET UP TABLE PTR.
R175 21 FF 01 2700  LXI  H,512-1 ;NO. OF PTS - 1.
R176 0A 2710  SCL6: LDAX P      ;GET DATA.
R177 FF 80 2720  CPI  80H ; TEST SIGN &
R178 2F 2730  CMC ; EXTEND IT TO CY.
R179 1F 2740  RAR ; DIVIDE BY 2.
R180 0A 2750  STAX P ; RETURN DATA TO TABLE.
R181 03 2760  INX  P ; PUMP PTR.
R182 19 2770  DAD  D ; NEXT PT.
R183 DA 6F 81 2780  JC  SCL6
R184 C9 2790  RET      ; DONE SCALING.
R185 77 2800  ;
R186 77 2810  ;SIGNFD MULTIPLY ROUTINE.
R187 77 2820  ;
R188 77 2830  ;EXTERNAL RFG. USAGE: = A <- (C*A)/128.
R189 77 2840  ;INTERNAL RFG. USAGE:
R190 77 2850  ;HL = PRODUCT (MSBY,LSBY).
R191 77 2860  ;DF = MULTIPLICAND.
R192 77 2870  ;PC = MULTIPLIER.
R193 77 2880  ;NO REGISTERS PRESERVED.
R194 5F 2890  MPY: MOV  F,A ;PUT ARG1 INTO MULTIPLICAND.
R195 7C 2900  ;ARG2 ALREADY IN MULTIPLIER.
R196 AF 2910  XRA  A
R197 47 2920  MOV  D,A ;CLEAR MSPY'S.
R198 57 2930  MOV  D,A
R199 67 2940  MOV  H,A ;CLEAR PRODUCT.
R200 6F 2950  MOV  L,A
R201 77 2960  XOV  A,F ;GET LSBY OF MULTIPLICAND.
R202 FF 00 2970  CPI  0
R203 2A 8A 81 2980  JP  MPY1 ;NEGATIVE MULTIPLICAND?
R204 7A 2990  MOV  A,D
R205 2F 3000  CMA ;EXTEND SIGN TO MSPY.
R206 57 3010  MOV  D,A
R207 79 3020  MPY1: MOV  A,C ;GET LSBY OF MULTIPLIER.
R208 FF 00 3030  CPI  0
R209 2A 93 81 3040  JP  MPY2 ;NEGATIVE MULTIPLIER?
R210 7A 3050  MOV  A,P
R211 2F 3060  CMA ;EXTEND NEG TO MSPY.
R212 47 3070  MOV  D,A
R213 3F 0F 3080  MPY2: MVI  A,15 ;SET ITERATION CTR
R214 55 F5 3090  MPY3: PUSH PSW ; & SAVE.
R215 19 3100  ;ARITH. SHIFT MULTIPLIER RIGHT (RC).
R216 7A 3110  MOV  A,P
R217 FF 80 3120  CPI  80H
R218 3F 3130  CMC ;MAKE CY = MSBIT.
R219 A7 3140  RAR
R220 47 3150  MOV  B,A
R221 C9 3160  MOV  A,C
R222 1F 3170  RAR ;LSBIT->CY.
R223 4F 3180  MOV  C,A
R224 1F 3190  ;TEST MULTIPLIER LSBIT & IF SFT,
R225 1F 3200  ; ADD MULTIPLICAND TO PARTIAL PRODUCT.
R226 1F D2 A3 81 3210  JNC  MPY4
R227 19 3220  DAD  D
R228 23 3230  ;ARITH. SHIFT MULTIPLIER LEFT (DF).
R229 2A 3240  MPY4: XCHG ;SWAP MULTIPLIER & PROD.
R230 1A 3250  DAD  H ;SHIFT LEFT.
R231 5F 3260  XCHG ;RESTORE REGS.
R232 A6 3270  ;CHECK LOOP CTR.
R233 A6 F1 3280  POP  PSW
R234 A7 3D 3290  DCR  A ;DECREMENT COUNT.
R235 A8 C2 95 81 3300  JNZ  MPY3
R236 1A 3310  ;DIVIDE 16-BIT PRODUCT BY 128 SO THAT
R237 1A 3320  ; SINE & COSINE AMPLITUDE = UNITY.
R238 29 3330  DAD  H ;SHIFT-IN MSBIT OF
R239 AC 7C 3340  MOV  A,H ;LSBYTE & RETURN IN A.
R240 AD C9 3350  RET
R241 A6 3360  ;
R242 A6 3370  ;POWER CALCULATION.
R243 1A 3380  ;
R244 1A 3390  ;NO REGISTERS PRESERVED.
R245 06 9F 3400  POWER: MVI  B,SGADR
R246 21 00 85 3410  LXI  H,REAL
R247 11 7F 87 3420  LXI  D,PAUF
R248 4F 3430  PWR1: MOV  C,M ;C=REAL.
R249 0A 3440  LDAX B ;A=(REAL*P)/64.
R250 1A 3450  STAX D ;STORE.
R251 2C 3460  INR  L
R252 1C 3470  INR  F
R253 C2 F6 81 3480  JNZ  PWR1
R254 1E 21 00 86 3490  LXI  H,IMAG ;RSET PTRS.
R255 IC 11 7F 87 3500  LXI  D,PAUF
R256 CA 4F 3510  PWR2: MOV  C,M ;C=IMAG.

```

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 AF 81 C3 E4 AF 3F 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 4F 81 21 00 85
8050 7F 4F 2C 46 2D 80 77 79 90 2C 77 2C C2 50 80 3E
8060 40 32 0B 83 32 0E 83 3F 02 32 0C 83 32 0D 83 CD
8070 4B 81 3A 0F 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 4F C5 3A 11 83 CD 7B 81 32 12 83 C1
80C0 3A 10 83 CD 7B 81 32 13 83 2A 06 83 4F C5 3A 10
80D0 83 CD 7E 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 7F 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 7F A7 1F B7 77 C8 23 7E 87 77 23
8140 7F 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 7E FE 00 F2 8A 81 7A 2F 57 79 FE 00 F2 93 81
8190 7A 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 E6 81 21 00
81C0 86 11 7F 87 4E 0A EB 86 D2 CD 81 3F FF 77 EB 2C
81D0 1C C2 C4 81 C9 21 00 84 0E 2B CD FA 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.**

```

9F00 00 00 00 00 00 00 01 01 01 01 02 02 02 03 03 04
9F10 04 05 05 06 06 07 08 08 09 0A 0B 0B 0C 0D 0E 0F
9F20 10 11 12 13 14 15 17 18 19 1A 1C 1D 1F 20 21 23
9F30 24 26 27 29 2A 2C 2F 2F 31 33 35 36 38 3A 3C 3F
9F40 40 42 44 46 48 4A 4D 4F 51 53 56 58 5A 5D 5F 62
9F50 64 67 69 6C 6E 71 74 76 79 7C 7F 81 84 87 8A 8D
9F60 90 93 96 99 9C 9F A3 A6 A9 AC E0 E3 E6 EA ED C1
9F70 C4 C8 CF CF D2 D6 DA DD E1 E5 E9 FC F0 F4 F8 FC
9F80 FF FC F8 F4 F0 FC F9 E5 E1 DD DA D6 D2 CF CF C8
9F90 C4 C1 ED BA E6 E3 F0 AC A9 A6 A3 9F 9C 99 96 93
9FA0 90 8D 8A 87 84 81 7F 7C 79 76 74 71 6E 6C 69 67
9FB0 64 62 5F 5D 5A 58 56 53 51 4F 4D 4A 48 46 44 42
9FC0 40 3E 3C 3A 3E 36 35 33 31 2F 2E 2C 2A 29 27 26
9FD0 24 23 21 20 1E 1D 1C 1A 19 18 17 15 14 13 12 11
9FE0 10 0F 0E 0D 0C 0B 0A 09 08 07 06 05 05 05 05
9FF0 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 6E 6F 70 71 73 74
9F30 75 76 78 79 7A 7A 7F 7C 7D 7D 7E 7E 7F 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 6A 68 66 64 6F 6E 6D 6C 6B 6A
9F60 5A 58 55 53 51 4F 4C 49 47 44 41 3F 3C 39 36 33
9F70 31 2E 2F 28 25 22 1F 1C 19 16 13 10 0C 09 06 03
9F80 00 FD FA F7 F4 F0 ED FA FE F4 E1 DF DB D8 D5 D2
9F90 CF CD CA C7 C4 C1 BF BC B9 B7 B4 B2 AF AD AE AB
9FA0 A6 A4 A2 A0 9E 9C 9A 98 96 95 93 91 90 8F 8D 8C
9FB0 8F 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 8F 8C 8D 8F 90 91 93 95 96 98 9A 9C 9E AD A2 A4
9FE0 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.**

```

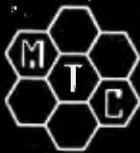
877F 01 01 01 01 00 01 00 00 00 00 00 01 00 01 00 00
878F 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
879F 00 00 00 00 00 00 01 01 02 03 10 3C 03 01 01 00
87AF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87BF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87CF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87DF 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
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 version 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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# 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 ( $6\frac{7}{8}$  by  $2\frac{3}{4}$  by  $1\frac{1}{32}$  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.

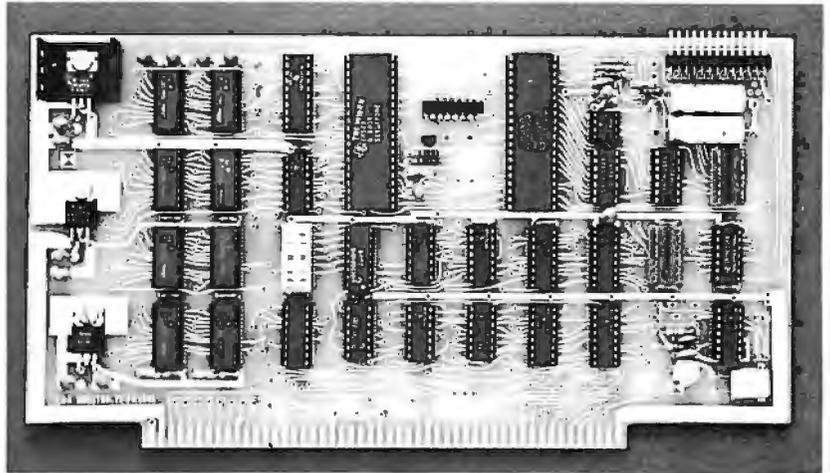
Circle 501 on inquiry card.

# What's New?

## PERIPHERALS

### Video and Audio on One Board

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 in-

cludes 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

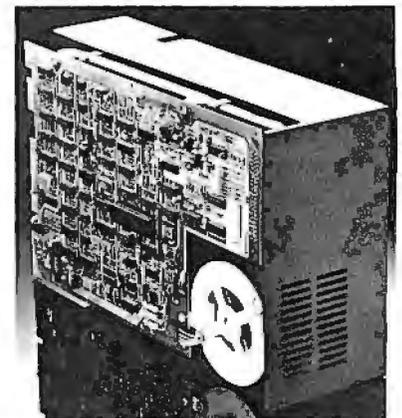
The Q2000 series of 8-inch fixed-hard-disk drives are compatible with Shugart's SA1000 disk drives, but offer 10-, 20-, and 30-megabyte unformatted capacities. This is achieved by using a special head-positioning tech-

nique. 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.

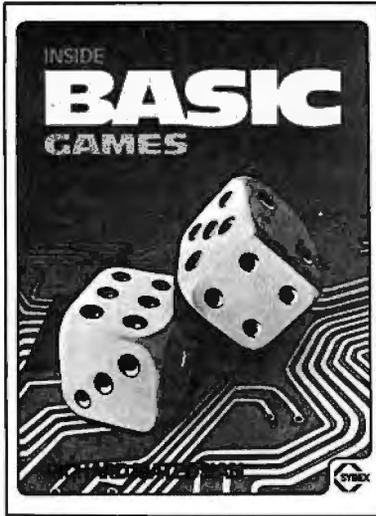
In OEM (original equipment manufacturer) quantities of 500 per year, pricing is \$1200 for the 10-megabyte Q2010, \$1500 for the 20-megabyte Q2020, and \$1800 for the 30-megabyte Q2030. For more information, contact Quantum Corporation, 2150 Bering Dr, San Jose CA 95131, (408) 262-1100.

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.

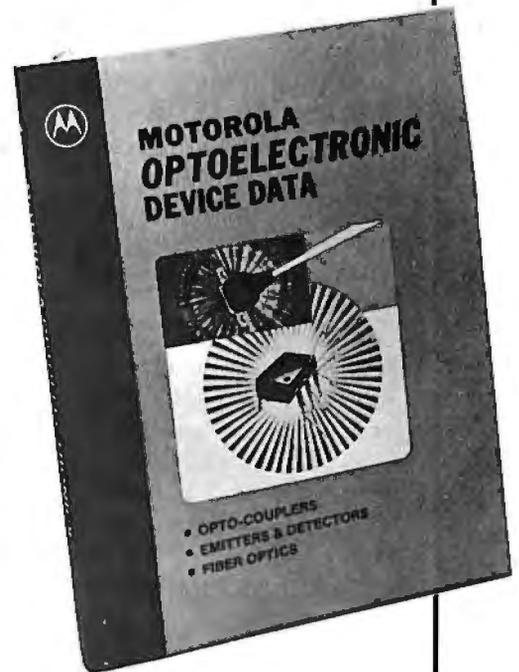
### Supercap Series Catalog

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, Motorola 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 programmable 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.

### 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

### 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.

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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**Microline 83**, bidirectional, 120 cps, uses 15" paper **\$995**

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Package-Compressed print, vertical form control **\$1830**

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**704-11**, 180 cps, 9x9 dot matrix, 132 col, parallel **\$1695**

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# 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 In-

ventory 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 Intelcolor 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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<b>DoubleVision 80 x 24 Video Interface</b> .....	295
CCS Arithmetic Processor .....	399
CCS Parallel Interface .....	119
<b>16K Ram Card</b> .....	195
Microworks DS-65 Digisector .....	339
SVA 8 inch Disk Controller .....	335
Sup-R-Mod .....	30
CCS Synchronous Serial Interface .....	159
CCS Asynchronous Serial Interface .....	159
Corvus 10 Meg. Hard Disk .....	4395
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## MISCELLANEOUS/SUPPLIES

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Verbatim Datalife Diskette (Box of 10) .....	30
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Leedex Video 100 12" .....	140
Sanyo 9" Monitor .....	195
KG-12C Green Phos. Monitor .....	275
Sanyo 12" Green Phosphor. Monitor .....	275
NEC 12" Green Phosphor. Monitor .....	275
Sanyo 12" B/W Monitor .....	250

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Apple Silentype with interface .....	525
IDS 445 (Paper Tiger) with Graphics .....	795
IDS 460 with Graphics .....	1199
IDS 560 with Graphics 10) .....	1695
Centronics 737 .....	895
NEC Spinwriter (RO, Serial) .....	2650

## SOFTWARE

The Controller .....	525
Apple Post (Mailing List Program) .....	40
Easywriter Professional System .....	195
Apple Pie 2.0 .....	95
DB Master Data Management .....	150
The Cashier .....	210
Apple Writer .....	65
<b>Visicalc</b> .....	125
<b>CCA Data Management System</b> .....	90
<b>Full Screen Mapping for CCA DMS</b> .....	59
Pascal Interactive Terminal Software (PITS) .....	29
Basic Interactive Terminal Software (BITS) .....	29
Data Capture .....	29
Data Factory DMS .....	95
Apple Plot .....	55
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# 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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<b>FOR TRS-80* Model I</b>		
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### ADD-ON DRIVES FOR ZENITH Z-89

<b>CCI-189</b>	5 1/4", 40 Track (102K)	\$394
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<b>Z-87</b>	Dual 5 1/4" system	\$995

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<b>DISCUS 2D</b>	1 DRIVE	\$ 938	2 DRIVE	\$1635
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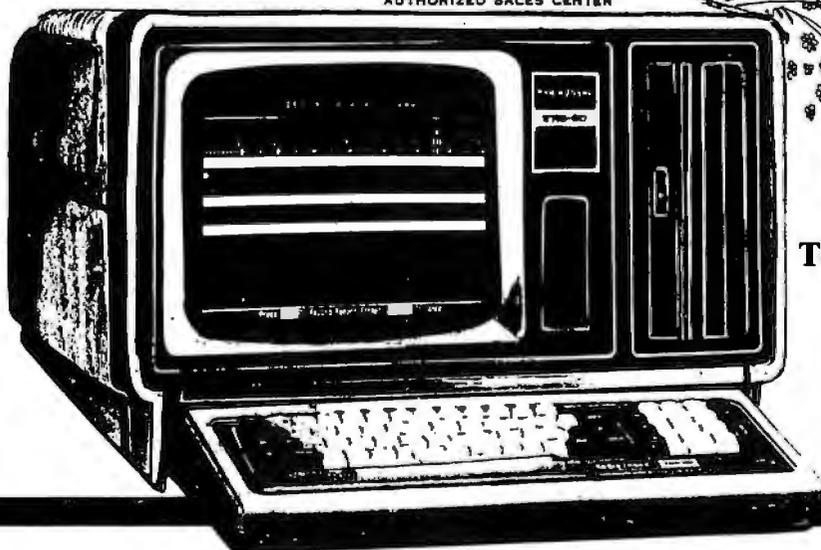
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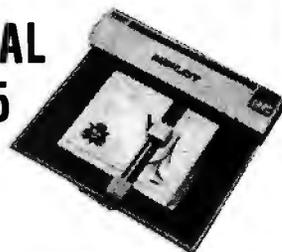
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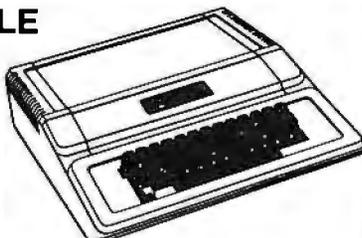
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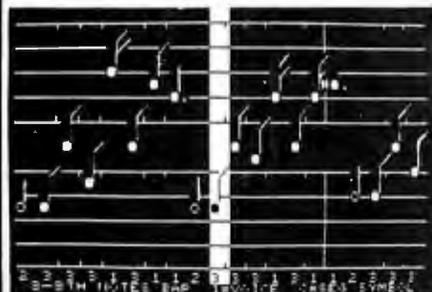
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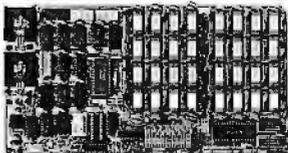
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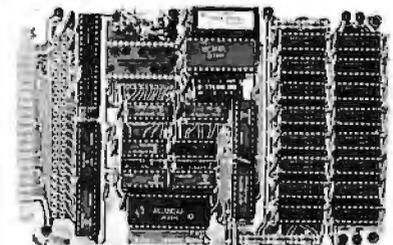
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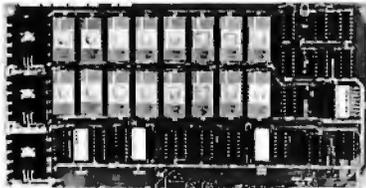
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**\$379<sup>00</sup>** KIT

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At Last! An affordable 32K Static RAM with full 6809 Capability.

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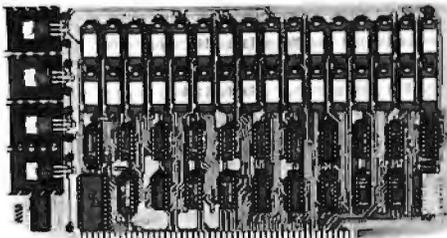
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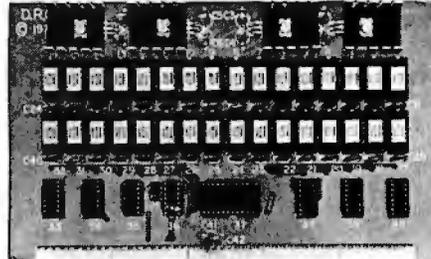
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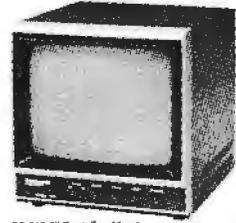
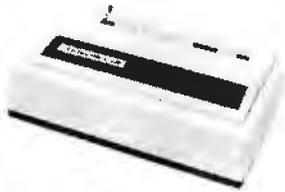
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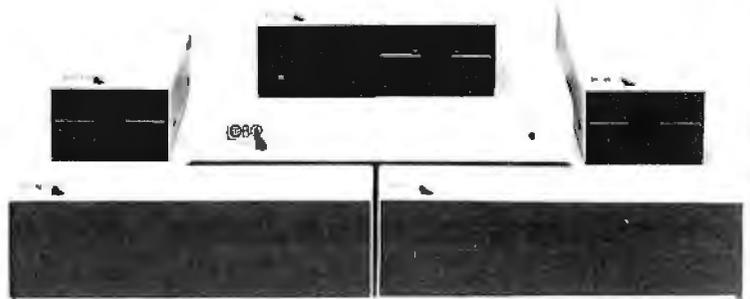
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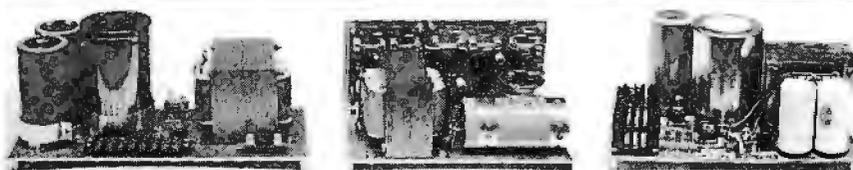
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7400TTL	LM339N-5	1.35	CD4026	2.50	2141L 450ns	4.00	CONNECTORS	50 pin edge	2.50
7400N	LM339N-12	1.35	CD4027	2.50	4116 200ns	4.50	32 pin edge	4.00	
7402N	LM339N-15	1.35	CD4028	2.50	4116 200ns	4.50	44 pin edge	2.75	
7404N	LM339N-25	1.35	CD4029	2.50	MM5252	4.00	86 pin edge	4.00	
7409N	LM339N-35	1.35	CD4030	2.50	MM5252	4.00	100 pin edge	4.50	
7410N	LM339N-12	1.35	CD4035	1.00	MM5320	9.95	100 pin edge WW	5.25	
7414N	LM339N-15	1.35	CD4040	1.25	MM5330	5.94			
7420N	LM339N-5	1.35	CD4042	85	PD411D-3	4.00			
7422N	LM339N-12	1.35	CD4043	85	PD411D-4	5.00			
7423N	LM339N-15	1.35	CD4044	85	PS1011	6.95			
7442N	LM339N-5	1.35	CD4046	1.67	4200A	9.95	8 -15 22 30		
7445N	LM339N-12	1.35	CD4049	45	82525	2.90	14 24 35		
7447N	LM339N-15	1.35	CD4050	90	9102A	1.50	12 16 28 42		
7448N	LM339N-5	1.35	CD4051	1.13	HDD165-3	6.95	18 27 36 39		
7458N	LM339N-12	1.35	CD4062	1.50	MM5703	1.50	29 40 57		
7474N	LM339N-15	1.35	CD4066	71	GM43850L1	9.95	2 level 14 pin w/2		
7475N	LM339N-5	1.35	CD4068	40	MC66075A	9.95			
7483N	LM339N-12	1.35	CD4069	40	3358	3.50			
7487N	LM339N-15	1.35	CD4070	50	410D	10.00			
7490N	LM339N-5	1.35	CD4071	45	416	16.00			
7492N	LM339N-12	1.35	CD4072	45	CIRCS				
7493N	LM339N-15	1.35	CD4073	45	MM5311	5.50			
7497N	LM339N-5	1.35	CD4075	1.45	MM5314	3.90			
7498N	LM339N-12	1.35	CD4076	1.45	MM5369	4.45			
7499N	LM339N-15	1.35	CD4077	1.45	MM5394	14.45			
74107N	LM339N-5	1.35	CD4079	40	MM5855	7.95	10 MHz		
74121N	LM339N-12	1.35	CD4081	35	MM5859	7.95	18 MHz		
74123N	LM339N-15	1.35	CD4082	35	MM5860	7.95	20 MHz		
74125N	LM339N-5	1.35	CD4116	47	MM5865	7.95	10 MHz		
74145N	LM339N-12	1.35	CD4140	37	MM5870	7.95	18 MHz		
74150N	LM339N-15	1.35	CD4507	1.00	CT7015	9.95	20 MHz		
74151N	LM339N-5	1.35	CD4508	2.85	MM5375AAM	3.90	32 MHz		
74152N	LM339N-12	1.35	CD4509	2.85	MM5375AC1G	3.90	32 MHz		
74157N	LM339N-15	1.35	CD4511	34	7205	16.50	1.8432 MHz		
74158N	LM339N-5	1.35	CD4512	34	7207	16.50	3.5735 MHz		
74159N	LM339N-12	1.35	CD4516	1.10	7208	15.95	10.0001 MHz		
74163N	LM339N-15	1.35	CD4518	1.50	7209	4.95	2.09152 MHz		
74174N	LM339N-5	1.35	CD4527	1.91	DS002620	3.75	2.4576MHz		
74175N	LM339N-12	1.35	CD4528	1.60	MM5310A	2.50	5.0688 MHz		
74176N	LM339N-15	1.35	CD4529	1.60	MM5310B	2.50	5.0688 MHz		
74177N	LM339N-5	1.35	CD4532	2.85	MICROPROCESSORS	1.15	3.143 MHz		
74178N	LM339N-12	1.35	CD4533	2.85	6502	5.50	3.143 MHz		
74179N	LM339N-15	1.35	CD4534	1.00	6504	9.95	8.8308 MHz		
74221N	LM339N-5	1.35	CD4535	1.00	6505	9.95	14.318 MHz		
74222N	LM339N-12	1.35	CD4536	1.00	6506	9.95	18.432 MHz		
74223N	LM339N-15	1.35	CD4537	1.00	6507	11.95	22.1184 MHz		
74224N	LM339N-5	1.35	CD4538	1.00	6508	11.95	22.1184 MHz		
74225N	LM339N-12	1.35	CD4539	1.00	6509	11.95	22.1184 MHz		
74226N	LM339N-15	1.35	CD4540	1.00	6510	11.95	22.1184 MHz		
74227N	LM339N-5	1.35	CD4541	1.00	6511	11.95	22.1184 MHz		
74228N	LM339N-12	1.35	CD4542	1.00	6512	11.95	22.1184 MHz		
74229N	LM339N-15	1.35	CD4543	1.00	6513	11.95	22.1184 MHz		
74230N	LM339N-5	1.35	CD4544	1.00	6514	11.95	22.1184 MHz		
74231N	LM339N-12	1.35	CD4545	1.00	6515	11.95	22.1184 MHz		
74232N	LM339N-15	1.35	CD4546	1.00	6516	11.95	22.1184 MHz		
74233N	LM339N-5	1.35	CD4547	1.00	6517	11.95	22.1184 MHz		
74234N	LM339N-12	1.35	CD4548	1.00	6518	11.95	22.1184 MHz		
74235N	LM339N-15	1.35	CD4549	1.00	6519	11.95	22.1184 MHz		
74236N	LM339N-5	1.35	CD4550	1.00	6520	11.95	22.1184 MHz		
74237N	LM339N-12	1.35	CD4551	1.00	6521	11.95	22.1184 MHz		
74238N	LM339N-15	1.35	CD4552	1.00	6522	11.95	22.1184 MHz		
74239N	LM339N-5	1.35	CD4553	1.00	6523	11.95	22.1184 MHz		
74240N	LM339N-12	1.35	CD4554	1.00	6524	11.95	22.1184 MHz		
74241N	LM339N-15	1.35	CD4555	1.00	6525	11.95	22.1184 MHz		
74242N	LM339N-5	1.35	CD4556	1.00	6526	11.95	22.1184 MHz		
74243N	LM339N-12	1.35	CD4557	1.00	6527	11.95	22.1184 MHz		
74244N	LM339N-15	1.35	CD4558	1.00	6528	11.95	22.1184 MHz		
74245N	LM339N-5	1.35	CD4559	1.00	6529	11.95	22.1184 MHz		
74246N	LM339N-12	1.35	CD4560	1.00	6530	11.95	22.1184 MHz		
74247N	LM339N-15	1.35	CD4561	1.00	6531	11.95	22.1184 MHz		
74248N	LM339N-5	1.35	CD4562	1.00	6532	11.95	22.1184 MHz		
74249N	LM339N-12	1.35	CD4563	1.00	6533	11.95	22.1184 MHz		
74250N	LM339N-15	1.35	CD4564	1.00	6534	11.95	22.1184 MHz		
74251N	LM339N-5	1.35	CD4565	1.00	6535	11.95	22.1184 MHz		
74252N	LM339N-12	1.35	CD4566	1.00	6536	11.95	22.1184 MHz		
74253N	LM339N-15	1.35	CD4567	1.00	6537	11.95	22.1184 MHz		
74254N	LM339N-5	1.35	CD4568	1.00	6538	11.95	22.1184 MHz		
74255N	LM339N-12	1.35	CD4569	1.00	6539	11.95	22.1184 MHz		
74256N	LM339N-15	1.35	CD4570	1.00	6540	11.95	22.1184 MHz		
74257N	LM339N-5	1.35	CD4571	1.00	6541	11.95	22.1184 MHz		
74258N	LM339N-12	1.35	CD4572	1.00	6542	11.95	22.1184 MHz		
74259N	LM339N-15	1.35	CD4573	1.00	6543	11.95	22.1184 MHz		
74260N	LM339N-5	1.35	CD4574	1.00	6544	11.95	22.1184 MHz		
74261N	LM339N-12	1.35	CD4575	1.00	6545	11.95	22.1184 MHz		
74262N	LM339N-15	1.35	CD4576	1.00	6546	11.95	22.1184 MHz		
74263N	LM339N-5	1.35	CD4577	1.00	6547	11.95	22.1184 MHz		
74264N	LM339N-12	1.35	CD4578	1.00	6548	11.95	22.1184 MHz		
74265N	LM339N-15	1.35	CD4579	1.00	6549	11.95	22.1184 MHz		
74266N	LM339N-5	1.35	CD4580	1.00	6550	11.95	22.1184 MHz		
74267N	LM339N-12	1.35	CD4581	1.00	6551	11.95	22.1184 MHz		
74268N	LM339N-15	1.35	CD4582	1.00	6552	11.95	22.1184 MHz		
74269N	LM339N-5	1.35	CD4583	1.00	6553	11.95	22.1184 MHz		
74270N	LM339N-12	1.35	CD4584	1.00	6554	11.95	22.1184 MHz		
74271N	LM339N-15	1.35	CD4585	1.00	6555	11.95	22.1184 MHz		
74272N	LM339N-5	1.35	CD4586	1.00	6556	11.95	22.1184 MHz		
74273N	LM339N-12	1.35	CD4587	1.00	6557	11.95	22.1184 MHz		
74274N	LM339N-15	1.35	CD4588	1.00	6558	11.95	22.1184 MHz		
74275N	LM339N-5	1.35	CD4589	1.00	6559	11.95	22.1184 MHz		
74276N	LM339N-12	1.35	CD4590	1.00	6560	11.95	22.1184 MHz		
74277N	LM339N-15	1.35	CD4591	1.00	6561	11.95	22.1184 MHz		
74278N	LM339N-5	1.35	CD4592	1.00	6562	11.95	22.1184 MHz		
74279N	LM339N-12	1.35	CD4593	1.00	6563	11.95	22.1184 MHz		
74280N	LM339N-15	1.35	CD4594	1.00	6564	11.95	22.1184 MHz		
74281N	LM339N-5	1.35	CD4595	1.00	6565	11.95	22.1184 MHz		
74282N	LM339N-12	1.35	CD4596	1.00	6566	11.95	22.1184 MHz		
74283N	LM339N-15	1.35	CD4597	1.00	6567	11.95	22.1184 MHz		
74284N	LM339N-5	1.35	CD4598	1.00	6568	11.95	22.1184 MHz		
74285N	LM339N-12	1.35	CD4599	1.00	6569	11.95	22.1184 MHz		
74286N	LM339N-15	1.35	CD4600	1.00	6570	11.95	22.1184 MHz		
74287N	LM339N-5	1.35	CD4601	1.00	6571	11.95	22.1184 MHz		
74288N	LM339N-12	1.35	CD4602	1.00	6572	11.95	22.1184 MHz		
74289N	LM339N-15	1.35	CD4603	1.00	6573	11.95	22.1184 MHz		
74290N	LM339N-5	1.35	CD4604	1.00	6574	11.95	22.1184 MHz		
74291N	LM339N-12	1.35	CD4605	1.00	6575	11.95	22.1184 MHz		
74292N	LM339N-15	1.35	CD4606	1.00	6576	11.95	22.1184 MHz		
74293N	LM339N-5	1.35	CD4607	1.00	6577	11.95	22.1184 MHz		
74294N	LM339N-12	1.35	CD4608	1.00	6578	11.95	22.1184 MHz		
74295N	LM339N-15	1.35	CD4609	1.00	6579	11.95	22.1184 MHz		
74296N	LM339N-5	1.35	CD4610	1.00	6580	11.95	22.1184 MHz		

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KIT 3	DISK SYSTEM	15A	1A	2A	2A	4A	14" x 6" x 4 7/8"	67.95

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SPECS: +5V @ 5A OVP, -5V @ 1A +24V @ 5A, SHORTS PROTECT. 2 SIZES AVAIL., 1) 9" (W) x 6 1/4" (D) x 4 3/8" (H), 2) 9" (W) x 5 3/8" (D) x 5 1/4" (H) OPTION: 1.) REPLACE +24V BY +12V. 2.) FOR SIZE 1 ONLY, ADD +12V @ 1A, AT AN ADDITIONAL \$12.00. IDEAL FOR THREE 8" or 5 1/4" FLOPPY DISK DRIVES, SUCH AS SHUGART 801/851, SIEMANS FDD 100-8/200-8 OR 100-5 ETC.

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T4	110/120	2 x 8 Vac, 6A	28 Vac, CT, 1.5A	48 Vac, CT, 3A	3 3/4" x 3 3/8" x 3 1/8"	22.95
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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	225
74LS83	44	74LS253	95
74LS85	95	74LS257	95
74LS86	95	74LS258	95
74LS90	69	74LS259	285
74LS93	69	74LS279	44
74LS107	45	74LS283	100
74LS112	38	74LS293	185
74LS113	48	74LS298	120
74LS122	48	74LS366	95
74LS123	95	74LS367	55
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SN7425N	25	SN7495N	.60	SN74174N	.95
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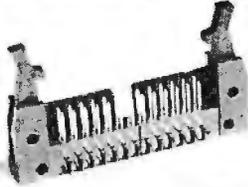
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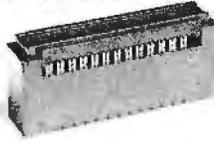
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10	IDH10SR .80	IDH10WR 1.75
20	IDH20SR 1.25	IDH20WR 2.75
26	IDH26SR 1.85	IDH26WR 3.60
34	IDS34SR 2.15	IDH34WR 4.15
40	IDH40SR 2.50	IDH40WR 4.90
50	IDH50SR 3.15	IDH50WR 6.15

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20	IDE20	3.50
26	IDE26	4.05
34	IDE34	4.85
40	IDE40	5.65
50	IDE50	5.90

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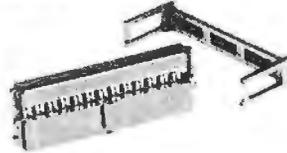
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10	2.90	17.00	4.00	30.00
14	3.40	23.80	5.00	42.00
16	3.70	27.20	5.60	48.00
20	4.40	34.00	7.00	60.00
24	5.00	40.80	8.00	72.00
26	5.40	44.20	8.60	78.00
34	6.80	57.80	11.00	102.00
40	7.80	68.00	13.00	120.00
50	9.50	85.00	16.00	150.00

### 25 PIN "D" CONNECTORS



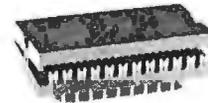
Style	Part #	Price
<b>SOLDER STYLE</b>		
Male	DB25P	2.25
Female	DB25S	3.00
Hood	DB25C	1.10
<b>INSULATION DISPLACEMENT</b>		
Male	IDC25P	4.95
Female	IDC25S	5.25
Hood	IDC25C	1.35

### SOCKETS



Pins	Part No.	Price	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.	Price
14	IDP14	1.25
16	IDP16	1.40
24	IDP24	2.25
40	IDP40	3.65

## WIRE WRAP WIRE

Length	100/Bag	500/Bag	1K/Bag	Length	100/Bag	500/Bag	1K/Bag
2.5"	\$1.25	\$3.58	\$ 6.19	6.5"	\$1.92	\$6.44	\$11.81
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

Kynar precut wire. All lengths are overall, including 1" strip on each end. Colors and lengths cannot be mixed for quantity pricing. Choose from colors Red, Blue, Black, Yellow, White, Green, Orange, and Violet.

## WIRE KITS

Kit No. 1	\$9.95	Kit No. 3	\$32.95
250 3"	100 4 1/2"	500 2 1/2"	500 4 1/2"
250 3 1/2"	100 5"	500 3"	500 5"
100 4"	100 6"	500 3 1/2"	500 5 1/2"
		500 4"	500 6"
Kit No. 2	\$24.95	Kit No. 4	\$59.95
250 2 1/2"	250 5"	1000 2 1/2"	1000 4 1/2"
500 3"	100 5 1/2"	1000 3"	1000 5"
500 3 1/2"	250 6"	1000 3 1/2"	1000 5"
500 4"	100 6 1/2"	1000 4"	1000 6"
250 4 1/2"	100 7"		

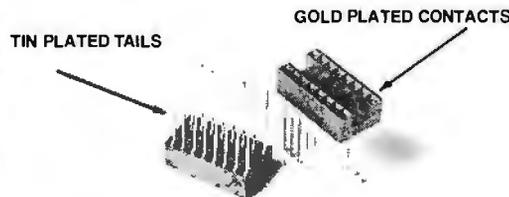
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14	30	.47	14.10
16	26	.51	13.26
18	23	.70	16.10
20	21	.87	18.27
22	19	.94	17.86
24	17	.96	16.32
28	15	1.25	18.75
40	10	1.70	17.00

\*FOR REFERENCE, MUST BE ORDERED IN TUBE QUANTITIES.

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3218 B	5.2420 B	9.9336 B	20.000 B	36.2868 B	42.8518 B	46.8128 B
5200 B	5.6110 B	9.98408 B	20.4968 B	36.3636 B	42.8768 B	47.3768 B
1.000 A	5.7143 B	9.98960 B	22.1184 B	37.6228 B	42.9258 B	47.8838 B
1.8432 A	5.965 B	10.000 B	22.6280 B	38.3768 B	42.9628 B	48.000 B
1.8437 B	5.982 B	10.2458 B	25.3558 B	38.4448 B	43.0008 B	48.3008 B
2.001 A	6.000 B	10.4000 B	26.5208 B	38.6728 B	43.0378 B	48.5568 B
2.0071 A	6.144 B	10.7755 B	26.6706 B	38.9258 B	43.0748 B	48.7006 B
2.4576 A	6.15030 B	10.8255 B	27.0000 B	39.3128 B	43.1858 B	48.8768 B
2.500 A	6.29700 B	10.8385 B	27.0006 B	39.5038 B	43.2568 B	49.7006 B
2.6657 B	6.400 B	11.1360 B	27.5506 B	39.9568 B	43.3338 B	49.7338 B
2.9848 B	6.5336 B	11.165 B	28.4008 B	39.7538 B	43.3708 B	49.8168 B
3.001 A	6.72530 B	11.2166 B	28.6278 B	39.8768 B	43.4078 B	50.2505 B
3.067 B	6.75840 B	11.2890 B	28.7538 B	39.9628 B	43.4378 B	51.0558 B
3.200 B	6.9000 B	11.4776 B	29.8758 B	40.4448 B	43.4448 B	51.3128 B
3.2766 A	7.0063 B	11.6566 B	29.9378 B	40.5928 B	43.5558 B	51.7778 B
3.500 B	7.0336 B	11.6816 B	30.0568 B	40.8128 B	43.6298 B	51.8505 B
3.579 B	7.0916 B	12.1440 B	30.3008 B	40.9338 B	43.6668 B	52.8128 B
4.000 B	7.1836 B	14.3182 B	30.6258 B	40.8768 B	43.7778 B	55.7506 B
4.1943 B	7.2586 B	14.4308 B	30.8768 B	40.8868 B	43.8128 B	60.6006 B
4.3426 B	8.000 B	15.0000 B	31.4378 B	40.9258 B	43.8148 B	60.7506 B
4.4803 B	8.0556 B	15.4008 B	31.7538 B	41.0208 B	43.8518 B	66.7506 B
4.6103 B	8.1416 B	15.5266 B	31.9308 B	41.1668 B	43.9888 B	70.4000 B
4.6503 B	8.1816 B	16.0000 B	32.0000 B	41.3768 B	43.9258 B	75.0005 B
4.8303 B	8.3303 B	16.3848 B	33.2006 B	41.9378 B	44.0008 B	90.8338 B
4.9152 B	8.4998 B	17.2248 B	33.6258 B	42.0008 B	44.0378 B	99.9668 B
5.001 B	8.5166 B	17.2422 B	34.5558 B	42.5838 B	44.3768 B	100.0668 B
5.0886 B	8.6356 B	18.030 B	34.7538 B	42.6268 B	44.7778 B	101.4668 B
5.1203 B	8.9808 B	18.4320 B	34.9776 B	42.7006 B	45.1256 B	103.0668 B
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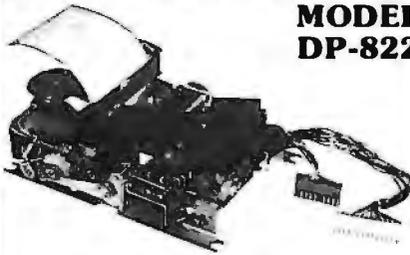


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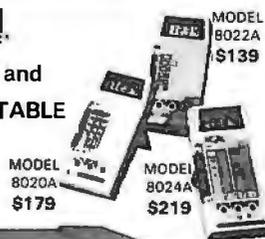
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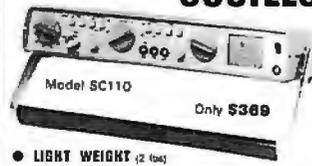
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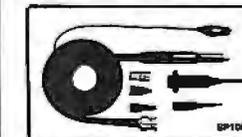


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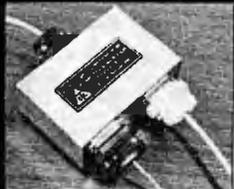
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Q1.98. System II Same as above with Dual 5 1/4 Double Sided Drives CPM 2.2 2295. 1215.  
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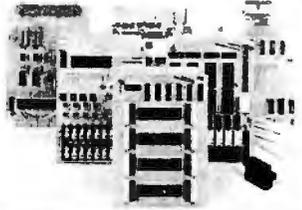
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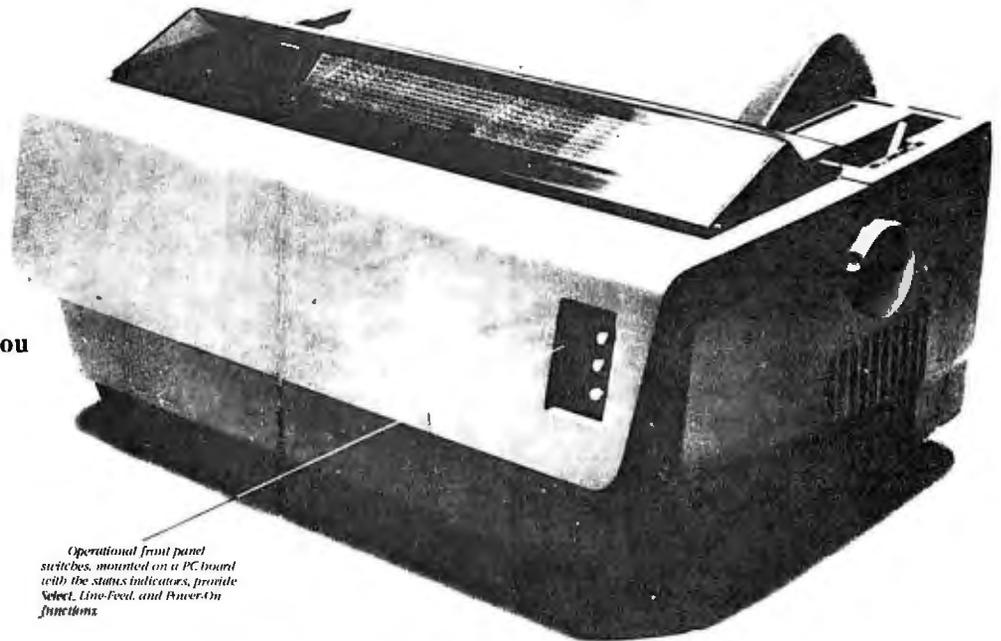
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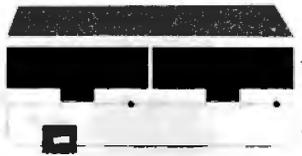
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the motor 7.5°

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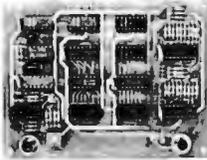
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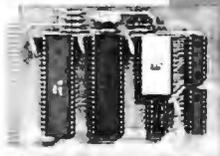


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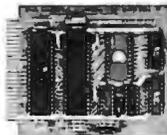
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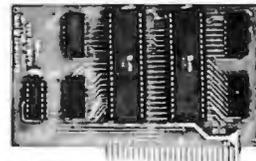
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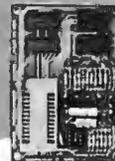
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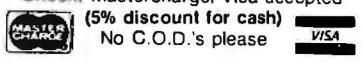
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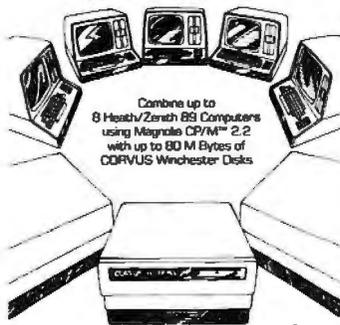
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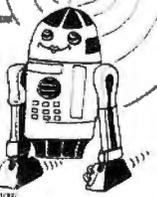
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This digital RF transmitter and receiver links your computer's intelligence to radios, appliances, remote stations, peripherals and toys without any wires, cables, physical attachments.

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- SERIAL INTERFACE (RS232)
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- EASY TO INSTALL
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Receiver and Transmitter . . . . . \$ 34.95  
Receiver w/ UART and Transmitter . . . . . \$ 49.95  
Receiver only . . . . . \$ 19.95  
Receiver w/ UART only . . . . . \$ 35.95  
Transmitter only . . . . . \$ 18.95

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(408) 578-8026

Circle 141 on inquiry card.

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- Programmable Scale Select

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## FOR TRS-80 MODEL I & III SPEECH & SOUND

**CUISION SOUND** is a computer controlled, complex sound generator capable of three tone music as well as special sound effects. Three tone generators operate with a "chirp" noise source and programmable volume control ramp generator to create a wealth of sound effects. All control functions are located, allowing the CS board to operate while the program continues, permitting continuous sound production during program execution.

The CS board comes as a kit or as an assembled PC board. It needs only 5VDC at 200ma, a forty connector cable and a speaker. With the double cable, two units may be operated simultaneously.

**X11** --\$49/ two for \$85  
**ASSEMBLED** --\$58/ two for \$98

**CUISION SPEECH SYNTHESIZER** is a software based speech synthesizer which can generate high quality, inflected human like speech of unlimited vocabulary. Forty max phrases allow the creation of most any english word as well as many non-english words. The unit comes fully assembled and tested and needs only a forty connector cable and a speaker.

**CSS** --\$178  
CABLE : ribbon cable with PC edge connectors, plugs into exp. port of CPU or TV/MT. --\$20  
double cable --\$25  
5VDC REGULATED POWER SUPPLY : fully assembled, 1.2amp, 400mA --\$23  
\$2 shipping & handling (\$3 for Canada)  
4% for R.L. res.  
Call or Money Order  
4-6 weeks for delivery



• MEMBER OF TERN

Circle 108 on inquiry card.

## TRS-80 SERIAL I/O

- Can input into basic
- Can use LIST and LPRINT to output, or output continuously
- RS-232 compatible
- Can be used with or without the expansion bus
- Onboard switch selectable baud rates of 110, 150, 300, 600, 1200, 2400, parity or no parity odd or even, 5 to 8 data bits, and 1 or 2 stop bits. D.T.R. line
- Requires +5, -12 VDC
- Board only \$19.95 Part No. 8010, with parts \$76.69 Part No. 8010A, assembled \$98.25 Part No. 8010C. No connectors provided, see below.



Fig. RS-232 connector Part No. DB25P \$5.00 with 3' B connector cable \$19.65 Part No. DB25P3

3 ribbon cable with attached connectors to fit TRS-80 and our serial board \$37.10 Part No. 3C484D

## VIDEO TERMINAL



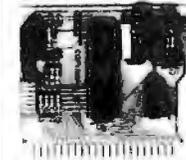
16 lines, 64 columns • Upper and lower case • 5x7 dot matrix • Serial RS-232 in and out with TTL parallel keyboard input • On board baud rate generator 75, 110, 150, 300, 600, & 1200 jumper selectable • Memory 1024 characters (7-21L02) • Video processor chip SFF96364 by Neculonic • Control characters (CR, LF, →, ←, ↑, ↓, non destructive cursor, CS, home, CL) • White characters on black background or vice-versa • With the addition of a keyboard, video monitor or TV set with TV interface (part no. 107A) and power supply this is a complete stand alone terminal • also S-100 compatible • requires +16, & -16 VDC at 100mA, and BVDC at 1A. Part No. 1000A \$296.45 kit.

## GAME PADDLES & SOUND FOR TRS-80



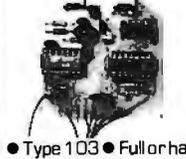
Includes: 2 game paddles, interface, software, speaker, power supply, full documentation including: schematics, theory of operation, and user guide; plus 2 games on cassette, Pong and Starship War \$157.29 Complete Part No. 7922C

## SERIAL/PARALLEL INTERFACE



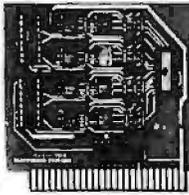
- Converts serial to parallel and parallel to serial
- Low cost on board baud rate generator
- 110 to 19.2K
- Low power drain +5 volts and -12 volts required
- TTL compatible
- All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity.
- All connections go to a 44 pin gold plated edge connector
- Board only \$11.95 Part No. 101, with parts \$42.89 Part No. 101A, 44 pin edge connector \$4.00 Part No. 44P

## MODEM



- Type 103
- Full or half duplex
- Works up to 300 baud
- Originate or Answer
- Serial TTL input and output
- connect B Ω speaker and crystal mic. directly to board
- Requires +5 volts
- Board only \$7.60 Part No. 109, with parts \$29.95 Part No. 109A.

## OPTO-ISOLATED PARALLEL INPUT BOARD FOR APPLE II



Part No. 120, with parts \$69.95 Part No. 120A.

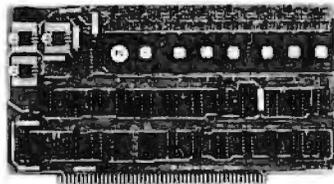
There are 8 inputs that can be driven from TTL logic or any 5 volt source. The circuit board can be plugged into any of the B sockets of your Apple II. It has a 16 pin socket for standard dip ribbon cable connection. Board only \$15.65

## SUPER MODEM



Originate, RS-232 and 20 mA compatible. Full duplex, and half duplex, direct connect or acoustic coupled, on board power supply, carrier detect light, DB25 plug, 300 BAUD, Type 103 compatible frequencies. Bare board Part No. 2000 \$21.89, Kit Part No. 2000A \$133.80

## 8K EPROM SAVER



- Programs 2708's address relocation of each 4K of memory to any 4K boundary
- Power on jump and reset jump option for "turnkey" systems and computers without a front panel
- Program saver software in 1 2708 EPROM \$25. Bare board \$45.59 including custom coil, board with parts but no EPROMS \$164.69.

## APPLE II SERIAL I/O INTERFACE



Baud rate is continuously adjustable from 0 to 30,000 • Plugs into any peripheral connector • Low current drain. RS-232 input and output • On board switch selectable 5 to 8 data bits, 1 or 2 stop bits, and parity or no parity either odd or even • Jumper selectable address • SOFTWARE • Input and Output routine from monitor or BASIC to teletype or other serial printer • Program for using an Apple II for a video or an intelligent terminal. Also can output in correspondence code to interface with some electrics. • Also watches DTR • Board only \$14.95 Part No. 2, with parts \$51.25 Part No. 2A, assembled \$62.95 Part No. 2C

## PARALLEL TRIAC OUTPUT BOARD FOR APPLE II



This board has 8 triacs capable of switching 110 volt 6 amp loads (660 watts per channel) or a total of 5280 watts. Board only \$15.65 Part No. 210, with parts \$119.95 Part No. 210A

## APPLE II PROTOTYPING HOBBY/CARD

Part No. 7907  
\$21.95

## RS-232/20mA INTERFACE

This board has two passive, opto-isolated circuits. One converts RS-232 to 20mA, the other converts 20mA to RS-232. All connections go to a 10 pin edge connector. Requires +12 and -12 volts. Board only \$9.95, part no. 7901, with parts \$14.95 Part No. 7901A.

## T.V. INTERFACE



- Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple
- Power required is 12 volts AC C.T., or +5 volts DC
- Board only \$8.19 part No. 107, with parts \$18.85 Part No. 107A

## S-100 BUS ACTIVE TERMINATOR



Board only \$18.15 Part No. 900, with parts \$29.89 Part No. 900A.

## SERIAL I/O



Four Serial I/O RS-232 ports. S-100 Bus, Software or jumper selectable baud rate (110, 300, 600, 1200, 2400, 4800, 9600, 19.2K), on board Xtal baud rate generator, Addressing, switch selectable, Parity or no parity (odd or even) switch selectable, 1 or 2 stop bits, 5 to 8 bits/character. Board only \$35.19 Part No. 7908. With parts (kit) \$199.95, Part No. 7908A.

## TAPE INTERFACE



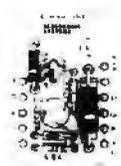
- Converts a low cost tape recorder to a digital recorder
- Works up to 1200 baud
- Digital in and out are TTL serial
- Output of board connects to mic. in of recorder
- Earphone of recorder connects to input on board
- No coils
- Requires +5 volts, low power drain
- Board only \$7.60 Part No. 111, with parts \$29.95 Part No. 111A

## RS-232/TTL INTERFACE



- Converts TTL to RS-232, and converts RS-232 to TTL
- Two separate circuits
- Requires -12 and +12 volts
- All connections go to a 10 pin edge connector; kit \$9.95 Part No. 232A 10Pin edge connector \$3.00 part No. 10P.

## RS-232/TTY INTERFACE



This board has two active circuits, one converts RS-232 to 20 mA, the other converts 20 mA to RS-232. Requires +12 and -12 volts. \$9.95 Part No. 600A Kit.

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# ELECTRONIC SYSTEMS

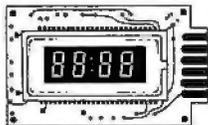
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## National Semiconductor Clock Modules



**12VDC AUTOMOTIVE/ INSTRUMENT CLOCK**

**APPLICATIONS:**

- In-dash auto clocks
- Aircraft marine clocks
- RV clocks
- 12VDC oper. instrs.
- Portable/battery powered instrumts.

Features: Bright 0.3" green display. Internal crystal time-base. ± 0.5 sec./day accur. Auto. display brightness control. Display color filterable to blue, blue-green, green & yellow. Complete—just add switches and lens.

MA1003 Module . . . . . \$16.95

MA1023 7" Low Cost Digital LED Clock Module 8.95  
 MA1026 7" Dig. LED Alarm Clock/Thermom. 18.95  
 MA5036 3" Low Cost Digital LED Clock/Timer 6.95  
 MA1002 5" LED Display Dig. Clock & Xformer 9.95

## National Semiconductor RAM SALE

MM5290N-4 (MK4116/UPD416) . . \$3.95 each  
 16K DYNAMIC RAM (250NS)  
 (8 EACH \$23.95) (100 EACH \$350.00/lot)

MM5290J-2 (MK4116/UPD416) . . \$5.25 each  
 16K DYNAMIC RAM (150NS)  
 (8 EACH \$39.95) (100 EACH \$475.00/lot)

MM5298J-3A . . . . . \$3.25 each  
 8K DYNAMIC RAM (LOW HALF OF MM5290J) 200NS  
 (8 EACH \$23.95) (100 EACH \$250.00/lot)

MM2114-3 . . . . . \$5.95 each  
 4K STATIC RAM (300NS)  
 (8 EACH \$43.95) (100 EACH \$450.00/lot)

MM2114-3 . . . . . \$6.25 each  
 4K STATIC RAM (LOW POWER 300NS)  
 (8 EACH \$44.95) (100 EACH \$475.00/lot)

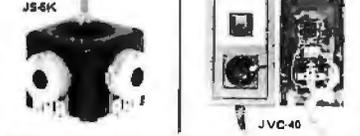
## EPROM Erasing Lamp



- Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.
- Erases up to 4 chips within 20 minutes.
- Main lens constant exposure distance of one inch.
- Special conductive foam liner eliminates static build-up.
- Built-in safety lock to prevent UV exposure.
- Compact — only 7-5/8" x 2-7/8" x 2"
- Complete with holding tray for 4 chips.

UVS-11E . . . . . \$79.95

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JS-5K 5K Linear Taper Pots . . . . . \$5.25  
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 JVC-40 40K (2) Video Controller in case . . . \$5.95

## 6-Digit Clock Kit



- Bright .300 ht. comm. cathode display.
- Uses MM5314 clock chip.
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA.
- 11.5VAC, 3-terminal adj. IC regulators with thermal overload protection.
- Heat sink regulator cooling.
- LED "on" indicator.
- Printed Board Construction.
- 120VAC input.
- Size: 3-1/2" x 3-1/8" x 1 3/4"

JE701 . . . . . \$19.95

## NEW! JE215 Adjustable Dual Power Supply

General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the supplies provides the user unlimited applications for IC current voltage requirements. The supply can also be used as a general all-purpose variable power supply.

**FEATURES:**

- Adjustable regulated power supplies, pos. and neg. 1.2VDC to 15VDC.
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA.
- 11.5VAC, 3-terminal adj. IC regulators with thermal overload protection.
- Heat sink regulator cooling.
- LED "on" indicator.
- Printed Board Construction.
- 120VAC input.
- Size: 3-1/2" x 3-1/8" x 2 1/4"

JE215 Adj. Dual Power Supply Kit (as shown) . . \$24.95

(Picture not shown but similar in construction to above)  
 JE200 Reg. Power Supply Kit (5VDC, 1 amp) . . \$14.95  
 JE206 Adapter Brd. (to JE200) + 5, +9 & ±12V. \$12.95  
 JE210 Var. Pwr. Sply. Kit, 5-15VDC, to 1.5amp. \$19.95

## MICROPROCESSOR COMPONENTS

### 8080A/8080A SUPPORT DEVICES

IN5350A	8-Bit Input/Output	4.95
OP821	Priority Interrupt Control	5.95
OP826	Bi-Directional Bus Driver	3.49
OP828	Clock Generator/Driver	3.49
OP826	Bus Driver	3.49
OP822	System Controller/Bus Driver	4.95
OP823	System Controller	5.95
IN54243	I/O Expander for 48 Series	9.95
IN5250	Asynchronous Comm. Element	16.95
OP825	Prog. Comm. I/O (USART)	1.95
OP8253	Prog. Interval Timer	14.95
OP8255	Prog. Peripheral I/O (PPI)	9.95
OP8251	Prog. DMA Control	15.95
OP8259	Prog. Interrupt Control	14.95
OP8275	Prog. CRT Controller	49.95
OP8279	Prog. Keyboard/Display Interface	6.95
OP8281	Digital Bus Receiver	5.95
OP8303	System Timing Element	6.95
DP8304	8-Bit Bi-Directional Receiver	3.95
OP8305	8-Bit Bi-Directional Receiver	3.95
DP8308	4-8K Bi-Directional Receiver	3.95

### 6800/6800 SUPPORT DEVICES

MC6800	MPU	4.95
MC6802CP	MPU with Clock and RAM	11.95
MC6801A	256-Byte RAM	1.95
MC6821	Peripheral Inter. Adp't (MC6801)	4.95
MC6822	Priority Interrupt Controller	4.95
MC6823	8081-Bit ROM (MC6801)	1.95
MC6850	Asynchronous Comm. Adapter	6.95
MC6852	Synchronous Serial Data Adapter	6.95
MC6850	4000bps Digital MODEM	12.95
MC6852	2000b Modulator	12.95
MC6850	Quad 3-State Bus Trans. (MC6821)	6.95

### MICROPROCESSOR CHIPS

280 (1M)C	CPU (MK380M) (2MHz)	13.95
280 (1M)D	CPU (MK380M)(2MHz)	13.95
CDP1802	CPU	19.95
950	MPU	19.95
LD8350A	CPU—4-Bit Slice (Com. Temp. Grade)	19.95
MC6502	MPU w/Clock (64Kbytes Memory)	11.95
IN5302N-4	MPU—8-Bit (MHz)	18.95
IN5302N-4	CPU—511-Byte (128-Bytes RAM)	19.95
IN5304N-6	CPU (256 Bytes RAM)	24.95
IN5302N	CPU—64 Bytes RAM	24.95
IN5302N	MPU w/Bi-Dir. Micro Interpreter	29.95
FM805	CPU	19.95
IN5300	CPU—16-Bit	29.95
TM59000AL	MPU—32-Bit	96.95

### SHIFT REGISTERS

MM5901	Dual 20-Bit Dynamic	4.95
MM5903	Dual 50-Bit Dynamic	4.95
MM5904	Dual 100-Bit Static	4.95
MM5905	Dual 64-Bit Accumulator	4.95
MM5902	24-Bit Dynamic/Accumulator	1.95
MM5903	102.5-Bit Dynamic/Accumulator	1.95
MM5904	500.0-Bit Dynamic	9.95
MM5905	1024-Bit Dynamic	9.95
MM5906	2048-Bit Dynamic	19.95
252V	Hex 32-Bit Static	4.95
252V	Dual 132-Bit Static	2.95
252V	312-Bit Dynamic	2.95
252V	1024-Bit Dynamic	2.95
252V	Dual 256-Bit Static	2.95
252V	Dual 512-Bit Static	4.00
252V	Dual 1024-Bit Static	4.00
252N	Quad 50-Bit Static	2.95
314PC	Fifo (Dual80)	8.95

### DATA ACQUISITION

AF100-1CN	Universal Active Filter: 25%	8.95
AF121-1CN	Touch Tone Low Pass Filter	79.95
LM3048A	Super Gain Dn Amp	1.20
LM334Z	Constant Current Source	1.20
LM131Z	Temperature Transducer	12.40
LF355N	JFET Input Op Amp	1.10
LF399N	Sample & Hold Amplifiers	8.95
LM339N	Comp. Comp. Rel. (Edpm/C)	4.95
AD0809CLN	8-Bit A/D Converter (1.5LSB)	2.75
DAC0809CLN	8-Bit D/A Converter (0.75% Lin.)	2.75

### DATA ACQUISITION (CONTINUED)

AD0809CLN	8-Bit A/D Converter (1.5-Ch. Multi.)	3.25
AD0817CN	10-Bit D/A Conv., Micro. Comp. (0.25%)	13.95
DAC0809CLN	10-Bit D/A Conv., Micro. Comp. (0.25%)	8.95
DAC0817CN	10-Bit D/A Converter (0.25% Lin.)	8.95
AD0825CLN	10-Bit D/A Converter (0.25% Lin.)	5.95
DAC1272CLN	12-Bit D/A Converter (0.25% Lin.)	9.95
CM0591N	8-Chan. Multiplexer	13.95
AV-3103	30K BAUD UART	5.95

### RAMS

100	1024 1-Static	4.95
100	1024 4-Static	9.95
200	2048 1-Static	4.95
200	2048 4-Static	9.95
2102	2048 1-Static	1.75
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2121	2048 1-Static MOS	4.95
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MM5251	2048 1-Dynamic Fully Decoded	7.95
MM5280	1024 1-Dynamic	4.95
MM5280Z07	4096 1-Dynamic 180ns	3.25
MM5290-2A(16)	16K Dynamic 180ns	4.95
MM5290-2A	8-K Dynamic (Low Power of MM5290J)	4.95
UPD414/MK4027	4K Dynamic 18-pin	4.95
TMS4244-4SNL	4K Static	14.95
MM5290	16K Static	12.95

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1708A	2K UV Erasable PROM	5.95
1708	8K EPROM	9.95
2716	16K EPROM (5V, +5V, +12V)	16.95
2716(16)25(16)T	16K EPROM (Single +5V)	10.95
2732(16)25(16)T	32K EPROM	13.95
2756	64K EPROM (450ns) (Single +5V)	7.95
5103	2048 PROM	16.95
82521(74538A)	32x8 PROM (0-Pin Collector)	4.95
825115	4096 Bipolar PROM	9.95
825123(74528)	32K Tri-State Bipolar PROM	4.95
825285	64K PROM	29.95

### ROMS

3212(3208)	Character Generator (Upper Case)	3.95
3212(3209)	Character Generator (Lower Case)	3.95
2616N	Character Generator	10.95
MM5920N	2048-Bit Read Only Memory	1.95

### AMOS READ ONLY MEMORIES

128x97	ASC II Shift key w/Greek	13.50
128x97	128x97 Matrix Symbols & Pictures	13.50
128x97	128x97 Alpha, Control Char. Gar.	13.50

### MICROPROCESSOR MANUALS

M-280	User Manual	1.50
M-COP1802	User Manual	1.50
M-280	User Manual	1.50

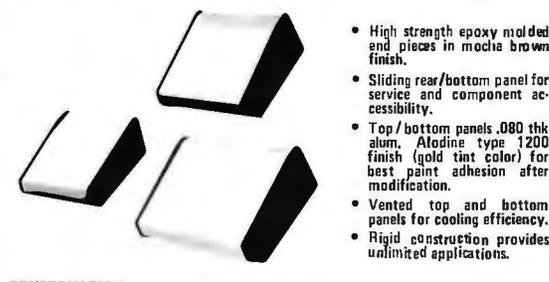
### SPECIAL FUNCTION

AD0809CLN	Dual MOS Clock Driver (5MHz)	1.50
D3509CN	Dual MOS Clock Driver (5M2)	1.95
IN5171A	Microprocessor Compatible Clock	24.95
IN5251N	Communication Chip	19.95
MM5484FN	Microprocessor Real Time Clock	8.95
MM5485FN	Microprocessor Compatible Clock	6.95
MCP402N	Microcontroller with 64-Digit RAM and Direct LED Drive	7.95
COP402N	Microcontroller with 64-Digit RAM & Direct LED Drive w/V. Bus Int.	7.95
COP402N	32-Seg. VAC Flip. Driver (20-pin pkg.)	3.25

### TELEPHONE KEYBOARD CHIPS

AV-5-3100	Pull Button Telephone Dialer	14.95
AV-5-3100	CMOS Clock Generator	14.95
AV-5-3100	CMOS Clock Generator	4.95
AV-5-3100	Keyboard Encoder (88 keys)	7.95
AV-5-3100	Keyboard Encoder (16 keys)	5.95
AV-5-3100	Keyboard Encoder (20 keys)	5.75
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## DESIGNERS' SERIES Blank Desk-Top Electronic Enclosures



- High strength epoxy molded end pieces in mottle brown finish.
- Sliding rear/bottom panel for service and component accessibility.
- Top/bottom panels .080 thick aluminum. Alodine type 1200 finish (gold tint color) for best paint adhesion after modification.
- Vented top and bottom panels for cooling efficiency.
- Rigid construction provides unlimited applications.

Enclosure Model No.	Panel Width	PRICE
DTE-8	8.00"	\$29.95
DTE-11	10.65"	\$32.95
DTE-14	14.00"	\$34.95

**CONSTRUCTION:** The "DTE" Blank Desk Top Electronic Enclosures are designed to blend and complement today's modern computer equipment and can be used in both industrial and home. The end pieces are precision molded with an internal slot (all around) to accept both top and bottom panels. The panels are then fastened to 1/4" thick tabs inside the end pieces to provide maximum rigidity to the enclosure. For ease of equipment servicing, the rear/bottom panel slides back on slotted tracks while the rest of the enclosure remains intact. Different panel widths may be used while maintaining a common profile outline. The molded end pieces can also be painted to match any panel color scheme.

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## Bourns Potentiometer



3/4 Watt Single Turn (TOP ADJUSTMENT)

Values: 500Ω 1K 2.5K 5K 10K 25K 50K 100K 250K 500K 5Meg

INDIVIDUAL PRICING:

1.49 50.99 100.999 1K-up  
 .19 .17 .15 .12

GB174 . . . . . \$1.95/lot  
 (25 pieces all 11 ass. values)

To order: Specify Bourns 3355 — (Value desired)

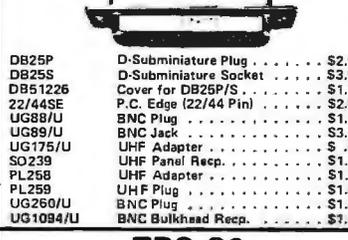
## AC and DC Wall Transformers



Ideal for use with clocks, game, power supplies or any other type of AC or DC application.

Part No.	Input	Output	Price
AC 250	117V/60Hz	12 VAC 250mA	\$3.95
AC 500	117V/60Hz	12 VAC 500mA	\$4.95
AC1100	117V/60Hz	12 VAC 1 amp	\$5.95
AC1700	117V/60Hz	9 VAC 1.7 amp	\$6.95
DC V200	117V/60Hz	9 VDC 200mA	\$3.25
DC 900	120V/60Hz	9 VDC 500mA	\$3.95

## CONNECTORS



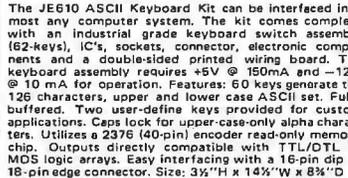
DB25P	D-Subminiature Plug	\$2.95
DB25S	D-Subminiature Socket	\$3.50
DB51226	Cover for DB25P/S	\$1.75
22/44SE	P.C. Edge (22/44 Pin)	\$2.95
UG68/U	BNC Plug	\$1.79
UG68/U	BNC Jack	\$3.79
UG75/U	UHF Adapter	\$ .49
UG139	UHF Panel Recp.	\$1.29
PL25B	UHF Adapter	\$1.60
PL259	UHF Plug	\$1.60
UG109/U	BNC Plug	\$1.79
UG109/U	BNC Bulkhead Recp.	\$1.29

## TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K.  
 Kit comes complete with:  
 \* 8 ea. MM5290 (UPD416/4116) 16K Dyn. Rams (\*NS)  
 \* Documentation for Conversion

TRS-16K2 \*150NS . . . . . \$39.95  
 TRS-16K4 \*250NS . . . . . \$29.95

## JE610 ASCII Encoded Keyboard Kit



The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and -12V @ 10 mA for operation. Features: 60 keys generates the 126 characters, upper and lower case ASCII set. Fully buffered. Two user-definable keys provided for custom applications. Caps lock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector. Size: 3 1/4" H x 8 1/4" W x 8 3/4" D

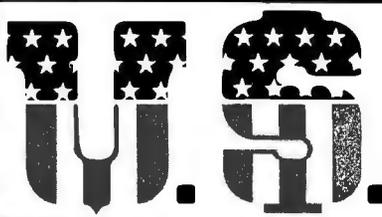
JE610/DTE-AK (as pictured above) . . . \$124.95  
 JE610 Kit (62-Key Keyboard, PC Board, & Components (no case)) . . . \$ 79.95  
 K62 62-Key Keyboard (Keyboard only) . . . \$ 34.95  
 DTE-AK (case only — 3 1/4" H x 8 1/4" W x 8 3/4" D) \$ 49.95

## JE600 Hexadecimal Digit Kit



FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD

The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries (without direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 8 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-definable keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation. Size:



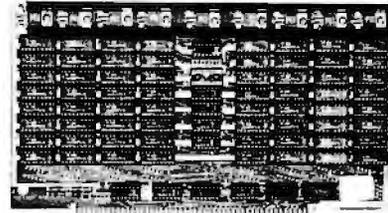
# MICRO SALES

DEALS □ DEALS □ DEALS

SHOP HERE AND  
**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.

# \$299



★ Extended Address Lines A16 - A17

★ Phantom Line

★ 9 Regulators

(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		CARD EDGE	
PINS	PRICE	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

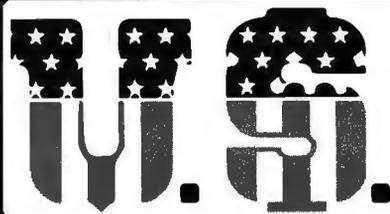
All 4MHZ (who wants 2MHZ?)

### 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 1.95
74LS32 .95	74LS160 .75	74LS293 1.29
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		

**DEALS □ DEALS □ DEALS**

OUR BUYERS ARE IN  
CONTACT WITH EVERY MAJOR  
SUPPLIER AND O.E.M.  
BUY HERE AT 1000 PIECE



# MICRO SALES

## QUANTITY PRICES

ALL MERCHANDISE 100%  
GUARANTEED! 15 DAY FULL  
CASH REFUND!

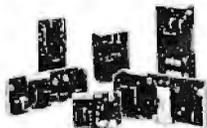
664 N. MICHIGAN AVE. ★ SUITE 1010 ★ CHICAGO, ILLINOIS 60611  
CALL TOLL FREE: 1-800-435-9357 ★ MONDAY thru SATURDAY  
(ILLINOIS RESIDENTS CALL: 815-485-4002) ★ 8:00 a.m. to 6:30 p.m.

TERMS: Prepayment - C.O.D. up to \$100.00 - M/C Visa  
\$5.00 Processing and Handling added to each order PLUS  
Shipping Charges. Please allow personal check  
to clear before shipment.

### JUST HOT STUFF

#### POWER SUPPLIES

If you can beat these prices we will be truly amazed. OEM's at 500 lot pay more than this. Call or write for full spec. sheets.



DISK POWER SUPPLIES				
PRIAM - SHUGART - CENTURY - MICROPOLIS				
+5V @ 9A	-5V @ .8A	+24V @ 7A	US-384	89.00
SHUGART - SIEMANS - MPI 5 1/2"				
+5V @ .5A	+12V @ .9A		US-340	33.50
+5V @ 2A	+12V @ 4A		US-323	56.25
SHUGART - SIEMANS - CDC 8"				
+5V @ 1A	-5V @ .5A	+24V @ 1.5A	US-205	52.50
+5V @ 2A	-5V @ .5A	+24V @ 3A	US-206	69.00
+5V @ 3A	-5V @ .6A	+24V @ 5A	US-162	89.00
+5V @ 1.7A	-5V @ 1.5A	+24V @ 2A	US-272	69.00
+5V @ 2A	+12V @ .4A	-12V @ .4A	US-HTAA	37.50

#### TELEVIDEO 912C

SOROC 1Q120 - \$675.00  
Televideo 912C - 665.00  
Televideo 920C - 720.00  
ADDS R-25 - 710.00

Also have 920C, SOROC, HAZELTINE, etc. What we don't have is room on this page. Call Toll Free 800 number for prices.



#### C-ITOH PRINTER

**\$499.00**

Look closely at the photo and see other adds in this rag at \$995.00. Perfect units, warranted. Only 500 pcs. Same story, manufacturer had too many.



#### S-100 CARD EXTENDER

**\$12.50**

(Gold Contacts)

As long as there is a price war, we will fight your battle. Compare at your local Dept. store and buy U\$ MICRO.



#### MEMOREX - VERBATUM - WABASH

##### BASF FLOPPIES

BOX OF 10 ONLY:

5 1/4"	SOFT	\$2.65 ea.
5 1/4"	HARD 10	2.65 ea.
5 1/4"	HARD 16	2.65 ea.
8"	SOFT 1D	3.25 ea.
8"	SOFT 2D	3.85 ea.
8"	SOFT 2DDS	5.00 ea.



### SPECIAL OF THE QUARTER

#### S1-MOD (KIT)

**\$189.00**



Complete S-100 12 Slot Computer. Ample system power with regulated power for drives. Excellent for Subsystem or Hobby use. 4 hours to build. (6 conn. incl., less fans)

#### DUAL DRIVE SUBSYSTEM

**\$995.00**

**\$195.00 w/no Drives**

If this looks like a Lobo Drive System, don't be fooled. Just because it looks like one, works like one, smells like one, and tastes like one (?) doesn't mean it has to cost like one!



2 SHUGART 801R POWER SUPPLY

#### TWIN VERTICAL DRIVES

5" \$550.00 - 8" \$980.00

Attractive, convenient and compact Two Drive Mass Storage includes Power Supply, Drives, Cabinets and Cables. Double Sided, Double Track available too!



#### Z-80 CPU (KIT)

The first time this world popular CPU offered in Kit. 2 serial, 3 parallel, CTC, EProm Z-80 at 4 mhz. Software buad rate, etc. (less Prom & cable) **\$212.00**



#### EXPANDABLE RAM

★SPECIAL★SPECIAL★SPECIAL★

This is the best all around 64K board you can buy. If after you see it, you don't agree return for full refund. Bank Select by extended address lines or I.O. 40H. **\$389.00 A & T★**



U\$ - D\$K **\$255.00**

Double Density 8" and 5" Disk Controller designed for S-100 IEEE standards. Uses Western Digital 1795, 1691 2143 Chip Set.



#### FANS \$14.95

These are brand new, in the box fans. Not noisy bearing pullouts. Never again at these low prices!



3-1/8"



4-5/8"

### SPECIALS OF THE MONTH

#### 4116s

**\$2.95**

200 NS

Expansion 16K Dynamic RAMs for Apple, TRS-80 S-100 systems. T.I., Mostek Intel, Call for manufacturer.

#### DIP-80 \$399.00

Don't be misled by this LOW price. This is a rugged 100% Duty Cycle 7 by 7 Dot Matrix Printer. Brand new, factory warr.



• RS-232 ADD \$65.00  
• TRACTOR FEED ADD \$70.00

#### 2114s

**\$3.45**

200 NS

One of the world's two most popular STATIC RAMs. Factory prime tested units. Sold in lots of 8 only. FUJITSU, HITACHI, etc.



#### TMS-4044

MM-5257

INTEL 2147

**\$4.25**

250 NS

The other of the world's most popular STATIC RAMs. This one is 4K by 1 organization. Don't buy Gold, buy these, the price won't last!

#### 2716s

**\$9.50 (450 NS)**

#### 2708s

**\$6.95 (450 NS)**

Remember when 2716s were \$50.00 and hard to get? These units are so beautiful it's hard to part with them. But we will, for a small price. Guaranteed!

#### SHUGART DRIVE



**8" 801R \$395.00**

Manufacturer had too many, buys at 1000 piece rate, sales dropped, so we got 'em. Fantastic buy, get them while they last! Full warranty.

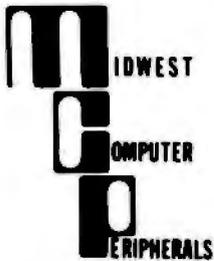
**8" 851R \$585.00**

#### SIEMANS DRIVE

**8" 120-8**

**\$375.00**

Very Special Price on these BRAND NEW current production units Add \$10.00 for Extended 1 Year Warrantee!



# INVENTORY CLEARANCE SALE PRICES SLASHED!!

## COMPUTER SYSTEMS

ALTOS MODEL ACS-8000-2 64k, 2 drive, single user	\$3769
MODEL ACS-8000-5MUZ 112k, 2 drive, two user	\$5809
APF IMAGINATION MACHINE Complete System	\$1015
APPLE II plus 16k	\$1096
ATARI 400	\$492
ATARI 800	\$877
COMPUCOLOR 3 8k complete package	\$1478
RADIO SHACK MODEL III 16k	\$899
EXPANSION INTERFACE OK	\$274
MODEL II 64k w/one drive	\$3499

We carry the complete RADIO SHACK line at a discount

SD SALES SDS-100	*\$6299
SDS-200	*\$6699
ZENITH Z-B9 (48k)	\$2447

## PRINTERS

ANACOM 150 150 cps, bi-directional, 9 x 9 matrix	\$1319
ANADEX DP-9500	\$1529
CENTRONICS MODEL 779 TRACTOR PRINTER	\$999
737 "Letter Quality" w/ cable	\$815

We Carry the complete CENTRONICS line!

DIABLO MODEL 630 RO w/Tractors	*\$2579
EPSON MX-70	\$399
MX-80 Tractor feed, bi-directional, 80 cps	\$550
INTEGRAL DATA IDS 445G w/2K Buffer & Graphics w/Cable	\$752
IDS-460 w/Cable	\$1209
MP! MT-88 TRACTOR PRINTER w/cable	\$659
MT-88G Graphics printer w/ cable	\$699
OKIDATA 82 Bi-directional w/ tractor cable	\$862
83 15" Carrage/Bi-directional	\$1099
NEC SPINWRITER 5510 RO Serial	*\$2579
5520 KSR Serial	*\$2879
5530 RO Parallel	*\$2579
OKIDATA MICROLINE 80 PRINTER 80 cps, 9 x 7 matrix	\$554
w/Tractors and cable	\$679
TEXAS INSTRUMENTS 810 Basic	*\$1499
TRS-232 PRINTER INTERFACE	\$59

Allows you to use any serial printer with the TRS-80.

WE NOW TAKE  
AMERICAN EXPRESS



## TERMINALS

HAZELTINE MODEL 1510	*\$1099
1520	*\$1360
PERKIN-ELMER BANTAM	*\$799
SOROC IQ 120	*\$759
IQ 140	*\$1199
TELEVIDEO 912C	*\$799
920C	*\$859
ZENITH Z-19	*\$899

## CALIFORNIA COMPUTER SYSTEMS

MODEL 2016C 16k Static RAM board, A & T	\$242
2200 MAINFRAME A & T	\$352
MOTHERBOARD 12 slots, A & T	\$101

## APPLE PRODUCTS

Model 7440 PROGRAMMABLE TIMER BOARD A & T	\$99
7470 3 1/4 DIGIT BCD A to D Converter A & T	\$102
7490 GPIB (IEEE 488-1978) INTERFACE A & T	\$202
7710 ASYNCHRONOUS SERIAL INTERFACE A & T	\$132
7712 SYNCHRONOUS SERIAL INTERFACE A & T	\$142
7720 PARALLEL INTERFACE A & T	\$99
7811 ARITHMETIC PROCESSOR A & T	\$356
7114 12k ROM/PROM Module A & T	\$69

We carry the complete line of CCS products

## SD SALES S-100 BOARDS

MODEL Expandoram (NO RAM)	KIT	\$192
VDP-8024	KIT	\$302
VDB-8024	A & T	\$402
VDB-8024	A & T	\$402
Z-80 STARTER KIT		\$302
Z-80 STARTER SYSTEM	A & T	\$382
SBC-100	KIT	\$252
SBC-100	A & T	\$305
SBC-200	KIT	\$274
Versafloppy	Kit	\$223
Versafloppy	A & T	\$295
Versafloppy II Double Density	KIT	\$305
Versafloppy II Double Density	A & T	\$376



# Midwest Computer Peripherals



WE PAY UPS CHARGES ON MOST ORDERS  
IN THE CONTINENTAL U.S.

1467 S. Michigan Ave.  
Chicago, IL 60605

## FLOPPY DISK STORAGE

**CORVUS 11T 10 MEGABYTE HARD DISK** \*\$4029  
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.**

## BARE DRIVES (No Case or Power Supply)

### 5" MODELS

<b>MPI MODEL 51</b>	40 tracks, 5 ms.	\$254
<b>MPI MODEL 52</b>	Double headed, 80 tracks	\$299
<b>MPI MODEL 91</b>	80 tracks	\$299
<b>MPI MODEL 92</b>	160 Tracks, Double headed	\$399

## 5.25" POWER SUPPLIES WITH CASE

<b>STANDARD MINI DISK POWER SUPPLY WITH CASE</b>	\$80
<b>DELUXE MINI DISK POWER SUPPLY w/CASE &amp; extender card</b>	\$131
<b>DUAL MINI DISK POWER SUPPLY w/CASE</b>	\$121

**DISK DRIVE EXTENDER CABLE** \$16

## DRIVE CABLES

<b>1 DRIVE TRS-80 CABLE</b>	\$24
<b>2 DRIVE TRS-80 CABLE</b>	\$29
<b>3 DRIVE TRS-80 CABLE</b>	\$35
<b>4 DRIVE TRS-80 CABLE</b>	\$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

<b>NEWDOS(40 Track)</b>	\$49
<b>NEWDOS + (40Track)</b>	\$99
<b>NEWDOS 80</b>	\$139
<b>MICROSOFT FORTRAN</b>	\$85
<b>Z80 Softcard</b>	\$305
<b>Super Utility</b>	\$49
<b>Make 80</b>	\$14
<b>Electric Pencil (disk)</b>	\$130

10% off all **RADIO SHACK** software

We carry SBSG, Microsoft, personal software, Apparatt and many other brands. All at a discount.

## DISKETTES

(Prices per box of 10)

NEW

		VERBATIM	SYNCOM	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" <b>LIBRARY CASE</b> holds 10 disks	\$3.95
<b>BINDER HOLDER</b> holds 2 disks	10 for \$7.95
8" <b>LIBRARY CASE</b> holds 10 disks	\$4.95
<b>BINDER HOLDER</b> holds 2 disks	10 for \$19.95
<b>FLOPPY SAVER</b>	5 1/4" \$14.95
	8" \$16.95

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:

**PHONE ORDERS: HOURS 10AM - 5PM CST MON - FRI**

**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.

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**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.**

**BY CREDIT CARD:** Neatly type or print your **MASTER CHARGE** or **VISA** account number along with the expiration date and 4 digit interbank number (MC only).

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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.

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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

Dealer Inquiries welcome  
TRS-80™ TANDYCORP.

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**IN ILLINOIS: 312-987-1024**



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Chicago, IL. 60605

We pay UPS charges on most orders in continental U.S.

# What is Jade doing in San Diego?

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.

Z-80	10.95
Z-80A	12.95
6502	11.50
6800	11.95
6802	17.95
6809	39.95
MICRO PROCESSORS	
8035	24.00
8080A	6.59
8085	15.95
8748	59.95
Z-80 SUPPORT	
3881 PIO	8.75
3881-4 PIO 4 MHz	12.95
3882 CTC	8.75
3882-4 CTC 4 MHz	12.95
3883 DMA	29.50
3883-4 DMA 4 MHz	36.95
3884 SIO	35.95
3884-4 SIO 4 MHz	39.95
BAUD RATE GENERATORS	
MC14411	10.00
1.843 MHz xtal	4.95

## Special Purchase - Save \$50.00 Novation Cat Modem 300 baud, answer and originate



(We have only 700 available at this special price)

IOM-5200A	List price \$189.95	\$139.95
D-CAT 300 baud, direct connect modem		
IOM-5201A	Special sale price	\$189.00
AUTO-CAT Auto answer/originate, direct connect		
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

SUPPORT DEVICES	
8212	3.25
8214	4.65
8216	2.95
8224	3.25
8224-4	5.75
8226	3.85
8228	4.95
8238	4.95
8243	8.00
8250	14.95
6800 SUPPORT	
6821P	4.95
6828P	15.95
6840P	15.75
6850P	4.80
6852P	5.95
6875P	5.95
68488P	27.95
8251	6.50
8253	17.95
8255	6.50
8257	19.95
8259	17.95
8275	49.95
8279	15.95

## 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!

END-000421	Cabinet kit	\$225.00
END-000420	Bare cabinet	\$59.95

Single sided, double density disk drive sub-system		
END-000423	Kit w/2 8" drives	\$975.00
END-000424	A & T w/2 8" drives	\$1195.00

Double sided, double density disk drive sub-system		
END-000426	kit w/2 8" drives	\$1495.00
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

Shugart 851R double sided, double density		
MSF-10851R	SA-851R	\$595.00
Special Sale Price		2 for \$1150.00

Siemens FDD100-8D2 single sided, double density		
MSF-201120	6 mo warranty	\$385.00
Special sale price		2 for \$750.00

Qume Datatrak 8 double sided, double density		
MSF-750080	SA-851R compatible	\$599.95
Special sale price		2 for \$1160.00

### JADE DISK PACKAGE

Double density controller, two 8" double density floppy disk drives, CP/M 2.2 (configured for controller), hardware and software manuals, boot PROM, cabinet, power supply, fan, & cables  
Special package price \$1395.00

### PROMS

2708 4500s	6.25
10 for \$4.90 ea	
2716 1250	9.95
2718 50	9.95
10 for \$7.95 ea	
2532 50	25.00
2732 50	25.00
2758 50	9.95

### RAMS

21L02 2 MHz	1.25
21L02A 4 MHz	1.50
2114L 2 MHz	3.50
2114LA 4 MHz	3.75
4116	3.50
4164 61K x1	39.95
5257 2 MHz	6.75
5257A 4 MHz	7.25
MK4118	17.95

### UARTS

AY5-1013A	5.25
AY3-101-4A	8.25
TR1602B	5.25
TMS6011	5.95
IM6402	9.00

## Accessories-Apple/TRS-80



### 16K MEMORY UPGRADE

Add 16K of RAM to your TRS-80, Apple, or Exidy in just minutes. We've sold thousands of these 16K RAM upgrades which include the appropriate memory chips (as specified by the manufacturer), all necessary jumper blocks, fool-proof instructions, and our 1 year guarantee.

MEX-16100K TRS-80 kit	\$29.00
MEX-16101K Apple kit	\$29.00
MEX-16102K Exidy kit	\$29.00

### 16K RAM Card - Microsoft

(There is life after 48K)

MEX-16300A A & T	\$174.95
------------------	----------

### Z-80\* CARD for APPLE

Two computers in one, Z-80 & 6502, more than doubles the power & potential of your Apple, includes Z-80\* CPU card, CP/M 2.2, & BASIC-80

CPX-30800A A & T	\$279.95
------------------	----------

### APPLE CLOCK - Cal Comp Sys

Real time clock w/battery back-up

IOK-2030A A & T	\$109.95
-----------------	----------

### DISK DRIVES for TRS-80

23% more storage, 8 times faster, 40 track with free patch, 120 day warranty, includes case, power supply, and cable

MSM-12410C Save \$125.00 !!!	\$299.95
------------------------------	----------

### 8" DRIVES for APPLE

Controller, DOS, two 8" double density drives, cabinet, power supply, & cables

Special package price	\$1475.00
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### APPLE STICK - Micromate

Joy stick with pots for Apple II

SYA-1510A A & T	\$49.95
-----------------	---------

### VISICALC - Personal Sftwr

The ultimate program for your Apple II

SFA-24101005M Complete package	\$139.95
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### PRINTER INTERFACE - C.C.S.

Centronics type I/O card w/ firmware

IOI-2041A A & T	\$99.95
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### 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

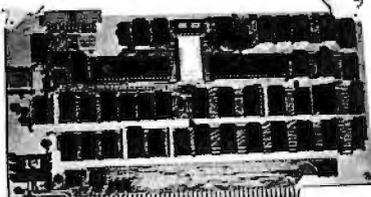
### A488 - S.S.M.

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



2.1 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, accommodates 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

### CB-2 Z-80 CPU - S.S.M.

2 or 4 MHz Z-80 CPU board with provision for up to 8K of ROM or 4K of RAM on board, extended addressing, IEEE S-100, front panel compatible.  
CPU-30300K Kit ..... \$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 5 1/4" A & T ..... \$389.95  
IOD-1200B Bare board ..... \$65.00

### DOUBLE DENSITY - Cal Comp Sys

5 1/4" 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" & 5 1/4"  
IOD-1160K Kit ..... \$379.95  
IOD-1160A Jade A & T ..... \$439.95

# S-100 Video

### VB-3 - S.S.M.

80 characters x 24 lines expandable to 80x48 for a full page of text, upper & lower case, 256 user defined symbols, 160x192 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

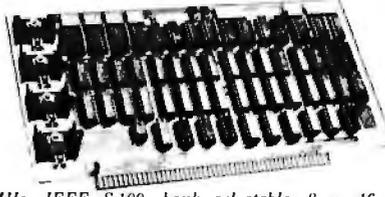
### ASCII KEYBOARDS - Microswitch

58 key plus numeric pad and control keys  
KBA-99058 A & T ..... \$39.95

Circle 207 on Inquiry card.

# 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

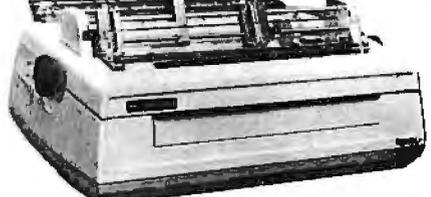
Latest & most powerful release of CP/M  
SFC-52506000D Manual set ..... \$24.95  
SFC-52506000M 5 1/4" disk & manual \$149.95  
SFC-52506000F 8" disk & manual \$149.95

### SDOS - SD Systems

DOS, CBASIC-2, Z-80\* assembler/editor/linker  
SFX-55001000D Manual set ..... \$24.95  
SFX-55001002M 5 1/4" 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  
PRD-55512 with 16K buffer ..... \$2895.00

### 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

### DISKETTES - Jade

Bargain prices on magnificent magnetic media  
5 1/4" single sided, single density, box of 10  
MMD-5110103 Soft sector ..... \$27.95  
MMD-5111003 10 sector ..... \$27.95  
MMD-5111603 16 sector ..... \$27.95  
5 1/4" 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  
8" double sided, double density, box of 10  
MMD-8220103 Soft sector ..... \$49.95

### S-100 CARD CAGE - Vector

19" rack mountable, adjustable, holds 21 cards  
VCT-CCK100 Anodized Al ..... \$47.95  
Metal cage with card guides & fan mounting  
ENX-106601 Six slot ..... \$29.95

## PLACE ORDERS TOLL FREE

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213-973-7707

# JADE

## Computer Products

4901 W. Rosecrans, Hawthorne, Ca 90250  
TERMS OF SALE: Cash, checks, credit cards, or Purchase Orders from qualified firms and institutions. Minimum order \$15.00. California residents add 6% tax. Minimum shipping and handling charge \$3.00 (Price and availability subject to change without notice.)

# California Digital

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## DISKETTES

FREE PLASTIC LIBRARY CASE INCLUDED WITH THE PURCHASE OF EVERY BOX OF DISKETTES.

Prices listed for California equal to one of the most respected producers of computer media. Each diskette is certified double density at 80 tracks. An unbreakable media life work diskette is manufactured with a reinforced hub-hole. And of course, a plastic library case is included with every box of diskettes. **MSD-CJ50(1)10**

### \$24.95 BOX

Ten boxes \$22.75      One hundred boxes \$21.50

MINISYSTEMS	Box	10 boxes	Box	10 boxes
Amnorse 4401	\$27.00	\$25.00	Scotch 7-140(10)(10)	\$31.00
Verbatim 5250(1)10	28.00	27.00	Dyan 10	45.00

1 1/4" INCH      Scotch box 10 bx.      Dyan box 10 bx.      3MxN box 10 bx.

Single side/single den. 740-0      \$35.      3740(1) 540.      \$47.      3090      \$ 3.      \$ 3.

Single side/double den. 741-0      \$5.      3740(1) 75.      73.      3090      37.      35.

Double side/2 sector      740-22      35.      33.      na.      na.      na.      na.

Double side/double D. 743-0      61.      59.      na.      31.5      40.      44.

SHUGART brand head cleaning kit. \$24.95 MSD-CM5(10) please specify 1 1/4" 8"

Prices available on request for tape, cartridges, diskpaks, volume diskettes.

## 26 Megabyte Hard Disk Drive from GEORGE MORROW'S Thinker Toys \$3950

Other Morrow Products:

Additional hard disk	\$240	Disc Jockey 20 controller	\$38
Busway 21 1 drive	127	Disk Jockey 1 Controller	19
Busway 21 2 drive	127	IBM hard disk Controller	29
Busway 21 3 drive	127	Southwood interface	21
Busway 21 4 drive	127	New Multitasker	27
Busway 21 5 drive	227	1 1/4" Full Stackable hard	6

## NEW from Shugart Technology 5 Megabyte Hard Disk Drive

Packaged in the same physical size as the industry standard 5 1/4" minifloppy disk drive. The micro-Winchester stores thirty times as much data (6.38 megabytes unformatted), accesses data twice as fast (170 milliseconds) and transfers data twenty times faster (5.0 megabits per second.)

The ST506 is factory sealed to protect the media from environmental contaminants. Requires only DC voltage. Dual California Digital 5 1/4" enclosure. **\$1500**

ST506 drive and power supply.

Shugart Associates SA400 removable media disk drive for above package. add: **\$300**

S-100 & Apple controller scheduled for spring release.

## HEWLETT PACKARD \$2650

### HP 85

The Hewlett Packard HP-85 is a complete low cost portable computer system. It is a self contained package including CPU, keyboard, printer, CRT monitor and cassette tape drive. 512K(128) 30 lbs.

## BSR SYSTEM X-10

The new BSR timer runs your home just like clockwork. Turns on lamps and appliances while you're away from home. Completely compatible with your existing X-10 devices.

BSR Timer eight channel	\$85.00	Appliance Module 500 Wts.	\$12.95
Timer control console	\$19.95	Lamp Module 500 Watts	\$3.95
UltraSonic Controller		NK-W full control wall switch	14.50

## MEMORY

### TRS-80 APPLE II \$25

#### 16k memory (8) 4116's

Factory prime. Unconditionally guaranteed for one full year. Add \$3.00 for TRS-80 jumpers and instructions.

## S-100 Mother Board \$35

### Quiet Buss

8803-18 IB SAI

## DYNAMIC

	ea.	32+	100+	1K+
4116- 200ns	3.25	3.00	2.75	2.50
4116 150ns	3.75	3.50	3.25	3.00
4164 84K	49.50	45.00		

## STATIC

211.02 450ns.	1.19	1.05	.99	
211.02 250ns	1.49	1.45	1.39	
2114L4 450ns	3.95	2.95	2.75	2.50
2114L3 300ns	4.25	3.75	3.00	2.75
4044-4 450ns	4.95	4.50	4.25	4.00
4044-2 250ns	5.50	4.95	4.50	4.35
5257-3 300ns	4.47	4.25	4.05	3.75

## EPROM

2708 450ns	4.95	4.50	3.75	3.25
2716 5V.	7.95	6.50	5.00	4.50
2716 tri-volt	9.95	9.00	8.25	7.50
2732 Intel	19.00	17.50	18.00	
2532 TI	21.50	19.00		
2764	*			

## SWITCHES

DP SWITCHES	16	16	16	16
1	1.95	1.75	.80	
2	1.90	1.75	.75	
3	1.85	1.70	.70	
4	1.80	1.65	.65	
5	1.75	1.60	.60	
6	1.70	1.55	.55	

TORQUE	16	16	16
7181 1/2" x 1/2"	1.10	1.00	
7181 1/2" x 3/8"	1.20	1.10	
7181 1/2" x 1/4"	1.30	1.10	
7181 1/2" x 1/8"	1.40	1.10	
7201 1/2" x 1/2"	1.80	1.40	

## Shugart Associates

### 801/ R Disk Drive 15 lbs.

Shugart 801/R with CP 285 power supply, multi-format for complete in shell enclosure with all the necessary interconnecting cables. Documentation included. 36 pounds. MSD-1801

Same as above but with two Shugart 801/R disk drives. 50 pounds. MSD-2801

Disk drive cable. 8 feet 50 minifloppy with edge card connector at both ends. WCA-6505 \$25.00

Expert Disk drives. 270V. 50AHz add \$50.00 per disk drive.

**\$795**  
**\$1195**

## CONNECTORS

GOLD EDGE CONNECTORS	each	100	each	100
S-100 (23P) centers	each	\$0.10	\$9.00	
Linear solder .380" row	each	\$2.95	\$25.00	
Linear wire-wrap (23P)	each	2.85	25.00	
Sullins Hi-Rel. 25P	each	3.10	40.00	
Sullins Hi-Rel. W/W	each	5.30	50.00	
Sullins (Altabe) 11P	each	4.95	30.00	

25P Centers (standard)	each	100	each	100
29244 Kim Keeble	each	3.50	24.50	
36722 Digital Group S/F	each	3.50	24.50	
36722 Digital Group W/W	each	6.00	61.50	
43786 Amptron 1000 W/W	each	6.50	64.50	
43786 Amptron 6000 W/W	each	7.00	68.50	

25P/36P/50P CIRCUIT SOCKETS	each	100	each	100
9 pin	\$1.00	\$8.00	\$4.00	\$31.00
14 pin	1.00	.80	.11	.81
16 pin	1.2	.11	.00	.11
18 pin	1.15	.13	.05	.18
24 pin	.26	.24	.04	.27
30 pin	.31	.30	0.00	0.31

17P Type	each	10-24	25+
D361P male	\$1.80	\$1.80	\$1.80
D361S female	2.25	2.00	1.80
D361P male	1.50	1.75	1.20
D361S female	2.25	2.15	2.00
DA 1/8S female	3.25	3.10	3.00
DA bus 2/P	1.60	1.45	1.30
DH125P male	3.50	3.25	3.25
DH25S female	4.25	3.15	3.05
DH125P 2/P	1.35	1.15	1.05
DC47P male	4.30	4.00	3.70
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25P/36P/50P	7.50	6.25	3.75
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MINIBUS CABLE CONNECTORS	17/24 8" disk	1.00	4.15	3.95
20/10 TRS-80	5.65	5.65	4.70	
32/50 8" disk	5.90	4.15	3.50	

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This Keyboard terminal was recently acquired from the CDC division of the Parson Corporation. The unit was originally designed for inputting data directly onto magnetic tape.

The system is comprised of a premium cast aluminum and fibreglass enclosure, along with a Honeywell 1100 series keyboard. Entry employs language editor the operator of the program status. Four inch loud speaker adds to the acceptance of data & alerts the operator of pending problems.

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Five volt regulated power supply is available for an additional \$20. (see June issue)

All units are in excellent condition. Original acquisition over \$700. 32 lbs.

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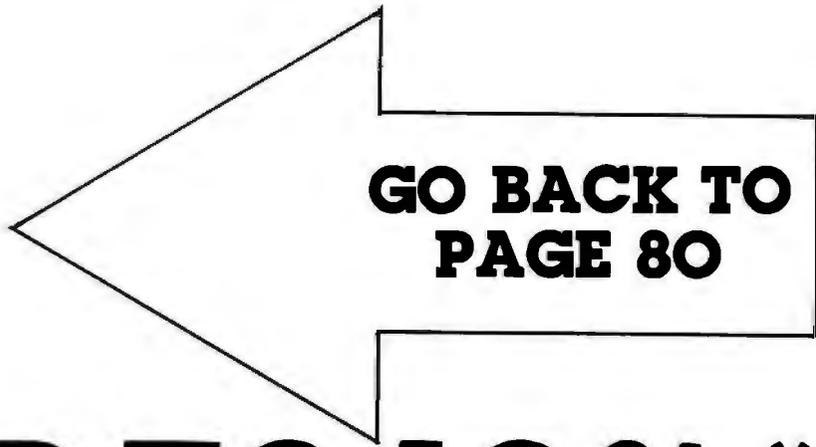
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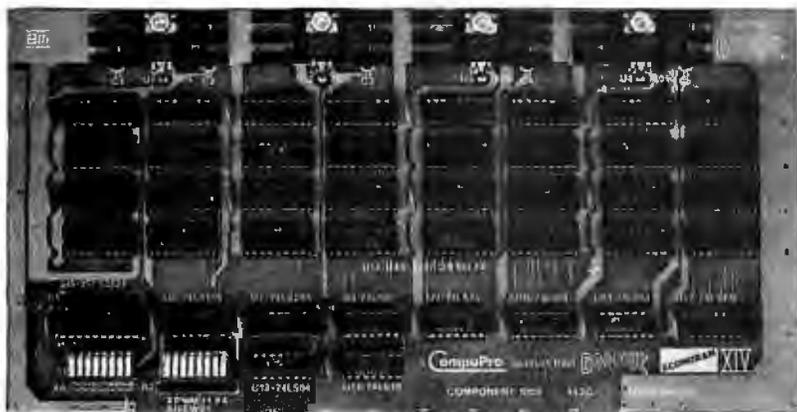
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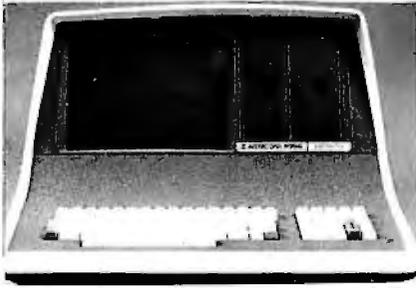
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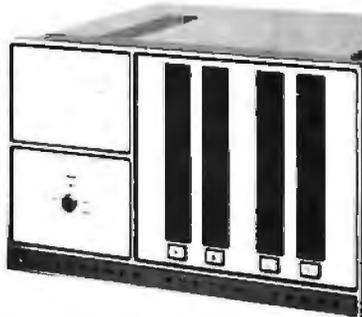
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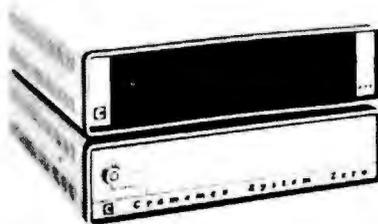
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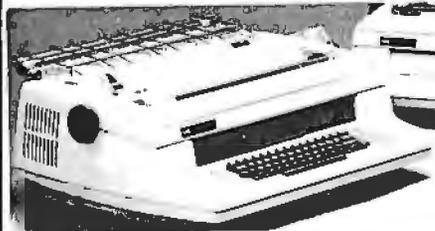


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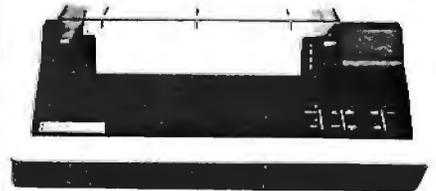
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**FOR SALE:** Texas Instruments TI-59 and PC-100 print cradle with all documentation and manuals. In mint condition; \$150 or trade for HP-97. Also, HP-67/97 Sta Pac 1, ME1, EE1, CE1, Surveying, Navigation, and Business Decisions Pac; all for \$50. Charlie Truax, 2862 King Edward Dr, El Dorado Hills CA 95630, [916] 933-3478 evenings.

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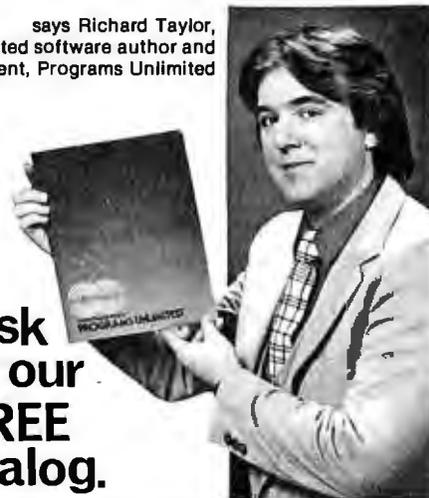


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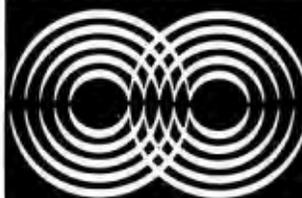


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# BOMB

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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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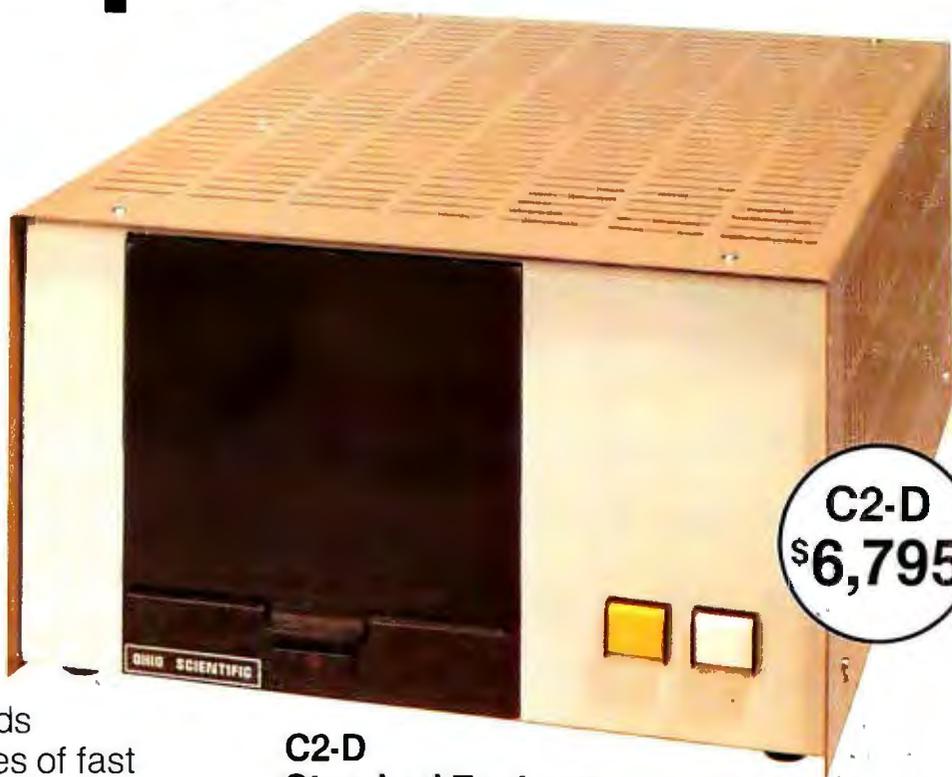


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