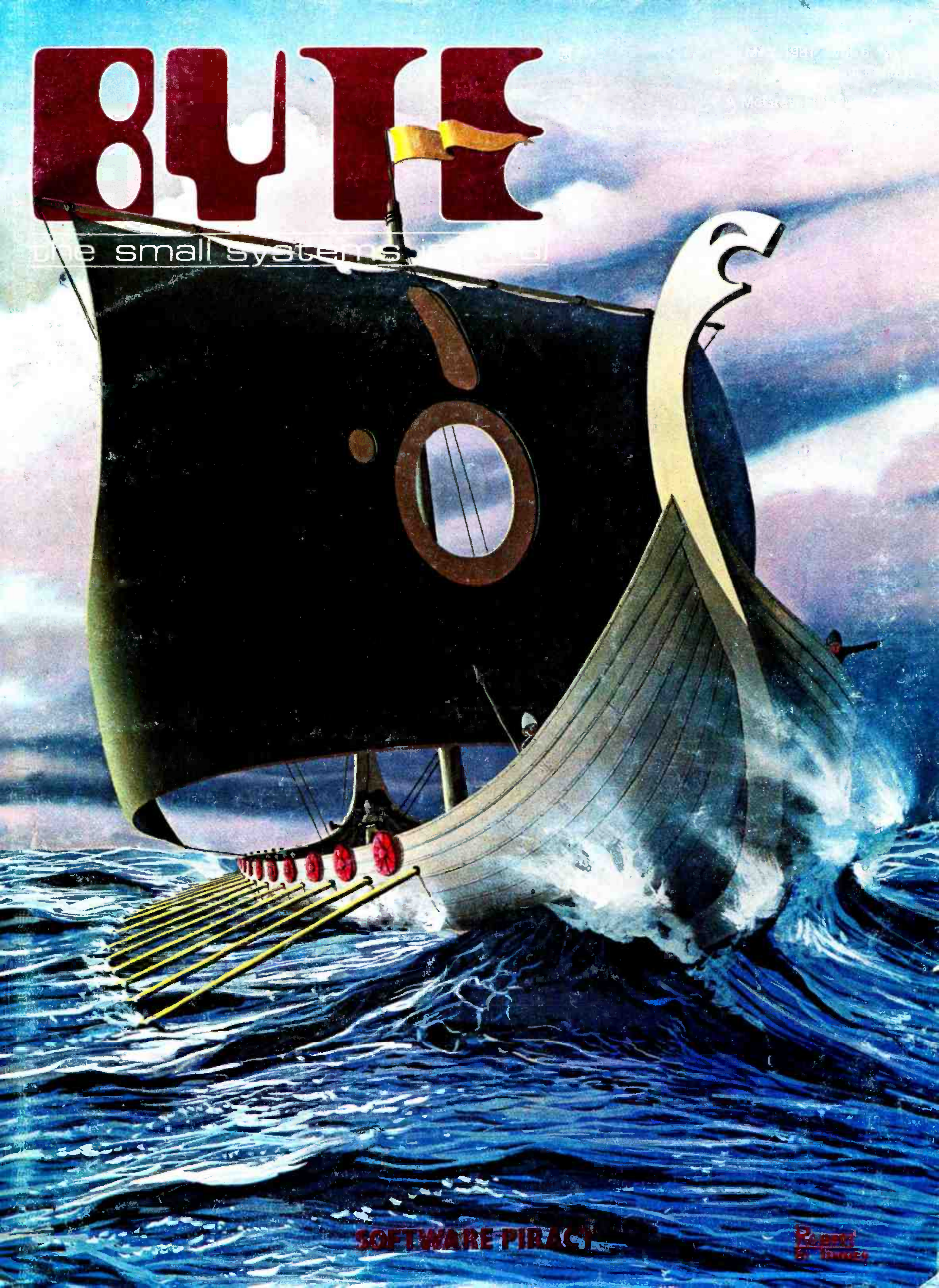
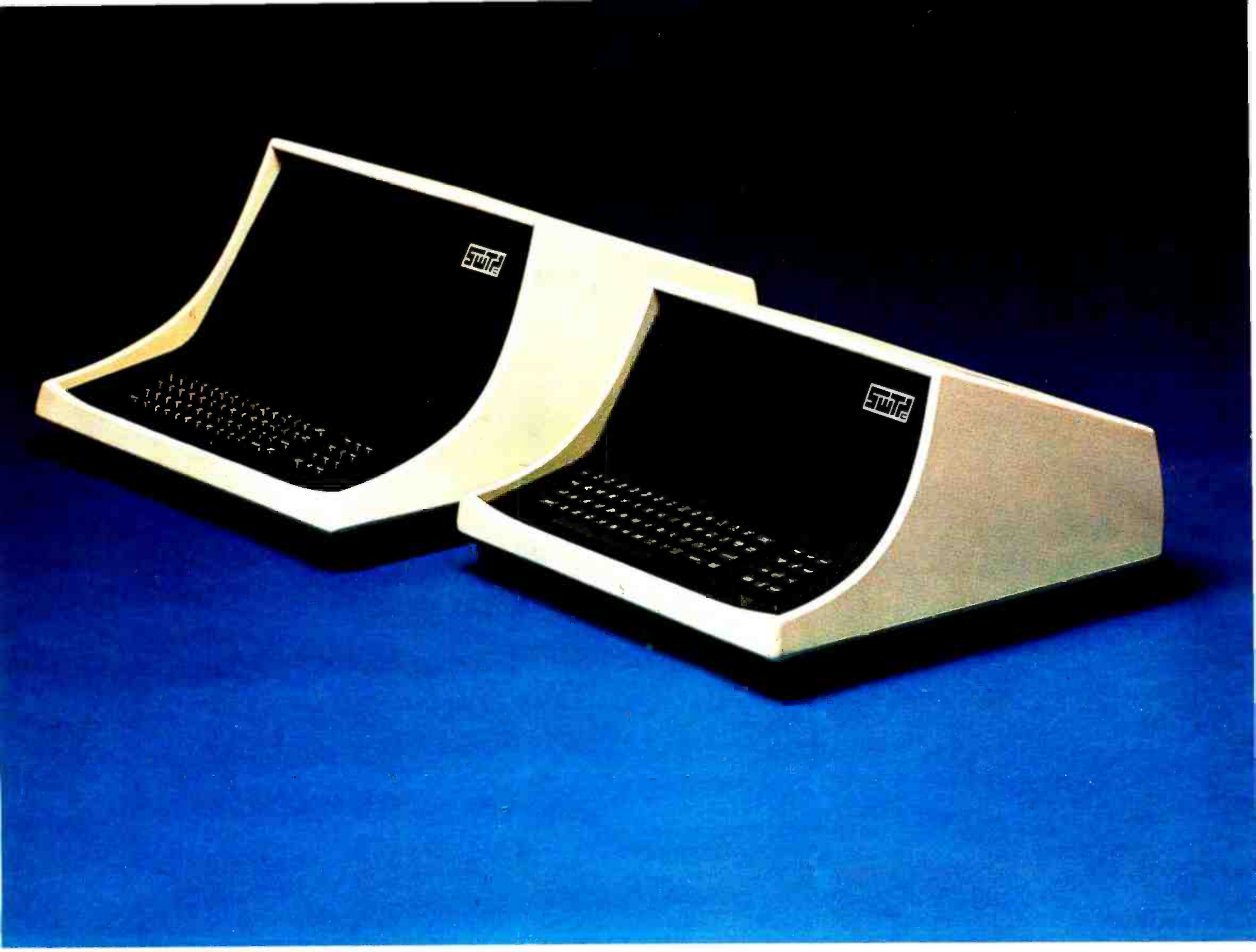

BYTE
the small systems journal
SOFTWARE PIRACY
Robert Tinney



YOUR CHOICE-smart either way

- Over 140 software driven functions
- 82 x 24 or 82 x 20 screen format — software selectable
- High resolution 7 x 12 matrix characters — P-31 green phosphor
- Upper/lower case character set — plus graphics character set
- 56-key alphanumeric keyboard — plus 12-key cursor, numeric pad
- Internal editing functions — insert, delete, scroll, roll, slide, etc.
- Parallel printer I/O port
- 50 to 38,400 baud operation — programmable
- Cursor type, cursor position, print control characters, protected fields, shift inversion, dual intensity and many other features

8212 — twelve-inch diagonal screen or **8209** — nine-inch diagonal screen

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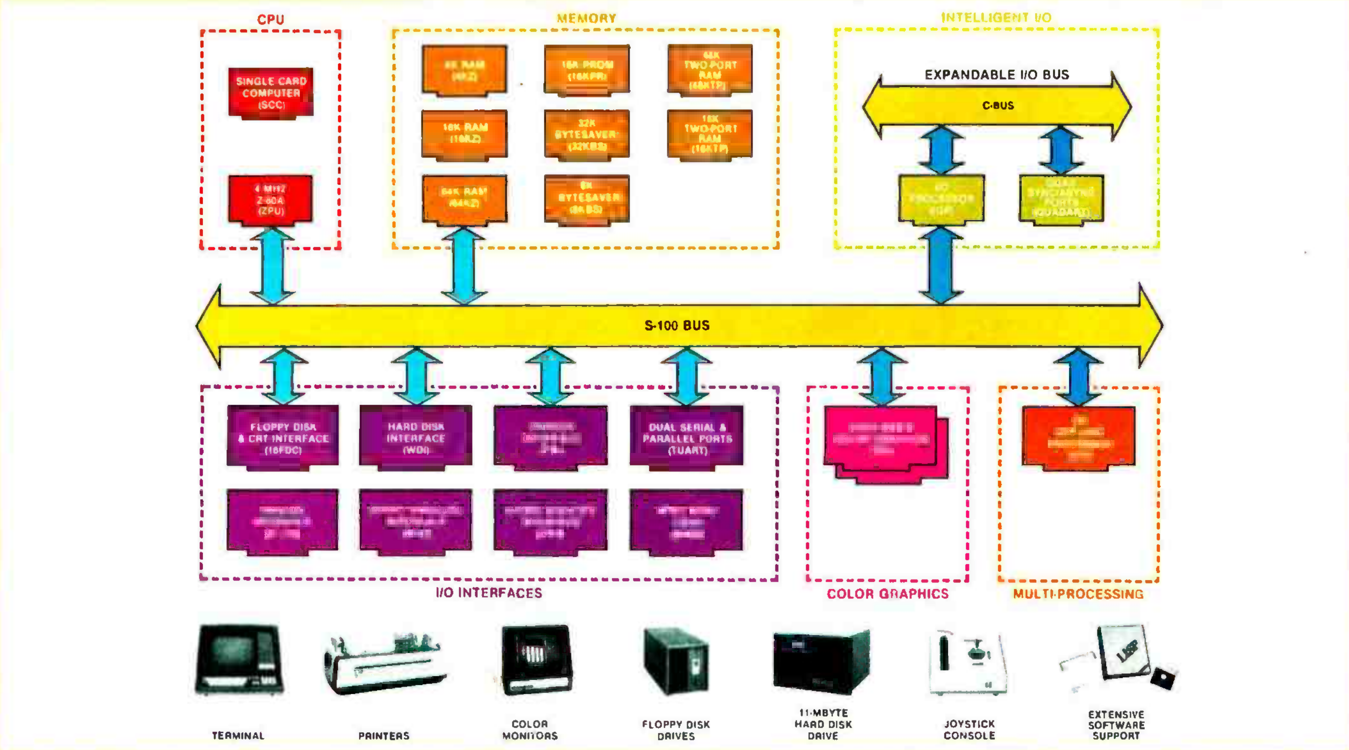

What Cromemco computer card capability can do for you

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

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

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

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

MULTI-PROCESSING AND INTELLIGENT I/O

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

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

HIGH RESOLUTION COLOR GRAPHICS

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

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

LOTS OF STORAGE

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

POWERFUL SOFTWARE AND PERIPHERAL SUPPORT

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

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

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

CONTACT YOUR CROMEMCO REP

There is even more capability than we're able to describe here.

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

CROMEMCO COMPUTER CARDS

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

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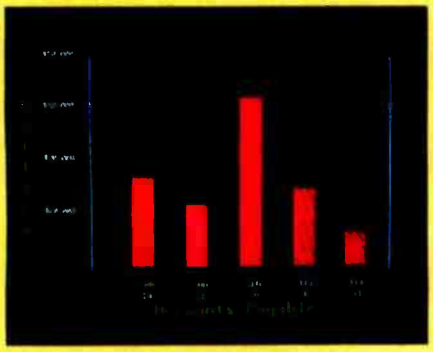
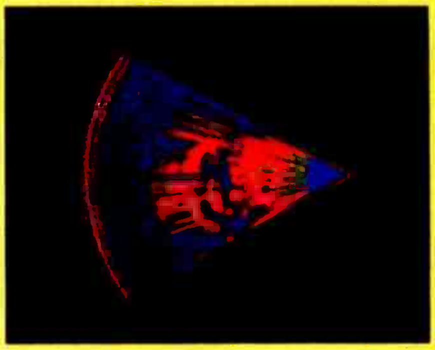


Management Information Display



Ultrasonic heart sector scan

High-resolution display with alphanumerics

Get the professional color display that has BASIC/FORTRAN simplicity

LOW-PRICED, TOO

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

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

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

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

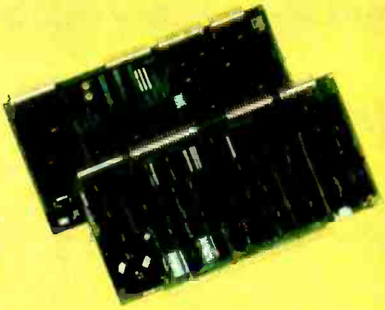
The resolution surpasses that of a color TV picture.

BASIC/FORTRAN programming

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

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

*U.S. Pat. No. 4121283



Model SDI High-Resolution Color Graphics Interface

HIGH RESOLUTION

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

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

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

DISPLAY MEMORY

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

CONTACT YOUR REP NOW

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

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

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In The Queue

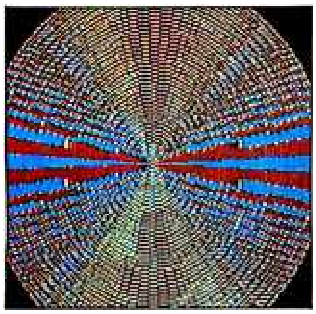
Volume 6, Number 5 May 1981

Features

Reviews

Nucleus

BYTE



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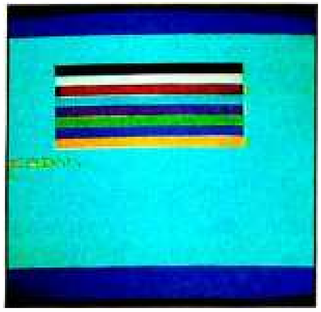

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In This Issue

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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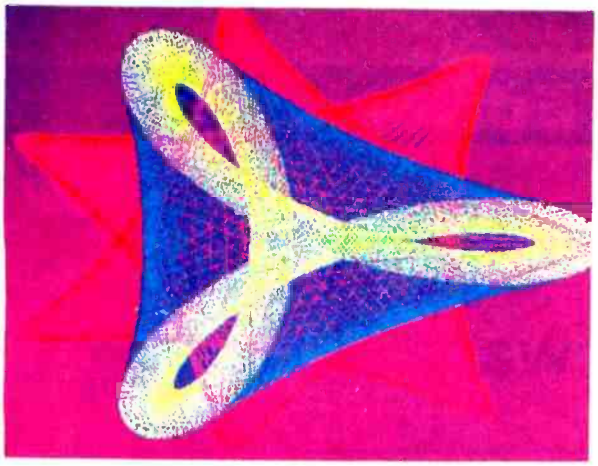
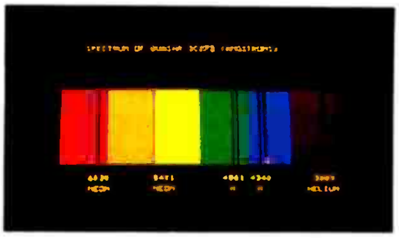


"...stands well above other S-100 graphics displays in its price and performance range."
BYTE, Product Review



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

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

- RS-170 composite or direct drive output
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- 4 Mhz Z80 microprocessor
- 60 hertz real-time clock
- 8 level interrupt tie-in
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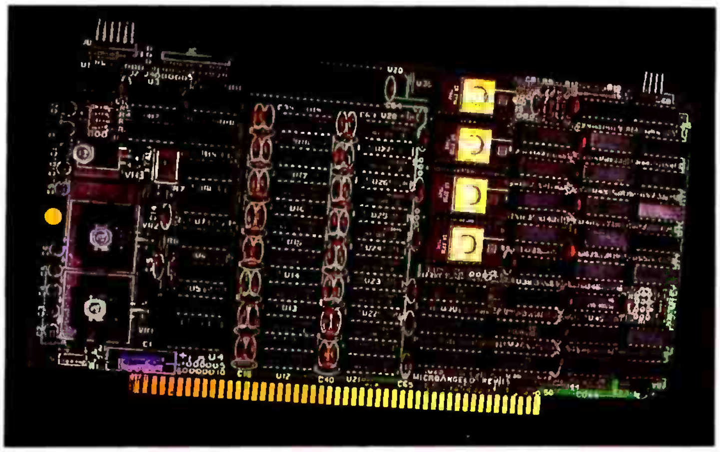

- Light pen interface
- Time multiplexed refresh
- 4K resident Screenware™ Pak I operating system
- 32K RAM isolated from host address space
- High speed communications over parallel bus ports

Screenware™ Pak I

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

Screenware™ Pak II

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

And now...COLOR!!

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

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Editorial

How Can We Stop Software Piracy?

Chris Morgan, Editor in Chief

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

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

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

The Persuasion Route

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

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

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

Editorial continued on page 10

Introducing the COLOR CONNECTION™

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

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

Mini-disk storage — today!

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

Get serious!

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

Beyond 16K

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

System Requirements

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

The COLOR CONNECTION. $99.95

The right motherboard

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

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

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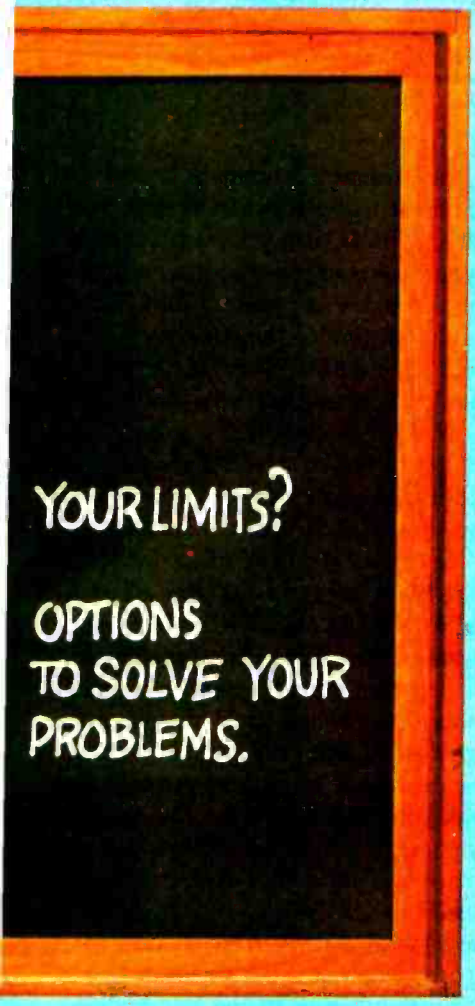
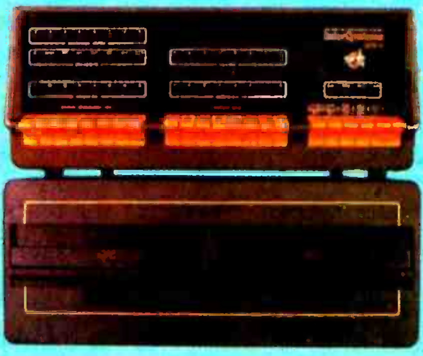


Board level options...

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

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

Extended systems options...



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

Or our complete Pascal Development System.

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

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

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

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

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

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

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

Your solution should be clear.

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

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Technological Measures

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

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

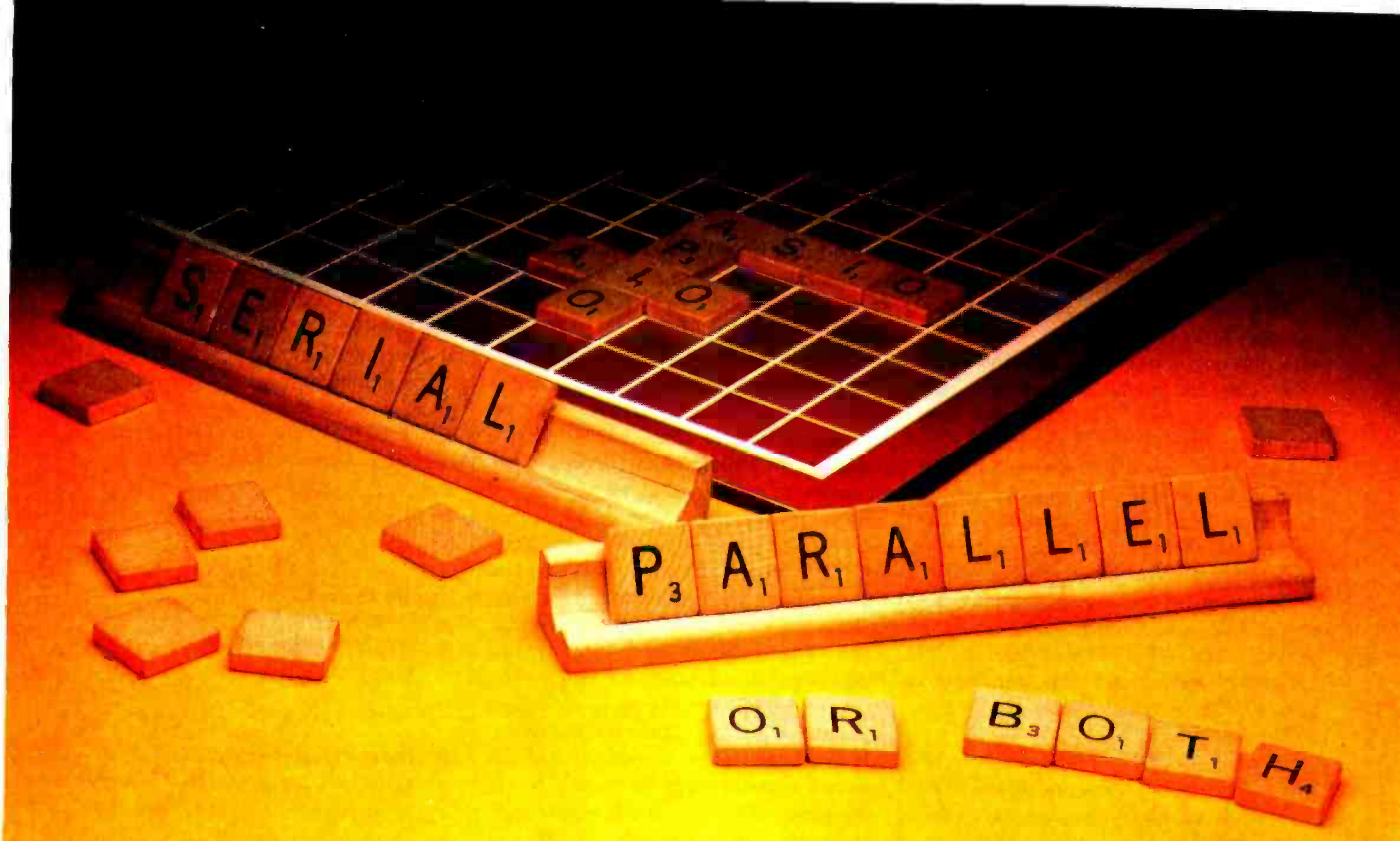
This technique puts one more stumbling block in the way of the pirate, and it does not add appreciably to the total cost of the software (the I.D. ROM costs about $20). Alas, there are some experts in Europe who have cracked the code of another I.D. ROM used in conjunction with a program called Wordcraft,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

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

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

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

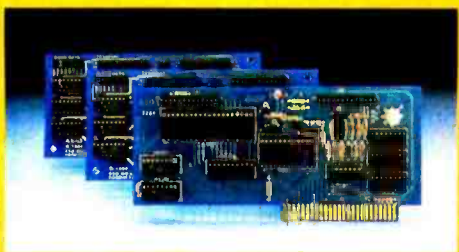
Illegitimate copies of programs threaten the fabric of personal computing. The software innovators in our field must be compensated fairly for their work, or we will no longer see the high-quality programs that currently grace the marketplace.

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

Apple* I/O Interfaces. SSM Spells Success Three Ways.

SSM helps you get the most from your Apple II* computer. Choose from three general purpose interface boards. With flexibility and prices that translate to big savings. Now, and when you upgrade.

Serial (ASIO™). Our ASIO gives you a full-duplex RS-232 interface. Plus jumper-selectable rates from 110 to 9600 baud. You also get software control, three handshaking lines and two output plugs—so you can connect your Apple to a modem or to a terminal/printer without modifying the cable.

Parallel (APIO™). For parallel interfaces, our APIO offers two 8-bit bidirectional ports. We also include additional interrupt and handshaking lines, plus software control of the interface configuration and data direction. Cables for Centronics and other printers are optional.



Or Both (AIO™). Choose our tried and proven AIO when you need a sometimes-serial or a sometimes-parallel operation. This single-board solution packs a lot of performance for the price. Thousands are now being used. It even lets you operate both ways—simultaneously—under Pascal, or with special drivers.

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Educational Dialog

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

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

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

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

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

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

Charles Heckel
1624 Hillcrest
Glendale CA 91202

Seymour Papert Replies:

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

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

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

Ada Manual Available

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

Superintendent of Documents
US Government Printing Office
Washington DC 20402

Order number: 008-000-00354-8

Cost: $5.50 per copy.

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

Mike Robinson
Rt 4, Box 70
Ringgold GA 30736

Hard Disk to Buy

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

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

John F Priebe
4804 Mt Airy Rd
Sylvania OH 43560

Plot: North by Northwest

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

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

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

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

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

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

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

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BYTE's BOMBworks

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

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

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

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

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

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.

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

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

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

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

B F Wheeler
22 Wilkins Ave
Haddonfield NJ 08033

Chessmate

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

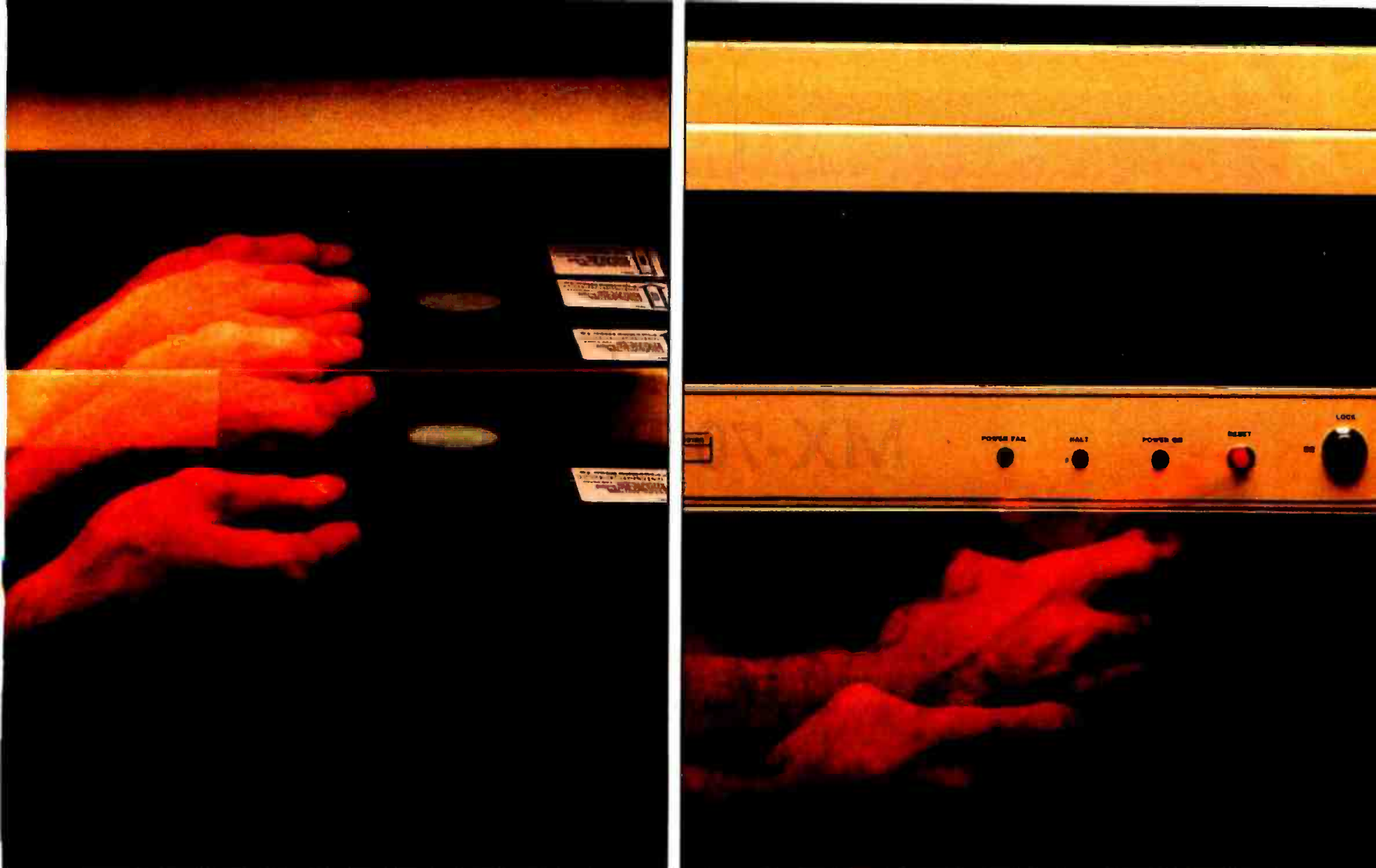
My Chess Challenger 7 on level 7 (tournament level) played exactly the same game as Sargon II, including the trap, through step 12. At step 12, Sargon played Nc3-d5 (N/B3-Q5); Chess Challenger 7 played Qd2-d1 (Q-Q1). My response was Qf6-g6 (Q-KN3), at which point Chess Challenger 7 conceded the game.

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

Tom Disque
Rt 7, Waldrap Dr
Mayfield KY 42066

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

Letters continued on page 268



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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.)

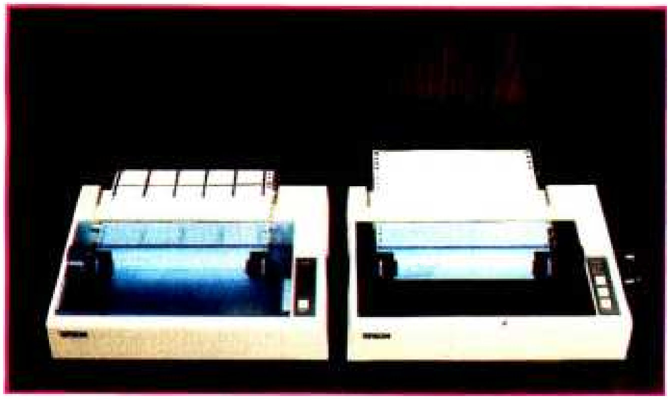


Photo 1: *The Epson MX-70 and MX-80 printers. The MX-70 (left) is a prototype of the final version which has a tan rather than a cream body.*

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 (14⁷⁄₁₀ by 12 by 4⅕ 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

Circle 260 on inquiry card. →

(2a)

(2b)

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

At a Glance

Name
Epson MX-80

Use
Dot-matrix impact printer

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

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

Price
$645

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

Additional Hardware
Interface card needed for Apple II

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

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

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

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

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

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

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

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

1a

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

1b

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

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

2a

2b

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

2c

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

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

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

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

The MX-70

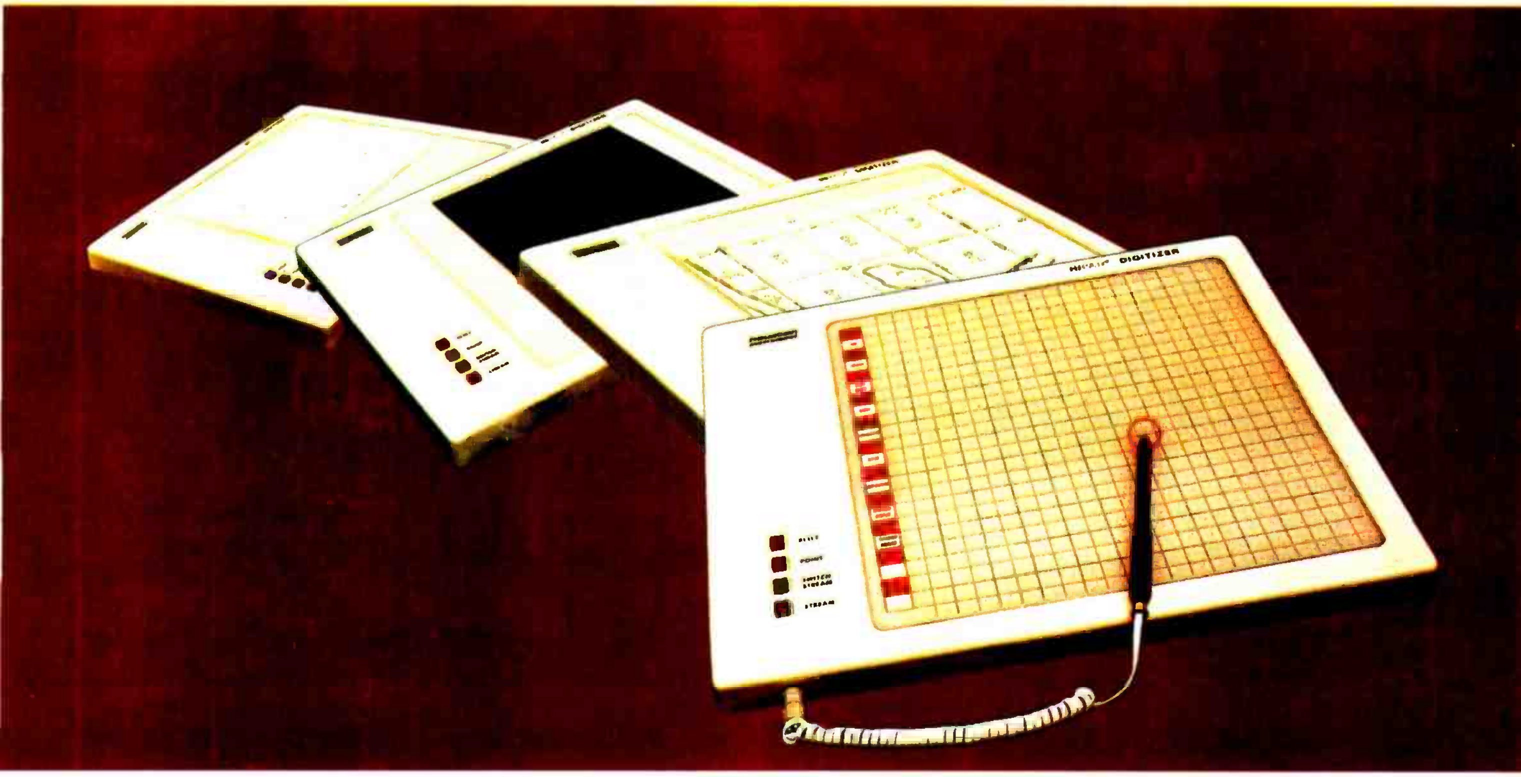
Similar in appearance to the MX-80, but with fewer features, the MX-70 is available for about $200 less (suggested retail price, $449). A 7-wire print head produces characters on a 7 by 5 dot matrix at a rate of 80 cps, but the unit does not offer the bidirectional logical-seeking capabilities of the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

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

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

In this age of runaway inflation...

Look what $795* will buy



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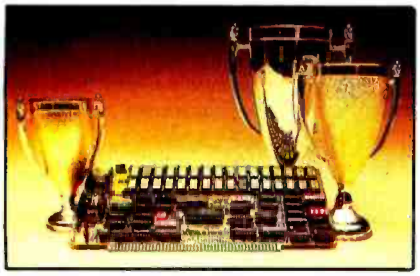
First was the development of the DMB6400 series of S-100 Memory boards featuring the



innovative Bank Select switching technique. This enables users to software select up to four totally independent memory banks per board.

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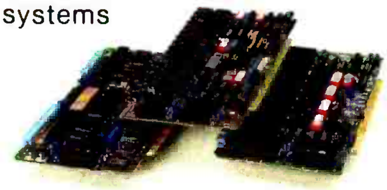
Then came the 2nd Generation of IEEE S-100 COMPATIBLE Z80 PROCESSORS, FLOPPY DISK CONTROLLERS and SERIAL I/O BOARDS. Each has been designed for single user, multi-user or network operating systems such as CP/M®, MP/M™, CP/Net™ and OASIS™.



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

The System 2800 comes with a choice of operating systems: CP/M with an enhanced CBIOS for single user systems and either MP/M or OASIS for multi-user, multi-tasking systems. MP/M is available with either a standard or

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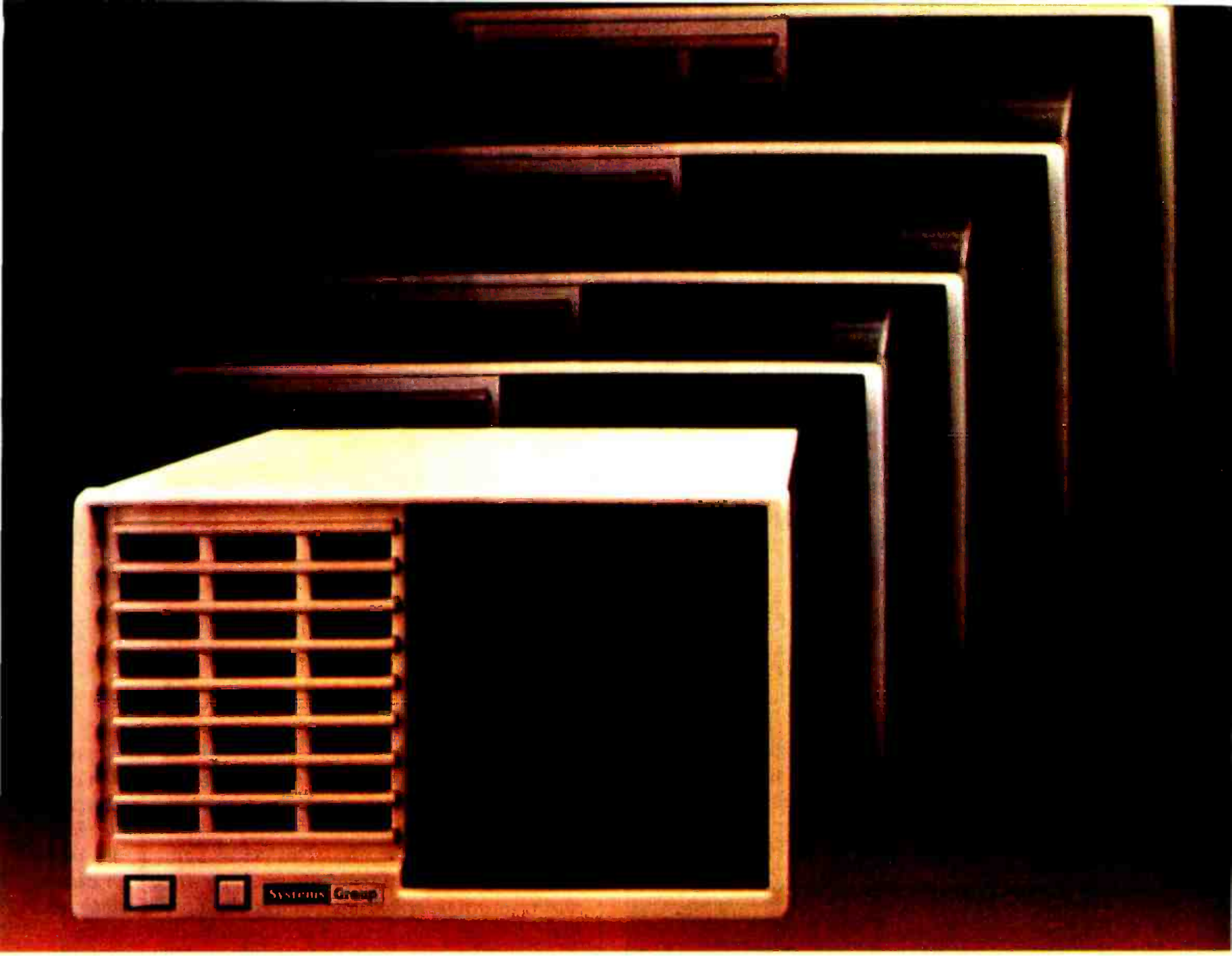

enhanced XIOS. The CP/M based System 2800 provides improved diagnostic reporting capability and increased sector sizes of 1024 bytes yielding disk performance throughput increases up to 400% over standard unblocked systems.

The enhanced multi-user, multi-tasking MP/M based System 2800 provides the same advanced features as CP/M. In addition, this interrupt driven implementation can offer performance throughput increases up to 2000% thru extensive disk buffering for applications requiring a large number of disk accesses.

Also available is the OASIS operating system with ISAM files, automatic record locking and multiple-user print spooling.

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

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See us at booth 5001, NCC show, Chicago, May 4-7, 1981.

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-*

Time & Money. Commodore®, Atari® & Apple® users get more with VisiCalc™ software.

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.

Thousands of other personal computer users are also sold on how VisiCalc is increasing their productivity. Besides saving time and money, they're simplifying their work and getting more information that helps them make better decisions. A typical user reaction comes from a New York dentist:

"VisiCalc has become an integral part of my business."

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.

"I am extremely impressed with VisiCalc's capability, flexibility and orderly presentation of instructions."

So writes the director of a New York corporation. He appreciates VisiCalc's powerful recalculation feature. Change any number in your model and instantly all numbers affected by that change are recalculated and new results are displayed. You can ask "What if . . ?," analyzing more alternatives and forecasting more outcomes. It really increases your decision-making batting average!

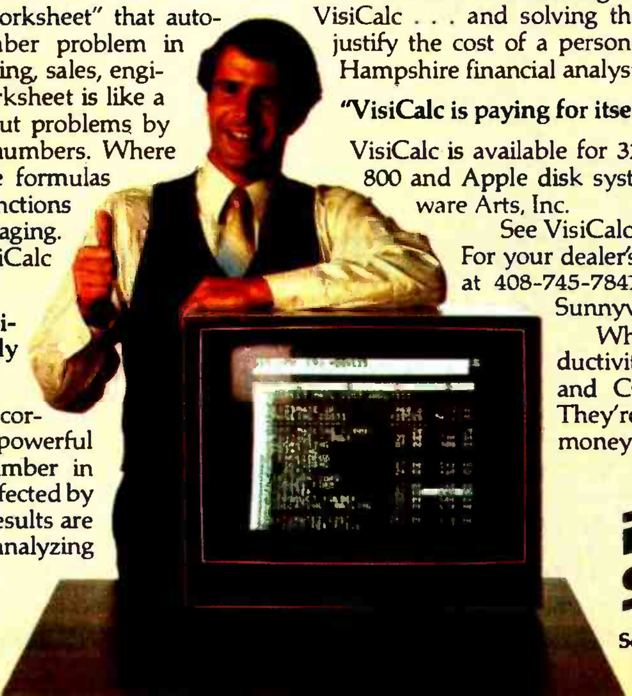
When you finish, you can print a copy of the worksheet just as it appears on the screen and/or save it on diskette.

"I like VisiCalc's ease of use."

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.

Users also like solving a wide variety of problems with VisiCalc . . . and solving them their way. VisiCalc can even justify the cost of a personal computer, according to a New Hampshire financial analyst:

"VisiCalc is paying for itself over and over."



VisiCalc is available for 32k Commodore PET/CBM, Atari 800 and Apple disk systems. VisiCalc is written by Software Arts, Inc.

See VisiCalc at your Personal Software dealer. For your dealer's name, call Personal Software Inc. at 408-745-7841, or write 1330 Bordeaux Drive, Sunnyvale, CA 94086.

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Circle 325 on inquiry card.

*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

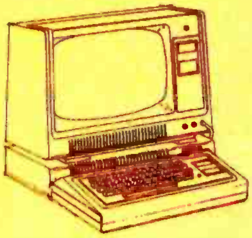
- The Epson MX-80, at $645, and the MX-70, at $449, both represent an unprecedented level of performance for the price. Although the low price of the MX-70 is particularly attractive, the added features of the MX-80 make it worth the extra $200. The most important features are the intelligent bidirectional 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

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

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

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

TRS-80* Model I Computer Owners . . .



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

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

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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.

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

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JONATHAN GRAVES '81

Extended Color BASIC for the TRS-80 Color Computer

Stan Miastkowski, Technical Editor

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

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

EXTENDED COLOR BASIC 1.0
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appears when you turn the Color Computer on. Extended Color BASIC is fast, memory-efficient, and so well designed that anyone (even children) can create graphics shapes in a few minutes. Best of all, it's fun to use and has features that advanced programmers will appreciate.

Getting Into Graphics

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

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

Graphics Modes

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

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

Color Combinations

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

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

CIRCLE (*x,y*), *r*, *c*, *hw*, *start*, *end*

Draws a circle, partial circle, or ellipse.

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

COLOR *foreground,background*

Sets the foreground and background screen colors within limits specified by the mode/color set combination.

- *foreground* is a color code (0 to 8).
- *background* is the background color (0 to 8).

DRAW *line*

Draws a line (or series of lines) by specifying the direction, angle, and color.

line is a string expression and may include:

Motion Commands

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

Modes

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

Options

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

EDIT

Allows editing of program lines.

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

GET *startpoint—endpoint, destination*, G

Places the graphics contents of a specified rectangle within a specified array.

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

LINE (*x1,y1*)—(*x2,y2*), *a,b*

Draws (or erases) a line between two specified points. Also draws a box using the coordinates as the opposing corners.

- *x1,y1* is the starting position of the line.
- *x2,y2* is the endpoint of the line.
- *a* is either PSET or PRESET.
- *b* is either B (for box) or BF (for filled box).

PAINT (*x,y*) ,*c,b*

Fills a specified area with a specified color. (The color is limited by the mode/color set combination.)

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

PCLEAR *n*

Clears a specified number of memory pages (1536 bytes each) for graphics use.

n is the number of graphics pages (1 to 8).

PCLS *color*

Clears the video display.

color is the number (0 to 8) of one of the colors available for the mode/color set combination in use.

If *color* is omitted, the existing background color is used.

PCOPY *source* TO *destination*

Copies the contents of one memory page to another memory page.

source and *destination* are memory page numbers (1 to 8).

PLAY

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

PMODE *mode, start-page*

Selects the graphics mode and the memory page on which a program starts.

Mode is the graphics mode (0 to 4). The default value is 2.

Start-page is the number of the graphics page (1 to 8) on which the program will start.

PSET (*x,y*,c)

Turns on selected graphics points.

- *x* is the position on the *x*-axis.
- *y* is the position on the *y*-axis.
- c is the color of the dot (0 to 8).

PRESET (*x,y*)

Turns off graphics points which were turned on by the PSET command.

- *x* is the coordinate on the *x*-axis.
- *y* is the coordinate on the *y*-axis.

PUT *startpoint—endpoint, source, action*

Places the graphics contents of a rectangle stored in an array by the GET command at a specified position.

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

SCREEN *type, color set*

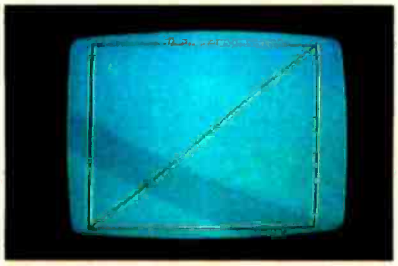
Tells the computer whether you want to use a text screen or a graphics screen and selects the color set.

- *type* is either 0 (text screen) or 1 (graphics screen).
- *color set* is either 0 or 1 (see table 4).

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

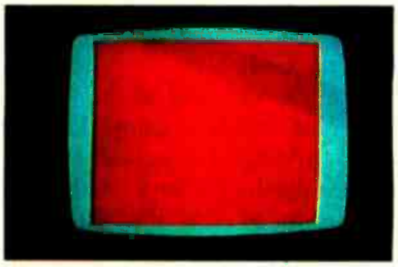
(a)

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



(b)

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



(c)

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

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

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

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

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

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

Graphics Pages

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

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

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

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

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

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

one page while another is on the screen.

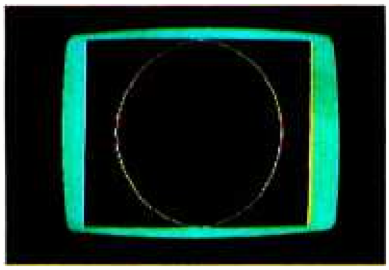
Creating Graphics

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

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

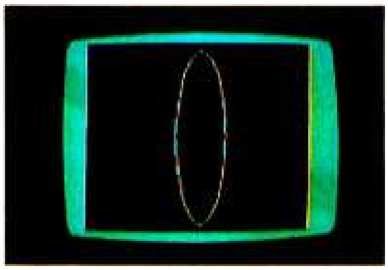
- LINE—Draws a line between two specified sets of coordinates. It will also draw a box and, if desired, fill the box with the foreground color.
- CIRCLE—Draws a circle with a specified radius at a specified coordinate. You also have the option of changing the height/width ratio and drawing only parts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

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



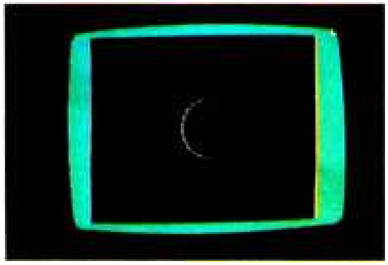
(a)

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



(b)

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



(c)

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

(d)

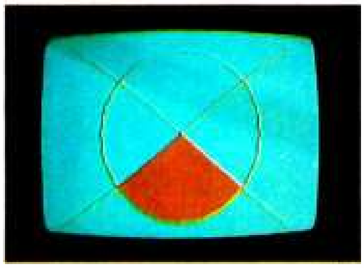
```
10 PMODE 4,1
20 PCLS
30 SCREEN 1,0
40 FOR RADIUS = 1 TO 100 STEP 10
50 CIRCLE (128,96),RADIUS
60 NEXT RADIUS
70 GOTO 70
```

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

Music

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

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



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

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

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

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

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

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

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

The Added Extras

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

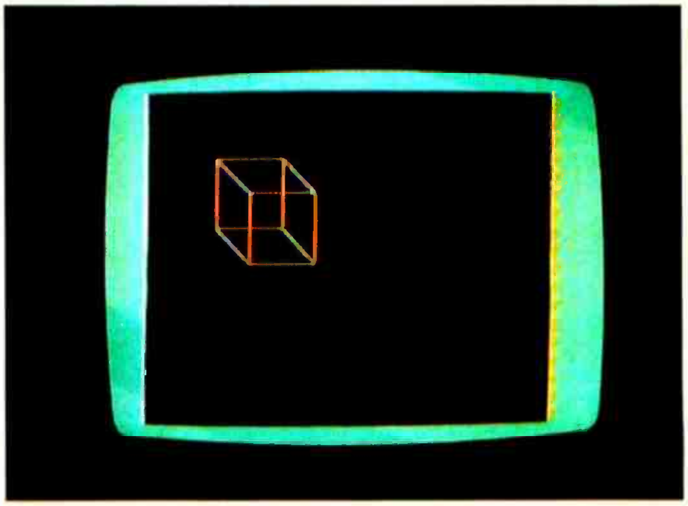
There are a number of differences. Since both extended and non-extended color BASIC use device numbers for I/O (input/output) operations (0 for the keyboard and video screen, −1 for the cassette, and −2 for the printer), OPEN, CLOSE, INPUT, and EOF (end-of-file) statements are available. Therefore, dumping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

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

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

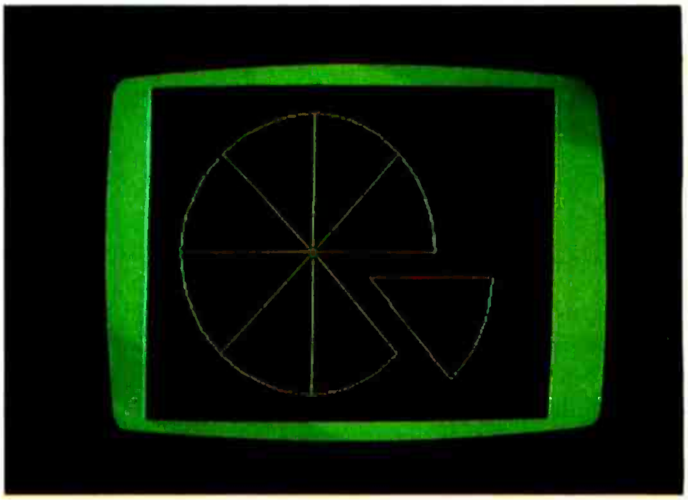
(a)

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



(b)

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



(c)

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

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

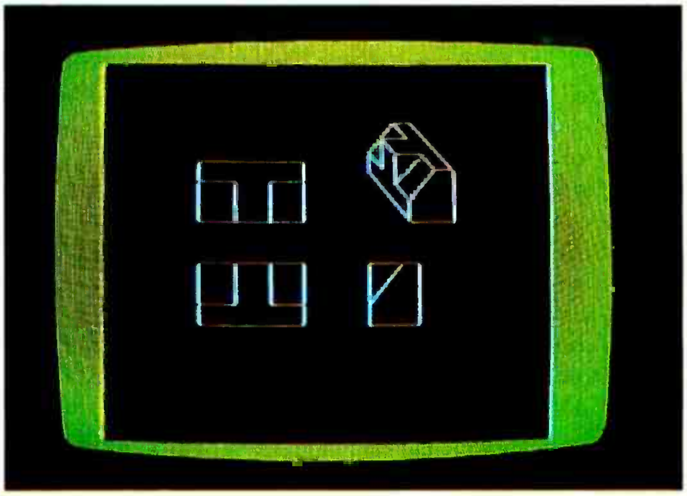
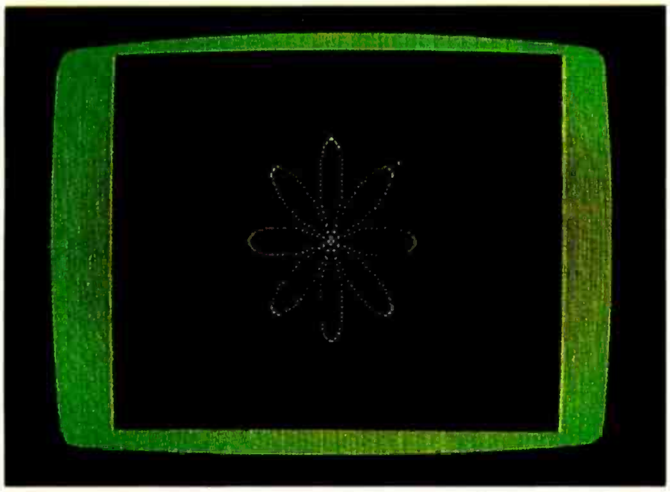
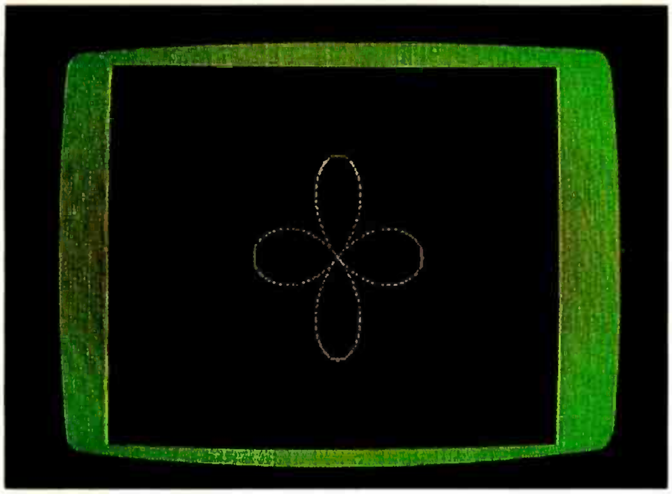


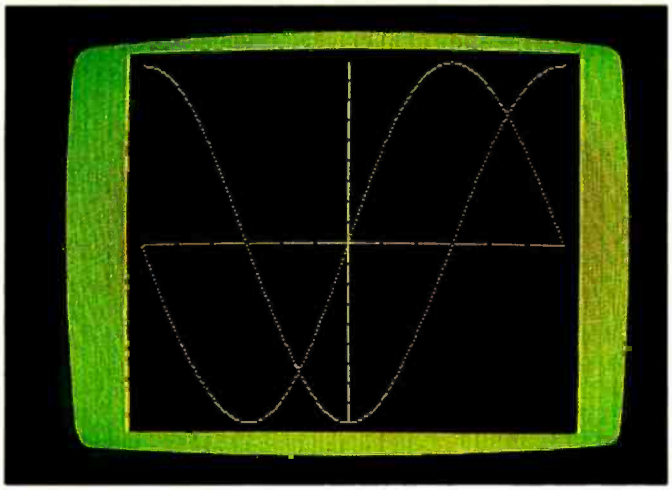
Photo 4: *Three examples of the DRAW statement, which allows you to specify the starting point, direction, angle, and color of a figure. The cube in photo 4a was created by DRAWing two squares (lines 25 and 30) and connecting them with four LINE statements (lines 40 thru 70). Photo 4b is an example of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





(a)

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



(b)

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

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

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

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

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

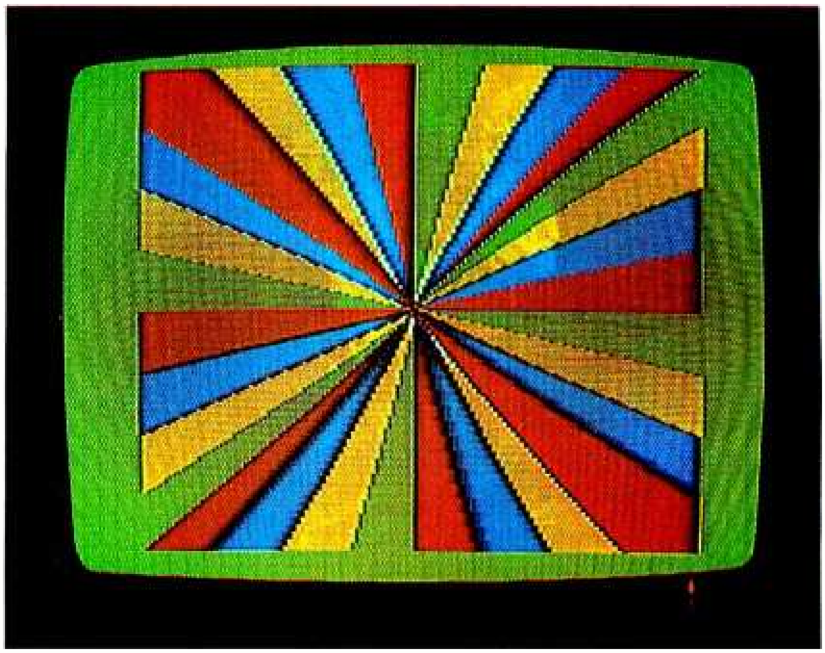
Although a lack of machine-language information might be considered a handicap by some, it is not. One of the most striking features of Extended Color BASIC is that it is *fast*—despite the fact that the microprocessor runs at the relatively slow speed (for computers) of .894 MHz (million cycles per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

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-FEFF	49152-65279	Cartridge Memory
FF00-FFFF	65280-65535	Input/Output

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

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

Summary

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

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

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

At a Glance

Name
Extended Color BASIC

Type of package
Color graphics, music, and BASIC extension

Manufacturer
Radio Shack
1300 One Tandy Ctr
Fort Worth TX 76102

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

Format
ROM (read-only memory)

Language used
BASIC

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

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

Of interest to
Everyone

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

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

Gregg Williams
Senior Editor

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

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

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.

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

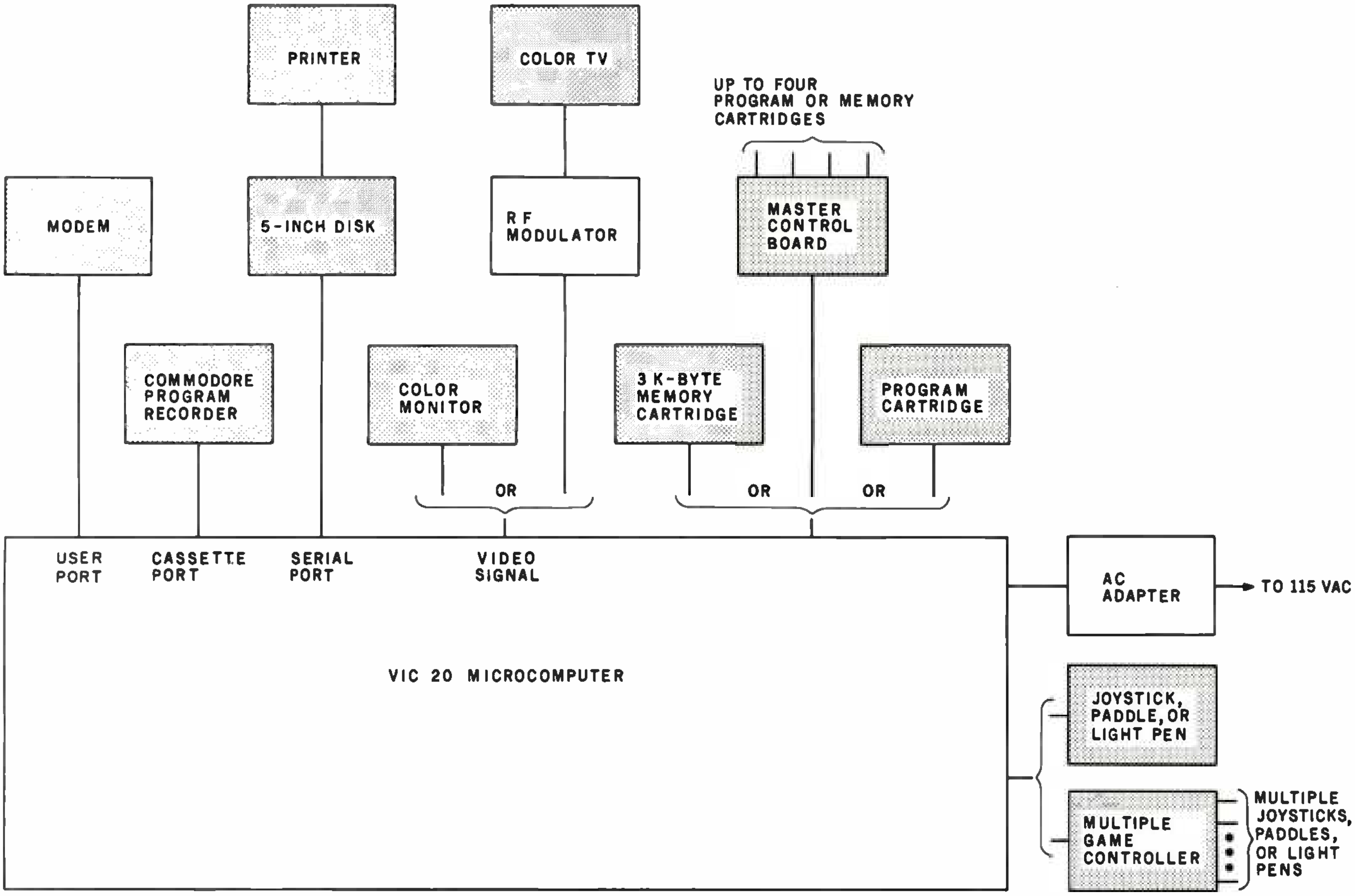


Figure 1: *A block diagram of the Commodore VIC 20 system (shaded components are available at extra cost).*

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

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

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

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

VIC Graphics

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

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

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

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

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

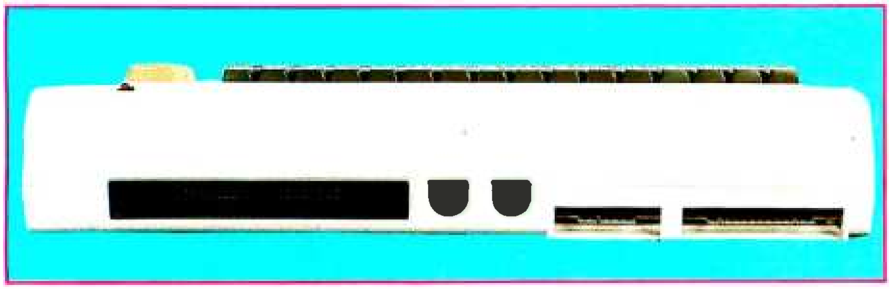
Finally, the number of graphics characters that can be displayed is doubled because *any* character can be displayed as is or in reverse (see photo 3). This can be done immediately or during program execution. Pressing the RVS ON key (the CTRL key plus the 9 key simultaneously) causes all displayed characters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

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.*

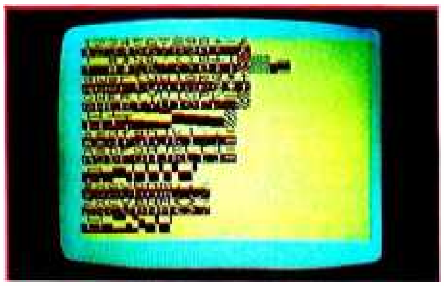

Photo 4: *The character set of the VIC 20. Any character can be displayed in reverse.*

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* ouput in the current color. In photo 5, since the last color used was yellow, the VIC responds with its end-of-program message in yellow.

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

POKE 36879,X

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

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

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

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

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

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

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

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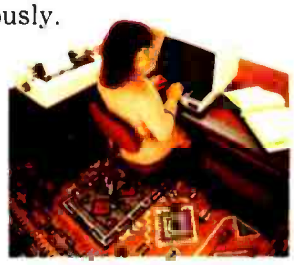

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screen can be directly manipulated by *poking* values into certain memory locations. Memory locations 7680 through 8185 (decimal) contain the code for a given character; memory locations 38,400 through 38,905 contain the code for the *color* of the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

VIC Sound and BASIC

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

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

The VIC Product Line

Although prices and availability of VIC peripheral devices were not

(6a)

(6b)

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

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.*

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.*

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

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

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

- *Memory-expansion products*—Commodore will sell a line of cartridges that add programmable memory to the VIC, increasing the size and complexity of programs that can be run. A 3 K-byte cartridge can be plugged directly into the VIC, and 8 and 16 K-byte cartridges can be plugged in through a Master Control Panel that plugs into the VIC cartridge slot and accepts up to four cartridges. The maximum amount of programmable memory is 32 K bytes.
- *Storage peripherals*—Commodore will sell both a low-cost cassette recorder (although existing Commodore recorders work with the VIC) and a low-cost single 5-inch floppy-disk drive. The disk drive will hold up to 170 K bytes of data.
- *Other peripherals*—These include a dot-matrix printer, joysticks, light pens, game paddles, and a Multiple Game Controller (discussed earlier).
- *Interfaces*—Commodore plans two interfaces for the VIC, a modem and an IEEE-488 bus interface. The modem allows communication with other computers over telephone lines. The IEEE-488 interface allows the VIC (like the PET and CBM machines) to interface with PET peripherals and a wide variety of test instruments and devices that use this standard bus.
- *Firmware*—A wide range of software will be distributed in cartridge form; three firmware cartridges have already been announced. The first, the RS-232C Interface Cartridge, allows you to use the VIC and a modem to communicate with other computers and access information utilities like MicroNet and The Source. The second, the VIC Programming Cartridge, will include a machine-language monitor and a number of utility functions useful during programming; it will also use the four function keys (on the right-hand side of the keyboard) to execute predetermined functions. The third, the VIC Super Expander Cartridge, will add 3 K bytes of programmable memory, a new level of high-resolution graphics, and additional music-related capabilities. The high-resolution graphics (which I have not seen) are said to be excellent (176 rows by 176 columns of graphics dots, also called *pixels*).
- *Documentation*—In addition to the *VIC User's Manual*, supplied with the VIC, Commodore plans a series of book-plus-cartridge packages explaining several aspects of using and programming the VIC. (Documentation is discussed in greater detail later in this article.)

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

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

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

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

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

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

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

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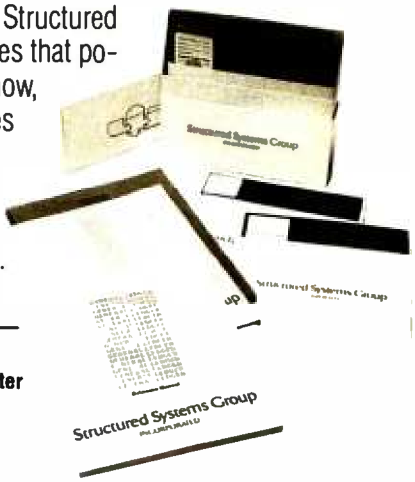

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Human Engineering on the VIC

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

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

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

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

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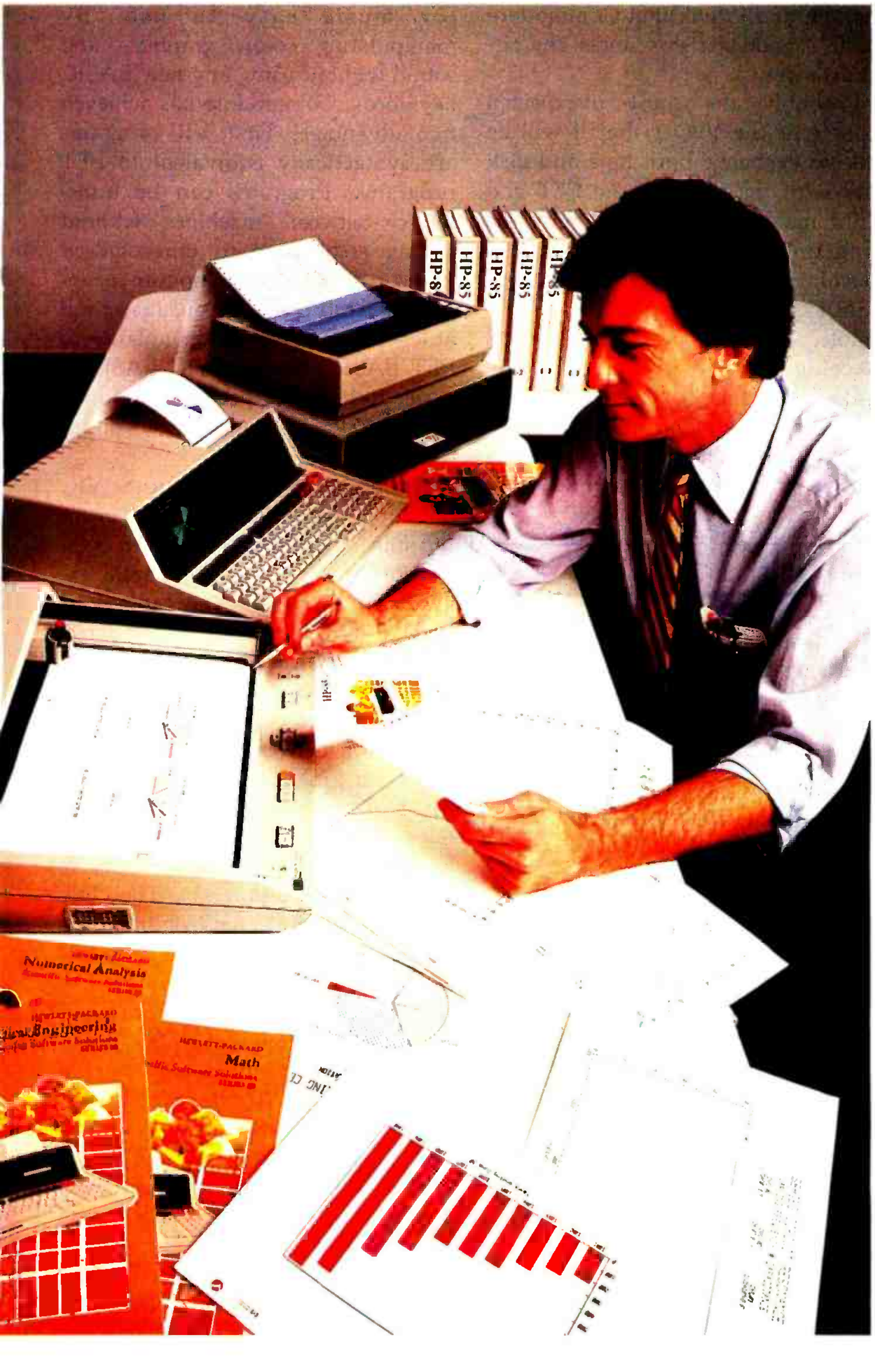

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text) keys is obvious when they have been used a few times.

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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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 program, it stopped the tape-transport motor but left the play button depressed. If you then give the SAVE command, the VIC initiates the process, even though the record button has not been pressed. (If no recorder buttons are pressed when the SAVE command is given, the VIC instructs you to press both the play and record button, and the recording process occurs without error.) The RUN/STOP key will not abort the loading process, although pressing the RUN/STOP and RESTORE keys will. Still, there are two chances to lose the program: one, not realizing that the program is not being recorded; two, realizing it but turning the VIC off from not knowing that the SAVE command can be aborted and restarted.

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

Documentation

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

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

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

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

Comparison to Other Computers

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

Conclusions

- The final verdict on the Commodore VIC 20 is not in yet because of the large amount of hardware and software not yet commercially released. But if the rest of the product line is as good as the VIC 20 microcomputer is, the VIC computer system will be one of the strongest on the market.

- The VIC 20 computer unit is unexcelled as a low-cost, consumer-oriented computer. Even with some of its limitations (eg: screen size of 23 rows by 22 columns, maximum programmable memory of 32 K bytes), it makes an impressive showing against more expensive microcomputers like the Apple II, the Radio Shack TRS-80, and the Atari 800.

- The low cost of the VIC ($299.95) is made possible by a custom computer-to-video interface circuit that replaces several other integrated circuits and by Commodore's manufacturing most of the VIC at in-house factories in Japan.

- The VIC is well designed and easy for the novice to use. A large part of its suitability for first-time users is due to its excellent documentation and attention to human-engineering factors. The unit has some small design flaws, but they are minor. ■

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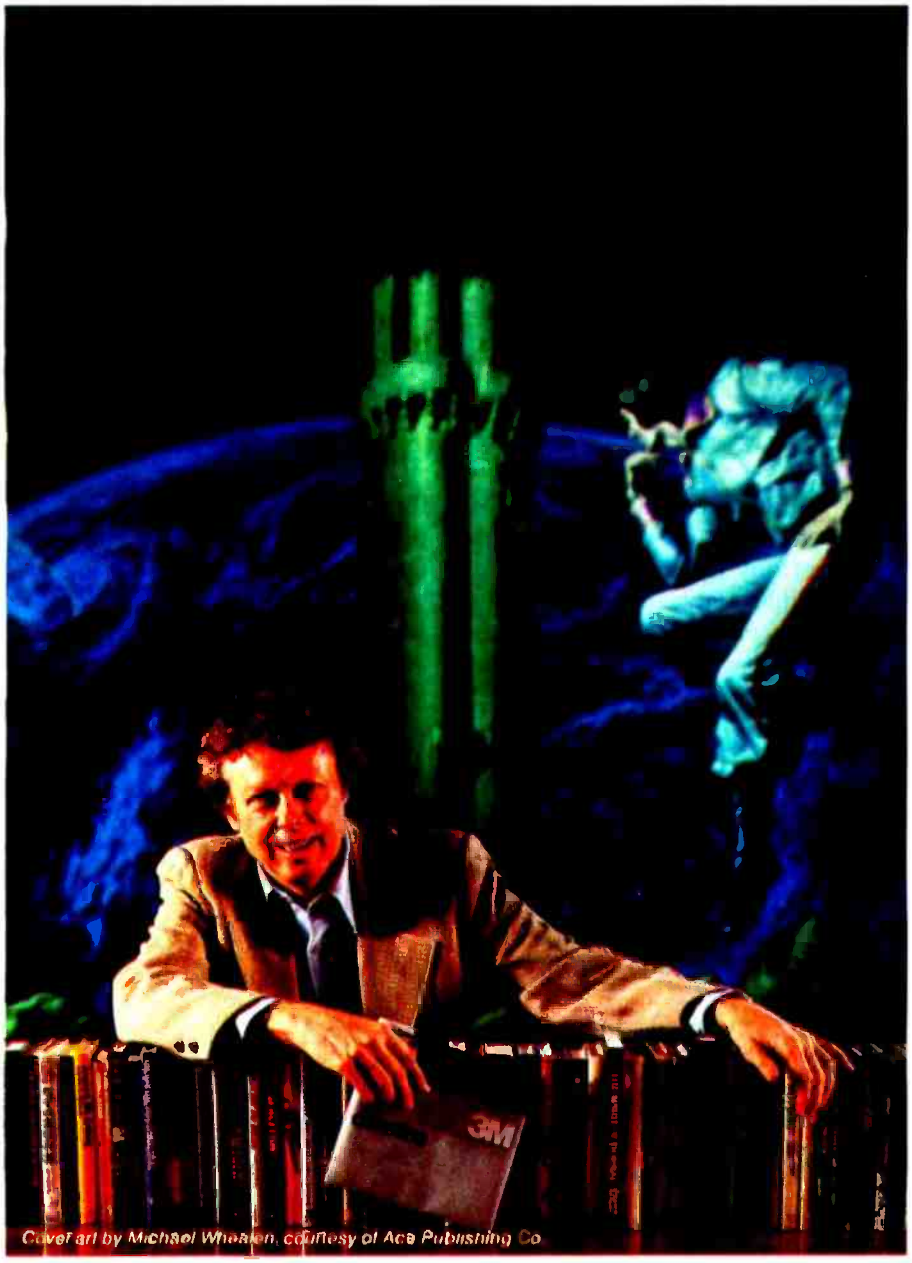
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Many of you grew up as I did, taking all your toys apart. In most cases, the wrapping was scarcely off a gift before a screwdriver was skillfully applied to pry it apart.

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

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

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.

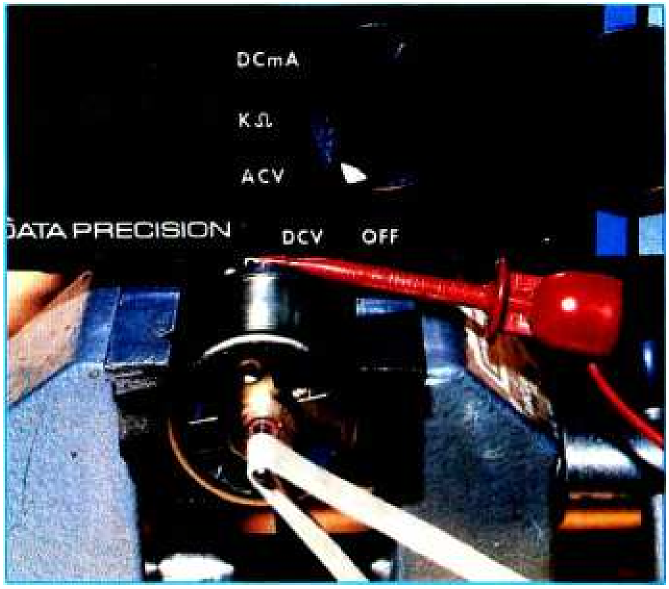

Photo 1: *A PM (permanent-magnet) DC motor can also be used as a generator-type tachometer, or tachometer-generator. When the shaft is turned, a DC current proportional to the speed is produced. In the case shown, a small PM DC motor is secured in a vise, and the shaft is slowly turned (by the belt attached 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.*

What Is a DC Motor?

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

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

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

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

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

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

Motor Classification

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

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

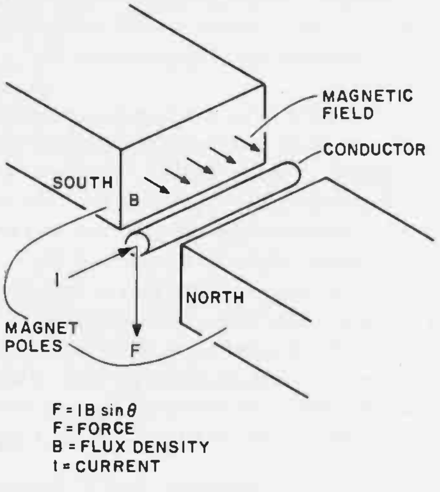

Figure 1: *Simplified diagram of the basic electromagnetic principles behind the DC motor. When a current-carrying conductor is placed in a magnetic field, the conductor feels a mechanical force, F, in the indicated direction, perpendicular to the current and the magnetic field. The force is greatest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

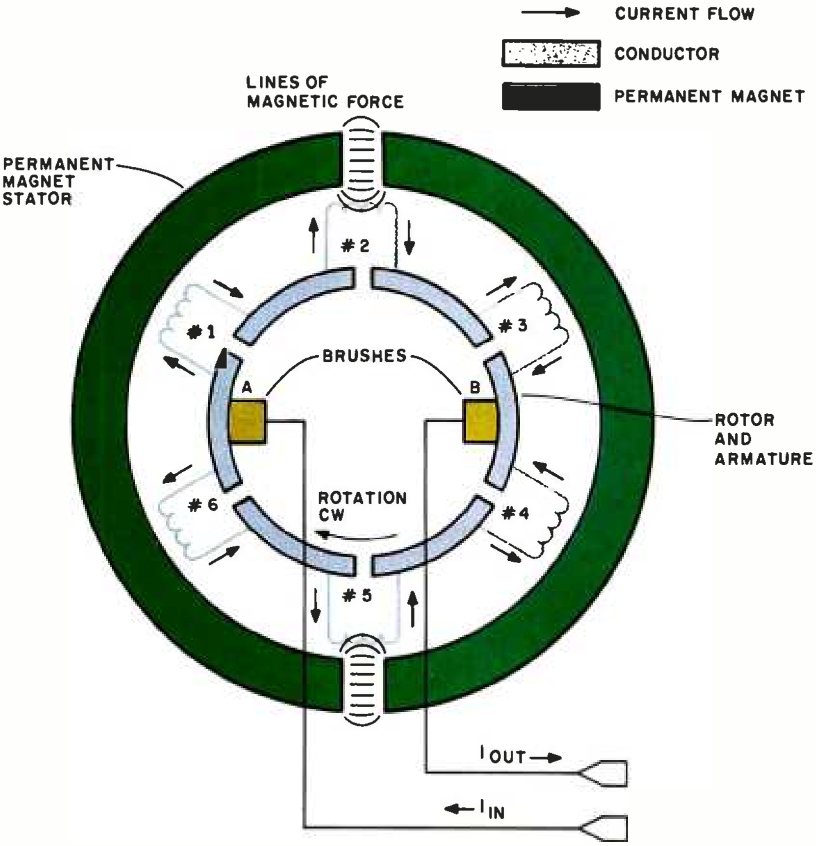

Figure 2: *Internal structure of a typical PM (permanent-magnet) DC motor. Brushes transfer current to the armature coils. As the armature rotates, the brushes contact the assembly at different points, reversing the direction of current flow in the appropriate coils to maintain the electromagnetic force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

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

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

Permanent-Magnet Motors

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

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

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

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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

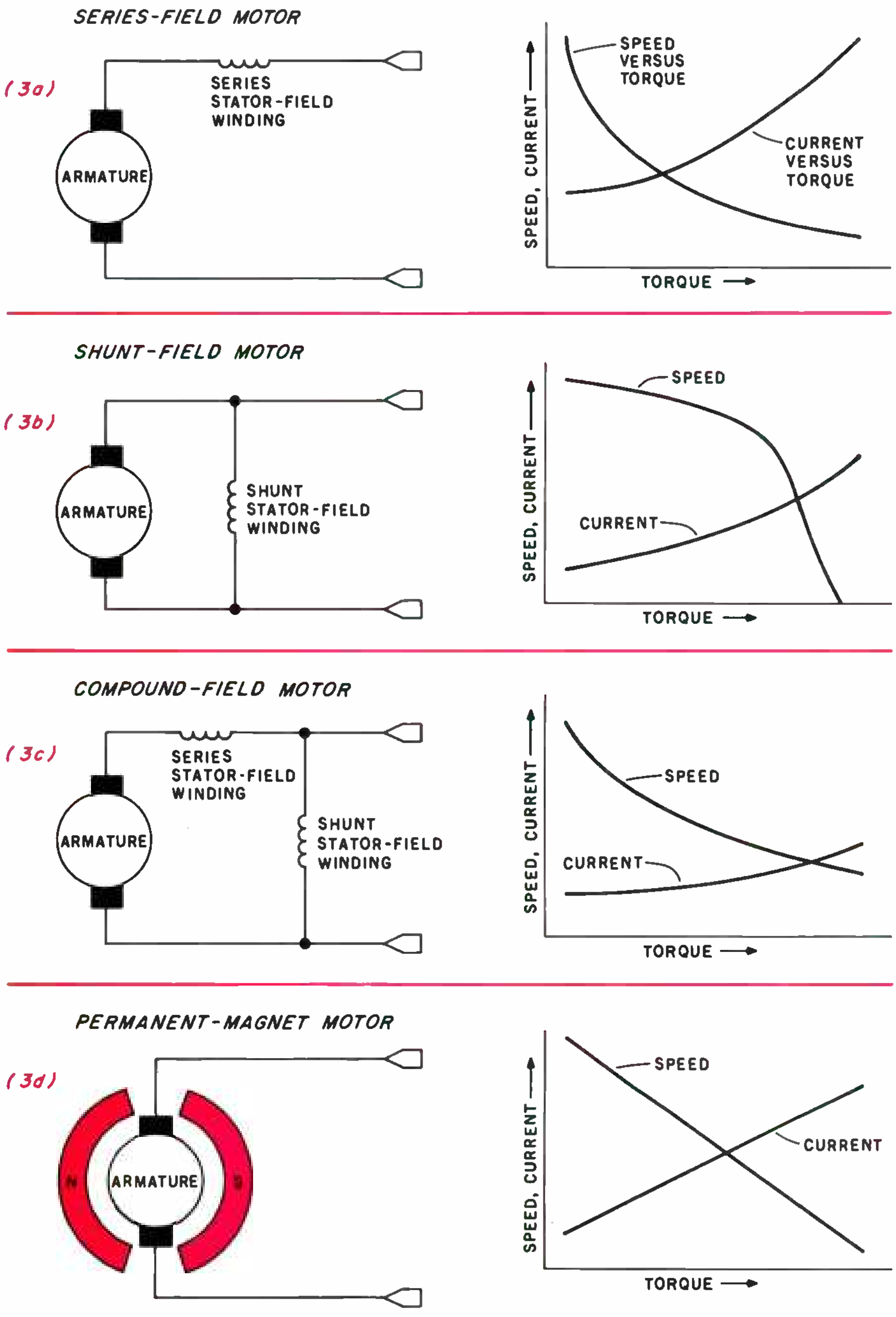
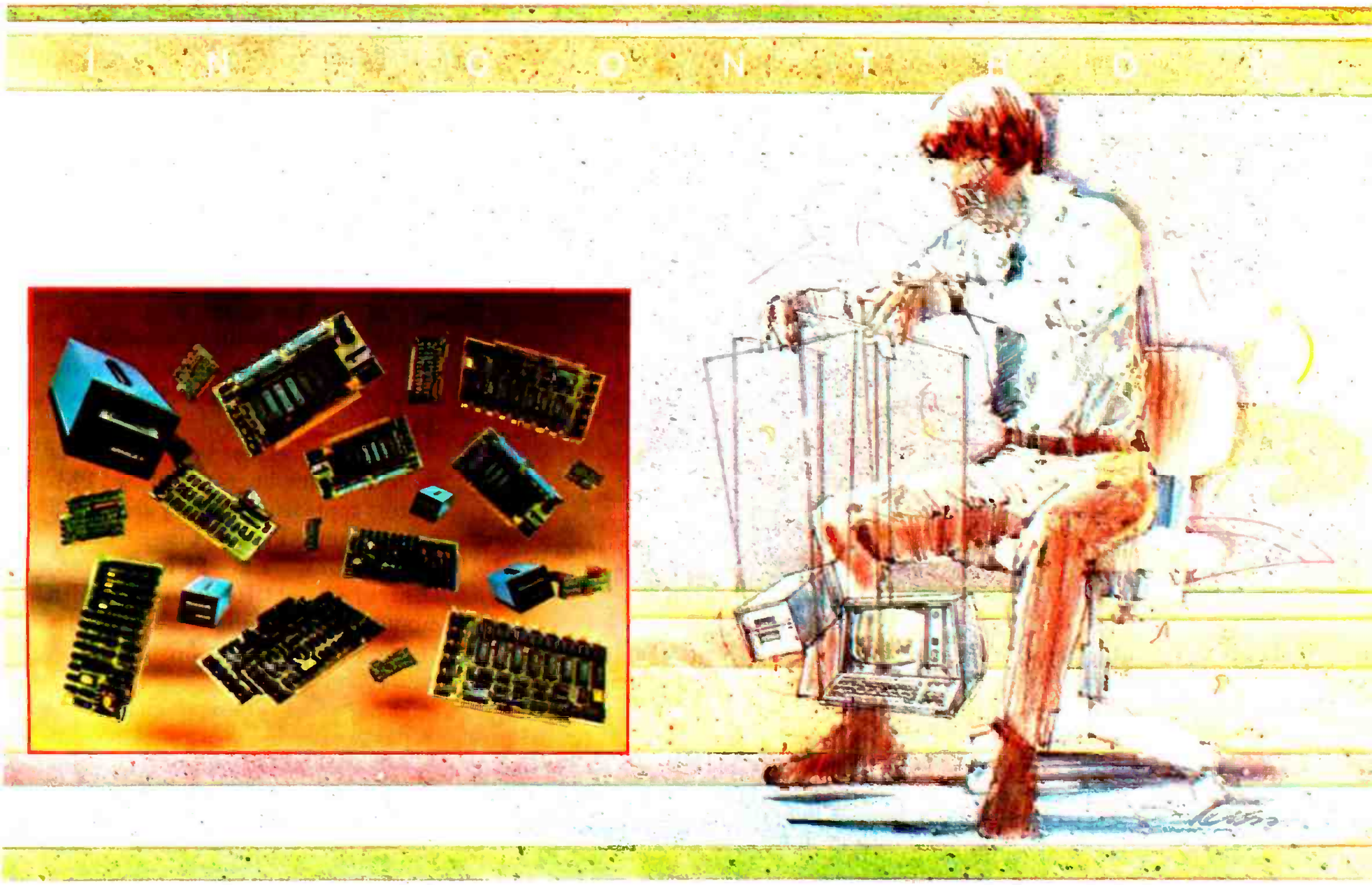


Figure 3: *Different types of DC motors are distinguished by the type of stator field. Three types use an electromagnet to produce the stator field; the fourth uses a permanent magnet. Different methods of connecting windings in the stator electromagnet produce different speed/torque and current/torque 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 can be physically accomplished using a rheostat, an autotransformer and rectifier, or a linear transistor-amplifier circuit (such as the one shown in figure 4). The objective is to apply a relatively constant current to the armature.

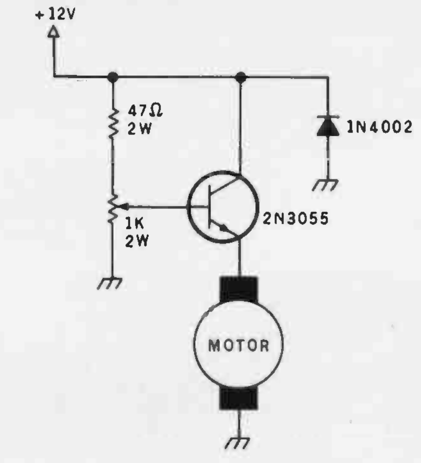

Figure 4: *A simple open-loop linear motor-speed control. Operating the controlling transistor in the linear region of its characteristic curve leads to loss of energy as heat.*

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

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

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

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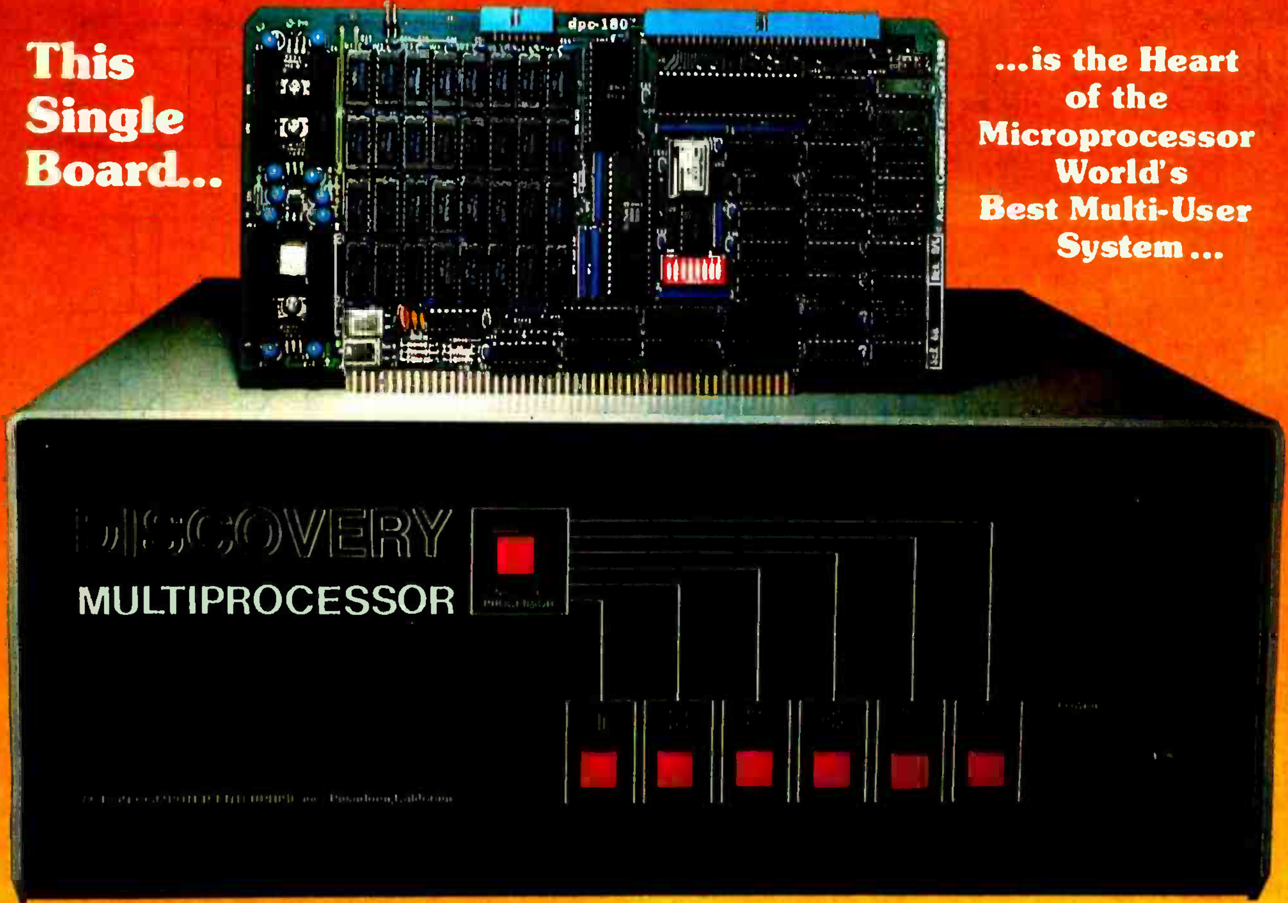

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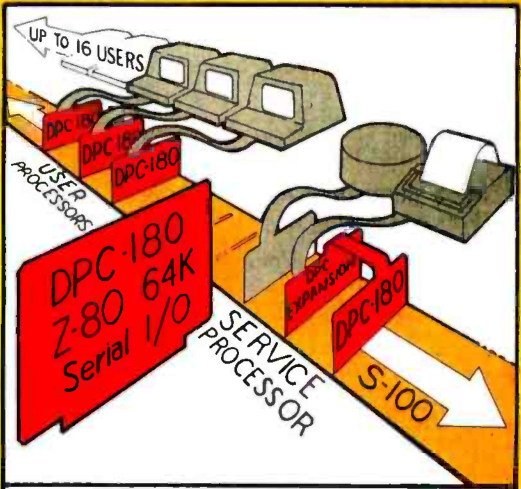

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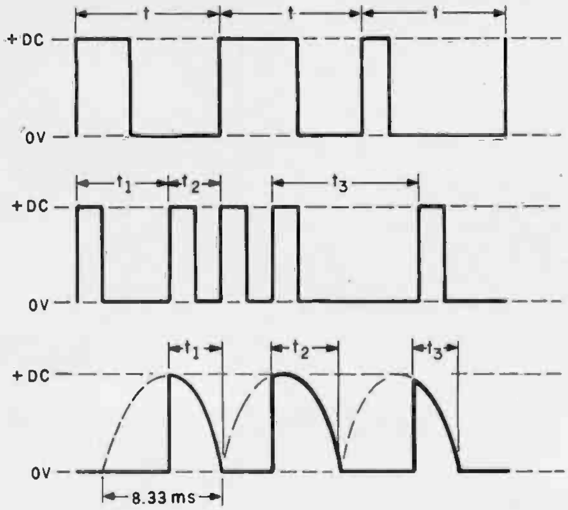

Figure 5: *Comparison of three basic switching-amplifier control-circuit output waveforms. The controlling semiconductors are saturated; the average amount of electrical current transferred to the motor is limited by rapidly cutting the current off and on.*

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

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

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

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

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

Closed-Loop Speed Control

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

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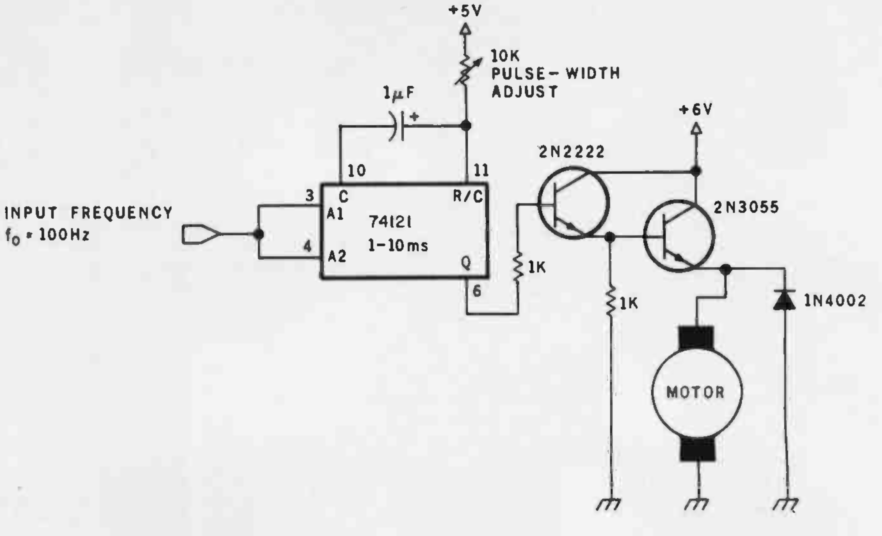

Figure 6: *A simple PWM (pulse-width-modulated) motor-speed control. The duty cycle of the monostable multivibrator (74121) is adjusted by the variable resistor to change the average integrated (in the mathematical sense) electrical current supplied to the motor through the driving transistors. Pin 14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

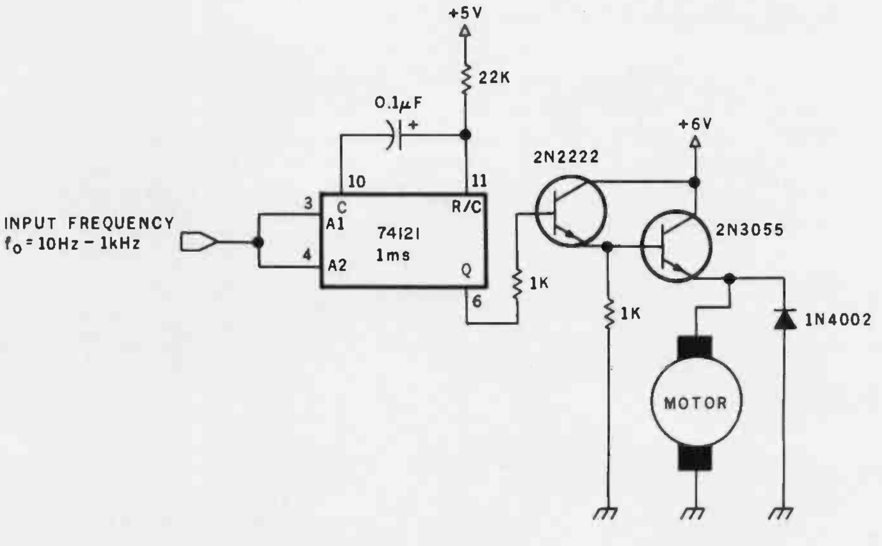

Figure 7: *A simple PFM (pulse-frequency-modulated) motor-speed control. The number of constant-duration pulses supplied to the driving transistors over a given interval controls the speed.*

employed.

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

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

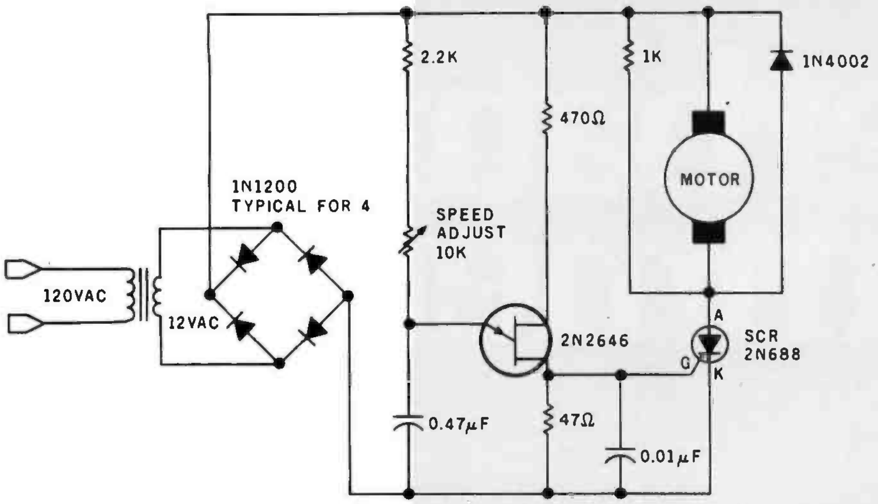

Figure 8: *An SCR- (silicon-controlled rectifier) controlled motor-speed circuit. This method, a variation of PWM (pulse-width modulation), has a wide speed range, high power-conversion efficiency, and low forward-voltage drop across the controlling semiconductor, but not the precise control resolution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

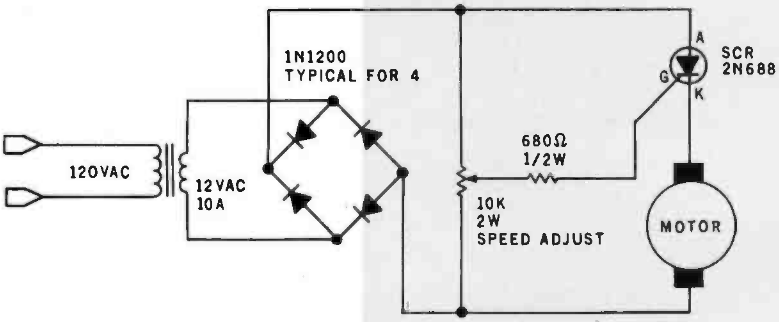

Figure 9: *A second type of SCR-controlled motor-speed control. This design has a limited speed range but maintains constant speed under varying load conditions.*

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

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

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

Servo Controls

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

When control systems capable of

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Operating in Quadrants

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

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

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

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

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

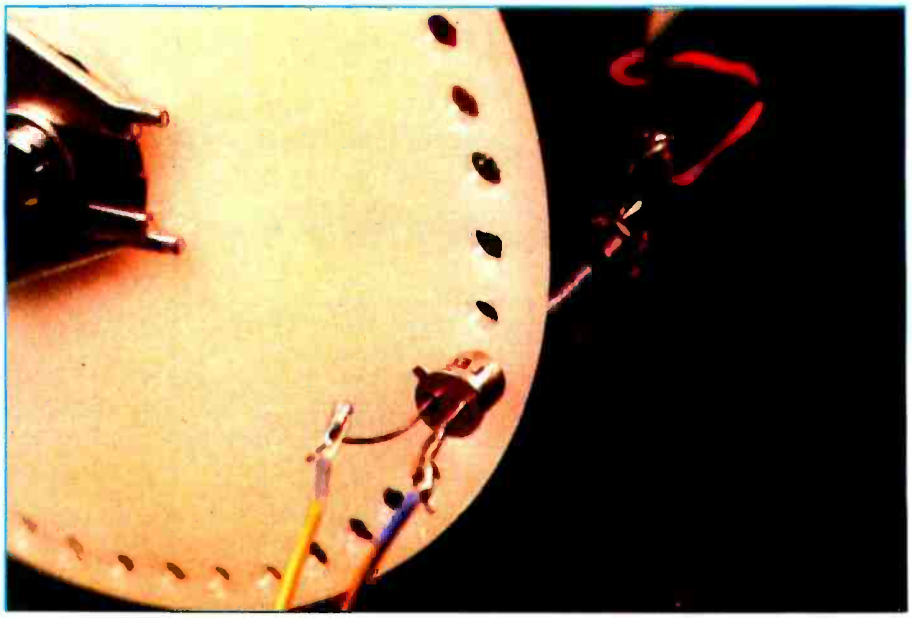

Photo 2: *The most frequently used nongenerator speed-feedback device is the incremental encoder. This is a homemade encoder, consisting of a plastic disk attached to the motor shaft. Around the perimeter of the disk are slots or holes. A light source is placed on one side; a light sensor on the other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


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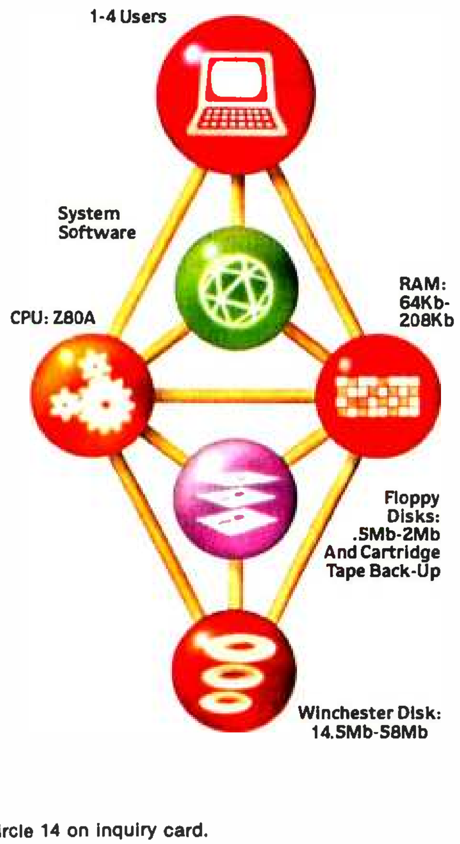

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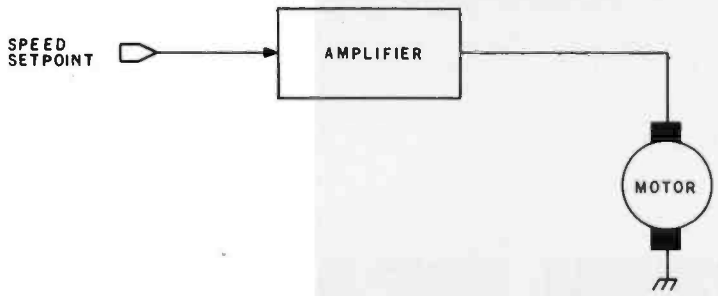

Figure 10a: *Block diagram of an open-loop controller. Variations in mechanical load cause the motor to speed up or slow down.*

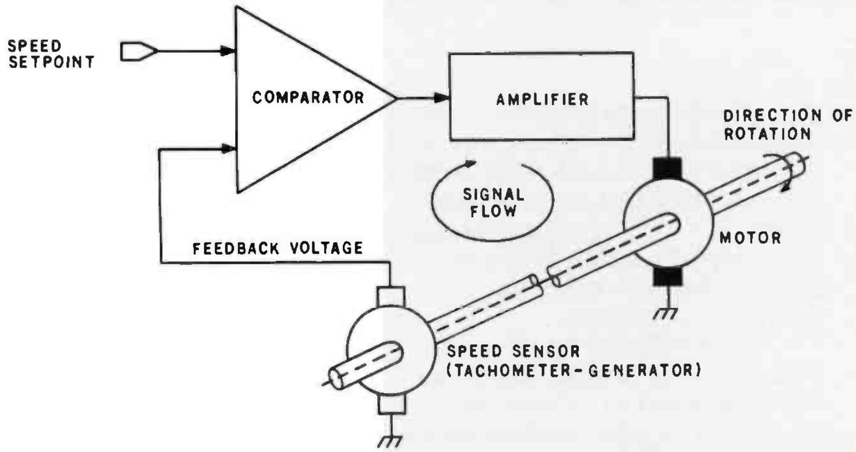

Figure 10b: *Block diagram of a closed-loop controller. The speed sensor detects too-fast or too-slow motion and keeps the motor running without variation in speed over wide variations in load.*

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 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.

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

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

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

Build a Motorized Platform

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

The cheapest high-power low-voltage PM DC motor I found was the one in a hand-held battery-operated drill. The motor I used was from a Black & Decker Model 9001 1/4-inch cordless drill. This same motor is probably used in a variety of other tools and appliances, possibly hedge trimmers and the like.

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

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

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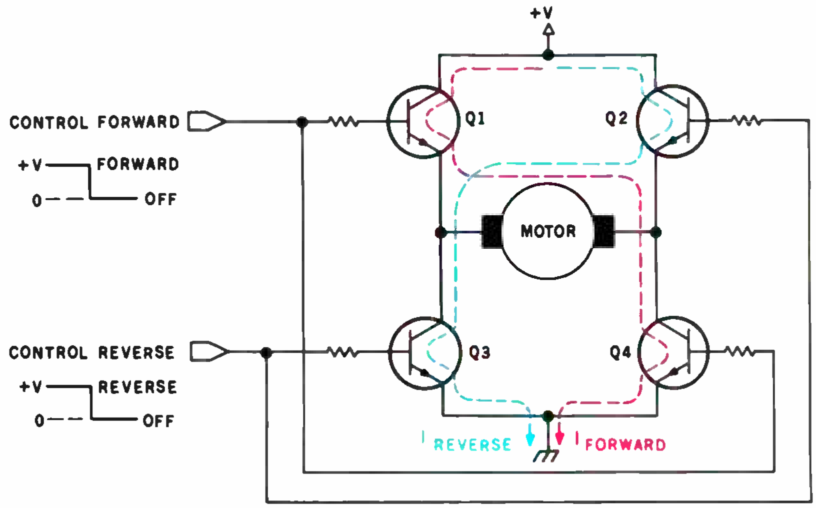


Figure 11a: *One of two basic reversing motor-control circuits. This bridge-type switch uses a single DC supply voltage and is used mostly in PWM or PFM controllers.*

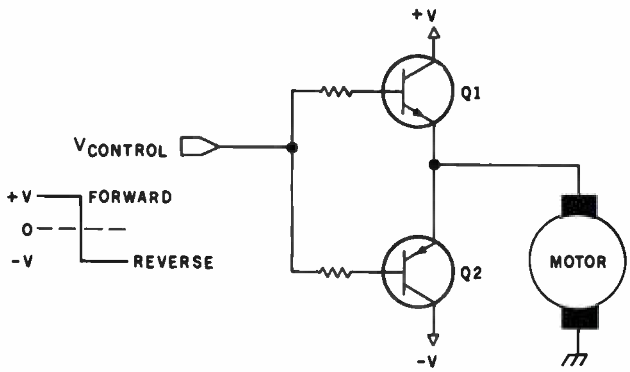


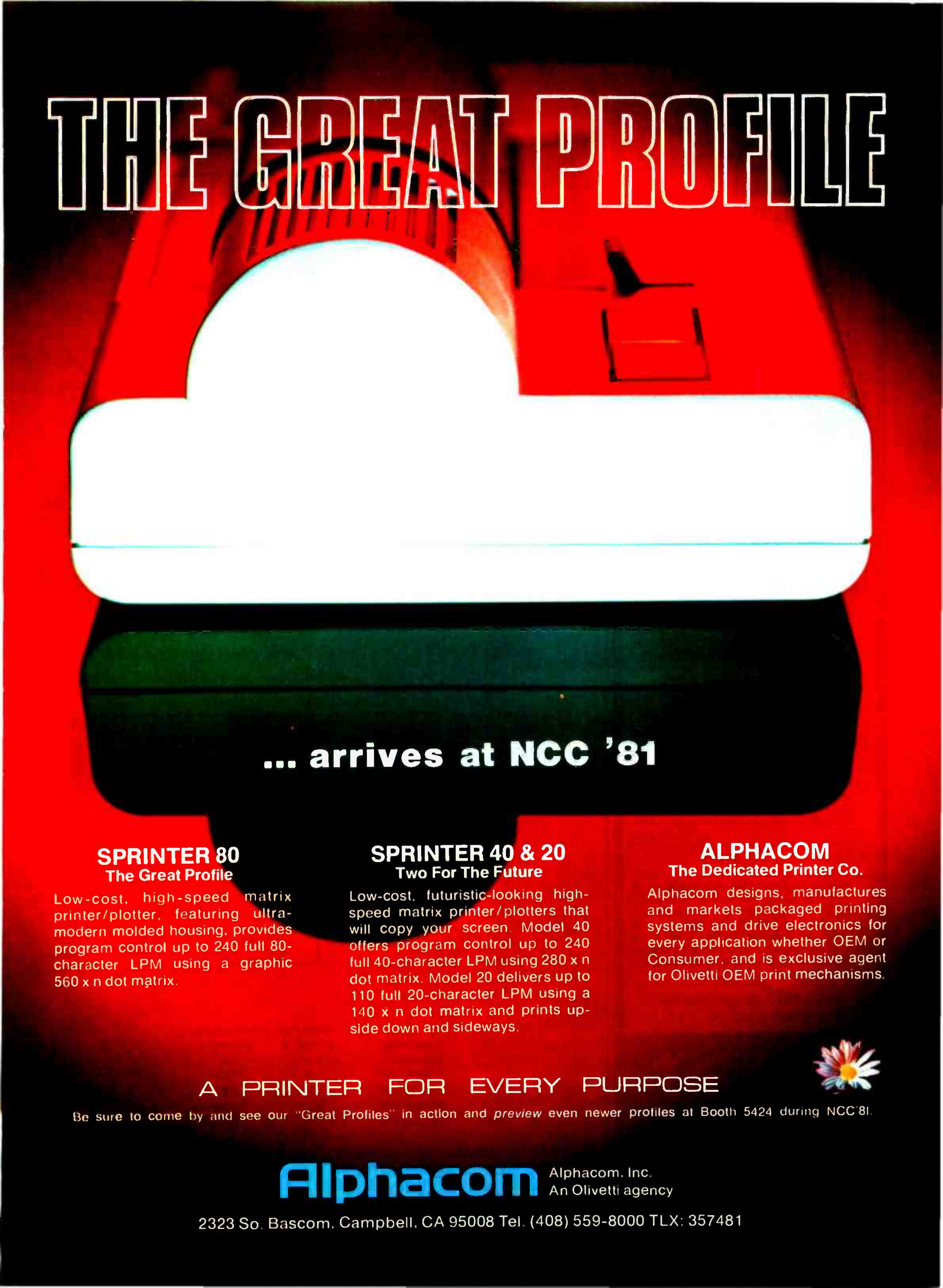
Figure 11b: *A complementary-type reversing circuit. It is more suitable for linear-amplifier control operation, while requiring two opposite-polarity power-supply voltages.*

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

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

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

Text continued on page 90



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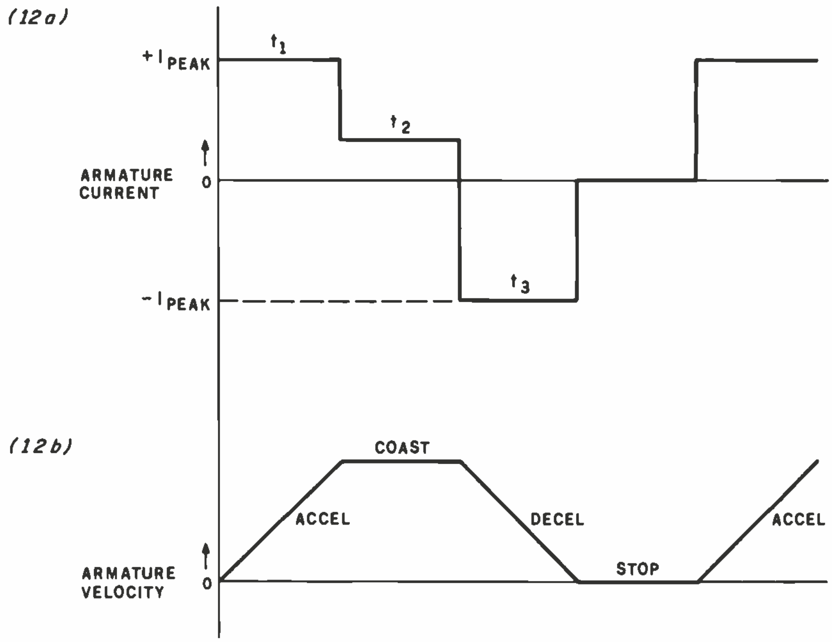
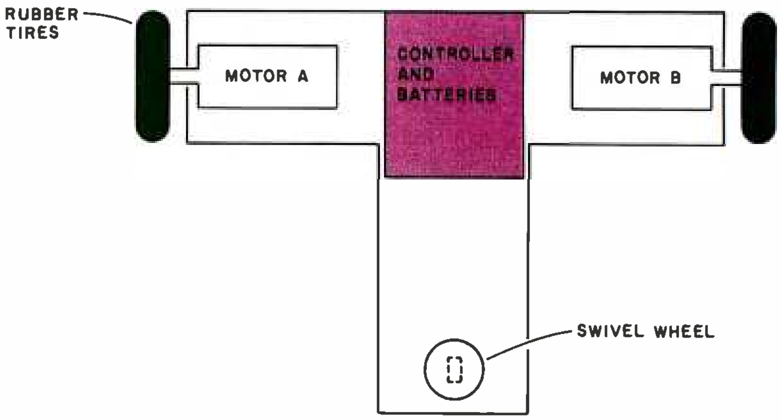
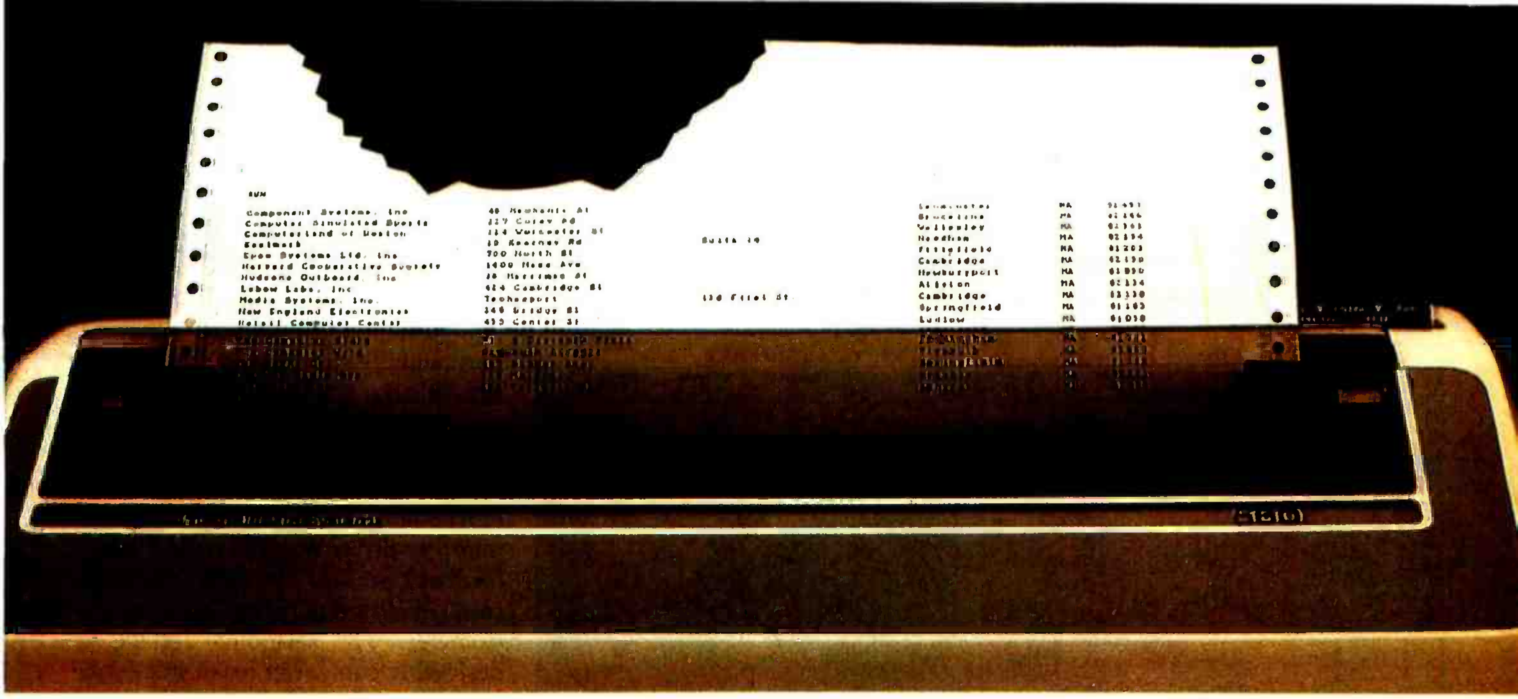


Figure 12: *Precise control can be achieved using incremental-motion controllers. During predetermined periods of time, variable-amplitude voltage pulses are applied to the motor's coils. With the system initially at rest, a high positive step voltage, t_1, is applied to the motor. After motion has begun,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



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

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



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

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

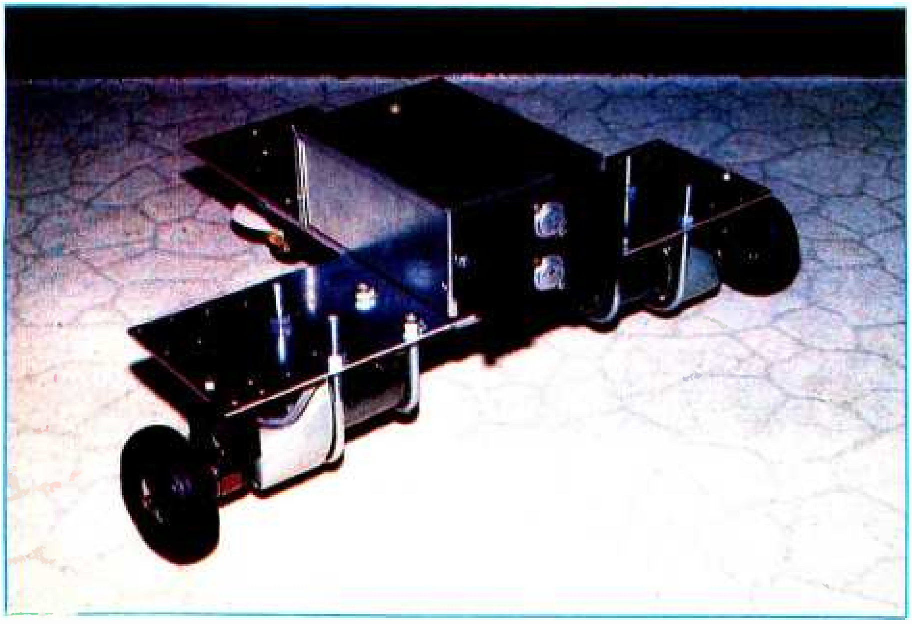

Photo 3: *A simple application of the DC motor controls presented in this article is to build a small mobile motorized platform. This one uses two battery-operated drill motors and a swiveling furniture caster. The T-shaped structure has complete mobility and can turn and pivot, as well as follow a straight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

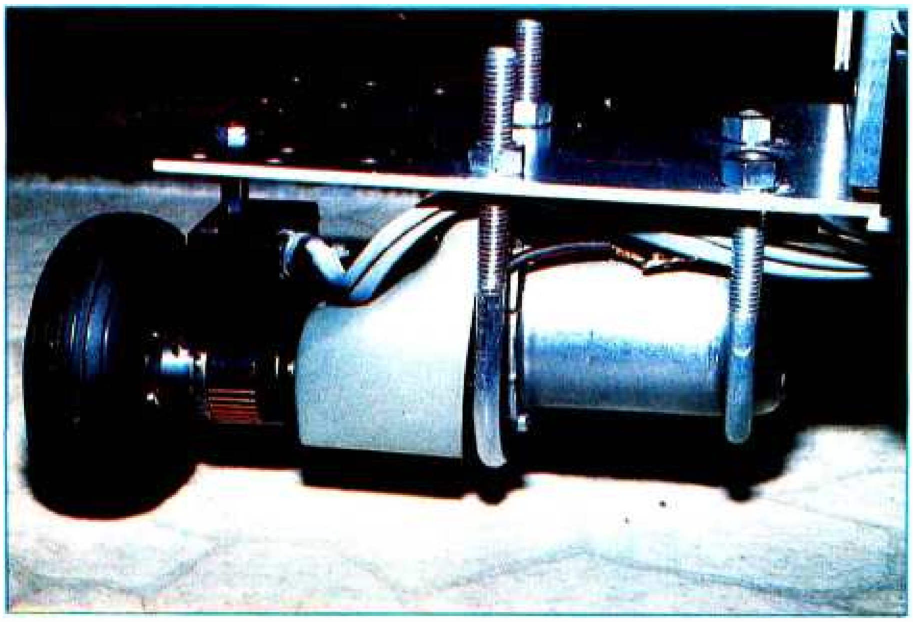

Photo 4: *Close-up of a drive motor on the platform. The motor is from a 4.8 V Black & Decker battery-operated ¼-inch drill. The drill's case and battery pack have been removed. It is secured to the aluminum T-frame with two U bolts. A 5/32-inch brass rod that serves as an axle is inserted into each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

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

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

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

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

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

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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

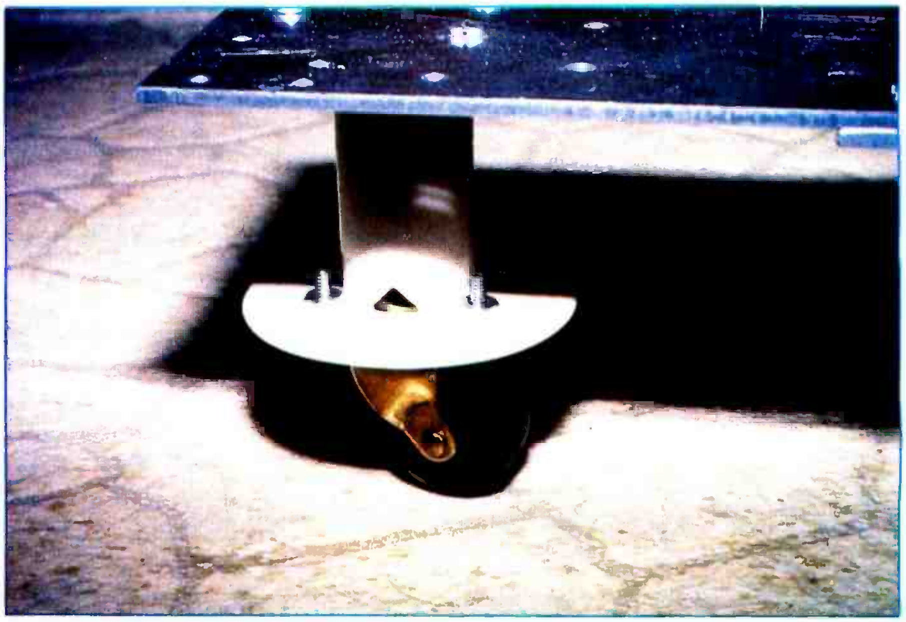

Photo 5: *The rear of the T-frame is supported on a furniture caster. This is a simple scheme allowing motion in any direction.*

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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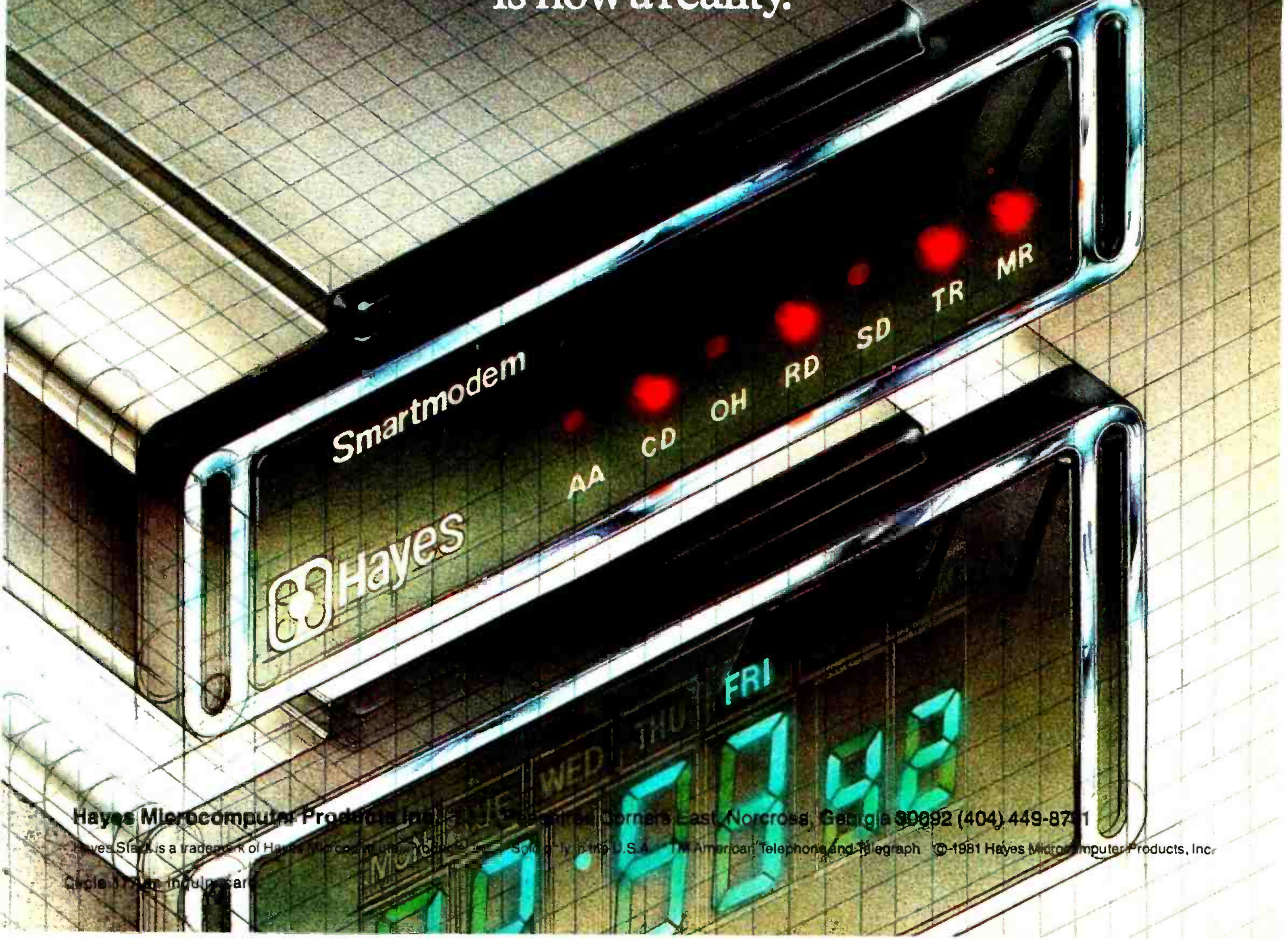

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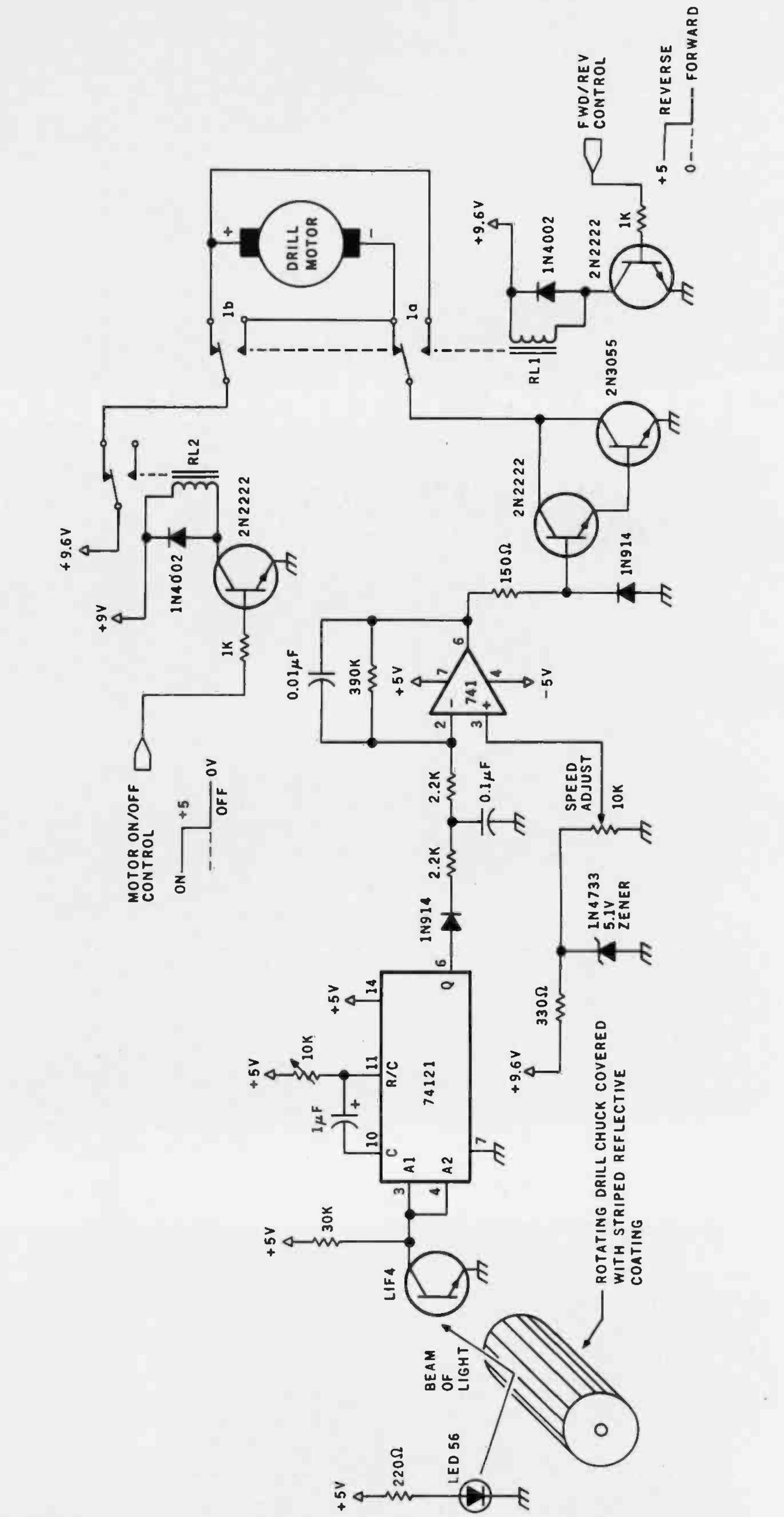

Figure 14: *The motor-control system of the platform, featuring incremental-motion control and reversing capability. Two such circuits were used, one for each motor. Values of the components were experimentally chosen for use with the motor from a Black & Decker Model 9001 portable drill. The 2N3055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

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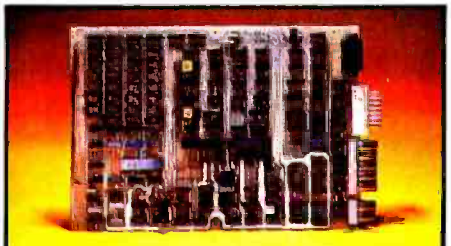

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Text continued from page 92:
The forward/reverse relays set the intended motor directions, and the power-on/off relay starts both motors. As long as the power is on, the platform goes in the direction set by the two forward/reverse relays.

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 (unfortunately, the small batteries lasted only about 5 minutes in constant use). Even with an additional 5 pounds of payload (a bottle of Hennessy cognac and two heavy BYTEs), it worked well.

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

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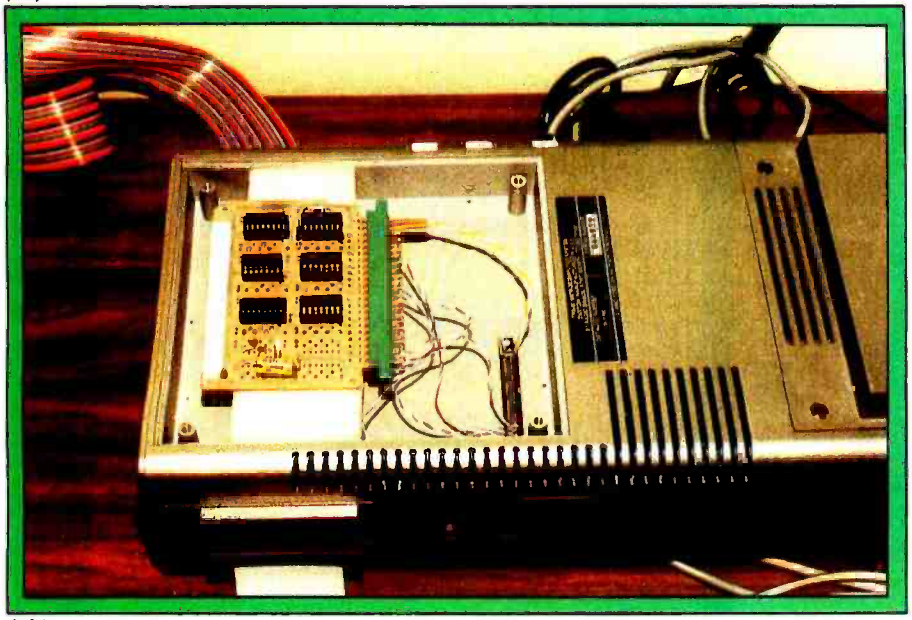
Add an External Data Separator

(1a)



(1b)

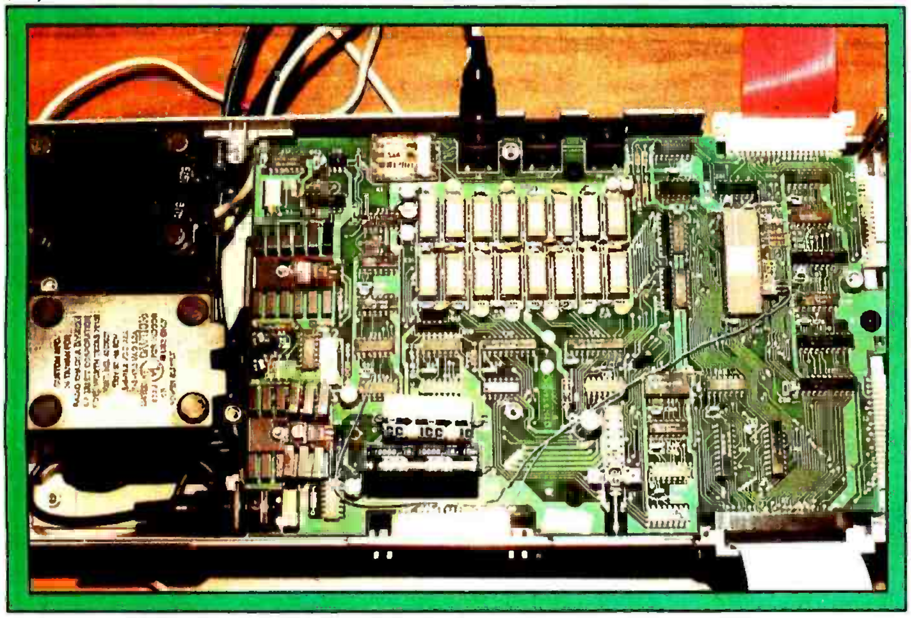


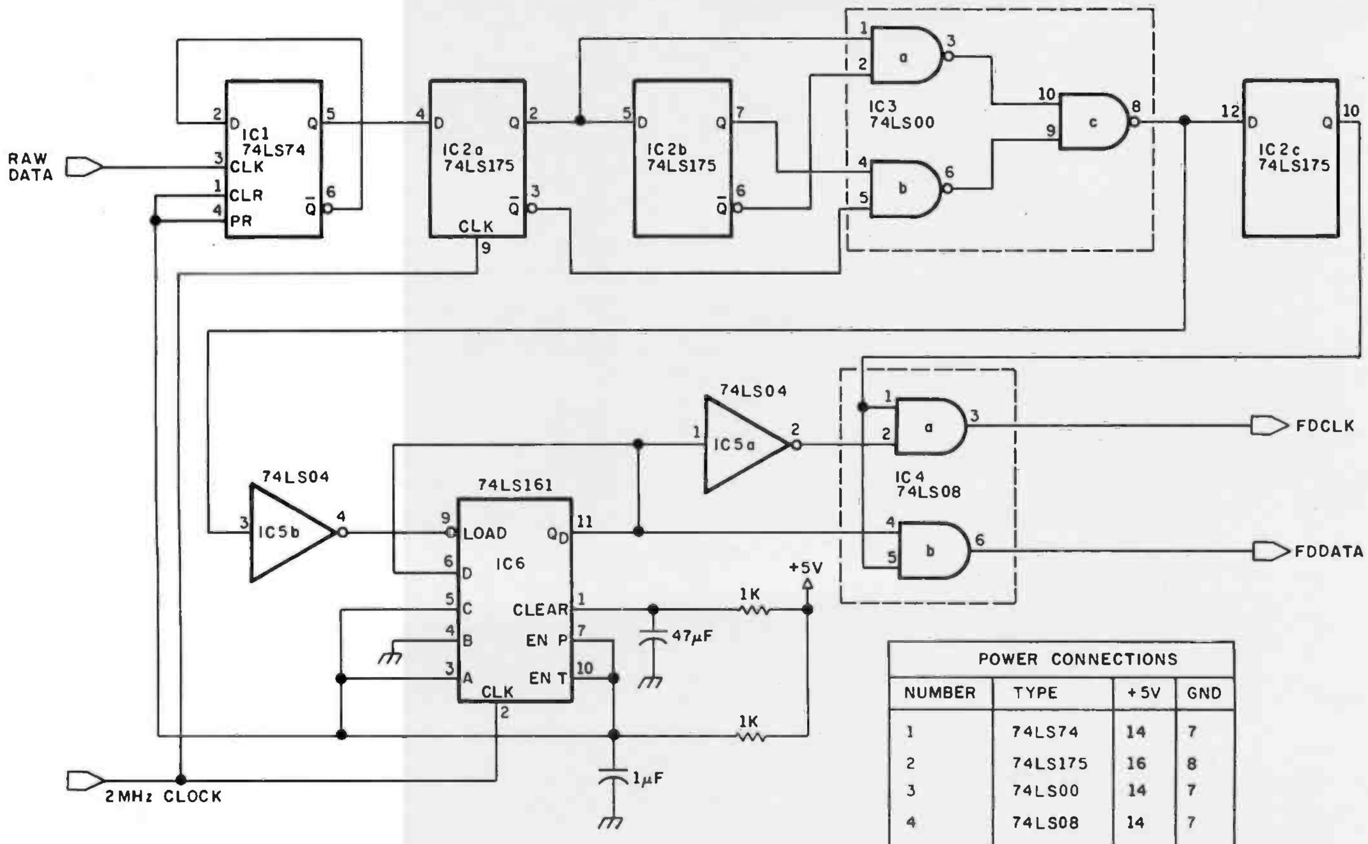
Photo 1: *External data separator circuitry as installed in the Radio Shack TRS-80 Expansion Interface. Most of the integrated circuits can occupy the space intended for the RS-232 interface (photo 1a). Irreversible changes can be avoided by bending a few pins on the FD1771 to obtain the necessary signals (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 10^8, an external data separator is recommended."

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



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

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

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

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

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

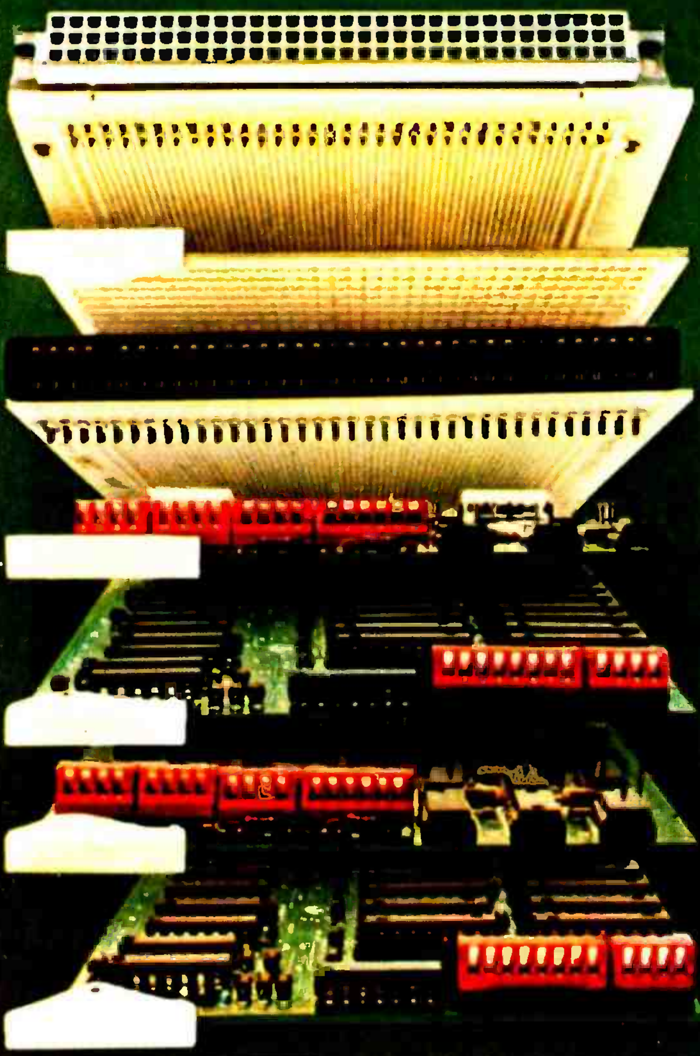
In order not to make any irreversible changes in the printed-circuit board of the TRS-80 Expansion Interface, the three connections to the FD1771 floppy-disk controller can be made through a 3-pin length of a dip strip, a type of socket. Remove the 1771 from its socket and carefully bend pins 25, 26,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

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

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

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

Play with a full deck.



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BYTE'S ARCADE

Star Raiders

Gregg Williams, Senior Editor

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

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

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

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

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

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

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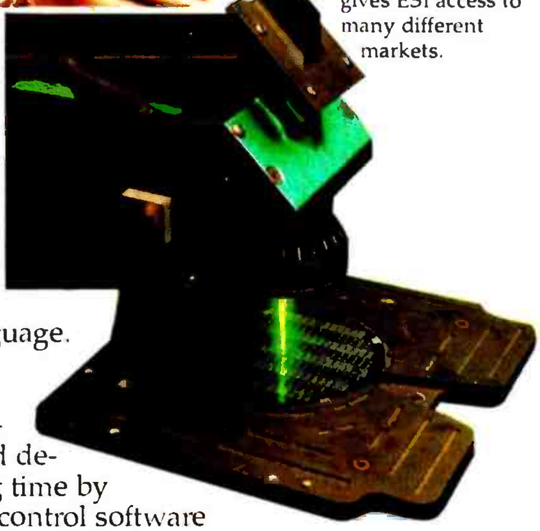

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Below: ESI dominates the industry in the computer-controlled laser adjustment of microcircuits. Pascal-1 programming flexibility gives ESI access to many different markets.

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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

Type
Arcade-style game

Manufacturer
Atari Inc
Consumer Division
1195 Borregas Ave
Sunnyvale CA 94086
(408) 745-2000

Price
$59.95

Author
Doug Neubauer

Format
Game cartridge

Language
6502 machine language

Computer
Atari 400 or 800

Documentation
10 pages, 22 by 28 cm
(8½ by 11 inches)

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

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

Super Nova

Bob Liddil, POB 66, Peterborough NH 03458

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

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

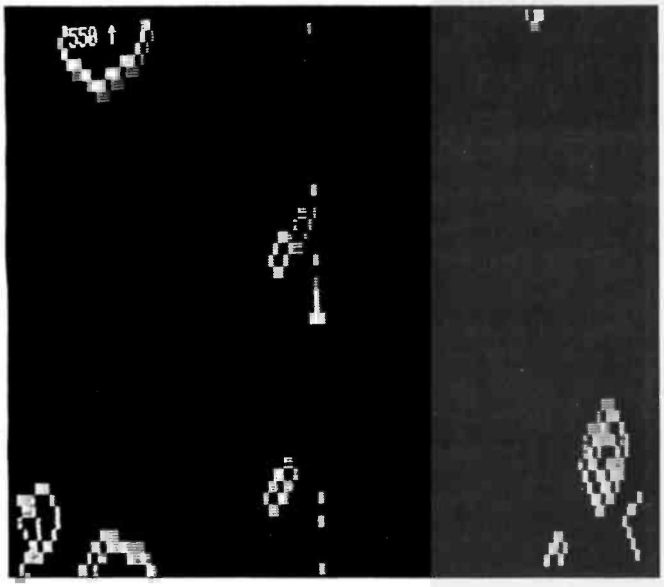

Photo 1: *The Super Nova game in play.*

At a Glance

Name
Super Nova

Type
Arcade-style game

Manufacturer
Big Five Software
POB 9078-185
Van Nuys CA 91409

Price
$14.95

Format
Cassette

Language
Z80 machine code

Computer
TRS-80 Model I with 16 K bytes of memory and Level I or Level II BASIC

Documentation
1-page insert sheet

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

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

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

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

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

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

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

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

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

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Tranquility Base

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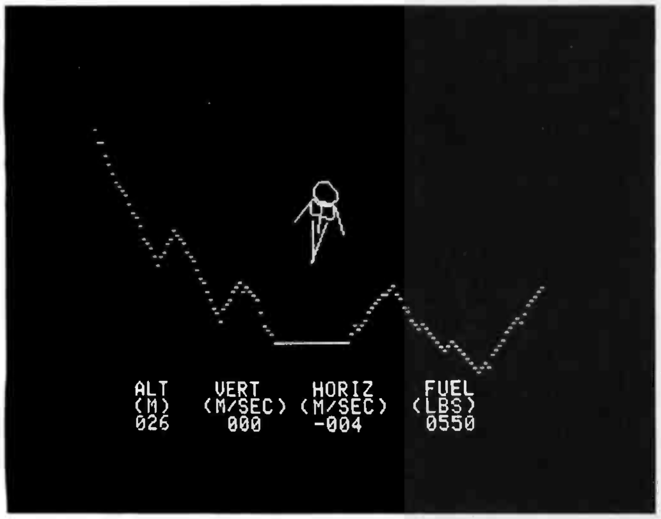


Photo 1: *The Tranquility Base game in progress.*

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.

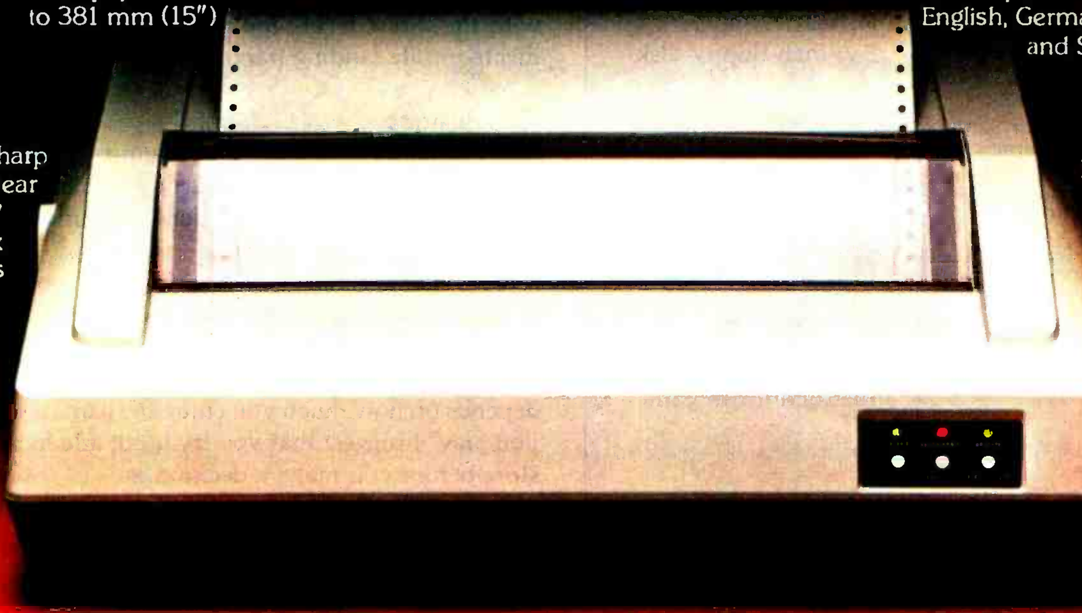
It is difficult to make a successful landing. The landing areas are never much larger than the width of the ship, and the rocket control is quite sensitive, so you might cause the ship to take off just as you are gently touching down. If the lunar module touches anything except a flat landing area, it 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

EXTRA. EXTRA.



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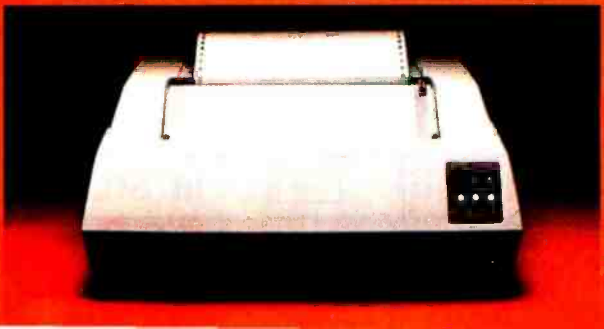

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level, horizontal and vertical velocities, and altitude are displayed in text form below the graphics display. This aspect might have been improved by using analog displays simulated with graphics.

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

At a Glance

Name
Tranquility Base

Type
Arcade-style game

Manufacturer
Stoneware
50 Belvedere
San Rafael CA 94901

Price
$24.95

Author
Bill Budge

Format
5¼-inch floppy disk

Language
6502 machine language

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

Documentation
Instructions in game

Conclusions

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

Asteroids in Space and Planetoids

Oliver Holt
Old Nashua Rd
Amherst NH 03031

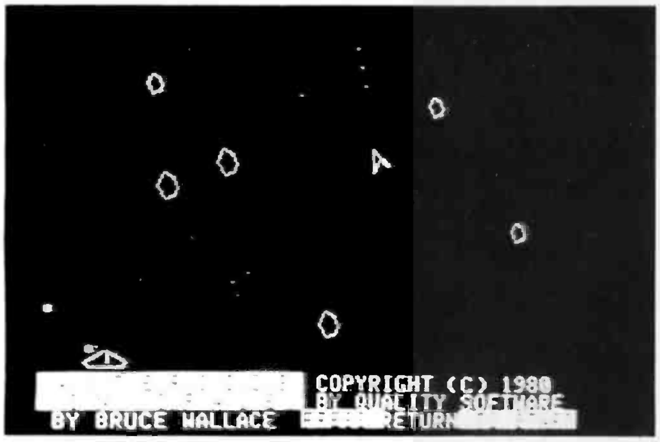

Photo 1: *Asteroids in Space is the title of the Asteroids game for the Apple from Quality Software. It is similar to the actual arcade game; the spaceship is controlled via the game paddles.*

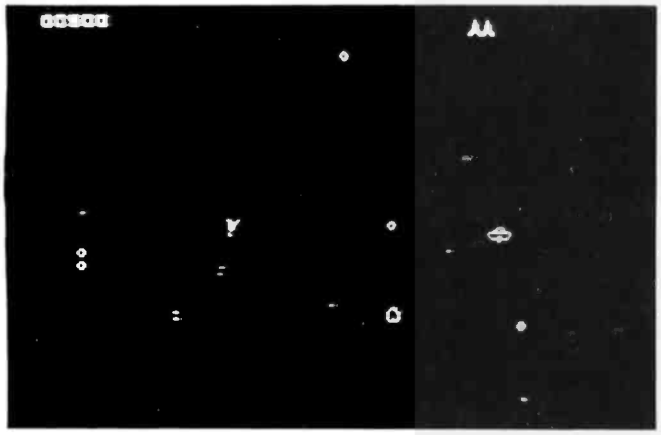

Photo 2: *Planetoids is Adventure International's offering. The use of machine-language programming combined with high-resolution graphics results in smooth action without a jittery picture.*

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

Planetoids

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

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

At a Glance

Name
Planetoids

Type of package
Arcade-style game

Manufacturer
Adventure
International
POB 3435
Longwood FL 32750

Price
$19.95

Format
5¼-inch floppy disk

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

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

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

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

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

Conclusions

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

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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:↑pab);
                     3 : (dptr:↑integer)
                   END;
```

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

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

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

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

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

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

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

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

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

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

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

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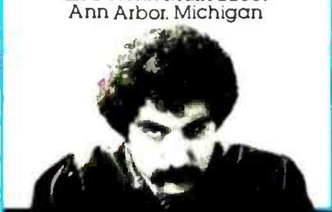

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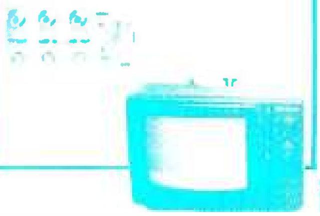

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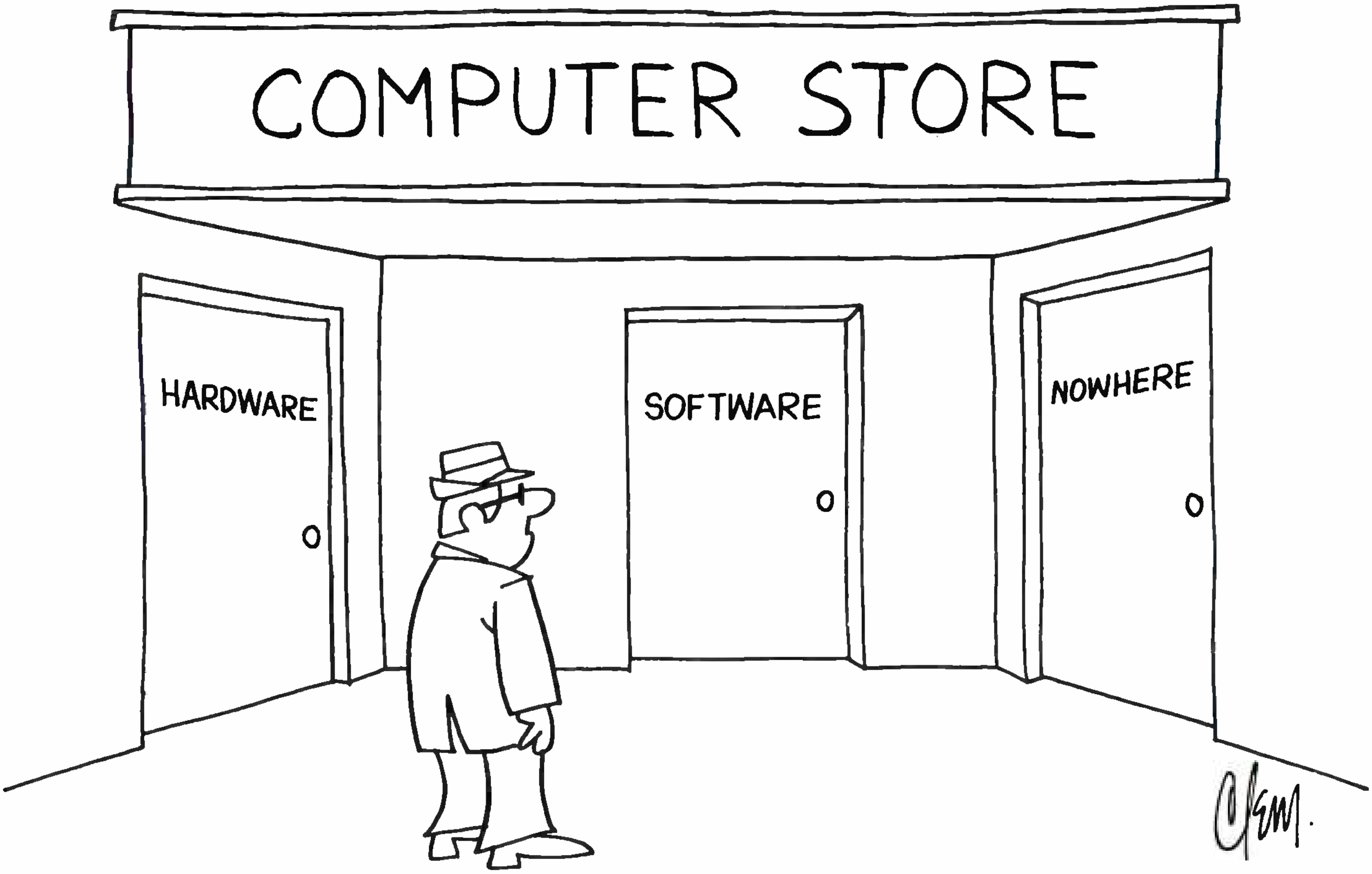

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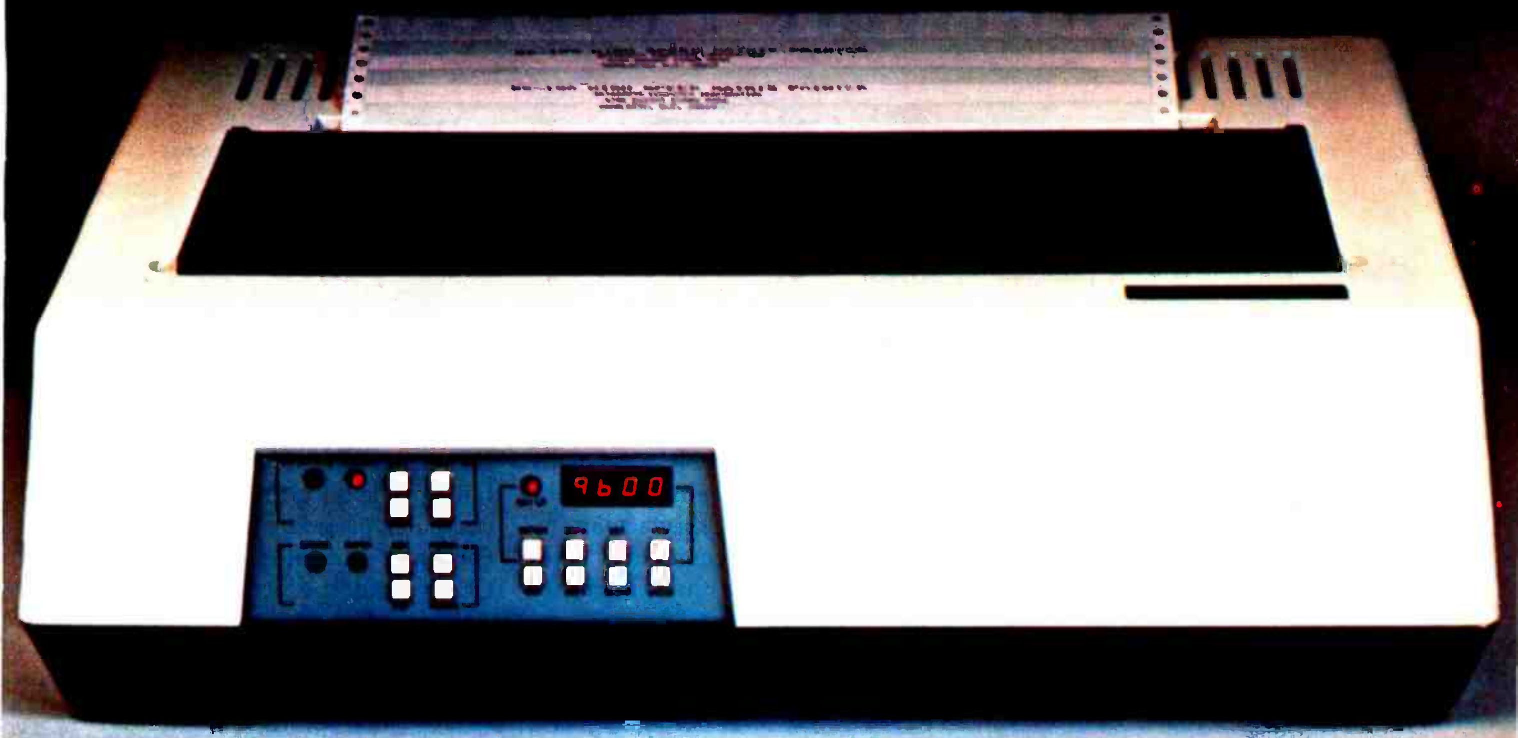

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Washington Tackles the Software Problem

Christopher Kern
201 I St SW, Apt 839
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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 commerical duplication—often entirely legal—of software and software-based products for commercial purposes.

The Copyright Problem

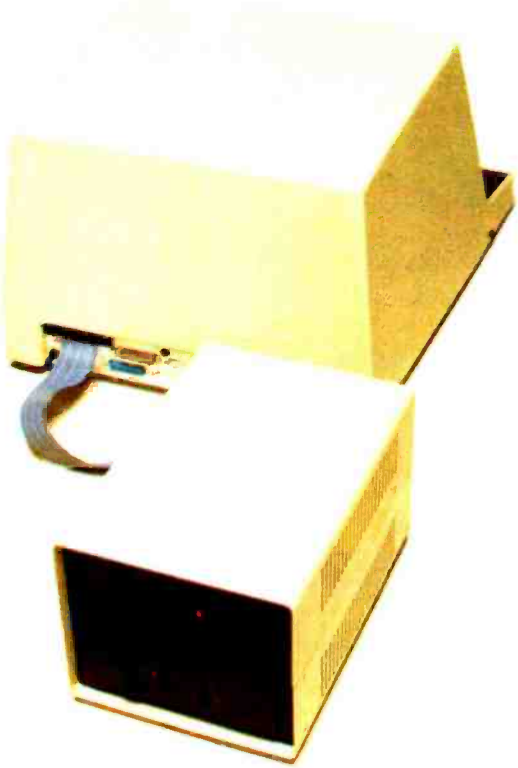
When Congress overhauled the nation's copyright laws in 1976, it sidestepped the software problem by failing to specify the extent to which computer programs were eligible for copyright protection. A source listing clearly could be protected by copyright; a listing of a program is, after all, just a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

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

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

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 statute by defining a computer program as "a set of statements or instructions to be used directly or indirectly in a computer to bring about a certain result." The word "directly" refers, of course, to the object code. But while the new copyright law protects both the source statements and the sequence of machine instructions in the program, it does not protect the underlying logic of the program—the operations that the software is designed to perform.

The Patent Problem

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

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

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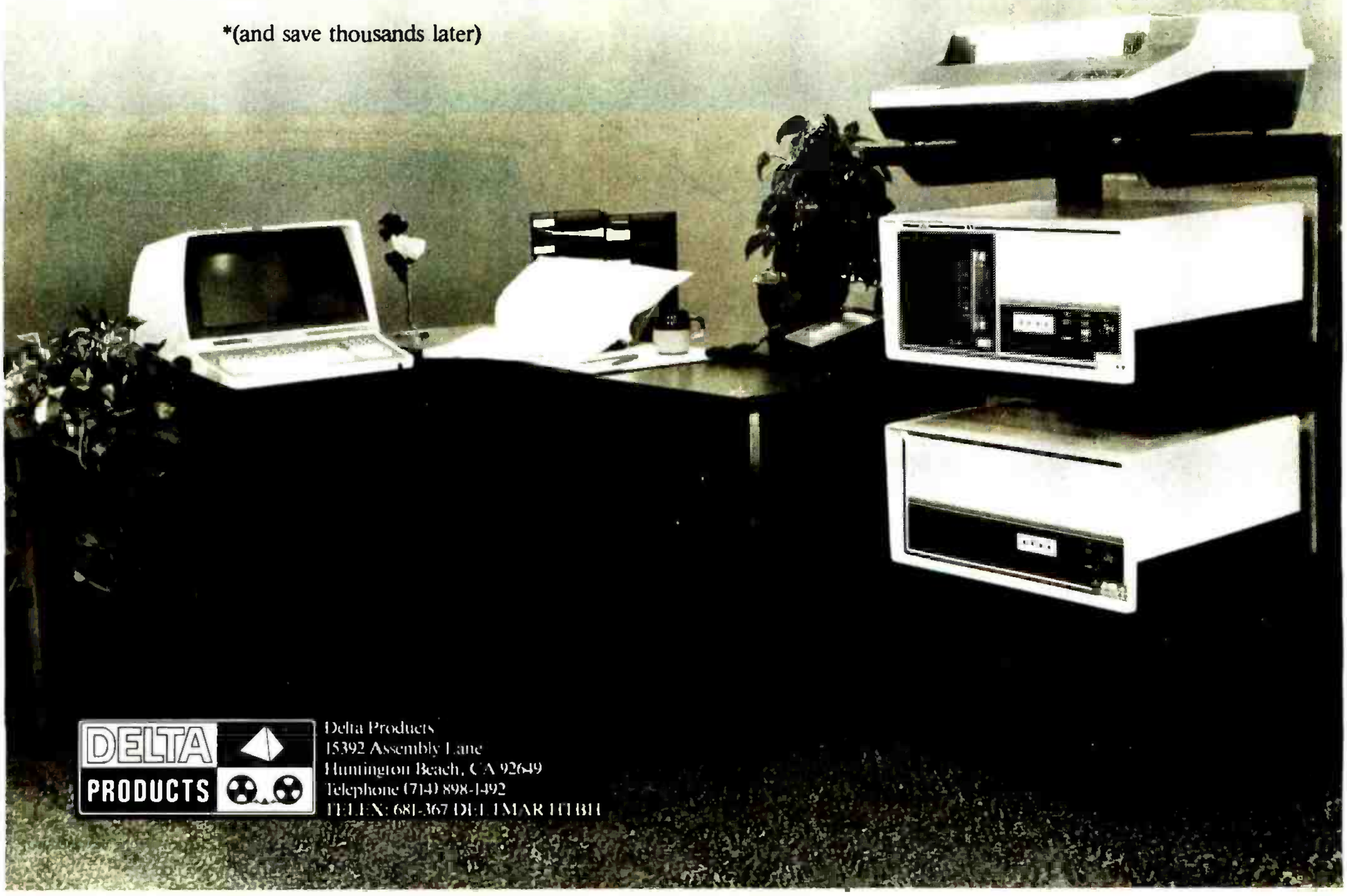

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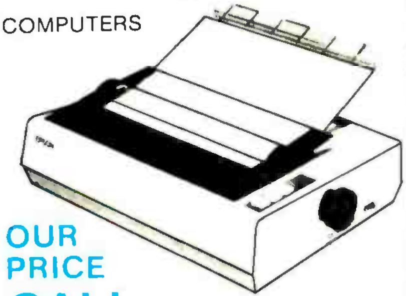

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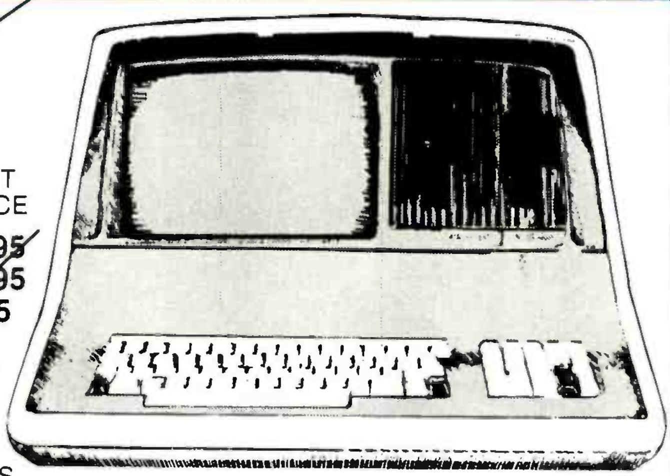

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idea of itself is not patentable," and concluded that granting a patent for the BCD-to-binary algorithm would amount to giving the applicant exclusive ownership of a mathematical abstraction.

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

The protection afforded by a patent borders on the absolute.

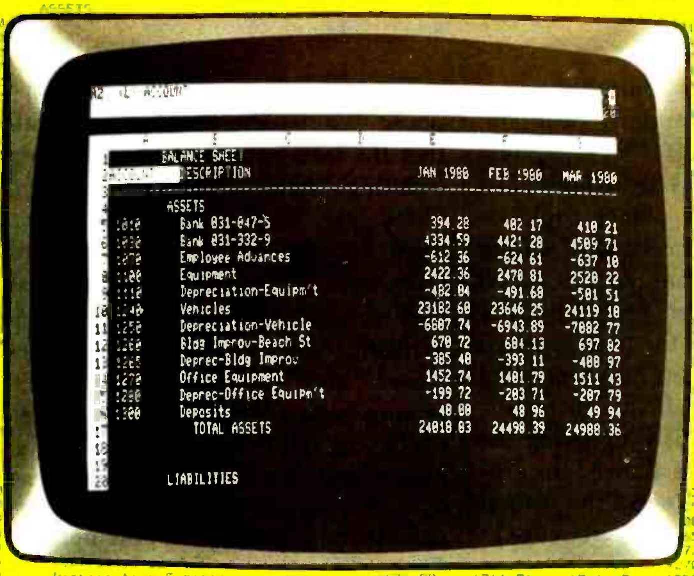
The Flook Decision

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

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

A Recent Interpretation

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



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

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

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

Prospects

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

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

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

What Does This Mean to Us?

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

Object code is now clearly subject to copyright laws.

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

New Technology Clashes With Old Laws

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

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

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

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

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

Concurrent with the activity in Congress, a commission was formed in 1975 to address the copyright problems of data processing. CONTU (the National Commission on New Technological Uses of Copyrighted Works) examined various existing laws that could, presumably, be modified to protect data bases and software. In 1978, CONTU issued its Final Report, *a study that recommended 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, humanly 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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Oroville CA 95965

Legal Protection for Computer Hardware and Software

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Arlington VA 22202

Picture the following:

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

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

Answer: There are no guarantees.

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

About the Author

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

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

Patents

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

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

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

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

are essentially mathematical algorithms, such as numerical conversion.

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

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

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

Copyrights

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

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

© John Doe 1979

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

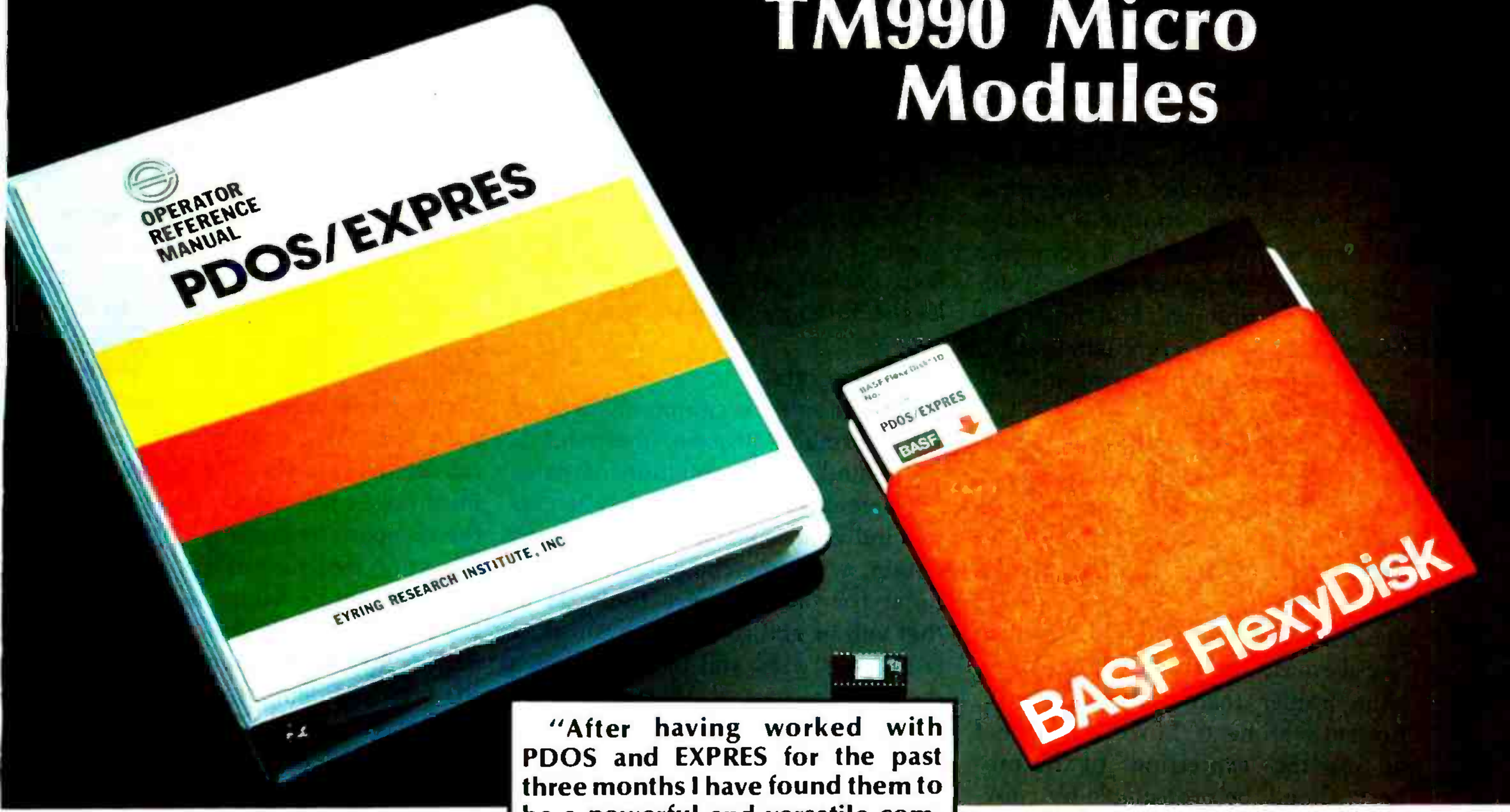
If the program is on magnetic tape or other non-readable form, a printout must also be deposited. Even if you do not register the copyright, you are required to deposit copies with the Copyright Office within three months of the date of first publication of the program with the copyright notice.

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

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

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

Development Software For Texas Instruments TM990 Micro Modules



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Tom Ochs
Assistant Research Professor
Desert Research Institute

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- Stand alone run module support

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The EXPRES BASIC interpreter uses advanced interpreting techniques which approach execution speeds of common threaded code compilers while maintaining the highly advantageous interactive approach to program development. Other features include:

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- Variable names of unlimited length
- Reverse Polish pseudo-source token storage

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*U.S. price, subject to change without notice who independently develop the same program; a copyright offers protection only against actual copying.

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

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

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

Trade Secrets

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

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

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

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

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

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

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

Protection

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

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

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

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

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

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

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GENERAL INSTRUMENT

Software Review

Dancing Demon from Radio Shack

Elizabeth Cooper and
Yvon Kolya
POB 22
Peterborough NH 03458

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

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

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

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

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

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

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

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

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

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

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

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

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

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

At a Glance

Name of software package
Dancing Demon

Type of package
Game

Manufacturer
Radio Shack
1600 Tandy Center
Fort Worth TX 76102

Price
$9.95

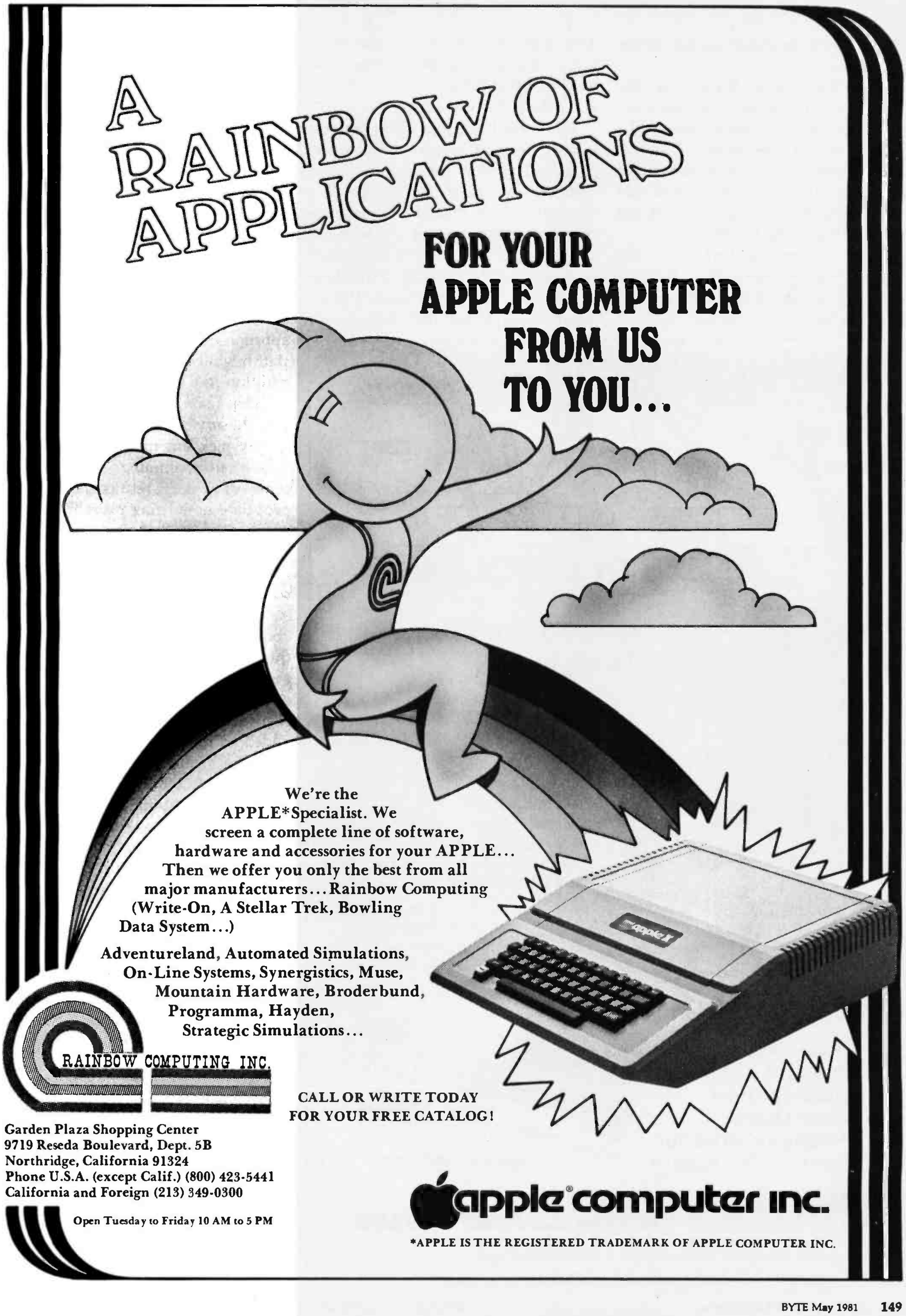
Format
Cassette tape

Language used
BASIC

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

Documentation
13 pages, 8½ by 11 inches

Of interest to
Children, parents and grown-ups who are kids at heart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entered into the music section of the program.

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

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

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

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

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

Conclusions

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

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

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Circle 4 on inquiry card.

Wire-Wrapping and Proto-System Techniques

Adolph Mangieri
POB 384
New Kensington PA 15068

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

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

Wrapped-Wire Connection

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

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

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

Wire-Wrapping Tools

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

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

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

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

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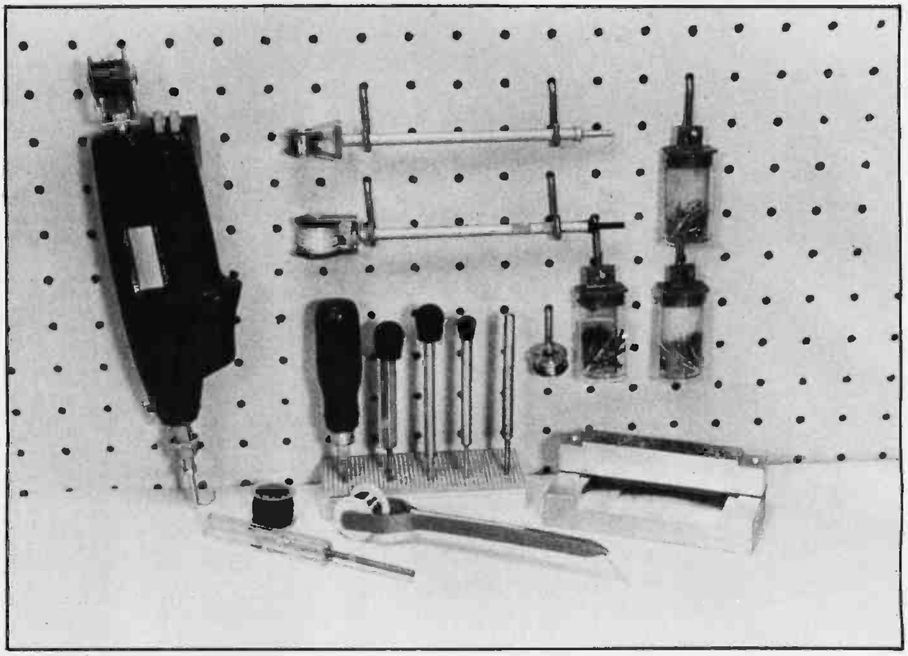

Photo 1: *Available wire-wrapping tools include the Vector P180 Slit-N-Wrap, installed in a P160-4R cordless driver unit (left), the P160-2A-1 Dual-Way Wrap-N-Strap (top center), and the P184-Tefzel Slit-N-Wrap (below). The stand (center) displays five different pin-insertion tools. In the foreground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

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

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

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

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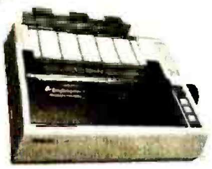

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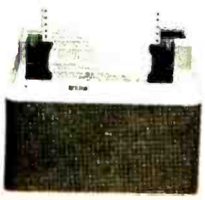

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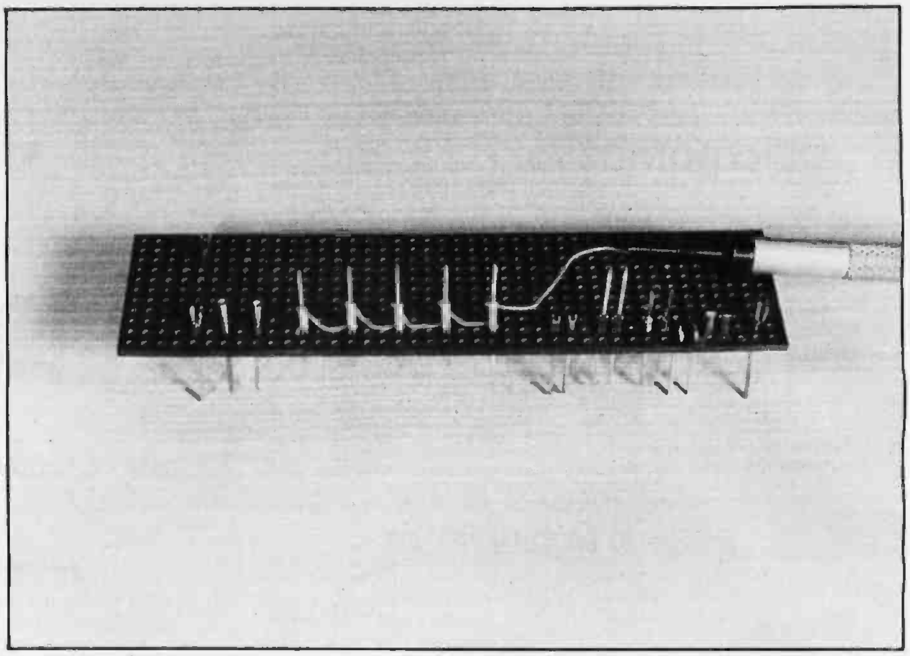

Photo 2: *Rapid assembly of circuit boards demands insulated-wire strapping or chaining techniques, as demonstrated with the P184 Tefzel Slit-N-Wrap tool. The wide variety of board pins shown can handle any wiring situation.*

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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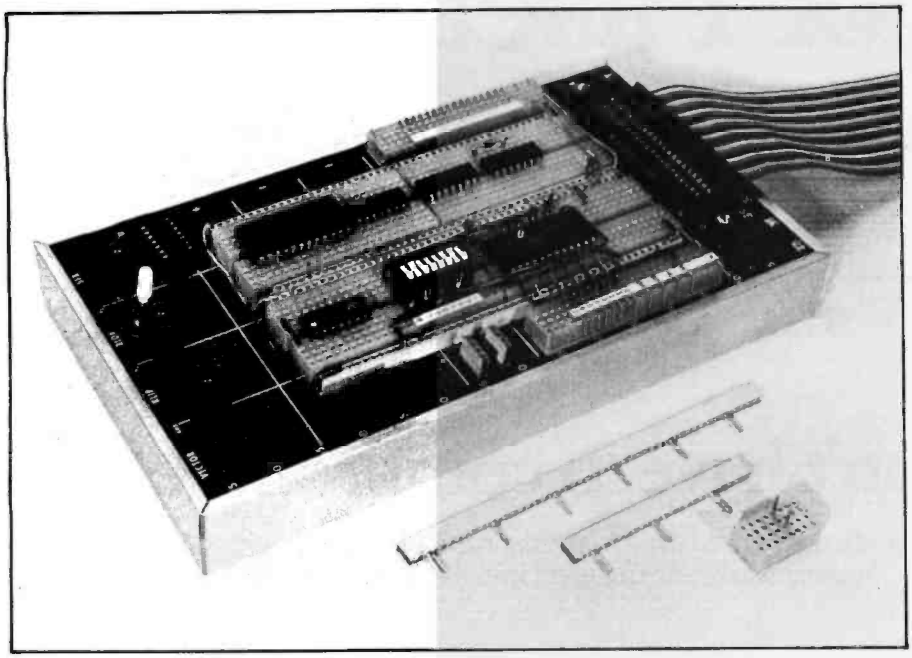

Photo 3: *A DIP (dual in-line package) patchboard or breadboard, such as the Vector 51X patchboard, is indispensable to circuit development. This patchboard is top and bottom wirable and can be easily linked to a computer with an IDC ribbon cable.*

amount of time devoted to the wiring operation.

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

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

Pencil Wiring

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

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

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

DIP Patchboard

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

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

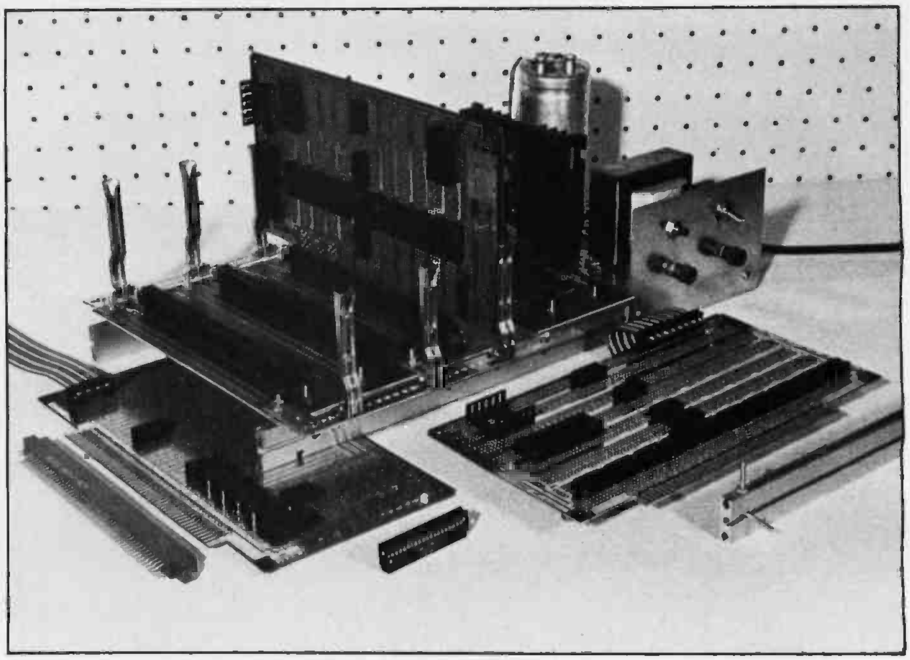

Photo 4: *Low-cost open-frame S-100 bus mainframe uses a Vector 8803 motherboard and T169 T-struts. S-100 prototyping boards include the model 8800V in the mainframe, an 8804 Any-Dip board (right), and the 8802 pad board (left). Shown in the foreground (left to right) are the R681-2 plugboard receptacle,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

remove the meter when you run operating tests.

Plugboard Proto Systems

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

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

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

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

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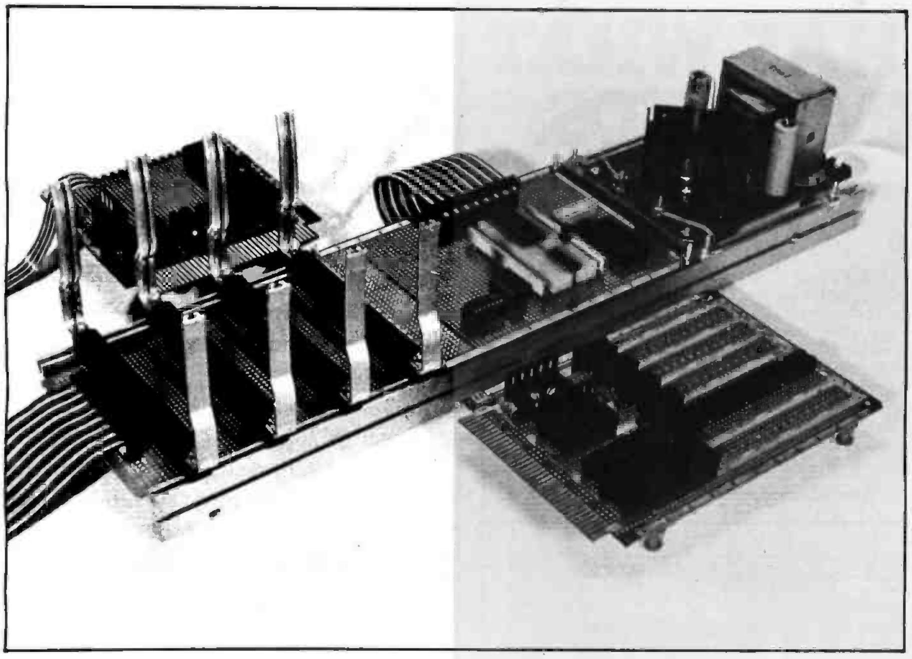

Photo 5: *A system bus with fewer than one hundred lines can also be assembled using standard Vector components. The seventy-two-line combination system pictured here is a typical example. Primary components include the R636-1 receptacles, a 3677-7 clearance ground-plane board on the wire-wrapped backplane,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

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

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

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

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

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

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

Circle 435 on inquiry card.

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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Circle 249 on inquiry card.

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

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

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

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

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

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

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

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

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

Notice of Omission

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

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

Speeding Up TRS-80 Graphics

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

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

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

POINT Graphics

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

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

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

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

Data Files and POKE Graphics

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

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

Listing 4 creates (in line 300) a new

Text continued on page 176

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Primary & Secondary keys maintained automatically—no need to rebuild keys after adding records	YES	Yes
Maximum record size (bytes)	1020	4064
Maximum number of fields/record	100	999
Handles files with more than one diskette of data	YES	Yes
Custom disk operating system (DOS) for faster data retrieval and program chaining	YES	No
User-designed screen formats	YES	No
Up to 9 screen "pages" per record	YES	Yes(16)
Ten field types, including dollar/cents, phone & social security number, date, etc.	YES	Yes(15)
Automatic data compaction for increased disk storage capacity	YES	Yes
Wild card, partial string, range and Boolean search capabilities	YES	Yes
Dynamic prompting (tm) - lists all available functions on screen—no need for quick reference card	YES	Yes
Password file protection	YES	Yes
Four function calculator mode	YES	Yes
Daily update lists for printout of all records added/edited on any day or range of dates	YES	Yes
REPORT GENERATOR:		
Send reports to screen or printer	YES	Yes
Sort on up to 6 fields at a time	YES	Yes(16)
Column subtotals and totals	YES	Yes
Subtotal and page breaks	YES	Yes
Up to 24 computed fields per report	YES	Yes(99)
Up to 9 lines of column titles	YES	Yes(16)
Up to 9 lines for each record	YES	Yes(16)
Maximum number of fields per report	100	999
Code fields - store short codes, print long descriptions	YES	Yes
Comment lines and footnotes	YES	Yes
Comment fields for printing labels or headers within each record	YES	Yes
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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 TO76:Y=32:SET(X,Y
):NEXT:Y=31:FOR X=76 TO 83:SET(X,Y):SET(X+1,Y):Y=Y-1:NEXT
70 FOR X=83 TO 90:Y=24:SET(X,Y):NEXT:Y=25:FOR X=90 TO 94:SET(X,Y):SET(X+1,Y):Y=Y
+1:NEXT:FOR X=96 TO 97:Y=31:SET(X,Y):NEXT
80 FOR X=33 TO 36:Y=27:SET(X,Y):NEXT:FOR X=85 TO 88:SET(X,Y):NEXT:FOR Y=30 TO 32
:X=30:SET(X,Y):NEXT:Y=30:FOR X=30 TO 32:SET(X,Y):SET(X+1,Y):Y=Y-1:NEXT
90 Y=28:FOR X=36 TO 38:SET(X,Y):SET(X+1,Y):Y=Y+1:NEXT:Y=32:FOR X=30 TO 33:SET(X,
Y):SET(X+1,Y):Y=Y+1:NEXT:FOR X=33 TO 36:Y=35:SET(X,Y):NEXT
100 Y=34:FOR X=36 TO 38:SET(X,Y):SET(X+1,Y):Y=Y-1:NEXT:FOR Y=30 TO 32:X=39:SET(X
,Y):NEXT:X=34:Y=30:SET(X,Y):SET(X+1,Y):SET(33,31):SET(36,31):X=34:Y=32:SET(X,Y):
SET(X+1,Y)
110 FOR Y=30 TO 32:X=82:SET(X,Y):SET(X+9,Y):NEXT:Y=30:FOR X=82 TO 85:SET(X,Y):SE
T(X+1,Y):Y=Y-1:NEXT:Y=32:FOR X=82 TO 84:SET(X,Y):SET(X+1,Y):Y=Y+1:NEXT:FOR X=85
TO 88:Y=35:SET(X,Y):NEXT
120 Y=34:FOR X=88 TO 90:SET(X,Y):SET(X+1,Y):Y=Y-1:NEXT:Y=28:FOR X=88 TO 90:SET(X
,Y):SET(X+1,Y):Y=Y+1:NEXT:FOR X=86 TO 87:Y=30:SET(X,Y):Y=32:SET(X,Y):NEXT:SET(85
,31):SET(88,31)
130 X=55:Y=15:SET(X,Y):SET(X,Y+1):SET(X+1,Y+2):SET(X+1,Y+3):SET(X+2,Y+4):SET(X+2
,Y+5):SET(X+3,Y+6):SET(X+4,Y+5):SET(X+4,Y+4):SET(X+5,Y+3):SET(X+5,Y+2):SET(X+6,Y
+1):SET(X+6,Y)
140 FOR Y=15 TO 21:X=65:SET(X,Y):NEXT:FOR X=69 TO 73:Y=15:SET(X,Y):NEXT:FOR Y=16
 TO 21:X=71:SET(X,Y):NEXT:FOR X=77 TO 81:Y=15:SET(X,Y):Y=21:SET(X,Y):NEXT:SET(78
,18):FOR Y=15 TO 21:X=77:SET(X,Y):NEXT
150 FOR Y=15 TO 21:X=85:SET(X,Y):NEXT:Y=18:FOR X=86 TO 89:SET(X,Y):Y=Y-1:NEXT:Y=
18:FOR X=86 TO 89:SET(X,Y):Y=Y+1:NEXT
160 FOR Y=24 TO 29:X=55:SET(X,Y):SET(X+4,Y):SET(X+9,Y):NEXT:Y=25:FOR X=60 TO 62:
SET(X,Y):SET(X+1,Y):Y=Y+1:NEXT:
170 FOR Y=25 TO 28:X=68:SET(X,Y):NEXT:FOR X=69 TO 71:Y=24:SET(X,Y):Y=29:SET(X,Y)
:NEXT:SET(72,25):SET(72,28):SET(74,29)
180 FOR X=1 TO 1500:NEXT:PRINT@64,STRING$(60,' '):PRINT@128,STRING$(60,' '):FOR
X=5 TO 125:Y=0:SET(X,Y):SET(X,Y+1):Y=47:SET(X,Y):SET(X,Y-1):NEXT:FOR Y=0 TO 47:X
=5:SET(X,Y):SET(X+1,Y):SET(X+2,Y):NEXT
185 FOR Y=0 TO 47:X=125:SET(X,Y):SET(X-1,Y):SET(X-2,Y):NEXT:FOR X=1 TO 1000:NEXT
```

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

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

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

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

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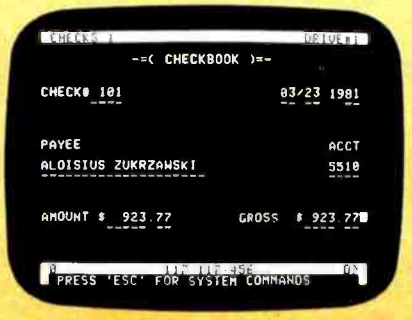

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Listing 4: *Recreation of a graphics picture. This listing shows how the DATA statements generated by listing 3 may be appended to a program that uses them to recreate the original graphics display.*

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

Text continued from page 171:

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

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

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

Replacing Blanks with Tabs

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

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

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

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

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

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

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

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

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

Listing 7 continued on page 180

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

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

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

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

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

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

Listing 7 continued:

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

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

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

top two lines off the top of the screen.

Graphics Using STRING$

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

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

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

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

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

Combining Methods

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

Text continued on page 184

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

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

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

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

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

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

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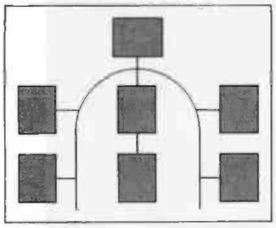

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Listing 12: *Routine that converts screen data to the most compact, fastest form discussed in this article.*

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

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

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

Text continued from page 180:

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

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

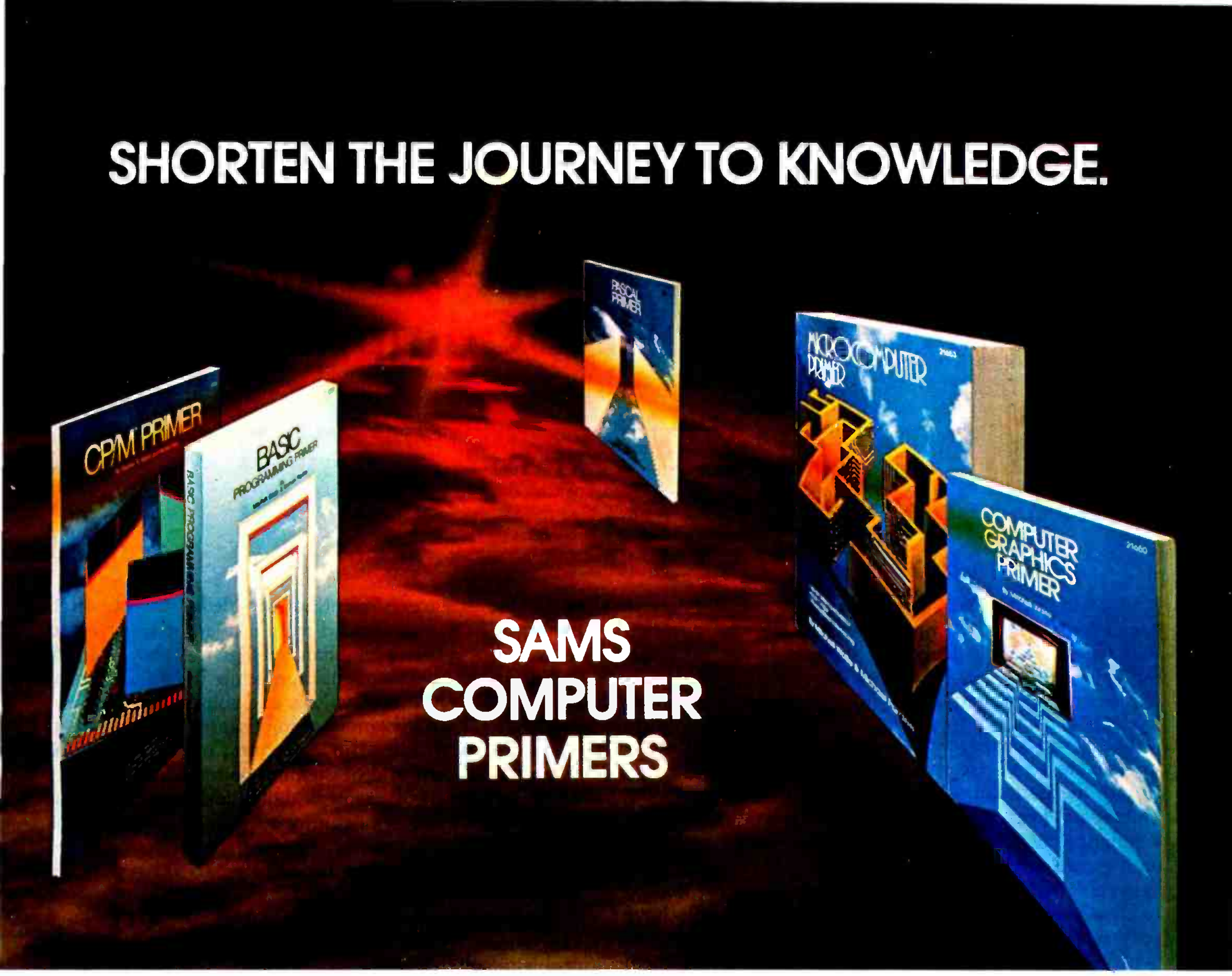
Features of several of these programs may be combined. The space saver, which prints a series of spaces as the value 192 plus the number of spaces (as done in listings 6 and 7), may be combined with printing of a string of graphic characters using STRING$ (see listings 8 and 9). By combining these with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

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

Conclusions

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

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



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Getting Problem-Solving Advice from a Computer

James W Garson
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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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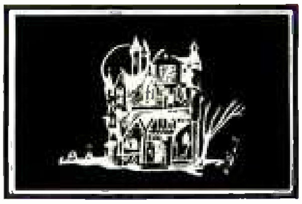

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Of course there are good reasons why tutoring is not widely used in introductory logic courses. These classes are usually quite large, so tutoring simply takes too much of the teacher's time. Besides that, grading formal proofs constructed by students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

Enter the Computer

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

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

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

Programming Strategies

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

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

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

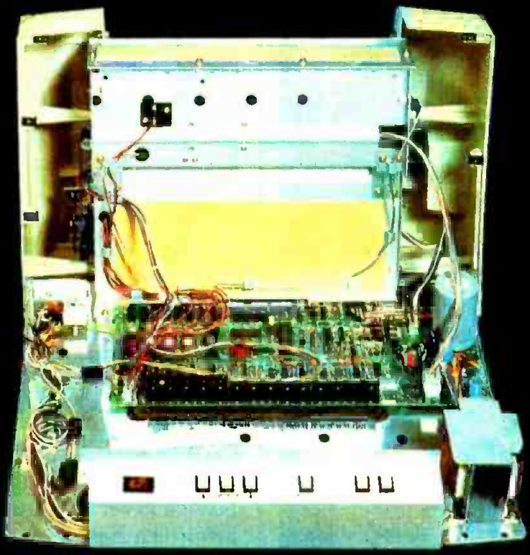
Another difficulty with both of these approaches to the design for an advice giver is that the program does not attempt to construct advice on the basis of whatever progress the student may have already made on the proof. This tends to discourage invention of novel, yet promising, partial solutions.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

Our Approach

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

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

Say Ahh...



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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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"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.

A Chessboard Journey on the TI-59 Programmable Calculator

Michael Gilpin
Michigan Technological University
Houghton MI 49931

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

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

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

Text continued on page 202

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

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

Listing 1 continued on page 200

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Listing 1 continued:

Step	Keystrokes	Comment
041	2 1 +/- SUM 10	Return KT to test square.
046	RCL 50 x⇌t RCL 89 *x≥t 0 60	Test for new minimum.
054	STO 50 RCL 10 STO 20	New minimum and position.
060	*CP	
061	*DSZ 9 0 06	Next test square.
065	2 1 +/- SUM 10	Return KT to last square.
070	RCL 10 - RCL 20 = *x=t 2 10	Stop if no move possible.
079	RCL *IND 10 STO *IND 20 RCL 20	
	STO 10 1 SUM *IND 10	Move knight.
090	RST	Look for further moves.
091	RCL 10 x⇌t 1 0 *x≥t 1 07	
	8 9 x⇌t *x≥t 1 07	Test for correct range.
105	RCL *IND 10 *CP INV SUB	Return 0 for legal move.
109	*LBL B	Prepare board for tour.
	*CMS 8 0 STO 00 8 +/-	
	STO *IND 00 *Op 30 STO *IND	
	00 SUM 00 *DSZ 0 1 18	Fill border squares.
130	2 STO 01 STO 07 4 STO 03	
	STO 05 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 × 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: 0	01: 2	02: 7	03: 4	04: 16	05: 4	06: 7	07: 2	08: -21	09: -8
10: -8	11: 0	12: 0	13: 0	14: 0	15: 0	16: 0	17: 0	18: 0	19: -8
20: -8	21: 0	22: 0	23: 0	24: 0	25: 0	26: 0	27: 0	28: 0	29: -8
30: -8	31: 0	32: 0	33: 0	34: 0	35: 0	36: 0	37: 0	38: 0	39: -8
40: -8	41: 0	42: 0	43: 0	44: 0	45: 0	46: 0	47: 0	48: 0	49: -8
50: -8	51: 0	52: 0	53: 0	54: 0	55: 0	56: 0	57: 0	58: 0	59: -8
60: -8	61: 0	62: 0	63: 0	64: 0	65: 0	66: 0	67: 0	68: 0	69: -8
70: -8	71: 0	72: 0	73: 0	74: 0	75: 0	76: 0	77: 0	78: 0	79: -8
80: -8	81: 0	82: 0	83: 0	84: 0	85: 0	86: 0	87: 0	88: 0	89: 0

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

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

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

Text continued from page 198:
ferent tour, press B, enter a new starting position, and proceed as before.

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

Acknowledgments

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

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

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

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

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

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Design of the Arithmetic Routines

The arithmetic routines (given in listing 1) use the HL register pair as a 16-bit wide "accumulator." Subroutines performing *dyadic* operations (ie: those with two operands) expect to find one operand in the HL register pair and the other in the DE register pair. The result is returned in the HL pair. The arithmetic subroutines also set the sign and zero flags to reflect the value of the result returned in the HL register pair. (For example, if the result of an operation is decimal −11034, then the minus flag will be set and the zero flag will be cleared.) The information in the carry flag is invalid and should be ignored. The B, C, D, and E registers are restored by all routines except EDIVMOD (the division routine), which returns the quotient in the HL register pair and the remainder in the DE register pair, with the B and C registers restored.

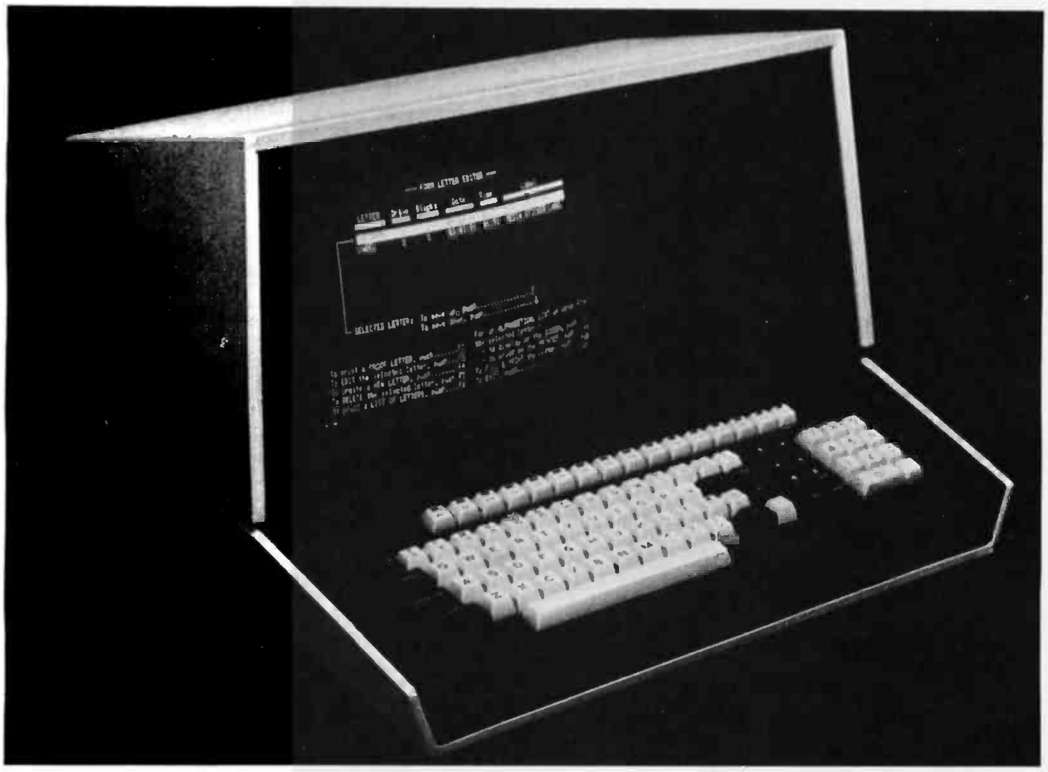
Internally, values are represented in two's complement form, with the most significant bit acting as a sign bit. (See text box on page 225.) This representation is a simple extension of the 8-bit representation used for normal accumulator operations.

Unfortunately, this also leads to one small anomaly. The smallest representable number is −32,768, but the largest is only +32,767. (See the text box on page 226.) Thus, if you negate the value −32,768, an overflow will result. As a consequence of this fact, you may add or subtract two values that give a result of exactly −32,768, but if you try to multiply or divide two numbers that will yield an answer of exactly −32,768, an overflow will result because the multiply and divide routines work on absolute values internally.

All operations, including the string-to-numeric conversions, will

Text continued on page 226

NO MEMORY PARITY? Good luck!



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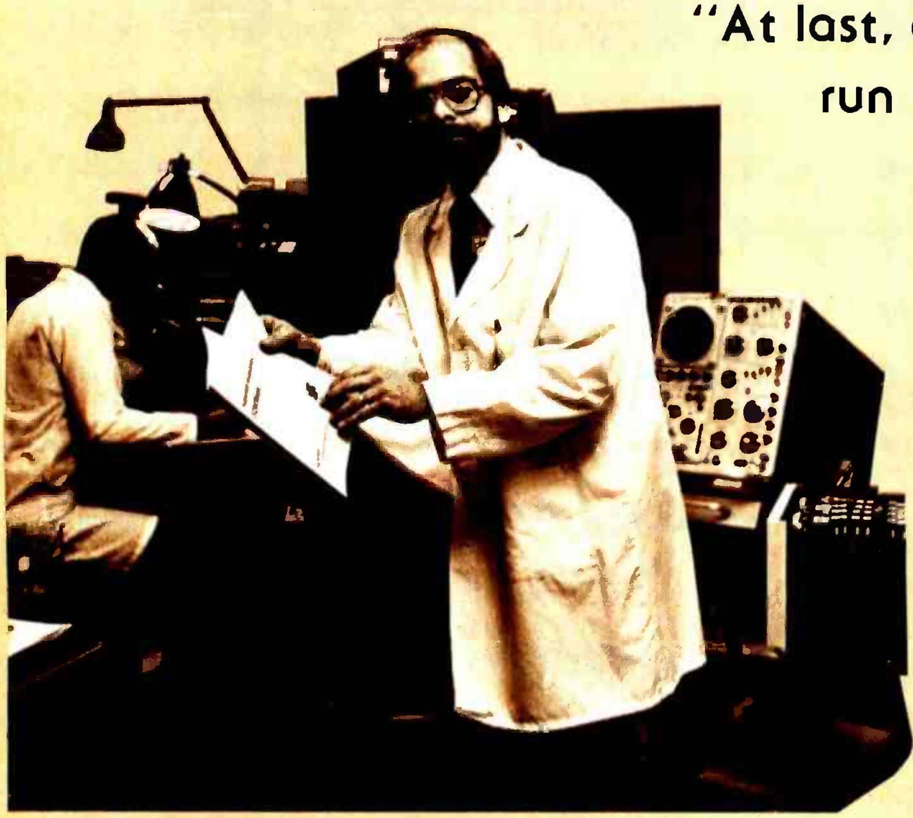

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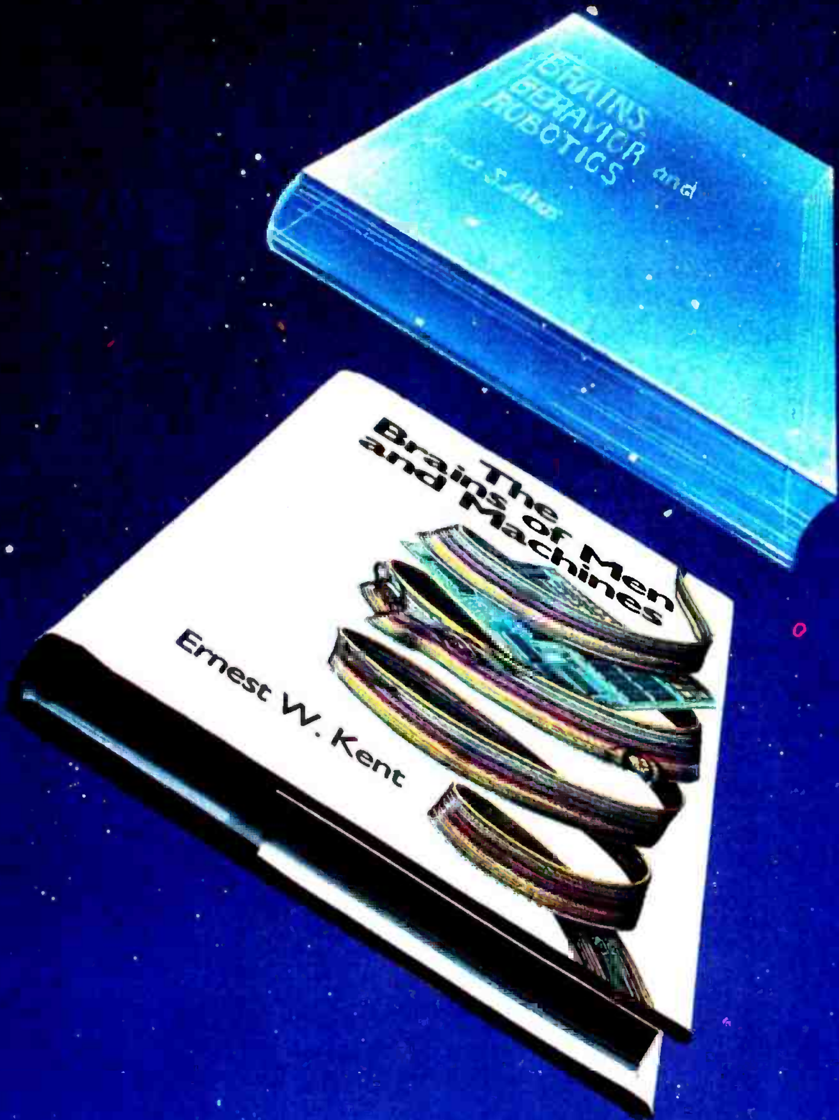
Listing 1: *16-bit arithmetic subroutines in 8080 assembly language. The eight routines, which are fully documented in the listing, operate on 16-bit numbers in two's complement form.*

```
                                ORG     4000H

                *******************************************************************
                *                                                                 *
                *       ***** EXTENDED ARITHMETIC SUBROUTINES FOR 8080 COMPUTERS *****  *
                *                                                                 *
                *       WRITTEN BY BRUCE D. CARBREY      REVISION 0      SEPT., 1977  *
                *                                                                 *
                *       THESE ROUTINES EXTEND THE ARITHMETIC CAPABILITIES OF      *
                *       THE 8080 MICROCOMPUTER TO INCLUDE INTEGER ARITHMETIC      *
                *       ON SIGNED, 16-BIT QUANTITIES, USING BINARY, TWOS-COMPLEMENT  *
                *       ARITHMETIC.   THE RANGE OF PERMISSABLE VALUES WITHOUT     *
                *       OVERFLOW IS                                               *
                *                   -32767 TO +32767                              *
                *                                   DECIMAL.  TO USE A MATH ROUTINE,  *
                *       SIMPLY LOAD THE REGISTER(S) INDICATED WITH THE OPERAND(S),  *
                *       AND CALL THE APPROPRIATE ROUTINE.  THE ANSWER WILL BE     *
                *       RETURNED IN THE REGISTER(S) INDICATED.  THE SIGN (S) AND  *
                *       ZERO (Z) FLAGS WILL BE SET TO REFLECT THE VALUE OF THE    *
                *       RESULT IN THE SAME WAY AS FOR AN ORDINARY 8-BIT ADD.      *
                *       LOGIC IS PROVIDED FOR DETECTING OVERFLOW FOR ALL OPERATIONS,  *
                *       WHICH RESULTS IN A CALL TO A ROUTINE NAMED OVERFLOW       *
                *       ( WHICH IS NOT SUPPLIED SINCE YOU MUST DECIDE WHAT YOU    *
                *       WANT TO DO IN CASE OF OVERFLOW--- PROBABLY PRINT A MESSAGE  *
                *       AND JUMP TO YOUR MONITOR).                                *
                *                                                                 *
                *       IN ADDITION TO THE MATH OPERATORS, TWO UTILITY SUBROUTINES  *
                *       ARE PROVIDED FOR STRING-NUMERIC AND NUMERIC-STRING CONVERSION.  *
                *                                                                 *
                *       ENTRY      SUBROUTINE FUNCTION                            *
                *       -----      ---------- --------                            *
                *                                                                 *
                *       EADD       (HL) = (HL) + (DE)                             *
                *       ESUB       (HL) = (HL) - (DE)                             *
                *       EMULT      (HL) = (HL) * (DE)                             *
                *       EDIVMOD    (HL) = (HL) / (DE), AND (DE) = (HL) MOD (DE)   *
                *       ESIGN      SET (S), (Z) FLAG TO REFLECT (HL), LEAVING (HL)  *
                *                  UNCHANGED.                                     *
                *       ECMP       SET (S), (Z) FLAGS TO REFLECT (HL) - (DE), LEAVING  *
                *                  (HL) AND (DE) UNCHANGED.                       *
                *                                                                 *
                *       DECBIN     CONVERT ASCII CHARACTER STRING REPRESENTING A SIGNED  *
                *                  DECIMAL INTEGER TO A SIGNED BINARY NUMBER.     *
                *       BINDEC     CONVERT A SIGNED BINARY NUMBER TO AN ASCII STRING  *
                *                  REPRESENTING THE SIGNED DECIMAL VALUE OF THE NUMBER.  *
                *                                                                 *
                *                                                                 *
                *******************************************************************

                  *       MATH PACKAGE EXECUTION TIMES IN MICRO-SECONDS:
                  *
                  *       ROUTINE  TYPICAL  WORST CASE
                  *
                  *       EADD       30        54
                  *       ESUB       50        74
                  *       EMULT     370       517
                  *       EDIVMOD   680      2500
                  *
                  *
                  *       ***** YOU MUST PROVIDE PATCHES TO THESE TWO ROUTINES... *****
                  *
                  OVERFLOW  EQU     0           WHERE TO GO AFTER OVERFLOW
                  CONVERR   EQU     0           WHERE TO GO ON STRING-NUMERIC ERROR
                  *

                *******************************************************************
                *                                                                 *
                * SUBROUTINE EADD - ADD (HL) TO (DE), RESULT TO (HL)              *
                *                                                                 *
                *******************************************************************

                  *        (HL) = (HL) + (DE)
                  *       ON RETURN, SIGN, ZERO FLAGS WILL REFLECT RESULT. CY CLEARED.
                  *       A REGISTER CLOBBERED. B, C, D, E REGS RESTORED.
                  *
        4000   7C       EADD    MOV     A,H         TEST IF SIGNS ARE SAME OR DIFFER...
        4001   AA               XRA     D
        4002   E680             ANI     80H
        4004   19               DAD     D           ADD, WITHOUT AFFECTING ZERO FLAG...
        4005   C20E40           JNZ     ESIGN       SKIP OVERFLOW TEST IF SIGNS DIFFER
        4008   1F               RAR                 TEST FOR OVERFLOW BY...
```

Listing 1 continued on page 212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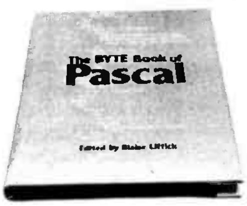

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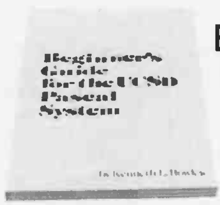

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Listing 1 continued from page 206:

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

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

               *
               *        A REGISTER CLOBBERED, ALL OTHERS RESTORED.
               *
400E   AF      ESIGN         XRA    A         CLEAR FLAGS
400F   84                    ADD    H         SET FLAGS TO REFLECT HI BYTE
4010   C0                    RNZ              RETURN IF HI-ORDER BYTE IS NON-0
4011   85                    ADD    L         ELSE, SEE IF L IS 0 TOO...
4012   C8                    RZ               AND IF SO, RETURN
4013   AF                    XRA    A         ELSE, FORCE FLAGS TO SHOW +
4014   3C                    INR    A
4015   C9                    RET

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

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

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

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

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

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

Listing 1 continued on page 214

Listing 1 continued:

```
                          *        A REGISTER CLOBBERED.  B, C, D, E RESTORED.
                          *
4038     C5       EMULT      PUSH     B
4039     D5                  PUSH     D
403A     CD6F40              CALL     RSLTSIGN  FIND RESULT SIGN, ABS VAL OF OPERANDS
403D     AF                  XRA      A
403E     84                  ADD      H
403F     CA4840              JZ       HLSMALL   BRANCH IF (HL) LESS THAN 8 BITS
4042     AF                  XRA      A
4043     82                  ADD      D         ELSE, OTHER OP MUST BE .LT. 8 BITS...
4044     C40000              CNZ      OVERFLOW  ...OR OVERFLOW WOULD RESULT
4047     EB                  XCHG               (HL) NOW HAS AN OP WITH .LT. 8 BITS
4048     7D       HLSMALL    MOV      A,L       MOVE 8-BIT OR LESS MULTIPLIER TO A
4049     210000              LXI      H,0       INITIALIZE PARTIAL PRODUCT
404C     37       XMLOOP     STC                CLEAR CARRY...
404D     3F                  CMC
404E     1F                  RAR                ROTATE MULTIPLIER RITE OFF END
404F     D25640              JNC      SHIFTOP   IF BIT SHIFTED-OUT WAS 0, SKIP
4052     19                  DAD      D         ELSE, ADD MULTIPLICAND TO PARTIAL PROD.
4053     DC0000              CC       OVERFLOW  ...WHILE CHECKING FOR OVERFLOW
4056     EB       SHIFTOP    XCHG
4057     29                  DAD      H         SHIFT MULTIPLICAND LEFT 1 BIT...
4058     DC0000              CC       OVERFLOW  ...WHILE CHECKING FOR OVERFLOW
405B     EB                  XCHG
405C     B7                  ORA      A
405D     C24C40              JNZ      XMLOOP    BRANCH TO TOP OF LOOP IF MULT IS NON-0
4060     D1                  POP      D         WHEN MULTIPLY DONE, RECALL (DE)
4061     7C       SIGNRCL    MOV      A,H
4062     07                  RLC                MAKE FINAL OVERFLOW CHECK...
4063     DC0000              CC       OVERFLOW  FOR VALUES BETWEEN32768 AND 65535 INCLUS.
4066     78                  MOV      A,B       THEN RECALL SIGN BYTE
4067     17                  RAL
4068     DC3040              CC       COMP2     CHANGE SIGN OF RESULT IF IT IS TO BE -
406B     C1                  POP      B
406C     C30E40              JMP      ESIGN     SET FLAGS AND RETURN
                          *
                          *        SUBROUTINE RSLTSIGN - COMPUTE SIGN OF RESULT FOR * AND /
                          *
                          *        ON RETURN: (HL) = ABSOLUTE VALUE OF (DE), (DE) = ABS. VAL (HL),
                          *        (B) = SIGN OF RESULT IN MOST SIGNIFICANT BIT.
                          *
406F     44       RSLTSIGN   MOV      B,H       FETCH SIGN BYTE OF 1ST OPERAND
4070     7C                  MOV      A,H       ...TO B AND ALSO TO A...
4071     17                  RAL
4072     DC3040              CC       COMP2     ABSOLUTE VALUE OF (HL)
4075     EB                  XCHG               2ND OPERAND...
4076     7C                  MOV      A,H       SIGN BYTE TO A...
4077     A8                  XRA      B         RESULTANT SIGN...
4078     47                  MOV      B,A       ...TO MSB OF REG B FOR LATER RECALL
4079     7C                  MOV      A,H       SIGN BYTE OF 2ND OP TO A
407A     17                  RAL
407B     DA3040              JC       COMP2     ABSOLUTE VALUE, THEN RETURN.
407E     C9                  RET


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

                          *        ON CALL: (HL) = DIVIDEND, (DE) = DIVISOR.
                          *        ON RETURN: (HL) = QUOTIENT, (DE) = REMAINDER.
                          *        FLAGS REFLECT VALUE OF QUOTIENT.  CY CLEARED.
                          *        A REGISTER CLOBBERED.  B, C RESTORED.
                          *        REMAINDER IS ALWAYS POSITIVE, REGARDLESS OF SIGN OF OPERANDS.
                          *
407F     C5       EDIVMOD    PUSH     B
4080     AF                  XRA      A         IF DIVISOR = 0...
4081     B3                  ORA      E
4082     B2                  ORA      D
4083     CC0000              CZ       OVERFLOW  ...THEN ABORT
4086     CD6F40              CALL     RSLTSIGN  COMPUTE RESULT SIGN; SWAP DE, HL
4089     7C                  MOV      A,H       INSURE THAT NEITHER OPERAND...
408A     B2                  ORA      D         ...WAS THAT NASTY SPECIAL CASE...
408B     07                  RLC                ...OF EXACTLY -32768...
408C     DC0000              CC       OVERFLOW  ...AND IF IT WAS, ABORT
408F     C5                  PUSH     B         SAVE RESULT SIGN BYTE
4090     4B                  MOV      C,E       MOVE DIVIDEND ( = REM) TO BC
4091     42                  MOV      B,D
4092     110000              LXI      D,0       INITIALIZE QUOTIENT = 0...
4095     D5                  PUSH     D         ...ON TOP OF STACK (TOS)
4096     EB                  XCHG               NOW BC = REM, DE=DIV, TOS=QUO
```

Listing 1 continued on page 216

Listing 1 continued:

```
4097   210100            LXI    H,1        INITIALIZE HOLD = 1
                *
409A   29       DBLDIV   DAD    H          LEFT SHIFT HOLD
409B   EB                XCHG              NOW BC=REM, DE=HOLD, HL=DIV, TOS=QUO
409C   29                DAD    H          LEFT SHIFT DIV
409D   CDC940            CALL   CMPBH      COMPARE DIV TO REM
40A0   EB                XCHG              NOW BC=REM, DE=DIV, HL=HOLD, TOS=QUO
40A1   D29A40            JNC    DBLDIV     BRANCH BACK IF DIV < REM
40A4   EB                XCHG              DUMMY XCHG TO MAKE LOOP WORK 1ST PASS...
40A5   EB       HALVEDIV XCHG              NOW BC=REM, DE=DIV, HL=HOLD, TOS=QUO
40A6   CDCE40            CALL   DIVBY2     HOLD = HOLD/2 (RITE SHIFT)
40A9   CAC240            JZ     DIVDONE    IF HOLD = 0, WERE DONE
40AC   EB                XCHG              NOW BC=REM, DE=HOLD, HL=DIV, TOS=QUO
40AD   CDCE40            CALL   DIVBY2     RITE SHIFT DIV
40B0   CDC940            CALL   CMPBH      COMPARE DIV TO REM...
40B3   FAA540            JM     HALVEDIV   IF DIV > REM, BRANCH BACK
40B6   79                MOV    A,C        REM = REM - DIV...
40B7   95                SUB    L
40B8   4F                MOV    C,A
40B9   78                MOV    A,B
40BA   9C                SBB    H
40BB   47                MOV    B,A
40BC   E3                XTHL              NOW BC=REM, DE = HOLD, HL=QUO, TOS=DIV
40BD   19                DAD    D          QUO = QUO + HOLD
40BE   E3                XTHL              NOW BC=REM, DE=HOLD, HL=DIV, TOS=QUO
40BF   C3A540            JMP    HALVEDIV   ENDDO.

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


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

                *        THIS ROUTINE CONVERTS A STRING OF ASCII CHARACTERS REPRESENTING
                *        A NUMBER TO A SIGNED 16-BIT NUMBER IN TWOS COMPLEMENT FORM.
                *        LEGAL RANGE OF CONVERTIBLE VALUES IS -32767 TO +32767.
                *        LEGAL FORM FOR STRING IS...
                *
                *        <BLANKS><SIGN><BLANKS><DIGITS><NON-DIGIT>
                *
                *        WHERE  <BLANKS> IS 0 OR MORE BLANKS,
                *               <SIGN>  IS +, -, OR OMITTED,
                *               <DIGITS> IS A STRING OF 1 OR MORE NUMERIC DIGITS,
                *                        REPRESENTING AN INTEGER NOT EXCEEDING 32767.
                *               <NON-DIGIT> IS ANY NON-DIGIT CHARACTER (E.G., A BLANK).
                *
                *        USAGE:
                *
                *        ON CALL:
                *        (DE) = ADDRESS OF START-OF-ASCII STRING TO BE CONVERTED.
                *        ON RETURN TO CALLING PROGRAM...
                *        (HL) = RETURNED SIGNED NUMERIC VALUE
                *        (DE) = ADDRESS OF TERMINAL CHARACTER OF STRING (<NON-DIGIT>)
                *        SIGN AND ZERO FLAGS WILL BE SET TO REFLECT VALUE IN (HL).
```

Listing 1 continued on page 220

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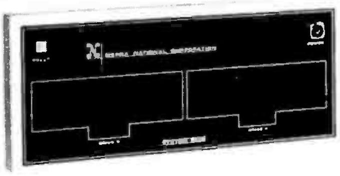
Listing 1 continued:

```
                      *         CY CLEARED. A REGISTER CLOBBERED. B, C RESTORED.
                      *
                      *         NOTES ON METHOD... B REG USED TO HOLD 3 FLAGS...
                      *         BIT 7="-" FLAG = MINUS SIGN ENCOUNTERED
                      *         BIT 6= "SE" FLAG = SIGN ENCOUNTERED
                      *         BIT 0 = "DE" = DIGIT ENCOUNTERED.
                      *
40D7    C5            DECBIN    PUSH    B
40D8    0600                    MVI     B,0         INITIALIZE FLAGS -,DE,SE
40DA    210000                  LXI     H,0         INITIALIZE RESULT
40DD    1A            AKLOOP    LDAX    D           FETCH NEXT ASCII CHARACTER
40DE    D630                    SUI     48          CONVERT CHAR TO BCD DIGIT IF POSSIBLE
40E0    4F                      MOV     C,A         SAVE (CHARACTER-48) IN C
40E1    FAFF40                  JM      NOTDIGIT    IS IT A DIGIT 0 THRU 9...
40E4    FE0A                    CPI     10
40E6    F2FF                    JP      NOTDIGIT
40E9    D5                      PUSH    D           ...IF SO, SAVE BUFFER POINTER
40EA    110A00                  LXI     D,10        ...MULTIPLY PARTIAL RESULT BY 10...
40ED    CD3840                  CALL    EMULT       ...(ALSO CHECKING FOR OVERFLOW)...
40F0    1600                    MVI     D,0         ...AND ADD IN VALUE OF DIGIT...
40F2    59                      MOV     E,C
40F3    CD0040                  CALL    EADD        (HL) = (HL)*10 + DIGIT
40F6    D1                      POP     D           RECALL BUFFER POINTER
40F7    13                      INX     D           BUMP BUFFER POINTER
40F8    3E01                    MVI     A,1         ...SET "DIGIT ENCOUNTERED (DE) FLAG...
40FA    B0                      ORA     B
40FB    47                      MOV     B,A
40FC    C3DD40                  JMP     AKLOOP      ...AND WERE READY FOR NEXT CHARACTER
                      *
                      *         COME HERE FOR ANY CHARACTER EXCEPT 0,1,...9
                      *
40FF    79            NOTDIGIT  MOV     A,C         RECALL (CHAR-48)
4100    FEF0                    CPI     -16         IS IT A BLANK. SET ZERO FLAG IF SO.
4102    78                      MOV     A,B         RECALL FLAGS
4103    0F                      RRC                 TEST "DIGIT ENCOUNTERED" FLAG IN CY
4104    DA6140                  JC      SIGNRCL     IF DIGITS ENCOUNTERED PRIOR, WERE DONE
4107    C20E41                  JNZ     TRYSIGN     ...ELSE, IF NOT BLANK TRY + OR -
410A    13                      INX     D           ...ELSE IGNORE LEADING BLANK,
410B    C3DD40                  JMP     AKLOOP      AND PROCEED WITH NEXT CHARACTER
410E    78            TRYSIGN   MOV     A,B         TEST "SE" FLAG IN CY
410F    07                      RLC
4110    07                      RLC
4111    DC0000                  CC      CONVERR
4114    79                      MOV     A,C         ELSE RECALL (CHAR-48)
4115    FEFD                    CPI     -3          IS IT "-"...
4117    C2                      JNZ     TRYPLUS     ...IF NOT TRY FOR "+" SIGN...
411A    3EC0                    MVI     A,0C0H      ...IF IT IS "-", SET SE AND - FLAG
411C    B0                      ORA     B
411D    47                      MOV     B,A
411E    13                      INX     D           BUMP BUFFER POINTER
411F    C3DD40                  JMP     AKLOOP      AND PROCEED WITH NEXT CHARACTER
4122    FEFB          TRYPLUS   CPI     -5          IS IT "+" CHARACTER...
4124    C40000                  CNZ     CONVERR     IF NOT ITS AN ERROR
4127    3E40                    MVI     A,40H       IF IT IS "+", SET "SE" FLAG
4129    B0                      ORA     B
412A    47                      MOV     B,A
412B    13                      INX     D           BUMP BUFFER POINTER
412C    C3DD40                  JMP     AKLOOP      AND PROCEED WITH NEXT CHARACTER
                      *

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

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

Listing 1 continued on page 222



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Listing 1 continued:

```
402   4134   E5                PUSH   H
403   4135   29                DAD    H          PUSH SIGN INTO CY
404   4136   E1                POP    H          RECALL UN-SHIFTED NO.
405   4137   D24241            JNC    DIV10K     FALL THRU FOR - NUMBER
406   413A   3E2D              MVI    A,45       ASCII MINUS SIGN
407   413C   12                STAX   D          INTO BUFFER
408   413D   04                INR    B          SET MINUS FLAG
409   413E   13                INX    D          AND BUFFER POINTER
410   413F   CD3040            CALL   COMP2      ABSOLUTE VALUE OF NUMBER
411   4142   EB     DIV10K     XCHG              N TO DE, BUFF ADDR TO HL
412   4143   228441            SHLD   BUFADR     SAVE BUFFER ADDRESS
413   4146   EB                XCHG
414   4147   111027            LXI    D,10000
415   414A   CD6E41            CALL   CNVT1DIG   FIND FIRST DECIMAL DIGIT
416   414D   11E803            LXI    D,1000
417   4150   CD6E41            CALL   CNVT1DIG   SECOND DEC DIGIT...
418   4153   116400            LXI    D,100
419   4156   CD6E41            CALL   CNVT1DIG   THIRD...
420   4159   110A00            LXI    D,10
421   415C   CD6E41            CALL   CNVT1DIG   4TH
422   415F   7D                MOV    A,L        LAST DIGIT IS FINAL REMAINDER
423   4160   C630              ADI    48         CONVERT TO ASCII CHAR
424   4162   0C                INR    C
425   4163   2A8441            LHLD   BUFADR     RECALL BUFFER POINTER
426   4166   EB                XCHG
427   4167   12                STAX   D          INSTALL LAST CHARACTER INTO BUFFER
428   4168   79                MOV    A,C        RETURN CHARACTER COUNT IN A REG
429   4169   80                ADD    B          ...AND ADD 1 FOR MINUS SIGN IF MINUS
430   416A   13                INX    D          POINT TO NEXT DIGIT IN BUFFER
431   416B   E1                POP    H          FINAL RESTORE FOR HL
432   416C   C1                POP    B          RECALL B
433   416D   C9                RET
434   416E   CD7F40 CNVT1DIG   CALL   EDIVMOD    DIVIDE REMAINDER BY 10**N
435   4171   EB                XCHG              NEW REM TO HL
436   4172   7B                MOV    A,E        DIGIT TO A
437   4173   B1                ORA    C          IF NO NON-ZERO DIGITS SO FAR...
438   4174   C8                RZ                ...AND THIS = 0, THEN SUPPRESS LEADING 0
439   4175   7B                MOV    A,E        ELSE, RECALL DIGIT
440   4176   C630              ADI    48         CONVERT DIGIT TO CHAR
441   4178   0C                INR    C          UPDATE CHAR COUNTER
442   4179   EB                XCHG
443   417A   2A8441            LHLD   BUFADR     BUFFER ADDRESS LOAD
444   417D   77                MOV    M,A        STORE CHAR IN BUFFER
445   417E   23                INX    H          NEXT CHAR
446   417F   228441            SHLD   BUFADR     SAVE BUFFER POINTER
447   4182   EB                XCHG
448   4183   C9                RET

                    ***********************************************************************
                    *                                                                     *
                    * FOLLOWING MUST BE IN READ/WRITE MEMORY...                           *
                    *                                                                     *
                    ***********************************************************************

450   4184          BUFADR     DS     2          TEMPORARY STORAGE FOR POINTER
451   4186                     END
```

```
                              --- SYMBOLIC CROSS-REFERENCE MAP ---

-SYMBOL-   -VALUE- -R      -DEFINED- -REFERENCED-

AKLOOP      40DD   *A        336      353   364   376   383
BINDEC      412F   *A        399       29
BUFADR      4184   *A        450      412   425   443   446
CHIN        0000               7       13
CHOUT       0000               8       27    36
CMPBH       40C9   *A        285      255   264
CNVT1DIG    416E   *A        434      415   417   419   421
COMP2       4030   *A        161      141   156   205   217   224   410
CONVERR     0000             102      368   378
DBLDIV      409A   *A        252      257
DECBIN      40D7   *A        333       20    23
DIVBY2      40CE   *A        294      260   263
DIVDONE     40C2   *A        277      261
DIV10K      4142   *A        411      405
EADD        4000   *A        110      142   347
ECHS        4020   *A        151     *UNUSED
ECHSGO      402A   *A        156      153
EDIVMOD     407F   *A        234      434
EMULT       403B   *A        175       25   344
ESIGN       400E   *A        125      114   157   207
```

Listing 1 continued on page 224

Circle 310 on inquiry card.

Listing 1 continued:

```
ESUB           4016   *A          139    *UNUSED
HALVEDIV       40A5   *A          259     265    275
HLSMALL        4048   *A          185     180
INBUF          303B   *A           40      12     19
MONITOR        0000                 9      35
NOTDIGIT       40FF   *A          357     339    341
OUTBUF         304F   *A           41      28     32
OVERFLOW       0000               101     118    155    183    192    195    202    238    243
RSLTSIGN       406F   *A          214     177    239
SHIFTOP        4056   *A          193     190
SIGNRCL        4061   *A          200     281    361
TEST           3000   *A           12    *UNUSED
TEST1          3003   *A           13      18
TEST2          3010   *A           19      16
TEST3          302F   *A           33      38
TRYPLUS        4122   *A          377     371
TRYSIGN        410E   *A          365     362
XMLOOP         404C   *A          187     198

-COMMON BLOCK-       -L      -

ABSOL                 010F
```


TECHNOLOGY:
AMERICA'S COMPETITIVE EDGE.
Westinghouse addresses the vital role of technology in industry.

Technology is the key to the world marketplace.

If we want to maintain America's competitive edge, we must make better use of present technologies, and encourage new ones.

Most of the firms and countries which have achieved conspicuous success in this world have done so because they possessed some special advantage. They had an edge over their competitors. In recent decades, America's competitive edge has been its technology. Our ability to originate and apply innovative scientific and engineering ideas earned us a commanding lead in the world marketplace.

Things have changed

Unfortunately, that lead has dwindled. America's share of the world's manufactured goods market has eroded over the past 20 years, lost to foreign manufacturers. Not only have they captured part of what had been our share of the world market, but they are now successfully penetrating our own domestic markets.

What happened?

A look at a few statistics helps reveal some of the reasons for our reversals. Take patents. The number of domestic patent applications by Americans has been flat for several years. In contrast, the number of those filed here by foreign countries has been rising every year. In 1978, almost 37 percent of the patents granted went to foreign applicants. Or take the percentage of our Gross National Product going into industrial R&D. Over the past two decades, it has dropped precipitously.

What is needed

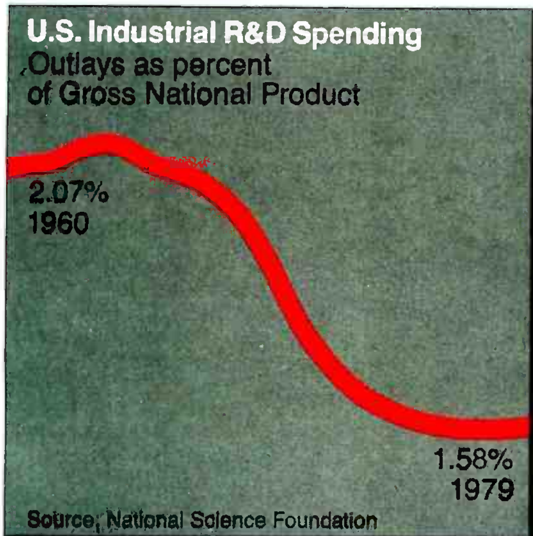
Fortunately, today Westinghouse and other corporations already have technologies which can help America maintain its technological leadership. And these same corporations are hard at work on technologies which can expand America's leadership. The problem lies in implementing those technologies. Because, while the development of new technologies costs a large amount of money, turning them into commercial realities requires far more.

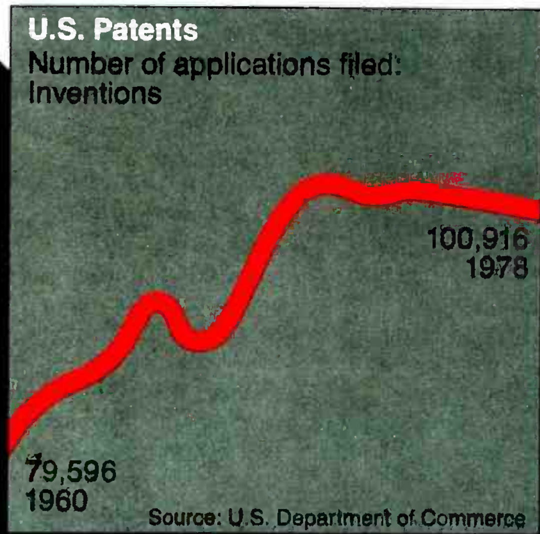
A national commitment

Something else is needed: a united effort by industry, labor and government. Obviously, management should make a greater R&D effort to refine today's technologies, and develop new ones for tomorrow. Employes must realize that their cooperation is vital if America is to remain the most productive nation in the world. And our elected officials need to reestablish a sound economic foundation, because that is basic to all social progress. In particular, tax laws and monetary policy must be structured to allow industry to accumulate capital needed to apply available technologies, and invest in the development of still more advanced ones.

The Westinghouse role

At Westinghouse, we believe technology is vital to our nation, our customers, and our own progress. We're supporting that belief by ambitious R&D programs, by building and modernizing existing facilities, and by introducing innovative methods to improve both our own quality and productivity and that of our customers. Today's proven Westinghouse technologies are focused on key areas such as productivity, services, energy, and America's national security. These existing technologies, together with the ones we are developing for the future, represent our efforts to help maintain this nation's competitive edge. On the following pages are some examples.





In the next five years, Westinghouse plans to invest:

$1 Billion on R&D and $2 Billion applying current technologies in:

- Modernization of existing plants and equipment
- Construction of new plants
- Productivity and quality improvement projects

WESTINGHOUSE TECHNOLOGY APPLIED TO ENERGY

Someday, Westinghouse technology will provide economical electricity from the sun, and clean gas from coal.

The fact that silicon photovoltaic cells can turn sunlight into electric current has been known for some time. The problem is the high cost involved. Westinghouse has invented a new dendritic web process that significantly reduces the cost of producing such cells. As a result, the U.S. Department of Energy's economic cost target now appears achievable. Westinghouse is working with the two largest electrical utilities in California to provide demonstration photovoltaic modules this year.

Advanced energy technologies
Westinghouse is involved in the advanced energy technologies that may play a role in this nation's energy future. For example, on the horizon are promising technologies like iron-nickel, and iron-air high power batteries. Also showing promise are fuel cells that chemically produce electricity. But until solar and other energy technologies become a reality, this nation will depend upon coal and nuclear power for its electricity. Westinghouse is focusing much of its effort on these two areas.

Clean gas from coal
Westinghouse has pioneered in coal gasification technology. Over the last decade we have developed a process to turn coal into a clean gas for power generation, and for industrial or synthetic natural gas applications. The process has the advantage that it can use virtually any type of coal, soft coal or hard coal. The environmental impact is minimal, regardless of the coal's moisture, sulphur, or ash content. With continued technical progress, Westinghouse coal gasification systems can be in commercial operation by the mid-1980's.

Nuclear technology
Nuclear power remains an economical and safe way of producing electricity. Westinghouse leads in the application of nuclear technology to generate electricity. And we are developing an advanced nuclear plant able to make more fuel than it uses.

A segment of silicon ribbon from the Westinghouse dendritic web process

WESTINGHOUSE
TECHNOLOGY APPLIED TO
SECURITY

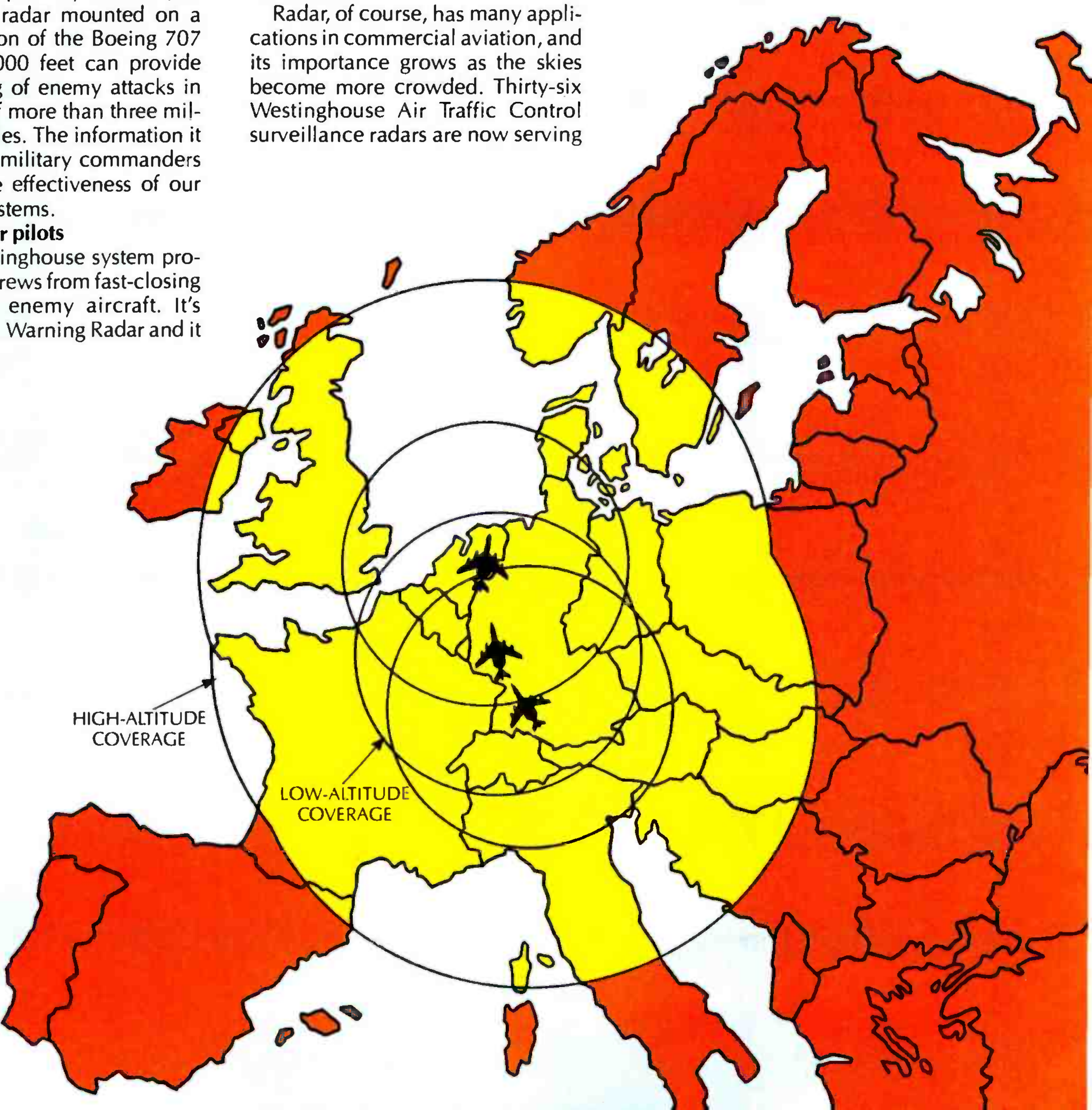
Today, Westinghouse Airborne Radar is one of our first lines of defense around the world.

It's called AWACS, an airborne warning and control system which provides long-range surveillance in an area at least 20 times greater than any surface-based system. It's already in use by our Air Force, and has been adopted by NATO. Just one AWACS radar mounted on a military version of the Boeing 707 flying at 30,000 feet can provide early warning of enemy attacks in an airspace of more than three million cubic miles. The information it helps give to military commanders multiplies the effectiveness of our air defense systems.

New safety for pilots

Another Westinghouse system protects aircraft crews from fast-closing missiles and enemy aircraft. It's called our Tail Warning Radar and it provides the pilot with accurate warnings to take evasive maneuvers. It also automatically triggers appropriate countermeasures. It's able to do all this in a split second, and with a phenomenally low false alarm rate.

Radar, of course, has many applications in commercial aviation, and its importance grows as the skies become more crowded. Thirty-six Westinghouse Air Traffic Control surveillance radars are now serving the FAA, the Switzerland Federal Air Office, and the Canadian Department of National Defense. The FAA uses the radars in some of the nation's most heavily traveled areas. So, nearly all domestic commercial flights come under the surveillance of a Westinghouse radar at some point during their flight.



WESTINGHOUSE TECHNOLOGY APPLIED TO PRODUCTIVITY

How Westinghouse product can increase industrial

How to increase output per hour...
How to eliminate waste...
How to cut energy costs...
Westinghouse has developed products and systems able to provide a wide variety of industries with effective answers.
Here are several of special interest.

The Westinghouse Numa-Logic® Control System

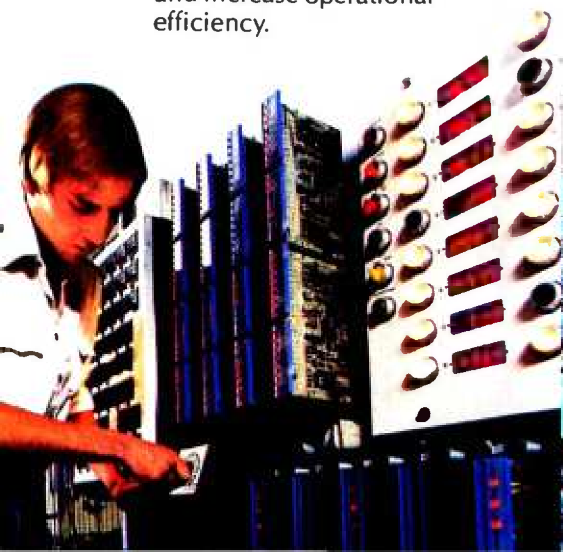
The Westinghouse Numa-Logic solid-state programmable controller uses microprocessor technology to provide more reliable operation for electrical control applications. It can economically replace as few as eight relays. It also has the capability to control the hundreds of sequences required by sophisticated, automated processes. The Westinghouse Numa-Logic system is being used in the machine tool, materials handling, textile, paper, steel-making and other industries to reduce downtime, give quick start-ups, and increase operational efficiency.

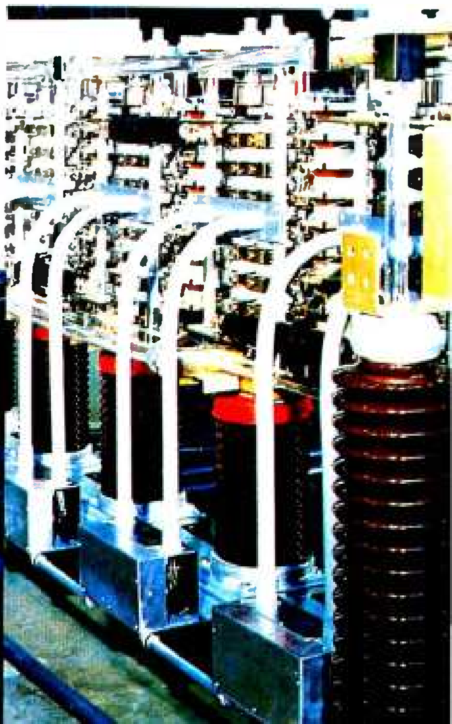
Factory computer systems

Also making major contributions to increased productivity are Westinghouse factory computer systems. They are capable of operating as many as 100 different machine tools simultaneously. They can also provide real time status and performance monitoring at four levels: maintenance, shop supervisor, middle and upper management. In application after application, downtime has been sharply reduced, and actual machine time has been increased up to 55 percent.

Power electronics

Solid-state static VAR generators are a key solution for utility and industrial system line problems because they provide system stability and improve power flow capability. Planning studies at a major utility concluded that 10 transmission lines with static VAR generators could deliver the power ordinarily requiring 16 lines. When it comes to industrial applications such as steel-making, VAR generators can improve the efficiency of power usage by improving the power factor and providing faster arc furnace melt times. One steel producer's productivity increased sufficiently to pay back the nearly $2 million cost of the static VAR generator in 15 months.





and service technologies productivity today.

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.
Westinghouse
A powerful part of your life.
Six Gateway Center–Dept. 10
Pittsburgh, PA 15222

Listing 2: *Test program for the arithmetic subroutines. This program receives two numbers from the keyboard and displays their product. Note that the user must supply entry points to character input and output routines and to the system monitor (or any other program to be jumped to when this program ends).*

```
                        ******************************************************************************
                        *                                                                            *
                        * TEST PROGRAM DISPLAYS PRODUCT OF 2 NUMBERS ENTERED FROM KEYBOARD           *
                        *                                                                            *
                        ******************************************************************************

                        *         ***** NOTE: YOU MUST SUPPLY THESE 3 ENTRY POINTS: *****
                        *
                        CHIN      EQU     0          SUBROUTINE TO GET KEYBOARD CHAR. IN A REG.
                        CHOUT     EQU     0          SUBROUTINE TO DISPLAY (A) AS ASCII CHAR.
                        MONITOR   EQU     0          ENTRY TO SYSTEM WHEN PROGRAM DONE
                        *
                                  ORG     3000H
        3000    213B30  TEST      LXI     H,INBUF    INPUT BUFFER ADDRESS TO HL
        3003    CD0000  TEST1     CALL    CHIN       GET AN ASCII CHARACTER IN A REGISTER
        3006    77                MOV     M,A        STORE CHARACTER INTO BUFFER
        3007    FE0D              CPI     13         AND IF ITS A CARRIAGE RETURN
        3009    CA1030            JZ      TEST2      THEN BRANCH
        300C    23                INX     H          ELSE, ADVANCE TO NEXT BYTE OF BUFFER
        300D    C30330            JMP     TEST1      ...AND CONTINUE
        3010    113B30  TEST2     LXI     D,INBUF    RECALL INPUT BUFFER STARTING ADDRESS
        3013    CDD740            CALL    DECBIN     CONVERT ASCII DECIMAL TO BINARY NUMBER
        3016    E5                PUSH    H          SAVE NUMBER
        3017    13                INX     D          ADDRESS OF START OF SECOND NUMBER STRING
        3018    CDD740            CALL    DECBIN     CONVERT SECOND NUMBER TO BINARY IN HL
        301B    D1                POP     D          RECALL FIRST NUMBER
        301C    CD3840            CALL    EMULT      FIND PRODUCT IN HL
        301F    3E0A              MVI     A,10       ASCII LINE FEED
        3021    CD0000            CALL    CHOUT      START ANSWER ON NEW LINE
        3024    114F              LXI     D,OUTBUF   OUTPUT BUFFER STARTING ADDRESS
        3027    CD2F41            CALL    BINDEC     CONVERT ANSWER TO ASCII STRING
        302A    AF                XRA     A
        302B    12                STAX    D          MARK END-OF-STRING WITH 0-BYTE
        302C    214F30            LXI     H,OUTBUF   RECALL START OF BUFFER
        302F    AF      TEST3     XRA     A
        3030    86                ADD     M          FETCH NEXT CHARACTER
        3031    CA0000            JZ      MONITOR    IF ITS 0-BYTE TERMINATOR, QUIT
        3034    CD0000            CALL    CHOUT      ELSE, DISPLAY BYTE
        3037    23                INX     H          ADVANCE BUFFER POINTER
        3038    C32F30            JMP     TEST3

        303B            INBUF     DS      20         INPUT BUFFER FOR 2 NUMBERS
        304F            OUTBUF    DS      10         OUTPUT BUFFER FOR RESULT
```

Two's Complement of Binary Numbers

Two's complement is a method of representing negative numbers in binary radix. It is only one of several methods of negative number representation, but it has the advantage of eliminating subtraction as a separate operation; subtraction can be performed by taking the two's complement of the subtrahend and adding it to the minuend.

The two's complement of a number is found by complementing every bit in the number (changing 1s to 0s and vice versa) and adding 1 to the resulting value. For example, suppose we want to take the two's complement of the number 4 stored as an 8-bit value:

4 in binary is:	*00000100*
complementing each bit:	*11111011*
adding 1:	*1*
−4 in two's complement:	*11111100*

(By the way, the numeral 11111011 is called the one's complement of 4.)

To show that subtraction can be performed using straight binary addition with two's complement, take the example of subtracting 4 from 7:

7 in binary is:	*00000111*
two's complement of 4:	*11111100*
adding, we get:	*1 00000011*

The carry, 1, is thrown away, and the result, 00000011, is decimal 3 in binary.

In two's complement, negative numbers always have a leftmost bit of 1; on the other hand, nonnegative numbers have a leftmost bit of 0. However, the absolute value of a negative number cannot be found by simply evaluating the lower bits; as before, you must complement the number and add 1.

These routines run an order of magnitude faster than full floating-point routines.

Text continued from page 204:
treat values outside the range of −32,768 to +32,767 as an overflow condition.

When an overflow is detected, a call is made to a subroutine called OVERFLOW, which is not provided because you will want to implement it in a manner appropriate to your system. A simple error-processing routine would display an error message and jump to the system monitor. If desired, a more sophisticated error-processing routine could continue processing, because the top of the stack contains the return address to the routine where the overflow was detected. Similarly, you must provide an entry point called CONVERR, which will be called in the event of a string-numeric conversion error.

The string-numeric conversion routine, DECBIN, will convert any legitimate numeric decimal representation, including those with leading blanks or blanks between the sign and the leading digit. It will reject errors including two signs or an illegal character. Any nonnumeric character after the start of the number terminates the conversion, facilitating parsing of free-format data entries. This is illustrated by the sample test program of listing 2, which accepts two numbers on one line and prints their product on the next line. ■

The Largest and Smallest Numbers in Two's Complement Notation

Another property of two's complement numbers is that the absolute value of the largest positive number that can be represented is 1 less than the absolute value of the smallest negative number that can be represented. As an example, look at all the possible 3-bit two's complement numbers:

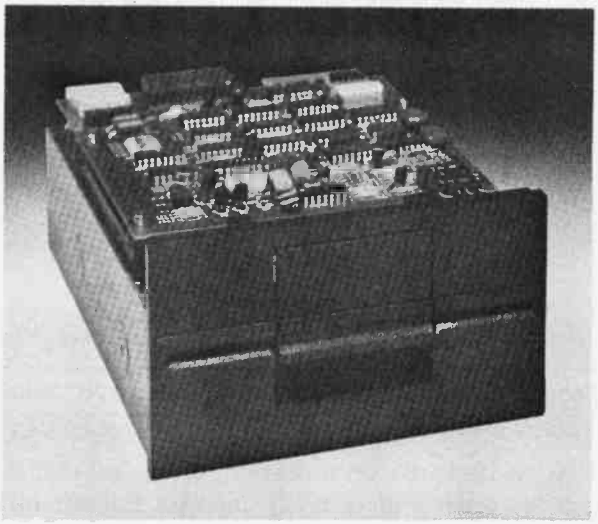
0 is 000; complementing and adding 1 gives 000 (or −0)
1 is 001; complementing and adding 1 gives 111 (or −1)
2 is 010; complementing and adding 1 gives 110 (or −2)
3 is 011; complementing and adding 1 gives 101 (or −3)
−1 is 111; complementing and adding 1 gives 001 (or 1)
−2 is 110; complementing and adding 1 gives 010 (or 2)
−3 is 101; complementing and adding 1 gives 011 (or 3)

But we have one number left over, 100. Inasmuch as the most significant bit is 1, it must be negative. To find its absolute value, take its two's complement:

the number is:	100
complement it:	011
add 1:	1
its two's complement is: which is binary for 4	100

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.

The DataTrack™ Floppy Disk Drives from Qume® Distributed by asap



The DataTrack™ 5

The DataTrak™ 5 double-sided double-density drive uses state-of-the-art technology to give you superior data integrity through improved disk life, data reliability, and drive serviceability using 5¼" media.

Qume's independent head load yields wear characteristics far superior to competitive drives. This superior wear performance produces savings on both diskette usage and drive maintenance.

Improved data reliability, resulting from superior amplitude and bit shaft characteristics, optimizes operator efficiency and reduces processing time for end-users.

And DataTrak's unique modular design means simplified field servicing for you and your customers.

Design Features

Expanded storage capacity • Two-sided, double density

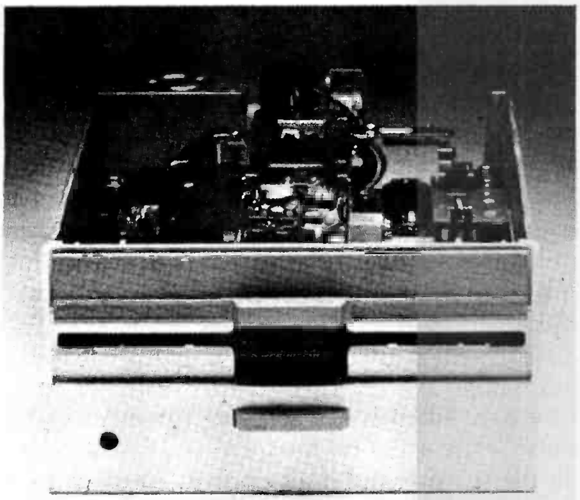
Proven head carriage assembly • Ceramic head with tunnel erase • Dual-head flex mounting arrangement • Superior head load dynamics

Precise lead screw actuator • Fast access time - 12 ms track-to-track • Low friction and minimum wear • Low power dissipation

Additional features • Industry standard 5¼" media format • ISO standard write protect • Door lock out for media protection • Requires DC voltage only • Daisy Chain up to 4 drives • Heads load on command independent of loading media

Product Specifications

Performance Specifications • Capacity: Unformatted: 437.5K or 500K bytes; Qume Formatted: 286.7K or 327.7K bytes • Recording Density: 5456 BPI • Track Density: 48 TPI • Cylinders: 35 or 40 • Tracks: 70 or 80 • Recording Method: FM or MFM • Rotational Speed: 300 RPM • Transfer Rate: 250K bits/second • Latency (avg.): 100 ms • Access Time: Track-to-track 12 ms; Settling 15 ms • Head Load Time: 50 ms



The DataTrack™ 8

The DataTrak™ 8 double-sided double-density drive uses state-of-the-art technology to give you superior data integrity through improved disk life, data reliability, and drive serviceability using 5¼" media.

Qume's innovative approach to controlling head load dynamics yields wear characteristics far superior to competitive drives. In independent evaluation, DataTrak 8 is setting industry standards for tap test performance. This superior wear performance produces savings on both diskette usage and drive maintenance.

Improved data reliability, resulting from superior amplitude and bit shift characteristics, optimizes operator efficiency and reduces processing time for end-users.

And DataTrak's unique modular design means simplified field servicing for you and your customers.

Design Features

Expanded storage capacity • Two-sided, double density

Fully IBM compatible • IBM 3740 and System 32 drives • IBM 3600 and 4964 drives • IBM System 34 drives

Proven head carriage assembly • Ceramic head with tunnel erase • Dual-head flex mounting arrangement • Superior head load dynamics

Fast, precise steel belt drive • Fast access time - 3 ms track-to-track • Low friction and minimum wear • Low power dissipation

Additional features • ISO standard write protect • Programmable door lock • Negative DC voltage not required • Daisy Chain up to 4 drives • Side-by-side mounting in standard 19" RETMA rack • Compatible with Shugart SA850/SA851

Product Specifications

Performance Specifications • Capacity: Unformatted: 1.6 Mbytes/disk; IBM Format: 1.2 M/bytes/disk • Recording Density: 6816 BPI • Track Density: 48 TPI • Cylinders: 77 • Tracks: 154 • Recording Method: MFM • Rotational Speed: 360 RPM • Transfer Rate: 500K bits/second • Latency (avg.): 83 ms • Access Time: Track-to-track 3 ms; Settling 15 ms; Average 91 ms • Head Load Time: 35 ms • Disk: Diskette 2D or equivalent

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Print Your Own Bar Codes

UPC Bar Codes With the Centronics 737

John Anderson, 149 Cliffside Dr, Wilmington NC 28403

Hewlett-Packard's introduction of a less-than-$100 bar-code reader will certainly increase interest in bar codes as a viable means of transporting program listings through the printed media. But reading bar codes is not enough. To maximize their usefulness, we must be able to generate them as well: only then will creative applications begin to emerge. There must be numerous instances where keyboard input to small-business data-processing systems can be replaced with bar-code input.

My interest in bar codes arose from a need for simple data entry in an educational application. The problem required easy generation as well as easy reading of bar codes. To generate bar code, you must be able to produce vertical lines and spaces of equal (or approximately equal) width. This can, of course, be done with a plotter or a high-resolution graphics printer. Or, it can be done with a low-cost, dot-matrix, proportional-spacing printer, such as the Centronics 737.

I had a Centronics 737, so I began to experiment with producing bar codes, and found that the printer can be used quite effectively. The Centronics 737 produces a high-density dot-matrix print in the proportional-spacing mode. With the concatenation symbol (|) as the basic vertical bar, the printer can be directed to backspace dot by *dot*, allowing the compression of vertical bars into a solid bar of variable width.

Text continued on page 276

PAPERBYTE® Bar Codes With Integral Data Systems Printers

Dr G Louis, OB/GYN Dept, St Michael's Hospital, 30 Bond St, Toronto M5B 1W8 Canada

The advent of Hewlett-Packard's low-cost bar-code reader, HEDS-3000, makes it possible to consider software distribution in machine-readable form via the printed page. The bar-code reader (described in Carl Helmers' editorial, "Bar Codes, Revisited...," April 1980 BYTE, page 6) can be interfaced to a computer for slightly more than $100.

This article will describe a program that uses the graphics plotting option of an Integral Data IP-225 (or IDS-440) printer to produce bar code. (The IP-225 sells for about $1000.) The format is the PAPERBYTE® format, described in Ken Budnick's book, *Bar-Code Loader* (Peterborough NH: BYTE Books, 1977).

In graphics mode, the Integral Data printers allow column by column control of the image printed. Each column is 7 dots high, and each dot is controlled by the corresponding bit in the byte of data sent. For example, if you send a question mark (hexadecimal 3F) to the printer while in graphics mode, a vertical bar of 6 dots is printed. If you send a NUL (0), the printer leaves a blank that is 1 dot-width across. This takes care of 0 bits and spaces. One bits (double-width bars) are simply printed as two question marks side by side. The bar-code loader program by Ken Budnick has software filtering to correct dropouts (white spots on the bars) and blotches (black dots in the spaces), and it also proves adequate to deal

Text continued on page 230

Editor's Note: *When we put the Hewlett-Packard HEDS-3000 bar-code wand on the cover of the April 1980 BYTE, we believed that the only major obstacle to the widespread use of bar codes—lack of a reliable wand at an affordable price—had been eliminated. You couldn't make your own bar codes (we thought), but you could read them. In the January 1981 BYTE, we published an article that showed how to make HP-41C bar codes on an expensive Diablo 1650 printer (see "Generating Bar Codes in the Hewlett-Packard Format," by Thomas McNeal, January 1981 BYTE, page 148). But few people have such an expensive printer, and (we thought) most people still couldn't make their own bar codes.*

*We were wrong. The two articles above show two different formats of bar codes produced on two different dot-matrix printers. All of the work is done in the software; the hardware only has to generate a thin vertical bar and place it anywhere on a line. With the proper bar-code reading software, even bar codes made with dot-matrix printers can be consistently and reliably read....*GW

Text continued from column 2, page 228:
with the tiny white spaces left between the dots in the double-width bars. The only restriction is that the printer ribbon *must* be in good condition; otherwise, the contrast between bar and space will not be sufficient for a reliable wand reading.

The program in listing 1 prints bar code from data in memory with start and stop addresses specified by the user. Tiny Pascal as described by K-M Chung and H Yuen (see reference 2) and implemented by me in 8080 assembly language (see reference 4) was used for this routine. Those who are unfamiliar with Pascal should have little difficulty following the algorithm: readability is one of the most important advantages of Pascal. Two minor points may give some trouble to BASIC programmers: percent signs (%) associated with numbers or variables indicate that the number or variable is expressed in hexadecimal, and the CASE X OF... statement is used to choose from among options to be executed depending on the value of X. However, interested readers

Figure 1: *Bar-code representation of part of listing 1, made on an Integral Data Systems IP-225.*

BAR-CODE PRINTER -- SOURCE LIST -- 800624

0000

0015

0029

003E

Listing 1: *Tiny Pascal source listing for a program that will generate printed bar codes from data in memory. Translation into BASIC or assembly language should prove fairly simple, even if the user is unfamiliar with Pascal.*

```
} *** BAR-CODE PRINTER PROGRAM
      FOR INTEGRAL DATA IP-225 (440) WITH GRAPHICS
      BY DR. G. LOUIS
         OB/GYN DEPT., ST. MICHAEL'S HOSPITAL
         30 BOND STREET, TORONTO, CANADA  M5B 1W8
      800501, LAST MODIFIED 800624
}
CONST MAXBAR=400  } MAX UNIT WIDTHS PER FRAME };
      PRINT=%85A  } DIRECTS OUTPUT TO PRINTER };
      NOPRINT=%84C  } NO OUTPUT TO PRINTER };
      DEL=127; CAN=24; FF=12; CR=13; TAB=9; } ASCII CTL }
      PLOT=3; PLTESCAP=3; NORMLPRT=2; } PLOT MODE CTL }
      CPI12=30  } SET PRINTER DENSITY 12 CHAR/IN };
      CPIMAX=31  } SET MAXIMUM DENSITY FOR PLOTTING };

VAR   I  } GENERAL-PURPOSE INDEX },
      IPT  } CHARACTER INPUT },
      ABSFLAG  } TRUE IF ABSOLUTE ADDRESSING CALLED FOR },
      ORIGIN  } ADDRESS OF 1ST BYTE TO BE CODED },
      LASTBYTE  } ADDRESS OF LAST BYTE TO CODE },
      POINTER  } ADDRESS OF NEXT BYTE TO CODE },
      FRAMEID  } VALUE OF ID BYTE OF NEXT FRAME }:
        INTEGER;
      JOBNAME: ARRAY [53] OF INTEGER;

FUNC WFRAME (START,STOP);
  } WRITE ONE FRAME BEGINNING AT START AND ENDING
    AT STOP OR WHEN THE PAGE IS FULL, WHICHEVER IS
    FIRST; RETURN THE ADDRESS OF THE BYTE FOLLOWING
    THE ONE LAST ENCODED }
  CONST SYNC=%96  } FIRST BYTE OF EVERY FRAME };
  VAR   ABSCK  } TRUE IF AN ABSOLUTE ADDRESS IS WANTED },
        BARCNT  } NUMBER OF UNIT WIDTHS IN FRAME },
        CKSUM  } HEX CHECKSUM },
        FRAMELEN  } NUMBER OF BYTES IN FRAME },
        I  } GENERAL-PURPOSE INDEX }:
          INTEGER;

  PROC WBYTE (VALUE);
  } WRITE BAR CODE FOR 8 LSB'S OF "VALUE" }
    VAR BUF, I: INTEGER;
    BEGIN
    BUF := VALUE AND 255;
    FOR I := 1 TO 8 DO BEGIN
      WRITE (SPACE, BAR); IF BUF > 127 THEN WRITE (BAR);
      BUF := (BUF SHL 1) AND 255 END
    END;

  FUNC SCANBYTE (VALUE);
  } RETURN THE NUMBER OF UNIT WIDTHS NEEDED TO WRITE
    BAR CODE FOR 8 LSB'S OF "VALUE" }
    VAR BUF, CNT, I: INTEGER;
    BEGIN
    BUF := VALUE AND 255; CNT := 0;
    FOR I := 1 TO 8 DO BEGIN
      CNT := CNT+2; IF BUF > 127 THEN CNT := CNT+1;
      } ONE SPACE + ONE BAR, + ONE MORE BAR IF BIT IS 1 }
      BUF := (BUF SHL 1) AND 255 END;
    SCANBYTE := CNT END;

  BEGIN  } WFRAME }
  ABSCK := ABSFLAG AND (START <= STOP);
  WRITE (CPI12);
  IF ABSFLAG THEN WRITE (START%)
    ELSE WRITE (START-ORIGIN%);
  WRITE (TAB,CPIMAX,PLOT); WBYTE (SYNC); FRAMELEN := 0;
  IF ABSCK THEN BEGIN
      CKSUM := (START SHR 8) + (START AND 255);
      BARCNT := SCANBYTE (START SHR 8) + SCANBYTE (START)
    END
    ELSE BEGIN CKSUM := 0; BARCNT := 0 END;
  IF START <= STOP THEN REPEAT
    I := MEM [START + FRAMELEN]; CKSUM := CKSUM + I;
    BARCNT := BARCNT + SCANBYTE (I);
    FRAMELEN := FRAMELEN + 1
  UNTIL (BARCNT > MAXBAR-24) OR (START+FRAMELEN = STOP+1);
  IF ABSCK THEN FRAMELEN := FRAMELEN+2;
  CKSUM := 256 - ((CKSUM + FRAMEID + FRAMELEN) AND 255);
  WBYTE (CKSUM); WBYTE (FRAMEID); WBYTE (FRAMELEN);
  IF ABSCK THEN BEGIN
    WBYTE (START SHR 8); WBYTE (START);
    FRAMELEN := FRAMELEN-2 END;
  FOR I := 1 TO FRAMELEN DO
    WBYTE (MEM [START + I - 1]);
  WRITE (SPACE, BAR, PLTESCAP, NORMLPRT, CPI12, CR);
  WFRAME := START + FRAMELEN
  END;

BEGIN  } *** MAIN PROGRAM *** }
CALL (NOPRINT); I := 0;
WRITE (FF,'BAR-CODE PRINTER',CR,CR,'JOB NAME: ');
WHILE I < 53 DO BEGIN
  READ (IPT); CASE IPT OF
    DEL: IF I > 0 THEN BEGIN WRITE (IPT); I := I-1 END;
    CAN: WHILE I > 0 DO BEGIN WRITE (DEL); I := I-1 END
    ELSE BEGIN
      WRITE (IPT); JOBNAME [I] := IPT; I := I+1;
      IF IPT = CR THEN I := 53  } TO GET OUT OF LOOP } END
    END  } CASE }
  END  } WHILE }; JOBNAME [53] := CR;
WRITE (CR,'START ADDRESS: '); READ (ORIGIN%);
WRITE (CR,'END ADDRESS: '); READ (LASTBYTE%);
WRITE (CR,'SPECIFY ABSOLUTE ADDRESSES? ');
REPEAT READ (IPT) UNTIL (IPT = 'Y') OR (IPT = 'N');
WRITE (IPT); ABSFLAG := (IPT='Y');
CALL (PRINT); WRITE (CPI12); I := -1;
REPEAT I := I+1; WRITE (JOBNAME [I])
UNTIL JOBNAME [I] = CR; WRITE (CR);
POINTER := ORIGIN; FRAMEID := 0;
REPEAT
  POINTER := WFRAME (POINTER,LASTBYTE);
  FRAMEID := FRAMEID+1;
  IF (0 = FRAMEID MOD 55) AND (POINTER <= LASTBYTE)
    THEN BEGIN WRITE (FF); I := -1;
    REPEAT I := I+1; WRITE (JOBNAME [I])
    UNTIL JOBNAME [I] = CR; WRITE (CR) END
UNTIL POINTER > LASTBYTE;
POINTER := WFRAME (POINTER,0)  } WRITE EOF FRAME }
WRITE (FF); CALL (NOPRINT)
END. } MAIN PROGRAM }
```

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should find it easy to adapt this routine to their own favorite languages and printers. Figure 1 shows the textually-encoded bar-code representation of a portion of listing 1.

The program need not be used exclusively for software distribution. Transfer of data of any kind between computers with incompatible mass-storage devices is easy if the source computer can create bar code and the recipient can read it. In addition, cheap, compact, archival storage of seldom-used information is possible if the length of files and frequency of use are such that entry via the wand is not unreasonably tedious.

Lest there be any doubt about the suitability of this program for use in software distribution, I will conclude by mentioning a recent experiment. I produced the bar-code listing (partially reproduced in figure 1) and photocopied it on a high-quality electrostatic photocopier. Both the original and the copy were scanned five times with the bar-code wand. I counted the number of passes needed to read each line and calculated the average. For the original and the copy, 1.1 and 1.3 passes with the wand sufficed to obtain a good read. Total time to enter the code ranged from 10 to 15 minutes, but this time could be decreased if a portable drafting tool or a T-square were used instead of a ruler to guide the wand across the page. The most time-consuming step in the entry process involved alignment of the ruler. Clearly, it is perfectly feasible to use this method to distribute machine-readable code on paper.■

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1. Budnick, K. *Bar Code Loader*. Peterborough NH: BYTE Books, 1977.
2. Chung, K-M and H Yuen. "A Tiny Pascal Compiler, Part 1: The P-Code Interpreter," September 1978 BYTE, page 58. Republished in *The BYTE Book of Pascal*. B W Liffick, editor. Peterborough NH: BYTE Books, 1979, page 59.
3. Helmers, Carl. "Bar Codes, Revisited...," April 1980 BYTE, page 6.
4. Louis, G. "Tiny Pascal in 8080 Assembly Language," July 1979 BYTE, page 174. Republished in *The BYTE Book of Pascal*. Blaise W Liffick, editor. Peterborough NH: BYTE Books, 1979.

BYTE's Bugs

Upside-Down Static Phoneme

Right in the middle of "Articulate Automata," there's an upside-down vowel spectrum! (See photo 3, page 170, February 1981 BYTE.)

Richard T Gagnon
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210 W Tienken
Rochester MI 48063

Mr Gagnon is correct: our phoneme spectrum was inverted. Thanks for setting us upright....CM■

STEP #1. PLUG IT IN.

(THERE IS NO STEP #2.)

APPLET.M.

PETT.M.

TRS-80T.M.

ETC.

System Notes

Faster BASIC for the Ohio Scientific

John A Sauter, Department of Biochemistry
5426 Med Sci I, University of Michigan, Ann Arbor MI 48109

"I don't believe it! The guy who wrote this program didn't know what he was doing." How many times have you seen a program and said that? Well, I never thought I would say it while looking at the Microsoft multiplication routines written for Ohio Scientific's BASIC.

Multiplication routines written in software are *slow*, especially when accurate to 9 digits. Programmers are always trying to optimize mathematical routines for speed. That's why I was surprised that the main loop for the multiplication routine contained line after line of inefficient instructions.

To comprehend the problem, you need to understand how a software multiplication routine works. For multiplication of large numbers, the process is similar to the longhand method taught in school. The two numbers to be multiplied, the multiplier and the multiplicand, are stored in the floating-point accumulator and the alternate floating-point accumulator, respectively. These accumulators are usually 4 to 5 bytes in length and preferably located in page 0 memory. The low bit of the multiplier is checked to see if it is set: if it is, the multiplicand is added to the product (initially 0); if it is not, no addition occurs.

Next, both the multiplier and the product are shifted 1 bit right (or, alternately, the multiplier is shifted right and the multiplicand is shifted left) and the low bit on the multiplier is checked again. This process is repeated for each bit in the multiplier. Four bytes are required for 9 digits of precision: a great deal of bit shifting must go on. In fact, the bit shifting uses most of the time required for a multiplication routine.

Fortunately, there is a convenient instruction in the 6502 microprocessor for shifting several contiguous bytes 1 bit to the right. The ROR instruction shifts a byte 1 bit to the right, with the carry shifted into the high-order bit, and the low-order bit of the byte shifted into the carry. Successive executions of the ROR instruction on contiguous bytes will shift all of the bytes 1 bit to the right, with the low bit of 1 byte shifting into the high bit of the next.

Listing 1 contains a portion of the Microsoft multiplication routine for the 6502. It is part of the routine that shifts the product 1 bit right. This sequence is repeated four more times in the subroutine, and requires a total time of 85 μs (with a 1 MHz clock rate while assuming

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Listing 1: *Section of the multiplication routine from Microsoft's disk BASIC, written for Ohio Scientific computers. This section can be replaced with a single ROR instruction (ROR $73, where the dollar sign denotes a hexadecimal 73). The replacement accomplishes the same task in much less time.*

LOC	CODE	MNEMONIC	TIME (uS)
1946	A9 80	LDA #$00	2
1948	90 02	BCC $194C	3
194A	A9 80	LDA #$80	2
194C	46 73	LSR $73	5
194E	05 73	ORA $73	3
1950	85 73	STA $73	3

Listing 2: *Part of a routine accessed by the addition and subtraction routines in Ohio Scientific's disk BASIC. This section can be replaced by the single instruction ROR $02,X.*

LOC	CODE	MNEMONIC	TIME (uS)
1854	A9 00	LDA #$00	2
1856	90 02	BCC $185A	3
1858	A9 80	LDA #$80	2
185A	56 02	LSR $02,X	6
185C	15 02	ORA $02,X	4
185E	95 02	STA $02,X	4

that, on the average, the instruction at hexadecimal 194A is executed only half of the time). This sequence is also in a loop that is repeated for all 8 bits of a multiplier byte, requiring a time of 680 μs for each subroutine call. Finally, the subroutine is called four (sometimes five) times for each floating-point multiplication. Thus, a total of 2.72 ms is used for each floating-point multiplication. However, the entire listing can be replaced by the single instruction (ROR $73). This instruction requires only 5 μs to execute, for a total time of 800 μs for each floating-point multiplication: a saving of 1.92 ms for each call to the multiplication routine.

My own tests with the changes have indicated that BASIC requires approximately 4.9 ms to complete a floating-point multiplication on a 9-digit number, whereas with the changes, it takes only 3.1 ms. This is an increase in speed of 37%!

Other routines that access the multiplication routines also execute more rapidly. For instance, the logarithm routine takes approximately 34.8 ms to complete a 9-digit logarithm; with the changes, it takes only 21.9 ms. This is also an increase in speed of 37%.

Similar mistakes were found in a section of the normalization routine (starting at hexadecimal 1854) accessed by the addition and subtraction routines (see listing 2). This sequence is repeated two more times. It can all be replaced by the instruction ROR $02,X. Another interesting section of the routine occurs at hexadecimal 1879 (see listing 3). This can be replaced by the instruction ROR A, which takes only 2 μs to execute. The actual increase in speed for the addition and subtraction routines with the changes installed was too difficult to measure since the routines are fairly rapid compared to the BASIC loops and other program segments used to test

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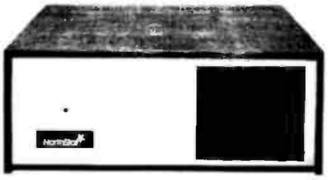

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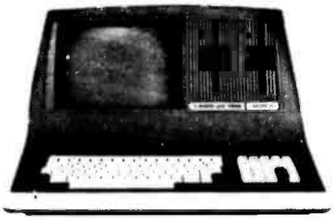

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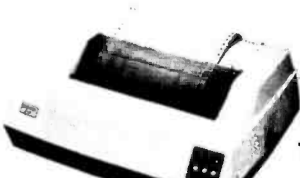

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Listing 3: *Section from the normalization routine used by the addition and subtraction routines in Ohio Scientific's disk BASIC. This section can be replaced by the instruction ROR A.*

```
LOC     CODE     MNEMONIC      TIME (uS)

1879    08       PHP               3
187A    4A       LSR A             2
187B    28       PLP               4
187C    90 02    BCC $1880         3
187E    09 80    ORA #$80          2
1880    C8       INY
```

them. I did notice that BASIC testing loops often executed approximately 10% faster with the changes. I attribute this to the faster addition routine.

I suspected that the division routines would also contain errors, but discovered that the ROL instruction was used wherever it was needed. (The ROR instruction isn't necessary in division.)

I immediately contacted Ohio Scientific and Microsoft to inform them of the problem. Both replied with an explanation that restored my faith in big-name software companies. Apparently, earlier versions of the 6502 microprocessor did not include an ROR instruction, but as customer demand grew, MOS Technology incorporated an ROR instruction in later versions of the 6502. Unfortunately, some of the earlier Ohio Scientific computers had already been sold with the old microprocessor. Therefore, Microsoft wrote its BASIC without any ROR instructions to make the software compatible with the earlier versions of the computer. Listings 1, 2, and 3 are actually macro expansions of the ROR instruction. [*Macros are one-line pseudoinstructions placed in an assembly-language source listing. When processed, they are replaced by a (predefined) set of assembly-language instructions and assembled into machine language....GW*] Microsoft assured me that this was done only for the KIM and Ohio Scientific computers. All other versions of 6502 BASIC were written using the ROR instruction.

For those who have later versions of Ohio Scientific computers and don't have BASIC permanently stored in read-only memory, there is a way to change Ohio Scientific's disk BASIC to use the ROR instruction. If you are using the OS-65D disk operating system, the program in listing 4 will permanently change your BASIC for 8-inch disks. It simply loads a part of the BASIC interpreter into memory, POKEs in the required changes, and stores the changed code back on disk. For 5-inch disks, statement 80 should be changed to read:

80 DISK!"CA 4200=03,1"

and statement 150 should be:

150 DISK!"SA 03,1=4200/8"

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I have not been able to test these changes for the 5-inch systems, and I suggest that you exercise caution in using them. For systems that use the OS-65U operating system, the program in listing 5 should be used to change your BASIC.

Ohio Scientific often boasts of supporting the fastest BASIC of any of the popular personal computers, and it can give you a great sense of satisfaction to make it run even faster. I have run BASIC with these changes for four months and have noticed that all of my programs run faster than before, especially those loaded with mathematical equations. If you decide to incorporate these changes into your system, I suggest that you first try them on an old copy of your operating system to ensure that the changes work on your computer. ■

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

```
10 REM DISK BASIC CORRECTION ROUTINE.  OS-65D, 8" DISKS
20 DATA 118,2,118,3,118,4,104,106,200,208,232,24,96
30 DATA 102,115,102,116,102,117,102,118,102,189,152
40 DATA 74,208,214,96
50 REM SET UP TOP OF MEMORY TO $47FF
60 POKE 132,255 : POKE 133,71 : POKE 128,255 : POKE 129,71
70 REM CALL IN A PORTION OF BASIC TO $4800
80 DISK!"CA 4800=04,1"
90 A1=18516 : REM 18516 = $4854
100 A2=18758 : REM 18758 = $4946
110 REM POKE IN THE CORRECTED CODE
120 FOR I=0 TO 12 : READ D : POKE A1+I,D : NEXT I
130 FOR I=0 TO 14 : READ D : POKE A2+I,D : NEXT I
140 REM SAVE THE CORRECTED BASIC BACK ON DISK
150 DISK!"SA 04,1=4800/B"
160 END
```

Listing 5: *Program used with the OS-65U operating system. This program does the same thing as listing 4, but begins at hexadecimal location 7800.*

```
10 REM DISK BASIC CORRECTION ROUTINE.  OS-65U
20 DATA 0,36,0,0,0,2,0,120
30 DATA 118,2,118,3,118,4,104,106,200,208,232,24,96
40 DATA 102,115,102,116,102,117,102,118,102,189,152
50 DATA 74,208,214,96
60 REM SET UP USR FUNCTION AND PUT AND GET ROUTINES
70 POKE 8778,192 : POKE 8779,36
80 POKE 9432,243 :POKE 9433,40
90 POKE 9435,232 : POKE 9436,40
100 REM DISK ADDRESS = $1800 + $0C00, NUMBER OF BYTES = $0200
110 REM RAM ADDRESS = $7800
120 CB=9889 : FOR I=1 TO 8 : READ D : POKE CB+I,D : NEXT I
130 REM CALL IN A PORTION OF BASIC TO $7800
140 ER=USR(0)
160 A1=30804 : REM 30804 = $7854
170 A2=31046 : REM 31046 = $7946
180 REM POKE IN THE CORRECTED CODE
190 FOR I=0 TO 12 : READ D : POKE A1+I,D : NEXT I
200 FOR I=0 TO 14 : READ D : POKE A2+I,D : NEXT I
210 REM SAVE THE CORRECTED BASIC BACK ON DISK
220 ER=USR(1):CLOSE
230 END
```

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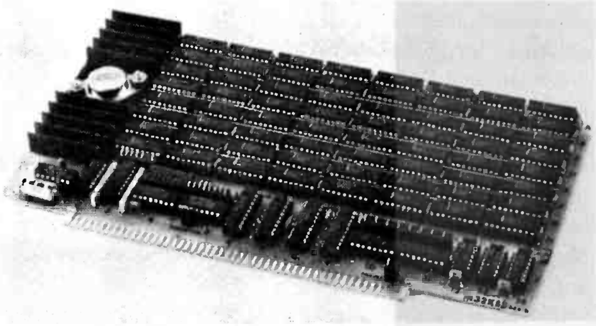

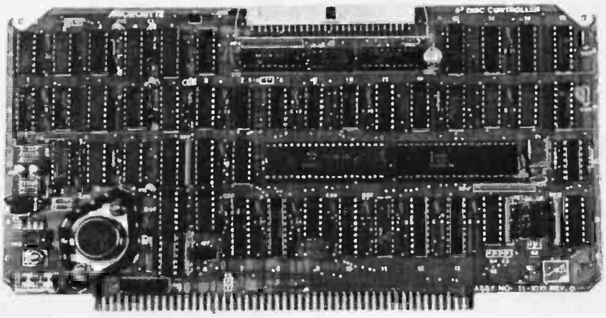

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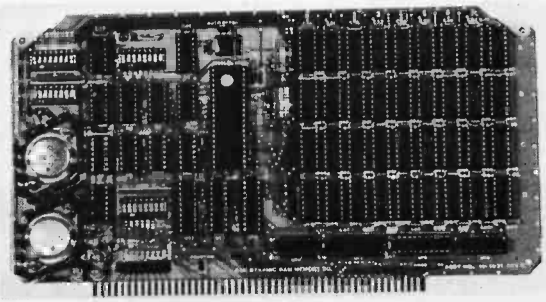

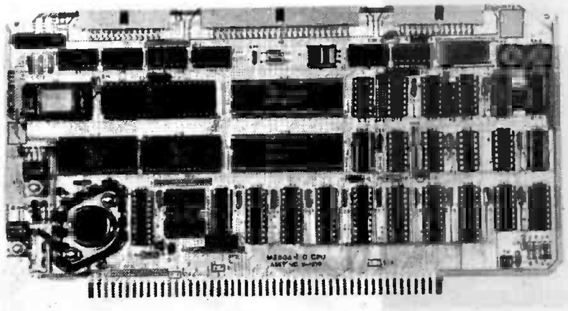

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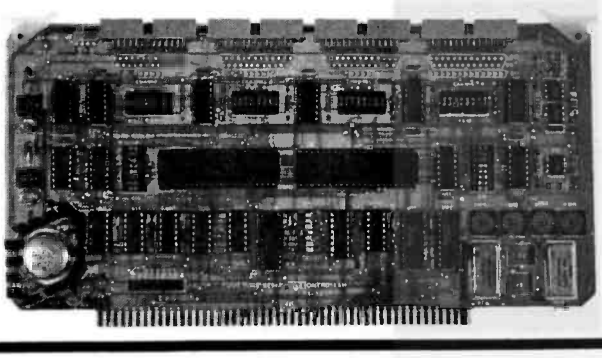

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Book Reviews

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 vectored translation of a quadratic polynomial synthesizing imaginary roots and real constraints utilizing classical fourth-order Runge-Kutta numerical techniques...").

With the second edition of *Principles of Interactive Computer Graphics*, you can explore the special techniques of computer-generated graphics (see page 146 of the December 1977 BYTE for a review of the first edition). The first edition, published in 1973, discussed algorithms and hardware in reference to vector-drawing displays, because these were the most common type of display. At the time, raster-scan displays were available, but programmers mainly used them for data entry and interactive-program preparation. When experimenters needed inexpensive, human-readable output devices for microprocessor-based computers, the raster-scan method was developed for graphics use. Newman and Sproull recognize this and have included a section devoted to the software techniques needed to implement graphics capabilities on raster-scan displays. This section describes angle and line generation, solids generation, interactive computation, hardware, and language implementation.

Another major change is the use of Pascal to describe the algorithms. The first edition used a language called SAIL, which required the inclusion of a user's manual. Because of the wide use of Pascal, today's readers will more easily understand the material presented. Even those whose knowledge of Pascal is limited will comprehend the algorithms with little difficulty.

There are twenty-six chapters arranged in six parts. Part 1 discusses line drawing, point plotting, transformations, windowing, and clipping. This material is applicable to raster-scan and vector-drawing displays. In part 2, emphasis is on graphics packages—that is, groups of subroutines to be invoked by applications programs. Part 3 describes the man-to-machine interface. Here, the authors identify several input devices (keyboards, light pens, tablets, three-dimensional input) and methods to use them. In part 4, the following subjects dealing with raster-scan graphics are covered: fundamentals, solid-area conversion, interactive methods, and hardware.

Three-dimensional graphics techniques are more thoroughly examined in part 5, which includes perspective, shading, curved surfaces, and hidden-line/hidden-surface algorithms. Part 6 brings it all together by outlining various hardware display units, methods of user interfacing, and graphics languages. Two appendices are included. The first is a discussion of matrix- and vector-arithmetic operations; the second, homogeneous coordinate techniques. Many of the clipping, windowing, and transformation techniques require a fundamental knowledge of vector and matrix computation. These two appendices provide that knowledge, as long as you understand mathematical notation.

Although this book still is a basic tool for college- and graduate-level computer science courses, the novice or personal computerist will find it understandable. This book will spark your imagination and challenge your creative abilities. Once that challenge is accepted, zapping Klingons will be a bore.■

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.
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- How tracks are formatted.
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- 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.
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- Handy reference card.
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- Many programming examples.

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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:

- Dynamically loads and relocates suitably prepared machine language programs anywhere in RAM.
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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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By Bruce Wallace

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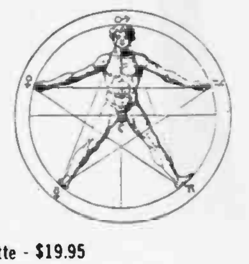
ASTROAPPLE™ by Bob Male.



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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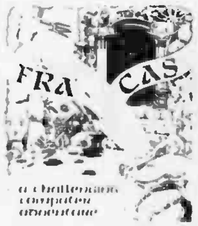

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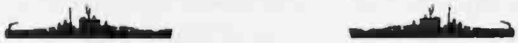
BATTLESHIP COMMANDER™ by Erik Kilk and Matthew Jew.



A game of strategy. You and the computer each start out by positioning five ships of different sizes on a ten by ten grid. Then the shooting starts. Place your volleys skillfully — a combination of logic and luck are required to beat the computer. Cartoons show the ships sinking and announce the winner. Sound effects and flashing lights also add to the enjoyment of the game. Both Applesoft and integer BASIC versions are included. Requires at least 32K of RAM.

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Also by Don Worth . . .

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CompuPro memories feature fully static design to eliminate dynamic timing problems, full conformance to all IEEE 696/S-100 specifications, high speed operation (4/5 MHz Unkit, 10 MHz A/T and CSC), low power consumption, extensive bypassing, and careful thermal design.

	Unkit	A/T	CSC
8K RAM 2A	$159	$189	$239
16K RAM 14 (extended addressing)	$279	$349	$429
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

NEW! 64K RAM 17. Amazingly low power in a 64K fully static RAM board; draws less than 1.75 Watts typical, 2.5 Watts max! It's fast, too; runs with 6 MHz Z-80* CPUs, or up to 10 MHz with 8086/88 family CPUs. Uses IEEE extended addressing protocol; also, user may turn off 2K windows from E000 to FFFF in order to accommodate memory-mapped peripherals/disk controllers. (The CompuPro disk controller can use the full 64K since it employs properly implemented DMA techniques). $1095 Unkit, $1395 A/T, $1595 CSC.

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.

SYSTEM SUPPORT 1

$295 Unkit, **$395** A/T, **$495** CSC

This multi-purpose S-100 board provides sockets for 4K of extended address EPROM or RAM (2716 pinout) with one battery backup socket; battery backup month/day/year/time crystal clock with BCD outputs; optional math processor (9511 or 9512); full RS-232 serial port; three 16 bit interval timers (cascade or use independently); two interrupt controllers service 15 levels of interrupts; power fail indicator; and comprehensive owner's manual with numerous software examples. Conforms fully to all IEEE 696/S-100 standards. (Add $195 to the above prices for the optional 9512 math processor.)

COMPUTER ENCLOSURE 2

$825 desk top version, **$895** rack mount version

Includes fused, constant voltage power supply (+8A at 25 Amps, +16V at 3 Amps, and −16V at 3 Amps); 20 slot shielded/active terminated motherboard; and rugged all-metal enclosure with dual AC outlets on rear, heavy-duty line filter, circuit breaker, quiet ventilation fan, and reset switch. Rack mount version includes slides for easy pull-out from rack frame.

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

HIGH SPEED S-100 CPU BOARDS

CompuPro CPU boards meet all IEEE 696/S-100 specifications (including timing). CPU 8085/88 uses two processors,an 8085 and 8088, to provide both 16 and 8 bit capability with a standard 8 bit bus.

8 Bit CPU Z (with Z80A* CPU).........$225 Unkit, $295 A/T, $395 CSC.
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

8088/8086 MONITOR-DEBUGGER: Supplied on single sided, single density, soft sectored 8" disk, CP/M* compatible. Great development tool; mnemonics used in debug conform as closely as possible to current CP/M* DDT mnemonics. $35.

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Software Review

Super STEP

Stanley D Robbins, 249 Willow Ter, Sterling VA 22170

Super STEP is a machine-language utility that works with and is an extension of Radio Shack's T-Bug program. Super STEP allows you to run a machine-language program either by stopping at predefined locations (*breakpoints*) or stopping after each machine-language instruction is executed (*single-stepping*).

The TRS-80 video display shows a great deal of information that is useful during debugging, including the instruction currently executed, the contents of the top 5 bytes of the Z80 stack area, the status of all registers and status flags, and a user-specified area of memory. In addition, much of the information is printed twice in order to show these values before and after execution of the current machine-language instruction. Although it is not evident from the documentation supplied, Super STEP is not merely a utility that interrupts program execution after each instruction: it is a *simulation* (or *model*) that behaves like an actual Z80.

The instruction booklet that accompanies Super STEP creates the first impression—and that impression is not the best. The small type is difficult to read in good

At a Glance

Name
Super STEP Z80 Processor Model

Type
Debugging utility for assembly-language programming (runs as an extension of Radio Shack's T-Bug program)

Manufacturer
Allen Gelder Software
Box 11721
Main Post Office
San Francisco CA 94101

Price
$19.95

Format
Cassette tape

Language
Machine language

Computer
TRS-80 Model I, with Level II BASIC and 16 K bytes of memory

Documentation
Instruction booklet of 16 pages, 11.5 by 14 cm (4½ by 5½ inches)

Audience
Assembly-language programmers

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Why wait up to 6 months for high quality 16-bit resident system software, when you can get it now?

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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. ■

BYTE's Bugs

Problematic Problem Solving

The article entitled "Machine Problem Solving" (November 1980 BYTE, by Peter Frey) has a bug on line 230 of the "Treasure Search" game. (See page 258, listing 1.)

The line should read:

```
230  X$= RIGHT$(STR$
       (B(I),1)):GOSUB 1000
```

Many thanks to those who called us about this typographical error. ■

Circle 70 on inquiry card.

Software Review

Wordsmith

Mark Dahmke, 1515 Superior Apt 15, Lincoln NE 68521

The greatest compliment I can give Scion Corporation's Wordsmith is that I am using it to write this review. I have searched long and hard for a word processor that would give me the features and capabilities of a big-system full-screen editor.

I used to do all of my writing on an IBM 370 computer, using a full-screen editor and a batch program that read in my text and formatted it for a high-speed printer. The full-screen editor was adequate, but the batch program was painful to use because you couldn't see the results without running it (over and over). It was like using a compiler instead of an interpreter—you had to wait.

Wordsmith combines the features of a good, full-screen editor (one of the nicest I have used) in a "what you see is what you get" format, thus allowing text to appear on the screen exactly as you want it printed.

Wordsmith Overview

Wordsmith runs on an 8080- or Z80-based microcomputer with either CP/M or North Star disk operating systems. The distribution disk also supplies a customization program that allows the user to define the ASCII codes of the special-function keys, the location of the memory-mapped video display, and the printer interface.

Unlike many other word processors, Wordsmith is page-oriented, ie: page boundaries are maintained in the disk file. Scion's Screensplitter video display has 86 characters per line and 40 lines, but Wordsmith uses the top line as a "scoreboard" to keep track of cursor position (line and column numbers), current page, total number of pages, and the maximum number of pages that can be used within the disk file that is currently open. The file name (fully qualified by the conventions of the operating system in use) is also shown on the scoreboard. The right portion of the scoreboard is used to enter commands. Getting to the command line is easy—just hit Break, or the key you have assigned to that function. The command line then becomes active, shows a cursor, and awaits your input. Hitting Break again terminates command entry and executes the command. If no command is entered (ie: if you hit Break twice without entering a command), nothing will happen. Wordsmith has over seventy commands, not including those used for cursor movement (up, down, left, right, etc).

About the Author

Mark Dahmke is a consulting editor for BYTE magazine. He also operates a computer consulting business called MCD Consulting and is involved in the design of office automation systems. His interests include astronomy, science fiction, writing, and painting.

At a Glance

Software
Wordsmith page-oriented word processor

Use
Word processing

Manufacturer
Scion Corporation
8455-D Tyco Rd
Vienna VA 22180
(703) 827-0888

Price
Wordsmith word processor (CP/M or North Star): $295; Screensplitter video board (86 characters by 40 lines) and firmware: $395. Video subsystem (Wordsmith, Screensplitter board, firmware, 15-inch green-phosphor video monitor, and high-quality word-processor keyboard IBM Selectric II style): $1795

Features
Wordsmith word processor (software) runs with a memory-mapped video display (the Screensplitter) with 86 characters per line and 40 lines. Wordsmith is completely reentrant and is written in 8080 assembly language

Operating System
CP/M 8-inch or North Star 5-inch (single-, double-, or quad-density) floppy-disk formats; also IMDOS, MDOS, CDOS (single-, double-, or quad-density formats)

Hardware
Any S-100 8080- or Z80-based microcomputer. Wordsmith will run in a CP/M system with only 16 K bytes of memory. The Scion Screensplitter memory-mapped video board is required.

Documentation
66-page manual, 21 by 27.5 cm (8½ by 11 inches), for Wordsmith; 70-page manual for Screensplitter (same size)

Firmware
1 K bytes of video-display software in a 2708 EPROM

Audience
Anyone requiring high-quality word-processing capability

Other Features

Wordsmith has many other features that make text entry less tedious. The *tab-stop line* allows you to set up any number of tabs in a given text file. When you enter the ET command, Wordsmith displays a reverse-video line just below the scoreboard. You can place a period wherever you want a tab stop, and Wordsmith will remember the tab-stop line (the line of periods) for each separate disk file. Once set up, the tab stops may be altered by entering the ET command again.

The *hold area* is a reserved area of memory that can be used to save up to an entire screen page (86 characters by 39 lines). Using this feature, any amount of text, from a single word or line to an entire screen page, may be copied to another part of the screen, another page in the file, or another disk file. Many commands are available for copying the held text back to the screen. For example, it may be put down "literally," meaning that it will be placed on the screen just as it was copied from the screen. The PF, or *put-formatted* command, will reformat the

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*Last August, Chris Morgan and I went to Washington DC to see a networked office-automation system that Scion had installed in a congressman's office. The system, called Rosenet, consists of a network of Z80 microcomputers running a modified version of the North Star disk operating system. Each workstation also includes a Wordsmith video subsystem. All workstations are tied to a central microcomputer that maintains data bases and an electronic mail/memo system. The master system also provides printer and dial-up modem services to the workstations, which communicate with the master through RS-232C lines running at 19,200 bits per second....*MCD

text in the hold area to fit a new shape or region of the screen. This allows you to work easily with "newspaper columns."

Up to 20 text *windows* may be defined on each page. Wordsmith keeps track of the windows on each page and the cursor location within each window. This extra information is stored in blocks at the end of the text file, which allows the file to be read in by an assembler or compiler without interference. A window may be any size, from 1 by 2 characters to a whole screen page. This feature is most useful in "cut and paste" operations. When several windows are defined on a page (the screen itself is called the *base window*), you can move from window to window by hitting the Cycle key. This moves you to the next window in the loop, and eventually returns you to the one you started at. When a window is active, it is impossible to type text or move the cursor to a location outside the window. It's like having a miniature screen within a screen. Windows are also useful for setting up *templates*—files with no text, but with a window structure. A template might, for example, be set up to look like a standard letter format with header, body, closing, and so on. It is then a simple matter to fill in the blanks when writing the letter.

A large selection of cursor-movement commands is available, beginning with the obvious: up, down, left, right and home (move to the upper lefthand corner of the window). On the video-subsystem keyboard, typing Shift in combination with one of the cursor-direction keys causes movement of the cursor in increments of eight character positions, instead of one. Also included are: delete to end of line, move to end of line, delete character, backspace, insert blank, insert mode, delete left, and tab.

Line control and movement commands include: insert line, delete line, insert multiple lines, delete multiple lines, center line, hold multiple lines (in hold area), split line and join line, and search line for string.

Among the window control and movement commands are: open window, clear window, set mark, clear marks, open line window, open paragraph window, drop window, drop all windows, cycle (to next window), go to base window, jump window (to new location on screen), illuminate all windows (ie: set to reverse video), change size transparently, change size, fill window (from hold area), adjust window (right justify), hold window, put text literally (from hold area), put text formatted, erase window, search for string, and search and replace string.

Page Control and Movement

Pages may be inserted and deleted, up to the limit of pages allowed in a disk file. When a new file is created (using the new-file command), you must specify the number of pages you require. Other commands include: NP (flip to next page), PP (flip to previous page), PG*n* (go to page *n*), PG+*n* (go forward *n* pages), PG−*n* (go backward *n* pages), IP (insert page), DP (delete page), CP (reread current page off disk), SP (split page into two pages—split at the cursor), JP (join two pages), save and recall page templates (window structures).

Disk-File Management

Files can be created with the NF (new-file) command. For example, the command NF B:TEST-10 will create a file (under CP/M) on the B disk called TEST, with room for ten text pages. The command OF B:TEST will get the old file called TEST from the B disk. The page that was saved in the previous editing session will be redisplayed on the screen. CL (close file) ends an editing session and closes a file. Since text pages are not necessarily in sequential order in a file, the SQ (sequence file) command will sort them into order. (This is not needed for normal operations, except when Wordsmith files are being used to store programs or other information that will subsequently be read by another program, such as an assembler or BASIC compiler.) Other file-level commands include: SRFs (search file for string "*s*"), SUFs (substitute next occurrence) and SAFs (substitute all occurrences in file).

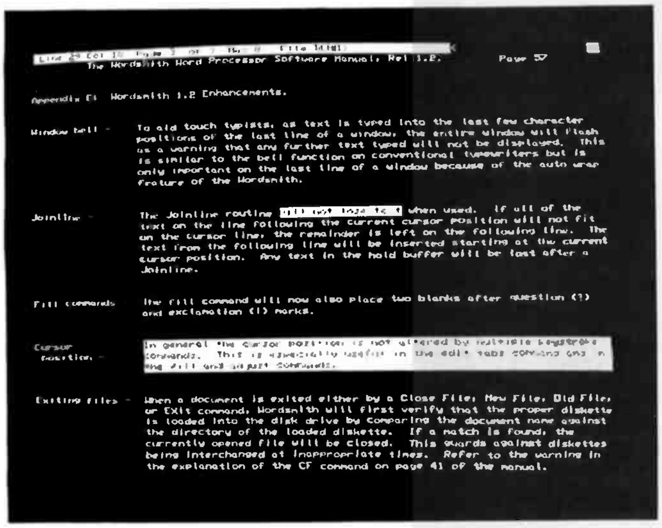

Photo 1: *The Wordsmith word processor as displayed on the Screensplitter video board.*

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:

$$(Command)\text{-}(t),(l),(h)$$

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. ■

WHY BUY FROM THE BEST?

NEECO

Service... Support... Software...

CBM™ 8000 SERIES BUSINESS COMPUTERS

The new Commodore 8000 series computers offer a wide screen display to show you up to 80-character lines of information. Text editing and report formatting are faster and easier with the new wide-screen display. The 8000 series also provides a resident Operating System with expanded functional capabilities. You can use BASIC on the 8000 computers in both interactive and program modes, with expanded commands and functions for arithmetic, editing, and disk file management. The CBM 8000 series computers are ideally suited for the computing needs of the business marketplace.

SCREEN
2000 character display, organized into twenty-five 80-column lines
64 ASCII, 64 graphic characters
3 x 8 dot matrix characters
Green phosphor screen
Brightness control
Line spacing: 1½ in Text Mode
1 in Graphics Mode

KEYBOARD
73-key typewriter style keyboard with graphic capabilities
Repeat key functional with all keys

MEMORY
CBM 8016: 16K (15359 net) random access memory (RAM)
CBM 8032: 32K (31743 net) random access memory (RAM)

POWER REQUIREMENTS
Volts: 110V
Cycles: 60 Hz
Watts: 100

SCREEN EDITING CAPABILITIES
Full cursor control (up, down, right, left)
Character insert and delete
Reverse character fields
Overstriking
Return key sends entire line to CPU regardless of cursor position

INPUT/OUTPUT
Parallel port
IEEE-488 bus
2 cassette ports
Memory and I/O expansion connectors

FIRMWARE
24K or ROM contains:
BASIC (version 4.0) with direct (interactive) and indirect (program) modes
9-digit floating binary arithmetic
Tape and disk file handling software

CBM 8032 Computer $1795

CBM™ 8050 DUAL DRIVE FLOPPY DISK

The CBM 8050 Dual Drive Floppy Disk in an enhanced version of the intelligent CBM 2040 Disk Drive. The CBM 8050 has all of the features of the CBM 2040, and provides more powerful software capabilities, as well as nearly one megabyte of online storage capacity. The CBM 8050 supplies relative record files and automatic diskette initialization. It can copy all the files from one diskette to another without copying unused space. The CBM 8050 also offers improved error recovery and the ability to append to sequential files.

HARDWARE SPECIFICATIONS
Dual Drives
Two microprocessors
974K Bytes storage on two 5.25" diskettes (ss)
Tracks 70
Sectors 17-21
Soft sector format
IEEE-488 interface
Combination power (green) and error (red) indicator lights
Drive Activity indicator lights
Disk Operating System Firmware (12K ROM)
Disk Buffer (4K RAM)

FIRMWARE
DOS version 2.0
Sequential file manipulation
Sequential user files
Relative record files
Append to sequential files
Improved error recovery
Automatic diskette initialization
Automatic directory search
Command parser for syntax validation
Program load and save

CBM 8050 Dual Price $1795

CBM	PRODUCT DESCRIPTION	PRICE
4016	16K RAM-Graphics(N) or Business(B) Keyboard	$ 995.00
4032	32K RAM-Graphics(N) or Business(B) Keyboard	$1295.00
8032	32K RAM-80 Col. Screen-Business Keyboard	$1795.00
4022	Tractor Feed Printer	$ 795.00
4040	Dual Floppy-343K-DOS 2.0	$1295.00
8050	Dual Floppy-974K-DOS 2.0	$1795.00
4010	Voice Synthesizer	$ 395.00
8010	300 Baud IEEE Modem	$ 279.95
C2N Cassette	External Cassette Drive	$ 95.00
CBMto IEEE	CBM to 1st IEEE Peripheral	$ 39.95
IEEE to IEEE	IEEE to 2nd IEEE Peripheral	$ 49.95
2.1 DOS	DOS Upgrade for 2040	$ 100.00
4.0 DOS	O/S Upgrade for 40 Column Computer	$ 100.00
Word Pro 4+	Word Processing Software used w/8032	$ 450.00

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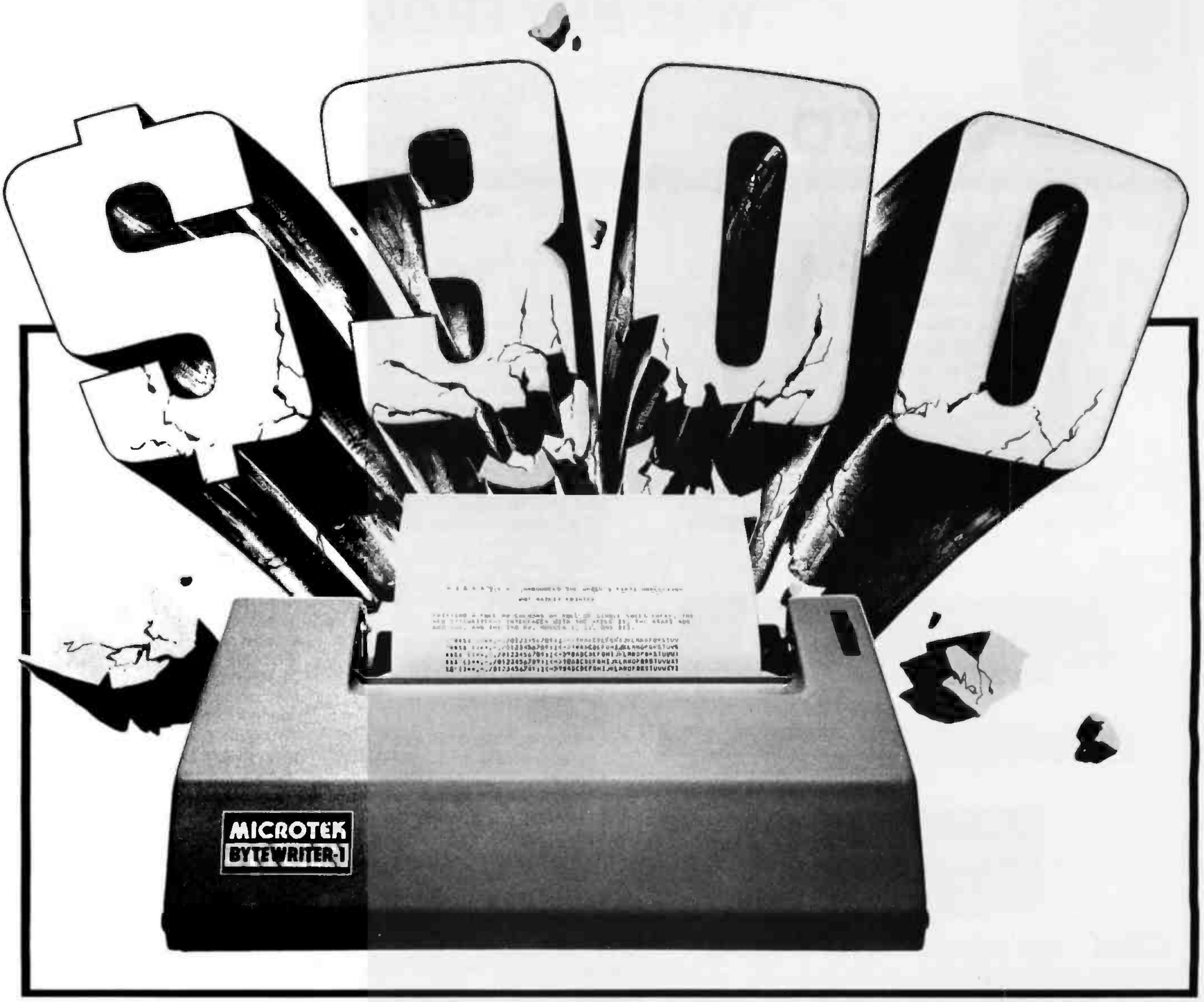

BYTEWRITER-1

Price Breakthrough from

MICROTEK inc.

The World's First Under $300 80 Column Dot Matrix Printer

WHY DID IT HAPPEN?

We were approached recently by a man with an idea. He is one of the leading American manufacturers of dot matrix print mechanisms. He had observed, as we had, that in recent months certain foreign printer manufacturers were increasing their share of the low-cost printer market at an alarming rate.

He thought there MUST be a way to fight back. And he was right. We've since formed a working alliance with this manufacturer, and have brought our first joint offering to the market.

HOW DID WE MAKE IT POSSIBLE?

We set out to combine his proven low cost print mechanism with the simplest possible control electronics. Advances in single-chip microprocessor technology and price erosion of components during the last year helped to make this long awaited dream come true - a printer that can be sold for less than half the cost of the computer that drives it. A $299 printer.

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.

TRS-80 is a trademark of Radio Shack, Div. of Tandy Corp.
Apple II is a trademark of Apple Computer, Inc.
Atari 400 & 800 are trademarks of Atari, Inc.
Bytewriter-1 is a trademark of Microtek, Inc.

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.

We realize it's unusual to point out the limitations of a product in an ad that promotes it, but we think it's important for mail order buyers to fully understand what they're buying.

The Bytewriter-1 will fill the needs of most people. People who don't see the sense in spending extra money for features they'll never use.

ORDER THE CONFIGURATION THAT'S JUST RIGHT FOR YOU

The Bytewriter-1 is available with an interface cable and complete instructions for use with three of the most popular small computers on the market today, the Apple II, the Atari 400/800, and TRS-80 Models I, II, and III. One of our divisions, MICROTEK PERIPHERALS CORP., can even provide you with the expansion card or module that your computer may require to drive a printer.

CALL OR WRITE TODAY FOR MORE INFORMATION.

We have people standing by to answer your questions.

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BYTELINES

News and Speculation About Personal Computing

Conducted by Sol Libes

An Apple III Emulation Mode: Axlon Inc is working on a project that will allow an Apple II to run most of the software designed for the Apple III—including the Apple III disk operating system, SOS. The product has its roots in another product recently introduced by Axlon, the Axlon 256 Memory System. The unit consists of an interface card and a card cage that contains up to 256 K bytes of memory. There are separate versions for the Atari and Apple II, and one for the Apple III is in the works. Expressed simply, the unit can exchange 32 K-byte blocks of its memory for the top 32 K bytes in the 48 K machine connected to it.

Special disk-operating-system software included with the unit makes its operation transparent to the user. The hardware/software combination looks to the host computer like a large-capacity disk drive. Program files in the memory of the unit can be run as if they were on floppy disk, and data files can be accessed in both random and serial fashion. There are two advantages to this unit: one, information can be accessed in microseconds (as opposed to milliseconds or longer for floppy-disk drives); and two, the increased main-memory space makes both existing and proposed programs that crowd the current 48 K-byte limit more feasible.

The Sunnyvale, California-based Axlon is working with Apple Computer to finalize the design of the Apple III emulation hardware/software combination. The proposed unit will include the Axlon 256 Memory System, a special hardware board, special software, and an 80-column adapter for the Apple II.

EEPROM Is Coming: Several IC designers are predicting that the EEPROM (electrically erasable programmable read-only memory) will replace the ultraviolet-light EPROM within three to four years and may, perhaps, be used as nonvolatile main memory. Several companies are now putting finishing touches on these devices for introduction later this year. For example, Hitachi has announced the HN48016, a 16 K-bit EEPROM (2 K by 8 bits) that is pin-compatible with the popular 2716 UV-EPROM. It uses the same voltages, takes 10 ms per byte to program, and can be completely erased with a 1-second pulse. Data retention is claimed to be more than ten years. Intel has a similar device called the 2816. Prices and access times are comparable to their EPROM equivalents.

Microsoft Adds Graphics Commands To BASIC: Microsoft is offering OEMs who have hardware graphics capability an enhanced version of the popular BASIC-80 interpreter. The added commands will allow you to create lines, boxes, circles, curves, do object painting and relocation, and save all your work. Seven new commands have been added: CIRCLE, PAINT, GETSET, LINE, DRAW, PUT, and PRESET.

Continuing AMSAT OSCAR Activity: AMSAT, the Radio Amateur Satellite Corporation, has survived the loss of its Phase-IIIA OSCAR satellite. (See "BYTELINES," September 1980 BYTE, page 166.)

Construction of a new Phase-IIIB satellite is underway in Marburg, West Germany; Budapest, Hungary; and Washington DC. AMSAT has scheduled the satellite's launch for February 24, 1982 on a European Space Agency Arriane-booster flight.

As part of its planned use, the satellite will relay computer data by amateur radio operators in personal-computer networks.

For information on how to join AMSAT and receive *Orbit* magazine, write to AMSAT, POB 27, Washington DC 20044.

Details On 32-Bit Microprocessors: Intel released more information on its new 32-bit microprocessor, called the iAPX432. The microprocessor, under development for six years, features an object-oriented architecture that treats high-level entities as elementary software components that can be easily manipulated. These entities include records, queues, tasks, and collections of procedures.

In its simplest form, the microprocessor consists of two integrated circuits. More processors can be added later to obtain multiprocessing without altering software. It is expected that samples will be available in the fall.

$100,000 Computer-Chess Prize Offered: Carnegie-Mellon University (CMU) is offering a prize of $100,000 to the first person to develop a computer program that can defeat the world chess champion. Dr Hans Berliner, a computer scientist at CMU and a former world chess champion, heads the competition-rules committee. He feels that the prize may be won by 1990 or sooner, but certainly no later than the year 2000.

Last year a $1000 CMU prize was won when Jack Gibson, a chess expert, was defeated by Belle, a computer-chess machine developed by Ken Thompson and Dr Joe Condon, researchers at Bell Laboratories, Murray Hill, New Jersey.

Mini-Winchester Update: Five companies have announced 5-inch Winchester drives. The drives' storage capacity ranges from 1.8 to 12.3 megabytes (unformatted), and prices vary from $690 to $1600 (500-unit quantity prices). Most suppliers are now shipping evaluation units to OEMs (original equipment manufacturers), with limited production expected by late summer. Don't expect full production until next year.

The five companies which have already announced mini-Winchester hard disks are Shugart Associates, Seagate Technology, Irwin International, Tandon Magnetics, and New World Computer Company. The price leader appears to be Shugart, with its SA602 3.3-megabyte drive at $660. The maximum storage leader is the 12.3-megabyte

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

TI Improves The 99/4 Home Computer: Texas Instruments is determined to make its TI 99/4 home computer a success. TI has improved the competitive position of the 99/4 by substantial price cuts and software improvements, the two areas in which the machine fared poorly. The new list price for the console is $649.95, a reduction of $300, and the radio-frequency (RF) modulator's price has been reduced from $75 to $50.

TI has introduced a software-development system that includes UCSD Pascal and a ROM (read-only memory) module with an assembly-language debugger. The console has been modified and includes dual floppy-disk drives and RS-232C interfaces. TI has also announced third-party software-incentive programs for software developers. TI plans to introduce extended BASIC and memory-expansion capabilities in the TI 99/4. Regrettably, TI has not seen fit to improve the keyboard or make any substantial hardware improvements other than the addition of memory.

More On Daisy-Wheel Printers: Daisy-wheel printers are the most widely used printers for letter-quality hard copy, but the market is undergoing substantial change. Last year, the number of daisy-wheel-printer manufacturers doubled. More competition meant lower prices and increased performance. The new entries came from Olivetti, Fujitsu, Ricoh, C Itoh, and Pertec. Qume and Diablo still dominate the market, but competitors are broadening their performance range from the traditional 45 to 55 cps (characters per second) to 15 to 80 cps.

The 45 to 55 cps range is dominated by Qume, an ITT subsidiary with 45% of the market, and Diablo, a Xerox subsidiary with 40% of the market. NEC also has a 10% market share, with the other companies dividing the remaining 5%. The prices of these machines should drop about $1000, to $2700 within the next two to three years, and the printer manufacturers will most likely introduce 30 cps versions selling for under $2000. Look for the 30 cps machines by year-end.

Expect a price war between the manufacturers of the lower-speed 15 to 20 cps printers. Prices may drop to $1200 or less by year-end. Those companies at loggerheads in this marketing war are Ricoh (which supplies Tandy), Olivetti, Pertec (which supplies machines made by Triumph-Adler), and C Itoh.

Fujitsu has already demonstrated an 80 cps daisy-wheel printer. Look for it in computer stores this summer. Qume, Diablo, and NEC are expected to introduce 80 cps machines, and some companies are working on 100 cps machines.

Ada On Microcomputers: At a recent ACM/SIGPLAN-sponsored meeting, TeleSoftware demonstrated the new Ada language on a 16-bit microcomputer. The compiler is 50 K bytes, supports run-time utilities, and produces pseudocode that runs directly on a Western Digital Pascal/Ada Microengine system. TeleSoftware said that the Ada code could be converted to the native code of some other microprocessor by use of a simple p-code interpreter (p-code is the machine language executed by the Microengine). Ken Bowles, the developer of UCSD Pascal and founder of TeleSoftware, said the company also intends to provide Ada compilers for 8086-, 68000-, and Z8000-based systems.

Western Digital will manufacture the Pascal/Ada Microengine for $12,750. It will include 128 K bytes of programmable memory, five I/O ports, a 10-slot chassis, video-display terminal, dual floppy-disk drives, and a line printer. The basic system will cost $6210. Western Digital also said that it soon expects to release a hard-disk controller, a cryptographic security module, a distributed multiprogramming operating system, and an X.25 packet-switching and local network product for the processor.

Computer Bulletin Boards Grow In Popularity: There are over 200 CBBS (computer bulletin board systems) in this country and their number grows weekly. Anyone with a terminal, modem, and telephone can access them. (If you use an Apple computer, they are called ABBS.) Most CBBS and ABBS serve as message centers for computer clubs. Some systems distribute software; for this service, a caller needs a computer with modem-driver software for file transfers.

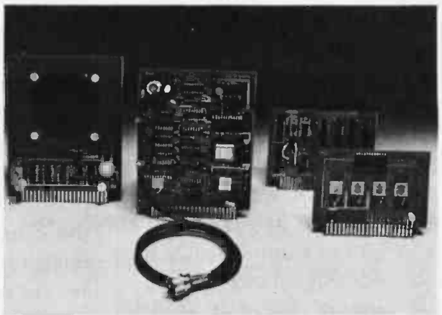
Other bulletin board systems serve special interests (eg: AMRAD's Blind Service CBBS 703-281-2222, the Family Historians' CBBS 703-978-7561, and Aviators' BBS 916-393-4459). For more information on all of these systems and how to access them, call the MAG-MEDIA-80 CBBS (415) 573-8768.

Here Come The Japanese: Expect to see several Japanese personal-computer systems in US stores this fall. Most of the systems will compete directly with the Apple II, Commodore PET, and Radio Shack TRS-80. They'll sell for the same price, perhaps slightly less, but offer extra features. NEC (Nippon Electric Company) *will* market the PC-8001 at the same price as the Apple II. (See "The NEC PC-8001: A New Japanese Personal Computer," by Michael Keith and C P Kocher, January 1981 BYTE, page 72.) Its features will match or exceed the Apple's. Matsushita (known in America as Quasar and Panasonic) and Sharp are also expected to have their systems on dealer shelves this fall. The Z80-based Sharp system is already on sale in England. One English distributor has already adapted CP/M for it.

Shopping Via Computer: Comparison retail shopping by home computer appears to be the wave of the future. One of the first computerized retailers is Comp-U-Card of Stamford, Connecticut. It claims to have 1.5 million members, of which 5000 already have computer I/O capability. To become a member it costs $18 per year, or $9 if you come under a group plan. To access the service's base of more than 30,000 items, you call it either via a toll-free telephone number or a two-way cable TV hookup. Comp-U-Card presents product specifications, price, and delivery charges. You can order any item at a typical savings of 20 to 40% or just use the service to compare prices.

Data-Base Systems Ex-

The VP-111 hobby computer: Start programming for only $99.



New! VP-111 Microcomputer.... $99. Assembled* and tested.

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Expandable on-board to 4K.
Expandable to 32K Bytes total.

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Ideal for low-cost control applications. Expandable to full VP-711 capability with VP-114 Kit.

*User need only connect cables (included), a 5-volt power supply and speaker.

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All the features of the VP-111 plus:

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- ☐ **VP-620** Cable—Connects VP-601/611 to VP-111/711 .... **$ 20**
- ☐ **VP-623** Cable—Unterminated for VP-601/611 .... **$ 20**
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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).

Computer Makers To Market Private Software: If you develop software for the HP-85 desk-top system in your spare time, Hewlett-Packard has a plan for marketing it. Hewlett-Packard will pay a royalty for the software and offer to sell you a system at a discount. Burroughs has a similar plan.

GM On Robotics Shopping Spree: GM has ordered 25 robots for its transmission-machining lines at its Warren, Michigan, facility. This is the largest undertaking of its kind in the automotive industry. The robots will cost almost $2 million. GM plans to buy as many as 1800 programmable robots between now and 1984.

In a related development, GM will use laser checking devices on its J-car-body assembly lines; the devices will check 20 to 30 points on each car for proper body fit and panel alignment. There will be no contact with the auto during this checking procedure.

AT&T To Enter Computer Market: In a landmark decision, the FCC will allow AT&T (American Telephone & Telegraph) to enter the computer business. The decision requires AT&T to set up a separate subsidiary to offer terminals and computer-enhanced services. Industry pundits speculate that AT&T will position itself to capitalize on the marriage of the telephone and computer technologies.

Used Word-Processor Market Burgeoning: You can save quite a bit of money by buying a used word processor. IBM, Xerox, Lanier, and Vydec systems are becoming available as companies upgrade to newer, more powerful machines. In Minneapolis, Word Systems Inc specializes in selling used word-processor systems, although they are also available through many other dealers.

Extra-Life Printer Ribbons: Replacing printer ribbons is expensive. Here's how to revive worn-out closed-loop ribbons housed in plastic cases: carefully pry open the case without disturbing the ribbon. Spray the ribbon lightly (don't overspray) with an all-purpose lubricant such as WD-40, close the case, and let it stand overnight. The lubricant causes the ink from the moist unused portions of the ribbon to flow down into the dry areas of the ribbon. This renewal process can usually be repeated several times before the ribbon is completely exhausted.

Random News Bits: United States Robots, Conshocken, Pennsylvania, claims to have developed a five-jointed robot arm using seven microprocessors—one for each joint, one for math calculations, and one for overall coordination. The microprocessors do multiprocessing on a shared bus and memory system. ...Toshiba and Hitachi have demonstrated "pocketbook TVs" that typically use 120- by 160-element LCDs (liquid-crystal displays). Matsushita and Hitachi reportedly will introduce products next year using these displays. ...Interested in learning more about possible health hazards associated with CRT (cathode-ray tube) terminals? Then you should get a copy of the 16-page pamphlet entitled *Health Protection for Operators of DCTs/CRTs*. It's published by the New York Committee for Occupational Safety and Health, 32 Union Sq, Rm 404, New York NY 10003 ($1 for individuals; $3 for institutions).

Random Rumors: Apple Computer may put off its plans to build 5-inch Winchester-disk drives for the Apple III and the rumored Apple IV. Apple has reportedly inked a contract for 10,000 six-megabyte ST-506 drives from Seagate Technology. Apple still plans to produce a hard-disk drive for introduction next year. ...It is rumored that Digital Equipment Corporation has developed a single-integrated-circuit version of the PDP-11 and that it exists in prototype form. No production plans have as yet been established. ...There is a lot of talk circulating that Xerox will soon release a version of the Smalltalk programming language and a complete book describing it. Most likely it will be released to universities who presently have the Xerox Alto system (an experimental personal computer). ...*Electronic News* recently reported that IBM and Tandy were holding discussions on the possibility of IBM 3103 video terminals being sold through Radio Shack stores. ...According to a report issued by International Resource Development Inc (IRD) in Norwalk, Connecticut, IBM, Xerox, and Matsushita will introduce typewriters with voice input by 1983. IRD predicts that the typewriters will correctly recognize 93% of "typical business English as spoken by the average executive," and that the unit will have a video screen that displays the spoken words. Corrections and changes can be made on the screen....

MAIL: I receive a large number of letters each month as a result of this column. If you write to me and wish a response, please include a self-addressed, stamped envelope.

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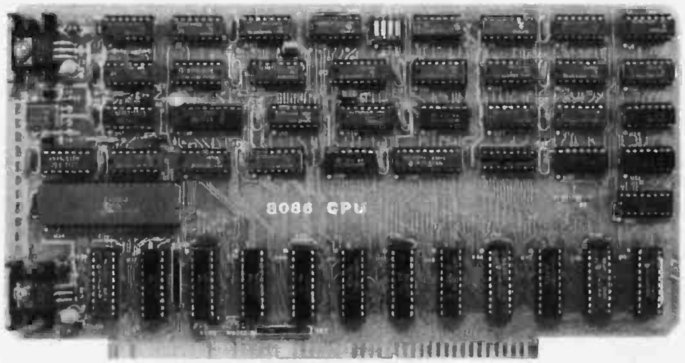

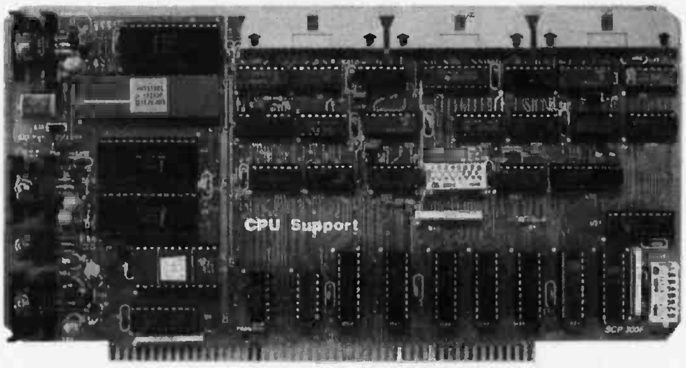

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Continued from page 20:

Resistible Puzzle

John Moore revived the earlier-published problem of creating a network with resistance of 355/113 (a very close approximation to π) with a minimum number of unit-valued resistors. (See the January 1981 BYTE, page 16.) He improved greatly on W Lloyd Milligan's 26-unit solution (see the August 1980 BYTE, page 20) by presenting two 18-unit solutions and asking if anyone could find a solution with 17 or fewer resistors.

By abandoning their continued-fraction method in favor of one based on Diophantine equations (those having positive, non-zero integer solutions), I was able to come up with two different 15-unit solutions. (See figures 1a and 1b.)

I believe these two to be minimal, and essentially the only minimal solutions (ie: except for other solutions created by trivial transpositions of series and parallel elements in one of these resistors) within the class of networks examined by this method and by the continued-fraction method (ie: all simple series-parallel networks).

But there are many more ways to connect a handful of resistors than just in simple series-parallel networks!

I looked for a solution with a bridge as a part of the total network. With the help of a TI-58 programmable calculator, I was able to find a 14-unit solution. (See figures 2 and 3 on page 270.)

Of course, with 12 or 13 resistances to connect together in an arbitrary fashion, much more complicated figures than bridges are possible. Unfortunately, the calculation of resulting network impedance, and the searching through the various configurations, becomes correspondingly complex. I suspect that the 14-unit solution can be improved upon.

David F Smith
3033 Turk Blvd, #3
San Francisco CA 94118

(1a) (1b)

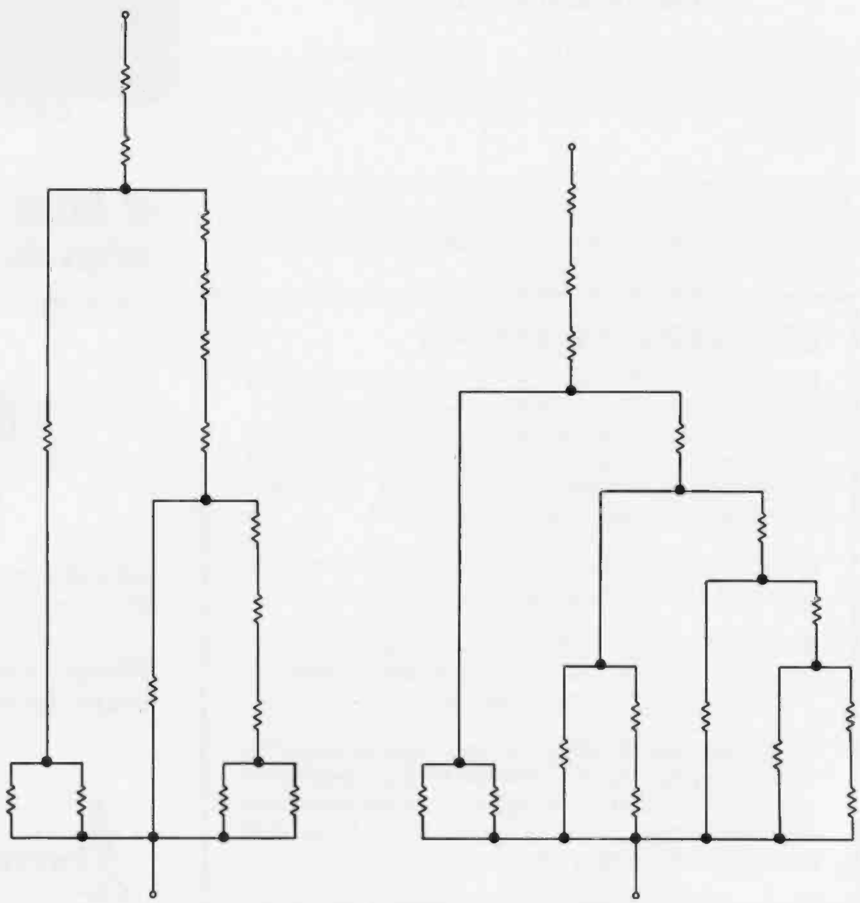

Figure 1: *Two 15-unit networks with* $Z = \frac{355}{113}$

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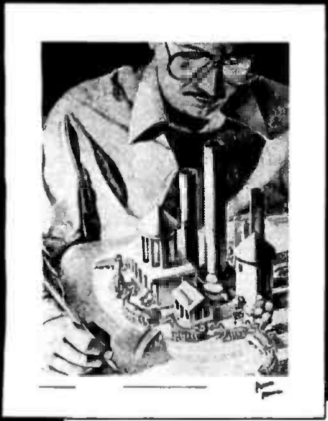
#1



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#2

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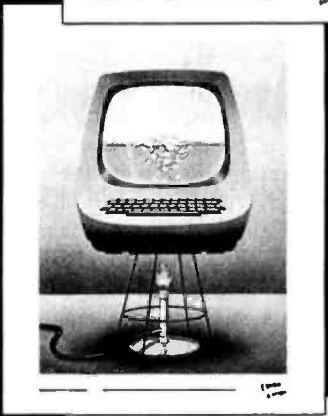
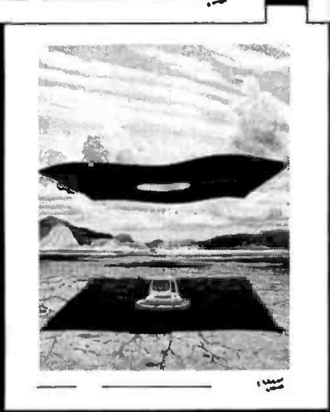
#3



#7

#4



#8

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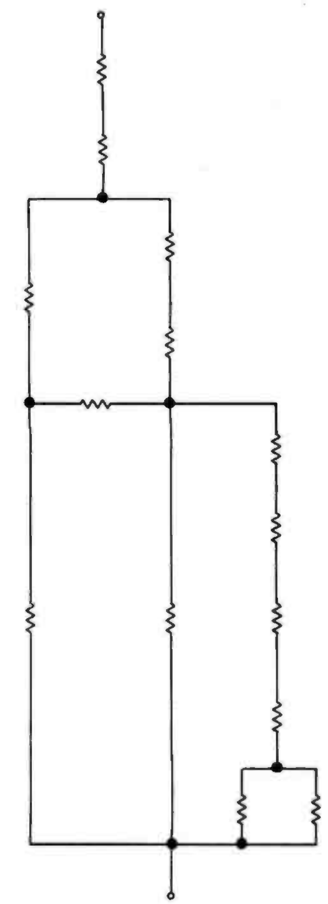
Figure 2: *A 14-unit network with* $Z = \frac{355}{113}$



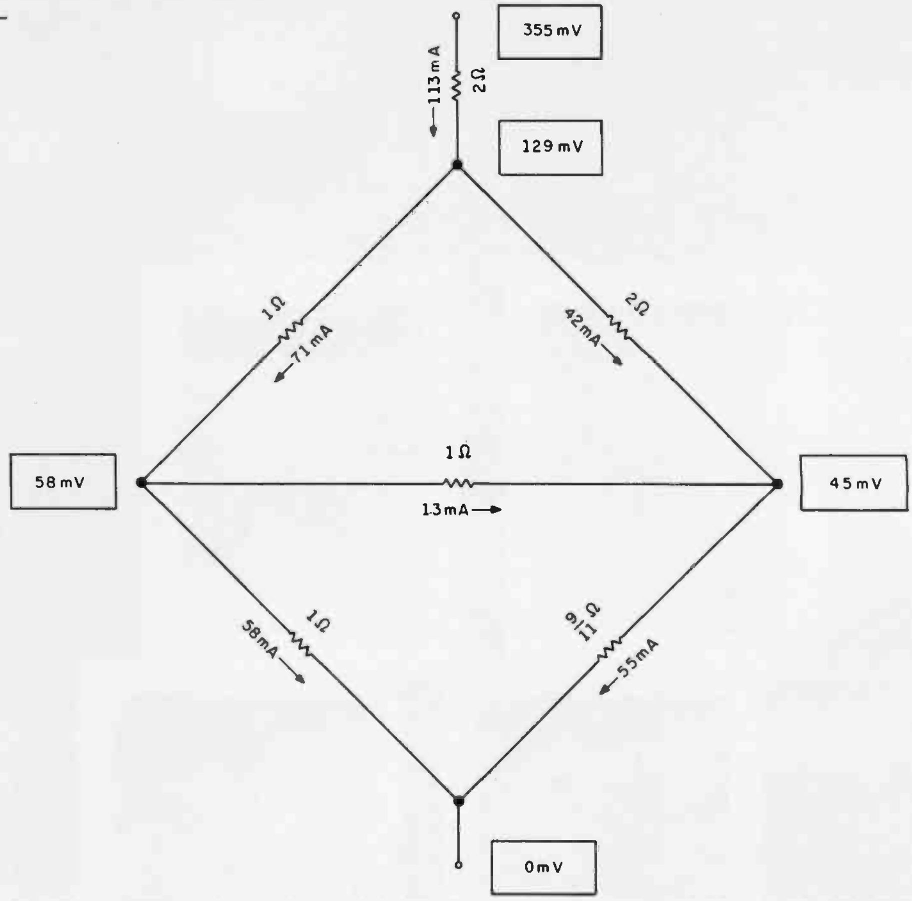


Figure 3: *Voltages and currents in the 14-unit network with 355 mV across it.*

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 V4 = V2 and V3 = V1. Line impedance can be compensated for by making R0 variable.

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

Smart Wheelchair Project

Steve Ciarcia's article "Home in on the Range! An Ultrasonic Ranging System" (November 1980 BYTE, page 32) was excellent. I would, however, like to make BYTE readers aware of another project that has incorporated the Polaroid Ultrasonic Ranging technology. The project was funded by the Veterans Administration Rehabilitative Engineering Research and Development Center of Palo Alto, California. The participants, Karen Altman, Rick Epstein, Leslie Gerding, Wayne Ledger, and Dave Parker, were graduate students last year at Stanford Mechanical Engineering.

The objective was to design, develop, and successfully fabricate a "smart" electronic wheelchair. Its construction included ten ultrasonic sensors, eight of which were used to detect approaching obstacles or the presence of a wall on either side of the chair. The remaining sensors were focused on the user's head from two angles.

The chair has many modes of operation: the most important is the head-control mode. Here, the user directs the movements of the chair by head motions. To move the chair forward, the user posi-

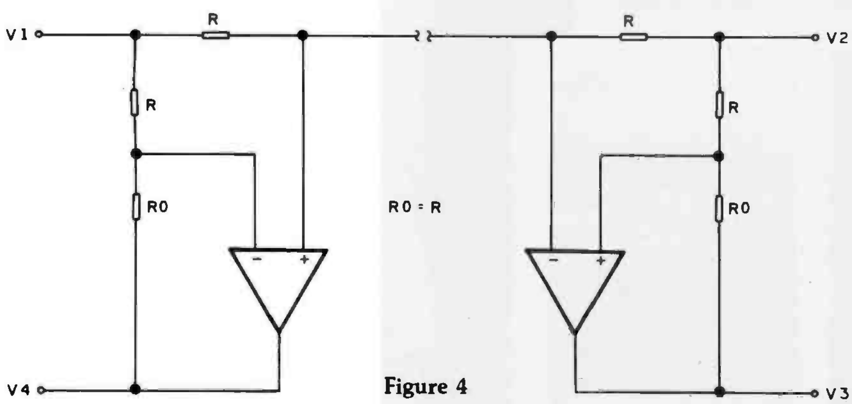


Figure 4

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tions his or her head toward the front of the chair. Similar operations control the three remaining directions. In effect, the user's head is a proportional-control joystick. One can readily see that this type of noncontacting control would be helpful for people who have no usable arm function.

In operation, the front-facing ultrasound sensors detect the presence of obstacles in the chair's path. When such an obstacle comes within a predetermined distance, the chair automatically slows and stops before running into it. If the "obstacle" moves away, the chair will follow at a fixed distance.

Side sensors serve to detect walls. A mode to "follow that wall" enables a chair to travel parallel to the chosen wall at a fixed distance. Open doorways are detected and passed over, but a discontinuity of more than a few feet disables the wall-following mode and waits for further commands from the user.

A "cruise control" mode does not use any additional sensors, but instead relies on wheel-speed data obtained from two optical shaft encoders. Once in this mode, the chair proceeds at a constant speed and heading despite changes in terrain.

A final mode allows the head to be moved without affecting the chair.

The user initializes the system to the range of his or her head motion by means of a "training" program that instructs the user to center the head, to move it to the left or right, and forward or backward. The program uses this information to calibrate the position/speed algorithm as well as set up a dead band around the user's rest position.

The hardware presently consists of a Z80 microprocessor, 64 K bytes of memory, and an external disk-drive system. Once the program is loaded, the disk is disconnected and the user drives off. The software executive is written in BASIC, with a majority of the actual real-time program coded in machine language and as arithmetic function calls. The listing consumes 40 pages.

The current construction phase will shrink the initial hardware and software configuration by one-third. A final design will capture the features on a single printed-circuit board.

The approach taken in pursuit of the interface between the ultrasound sensors and the microprocessor is considerably different from the method described in Steve's article. Since the Polaroid kits were not available at the time of construction, several new cameras were sacrificed to acquire the parts required. In addition, the computer interface was done not at the EDB level, but at the custom ultrasound board level. To perform a ranging, the computer generates a transmit request pulse via a convenient parallel output bit. The output from the board is then interrogated to start a software timing loop that is terminated by the received echo signal. The number of times the loop is performed gives a fairly precise measure of the range. Dividing this value by an appropriate factor will yield the range in whatever units are required. In the course of the project, a resolution of about a quarter of an inch was obtained over distances ranging from 9 inches to 20 feet (depending on surface characteristics).

Additional information about this ongoing project can be obtained by writing me at the address below.

David L Jaffe
Palo Alto VA Medical Center
Rehabilitative Engineering Research and Development Center
3801 Miranda (153)
Palo Alto CA 94304■

dBASE™ II vs. the Bilge Pumps.

by Hal Pawluk

We all know that bilge pumps suck.

And by now, we've found out—the hard way—that a lot of software seems to work the same way.

So I got pretty excited when I ran across **dBASE II**, an assembly-language relational Database Management System for CP/M. It works! And even a rank beginner like myself got it up and running the first time I sat down with it.

If you're looking for software to deal with your data, too, here are some tips that will help:

Tip #1: Database Management vs. File Handling:

Any list or collection of data is, loosely, a data base, but most of those "data base management" articles in the buzzbooks are really about file handling programs for specific applications. A real Database Management System gives you data and program independence (no reprogramming when data changes), eliminates data duplication and makes it easy to turn data into information.

Tip #2: Assembly Language vs. BASIC:

This one's easy: if you're setting up a DBMS, you're going to be doing a lot of sorting, and Basic sorts are s-l-o-w. Run a benchmark on a Basic system like S*-IV against a relational DBMS like **dBASE II** and you'll see what I mean. (But watch it: I've also seen one extremely slow assembly-language file management system.)

Tip #3: Relational vs. Hierarchal & Network DBMS.

CODASYL-like hierarchal and network systems, around since the 1960's, are being phased out on the big machines so why get stuck with an old-fashioned system for your micro? A relational DBMS like **dBASE II** eliminates the predefined sets, pointers and complex data structures of a CODASYL-type DBMS. And you don't need to be a programmer to use it.

dBASE II vs. everything else.

dBASE II really impressed me.

Written in assembly language (with no need for a host language), it handles up to 65,000 records (up to 32 fields and 1000 bytes each), stores numeric data as packed strings so there are no round-off errors, has a super-fast multiple-key sort, and supports ISAM based on B* trees.

You can use it interactively with English-like commands (DISPLAY 10 PRODUCTS), or program it (so when you've set up the formats, your secretary can do the work). Its report generator and user-definable full screen operations mean that you can even use your existing forms.

And if all this makes your mouth water, but you've already got all your data on a disk, that's okay: **dBASE II** reads your ASCII files and adds the data to its own database.

Right now, I'm using **dBASE II** with my word processor for budgeting, scheduling and preparing reports for my clients.

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An Unheard-of Money-Back Guarantee.

dBASE II is the first software I've seen with a full money-back guarantee.

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• REPEAT...UNTIL • WHILE • IF...THEN...ELSE
SSS RATFOR is supplied with *source code* in FORTRAN and RATFOR.
System Requirements & Prices:
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- terminal mode for timesharing between systems
- conversational mode • send files • receive files

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Encode/Decode II provides enhanced security for the most demanding needs.
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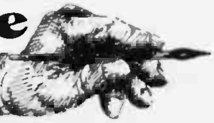


CP/M REGISTERED TRADEMARK DIGITAL RESEARCH

Text continued from page 228:

My application required that I code the 10 decimal digits (0 thru 9). I borrowed the 7-bit-per-digit bar code used in the UPC (Universal Product Code) to represent those digits. [*Note that UPC bar codes, as shown in figure 1, have a different appearance from 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:

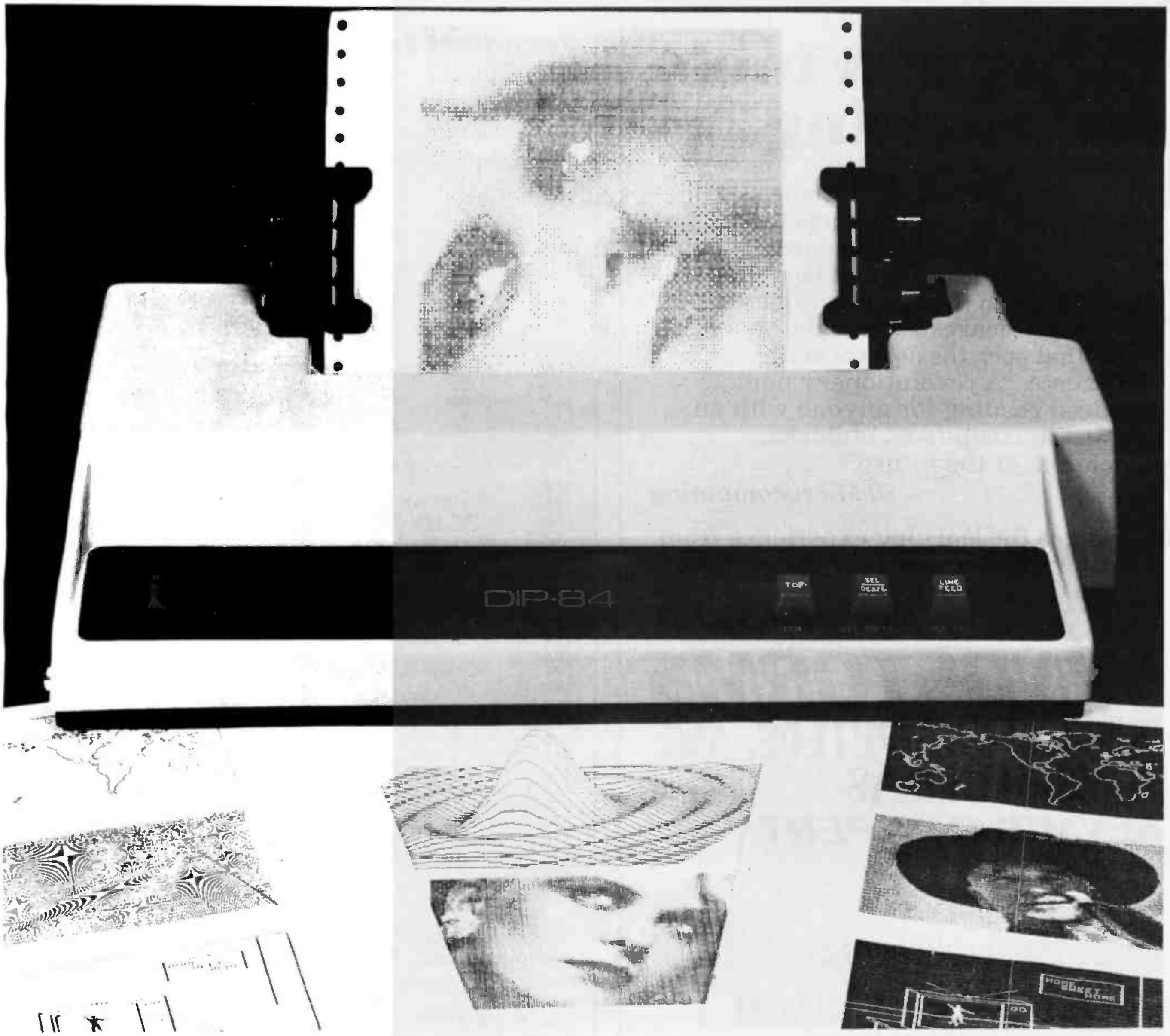
```
LPRINT CHR$(08); CHR$(4);
```

In my application, I placed equivalent Arabic numerals

800218

824009

Figure 1: *Bar codes generated by a Centronics 737 dot-matrix printer and a TRS-80 computer, using the program in listing 1. The program also prints the equivalent Arabic numerals under the code.*



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Listing 1: *Bar-code generator. The program, written for the Radio Shack TRS-80 with Level II BASIC, generates bar codes for the decimal digits 0 thru 9 on a Centronics 737 printer.*

```
10 DIM B(10,7)
20 '
30 '     LOAD THE BINARY ARRAY
40 '
50 FORI=0TO9:FORJ=1TO7:READB(I,J):NEXTJ:NEXTI
60 '
70 '     SET THE FROFORTIONAL SFACING MODE ON THE FRINTER
80 '
90 LFRINTCHR$(27);CHR$(17);
100 '
110 '     BEGIN SIX-DIGIT INFUT LOOF
120 '
130 FORN=1TO6
140 '
150 '     STROBE KEYBOARD FOR AN INFUT DIGIT
160 '
170 Y$=INKEY$:IFY$=""THEN170  ELSEI=VAL(Y$):A$(N)=Y$
180 '
190 '     RETRIEVE BINARY CODE FOR THE DIGIT AND FRINT
200 '     THE BAR CODE REFRESENTATION FOR IT.
210 '
220 FOR K=1TO7:J=B(I,K)
230 LFRINTCHR$(92*J+32);CHR$(08);CHR$(4);:NEXTK:NEXTN
240 '
250 '     FRINT THE ARABIC NUMERALS
260 '
270 LFRINT" ":FORN=1TO6:LFRINTA$(N);:NEXTN
280 '
290 '     BINARY CODE FOR DIGITS 0 - 9
300 '
310 DATA 0,0,0,1,1,0,1
320 DATA 0,0,1,1,0,0,1
330 DATA 0,0,1,0,0,1,1
340 DATA 0,1,1,1,1,0,1
350 DATA 0,1,0,0,0,1,1
360 DATA 0,1,1,0,0,0,1
370 DATA 0,1,0,1,1,1,1
380 DATA 0,1,1,1,0,1,1
390 DATA 0,1,1,0,1,1,1
400 DATA 0,0,0,1,0,1,1
410 END
```

after the 6-digit bar code to allow a quick check of the coded identifier. An example of bar codes generated with the Centronics 737 appears in figure 1.

The program in listing 1 was written for the Radio Shack TRS-80 using Level II BASIC. This is only a sample program that can be modified to suit your taste, but it demonstrates how you can generate bar codes on a low-cost printer. ■

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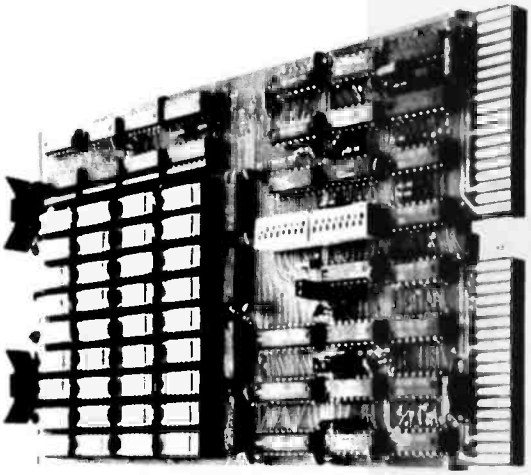

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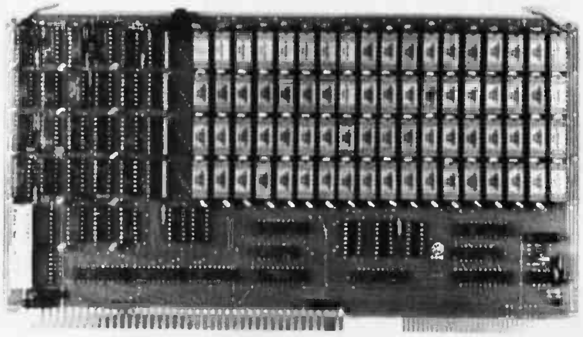

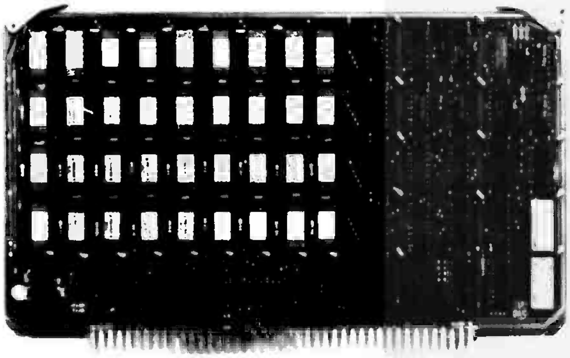

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Using Interrupts on the Apple II System

George M White
Computer Science Department
University of Ottawa
Ottawa, Ontario K1N 6N5 Canada

The designers of the Apple II personal computer made a judicious choice of software/hardware tradeoffs. The most important software systems are stored in ROM (read-only memory) at high addresses where they are, for the most part, out of sight. Since the monitor, BASIC interpreter, and miniassembler are stored in ROM, they cannot be destroyed by user programs running out of control, nor can they be altered to produce strange results.

A surprising feature of the Apple II's system software is that it makes little use of the 6502 interrupt system.

A surprising feature of the Apple II's system software is that it makes little use of the interrupt system of the 6502 microprocessor. However, the creators of the monitor have correctly assumed that some users might want to make use of interrupts, so they have provided several facilities to aid the user in doing so. The hardware and software facilities permit the user to write interrupt-service routines and to wire up interrupt generators that easily fit into one or more of the eight I/O (input/output) card slots, conveniently located under the Apple's removable plastic cover.

Interrupt-Service Software

Let's compare interrupt-service routines to program subroutines. In the BASIC language, subroutines are called at a known *location* within a program by a GOSUB statement. The subroutine is not executed (or shouldn't be) until the GOSUB statement is encountered during the course

Acknowledgment

Most of this article was written while the author was enjoying the incomparable hospitalité of L'Institut de Recherche d'Informatique et d'Automatique in Rocquencourt, France.

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of the program. Subroutines are usually written to perform a specific action such as altering values of variables, I/O operations, etc.

Interrupt routines, on the other hand, are called at a specific point in *time*. An interrupt signal arrives, and the interrupt-service routine is called. There is no warning. The signal can arrive at any time, and the program being executed can be interrupted at any point.

The interrupt routine is a program like any other program. It can do everything an ordinary program can do, such as calculate numbers, manipulate strings, ring bells, or print messages on the console. Usually, the interrupt system found on microprocessors is used to control a computer peripheral device or to monitor and control external machinery.

The interrupt system can continuously watch the temperature of a furnace, the condition of a fire or burglar alarm, or the time of day. When something unusual happens, when the temperature goes too high or a burglar alarm sounds, the interrupt system alerts the computer to respond to the unusual condition and perform necessary actions.

However, the writing of such a program is a demanding task. The programmer must be aware of five aspects of interrupts that involve both the hardware and software of the system.

Necessary Conditions

1. *There must be an external device capable of sending an interrupt signal to the computer.*

The smaller systems used by novice BASIC programmers usually do not contain devices capable of generating interrupts. Even if they did, the BASIC language system available is not able to handle them directly, because most versions of BASIC do not recognize that interrupts exist.

The external device that sends the interrupt can be anything external to the processor and memory; it does not have to be physically located outside the computer box itself. Some common devices used as sources of interrupts are real-time clocks, terminals, and other computers. This list is not exhaustive. *Anything* capable of generating an electrical signal—automobile, household appliance, or burglar alarm—can be used as a source of interrupts.

2. *The processor must be capable of receiving and acting upon the interrupt signal.*

This implies not only that the signal must be wired into the computer with all its voltages having the correct values, but also that the processor must be set up to respond to the signal. We shall see later that the 6502 microprocessor can actually ignore some kinds of interrupts if the programmer has told it to ignore them.

Anything capable of generating an electrical signal—automobile, household appliance, or burglar alarm—can be used as a source of interrupts.

3. *The processor must be able to tell which of several possible devices generated the interrupt.*

If there is only one interrupt-generating device wired into the system, there won't be any problem identifying the source of the interrupt when it arrives. But if there are several interrupt sources—all trying to get the attention of the processor—the computer must have some way of telling which interrupt source is responsible for sending the signal, so it can take appropriate action.

4. *The processor must respond to the interrupt by doing something.*

When an interrupt signal arrives and is accepted by the computer, the program must perform an appropriate action (ie: "service" the interrupt). In some cases, this action is very simple, such as printing a character on a terminal. In other cases, the system may have to do something much more complicated, like placing a telephone call, sounding an alarm, or aborting the program it was executing.

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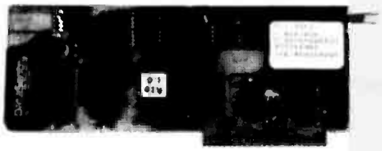

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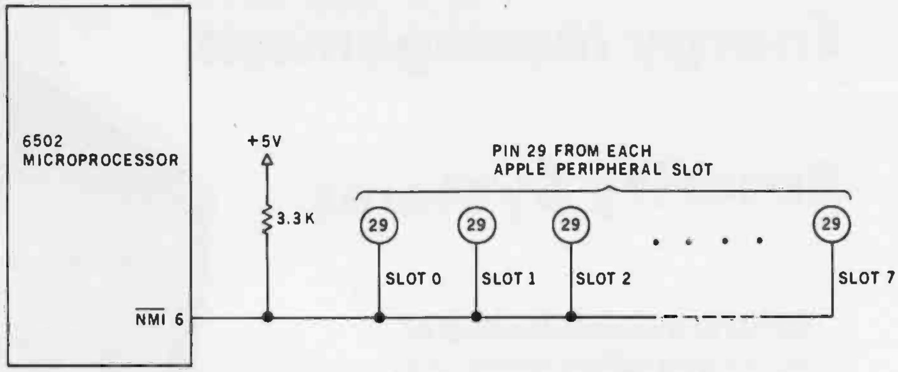

Figure 1: *The 6502 $\overline{NMI}$ signal and the Apple II peripheral slots. The $\overline{NMI}$ signal is connected to pin 29 of each of the slots and is held high by the pull-up resistor shown. An interrupt is generated if the peripheral card in any of the slots presents a low impedance to ground to its pin 29.*

5. *After the service has been performed, the processor usually must return to the interrupted program and continue from the point of interruption.*

When an interrupt signal arrives and is accepted by the computer, the program must perform an appropriate action.

Usually (but not always), the interrupt has interfered with the execution of a program. After the interrupt has been successfully serviced, control should return to the interrupted program or process at the point of interruption without modifying the process in any way. Sometimes this program is nothing other than an endless loop waiting for interrupts to arrive.

Nonmaskable Interrupts

The Apple II has two separate interrupt lines entering its 6502 processor. They work somewhat differently.

Pin number 6 on the 6502 package is an active-low signal input called the *nonmaskable interrupt*, $\overline{NMI}$. It is connected through the printed-circuit board to a pull-up resistor and to pin 29 in each of the eight I/O slots shown in figure 1.

If none of the circuit cards in the slots has anything attached to its pin 29, the potential at the $\overline{NMI}$ input observed by the 6502 is always held high by the pull-up resistor. This is the normal mode of operation. If a low impedance to ground is presented to pin 29 by *any* of the slots, the $\overline{NMI}$ line goes low, causing an interrupt condition to be generated in the 6502. This is the definition of the nonmaskable interrupt. This interrupt can be better understood by examining each of the five aspects presented earlier.

1. Any external device can generate an interrupt by presenting a ground (or low impedance to ground) potential to pin 29 in any of the I/O slots. Thus, the Apple II can have eight different interrupt sources, and they all may decide to interrupt at once.
2. The $\overline{NMI}$ signal is always recognized by the 6502 microprocessor, because it is nonmaskable. (Maskable interrupts will be discussed shortly.)
3. If there is only one device capable of sending the $\overline{NMI}$ signal, there is no question which device sent it. But if there are two or more interrupting devices, a problem arises. The 6502 microprocessor has only a single $\overline{NMI}$ input line, and every $\overline{NMI}$ signal goes there. In the Apple II, the processor can differentiate among several possible sources by *polling* the devices.

Polling is done by asking each device if it sent the interrupt signal or not. A program directs the computer

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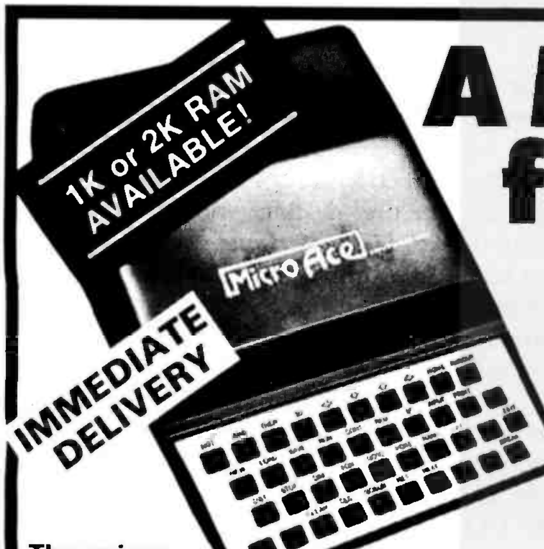

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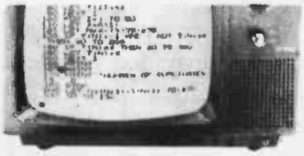

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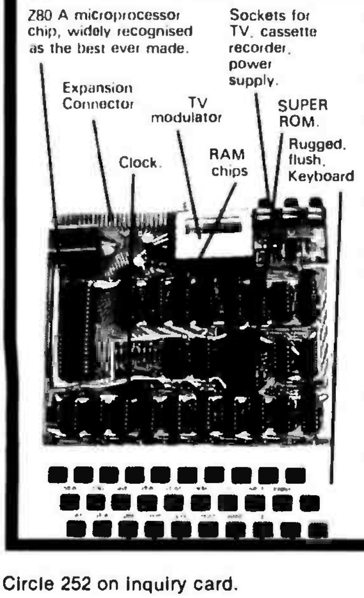

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to examine the status of each device which might have sent the interrupt. The details of this depend greatly on the way the devices are wired up, but in principle some of the 50 lines in the I/O slots can be used by the device to present logical flags or form data buffers. Examination of these signal lines by the program can then determine whether the device in question sent the $\overline{\text{NMI}}$ or not.

Daisy-chain inhibition of interrupts can be provided for in hardware by using control lines INT IN (pin 28) and INT OUT (pin 23) on the I/O slots, which are reserved for such a purpose. Various I/O devices can thereby have different priorities for interrupt servicing.

The Apple II's motherboard contains the wiring that links the boards together. This arrangement is shown in figure 2. Pin 28 (the INT IN line) of slot 0 has no connection, but pin 23 (INT OUT) of slot 0 connects to pin 28 of slot 1. Pin 23 of slot 1 connects to pin 28 of slot 2, and so on, up to slot 7. Pin 23 of slot 7 has no connection.

There are several methods for wiring the daisy chain, but in the most common configuration there is a low impedance (or a direct connection) on each interrupt-using card between INT IN and INT OUT. I/O cards have priority in interrupt service according to their physical position in the I/O slots. Cards in the lower-numbered slots have higher priority, while cards in the higher-numbered slots have lower priority: it is not that the processor will process the I/O functions of the higher-priority cards before dealing with lower-priority cards if interrupts occur at the same time, but that the lower-priority cards are *not permitted* to generate an interrupt signal until the higher-priority device allows it.

In this scheme, *I/O slots must be contiguously filled with cards so a continuous circuit, the daisy chain, is completed between the cards on the INT IN and INT OUT lines.* I/O cards that do not use the interrupt system can be placed between cards that do if the noninterrupting cards have a jumper or connection between the contacts for pins 28 and 23 to maintain circuit continuity.

The highest-priority I/O card must reside in a lower-numbered slot than any other interrupt-generating card. The highest-priority card is special: it is responsible for placing a voltage indicating a high logic condition (usually +5 V) on the INT OUT pin for its slot. The lower-priority cards need not have this capability. They need only have the capability of opening the circuit between the INT IN and INT OUT pins for their slots.

Suppose, for example, that there are interrupt-generating I/O interface cards in slots 5, 6, and 7. The card in slot 5 must be capable of placing a potential of +5 V on the INT OUT connection. The card in slot 6 must

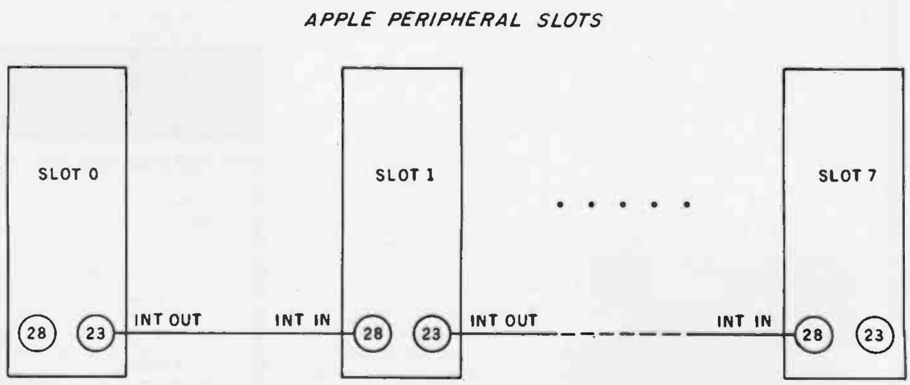

Figure 2: *Using daisy chaining to create a priority system of interrupts. The INT OUT (pin 23 of each slot) and INT IN (pin 28 of each slot) signals are connected to each other to create a daisy chain that is broken by an interrupting slot. A peripheral device is not allowed to generate an interrupt unless it has highest priority or "permission" from higher-priority devices. Peripherals in lower slots have a higher interrupt priority than peripherals in higher slots. See the text for details.*

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Perhaps the most annoying shortcoming of the Apple II® is its limitation of displaying only 40 columns by 24 lines of text, all in uppercase. At last, Apple II® owners have a reliable, trouble-free answer to their text display problem. VIDEOTERM generates a full 80 columns by 24 lines of text, in upper and lower case. Twice the number of characters as the standard Apple II® display. And by utilizing a 7 by 9 character matrix, lower case letters have true descenders. But this is only the start.

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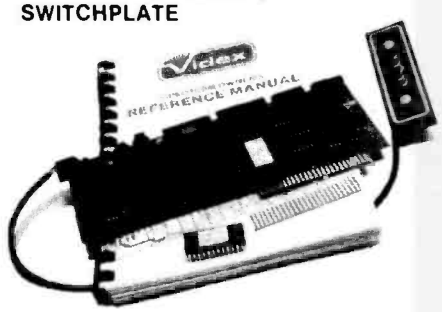
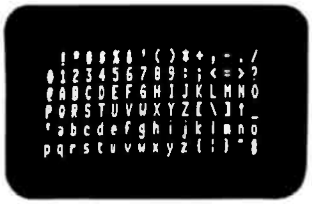


7X12 MATRIX
18X80 OPTIONAL



7X9 MATRIX
24X80 STANDARD

VIDEOTERM

BASICs VIDEOTERM lists BASIC programs, both Integer and Applesoft, using the entire 80 columns. Without splitting keywords. Full editing capabilities are offered using the ESCape key sequences for cursor movement. With provision for stop/start text scrolling utilizing the standard Control-S entry. And simultaneous on-screen display of text being printed.

Pascal Installation of VIDEOTERM in slot 3 provides Pascal immediate control of the display since Pascal recognizes the board as a standard video display terminal and treats it as such. No changes are needed to Pascal's MISC.INFO or GOTOXY files, although customization directions are provided. All cursor control characters are identical to standard Pascal defaults.

Other Boards The new Microsoft Softcard* is supported. So is the popular D. C. Hayes Micromodem II*, utilizing customized PROM firmware available from VIDEX. The powerful EasyWriter* Professional Word Processing System and other word processors are now compatible with VIDEOTERM. Or use the Mountain Hardware ROMWriter* (or other PROM programmer) to generate your own custom character sets. Naturally, VIDEOTERM conforms to all Apple OEM guidelines, assurance that you will have no conflicts with current or future Apple II* expansion boards.

Advanced Hardware Design VIDEOTERM's on-board asynchronous crystal clock ensures flicker-free character display. Only the size of the Pascal Language card, VIDEOTERM utilizes CMOS and low power consumption ICs, ensuring cool, reliable operation. All ICs are fully socketed for easy maintenance. Add to that 2K of on-board RAM, 50 or 60 Hz operation, and provision of power and input connectors for a light pen. Problems are designed out, not in.

Available Options The entire display may be altered to inverse video, displaying black characters on a white field. PROMs containing alternate character sets and graphic symbols are available from Videx. A switchplate option allows you to use the same video monitor for either the VIDEOTERM or the standard Apple II* display, instantly changing displays by flipping a single toggle switch. The switchplate assembly inserts into one of the rear cut-outs in the Apple II* case so that the toggle switch is readily accessible. And the Videx KEYBOARD ENHANCER can be installed, allowing upper and lower case character entry directly from your Apple II* keyboard.

Firmware 1K of on-board ROM firmware controls all operation of the VIDEOTERM. No machine language patches are needed for normal VIDEOTERM use.

Firmware Version 2.0

Characters	7 x 9 matrix	Display	24 x 80 (full descenders)
Options	7 x 12 matrix option; Alternate user definable character set option; Inverse video option.		18 x 80 (7 x 12 matrix with full descenders)

Want to know more? Contact your local Apple dealer today for a demonstration. VIDEOTERM is available through your local dealer or direct from Videx in Corvallis, Oregon. Or send for the VIDEOTERM Owners Reference Manual and deduct the amount if you decide to purchase. Upgrade your Apple II* to full terminal capabilities for half the cost of a terminal. VIDEOTERM. At last.

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Softcard* is a trademark of Microsoft
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PRICE:
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- MANUAL refund with purchase .... $ 19
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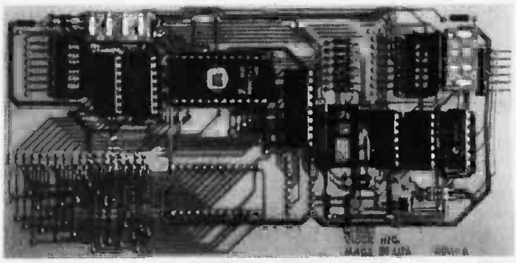
Videx has the perfect companion for your word processor software: the **KEYBOARD AND DISPLAY ENHANCER**. Install the enhancer in your APPLE II and be typing in lower case just like a typewriter. If you want an upper case character, use the SHIFT key or the CTRL key for shift lock. Not only that, but you see upper and lower case on the screen as you type. Perfectly compatible with Apple Writer and other word processors like, for example, Super-Text.

If you want to program in BASIC, just put it back into the alpha lock mode; and you have the original keyboard back with a few improvements. Now you can enter those elusive 9 characters directly from the keyboard, or require the Control key to be pressed with the RESET to prevent accidental resets.

KEYBOARD AND DISPLAY ENHANCER is recommended for use with all revisions of the APPLE II. It includes 6 ICs, and EPROM and dip-switches mounted on a PC board, and a jumper cable. Easy installation, meaning no soldering or cutting traces. Alternate default modes are dip-switch selectable. You can even remap the keyboard, selecting an alternate character set, for custom applications.



PRICE
- KDE-700 (REV. 7 or greater) .... $129.
- KDE-000 (REV. 6 or less) .... $129.

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Videx INC

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have a low impedance from INT IN to INT OUT as a normal condition (so the card in slot 7 will be able to "see" the +5 V provided by the card in slot 5), and the cards in both 6 and 7 must be able to detect the absence of the +5 V potential on the INT IN line. The controlling circuitry of the slot-6 and slot-7 cards must recognize the absence of the INT IN high logic level and interpret it as denoting a condition in which the lower-priority cards are not permitted to generate an interrupt.

When the slot-5 device needs to interrupt the processor, it causes a low logic level to be placed on the $\overline{\text{NMI}}$ line, pin 29, as previously described. At the same time, it removes the high logic level from the INT OUT line, pin 23. The slot-6 and slot-7 devices sense the low level on their INT IN pins, and they refrain from issuing an interrupt signal as long as this condition persists.

Meanwhile, the polling software in the processor polls the slot-5 card, as it has been set up to do first; the software polls the I/O cards in order of priority. Finding the slot-5 card needing attention, the software branches to the appropriate interrupt-servicing routine.

When the interrupt routine for the slot-5 device has finished its business, the interrupt condition is cleared, and control returns to the interrupted processing. At this point, the slot-5 card restores the +5 V potential to the INT OUT line, and the slot-6 and slot-7 cards can issue interrupts as necessary.

If the slot-6 card needs to issue an interrupt (and +5 V is present on its INT IN pin), it activates the $\overline{\text{NMI}}$ line in the same way. But because it is not the source of the +5 V on the INT IN/INT OUT path, it merely activates logic to create a high impedance between the INT IN and INT OUT pins for its own slot, thereby preventing the slot-7 device from seeing the +5 V INT IN level. In this way, the slot-6 card asserts its higher interrupt priority over the slot-7 card. When the slot-6 interrupt has been serviced by the processor, the low impedance is restored between the INT IN and INT OUT pins of slot 6, and the +5 V potential propagates once more along the motherboard traces to slot 7.

4. When an interrupt arrives at the 6502, the microprocessor responds by performing the following operations on its stack:

Push program-counter high byte
Push program-counter low byte
Push status register
Jump via hexadecimal FFFA

Thus, the PC (program counter) and the status register are pushed (saved) onto the stack (the high byte of the PC is pushed first, then the lower byte, and, finally, the status register, P). After these stacking operations, the processor executes an indirect jump via hexadecimal memory location FFFA (ie: the location jumped to is the contents of FFFB (high byte) and FFFA (low byte) considered as a 16-bit number). In the Apple II computer, this is a ROM address, and Apple Computer Inc has set its contents to hexadecimal 03FB (remember that the lower byte contains the low-order address). Therefore, the system jumps to hexadecimal location 03FB and starts executing what it finds there. This area contains programmable memory, and it is the user's responsibility to start the interrupt-service routine there. Unfortunately, this area is organized so there are only 3 bytes of memory actually available here. Because of this, the user must store a jump instruction in these 3 bytes that will direct execution to another area of memory, typically to the page beginning at hexadecimal location 0300 or to some higher area such as hexadecimal 0800 or 1000.

Generally, the first instructions in the interrupt-service routine are those to save the present value of the A, X, and Y registers on the stack. After that, the interrupt service is performed, and the A, X, and Y registers are restored. The routine should always be terminated with an RTI (return from interrupt) instruction. This instruction will unstack the status registers and program counter, and execution will continue from the point it had reached just before the occurrence of the interrupt. The inter-

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GAMES, SIMULATIONS, EDUCATION and MISCELLANEOUS

BRIDGE 2.0 (Available for all computers) — Price: $17.95 Cassette/$21.95 Diskette
An all-inclusive version of this most popular of card games. This program both BIDS and PLAYS either contract or duplicate bridge. Depending on the contract, your computer opponents will either play the offense OR defense. If you bid too high, the computer will double your contract! BRIDGE 2.0 provides challenging entertainment for advanced players and is an excellent learning tool for the bridge novice.

HEARTS 1.5 (Available for all computers) — Price: $14.95 Cassette/$18.95 Diskette
An exciting and entertaining computer version of this popular card game. Hearts is a trick-oriented game in which the purpose is not to take any hearts or the queen of spades. Play against two computer opponents who are armed with hard-to-beat playing strategies.

CRIBBAGE (TRS-80 only) — Price: $14.95 Cassette/$18.95 Diskette
This is simply the best cribbage game available. It is an excellent program for the cribbage player in search of a worthy opponent as well as for the novice wishing to improve his game. The graphics are superb and assembly language routines provide rapid execution.

STUD POKER (ATARI only) — Price: $11.95 Cassette/$15.95 Diskette
This is the classic gambler's card game. The computer deals the cards one at a time and you (and the computer) bet on what you see. The computer does not cheat and *usually* bets the odds. However, it sometimes bluffs! Also included is a five card draw poker betting practice program. This package will run on a 16K ATARI. Color, graphics, sound.

POKER PARTY (Available for all computers) — Price: $17.95 Cassette/$21.95 Diskette
POKER PARTY is a draw poker simulation based on the book, POKER, by Oswald Jacoby. This is the most comprehensive version available for microcomputers. The party consists of yourself and six other (computer) players. Each of these players (you will get to know them!) has a different personality in the form of a varying propensity to bluff or fold under pressure. Practice with POKER PARTY before going to that expensive game tonight! Apple Cassette and diskette versions require a 32 K (or larger) Apple II.

NOMINOES JIGSAW (Atari, Apple and TRS-80 only) — Price: $16.95 Cassette/$20.95 Diskette
A jigsaw puzzle on your computer! Complete the puzzle by selecting your pieces from a table consisting of 60 different shapes. NOMINOES JIGSAW is a virtuoso programming effort. The graphics are superlative and the puzzle will challenge you with its three levels of difficulty. Scoring is based upon the number of guesses taken and by the difficulty of the board set-up.

CRANSTON MANOR ADVENTURE (North Star only) — Price: $19.95
At last! A comprehensive Adventure game for the North Star. CRANSTON MANOR ADVENTURE takes you in mysterious CRANSTON MANOR where you attempt to gather fabulous treasures. Lurking in the manor are wild animals and robots who will not give up the treasures without a fight. The number of rooms is greater and the associated descriptions are much more elaborate than the current popular series of Adventure programs, making this game the top in its class. Play can be stopped at any time and the status stored on diskette. Requires 32K.

VALDEZ (Available for all computers) — Price: $14.95 Cassette/$18.95 Diskette
A simulation of supertanker navigation in the Prince William Sound and Valdez Narrows. The program uses an extensive 256X256 element radar map and employs physical models of ship response and tidal patterns. Chart your own course through ship and iceberg traffic. Any standard terminal may be used for display.

FLIGHT SIMULATOR (Available for all computers) — Price: $17.95 Cassette/$21.95 Diskette
A realistic and extensive mathematical simulation of take-off, flight and landing. The program utilizes aerodynamic equations and the characteristics of a real airfoil. You can practice instrument approaches and navigation using radials and compass headings. The more advanced flyer can also perform loops, half-rolls and similar aerobatic maneuvers.

STARTREK 3.2 (Available for all computers) — Price: $ 9.95 Cassette/$13.95 Diskette
This is the classic Startrek simulation, but with several new features. For example, the Klingons now shoot at the Enterprise without warning while also attacking starbases in other quadrants. The Klingons also attack with both light and heavy cruisers and move when shot at! The situation is hectic when the Enterprise is besieged by three heavy cruisers and a starbase S.O.S. is received! The Klingons get even!

CHESS MASTER (North Star and TRS-80 only) — Price: $19.95 Cassette/$23.95 Diskette
This complete and very powerful program provides five levels of play. It includes castling, en passant captures and the promotion of pawns. Additionally, the board may be preset before the start of play, permitting the examination of "book" plays. To maximize execution speed, the program is written in assembly language (by SOFTWARE SPECIALISTS of California). Full graphics are employed in the TRS-80 version, and two widths of alphanumeric display are provided to accommodate North Star users.

BLACK HOLE (Apple only) — Price: $14.95 Cassette/$18.95 Diskette
This is an exciting graphical simulation of the problems involved in closely observing a black hole with a space probe. The object is to enter and maintain, for a prescribed time, an orbit close to a small black hole. This is to be achieved without coming so near the anomaly that the tidal stress destroys the probe. Control of the craft is realistically simulated using side jets for rotation and main thrusters for acceleration. This program employs Hi-Res graphics and is educational as well as challenging.

HODGE PODGE (Apple only, 48K Integer BASIC) — Price: $19.95 Cassette/$23.95 Diskette
Let HODGE PODGE be your child's baby sitter. Pressing any key on your Apple will result in a different and intriguing "happening" related to the letter or number of the chosen key. The program's graphics, color and sound are a delight for children from ages 1½ to 9. HODGE PODGE is a non-intimidating teaching device which brings a new dimension to the use of computers in education. HODGE PODGE requires a 48K Apple running with Integer BASIC.

TEACHER'S PET I (Available for all computers) — Price: $ 9.95 Cassette/$13.95 Diskette
This is the first of DYNACOMP's educational packages. Primarily intended for pre-school to grade 3, TEACHER'S PET provides the young student with counting practice, letter-word recognition and three levels of math skill exercises.

SPACE TILT (Apple only) — Price: $10.95 Cassette/$14.95 Diskette
Use the game paddles to tilt the plane of the TV screen to "roll" a ball into a hole in the screen. Sound simple? Not when the hole gets smaller and smaller! A built-in timer allows you to measure your skill against others in this habit-forming action game.

MOVING MAZE (Apple only) — Price: $10.95 Cassette/$14.95 Diskette
MOVING MAZE employs the games paddles to direct a puck from one side of a maze to the other. However, the maze is dynamically (and randomly) built and is continually being modified. The objective is to cross the maze without touching (or being hit by) a wall. Scoring is by an elapsed time indicator, and three levels of play are provided.

ALPHA FIGHTER (Atari only) — Price: $14.95 Cassette/$18.95 Diskette
Two excellent graphics and action programs in one! ALPHA FIGHTER requires you to destroy the alien starships passing through your sector of the galaxy. ALPHA BASE is in the path of an alien UFO invasion: let five UFO's get by and the game ends. Both games require the joystick and get progressively more difficult the higher you score!

INTRUDER ALERT (Atari only) — Price: $16.95 Cassette/$20.95 Diskette
This is a fast paced graphics game which places you in the middle of the "Dreadstar" having just stolen its plans. The droids have been alerted and are directed to destroy you at all costs. You must find and enter your ship to escape with the plans. Five levels of difficulty are provided. INTRUDER ALERT requires a joystick and will run on 16K systems.

GIANT SLALOM (Atari only) — Price: $14.95 Cassette/$18.95 Diskette
This real-time action game is guaranteed addictive! Use the joystick to control your path through slalom courses consisting of both open and closed gates. Choose from different levels of difficulty, race against other players or simply take practice runs against the clock. GIANT SLALOM will run on 16K systems.

CRYSTALS (ATARI only) — Price: $ 9.95 Cassette/$13.95 Diskette
A unique algorithm randomly produces fascinating graphics displays accompanied with tones which vary as the patterns are built. No two patterns are the same, and the combined effect of the sound and graphics are mesmerizing. CRYSTALS has been used in local stores to demonstrate the sound and color features of the Atari.

CHOMP-OTHELLO (Atari only) — Price: $11.95 Cassette/$15.95 Diskette
CHOMP-OTHELLO? It's really two challenging games in one. CHOMP is similar in concept to NIM; you must bite off part of a cookie, but avoid taking the poisoned portion. OTHELLO is the popular board game set to fully utilize the Atari's graphics capability. It is also very hard to beat! This package will run on a 16K system.

GAMES PACK I (Available for all computers) — Price: $9.95 Cassette/$13.95 Diskette
GAMES PACK I contains the classic computer games of BLACKJACK, LUNAR LANDER, CRAPS, HORSERACE, SWITCH and more. These games have been combined into one large program for ease in loading. They are individually accessed by a convenient menu.

GAMES PACK II (Available for all computers) — Price: $9.95 Cassette/$13.95 Diskette
GAMES PACK II includes the games CRAZY EIGHTS, JOTTO, ACEY-DUCEY, LIFE, WUMPUS and others. As with GAMES PACK I, all the games are loaded as one program and are called from a menu.

Why pay $7.95 or more per program when you can buy a DYNACOMP collection for just $9.95?

NORTH STAR SOFTWARE EXCHANGE (NSSE) LIBRARY — Price $9.95 Diskette
DYNACOMP now distributes the 20+ volume NSSE library. Most of these diskettes offer an outstanding value for the purchase price. Write for details regarding the contents of this library and quantity (four or more) purchases.

Availability

DYNACOMP software is supplied with complete documentation containing clear explanations and examples. Unless otherwise specified, all programs will run within 16K program memory space (ATARI requires 24K). Except where noted, programs are available on ATARI, PET, TRS-80 (Level II) and Apple (Applesoft) cassette and diskette as well as North Star single density (double density compatible) diskette. Additionally, most programs can be obtained on standard (IBM format) 8" CP/M floppy disks for systems running under MBASIC.

BUSINESS and UTILITIES

MAIL LIST 2.2 (Apple, Atari and North Star diskette only) — Price: $34.95
This program is unmatched in its ability to store a maximum number of addresses on one diskette (minimum of 1100 per diskette, more than 2200 for "double density" systems!). Its many features include alphabetic and zip code sorting, label printing, merging of files and a unique keyword seeking routine which retrieves entries by a virtually limitless selection of user defined codes. A very valuable program!

FORM LETTER SYSTEM (FLS) (Apple and North Star diskette only) — Price: $21.95
Use FLS to create and edit form letters and address lists. Form letters are produced by automatically inserting each address into a predetermined portion of your letter. FLS is completely compatible with MAIL LIST 2.2, which may be used to manage your address files.

FLS and MAIL LIST 2.2 are available as a combined package for $49.95.

PERSONAL FINANCE SYSTEM (ATARI only) — Price: $34.95 Diskette
PFS is a single disk menu oriented system composed of 10 programs designed to organize and simplify your personal finances. Features include a 300 transaction capacity; fast access; 26 optional user codes; data retrieval by month, code or payee; optional printing of reports; checkbook balancing; bar graph plotting and more. Also provides on the diskette is ATARI DOS 2.

FINDIT (North Star only) — Price: $19.95
This is a three-in-one program which maintains information accessible by keywords of three types: Personal (eg: last name), Commercial (eg: plumbers) and Reference (eg: magazine articles, record albums, etc). In addition to keyword searches, there are birthday, anniversary and appointment searches for the personal records and appointment searches for the commercial records. Reference records are accessed by a single keyword or by cross-referencing two or three keywords.

DFILE (North Star only) — Price: $19.95
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/$16.95 Diskette
This unique program allows you to easily create graphics directly from the keyboard. You "draw" your figure using the program's extensive cursor controls. Once the figure is made, it is automatically appended to your BASIC program as a string variable. Draw a "happy face", call it H$ and then print it from your program using PRINT H$! 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 renumber 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!

STATISTICS and ENGINEERING

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 or in order. The original data is sorted and a cubic spline interpolation is used to create the data file required by the FFT algorithm.

FOURIER ANALYZER, TFA and HARMONIC ANALYZER may be purchased together for a combined price of $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 imbedded (possibly nonlinearly) in the fitting function. The user simply inserts the functional form, including the parameters (A(1), A(2), etc.) as one or more BASIC statement lines. Data 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 interrogate the solution by supplying values for the independent variables. The number of variables and data size is limited only by the available memory.

REGRESSION I, II and MULTILINEAR REGRESSION may be purchased together for $49.95 (three cassettes) or $61.95 (three diskettes).

BASIC SCIENTIFIC SUBROUTINES, Volume I (Not available for ATARI)
DYNACOMP is the exclusive distributor for the software keyed to the text *BASIC Scientific Subroutines, Volume I* by F. Ruckdeschel (see the BYTE/McGraw-Hill advertisement in BYTE magazine, January 1981). These subroutines have been assembled according to chapter. Included with each collection is a menu program which selects and demonstrates each subroutine.

- Collection #1: Chapters 2 and 3: Data and function plotting, complex variables
- Collection #2: Chapter 4: Matrix and vector operations
- Collection #3: Chapters 5 and 6: Random number generators, series approximations

Price per collection: $14.95 Cassette/$18.95 Diskette

All three collections are available for $39.95 (three cassettes) and $49.95 (three diskettes).

Because the text is a vital part of the documentation, *BASIC Scientific Subroutines, Volume I* is available from DYNACOMP for $19.95 plus 75¢ postage and handling.

ROOTS (Available for all computers) — Price $9.95 Cassette/$13.95 Diskette
In a nutshell, ROOTS simultaneously determines all the zeroes of a polynomial having real coefficients. There is no limit on the degree of the polynomial, and because the procedure is iterative, the accuracy is generally very good. No initial guesses are required as input, and the calculated roots are substituted back into the polynomial and the residuals displayed.

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All orders are processed and shipped postpaid within 48 hours. Please enclose payment with order along with computer information. If paying by VISA or Master Card, include all numbers on card. For orders outside North America add 10% for shipping and handling.

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*TRS-80 diskettes are not supplied with DOS or BASIC.

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Circle 140 on inquiry card.

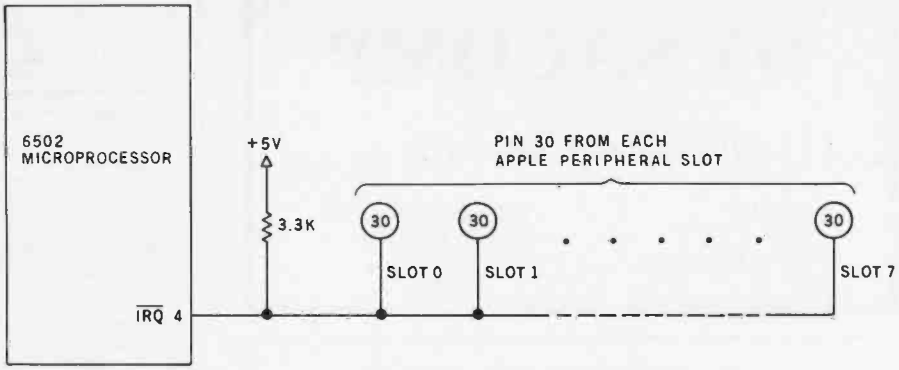

Figure 3: *The 6502 $\overline{IRQ}$ signal and the Apple II peripheral slots. The $\overline{IRQ}$ signal is connected to pin 30 of each of the slots and is held high by the pull-up resistor shown. A maskable interrupt is generated if the peripheral card in* any *of the slots presents a low impedance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

rupt-service routine itself must be written very carefully. It must, of course, perform whatever service you wish it to—such as printing a message on the console, ringing a bell, dialing a telephone, or turning on the furnace. But while it is doing these things, the service routine must not disturb any code used by the other routines stored in memory. The stacks should be in exactly the same state upon exit as they were when the service routine began.

5. The RTI instruction at the end of the service routine unstacks the status registers and program counter. This ensures that execution will continue from the point reached just before the arrival of the interrupt. Functionally, it is equivalent to:

Pop status register
Pop program-counter low byte
Pop program-counter high byte
Execute next instruction

Maskable Interrupts

Pin number 4 on the 6502 chip is an input signal called the interrupt request, $\overline{IRQ}$. This is a *maskable* interrupt. In the Apple II, $\overline{IRQ}$ is connected through the printed-circuit board to a pull-up resistor and to each of the eight I/O slots, as shown in figure 3.

This is the same scheme used for the $\overline{NMI}$ except that the interrupt request will not be accepted if the interrupt-disable bit, I, in the status register, P, is set (ie: contains a 1). As before, this interrupt scheme can be better understood by considering the five aspects of interrupts.

1. Any external device can generate an interrupt request by driving pin 30 on any I/O slot to ground potential. Once again, the Apple II can have eight different interrupt sources, and they all may decide to fire at the same time.

2. The 6502 microprocessor will respond to this request only if the interrupt-disable bit, I, in the status register, P, is cleared (ie: bit I must be a 0). This is done by executing a CLI (clear interrupt-disable bit) instruction any time before the arrival of the interrupt request. However, the 6502 will completely ignore the request if bit I has been set by executing an SEI (set interrupt-disable bit) instruction before the arrival of the interrupt.

3. Once again, the microprocessor is unable to determine the source of the interrupt. If there is only one device capable of sending an $\overline{IRQ}$ signal, there is no problem. If more than one device can do this, the same factors apply that were discussed earlier in the section on the nonmaskable interrupt, and polling can be used to determine which device caused the $\overline{IRQ}$.

4. If bit I has been cleared and the $\overline{IRQ}$ signal arrives at the 6502, the following actions occur:

Push program-counter high byte
Push program-counter low byte
Push status register
Jump via hexadecimal FFFE

Text continued on page 294

Listing 1: *Assembly-language routines to test maskable and nonmaskable interrupts. Routines RNMI and RIRQ print the messages "NMI" and "IRQ", respectively, 255 times when the appropriate interrupt is generated. The short routines at hexadecimal 352 (decimal 850) and hexadecimal 354 (decimal 852) are meant to be called from BASIC to enable and disable, respectively, the maskable interrupt. See the text for details on generating the interrupts necessary to test these routines.*

```
                         *TEST OF INTERRUPT SYSTEM
                                .OR     $3FB
03FB-   4C  00 03               JMP     RNMI
03FE-   21  03                  .DA     RIRQ
                                .OR     $300
                         ********************************************
                         *                                          *
                         ***********   ROUTINE   FOR   NMI   ********
                         *                                          *
                         ********************************************
0300-   48               RNMI   PHA                 SAVE REGISTERS
0301-   8A                      TXA
0302-   48                      PHA
0303-   98                      TYA
0304-   48                      PHA
0305-   A2  FF                  LDX     #$FF
0307-   A9  CE           L1     LDA     #$CE        PRINT "N"
0309-   20  ED FD               JSR     $FDED
030C-   A9  CD                  LDA     #$CD        PRINT "M"
030E-   20  ED FD               JSR     $FDED
0311-   A9  C9                  LDA     #$C9        PRINT "I"
0313-   20  ED FD               JSR     $FDED
0316-   CA                      DEX
0317-   E0  00                  CPX     #0
0319-   D0  EC                  BNE     L1
031B-   68                      PLA                 RESTORE REGISTERS
031C-   A8                      TAY
031D-   68                      PLA
031E-   AA                      TAX
031F-   68                      PLA
0320-   40                      RTI                 GO BACK
                         ********************************************
                         *                                          *
                         ***********   ROUTINE   FOR   IRQ   ********
                         *                                          *
                         ********************************************
0321-   48               RIRQ   PHA                 SAVE REGISTERS
0322-   8A                      TXA
0323-   48                      PHA
0324-   98                      TYA
0325-   48                      PHA
0326-   A2  FF                  LDX     #$FF
0328-   A9  C9           L2     LDA     #$C9        PRINT "I"
032A-   20  ED FD               JSR     $FDED
032D-   A9  D2                  LDA     #$D2        PRINT "R"
032F-   20  ED FD               JSR     $FDED
0332-   A9  D1                  LDA     #$D1        PRINT "Q"
0334-   20  ED FD               JSR     $FDED
0337-   CA                      DEX
0338-   E0  00                  CPX     #0
033A-   D0  EC                  BNE     L2
033C-   68                      PLA                 RESTORE REGISTERS
033D-   A8                      TAY
033E-   68                      PLA
033F-   AA                      TAX
0340-   68                      PLA
0341-   40                      RTI                 GO BACK
                         ********************************************
                         *                                          *
                         ********   ROUTINES   FOR   BASIC   *******
                         *                                          *
                         ********************************************
                                .OR     850
0352-   58                      CLI                 ENABLE INTERRUPTS
0353-   60                      RTS
0354-   78                      SEI                 DISABLE INTERRUPTS
0355-   60                      RTS
                                .EN

SYMBOL TABLE

RNMI    0300    L1    0307    RIRQ    0321
L 2     0328
```

Circle 15 on inquiry card. →

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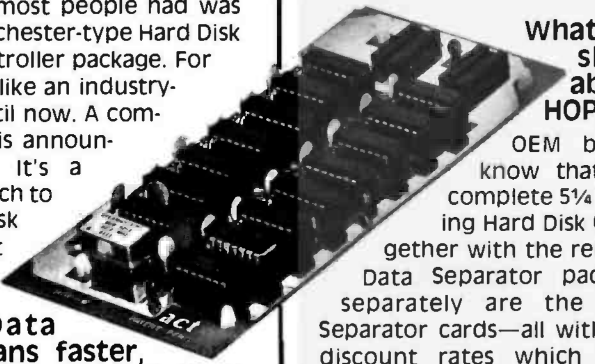

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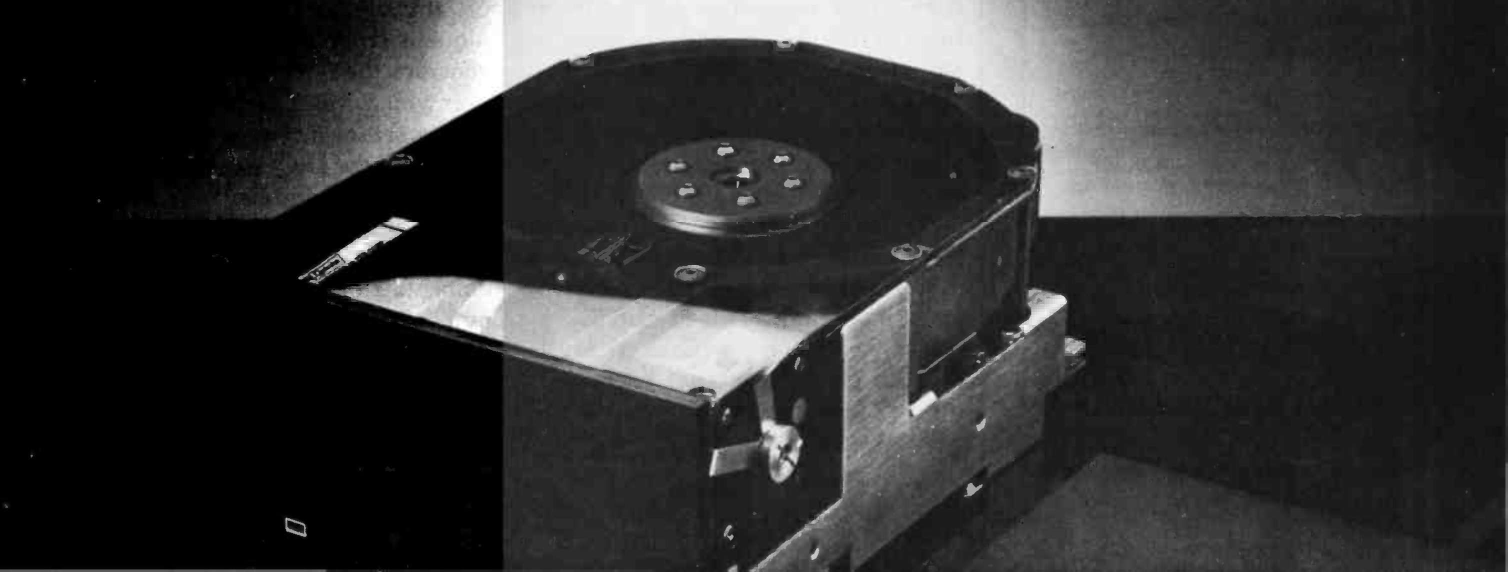

Text continued from page 290:

As before, the program counter and the status register are placed on the stack, and the processor executes an indirect jump via hexadecimal location FFFE. This is again a ROM area in the Apple II and has been set by Apple Computer Inc to the value hexadecimal FA86 (or FA40 in the autostart version), which is an address in ROM. Thus, the processor starts executing at location FA86 (or FA40), where it finds the following instructions (a "$" indicates a hexadecimal address):

```
STA $45
PLA
PHA
ASL A
ASL A
ASL A
BMI $FA92 or BMI $FA4C
JMP ($03FE)
```

This section of code stores the accumulator at hexadecimal location 45 in page zero and checks to see if the fourth bit in the status register, the "break" bit B, is high or not. An interrupt request, $\overline{\text{IRQ}}$, always forces this bit low, so the BMI instruction never succeeds and finally the indirect jump, JMP ($03FE), is encountered. The hexadecimal address 03FE is in programmable memory, and the writer of the service routine must place the address of the routine here. Note that this is somewhat different from the way in which the $\overline{\text{NMI}}$ request is routed. For the $\overline{\text{IRQ}}$ interrupts, the *address* of the service routine rather than a jump instruction including an address must be stored in the 2 bytes, hexadecimal 03FE and 03FF. Also, remember that the lower byte of the 2-byte address must be stored first.

As before, the registers are usually stacked first, although this time the accumulator can be left alone, since it has already been stored at hexadecimal location 45 by the program in ROM. Then the interrupt service is performed, the registers are restored, and, finally, an RTI is executed.

5. The processor returns to its original program after it encounters the RTI. As before, this instruction will:

Pop status register
Pop program-counter low byte
Pop program-counter high byte
Execute next instruction

In principle, any program in any language can be interrupted by an external signal, and the interrupts can be serviced using the techniques described above. In microprocessor systems such as the Apple II, the interrupted program is usually a BASIC program, and the interrupt-service routines are usually written in assembly language. An example of such a service routine is shown in listing 1. It is assumed that there is only one device capable of generating an interrupt, that the service to be performed consists only of writing a message to the console, and that interrupts will not interrupt themselves.

To test this routine, a BASIC program should be written and executed. When you wish to enable the $\overline{\text{IRQ}}$ signal from your BASIC program, it is only necessary to execute:

```
CALL 850
```

and when you wish to disable the $\overline{\text{IRQ}}$, all you have to do is:

```
CALL 852
```

If you do not have any device in your I/O slots capable of generating an interrupt request, you can easily make one by bending a resistor with a pair of long leads so that the leads are about one-half inch apart. A 100-ohm resistor works well. Then *very carefully* connect pin 29 (for the $\overline{\text{NMI}}$) or pin 30 (for the $\overline{\text{IRQ}}$) through the resistor to the ground pin (pin 26) on any of the I/O slots. This technique is crude but effective, and will generate the interrupt request whenever you wish. The $\overline{\text{NMI}}$ signal will always set the interrupt system in motion, but the $\overline{\text{IRQ}}$ signal will be accepted only if you have executed the BASIC instruction CALL 850.

Once you have mastered the fundamentals of interrupt handling, the number of interrupts that can be serviced and the complexity of the service are limited only by the speed of the interrupting devices and ingenuity of the servicing programs. ■

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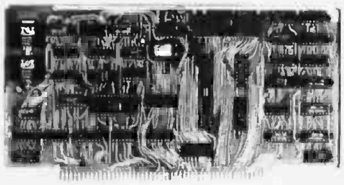

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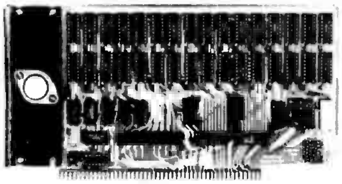

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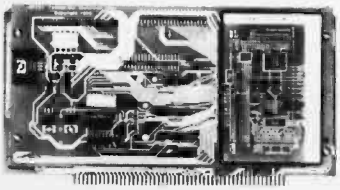

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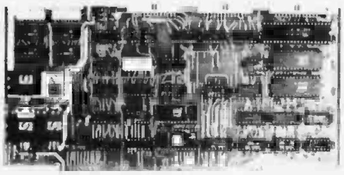

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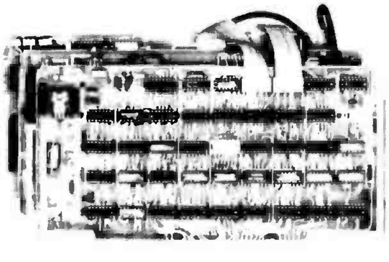

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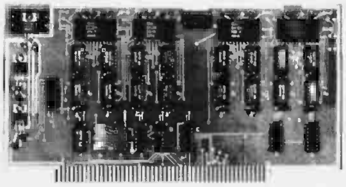

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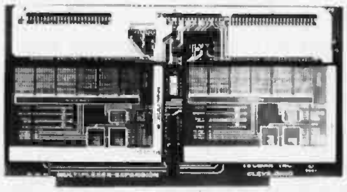

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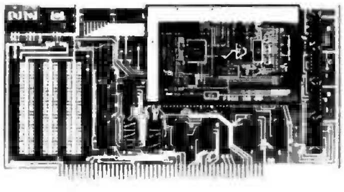

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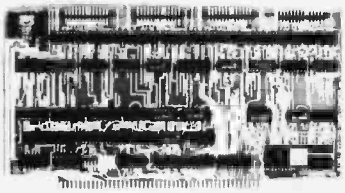

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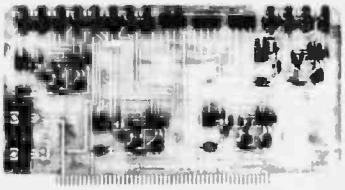

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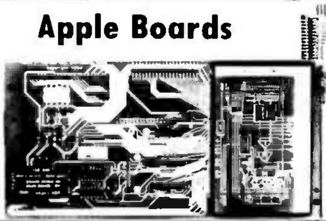

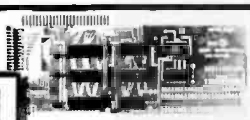

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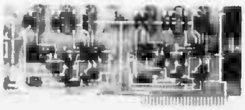

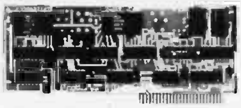

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Digital Plotting with the Apple II Computer

Dr Richard C Hallgren
Department of Biomechanics
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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

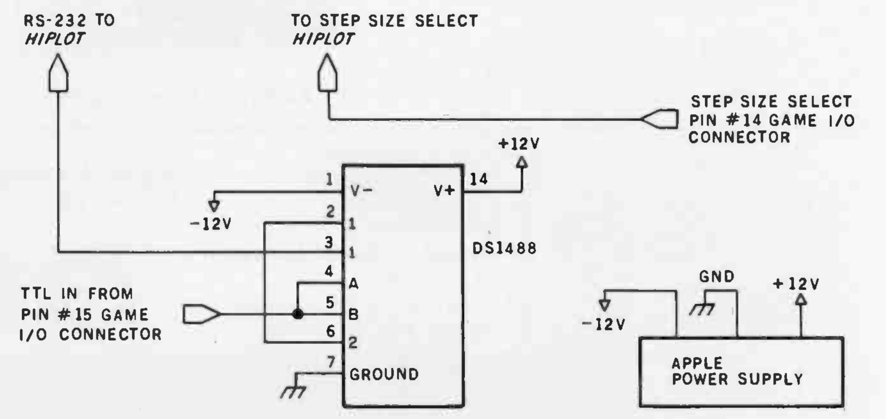

Figure 1: *Schematic of Apple II TTL (transistor-transistor logic) to RS-232C interface utilizing only one line-driver integrated circuit, a DS1488.*

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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 flowchart for the software routine that replaces the UART; listing 1 (above) shows the program with comments. To reduce the plotting time to a minimum, I decided to operate the Hiplot at its maximum data rate of 9600 bps (bits per second). Executing the output routine loads the Y register with a count of nine and clears the carry bit. The routine then writes a mark (a digital 1 or a *low* signal) if the carry bit is cleared, or a space (the opposite of mark) if the carry bit is set, and loops for a time period equal to the time spacing between bits. The routine then shifts the data so the most significant bit goes into the carry bit and checks to see if all the data bits have been sent. If not, it loops to process the next bit. Otherwise, it transmits 2 stop bits and returns to the calling program.

Getting to the point where data can be transferred from the Apple to the Hiplot is only the first part of using the plotter. Since the plotter comes with no software, it is necessary to write routines which will generate axis systems and, if desired, alphanumeric characters.

Text continued on page 314

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- ★ USES TEXAS INSTRUMENT TMS 5200 V.S.P.
- ★ SOFTWARE VOICE DATA ASSEMBLER
- ★ 32 WORD VOCABULARY INCLUDED
- ★ AUDIO AMP W/SPEAKER
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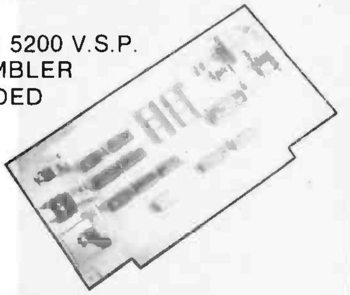

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TMS-5200 VOICE SYNTHESIS PROCESSOR
Chip with Data Sheet **$69.00**

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"CONTROL TALKER II"

- ★ 110V 50/60 HZ
- ★ 32 INPUT LINES (TTL)
- ★ 32 10 AMP (50V) OUTPUT LINES
- ★ Z80 BASED SYSTEM
- ★ 8K PROM (SOCKET)
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- ★ VOICE OUTPUT
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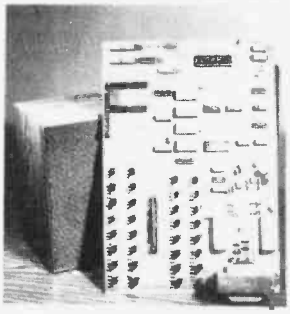
- ★ STEPPING MOTOR CONTROL (UP TO 8)



Control Talker II can be used to control stepping motors, relays, counters, etc., and support a variety of uses including robotics, telephone dialer, digital access, security, auto drilling, measuring, counting and virtually unlimited applications with added speech output to advise of status etc. Put one to work for you today!

$550.

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2032A 32K Static MEM-450NS	$ 560.00
2032B 32K Static MEM-300NS	640.00
2032C 32K Static MEM-200NS	649.00
2065C 64K Dynamic MEM-200NS	569.00
2116A 16K Static MEM-450NS	257.00
2116B 16K Static MEM-300NS	261.00
2116C 16K Static MEM-200NS	290.00
2116X 16K BD only	67.00
2200A Mainframe 110/60	386.00
2422A Floppy Controller	320.00
2710A 4-Port Serial I/O	279.00
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2720A 4-Port Parallel I/O	200.00
2810A Z-80 CPU BD	235.00

APPLE BDS:

Order Number	Our Price
7114A 12K Rom/Prom Bd.	$ 63.00
7424A Calendar Clock Bd.	103.00
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7470A A/D Converter	97.00
7490A GPIB IEEE 488	230.00
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7720B Centronic Parallel Interface	99.00
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VOLTAGE REGULATORS

Part#	Case	Price
78L05	TO92	.45
78L12	TO92	.45
78L15	TO92	.45
79L05	TO92	.65
79L12	TO92	.65
79L15	TO92	.65
7805P	TO220	1.20
7812P	TO220	1.20
7815P	TO220	1.20
7905P	TO220	1.25
7912P	TO220	1.25
7915P	TO220	1.25
7805K	TO3	1.50
7812K	TO3	1.50
7815K	TO3	1.50
7905K	TO3	1.60
7912K	TO3	1.60
7915K	TO3	1.60
309H	TO39	.95
309K	TO3	1.25
317P	TO220	1.95
317K	TO3	2.95
323K	TO3	5.50
337P	TO220	2.40
337K	TO3	3.80
350K	TO3	5.75

CRYSTALS
(Part# includes frequency in MHZ)

Part#	Price
SY1	5.75
SY1.8432	5.75
SY2	5.75
SY2.4576	5.75
SY3.579	5.75
SY4	4.50
SY5.068	4.50
SY6	4.50
SY6.144	4.50
SY8	4.50
SY10	4.50
SY12	4.50
SY14.31818	4.50
SY15	4.50
SY18	4.50
SY18.432	4.50

CERAMIC DISC CAPACITORS 50V

Value	1+	25+	100+
4.7pf	.07	.06	.04
10pf	.07	.06	.04
22pf	.07	.06	.04
33pf	.07	.06	.04
39pf	.07	.06	.04
47pf	.07	.06	.04
68pf	.07	.06	.04
100pf	.07	.06	.04
150pf	.07	.06	.04
220pf	.07	.06	.04
270pf	.07	.06	.04
330pf	.07	.06	.04
470pf	.07	.06	.04
.001mf	.07	.06	.04
.0022mf	.07	.06	.04
.0033mf	.07	.06	.04
.0047mf	.07	.06	.04
.01mf	.07	.06	.04
.022mf	.10	.08	.06
.033mf	.10	.08	.06
.047mf	.11	.09	.07
.1mf	.14	.12	.10

DIODES
Switching

1N914	12/$1.00
1N4148	12/$1.00

SOCKETS

LOW-PROFILE SOLDER TIN

Part#	1+	25+	100+
S8LT	.15	.11	.08
S14LT	.18	.16	.14
S16LT	.21	.18	.16
S18LT	.26	.22	.18
S20LT	.31	.26	.20
S22LT	.33	.28	.22
S24LT	.35	.29	.24
S28LT	.41	.34	.28
S40LT	.53	.47	.40

WIRE-WRAP SOLDER TIN

Part#	1+	25+	100+
S8WT	.37	.33	.30
S14WT	.48	.43	.39
S16WT	.53	.48	.43
S18WT	.61	.55	.50
S20WT	.85	.77	.69
S22WT	.89	.80	.72
S24WT	.96	.86	.77
S28WT	1.22	1.11	.99
S40WT	1.75	1.57	1.40

WIRE-WRAP GOLD

Part#	1+	25+	100+
S8WG	.54	.49	.44
S14WG	.77	.69	.62
S16WG	.83	.75	.68
S18WG	1.00	.90	.81
S20WG	1.24	1.11	.99
S22WG	1.35	1.22	1.10
S24WG	1.40	1.26	1.13
S28WG	1.78	1.60	1.44
S40WG	2.25	2.03	1.83

SOLID DIPPED TANTALUM CAPACITORS 20%

Value	Volts	1+	25+	100+
.1mf	35v	.35	.30	.26
.15mf	35v	.35	.30	.26
.22mf	25v	.35	.30	.26
.33mf	35v	.35	.30	.26
.47mf	35v	.35	.30	.26
.68mf	35v	.35	.30	.26
1mf	35v	.35	.30	.26
1.5mf	35v	.45	.39	.33
2.2mf	35v	.45	.39	.33
3.3mf	35v	.50	.42	.36
4.7mf	25v	.50	.42	.36
4.7mf	35v	.65	.56	.44
6.8mf	35v	.65	.56	.44
10mf	25v	.85	.72	.61
10mf	35v	1.19	1.00	.84
15mf	25v	1.30	1.09	.92
22mf	25v	1.30	1.09	.92
33mf	25v	1.35	1.12	.95
47mf	25v	1.55	1.29	1.05
100mf	6v	2.95	2.48	2.08

¼ WT & ½ WT CARBON FILM 5% RESISTORS

10	100	1K	10K	100K	1M
11	110	1.1K	11K	110K	1.1M
12	120	1.2K	12K	120K	1.2M
13	130	1.3K	13K	130K	1.3M
15	150	1.5K	15K	150K	1.5M
16	160	1.6K	16K	160K	1.6M
18	180	1.8K	18K	180K	1.8M
20	200	2K	20K	200K	2M
22	220	2.2K	22K	220K	2.2M
24	240	2.4K	24K	240K	2.4M
27	270	2.7K	27K	270K	2.7M
30	300	3K	30K	300K	3M
33	330	3.3K	33K	330K	3.3M
36	360	3.6K	36K	360K	3.6M
39	390	3.9K	39K	390K	3.9M
43	430	4.3K	43K	430K	4.3M
47	470	4.7K	47K	470K	4.7M
51	510	5.1K	51K	510K	5.1M
56	560	5.6K	56K	560K	5.6M
62	620	6.2K	62K	620K	
68	680	6.8K	68K	680K	
75	750	7.5K	75K	750K	
82	820	8.2K	82K	820K	
91	910	9.1K	91K	910K	

MINIMUM ORDER PER TYPE:
5 pcs—any qty 5 pack @ $.25

MINIMUM ORDER PER TYPE:
100 pcs
Price Per 100 Pk:

QTY	¼ WT	½ WT
100 up	$1.70	$1.80
1,000 up	1.50	1.60
5,000 up	1.30	1.40
10,000 up	1.10	1.20

ZENER DIODES
½ WT

Part#	Price
1N5231B	.20
1N5239B	.20
1N5242B	.20
1N5245B	.20
1N5248B	.20
1N5250B	.20
1N5252B	.20
1N5255B	.20

1 WT

Part#	Price
1N4733A	.30
1N4739A	.30
1N4742A	.30
1N4744A	.30
1N4746A	.30
1N4747A	.30
1N4749A	.30

POLYESTER CAPACITORS + & − 10% TOLERANCE 50V

Value	1+	25+	100+
.001mf	.13	.11	.08
.0012mf	.13	.11	.08
.0015mf	.13	.11	.08
.0018mf	.13	.11	.08
.0022mf	.13	.11	.08
.0027mf	.13	.11	.08
.0033mf	.13	.11	.08
.0039mf	.13	.11	.08
.0047mf	.13	.11	.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

TRANSISTORS

2N2219A	$ .35
2N2222A	.25
2N2905A	.30
2N2907A	.25
2N2369A	.25
2N3904	.20
2N3906	.20
PN2222A	.19
PN2907A	.19

RECTIFIERS (1A)

		100+
1N4001	12/1.00	.07
1N4002	12/1.00	.07
1N4003	12/1.00	.07
1N4004	12/1.00	.07
1N4005	10/1.00	.08
1N4006	10/1.00	.08
1N4007	10/1.00	.08

74 LS

Part #	Price	Part #	Price
74LS00	.32	74LS152	.79
74LS01	.32	74LS153	.79
74LS02	.32	74LS154	2.05
74LS03	.32	74LS157	1.15
74LS04	.32	74LS158	1.15
74LS05	.32	74LS160	.85
74LS08	.32	74LS161	.85
74LS09	.35	74LS162	.85
74LS10	.38	74LS163	.95
74LS11	.38	74LS164	1.10
74LS12	.39	74LS165	1.10
74LS13	.32	74LS166	2.55
74LS14	.65	74LS170	1.90
74LS15	.35	74LS173	1.35
74LS20	.32	74LS174	1.25
74LS21	.36	74LS175	.95
74LS22	.36	74LS181	2.35
74LS26	.35	74LS190	1.15
74LS27	.39	74LS191	1.15
74LS28	.37	74LS192	1.15
74LS30	.36	74LS193	1.15
74LS32	.40	74LS194	1.15
74LS37	.38	74LS195	1.15
74LS38	.39	74LS196	.99
74LS40	.36	74LS197	.99
74LS42	.95	74LS221	.95
74LS47	1.15	74LS240	1.05
74LS48	1.15	74LS241	1.05
74LS51	.32	74LS242	1.45
74LS54	.38	74LS243	1.45
74LS55	.34	74LS244	1.05
74LS73	.49	74LS245	2.15
74LS74	.49	74LS251	1.29
74LS75	.63	74LS253	.99
74LS76	.55	74LS255	.99
74LS83	.95	74LS257	1.15
74LS85	1.25	74LS258	1.15
74LS86	.55	74LS260	.95
74LS90	.79	74LS261	2.49
74LS92	.75	74LS266	.65
74LS93	.75	74LS273	1.65
74LS95	.99	74LS283	1.05
74LS107	.50	74LS365	.85
74LS109	.50	74LS366	.85
74LS112	.52	74LS367	.85
74LS113	.52	74LS368	.85
74LS114	.52	74LS373	1.65
74LS123	1.05	74LS374	1.45
74LS125	.70	74LS375	.99
74LS126	.70	74LS377	1.15
74LS132	.95	74LS386	.59
74LS136	.53	74LS390	1.75
74LS138	.85	74LS393	1.75
74LS139	.85	81LS95	1.35
74LS148	1.75	81LS96	1.35
74LS151	.79	81LS97	1.35
		81LS98	1.35

4000 CMOS B SERIES ONLY

Part #	Price
4000	.35
4001	.35
4002	.35
4006	1.05
4007	.35
4008	1.15
4009	.45
4010	.45
4011	.35
4012	.35
4013	.50
4014	.85
4015	.75
4016	.55
4017	1.05
4018	.95
4019	.55
4020	1.10
4021	1.10
4022	.75
4023	.35
4024	.85
4025	.35
4026	1.45
4027	.50
4028	.75
4029	1.15
4030	.50
4034	2.55
4035	.99
4040	1.15
4041	1.15
4042	1.05
4043	.95
4044	.95
4046	1.15
4047	1.35
4048	.99
4049	.50
4050	.50
4051	1.10
4052	1.10
4053	.85
4060	1.39
4066	.39
4068	.35
4069	.35
4070	.39
4071	.39
4072	.39
4073	.39
4075	.39
4076	1.15
4077	.39
4078	.35
4081	.35
4082	.35
4093	.95
4503	.85
4508	2.95
4510	.89
4511	.89
4512	1.10
4514	2.55
4515	2.55
4516	1.25
4518	1.25
4519	.55
4520	1.25
4526	1.65
4527	1.65
4528	1.45

SERIAL PORT CARD
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WITH 2 PORTS $260

MIN ORDER: $10.00 SHIPPING: ADD $2.00
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OEM AND INSTITUTIONAL INQUIRIES INVITED

Circle 381 on inquiry card.

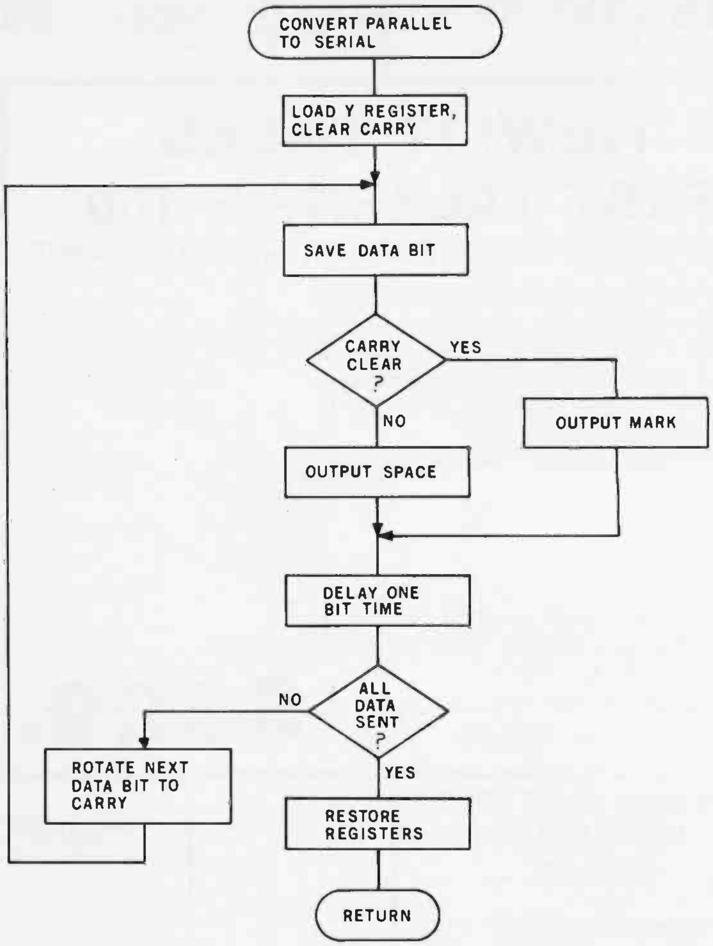
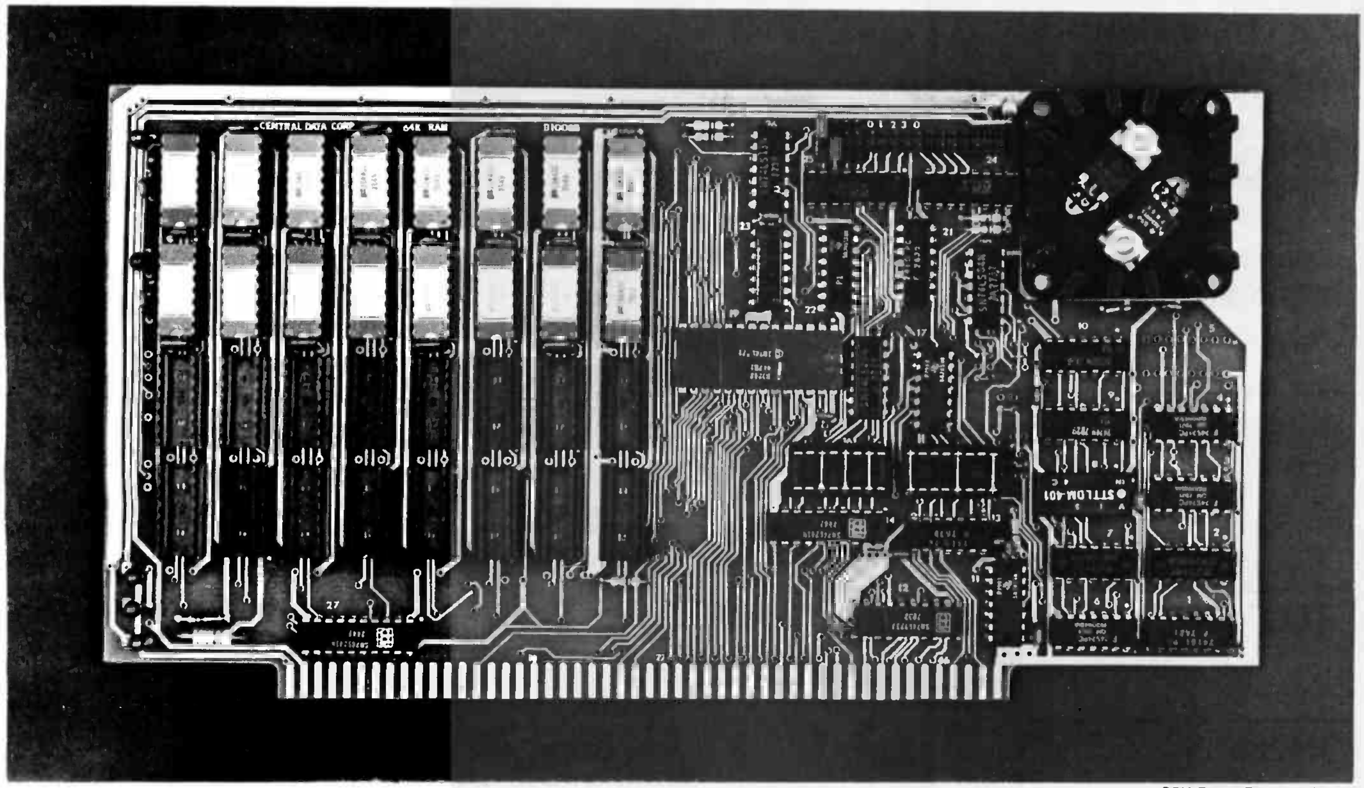


Figure 2: *Flowchart for machine-language software UART in listing 1.*

Listing 2: *Machine-code command generator to select a specified plotter command before calling the UART subroutine.*

```
8038-   48         PHA               Save accumulator
8039-   08         PHP               Save processor status
803A-   A9 70      LDA    #$70       Output 'p'
803C-   20 00 80   JSR    $8000      Jump to parallel to serial conversion
803F-   28         PLP               Restore processor status
8040-   68         PLA               Restore accumulator
8041-   60         RTS               Return
8042-   48         PHA
8043-   08         PHP
8044-   A9 71      LDA    #$71       Output 'q'
8046-   4C 3C 80   JMP    $803C
8049-   48         PHA
804A-   08         PHP
804B-   A9 72      LDA    #$72       Output 'r'
804D-   4C 3C 80   JMP    #803C
8050-   48         PHA
8051-   08         PHP
8052-   A9 73      LDA    #$73       Output 's'
8054-   4C 3C 80   JMP    $803C
8057-   48         PHA
8058-   08         PHP
8059-   A9 74      LDA    #$74       Output 't'
805B-   4C 3C 80   JMP    $803C
805E-   48         PHA
805F-   08         PHP
8060-   A9 75      LDA    #$75       Output 'u'
8062-   4C 3C 80   JMP    $803C
8065-   48         PHA
8066-   08         PHP
```

Listing 2 continued on page 302



32K Board Pictured Above

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	2MHz	4MHz
16K	—$249	$259
32K	—$375	$395
48K	—$500	$530
64K	—$625	$665

We have now been shipping our 2MHz dynamic RAM boards for over two years. Hundreds of 4MHz boards have been going out every month since early 1979. Our reliability is proven in the thousands of systems which contain our board. Many quality-minded systems houses across the country and overseas are using our boards for their equipment.

Our prices still beat all. Despite rising 16K memory chip prices (at least from reputable suppliers), Central Data continues to give you the best buy in memory today. Nobody offers a board with a capacity of 64K, assembled, tested, and guaranteed for a full year at the price we do.

Deselect around PROMs. Our boards have the important deselect feature which lets you overlap any fixed memory in your system with no interference.

Our features make the board easily used and expanded. You address our boards on 16K boundaries with mini-jumps (small shorting plugs that slide over wire-wrap pins) near the top of the board for easy access. If you want to expand your board after you have purchased it, all that you need to do is add memory. We can supply you with expansion packages ($150-2MHz, $160-4MHz) which include eight RAMs that you can depend on as well as two mini-jumps for addressing. And of course, our board **never** generates wait states.

Low power consumption keeps your computer running cool and reliable. The total power consumption of our 16K board is typically less than 4 watts (+8V @ 300ma, +16V @ 150ma and −16V @ 20ma). Boards with additional memory typically increase power consumption only 1 watt per 16K!

Standard S-100 Interface. Our board is designed to interface with any standard S-100 CPU. All of the timing of the board is independent of the processor chip, and the board is set up for different processors by changing two plugs on the board.

Call or write us today. That will guarantee a fast response with more information on the board. Or make an order — you'll probably have the board in two weeks! **If you're interested, also ask for a catalog on our Z8000 16-bit processor board designed for the MULTIBUS.** All of these products are available to your local dealer, also.

Central Data Corporation, 713 Edgebrook Drive, PO Box 2530, Station A, Champaign, IL 61820. (217) 359-8010

Central Data

Circle 65 on inquiry card.

Listing 2 continued:

```
8067-    A9 76      LDA   #$76    Output 'v'
8069-    4C 3C 80   JMP   $803C
806C-    48         PHA
806D-    08         PHP
806E-    A9 77      LDA   #$77    Output 'w'
8070-    4C 3C 80   JMP   $803C
8073-    48         PHA
8074-    08         PHP
8075-    A9 79      LDA   #$79    Output 'y'
8077-    4C 3C 80   JMP   #803C
807A-    48         PHA
807B-    08         PHP
807C-    A9 7A      LDA   #$7A    Output 'z'
807E-    4C 3C 80   JMP   $803C
```

Listing 3: *BASIC program to produce a plot of the voltage across a charging capacitor.*

```
10  REM  MAIN PROGRAM
12  HOME : VTAB 12
14  PRINT "POSITION PEN IN LOWER LEFT HAND"
16  PRINT "CORNER.  PRESS ANY KEY TO CONTINUE."
18  GET A$
19  HOME
20  GOSUB 1000  REM DRAW X,Y AXIS
30  REM  EXPONENTIAL RISE
32  POKE  - 16293,0  REM SET RESOLUTION TO 200 POINTS PER INCH
34 Z = 0
36  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I  REM PEN DOWN
38  FOR I =  0 TO 8.99 STEP  .005
40 V = 5 *  (1 -  EXP ( - I))  REM FIND CAPACITOR VOLTAGE
42 K =  INT  (200 * V)
44  IF K - Z = 0 THEN GOTO 90  REM NO CHANGE IN PREVIOUS POTENTIAL
46  IF K - Z < 0 THEN GOTO 60  REM POTENTIAL IS DECREASING
48  FOR J = 1 TO (K - Z) REM POTENTIAL IS INCREASING
50  CALL  - 82712  REM MOVE IN +Y DIRECTION
52  NEXT J
54  GOTO 70
60  FOR J = 1 TO (Z - K)
62  CALL  - 32681  REM MOVE IN -Y DIRECTION
64  NEXT J
70 Z = K
90  CALL  - 32695  REM MOVE IN +X DIRECTION
92  NEXT I
94  CALL  - 32653  REM PEN UP
99  END
300  REM  "1"
301  CALL  - 32653:  FOR I = 1 TO 8:  CALL  - 32674:  Next I
302  CALL  - 32646
304  FOR I = 1 TO 8:  CALL  - 32702:  NEXT I
306  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
308  CALL  - 32653
310  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
312  CALL  - 32646
314  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
316  CALL  - 32653
317  FOR I = 1 TO 8:
318  FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
319  RETURN
320  REM  "2"
321  CALL  - 32653:  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
322  CALL  - 32646
324  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
326  FOR I = 1 TO 13:  CALL  - 32681:  NEXT I
328  FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
330  FOR I = 1 TO 13:  CALL  - 32681:  NEXT I
332  FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
334  CALL  - 32653
336  FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
337  FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
339  RETURN
```

Listing 3 continued on page 304

OUR TIMING CONTROL UNIT HELPS YOUR COMPUTER KEEP SCORE OF TIME AND DATE.

Power-up or power-down, your computer always knows the time, *exactly*, with Digital Pathway's Timing Control Unit (TCU). Even during extended power interruptions. Rechargeable battery support makes our TCU immune from power failure of any kind. For as long as three months. And an on-board crystal-controlled oscillator ensures supreme accuracy.

No matter what model computer you have, you'll find our TCUs offer many features that make living with computer timeouts less complicated. And some models can even be set to initiate an interrupt at a chosen date and time. Or at specified intervals.

Find out how we can help make your time more productive. Call or write Digital Pathways today for more information at 1260 L'Avenida, Mountain View, CA 94043. Telephone (415) 969-7600, TWX: 910-379-5034.

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	TCU-150	$460
*LSI-11/2	TCU-50D	$325
*Multi-Bus	TCU-410	$325
*EXORcisor	TCU-68	$325
*HP 2100	TCU-2100	$395
*Lockheed SUE	TCU-200	$550
*Naked Mini	TCU-310	$385
Any Model Computer (RS-232/20mA)	SLC-1	$640

DIGITAL PATHWAYS

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Listing 3 continued:

```
340 REM "3"
341 CALL - 32653: FOR I = 1 TO 8: CALL - 32667: NEXT I
342 CALL - 32646
344 FOR I = 1 TO 16: CALL - 32695: NEXT I
346 FOR I = 1 TO 13: CALL - 32681: NEXT I
348 FOR I = 1 TO 16: CALL - 32667: NEXT I
350 FOR I = 1 TO 16: CALL - 32695: NEXT I
352 FOR I = 1 TO 13: CALL - 32681: NEXT I
354 FOR I = 1 TO 16: CALL - 32667: NEXT I
356 CALL - 32653
357 FOR I = 1 TO 8: CALL - 32695: NEXT I
358 FOR I = 1 TO 26: CALL - 32712: NEXT I
359 RETURN
360 REM "4"
361 CALL - 32653: FOR I = 1 TO 8: CALL - 32667: NEXT I
362 CALL - 32646
364 FOR I = 1 TO 13: CALL - 32681: NEXT I
366 FOR I = 1 TO 16: CALL - 32695: NEXT I
368 CALL - 32653
372 FOR I = 1 TO 13: CALL - 32712: NEXT I
374 CALL - 32646
376 FOR I = 1 TO 26: CALL - 32681: NEXT I
377 CALL - 32653
378 FOR I = 1 TO 26: CALL - 32712: NEXT I
379 FOR I = 1 TO 8: CALL - 32667: NEXT I: RETURN
380 REM "5"
381 CALL - 32653: FOR I = 1 TO 8: CALL - 32695: NEXT I
382 CALL - 32646
384 FOR I = 1 TO 16: CALL - 32667: NEXT I
386 FOR I = 1 TO 13: CALL - 32681: NEXT I
388 FOR I = 1 TO 16: CALL - 32695: NEXT I
390 FOR I = 1 TO 14: CALL - 32681: NEXT I
392 FOR I = 1 TO 16: CALL - 32667: NEXT I
394 CALL - 32653
396 FOR I = 1 TO 26: CALL - 32712: NEXT I
397 FOR I = 1 TO 8: CALL - 32695: NEXT I
399 RETURN
400 REM "6"
401 CALL - 32653: FOR I = 1 TO 8: CALL - 32667: NEXT I
402 CALL - 32646: FOR I = 0 TO 10: NEXT I
404 FOR I = 1 TO 26: CALL - 32681: NEXT I
406 FOR I = 1 TO 16: CALL - 32695: NEXT I
408 FOR I = 1 TO 13: CALL - 32712: NEXT I
410 ROR I = 1 TO 16: CALL - 32667: NEXT I
412 CALL - 32653
414 FOR I = 1 TO 13: CALL - 32712: NEXT I
415 FOR I = 1 TO 8: CALL - 32695: NEXT I
416 RETURN
420 REM "7"
422 CALL - 32653
424 FOR I = 1 TO 8: CALL - 32667: NEXT I
426 CALL - 32646: FOR I = 0 TO 10: NEXT I
428 FOR I = 1 TO 16: CALL - 32695: NEXT I
430 FOR I = 1 TO 26: CALL - 32681: NEXT I
432 CALL - 32653
434 FOR I = 1 TO 26: CALL - 32712: NEXT I
436 FOR I = 1 TO 8: CALL - 32667: NEXT I
439 RETURN
440 REM "8"
442 CALL - 32653
444 FOR I = 1 TO 8: CALL - 32695: NEXT I
445 CALL - 32646: FOR I = 0 TO 10: NEXT I
446 FOR I = 1 TO 16: CALL - 32667: NEXT I
448 FOR I = 1 TO 26: CALL - 32681: NEXT I
450 FOR I = 1 TO 16: CALL - 32695: NEXT I
452 FOR I = 1 TO 26: CALL - 32712: NEXT I
454 CALL - 32653
456 FOR I = 1 TO 13: CALL - 32681: NEXT I
457 CALL - 32646
458 FOR I = 1 TO 16: CALL - 32667: NEXT I
460 CALL - 32653
462 FOR I = 1 TO 8: CALL - 32695: NEXT I
464 FOR I = 1 TO 13: CALL - 32712: NEXT I
469 RETURN
```

Listing 3 continued on page 306

Let onComputing be your guide to personal computing.

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Card Number ____________ Expiration ____________

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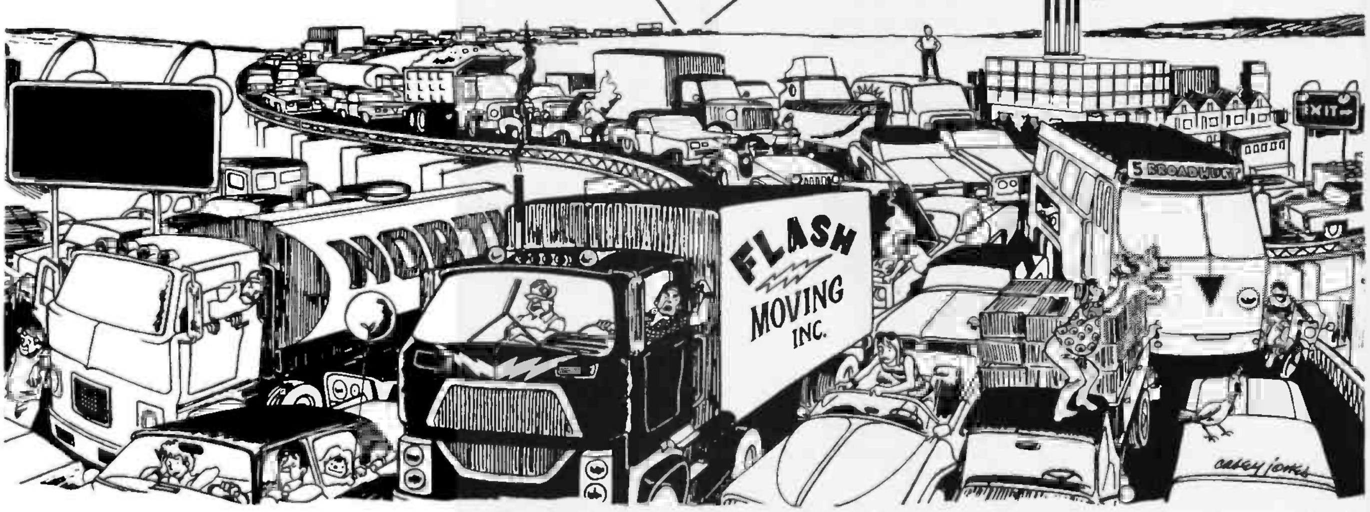
Listing 3 continued:

```
480   REM  "9"
482   CALL  - 32653
483   FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
484   CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
485   FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
486   FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
487   CALL  - 32653
488   FOR I = 1 TO 13:  CALL  - 32712:  NEXT I
489   CALL  - 32646
490   FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
492   FOR I = 1 TO 13:  CALL  - 32712:  NEXT I
493   CALL  - 32653
494   FOR I = 1 TO 8:  CALL  - 32695:  NEXT I
499   RETURN
500   REM  "0"
502   CALL  - 32653
504   FOR I = 1 TO 8:  CALL  - 32695:  NEXT I
506   CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
508   FOR I = 1 TO 16:  CALL  - 32667:  NEXT I
510   FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
512   FOR I = 1 TO 16:  CALL  - 32695:  NEXT I
514   FOR I = 1 TO 26:  CALL  - 32712:  NEXT I
516   CALL  - 32653
518   FOR I = 1 TO 8:  CALL  - 32667:  NEXT I
519   RETURN
999   END
1000  REM  X AXIS
1010  POKE  - 16294,0:  CALL  - 32653
1012  FOR I = 1 TO 50:  CALL  - 32712:  NEXT I
1014  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1016  FOR I = 1 TO 1000:  CALL  - 34695:  NEXT I
1018  CALL  - 32653
1100  REM  X AXIS SCALE
1110  FOR I = 1 TO 20:  CALL  - 32712:  NEXT I
1112  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1114  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1116  CALL  - 32653
1118  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1120  POKE  - 16293,0
1122  GOSUB 480
1124  POKE  - 16294,0
1126  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1128  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1130  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1132  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1134  CALL  - 32653
1146  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1148  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1150  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1152  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1154  CALL  - 32653
1156  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1158  POKE  - 16293,0
1160  GOSUB 440
1162  POKE  - 16294,0
1164  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1166  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1168  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1170  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1172  CALL  - 32653
1174  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1176  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1178  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1180  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1182  CALL  - 32643
1184  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1186  POKE  - 16293,0
1188  GOSUB 420
1190  POKE  - 16294,0
1192  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1194  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1196  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1198  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1199  CALL  - 32653
```

Listing 3 continued on page 308

"By the time we get out of this traffic, my 6-month auto policy will be up for renewal. And they may raise my rate, too!"

"6 months? Next time, call GEICO and get a 12-month policy."



Unlike most companies, GEICO still offers the 12-month auto policy...a full year's coverage at a low rate. With a choice of convenient payment plans to fit your budget. Up to 9 payments if you wish.

And this is possible because GEICO tries to insure only good drivers. Good drivers are the best inflation-fighters around. You have fewer accidents. You cost us less. So you are one reason we can afford to charge you less.

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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.

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Where good drivers get the low rates they deserve.

Call toll-free **800-841-3000** (8 a.m.-9 a.m. East Coast Time)
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 ______

List all drivers	M or F	Relation	Age	Marital Status	Occupation	Yrs. lic.	Driver Training Yes	Driver Training No	% of Use of Cars #1	#2	#3	Accidents in Past 5 Years* Yes	No	Violations in Past 3 Years° Yes	No	License Suspension° Yes	No
		SELF															

If student away at school, how many miles to school? ______ miles.

	CAR 1	CAR 2	CAR 3
Year & Make			
Model (Nova, Granada, etc.)			
Body type: 2/4 dr. sdn, hardtop, sta. wag			
No. of cylinders			
Est. Annual Mileage			
Days per week driven to work or parking area			
One way driving distance			
Is car used in business (except to/from job)?			

If "yes" explain ______

°For accidents, violations, or license suspension, give dates and complete details, including cost of damages, on a separate sheet.
Check for Information on ☐ Homeowners/Renter's Insurance ☐ Boatowner's Insurance

684

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

Not available in New Jersey or Massachusetts.

Circle 166 on inquiry card.

Listing 3 continued:

```
1200  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1202  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1204  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1206  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1208  CALL  - 32653
1210  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1212  POKE  - 16293,0
1214  GOSUB 400
1216  POKE  - 16294,0
1218  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1220  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1222  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1224  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1226  CALL  - 32653
1228  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1230  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1232  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1234  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1236  CALL  - 32653
1238  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1240  POKE  - 16293,0
1242  GOSUB 380
1244  POKE  - 16294,0
1246  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1248  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1250  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1252  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1254  CALL  - 32653
1256  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1258  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1260  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1262  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1264  CALL  - 32653
1266  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1268  POKE  - 16293,0
1270  GOSUB 360
1272  POKE  - 16294,0
1274  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1276  FOR I = 1 TO 38:  CALL  - 32667:  NEXT I
1278  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1280  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1282  CALL  - 32653
1284  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1286  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1288  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1290  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1292  CALL  - 32653
1294  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1296  POKE  - 12394,0
1298  GOSUB 340
1300  POKE  - 16294,0
1302  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1304  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1306  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1308  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1312  FOR I - 1 TO 50:  CALL  - 32667:  NEXT I
1314  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1316  CALL  - 32546:  FOR I = 0 TO 10:  NEXT I
1318  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1320  CALL  - 32653
1322  For I = 1 TO 5:  CALL  - 32681:  NEXT I
1324  POKE  - 16293,0
1326  GOSUB 320
1328  POKE  - 16294,0
1330  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1332  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1334  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1336  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1338  CALL  - 32653
1340  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1342  FOR I = 1 TO 33:  CALL  - 32712:  NEXT I
1344  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1346  FOR I = 1 TO 40:  CALL  - 32681:  NEXT I
1348  CALL  - 32653
```

Listing 3 continued on page 310

Listing 3 continued:

```
1350  FOR I = 1 TO 5:  CALL  - 32681:  NEXT I
1352  POKE  - 16293,0
1354  GOSUB 300
1356  POKE  - 16294,0
1358  FOR I = 1 TO 50:  CALL  - 32667:  NEXT I
1360  FOR I = 1 TO 38:  CALL  - 32712:  NEXT I
1362  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1364  FOR I = 1 TO 26:  CALL  - 32681:  NEXT I
1366  CALL  - 32653
1368  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1370  FOR I = 1 TO 37:  CALL  - 32681:  NEXT I
1372  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1373  REM  Y AXIS
1374  FOR I = 1 to 700:  CALL  - 32712:  NEXT I
1376  FOR I = 1 to 13:  CALL  - 32667:  NEXT I
1378  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1380  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1381  CALL  - 32653
1382  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1384  FOR I = 1 TO 43:  CALL  - 32667:  NEXT I
1386  POKE  - 16293,0
1388  GOSUB 400
1390  POKE  - 16294,0
1392  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1394  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1396  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1398  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1400  CALL  - 32653
1402  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1404  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1406  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1408  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1410  CALL  - 32653
1412  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1414  FOR I = 1 TO 43:  CALL  - 32667:  NEXT I
1416  POKE  - 16293,0
1418  GOSUB 380
1420  POKE  - 16294,0
1422  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1424  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1426  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1428  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1430  CALL  - 32653
1432  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1434  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1436  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1438  FOR I = 0 TO 26:  CALL  - 32695:  NEXT I
1440  CALL  - 32653
1442  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1444  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1446  POKE  - 15293,0
1448  GOSUB
1450  POKE  - 16294,0
1452  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1454  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1456  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1458  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1460  CALL  - 32653
1462  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1464  FOR I = 1 to 33:  CALL  - 32667:  NEXT I
1466  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1468  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1470  CALL  - 32653
1472  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1474  FOR I = 1 TO 43:  CALL  - 32667:  NEXT I
1476  POKE  - 16293,0
1478  GOSUB 340
1480  POKE  - 16294,0
1482  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1484  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1486  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1488  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1490  CALL  - 32653
1492  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
```

Listing 3 continued on page 312

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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Z-80 is a trademark of Zilog Corp.

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Quasar Data Products

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Phone: 216/526-0838 / 526-0839
Telex: 241596

Circle 341 on inquiry card.

Listing 3 continued:

```
1494  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1496  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1498  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1500  CALL  - 32653
1502  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1504  FOR I = 1 TO 43:  CALL  - 32667:  NEXT I
1506  POKE  - 16293,0
1508  GOSUB 320
1510  POKE  - 16294,0
1512  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1514  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1516  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1518  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1520  CALL  - 32653
1522  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1524  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1526  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1528  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1530  CALL  - 32653
1532  FOR I = 1 TO 44:  CALL  - 32681:  NEXT I
1534  FOR I = 1 TO 43:  CALL  - 32667:  NEXT I
1536  POKE  - 16293,0
1538  GOSUB 300
1540  POKE  - 16294,0
1542  FOR I = 1 TO 6:  CALL  - 32681:  NEXT I
1544  FOR I = 1 TO 10:  CALL  - 32695:  NEXT I
1546  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1548  FOR I = 1 TO 40:  CALL  - 32695:  NEXT I
1550  CALL  - 32653
1552  FOR I = 1 TO 50:  CALL  - 32681:  NEXT I
1554  FOR I = 1 TO 33:  CALL  - 32667:  NEXT I
1556  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1558  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1560  CALL  - 32653
1562  FOR I = 1 TO 26:  CALL  - 32667:  NEXT I
1564  FOR I = 1 TO 100:  CALL  - 32681:  NEXT I
1566  CALL  - 32646:  FOR I = 0 TO 10:  NEXT I
1568  FOR I = 1 TO 26:  CALL  - 32695:  NEXT I
1570  CALL  - 32653
1572  FOR I = 1 TO 13:  CALL  - 32667:  NEXT I
1574  FOR I = 1 TO 50:  CALL  - 32712:  NEXT I
1999  RETURN
```

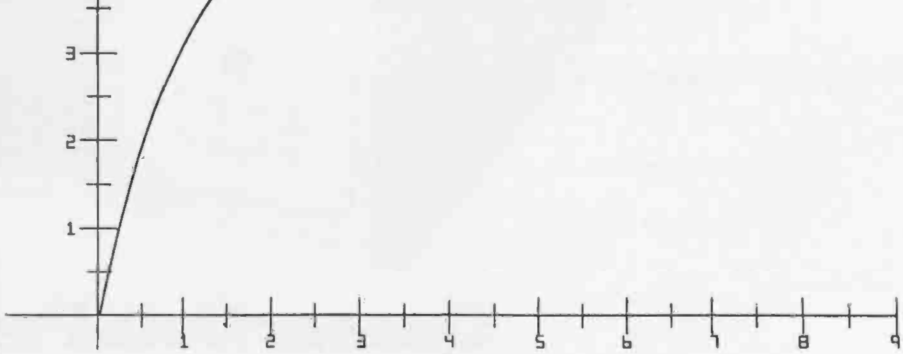

Figure 3: *Sample plot of results obtainable with the information included in this article.*

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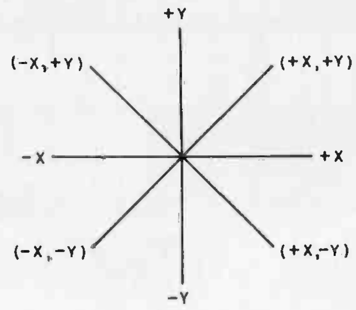

VECTOR NOTATION

COMMAND	CHARACTER	HEXADECIMAL ADDRESS
+Y	p	8038
+X, +Y	q	8042
+X	r	8049
+X, -Y	s	8050
-Y	t	8057
-X, -Y	u	805E
-X	v	8065
-X, +Y	w	806C
PEN UP	y	8073
PEN DOWN	z	807A

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

Text continued from page 298:

Table 1 shows plotter commands and the vector notation associated with each. Listing 2 on page 300 is a machine-language routine that generates the specified command characters. To execute a given command, a jump is made to the appropriate hexadecimal address, where the proper character is loaded into the accumulator. A call is then made to the parallel-to-serial subroutine, where the command character is transferred from the computer to the plotter.

Results with the digital plotter have been encouraging. Figure 3 on page 312 shows an actual plot made on the plotter. A #0 Rapidograph pen was used to produce a high-quality plot. The plot is a simulation of the voltage drop across a capacitor that is placed in series with a resistor and a fixed voltage source. Figure 4 shows the flowchart of the program, and listing 3 beginning on page 302 shows the program with comments.

At present, the Apple II and Hiplot digital plotter are being used for several projects that include the spectral analysis of breath sounds, muscle voltages, and neural characteristics. The two units working together provide a low-cost, high-quality record of the analysis of scientific data. ■

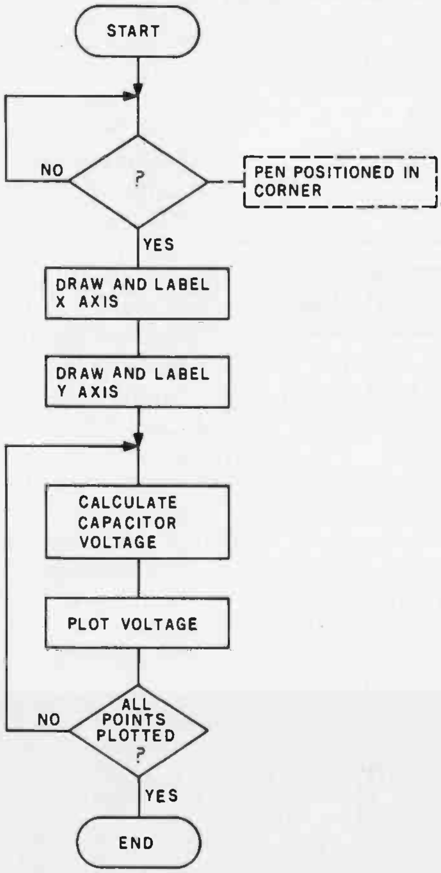

Figure 4: *Flowchart for the BASIC program used to produce figure 3.*

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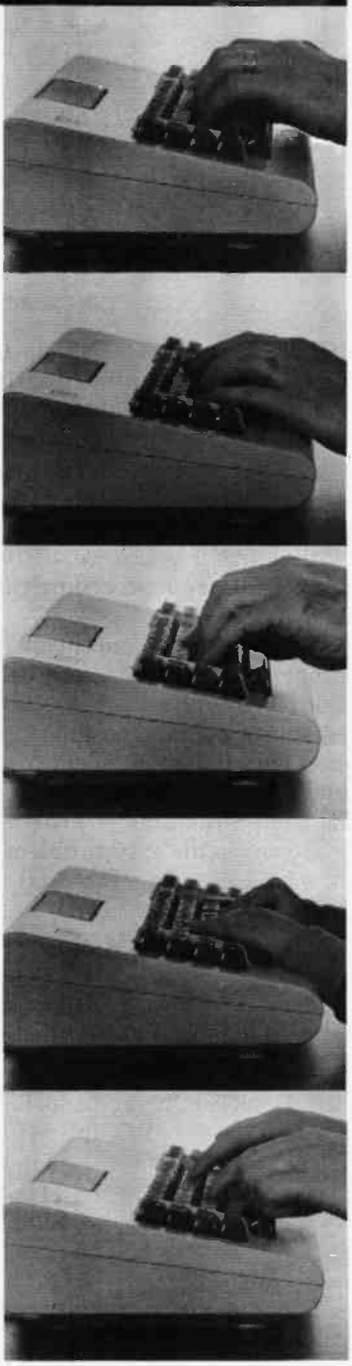

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Recursion and Side Effects in Pascal

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 $n! = 1 \times 2 \times \ldots \times n$. Factorial is defined recursively as follows:

$$n! = n(n-1)! \text{ if } n > 1$$
$$n! = 1 \qquad \text{if } n = 1$$

The following Pascal function computes the factorial function recursively:

```
FUNCTION fac(n: INTEGER): INTEGER;
    BEGIN
        IF n = 1
        THEN fac := 1
        ELSE fac := fac(n - 1)*n
    END
```

Suppose that a main program contains the following calling sequence:

```
m := 3; y := fac(m)
```

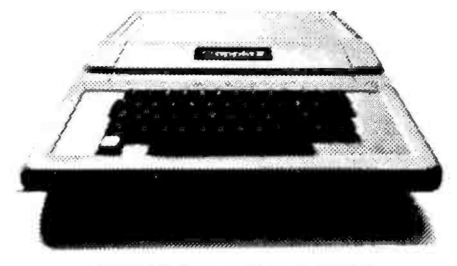
The function "fac" is recursive. That is, "fac(3)" will call "fac(2)", which will call "fac(1)". We say that there are three activations of this function, with parameter values of 3, 2, and, finally, 1.

Each activation of a recursive function (or procedure) must have a separate location (called the *stack frame*) for its local variables, parameters, etc. In this way, one activation (say, "fac(2)") does not disturb the contents of another activation (say, "fac(3)"). As each activation begins, a new stack frame is created (or *pushed*) for its local variables. As that activation is completed, its stack frame is destroyed (or *popped*), and control returns to the previous activation. The "current" values of the local variables are then taken from the stack frame of the previous activation, which is now at the bottom of the (downward-growing) stack. [*In a stack, only the item most recently placed there can be accessed. We call this the* top *of the stack if the stack is growing "up." Since the stack in this context is growing "down," we will refer to the item that can be removed as the* bottom *of the stack*....GW]

Snapshots of the stack are shown in figure 1. The global variables "m" and "y" (ie: those declared in the main program) are allocated storage in the stack frame of the main program, which is shown at the top frame of the stack. These variables are not duplicated with each activation of the function. A function or procedure may be able to directly access and modify a global variable. That, as you will see, can lead to surprising results.

Above and between the snapshots of the stack in figure 1 is the fragment of code (plus comments, in braces) which caused the changes to the stack. This information helps specify the time when each snapshot was taken.

At any point in time, there are two currently active frames that are of immediate interest. These two frames contain the values that are currently accessible; they are the top and bottom frames in figure 1. The top frame contains the (global) variables of the main program. The local frames are shown below it, growing downward. The bottom frame is the only local frame that is currently accessible (ie: belongs to the current activation). In addition to local variables, the stack frame contains the value of the function (marked "P" if it is pending further calculations) and the return address (so that control will be transferred back to the correct calling sequence). The



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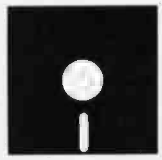

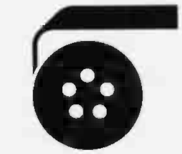

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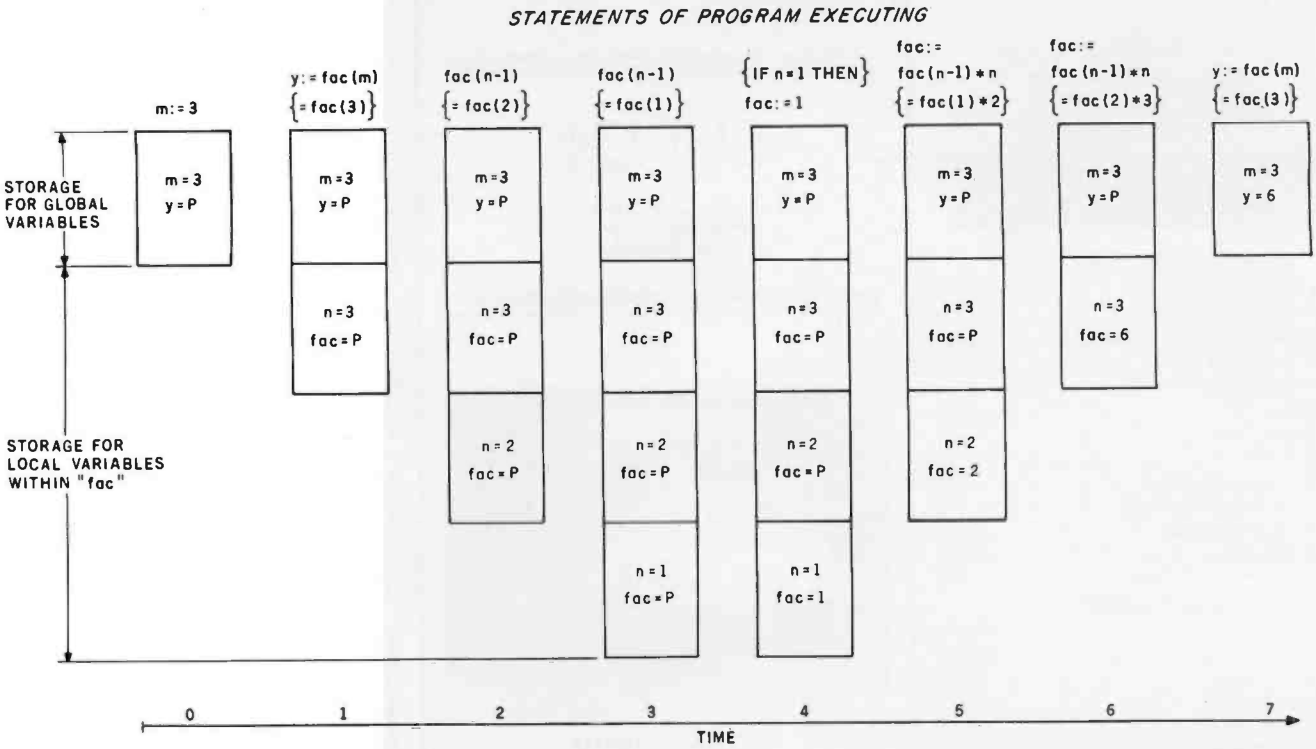


Figure 1: *Execution of the Pascal statements "m := 3; y := fac(m)". The columns of boxes represent the stack at time t=0, 1, 2,...7. The statements above each column indicate the part of the function that is executed to give the stack illustrated below, and the comments in braces are used to clarify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

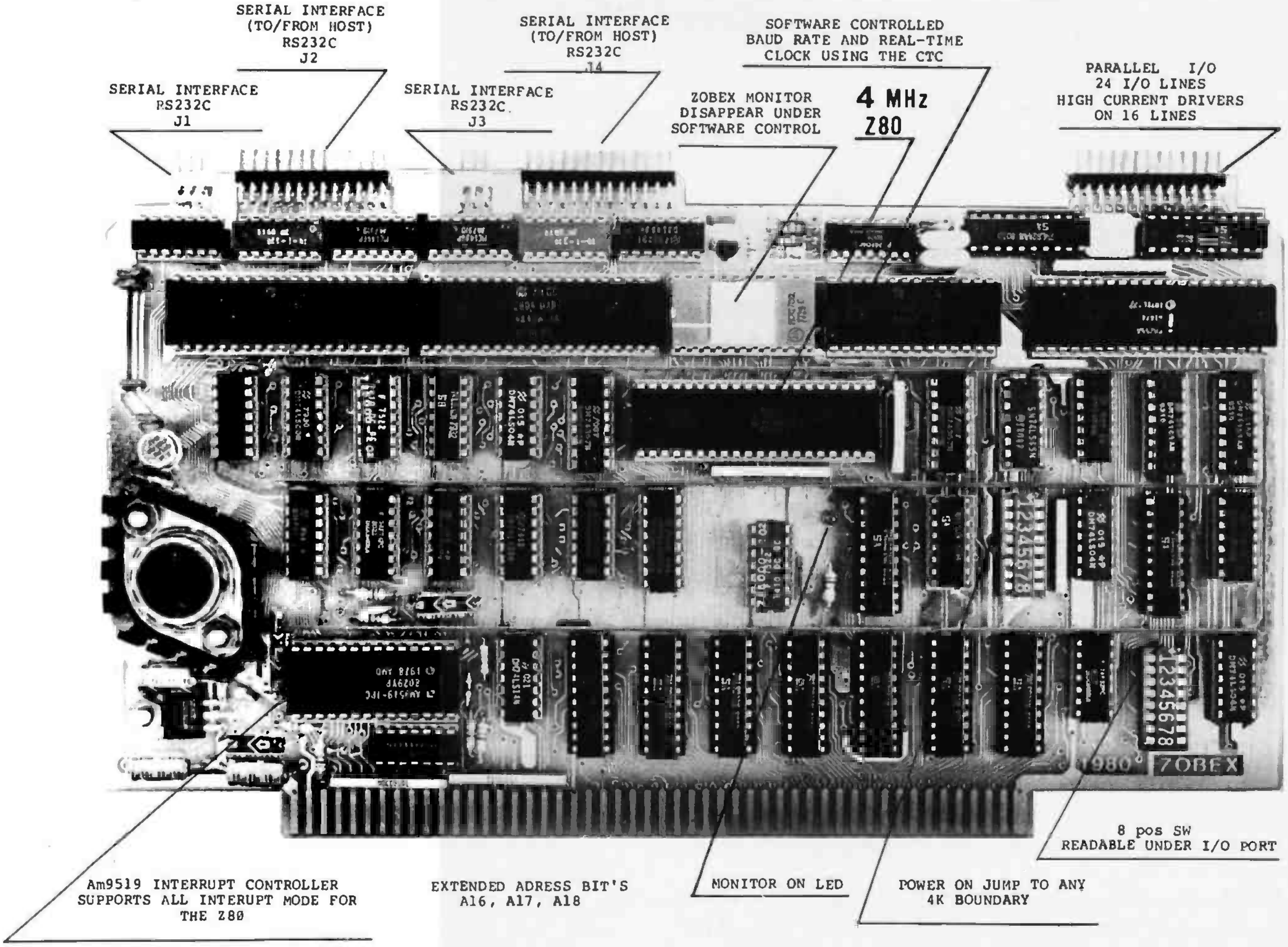
addresses have not been shown in figure 1.

Had the variables "m" or "y" occurred inside "fac" without a new declaration, these variables would be said to be *global* to the function, and then "fac" could access or change their values. When global variables are changed within a function, the function is said to cause *side effects*. Sometimes this is useful, but often it is dangerous, and should be used with caution.

When the program execution begins, the global frame is set up, and soon the variable "m" is assigned the value of 3 (see column 0 in figure 1). When the function call "fac(m)" is reached, a stack frame for "fac" is set up (column 1) below the global frame, and the value, 3, of the argument "m" is assigned the parameter "n" and stored in the local stack frame. (This *call by value* is the default behavior in Pascal. The alternative method of passing values, *variable parameters*, will be discussed shortly.)

Now the value of "fac(n−1)=fac(2)" is required. In order to compute this, the function "fac" is called (recursively), this time with a parameter value of 2. A second local stack frame is set up with n=2 (column 2).

This activation will call "fac(1)", and its frame is set up



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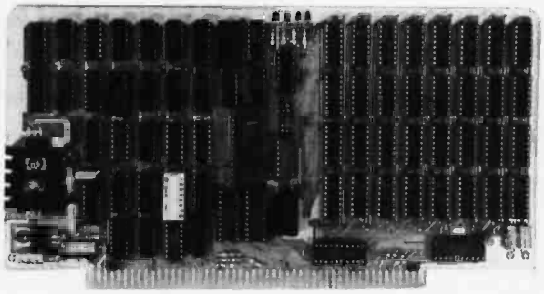

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at the bottom of column 3. Since n=1, this can be evaluated without further recursion: the answer is 1, and is stored in the variable "fac" in column 4. Now the previous invocation of "fac" (with n=2) can complete its work. Its answer is 2×fac(1)=2×1=2, which is assigned to the variable "fac" in column 5 (where the stack frame of "fac(1)" has been popped).

The unwinding process continues as control returns to the previous call of "fac" (with n=3), where the answer can now be computed as fac=3×fac(2)=3×2=6, and stored in column 6. Finally, the answer is assigned to the global variable "y" in column 7.

Applications of Side Effects

Before we see how side effects can lead to unexpected trouble, we should point out that they can be used in many legitimate ways. For example, no useful language can exist without the statement READ(x). It may also be useful to have a function that includes the following code:

```
IF denominator = 0
THEN write('attempt to divide by zero')
ELSE quotient := numerator/denominator
```

The procedures read and write both have side effects—they affect the status of the (global) files input and output.

Another useful application of side effects occurs when each activation of a procedure computes only part of the answer and places it into the appropriate section of a global buffer. When all activations of the procedure have done their jobs, this buffer will contain the entire answer, which can then be worked on. Examples are the recursive algorithms for sorting arrays and for backtracking (see Wirth, Chapter 3 and page 79, listed in the references). This mechanism is not without risk, however, because procedures other than the one intended can inadvertently modify the global variable.

Some languages provide the appropriate mechanism, eg: "own" variables in ALGOL-60 or static storage in PL/I and C. These variables have "local name scope" (ie: they can not be directly accessed from outside the procedure). However, they are allocated storage only once. Thus, like global variables, new copies are not made with each activation of the procedure, so their values are retained from one activation of the procedure to the next. The loss of this feature in Pascal is generally overshadowed by the pleasant fact that Pascal is a simplification of ALGOL-60, whereas PL/I is a "complification."

A Faulty "fac" Function

Now we'll look at a modification of the factorial program, where a variable parameter is used. Although it looks very much like the first version of "fac", you will see that it computes the wrong answer:

```
FUNCTION fac2 (VAR n:INTEGER):INTEGER;
BEGIN
        IF n = 1
        THEN fac2 := 1
        ELSE
        BEGIN
                n := n - 1;
                fac2 := fac2(n) * (n + 1)
        END
END
```

Assume that it is called, as before, by the following sequence:

```
m := 3; y := fac2(m);
```

Note the keyword "VAR" in the function header. A variable parameter in Pascal does not copy the value of its argument onto the stack frame. Instead, a reference (ie: a pointer) to the argument (in this case, the variable "m") is placed on the stack frame. This method is known as "call by reference." There are times when you want to use this method—for example, when a large item like an array or file is a parameter, or when you want to change the value of a global variable. But disaster lurks, as we will indicate shortly.

The argument in a call by reference must also be a variable (see Wirth, page 71). This prohibits a call like "fac2(n−1)", since (n−1) is an expression, not a variable. Therefore, the variable "n" must be decremented in the ELSE clause. This appears to make the same mathematical calculation as in the previous version of the function "fac" because the multiplication is now by (n+1), the original value of n. In fact, it does not.

By having a variable parameter, "fac2" is able to get into the global variable "m" and (if you are not careful) change its value.

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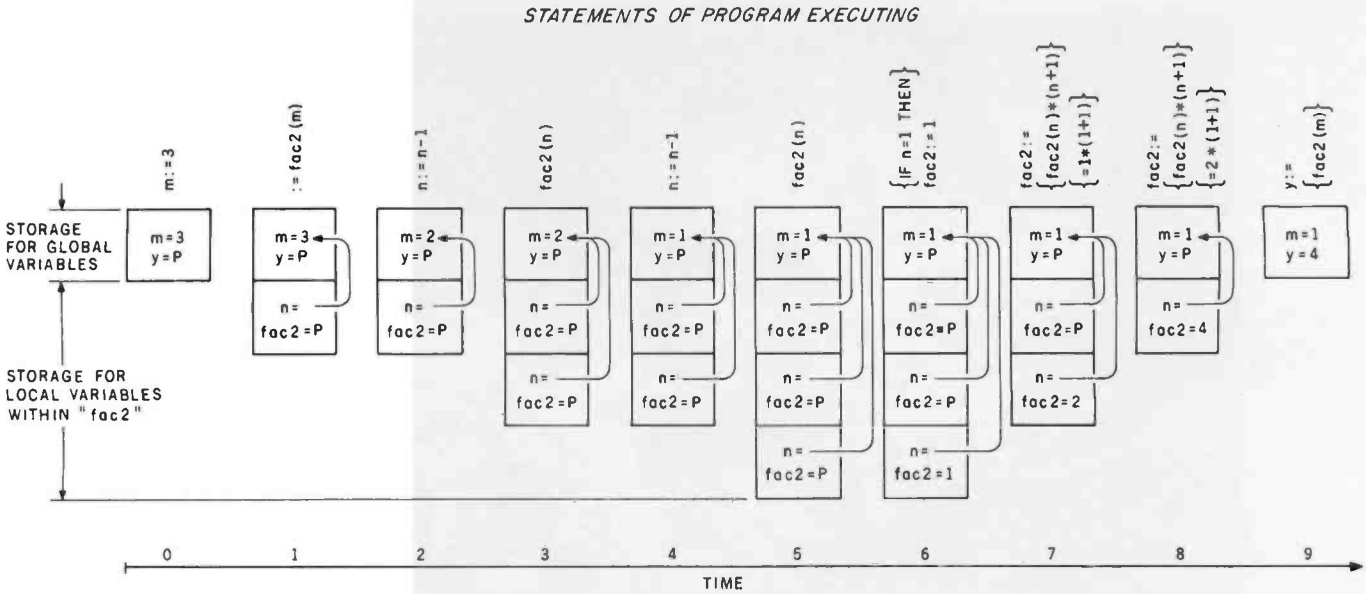

Figure 7: *Execution of the Pascal statements "m := 3; y := fac2(m)". In this case, the variable "n" within the function "fac2" (listed in the text) points to the global variable "m" and can change its value; the arrows from "n" to "m" indicate this relationship.*

Consider the stack diagrams for the function "fac2" (see figure 2). This time, each new instance of "n" gets a pointer to the variable "m" and the code "n := n−1" causes the global variable, "m", to be decremented by 1. Still, no values can be assigned to "fac2" until the stack starts to unwind, and when that happens, the value of "m" has been decreased to 1. Thus the multiplication is always by 2.

As you see, this function is not computing factorials at all, but 2^{m-1}. The problem arises because "fac2" is altering the value of its parameter, a situation to be avoided when not absolutely necessary. After the entire function terminates, the variable "m" will be left at 1, regardless of its initial value. The function "fac2" is exerting a side effect on "m".

Side effects can occur whenever a procedure accesses a global variable either directly or indirectly via a variable parameter. Side effects are avoided by the use of local parameters (declared within the procedure or function) and value parameters. Many side-effect errors are so easy to make and so hard to debug that language designers will prohibit certain dangerous constructs (or encourage the implementors to do so). (See *Pascal User Manual and Report*, page 79, listed in the references.) For example, the use of global variables (or parameters) for the control of "for" loops is prohibited by the CDC implementation of Pascal described in *The Pascal User Manual and Report* (pages 120 and 121, and error messages 155 and 180).

One of the most discomforting difficulties in debugging

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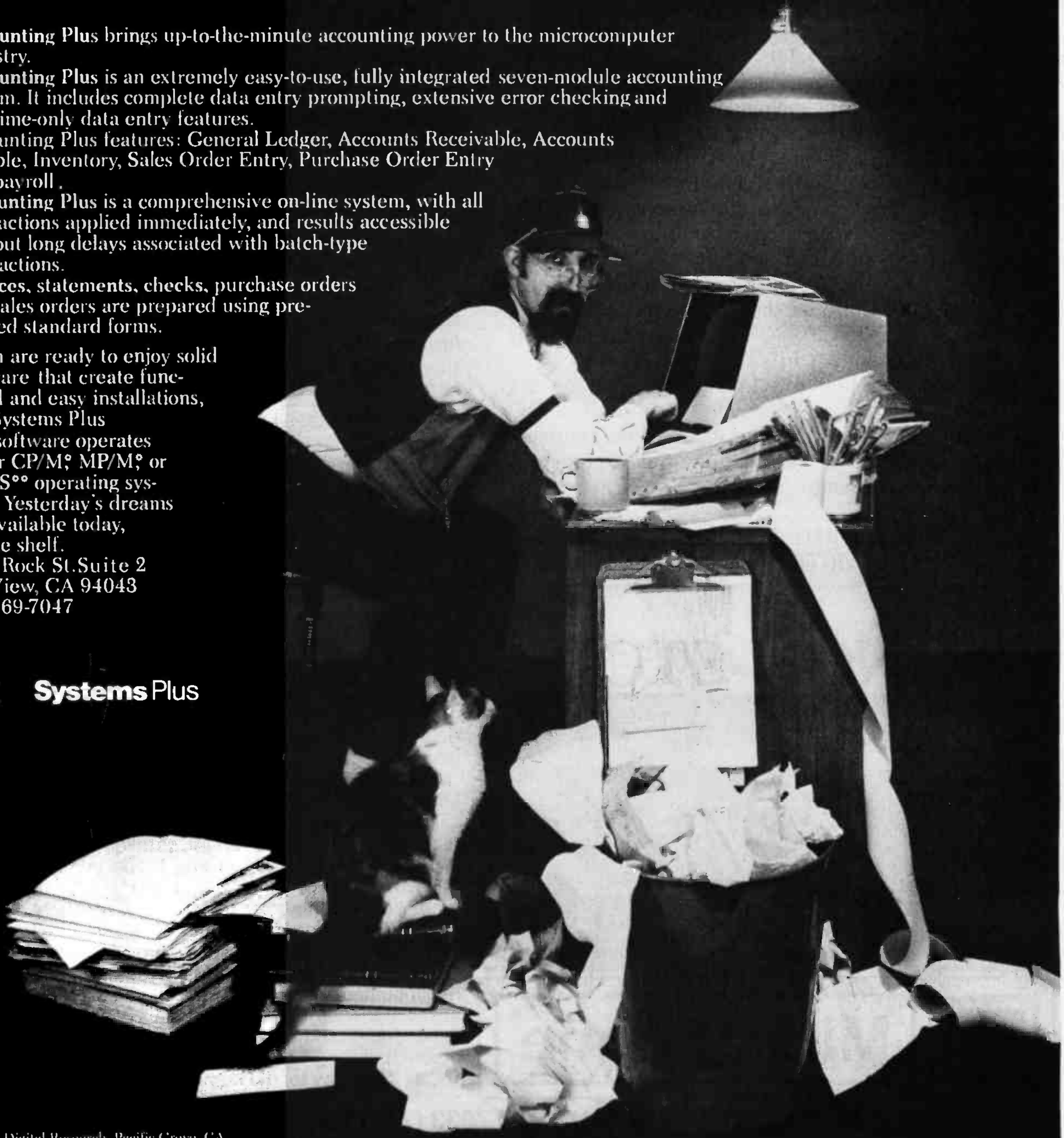

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Programmers should strive to write code that is clear, correct, verifiable, and easily transported to other implementations.

functions with side effects may occur if f×g is not equal to g×f, at least if "f" or "g" is a function. Consider, for example, the apparently simple modification of the "fac2" function that is made by changing the key line to:

```
fac2 := (n + 1)*fac2(n)
```

The reader is invited to make a stack history as above. Assume that multiplications are performed left to right, and that the stack frame for "fac2" also allocates a location to hold the value of the expression (n+1) until after "fac2(n)" is computed, with the two values then being multiplied. (In practice, values of such expressions may be stored as temporary variables in registers.)

As a result of this single change, "fac2" will compute the correct value of factorial. What is the moral? Whenever the spectre of unplanned side effects rears its ugly head, discovery of the "correct" solution may be a matter of luck (and might depend on the implementation!). In any case, programs are certainly hard to debug whenever f×g and g×f are not equal.

There are, of course, simpler examples that illustrate this phenomenon. Consider the following function:

```
FUNCTION f(VAR i:INTEGER):INTEGER;
BEGIN f := i; i := i + 1 END;
```

This function simply returns the value of its argument, but has the side effect of incrementing that argument.

The following sequence:

```
x := 1; WRITE ( (x + 1)*f(x) );
x := 1; WRITE ( f(x) * (x + 1) );
```

produces a printout of:

```
2     3
```

In this case, the printout (which would have been "2 2" if the order of multiplication had not mattered) vindicates our assumption that multiplication was performed left to right.

The order in which multiplications are performed is (deliberately) left unspecified by the semantics of most programming languages. For example:

```
x := 1; WRITE(x*f(x));
x := 1; WRITE(f(x)*x);
```

produces a printout of:

```
2     2
```

and we must conclude that the value of the expression f(x) is evaluated before the value of the variable "x". This may be done for optimization reasons, in order to minimize register use. Furthermore, an optimizing compiler may choose not to evaluate f(x) at all in an expression like 0*f(x), since the answer is always zero. In that case, any side effects of the function "f" on "x" would not appear.

In short, the results of these examples can very well depend on the implementation! It is bad practice to write this kind of code, and programmers should strive to write code that is clear, correct, verifiable, and easily transported to other implementations. If you can avoid unnecessary side effects, you will be one step closer to this goal. ■

References

1. Jensen, K and N Wirth. *Pascal User Manual and Report*. Springer-Verlag, 1974.
2. Wirth, N. *Algorithms + Data Structures = Programs*. Englewood Cliffs NJ: Prentice-Hall, 1976.

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DEMONS includes a flexible disassembler that can be used by itself, with your programs, or with DEMONS. All variables are stored in the MIKBUG scratchpad memory (hexadecimal locations A000 thru A07F), making DEMONS a candidate for being stored in read-only memory. Single-step and trace functions are implemented with a peripheral interface adapter (PIA) and two readily available integrated circuits, which together form a hardware cycle counter producing nonmaskable interrupts. This cycle counter technique is the same as that used in Motorola's EXORciser development system, and allows stepping through programs in read-only memory.

Debug machine-language programs for 6800 systems using instruction mnemonics.

The disassembler requires less than 1 K bytes of read-only memory, produces symbolic program listings similar to those produced by an assembler, and can be used to produce source code for input to an assembler (for instance, if you need to reassemble a program to incorporate modifications). As an added feature, the disassembler calculates and displays the effective address referenced by relative address mode instructions.

Disassembler Routines

The disassembler subsystem consists of three main routines: operator interface, disassembler, and an output routine for terminal display of disassembled code. The user can write his own interface and other routines for special applications. Any operator interface routine must set the first (or only) address of code to be disassembled, the number of lines of disassembled code to be produced (128 lines maximum), and the address of an output routine.

The operator interface routine calls the disassembler as a subroutine. Control will not be returned to the operator interface until the disassembler has produced the required number of lines of code. As each line of code is completed, the disassembler calls the output routine. When the disassembler is done, it returns control to the operator interface routine with the line count set to 0 and the address of the input code incremented to point to the next instruction.

The built-in operator interface is designed for use with video terminals having displays in a format of sixteen lines of thirty-two characters each, although it will work with other types of terminals. Since each line of output is thirty-two characters in length, the interface routine will cause a single page of fifteen lines to be displayed, with the cursor at the bottom of the display (as illustrated in figure 1). A new address can then be entered. If

About the Author

Aillil Ian Halsema has worked as a programmer since 1971. He is now a senior member of the programming staff at Xerox Corporation. He owns a Southwest Technical Products Corporation 6800 system equipped with 16 K bytes of memory, a CT-1024 video terminal, an AC-30 cassette tape interface, and an Okidata CP-110 printer.

you wish to view the next sequential set of fifteen lines, type a nonhexadecimal character followed by a G. The disassembler executes quickly; it will be input/output (I/O) bound (having to wait for I/O operations to finish) up to terminal data rates of about 3000 bps.

Disassembler Tables

Almost half of the memory space taken up by the disassembler is used for two tables. The larger of the two is the *packed-mnemonic* table. Each entry in this table is 2 bytes long, with entries arranged in ascending operation code order. Those operation codes which are undefined (such as hexadecimal 00) are represented in the table by the FCB pseudo-operation mnemonic. Each entry is formed by dropping the fourth character of the mnemonic (either an A or a B as in LDAA), masking out the 3 high-order bits of each of the remaining characters, and packing them into 16 bits. The high-order bit of the 16 is used as a flag to specify an alternate entry in the smaller table. Note that this method of packing characters is valid only for character codes with the same high-order 3 bits. Numeric and alphabetic ASCII characters cannot be packed together. Figure 2 gives an example of mnemonic packing.

The smaller table is the *format* table. It defines the address mode, the fourth character of the mnemonic symbol, and the number of bytes in the input object code. The format table consists of thirty-two 1-byte entries with two entries for each possible value of the high-order nybble (ie: half-byte) of the input op code. The second entry of a pair is selected when bit 16 is set to the value 1 in the corresponding packed-mnemonic-table entry.

This method of defining formats and mnemonics works for all but three mnemonic symbols. The PSHB, PULB, and BSR op codes are exceptions that must be handled differently in the program. A fourth exception is the FCB pseudo-operation which has its own *format-flags byte* outside of the table.

During execution of the disassembler, the op code is used as an index into the packed-mnemonic table, while the high-order nybble of the op code is multiplied by 2 and is used as an index into the format table. The packed mnemonic is unpacked, and the 3 high-order bits of each character are restored by adding hexadecimal 40 to each 5-bit value. The unpacked ASCII characters are stored in a line buffer along with the fourth character, if any, of the mnemonic.

The operand field is built using format table data indicating the length and address mode of the instruction. If an immediate-mode instruction is being processed, the operand is preceded by a "#" character. If the instruction uses relative addressing, the absolute effective address is calculated and is placed in the comments field of the output buffer. If the instruction uses indexing, the operand is followed by a ",X" sequence. All operands are in hexadecimal. All fields in the line start at fixed locations, making for easier user processing.

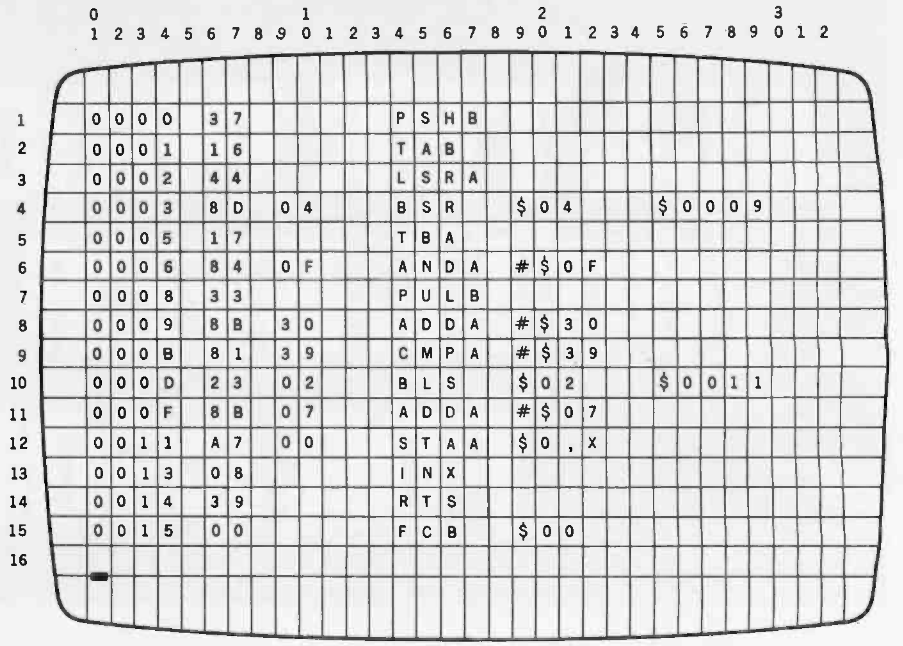


Figure 1: *Example of disassembled code as it appears when output to a video terminal screen.*

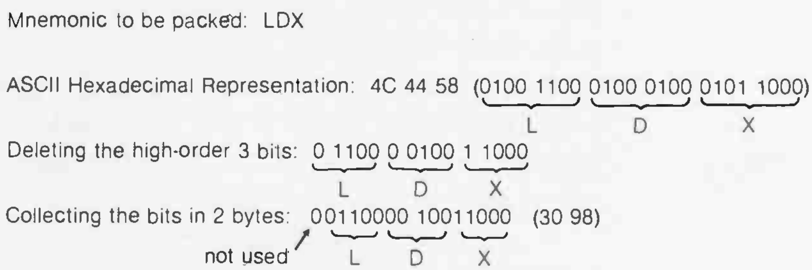
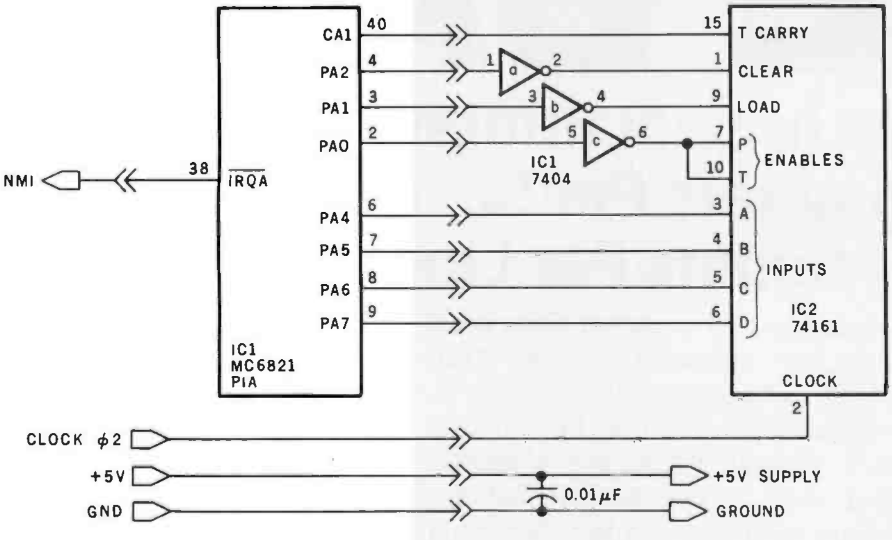


Figure 2: *Forming an entry in the packed-mnemonic table. The three high-order bits are stripped from the ASCII representation of each character of the three-letter mnemonic. The 5-bit characters are packed into two 8-bit bytes, with one bit not used. The characters are restored to 8-bit form by adding hexadecimal 40 to the 5-bit value.*

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.



PIA I/O REGISTER A							
7	6	5	4	3	2	1	0
COUNT BIT 3	COUNT BIT 2	COUNT BIT 1	COUNT BIT 0		$\overline{\text{CLEAR}}$	$\overline{\text{LOAD}}$	$\overline{\text{ENABLE}}$

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

Number	Type	+5 V	GND
IC1	7404	14	7
IC2	74161	16	8

From the program's viewpoint, the counter clear is off when IORA bit 2 is a 1, counter load is off when IORA bit 1 is a 1, and counter enable is on when IORA bit 0 is 0. IORA bits 4, 5, 6, and 7 are used to output the value to be loaded into the counter, leaving IORA bit 3 unused.

The 74161 device in figure 3 is a 32 MHz synchronous 4-bit counter whose carry output will go high for a period equal to one full machine cycle when a count of 15 is reached. By presetting the counter, the carry output can be made to go high after 1 to 15 clock cycles.

I built the prototype version of the cycle counter on a perforated circuit board and attached it to the MP-L board, which supplies power and clock signals. You can see this mounting technique in photos 1 and 2. This assembly plugs into the motherboard and I/O board slot 3, giving it the hexadecimal address range 800C through 800F. If the cycle counter is to be plugged into some other slot, DEMONS will have to have the new address of IORA patched in at hexadecimal locations 03E9, 03EA, 040B, and 040C. DEMONS uses the nonmaskable interrupt (NMI), so the interrupt-request acknowledge (IRQA) line must be wired to the NMI input on the cycle counter's peripheral interface adapter board.

How the Cycle Counter Works

Upon start-up DEMONS initializes the peripheral interface adapter and loads an initial value of 6 (count 9 phase-2 clock cycles) into the counter. The counter is started and a return from interrupt (RTI) instruction is executed. The counter will reach the terminal count value and toggle the CA1 line one cycle before the RTI instruction completes execution. Upon completion of the RTI instruction, the processor will recognize the interrupt, save the registers in the stack, and transfer control to the DEMONS interrupt routine via the previously set NMI vector address.

DEMONS' interrupt processor will test the cycle counter's peripheral interface adapter control register A to verify that it was entered as a result of a valid interrupt. If the cycle counter did not cause the interrupt, the instruction at hexadecimal location

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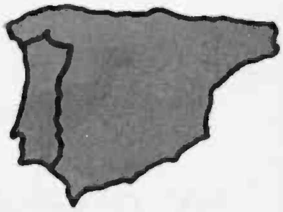

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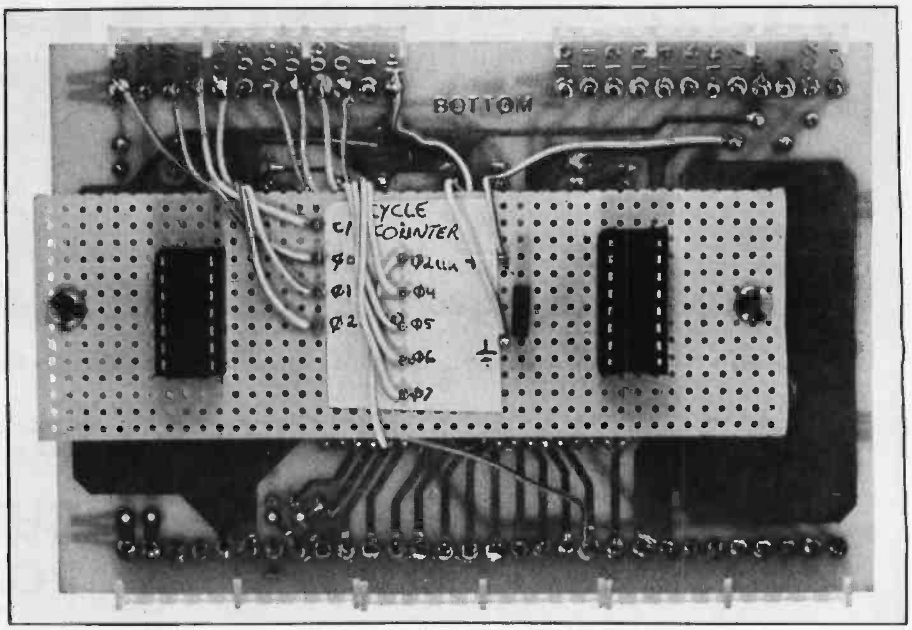

Photo 1: *The cycle-counter circuit was constructed on a small piece of perforated board and mounted on the MP-L parallel interface board inside the SwTPC 6800.*

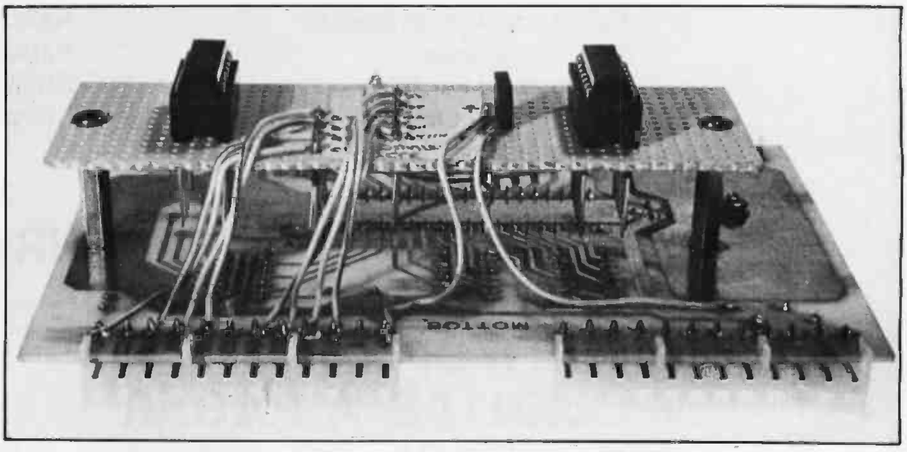

Photo 2: *Shown here is the method of mounting the cycle-counter circuit board.*

0411 will be executed. DEMONS is supplied with three no-operation instructions (NOPs) starting at this address. You should patch DEMONS to jump to another nonmaskable interrupt processing routine if the cycle counter is not the only source of nonmaskable interrupts.

If the interrupt is valid, the counter is halted, cleared, and reloaded with a value of 3. The registers are fetched from the stack and displayed on the terminal along with the next instruction to be executed, in this case the first instruction of the problem program. DEMONS then waits for the user to enter a command. If the *step* command is entered, the counter is started and a return from interrupt (RTI) instruction is executed. Twelve phase-2 (ϕ2) 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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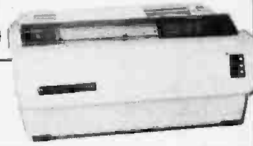

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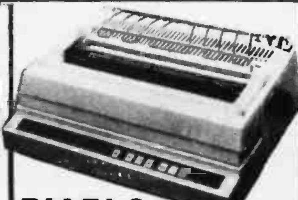

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Command	Description
S.	Step and execute from current address.
S*nnnn*	Set hexadecimal address *nnnn* as the new current address.
T*nnnn*.	Set trace mode and break address *nnnn*. Break count set to 1.
T*nnnn*,11	Set trace mode and break address *nnnn*. Set break count to 11.
C*nn*	Set condition codes to hexadecimal value *nn*.
B*nn*	Set B register to hexadecimal value *nn*.
A*nn*	Set A register to hexadecimal value *nn*.
X*nnnn*	Set X register to hexadecimal value *nnnn*.
R	Display registers.
D.	Display 14 instructions in disassembled form starting at the current address.
D*nnnn*	Display 14 instructions in disassembled form starting at hexadecimal address *nnnn*.
G	Exit from DEMONS and resume problem program execution at the current address.
P*nnnn*,*oo oo* ...	Patch memory starting at address *nnnn* with the hexadecimal values *oo*. Terminate entry with a carriage return.

Table 1: *Summary and description of the DEMONS command set.*

Dialogue at Terminal	Comments
*L	Command MIKBUG to load DEMONS from tape.
*G	Start DEMONS execution.
P *1E00*	Tell DEMONS where to start problem program being debugged.
CC B A X E1 00 00 3745	DEMONS displays registers.
1E00 BD 1E45 JSR $1E45	DEMONS displays the next instruction.
: *S.*	Operator commands an instruction step.
CC B A X E1 00 00 3745	DEMONS displays registers.
1E45 37 PSHB	DEMONS displays the next instruction.
:*T1E5F,03*	Enter trace mode.
: *S.*	Start tracing.

Table 2: *Example of a typical user work session with DEMONS, with commentary. Characters in italics have been typed by the user.*

	Simultaneous Interrupts	Processor Action
Early (PK) Mask	NMI and SWI	*treats as IRQ*
	NMI and IRQ	handles NMI first
	IRQ and SWI	handles SWI first
Later Masks	NMI and SWI	handles NMI first
	NMI and IRQ	handles NMI first
	IRQ and SWI	handles IRQ first

Table 3: *Sequence of interrupt handling in the Motorola 6800 microprocessor. Parts produced during early production runs used the PK chip mask, and demonstrate unexpected behavior under certain interrupt conditions, most notably the simultaneous occurrence of a nonmaskable hardware interrupt (NMI) and a software interrupt (SWI). The PK series of 6800 branches to the* IRQ *(maskable hardware interrupt) vector location whenever this happens. (Parts of the PK series have the letters PK inscribed somewhere on the surface of the package; therefore they may be identified.) Later production runs of the 6800 processor used an improved chip mask, and devices from these later runs handle interrupts in a more logical manner.*

The following rule holds true for all 6800 processors: in the case where the IRQ signal is overruled by one of the other two interrupts, the IRQ may be ignored and lost unless its interrupt signal has been latched. Fortunately, the IRQ signal from the peripheral interface adapter (PIA) is latched.

allow user input. At this point, the user can modify the program; alter the path taken through the program; change the contents of the condition code registers, index register, or either accumulator; display memory content in disassembled form; or enter the trace mode.

In *trace* mode, DEMONS continues to receive control following execution of problem program instructions, but the user is not given control (that is, a chance to input commands) until the *break* address (or breakpoint) is encountered and the break counter is decremented to 0. The user sets the break address and the break count. Once set, these cannot be cleared without going through DEMONS initialization or executing the program being debugged until the break address is encountered N times. The break address entered must always be the address of the op code (ie: first byte) of an instruction byte sequence. Once trace mode is selected, tracing will be started by entry of the step command. Using the trace feature, the user can avoid stepping through long loops and previously debugged code one instruction at a time. Table 1 shows the complete command set of DEMONS; table 2 shows an example of user interaction.

DEMONS may be exited by use of the GO function, which bypasses the counter start-up code, or by activating the system reset line (by hitting the reset switch).

Possible Problems

All debugging monitors have drawbacks; DEMONS is no exception. Since DEMONS relies on having the stack-pointer (SP) register properly set, code which uses the stack pointer as an index register must be bypassed using the step function. Any code that is synchronized with some external process or has critical timing requirements will be delayed by at least 130 machine cycles per instruction, causing possible errors. If a software interrupt (SWI) or regular maskable hardware interrupt (IRQ) occurs simultaneously with the cycle counter's nonmaskable interrupt (NMI), possible vectoring problems may occur. (Table 3 summarizes these effects.) Thus care must be

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I stated that the disassembler executes quickly, and will have to wait for input/output (I/O) operations when using terminals having data rates of up to about 3000 bits per second (bps). I calculated this figure by disassembling 128 instructions and noting the time required to complete this task (T1). The time required for I/O operations (T2) was determined from the following formula:

$$T2 = (C \times L) \times D$$

where:

C is the number of characters per line (32)
L is the number of lines in the test (128)
D is the time required to transmit one character (0.033 seconds at 300 bps)

The processor time required to disassemble the 128 instructions is then:

$$T_p = T1 - T2.$$

The disassembler is no longer I/O bound in speed of execution when $T_p = T2$ for the 128-line test. The system is I/O bound when $T_p < T2$, and is compute bound when $T_p > T2$.

taken when using DEMONS to avoid stepping through software interrupt (SWI) instructions. Likewise, I/O operations involving a regular maskable interrupt (IRQ) may not work correctly every time.

Other Considerations

Several extensions to DEMONS are possible. The *patch* function is not symbolic, but may be made so by using the disassembler tables in reverse and using a subset of the 6800 assembly language restricted to hexadecimal operands. This feature was not included in this version of DEMONS because of the need to avoid using excessive amounts of programmable memory. Another extension could be to allow the entry of multiple addresses for the trace function to compare against. This feature would be useful if a situation arose in which the program under test could take several possible and unpredictable paths.

To use the disassembler in stand-alone mode, control should be passed to hexadecimal location 0000. The disassembler will reply by outputting a blank character to the terminal. Enter the four-digit hexadecimal address of the area of memory whose contents are to be displayed. The disassembler will issue home-up and erase-to-end-of-frame cursor commands to the terminal and will begin displaying lines of disassembled code. When 15 instructions have been displayed, the disassembler will pause awaiting entry of the address of the next area of memory to be displayed. If a nonhexadecimal character is entered, MIKBUG will resume control.

DEMONS is started by transferring control to hexadecimal address 03CC. DEMONS will output the character P to the terminal and await entry of the four-digit hexadecimal address of the program to be debugged. Following entry of this address, the contents of the registers and the next instruction to be executed from the program being debugged will be displayed. DEMONS then issues a colon (:) as a prompt character and awaits entry of a command at the control terminal. If a format error is made while entering a command, DEMONS will output a question mark and again prompt for input.

The most efficient way to use DEMONS is to step through undebugged code a single instruction at a time, patching errors as they are encountered and correcting the contents of the registers when necessary, in an attempt to find as many bugs as possible in a single run. When the number of patches becomes unwieldy, or an unpatchable bug is found, or the last bug is found, only then should you reload the assembler and reassemble the problem program. This technique will reduce the number of times you have to load memory from your mass-storage device and so will increase productivity. ■

Listing 1: *The main debugging routine of DEMONS, assembled in code for the 6800 microprocessor. This program uses the cycle counter, shown in figure 3, to generate interrupts that allow it to take command from the user program.*

```
                          NAM     DEMON
                  *
                  * AUTHOR: A.I. HALSEMA
                  * DATE: 11/08/77
                  * OBJECT MACHINE: SWTPC 6800
                  * PROGRAM NAME: DEMON(S) VERSION 1.0
                  * DEBUG MONITOR (SYMBOLIC) INITIALIZATION
                  *
                  *       THIS ROUTINE READIES THE PIA AND STARTS THE HARDWARE CYCLE
                  *       COUNTER. IT WILL REQUEST THE STARTING ADDRESS OF THE CODE
                  *       TO BE DEBUGGED WITH A 'P' PROMPT. IT ALSO REMOVES TRACE
                  *       SETTINGS.
                          OPT     O
03CC                      ORG     $03CC
                  *
        A075      XSAV    EQU     $A075               X-REGISTER SAVE AREA
        A02F      STAK    EQU     $A02F               DEMON(S) STACK ADDRESS
        A006      NMIV    EQU     $A006               NMI INTERRUPT VECTOR ADDRESS
        E1D1      OUTEEE  EQU     $E1D1               OUTPUT CHARACTER ROUTINE
        A078      TFLAG   EQU     $A078               TRACE ACTIVE FLAG, 1= ACTIVE
        A00C      ADDR    EQU     $A00C               ADDRESS STORAGE USED BY BADDR
        800C      HCCPIA  EQU     $800C               CYCLE COUNTER PIA ADDRESS
        A07C      APPND   EQU     $A07C               APPENDAGE ADDRESS FOR DISASM
        A077      LINES   EQU     $A077               LINES FOR DISASM TO DISPLAY
        01A4      APP     EQU     $01A4                APPENDAGE ADDRESS IN DISASM
        E0CA      OUT2HS  EQU     $E0CA               OUTPUT 2 HEX DIGITS AND SPACE
```

Listing 1 continued on page 338

Listing 1 continued:

```
        E0C8      OUT4HS    EQU    $E0C8         OUTPUT 4 HEX DIGITS AND SPACE
        A079      TADDR     EQU    $A079         TRACE RECOGNITION ADDRESS
        E1AC      INEEE     EQU    $E1AC         CHARACTER INPUT ROUTINE
        E07E      PDATA1    EQU    $E07E         PRINT BLOCK ROUTINE
        0018      NEXTL     EQU    $0018           DISASSEMBLER ENTRY POINT
                  *
                  * DEMON(S) START-UP ENTRY POINT
                  *
03CC 8E A02F      START     LDS    #STAK         SET STACK ADDRESS
03CF 7F A078                CLR    TFLAG         RESET TRACE FLAG
03D2 BD 047D      UG        JSR    CURL          ISSUE CR/LF
03D5 86 50                  LDAA   #'P
03D7 BD E1D1                JSR    OUTEEE        ISSUE PROMPT
03DA BD 0482                JSR    BADDR         GET START OF PROBLEM PROGRAM
03DD 25 F3                  BCS    UG            BAD INPUT- TRY AGAIN
03DF BD 0561                JSR    SETAD
03E2 CE 040A                LDX    #INTRP        SET UP NMI VECTOR
03E5 FF A006                STX    NMIV
03E8 CE 800C                LDX    #HCCPIA       INITIALIZE PIA/CYCLE COUNTER
03EB 6F 01                  CLR    1,X          SELECT DDRA
03ED 86 FF                  LDAA   #$FF         AND SET UP ALL LINES TO OUTPUTS
03EF A7 00                  STAA   X
03F1 86 04                  LDAA   #$04           SELECT IORA
03F3 A7 01                  STAA   1,X
03F5 86 6B                  LDAA   #$6B         TURN OFF COUNTER RESET
03F7 A7 00                  STAA   X             AND SET INITIAL COUNTER VALUE
03F9 A6 00        SETUP     LDAA   X
03FB 84 F9                  ANDA   #$F9         TURN OFF COUNTER LOAD
03FD A7 00                  STAA   X
03FF 86 07                  LDAA   #$07           ENABLE CA1 INTERRUPT ON LOW TO
0401 A7 01                  STAA   1,X          ,HIGH TRANSITIONS
0403 A6 00                  LDAA   X
0405 84 FB                  ANDA   #$FB         START COUNTER
0407 A7 00                  STAA   X
0409 3B                     RTI                  GO TO PROBLEM PROGRAM
                  *
                  * DEMON(S) INTERRUPT PROCESSOR AND OPERATOR COMMAND DECODING.
                  *        ENTERED ONLY UPON OCCURENCE OF NMI INTERRUPT.
                  *        LOCATION LABELLED 'USER' ALLOWS FOR PATCHING IN JUMPS
                  *        TO FURTHER INTERRUPT PROCESSING IF MORE THAN ONE SOURCE
                  *        OF NMI INTERRUPTS IS AVAILABLE.
                  *
040A CE 800C      INTRP     LDX    #HCCPIA       GET PIA ADDRESS
040D 6D 01                  TST    1,X          ,AND CHECK FOR CYCLE COUNTER
040F 2B 03                  BMI    MINE          ,INTERRUPT
0411 01           USER      NOP                  PATCH A JUMP TO SOME OTHER NMI
0412 01                     NOP                  ,PROCESS HERE, BECAUSE THIS
0413 01                     NOP                  ,INTERRUPT IS NOT FROM CYCLES.
0414 86 04        MINE      LDAA   #$04           DISABLE COUNTER INTERRUPTS
0416 A7 01                  STAA   1,X
0418 86 3F                  LDAA   #$3F         STOP COUNTER
041A A7 00                  STAA   X
041C 86 3B                  LDAA   #$3B         RESET COUNTER- SET LOAD VALUE
041E A7 00                  STAA   X             , TO 3
0420 A6 00                  LDAA   X             DUMMY READ TO INSURE NMI OFF
0422 30                     TSX
0423 EE 05                  LDX    5,X          GET ADDRESS OF NEXT INSTRUCTION
0425 FF A00C                STX    ADDR         SET ADDRESS FOR DISASSEMBLER
0428 7D A078                TST    TFLAG         TRACE MODE RUNNING?
042B 27 0A                  BEQ    NOT           IF NOT- BRANCH
042D BC A079                CPX    TADDR         TRACE FLAG SET- TEST ADDRESS
0430 26 52                  BNE    NOPE          BRANCH IF WRONG ADDRESS
0432 7A A078                DEC    TFLAG         ADDRESSES ARE EQUAL- COUNT HIT
0435 26 4D                  BNE    NOPE          IF NOT ZERO- GO TRACE SOME MORE
0437 86 01        NOT       LDAA   #$01           SET NUMBER OF LINES FOR DISASM
0439 B7 A077                STAA   LINES
043C 8D 2B                  BSR    REGS          DO A CR LF AND DISPLAY REGISTERS
043E BD 056E                JSR    SHOLIN        DISPLAY INSTRUCTION
0441 86 3A        COMON     LDAA   #':           GET COMMAND- ISSUE PROMPT
0443 BD E1D1                JSR    OUTEEE
0446 BD E1AC                JSR    INEEE          GET INPUT
0449 CE 0578                LDX    #COMTAB       GET COMMAND TABLE ADDRESS
044C E6 00        TEST      LDAB   X             GET RECOGNITION CHARACTER
044E 11                     CBA                  SAME AS INPUT?
044F 26 04                  BNE    MORE          IF NOT- GO LOOK AGAIN
0451 EE 01                  LDX    1,X          EQUAL- GET CURRENT ADDRESS
0453 6E 00                  JMP    X             GO DO IT TO IT
                  *
0455 5D           MORE      TSTB                 FOUND END OF TABLE?
0456 27 05                  BEQ    BAD           YES- TELL OPERATOR
0458 08                     INX                  NO- POINT TO NEXT ENTRY IN TABLE
0459 08                     INX
045A 08                     INX
045B 20 EF                  BRA    TEST          AND GO TEST IT
                  * INPUT IS BAD- TELL OPERATOR AND GIVE HIM ANOTHER CHANCE TO DO IT RIGHT
045D 86 3F        BAD       LDAA   #'?           DISPLAY QUESTION MARK
045F BD E1D1                JSR    OUTEEE
0462 8D 19        NEXT1     BSR    CURL          DO CARRIAGE RETURN/LINE FEED
0464 20 DB                  BRA    COMON         AND GO TRY AGAIN
```

Listing 1 continued on page 340

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Listing 1 continued:

```
                         *
                         *
                         * REGS- DISPLAY REGISTERS
                         *
0466 8D 15     REGS       BSR     CURL          DO CR/LF
0468 CE 059A              LDX     #CCL          DISPLAY 'CC B A X' CRLF
046B BD E07E              JSR     PDATA1
046E 30                   TSX                   GET STACK ADDRESS
046F 08                   INX                   CORRECT FOR REGS RETURN ADDRESS
0470 08                   INX
0471 BD E0CA              JSR     OUT2HS        DISPLAY CC
0474 BD E0CA              JSR     OUT2HS        DISPLAY B
0477 BD E0CA              JSR     OUT2HS        DISPLAY A
047A BD E0C8              JSR     OUT4HS        DISPLAY X
047D CE 05A4   CURL       LDX     #CRLF         DO CARRIAGE RETURN/LINE FEED
0480 BD E07E              JSR     PDATA1
0483 39                   RTS                   EXIT
                         *
0484 CE 800C   NOPE       LDX     #HCCPIA       GET PIA ADDRESS
0487 7E 03F9              JMP     SETUP         GO START COUNTER AND EXECUTE
                         *
                         * GET HEX INPUT
                         *
048A BD E1AC   INHEX      JSR     INEEE          GO GET CHARACTER
048D 80 30                SUBA    #$30         HEX?
048F 2B 10                BMI     BADHEX        NO- JUMP
0491 81 09                CMPA    #$09           BETWEEN 0 AND $09?
0493 2F 0A                BLE     OKHEX         YES- OK
0495 81 11                CMPA    #$11         A OR GREATER?
0497 2B 08                BMI     BADHEX        NO- ERROR
0499 81 16                CMPA    #$16        F OR LESS?
049B 2E 04                BGT     BADHEX        NO- ERROR
049D 80 07                SUBA    #$07           ADJUST FOR A THROUGH F VALUES
049F 0C        OKHEX      CLC                   CLEAR ERROR FLAG
04A0 39                   RTS                   EXIT
04A1 0D        BADHEX     SEC
04A2 39                   RTS
                         *
                         *GET ONE BYTE OF HEX INPUT- EXIT WITH DIGIT IN A AND CARRY CLEAR IF OK.
                         *
04A3 8D E5     BYTE       BSR     INHEX         GET A DIGIT
04A5 25 0A                BCS     BADB          BAD- NOT HEX- JUMP
04A7 48                   ASLA                  MOST SIGNIFICANT DIGIT, SO LEFT
04A8 48                   ASLA                  . JUSTIFY IT
04A9 48                   ASLA                  .
04AA 48                   ASLA                  .
04AB 16                   TAB                   . AND SAVE IN B-REGISTER
04AC 8D DC                BSR     INHEX         GET LEAST SIGNIFICANT DIGIT
04AE 25 01                BCS     BADB          IF INPUT IS BAD- JUMP
04B0 1B                   ABA                   COMBINE BOTH IN A
04B1 39        BADB       RTS                   EXIT
                         *
                         * BADDR- BUILD ADDRESS, RESULT IN $A00C AND X IF GOOD, ELSE CARRY SET.
                         *
04B2 8D EF     BADDR      BSR     BYTE          GET HEX BYTE
04B4 25 0D                BCS     ADBAD         JUMP IF BAD
04B6 B7 A00C              STAA    ADDR          SAVE BYTE
04B9 8D E8                BSR     BYTE          GET SECOND BYTE
04BB 25 06                BCS     ADBAD         JUMP IF BAD
04BD B7 A00D              STAA    ADDR+1        SAVE IT
04C0 FE A00C              LDX     ADDR          GET IN X
04C3 39        ADBAD      RTS                   EXIT
                         *
                         * TRACE PROCESSING, COMMAND FORMAT: TXXXX, OR TXXXX,NN
                         *                                WHERE T IS THE COMMAND CHARACTER
                         *                                      XXXX IS A FOUR-DIGIT HEX ADDRESS
                         *                                      NN IS A TWO  DIGIT TRAP COUNT=$7F MAX.
                         *         TRACE MODE IS SET WITH THIS COMMAND. STEP COMMAND STARTS RUN.
                         *         THE PROBLEM PROGRAM WILL RUN UNTIL DEMON(S) HAS ENCOUNTERED
                         *         ADDRESS XXXX NN TIMES, WHEN IT WILL RETURN OPERATOR CONTROL.
                         *         ADDRESS XXXX MUST BE THE ADDRESS OF THE FIRST BYTE OF AN INSTRUCTION.
                         *         NOTE THAT ZERO IS A DISALLOWED VALUE FOR NN IN INPUT.
                         *         TXXXX. FORM SETS NN TO 01 AUTOMATICALLY.
04C4 8D EC     TRACE      BSR     BADDR         GO GET TRACE ADDRESS
04C6 25 95                BCS     BAD           BAD INPUT
04C8 FF A079              STX     TADDR
04CB BD E1AC              JSR     INEEE          GET PERIOD OR COMMA
04CE 81 2E                CMPA    #'.           PERIOD?
04D0 27 0F                BEQ     SETONE        YES- SET TFLAG TO ONE
04D2 81 2C                CMPA    #',           COMMA?
04D4 26 87                BNE     BAD           NO- BAD INPUT
04D6 8D CB                BSR     BYTE          IT IS COMMA- GET LOOP COUNT
04D8 25 83                BCS     BAD
04DA 27 81                BEQ     BAD
04DC B7 A078   SETT       STAA    TFLAG         SET IN TRACE FLAG
04DF 20 B1     NEXT2      BRA     NEXT1         GO GET A COMMAND
04E1 86 01     SETONE     LDAA    #$01
04E3 20 F7                BRA     SETT
```

Listing 1 continued on page 342

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Listing 1 continued:

```
                      * STEP COMMAND PROCESSING. CAUSES TRANSFER OF CONTROL TO ADDRESS.
                      *                   COMMAND FORMAT: SXXXX OR S.
                      *                           WHERE XXXX IS A FOUR DIGIT HEX ADDRESS.
                      *                   SXXXX FORM SETS NEW CURRENT ADDRESS
                      *                   S. FORM STARTS RUN AT CURRENT ADDRESS.
                      *
04E5 8D CA            STEP       BSR      BADDR                GO GET ADDRESS
04E7 25 98                       BCS      NOPE                 IF NOT HEX- ASSUME PERIOD
04E9 8D 76                       BSR      SETAD                ELSE PUT ADDRESS IN STACK
04EB 7E 0437                     JMP      NOT                  DISPLAY AND GET NEXT COMMAND
04EE 01                          NOP
04EF 01                          NOP
04F0 01                          NOP
04F1 01                          NOP
                      * GO COMMAND PROCESSING. CAUSES EXIT FROM DEMON(S) WITH CYCLE COUNTER
                      *                         HALTED. USE WHEN FINISHED WITH DEBUGGING.
                      *                         CONTROL IS PASSED TO THE CURRENT ADDRESS REACHED
                      *                         WHILE STEPPING OR TRACING.
04F2 3B               GO         RTI                           EXIT FROM DEMON(S)
                      * DISPLAY COMMAND PROCESSING. DISPLAYS 15 INSTRUCTIONS FROM MEMORY IN
                      *                              DISASSEMBLED FORM.
                      *                              COMMAND FORMS: DXXXX OR D.
                      *                                 WHERE XXXX IS A 4 DIGIT HEX ADDRESS
                      *                              D. CAUSES DISPLAY TO START WITH THE CURRENT
                      *                              INSTRUCTION
04F3 7E 045D          DAB        JMP      BAD
04F6 86 0E            DISPLA     LDAA     #$0E                 SET UP LINES FOR DISASM
04F8 B7 A077                     STAA     LINES
04FB 8D B5                       BSR      BADDR                GET ADDRESS
04FD 24 06                       BCC      SHOW                 IF NO ERROR ON ENTRY- BRANCH
04FF 30                          TSX                           GET ADDRESS FROM STACK
0500 EE 05                       LDX      5,X                  .
0502 FF A00C                     STX      ADDR                 .AND SET FOR DISASSEMBLER
0505 86 10            SHOW       LDAA     #$10                  HOME UP
0507 BD E1D1                     JSR      OUTEEE
050A 8D 62                       BSR      SHOLIN               GO DISPLAY INSTRUCTION
050C 20 D1                       BRA      NEXT2                GET ANOTHER COMMAND
                      * REGISTER DISPLAY. THE REGISTERS IN THE STACK ARE DISPLAYED.
                      *                   COMMAND FORM: R
                      *
050E BD 0466          SHOREG     JSR      REGS                 DISPLAY REGISTERS
0511 7E 0441          BACKUP     JMP      COMON                GO GET ANOTHE COMMAND
                      *
                      * SUPPORT SUBROUTINE- GET INPUT AND PREPARE X REGISTER
                      *
0514 8D 8D            BYN        BSR      BYTE                 GET INPUT BYTE
0516 25 04                       BCS      GAG                  BAD VALUE?
0518 30                          TSX                           SET VALUE IN STACK
0519 08                          INX                           ADJUST ADDRESS FOR BEING IN A SUBROUTINE
051A 08                          INX
051B 39                          RTS
051C 31               GAG        INS
051D 31                          INS
051E 20 D3                       BRA      DAB
                      *
                      * SET CONDITION CODE REGISTER. COMMAND FORM: CXX
                      *                               WHERE XX IS A 2-DIGIT HEX VALUE THAT
                      *                               THE CC REGISTER IN THE STACK WILL BE SET
                      *                               TO.
                      *
0520 8D F2            RSETC      BSR      BYN                  GET INPUT BYTE
0522 A7 00            SETREG     STAA     X
0524 20 B9                       BRA      NEXT2                GO GET ANOTHER COMMAND
                      *
                      * SET B-REGISTER.  COMMAND FORM: BXX
                      *
0526 8D EC            RSETB      BSR      BYN                  GET INPUT BYTE
0528 08               BSETS      INX
0529 20 F7                       BRA      SETREG
                      *
                      * SET A-REGISTER.  COMMAND FORM: AXX
                      *
052B 8D E7            RSETA      BSR      BYN
052D 08                          INX
052E 20 F8                       BRA      BSETS
                      * SET X-REGISTER.  COMMAND FORMAT: XNNNN
                      *                         WHERE NNNN IS A 4-DIGIT HEX VALUE
                      *
0530 BD 04B2          RSETX      JSR      BADDR                GET 4 DIGITS
0533 25 BE                       BCS      DAB                  BAD INPUT?
0535 30                          TSX                           NO- GET STACK ADDRESS
0536 09                          DEX                           SET X VALUE IN STACK
0537 09                          DEX
0538 09                          DEX
0539 8D 28                       BSR      SETS
```

Listing 1 continued on page 344

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

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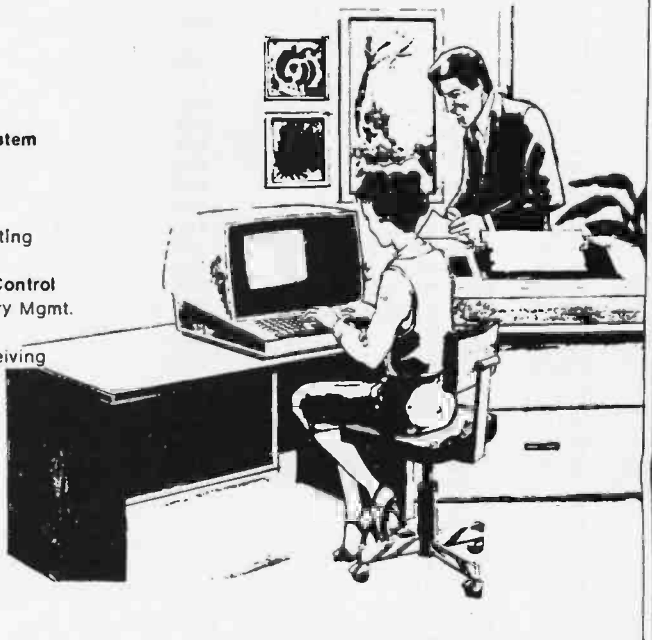
- Parts Inventory Mgmt.
- Parts Purchasing & Receiving
- Bill of Material
- Production Scheduling



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Circle 201 on inquiry card.

Listing 1 continued:

```
0538 20 A2  NEXT3     BRA    NEXT2
                      * PATCH COMMAND PROCESSOR. COMMAND FORMAT: PXXXX,NN NN NN ....(CR)
                      *                                WHERE XXXX IS A 4-DIGIT HEX ADDRESS
                      *                                AND NN IS A 2-DIGIT HEX VALUE
                      *          ENTER AS MANY 2 DIGIT VALUES AS NEEDED, THEN TERMINATE STRING
                      *          WITH A CARRIAGE RETURN. EACH NN VALUE IS PLACED IN MEMORY AS
                      *          IT IS ENTERED, UNLESS AN ERROR IS MADE. THEN THE NN VALUE
                      *          CONTAINING THE ERROR IS REJECTED AND IS NOT STORED.
                      *
053D BD 04B2 PATCH    JSR    BADDR                 GET ADDRESS
0540 25 81            BCS    DAB                   JUMP IF NOT HEX
0542 FF A075 GETMOR   STX    XSAV                  SAVE X FOR LATER
0545 BD 04A3 GETS     JSR    BYTE                  GET 2 DIGIT VALUE
0548 25 0D            BCS    WHAT                  JUMP IF NOT HEX
054A FE A075          LDX    XSAV                  RESTORE X
054D A7 00            STAA   X                     ,AND STORE THE VALUE
054F 08               INX                          POINT TO NEXT LOCATION
0550 86 20            LDAA   #'                    SPACE BETWEEN INPUTS
0552 BD E1D1          JSR    OUTEEE
0555 20 EB            BRA    GETMOR                GO GET MORE INPUT
0557 88 DD   WHAT     EORA   #$DD                 INPUT NOT HEX- CARRIAGE CODE?
0559 27 E0            BEQ    NEXT3                 JUMP IF YES
055B 88 21            EORA   #$21                 COMMA?
055D 27 E6            BEQ    GETS                  JUMP IF YES
055F 20 92            BRA    DAB                   ,ELSE ERROR IF NOT
                      *
                      * SUPPORT SUBROUTINE- MOVE ADDRESS INTO STACK
                      *
0561 30      SETAD    TSX                          PUT THE ADDRESS IN THE STACK
0562 08               INX
0563 B6 A00C SETS     LDAA   ADDR
0566 A7 06            STAA   6,X
0568 B6 A00D          LDAA   ADDR+1
056B A7 07            STAA   7,X
056D 39               RTS
                      *
                      * SUPPORT SUBROUTINE- SET APPENDAGE ADDRESS AND CALL DISASSEMBLER
                      *
056E CE 01A4 SHOLIN   LDX    #APP                  SET APPENDAGE FOR DISASSEMBLER
0571 FF A07C          STX    APPND
0574 BD 001E          JSR    NEXTL                 GO TO DISASSEMBLER
0577 39               RTS
                      * COMMAND TABLE. EACH ENTRY IS 3 BYTES LONG. THE FIRST BYTE IS THE ASCII
                      *                COMMAND CHARACTER. THE NEXT 2 BYTES ARE THE PROCESS
                      *                ADDRESS. THE TABLE IS TERMINATED WITH A BYTE OF ZEROS.
                      *
0578 53      COMTAB   FCC    /S/                   STEP COMMAND
0579 04E5             FDB    STEP
057B 54               FCC    /T/                   TRACE COMMAND
057C 04C4             FDB    TRACE
057E 52               FCC    /R/                   REGISTER DISPLAY
057F 050E             FDB    SHOREG
0581 47               FCC    /G/                   GO COMMAND
0582 04F2             FDB    GO
0584 44               FCC    /D/                   DISPLAY COMMAND
0585 04F6             FDB    DISPLA
0587 43               FCC    /C/                   SET CONDITION CODES
0588 0520             FDB    RSETC
058A 41               FCC    /A/                   SET A-REGISTER
058B 052B             FDB    RSETA
058D 42               FCC    /B/                   SET B-REGISTER
058E 0526             FDB    RSETB
0590 58               FCC    /X/                   SET X-REGISTER
0591 0530             FDB    RSETX
0593 50               FCC    /P/                   PATCH
0594 053D             FDB    PATCH
0596 00               FCB    0,0,0                 SPACE FOR PATCHING AN ENTRY
0597 00
0598 00
0599 00               FCB    0                     END OF TABLE
                      * REGISTER IDENTIFICATION
059A 43      CCL      FCC    /CC B  A  X/          REGISTER ID LINE
059B 43
059C 20
059D 42
059E 20
059F 20
05A0 41
05A1 20
05A2 20
05A3 58
05A4 0D      CRLF     FCB    $0D,$0A,4             CARRIAGE RETURN/LINE FEED
05A5 0A
05A6 04
                      END
```

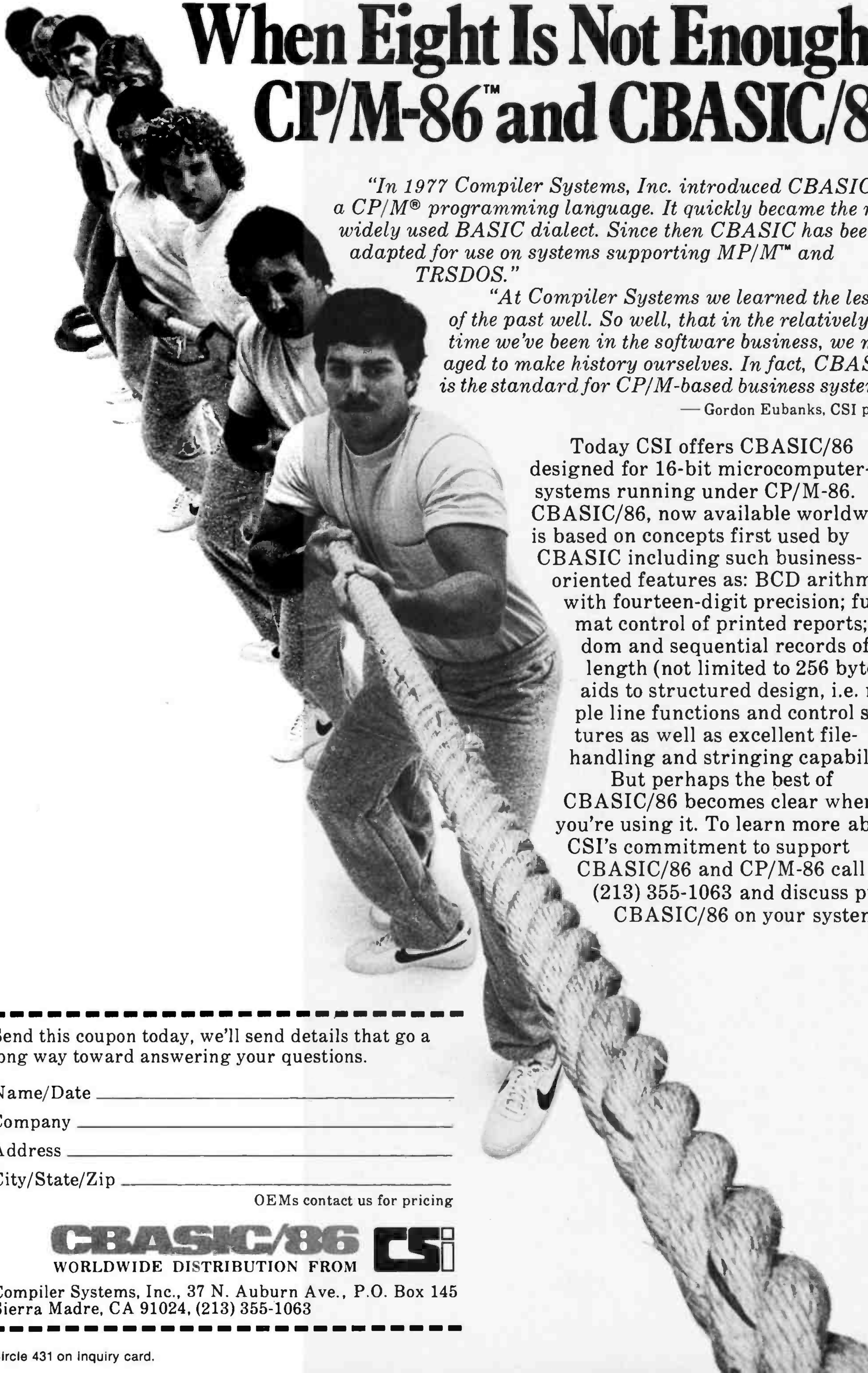
Listing 2 starts on page 346
Listing 3 is on page 358

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

```
                                NAM     DISASM
                        *
                        * AUTHOR: A.I. HALSEMA
                        * DATE: 10-28-1977
                        * OBJECT MACHINE: SWTPC 6800
                        * PROGRAM NAME: DISASSEMBLER VERSION 1.1
                        *
                                OPT     0
       0000                     ORG     $0000
            E047        BADDR   EQU     $E047
            A00C        ADDR    EQU     $A00C
            E07E        PDATA1  EQU     $E07E
                        *
                        * OPERATOR INTERFACE
                        *
       0000 BD E047 START       JSR     BADDR          GET DUMP ADDRESS FROM OPERATOR VIA MIKBUG
       0003 86 0F               LDAA    #15            SET # OF LINES TO DUMP
       0005 B7 A077             STAA    LINES
       0008 CE 0169             LDX     #ERASE         ERASE CRT SCREEN
       000B BD E07E             JSR     PDATA1
       000E CE 01A4             LDX     #APP           SET APPENDAGE ROUTINE ADDRESS
       0011 FF A07C             STX     APPND
       0014 8D 02               BSR     NEXTL
       0016 20 E8               BRA     START
                        * DISASSEMBLER. ENTER WITH DISPLAY START ADDRESS AT $A00C.
                        *               NUMBER OF LINES TO DISPLAY AT LABEL 'LINES'.
                        *             SET ADDRESS OF APPENDAGE ROUTINE AT A07C
                        *               ENTER VIA JSR.
                        *             EACH TIME A LINE IS READY, APPENDAGE RECIEVES CONTROL VIA JSR. RETURN VIA RTS.
                        *               EXIT WITH $A00C CONTAINING ADDRESS OF NEXT
                        *               INSTRUCTION, LOCATION $A04A CONTAINING 32
                        *               BYTES OF ASCII TEXT TERMINATED BY CR,LF,04.
                        *               LOCATION 'LINES' WILL CONTAIN ZERO.
       0018 FE A00C NEXTL       LDX     ADDR           GET ADDRESS OF DATA
       001B A6 00               LDAA    X              GET DATA BYTE
       001D CE A06B             LDX     #WORKA
       0020 A7 03               STAA    BYTE,X         SAVE IT
       0022 5F                  CLRB                   NOW MULTIPLY BY 2
       0023 48                  ASLA
       0024 59                  ROLB
       0025 AB 02               ADDA    TAD+1,X        ADD MNEMONIC TABLE ADDRESS
       0027 E9 01               ADCB    TAD,X
       0029 A7 07               STAA    BASE+1,X       SAV THE DISPLACEMENT INTO TABLE
       002B E7 06               STAB    BASE,X
       002D A6 03               LDAA    BYTE,X         GET HIGH ORDER NYBBLE
       002F 44                  LSRA
       0030 44                  LSRA                   RIGHT JUSTIFY IT
       0031 44                  LSRA                   AND MULTIPLY BY 2
       0032 84 FE               ANDA    #$FE
       0034 5F                  CLRB
       0035 AB 05               ADDA    FAD+1,X        ADD BASE OF FLAG TABLE
       0037 E9 04               ADCB    FAD,X
       0039 A7 09               STAA    FLAGA+1,X      SET POINTER INTO FLAG TABLE
       003B E7 08               STAB    FLAGA,X
       003D CE A04A             LDX     #LINE          BLANK THE DISPLAY LINE
       0040 C6 1B               LDAB    #27
       0042 86 20               LDAA    #$20
       0044 A7 04   BLOP        STAA    4,X
       0046 08                  INX
       0047 5A                  DECB
       0048 26 FA               BNE     BLOP
       004A 86 04               LDAA    #4             SET EOL MARKER
       004C A7 05               STAA    5,X
       004E CE 0D0A             LDX     #$0D0A         SET CRLF IN LINE
       0051 FF A068             STX     LINE+30
       0054 FE A071             LDX     WBAS           GET THE PACKED MNEMONIC
       0057 A6 00               LDAA    X              AND EXPAND INTO DISPLAY LINE
       0059 84 7F               ANDA    #$7F
       005B E6 01               LDAB    1,X
       005D 44                  LSRA
       005E 56                  RORB
       005F 44                  LSRA
       0060 56                  RORB
       0061 8B 40               ADDA    #$40
       0063 B7 A058             STAA    OPER
       0066 54                  LSRB
       0067 54                  LSRB
       0068 54                  LSRB
       0069 CB 40               ADDB    #$40
       006B F7 A059             STAB    OPER+1
       006E A6 01               LDAA    1,X
       0070 84 1F               ANDA    #$1F
       0072 8B 40               ADDA    #$40
       0074 B7 A05A             STAA    OPER+2
       0077 A6 00               LDAA    X              GET HI BYTE AGAIN
       0079 81 18               CMPA    #$18           TEST FOR FCB MNEMONIC
       007B 26 05               BNE     NFC            NOT FCB
       007D CE 03CB             LDX     #FFLAG         IS FCB- SET FCB FLAG ADDRESS
       0080 20 26               BRA     OFF
```

Listing 2 continued on page 348

When Eight Is Not Enough: CP/M-86™ and CBASIC/86™



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Circle 431 on inquiry card.

Listing 2 continued:

```
                     *************************************************
0082 F6 A06E NFC      LDAB    WBYT                    TEST FOR EXCEPTIONS
0085 C1 37            CMPB    #$37               PULB?
0087 26 05            BNE     TPSH
0089 CE 03B5          LDX     #PULB
008C 20 1A            BRA     OFF
008E C1 33   TPSH     CMPB    #$33               PSHB?
0090 26 05            BNE     TBSR
0092 CE 03B5          LDX     #PULB
0095 20 11            BRA     OFF
0097 C8 8D   TBSR     EORB    #$8D               BSR?
0099 26 05            BNE     SET
009B CE 03AF          LDX     #BSR
009E 20 08            BRA     OFF
                     *************************************************
     00A0    SET      EQU     *
00A0 FE A073          LDX     WFLG               GET FLAG ADDRESS
00A3 85 80            BITA    #$80               TEST FLAG BIT
00A5 27 01            BEQ     OFF                BIT IS OFF
00A7 08               INX                        BIT IS ON= POINT TO 2ND FLAG
00A8 A6 00   OFF      LDAA    X                  GET THE FLAG
00AA B7 A06B          STAA    FLAGD              ,AND SAVE IT
00AD CE A04A          LDX     #AADR              POINT ASCII ADDRESS IN LINE
00B0 B6 A00C          LDAA    ADDR               GET CURRENT ADDRESS
00B3 8D 2A            BSR     CVASC              CONVERT TO ASCII
00B5 B6 A00D          LDAA    ADDR+1             SAME FOR LOW BYTE
00B8 8D 25            BSR     CVASC
00BA B6 A06E          LDAA    WBYT               GET CURRENT BYTE
00BD 08               INX                        LEAVE SPACE BETWEEN ADDR,+ DATA
00BE 8D 1F            BSR     CVASC              CURRENT BYTE TO ASCII
00C0 F6 A06B          LDAB    FLAGD              GET FLAG DATA
00C3 C4 03            ANDB    #$3                SAVE ONLY INSTRUCTION LENGTH
00C5 F7 A07B          STAB    SIZE               SAVE IT
00C8 08               INX
00C9 FF A075 CLOP     STX     XSAV               SAVE POINTER INTO DISPLAY LINE
00CC FE A00C          LDX     ADDR               GET DATA ADDRESS
00CF 08               INX
00D0 5A               DECB                       COUNT BYTES
00D1 27 10            BEQ     NMR                NO MORE
00D3 A6 00            LDAA    X                  GET DATA
00D5 FF A00C          STX     ADDR
00D8 FE A075          LDX     XSAV
00DB 8D 02            BSR     CVASC              AND PUT IN DISPLAY LINE AS OBJ.
00DD 20 EA            BRA     CLOP
00DF 7E 018C CVASC    JMP     TOASC
00E2 FF A00C NMR      STX     ADDR               X NOW POINTS TO NEXT DATA
00E5 B6 A06B          LDAA    FLAGD              GET FLAG DATA
00E8 85 40            BITA    #$40               SET REGISTER A?
00EA 27 07            BEQ     NOTA               NO
00EC 86 41            LDAA    #'A                YES= ADD TO ASCII MNEMONIC
00EE B7 A05B SETR     STAA    OPER+3
00F1 20 08            BRA     FORM
00F3 85 80   NOTA     BITA    #$80               SET REGISTER B?
00F5 27 04            BEQ     FORM               NO= NO REGISTER SYMBOL
00F7 86 42            LDAA    #'B                YES
00F9 20 F3            BRA     SETR
00FB CE A05E FORM     LDX     #ARG               POINT ARGUMENT POSITION IN LINE
00FE B6 A06B          LDAA    FLAGD              GET FORMAT CODE
0101 44               LSRA
0102 44               LSRA
0103 84 07            ANDA    #7
0105 27 0F            BEQ     DISPLY             INHERENT FORMAT
0107 4A               DECA
0108 27 1A            BEQ     REL                RELATIVE FORMAT
010A 4A               DECA
010B 27 3D            BEQ     IND                INDEXED FORMAT
010D 4A               DECA
010E 27 46            BEQ     IMM                IMMEDIATE FORMAT
0110 80 03            SUBA    #3                 FCB?
0112 27 49            BEQ     FCBFR
0114 8D 57   DOMV     BSR     SETM               NONE OF THE ABOVE= MUST BE EXTENDED OR DIRECT
0116 FE A07C DISPLY   LDX     APPND              GET APPENDAGE ROUTINE ADDRESS
0119 AD 00            JSR     X
011B 7A A077          DEC     LINES              COUNT LINES
011E 27 03            BEQ     FIN                ALL DONE?
0120 7E 0018          JMP     NEXTL              NO= DO NEXT LINE
0123 39      FIN      RTS                   GO AWAIT NEXT COMMAND
             * FORMAT ARGUMENT FIELD FOR A RELATIVE INSTRUCTION
0124 8D 47   REL      BSR     SETM               SET $ AND MOVE BYTES
0126 FE A00C          LDX     ADDR               POINT TO DATA
0129 09               DEX
012A 4F               CLRA                       CALCULATE EFFECTIVE ADDRESS OF
012B E6 00            LDAB    X                   RELATIVE INSTRUCTION
012D 2A 01            BPL     POS
012F 43               COMA
0130 FB A00D POS      ADDB    ADDR+1
0133 B9 A00C          ADCA    ADDR
0136 01               NOP
0137 01               NOP
0138 01               NOP
0139 CE A064          LDX     #ABS+1
013C 8D 4E            BSR     TOASC
```

Listing 2 continued on page 350

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Circle 324 on inquiry card.

Listing 2 continued:

```
0139E 17                      TBA
013F 01                       NOP
0140 01                       NOP
0141 8D 49                    BSR    TOASC
0143 86 24                    LDAA   #'$
0145 B7 A063                  STAA   ABS
0148 20 CC                    BRA    DISPLY
                * FORMAT ARGUMENT FIELD FOR AN INDEXED INSTRUCTION
014A 8D 21      IND           BSR    SETM             SET $ AND MOVE BYTES
014C 86 2C                    LDAA   #',              APPEND ,X TO FIELD
014E A7 01                    STAA   1,X
0150 86 58                    LDAA   #'X
0152 A7 02                    STAA   2,X
0154 20 C0                    BRA    DISPLY
                * FORMAT ARGUMENT FIELD FOR AN IMMEDIATE INSTRUCTION
0156 86 23      IMM           LDAA   #'#              PRECEED FIELD WITH A #
0158 A7 00                    STAA   X
015A 08                       INX
015B 20 B7                    BRA    DOMV
                * FORMAT ARGUMENT FIELD FOR AN FCB PSEUDO
015D 86 24      FCBFR         LDAA   #'$              MOVE DATA FOR FCB
015F A7 00                    STAA   X
0161 FE A04F                  LDX    LINE+5
0164 FF A05F                  STX    ARG+1
0167 20 AD                    BRA    DISPLY
0169 10         ERASE         FCB    $10,$16,$04
016A 16
016B 04
016C 01                       NOP
                * GENERAL ARGUMENT FIELD FORMATTING
016D 86 24      SETM          LDAA   #'$              SET DOLLAR SIGN
016F A7 00                    STAA   X
0171 BF A073                  STS    WFLG             PREPARE TO MOVE BYTES
0174 8E A051                  LDS    #LINE+7
0177 F6 A07B                  LDAB   SIZE            GET OBJECT INPUT SIZE
017A C1 03                    CMPB   #3              IF SIZE= 3, MOVE 4 BYTES OF ASCII
017C 26 01                    BNE    DLOOP
017E 5C                       INCB
017F 08         DLOOP         INX
0180 32                       PULA
0181 A7 00                    STAA   X
0183 5A                       DECB
0184 26 F9                    BNE    DLOOP
0186 BE A073                  LDS    WFLG            RESTORE SP
0189 39                       RTS
018A 01                       NOP
018B 01                       NOP
                * CONVERT CONTENTS OF A TO ASCII AND STORE AT ADDRESS POINTED TO BY X,
                * RETURN WITH X INCREMENTED AND B UNCHANGED.
018C 37         TOASC         PSHB                   SAVE B
018D 16                       TAB                    COPY A
018E 44                       LSRA                   GET LEFT NYBBL
018F 44                       LSRA
0190 44                       LSRA
0191 44                       LSRA
0192 8D 04                    BSR    ASC             CONVERT TO ASCII AND STORE
0194 17                       TBA
0195 84 0F                    ANDA   #$F             GET RIGHT NYBBL
0197 33                       PULB                  RESTORE B
0198 8B 30      ASC           ADDA   #$30            CONVERT A DIGIT TO ASCII
019A 81 39                    CMPA   #$39
019C 23 02                    BLS    OU
019E 8B 07                    ADDA   #$7
01A0 A7 00      OU            STAA   X
01A2 08                       INX
01A3 39                       RTS
                * APPENDAGE FOR LINE DISPLAY
01A4 CE A04A    APP           LDX    #LINE            GET ADDRESS OF TEXT.
01A7 BD E07E                  JSR    PDATA1          DISPLAY THE LINE
01AA 39                       RTS
                *
                * PACKED MNEMONIC TABLE
                *
                *  MNEMONICS (ALPHA ONLY) ARE TRUNCATED TO THE 5 LOW ORDER BITS
                *  AND STORED 3 IN 16 BITS.  THE HIGH ORDER BIT OF THE 16 IS USED
                *  AS A FLAG WHICH, IF SET, INDICATES THAT THE SECOND FORMAT FLAG
                *  BYTE OF A PAIR SHOULD BE USED.
01AB 1862       MTAB          FDB    $1862           FCB     00
01AD 39F0                     FDB    $39F0           NOP     01
01AF 1862                     FDB    $1862           FCB     02
01B1 1862                     FDB    $1862           FCB     03
01B3 1862                     FDB    $1862           FCB     04
01B5 1862                     FDB    $1862           FCB     05
01B7 5030                     FDB    $5030           TAP     06
01B9 5201                     FDB    $5201           TPA     07
01BB 25D8                     FDB    $25D8           INX     08
01BD 1088                     FDB    $1088           DEX     09
01BF 0D96                     FDB    $0D96           CLV     0A
01C1 4CB6                     FDB    $4CB6           SEV     0B
01C3 0D83                     FDB    $0D83           CLC     0C
01C5 4CA3                     FDB    $4CA3           SEC     0D
```

Listing 2 continued on page 352

4MHZ, DOUBLE DENSITY, COLOR & B/W GRAPHICS . . THE LNW80 COMPUTER

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FEATURES	LNW80	PMC-80**	TRS-80* MODEL III
PROCESSOR	4.0 MHZ	1.8 MHZ	2.0 MHZ
LEVEL II BASIC INTERP.	YES	YES	LEVEL III BASIC
TRS80 MODEL 1 LEVEL II COMPATIBLE	YES	YES	NO
48K BYTES RAM	YES	YES	YES
CASSETTE BAUD RATE	500/1000	500	500/1500
FLOPPY DISK CONTROLLER	SINGLE/ DOUBLE	SINGLE	SINGLE/ DOUBLE
SERIAL RS232 PORT	YES	YES	YES
PRINTER PORT	YES	YES	YES
REAL TIME CLOCK	YES	YES	YES
24 X 80 CHARACTERS	YES	NO	NO
VIDEO MONITOR	YES	YES	YES
UPPER AND LOWER CASE	YES	OPTIONAL	YES
REVERSE VIDEO	YES	NO	NO
KEYBOARD	63 KEY	53 KEY	53 KEY
NUMERIC KEY PAD	YES	NO	YES
B/W GRAPHICS, 128 X 48	YES	YES	YES
HI-RESOLUTION B/W GRAPHICS, 480 X 192	YES	NO	NO
HI-RESOLUTION COLOR GRAPHICS (NTSC), 128 X 192 IN 8 COLORS	YES	NO	NO
HI-RESOLUTION COLOR GRAPHICS (RGB), 384 X 192 IN 8 COLORS	OPTIONAL	NO	NO
WARRANTY	6 MONTHS	90 DAYS	90 DAYS
TOTAL SYSTEM PRICE	$1,664.00	$1,840.00	$2,187.00
LESS MONITOR AND DISK DRIVE	$1,200.00	$1,375.00	---

LNW80

- BARE PRINTED CIRCUIT BOARD & MANUAL $89.95

The LNW80 - A high-speed color computer totally compatible with the TRS-80*. The LNW80 gives you the edge in satisfying your computation needs in business, scientific and personal computation. With performance of 4 MHz, Z80A CPU, you'll achieve performance of over twice the processing speed of a TRS-80*. This means you'll get the performance that is comparable to the most expensive microcomputer with the compatibility to the world's most popular computer (TRS-80*) resulting in the widest software base.

FEATURES:

. TRS-80 Model 1 Level II Software Compatible
. High Resolution Graphics
  . RGB Output - 384 x 192 in 8 Colors
  . NTSC Video or RF MOD - 128 x 192 in 8 Colors
  . Black and White - 480 x 192
. 4 MHz CPU
. 500/1000 Baud Cassette
. Upper and Lower Case
. 16K Bytes RAM, 12K Bytes ROM
. Solder Masked and Silkscreened

LNW SYSTEM EXPANSION

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

The System Expansion will allow you to expand your LNW80, TRS-80*, or PMC-80** to a complete computer system that is still totally software compatible with the TRS-80* Model 1 Level II.

FEATURES:

. 32K Bytes Memory
. 5" Floppy Controller
. Serial RS232 120ma I/O
. Parallel Printer
. Real Time Clock
. Screen Printer Bus
. On Board Power Supply
. Solder Masked and Silkscreened

KEYBOARD

LNW80 KEYBOARD KIT $84.95

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

LNDoubler

- Assembled and Tested $149.00

Double-density disk storage for the LNW Research's "System Expansion" or the Tandy's "Expansion Interface". The LNDoubler™ is totally software compatible with any double density software generated for the Percom's Doubler***. The LNDoubler™ provides the following outstanding features.

. Store up to 350K bytes on a single 5" disk
. Single and double density data separation
. Precision write precompensation circuit
. Software switch between single and double density
. Hardware override into single density only
. Easy plug in installation requiring no etch cuts, jumpers or soldering
. 35, 40, 77, 80 track 5" disk operation
. 120 day parts and labor Warranty

*** Doubler is a product of Percom Data Company, Inc.

DOS PLUS 3.20 . . . . $95.00

Micro Systems software's double density disk operating system. This operating system contains all the outstanding features of a well developed DOS, with ease in useability.

LNW DATA SEPERATOR

- Assembled and Tested $17.95

The LNW Data Separator provides you with a reliable and inexpensive means of solving your disk data read error problems for your 5" single density drives. Compatible with both the LNW System Expansion and Tandy's Expansion Interface. Some soldering is required.

CASE

LNW80 CASE $84.95

The streamline design of this metal case will house the LNW80, LNW System Expansion, LNW80 Keyboard, power supply and fan, LNDoubler™, or LNW Data Separator. This kit includes all the hardware to mount all of the above. Add $12.00 for shipping

PARTS AVAILABLE FROM LNW 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

. LNW80 "Start up parts set" LNW80-1 . . . . $82.00
. LNW80 "Video parts set" LNW80-2 . . . . $31.00
. LNW80 Transformer LNW80-3 . . . . $18.00
. LNW80 Keyboard cable LNW80-4 . . . . $16.00
. 40 Pin computer to expansion cable $15.00
. System Expansion Transformer $19.00
. Floppy Controller (FD1771) and UART (TR1602) . . . $30.00

Circle 219 on inquiry card.

LNW RESEARCH CORPORATION
14661-C MYFORD RD.
TUSTIN CA. 92680

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

Listing 2 continued:

```
01C7 0D89      FDB     $0D89      CLI      0E
01C9 4CA9      FDB     $4CA9      SEI      0F
01CB 4C41      FDB     $4C41      SBA      10
01CD 0C41      FDB     $0C41      CBA      11
01CF 1862      FDB     $1862      FCB      12
01D1 1862      FDB     $1862      FCB      13
01D3 1862      FDB     $1862      FCB      14
01D5 1862      FDB     $1862      FCB      15
01D7 5022      FDB     $5022      TAB      16
01D9 5041      FDB     $5041      TBA      17
01DB 1862      FDB     $1862      FCB      18
01DD 1021      FDB     $1021      DAA      19
01DF 1862      FDB     $1862      FCB      1A
01E1 0441      FDB     $0441      ABA      1B
01E3 1862      FDB     $1862      FCB      1C
01E5 1862      FDB     $1862      FCB      1D
01E7 1862      FDB     $1862      FCB      1E
01E9 1862      FDB     $1862      FCB      1F
01EB 0A41      FDB     $0A41      BRA      20
01ED 1862      FDB     $1862      FCB      21
01EF 0909      FDB     $0909      BHI      22
01F1 0993      FDB     $0993      BLS      23
01F3 0863      FDB     $0863      BCC      24
01F5 0873      FDB     $0873      BCS      25
01F7 09C5      FDB     $09C5      BNE      26
01F9 08B1      FDB     $08B1      BEQ      27
01FB 0AC3      FDB     $0AC3      BVC      28
01FD 0AD3      FDB     $0AD3      BVS      29
01FF 0A0C      FDB     $0A0C      BPL      2A
0201 09A9      FDB     $09A9      BMI      2B
0203 08E5      FDB     $08E5      BGE      2C
0205 0994      FDB     $0994      BLT      2D
0207 08F4      FDB     $08F4      BGT      2E
0209 0985      FDB     $0985      BLE      2F
020B 5278      FDB     $5278      TSX      30
020D 25D3      FDB     $25D3      INS      31
020F C2AC      FDB     $C2AC      PUL A    32
0211 42AC      FDB     $42AC      PUL B    33   EXCEPTION
0213 10B3      FDB     $10B3      DES      34
0215 5313      FDB     $5313      TXS      35
0217 C268      FDB     $C268      PSH A    36
0219 4268      FDB     $4268      PSH B    37   EXCEPTION
021B 1862      FDB     $1862      FCB      38
021D 4A93      FDB     $4A93      RTS      39
021F 1862      FDB     $1862      FCB      3A
0221 4A89      FDB     $4A89      RTI      3B
0223 1862      FDB     $1862      FCB      3C
0225 1862      FDB     $1862      FCB      3D
0227 5C29      FDB     $5C29      WAI      3E
0229 4EE9      FDB     $4EE9      SWI      3F
022B 38A7      FDB     $38A7      NEG A    40
022D 1862      FDB     $1862      FCB      41
022F 1862      FDB     $1862      FCB      42
0231 0DED      FDB     $0DED      COM A    43
0233 3272      FDB     $3272      LSR A    44
0235 1862      FDB     $1862      FCB      45
0237 49F2      FDB     $49F2      ROR A    46
0239 0672      FDB     $0672      ASR A    47
023B 066C      FDB     $066C      ASL A    48
023D 49EC      FDB     $49EC      ROL A    49
023F 10A3      FDB     $10A3      DEC A    4A
0241 1862      FDB     $1862      FCB      4B
0243 25C3      FDB     $25C3      INC A    4C
0245 5274      FDB     $5274      TST A    4D
0247 1862      FDB     $1862      FCB      4E
0249 0D92      FDB     $0D92      CLR A    4F
024B 38A7      FDB     $38A7      NEG B    50
024D 1862      FDB     $1862      FCB      51
024F 1862      FDB     $1862      FCB      52
0251 0DED      FDB     $0DED      COM B    53
0253 3272      FDB     $3272      LSR B    54
0255 1862      FDB     $1862      FCB      55
0257 49F2      FDB     $49F2      ROR B    56
0259 0672      FDB     $0672      ASR B    57
025B 066C      FDB     $066C      ASL B    58
025D 49EC      FDB     $49EC      ROL B    59
025F 10A3      FDB     $10A3      DEC B    5A
0261 1862      FDB     $1862      FCB      5B
0263 25C3      FDB     $25C3      INC B    5C
0265 5274      FDB     $5274      TST B    5D
0267 1862      FDB     $1862      FCB      5E
0269 0D92      FDB     $0D92      CLR B    5F
026B 38A7      FDB     $38A7      NEG,X    60
026D 1862      FDB     $1862      FCB      61
026F 1862      FDB     $1862      FCB      62
0271 0DED      FDB     $0DED      COM,X    63
0273 3272      FDB     $3272      LSR,X    64
0275 1862      FDB     $1862      FCB      65
0277 49F2      FDB     $49F2      ROR,X    66
0279 0672      FDB     $0672      ASR,X    67
027B 066C      FDB     $066C      ASL,X    68
```

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

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 8000-1S	64K	250K	$2840
ACS 8000-28	64K	500K	3500
ACS 8000-1	64K	500K	3840
ACS 8000-2	64K	1M	4500
ACS 8000-4	64K	2M	5600
ACS 8000-5	64K	1M	5990
ACS 8000-6 Mul2 - Multi-User			
(14.5 M-Winchester)	112K	1M	10,670
(29 M-Winchester)	112K	1M	11,870
ACS 8000-6 Mul4 Multi-User			
(14.5 M-Winchester)	208K	1M	11,960
(29 M Winchester)	208K	1M	13,160

apple computer
Authorized Dealer

16K APPLE II+	$1330
32K " II+	1430
48K " II+	1530
APPLE DISK w/3.3 DOS	650
APPLE DRIVE Only	495

APPLE III in Stock!!

128K, with Monitor and Info Analystpak 4740

EPSON PRINTER MX-80

80 Columns, 9x9 Dot Matrix
Bidirectional Printing .. $645
Interface Cards

8140 (RS-232)	$55
8161 (IEEE 488)	55
8131 (Apple Card)	85
8230 (Apple Cable)	25
8220 (TRS-80 Cable)	35

PROFESSIONAL SOFTWARE

WordPro I (8K)	$29.95
WordPro III (40 Col.) 16K	199.95
WordPro III+ Enhanced Version	295.00
WordPro IV 80 Col., 32K	375.00
WordPro IV+ Enhanced Version	450.00

Multi-Cluster for Commodore Systems.

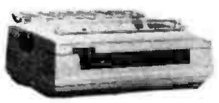
Allows 3 CPU's (Expandable to 8) to access a single Commodore Disk.

Multi-Cluster .... $795 (3 CPU's)
Each Additional CPU $199 (up to 8)

DIABLO 630

45 CPS, Letter Quality
RS-232 Port $2,710
Tractor Option 250

NEC Spinwriter



5530 (Parallel)	$3055
5510 (Serial)	3055
5520 (KSR-Serial)	3415
TRACTOR OPTION	225

55 CPS
Letter Quality
High Reliability

C. ITOH Starwriter

Serial or Parallel $1995

FP 1500
25 CPs,
Letter Quality

NEECO

679 Highland Avenue
Needham, MA 02194

NEECO Order Lines: (617) 449-1760

MON - FRI 9:00 - 5:00 VISA/MC Accepted Telex 951021

NEECO Order Lines: (617) 449-1760

Circle 282 on inquiry card.

Listing 2 continued:

```
027D 49EC       FDB   $49EC       ROL,X    69
027F 10A3       FDB   $10A3       DEC,X    6A
0281 1862       FDB   $1862       FCB      6B
0283 25C3       FDB   $25C3       INC,X    6C
0285 5274       FDB   $5274       TST,X    6D
0287 29B0       FDB   $29B0       JMP,X    6E
0289 0D92       FDB   $0D92       CLR,X    6F
028B 38A7       FDB   $38A7       NEG      70
028D 1862       FDB   $1862       FCB      71
028F 1862       FDB   $1862       FCB      72
0291 0DED       FDB   $0DED       COM      73
0293 3272       FDB   $3272       LSR      74
0295 1862       FDB   $1862       FCB      75
0297 49F2       FDB   $49F2       ROR      76
0299 0672       FDB   $0672       ASR      77
029B 066C       FDB   $066C       ASL      78
029D 49EC       FDB   $49EC       ROL      79
029F 10A3       FDB   $10A3       DEC      7A
02A1 1862       FDB   $1862       FCB      7B
02A3 25C3       FDB   $25C3       INC      7C
02A5 5274       FDB   $5274       TST      7D
02A7 29B0       FDB   $29B0       JMP      7E
02A9 0D92       FDB   $0D92       CLR      7F
02AB 4EA2       FDB   $4EA2       SUB A    80
02AD 0DB0       FDB   $0DB0       CMP A    81
02AF 4C43       FDB   $4C43       SBC A    82
02B1 1862       FDB   $1862       FCB      83
02B3 05C4       FDB   $05C4       AND A    84
02B5 0934       FDB   $0934       BIT A    85
02B7 3081       FDB   $3081       LDA A    86
02B9 1862       FDB   $1862       FCB      87
02BB 15F2       FDB   $15F2       EOR A    88
02BD 0483       FDB   $0483       ADC A    89
02BF 3E41       FDB   $3E41       ORA A    8A
02C1 0484       FDB   $0484       ADD A    8B
02C3 8E18       FDB   $8E18       CPX      8C
02C5 0A72       FDB   $0A72       BSR      8D      EXCEPTION
02C7 B093       FDB   $B093       LDS      8E
02C9 1862       FDB   $1862       FCB      8F
02CB 4EA2       FDB   $4EA2       SUB A    90
02CD 0DB0       FDB   $0DB0       CMP A    91
02CF 4C43       FDB   $4C43       SBC A    92
02D1 1862       FDB   $1862       FCB      93
02D3 05C4       FDB   $05C4       AND A    94
02D5 0934       FDB   $0934       BIT A    95
02D7 3081       FDB   $3081       LDA A    96
02D9 4E81       FDB   $4E81       STA A    97
02DB 15F2       FDB   $15F2       EOR A    98
02DD 0483       FDB   $0483       ADC A    99
02DF 3E41       FDB   $3E41       ORA A    9A
02E1 0484       FDB   $0484       ADD A    9B
02E3 8E18       FDB   $8E18       CPX      9C
02E5 1862       FDB   $1862       FCB      9D
02E7 B093       FDB   $B093       LDS      9E
02E9 CE93       FDB   $CE93       STS      9F
02EB 4EA2       FDB   $4EA2       SUBA,X   A0
02ED 0DB0       FDB   $0DB0       CMPA,X   A1
02EF 4C43       FDB   $4C43       SBCA,X   A2
02F1 1862       FDB   $1862       FCB      A3
02F3 05C4       FDB   $05C4       ANDA,X   A4
02F5 0934       FDB   $0934       BITA,X   A5
02F7 3081       FDB   $3081       LDAA,X   A6
02F9 4E81       FDB   $4E81       STAA,X   A7
02FB 15F2       FDB   $15F2       EORA,X   A8
02FD 0483       FDB   $0483       ADCA,X   A9
02FF 3E41       FDB   $3E41       ORAA,X   AA
0301 0484       FDB   $0484       ADDA,X   AB
0303 8E18       FDB   $8E18       CPX,X    AC
0305 AA72       FDB   $AA72       JSR,X    AD
0307 B093       FDB   $B093       LDS,X    AE
0309 CE93       FDB   $CE93       STS,X    AF
030B 4EA2       FDB   $4EA2       SUBA     B0
030D 0DB0       FDB   $0DB0       CMPA     B1
030F 4C43       FDB   $4C43       SBCA     B2
0311 1862       FDB   $1862       FCB      B3
0313 05C4       FDB   $05C4       ANDA     B4
0315 0934       FDB   $0934       BITA     B5
0317 3081       FDB   $3081       LDAA     B6
0319 4E81       FDB   $4E81       STAA     B7
031B 15F2       FDB   $15F2       EORA     B8
031D 0483       FDB   $0483       ADCA     B9
031F 3E41       FDB   $3E41       ORAA     BA
0321 0484       FDB   $0484       ADDA     BB
0323 8E18       FDB   $8E18       CPX      BC
0325 AA72       FDB   $AA72       JSR      BD
0327 B093       FDB   $B093       LDS      BE
0329 CE93       FDB   $CE93       STS      BF
032B 4EA2       FDB   $4EA2       SUBB     C0
032D 0DB0       FDB   $0DB0       CMPB     C1
032F 4C43       FDB   $4C43       SBCB     C2
0331 1862       FDB   $1862       FCB      C3
```

Listing 2 continued on page 356

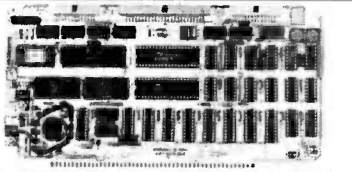
asap computer products, inc.

NEW LOCATION
1198 E. Willow Street
Signal Hill, CA 90806
Toll Free (800) 421-7701 Outside Calif.
(213) 595-6431 Inside Calif.

ORDERING INFO
Name, address, phone
Ship By: UPS or Mail
Shipping Chrg. Add $2.50 up to 2 lbs. (UPS Blue)
U.S. Mail Add $1.50 (U.S. Only)
($25.00 Minimum Order)

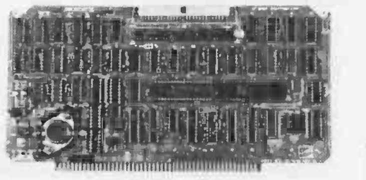
TERMS
We Accept Cash, Check, Money Orders, Visa & Master Charge
(U.S. Funds Only)
Tax: 6% Calif. Res.
COD's & Terms Available on Approval (School PO's Accepted)

MICROBYTE S-100 BOARDS



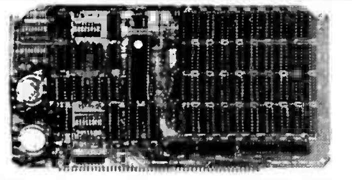
Z-80A/I-O $349.00
Assembled & Tested
Optional Monitor Program $50.00

- A 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 — 8 bit with MNI (1 bit)
- 2MHz or 4MHz operation is jumper selectable
- Selectable auto-wait state insertion for extending M1*, MRED*, IORQ* and/or on board ROM
- Dual RS 232 serial I/O ports using the Z80A DART with individual baud rate selection (from 50-19 200 baud)
- Up to 24 bit parallel I/O port—fully programmable Intel 8255A



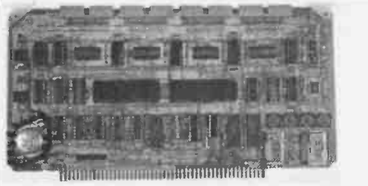
MICROBYTE
- Fully S100 bus compatible
- 64K x 8 bit dynamic RAM
- Low power
  - + 8VDC @ 700 ma
  - + 16VDC @ 100 ma
  - − 16VDC @ 25 ma
- Built-in-parity with LED indicator and vector interrupt
- Memory addressable in four 16K banks
- Hidden refresh
- Gold contacts for high reliability
- 72-hour Burn-in
- Memory mapped via DIP switch
- Built-in programmable write protect
- Programmable control port for parity and bank control
- Alpha-Micro Compatible

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



Disc Controller $389.00
Assembled & Tested
CPM Available (Optional)

MICROBYTE
- DMA to within 16M byte of memory
- State of-the art NEC765 LSI Controller
- IEEE-S100 compatible
- DMA arbitration allows use of multiple boards within a system
- PLL data recovery for totally reliable operation
- Write pre-comp switched at mid-disc for reliable double density operation
- Supports up to four (4) drives
- Power On, Power Off or Reset deselects drives to avoid damaging files
- Drive deselect Time Out, deselect drives not in use
- Single or double sided operation
- Single density/double density operation
- 8" standard drives
- Separate V_{CC} supply for data recovery to eliminate possible noise problems



I/O Board $289.00
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 Z80A-Dart(TM) or Synchronous Communications with Z80A-SIO/0(TM)
- Full Set of Modem Control Signals, including RI (Ring Indicator)
- Easily Configurable to Any Type of Terminal Interface
- I/O Servicing Environments: (1) Polled, (2) Bus Vector; (3) Z80 Mode 2 Vector
- Off Board Interrupt Daisy Chain Capability
- Special Receive Conditions: (1) Framing Error; (2) Parity Error; (3) Receiver Overrun Error
- Baud Rates Selected Individually from 50 Baud to 300K Baud
- 72 Hour Burn-In

INFLATION FIGHTER

4116's (200 ns.)
Apple, TRS-80, Heath
8 for $22.00

16- 49	$2.60
50- 99	$2.50
100-499	$2.40
500 Up	$2.25

2114 L-2/200 NS

1-16	$3.60 ea.
17-49	$3.40 ea.
50-99	$3.25 ea.
100-499	$3.00 ea.
500 Up	$2.85 ea.

COMPONENTS

74LS240	1.25 ea.
74LS241	1.10 ea.
74LS244	1.25 ea.
74LS373	1.25 ea.
74LS374	1.25 ea.
8T245	1.45 ea.

S.D. SYSTEM / S-100 BOARDS

EXPANDORAM I 2MHz DYNAMIC RAM BOARD KITS — 16K $239.00; 32K $265.00; 48K $289.00; 64K $315.00

EXPANDO RAM II 4MHz DYNAMIC RAM BOARD KITS — 16K $250.00; 32K $275.00; 48K $300.00; 64K $325.00

SBC-100 KIT $299.00
2.5 MHz/Z-80 CPU WITH SERIAL & PARALLEL I/O PORTS

SBC-200 KIT $325.00
4MHz/Z-80 CPU WITH SERIAL & PARALLEL I/O PORTS

VDB-8024 KIT $380.00
80x24 I/O MAPPED VIDEO BOARD WITH KEYBOARD I/O

VERSAFLOPPY I KIT $250.00
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40 PIN	.40	.38

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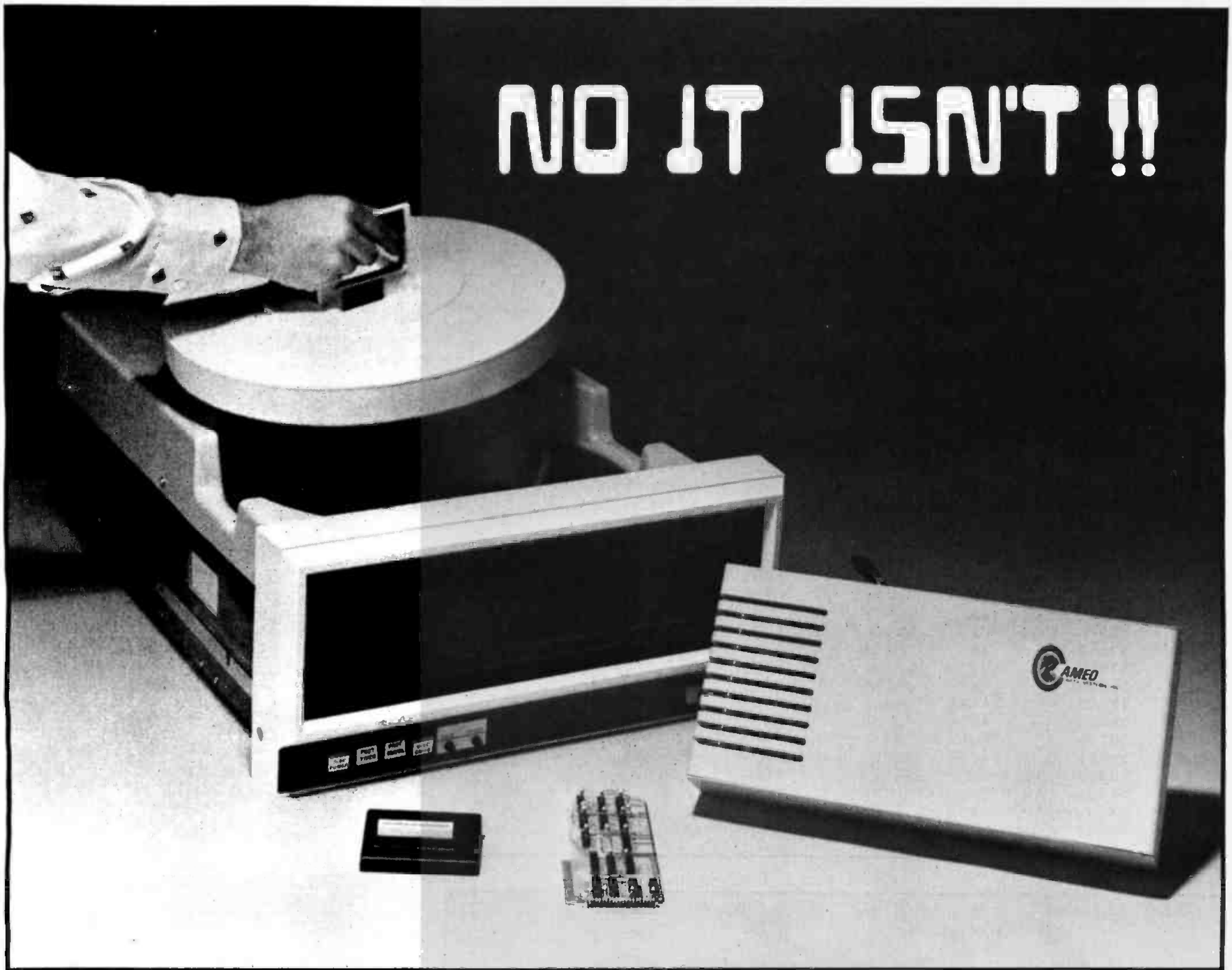
Circle 33 on inquiry card.

Listing 2 continued:

```
0333 05C4                FDB     $05C4          ANDB     C4
0335 0934                FDB     $0934          BITB     C5
0337 3081                FDB     $3081          LDAB     C6
0339 1862                FDB     $1862          FCB      C7
033B 15F2                FDB     $15F2          EORB     C8
033D 0483                FDB     $0483          ADCB     C9
033F 3E41                FDB     $3E41          ORAB     CA
0341 0484                FDB     $0484          ADDB     CB
0343 1862                FDB     $1862          FCB      CC
0345 1862                FDB     $1862          FCB      CD
0347 B098                FDB     $B098          LDX      CE
0349 1862                FDB     $1862          FCB      CF
034B 4EA2                FDB     $4EA2          SUBB     D0
034D 0DB0                FDB     $0DB0          CMPB     D1
034F 4C43                FDB     $4C43          SBCB     D2
0351 1862                FDB     $1862          FCB      D3
0353 05C4                FDB     $05C4          ANDB     D4
0355 0934                FDB     $0934          BITB     D5
0357 3081                FDB     $3081          LDAB     D6
0359 4E81                FDB     $4E81          STAB     D7
035B 15F2                FDB     $15F2          EORB     D8
035D 0483                FDB     $0483          ADCB     D9
035F 3E41                FDB     $3E41          ORAB     DA
0361 0484                FDB     $0484          ADDB     DB
0363 1862                FDB     $1862          FCB      DC
0365 1862                FDB     $1862          FCB      DD
0367 B098                FDB     $B098          LDX      DE
0369 CE98                FDB     $CE98          STX      DF
036B 4EA2                FDB     $4EA2          SUBB,X   E0
036D 0DB0                FDB     $0DB0          CMPB,X   E1
036F 4C43                FDB     $4C43          SBCB,X   E2
0371 1862                FDB     $1862          FCB      E3
0373 05C4                FDB     $05C4          ANDB,X   E4
0375 0934                FDB     $0934          BITB,X   E5
0377 3081                FDB     $3081          LDAB,X   E6
0379 4E81                FDB     $4E81          STAB,X   E7
037B 15F2                FDB     $15F2          EORB,X   E8
037D 0483                FDB     $0483          ADCB,X   E9
037F 3E41                FDB     $3E41          ORAB,X   EA
0381 0484                FDB     $0484          ADDB,X   EB
0383 1862                FDB     $1862          FCB      EC
0385 1862                FDB     $1862          FCB      ED
0387 B098                FDB     $B098          LDX,X    EE
0389 CE98                FDB     $CE98          STX,X    EF
038B 4EA2                FDB     $4EA2          SUBB     F0
038D 0DB0                FDB     $0DB0          CMPB     F1
038F 4C43                FDB     $4C43          SBCB     F2
0391 1862                FDB     $1862          FCB      F3
0393 05C4                FDB     $05C4          ANDB     F4
0395 0934                FDB     $0934          BITB     F5
0397 3081                FDB     $3081          LDAB     F6
0399 4E81                FDB     $4E81          STAB     F7
039B 15F2                FDB     $15F2          EORB     F8
039D 0483                FDB     $0483          ADCB     F9
039F 3E41                FDB     $3E41          ORAB     FA
03A1 0484                FDB     $0484          ADDB     FB
03A3 1862                FDB     $1862          FCB      FC
03A5 1862                FDB     $1862          FCB      FD
03A7 B098                FDB     $B098          LDX      FE
03A9 CE98                FDB     $CE98          STX      FF
                   *
                   *       FORMAT FLAGS
                   *
                   *   FLAGS ARE 1 BYTE LONG AND ARRANGED IN PAIRS.
                   *  BIT: 76543210
                   *       RR-FFFSS
                   *  WHERE; RR= REGISTER CODE, 0=NONE, 1=A, 2=B
                   *         FFF= ADDRESS MODE, 0=INHERENT, 1=RELATIVE, 2=INDEXED
                   *                            3=IMMEDIATE, 4=EXTENDED, 5=DIRECT
                   *                            6= NONE (FCB PSEUDO)
                   *         SS= SIZE OF INSTRUCTION IN BYTES.
                   *
03AB 01            FTAB  FCB     $01            00-0F   INHERENT
03AC 00                  FCB     0
03AD 01                  FCB     $01            10-1F   INHERENT
03AE 00                  FCB     0
03AF 06            BSR   FCB     $06            20-2F   RELATIVE (USED BY BSR)
03B0 00                  FCB     0
03B1 01                  FCB     $01            30-3F   INHERENT
03B2 41                  FCB     $41            PULA AND PSHA
03B3 41                  FCB     $41            40-4F   INHERENT
03B4 00                  FCB     0
03B5 81            PULB  FCB     $81            50-5F   INHERENT (USED BY PULB)
03B6 00                  FCB     0
03B7 0A                  FCB     $0A            60-6F   INDEXEXED
03B8 00                  FCB     0
03B9 13                  FCB     $13            70-7F   EXTENDED
03BA 00                  FCB     0
03BB 4E                  FCB     $4E            80-8F             IMMEDIATE
03BC 0F                  FCB     $0F            CPX,LDS
```

Listing 2 continued on page 358



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Circle 61 on Inquiry card.

Listing 2 continued:

```
03BD 56                FCB     $56        90-9F           DIRECT
03BE 16                FCB     $16        CPX,LDS,STS
03BF 4A                FCB     $4A        A0-AF           INDEXED
03C0 0A                FCB     $0A        CPX,JSR,LDS,STS
03C1 53                FCB     $53        B0-BF           EXTENDED
03C2 13                FCB     $13        CPX,,JSR,LDS,STS
03C3 8E                FCB     $8E        C0-CF           IMMEDIATE
03C4 0F                FCB     $0F        LDX
03C5 96                FCB     $96        D0-DF           DIRECT
03C6 16                FCB     $16        LDX,STX
03C7 8A                FCB     $8A        E0-EF           INDEXED
03C8 0A                FCB     $0A        LDX,STX
03C9 93                FCB     $93        F0-FF           EXTENDED
03CA 13                FCB     $13        LDX,STX
                *
03CB 19         FFLAG  FCB     $19        FCB FLAGS
                *
A04A                   ORG     $A04A
A04A 20         LINE   RMB     32
A06A 04                FCB     04
     A06B       WORKA  EQU     *
A06B CE 01AB    FLAGD  LDX     #MTAB      MNEMONIC TABLE BASE
     A06C       WTAD   EQU     FLAGD+1
A06E CE 03A8    WBYT   LDX     #FTAB      FLAG TABLE BASE
     A06F       WFAD   EQU     WBYT+1
A071 0000       WBAS   FDB     0
A073 0000       WFLG   FDB     0
A075 0000       XSAV   FDB     0
A077 00         LINES  FCB     0
     03         BYTE   EQU     WBYT-WORKA
     01         TAD    EQU     WTAD-WORKA
     06         BASE   EQU     WBAS-WORKA
     04         FAD    EQU     WFAD-WORKA
     08         FLAGA  EQU     WFLG-WORKA
     A04A       AADR   EQU     LINE
     A058       OPER   EQU     LINE+13     MNEMONIC POSITION
     A063       ABS    EQU     LINE+24    ABS. ADDRESS FOR RELATIVE MODES
     A05E       ARG    EQU     LINE+19    ARGUMENT POSITION
A078 00                FCB     0,0,0
A07B 00         SIZE   FCB     0
A07C 0000       APPND  FDB     00         COMPLETION APPENDAGE ADDRESS
                       END
```


Listing 3: *Cross-references for symbols used in the disassembler source code of listing 2.*

```
        =
APP    =01A4   000E
APPND  =A07C   0011   0116
ASC    =019B   0192
BLOP   =0044   0048
BSR    =03AF   009B
CLOP   =00C9   00DD
CVASC  =00DF   0063   0088   00BF   00D8
DISPL  =0116   0105   0148   0154   0167
DLOOP  =017F   017C   0184
DUMV   =0114   015B
ERASE  =0169   0008
FCBFR  =015D   0112
FFLAG  =03CB   007D
FIN    =0123   011E
FLAGD  =A06B   00AA   00C0   00E5   00FE
FORM   =00FB   00F1   00F5
FTAB   =03A8   A06E
IMM    =0156   010E
IND    =014A   010B
LINE   =A04A   003D   0051   0161   0174   01A4
LINES  =A077   0005   011B
MTAB   =01AB   A06B
NEXTL  =0018   0014   0120
NFC    =0082   007B
NMR    =00E2   00D1
NOTA   =00F3   00EA
OFF    =00A8   0080   008C   0095   009E   00A5
OU     =01A0   019C
POS    =0130   012D
PULB   =03B5   0089   0092
REL    =0124   0108
SETM   =016D   0114   0124   014A
SETR   =00EE   00F9
SIZE   =A07B   00C5   0177
START  =0000   0016
TBSR   =0097   0090
TOASC  =018C   00DF   013C   0141
TPSH   =008E   0087
WBAS   =A071   0054
WBYT   =A06E   00BA
WFLG   =A073   00A0   0171   0186
XSAV   =A075   00C9   00D8
```

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Circle 211 on inquiry card.

Build a Super Simple Floppy-Disk Interface, Part 1

James Nicholson and Roger Camp
1046 Gaskill
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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 tell where a sector begins, and there are two ways of doing this. Each sector can be distinguished by its position relative to holes punched in the disk (this is called *hard sectoring*), or it can be distinguished by special sequences of information recorded on the disk (*soft sectoring*). In either case, the disk has one hole that is used as an index to signal the start of the first sector on all tracks.

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

The most common 8-inch floppy-disk format provides for 77 tracks of 26 sectors each, with 128 bytes recorded in each sector. The address of each sector, in the form of a track number (0 through 76) and a sector number (1 through 26), is recorded on the disk at the start of the sector itself.

The disk drive has two motors: one that spins the disk at 360 rpm (revolutions per minute), and one that moves the head from track to track on command. Each drive also has a printed-circuit board to control both motors. The inputs and outputs of this circuit board (see figure 1) follow a standard set by Shugart Associates, manufacturer of one of the first popular floppy-disk drives.

A single pulse on either the STEP-IN line or the STEP-OUT line moves the head one track toward the center of the disk (track 76) or toward the

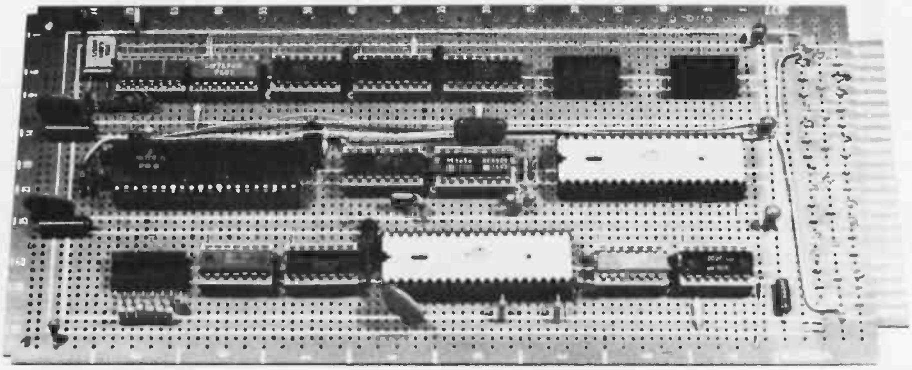

Photo 1: *The authors' wire-wrapped floppy-disk controller board.*

About the Authors

Roger Camp is a Professor of Electrical Engineering at Iowa State University. He is the author of several technical papers and patents, and his most recent book is Micro-Processor Systems Engineering.

James Nicholson, currently Project Manager, Business Recovery Planning, has been involved in large data-center activities for Donnelley Marketing. He has designed and built several microcomputer systems in the last five years.

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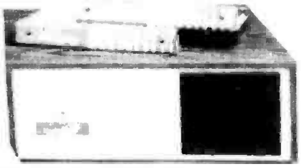

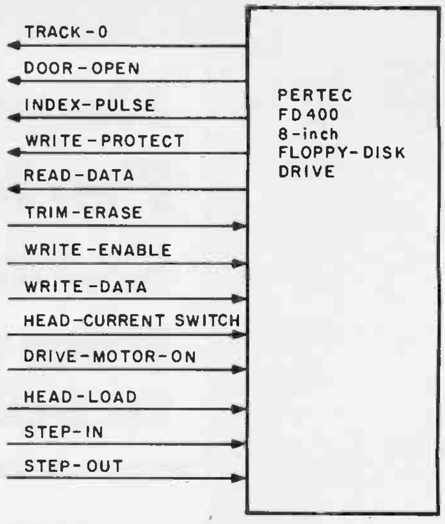

Figure 1: *Input and output lines available for controlling a Pertec FD400 8-inch floppy-disk drive. These signals are the same as those found on any Shugart-compatible drive, so nearly any drive may be substituted for the FD400.*

outside (track 0), respectively. When the head is positioned over track 0, the outermost track, the TRACK-0 output is activated. To turn on the spindle motor, the DRIVE-ON input must be activated, and the disk door in the front of the drive must be closed (this deactivates the DOOR-OPEN output line). As the disk rotates, a photoelectric sensor in the drive detects the index hole in the disk; this generates the INDEX signal that allows the system to begin counting sectors at the first one.

To read data, the HEAD-LOAD line is activated to force the head to contact the rotating disk surface. A mixture of data and clock bits are then detected and amplified by the drive's electronics; these appear as logic levels on the DATA-READ output at the rate of 250 K-bits per second.

To write data on the disk, the head must be loaded, the WRITE-ENABLE line must be activated, and the data must be sent to the drive on the WRITE-DATA line. (This must occur with very specific timing.) If the WRITE-PROTECT output has been activated, the drive has detected the presence of a write-protect notch in the disk's envelope.

Obviously, communication at this level between a disk drive and a microcomputer is possible but not desirable. The microcomputer would spend much of its time catering to the needs of the disk rather than computing. The purpose of the FD1771 (actually a microprocessor in its own right) is to act as a high-level communications interface between the two.

When instructed to *seek* (move the head) to track 30, the 1771 will generate the appropriate number of STEP-IN or STEP-OUT pulses to move the head from its current position, wherever it may be, to track 30. Another example of the 1771's capabilities is the process of reading a specific sector: the 1771 will search a given track for the proper sector address; when located, the data following the address is transferred to the microprocessor. Simultaneously, the 1771 can maintain synchronization with the disk drive and check for errors. Therefore, using the 1771 floppy-disk controller circuit results in a greatly simplified hardware and software design.

Software must be an integral part of the design of any computer subsystem—a subroutine of about 256 bytes is required to communicate the proper commands to the disk controller. Additional software is required to handle complex data-file structures (this software and various structuring techniques will be discussed in part 2 of this article).

Disk Format

Figure 2 schematically describes the format of recorded data on a soft-sectored disk. The pulse generated by the index hole passing the sensor provides a physical reference point to determine the beginning and the end of a track. The diagram represents 16 256-byte sectors (the authors' choice for format) rather than the usual 26

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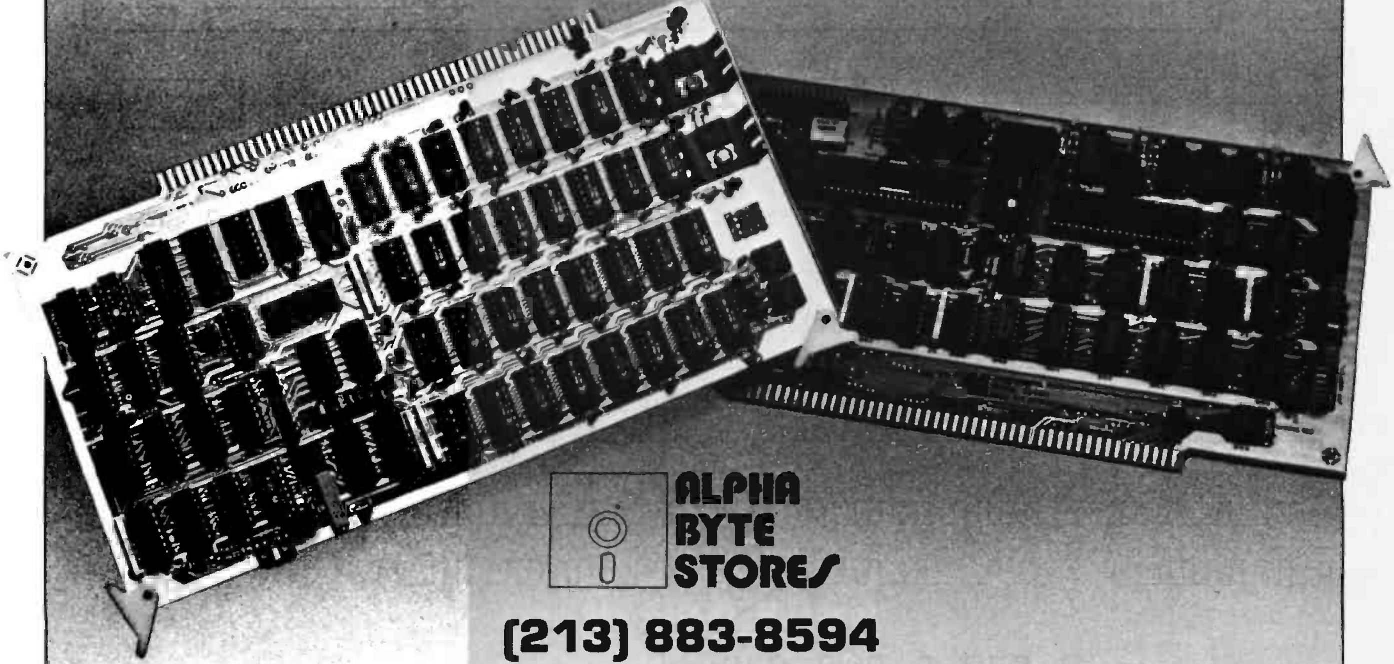

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sectors containing 128 bytes.

The disk rotates once every 166.67 ms, which allows the drive to read 41,665 bits of information; that is, a byte every 32 μs. Each track contains 5208 bytes (divided into data and control bytes), as well as gaps between sectors. (The gaps are required to allow sufficient time to turn write-head current on and off without destroying valid data.)

The IAM (index-address mark) that provides a recorded indication of the beginning of the track has 16 sectors recorded after it. The sectors consist of two records: the ID (identification record) and the DATA (data record). The ID contains information on the track number and the sector number of the DATA that follows. Each of the records begins with an AM (address mark). In addition, each record is ended with a 2-byte CRC (cyclic-redundancy-check) code.

Each byte of data recorded on the disk consists of interleaved clock and data bits. The clock bits convey information used for synchronization and for the identification of AMs. AMs always have clock bits corresponding to hexadecimal C7 (D7 in the case of the IAM); all other bytes of information have clock bits corresponding to hexadecimal FF. In other words, some clock bits are omitted in AMs. This scheme allows the data bits of a data-address mark (hexadecimal FB) to be distinguished from a hexadecimal FB recorded as data.

Figure 2 also illustrates that these data and clock bits are recorded as a single stream. When reading from the disk, the 1771 separates the data and clock bits (although our system uses discrete components to achieve greater reliability).

As a general rule, the larger the sector, the greater the total amount of data that can be recorded on one disk. This is due to the reduced amount of area necessary for gaps and indexing information. Using 16 256-byte sectors, 315,392 bytes of data can be recorded. The usual configuration of 256-byte sectors allows tracks with only 15 sectors; however, it has been found that sufficient space is available to reliably record 16 sectors.

Western Digital's 1771 Floppy-Disk Controller

This device is essentially a microprocessor dedicated to the specific task of controlling disk drives (see figure 3). It has five programmable registers and accepts a number of commands through various combinations of them. For economic reasons, there is a desire to connect multiple drives to a single 1771, but, since the device "remembers" the track the head was last positioned to, switching from one drive to another would place an added burden on the driving software. A case can be made for complete duplication of the controller electronics for each disk drive.

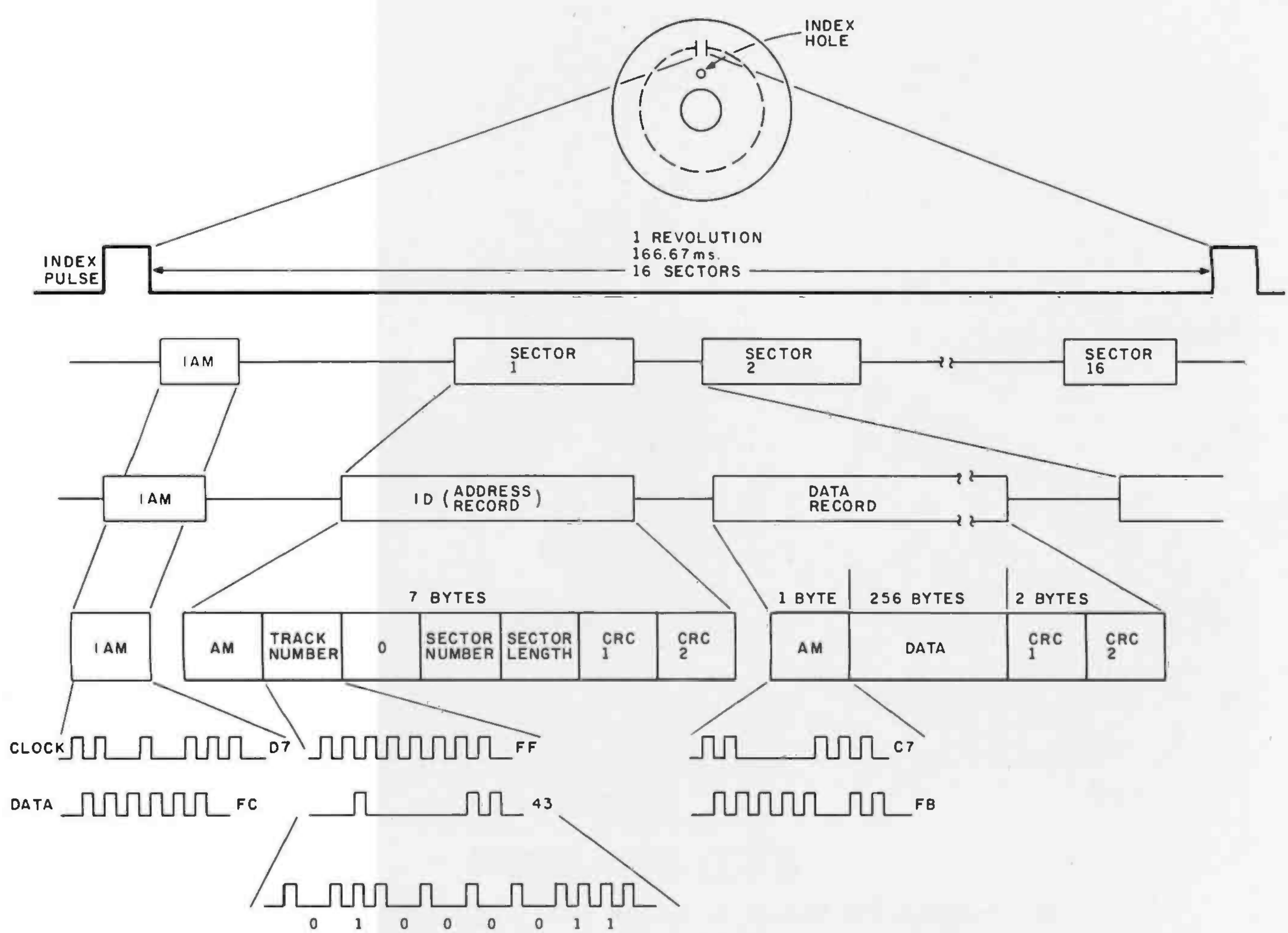

Figure 2: *The format of recorded data on one track of a soft-sectored floppy-disk drive. The IAM (index-address mark) marks the beginning of each track. See the text for details.*

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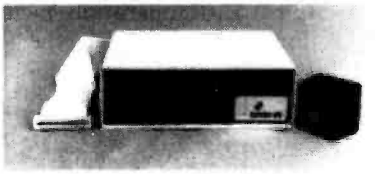

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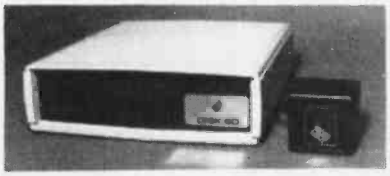

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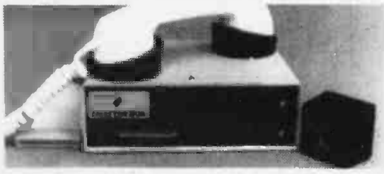

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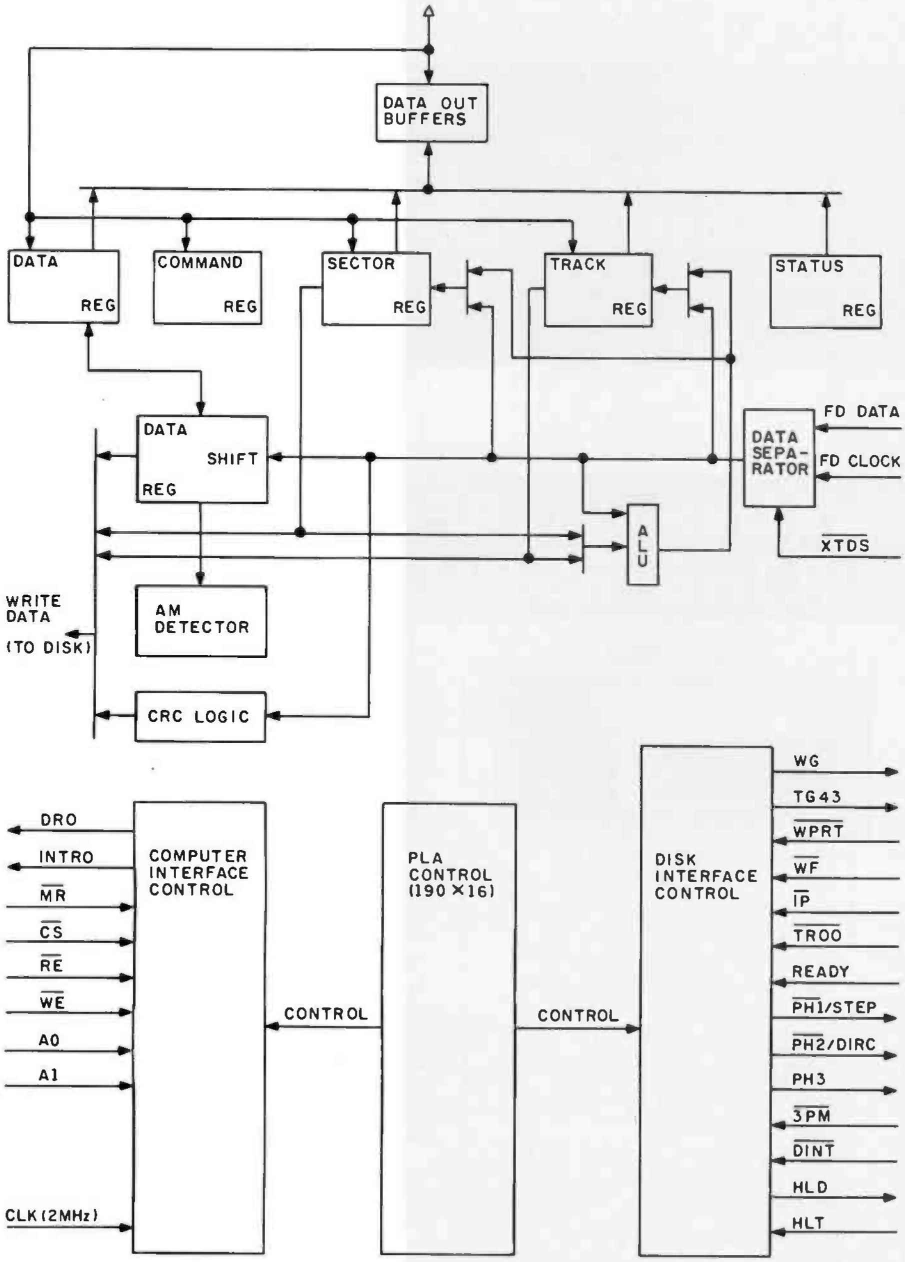
The registers in the 1771 that can be programmed by the user are the data, track, sector, and command registers—there is also a status register that can be read from but not written to. These 8-bit registers form the basis for software control of any disk drive:

- 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, $\overline{RE}$, and $\overline{WE}$ lines, as shown in table 2. Other logic levels in the 1771 perform functions to:

- Generate and check the 16-bit CRC code
- Increment, decrement, and compare register values
- Detect ID, data, and index-address marks
- Provide control signals based on an external 2.0 MHz clock

A typical disk operation includes the following steps. First, the soft-



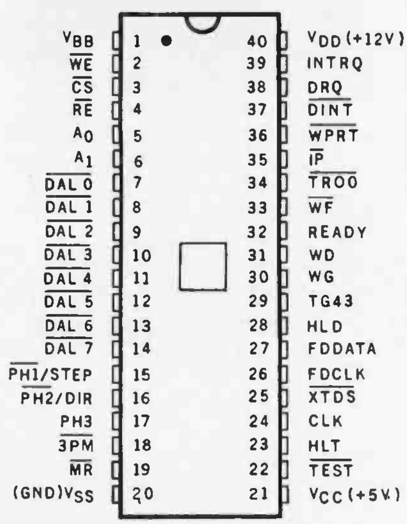


Figure 3: *Internal architecture and pinout diagram of the Western Digital FD1771 floppy-disk controller. The four programmable registers and eleven commands of the 1771 allow any microprocessor to control a disk subsystem using high-level instructions, thus removing a significant burden from the disk-driving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

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TYPE	COMMAND	7	6	5	4	3	2	1	0
		BITS							
I	Restore	0	0	0	0	h	V	r_1	r_0
I	Seek	0	0	0	1	h	V	r_1	r_0
I	Step	0	0	1	u	h	V	r_1	r_0
I	Step In	0	1	0	u	h	V	r_1	r_0
I	Step Out	0	1	1	u	h	V	r_1	r_0
II	Read Command	1	0	0	m	b	E	0	0
II	Write Command	1	0	1	m	b	E	a_1	a_0
III	Read Address	1	1	0	0	0	1	0	0
III	Read Track	1	1	1	0	0	1	0	$\overline{s}$
III	Write Track	1	1	1	1	0	1	0	0
IV	Force Interrupt	1	1	0	1	I_3	I_2	I_1	I_0

(a)

BIT VALUES FOR TYPE 1

h = Head Load flag (Bit 3)
- h = 1, Load head at beginning
- h = 0, Do not load head at beginning

V = Verify flag (Bit 2)
- V = 1, Verify on last track
- V = 0, No verify

r_1r_0 = Stepping motor rate (Bits 1 through 0)
- r_1r_0 = 11 gives 40 ms step time

u = Update flag (Bit 4)
- u = 1, Update track register
- u = 0, No update

(b)

BIT VALUES FOR TYPE II

m = Multiple Record flag (Bit 4)
- m = 0, Single record
- m = 1, Multiple records

b = Block length flag (Bit 3)
- b = 1, IBM format (128 to 1024 bytes)
- b = 0, Non-IBM format (16 to 4096 bytes)

a_1a_0 = Data Address Mark (Bits 1 through 0)
- a_1a_0 = 00, FB (Data Mark)
- a_1a_0 = 01, FA (User defined)
- a_1a_0 = 10, F9 (User defined)
- a_1a_0 = 11, F8 (Deleted Data Mark)

(c)

BIT VALUES FOR TYPE III

$\overline{s}$ = Synchronize flag (Bit 0)
- $\overline{s}$ = 0, Synchronize to Address Mark
- $\overline{s}$ = 1, Do not synchronize to Address Mark

(d)

BIT VALUES FOR TYPE IV

I_0 thru I_3 = Interrupt Condition flags (Bits 3 through 0)
- I_0 = 1, Not Ready to Ready transition
- I_1 = 1, Ready to Not Ready transition
- I_2 = 1, Index pulse
- I_3 = 1, Immediate interrupt

E = Enable HLD and 10 ms Delay
- E = 1, Enable HLD, HLT and 10 ms delay
- E = 0, Head is assumed engaged and there is no 10 ms delay

(e)

Table 1: *The high-level instructions of the FD1771 disk formatter/controller device. When one of the instructions defined by table 1a is loaded into the command register of the FD1771, the FD1771 executes one or a series of actions. Bits represented by a letter within a command are defined in the bit-value tables for that type of instruction, tables 1b through 1e.*

ware coordinating the disk operation checks to see if the controller is busy from the last command. If it is not, the software writes the desired command into the command register. If data is to be transferred as each byte is assembled (or disassembled) by the shift register, the controller sends a DRQ (*data request*) signal. When the operation is completed, the controller sends an INTRQ (*interrupt request*) signal. The status register can then be checked by the controlling software for seek, write protect, busy, or CRC errors.

Controller Hardware

The schematic diagram for the floppy-disk controller is given in figure 4. In addition to the 1771 and the 6520 PIA (peripheral interface adapter), circuitry is included for read/write control, clock and data bit separation, head loading, and inversion of various signals as required by the FD400 disk drive.

Three gates convert the DIR (direction) and STEP signals from the 1771 into the STEP-IN and STEP-OUT signals needed by the FD400 disk drive. The HEAD-LOAD signal is conditioned by a simple one-shot (monostable multivibrator) and an inverter; this guarantees a fixed 40 ms pause allowing the head to load and settle. Once the interval has passed, a signal is sent to the 1771 to acknowledge the fact.

The data-separator and clock circuit was designed by Steve Christiansen of Iowa State University. This circuit contains four of the ten integrated circuits in the system. (If the disk drive you intend to use has sepa-

A1	A0	Register Affected During Read ($\overline{RE}$ = 0, $\overline{WE}$ = 1)	Register Affected During Write ($\overline{RE}$ = 1, $\overline{WE}$ = 0)
0	0	Status Register	Command Register
0	1	Track Register	Track Register
1	0	Sector Register	Sector Register
1	1	Data Register	Data Register

Table 2: *Access to registers within the Western Digital FD1771 disk formatter/controller device. The FD1771 has five internal registers: command, data, sector, status, and track. A given register is read or written by placing the appropriate values on lines A1 and A0 and pulling down either the READ-ENABLE (RE) line for a read operation, or the WRITE-ENABLE (WE) line for a write operation. The sector and track registers specify the sector and track when these parameters are needed by a given command byte. The command register, when filled, causes one of eleven high-level instructions to be executed (see table 1). Data passes between the computer and the disk drive through the data register. After a command has been executed by the FD1771, the status register must be read before another command can be executed.*

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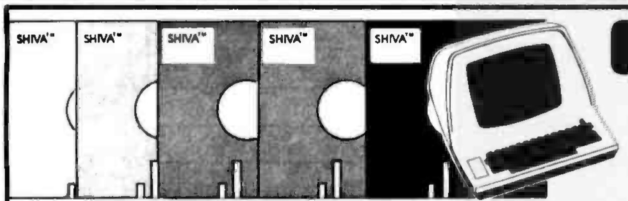

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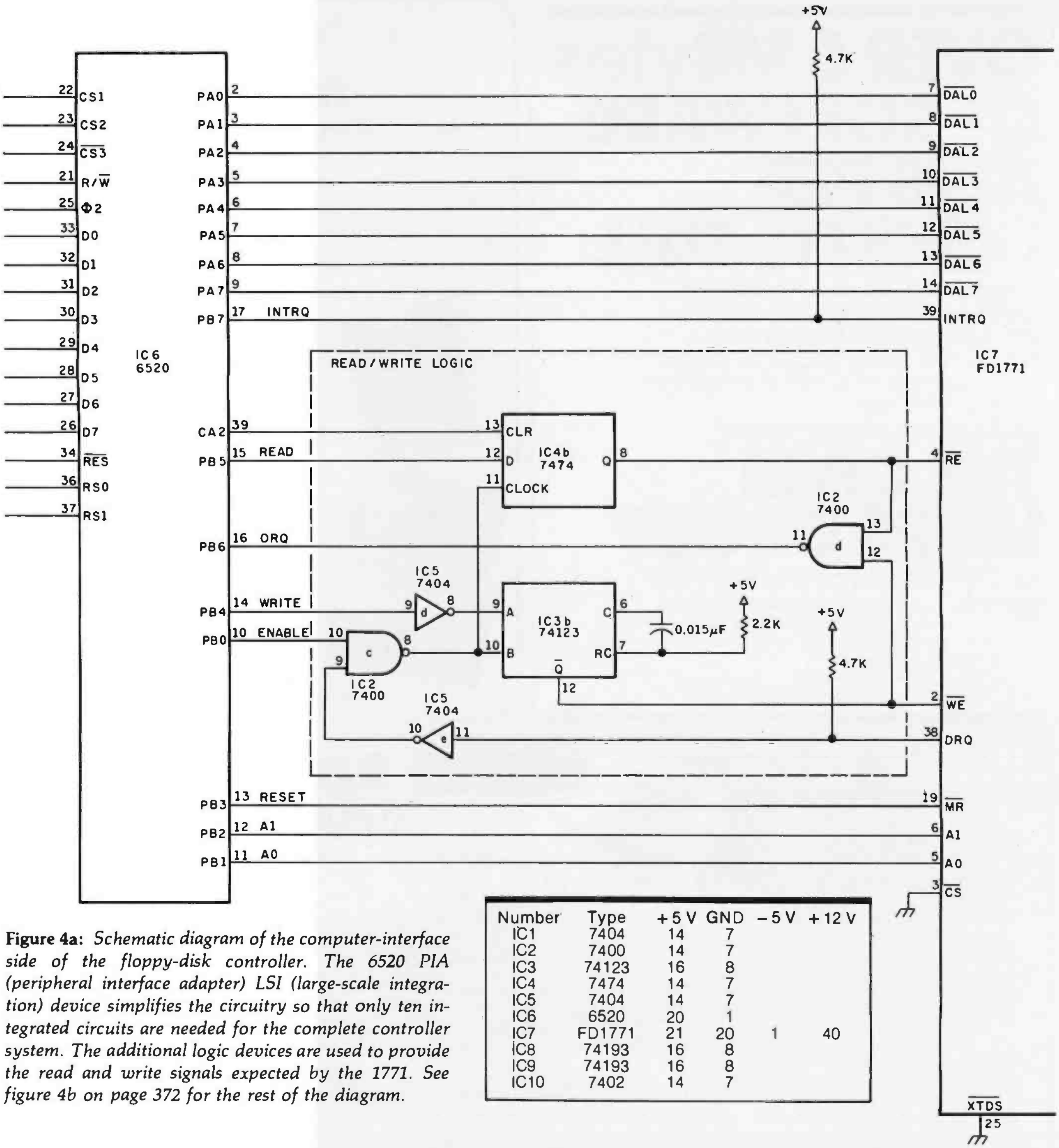

Number	Type	+5 V	GND	−5 V	+12 V
IC1	7404	14	7		
IC2	7400	14	7		
IC3	74123	16	8		
IC4	7474	14	7		
IC5	7404	14	7		
IC6	6520	20	1		
IC7	FD1771	21	20	1	40
IC8	74193	16	8		
IC9	74193	16	8		
IC10	7402	14	7		

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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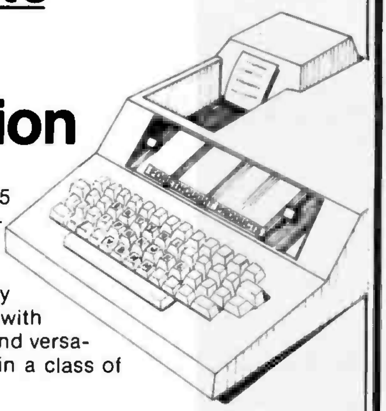

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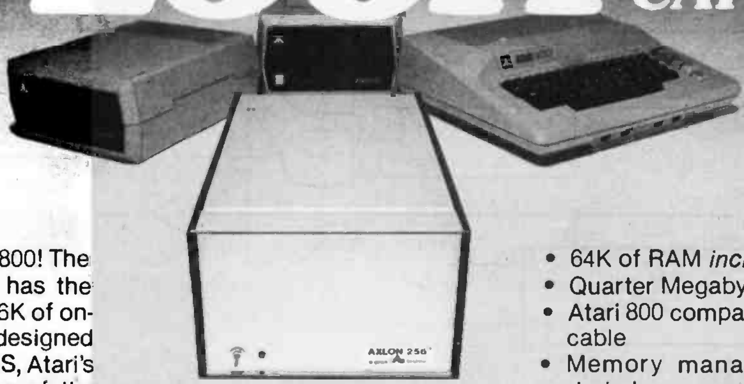

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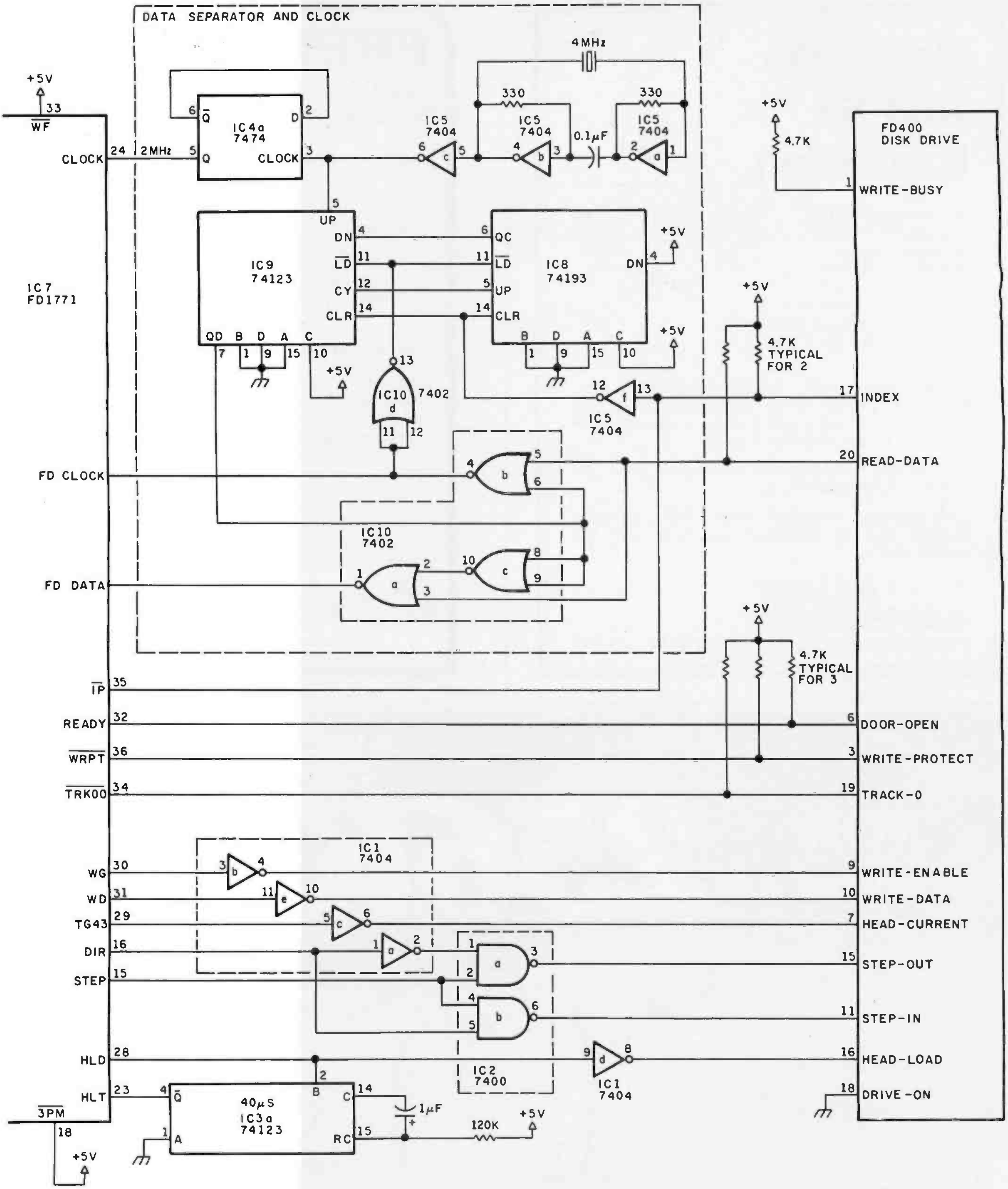

Figure 4b: *Schematic diagram of the drive-interface side of the floppy-disk controller. Clock signals and minor control functions are provided for by the additional circuitry, as well as the separation of recorded data from recorded synchronization pulses.*

of which only 17 are used in this system to interface with the 1771. The A port is programmed as eight bidirectional data lines, and is connected to the 1771's data lines, while the B port pins are programmed as necessary to provide control lines. The data lines of the 6520 can be connected to like lines on the microprocessor, while its three device-select lines can be connected to match whatever address-decoding scheme is appropriate. The

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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*	*DDRB Access*	*CB1 Control*

Control of CA2 Output Modes

Bit 5	*CRA Bit 4*	*Bit 3*	*Mode*	*Description*
1	0	0	"Handshake" on Read	CA2 is set high on an active transition of the CA1 interrupt input signal and set low by a microprocessor "read A data" operation. This allows positive control of data transfers from the peripheral device to the microprocessor.
1	0	1	Pulse Output	CA2 goes low for one cycle after a "read A data" operation. This pulse can be used to signal the peripheral device that data was taken.
1	1	0	Manual Output	CA2 set low
1	1	1	Manual Output	CA2 set high

Table 3: *Control codes for the 6520. This device offers 20 pins that may be programmed (either individually or in groups) as input, output, or bidirectional lines.*

6520 controls and modes are listed in table 3.

Construction Notes

The prototype floppy-disk controller was built on a Vector 3677 wire-wrap board (see photo 1). There are no special layout considerations, but adequate power supply bypassing must be observed (i.e., 0.1 μf capacitors across the supply and ground pins of each integrated circuit). A 16-pin DIP (dual in-line package) socket is used to connect the controller to a ribbon cable from the disk drive (use proper terminations).

Debugging

The read/write circuit can be debugged by using a microcomputer. Move the DRQ input (IC5, pin 11 in figure 4) from the 1771 to a convenient 6520 output. With the microcomputer running a diagnostic program, check to see that the $\overline{WE}$ pulse (IC3, pin 12 in figure 4) is about 14 μs.

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

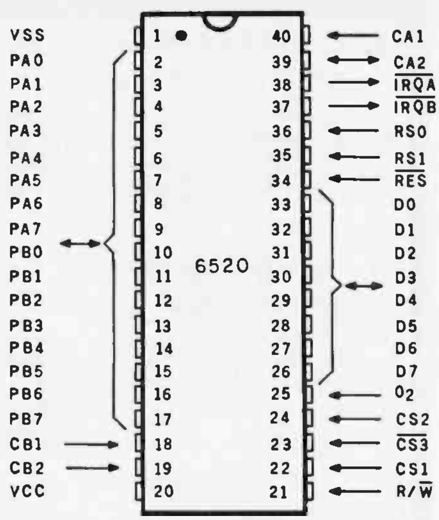

Figure 5: *Pin description of the MOS Technology 6520 PIA. Use of this particular device allows easy interfacing of a disk controller to a 6502-based computer. One I/O port handles control signals; the other is used to transfer parallel bytes of data.*

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	Letter Quality, 55/25 KSR	3,295	316	175	119
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	Letter Quality RO, 55 CPS	2,895	278	154	104
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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 controller through a 6520. Whatever route you choose, this basic design will provide reliable, trouble-free operation.

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

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Favorite Benchmarks and Other Programs

In the July 1980 BYTE, Carl Helmers wrote a Technical Forum entitled "Some More on Performance Evaluation" (page 216), in which he requested readers to send in benchmark routines that are "appropriate to the typical language and operating-system environment of the contemporary small computer." The following submission from David I Wilcox, of Mansfield, Pennsylvania, is one of the most noteworthy.

While in college, I was shown a simple way to calculate the number of decimal digits a computer retains in its internal representation of floating-point numbers. If:

$$A = 1./3.$$

then, by computing:

$$\text{abs}(\log_{10}(\text{abs}(1.-(A+A+A))))$$

the number of digits of accuracy is obtained.

The choice of 1./3. is deliberate because it is an infinitely repeating rational number in the binary-number system. Therefore, a difference between 1. and the sum $A+A+A$ must exist in any attempt to represent 1./3. with a finite number of bits.

If the machine does not have the common logarithm function available, then compute:

$$1./(\text{abs}(1.-(A+A+A)))$$

The number of digits of accuracy is approximately the exponent of the result expressed in scientific notation. Better yet, use a calculator or math tables to find the common logarithm of the result.

The number of digits of accuracy available generally depends on both the machine and the language. This method offers a quick, in-the-store check of the actual number of digits used by a given system to represent floating-point numbers.

However, other letters we received bearing the "Favorite Benchmarks" title contained still more programs written in Pascal or BASIC that shaved minutes or seconds from the prime-number-generating program used as a benchmark in Carl Helmers's article. Although we appreciate the attempt at participation represented by these letters, they missed the point expressed by Carl Helmers in that article: "...the goal of the exercise was not to code the most efficient algorithm. It was, rather, to code an algorithm that takes a measurable amount of time while performing a certain group of calculations." The same algorithm (preferably embedded in a common computer language) can then be run on several computers and the times compared as performance indices of the respective language/machine combinations.

For example, the benchmark given by David Wilcox, above, results in a number (calculated in this case, not timed with a stopwatch) that can be used to compare, say, an Atari 400 with a Commodore PET; the comparison being made is one of digits of accuracy.

*One prime-number-generating benchmark sent to us gave two times, one for execution of the program using a video terminal and another using a printer. In my opinion, such a benchmark confuses the issue under consideration (computer speed in generating a given set of prime numbers). Unless a benchmark is trying to measure the efficiency of a given computer in displaying numbers, the interval being timed should end as soon as the first display is printed. This assumes, as was done in the prime-number benchmark, that all results are stored and the printing is done after the computation being measured has finished. In fact, I sometimes bracket the part of the program being measured with print statements that say BEGIN TIMING and END TIMING. This allows me to isolate the function being evaluated....*GW■

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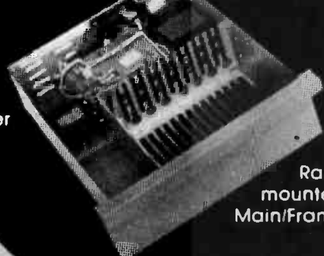

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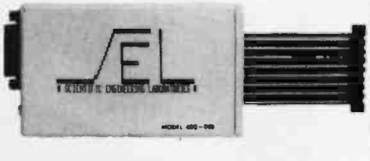

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Book Reviews

Travels in Computerland, or Incompatibilities & Interfaces

by Ben Ross Schneider Jr
Reading MA:
Addison-Wesley
Publishing Company
1974, Softcover, $6.50

Reviewed by
Jonathan Jacky
6551 5th Ave NE
Seattle WA 98115

How many seemingly impractical projects have been attempted only because someone thought, "That should be a trivial exercise for a computer"? So it seemed to theater historian Ben Ross Schneider Jr, when he proposed organizing a data base from *The London Stage*, an eleven-volume, 8000-page calendar of eighteenth-century theater performances. As Schneider envisioned, "It would be like having an index to every kind of thing in the book, only the computer would even turn the pages and take notes for you."

As he became involved in the project, Schneider soon realized that what is conceivable for the computer is sometimes not easily accomplished. He learned that the system which saves the scholar months of repetitive clerical work may well require several times that much effort to get running. Schneider recounts his experience in *Travels in Computerland*, an entertaining book that gives a true-to-life case study illustrating information-retrieval techniques. It is the best account of an ambitious computing project I have read.

Schneider describes the problems of creating a computer-accessible data base from source text intended for human readers. He intended his data bank to produce, for example, listings of every role an actor played during his career. That meant sorting all the entries in *The London Stage* by actor—but *The London Stage* was not arranged by actor; it consisted of theater programs arranged chronologically. Each program included many items: titles, roles, actors... To enable the computer to identify each item, they must be clearly delimited and follow each other in undeviating order.

Schneider believed that the syntax and typography of *The London Stage* satisfied these conditions, but programmer Will Daland recognized otherwise: "Too much variation," he explained. "A computer can't tolerate as much ambiguity as a human... The human being uses an immense store of experience to resolve ambiguities."

So they faced the mammoth task of recopying the entire text to better reveal its contents to the machine.

"The structure of *The London Stage*, which we had to describe before we could analyze it by machine, continually evaded us. To retrieve what was in it we had to know what kinds of things were in it and how this information was arranged. It was like nature itself. We always thought we knew more about it than we actually did."

Eventually they found the precise form in which the text would be presented to the computer, but only after Schneider learned to view his specialty from a new perspective. At one point he was startled when Daland, in trying to allow for all conceivable possibilities, suggested a plausible variation in eighteenth-century casting practices that had never occurred to Schneider. He recalls: "This episode is an example of how computer methods, by imposing logic, increase one's comprehension of one's subject. And that is why Will, who never studied it for an hour, could teach me something about theater history."

The book vividly conveys the day-to-day feel of the project. The reader shares Schneider's dismay when, as deadlines approach and seemingly banal practical problems threaten to scuttle the project, the drama scholar must become a reluctant expert in the countless technical aspects of computing.

Because this work was done in the premicroprocessor era (about ten years ago), some of the problems seem very dated; inestimable difficulty resulted when terminals capable of producing lower-case characters proved to be unavailable. Other problems are perennially familiar; Schneider ruefully recalls the time invested in "persuading data-processing firms to meet declared standards, and explaining to sales representatives what their products were." In a final, ironic twist, humanist Schneider realizes that his achievement is poorly accepted and little understood by fellow scholars because he neglected to communicate effectively with them.

This book should be required reading for anyone planning to apply a computer to an intricate real-world activity, be it business or research. The nature of Schneider's project, his unusual perspective and lively writing, and particularly his vivid characterizations and keen appreciation of the way personalities shape projects, recommend the book to those on the fringes of the computing world. *Travels in Computerland, or Incompatibilities & Interfaces* is especially relevant to those technologically innocent people who think that computers are for doing math, and wonder how anyone could think a machine can help him appreciate a work of art.■

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Ask BYTE

Conducted by Steve Ciarcia

Here's LED In Your Display

Dear Steve,

I enjoyed your article "Self-Refreshing LED Graphics Display" (October 1979 BYTE, page 58), and think I can use such an output display. My present system is a KIM-1 computer with an 8 K-byte memory board. I use the KIM-1's keypad and LED display for input and output, but I'm having difficulty expanding the display board.

Your design is an 8 by 16 display, but I would like to expand that to 8 by 64; then I could have a small amount of alphanumerics and graphics.

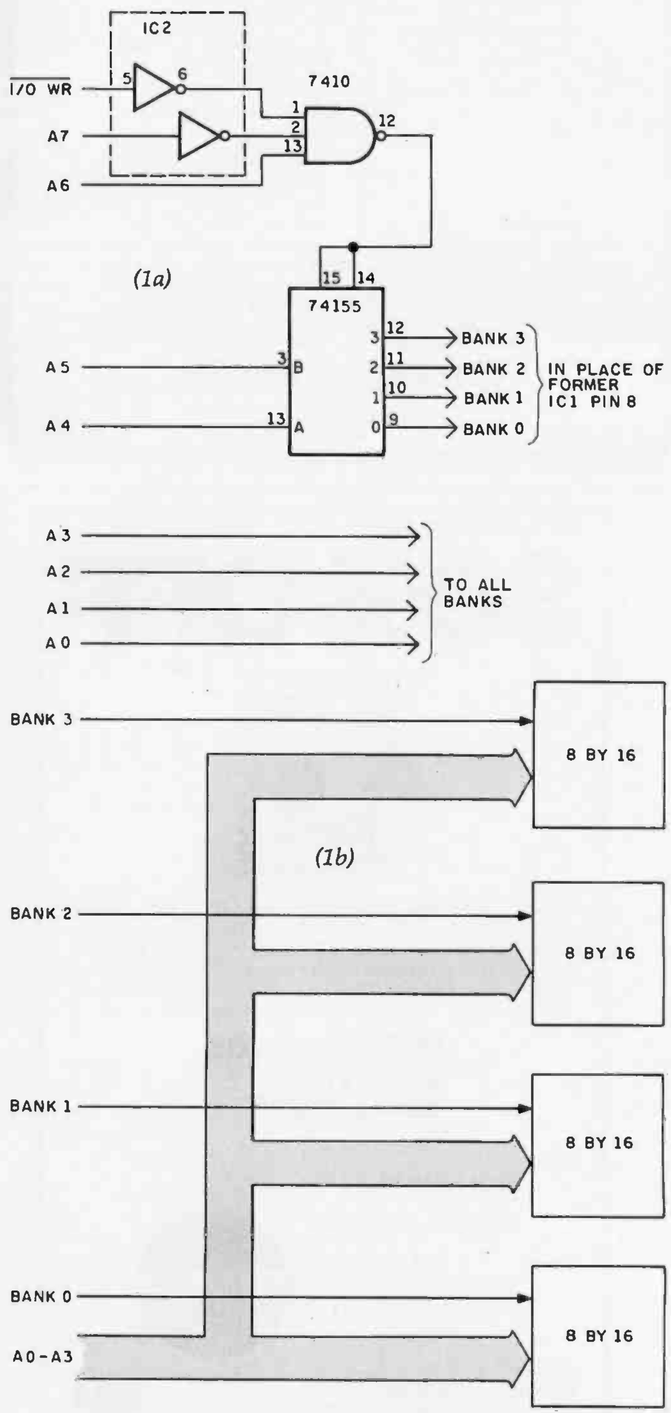
Near the end of your article, you mentioned that to expand on your design, simply add more memory and column decoders. Please be more specific. Would I have to use six address lines, and spread this out over four 74154 1-of-16 decoders? I assume a total of eight 7489 memory devices would be needed. How do I tie this stuff together? Would this affect the refresh and scan rates? Could I substitute LS-type logic circuits in your design?

Charlie Timbers

There are several ways to expand the basic 8 by 16 display into an 8 by 64. The easiest thing to do is to make four of the basic units, then change the addressing to be four blocks of sixteen, for a total of sixty-four 8-bit output ports. To accomplish this, the address decoding presently done by IC1 and IC2 must be changed. Figures 1a and 1b should help.

You can use LS TTL (transistor-transistor logic) devices for those integrated circuits that have an equivalent. Some don't. ...**Steve**

Figure 1



One Shall Be Two

Dear Steve,

We use Maxell MD1 single-sided 5-inch floppy disks on our Apple II. We noticed that the disks have a head-access slot on both sides, so we decided to experiment. We cut a write-enable notch on the opposite edge, and, to our surprise, we were able to write a full 16 sectors on the other side of a single-sided disk. A scan of the disk showed the written data to be in good shape and no physically damaged areas. So, what is the difference between single-sided and double-sided disks—and why purchase a double-sided disk at the extra cost?

Michael Berch
John Oswalt
Berkeley CA

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

When a disk is made, it is tested for data retention. This means writing data (usually at a higher density than you will ultimately use) onto the disk and reading it back. If all goes well, the disk is certified. On double-sided disks, both sides are checked and certified.

As a matter of economics, some manufacturers do not bother to check more than what is required to meet production schedules. For example, if 100,000 disks are made and 10,000 must be certified as double sided, the manufacturer may stop testing both sides after getting 10,000 good ones. This often requires checking 15,000 disks to get the 10,000 that pass. Most often, the 5000 rejects end up in the single-sided

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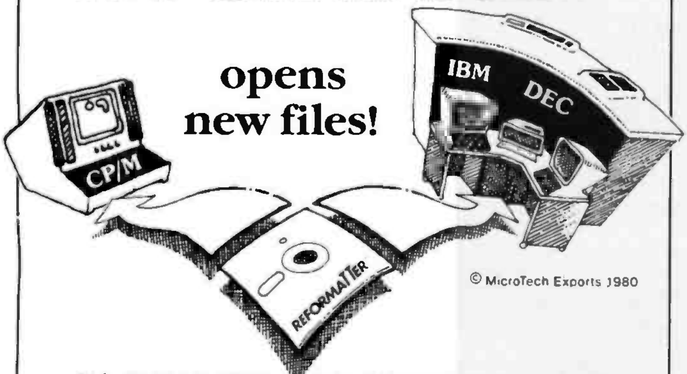

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stock (presuming that one side was good). The remaining 85,000 are only checked for one good side.

In your case, one of the following situations may exist:

1. Both sides were checked, but the manufacturer decided to put the disk in a single-sided envelope anyway.
2. The second side was untested by the manufacturer.
3. The second side failed the manufacturer's data test, and the disk could only be certified as single sided.

In the first case, you are handed a golden opportunity. Cut another access hole and use the other side. In the second and third cases, you are playing the odds. Of course, all three are merely conjecture, since the manufacturer doesn't specify the performance capabilities of the uncertified side.

I suggest that you only use the modified disks for noncritical storage. While it may appear that your experiment has always worked in the disks you've tried, this may be more of a testimonial to the quality of that particular manufacturer's product than a general axiom for all disk users. ...Steve

RF Substitute?

Dear Steve,

I've been thinking about buying either an Apple II or an OSI C4P. While saving money and trying to make my decision, I ordered an Interact computer from Manu-Tronics. Each of these devices needs either a monitor or a television set with an RF (radio-frequency) modulator. Since I already have a videocassette recorder, can I hook the device into the video input jack of the cassette recorder and use its built-in RF modulator (channel 3 for

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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**

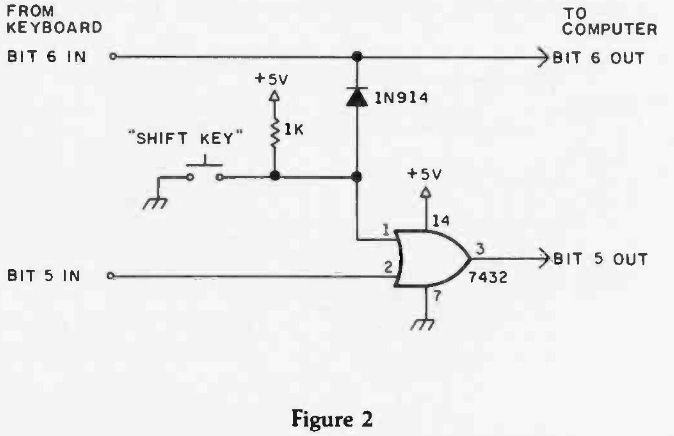

Figure 2

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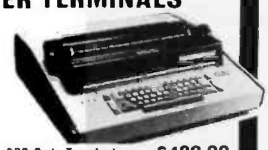

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CX70 Light Pen	64
CX30 Paddle	18
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CBM 2022 Printer	675
CBM 4040 Drive	1090
CBM 8050 Drive	1420
CBM C2N Drive	87
PET-IEEE Cable	37
IEEE-IEEE Cable	46

Software

WordPro 3 (40 col.)	$186
WordPro 4 (80 col.)	279
WordPro 4 Plus (80 col.)	339
Visicalc - Apple	122
Visicalc - Atari	163
Visicalc - PET	163
Commodore Tax Package	399

Microtek - for Atari

Microtek 16K RAM	99
Microtek 32K RAM	189

Disks

Sycom 5¼" Single Density Box of 10	$29
Maxell 5¼" Floppy- MD1 Single Density Box of 10	34
MD2 Double Density Box of 10	44

Printers

Trendcom 200	489
Epson MX-80	539
Commodore Tally 8024	1679

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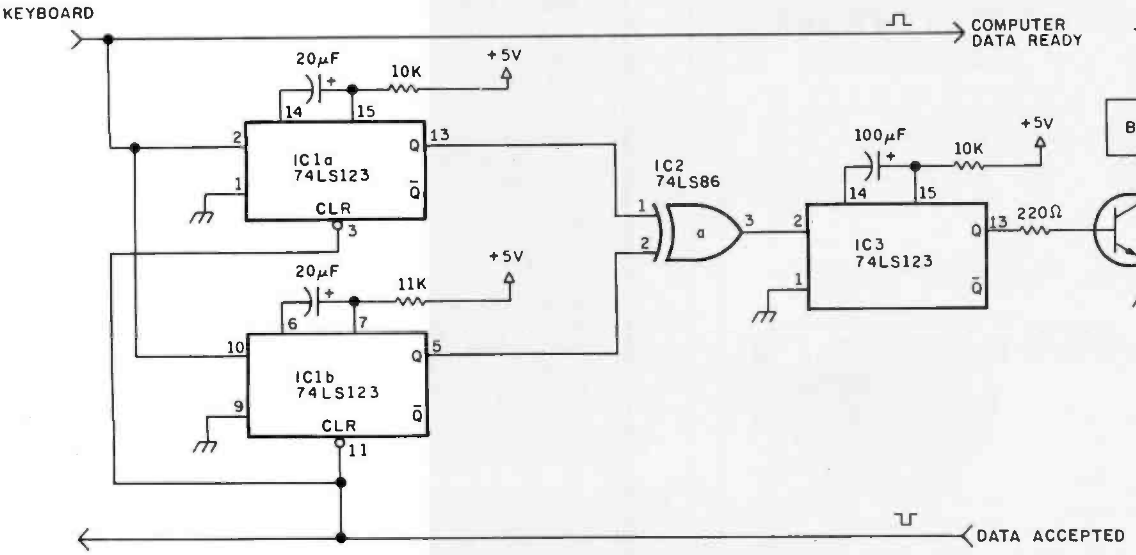

Figure 3

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

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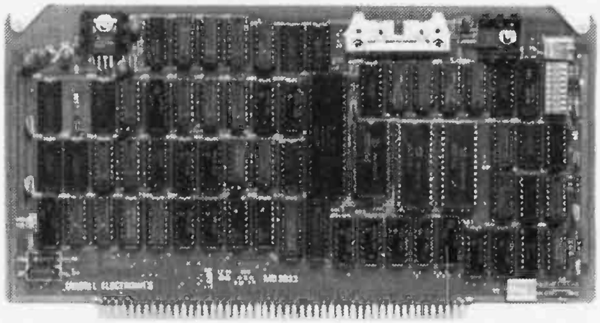

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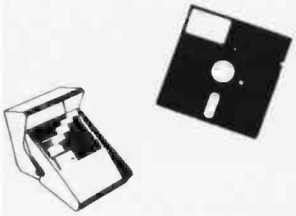

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Software Received

Apple

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

E, Applesoft editing utility for the Apple II Plus. Cassette, $14.95. Apollo Software Company, 318 Harvard St, Suite 10, Brookline MA 02146.

Electronics I, electronics-design application programs for the Apple II. Floppy disk, $29.95. Howard W Sams & Company Inc, 4300 W 62nd St, POB 558, Indianapolis IN 46268.

Electronics II, electronics-design programs for the Apple II. Floppy disk, $29.95. Howard W Sams & Company Inc (see above).

Electronics III, electronics-design programs for the Apple II. Floppy disk, $29.95. Howard W Sams & Company Inc (see above).

Masterdos, disk customizing programs for the Apple II Plus. Floppy disk, $29.95. Masterworks Software Inc POB 7000-285, Rolling Hills Estates CA 90274.

Micro-Painter, color drawing program for the Apple II. Floppy disk, $34.95. Datasoft Inc, 16606 Schoenborn St, Sepulveda CA 91343.

1981 Tax Preparer, IRS tax-preparation aid for the Apple II. Floppy disk, $99. Howard Software Services, 7722 Hosford Ave, Los Angeles CA 90045.

Reversal, graphics strategy game for the Apple II (plays Othello, a trademark of CBS Inc). Floppy disk, $34.95. Hayden Book Company Inc, 50 Essex St, Rochelle Park NJ 07662.

Sex-O-Scope, horoscope for the Apple II. Floppy disk, $30. Astro-Graphics Services Inc (see above).

TRS-80

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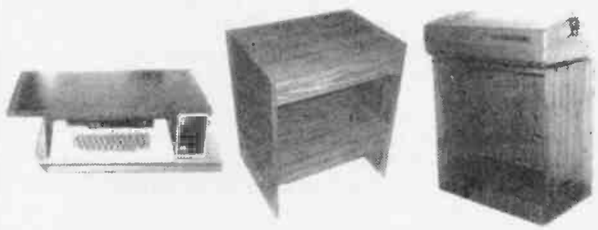

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electronic-design program for the TRS-80. Cassette, $24.95. Howard W Sams & Company Inc, 4300 W 62nd St, POB 558, Indianapolis IN 46268.

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.

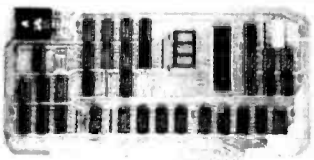
MINCE Version 2.4, word processor for the CP/M system. Eight-inch floppy disk, $125. Mark of the Unicorn, POB 423, Arlington MA 02174.

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.

Circle 355 on inquiry card.



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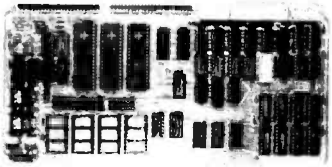

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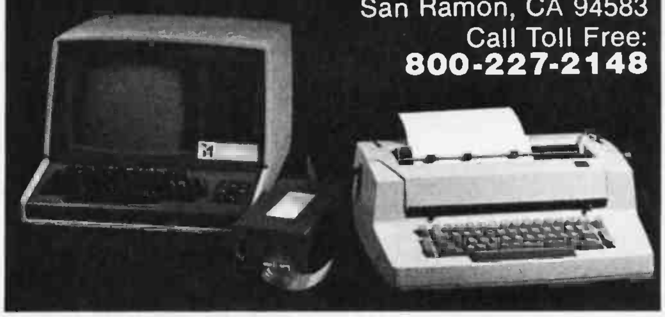

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Books Received

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.

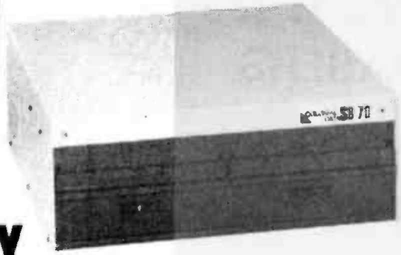
Experimentation with Microprocessor Applications, Thomas W Davis. Reston VA: Reston Publishing Company Inc, 1981; 17.5 by 23.5 cm, 237 pages; softcover, ISBN 0-8359-1812-2, $9.95.

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

Circle 71 on inquiry card.

SB/70



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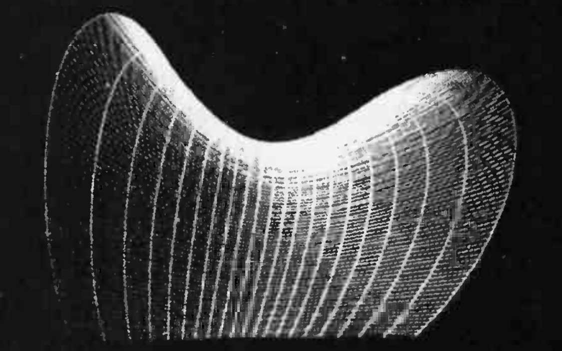
S-100 GRAPHICS



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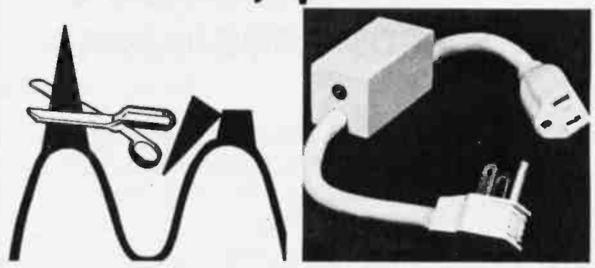

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Greenberg, and A Hoffberg. Somerset NJ: John Wiley & Sons Inc, 1981; 17 by 25.5 cm, 499 pages; softcover, ISBN 0-471-07771-2, $10.95.

Fundamental Structures of Computer Science, W A Wulf, M Shaw, P N Hilfinger and L Flon. Reading MA: Addison-Wesley Publishing, 1981; 17 by 24.5 cm, 621 pages; hardcover, ISBN 0-201-08725-1, $21.95.

H-8 Programming for Beginners, Don Inman and Bob Albrecht. Portland OR: Dilithium Press, 1980; 13.5 by 21.5 cm, 194 pages; softcover, ISBN 0-918398-17-7, $8.95.

LISP, P H Winston and B K P Horn. Reading MA: Addison-Wesley Publishing, 1981; 16 by 23.5 cm, 430 pages; softcover, ISBN 0-201-08329-9, $13.95.

Multinational Computer Nets, Richard H Veith. Lexington MA: Lexington Books, 1981; 16.5 by 23.5 cm, 133 pages; hardcover, ISBN 0-669-04092-4, $18.95.

Problem-Solving and Structured Programming in Pascal, Elliot B Koffman. Reading MA: Addison-Wesley Publishing, 1981; 16 by 23 cm, 483 pages; softcover, ISBN 0-201-03893-5, $13.95.

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

Protocols & Techniques for Data Communication Networks, Franklin F Kuo, editor. Englewood Cliffs NJ: Prentice-Hall Inc, 1981; 18.5 by 24 cm, 468 pages; hardcover, ISBN 0-13-731729-8, $29.95.

The Small Computer in Small Business, A Guide to Selection and Use, Brian R Smith. Brattleboro VT: Stephen Greene Press, 1981; 16 by 23.5 cm, 143 pages; hardcover, ISBN 0-8289-0407-3, $12.50.

Small Computers for the Small Businessman, Nicholas Rosa and Sharon Rosa. Portland OR: Dilithium Press, 1980; 14 by 21 cm, 301

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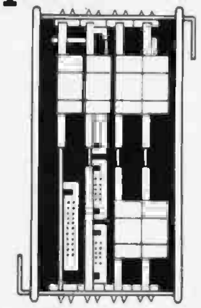

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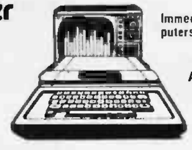

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pages; softcover, ISBN 0-918398-31-2, $12.95.

33 Challenging Computer Games for TRS-80/Apple/PET, David Chance. Blue Ridge Summit PA: Tab Books Inc, 1981; 13 by 21 cm, 256 pages; softcover, ISBN 0-8306-1275-0, $7.95; hardcover, ISBN 0-8306-9703-9, $14.95.

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

Understanding Computer Systems, Harold W Lawson, Jr. Linkoping, Sweden: Harold W Lawson Jr, 1979; 20.5 by 29 cm, 150 pages; softcover, ISBN 91-7372-222-9, $15.25.

Understanding Microprocessors, Lloyd Rich. Reston VA: Reston Publishing Company Inc, 1981; 16 by 23.5 cm, 296 pages; hardcover, ISBN 0-8359-8057-X, $17.95.

Without Me You're Nothing, The Essential Guide to Home Computers, Frank Herbert with Max Barnard. New York: Simon and Schuster, 1980; 16.5 by 24 cm, 304 pages; hardcover, ISBN 0-671-41287-6, $14.95.

Word Processing, Rod Van Uchelen. New York: Van Nostrand Reinhold Company, 1981; 20.5 by 23.5 cm, 128 pages; softcover, ISBN 0-442-28646-5, $7.95.■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

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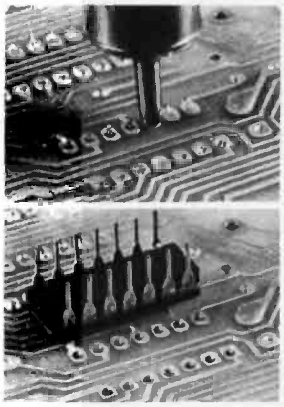

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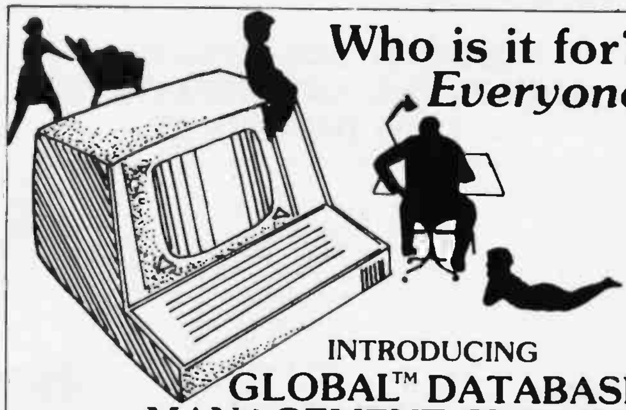

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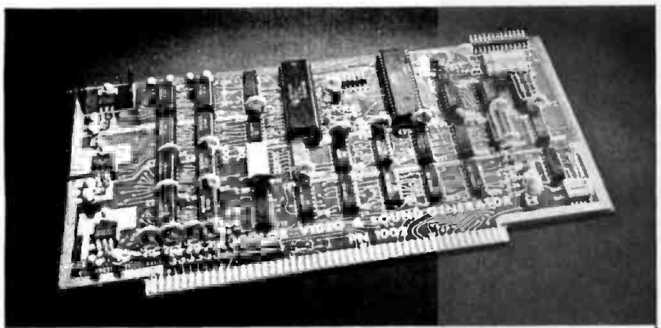

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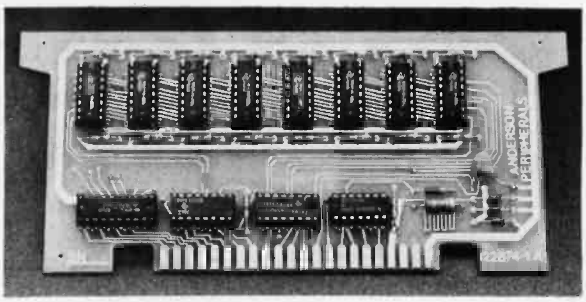

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This group is dedicated to using micrcomputers in the field of planning. The emphasis is on the use of microcomputers for physical or social planning, in public agencies, academia, or private firms. The dues are $10 per year, which includes a bimonthly newsletter.

For further details, contact the group at 1204 People's Bldg, 60 Monroe at Ionia, Grand Rapids MI 49503, (616) 454-9375.

MP/M Users Group

MAPS is an MP/M users group that publishes a quarterly newsletter called *MAPS Digest*. The newsletter contains application reports, compatibility issues, MP/M support product reviews, and problem areas and solutions discovered by MP/M users. Members receive a list of programs in the MAPS software library and can participate in the MAPS bulletin-board service. Contact Digiac Corporation, Commercial Products Division, 175 Engineers Rd, Smithtown NY 11787, (516) 273-8600.

Monadnock Computer Society

The Monadnock Computer Society meets on the first Thursday of each month at the Keene State College Library in Keene, New Hampshire. Club members own and use the most popular microcomputers on the market. The club is actively seeking information from other organizations. *MCS Output*, a monthly

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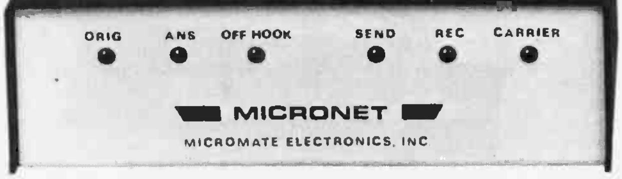

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newsletter, is available. Contact Doug Scribner, POB 405, Keene NH 03431, (603) 352-5558.

Computer Neophyte Newsletter

ComputerTalk Associates, publisher of *ComputerTalk for the Pharmacist*, has introduced a monthly newsletter for first-time buyers and users of small-business computers. The newsletter covers software, hardware, legal issues, new products, and it gives advice on what to look for when purchasing a computer. It is designed for readers with no prior background in electronic data processing. Subscriptions are available for $35 per year from ComputerTalk Associates, Whitpain Office Campus, 1750 Walton Rd, Blue Bell PA 19422, (215) 825-4918.

TRS-80 Users Group of Delaware

If you live in the Delaware Valley area, there's a users group that would like to hear from you. For more information on the group and its activities, contact Tim J Ihde, 1116 Piper Rd, Wilmington DE 19803, (302) 478-7415.

PDP-8 Users Software Exchange

There's a free software exchange service for DEC (Digital Equipment Corporation) PDP-8 users. The service allows users to submit their software for exchange credits that can be used to obtain any software listed in the *Quarterly Software Exchange Bulletin*. Also available is the electronic magazine *Digital Digest*. Contact PDP-8 Software Exchange, 3169 Holcomb Bridge Rd, Suite 307, Department 1019, Norcross GA 30071, (404) 447-4736.

Computernews for Dentists

This monthly 4-page newsletter contains information about computers, developments in technology, and explanations of components. The newsletter shows dentists how the computer can help in their work, especially in management. *Computernews for Dentists* is published by Praxis Computer Inc, 431 St Paul St, St Catherines, Ontario, L2R 3N4, Canada, (416) 688-2611.

MICRO

MICRO (Midwest Interactive Computer Organization) meets on the second Saturday of each month. Dues are $15 per year. Members own Apple, TRS-80, OSI, TI 99/4, KIM, Technico, and other makes of computers. Contact MICRO at 1520 W Capitol Dr, Appleton WI 54911.

The Aurora Computer Society

The Aurora Computer Society meets on the second Wednesday of each month at the Holyrood School, 7920 94th Ave, Edmonton, Alberta, at 7:30 PM. The group is involved in computer-to-amateur radio interfacing and BASIC classes. Members own PET, TRS-80, SwTPC, and other kinds of microcomputers. A monthly magazine, *Intercom 80*, features technical articles and news of the Society. They are interested in communicating with other groups. Contact Bob Huntingford, POB 4342 South Edmonton, Alberta; or Bill Gillespie, 10129 90th St, Edmonton, Alberta, T5H 1R5, Canada.■

A File Catalog System for UCSD Pascal

Edward Heyman
300 Center Hill Rd
Centerville DE 19807

It doesn't take long to accumulate a large number of disks with assorted software, particularly if you insist on a reasonable amount of backup. Finding a program you worked on two months ago can be a problem without some type of file organization. Ward Christenson provided the CP/M world with that organization in his UCAT disk catalog system. I'd be lost without it.

As my collection of UCSD Pascal files grew I needed a system similar to UCAT to cope with the problem. Hence, I created CATALOG (see listing 1). Written in Pascal, it does all the things that UCAT does as fast or faster than UCAT (even though UCAT is written in assembly language). A new directory can be merged into a 600-entry catalog in about 30 seconds. A search for a file in a 600-entry catalog takes less than a second. A 600-entry catalog uses about thirty-six blocks, as does the backup file. The program code file and pointer file use another twenty blocks for a total of ninety-two blocks.

What CATALOG Does

CATALOG maintains a file of records in which each record is similar to a UCSD Pascal directory entry. The record contains the name of the volume, the file name, the type of file, the date the file was last changed, and the length of the file. CATALOG gets the records directly from a volume directory during UPDATE. Once the CATALOG file is filled with records you can locate a file with the SEARCH command.

Being lazy, I like to have my machine do as much of my work as possible, so I've added a few bells and whistles to the essential features.

Using CATALOG

For the CATALOG program to work, the files MASTCAT.DATA and CAT.POINT.DATA must be on Drive five. If they are not, the program asks if you want to create them. The first time the program is run you must respond with a "Y" to the prompts for file creation before you can proceed.

Thereafter, executing CATALOG will bring forth the command line:

```
CATALOG→S)earch D)isplay B)ackup U)pdate
        R)emove Q)uit.
```

The S Command

Entering "S" will put the program in the Search mode with the prompt:

```
ENTER THE NAME OF FILE TO BE FOUND→
```

Uppercase must be used for the file name. Wild-card searches can be made by replacing the wild-card section with "=". For example, the following entries may be made to find CATALOG.TEXT:

```
CATALOG.TEXT
CAT=
=LOG.TEXT
```

The directory of an entire volume can be obtained by typing the name of the volume followed by ":".

Entering file name FREE.SPACE will display a list of all the cataloged volumes, the available space, and the most recent date of catalog update of each volume.

The output of the Search command can be directed to the printer by typing "<" before the name of the file to be searched.

The D Command

Entering "D" in response to the main prompt line will display the entire catalog in alphabetical order.

The B Command

Entering "B" in response to the main prompt line will display all files that exist on only one volume (all files that do not have a backup). The routine checks only for the same file name; therefore, files with the same name but different dates are considered to be backed up.

The U Command

A response of "U" to the main prompt line will activate the update routine, which will produce the prompt:

ENTER UNIT NUMBER CONTAINING UPDATE VOLUME→

If UNIT 5 is selected, the catalog file will be updated with the contents of the volume containing the catalog files (with the exception of MASTCAT.DATA). For all other volumes UNIT 4 should be used.

The update procedure will first rename the main catalog file (MASTCAT.DATA) to BACKCAT.DATA and then read the directory for the volume on the selected unit and create a file name FREE.SPACE with the unused space on the volume. It will then sort the files by alphabetical order and merge the volume list with the *catalog file* (MASTCAT.DATA) and at the same time create the pointer file (CAT.POINT.DATA.).

While merging, any file names added will be displayed on the console terminal and any files that were previously on the volume but were removed will be removed from the master file and displayed as having been deleted. After completion, the number of entries in both the main and backup files will be displayed.

The beauty of Pascal is its self-documenting features—the program should not be difficult to follow.

The R Command

Entering an "R" in response to the main prompt will invoke the prompt line:

ENTER NAME OF VOLUME TO BE REMOVED→

Entering a volume name and a carriage return will cause all entries in the main catalog file for the selected volume to be removed from the file and to be listed on the terminal.

The Q Command

To leave CATALOG enter "Q". UNIT 4 will be checked to see if it contains the booted system volume; if not, a prompt to insert the original system volume will be displayed on the terminal before the program is exited (to prevent a system crash).

How the Program Works

The beauty of Pascal is its self-documenting features—the program should not be difficult to follow.

Since most systems will not have sufficient memory to hold a copy of both the old (BACKCAT.DATA) and the new catalog (MASTCAT.DATA) at one time, the files are read in and written out in sections. OCAT and NCAT are arrays that hold the records read from the old file and the records to be written to the new file, respectively. The size of these arrays is determined by the constant MAXREC. MAXREC should be adjusted to suit your memory size. NREC and OREC are variables associated with the number of records read or records written during the current read or write. DREC is associated with the number of records in the directory. OTOTREC and NTOTREC are the total records read or written to or from a file.

In order to speed the action of the SEARCH command a pointer file is created during UPDATE. The index to the pointers are the characters "A" to "Z". The array holding the pointers is called DEXRAY and is stored on disk in the file CAT.POINT.DATA. The pointer list is created by calls to the procedure SETDEX. It is written to file by procedure WRITEDEX and read into array DEXRAY by procedure READDEX.

Procedure BACKUP checks to see if the file name of a record is unequal to its predecessor and successor. If it is, it is not backed up. Since the array is not large enough to hold all of the catalog file, provisions must be made to compare the last entry in one array with the first entry in the next array. The Boolean variables PASS and UNBACK are used for this purpose.

To simplify the logic of procedure MERGE, several IF statements as well as the CASE statement have been used. The problem may be stated as follows:

- If the current directory record file name is less than the current old catalog record file name, insert the directory record in the new catalog and increment the new file pointer (NREC) and the directory pointer (D).
- If the current directory record file name is equal to the current old catalog record file name, check the volume names. If the current directory record volume name is less than the old catalog record volume name, insert the directory record and increment the new catalog (NREC) and the directory (D) pointers. If the current directory record volume name is equal to the old catalog record volume file name, insert the directory record and increment NREC, OREC, and D. If the directory record volume name is greater than the old file record name, insert the old catalog record into the new catalog and increment the new catalog and old catalog pointers.
- If the current directory record file name is greater than the old catalog record file name, insert the old catalog record in the new catalog and increment the new catalog pointer and the old catalog pointer. If the directory record volume name is equal to the old file record volume name, do not enter the record in the new catalog, and simply increment the old catalog pointer.

I hope that you will find CATALOG useful in keeping track of your files and programs.■

Listing 1: *A disk catalog system for UCSD Pascal. This program maintains a file of records in which each record is similar to a UCSD Pascal directory. Each record contains the name of the volume, the file name, the type of file, the date the file was last changed, and the length of the file.*

```
{$S+}{L CONSOLE:}{L PRINTER:}{L CAT.PRN.TEXT}

PROGRAM CATALOG;

{* written by edward heyman    *}
{* 300 center hill road        *}
{* centerville delaware 19807 *}

CONST
        BLANKS = '                ';
        MAXREC=200;
        MAXREC_1=201;
        NFILENAME='#5:MASTCAT.DATA';
        OFILENAME='#5:BACKCAT.DATA';
        PFILENAME='#5:CAT.POINT.DATA';
        CLEARSCREEN=12;

TYPE

     DATE_RECORD = PACKED RECORD
                        MONTH: 0..12;
                        DAY: 0..31;
                        YEAR: 0..100
             END;

     DIR_SIZE = 0..77;
     VOL_ID = STRING[7];
     FILE_ID = STRING[15];
     FILE_TYPE = (UNTYPED,XDISK,CODE,TEXT,
                 INFO,DATA,GRAF,FOTO,SECUREDIR);
     DIR_RECORD = RECORD
                     FIRST_BLOCK: INTEGER;
                     LAST_BLOCK: INTEGER;
```

Listing 1 continued on page 411

Listing 1 continued:

```
                    CASE DIR_FILE_KIND:FILE_TYPE OF
                      SECUREDIR,UNTYPED:
                                          (DIR_VOL_NAME:VOL_ID;
                                           ZERO_BLOCK,
                                           NUM_OF_FILES,
                                           TOTAL_BLOCKS:INTEGER;
                                           LAST_BOOT:DATE_RECORD);
                      XDISK,CODE,TEXT,INFO,DATA,
                      GRAF,FOTO:
                                  (DIR_FILE_NAME:FILE_ID;
                                   LASTBYTE:1..512;
                                   DIR_FILE_DATE:DATE_RECORD)
                END;

    CATALOG_RECORD=PACKED RECORD
                     VOL_NAME:VOL_ID;
                     FILE_NAME:FILE_ID;
                     FILE_KIND:FILE_TYPE;
                     FILE_DATE:DATE_RECORD;
                     FILE_SIZE:0..988;
            END;

    DIRECTORY = ARRAY[DIR_SIZE] OF DIR_RECORD;
    CATARRAY = ARRAY [0..MAXREC] OF CATALOG_RECORD;
    FILEN = STRING[20];
    RECNUM = 0..MAXREC_1;
    INDEX = 'A'..'Z';
    INDEXARRAY = ARRAY [INDEX ] OF INTEGER;

VAR

      NREC,NLREC,OREC,OLREC,DREC,DLREC:RECNUM;
      NTOTREC,OTOTREC:0..2047;
      REMOV,NFILEEND,OFILEEND,DONE:BOOLEAN;
      CH:CHAR;
      DEX: INDEX;
      DEXRAY : INDEXARRAY;
      P : FILE OF CHAR;         {used to switch from console to printer}
      VOL,TEST,SYSTEMVOLUME:VOL_ID;
      CATFILE,OCATFILE,NCATFILE:FILE OF CATALOG_RECORD;
      NCAT,OCAT:CATARRAY;
```

Listing 1 continued on page 412

Listing 1 continued:

```
FUNCTION LOOKUP(FN:FILEN):BOOLEAN;FORWARD;

SEGMENT PROCEDURE INITIALIZE;
  VAR
        I:RECNUM;
        CAT:CATARRAY;
        DEXFILE:FILE OF INDEXARRAY;
  BEGIN
    IF (NOT LOOKUP(NFILENAME))
      THEN BEGIN
             WRITELN('THERE IS NO FILE NAMED ',NFILENAME,' ON THIS DISK');
             WRITELN('DO YOU WANT TO CREATE A ',NFILENAME,'  {Y/N}');
             REPEAT
               READ(CH)
             UNTIL (CH IN ['Y','y','N','n']);
             IF ((CH<>'Y') AND (CH<>'y')) THEN EXIT(CATALOG);
             writeln('FILLING ARRAY[0]');
             WITH CAT[0] DO
               BEGIN
                 VOL_NAME:='       ';
                 FILE_NAME:='               ';
                 FILE_KIND:=UNTYPED;
                 FILE_DATE.MONTH:=0;
                 FILE_DATE.DAY:=0;
                 FILE_DATE.YEAR:=0;
                 FILE_SIZE:=0;
               END;
             FOR I:=1 TO MAXREC DO CAT[I]:=CAT[0];
             writeln('ARRAY IS FILLED');
             REWRITE(CATFILE,NFILENAME);
               FOR I:=0 TO MAXREC DO
                 BEGIN
                   CATFILE^:=CAT[I];
                   PUT(CATFILE);
                 END;{for I}
             CLOSE(CATFILE,LOCK)
           END{if}
      ELSE WRITELN('THE FILE ',NFILENAME,' ALREADY EXITS ON THIS VOLUME ');
```

Listing 1 continued on page 413

Listing 1 continued:

```
  IF NOT LOOKUP(PFILENAME)
    THEN BEGIN
             WRITELN('THERE IS NO FILE NAMED ',PFILENAME,' ON THIS DISK');
             WRITELN('DO YOU WANT TO CREATE A ',PFILENAME,'  {Y/N}');
             REPEAT
               READ(CH)
              UNTIL (CH IN ['Y','y','N','n']);
              IF ((CH<>'Y') AND (CH<>'y')) THEN EXIT(CATALOG);
              FOR DEX:='A' TO 'Z' DO DEXRAY[DEX]:=0;
              REWRITE(DEXFILE,PFILENAME);
              DEXFILE^:=DEXRAY;
              PUT(DEXFILE);
              CLOSE(DEXFILE,LOCK);
              WRITELN(PFILENAME,' WRITTEN TO DISK')
              END{if}
      ELSE WRITELN('FILE ',PFILENAME,' EXISTS');
END;{init}




FUNCTION LOOKUP;
{returns TRUE if filename present FALSE if not}
    VAR
          IOR:0..15;
    BEGIN
      {$I-}
      RESET(CATFILE,FN);
      IOR:=IORESULT;
      CLOSE(CATFILE);
      {$I+}
      IF (IOR=0)
          THEN LOOKUP:=TRUE
          ELSE BEGIN
                 LOOKUP:=FALSE;
                 IF(IOR<>10) THEN WRITELN('IORESULT FOR ',FN,' IS ',IOR);
          END;{else}
    END;{lookup}
```

Listing 1 continued on page 414

Listing 1 continued:

```
PROCEDURE WAIT;
  BEGIN
    GOTOXY(10,24);
    WRITE('PRESS SPACE BAR TO CONTINUE');
    READ(CH)
  END;{wait}

PROCEDURE MEM(FN:STRING);
  BEGIN
      writeln('MEMORY AVAILABLE AT PROCEDURE ',FN,' = ',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

Circle 317 on inquiry card.

Listing 1 continued:

```
   BEGIN
     VOL:='        ';
     REPEAT
       WRITE(CHR(CLEARSCREEN));
       WRITE('ENTER NAME OF VOLUME TO BE REMOVED --> ');
       READLN(VOL);
     UNTIL (LENGTH(VOL)<=8);
     IF (POS(':',VOL)<>0) THEN DELETE(VOL,POS(':',VOL),1);
     SPS:=COPY(BLANKS,1,7-LENGTH(VOL));
     VOL:=CONCAT(VOL,SPS);
     WRITELN(VOL,'|');
     DREC:=0
   END;{enter_vol_name}


PROCEDURE PRINT_DATE (REC:DATE_RECORD);
{prints date to console or printer}
BEGIN
 WITH REC DO
   BEGIN
      WRITE(P,DAY:3,'-');
        CASE MONTH OF
          1: WRITE(P,'Jan');
          2: WRITE(P,'Feb');
          3: WRITE(P,'Mar');
          4: WRITE(P,'Apr');
          5: WRITE(P,'May');
          6: WRITE(P,'Jun');
          7: WRITE(P,'Jul');
          8: WRITE(P,'Aug');
          9: WRITE(P,'Sep');
          10: WRITE(P,'Oct');
          11: WRITE(P,'Nov');
          12: WRITE(P,'Dec');
        END;{case}
        WRITE(P,'-',YEAR:2,'  ':3);
    END;{with}
   END;{print_date}
```

Listing 1 continued on page 416

Listing 1 continued:

```
PROCEDURE PRINT_KIND(FILE_KIND:FILE_TYPE);
{prints file type to console or printer}
   BEGIN
     CASE FILE_KIND OF
         XDISK: WRITE(P,'Bad block');
         CODE:  WRITE(P,'Code file');
         TEXT:  WRITE(P,'Text file');
         INFO:  WRITE(P,'Info file');
         DATA:  WRITE(P,'Data file');
         GRAF:  WRITE(P,'Graf file');
         FOTO:  WRITE(P,'Foto file');
       END; { case }
   END;{print_kind}

 PROCEDURE PRINT_RECORD(CAT1:CATALOG_RECORD);
 {prints record to console or printer}
     BEGIN
       WITH CAT1 DO
         BEGIN
           WRITE(P,FILE_NAME,'   ':18-LENGTH(FILE_NAME));
           WRITE(P,VOL_NAME,' ':8-LENGTH(VOL_NAME));
           WRITE(P,FILE_SIZE:4);
           PRINT_DATE(FILE_DATE);
           PRINT_KIND(FILE_KIND);
           WRITELN(P);
         END;{with}
     END;{print_record}

 PROCEDURE READ_NEW_CAT;
 {reads NREC records or to eof from NCATFILE}
   VAR
         I:RECNUM;
   BEGIN
     I:=1;NREC:=0;
     GET(NCATFILE);
     WHILE (NOT EOF(NCATFILE)) DO
         BEGIN
           NCAT[I]:=NCATFILE^;
           IF ((NCAT[I].VOL_NAME='          '))
             THEN BEGIN
                     NREC:=I-1;
                     NTOTREC:=NTOTREC+NREC;
                     NFILEEND:=TRUE;
                     EXIT(READ_NEW_CAT);
                   END;{if}
```

Listing 1 continued on page 417

Listing 1 continued:

```
            IF (I=NLREC)
               THEN BEGIN
                     NREC:=I;
                     NTOTREC:=NTOTREC+I;
                     EXIT(READ_NEW_CAT);
                    END;{if}
            I:=I+1;
            GET(NCATFILE);
          END;{while}
        NREC:=I-1;
        NTOTREC:=NTOTREC+NREC;
        NFILEEND:=TRUE;
  END;{nreadcat}

PROCEDURE READ_OLD_CAT;
{reads OREC records or to eof from OCATFILE}

VAR
      I:RECNUM;
BEGIN
  I:=1;OREC:=0;
  GET(OCATFILE);
  WHILE (NOT EOF(OCATFILE)) DO
      BEGIN
        OCAT[I]:=OCATFILE^;
        IF ((OCAT[I].VOL_NAME='         '))
          THEN BEGIN
                 OREC:=I-1;
                 OTOTREC:=OTOTREC+OREC;
                 OFILEEND:=TRUE;
                 EXIT(READ_OLD_CAT);
               END;{if}
        IF (I=OLREC)
          THEN BEGIN
                 OREC:=I;
                 OTOTREC:=OTOTREC+I;
                 EXIT(READ_OLD_CAT);
               END;{if}
        I:=I+1;
        GET(OCATFILE);
      END;{while}
    OREC:=I-1;
    OTOTREC:=OTOTREC+OREC;
    OFILEEND:=TRUE;
END;{readcat}
```

Listing 1 continued on page 418

Listing 1 continued:

```
PROCEDURE WRITECAT;
{writes NREC records to NCATFILE}
  VAR
        I:RECNUM;
  BEGIN
    IF (NTOTREC=0) THEN WITH NCAT[0] do
                        BEGIN
                          VOL_NAME:='       ';
                          FILE_NAME:='               ';
                          FILE_KIND:=UNTYPED;
                          FILE_DATE.MONTH:=0;
                          FILE_DATE.DAY:=0;
                          FILE_DATE.YEAR:=0;
                          FILE_SIZE:=0;
                          NCATFILE^:=NCAT[0];
                          PUT(NCATFILE);
                        END;
    FOR I:=1 TO NREC DO
      BEGIN
        NCATFILE^:=NCAT[I];
        PUT(NCATFILE);
        WRITE('.');
      END;
    WRITELN;
    NTOTREC:=NTOTREC+NREC;
    NREC:=0;
    IF DONE THEN CLOSE(NCATFILE,LOCK);
  END;{writecat}
PROCEDURE DISPLAY;
{writes the entire MASTCAT.DAT file to the console}
   VAR
         I:RECNUM;
   BEGIN
    REWRITE(P,'CONSOLE:');
    IF ( LOOKUP(NFILENAME))
      THEN BEGIN
             NREC:=0;
             RESET(NCATFILE,NFILENAME);
             REPEAT
               READ_NEW_CAT;
               FOR I:=1 TO NREC DO PRINT_RECORD(NCAT[I]);
             UNTIL NFILEEND;
```

Listing 1 continued on page 419

Listing 1 continued:

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

PROCEDURE BACKUP;
{compares file names and reports files without backup}
  VAR
          PASS,UNBACK:BOOLEAN;
          N:RECNUM;
  BEGIN
    PASS:=FALSE;UNBACK:=FALSE;
    REWRITE(F,'CONSOLE:');
    IF ( LOOKUP(NFILENAME))
        THEN BEGIN
               WRITE(CHR(CLEARSCREEN));
               WRITELN('THE FOLLOWING FILES ARE NOT BACKED UP');
               RESET(NCATFILE,NFILENAME);
               REPEAT
                 IF (PASS AND UNBACK)
                     THEN IF (NCAT[0].FILE_NAME<>NCAT[1].FILE_NAME)
                              THEN PRINT_RECORD(NCAT[0]);
                 READ_NEW_CAT;
                 FOR N:=1 TO NREC-1 DO
                    IF ((NCAT[N].FILE_NAME <> NCAT[N-1].FILE_NAME) AND
                          (NCAT[N].FILE_NAME <> NCAT[N+1].FILE_NAME))
                                THEN PRINT_RECORD(NCAT[N]);
                 PASS:=TRUE;
                 IF (NCAT[NREC].FILE_NAME <> NCAT[NREC-1].FILE_NAME)
                          THEN UNBACK:=TRUE;
                 NCAT[0]:=NCAT[NREC];
                 IF (NFILEEND AND UNBACK) THEN PRINT_RECORD(NCAT[NREC]);
               UNTIL NFILEEND;
               CLOSE(NCATFILE);
             END{if}
        ELSE WRITELN(NFILENAME,' NOT PRESENT');
     CLOSE(F);
     WAIT;
  END;{backup}
```

Listing 1 continued on page 420

Circle 114 on inquiry card.

Listing 1 continued:

```
PROCEDURE UPDATE;

VAR
      DCAT : ARRAY [DIR_SIZE] OF CATALOG_RECORD;
      RN:RECNUM;

 PROCEDURE RENAME;      {changes name of MASTCAT.DATA to BACKCAT.DATA}
   VAR
         I:INTEGER;
         SPS:STRING[16];
         VOL,AVOL:VOL_ID;
         DIR:DIRECTORY;
   BEGIN
     UNITREAD(5,DIR[0],2048,2);
     VOL:=DIR[0].DIR_VOL_NAME;
     SPS:=COPY(BLANKS,1,7-LENGTH(VOL));
     AVOL:=CONCAT(VOL,SPS);
     FOR I:=1 TO DIR[0].NUM_OF_FILES DO
         WITH DIR[I] DO
           IF (DIR_FILE_NAME='MASTCAT.DATA')
             THEN DIR_FILE_NAME:='BACKCAT.DATA';
     UNITWRITE(5,DIR[0],2048,2);
   END;{rename}


 PROCEDURE WRITEDEX;
 {writes a file of pointers to the first occurrence of each letter in the alpha
   VAR
       DEXFILE : FILE OF INDEXARRAY;
   BEGIN
     REWRITE(DEXFILE,PFILENAME);
     DEXFILE^:=DEXRAY;
     PUT(DEXFILE);
     CLOSE(DEXFILE,LOCK);
   END;{writedex}

 PROCEDURE SORT;
 {sorts the directory file in alphabetical order}
   VAR
         I:RECNUM;
         BUF:CATALOG_RECORD;        {holds record during exchange}
         FLAG:BOOLEAN;              {FALSE if an exchange made during pass}
```

Listing 1 continued on page 421

Listing 1 continued:

```
    BEGIN
      WRITELN('SORTING ',DREC,' RECORDS');
      REPEAT
        FLAG:=TRUE;
        FOR I:=DREC DOWNTO 2 DO
           IF (DCAT[I].FILE_NAME < DCAT[I-1].FILE_NAME) THEN
              BEGIN        {exchange routine}
                BUF:=DCAT[I];
                DCAT[I]:=DCAT[I-1];
                DCAT[I-1]:=BUF;
                FLAG:=FALSE;
              END;{if}
       WRITE('.');
       UNTIL FLAG;
      WRITELN;
      WRITELN('DONE SORTING');
    END;{sort}

PROCEDURE GETDIR;
{reads directory of update volume and puts it in DCAT}
  VAR
      DIRX:DIRECTORY;
      UNITNUM,I: INTEGER;
      CHBUF : char;
      VOL:VOL_ID;
      SPS:STRING[16];
      BLOCKS_USED:0..988;


  BEGIN
  BLOCKS_USED:=10;        {assumes duplicate directories}
  DREC:=0;
    MEM('GETDIR');
    repeat
      WRITE('Enter unit number for required directory --> ');
      READLN(UNITNUM);
      WRITELN
    until unitnum in [ 4 .. 5 ];
    UNITREAD(UNITNUM,DIRX[0],2048,2);              {read directory into array DIF
    IF IORESULT <> 0
      THEN
        BEGIN
          WRITELN('Unit not online');
          EXIT(CATALOG);
        END;
```

Listing 1 continued on page 422

Listing 1 continued:

```
  VOL:=DIRX[0].DIR_VOL_NAME;
  SPS:=COPY(BLANKS,1,7-LENGTH(VOL));  {put VOL in consistent format}
  VOL:=CONCAT(VOL,SPS);
  FOR I:=1 TO DIRX[0].NUM_OF_FILES DO          {move directory to DCAT}
    BEGIN
      WITH DIRX[I] DO
        BEGIN
          IF LENGTH(DIR_FILE_NAME)>0
            THEN
              BEGIN
                DREC:=DREC+1;
                WITH DCAT[DREC] DO
                  BEGIN
                    VOL_NAME:=VOL;
                    FILE_NAME:=DIR_FILE_NAME;
                    SPS:=COPY(BLANKS,1,15-LENGTH(FILE_NAME));
                    FILE_NAME:=CONCAT(FILE_NAME,SPS);
                    FILE_KIND:=DIR_FILE_KIND;
                    FILE_DATE:=DIR_FILE_DATE;
                    FILE_SIZE:=LAST_BLOCK-FIRST_BLOCK;
                    BLOCKS_USED:=BLOCKS_USED+FILE_SIZE;
                  END;{with}
              END;{if length}
        END;{with dirx}
    END;{for}
{create entry with name FREE.SPACE containing the unused space on the volume}
      DREC:=DREC+1;
      WITH DCAT[DREC] DO
```

Listing 1 continued on page 423

 Circle 452 on inquiry card. Circle 453 on inquiry card.

Listing 1 continued:

```
        BEGIN
          VOL_NAME:=VOL;
          FILE_NAME:='FREE.SPACE';
          SPS:=COPY(BLANKS,1,15-LENGTH(FILE_NAME));
          FILE_NAME:=CONCAT(FILE_NAME,SPS);
          FILE_KIND:=INFO;
          FILE_DATE:=DIRX[0].LAST_BOOT;
          FILE_SIZE:=DIRX[0].TOTAL_BLOCKS-BLOCKS_USED;
        END;{with}
  END;{setdir}


  PROCEDURE SETDEX;
  {if first occurance of file name with DEX as first letter then
                                 put record number in DEXRAY and increment DEX}
   BEGIN
     IF NCAT[NREC].FILE_NAME[1] >= DEX
     {have we reached or exceeded the next index?}
        THEN BEGIN
               IF NCAT[NREC].FILE_NAME[1] > DEX
                  THEN REPEAT        {fills dexray to the next valid index}
                         DEXRAY[DEX]:=0;
                         IF DEX='Z' THEN EXIT(SETDEX);
                         DEX:=SUCC(DEX);
                       UNTIL (NCAT[NREC].FILE_NAME[1] = DEX);
               DEXRAY[DEX]:=NTOTREC+NREC;
               IF DEX='Z' THEN EXIT(SETDEX);
               DEX:=SUCC(DEX);
             END;{if}
    END;{setdex}

  PROCEDURE MERGE;
  {merges DCAT with OCAT to form NCAT}
    VAR
          X,Y,Z:1..33;
          CONTINUE:BOOLEAN;
          OO,O,D:RECNUM;
    BEGIN
      DEX:='A';                  {set first match char for index at 'A'}
      O:=OREC;
      OREC:=1;
      D:=1;
                                 {REMOV is true if volume to be deleted}
      IF (NOT REMOV) THEN VOL:=DCAT[1].VOL_NAME;
                                 {DREC+1 is 1 more than the number of files in DCAT}
       WHILE (D < DREC+1) DO
        BEGIN
          WITH DCAT[D] DO
            BEGIN{with}
              IF (FILE_NAME < OCAT[OREC].FILE_NAME)
                  THEN X:=10
                  ELSE IF (FILE_NAME = OCAT[OREC].FILE_NAME)
                         THEN X:=20
                         ELSE X:=30;

              IF (VOL_NAME < OCAT[OREC].VOL_NAME)
                     THEN Y:=1
                     ELSE IF (VOL_NAME = OCAT[OREC].VOL_NAME)
                            THEN Y:=2
                            ELSE Y:=3;

                Z:=X+Y;
                IF ((OREC=0) or (OREC>O)) THEN Z:=11;
```

Listing 1 continued on page 424

Listing 1 continued:

```
            CASE Z OF
                11,12,13,21 : BEGIN       {add record to NCAT from DCAT}
                                NREC:=NREC+1;
                                NCAT[NREC]:=DCAT[D];
                                D:=D+1;                    {increment D}
                                WRITE('ADD    ',NCAT[NREC].FILE_NAME:18);
                                WRITELN(NCAT[NREC].VOL_NAME:10)
                              END;

                22          : BEGIN           {add record to NCAT from DCAT}
                                NREC:=NREC+1;
                                NCAT[NREC]:=DCAT[D];
                                OREC:=OREC+1;             {increment OREC}
                                D:=D+1                    {increment D}
                              END;

                23,31,33    : BEGIN           {add record to NCAT from OCAT}
                                NREC:=NREC+1;
                                NCAT[NREC]:=OCAT[OREC];
                                OREC:=OREC+1;             {increment OREC}
                              END;

                32          : BEGIN               {do not add record to NCAT}
                                WRITE('DELETE ',OCAT[OREC].FILE_NAME:18);
                                WRITELN(OCAT[OREC].VOL_NAME:10);
                                OREC:=OREC+1;             {increment OREC}
                              END;
            END;{case of Z}
         SETDEX;           {check poniter index}
       END;{with}
    IF (NREC=NLREC) THEN WRITECAT;       {NLREC is the max array size}
    IF ((OREC>OLREC) AND (NOT OFILEEND)) {if you are out of OCAT get some more}
         THEN BEGIN
                READ_OLD_CAT;
                O:=OREC;
                OREC:=1;
              END;{if}
  END;{while}              {DCAT is empty}
REPEAT                     {get whats left of OCAT}
  CONTINUE:=FALSE;
  IF (OREC<=O)
       THEN FOR OO:=OREC TO O DO
              IF (OCAT[OO].VOL_NAME <> VOL)
                   THEN BEGIN
                          NREC:=NREC+1;
                          NCAT[NREC]:=OCAT[OO];
                          IF (NREC=NLREC) THEN WRITECAT;
                          SETDEX;
                        END{then}
                   ELSE BEGIN
                         WRITE('DELETE ',OCAT[OO].FILE_NAME:18);
                         WRITELN(OCAT[OO].VOL_NAME:10)
                        END;{else}
  IF (NOT OFILEEND) THEN BEGIN       {if you are out of OCAT get some more}
                          READ_OLD_CAT;
                          O:=OREC;
                          OREC:=1;
                          CONTINUE:=TRUE;
                         END;{if}
UNTIL (NOT CONTINUE);
IF (DEX <'Z')
  THEN FOR CH:=DEX TO 'Z' DO DEXRAY[CH]:=DEXRAY[PRED(DEX)];
```

Listing 1 continued on page 425

Listing 1 continued:

```
  DONE:=TRUE;
  WRITECAT;
  WRITEDEX;
END;{match}

 BEGIN{update}
   REWRITE(P,'CONSOLE:');
   IF LOOKUP(OFILENAME)
       THEN BEGIN
               RESET(OCATFILE,OFILENAME);
               CLOSE(OCATFILE,PURGE);              {remove old BACKCAT}
             END;{if}
   RENAME;                                         {MASTCAT --> BACKCAT}
   IF (NOT REMOV)
             THEN BEGIN
                    GETDIR;
                    SORT;
                    FOR RN:=1 TO DREC DO PRINT_RECORD(DCAT[RN]);
                  END;{if}
   IF LOOKUP(OFILENAME)
         THEN BEGIN
                RESET(OCATFILE,OFILENAME);
                READ_OLD_CAT;
              END{if}
         ELSE OREC:=0;
   REWRITE(NCATFILE,NFILENAME);
   NREC:=0;
   MERGE;
   CLOSE(OCATFILE);
   CLOSE(P);
   WRITELN('BACKCAT CONTAINS  ',OTOTREC,' RECORDS');
   WRITELN('MASTCAT CONTAINS  ',NTOTREC,' RECORDS');
   CLOSE(NCATFILE,LOCK);
   WAIT;
END;{update}


PROCEDURE SEARCH;
     VAR
         STOP,FOUND:BOOLEAN;
         TAR1,TAR2:CHAR;
         START:INTEGER;
         WILDCARD:0..16;
         CAT:CATALOG_RECORD;
         TARGET,SPS:STRING;

    PROCEDURE LONGSEARCH;
    {search used when alphabetical pointer cannot be used }
VAR
           N:RECNUM;

BEGIN
   DELETE(TARGET,1,1);                   {remove wildcard char}
   writeln(TARGET);
   REPEAT
     READ_NEW_CAT;
     FOR N:=1 TO NREC DO IF POS(TARGET,NCAT[N].FILE_NAME) <> 0
                                THEN PRINT_RECORD(NCAT[N]);
   UNTIL (NFILEEND);
   CLOSE(NCATFILE);
   WAIT;
```

Listing 1 continued on page 426

Listing 1 continued:

```
      CLOSE(P);
      EXIT(SEARCH)
    END;{longsearch}

   PROCEDURE SEARCH_FOR_VOLUME;
    VAR
               BLKS,SPS:STRING[7];
               N:RECNUM;

    BEGIN
      BLKS:='       ';
      DELETE(TARGET,POS(':',TARGET),1);
      SPS:=COPY(BLKS,1,7-LENGTH(TARGET));
      TARGET:=CONCAT(TARGET,SPS);
      writeln(TARGET);
      REPEAT
        READ_NEW_CAT;
        FOR N:=1 TO NREC DO
          IF (NCAT[N].VOL_NAME=TARGET) THEN PRINT_RECORD(NCAT[N]);
      UNTIL (NFILEEND);
      CLOSE(NCATFILE);
      WAIT;
      CLOSE(P);
      EXIT(SEARCH)
    END;{vsearch}

BEGIN{search}
  STOP:=FALSE;FOUND:=FALSE;
  REPEAT
    WRITE('ENTER NAME OF FILE TO BE FOUND--> ');
    READLN(TARGET);
    IF(LENGTH(TARGET)>16) THEN WRITELN('NAME TOO LONG ');
  UNTIL (LENGTH(TARGET)<=16);
  IF (POS('<',TARGET)=1)     {'<' sends output to printer}
          THEN BEGIN
                 DELETE(TARGET,1,1);
                 REWRITE(P,'PRINTER:');
               END{if}
          ELSE REWRITE(P,'CONSOLE:');
  RESET(NCATFILE,NFILENAME);
  IF (POS(':',TARGET)<>0) THEN SEARCH_FOR_VOLUME;
  WILDCARD:=POS('=',TARGET);
  IF (WILDCARD = 1) THEN LONGSEARCH;
  IF (WILDCARD > 1) THEN TARGET:=COPY(TARGET,1,WILDCARD-1);
  TAR1:=TARGET[1];                {TAR1 used to set pointer from DEXRAY}
  IF (WILDCARD <> 2)              {TAR2 used to end search}

      THEN TAR2:=TARGET[2]
      ELSE TAR2:='z';
IF (TAR1 < 'A')
    THEN START:=0
    ELSE IF (TAR1 > 'Z')
         THEN START:=DEXRAY['Z']
         ELSE START:=DEXRAY[TAR1];
SEEK(NCATFILE,START);
GET(NCATFILE);
REPEAT
  CAT:=NCATFILE^;
  IF ((WILDCARD = 0) AND (POS(TARGET,CAT.FILE_NAME) = 1))
                                            THEN BEGIN
                                              PRINT_RECORD(CAT);
                                              FOUND:=TRUE;
                                            END;
```

Listing 1 continued on page 427

Listing 1 continued:

```
    IF ((WILDCARD > 1) AND (POS(TARGET,CAT.FILE_NAME) >= 1))
                                                    THEN BEGIN
                                                      PRINT_RECORD(CAT);
                                                      FOUND:=TRUE;
                                                    END;

    IF ((CAT.FILE_NAME[1] > TAR1 ) OR (CAT.FILE_NAME[2] > TAR2))
                    THEN STOP:=TRUE;
    GET(NCATFILE);
  UNTIL (STOP OR EOF(NCATFILE));
  IF (NOT FOUND) THEN WRITELN('FILE ',TARGET,' NOT FOUND');
  CLOSE(NCATFILE);
  CLOSE(P);
  WAIT
END;{SEARCH}



BEGIN {main}
  IF ((NOT LOOKUP(NFILENAME)) OR (NOT LOOKUP(PFILENAME))) THEN INITIALIZE;
  GET_SYS_VOL(SYSTEMVOLUME);      {record system volume name for rebooting}
  DLREC:=MAXREC;OLREC:=MAXREC;NLREC:=MAXREC;
  READDEX;                  {load the pointer array}
  REPEAT
    REMOV:=FALSE;NFILEEND:=FALSE;OFILEEND:=FALSE;DONE:=FALSE;
    NREC:=0;OREC:=0;DREC:=0;
    NTOTREC:=0;OTOTREC:=0;
    VOL:='          ';
    REPEAT
      WRITE(CHR(CLEARSCREEN));
      MEM('MAIN');
      WRITE('CATALOG -->  S)earch D)isplay B)ackup U)pdate R)emove Q)uit');
      READ(KEYBOARD,CH);
      WRITELN;
    UNTIL (CH IN ['R','r','B','b','U','u','S','s','D','d','Q','q']);
    CASE CH OF
          'U','u' : UPDATE;

          'S','s' : SEARCH;

          'D','d' : DISPLAY;

          'R','r' : BEGIN

                      REMOV:=TRUE;
                      ENTER_VOL_NAME;
                      UPDATE
                    END;{case of R}

          'B','b' : BACKUP;


          'Q','q' : REPEAT
                      GET_SYS_VOL(TEST);
                      IF (TEST=SYSTEMVOLUME)
                            THEN EXIT(CATALOG)
                            ELSE WRITELN('INSERT SYSTEM DISK AND PRESS RETURN');
                      READLN(CH)
                    UNTIL CH='P';

        END;{case}
  UNTIL (CH IN ['Q','q']);
END.
```

Market Report for Software Writers

The 1981 Software Writers Market lists more than 1800 firms that will market and distribute programs developed by independent software writers. The report outlines the usual procedures you must take to contact one of these firms with information about a program. If a firm deems that a program has market potential, it will enter into an agreement with you, market the software, and either pay you a royalty based on sales or buy the rights to the program for exclusive use.

The 1981 Software Writers Market provides addresses and telephone numbers of key contact people in service bureaus, hardware manufacturers, mail-order distributors, book publishers, computer magazines, consulting companies, and more than 1500 retail computer stores. It explains how companies market software, what kinds of software they seek, how you are dealt with, royalty rates, and contract details. The price for *The 1981 Software Writers Market* is $45 (with updates offered).

For complete details, contact Kern Publications, 190 Duck Hill Rd, Duxbury MA 02332, (617) 934-0445.

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More than 700 Apple dealers in the US and Canada are participating in the Apple Seed program, which provides qualifying elementary and high school students with computer-course materials. Under the program, Apple Computer will donate a $500 bonus kit of course materials to junior and senior high schools which qualify as "start-up" schools and which buy a 32 K-byte Apple computer with at least one disk drive. Schools that are initiating computer education curricula and schools that are expanding ongoing computer education programs with additional Apple systems are welcomed under the plan.

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For complete details on the Apple Seed computer-literacy program, contact Apple Computer, 10260 Bandley Dr, Cupertino CA 95014.

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Programming Quickies

Printf for the C Function Library

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One of the most-used functions in the standard library for the C programming environment is printf, the formatting print function. Printf accepts character, string, and numeric values as arguments and sends them to the standard output (normally the user's console) according to a specified format. It is used both as the main way to provide a program's output to the console and as a way of testing variable values during debugging. Its control-format string may specify that numerical values be represented in hexadecimal, octal, or decimal notation, that right or left justification be employed, and that arguments be printed in a given field width or restricted to a limited precision.

Although present versions of the BDS C compiler for the 8080 CP/M operating system have the standard printf function, earlier versions had a more primitive version of printf. If you have a version that *cannot* print numerical data in octal, does not permit precision to be specified to limit the length of a string, and only left justifies, the program shown in listing 1 will add all the standard features and a few new ones.

Except for the features that apply only to floating-point and long numerical data, this program conforms to the specifications for printf in Kernighan and Ritchie's *The C Programming Language* (Prentice-Hall, 1978). It is simple to adapt printf to other languages, so long as they permit functions, procedures, and subroutines with a variable number of arguments.

Functions compiled with the BDS C compiler find their arguments along an array of vectors stored at location BASE + 0x3f7, where BASE is the base address of the CP/M operating system for the particular machine being used (and "0x3f7" is C's idiosyncratic notation for hexadecimal 3F7). Up to twenty-four arguments are allowed. Because printf doesn't know in advance how many arguments will be needed as interpretation of the control format proceeds, and because the same function-argument vector will be used by subordinate functions called by printf, all the arguments are collected at the outset and stored in local argument array, "localarg[]." This is the one feature of the function that is specific to the BDS compiler. Note that because the control format is passed to printf as a formal parameter, the processing of the remaining arguments begins at FARGV + 2.

Listing 2 shows a sample run and a demonstration program that exercises printf by printing a series of integers in various notations and by printing a string in various

Text continued on page 434

Listing 1: *This is a program for adding a full-featured printf function to some early versions of C compilers. These earlier versions did not allow the printing of numerical data in octal, and did not permit precision to be specified to limit the length of a string; they allowed only left justification. Two new functions which are called by printf have been added: "Nbase" converts a binary integer into a digit string in the requested radix; "Nspoct" does the same for split octal.*

```
#define BASE            0x4200  /* CP/M base address */
#define FARGV           0x3f7   /* BDS C compiler argument vector */

printf(control)
char *control;
{
        char c, *ps, rjustify, s[17], zerofill;
        int *args, k, localarg[23], prcisn, slen, width;

        /* copy arguments from function argument vector */
        for (k = 0, args = BASE + FARGV + 2; k < 23; ++k, ++args)
                localarg[k] = *args;
        args = localarg;

        while (c = *control++)

                /* check for conversion specification */
                if (c == '%') {

                        /* check for various options */

                        if ((c = *control) == '-') {
                                rjustify = 0;
                                c = *control++;
                        }
                        else
                                rjustify = 1;

                        if (c == '0')
                                zerofill = 1;
                        else
                                zerofill = 0;

                        width = 0;
                        while (isdigit(c = tolower(*control++)))
                                width = 10*width + c - '0';

                        if (c == '.') {
                                prcisn = 0;
                                while (isdigit(c = tolower(*control++)))
                                        prcisn = 10*prcisn + c - '0';
                        }
                        else
                                prcisn = 32767;

                        /* process conversion characters */
                        switch (c) {
                        case 'b':
                                ps = nbase(*args++, 2, s);
                                break;
                        case 'o':
                                ps = nbase(*args++, 8, s);
```

Listing 1 continued on page 432

Listing 1 continued:

```
                        break;
                case 'd':
                        if (*args < 0) {
                                ps = nbase(-*args++, 10, s);
                                *--ps = '-';
                        }
                        else
                                ps = nbase(*args++, 10, s);
                        break;
                case 'u':
                        ps = nbase(*args++, 10, s);
                        break;
                case 'x':
                        ps = nbase(*args++, 16, s);
                        break;
                case 'o':
                        ps = nspoct(*args++, s);
                        break;
                case 's':
                        ps = *args++;
                        break;
                case 'c':
                        c = *args++;
                default:
                        *(ps = s) = c;
                        s[1] = '\0';
                }

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

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

                for (k = 1; *ps && k <= prcisn; ++k)
                        putchar(*ps++);

                if (!rjustify)
                        while (width-- > slen)
                                putchar(' ');
        }
        else
                putchar(c);
nbase(n, base, s)
unsigned n, base;
char *s;
{
        int d;

        *(s += 16) = '\0';
        if (n == 0)
```

Listing 1 continued on page 433

Listing 1 continued:

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




nspoct(n, s)
unsigned n;
char s[];
{
        int d; d = 16384;
        char *ps; ps = s;

        while (d > 0) {
                *ps++ = n/d + '0';
                n %= d;
                if (d == 256) {
                        d = 64;
                        *ps++ = '.';
                }
                else
                        d /= 8;
        }
        *ps = '\0';
        return s;
}
```

Listing 2: *Listing and sample run of a demonstration program which exercises the printf function.*

```
A>TYPE PRINTX.C

main()
{
        unsigned i;
        char *string; string = "hello, world";

        for (i = 1; i <= 16384; i *= 2) {
                printf("dec: %5d  oct: %6o  sploct: %q  ", i, i, i);
                printf("hex: %4x  bin: %016b\n", i, i);
        }

        printf("\n");
        printf(":%10s:\n", string);
        printf(":%-10s:\n", string);
        printf(":%20s:\n", string);
        printf(":%-20s:\n", string);
        printf(":%20.10s:\n", string);
```

Listing 2 continued on page 434

Listing 2 continued:

```
printf(":%-20.10s:\n", string);
printf(":%.10s:\n", string);
}

A>PRINTX

dec:     1  oct:      1  sploct: 000.001  hex:    1  bin: 0000000000000001
dec:     2  oct:      2  sploct: 000.002  hex:    2  bin: 0000000000000010
dec:     4  oct:      4  sploct: 000.004  hex:    4  bin: 0000000000000100
dec:     8  oct:     10  sploct: 000.010  hex:    8  bin: 0000000000001000
dec:    16  oct:     20  sploct: 000.020  hex:   10  bin: 0000000000010000
dec:    32  oct:     40  sploct: 000.040  hex:   20  bin: 0000000000100000
dec:    64  oct:    100  sploct: 000.100  hex:   40  bin: 0000000001000000
dec:   128  oct:    200  sploct: 000.200  hex:   80  bin: 0000000010000000
dec:   256  oct:    400  sploct: 001.000  hex:  100  bin: 0000000100000000
dec:   512  oct:   1000  sploct: 002.000  hex:  200  bin: 0000001000000000
dec:  1024  oct:   2000  sploct: 004.000  hex:  400  bin: 0000010000000000
dec:  2048  oct:   4000  sploct: 010.000  hex:  800  bin: 0000100000000000
dec:  4096  oct:  10000  sploct: 020.000  hex: 1000  bin: 0001000000000000
dec:  8192  oct:  20000  sploct: 040.000  hex: 2000  bin: 0010000000000000
dec: 16384  oct:  40000  sploct: 100.000  hex: 4000  bin: 0100000000000000

:hello, world:
:hello, world:
:     hello, world:
:hello, world     :
:          hello, wor:
:hello, wor          :
:hello, wor:

A>
```

Text continued from page 430:
combinations of justification, field width, and precision (the ":" serves to delimit the field). Calls to printf take the form:

printf(control, argument 1, argument 2, ...)

where "control" is a format string composed of text interspersed with conversion specifications—one for each argument.

Each conversion specification begins with the "%" character and ends with a conversion character indicating the format to be used in printing the corresponding argument (character, string, or number). The standard conversion characters "d" (decimal notation), "u" (unsigned decimal), "o" (octal), "x" (hexadecimal), "c" (character), and "s" (string), are supported. I have added two others not specified in Kernighan and Ritchie's book: "b" (binary notation), which is especially useful for debugging programs that use bitwise logical operators, and "q" (split octal), because the front panel of my Heath H-8 computer has a split-octal display.

A number of options may be specified between the "%" character, which introduces the conversion specification, and the conversion character. A minus sign (−) indicates that left justification (instead of the default right justification) is requested. A digit string indicates the field width; a number that fails to fill the width will be padded on the left or right, as necessary. If the field width is specified with a leading zero, a right-justified number will be padded with zeros instead of blanks, so an 8-bit binary number can be printed as 00100101 instead of 100101. A period followed by another digit string indicates the precision, the maximum field width in which an argument is to be printed; this is primarily useful for truncating strings that exceed the permissible line length.

This version of printf uses four other standard C library functions: "tolower(character)," which converts its argument to lowercase if it isn't lowercase already; "isdigit(character)," which returns true (not zero) if its argument is a digit and false (zero) otherwise; "putchar (character)," which outputs a character to the console; and "strlen(pointer to string)," which returns the length of the string its argument points to.

Two other functions, called by printf and independently useful additions to the standard library, are also included (see listing 1). "Nbase(number, base, pointer to array in which to store result)" converts a binary integer to a digit string of the requested number base. "Nspoct (number, string pointer)" does the same (with leading zeros, and a "." separating the 2 bytes) for the special case of split octal.■

Numerical Methods in Data Analysis

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In engineering research and design work, it is often necessary to determine analytically from a given set of n pairs of discrete data a function which best represents the dependence of one parameter (X) upon the other (Y). Moreover, other characteristics of the obtained function represent this dependence, such as information about its stationary (maximum or minimum) point and its roots, that is, values of X which make Y equal to zero.

Calling on our mathematical background, we know that most continuous functions with defined derivatives may be expressed in a form of a polynomial:

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

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

For a given set of n pairs of data, there is usually a polynomial of degree m with corresponding coefficients $a_0, a_1, \ldots, a_m$ which will approximately describe the general continuous relationship between the two parameters X and Y. The error incurred in obtaining this polynomial will usually be minimal when m is sufficiently large and useful values of Xs and Ys are in the neighborhood of the range $[(X_1, Y_1),(X_n, Y_n)]$ where $X_1 < X_2 < \ldots < X_n$.

By definition, the stationary point of a function is the point at which the dependent parameter Y attains a local maximum or minimum value. This stationary value of the variable X may be obtained by solving the equation $Y' = 0$, or:

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

The determination of function $Y = f(X)$ may be done by curve fitting, which requires solving a large set of simultaneous linear equations. The Gauss-Jordan elimination method may be utilized to solve these simultaneous equations. Once the function $f(X)$ is obtained, the values of quantity X for which $f(X)$ equals zero may be calculated by the Newton-Raphson method, which is one of the various numerical methods for obtaining the roots of a continuous differentiable function.

Because many calculations will be performed repetitively, these tasks will be conveniently handled by a digital computer utilizing its ability for high-speed calculations. A scientific high-level language, such as FORTRAN IV, is a suitable language for the development of a computer program for use in this application.

This article will briefly review the principle of curve fitting, the Gauss-Jordan elimination technique, and the Newton-Raphson method. Included is a computer program written in FORTRAN IV with corresponding flowchart and explanations. Examples of practical engineering problems in different fields are also presented.

About the Author

Toan C Nguyen is a registered professional engineer in the state of California and a member of the American Society of Mechanical Engineers. He has a master's degree in mechanical engineering from the University of Southern California.

Mr Nguyen has devoted much of his time to the application of computer programming in solving engineering problems. He is presently a senior engineer with the Pipe Hanger Division of ITT Grinnell Corporation.

Curve Fitting: Method of Least Squares

In fitting a curve through the points representing $(X_1, Y_1), \ldots, (X_n, Y_n)$, we employ a mathematical principle that yields a *best-fit curve*: the method of least squares. This method utilizes the laws of probability in obtaining the most probable values for a given set of observations of independent and dependent parameters. According to this method, the coefficients $a_0, a_1, \ldots, a_m$ of a polynomial of degree m may be determined from the following $m+1$ simultaneous equations:

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

where:

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

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

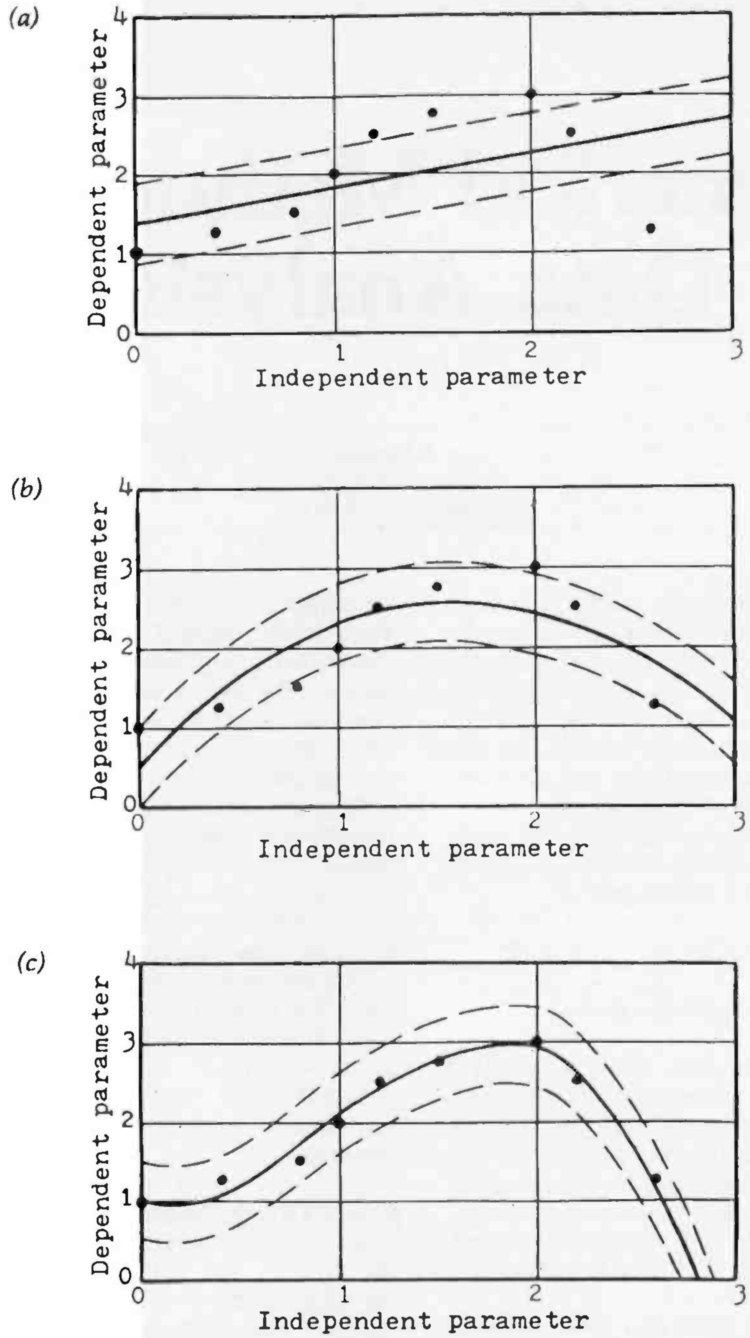


Figure 1: *A representation of the least-squares curve-fitting method. In (a) we see the first-degree curve, which is not acceptable because the uncertainty envelope does not contain all the data points. The figure in (b) shows the second-degree curve, which is not acceptable for the same reason as (a). The third-degree curve is illustrated in figure (c). Here we can observe that the uncertainty envelope does contain all the data points and is, therefore, the desired degree of the least-squares polynomial.*

and the summations $\sum^{n}$ are performed from 1 to n, the number of pairs of data.

Most engineering data is taken with an uncertainty margin. This margin may be expressed as an absolute deviation or as a relative deviation, such as 50 ± 0.5 inches and 50 inches ±1%, respectively. Therefore, when the uncertainty envelope has the most probable least-squares curve as its center line, it also has to cover all the given data points. This condition is illustrated in figure 1.

We usually start with a least-squares equation of relatively low degree and then check to see if all data points fall inside the uncertainty envelope before proceeding to the next higher degree least-squares equation. The process will continue until the uncertainty requirements are satisfied.

Gauss-Jordan Elimination Method

After all the summations of the set of simultaneous equations in equation (1) are calculated, our next step is to solve the set of simultaneous equations for $a_0, a_1, \ldots, a_m$. Although there are numerous techniques to handle this task, the method presented here is the Gauss-Jordan elimination method. The reason for using this method in-

Variable Definitions

FORTRAN Variable	Definition
A (M)	a_m, the mth coefficient of a least-squares polynomial
C (I,J)	c_{ij}, element at ith row and jth column of the augmented matrix of the set of m+1 simultaneous equations to be solved for $a_0, \ldots, a_m$
ERR	$\|f(X_n)/f'(X_n)\|$, absolute value of the nth incurring error in the determination of X for which f(X)=0 by Newton-Raphson method
ERROR	ϵ, general term for allowable error (at the beginning of the iteration process) or resulting error (at the end of the process) in the determination of $X_{Y=0}$ and X_{STA}, used in subroutine NEWRAP
ERT	$\epsilon_{Y=0}$, allowable error in the determination of $X_{Y=0}$
EROOT	Error in the determination of $X_{Y=0}$ (before calling subroutine NEWRAP: allowable error; after: resulting error)
ESTN	ϵ_{STA}, allowable error in the determination of X_{STA}
ESTATN	Error in the determination of X_{STA} (before calling subroutine NEWRAP: allowable error; after: resulting error)
I	DO loop index
ICHANG	String input specifying the name of the particular variable of which the value is to be changed
ICONTI	String input (YES or NO) to continue or to stop the process of changing values of some variables
IROOT	Code indicating whether the calculation of $X_{Y=0}$ is needed or not (0: No, 1: Yes)
ISTATN	Code indicating whether the calculation of X_{STA} is needed or not (0: No, 1: Yes)
IUNCER	Code indicating whether the uncertainty is entered as absolute or relative value (0: absolute, 1: relative)
J	DO loop index
K	DO loop index
KPLUS	K+1
LROOT	ROOT, string variable for printout purpose
LSTAT	STATN, string variable for printout purpose
M	DO loop index
MDEG	m, degree of the least-squares polynomial to be fitted through the given set of data, used as the first trial
MDEGRE	Incrementing m, starting from MDEG to a maximum of 10
MMINUS	M−1
MPLUS1	MDEGRE+1
MPLUS2	MDEGRE+2
N	DO loop index for loop which calculates root of f(X)=0
NCODE	Code used before subroutine NEWRAP is called to indicate whether the calculation will be for $X_{Y=0}$ or X_{STA} (1: for $X_{Y=0}$, 2: for X_{STA})
NEWTON	Code used in subroutine NEWRAP having the same function as NCODE; its value is transmitted from main program
NITERA	Before the iteration process: maximum allowable number of iterations, transmitted from main program; after the iteration process: actual number of iterations used to obtain the required accuracy ϵ (this new value will be returned to main program)
NMINUS	N−1
NPAIRS	Number of pairs of data
NPLUS	N+1
NRERUN	Code to direct the calculation flow to the beginning of the program (NRERUN=1) or only to the portion computing $X_{Y=0}$ and X_{STA} (NRERUN=0)
NROOT	Similar to NITERA, except that it is in main program and is used primarily for calculating $X_{Y=0}$
NSTATN	Similar to NITERA, except that it is in main program and is used primarily for calculating X_{STA}
SUM	Σs, summations representing b_i or c_{ij}
UNCERT	Uncertainty margin, may be entered as absolute or relative value
UNMARG	Uncertainty margin, calculated from the given UNCERT and IUNCER, and is converted into an absolute value
X(N)	Xs, data entered as independent parameters
X0	Before the iteration process: initial approximation of X_n, transmitted from main program; after the iteration process: obtained value of X_n which satisfies the required accuracy (this new value will be returned to main program)
XS(N)	X_n, nth value of iterated X in Newton-Raphson formula
XRT1	Similar to X0, except that it is in main program and is used primarily for calculating $X_{Y=0}$
XSTN1	Similar to X0, except that it is in main program and is used primarily for calculating X_{STA}
Y(N)	Ys, data entered as dependent parameters
YDEN	$f'(X_n)$, denominator value in Newton-Raphson formula
YNUM	$f(X_n)$, numerator value in Newton-Raphson formula
YOFX	Y(X), value of Y corresponding to a given value of X

Listing 1: *FORTRAN listing of the program CURFIT that solves the least-squares polynomial for the entered pairs of data X(n) and Y(n). Some language features used here differ from standard FORTRAN.*

```
PROGRAM CURFIT (INPUT,OUTPUT)
DIMENSION X(100),Y(100),A(11),C(11,12)
COMMON/BLOCK/A,MPLUS1,MPLUS2
*****
***** DATA STATEMENTS
*****
DATA NPAIRS,MDEG,IUNCER,UNCERT,IROOT,XRT1,ERT,ISTATN,XSTN1,ESTN/
+10,1,0.,1,1,-1.,.001,1,0.,.001
+/,X/
+-2.,-1.5,-1.,0.,1.,2.,2.5,3.,4.,5.
+/,Y/
+-25.1,-6.9,3.1,5.,-6.9,-21.,-25.,-25.1,-7.,45.
+/
*****
***** FORMAT STATEMENTS
*****
10 FORMAT (//2X,12HTHE DESIRED ,I2,47H-TH DEGREE LEAST-SQUARES EQUATION HA
+S A FORM OF ,/5X,14HY(X) = SUM OF ,I2,19H-TERMS OF A(I)*X**I,5X,12HI = 0,1
+,..., ,I2,//20X,1HI,5X,4HA(I),/19X,3H---,2X,8H--------,/)
20 FORMAT (19X,I2,3X,F8.3)
30 FORMAT (//2X,6HAFTER ,I2,35H ITERATIONS, THE OBTAINED VALUE OF ,A6,3H I
+S ,F8.3,7H GIVING,/12HAN ERROR OF ,F8.5,2X,33HIF YOU WANT TO TRY NEW VALUE
+S OF ,A6,11H AND ERROR,,/45HENTER THEM IN THAT ORDER; IF NOT, ENTER 0.,0.)
40 FORMAT (/2X,6HAFTER ,I2,35H ITERATIONS, THE OBTAINED VALUE OF ,A6,4H IS
+ ,F8.3)
50 FORMAT (//2X,*DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, E
+RT, ESTN,*,/1X,*XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)*)
60 FORMAT (/2X,*ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN IT
+S NEW VALUE*)
70 FORMAT (/2X,*ANY MORE VARIABLES TO BE CHANGED ?*)
80 FORMAT (//2X,*ALTHOUGH A *,I2,*-TH DEGREE LEAST SQUARES CURVE HAS BEEN
+FITTED THROUGH THE*,/1X,*GIVEN SET OF DATA, THE SPECIFIED UNCERTAINTY MARG
+IN IS NOT YET SATISFIED*)
90 FORMAT (2X,*THE CORRESPONDING VALUE OF Y(XSTATN) IS *,F8.3)
100 FORMAT (//2X,*THE SPECIFIED DEGREE OF THE LEAST SQUARES EQUATION IS =>
+ THE NUMBER*,/1X,*OF PAIRS OF DATA. REENTER MDEG (< NPAIRS )*)
*****
***** DEFINITIONS OF SOME VARIABLES
*****
LROOT=5HXROOT
LSTAT=6HXSTATN
110 MDEGRE=MDEG
112 EROOT=ERT
ESTATN=ESTN
115 IF (MDEGRE.LT.NPAIRS) GO TO 120
PRINT 100
READ,MDEG
GO TO 110
120 NROOT=NSTATN=20
MPLUS1=MDEGRE+1
MPLUS2=MDEGRE+2
*****
***** DETERMINATION OF ALL SUMMATIONS IN THE SET OF M+1 SIMULTANEOUS EQNS.
*****
DO 210 I=1,MPLUS1
DO 200 J=1,MPLUS2
SUM=0.
DO 220  N=1,NPAIRS
IF (J.NE.MPLUS2) SUM=SUM+X(N)**(I+J-2)
IF (J.EQ.MPLUS2) SUM=SUM+Y(N)*X(N)**(I-1)
220 CONTINUE
C(I,J)=SUM
200 CONTINUE
210 CONTINUE
*****
***** DETERMINATION OF COEF. A0,...,AM OF THE M-TH DEGREE LEAST-SQUARES
*****     POLYNOMIAL BY GAUSS-JORDAN ELIMINATION METHOD
*****
DO 330 K=1,MPLUS1
KPLUS=K+1
DO 300 J=KPLUS,MPLUS2
C(K,J)=C(K,J)/C(K,K)
300 CONTINUE
DO 320 I=1,MPLUS1
IF (I.EQ.K) GO TO 320
DO 310 J=KPLUS,MPLUS2
C(I,J)=C(I,J)-C(I,K)*C(K,J)
310 CONTINUE
320 CONTINUE
330 CONTINUE
*****
***** CHECK FOR UNCERTAINTY REQUIREMENTS
*****
DO 410 N=1,NPAIRS
YOFX=0.
DO 400 M=1,MPLUS1
A(M)=C(M,MPLUS2)
YOFX=YOFX+A(M)*X(N)**(M-1)
400 CONTINUE
IF (IUNCER.NE.1) UNMARG = UNCERT
IF (IUNCER.EQ.1) UNMARG = ABS(UNCERT*YOFX)
IF (ABS(Y(N)-YOFX).LE.UNMARG) GO TO 410
MDEGRE=MDEGRE+1
IF (MDEGRE.LT.NPAIRS.AND.MDEGRE.LE.10) GO TO 112
MDEGRE=MDEGRE-1
PRINT 80,MDEGRE
GO TO 700
410 CONTINUE
*****
***** PRINT-OUT OF COEF. A0,...,AM OF THE OBTAINED M-TH DEGREE
*****     LEAST SQUARES EQUATION
*****
PRINT 10,MDEGRE,MPLUS1,MDEGRE
DO 500 M=1,MPLUS1
MMINUS=M-1
PRINT 20,MMINUS,A(M)
500 CONTINUE
*****
***** CALCULATION OF VALUES OF XROOT OR XSTA
*****
IF (MDEGRE.EQ.1) IROOT=0
550 IF (IROOT.NE.1.AND.ISTATN.NE.1) GO TO 700
IF (IROOT.NE.1) GO TO 620
600 NCODE = 1
CALL NEWRAP (XRT1,EROOT,NROOT,NCODE)
IF (NROOT.LT.20) GO TO 610
PRINT 30,NROOT,LROOT,XRT1,EROOT,LROOT
READ,XRT1,ERT
EROOT=ERT
IF (XRT1.EQ.0..AND.EROOT.EQ.0.) GO TO 620
GO TO 600
610 PRINT 40,NROOT,LROOT,XRT1
620 IF (ISTATN.NE.1) GO TO 700
630 NCODE = 2
CALL NEWRAP (XSTN1,ESTATN,NSTATN,NCODE)
IF (NSTATN.LT.20) GO TO 640
PRINT 30,NSTATN,LSTAT,XSTN1,ESTATN,LSTAT
READ,XSTN1,ESTN
ESTATN=ESTN
IF (XSTN1.EQ.0..AND.ESTATN.EQ.0.) GO TO 700
GO TO 630
640 PRINT 40,NSTATN,LSTAT,XSTN1
YOFX=0.
DO 650 M=1,MPLUS1
YOFX=YOFX+C(M,MPLUS2)*XSTN1**(M-1)
650 CONTINUE
PRINT 90,YOFX
*****
***** CHANGING VALUES OF SOME VARIABLES
*****
700 PRINT 50
READ,ICONTI
IF (ICONTI.EQ.2HNO) GO TO 800
NRERUN=0
710 PRINT 60
READ,ICHANG
IF (ICHANG.EQ.4HMDEG) READ,MDEG
IF (ICHANG.EQ.6HUNCERT) READ,UNCERT
IF (ICHANG.EQ.3HERT) READ,ERT
IF (ICHANG.EQ.4HESTN) READ,ESTN
IF (ICHANG.EQ.4HXRT1) READ,XRT1
IF (ICHANG.EQ.5HXSTN1) READ,XSTN1
IF (ICHANG.EQ.6HIUNCER) READ,IUNCER
IF (ICHANG.EQ.5HIROOT) READ,IROOT
IF (ICHANG.EQ.6HISTATN) READ,ISTATN
NROOT=NSTATN=20
EROOT=ERT
ESTATN=ESTN
IF (ICHANG.EQ.4HMDEG.OR.ICHANG.EQ.6HUNCERT.OR.ICHANG.EQ.IUNCER) NRERUN=1
PRINT 70
READ,ICONTI
IF (ICONTI.EQ.3HYES) GO TO 710
IF (NRERUN.EQ.1) GO TO 110
GO TO 550
800 STOP
END
*****
***** CALCULATION OF ROOT OF F(X)=0., AT THE NEIGHBORHOOD OF X=X0.
*****     BY NEWTON-RAPHSON METHOD
*****
SUBROUTINE NEWRAP (X0,ERROR,NITERA,NEWTON)
DIMENSION XS(21),A(11)
COMMON/BLOCK/A,MPLUS1,MPLUS2
XS(1)=X0
IF (X0.EQ.0.) XS(1)=X0=.0001
DO 950 N=1,NITERA
NPLUS=N+1
NMINUS=N-1
910 YNUM=YDEN=0.
DO 930 I=1,MPLUS1
IF (NEWTON.EQ.2) GO TO 920
YNUM=YNUM+A(I)*XS(N)**(I-1)
YDEN=YDEN+(I-1)*A(I)*XS(N)**(I-2)
GO TO 930
920 YNUM=YNUM+(I-1)*A(I)*XS(N)**(I-2)
YDEN=YDEN+(I-1)*(I-2)*A(I)*XS(N)**(I-3)
930 CONTINUE
IF (YDEN.NE.0.) GO TO 940
XS(N)=(XS(N)+XS(NMINUS))/2.
GO TO 910
940 ERR=ABS(YNUM/YDEN)
IF (ERR.LE.ERROR) GO TO 960
XS(NPLUS)=XS(N)-YNUM/YDEN
950 CONTINUE
X0=XS(NPLUS)
GO TO 970
960 X0=XS(N)-YNUM/YDEN
970 ERROR=ERR
NITERA=N
RETURN
END
READY.
```

stead of Cramer's rule is that it proves to be a simpler and a less time-consuming procedure, especially when the system to be solved has more than three simultaneous linear equations.

This method is a combination of the Gaussian forward and backward eliminations. The forward elimination consists of the following steps:

- Elimination of a_0 from the second and succeeding equations by dividing the first equation by c_{11}; multiplying the modified equation respectively by $c_{21}, c_{31}, \ldots, c_{[m+1]1}$; and then subtracting the obtained equations respectively from the second, third, . . . , $(m+1)$th equations. The resulting set of equations is of the form:

$$\begin{array}{l} a_0 + c'_{12}a_1 + c'_{13}a_2 + \ldots + c'_{1[m+1]}\, a_m = b'_1 \\ \qquad c'_{22}a_1 + c'_{23}a_2 + \ldots + c'_{2[m+1]}\, a_m = b'_2 \\ \qquad \vdots \\ \qquad c'_{[m+1]2}a_1 + \ldots + c'_{[m+1]\,[m+1]}a_m = b'_{[m+1]} \end{array} \quad (2)$$

- Elimination of a_1 from the third and succeeding equations by dividing the second equation in the set of equations in (2) by c'_{22}; multiplying the modified equation respectively by $c'_{32}, c'_{42}, \ldots, c'_{[m+1]2}$; and then subtracting the obtained equations respectively from the third, fourth, . . . , $(m+1)$th equations.
- The elimination process continues until the system is of the form:

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

The backward substitution process may now be used to find the values for all a_i in the reverse order. The value of a_m is calculated from the last equation in equation set (3) and is substituted in the next-to-last equation to solve for a_{m-1}, etc.

In the Gauss-Jordan elimination method, the last procedure (backward substitution process) is replaced by the elimination of a_i, starting from the second step, not only from the $(i+2)$th and succeeding equations, as previously mentioned, but also from all preceding equations, (from the first to the ith equation). Thus, at the end of the process, the final set of equations is of the form:

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

As we notice, the values of $a_0, a_1, \ldots, a_m$ are obtained directly from equation set (4) as $b'_1, b''_2, \ldots, b^{\{m+1\}}_{[m+1]}$.

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

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

The roots of $Y(X)=0$ and the X-coordinates of the stationary points (referred to as X_{sta}) are determined by the following equations:

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

As long as $Y(X)$ has first and second defined derivatives and the equations $Y(X) = 0$ and $Y'(X) = 0$ are solvable, the values of $X_{Y=0}$ and X_{STA} may be calculated by using the well-known Newton-Raphson method.

This is an iteration process in which successive approximations are made in accordance with the formula

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

For rapid convergence, the initial approximation X_0 should be in the neighborhood of the desired root of the equation $f(X)$ and such that $f'(X) \neq 0$. This value of X_0 may be obtained with the aid of a rough sketch or tabulation of $f(X)$ versus X.

The iteration process continues with converging X_{n+1} until the required accuracy ϵ is obtained, that is

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

When $f(X)$ is not a monotonically increasing or decreasing function, or when there is a point of inflection in the interval $[X_1, X_2]$, the Newton-Raphson method may cause difficulties. In this case, X_{n+1} may tend to diverge or $f'(X_n)$ may happen to be very small or equal to zero, as illustrated in figure 2. A new value of X_n should be reassigned to avoid additional unnecessary iterations or to make $f'(X_n) \neq 0$. This may be accomplished by taking the average of that particular X_n and the previous value X_{n-1} (that is, $(X_n)_{new} = (X_n + X_{n-1})/2$).

Application of this method to our problem yields:

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

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

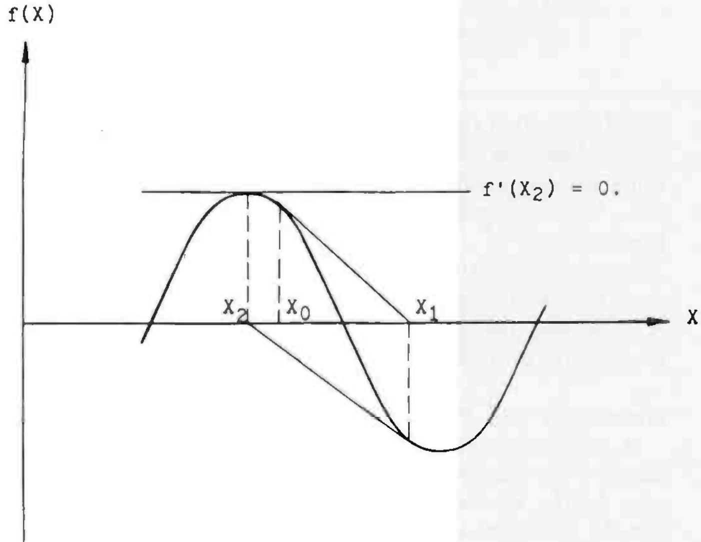


Figure 2: *An example of a function f(X) that is not monotonically increasing or decreasing. This is clearly an undesirable situation for application of the Newton-Raphson method as the successive approximations diverge rather than converge on the desired root of the equation.*

Computer Program

The program is written in an interactive manner for use with a timesharing system. To provide flexibility and ease of execution, some of the variables of the program

Listing 2: *Sample execution of the program CURFIT.*

```
00170+10,1,0,.1,1,-1.,.001,1,0.,.001
00190+-2.,-1.5,-1.,0.,1.,2.,2.5,3.,4.,5.
00210+-25.1,-6.9,3.1,5.,-6.9,-21.,-25.,-25.1,-7.,45.

RUN

PROGRAM   CURFIT


  THE DESIRED  3-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  4-TERMS OF A(I)*X**I       I = 0,1,..., 3

                    I      A(I)
                   ---   --------

                    0       5.090
                    1      -7.010
                    2      -7.028
                    3       2.005

  AFTER  4 ITERATIONS, THE OBTAINED VALUE OF XROOT  IS    -1.195

  AFTER  4 ITERATIONS, THE OBTAINED VALUE OF XSTATN IS     -.422
  THE CORRESPONDING VALUE OF Y(XSTATN) IS    6.646


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? XRT1
? 0.

  ANY MORE VARIABLES TO BE CHANGED ?
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? XSTN1
? 2.5

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  AFTER  4 ITERATIONS, THE OBTAINED VALUE OF XROOT  IS      .506

  AFTER  3 ITERATIONS, THE OBTAINED VALUE OF XSTATN IS     2.759
  THE CORRESPONDING VALUE OF Y(XSTATN) IS  -25.629


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? XRT1
? 4.

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  AFTER  3 ITERATIONS, THE OBTAINED VALUE OF XROOT  IS     4.194

  AFTER  1 ITERATIONS, THE OBTAINED VALUE OF XSTATN IS     2.759
  THE CORRESPONDING VALUE OF Y(XSTATN) IS  -25.629


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? NO
    STOP
```

Listing 3: *Application of the program CURFIT to a chemical engineering problem.*

```
00170+6,2,1,.005,0.0,.0,.0,0.,0.
00190+5.,10.,20.,30.,40.,45.
00210+18.24,18.56,19.03,19.42,19.74,19.89
RUN

PROGRAM   CURFIT


  THE DESIRED  2-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  3-TERMS OF A(I)*X**I       I = 0,1,..., 2

                    I      A(I)
                   ---   --------

                    0      17.960
                    1        .062
                    2       -.000

  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .002

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  THE DESIRED  2-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  3-TERMS OF A(I)*X**I       I = 0,1,..., 2

                    I      A(I)
                   ---   --------

                    0      17.960
                    1        .062
                    2       -.000

  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .001

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  THE DESIRED  3-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  4-TERMS OF A(I)*X**I       I = 0,1,..., 3

                    I      A(I)
                   ---   --------

                    0      17.894
                    1        .076
                    2       -.001
                    3        .000

  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? NO
    STOP
```

may be modified directly at the terminal in response to those questions printed by the program (see listing 2).

General Features

The program allows the user to:

- Enter up to 100 pairs of data.
- Enter the uncertainty margin as an absolute or relative value.
- Specify the magnitudes of the accuracy margins $\epsilon_{Y=0}$ and ϵ_{STA} required in the calculation of $X_{Y=0}$ and X_{STA}.
- Determine the least-squares polynomial and the values of $X_{Y=0}$ and X_{STA}.
- Initialize the iteration for finding the least-squares polynomial with any degree which, in the user's opinion, may be the desired one. This option eliminates unnecessary calculations resulting from the choice of the first degree as the initial trial.
- Modify information or values of variables after the completion of the first run. These variables include the lowest desired degree of the least-squares polynomial *m*, the uncertainty margin, the initially guessed values of $X_{Y=0}$ and of the abscissa of the stationary point X_{STA} (this is helpful when the least-squares function in question has more than one value of $X_{Y=0}$ or X_{STA} in the range under consideration), and desired accuracy margins $\epsilon_{Y=0}$ and ϵ_{STA}. (This option may be repeated as many times as the user wishes.)
- Monitor when the Newton-Raphson iteration process does not converge or does not give the required values of $X_{Y=0}$ or X_{STA} the desired accuracy so that a new value of $\epsilon_{Y=0}$ or ϵ_{STA} may be entered.

Flowchart and Program Listing

A detailed flowchart and the complete program listing are given in figure 3 and listing 1 respectively. The structure of the flowchart is relatively straightforward and should be reviewed along with those definitions or explanations given in the variable-definition text box on page 437.

- Input: the input data is arranged in three groups of DATA statements in the program listing. The first group contains the values for NPAIRS, MDEG, IUNCER, UNCERT, IROOT, XRT1, ERT, ISTATN, XSTN1, and

Figure 3: *Detailed flowchart of the program CURFIT.*

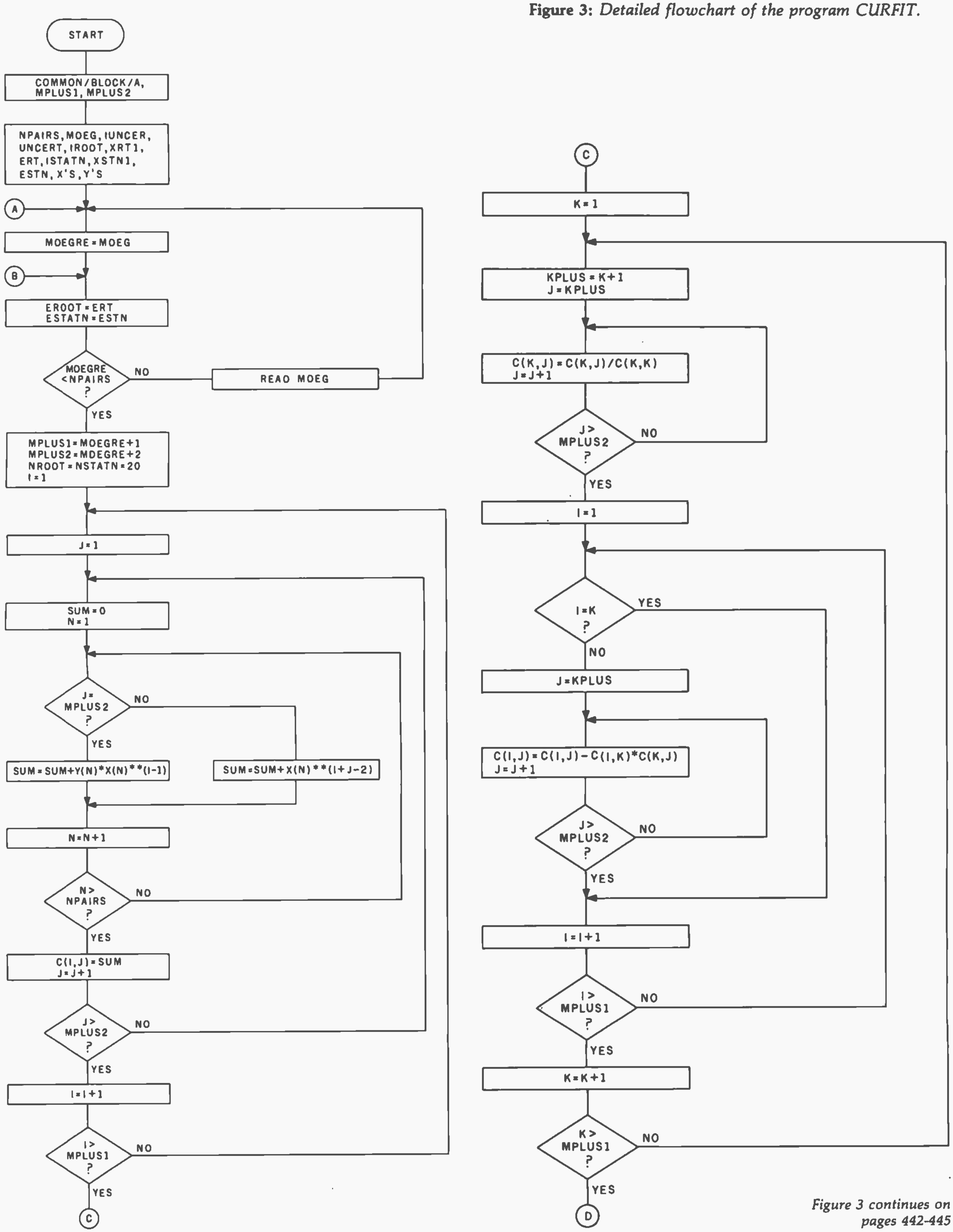


Figure 3 continues on pages 442-445

ESTN. The second group contains the n values for the independent points X_n, or X (NPAIRS). The third group contains the n values for the dependent points Y_n, or Y(NPAIRS). These statements are modified to accommodate different data.

- Output: the results consist of the degree of the sought-for least-squares polynomial and a set of calculated values, which are printed in two columns, representing the ith subscript and corresponding a_i in the representation $Y(X)=\sum_{0}^{m} a_i \times X^i$.

Sample Run

Assuming that the following set of 10 pairs of data is given:

i	1	2	3	4	5	6	7	8	9	10
X(i)	-2.0	-1.5	-1.0	0.0	1.0	2.0	2.5	3.0	4.0	5.0
Y(i)	-25.1	-6.9	3.1	5.0	-6.9	-21.0	-25.0	-25.1	-7.0	45.0

Figure 3 continued:

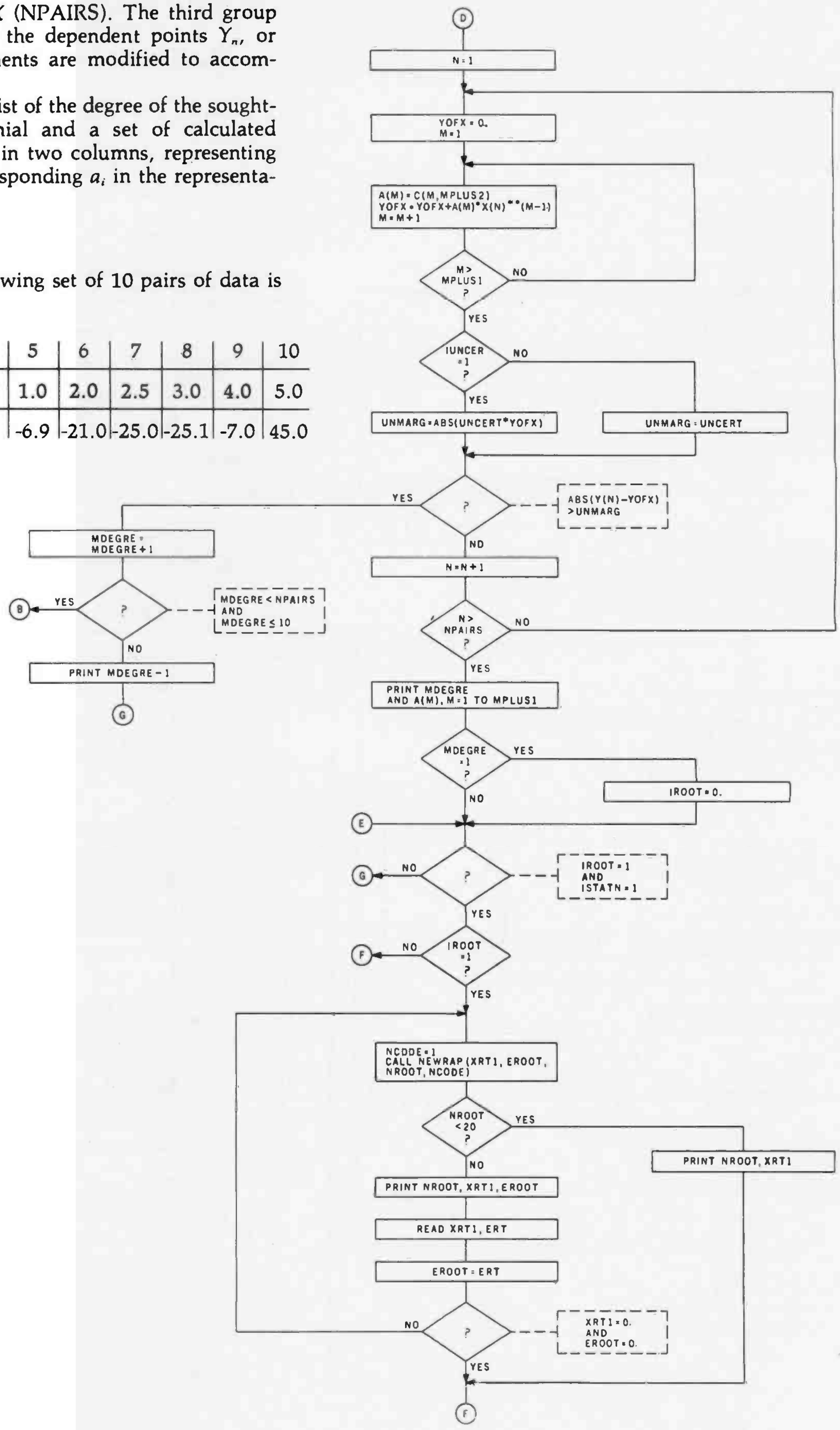


Figure 3 continued:

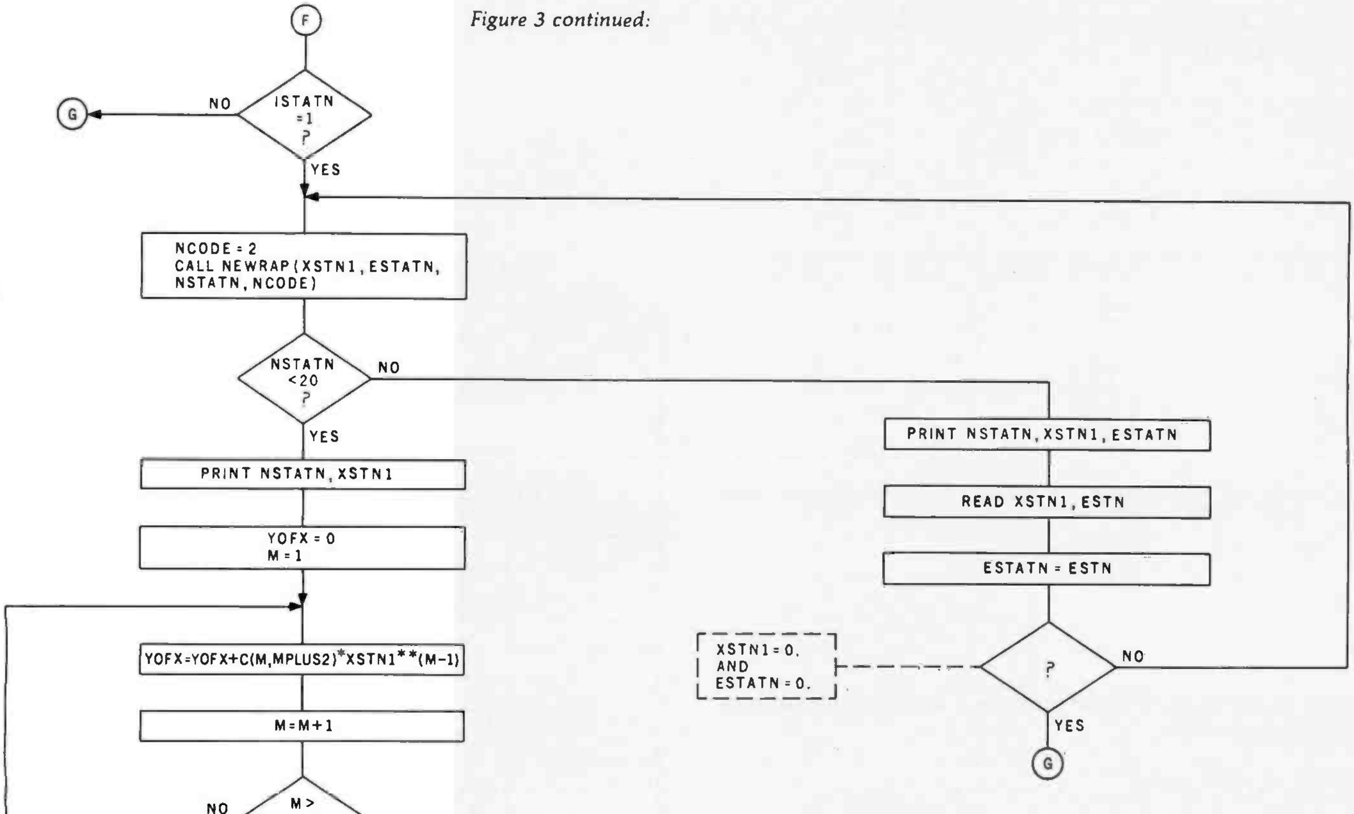
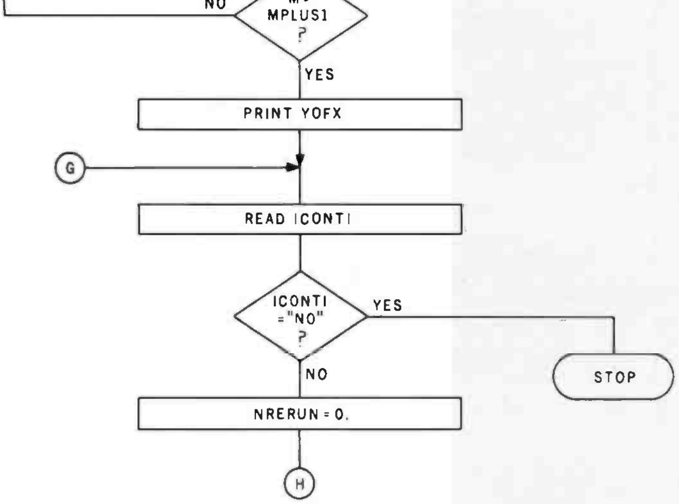



Figure 3 continued on page 444

We are going to use the program CURFIT to determine the continuous relationship between quantities X and Y as well as all values of $X_{Y=0}$ and X_{STA}. A quick look at the foregoing tabulation reveals that, in the specified range of Xs (-2.0 to 5.0), there are:

- three distinct values of $X_{Y=0}$ between $[X(2),X(3)]$, $[X(4),X(5)]$, and $[X(9),X(10)]$ due to the change in signs of corresponding pairs of $Y(i)$s
- two stationary points of which the maximum one is in the neighborhood of pair number 4 and the minimum near pair number 8.

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

Application to Some Engineering Problems

The applications of the program CURFIT to engineering problems are innumerable. Here are a few simple examples of these applications:

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

Gravity, °API	5.0	10.0	20.0	30.0	40.0	45.0
H_c, 1000 BTU/lb	18.24	18.56	19.03	19.42	19.74	19.89

a second-degree function representing H_c versus °API with an uncertainty of less than 0.5% (UNCERT=0.005) for the given range of degrees API (5 to 45).

As illustrated in listing 3, the required function may be obtained with an uncertainty (to third decimal place) of 0.2% as follows:

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

To obtain an uncertainty of 0.1%, a third-degree function will be required, as shown in the last portion of the listing.

- Civil Engineering: in an experiment determining the compressive stress-strain diagram of a concrete mix of cement, sand, and gravel (mix proportion by volume is 1, 2, and 4, respectively), the following data is observed (a kip is a 1000-pound load):

unit strain ϵ (10^{-3} inch/inch)	0.1	0.2	0.3	0.5	0.6	0.8	1.0
unit stress σ (kips /inch²)	0.44	0.82	1.21	1.78	2.08	2.54	2.83

Listing 4: *Application of the program CURFIT to a civil engineering problem.*

```
00170+7,2,0,.02,0,0.,0.,0,0.,0.
00190+.1,.2,.3,.5,.6,.8,1.
00210+.44,.82,1.21,1.78,2.08,2.54,2.83
RUN

PROGRAM   CURFIT


  THE DESIRED  6-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  7-TERMS OF A(I)*X**I      I = 0,1,...., 6

                         I       A(I)
                        ---    --------

                         0         .641
                         1       -8.762
                         2       95.608
                         3     -333.314
                         4      573.012
                         5     -477.630
                         6      153.274


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? NO
    STOP
```

Listing 5: *Application of the program CURFIT to an electrical engineering problem.*

```
00170+5,1,1,.001,0,0.,0.,0,0.,0.
00190+50.,55.,60.,70.,75.
00210+239.2,243.1,247.,254.9,258.8
RUN

PROGRAM   CURFIT


  THE DESIRED  1-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  2-TERMS OF A(I)*X**I      I = 0,1,...., 1

                         I       A(I)
                        ---    --------

                         0      199.937
                         1         .785


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .0005

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  THE DESIRED  1-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  2-TERMS OF A(I)*X**I      I = 0,1,...., 1

                         I       A(I)
                        ---    --------

                         0      199.937
                         1         .785


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .0001

  ANY MORE VARIABLES TO BE CHANGED ?
? NO

  THE DESIRED  3-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  4-TERMS OF A(I)*X**I      I = 0,1,...., 3

                         I       A(I)
                        ---    --------

                         0      207.832
                         1         .405
                         2         .006
                         3        -.000


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? NO
    STOP
```

Figure 3 continued:

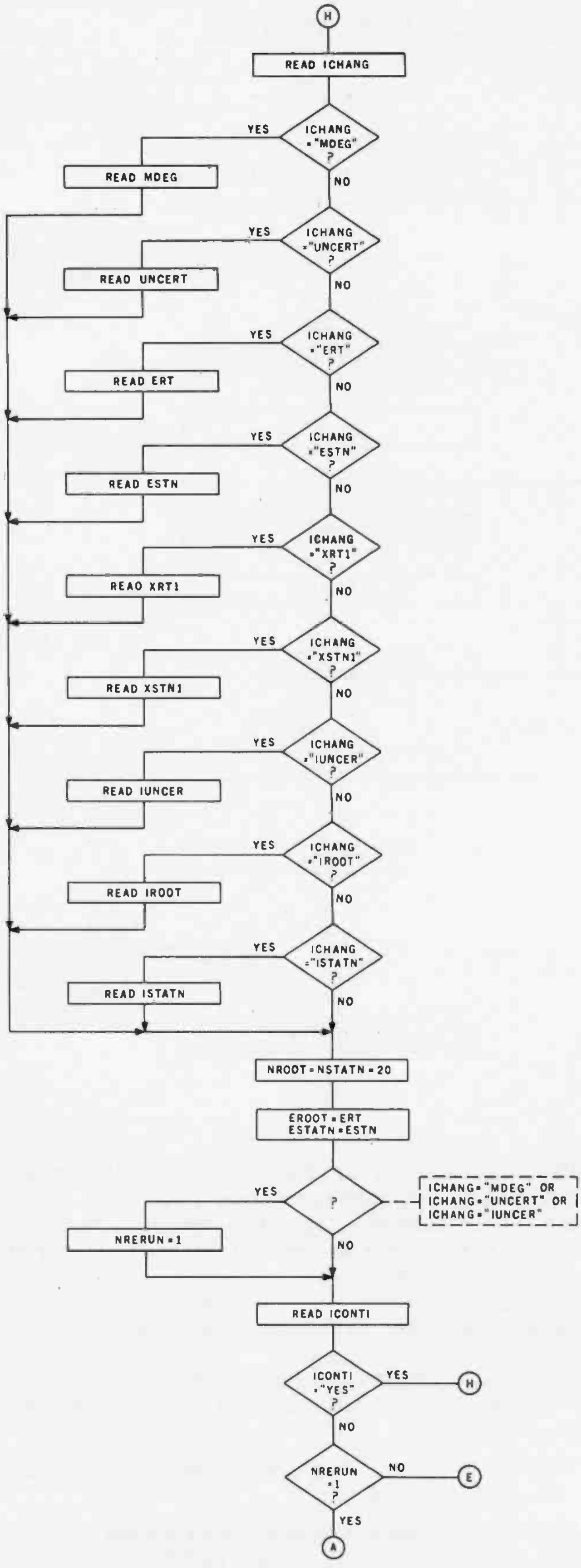
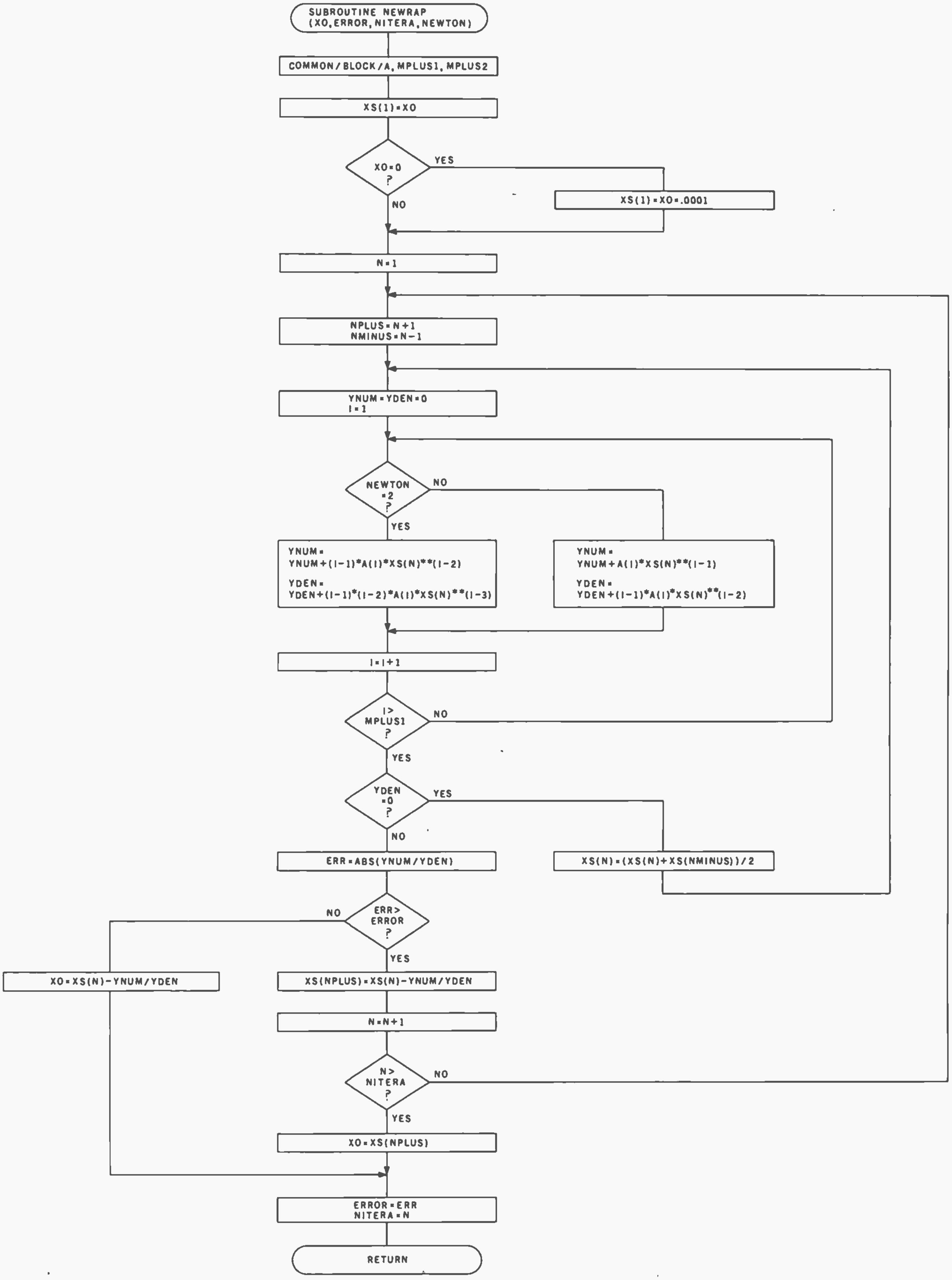


Figure 3 continued:



Deflection (inches)	10.8	21.6	27.0	37.8	48.6	64.8	81.0	86.4	97.2	108.0
Load (pounds)	74.0	117.0	132.0	145.0	150.0	152.0	168.0	183.0	226.0	300.0

Table 1: *Data collected when determining the load/deflection characteristics of a bevel spring, supported and loaded at the edges. The program execution in listing 6 will generate the best-fit curve for all points.*

For a required absolute uncertainty of ±0.02 kips/inch², from listing 4 we know that a sixth-degree polynomial representing σ versus ϵ is obtained as follows:

$$\sigma = 0.641 - 8.762\epsilon + 95.608\epsilon^2 - 333.314\epsilon^3 + 573.012\epsilon^4 - 477.63\epsilon^5 + 153.274\epsilon^6$$

Listing 6: *Application of the program CURFIT to a mechanical engineering problem.*

```
00170+10,2,1,.03,0,0.,0.,0,0.,0.
00190+10.8,21.6,27.,37.8.48.6,64.8,81.,86.4,97.2,108.
00210+74.,117.,132..145.,150.,152.,168..183.,226.,300.
RUN


PROGRAM    CURFIT


  THE DESIRED  3-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  4-TERMS OF A(I)*X**I       I = 0,1,..., 3

                       I     A(I)
                      ---   --------

                       0      1.164
                       1      8.261
                       2      -.153
                       3       .001


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .01

  ANY MORE VARIABLES TO BE CHANGED ?
? NO


  THE DESIRED  3-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  4-TERMS OF A(I)*X**I       I = 0,1,..., 3

                       I     A(I)
                      ---   --------

                       0      1.164
                       1      8.261
                       2      -.153
                       3       .001


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? YES

  ENTER THE VARIABLE TO BE CHANGED (HIT RETURN), AND THEN ITS NEW VALUE
? UNCERT
? .005

  ANY MORE VARIABLES TO BE CHANGED ?
? NO


  THE DESIRED  8-TH DEGREE LEAST-SQUARES EQUATION HAS A FORM OF
     Y(X) = SUM OF  9-TERMS OF A(I)*X**I       I = 0,1,..., 8

                       I     A(I)
                      ---   --------

                       0    178.423
                       1    -32.937
                       2      3.555
                       3      -.172
                       4       .005
                       5      -.000
                       6       .000
                       7      -.000
                       8       .000


  DO YOU WANT TO CHANGE ANY VARIABLES AMONG MDEG, UNCERT, ERT, ESTN,
 XRT1, XSTN1, IUNCER, IROOT, ISTATN ? (YES OR NO)
? NO
   STOP
```

• Electrical Engineering: in an electrical testing laboratory, a technician obtains the following set of data for the determination of resistance R_o at 0°C and temperature coefficient of resistance α of a conductor.

T, °C	50.0	55.0	60.0	70.0	75.0
R_T, ohms	239.2	243.1	247.0	254.9	258.8

Listing 5 gives the following results:

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

This value of α indicates that the conductor is made of platinum.

• Mechanical Engineering: the data observed in the determination of the load/deflection characteristics of a bevel spring, supported and loaded at its edges, is illustrated in table 1.

As shown in listing 6, for an uncertainty of 1%, a third-degree polynomial is determined as follows, where D is the deflection:

$$\text{Load} = 1.164 + 8.261(D) - 0.153(D)^2 + 0.001(D)^3$$

An eighth-degree polynomial will be required for an uncertainty of 0.5%.■

Glossary

Gauss-Jordan elimination: *This mathematical algorithm is a means of solving a system of simultaneous equations. It proves to be most effective when the system to be solved has more than three simultaneous linear equations. The procedure itself involves the simplification of a matrix formed from the coefficients of the system of simultaneous equations. This method is also referred to as the Gaussian reduction method.*

Newton-Raphson method: *A mathematical technique which employs an iteration process in which successive approximations are made to determine the roots of a polynomial equation. These successive approximations are calculated from the following formula:*

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

Cramer's Rule: *An approach to solving a system of simultaneous equations involving the use of determinants. This method is most desirable when dealing with a small system of equations.*

Event Queue

May 1981

May-June
Data-Processing Courses, the Hartford Graduate Center, Hartford CT. For information on these courses, contact the Hartford Graduate Center, Attn: Don Florek, 275 Windsor St, Hartford CT 06120, (203) 549-3600, ext 252.

May-June
Workshops from the National Institute for Management Research, various cities throughout the US. 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 cites throughout the US. Courses on computer network design and protocols, multiple micro- and minicomputer systems, and fiber-optics communications systems are to be held. The fees for these 3- to 4-day courses range from $695 to $795. Contact Integrated Computer Systems Inc, 3304 Pico Blvd, POB 5339, Santa Monica CA 90405, (213) 450-2060.

May-July
Courses from Zilog, various cities throughout the US. An introduction to microprocessors; the Z80, Z8, and Z8000 family of components; PLZ/SYS programming; development systems; and other topics concerning Zilog products are covered in these courses. Fees range from $150 to $595. For a schedule of times and places, contact Zilog, 10340 Bubb Rd, Cupertino CA 95014, (408) 446-4666, ext 5586.

May 1-2
The Third Annual Computers in Education Conference, Seattle Pacific University, Seattle WA. This conference will feature panel discussions, workshops, and exhibits. Special emphasis will be placed on the use of microcomputers in elementary and high schools. Contact Jerry Johnson, Seattle Pacific University, Seattle WA 98119.

May 4-7
National Computer Conference, McCormick Pl, Chicago IL. Approximately 90,000 people are expected to attend this year's National Computer Conference (NCC). The use of robots and artificial intelligence will be among the program sessions at the Personal Computing Festival during the NCC. This will be the first time that personal-computing exhibits

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc, notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, 70 Main St, Peterborough NH 03458. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

have joined the rest of the conference in the main exhibit area. Over thirty technical sessions will be held. All major companies will be represented. Contact the American Federation of Information Processing Societies Inc, POB 9658, 1815 N Lynn St, Arlington VA 22209, (703) 558-3617.

May 5-8

INTELCOM 81/Paris, Paris, France. INTELCOM (International Telecommunications and Computer Conference and Exhibition) 81/Paris is part of a program to promote an international dialog on vital subjects in the telecommunications field. This conference attempts to guide the evolution of the computer and its technology by combining the efforts of private companies, government, and equipment users.

For information about attending, presenting a paper, or exhibiting at INTELCOM 81/Paris, contact the Conference Affairs Group, Horizon House, 610 Washington St, Dedham MA 02026, (800) 225-9977; in Massachusetts (617) 326-8220.

May 7-8

The Eighth Annual Computer Show, Valley Plaza Midland, Midland MI. This show is being sponsored by the Saginaw Valley Chapter of the Data Processing Management Association. It will feature data processing software and hardware, computer peripherals and equipment, forms, supplies, graphics equipment, and educational services. Contact Don Seidel, DPMA, Saginaw Valley Chapter, University Center MI 48710, (517) 790-4220.

May 11-13

Custom Integrated Circuits Conference, CICC'81, Americana Hotel, Rochester NY. The CICC aims to bring together designers, producers, and users of custom integrated circuits to discuss recent developments and future directions in the field. Papers will be read on applications, algorithm-implementing integrated circuits, fabrication techniques, interfaces and interconnects, computer-aided design, and testing and qualification. Contact Dr Rajinder Khosla, General Chairman, Research Laboratories, B-81, Eastman Kodak Company, Rochester NY 14650, (716) 722-2525.

May 11-13

Fourth Annual Rosen Research Personal-Computer Forum, Playboy Resort, Lake Geneva WI. This forum features guest speakers from all the major personal-computer hardware and software companies. The Rosen Forum is one of the most prestigious and important seminars in the industry. The registration fee for this 3-day session is $295. For further details, contact Rosen Research Inc, 200 Park Ave, New York NY 10166, (212) 586-3530.

May 11-13

The Thirty-First Electronic Components Conference, Colony Square Hotel, Atlanta GA. Papers will be read on semiconductor-processing technology, optoelectronic devices, manufacturing technology, materials, hybrid microcircuits, discrete components, interconnections, reliability, and connectors. Contact T G Grau, Bell Laboratories, Whippany Rd, Rm 3B-312, Whippany NJ 07981; or Electronic Industries Association, 2001 Eye St NW, Washington DC 20006.

May 14-16

The Tenth ASIS Mid-Year Meeting, Fort Lewis College, Durango CO. The American Society for Information Science's (ASIS's) theme for this year's meeting is "Using Information." Among the topics to be addressed are user studies, decision making, organizational change, government, education, management, access to information, and designing information systems for use. For information, contact ASIS, 1010 16th St NW, Washington DC 20036, (202) 659-3644.

May 16

Introduction to Pascal, Princeton NJ. The Princeton, New Jersey, chapter of the ACM (Association for Computing Machinery) is sponsoring this seminar. Contact Ronald Orcutt, EDUCOM, POB 364, Princeton NJ 08540; or Bill Hafstad, (201) 457-4055.

May 17-20

Expo '81, Loew's Anatole Hotel, Dallas TX. Expo '81 is a combination of exhibits and technical sessions. The exhibits cover everything from graphics systems to industrial computer-control systems. The technical sessions range from tool design, design engineering, and robotics to numerical control. For more information, contact Numerical Control Society, 519 Zenith Dr, Glenview IL 60025, (312) 297-5010.

May 20-22

Joint Conference on Easier and More Productive Use of Computing Systems, University of Michigan, Ann Arbor MI. This conference intends to combine the insights of the social sciences, humanities, computer science, and human-factors engineering. Contact Gregory A Marks, 4258 Institute for Social Research, University of Michigan, Ann Arbor MI 48106, (313) 763-3482.

May 20-22

Videotex '81, Royal York Hotel, Toronto, Ontario, Canada. Videotext information systems allow users to call up information, make reservations, pay bills, exchange electronic mail, read an electronic newspaper, shop, and play video games. This conference will review videotext developments in Europe, Japan, and North and South America. Demonstrations of videotext systems will be given. Seminars on standards, legal aspects, and economic issues will be featured. Contact Videotex '81, 316 Lonsdale Rd, Suite 3, Toronto, Ontario, M4V 1X4, Canada, (416) 598-1981.

May 21-23
Annual Conference of the Educational Computing Organization of Ontario, Sheraton Centre and the Ontario Institute for Studies in Education, Toronto, Ontario, Canada. Exhibits on the use of computers in schools and discussions on how to locate suitable educational materials will be featured. Contact the Conference Office, OISE, 252 Bloor St W, Toronto, Ontario, M5S 1V6, Canada.

May 22-24
National TRS-80 Microcomputer Show, Statler Exposition Center, New York NY. Exhibits from over 100 manufacturers, distributors, and retailers of equipment for the TRS-80 Models I, II, and III, and Color and Pocket computers, will be featured. Seminars and talks will be held at the show. Contact Kengore Corporation, 3001 Rt 27, Franklin Park NJ 08823, (201) 297-6918.

May 26-29
Office Korea 81, Korea Exhibition Center, Seoul, South Korea. Exhibitors will come from the United States, Japan, the United Kingdom, and South Korea. Computers, copiers, facsimile systems, and office equipment and supplies will be presented. Further information may be obtained from Clapp & Poliak International, 7315 Wisconsin Ave, Washington DC 20014, (301) 657-3090.

May 30
Amateur Fair, Minnesota State Fairgrounds, St Paul MN. Exhibits, prizes, and booths are featured at this swapfest for computer hobbyists. Contact the Amateur Fair, POB 30054, St Paul MN 55175.

June 1981

June 6-9
Atlanta Small Computer Show, Atlanta Hilton, Atlanta GA. Producers of small computers, peripherals, supplies, and services will be exhibiting at this show. Business owners, corporate and government executives, data-processing managers, doctors, lawyers, and other professionals are expected to attend. Obtain additional information from The Atlanta Small Computer Show, 4060 Janice Dr, Suite C-1, East Point GA 30344, (404) 767-9798.

June 9-11
Understanding and Using Computer Graphics, Chicago IL. This seminar covers the latest in graphic-system technology, including hardware, software, and applications. Contact Bob Sanzo, Frost & Sullivan Inc, 106 Fulton St, New York NY 10038, (212) 233-1080.

June 14-18
The Second National Conference of the National Computer Graphics Association, Baltimore Convention Center, Baltimore MD. Computer-graphics demonstrations, exhibits, and workshops will be held. Contact the National Computer Graphics Association Inc, 2033 M Street NW, Suite 330, Washington DC 20036, (202) 466-5895.

June 16-18
NEPCON East '81, New York Coliseum, New York NY. This exposition is aimed at

engineers, prototype developers, production specialists, and testing personnel. Technical programs will be presented. Contact Industrial & Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606, (312) 263-4866.

June 17-19
National Educational Computing Conference, North Texas State University, Denton TX. This conference will provide a forum for individuals and institutions interested in educational computing. Computer literacy, computer education for teachers, and computers in education are some of the topics to be covered. Contact Dr Jim Poirot, NECC-81 General Chairman, Computer Sciences Department, North Texas State University, Denton TX 76203.

May 29-31
The Sixth Annual Computerfest, Franklin University, Columbus OH. Talks on robots and calculators will be featured. Microcomputers and small-business systems will be presented. This show is being sponsored by the Midwest Affiliation of Computer Clubs and Franklin University. Contact Computerfest '81, Paul Pittenger, 215 Delhi Ave, Apt J, Columbus OH 43202, (614) 224-6237.

June 23-25
Comdex/Spring, Madison Square Garden and the New York Statler Hotel, New York NY. Computer and computer-related manufacturers, systems houses, computer retailers, dealers, distributors, manufacturers' representatives, commercial OEMs (original equipment manufacturers), and other related businesses will be exhibiting. Contact The Interface Group, 160 Speen St, Framingham MA 01701, (800) 225-4620; in Massachusetts, (617) 879-4502.

June 29-July 1
The Nineteenth Annual Meeting of the Association for Computational Linguistics, Stanford University, Stanford CA. Syntax, parsing, and sentence generation, computational semantics, discourse analysis and speech acts, speech analysis and synthesis, machine and machine-aided translation, and mathematical foundations of computational linguistics are some of the topics that will be discussed. Contact Don Walker, Artificial Intelligence Center, SRI International, Menlo Park CA 94025, (415) 326-6200, ext 3071.

July 1981

July 29-31
The 1981 Microcomputer Show, Wembley Conference Centre, London, England. Seminars on microcomputer applications in business, production, and education will be presented. Topics for conference sessions include hardware availability, software packages and development, automatic test equipment, robotics, and process control. Exhibits from major European and American manufacturers will be featured. Contact TMAC, 680 Beach St, Suite 428, San Francisco CA 94109, (800) 227-3477; in California, (415) 474-3000. ■

Technical Forum

Build a Noise-Based Random Number Generator

Terry Mayhugh, 11632 Midhurst Dr, Concord TN 37922

At some time, nearly every programmer finds it necessary to generate random numbers. If a card dealer is being simulated, or a Klingon scanner display is being created, the RND function available in most versions of BASIC may be adequate. However, the pseudorandom sequence generated by RND can bomb in critical applications where a truly random number sequence is needed. Truly random numbers are extremely difficult to generate, especially within a nonrandom machine such as a computer.

The best that can be accomplished purely by software is the generation of finite-length sequences that appear to be random. However, the actual members may be related to specific calculations recently completed by the computer. Such complications will contaminate the results of signal-recovery simulations or digital-filter problems. Even a computer card game may be biased by a previous bet. Ideally, the actual random number generation should be done outside the computer.

Figure 1 is a block diagram of a simple generator capable of producing *truly random* sequences of any length. A free-running oscillator, running asynchronous

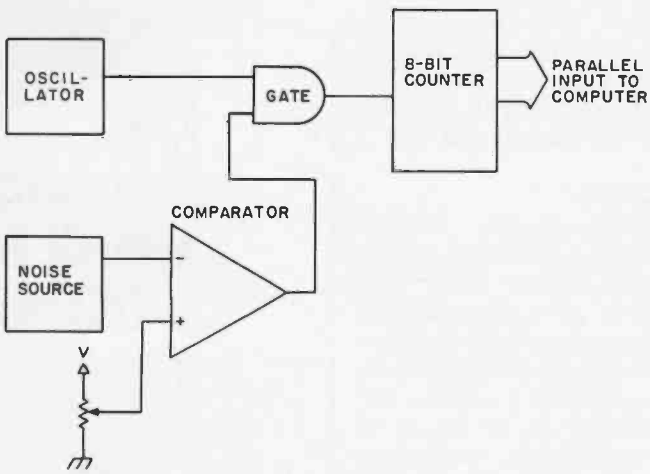


Figure 1: *Block diagram of a generator that produces true random numbers. Through pulses created by the random-noise source, the free-running oscillator is gated to the 8-bit binary counter. Since the instantaneous amplitude of the voltage from the noise source is unpredictable, the width and arrival of the gate pulse generated by the comparator are also random. Therefore, the 8 bits available from the counter are truly random.*

to the microprocessor clock in the computer is gated to an 8-bit binary counter through pulses created by a random-noise source. Since the instantaneous amplitude of the voltage from the noise source is not predictable, the width and the time of arrival of the gate pulse generated by the comparator are unpredictable. The sequence of numbers available from the counter is truly random (if you do not try to sample them at an excessively high rate). For the component values shown in figure 2, there should be no problem in any microprocessor application.

The numbers generated by this technique are uniformly distributed; any number in the set of all possible numbers (0 thru 255) has the same probability of occurring. The mean or expected value of the distribution lies at the center of the set of all possible numbers.

Circuit Description

The noise of zener diode D1 is amplified by IC4 and IC5, which are configured as high-gain wideband amplifiers. The amplified noise from IC5 is compared with the DC wiper voltage of R18 at the input of comparator IC6. A logic level is generated at the comparator output and is used to gate on and off a TTL (transistor-transistor logic) oscillator (IC2), which runs free at about 3 MHz. A cascaded dual 4-bit binary counter (IC3) is clocked by this oscillator.

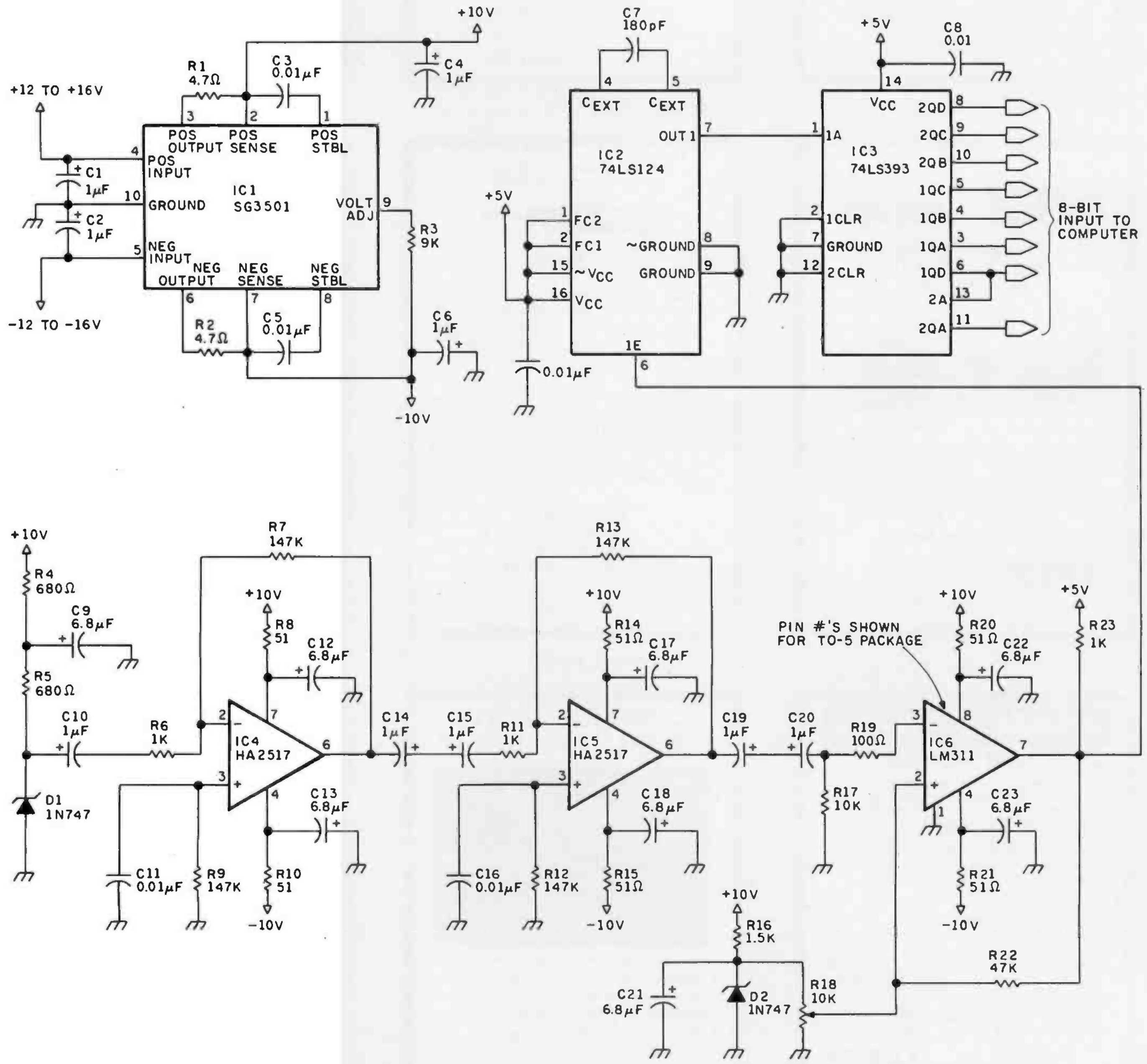


Figure 2: *Schematic diagram of the random number generator described in this article. The noise of D1 is amplified by IC4 and IC5. The amplified noise from IC5 is compared with the DC wiper voltage of R18 at the comparator input of IC6. The level generated at the comparator input gates IC2 (running at about 3 MHz). The oscillator is clocked by IC3 (a cascaded 4-bit binary counter). The circuit should be shielded. Pin numbers shown for IC1 (Silicon General 3501) are those for a TO-5 package.*

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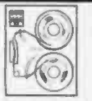

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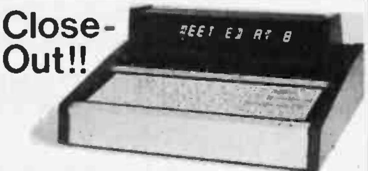

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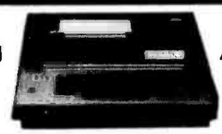

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Parts List

IC1 Silicon General SG3501 dual regulator
IC2 74LS124 oscillator
IC3 74LS393 dual 4-bit counter
IC4, IC5 Harris HA2517 op-amp
IC6 LM311 comparator

R1, R2 4.7 ohm 1/4 W 5% CC (carbon composition)
R4, R5 680 ohm 1/4 W 5% CC
R8,R10,R14,R15,R20,R21 51 ohm 1/4 W 5% CC
R17 10 k-ohm 1/4 W 5% CC
R19 100 ohm 1/4 W 5% CC
R22 47 k-ohm 1/4 W 5% CC
R23 1 k-ohm 1/4 W 5% CC
R16 1.5 k-ohm 1/4 W 5% CC
R3 9.00 k-ohm 1/8 W 1% mF
R6, R11 1.00 k-ohm 1/8 W 1% mF
R7,R9,R12,R13 147 k-ohm 1/8 W mF
R18 10 k-ohm miniature 10-turn potentiometer

C1,C2,C4,C6,C10,C14,C15,C19,C20 1 μF 25 V tantalum
C9,C12,C13,C17,C18,C21,C22,C23 6.8 μF 25 V tantalum
C3,C5,C8,C11,C16 0.01 μF disc ceramic
C7 180 pF disc ceramic
D1, D2 IN747 zener diode

Table 1: *Parts list for the circuit shown in figure 2.*

A great deal of power-supply decoupling and isolation is used in the analog section of the generator. This is necessary to avoid picking up the 60 Hz power signal or any other periodic power-supply noise that could destroy the randomness of this circuit.

The circuit should be constructed within a shielded enclosure to avoid RF (radio frequency) or other interference that could cause a periodic output from IC6. The ±12 V supply in my SwTPC 6800/2 (actually ±14 V) has an unacceptable amount of 60 Hz ripple for this application, so a dual IC regulator (IC1) regulates this voltage to a clean ±10 V for the analog electronics.

Alignment of the generator is relatively simple if an oscilloscope is available. R18 is adjusted while viewing the waveform at pin 7 of IC2. This potentiometer should be adjusted until the waveform at pin 7 spends an equal amount of time in its high and low status. That is, the brightness of the scope trace should be adjusted for uniform brightness at its top and bottom edges. If no scope is available, set the potentiometer for 50 to 100 mV at the wiper.

The eight counter bits may be connected in any order to the eight lines of the parallel port of the computer. In my particular application the port is read with a load-accumulator instruction when a number is needed. No strobe or handshaking is used.

A Gaussian, or normal, distribution can also be created using this uniform generator. Using what statisticians call the Central Limit Theorem, a normal distribution can be created by averaging several random numbers of any other type distribution. I have found that a convenient and sufficient number of samples in most cases is 64. Averaging multiples of 2 maintains maximum speed because the division in the averaging process can be done with simple accumulator shifts. Of course, speed is sacrificed with this method because only one normally distributed number is created for every 64 uniform numbers generated. ■

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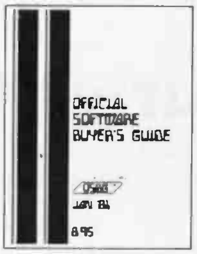

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Fast Fourier Comes Back

Alastair Roxburgh, 50 Maitland St, Dunedin, New Zealand

The program "Fast Fourier for the M6800," by Richard H Lord (February 1979 BYTE, page 108), contains an overflow bug that I discovered while testing a version of the program written for the 8080 processor. (See listing 1.) After the exact nature of the fault was ascertained, a theoretical explanation for it was easy to find. The problem concerns the maximum two's-complement value allowed before scaling commences. The 6800 program requires that any data point outside the range of $-64 <$ data < 64 be scaled down before the next pass. Scaling divides all data values by 2. However, during passes 2 thru 8 it is quite possible for the results of arithmetic operations to exceed the 8-bit two's-complement-number range of $-128 \leq$ data < 127. The reason for this can be seen by referring to lines 205 and 215 in the original program. These lines yield:

$$RM' = RM + RN*COS(X) + IN*SIN(X)$$

Letting RM=RN=IN=M, the maximum data value, then:

$$RM' = M*(1 + COS(X) + SIN(X)).$$

The maximum value of RM' is then M times the maximum value of 1 + COS(X) + SIN(X). This maximum value occurs at an angle of 45°, given by TAN(X) = 1.

Thus, the maximum value of RM' is $M(1 + \sqrt{2})$ or approximately (2.414)M. Letting RM' = 127 (the maximum positive 8-bit two's-complement-data value), then $M = INT(127/(1 + \sqrt{2})) = 52$.

Thus, the data should be scaled before *each* pass if any point exceeds the range $-52 \leq$ data ≤ 52. It makes little difference to the spectra whether the relational operators here are greater-than-or-equal or merely just greater-than. The 6800 program should be amended accordingly:

```
00268     CMP A        # $CC     (-52)
00270     CMP A        # $34      (52)
```

The test program that uncovered the overflow error used program-generated square waves with a period of six data points (equivalent to 10.667 Hz using a sampling rate of 64 Hz). Every amplitude from 128 ± 127 down to 128 ± 1 was tested and the power spectra, as well as SCLFCT, were printed out (requiring approximately three hours at 110 bits per second).

Each transform in the 8080 program takes 3.6 seconds to compute with a 2 MHz processor clock. The power calculation is fast, because a lookup table is used.

When FFTs (fast Fourier transforms) are computed on a minicomputer that has sophisticated error-trapping hardware, the usual practice is not to perform any prescaling, but instead to allow arithmetic overflow to occur, do a software interrupt to a scaling routine, and return. This way, fewer scalings of all the data are required, yielding results with the maximum possible numerical precision. The 6800 can detect two's-complement overflows and can efficiently perform (two's complement) arithmetic shifts to scale the data, but it does not have an automatic overflow trap. The advantage of slightly better numerical results would be outweighed by the time required to call an overflow-checking subroutine after most arithmetic operations. The 8080 is even worse off; it has neither a two's-complement-overflow indicator nor a single-instruction equivalent of the 6800's ASR.

Text continued on page 460

Listing 1: *The 8080 version of the fast Fourier transform program originally written for the 6800 processor by Richard Lord. In this version, Mr Roxburgh has corrected an overflow problem that he discovered and diagnosed in the original version.*

```
0000            ;; F A S T   F O U R I E R   T R A N S F O R M.
0000            ;; = = = =   = = = = = = =   = = = = = = = = =
0000            ;;ORIGINAL:- M6800 FFT BYTE FEB 1979.
0000            ;;8080 VERSION BY:- ALASTAIR ROXBURGH.
0000            ;;DATE:- 4 OCT 1979.
0000            ;;256 POINT IN-PLACE COMPLEX FOURIER TRANSFORM.
0000            ;;INPUT DATA UNSIGNED WITH ZERO = 80H.
0000            ;;COMPLEX OUTPUT SIGNED (2'S COMP.).
0000            ;;REAL OUTPUT (POWER OR AMPLITUDE) UNSIGNED.
0000            ;;
0000            ;
0000            SCADR EQU  9F00H   ;2'S COMP. SCU. TABLE.
0000            STADR EQU  9F00H   ;2'S COMP. SINE TABLE.
0000            ;
0000                  ORG  8300H
8300            RLPT1  DS  2       ;REAL PTR 1.
8302            RLPT2  DS  2       ;REAL PTR 2.
8304            IMPT1  DS  2       ;IMAG. PTR 1.
8306            IMPT2  DS  2       ;IMAG. PTR 2.
8308            SINPT  DS  2       ;SINE TABLE PTR.
830A            CELCT  DS  1       ;CELL CTR.
830B            CELNUM DS  1       ;NO. OF CELLS.
830C            PAIRNM DS  1       ;PAIRS PER CELL.
830D            CELDIS DS  1       ;SPAN BETWEEN PAIRS.
830E            DELTA  DS  1       ;ANGLE INCREMENT.
830F            SCLFCT DS  1       ;MULTIPLY OUTPUT AMPLITUDE
8310                               ; BY 2^SCLFCT.
8310            SINE   DS  1
8311            COSINE DS  1
8312            TREAL  DS  1
8313            TIMAG  DS  1
8314            ;
8314                  ORG  8400H
8400            INPD   DS  256     ;INPUT DATA BUFF.
8500            REAL   DS  256     ;"REAL" BUFF.
8600            IMAG   DS  256     ;"IMAG" BUFF.
8700            ;
8700                  ORG  877FH
877F            PABUF  DS  129     ;POWER/AMPLITUDE SPECTRUM.
8800            ;
8800                  ORG  8000H
8000            ;;
8000            ;;TEST FFT PROGRAM.
8000            ;;
8000 CD D5 81          CALL WAVE   ;GET TEST SIGNAL.
8003 CD 0C 80          CALL FFT    ;FORM COMPLEX SPECTRUM.
8006 CD AE 81          CALL POWER  ;CONVERT COMPLEX SPECTRUM
8009                               ; TO 128 PT POWER SPECTRUM.
8009                  ;CALL MAGNI  ;CONVERT COMPLEX SPECTRUM
8009                               ; TO 128 PT AMPLITUDE SPECTRUM
8009 C3 F4 AF          JMP  0AFF4H ;RETURN TO BMCOS.
800C            ;
800C            ;;
800C            ;;INITIALISE DATA AREAS.
800C            ;;
800C 3E 00      FFT:   MVI  A,0
800E 32 0F 83          STA  SCLFCT
8011            ;
8011            ;CLEAR IMAG. ARRAY.
8011 21 00 86   CLEAR:LXI  H,IMAG
8014 36 00      CLR1:  MVI  M,0
8016 2C                INR  L
8017 C2 14 80          JNZ  CLR1
801A            ;
801A            ;MOVE INPUT DATA INTO REAL ARRAY:
801A            ;DE=SOURCE, HL=DEST.
801A 11 00 84   MOVE: LXI  D,INPD
801D 21 00 85         LXI  H,REAL
8020 1A         MOV1: LDAX D
8021 D6 80            SUI  80H     ;CONVERT TO 2'S COMPLEMENT.
8023 77               MOV  M,A
8024 1C               INR  E
8025 2C               INR  L
8026 C2 20 80         JNZ  MOV1
8029            ;;
8029            ;;PRE-TRANSFORM BIT SWAP.
8029            ;;
8029 11 00 85         LXI  D,REAL
802C 21 00 85         LXI  H,REAL
802F 06 08      BITREV:MVI B,8     ;SET BIT CTR.
8031 7D               MOV  A,L     ;LOW-ORDER BITS OF RLPT1.
8032 1F         BRV1: RAR          ;MOVE LS BIT OF RLPT1
8033 4F               MOV  C,A     ; INTO CY & SHIFT
8034 7B               MOV  A,E
8035 17               RAL          ; IN REVERSE ORDER BACK
8036 5F               MOV  E,A     ; INTO RLPT2.
8037 79               MOV  A,C
8038 05               DCR  B
8039 C2 32 80         JNZ  BRV1
803C 7D               MOV  A,L
803D BB               CMP  E       ;COMPARE VALS, & IF
803E DA 46 80         JC   SWP1    ; SAME, DON'T SWAP.
8041 4E         SWAP: MOV  C,M     ;GET VAL 1 INTO C.
8042 1A               LDAX D       ;GET VAL 2 INTO A.
8043 77               MOV  M,A     ;STORE IN SWAPPED ORDER.
8044 79               MOV  A,C
8045 12               STAX D
8046 2C         SWP1: INR  L
8047 C2 2F 80         JNZ  BITREV
804A            ;;
804A            ;;FFT FIRST PASS.
804A            ;;
804A CD 4B 81   PASS1:CALL SCALE   ;SCALE IF DATA OVER-RANGE.
804D 21 00 85         LXI  H,REAL
8050 7E         PA1:  MOV  A,M     ;GET RM.
8051 4F               MOV  C,A     ;SAVE RM.
8052 2C               INR  L
8053 46               MOV  B,M     ;GET RN TOO.
8054 2D               DCR  L
8055 80               ADD  B       ;RM' = RM+RN.
8056 77               MOV  M,A     ;STORE NEW RM'.
8057 79               MOV  A,C     ;RETRIEVE RM.
8058 90               SUB  B       ;RN' = RM-RN.
8059 2C               INR  L
805A 77               MOV  M,A     ;STORE RN'.
805B 2C               INR  L       ;NEW PAIR.
805C C2 50 80         JNZ  PA1
805F            ;;
805F            ;;COMPUTATION OF FFT. PASS 2 THRU N.
805F            ;;
805F 3E 40      FPASS:MVI  A,64    ;SET UP PARAMETERS
8061 32 0B 83         STA  CELNUM  ; FOR NO. OF CELLS,
8064 32 0E 83         STA  DELTA   ; ANGLE,
8067 3E 02            MVI  A,2     ; & FOR
8069 32 0C 83         STA  PAIRNM  ; PAIRS/CELL.
806C 32 0D 83         STA  CELDIS  ;SPAN BETWEEN PAIRS.
806F CD 4B 81   NPASS:CALL SCALE   ;KEEP DATA IN RANGE.
8072 3A 0B 83         LDA  CELNUM  ;GET NO. OF CELLS &
8075 32 0A 83         STA  CELCT   ; PUT INTO CELL CTR.
8078 21 00 85         LXI  H,REAL
807B 22 00 83         SHLD RLPT1
807E 22 02 83         SHLD RLPT2
8081 21 00 86         LXI  H,IMAG
8084 22 04 83         SHLD IMPT1
8087 22 06 83         SHLD IMPT2
808A 21 00 9F   NCELL:LXI  H,STADR
808D 22 08 83         SHLD SINPT
8090 3A 0C 83         LDA  PAIRNM  ;GET PAIRS/CELL CTR.
8093 47               MOV  B,A
8094 21 0D 83   NC1:  LXI  H,CELDIS
8097 3A 00 83         LDA  RLPT1   ;PTR 1 LSBY.
809A 86               ADD  M       ;ADD PAIR OFFSET.
809B 32 02 83         STA  RLPT2   ;SET UP BOTH
809E 32 06 83         STA  IMPT2   ; 2ND PTRS.
80A1 C5               PUSH B       ;SAVE PAIR CTR.
80A2 2A 08 83         LHLD SINPT
80A5 7E               MOV  A,M     ;GET SINE OF ANGLE
80A6 32 10 83         STA  SINE    ; & SAVE.
80A9 3E 40            MVI  A,64    ;ADD COSINE OFFSET
80AB 85               ADD  L       ; MODULO 256.
80AC 6F               MOV  L,A
80AD 7E               MOV  A,M     ;GET COSINE OF ANGLE
80AE 32 11 83         STA  COSINE  ; & SAVE.
80B1 2A 02 83         LHLD RLPT2   ;GET REAL PTR 2.
80B4 4E               MOV  C,M     ;GET RN.
80B5 C5               PUSH B       ;SAVE RN.
80B6 3A 11 83         LDA  COSINE  ;GET COSINE.
80B9 CD 7B 81         CALL MPY     ;A = RN*COS(Z).
80BC 32 12 83         STA  TREAL   ;SAVE PRODUCT.
80BF C1               POP  B       ;GET RN.
80C0 3A 10 83         LDA  SINE
80C3 CD 7B 81         CALL MPY     ;A = RN*SIN(Z).
80C6 32 13 83         STA  TIMAG   ;SAVE PRODUCT.
80C9 2A 06 83         LHLD IMPT2
80CC 4E               MOV  C,M     ;GET IN.
80CD C5               PUSH B       ;SAVE IN.
80CE 3A 10 83         LDA  SINE
80D1 CD 7B 81         CALL MPY     ;A = IN*SIN(Z).
80D4 21 12 83         LXI  H,TREAL
80D7 86               ADD  M
80D8 77               MOV  M,A     ;TR = RN*COS + IN*SIN.
80D9 C1               POP  B       ;GET IN.
80DA 3A 11 83         LDA  COSINE
80DD CD 7B 81         CALL MPY     ;A = IN*COS(Z).
80E0 21 13 83         LXI  H,TIMAG
80E3 96               SUB  M
80E4 77               MOV  M,A     ;TI = IN*COS - RN*SIN.
80E5            ;
80E5 2A 00 83         LHLD RLPT1
80E8 7E               MOV  A,M     ;GET RM.
80E9 4F               MOV  C,A     ;SAVE RM.
80EA 3A 12 83         LDA  TREAL
80ED 81               ADD  C
80EE 77               MOV  M,A     ;RM' = RM+TR.
80EF 79               MOV  A,C     ;GET RM.
80F0 21 12 83         LXI  H,TREAL
80F3 96               SUB  M
80F4 2A 02 83         LHLD RLPT2
80F7 77               MOV  M,A     ;RN' = RM-TR.
80F8            ;
80F8 2A 04 83         LHLD IMPT1
80FB 7E               MOV  A,M     ;GET IM
80FC 4F               MOV  C,A     ;SAVE IM.
80FD 3A 13 83         LDA  TIMAG
8100 81               ADD  C
8101 77               MOV  M,A     ;IM' = IM+TI.
8102 79               MOV  A,C     ;GET IM.
8103 21 13 83         LXI  H,TIMAG
8106 96               SUB  M
8107 2A 06 83         LHLD IMPT2
810A 77               MOV  M,A     ;IN' = IM-TI.
810B            ;
810B 21 08 83         LXI  H,SINPT
810E 3A 0E 83         LDA  DELTA
8111 86               ADD  M       ;INCR. PTR ANGLE BY DELTA.
8112 77               MOV  M,A
8113 21 00 83         LXI  H,RLPT1
8116 34               INR  M
8117 21 04 83         LXI  H,IMPT1
811A 34               INR  M
811B C1               POP  B
811C 05               DCR  B       ;DECREMENT PAIR CTR.
811D C2 94 80         JNZ  NC1
8120            ;;;;
8120 21 00 83         LXI  H,RLPT1 ;GET PTRS &
8123 3A 0D 83         LDA  CELDIS
8126 86               ADD  M       ; ADD CELL OFFSET.
8127 77               MOV  M,A
8128 32 04 83         STA  IMPT1
812B 21 0A 83         LXI  H,CELCT
812E 35               DCR  M       ;DECR. CELL CTR.
812F C2 8A 80         JNZ  NCELL
8132            ;;
8132            ;;CHANGE PARAMETERS FOR NEXT PASS.
8132            ;;
8132 21 0B 83   NP1:  LXI  H,CELNUM
```

Listing 1 continued on page 460

Listing 1 continued:

```
8135 7E          2300       MOV  A,M
8136 A7          2310       ANA  A       ;CLEAR CY & SHIFT
8137 1F          2320       RAR          ; RIGHT TO HALVE NO. CELLS.
8138 B7          2330       ORA  A       ;SET FLAGS.
8139 77          2340       MOV  M,A
813A C8          2350       RZ           ;OUT OF CELLS -> ***FINISH***.
813B 23          2360       INX  H       ;PAIRNM.
813C 7E          2370       MOV  A,M
813D 87          2380       ADD  A       ;TWICE AS MANY PAIRS.
813E 77          2390       MOV  M,A
813F 23          2400       INX  H       ;CELDIS.
8140 7E          2410       MOV  A,M
8141 87          2420       ADD  A       ;TWICE AS FAR APART.
8142 77          2430       MOV  M,A
8143 23          2440       INX  H       ;DELTA.
8144 7E          2450       MOV  A,M
8145 A7          2460       ANA  A       ;CLEAR CY & SHIFT
8146 1F          2470       RAR          ; RIGHT TO HALVE THE ANGLE.
8147 77          2480       MOV  M,A
8148 C3 6F 80    2490       JMP  NPASS
814B             2500 ;;
814B             2510 ;;SCALE OVER-RANGE DATA.
814B             2520 ;;
814B             2530 ;SCALE REAL & IMAG IF -52 > ANY DATA >= 52.
814B             2540 ;NO REGISTERS PRESERVED.
814B 01 00 85    2550 SCALE:LXI  B,REAL  ;SET UP TABLE PTR.
814E 11 FF FF    2560       LXI  D,-1
8151 21 FF 01    2570       LXI  H,512-1 ;NO. OF PTS - 1.
8154 0A          2580 SCL2: LDAX B       ;GET DATA.
8155 03          2590       INX  B       ;BUMP PTR.
8156 FE CC       2600       CPI  -52     ;TEST LOWER LIMIT.
8158 D2 60 81    2610       JNC  SCL3    ;SKIP TO NEXT PT.
815B FE 34       2620       CPI  52      ;TEST UPPER LIMIT.
815D D2 65 81    2630       JNC  SCL4    ;SCALE ALL IF OUT OF RANGE.
8160 19          2640 SCL3: DAD  D       ;TEST NEXT PT.
8161 DA 54 81    2650       JC   SCL2
8164 C9          2660       RET          ;DONE TESTING.
8165 21 0F 83    2670 SCL4: LXI  H,SCLFCT
8168 34          2680       INR  M       ;BUMP SCALE FACTOR COUNT.
8169 01 00 85    2690       LXI  B,REAL  ;SET UP TABLE PTR.
816C 21 FF 01    2700       LXI  H,512-1 ;NO. OF PTS - 1.
816F 0A          2710 SCL6: LDAX B       ;GET DATA.
8170 FE 80       2720       CPI  80H     ; TEST SIGN &
8172 3F          2730       CMC          ; EXTEND IT TO CY.
8173 1F          2740       RAR          ;DIVIDE BY 2.
8174 02          2750       STAX B       ;RETURN DATA TO TABLE.
8175 03          2760       INX  B       ;BUMP PTR.
8176 19          2770       DAD  D       ;NEXT PT.
8177 DA 6F 81    2780       JC   SCL6
817A C9          2790       RET          ;DONE SCALING.
817B             2800 ;;
817B             2810 ;;SIGNED MULTIPLY ROUTINE.
817B             2820 ;;
817B             2830 ;EXTERNAL REG. USAGE:-   A <- (C*A)/128.
817B             2840 ;INTERNAL REG. USAGE:-
817B             2850 ; HL = PRODUCT         (MSBY,LSBY).
817B             2860 ; DE = MULTIPLICAND.
817B             2870 ; BC = MULTIPLIER.
817B             2880 ;NO REGISTERS PRESERVED.
817B 5F          2890 MPY:  MOV  E,A     ;PUT ARG1 INTO MULTIPLICAND.
817C             2900                    ;ARG2 ALREADY IN MULTIPLIER.
817C AF          2910       XRA  A
817D 47          2920       MOV  B,A     ;CLEAR MSBY'S.
817E 57          2930       MOV  D,A
817F 67          2940       MOV  H,A     ;CLEAR PRODUCT.
8180 6F          2950       MOV  L,A
8181 7B          2960       MOV  A,E     ;GET LSBY OF MULTIPLICAND.
8182 FE 00       2970       CPI  0
8184 F2 8A 81    2980       JP   MPY1    ;NEGATIVE MULTIPLICAND?
8187 7A          2990       MOV  A,D
8188 2F          3000       CMA          ;EXTEND SIGN TO MSBY.
8189 57          3010       MOV  D,A
818A 79          3020 MPY1: MOV  A,C     ;GET LSBY OF MULTIPLIER.
818B FE 00       3030       CPI  0
818D F2 93 81    3040       JP   MPY2    ;NEGATIVE MULTIPLIER?
8190 78          3050       MOV  A,B
8191 2F          3060       CMA          ;EXTEND NEG TO MSBY.
8192 47          3070       MOV  B,A
8193 3E 0F       3080 MPY2: MVI  A,15    ;SET ITERATION CTR
8195 F5          3090 MPY3: PUSH PSW     ; & SAVE.
8196             3100       ;ARITH. SHIFT MULTIPLIER RIGHT (BC).
8196 78          3110       MOV  A,B
8197 FE 80       3120       CPI  80H
8199 3F          3130       CMC          ;MAKE CY = MSBIT.
819A 1F          3140       RAR
819B 47          3150       MOV  B,A
819C 79          3160       MOV  A,C
819D 1F          3170       RAR          ;LSBIT->CY.
819E 4F          3180       MOV  C,A
819F             3190       ;TEST MULTIPLIER LSBIT & IF SET,
819F             3200       ; ADD MULTIPLICAND TO PARTIAL PRODUCT.
819F D2 A3 81    3210       JNC  MPY4
81A2 19          3220       DAD  D
81A3             3230       ;ARITH. SHIFT MULTIPLICAND LEFT (DE).
81A3 EB          3240 MPY4: XCHG         ;SWAP MULTIPLIER & PROD.
81A4 29          3250       DAD  H       ;SHIFT LEFT.
81A5 EB          3260       XCHG         ;RESTORE REGS.
81A6             3270       ;CHECK LOOP CTR.
81A6 F1          3280       POP  PSW
81A7 3D          3290       DCR  A       ;DECREMENT COUNT.
81A8 C2 95 81    3300       JNZ  MPY3
81AB             3310       ;DIVIDE 16-BIT PRODUCT BY 128 SO THAT
81AB             3320       ; SINE & COSINE AMPLITUDE = UNITY.
81AB 29          3330       DAD  H       ;SHIFT-IN MSBIT OF
81AC 7C          3340       MOV  A,H     ; LSBYTE & RETURN IN A.
81AD C9          3350       RET
81AE             3360 ;;
81AE             3370 ;;POWER CALCULATION.
81AE             3380 ;;
81AE             3390 ;NO REGISTERS PRESERVED.
81AE 06 9E       3400 POWER:MVI  B,>SCADR
81B0 21 00 85    3410       LXI  H,REAL
81B3 11 7F 87    3420       LXI  D,PABUF
81B6 4E          3430 PWR1: MOV  C,M     ;C=REAL.
81B7 0A          3440       LDAX B       ;A=(REAL↑2)/64.
81B8 12          3450       STAX D       ;STORE.
81B9 2C          3460       INR  L
81BA 1C          3470       INR  E
81BB C2 B6 81    3480       JNZ  PWR1
81BE 21 00 86    3490       LXI  H,IMAG  ;RESET PTRS.
81C1 11 7F 87    3500       LXI  D,PABUF
81C4 4E          3510 PWR2: MOV  C,M     ;C=IMAG.
81C5 0A          3520       LDAX B       ;A=(IMAG↑2)/64.
81C6 EB          3530       XCHG
81C7 86          3540       ADD  M       ;A=(REAL↑2 + IMAG↑2)/64.
81C8 D2 CD 81    3550       JNC  $+2
81CB 3E FF       3560       MVI  A,0FFH  ;A SATURATES AT 0FFH.
81CD 77          3570       MOV  M,A     ;STORE POWER.
81CE EB          3580       XCHG
81CF 2C          3590       INR  L
81D0 1C          3600       INR  E
81D1 C2 C4 81    3610       JNZ  PWR2
81D4 C9          3620       RET
81D5             3630 ;;
81D5             3640 ;;FILL INPD WITH 10.666 HZ SQUARE WAVE.
81D5             3650 ;;
81D5 21 00 84    3660 WAVE: LXI  H,INPD
81D8 0E 2B       3670       MVI  C,43
81DA CD EA 81    3680 WAVE2:CALL LO
81DD CD E5 81    3690       CALL HI
81E0 0D          3700       DCR  C
81E1 C2 DA 81    3710       JNZ  WAVE2
81E4 C9          3720       RET
81E5             3730       ;
81E5             3740 ABC   EQU  117
81E5             3750 MID   EQU  128
81E5 3E F5       3760 HI:   MVI  A,MID+ABC
81E7 C3 EC 81    3770       JMP  $+2
81EA 3E 0B       3780 LO:   MVI  A,MID-ABC
81EC 06 03       3790       MVI  B,3
81EE 77          3800 WAVE3:MOV  M,A
81EF 23          3810       INX  H
81F0 05          3820       DCR  B
81F1 C2 EE 81    3830       JNZ  WAVE3
81F4 C9          3840       RET
81F5             3850       ;

ABC    0075    3740  3760  3780
BITRE  802F    0830  1020
BRV1   8032    0850  0920
CELCT  830A    0210  1320  2230
CELDI  830D    0240  1290  1430  2190
CELNU  830B    0220  1250  1310  2290
CLEAR  8011    0630
CLB1   8014    0640  0660
COSIN  8311    0290  1560  1600  1760
DELTA  830E    0250  1260  2070
FFT    800C    0460  0590
FPASS  805F    1240
HI     81E5    3690  3760
IMAG   8600    0370  0630  1360  3490
IMPT1  8304    0180  1370  1940  2120  2220
IMPT2  8306    0190  1380  1470  1670  2030
INPD   8400    0350  0700  3660
LO     81EA    3680  3780
MID    0080    3750  3760  3780
MOV1   8020    0720  0770
MOVE   801A    0700
MPY    817B    1610  1650  1710  1770  2890
MPY1   818A    2980  3020
MPY2   8193    3040  3080
MPY3   8195    3090  3300
MPY4   81A3    3210  3240
NC1    8094    1430  2160
NCELL  808A    1390  2250
NP1    8132    2290
NPASS  806F    1300  2490
PA1    8050    1080  1200
PABUF  877F    0385  3420  3500
PAIRN  830C    0230  1280  1410
PASS1  804B    1060
POWER  81AE    0470  3400
PWR1   81B6    3430  3480
PWR2   81C4    3510  3610
REAL   8500    0360  0710  0810  0820  1070  1330  2550  2690  3410
RLPT1  8300    0160  1340  1440  1820  2100  2180
RLPT2  8302    0170  1350  1460  1570  1910
SCALE  814B    1060  1300  2550
SCL2   8154    2580  2650
SCL3   8160    2610  2640
SCL4   8165    2630  2670
SCL6   816F    2710  2780
SCLFC  830F    0260  0600  2670
SINE   8310    0280  1510  1640  1700
SINPT  8308    0200  1400  1490  2060
SCADR  9E00    0120  3400
STADR  9F00    0130  1390
SWAP   8041    0960
SWP1   8046    0950  1010
TIMAG  8313    0310  1660  1780  1970  2010
TREAL  8312    0300  1620  1720  1850  1890
WAVE   81D5    0430  3660
WAVE2  81DA    3680  3710
WAVE3  81EE    3800  3830
```

Text continued from page 458:

I intend to write a subroutine to compute amplitude spectra following the method pointed out by Bob Leedom. (See "Approximation Makes a Magnitude of Difference," June 1979 BYTE, page 188.) This routine does not appear in listing 1, except as a comment.

Pass 1 of the FFT requires a trivial amount of computer arithmetic. Pass 2 is fairly trivial too, since sine and cosine have only the values −1, 0, and 1. Therefore, a simple way to increase the speed of the program would be to largely duplicate the coding of passes 2 thru *N* (inserting constants instead of variables and using a new sine/cosine table {0,1,0,−1,0 }, etc). A special multiply subroutine could be used for this: a subroutine that can multiply only by 0, 1, or −1, but do it very quickly. This could shave up to one second off the transform time.

Listing 2: *Object-code listing in hexadecimal format of the assembly-language program given in listing 1. The /BC at the end of this listing is a checksum of the whole code.*

```
8000 CD D5 81 CD 0C 80 CD AE 81 C3 E4 AF 3E 00 32 0F
8010 83 21 00 86 36 00 2C C2 14 80 11 00 84 21 00 85
8020 1A D6 80 77 1C 2C C2 20 80 11 00 85 21 00 85 06
8030 08 7D 1F 4F 7B 17 5F 79 05 C2 32 80 7D BB DA 46
8040 80 4E 1A 77 79 12 2C C2 2F 80 CD 4B 81 21 00 85
8050 7E 4F 2C 46 2D 80 77 79 90 2C 77 2C C2 50 80 3E
8060 40 32 0B 83 32 0F 83 3E 02 32 0C 83 32 0D 83 CD
8070 4B 81 3A 0B 83 32 0A 83 21 00 85 22 00 83 22 02
8080 83 21 00 86 22 04 83 22 06 83 21 00 9F 22 08 83
8090 3A 0C 83 47 21 0D 83 3A 00 83 86 32 02 83 32 06
80A0 83 C5 2A 08 83 7E 32 10 83 3E 40 85 6F 7E 32 11
80B0 83 2A 02 83 4E C5 3A 11 83 CD 7B 81 32 12 83 C1
80C0 3A 10 83 CD 7B 81 32 13 83 2A 06 83 4E C5 3A 10
80D0 83 CD 7B 81 21 12 83 86 77 C1 3A 11 83 CD 7B 81
80E0 21 13 83 96 77 2A 00 83 7E 4F 3A 12 83 81 77 79
80F0 21 12 83 96 2A 02 83 77 2A 04 83 7E 4F 3A 13 83
8100 81 77 79 21 13 83 96 2A 06 83 77 21 08 83 3A 0E
8110 83 86 77 21 00 83 34 21 04 83 34 C1 05 C2 94 80
8120 21 00 83 3A 0D 83 86 77 32 04 83 21 0A 83 35 C2
8130 8A 80 21 0B 83 7E A7 1F B7 77 C8 23 7E 87 77 23
8140 7E 87 77 23 7E A7 1F 77 C3 6F 80 01 00 85 11 FF
8150 FF 21 FF 01 0A 03 FE CC D2 60 81 FE 34 D2 65 81
8160 19 DA 54 81 C9 21 0F 83 34 01 00 85 21 FF 01 0A
8170 FE 80 3F 1F 02 03 19 DA 6F 81 C9 5F AF 47 57 67
8180 6F 7B FE 00 F2 8A 81 7A 2F 57 79 FE 00 F2 93 81
8190 78 2F 47 3E 0F F5 78 FE 80 3F 1F 47 79 1F 4F D2
81A0 A3 81 19 EB 29 EB F1 3D C2 95 81 29 7C C9 06 9E
81B0 21 00 85 11 7F 87 4E 0A 12 2C 1C C2 B6 81 21 00
81C0 86 11 7F 87 4E 0A EB 86 D2 CD 81 3E FF 77 EB 2C
81D0 1C C2 C4 81 C9 21 00 84 0E 2B CD EA 81 CD E5 81
81E0 0D C2 DA 81 C9 3E F5 C3 EC 81 3E 0B 06 03 77 23
81F0 05 C2 EE 81 C9 /BC
```

Listing 3: *Listing in hexadecimal format of the two's-complement square table and sine table used by the FFT program.*

```
9E00 00 00 00 00 00 00 01 01 01 01 02 02 02 03 03 04
9E10 04 05 05 06 06 07 08 08 09 0A 0B 0B 0C 0D 0E 0F
9E20 10 11 12 13 14 15 17 18 19 1A 1C 1D 1F 20 21 23
9E30 24 26 27 29 2A 2C 2E 2F 31 33 35 36 38 3A 3C 3E
9E40 40 42 44 46 48 4A 4D 4F 51 53 56 58 5A 5D 5F 62
9E50 64 67 69 6C 6E 71 74 76 79 7C 7F 81 84 87 8A 8D
9E60 90 93 96 99 9C 9F A3 A6 A9 AC B0 B3 B6 BA BD C1
9E70 C4 C8 CB CF D2 D6 DA DD E1 E5 E9 EC F0 F4 F8 FC
9E80 FF FC F8 F4 F0 EC E9 E5 E1 DD DA D6 D2 CF CB C8
9E90 C4 C1 BD BA B6 B3 B0 AC A9 A6 A3 9F 9C 99 96 93
9EA0 90 8D 8A 87 84 81 7F 7C 79 76 74 71 6E 6C 69 67
9EB0 64 62 5F 5D 5A 58 56 53 51 4F 4D 4A 48 46 44 42
9EC0 40 3E 3C 3A 38 36 35 33 31 2F 2E 2C 2A 29 27 26
9ED0 24 23 21 20 1E 1D 1C 1A 19 18 17 15 14 13 12 11
9EE0 10 0F 0E 0D 0C 0B 0B 0A 09 08 08 07 06 06 05 05
9EF0 04 04 03 03 02 02 02 01 01 01 01 00 00 00 00 00
9F00 00 03 06 09 0C 10 13 16 19 1C 1F 22 25 28 2B 2E
9F10 31 33 36 39 3C 3F 41 44 47 49 4C 4E 51 53 55 58
9F20 5A 5C 5E 60 62 64 66 68 6A 6B 6D 6F 70 71 73 74
9F30 75 76 78 79 7A 7A 7B 7C 7D 7D 7E 7E 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 6B 6A 68 66 64 62 60 5E 5C
9F60 5A 58 55 53 51 4E 4C 49 47 44 41 3F 3C 39 36 33
9F70 31 2E 2B 28 25 22 1F 1C 19 16 13 10 0C 09 06 03
9F80 00 FD FA F7 F4 F0 ED EA E7 E4 E1 DE DB D8 D5 D2
9F90 CF CD CA C7 C4 C1 BF BC B9 B7 B4 B2 AF AD AB A8
9FA0 A6 A4 A2 A0 9E 9C 9A 98 96 95 93 91 90 8F 8D 8C
9FB0 8B 8A 88 87 86 86 85 84 83 83 82 82 82 81 81 81
9FC0 81 81 81 81 82 82 82 83 83 84 85 86 86 87 88 8A
9FD0 8B 8C 8D 8F 90 91 93 95 96 98 9A 9C 9E A0 A2 A4
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 00
879F 00 00 00 00 00 00 01 01 02 03 10 3C 03 01 01 00
87AF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87BF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87CF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87DF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87EF 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
87FF 13 /72
```

Richard Lord Replies

Mr Roxburgh is indeed correct about the possibility of overflow with my scaling routine. I tried slowly increasing the amplitude of a square-wave input and discovered that for amplitude pairs of ± hexadecimal 1B, 1F; 33, 3F; and 6A, 6E the algorithm produces overflow artifacts. This did not show up in initial testing because integral binary amplitudes (10, 20, 40) were used. The scaling routine immediately fixes these values before overflow has a chance to occur. For sampled audio, this overflow has undoubtedly introduced errors. Insertion of new limits, as Mr Roxburgh proposed, fixed the overflow problem so that the FFT yields correct results at all amplitudes. My thanks to Mr Roxburgh for pointing this out. I hope that this has not created too many difficulties for anyone who has been using the FFT previous to this discovery.

*Many letters have come to me in response to this article and the response has been very gratifying. Most of the letters have been requests for the 6502 verison which I never got around to writing. (At this time I'd be more inclined to try a 6809 version.) Quite a few readers suggested great improvements to the "sum of absolute values" method, and one letter pointed out that the SIN table is actually a −1*SIN yielding inverted imaginary terms. All these improvements are greatly appreciated.* ■

Circle 236 on inquiry card.

Handy Pocket Computer Uses BASIC

Sharp Corporation will announce the introduction of its PC-1211 Pocket Computer into the American market at this month's National Computer Conference (NCC). Measuring only 17.5 by 7 by 1.5 cm (6⅞ by 2¾ by ¹⁹⁄₃₂ 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.

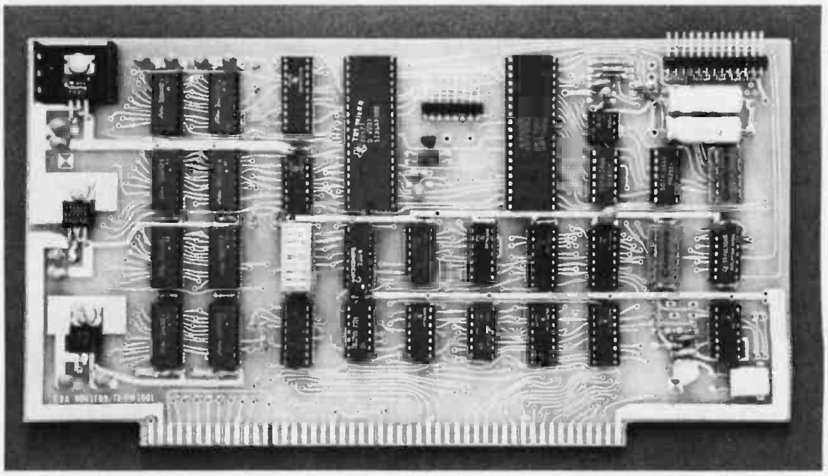
Master Controller Board

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.

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 includes programming examples and test routines. It is available for $475 assembled and tested or $375 in kit form. Contact Electronic Design Associates, POB 94055, Houston TX 77018, (713) 999-2255.

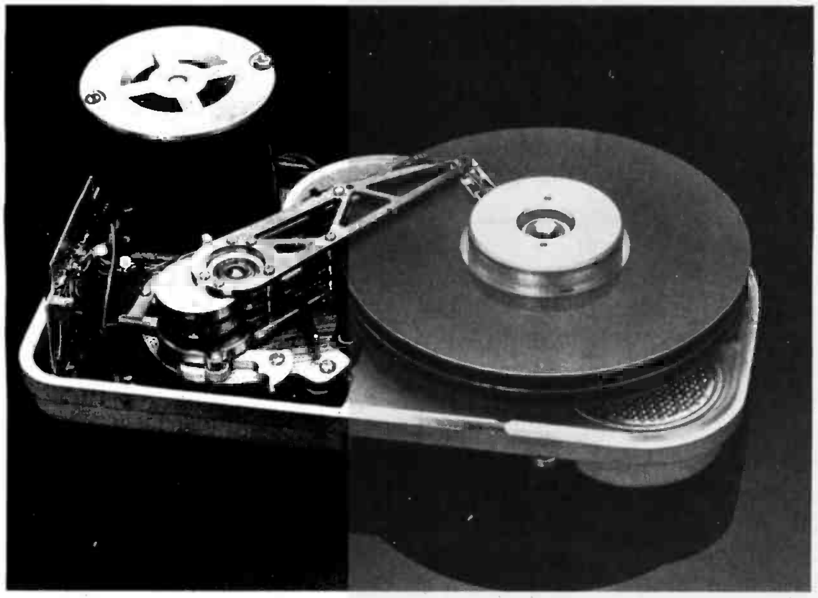
Circle 502 on inquiry card.

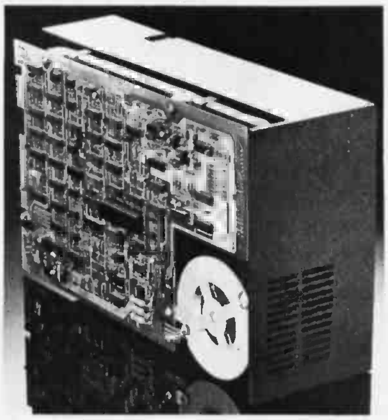
Q2000—Family of Hard-Disk Drives

The Q2000 series of 8-inch fixed-hard-disk drives are compatible with Shugart's SA1000 disk drives, but offer 10-, 20-, and 30-megabyte unformatted capacities. This is achieved by using a special head-positioning technique. The Q2000 family features a 4.34-megabit-per-second transfer rate, an average latency of 10 ms, and access times of 15 ms track-to-track, 100 ms maximum, and 50 to 60 ms average. Maximum recording density is 6600 bits per inch, and track density is 345 tracks per inch. Rotational speed is 3000 rpm (revolutions per minute). Soft-sectoring is offered.

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

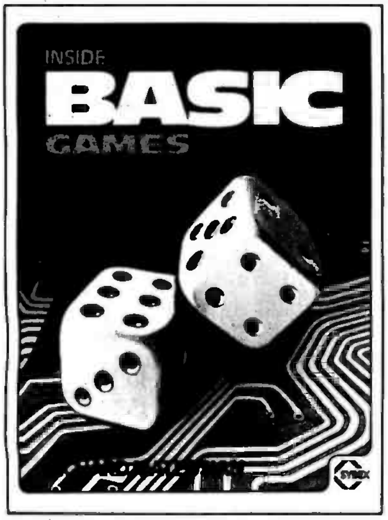
Circle 503 on inquiry card.





What's New?

PUBLICATIONS



Inside BASIC Games

Inside BASIC Games, by Richard Mateosian, uses games as a framework for teaching BASIC programming. Eight games, ranging from simple arithmetic to complex matching games, are described and analyzed so that readers can learn how to design their own programs, as well as play the game. The games are written for most microcomputers. Inside BASIC Games is a Sybex publication, and it costs $13.95. Contact Sybex Inc, 2344 6th St, Berkeley CA 94710, (415) 848-8233.

Circle 504 on inquiry card.

Optoelectronics and Fiber-Optics Manual

A 286-page optoelectronics and fiber-optics data manual has been published by Motorola Semiconductor Products Inc. The manual provides device data sheets, selector guides, cross-references, and applications information. The manual includes gallium-arsenide infrared emitters, silicon detectors, opto-coupler/isolators, the family of opto-triac drivers, and Motorola's SCR (silicon-controlled rectifier) couplers.

The manual's fiber-optic section is intended principally to address fiber-optic communications systems in the computer, industrial controls, medical electronics, consumer, and automotive applications.

The data book, Mototola Optoelectronics Device Data, costs $3.25. It is available from Motorola Semiconductor Products Inc, POB 20912, Phoenix AZ 85036, (602) 244-4306.

Circle 508 on inquiry card.

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.

What's New?

SOFTWARE

Two New Products from Commodore

Ozz—The Information Wizard lets users design data-management and retrieval systems. Ozz was created for the Commodore CBM 8032 microcomputer. The program allows users to set up formats, store information, perform calculations and global searches, design forms and documents, analyze information, and access files.

Wordcraft 80 is a word-processing program designed for the 8032 system. Wordcraft 80 offers variable page layouts of up to 117 characters by 98 lines; screen display of finished-format documents; tabs, indentations, decimal tabs, columns; automatic centering and right-margin justification; automatic pagination, headers, and trailers; deletion and insertion of text; transfer of text from one page to another; merging of form letters with name/-address files; handling of single sheets or continuous-form paper; sub- and superscripts; and automatic underlining and emboldening of text.

For more information on both products, contact Commodore Business Machines Inc, 950 Rittenhouse Rd, Norristown PA 19403, (215) 666-7950.

Circle 509 on inquiry card.

Atari Graphic Editor

Plot & Draw is a cassette-based graphics-generation and editing package that creates graphics in three colors plus a background. Video drawings can be created and saved on cassette. It requires an Atari computer with 8 K bytes of programmble memory and a joystick. The price is $18 from Mosaic Electronics, POB 748, Oregon City OR 97045.

Circle 510 on inquiry card.

The Voice

The Voice gives the Apple II or the Apple II Plus the power of speech. The Voice's built-in vocabulary allows expression of many combinations of phrases, or the user can enter his own vocabulary and make the 48 K-byte Apple say anything. Floppy disks store up to 80 words or phrases that can later be sorted for quick reference. The Voice allows any BASIC program to speak by using PRINT statements. The price is $39.95, from Muse Software, 330 N Charles St, Baltimore MD 21201, (301) 659-7212.

Circle 511 on inquiry card.

FORTH-79 for the Apple

MicroMotion's FORTH-79 conforms to the International FORTH-79 standard. It is suited for data acquisition, process control, animation, and video games.

FORTH-79 comes with a screen editor and macroassembler, and vocabularies for strings, double-precision integers, low-resolution graphics, and modem communications. The operating system allows for multiple disk drives and is 13- or 16-sector disk compatible. It runs on a 48 K-byte Apple II or Apple II Plus. FORTH-79 can be obtained for $89.95 from MicroMotion 12077 Wilshire Blvd, Suite 506, Los Angeles CA 90025, (213) 821-4340.

Circle 512 on inquiry card.

A Stellar Trek

This high-resolution color version of the Star Trek game runs on the Apple II. Three different Klingon opponents and the Romulan Star Empire are pitted against the user. Users have many command prerogatives, including movement throughout the galaxy, use of starship weaponry, maintenance of energy reserves, repair of damage, and more. A Stellar Trek requires 48 K bytes of memory and Applesoft BASIC in ROM (read-only memory). The price is $24.95 on floppy disk. Contact Rainbow Computing, 9719 Reseda Blvd, Northridge CA 91324, (213) 349-5560.

Circle 513 on inquiry card.

Combine Hard Disks and the TRS-80

HDOS-2 is a hard-disk operating system designed to be used with TRSDOS 1.2 on the TRS-80 Model II. The advantage of this software is that it allows a Corvus hard-disk drive to be interfaced with existing software with only minor changes to the programs. HDOS-2 requires 1 K bytes of memory and allows use of multiple drives. The system costs $125. Contact Computer Program Associates, 15076 Beltway Dr, Dallas TX 75234, (214) 233-2039.

Circle 514 on inquiry card.

TFORTH

TFORTH is a fig- (FORTH Interest Group) standard version of FORTH, extended for the TRS-80. It contains an operating system, assembler, text editor, floating-point mathematics package, I/O (input/output) package, graphics links into TRS-80 BASIC, and a phoneme assembler to support voice synthesizers. TFORTH is supplied on 5-inch floppy disks for $130. Contact Advanced Technology Corporation, 1617 Euclid Ave, Knoxville TN 37921, (615) 525-1632.

Circle 515 on inquiry card.

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OKIDATA Microline 80, 80 cps, 9x7 dot matrix	**$525**
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TI-810, 150 cps, Basic	**$1695**
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CENTRONICS 704-9,180 cps, 9x9 dot matrix, 132 col, RS-232	**$1595**
704-11,180 cps, 9x9 dot matrix, 132 col, parallel	**$1695**
730,100 cps, 7x7 dot matrix, same as R.S. LPII	**$660**
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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 Inventory program for HDOS systems is $69.95. The CBASIC language, a disk-based, noninteractive language with pseudocode compiler and run-time interpreter for CP/M systems is priced at $110. The BDS C compiler includes a linking loader, a library containing file I/O (input/output) and floating-point functions, and a library manager. The C compiler runs on CP/M systems and is priced at $119.95.

The Softstuff product line also offers the Microsoft MACRO-80 package, a full-screen editor, a sort program, and a network system. For more information on Softstuff programs, contact Heath Company, Department 350-670, Benton Harbor MI 49022, (616) 982-3210.

Circle 518 on inquiry card.

Software for Law Offices

Law-1 is a time-management and billing system for the legal professional. It features system and program security, client/matter and attorney reporting, accounts-receivable ledgers, ageing analysis, pre-billing worksheets, invoicing, and automatic file backup, and it performs other-than-standard inquiries.

Law-1 is written in CBASIC for CP/M-based systems. It comprises 38 applications packages. The system is parameter driven and can support floppy- and hard-disk configurations. Different terminals are supported. A demonstration package is available for $75, and the single-user package price is $800. For further information, contact Microcon Inc, POB 805, Amherst NH 03031, (603) 673-0230.

Circle 519 on inquiry card.

Learn Trigonometry on the Compucolor II

Using a circular functions approach to trigonometry, these teaching programs provide experiences with radian measure, sine function development, graphing the sums of functions, drill with identities, and polar graphs. All programs encourage the user to explore functions under computer guidance, to recognize identities, and to notice patterns. Program listings are included, so users can create additional variations and drills. This disk for the Compucolor or Intecolor computers requires a 64- by 32-character screen with 127 by 127 color blocks in low- and high-resolution graphics. It is available for $29.95 from Metra Instruments Inc, 2056 Bering Dr, San Jose CA 95131, (408) 297-8530.

Circle 520 on inquiry card.

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What's New?

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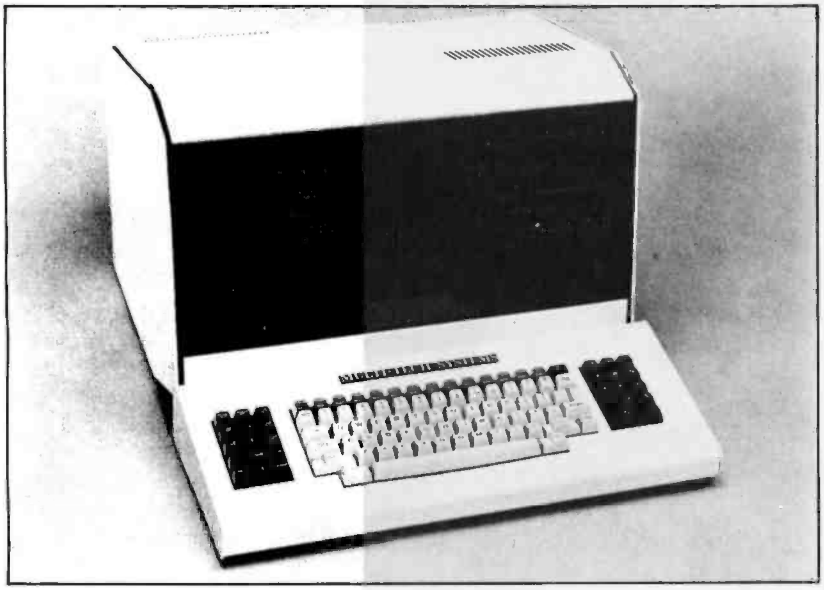

MT500 System

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.

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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 developed 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.

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The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

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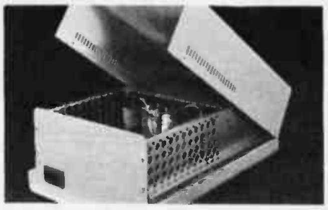

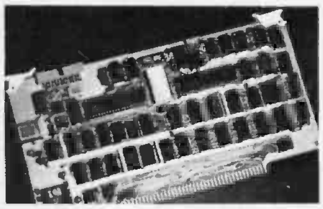

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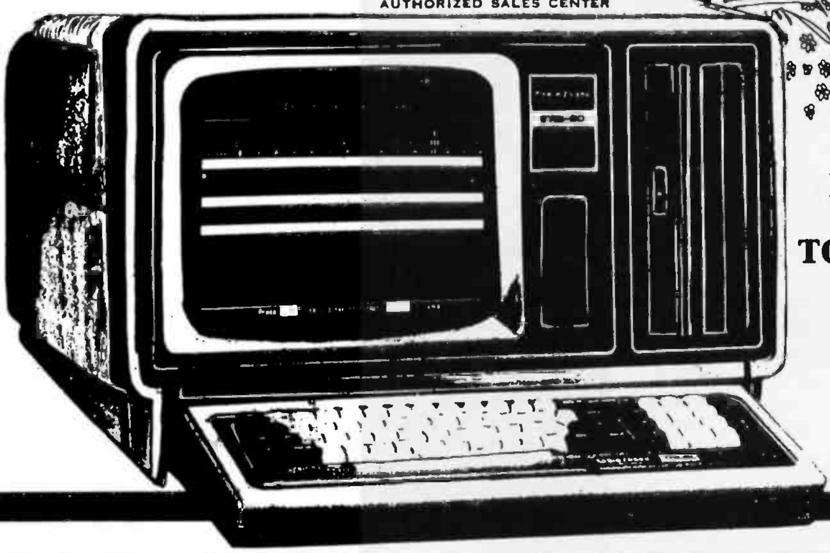

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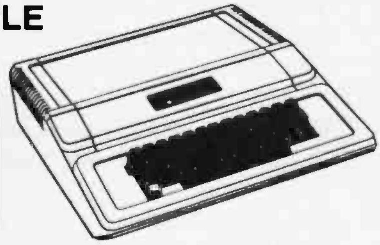

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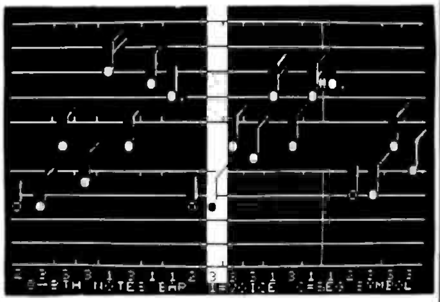

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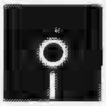

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8216	1.85	4023	.38	4086	.79	74C42	1.85	74LS30	.26	74LS162	.98	74LS324	1.75
8224	2.65	4024	.79	4093	.99	74C48	2.39	74LS32	.39	74LS163	.98	74LS347	1.95
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8282	6.70	4043	.85	4519	.99	74173	2.59	74LS86	.45	74LS197	.89	74LS393	1.95
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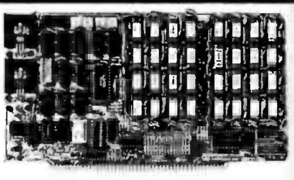

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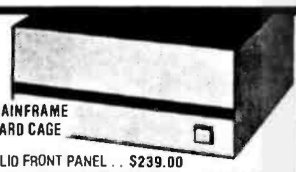

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★ CONNECTS TO PET OR KIM USING AN ADAPTOR CABLE.
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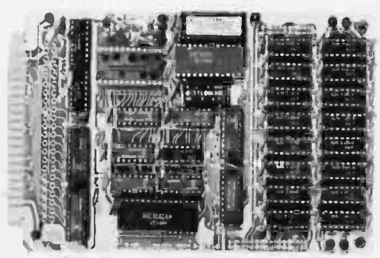

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32K S-100 EPROM CARD
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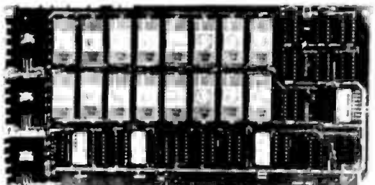

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Blank PC Board - $34

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SPECIAL: 2716 EPROM's (450 NS) Are $11.95 EA. With Above Kit.

KIT FEATURES:
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3. IEEE S-100 Compatible.
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5. Cromemco extended or Northstar bank select.
6. On board wait state circuitry if needed.
7. Any or all EPROM locations can be disabled.
8. Double sided PC board, solder-masked, silk-screened.
9. Gold plated contact fingers.
10. Unselected EPROM's automatically powered down for low power.
11. Fully buffered and bypassed.
12. Easy and quick to assemble.

32K SS-50 RAM

$379.00 KIT

For 2MHZ
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Support IC's
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Complete Socket Set
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At Last! An affordable 32K Static RAM with full 6809 Capability.

FEATURES:
1. Uses proven low power 2114 Static RAMS.
2. Supports SS50C - EXTENDED ADDRESSING.
3. All parts and sockets included.
4. Dip Switch address select as a 32K block.
5. Extended addressing can be disabled.
6. Works with all existing 6800 SS50 systems.
7. Fully bypassed. PC Board is double sided, plated thru, with silk screen.

16K STATIC RAM KIT-S 100 BUSS

PRICE CUT!

$199.95 KIT

FOR 4MHZ
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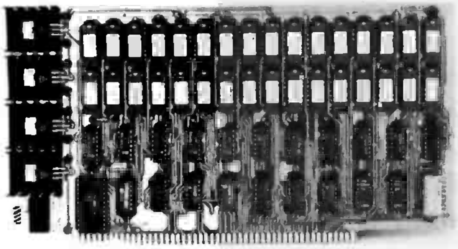

KIT FEATURES:
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2. ON BOARD BANK SELECT circuitry. (Cromemco Standard!). Allows up to 512K on line!
3. Uses 2114 (450NS) 4K Static Rams.
4. ON BOARD SELECTABLE WAIT STATES.
5. Double sided PC Board, with solder mask and silk screened layout. Gold plated contact fingers.
6. All address and data lines fully buffered.
7. Kit includes ALL parts and sockets.
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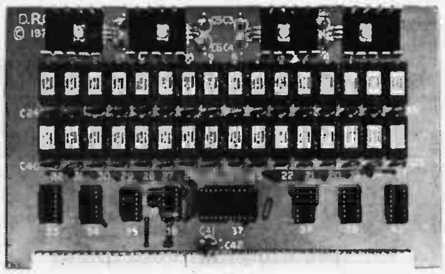

FOR SWTPC
6800 BUSS!

ASSEMBLED AND
TESTED - $35

KIT FEATURES:
1. Addressable on 16K Boundaries
2. Uses 2114 Static Ram
3. Fully Bypassed
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5. All Parts and Sockets included
6. Low Power: Under 1.5 Amps Typical

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#5280-5N 4096 BITS x 1 270 NS ACCESS

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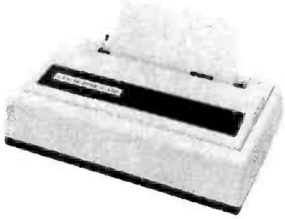

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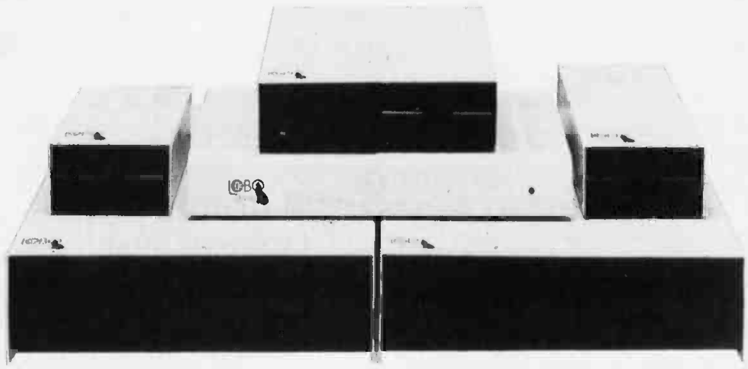

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8212C	Two SA801 in cabinet w/power $1329
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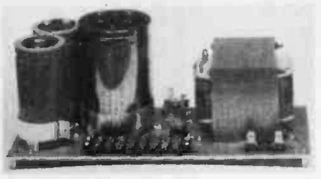
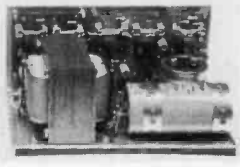
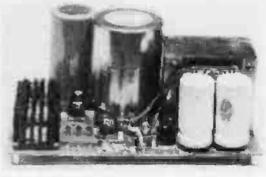
FOR S-100, FLOPPY DISKS.



KIT 1, 2 & 3 For S–100



R3 For Three 8" or 5¼" Disk Drives



S3 2 in 1 Unit for S–100 and two 8" or 5¼" Disk Drives. It fits most Disk System Mainframes.

S-100 POWER SUPPLY KITS (OPEN FRAME WITH BASE PLATE, 3 HRS. ASSY. TIME)

ITEM	USED FOR	@ + 8 Vdc	@ – 9 Vdc	@ + 16 Vdc	@ – 16 Vdc	@ + 28 Vdc	SIZE W × D × H	PRICE
KIT 1	15 CARDS SOURCE	15A	———	2.5A	2.5A	———	12" × 5" × 4⅞"	52.95
KIT 2	SYSTEM SOURCE	25A	———	3A	3A	———	12" × 5" × 4⅞"	59.95
KIT 3	DISK SYSTEM	15A	1A	2A	2A	4A	14" × 6" × 4⅞"	67.95

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SPECS: + 5V @ 5A OVP. –5V @ 1A + 24V@ 5A. SHORTS PROTECT. 2 SIZES AVAIL., 1.) 9" (W) × 6¼" (D) × 4⅜" (H), 2) 9" (W) × 5⅜" (D) × 5¼" (H)
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T_2	110/120	2 × 8 Vac. 25A	28 Vac. CT. 3.5A		3¾" × 4⅜" × 3⅛"	27.95
T_3	110/120	2 × 8 Vac. 15A	28 Vac. CT. 2.5A	48 Vac. CT. 2A	3¾" × 4⅜" × 3⅛"	29.95
T_4	110/120	2 × 8 Vac. 6A	28 Vac. CT. 1.5A	48 Vac. CT. 3A	3¾" × 3⅝" × 3⅛"	22.95
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74LS21	.28	74LS170	175					
74LS22	.26	74LS174	75					
74LS26	.49	74LS175	75					
74LS27	.26	74LS190	75					
74LS30	28	74LS193	96					
74LS32	.32	74LS195	96					
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	.96	74LS258	96					
74LS90	.69	74LS259	285					
74LS93	.69	74LS279	44					
74LS107	.45	74LS283	100					
74LS112	.38	74LS293	185					
74LS113	.48	74LS298	120					
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2114L 200ns	4.25
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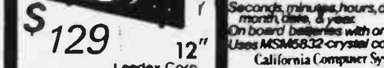

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INSULATION DISPLACEMENT SOCKETS

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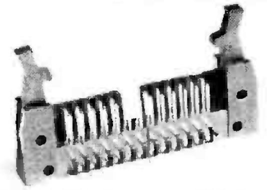
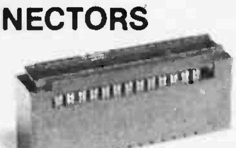


Pins	PC Mounting		Wire Wrap	
10	IDH10SR	.80	IDH10WR	1.75
20	IDH20SR	1.25	IDH20WR	2.75
26	IDH26SR	1.85	IDH26WR	3.60
34	IDS34SR	2.15	IDH34WR	4.15
40	IDH40SR	2.50	IDH40WR	4.90
50	IDH50SR	3.15	IDH50WR	6.15

EJECTOR EARS .25 EACH

CARD EDGE CONNECTORS



Pins	Part No.	
10	IDE10	3.25
20	IDE20	3.50
26	IDE26	4.05
34	IDE34	4.85
40	IDE40	5.65
50	IDE50	5.90

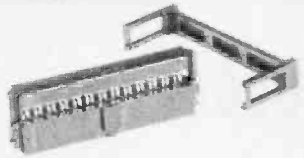
RIBBON CABLE

Conductors:	Solid Color 10 ft.	Solid Color 100 ft.	Color Coded 10 ft.	Color Coded 100 ft.
10	2.90	17.00	4.00	30.00
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

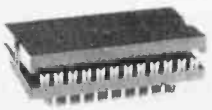
Style	Part #	
SOLDER STYLE		
Male	DB25P	2.25
Female	DB255	3.00
Hood	DB25C	1.10
INSULATION DISPLACEMENT		
Male	IDC25P	4.95
Female	IDC255	5.25
Hood	IDC25C	1.35

SOCKETS



Pins	Part No.		Stain Relief
10	IDS10	1.25	.25
20	IDS20	2.02	.25
26	IDS26	2.65	.25
34	IDS34	3.50	.25
40	IDS40	4.05	.25
50	IDS50	5.06	.25

CABLE PLUGS



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

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.

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250	3"	100	4½"
250	3½"	100	5"
100	4"	100	6"

Kit No. 2	$24.95		
250	2½"	250	5"
500	3"	100	5½"
500	3½"	250	6"
500	4"	100	6½"
250	4½"	100	7"

Kit No. 3	$32.95		
500	2½"	500	4½"
500	3"	500	5"
500	3½"	500	5½"
500	4"	500	6"

Kit No. 4	$59.95		
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1000	3"	1000	5"
1000	3½"	1000	5"
1000	4"	1000	6"

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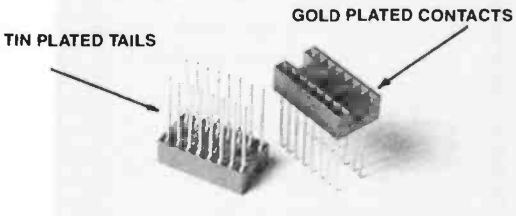

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14	30	.47	14.10
16	26	.51	13.26
18	23	.70	16.10
20	21	.87	18.27
22	19	.94	17.86
24	17	.96	16.32
28	15	1.25	18.75
40	10	1.70	17.00

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1.000-A	5.7143-B	9.98960-B	22.1184-B	37.9628-B	42.9258-B	47.8838-B
1.8432-A	5.955-B	10.000-B	22.8258-B	38.3768-B	42.9628-B	48.000-B
1.8437-B	5.982-B	10.2458-B	26.3556-B	38.4448-B	43.0008-B	48.3006-B
2.000-A	6.000-B	10.4988-B	26.5006-B	38.8258-B	43.0378-B	48.6668-B
2.0971-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	27.000-B	39.3128-B	43.1858-B	48.8788-B
2.500-A	6.29780-B	10.8386-B	27.0006-B	39.5038-B	43.2588-B	49.7006-B
2.6657-B	6.400-B	11.1360-B	27.6506-B	39.6668-B	43.3338-B	49.7338-B
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3.067-B	6.75840-B	11.2890-B	28.7538-B	39.9628-B	43.4378-B	51.0556-B
3.200-B	6.9003-B	11.4778-B	29.8758-B	40.4448-B	43.4448-B	61.3128-B
3.2768-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	11.6818-B	30.0648-B	40.8128-B	43.6298-B	51.8506-B
3.579-B	7.0816-B	12.440-B	30.3606-B	40.8336-B	43.6668-B	52.8128-B
4.000-B	7.1836-B	14.3182-B	30.6258-B	40.8758-B	43.7778-B	56.7506-B
4.1943-B	7.2586-B	14.4308-B	30.8768-B	40.8888-B	43.8128-B	60.8006-B
4.3428-B	8.000-B	15.000-B	31.4378-B	40.9258-B	43.8148-B	60.7508-B
4.4803-B	8.0556-B	15.4408-B	31.7538-B	41.0008-B	43.8518-B	66.7506-B
4.6103-B	8.1416-B	15.5066-B	31.9008-B	41.1666-B	43.8888-B	70.4006-B
4.6503-B	8.1818-B	16.000-B	32.000-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
5.000-B	8.5766-B	17.2422-B	34.5558-B	42.5836-B	44.3768-B	100.6668-B
5.0688-B	8.6056-B	18.000-B	34.7538-B	42.6268-B	44.7778-B	101.4668-B
5.1203-B	8.9608-B	18.4320-B	34.9776-B	42.7006-B	45.1256-B	103.0668-B
5.1850-B	8.9906-B	19.4680-B	35.9256-B	42.7538-B	46.3006-B	103.4668-B
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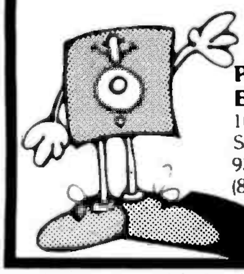

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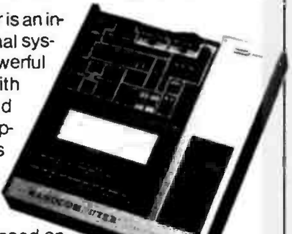

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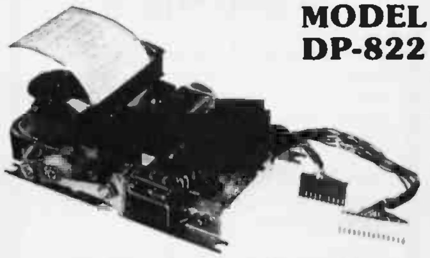

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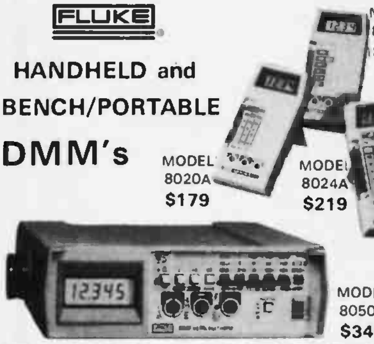

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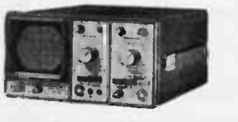

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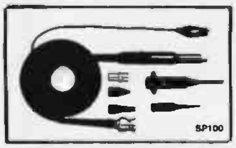

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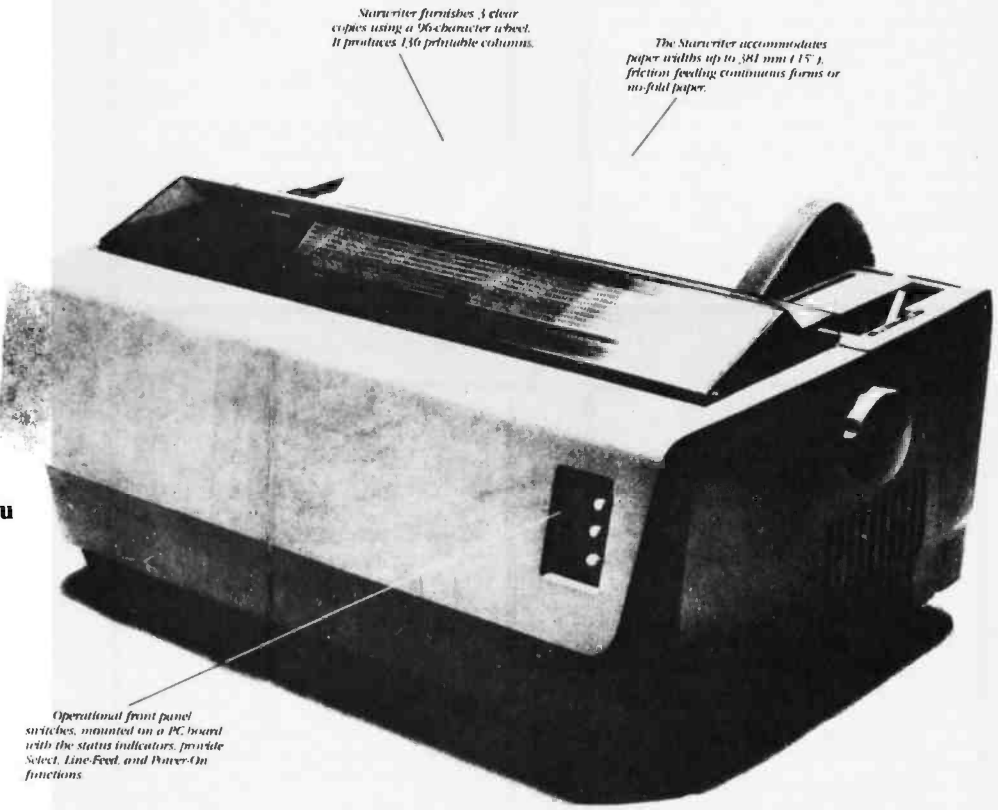

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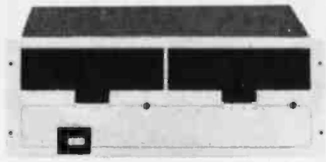

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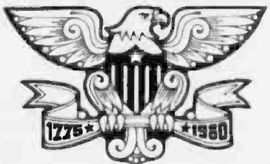

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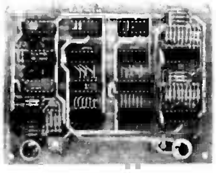

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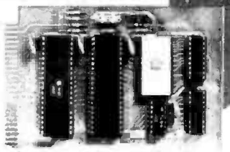

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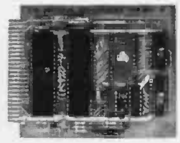

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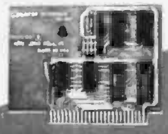
PRINTER INTERFACE



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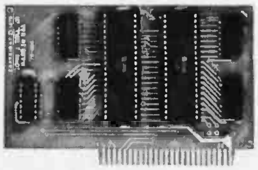
6522 APPLE II INTERFACE



• Interfaces printers, synthesizers, keyboards, JBE A-D & D-A Converter & Solid State Switches • Has handshaking logic, two 6522 VIAs & a 74LS74 for timing. Inputs & outputs are TTL compatible.

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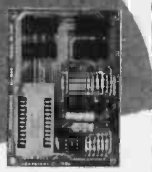
2716 EPROM PROGRAMMER



JBE 2716 EPROM Programmer was designed to program 5V 2716 EPROMS • It can also read 2716s • Interfaces to the Apple II using JBE Parallel I/O Card & four ribbon cable connectors • An LED indicates when power is being applied to the EPROM • A textool zero insertion force socket is used for the EPROM • Comes with complete doc. for writing and reading in the Apple II or Apple II + • Cables available separately.

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74LS15	.35	74LS170	1.89
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74LS30	.35	74LS192	.88
74LS32	.39	74LS193	.98
74LS33	.54	74LS194	1.80
74LS37	.78	74LS195	1.39
74LS38	.39	74LS196	.82
74LS40	.25	74LS197	.82
74LS42	.79	74LS221	1.28
74LS47	.78	74LS240	1.89
74LS48	.78	74LS241	1.89
74LS51	.35	74LS242	1.89
74LS54	.35	74LS243	1.89
74LS55	.32	74LS244	1.79
74LS73	.44	74LS245	2.89
74LS74	.48	74LS251	1.32
74LS75	.58	74LS253	.89
74LS76	.50	74LS257	.89
74LS78	.59	74LS258	.89
74LS83	.90	74LS259	2.89
74LS85	1.23	74LS260	.68
74LS86	.45	74LS266	.68
74LS90	.70	74LS273	1.69
74LS92	.82	74LS275	3.39
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74LS95	1.11	74LS283	1.03
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74LS107	.43	74LS293	1.89
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SN7417N	.29	SN74152N	.67
SN7420N	.22	SN74153N	.67
SN7421N	.35	SN74154N	1.19
SN7422N	.29	SN74155N	.82
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SN7427N	.29	SN74160N	.95
SN7429N	.45	SN74161N	.95
SN7430N	.23	SN74162N	.89
SN7432N	.29	SN74163N	.87
SN7437N	.29	SN74164N	.97
SN7438N	.29	SN74165N	.97
SN7439N	.29	SN74166N	1.20
SN7440N	.24	SN74167N	1.95
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SN7442N	.57	SN74172N	5.95
SN7443N	.79	SN74173N	.79
SN7444N	.79	SN74174N	.89
SN7445N	.79	SN74175N	.89
SN7446N	.79	SN74176N	.85
SN7447N	.59	SN74177N	.85
SN7448N	.79	SN74179N	1.80
SN7450N	.23	SN74180N	.75
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SN7480N	.59	SN74196N	.85
SN7481N	1.10	SN74197N	.85
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SN7483N	.55	SN74199N	1.39
SN7485N	.65	SN74221N	1.39
SN7486N	.39	SN74251N	.95
SN7489N	1.75	SN74273N	1.05
SN7490N	.39	SN74279N	.89
SN7491N	.65	SN74283N	2.15
SN7492N	.52	SN74284N	3.90
SN7493N	.49	SN74285N	3.90
SN7494N	.72	SN74290N	1.25
SN7495N	.65	SN74298N	.95
SN7496N	.72	SN74365N	.68
SN7497N	3.10	SN74366N	.68
SN74100N	.99	SN74367N	.79
SN74107N	.32	SN74368N	.79
SN74109N	.53	SN74390N	1.90
SN74116N	1.95	SN74393N	1.90
SN74121N	.29	SN74490N	1.90
SN74122N	.39		

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74LS00N	.35	74LS164N	1.19
74LS01N	.28	74LS165N	.89
74LS02N	.28	74LS166N	2.48
74LS03N	.28	74LS168N	1.89
74LS04N	.39	74LS169N	1.89
74LS05N	.28	74LS170N	1.99
74LS08N	.39	74LS173N	.89
74LS09N	.39	74LS174N	.99
74LS10N	.2	74LS175N	.99
74LS11N	.39	74LS181N	2.20
74LS12N	.39	74LS190N	1.15
74LS13N	.47	74LS191N	1.15
74LS14N	1.25	74LS192N	.98
74LS15N	.39	74LS193N	.98
74LS20N	.26	74LS194N	1.15
74LS21N	.38	74LS195N	.95
74LS22N	.38	74LS196N	.89
74LS26N	.39	74LS197N	.89
74LS27N	.39	74LS221N	1.49
74LS28N	.39	74LS240N	1.95
74LS30N	.26	74LS241N	1.90
74LS32N	.39	74LS242N	1.95
74LS37N	.79	74LS243N	1.95
74LS38N	.39	74LS244N	1.95
74LS40N	.26	74LS245N	4.95
74LS42N	.79	74LS247N	1.10
74LS47N	.79	74LS248N	1.10
74LS48N	.79	74LS249N	1.69
74LS51N	.26	74LS251N	1.79
74LS54N	.35	74LS253N	.98
74LS55N	.35	74LS257N	.98
74LS73N	.45	74LS258N	.98
74LS74N	.59	24LS259N	2.95
74LS75N	.68	74LS260N	.69
74LS76N	.45	74LS261N	2.49
74LS78N	.65	74LS266N	.59
74LS83AN	.99	74LS273N	1.75
74LS85N	1.19	74LS275N	4.40
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74LS90N	.75	74LS283N	1.10
74LS92N	.75	74LS290N	1.29
74LS93N	.75	74LS293N	1.95
74LS95N	.88	74LS295N	1.10
74LS96N	.98	74LS298N	1.29
74LS107N	.45	74LS324N	1.75
74LS109N	.45	74LS347N	1.95
74LS112N	.49	74LS348N	1.95
74LS113N	.49	74LS352N	1.65
74LS114N	.55	74LS353N	1.65
74LS122N	.55	74LS363N	1.49
74LS123N	1.19	74LS365N	.99
74LS124N	1.35	74LS366N	.99
74LS125N	.89	74LS367N	.73
74LS126N	.89	74LS368N	.73
74LS132N	.79	74LS373N	2.75
74LS136N	.59	74LS374N	2.75
74LS138N	.89	74LS375N	.69
74LS139N	.89	74LS377N	1.95
74LS145N	1.25	74LS385N	1.95
74LS148N	1.49	74LS386N	.65
74LS151N	.79	74LS390N	1.95
74LS153N	.79	74LS393N	1.95
74LS154N	2.49	74LS395N	1.70
74LS155N	1.19	74LS399N	2.95
74LS156N	.99	74LS424N	2.95
74LS157N	.99	74LS668N	1.75
74LS158N	.75	74LS670N	2.29
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CD4023	.38	CD4515	3.95
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CD4027	.65	CD4520	1.39
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CD4030	.45	CD4566	2.25
CD4031	3.25	74C00	.39
CD4032	2.15	74C02	.39
CD4034	3.25	74C04	.39
CD4035	.95	74C08	.49
CD4037	1.95	74C10	.49
CD4040	1.29	74C14	1.65
CD4041	1.25	74C20	.39
CD4042	.95	74C30	.39
CD4043	.85	74C32	.99
CD4044	.85	74C42	1.85
CD4046	1.75	74C48	2.39
CD4047	1.25	74C73	.85
CD4048	.99	74C74	.85
CD4049	.69	74C85	2.49
CD4050	.69	74C89	4.95
CD4051	1.10	74C90	1.85
CD4052	1.10	74C93	1.85
CD4053	1.10	74C95	1.85
CD4055	3.95	74C107	1.19
CD4056	2.95	74C151	2.49
CD4059	9.95	74C154	3.50
CD4060	1.19	74C157	2.10
CD4066	.75	74C160	2.39
CD4069	.35	74C161	2.30
CD4070	.49	74C163	2.39
CD4071	.35	74C164	2.39
CD4072	.35	74C173	2.59
CD4073	.35	74C174	2.75
CD4075	.35	74C175	2.75
CD4076	1.29	74C192	2.39
CD4077	.35	74C193	2.39
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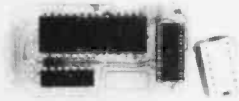

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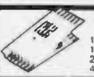

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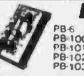

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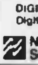

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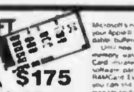

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Z80-CTC	2.5 MHz	8.75
Z80A-CTC	4.0 MHz	12.95
Z80-DMA	2.5 MHz	29.95
Z80A-DMA	4.0 MHz	36.95
Z80-SIO/0	2.5 MHz	35.95
Z80A-SIO/0	4.0 MHz	39.40
Z80-SIO/1	2.5 MHz	35.95
Z80A-SIO/1	4.0 MHz	39.40
Z80-SIO/2	2.5 MHz	35.95
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8080/8085 SUPPORT

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6875	6.95
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2112-1	3.75	3.65	3.55
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4044 450ns	8.95	7.50	6.90
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5270	4.95	6605	7.95
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14	15	36	59
16	20	38	62
18	24	59	84
20	29	69	99
22	24	79	1.10
24	38	85	1.20
28	43	1.10	1.49
36	58	1.26	1.69
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FND508	500	Red	Comm Anode (+1)	.99
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FND807/810	800	Red	Comm Anode	1.75
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SN7401N	.20	SN7473N	.35	SN74157N	.69
SN7402N	.25	SN7474N	.35	SN74160N	.89
SN7403N	.25	SN7475N	.49	SN74161N	.89
SN7404N	.25	SN7476N	.35	SN74162N	.89
SN7405N	.29	SN7479N	5.00	SN74163N	.89
SN7406N	.35	SN7480N	.50	SN74164N	.89
SN7407N	.35	SN7482N	.99	SN74165N	.89
SN7408N	.29	SN7483N	.69	SN74166N	1.25
SN7409N	.29	SN7485N	.89	SN74167N	2.79
SN7410N	.25	SN7486N	.35	SN74170N	1.95
SN7411N	.29	SN7489N	1.75	SN74172N	4.95
SN7412N	.35	SN7490N	.49	SN74173N	1.39
SN7413N	.40	SN7491N	.59	SN74174N	.99
SN7414N	.69	SN7492N	.45	SN74175N	.89
SN7416N	.29	SN7493N	.45	SN74176N	.79
SN7417N	.29	SN7494N	.69	SN74177N	.79
SN7420N	.25	SN7495N	.69	SN74179N	1.49
SN7421N	.29	SN7496N	.69	SN74180N	.79
SN7422N	.45	SN7497N	3.00	SN74181N	2.25
SN7423N	.29	SN74100N	1.49	SN74182N	.79
SN7425N	.29	SN74107N	.35	SN74184N	2.49
SN7426N	.29	SN74109N	.39	SN74185N	2.49
SN7427N	.25	SN74116N	1.95	SN74190N	1.25
SN7428N	.49	SN74121N	.39	SN74191N	1.25
SN7430N	.25	SN74122N	.55	SN74192N	.89
SN7432N	.29	SN74123N	.59	SN74193N	.89
SN7437N	.25	SN74125N	.49	SN74194N	.89
SN7438N	.40	SN74126N	.49	SN74195N	.69
SN7439N	.25	SN74132N	.75	SN74196N	.89
SN7440N	.20	SN74136N	.75	SN74197N	.89
SN7441N	.89	SN74141N	.99	SN74198N	1.49
SN7442N	.59	SN74142N	3.25	SN74199N	1.49
SN7443N	1.10	SN74143N	3.49	SN74221N	1.25
SN7444N	1.10	SN74144N	3.49	SN74251N	.99
SN7445N	.89	SN74145N	.79	SN74276N	1.95
SN7446N	.79	SN74147N	1.95	SN74279N	.79
SN7447N	.69	SN74148N	1.29	SN74283N	1.49
SN7448N	.79	SN74150N	1.25	SN74284N	3.95
SN7450N	.20	SN74151N	.69	SN74285N	3.95
SN7451N	.20	SN74152N	.69	SN74365N	.69
SN7453N	.20	SN74153N	.79	SN74366N	.69
SN7454N	.20	SN74154N	1.25	SN74367N	.69
SN7459A	.25	SN74155N	.79	SN74368N	.69
SN7460N	.20			SN74390N	1.49
SN7470N	.29			SN74393N	1.49

74LS

74LS00	.29	74LS92	.75	74LS192	1.15
74LS01	.29	74LS93	.75	74LS193	1.15
74LS02	.29	74LS95	.99	74LS194	1.15
74LS03	.29	74LS96	1.15	74LS195	1.15
74LS04	.35	74LS107	.45	74LS197	1.19
74LS05	.29	74LS109	.45	74LS221	1.19
74LS08	.29	74LS112	.45	74LS240	1.95
74LS09	.35	74LS113	.49	74LS241	1.95
74LS10	.29	74LS114	.49	74LS242	1.95
74LS11	.75	74LS122	.89	74LS243	1.95
74LS12	.35	74LS123	1.25	74LS244	1.95
74LS13	.59	74LS125	.89	74LS245	2.95
74LS14	.99	74LS126	.55	74LS247	1.19
74LS15	.35	74LS132	.99	74LS248	1.19
74LS20	.29	74LS133	.89	74LS249	1.19
74LS21	.35	74LS136	.49	74LS251	1.49
74LS22	.35	74LS138	.89	74LS253	.99
74LS26	.35	74LS139	.89	74LS257	.89
74LS27	.35	74LS145	1.19	74LS258	.99
74LS28	.35	74LS151	.89	74LS260	.69
74LS30	.29	74LS153	.89	74LS266	.69
74LS32	.35	74LS154	1.75	74LS273	1.95
74LS33	.59	74LS155	1.19	74LS279	.75
74LS37	.45	74LS156	.89	74LS283	1.09
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74LS40	.35	74LS158	.99	74LS293	.99
74LS42	.79	74LS160	1.15	74LS298	1.25
74LS47	.89	74LS161	1.15	74LS352	1.29
74LS48	1.15	74LS162	1.15	74LS353	1.29
74LS49	1.15	74LS163	1.15	74LS365	.75
74LS51	.29	74LS164	1.25	74LS366	.75
74LS54	.29	74LS165	1.25	74LS367	.75
74LS55	.29	74LS166	1.25	74LS368	.75
74LS73	.45	74LS168	1.19	74LS373	1.95
74LS74	.45	74LS169	1.19	74LS374	1.95
74LS75	.59	74LS170	2.49	74LS375	.89
74LS76	.45	74LS173	1.39	74LS386	.69
74LS78	.49	74LS174	.99	74LS393	2.49
74LS83	.89	74LS175	.99	74LS399	2.49
74LS85	1.25	74LS181	2.95	74LS670	2.49
74LS86	.45	74LS190	1.25	81LS95	1.95
74LS90	.59	74LS191	1.25	81LS97	1.95

74S

74S00	.50	74S133	.55	74S244	3.25
74S02	.50	74S134	.69	74S251	1.45
74S03	.50	74S135	1.19	74S253	1.45
74S04	.55	74S136	1.75	74S257	1.35
74S05	.55	74S138	1.35	74S258	1.35
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74S20	.50	74S158	1.35	74S374	3.49
74S22	.50	74S174	1.59	74S387*	5.95
74S30	.50	74S175	1.59	74S471*	19.95
74S32	.55	74S188	4.95	74S472*	19.95
74S40	.55	74S194	1.95	74S473*	19.95
74S51	.50	74S195	1.95	74S474*	21.95
74S64	.50	74S196	3.95	74S475*	21.95
74S65	.50	74S240	2.95	74S570*	7.95
74S74	.79	74S241	2.95	74S571*	7.95
74S86	.79	74S242	3.25	74S572*	19.95
74S112	.79	74S243	3.25	74S573*	19.95
74S113	.79			74S940	3.15
74S114	.79			74S941	3.15

* LIMITED AVAILABILITY ON THESE PROMS

CA—LINEAR

CA3013H	2.15	CA3081N	2.00	CA3089N	3.75
CA3023H	3.25	CA3082N	2.00	CA3096N	3.95
CA3039H	1.35	CA3083N	1.60	CA3130H	1.39
CA3046N	1.30	CA3086N	.85	CA3140H	1.25
CA3059N	3.25			CA3160H	1.25
CA3060N	3.25			CA3401N	.59
CA3080H	1.25			CA3600N	3.50

CD—CMOS

CD4000	.39	CD4041	1.49	CD4082	.39
CD4001	.39	CD4042	.99	CD4093	.99
CD4002	.39	CD4043	.89	CD4098	2.49
CD4006	1.19	CD4044	.89	CD4506	.75
CD4007	.25	CD4046	1.79	CD4507	.99
CD4009	.49	CD4047	2.50	CD4508	3.95
CD4010	.49	CD4048	1.35	CD4510	1.39
CD4011	.39	CD4049	.49	CD4511	1.29
CD4012	.25	CD4050	.69	CD4512	1.39
CD4013	.49	CD4051	1.19	CD4514	3.95
CD4014	1.39	CD4052	1.19	CD4515	2.95
CD4015	1.19	CD4053	1.19	CD4516	1.49
CD4016	.59	CD4056	2.95	CD4518	1.79
CD4017	1.19	CD4059	9.95	CD4520	1.29
CD4018	.99	CD4060	1.49	CD4522	1.49
CD4019	.49	CD4066	.79	CD4526	1.79
CD4020	1.19	CD4068	.39	CD4528	1.79
CD4021	1.39	CD4069	.45	CD4529	1.95
CD4022	1.19	CD4070	.55	CD4543	2.79
CD4023	.29	CD4071	.49	CD4562	11.95
CD4024	.79	CD4072	.49	CD4566	2.79
CD4025	.23	CD4073	.39	CD4583	2.49
CD4026	2.95	CD4075	.39	CD4723	1.95
CD4027	.69	CD4076	1.39	CD4724	1.95
CD4028	.89	CD4078	.55	MC14409	14.95
CD4029	1.49	CD4081	.39	MC14410	14.95
CD4030	.49			MC14411	11.95
CD4035	.99			MC14412	11.95
CD4040	1.49			MC14419	4.95
				MC14433	13.95

LITRONIX DISPLAY SALE

LIMITED OFFER!! — WHILE THEY LAST!!

DL-4500 · DL-4507 · DL-4520A · DL-4120A · DL-2300 · DLG-2535 · DL-4509 · DL-6500 · DL-6530 · DL-3130

MULTI DIGIT REFLECTOR ARRAYS FOR CLOCKS

PART NUMBER	CHAR HT (IN.)	POLARITY	DESCRIPTION	LIGHT OUTPUT (MCD) TYP	MIN	@mA	FORWARD VOLTAGE SEGMENT (V) I_F = 20mA TYP	MAX	CONTINUOUS FORWARD CURRENT PER SEGMENT (mA) MAX	PRICE
DL 4500 (Red)	.50	C.C. MPX	4 Digit 7 Segment With Colon And Auxiliary Indicators	8	5	10	1.7	2.0	30	2.49
DL 4507 (Red)		C.C. MPX		—	10					2.49
DLO 4507 (orng)		C.C. non MPX		8	5					4.95
DLG 4507 (grn)		C.C. non MPX								4.95
DL 4520A (red)		C.C. non MPX								2.49
DL 4120A (red)	1.0	C.C. non MPX		15	8		3.4	4.0		4.95

MULTI-DIGIT REFLECTOR ARRAYS

PART NUMBER	CHAR HT (IN.)	POLARITY	DESCRIPTION	TYP	MIN	@mA	TYP	MAX	MAX	PRICE
DL 2300 (Red)	.30	C.C. MPX	7 Seg. 2 Digit D.P. Right	7.8	1.1	20	1.7	2.0	30	.99
DLG 2535 (green)	.60	C.A. MPX	9 Seg. 2 Digit		2.8	20		3.5	25	1.49
DL 4509 (Red)	.50	C.C. MPX	8 Seg. 4 Digit D.P. Right	8	5	10	1.7	2.0	30	2.49
DL 6500 (Red)	.50	C.C. MPX	7 Seg. 6 Digit D.P. Right	8	5	10	1.7	2.0	30	2.99
DL 6530 (Red)	.50	C.A. MPX	7 Seg. 6 Digit D.P. Right	8	5	10	1.7	2.0	30	2.95
DL 3130 (Red)	1.0	C.A. MPX	7 Seg. 3 Digit D.P. Right	15	10	10	3.4	4.0	30	3.95

DISCRETE LEDS

XC556R	.200"	red	5/$1	MV50	.085"	red	6/$1	XC111R	.190"	red	5/$1
XC556G	.200"	green	4/$1	XC209R	.125"	red	5/$1	XC111G	.190"	green	4/$1
XC556Y	.200"	yellow	4/$1	XC209G	.125"	green	4/$1	XC111Y	.190"	yellow	4/$1
XC556C	.200"	clear	4/$1	XC209Y	.125"	yellow	4/$1	XC111C	.190"	clear	4/$1
XC22R	.200"	red	5/$1	XC526R	.185"	red	5/$1				
XC22G	.200"	green	4/$1	XC526G	.185"	green	4/$1				
XC22Y	.200"	yellow	4/$1	XC526Y	.185"	yellow	4/$1				
MV10B	.170"	red	4/$1	XC526C	.185"	clear	4/$1				

XC556 RED LED, METAL MTG. HDW. 2-4" LEADS.
RL-2 . . $.39 ea. or 3/$1.00

DISPLAY LEDS

C.A. — Common Anode · C.C. — Common Cathode

Type	Polarity	Ht	Price	Type	Polarity	Ht	Price
MAN 1	C.A.—red	.270	2.95	DLG507	C.A.—green	.500	1.25
MAN 2	5x7 D.M.—red	.300	4.95	DL704	C.C.—red	.300	1.25
MAN 3	C.C.—red	.125	.25	DL707	C.A.—red	.300	1.25
MAN 52	C.A.—green	.300	1.25	DL728	C.C.—red	.500	1.49
MAN 54	C.C.—green	.300	1.25	DL741	C.A.—red	.600	1.25
MAN 71	C.A.—red	.300	.75	DL746	C.A.—red ± 1	.630	1.49
MAN 72	C.A.—red	.300	.75	DL747	C.A.—red	.600	1.49
MAN 74	C.C.—red	.300	1.25	DL750	C.C.—red	.600	1.49
MAN 82	C.A.—yellow	.300	.49	DLO847	C.A.—orange	.800	1.49
MAN 84	C.C.—yellow	.300	.99	DLO850	C.C.—orange	.800	1.49
MAN 3620	C.A.—orange	.300	.49	DL338	C.C.—red	.110	.35
MAN 3630	C.A.—orange ± 1	.300	.99	FND358	C.C. ± 1	.357	.99
MAN 3640	C.C.—orange	.300	.99	FND359	C.C.	.357	.75
MAN 4610	C.A.—orange	.400	.99	FND503	C.C. (FND500)	.500	.99
MAN 6610	C.C.—orange—DD	.560	.99	FND507	C.A. (FND510)	.500	.99
MAN 6630	C.A.—orange ± 1	.560	.99	HDSP-3401	C.A.—red	.800	1.50
MAN 6640	C.C.—orange—DD	.560	.99	HDSP-3403	C.C.—red	.800	1.50
MAN 6650	C.C.—orange ± 1	.560	.99	5082-7751	C.A.,R.H.D.—red	.430	1.25
MAN 6660	C.A.—orange	.560	.99	5082-7760	C.C.,R.H.D.—red	.430	1.75
MAN 6710	C.A.—red—DD	.560	.99	5082-7300	4x7 sgl. dig. RHD	.600	22.00
MAN 6750	C.C.—red ± 1	.560	.99	5082-7302	4x7 sgl. dig. LHD	.600	22.00
MAN 6780	C.C.—red	.560	.99	5082-7304	Overnge. char. (±1)	.600	19.95
DLO304	C.C.—orange	.300	1.25	4N28	Photo Xsistor Opto-Isol.		.99
DLO307	C.A.—orange	.300	1.25	LIT-1	Photo Xsistor Opto-Isol.		.69
DLG500	C.C.—green	.500	1.25	MOC3010	Optically Isol. Triac Driver		1.25

SOCKETS · Test TEXTOOL Sockets · RECEPTACLES

ZERO INSERTION FORCE

- Nickel Boron Plating
- G.F. PSF Plastic Body
- For testing IC's

- Nickel Boron Plating
- G.F. PSF Plastic Body
- Wire Wrap Contacts

Part No.	Pins	Price	Part No.	Pins	Price
214-3339	14 pin	5.95	222-3343	22 pin	9.95
216-3340	16 pin	6.49	224-3344	24 pin	9.75
218-3341	18 pin	7.95	228-3345	28 pin	11.95
220-3342	20 pin	8.95	240-3346	40 pin	12.95

Part No.	Pins	Price	Part No.	Pins	Price
214-3592	14 pin	9.75	222-3596	22 pin	12.95
216-3593	16 pin	9.95	224-3597	24 pin	12.75
218-3594	18 pin	10.95	228-3598	28 pin	13.95
220-3595	20 pin	11.95	240-3599	40 pin	15.95

LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD

	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.29	2.09	1.89

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea.	10 Ohm 12 Ohm 15 Ohm 18 Ohm 22 Ohm / 27 Ohm 33 Ohm 39 Ohm 47 Ohm 56 Ohm	50 pcs.	$1.95
ASST. 2	5 ea.	68 Ohm 82 Ohm 100 Ohm 120 Ohm 150 Ohm / 180 Ohm 220 Ohm 270 Ohm 330 Ohm 390 Ohm	50 pcs.	$1.95
ASST. 3	5 ea.	470 Ohm 560 Ohm 680 Ohm 820 Ohm 1K / 1.2K 1.5K 1.8K 2.2K 2.7K	50 pcs.	$1.95
ASST. 4	5 ea.	3.3K 3.9K 4.7K 5.6K 6.8K / 8.2K 10K 12K 15K 18K	50 pcs.	$1.95
ASST. 5	5 ea.	22K 27K 33K 39K 47K / 56K 68K 82K 100K 120K	50 pcs.	$1.95
ASST. 6	5 ea.	150K 180K 220K 270K 330K / 390K 470K 560K 680K 820K	50 pcs.	$1.95
ASST. 7	5 ea.	1M 1.2M 1.5M 1.8M 2.2M / 2.7M 3.3M 3.9M 4.7M 5.6M	50 pcs.	$1.95
ASST. 8R		Includes Resistor Assts. 1-7 (350 pcs.)		$10.95 ea.

INTERSIL

Part No.	Function	Price
7045IPI	CMOS Precision Timer	14.95
7045EV/Kit*	Stopwatch Chip, XTL	22.95
7106CPL	3½ Digit A/D (LCD Drive)	16.95
7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	28.95
7116CPL	3½ Digit A/D LCD Dis. HLD.	18.95
7117CPL	3½ Digit A/D LED Dis. HLD.	17.95
72011DR	Low Battery Volt Indicator	2.25
7205IPG	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	Stopwatch Chip, XTL	19.95
7206CJPE	Tone Generator	5.15
7206CEV/Kit*	Tone Generator Chip, XTL	9.95
7207AIPD	Oscillator Controller	6.50
7207AEV/Kit*	Freq. Counter Chip, XTL	11.10
7208IPI	Seven Decade Counter	17.95
7209IPA	Clock Generator	3.95
7215IPG	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL	19.95
7216AIJI	8-Digit Univ. Counter C.A.	32.00
7216CIJI	8-Digit Freq. Counter C.A.	26.95
7216DIPI	8-Digit Freq. Counter C.C.	21.95
7217IJI	4-Digit LED Up/Down Counter	12.95
7218CIJI	8-Digit Univ. LED Drive	10.95
7224IPL	LCD 4½ Digit Up Counter DRI	11.25
7226AIJL	8-Digit Univ. Counter	31.95
7226AEV/Kit*	5 Function Counter Chip, XTL	74.95
7240IJE	CMOS Bin Prog. Timer/Counter	4.95
7242IJA	CMOS Divide-by-256 RC Timer	2.05
7250IJE	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	CMOS BCD Prog. Timer/Counter	5.25
7555IPA	CMOS 555 Timer (8 pin)	1.45
7556IPD	CMOS 556 Timer (14 pin)	2.20
7611BCPA	CMOS Op Amp Comparator 5MV	2.25
7612BCPA	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	CMOS Dual Op Amp Comp. 5MV	3.95
7631CCPE	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
8069CCQ	50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	Volt Ref/Indicator	2.50
8212CPA	Volt Ref/Indicator	2.50

* INTERSIL'S EVALUATION KITS

74C

74C00	.39	74C106	.75	74C195	1.59
74C02	.39	74C107	1.89	74C221	1.95
74C04	.39	74C151	2.95	74C240	2.25
74C08	.39	74C154	3.95	74C244	2.25
74C10	.39	74C157	2.25	74C373	2.49
74C14	.75	74C160	1.69	74C374	2.59
74C20	.39	74C161	1.60	74C901	.89
74C30	.39	74C162	1.49	74C903	1.15
74C42	1.39	74C163	1.69	74C911	10.95
74C48	1.95	74C164	1.59	74C912	10.95
74C73	.79	74C173	1.39	74C915	1.69
74C74	.79	74C174	1.39	74C917	10.95
74C85	1.95	74C175	1.39	74C922	5.49
74C86	.99	74C192	1.69	74C923	5.75
74C89	6.95	74C193	1.69	74C925	7.50
74C90	1.29			74C926	7.50
74C93	1.29			80C95	.79
74C95	1.59			80C97	.79

LINEAR

LH0002CN	6.85	LM340T-5	1.25	NE570N	4.95
LM10CLH	4.50	LM340T-12	1.25	LM702H	.79
LM11CLH	4.75	LM340T-15	1.25	LM703CN	.89
LH0070-OH	6.05	LM341P-5	.75	LM709N	.49
TL071CP	.79	LM341P-12	.75	LM710N	.79
TL072CP	1.39	LM341P-15	.75	LM711N	.79
TL074CN	2.49	LM342P-5	.69	LM723N	.69
LH0082CD	35.80	LM342P-12	.69	LM733N	1.00
TL082CP	1.19	LM342P-15	.69	LM739N	1.19
TL084CN	2.19	LM348N	1.25	LM741CN	.35
LH0094CD	36.80	LM350K	5.75	MC1741SCG	3.00
LM300H	.99	LF351N	.60	LM747N	.79
LM301CN	.35	LF353N	1.00	LM748N	.59
LM302H	1.95	LF355N	1.10	LM1014N	2.75
LM304H	1.95	LF356N	1.10	LM1310N	1.95
LM305H	.99	LM358N	1.00	LM1458CN	.59
LM307CN	.45	LM359N	1.79	LM1488N	1.25
LM308CN	1.00	LM370N	4.49	LM1489N	1.25
LM309H	1.95	LM373N	3.25	LM1496N	1.95
LM309K	1.25	LM377N	2.95	LM1556V	1.75
LM310CN	1.75	LM380N	1.25	LM1800N	2.95
LM311H	.90	LM381N	1.95	LM1877N-9	3.25
LM312H	2.49	LM382N	1.79	LM1889N	3.20
LM317MP	1.15	LM384N	1.95	LM1896N	1.75
LM317T	1.75	LM386N-3	1.29	LM2002T	1.49
LM317K	3.95	LM387N	1.45	LM2877P	2.05
LM318CN	1.95	LM389N	1.35	LM2878P	2.25
LM319N	1.95	LM392N	.69	LM2896P-1	2.25
LM320K-5	1.35	LF398N	4.00	LM3189N	2.95
LM320K-12	1.35	LM399H	5.00	LM3900N	.69
LM320K-15	1.35	TL494CN	4.49	LM3905CN	1.25
LM320T-5	1.25	TL496CP	1.75	LM3909N	1.15
LM320T-12	1.25	NE510A	6.00	LM3914N	3.95
LM320T-15	1.25	NE529A	4.95	LM3915N	3.95
LM323K-5	5.95	NE531H	3.95	LM3916N	3.95
LM324N	.99	NE536H	6.00	RC4136N	1.25
LM329DZ	.65	NE540H	6.00	RC4151NB	3.95
LM331N	3.95	NE544N	4.95	RC4194TK	5.95
LM334Z	1.30	NE550A	1.30	RC4195TK	5.49
LM335Z	1.40	NE555V	.39	KB4428	4.25
LM336Z	1.75	LM556N	.99	KB4429	5.95
LM337T	1.95	NE564N	3.95	LM4500A	3.25
LM337MP	1.15	LM565N	1.25	ICL8038B	4.95
LM338K	6.95	LM566CN	1.95	LM13080N	1.29
LM339N	.99	LM567V	1.25	LM13600N	1.49
LM340K-5	1.35			75138N	1.95
LM340K-12	1.35			75450N	.89
LM340K-15	1.35			75451CN	.39

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
10 pf	.08	.06	.05	.001µF	.08	.06	.05
22 pf	.08	.06	.05	.0047µF	.08	.06	.05
47 pf	.08	.06	.05	.01µF	.08	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
470 pf	.08	.06	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (Solid) CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
.1/35V	.39	.34	.29	1.5/35V	.41	.37	.29
.15/35V	.39	.34	.29	2.2/35V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial	1-99	100-499	500+	Radial	1-99	100-499	500+
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.19	.16	.12	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

$10.00 Min. Order – U.S. Funds Only
Calif. Residents Add 6% Sales Tax
Postage – Add 5% plus $1 Insurance

Spec Sheets — 25¢
Send 41¢ Postage for your FREE 1981 JAMECO CATALOG

NEW 1981 CATALOG

Jameco ELECTRONICS

PHONE ORDERS WELCOME (415) 592-8097

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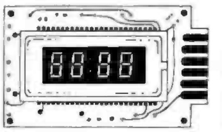
6/81

National Semiconductor Clock Modules



12VDC AUTOMOTIVE/ INSTRUMENT CLOCK

APPLICATIONS:
- In-dash autoclocks
- After-market auto/ RV clocks
- Aircraft-marine clks.
- 12VDC oper. instru.
- Portable/battery powered instrumnts.

Features: Bright 0.3" green display. Internal crystal time-base. ± 0.5 sec./day accur. Auto. display brightness control logic. 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/Thermometer	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 $29.95) (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)

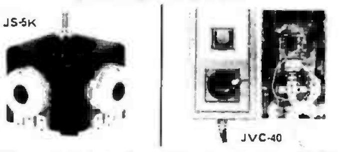
MM2114L-3 . . . . **$6.25 each**
4K STATIC RAM (LOW POWER 300NS)
(8 EACH $44.95) (100 EACH $475.00/lot)

EPROM Erasing Lamp

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

UVS-11E $79.95

JOYSTICKS



JS-5K	5K Linear Taper Pots	$5.25
JS-100K	100K Linear Taper Pots	$4.95
JVC-40	40K (2) Video Controller in case	$5.95

6-Digit Clock Kit

- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

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.
- Two, 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" w x 5-1/16" L x 2" H

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

(Picture not shown but similar in construction to above)

JE200	Reg. Power Supply Kit (5VOC, 1 amp)	$14.95
JE205	Adapter Brd. (to JE200) ±5, ±9 & ±12V.	$12.95
JE210	Var. Pwr. Sply. Kit, 5-15VOC, to 1.5amp.	$19.95

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES		
INS8080A	CPU	4.95
DP8212	8-Bit Input/Output	3.25
DP8214	Priority Interrupt Control	5.95
DP8216	Bi-Directional Bus Driver	3.49
DP8224	Clock Generator/Driver	3.95
DP8226	Bus Driver	3.49
DP8228	System Controller/Bus Driver	4.95
DP8238	System Controller	5.95
INS8243	I/O Expander for 48 Series	9.95
INS8250	Asynchronous Comm. Element	16.95
DP8251	Prog. Comm. I/O (USART)	7.95
DP8253	Prog. Interval Timer	14.95
DP8255	Prog. Peripheral I/O (PPI)	9.95
DP8257	Prog. DMA Control	19.95
DP8259	Prog. Interrupt Control	14.95
DP8275	Prog. CRT Controller	49.95
DP8279	Prog. Keyboard/Display Interface	19.95
DP8300	Octal Bus Receiver	6.95
DP8303	System Timing Element	6.95
DP8304	8-Bit Bi-Directional Receiver	3.95
DP8307	8-Bit Bi-Directional Receiver	3.95
DP8308	8-Bit Bi-Directional Receiver	3.95

6800/6800 SUPPORT DEVICES		
MC6800	MPU	14.95
MC6802CP	MPU with Clock and RAM	19.95
MC6810API	128x8 Static RAM	4.95
MC6821	Peripheral Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	10.95
MC6830L8	1024x8-Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	6.95
MC6852	Synchronous Serial Data Adapter	6.95
MC6860	0-600bps Digital MODEM	10.95
MC6862	2400bps Modulator	12.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25

MICROPROCESSOR CHIPS		
Z80 (780C)	CPU (MK3880N) (2MHz)	13.95
Z80A (780-1)	CPU (MK3880N-4) (4MHz)	15.95
CDP1802	CPU	19.95
2650	MPU	16.95
IDM2901ADC	CPU—4-Bit Slice (Com. Temp. Grade)	19.95
MCS6502	MPU w/Clock (65K Bytes Memory)	11.95
INS8035N-6	MPU—8-Bit (6MHz)	16.95
INS8039N-6	CPU—Sgl Chip 8-Bit (128 bytes RAM)	19.95
INS8040N-6	CPU (256 Bytes RAM)	24.95
INS8070N	CPU—64 Bytes RAM	24.95
INS8073N	CPU w/Basic Micro Interpreter	29.95
P8085	CPU	19.95
INS8900	CPU—16-Bit	29.95
TMS9900JL	MPU—16-Bit	49.95

SHIFT REGISTERS		
MM500H	Dual 25-Bit Dynamic	.50
MM503H	Dual 50-Bit Dynamic	.50
MM506H	Dual 100-Bit Static	.50
MM510H	Dual 64-Bit Accumulator	.50
MM1402	256-Bit Dynamic	3.95
MM5013	1024-Bit Dynamic/Accumulator	1.95
MM5016H	500/512-Bit Dynamic	.89
MM5034N	Octal 80-Bit	9.95
MM5035N	Octal 80-Bit	9.95
2504V (1404A)	1024-Bit Dynamic	3.95
2518N	Hex 32-Bit Static	4.95
2522V	Dual 132-Bit Static	2.95
2524V	512-Bit Dynamic	.99
2525V	1024-Bit Dynamic	2.95
2527V	Dual 256-Bit Static	2.95
2528V	Dual 250-Bit Static	4.00
2529V	Dual 240-Bit Static	4.00
2532N	Quad 80-Bit Static	2.95
3341PC	Fifo (Dual 80)	6.95

DATA ACQUISITION		
AF100-1CN	Universal Active Filter 2.5%	5.95
AF121-1CJ	Touch Tone Low Pass Filter	19.95
AF122-1CJ	Touch Tone Low Pass Filter	19.95
LM308AH	Super Gain Op Amp	1.00
LM334Z	Constant Current Source	1.30
LM335Z	Temperature Transducer	1.40
LF356N	JFET Input Op Amp	1.10
LF398N	Sample & Hold Amplifiers	3.95
LM399H	Temp. Comp. Prec. Ref. (.5ppm/C°)	4.95
ADC0804LCN	8-Bit A/D Converter (1 LSB)	4.95
DAC0806LCN	8-Bit D/A Converter (0.78% Lin.)	2.25

DATA ACQUISITION (CONTINUED)		
ADC0809CCN	8-Bit A/D Converter (8-Ch. Multi.)	5.25
ADC0817CCN	8-Bit A/D Converter (16-Ch. Multi.)	10.95
DAC1000LCN	10-Bit D/A Conv. Micro. Comp. (0.05%)	13.95
DAC1008LCN	10-Bit D/A Conv. Micro. Comp. (0.20%)	8.95
DAC1020LCN	10-Bit D/A Converter (0.05% Lin.)	8.49
DAC1022LCN	10-Bit D/A Converter (0.20% Lin.)	5.95
DAC1222LCN	12-Bit D/A Converter (0.20% Lin.)	9.95
CD4051N	8-Channel Multiplexer	1.19
AY-5-1013	30K BAUD UART	5.95

RAM'S		
1101	256x1 Static	1.49
1103	1024x1 Dynamic	.99
2101 (8101)	256x4 Static	3.95
2102	1024x1 Static	1.75
21L02	1024x1 Static	1.95
2111 (8111)	256x4 Static	3.95
2112	256x4 Static MOS	4.95
2114	1024x4 Static 450ns	3.95
2114L	1024x4 Static 450ns Low Power	4.95
2114-3	1024x4 Static 300ns	4.95
2114L-3	1024x4 Static 300ns Low Power	5.95
2117	16,384x1 Dynamic 550ns (house marked)	4.95
4116 (UPD416)	16K Dynamic 250ns	3.95
4164	64K Dynamic 250ns	49.95
MM2147J	4096x1 Fast 70ns	19.95
5101	256x4 Static	7.95
MM5261	1024x1 Dynamic Fully Decoded	.99
MM5262	2Kx1 Dynamic	.25
MM5290/2107	4096x1 Dynamic	4.95
MM5290J-2(4116)	16K Dynamic 150ns	5.25
MM5298J-3A	8K Dyn. 200ns (lower ½ of MM5290J)	4.95
UPD414/MK4027	4K Dynamic 16-Pin	4.95
TMS4044-45NL	4K Static	14.95
TMS4045	1024x4 Static	14.95

PROMS/EPROMS		
1702A	2K UV Erasable PROM	5.95
2708	8K EPROM	6.95
TMS2716	16K EPROM (-5V, +5V, +12V)	19.95
2716 Intel (2516) TI	16K EPROM (Single +5V)	10.95
2732 Intel (2532) TI	32K EPROM	19.95
2758	8K EPROM (450ns) (Single +5V)	7.95
5203	2048 PROM	14.95
82S23 (74S188)	32x8 PROM (Open Collector)	4.95
82S115	4096 Bipolar PROM	19.95
82S123 (74S288)	32x8 Tri-State Bipolar PROM	4.95
82S165	8K PROM	29.95

ROM'S		
2513 (2140)	Character Generator (Upper Case)	9.95
2513 (3021)	Character Generator (Lower Case)	9.95
2516N	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95

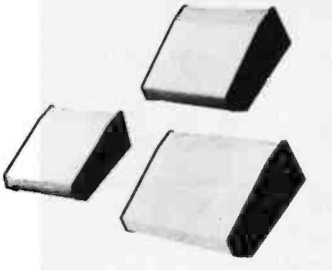
NMOS READ ONLY MEMORIES		
MCM66710P	128x9x7 ASCII Shifted w/Greek	13.50
MCM66740P	128x9x7 Math Symbol & Pictures	13.50
MCM66750P	128x9x7 Alpha. Control Char. Gen.	13.50

MICROPROCESSOR MANUALS		
M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

SPECIAL FUNCTION		
DS0025CN	Dual MOS Clock Driver (5MZ)	3.50
DS0026CN	Dual MOS Clock Driver (5MZ)	1.95
INS1771N-1	Floppy Disc Controller	24.95
INS2651N	Communication Chip	19.95
MM58167N	Microprocessor Real Time Clock	8.95
MM58174N	Microprocessor Compatible Clock	11.95
COP402N	Microcontroller with 64-Digit RAM and Direct LED Drive	6.95
COP402MN	Microcontroller with 64-Digit RAM & Direct LED Drive w/N Buss Int.	7.49
COP470N	32-Seg. VAC Fluor. Driver (20-pin pkg.)	3.25

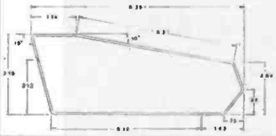
TELEPHONE/KEYBOARD CHIPS		
AY-5-9100	Push Button Telephone Dialer	14.95
AY-5-9200	Repertory Dialer	14.95
AY-5-9500	CMOS Clock Generator	4.95
AY-5-2376	Keyboard Encoder (88 keys)	11.95
HD0165-5	Keyboard Encoder (16 keys)	7.95
74C922	Keyboard Encoder (16 keys)	5.49
74C923	Keyboard Encoder (20 keys)	5.75
MM53190N	Push Button Pulse Dialer	7.95
MM57499N	96/144-Key Serial Keyboard Encoder	8.95

DESIGNERS' SERIES
Blank Desk-Top Electronic Enclosures



- High strength epoxy molded end pieces in mocha brown finish.
- Sliding rear/bottom panel for service and component accessibility.
- Top/bottom panels .080 thk alum. 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.

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 ¼" 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.



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

$10.00 Min. Order — U.S. Funds Only
Calif. Residents Add 6% Sales Tax
Postage — Add 5% plus $1 Insurance

Spec Sheets — 25¢
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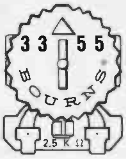
Bourns Potentiometer



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 asst. values)

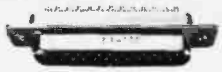
To order: Specify Bourns 3355 — (Value desired)

AC and DC Wall Transformers

Ideal for use with clocks, games, 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
AC1000	117V/60Hz	12 VAC 1 amp	$5.95
AC1700	117V/60Hz	9 VAC 1.7 amp	$6.95
OV 9200	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
UG88/U	BNC Plug	$1.79
UG89/U	BNC Jack	$3.79
UG175/U	UHF Adapter	$ .49
SO239	UHF Panel Recp.	$1.29
PL258	UHF Adapter	$1.60
PL259	UHF Plug	$1.60
UG260/U	BNC Plug	$1.79
UG1094/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**

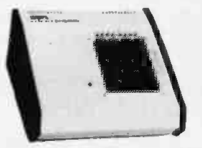
JE610 ASCII Encoded Keyboard Kit

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 generate the 126 characters, upper and lower case ASCII set. Fully buffered. Two user-define 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: 3½"H x 14½"W x 8¾"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 — 3¼"Hx11"Wx8¾"D) **$ 49.95**

JE600 Hexadecimal Encoder Kit

FULL 8-BIT
LATCHED OUTPUT
19-KEY KEYBOARD



The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow 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 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define 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: 3½"H x 8¼"W x 8¾"D

JE600/DTE-HK (as pictured above) **$99.95**
JE600 Kit 19-Key Hexadec. Keyboard, PC Board & Cmpnts. (no case) . . **$59.95**
K19 19-Key Keyboard (Keyboard only) **$14.95**
DTE-HK (case only — 3½"Hx8¼"Wx8¾"D) **$44.95**

Circle 208 on inquiry card.

Circle 418 on inquiry card.

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

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

5.25" POWER SUPPLIES WITH CASE

STANDARD MINI DISK POWER SUPPLY WITH CASE	$80
DELUXE MINI DISK POWER SUPPLY w/CASE & extender card	$131
DUAL MINI DISK POWER SUPPLY w/CASE	$121
DISK DRIVE EXTENDER CABLE	$16

DRIVE CABLES

1 DRIVE TRS-80 CABLE	$24
2 DRIVE TRS-80 CABLE	$29
3 DRIVE TRS-80 CABLE	$35
4 DRIVE TRS-80 CABLE	$40

We'll make any cable! Call us with specs.

THE DOUBLER by PERCOM DATA $203
Double density controller for TRS-80 Model I. With data separator. (Use your PERCOM DISCOUNT coupon)

DATA SEPARATOR by Percom Data $29
Stops read errors on inner tracks.

SOFTWARE

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

10% off all RADIO SHACK software

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

?30181

Circle 264 on inquiry card.

DISKETTES
(Prices per box of 10)

		VERBATIM	SYNCOM (NEW)	MEMOREX
5 1/4"	Single sided, single density	$31	$35	$28
	Single sided, double density	$40	$39	$32
	Double sided, single density	$48	N/A	N/A
	Double sided, double density	$48	$52	$40
8"	Single sided, single density	$41	$31	$33
	Single sided, double density	$51	$40	$41
	Double sided, single density	$61	$49	$55
	Double sided, double density	$61	$49	$50

When ordering diskettes, please give us your make and model number of computer or disk drive, or give us the brand and part number of the diskettes you are currently using.

5 1/4" LIBRARY CASE holds 10 disks	$3.95
BINDER HOLDER holds 2 disks	10 for $7.95
8" LIBRARY CASE holds 10 disks	$4.95
BINDER HOLDER holds 2 disks	10 for $19.95
FLOPPY SAVER	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.
MAIL ORDERS: NEW ADDRESS 1467 South Michigan Ave., Chicago, IL 60605.
ALL MAIL ORDERS: Send your NAME and STREET ADDRESS (we ship UPS), CITY, STATE, ZIP CODE AND TELEPHONE NUMBER along with your order.
BY CHECK: Include a cashiers check or money order with your order. Personal checks require 10-14 days to clear. For your safety, mail your order via insured mail. BETTER SAFE THAN SORRY.
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).
IL. RES. ADD 6% SALES TAX

SHIPPING INFORMATION: We pay all UPS ground service charges (USA only, BLUE LABEL EXTRA) on all items except those denoted with an asterisk (*). (*) items must go airfreight or truck and can be sent freight collect.
FOREIGN ORDERS WELCOME, CALL OR WRITE.
ALL orders F.O.B. Chicago, Il.

WARRANTY INFORMATION: All Equipment carries a 90 day parts and labor warranty, unless otherwise noted. Warranty repair or replacement will be provided at no charge, excluding shipping costs. 10 DAY MONEY BACK GUARANTEE: If within ten days you return merchandise in new and re-saleable condition we will refund your original purchase price. All refunds, exchanges or repairs include original cartons, packaging, and manuals and be in new and re-saleable condition and accompanied by your original invoice. A 10% re-stocking fee may be charged on returns at our discretion.
Not responsible for typographical errors
Prices subject to change without notice
Dealer inquiries welcome
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What is Jade doing in San Diego ?

We've opened a new retail store. To celebrate this latest addition to our family we've reduced our prices on products from SSM, SD Systems, CCS, our own line, as well as our best selling printers, disk drives, and modems. Help us celebrate and we'll help you save money.

PROMS

2708	450ns	6.25
	10 for $4.90 ea	
2716	12.5v	9.95
2716	5v	9.95
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2532	5v	25.00
2732	5v	25.00
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21L02	2 MHz	1.25
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2114L	2 MHz	3.50
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5257	2 MHz	6.75
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AY3-1014A	8.25
TR1602B	5.25
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8226	3.85
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8238	4.95
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8250	14.95
8251	6.50
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6850P	4.80
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Z-80	10.95
Z-80A	12.95
6502	11.50
6800	11.95
6802	17.95
6809	39.95
8035	24.00
8080A	6.59
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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
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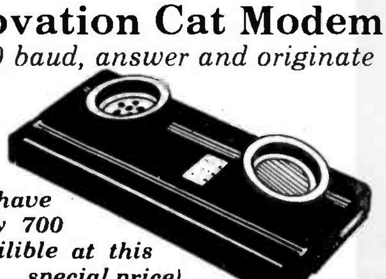
BAUD RATE GENERATORS

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 availible 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/origiate, 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
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Disk Drives

*JADE's new dual disk sub-assemblies include: **Handsome metal cabinet** with **proportionally balanced air flow system, assembled & tested** dual drive power supply, **quiet whisper type** cooling fan, power-cable kit, lighted power switch, approved fuse assembly, line cord, **Never-Mar** rubber feet, and all necessary hardware to mount 2-8" disk drives - it's **all American made, guaranteed for six months**, and it's in stock!*

Dual 8" Sub-Assembly Cabinet
END-000421 *Cabinet kit* $225.00
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Single sided, double density disk drive sub-system
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Double sided, double density disk drive sub-system
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8" DISK DRIVES
Highly reliable double density floppy disk drives
Shugart 801R single sided, double density
MSF-10801R *SA-801R* $425.00
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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
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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

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Add 16K of RAM to your TRS-80, Apple, or Exidy in just minutes. We've sold thousands of these 16K RAM upgrades which include the appropriate memory chips (as specified by the manufacturer), all necessary jumper blocks, fool-proof instructions, and our 1 year guarantee.
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MEX-16102K *Exidy kit* $29.00

16K RAM Card - Microsoft
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Two computers in one, Z-80 & 6502, more than doubles the power & potential of your Apple, includes Z-80 CPU card, CP/M 2.2, & BASIC-80*
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Real time clock w/battery back-up
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Joy stick with pots for Apple II
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VISICALC - Personal Sftwr
The ultimate program for your Apple II
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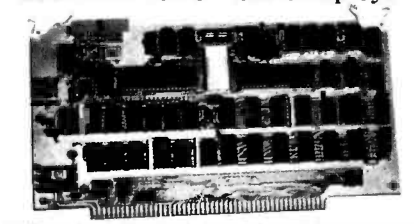
PRINTER INTERFACE - C.C.S.
Centronics type I/O card w/ firmware
IOI-2041A *A & T* $99.95

AIO, ASIO, APIO - S.S.M.
Parallel & serial interface for your Apple (see Byte pg 11)
IOI-2050K *Par & Ser kit* $129.95
IOI-2050A *Par & Ser A & T* $159.95
IOI-2052K *Serial kit* $89.95
IOI-2052A *Serial A & T* $99.95
IOI-2054K *Parallel kit* $69.95
IOI-2054A *Parallel A & T* $89.95

A488 - S.S.M.
IEEE 488 controller, uses simple basic commands, includes firmware and cable, 1 year guarantee. (see April Byte pg 11)
IOX-7488A *A & T* $399.95

S-100 CPU

2810 Z-80* CPU - Cal Comp Sys



2-4 MHz Z-80A CPU with RS-232C serial I/O port and on-board MOSS 2.2 monitor PROM, front panel compatible.*

CPU-30400A *A & T* $269.95

THE BIG Z* - Jade

2 or 4 MHz switchable Z-80 CPU with serial I/O, accomodates 2708, 2716, or 2732 EPROM, baud rates from 75 to 9600*

CPU-30201K *Kit* $145.00
CPU-30201A *A & T* $199.00
CPU-30200B *Bare board* $35.00

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 *5¼" A & T* $389.95
IOD-1200B *Bare board* $65.00

DOUBLE DENSITY - Cal Comp Sys

5¼" and 8" disk controller, single or double density, with on-board boot loader ROM, and free CP/M 2.2 and manual set.*

IOD-1300A *A & T* $369.95

VERSAFLOPPY II - SD Systems

New double density controller for both 8" & 5¼"

IOD-1160K *Kit* $379.95
IOD-1160A *Jade A & T* $439.95

S-100 Video

VB-3 - S.S.M.

80 characters x 24 lines expandable to 80 x 48 for a full page of text, upper & lower case, 256 user defined symbols, 160 x 192 graphics matrix, memory mapped, has key board input.

IOV-1095K *4 MHz kit* $345.00
IOV-1095A *4 MHz A & T* $395.95
IOV-1096K *80 x 48 upgrade* $39.95

VDB-8024 - SD Systems

80 x 24 I/O mapped video board with keyboard I/O, and on-board Z-80A.*

IOV-1020K *Kit* $399.95
IOV-1020A *Jade A & T* $459.95

VIDEO BOARD - Jade

64 characters x 16 lines, 7 x 9 dot matrix, full upper/lower case ASCII character set, numbers, symbols, and greek letters, normal/reverse/blinking video, S-100.

IOV-1050K *Kit* $99.95
IOV-1050A *A & T* $125.00
IOV-1050B *Bare board* $19.95

MAINFRAME - Cal Comp Sys

12 slot S-100 mainframe with 20 amp power supply

ENC-112106 *A & T* $429.95

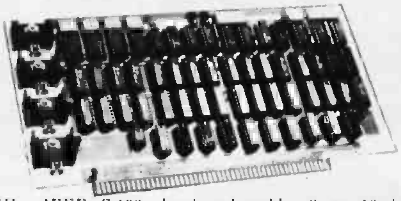
ASCII KEYBOARDS - Microswitch

58 key plus numeric pad and control keys

KBA-99058 *A & T* $39.95

S-100 Memory

MEMORY BANK - Jade



4 MHz, IEEE S-100, bank selectable, 8 or 16 bit, expandable from 16K to 256K

MEM-99730B *Bare board* $55.00
MEM-99730K *Kit, no RAM* $219.95
MEM-16730K *16K kit* $249.95
MEM-32731K *32K kit* $289.95
MEM-48732K *48K kit* $324.95
MEM-64733K *64K kit* $359.95
Assembled & tested .... add $50.00

64K RAM - Calif Computer Sys

4 MHz bank port / bank byte selectable, extended addressing, 16K bank selectable, PHANTOM line allows memory overlay, 8080 / Z-80 / front panel compatible.

MEM-64565A *A & T* $575.00

EXPANDORAM II - S D Systems

4 MHz RAM board expandable from 16K to 64K

MEM-16630K *16K kit* $275.95
MEM-32631K *32K kit* $295.95
MEM-48632K *48K kit* $315.95
MEM-64633K *64K kit* $335.95
Assembled & tested .... add $50.00

32K STATIC RAM - Jade

2 or 4 MHz expandable static RAM board uses 2114L's

MEM-16151K *16K 4 MHz kit* $169.95
MEM-32151K *32K 4 MHz kit* $299.95
Assembled & tested .... add $50.00

16K STATIC RAM - Cal Comp Sys

2 or 4 MHz 16K static RAM board, IEEE S-100, bank selectable, Phantom capability, addressable in 4K blocks

MEM-16160A *16K 2 MHz A & T* ... $286.95
MEM-16162A *16K 4 MHz A & T* ... $289.95
MEM-16160B *Bare board* $50.00

PB-1 - S.S.M.

2708, 2716 EPROM board with built-in programmer

MEM-99510K *Kit* $139.95
MEM-99510A *A & T* $199.95

PROM-100 - SD Systems

2708, 2716, 2732, 2758, & 2516 EPROM programmer

MEM-99520K *Kit* $219.95
MEM-99520A *Jade A & T* $269.95

S-100 I/O

I/O-4 - S.S.M.

2 serial I/O ports plus 2 parallel I/O ports

IOI-1010K *Kit* $159.95
IOI-1010A *A & T* $219.95
IOI-1010B *Bare board* $35.00

S.P.I.C. - Jade

Our new I/O card with 2 SIO's, 4 CTC's, and 1 PIO

IOI-1045K *2 CTC's, 1 SIO, 1 PIO* .. $199.00
IOI-1045A *A & T* $259.00
IOI-1046K *4 CTC's, 2 SIO's, 1 PIO* $259.00
IOI-1046A *A & T* $319.00
IOI-1045B *Bare board w/ manual* ... $59.95
IOI-1045D *Manual only* $20.00

Software

CP/M 2.2 - Digital Research

Latest & most powerful release of CP/M

SFC-52506000D *Manual set* $24.95
SFC-52506000M *5¼" disk & manual* $149.95
SFC-52506000F *8" disk & manual* $149.95

SDOS - SD Systems

DOS, CBASIC-2, Z-80 assembler/editor/linker*

SFX-55001000D *Manual set* $24.95
SFX-55001002M *5¼" disks & man* $199.95
SFX-55001006F *8" disk & manual* $199.95

Printers

SPINWRITER - NEC

65 cps, bi-directional, letter quality printer with deluxe tractor mechanism, both parallel and serial interfaces on-board, 16K buffer, ribbon, print thimble, graphics, micro-space justification, data cable, and self test/diagnostic ROM.

PRD-55511 *without 16K buffer* ... $2795.00
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

5¼" single sided, single density, box of 10

MMD-5110103 *Soft sector* $27.95
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MMD-5220103 *Soft sector* $39.95

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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

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Circle 207 on inquiry card.

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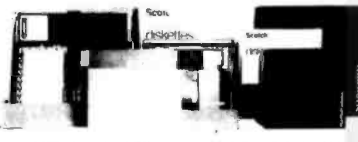


DISKETTES

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

Private labeled for California Digital by one of the most respected producers of magnetic media. Each diskette is certified double density at 40 tracks. To insure extended media life each diskette is manufactured with a reinforced hub-hole. And of course, a plastic library case is included with every box of diskettes. MMD-CD5(01)(10) Please specify computer or required sectors.

$24.95 BOX

Ten boxes $22.75 One hundred boxes $21.50

MINIDISKETTES	Box	10 boxes		Box	10 boxes
Memorex 3401	$27.00	$25.00	Scotch 744(0X10)(16)	$31.00	$29.00
Verbatim 525(01X10)	29.00	27.00	Dysan	45.00	43.00

EIGHT INCH	Scotch	box	10 bx.	Dysan	box	10 bx.	MRX	box	10 bx.
Single side/single den.	740-0	$35.	$33.	3740/1	$49.	$47.	3060	$ 5.	$ 3.
Single side/double den.	741-0	45.	43.	3740/1d	75.	73.	3090	37.	35.
Single side/32 sector	740-32	35.	33.	na.			na.		
Double side/double D.	743-0	65.	59.	na.			3115	49.	45.

SCOTCH brand head cleaning kit. $24.95 MMA-CK(5X8) please specify 5 1/4 8"
Prices available on request for: tape, cartridges, diskpacks, volume diskettes.

MEMORY

TRS-80 APPLE II $25
16k memory (8) 4116's

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

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 64K		49.50	45.00		

STATIC

21L02	450ns.	1.19	1.05	.99	
21L02	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	16.00	
2532 TI		21.50	19.00		
2764		*			

direct connect MODEM Your Choice **$169**

Direct connect modems eliminate loss of information due to the carbon compression associated with acoustic modems. Choose either of these two great units.

The Universal Data Systems 103LP is switch selectable between answer and originate modes. Fully Bell 103 compatable. Directly connects to the new modular telephone jack. 100% powered from the telephone line. No need to locate modem in proximity to A.C. power recepticle. MOD-103LP 2 pounds.

Novation "D" Cat connects to most of the new "Bell" modular handsets. Ideal for multiple line office telephones. Requires external A.C. power. MOD-DCAT 2 Lb.

UDS 103J/LP AUTO ANSWER $219

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

Other Morrow Products:			
Additional hard disk	$3650	Disc Jockey 2D controller	$345
Discus 2D 1 drive	950	Disk Joe' / 1 Controller	195
Discus 2D 2 drives	1627	M26 hard disk Controller	625
Discus 2*2 1 drive	1250	Switchboard interface	219
Discus 2*2 2 drives	2237	"New" Multiboard	275
		M-10 Ten Megabyte hard	2530

HEWLETT PACKARD $2650

HP 85

The Hewlett Packard HP-85 is a complete, low cost portable computer system. This self contained package includes CPU, keyboard, printer, CRT display and cassette tape drive. SYS-HP85 30 lbs.

BSR SYSTEM X-10

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

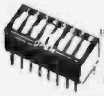
BSR Timer eight channel	$65.00	Appliance Module 500 W.	$13.95
Master control console	34.95	Lamp Module 300 Watts	13.95
Ultrasonic Controller	19.95	NEW full control wall switch	14.50

S-100 Mother Board $35

Quiet Buss

8803-18
18 slot
IMSAI

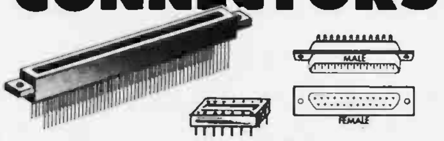
SWITCHES



DIP SWITCHES pos.	ea.	100+	1K+
4	.88	.75	.69
7	.99	.83	.79
8	1.05	.91	.87
12	1.19	.99	.91

TOGGLE		ea.	100+
7101	on/on	1.19	.98
7103	on/off/on	1.39	1.19
7107	mnt. on	1.39	1.19
7108	mnt. on	1.39	1.19
7205	dpdt mnt	1.85	1.65

CONNECTORS



GOLD EDGE CONNECTORS

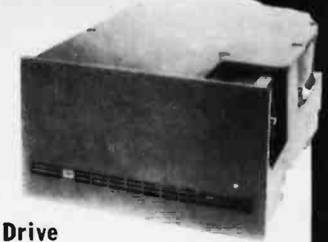
S-100 .125" centers	each	10+
Imsai solder .250" row	$2.95	$2.50
Imsai wire wrap (TI)	3.95	3.50
Sullins Hi-Rel. .250"	4.50	4.00
Sullins Hi-Rel. W/W	5.35	4.90
Sullins / Altair .140"	4.95	4.50
.156" Centers (standard)		
22/44 Kim Eyelet	2.50	2.15
36/72 Digital Group S/T	5.95	5.50
36/72 Digital Group W/W	6.60	6.15
43/86 Motorola 6800 S/T	6.60	6.15
43/86 Moto. 6800 W/W	7.00	6.85

INTEGRATED CIRCUIT SOCKETS

	Low Profile each	Low Profile 100+	Wire Wrap each	Wire Wrap 100+
8 pin	$.10	$.09	$.48	$.41
14 pin	.10	.09	.45	.41
16 pin	.12	.11	.50	.45
18 pin	.15	.13	.68	.61
24 pin	.26	.24	.94	.87
40 pin	.42	.40	1.60	1.47

"D" Type	each	10-24	25+
DE9P male	$1.60	$1.40	$1.30
DE9S female	2.25	2.00	1.90
DE hood	1.50	1.35	1.20
DA15P male	2.35	2.15	2.00
DA15S female	3.25	3.10	2.90
DA hood 2/P	1.60	1.35	1.30
DB25P male	2.50	2.35	2.25
DB25S female	3.35	3.15	3.05
DB hood 2/P	1.35	1.15	1.05
DC37P male	4.20	4.00	3.70
DC37S female	6.00	5.75	5.50
DC hood 2/P	2.25	2.00	1.75
DD50P male	5.50	5.10	4.75
DD50S female	9.40	8.60	8.00
DD50 hood 2/P	2.60	2.40	2.10
CENTRONICS			
57-30360	7.95	6.75	5.75
RIBBON CABLE CONNECTORS			
17/34 5" disk	4.85	4.15	3.95
20/40 TRS-80	5.65	5.05	4.70
25/50 8" disk	5.90	5.15	4.90

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 contaminates. Requires only DC voltage.

Dual California Digital 5 1/4" enclosure, ST506 drive and power supply. **$1500**

Shugart Associates SA400 removable media disk drive for above package. add: **$300**
S-100 & Apple controller scheduled for spring release.

Shugart Associates

$395 801/ R Disk Drive 15 lbs.

Shugart 801/R with CP 206 power supply, muffin exhaust fan, complete in dual enclosure with all the necessary harnessing cables. Documentation included. 30 pounds. MSD-1801 **$795**
Same as above but with two Shugart 801R disk drives. 50 pounds. MSD-2801 **$1195**
Disk drive cable. 6 feet 50 conductor with edge card connector at both ends. WCA-650S $25.00
Export Disk drives. 220V. 50MHz add $50.00 per disk drive.

SURPLUS

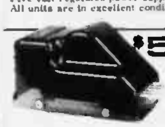
DATA INPUT TERMINAL

This Keystation terminal was recently acquired from the CMC division of the Pertec Corporation. The unit was originally designed for inputing data directly onto magnetic tape.

The system is comprised of a premium cast aluminium and fiberglass enclosure, along with a Honeywell / Microswitch hall effect keyboard. Thirty display lamps advise the operator of the systems status. Four inch load speaker acknowledges acceptance of data and alerts the operator of pending problems.

But most of all this "USED" terminal, with a little imagination, can be engineered to make the perfect home for an S-100 computer and video display: or with slight modification will accept the Rockwell AIM-65 micro/computer.

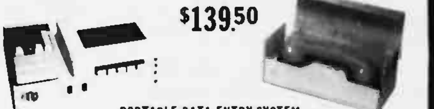
Five volt regulated power supply is available for an additional $20. (see June Byte) All units are in excellent condition. Original acquisition over $700. 22 lbs.



$59 Sankyo Magnetic Card Transport

This Sankyo card transport is capable of storing and retrieving over 400 characters of data from a single 2 x 4" HP style magnetic data card. Motorized mechanism pulls the magnetic card across the four channel read/write head in under two seconds. Ideal for any data processing application where small amounts of information must be randomly retrieved. Original cost over $200.00 Documentation and sample card included. New surplus. SPC-SCR

$139.50

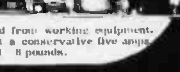


PORTABLE DATA ENTRY SYSTEM

These used data terminals were originally designed for retail store order entry systems. The operator enters the inventory control number, merchandise on hand and the unit price. After all pertinent data has been entered, the main warehouse is telephoned, the handset is placed in the acoustic coupler an all the recorded information is transmitted back the master computer.

Each system includes: Cassette drive unit; Removable hex keyboard with LED display; Five Gould "D" NiCads with charger; Acoustical coupler and DB25 cable. All units removed from service in working condition. Original cost over $2,500.

Regulated Power Supply 5 VOLT 5 AMP $11.95



This USED surplus power supply was removed from working equipment. Pass transistor regulation outputs five volts at a conservative five amps. Suitable for TTL hobby applications. SPC-PS1 8 pounds.

VISA
master charge

All merchandise sold by California Digital is premium grade. Shipping: First five pounds $2.00; each additional add $.40 Foreign orders 10% shipping. Excess will be refunded. California residents add 6% sales tax. COD's discouraged. Open accounts extended to state supported educational institutions and companies with a "Strong Dun & Bradstreet." Warehouse: 15608 Inglewood Blvd. Visitors by appointment.

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MEMOREX 8" DISKETTES

$25 WITH FREE LIBRARY CASE

Recently the Memorex Corporation had a cancellation on a contract for a truck load of eight inch diskettes. California Digital was fortunate to be offered this load of prime magnetic media.

These diskettes are "UNBRANDED" but are guaranteed first quality Memorex Brand. (#3060 single den.)

Like all diskettes sold by California Digital, a library case is supplied free with the purchase of every box.

This offer is subject to remaining inventory on hand.

SUPER BUY

World's Best Selling Printer

EPSON MX80

Immediate Delivery

Only $475

Correspondence quality printing.
A lot of printers costing a lot more can't touch the MX-80's performance. It gives you a choice of 40, 80, 66 or 132 columns of printing in as many as four distinct printing density modes, a total of twelve different combinations which can accommodate nearly any printing requirement.

Bidirectional printing. Logical seeking of shortest lines. 80 CPS. 64 graphics characters. Forms handling. The list of standard features goes on and on. The fact is that there are few printers that can compete with the MX-80 at ANY price. And none—ZERO—in its extraordinarily affordable price range.

ABCDEFGHIJKLMNOPQRSTUVWXYZABCDEFGHIJ

NEW from INTEGRAL DATA 460 Paper Tiger with GRAPHICS $1150

The 460 Paper Tiger uses a dot matrix character formation technique in which the placement of the dots overlap both horizontally and vertically to achieve a correspondence quality printing.
The printer's nine-wire print head uses staggered needle rows to create the vertically overlapping dots. The head is driven bi-directionally under microprocessor control by a stepper motor driven mechanism.
"Two K" buffer allows the printer to accept the entire content of a 1,920 character CRT screen. With graphics suggested retail price $1,395 27 lbs. PRG-460G

NEC Spinwriter 5510P/S $2795

The word processing quality Spinwriter prints at speeds upto 55 characters per second. The Model 5510 P/S is supplied with both parallel and RS-232 serial interfaces. Also included is the tractor feed mechanism, along with print thimble and ribbon. PRN-5510PS 70 lbs. Keyboard (KSR) Model 5520 P/S available $2995. PRN-5520PS 75 lbs.

TEC V-300 Word Processing

Daisy Wheel Printer

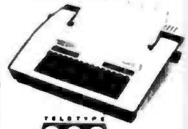
$1595

Finally a reasonably priced letter quality printer... Bi-directional printing at 25 characters per second. Full 136 print positions wide. Proportional spacing 1/120" horizontal, 1/48" vertical.
Uses standard Diablo brand interchangable daisy print wheels.
Intel 8085 CPU microprocessor controlled. Interfaces via Centronics parallel connector. Shipping 58 lbs. PRV-300.

TELETYPE® MODEL 43

4320 KEYBOARD MODELS

TTL serial output	AAA	$ 995
RS232 serial	AAK	1050
Friction 80 column	AAE	1100
Friction 80 RS232	AAL	1195
Bell 103 Modem	AAB	1495

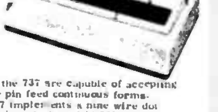


Ultra-Violet Products UVS 11E UV EPROM ERASER

$65

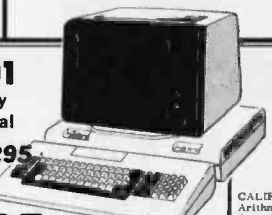
CENTRONICS

730 $595
737 $750



Both the Centronics 730 and the 737 are capable of accepting standard office letterhead or pin feed continuous forms. For higher resolution the 737 implements a nine wire dot matrix print head. Parallel interfacing. Add $65 for RS232. PRC-730P (S). PRC-737P (S) 17 lbs.

IBM 3101 Display Terminal



IBM Direct Price $1295
California Digital discount price **$1195**

AMPEX DIALOGUE 80 CRT TERMINAL

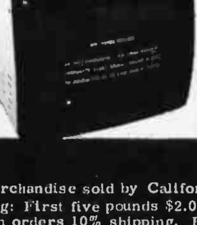
$995

New from the Ampex Corporation. The Dialogue 80 features removable keyboard, displayable two pages (four optional) dual program keys, half intensity protected fields and status line. Transmits data either block, line or character mode. Excellent value. VDT-D80 shipping 47 lbs.

VIDEO TERMINALS

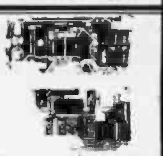
ADDS Regent 25 numeric cluster	VDT-R25	$850
ADDS Regent 30 25th status line	VDT-R30	950
ADDS Regent 40 limited graphics	VDT-R40	1195
ADDS Regent 60 Block mode	VDT-R60	1495
Ampex Dialouge 80 two page.detatch	VDT-D80	995
Digital Equipment VT-100	VDT-V100	1595
Digital Equipment VT-132	VDT-V132	1895
Direct VP-800A emulator	VDT-P800	call
Hazeltine 1410	VDT-H1410	750
Hazeltine 1420	VDT-H1420	795
Hazeltine 1500	VDT-H1500	850
Hazeltine 1510	VDT-H1510	1025
Hazeltine 1520	VDT-H1520	1225
Hewlett Packard 2621A	VDT-HP21A	
Hewlett Packard 2621P	VDT-HP21P	
IBM 3101-10 character mode green	VDT-3101	1195
IBM 3101-20 block mode	VDT-31012	1395
Lear Seigler 3A upper case only	VDT-L3A	850
Lear Seigler ADM5	VDT-L5	945
Lear Seigler ADM31	VDT-L31	1385
Lear Seigler ADM42	VDT-L42	1995
Soroc IQ 120	VDT-Q120	675
Soroc IQ 135 NEW	VDT-Q135	850
Soroc IQ 140 detatchable keyboard	VDT-Q140	1150
Televideo 912C	VDT-T912	665
Televideo 920C	VDT-T920	745
Televideo 950C detatchable keybd.	VDT-T950	985
Zenith Z-19	VDT-Z-19	735

VIDEO MONITORS



BMC KG12C 18MHz P-31 grn phosphor	$259
Leedex/Amdek 12"100	129
Leedex 100 green	169
Leedex 100-80	197
Hitachi color 13"	389
Zenith color 13"	379
NEC green phosphor	219
Panasonic color 10"	
Sanyo 9" BW	149
Sanyo 12" green phos.	235
Sanyo 15" BW	259
Sanyo 13" color	419

ACCESSORIES FOR THE APPLE COMPUTER



CALIFORNIA COMPUTER SYSTEMS	
Arithmetic Processor 7811 B/C	$319
Asynchronous serial interface 7710	129
Centronics interface card 7728	95
12K PROM Module 7114	69
Calender/Clock, Bat. back-up 7424	99
Parallel interface 7720A	99
Programable Timer 7740A	99
Analog/Digital converter 7470A	99
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Apple to Z-80 CPU card	379
D. C. HAYES PRODUCTS	
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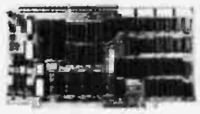
Apple parallel interface	175
SSM MICROCOMPUTER	
Dual serial parallel interface AIO	
SORRENTO VALLEY ASSOCIATES	
8" floppy controller (Pascal)	360

S-100 BOARDS

Assembled • Tested • Burned-in



CPU BOARDS		
Calif. Computer 2810A Z-80 DMA, 4MHz	BDC-C2810	$250
Godbout Z-80 24 bit, 4MHz	BDC-GZ80	239
Godbout 8085/8088 dual 16 bit processor	BDC-G88	375
Measurement Systems Z-80 4 serial 2 parallel real time clock, 8 vector	BDC-MZ80	395
SD Systems SBC-200 Z-80 with serial & parallel I/O ports	BDC-SBC2	385
Teletek FDC-1 single board CPU & floppy disk controller plus I/O	BDC-FDC1	695
MAINFRAMES		
Calif. Computer 2200A 12 slot & power supply	ENM-C2200	349
TEI 12 slot table	ENM-T12	495
TEI 22 slot table	ENM-T22	650
Godbout mainfrm.	ENM-GMF	
MEMORY BOARDS		
Calif. Computer 2065A 64K dyamic memory	BDM-C2065	$429
Calif. Computer 2016 16K static memory	BDM-C2016	259
Calif. Computer 2032 32K static memory	BDM-C2032	585
Godbout Ram 17 64K static memory 16 bit	BDM-G17	1025
SD Systems Expandoram II 16K dynamic	BDM-EX16	295
SD Systems Expandoram II 64K dynamic	BDM-EX64	375
Measurement Systems DMB6400 for Alpha Micro	BDM-M6400	685
EPROM BOARDS		
Digital Research 32K, 2716 proms extra	BDM-DP32	69
SD Systems Prom-100 programmer	BDM-P100	250
FLOPPY DISK CONTROLLER		
Calif. Computer 2422A with 2.2 CPM	BDF-C2422	329
Godbout "Disk One" features the NEC 765 controller. DMA arbitration	BDF-GD1	395
Measurement Systems 765 chip, single & double density. Error recovery	BDF-MF	419
SD Systems Versafloppy II double density	BDF-VF2	419
Tarbell D/D	BDF-TF2	419
Morrow Design Disk Jockey I single density	BDF-DJ1	195
Morrow Design Disk Jockey II double density	BDF-DJ2	345
INTERFACE BOARDS		
Calif. Computer 2718 I/O 2 serial/2 par'l	BDT-C2718	
Morrow Designs Switchboard 2 serial/4 par'l	BDT-MSB	219
Morrow Designs Multiboard 3 serial/3P. +++	BDT-MMB	275
Godbout Interfacer One 2 serial/2 par'l	BDS-GE1	199
Godbout Interfacer Two 1 serial/3 par'l	BDS-GI2	199
SPECIALITY BOARDS		
QT Computer real time clock/calendar	BDS-QCK	135
Artec Elec. Wire wrap prototype board	BDS-AWW	25
Artec Elec. General Purpose proto board	BDS-AGP	25
Godbout Spectrum color board	BDS-GSC	295
D. C. Hayes S-100 Micromodem	BDS-HMI	350
Mullen Products extender board & logic probe kt	BDS-MTBI	49
Mullen Products Opto-contro board kit	BDS-MOC	139

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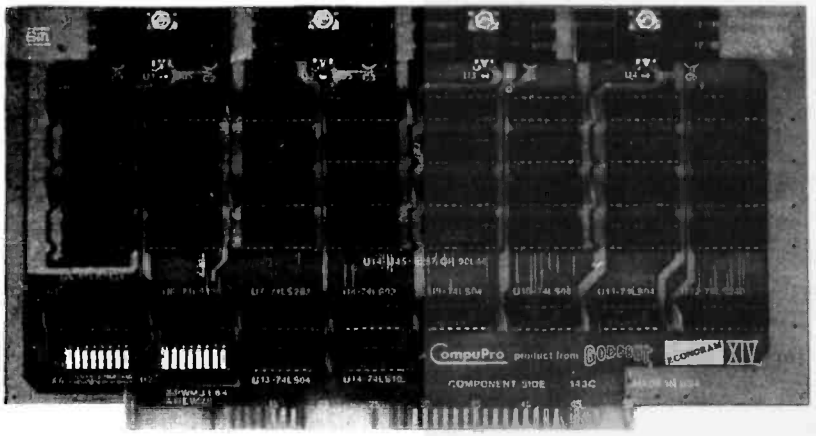

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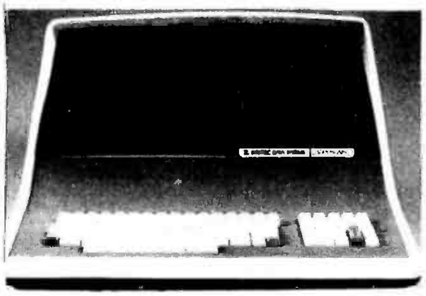

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703 w/Tractor, VFU, List $2975	$1695
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TI 745 w/full ASCII, List $1695	$1399
COMPRINT 912 w/parallel interface ..	$ 559
912 w/serial interface, List $699	$ 589
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OKIDATA Microline 80, List $949	$ 599
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CPU BOARDS

(assembled unless noted)

NORTH STAR Z80A (ZPB-A/A), $299	$254
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INTERSYSTEMS (formerly Ithaca Audio) new Series II Z-80, 4 MHz, List $395 ...	$349
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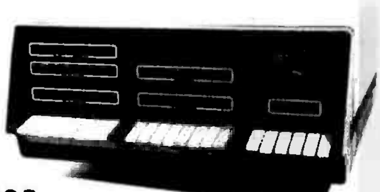

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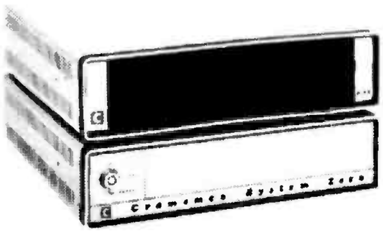

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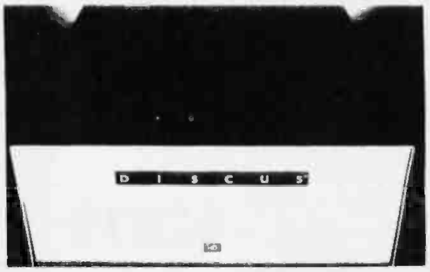

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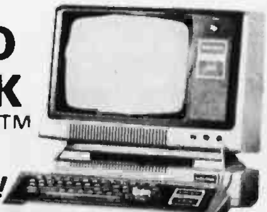

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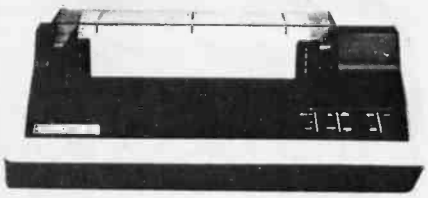

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Please note that it may take three or four months for an ad to appear in the magazine.

FOR SALE: Pascal microengine, Western Digital WD90 (includes factory power supply and cabinet). High-speed UCSD Pascal computer with 64 K memory, single- and dual-density 8-inch floppy software, and all documentation. $1200 plus shipping. Dave Werner, (212) 998-3929.

FOR SALE: GE Terminet 300 ASCII terminal with digital cassette, adjustable tractors, 10-15-30 cps, paper out, etc. Letter-like quality, not dot-matrix. Also, GE acoustic coupled modem (Bell 103). All in excellent condition. Execute commands from disk file with Command Processor software. Includes RTC, printer formatting, dynamic I/O reconfiguration, plus fifteen more commands for North Star Disk (Horizon). Please send SASE. Rich Adamson, 7310 Adams, Lincoln NE 68507, (402) 464-0718.

FOR SALE: Hazeltine 1500 CRT; $700, Hazeltine 1520 CRT; $1100, DEC LA-36; $1250, Omnitech acoustic coupler; $150, Novation CAT acoustic coupler; $150. Above items less than three years old and working. 200 new vacuum tubes; $300, 55 new Calectro & Lafayette panel meters; $165. Buyer pays shipping. Charles B Wall, Rte 3 Wingate, Clarksville TN 37040, (615) 552-2199.

FOR SALE: Twenty-four conductor (shielded coax) computer grade cable, ½-inch O/D vinyl clad bundle. Ideal for low-noise interfaces. Conductors appear to be silver plated and dielectric is teflon. SASE brings conductor sample. $0.95/foot plus postage and handling. Maximum of thirty foot lengths. Also, wanted: rack-mount multidrive 8-inch floppy-disk system. Jim Beistle, POB 501, Gilbert AR 72636, (501) 439-2305.

FOR SALE: SwTPC Model MP-68. All working with documentation, PIA, and 4 K programmable memory; $200. Two 4 K programmable memory boards; $75 each. 8 K programmable memory board with boundary switch; $150. Two MPS serial interfaces; $35 each. MP-LA parallel interface; $35. AC-30 dual cassette interface; $75. $600 takes it all. Herbert Friedman, POB 153, Malverne NY 11565, (516) 481-2717.

FOR SALE: Digital Group TVC-F 512-character video programmable memory/1.1 Kbaud audio-cassette board with all documentation. Assembled and in perfect working order. Also, listings for Z80 operating system, and documentation and listing for EDFORM1 text editor. All for $95 including UPS shipping, or make offer. Martin Tobias, POB 3766, Nashua NH 03061, (603) 889-0901.

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

FOR SALE: Extra paper, 14- and 8½-inch widths. $15 a box or trade for a TRS-80 disk drive. Van, (616) 429-6788.

FOR SALE: Perkin-Elmer letter-quality printer, KSR, 110 to 300 bps, good condition, switch-selectable U/C or full ASCII, half or full duplex, RS-232C. Bill Touchstone, (216) 333-3114 9:30 AM to 5 PM weekdays.

FOR SALE: 150 lpm Centronics P1 printer (same as Radio Shack Quick Print) with cable to a TRS-80. Excellent condition. $265 (50% of list). D E Johnson, RD 2, Box 197, Corning NY 14830, (607) 524-6740.

FOR SALE: IBM Selectric remote I/O terminal, with ASCII conversion, RS-232, as sold by Worldwide for $645. Fully checked out with manual. Best offer over $400. Steven Mather-Lees, 6 Holly Ln, Hudson NH 03051.

FOR SALE: Antique computer system, 1954 Royal McBee LGP-30, 800 lbs, desk size, 6.5- by 7-inch magnetic drum memory holds 4096 words, 32 bits per word, 113 electron tubes, 1450 diodes, and 34 plug-in cards. Two Friden Flexowriters, paper-tape punch, and plotter. Internal CRT for display in registers. Best offer over $5000. Richard Petras, (215) 356-6637.

FOR SALE: Kilobaud Microcomputing issue #6 (June 1977) through issue #18 (June 1978) in very good condition. Complete, some marks. Best offer. Daniel Q Dye Jr, 4861 Gray St, Denver CO 80212.

FOR SALE: IBM 3767 communications terminal. Excellent condition, with forms feeder and cables. Make offer, will sacrifice. Barney Lejeune, POB 3935, Lafayette LA 70502.

FOR SALE: SD Systems VDB-8024 video board; $275. Selectric typewriter, Model 73, with Micromation S-100 interface; $500. Sanyo 15-inch video monitor; $150. Cromemco 8 K Bytesaver with 2708 programmer for S-100; $75. Processor Technology 3P+S parallel/serial I/O board, S-100; $50. Keytronics keyboard with numeric keypad and enclosure; $175. SwTPC KBD-5 keyboard with enclosure; $30. George East, 38 Edwin St, Randolph MA 02368, (617) 963-2265.

FOR SALE: Centronics 730 7 by 7 matrix printer, same as RS Line Printer II. Almost new, in perfect working condition. $560. Also, adapter port when no EI for $20. G Kish, 227 W Meadow Rd, Rockaway NJ 07866, (201) 627-0052 evenings.

FOR SALE: Heathkit H-19, smart video terminal, assembled and tested; $700. Heathkit H-14, microprocessor-based printer, assembled; $700. SD Systems Expandoram 48 K, assembled and tested; $300. Jade Double-D, double-density, 5-inch or 8-inch floppy-disk controller with cable for 8-inch drive, assembled; $350. Everything includes documentation, manuals, schematics, etc. James Gerber, 12850 Kern Rd, Mishawaka IN 46544, (219) 259-9929.

FOR SALE: One almost new CAT/Novation modem, works very well; $100. One almost new Apple II disk drive with DOS 3.3 controller; $425 or best offer. Jon Taute, 2314 S 40th St, Omaha NE 68105, (402) 556-6695 evenings only.

FOR SALE: Z80 computer: 4 K programmable memory, monitor, keyboard, readout-cassette interface, EPROM programmer with sixteen I/O ports S-100; $325. State logic analyzer: 16-bit input, 5 MHz, 16 LED, 4 hexadecimal readout edge clocking, forward and backward stepping; $390. 6809 computer: monitor, Editor/Assembler, RS-232, sixteen I/O ports, timer, cassette interface; $400. Mitra Gopaul, 3 Weymouth Ave, Toronto Ontario, M4C 1R6 Canada, (416) 698-4405.

FOR SALE: Three Godbout memory boards with 8 K. Fully assembled and tested. All for $280 or $95 each. TI SR-52 calculator with PC-100 printer; $260. SSM VB1 video board. Fully assembled and tested; $100. I pay shipping. Chuck Terra, 8415 Bird Run, Missouri City TX 77489, (713) 437-1242 after 4 PM.

FOR SALE: Execuport 300 portable terminal. Hard copy, built-in acoustic coupler, carrying case. Can also be used as printer. $600 plus shipping. M A Graziano, (203) 563-5750 after 9 PM.

FOR SALE: Teletype Model ASR33 in mint condition. Used as a system console, upgraded to a CRT. Will sell for best offer. David Wong, 1916 Grand Conc, New York NY 10457, (212) 294-8087 evenings.

FOR SALE: North Star 48 K double-density, two serial ports, one parallel output and one parallel input port, two 5-inch DD disks; $3100. Intertube II, reverse video, dual intensity, extra RS-232 port, absolute addressing, protected data mode, line drawing graphics, 25 by 80, keypad; $650. L A Ludden, 30 Blanchard Rd, Marlton NJ 08053.

FOR SALE: 64 K Digital Group (Bytemaster) complete system, with Oasis 5.4, in perfect condition. Only $2500. S E Rudlin, 4600 Grove Ave, Richmond VA 232_9, (804) 353-1000.

FOR SALE: S-100 boards: Biotech CGS-808 color graphics with 6847 and 4 MHz 8085 processor on board; $275. Bytesaver I; $75. Polly (VTI) video-display board, 16 by 64 characters with graphics symbols; $60. Cromemco JS-1 joystick; $50. Edward March Jr, 2093 Fox Ln, Des Plaines IL 60018, (312) 635-7625 home, (312) 541-7300 work.

FOR SALE: NCR Model 761 cassette deck (Phillips-type). Computer controllable play, record, fast forward, reversed. $250. E J Haas, 3448 S Marcella Ave, Stow OH 44224.

FOR SALE: 8800B 18-slot mainframe; $400. MITS 3203 dual-disk drive; $800. MITS 16MCS 16 K static-memory card; $200. MITS 32-sector disk controller; $600. Pertec FD-410 drives; $300. 88-2SIO serial interface card; $200. QUME Sprint Micro 3 interface card; $200. 88-Prom 1702 prom programmer for 8800B; $150. LA-36 DECwriter II; $800. Gene Friesen, 6435 Colby, Lincoln NE 68505, (402) 467-1903.

FOR SALE: Netronics ELF II boards. Two 4 K programmable memories. Each $72, both $135. Giant Mon and I/O board; $30. Full BASIC (EPROM) board; $120. All for $260. All boards are wired and tested. Robert Foltz, 1911 Mulford Ave, Bronx NY 10461, (212) 863-0964 after 6 PM ET.

FOR SALE: These items by Percom: Data Separator; $15. Microdos (OS-80 version 1.14); $15. Patchpak; $4.50. All complete with manuals. Add $1 for shipping and handling. Albert Nijenhuis, 4310 Osage, Philadelphia PA 19104, (215) 222-1279.

FOR SALE: Altair 8800b computer with 32 K memory, one serial I/O port, ACR cassette-interface board, 2 K PROM board, MBL and DBL bootstrap PROMs, 3202 dual 8-inch disk drive and controller, Lear-Siegler ADM3A video-display terminal, Altair (Microsoft) cassette 8 K BASIC, cassette Extended BASIC, Disk Extended BASIC, and Altair disk operating system. All in perfect condition. Original value over $7300. Asking $4380 or reasonable offer. B Verner, 11404 Woodland Dr, Lutherville MD 21093, (301) 828-8422 evenings.

FOR SALE: Houston Instrument 11- by 11-inch bitpad. James Kientz, RR #1, Wamego KS 66547, (913) 532-3722.

WANTED: Tax-deductible donations are urgently needed. We are engaged in many building and maintenance projects and need CB radios, antennas, lighting apparatus, microscope attachments, and video equipment. Paul Oravis c/o Queen Anne School, 14111 Oak Grove Rd, Upper Marlboro MD 20870.

FOR SALE: Manuals, schematics, and spare boards for Sanders Associates Model 720 Data Display System. Jeff Weger, 614 Willowood Dr, Apt 209, Carol Stream IL 60187.

FOR SALE: IMSAI multiple I/O (MIO) board. Two parallel ports, one serial port, one control port, and a Tarbell tape-cassette interface plus two cables and documentation. Best offer. Eric Aronson, N64 W26611 Hillcrest Cir, Sussex WI 53089, (414) 246-3518 evenings.

BOMB

BYTE's Ongoing Monitor Box

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February BOMB Falls on Tank

Steve Ciarcia captured first place in the voting with "A Computer-Controlled Tank" (page 44), a description of his effort at wireless remote control. He will receive the $100 prize.

James C Anderson took second place with "An Extremely Low-Cost Computer Voice Response System" (page 36), the lead article in our issue theme of "The Computer and Voice Synthesis." He wins the $50 second-place prize.

Third place was shared by Mark Zimmermann, who wrote "A Beginner's Guide to Spectral Analysis, Part 1" (page 68), and Roger Mikel, who contributed "A/D and D/A Conversion—An Inexpensive Approach" (page 312).

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